

CT1-13ET with SIMpull Jacket



15 kVU Type MV-105

Copper Conductor

Thermosetting
Conductor Shield

EPR Insulation

Thermosetting Insulation
Shield

Copper Tape Shield

SIMpull® PVC Jacket

Sizes AWG 1/0 and
Larger Listed for CT Use

APPLICATIONS

Southwire CT1-13ET Type MV-105 Cable is for use in aerial, direct burial, cable trays, conduit, and underground duct installations as permitted by the NEC®. These cables are capable of operating continuously at a conductor temperature not in excess of 105°C for normal operation, 140°C for emergency overload conditions, and 250°C for short circuit conditions, and are rated at 15,000 V, 133% insulation level (ungrounded system). This cable may be installed without the need for pulling lubricant.

SPECIFICATIONS

Southwire CT1-13ET Type MV-105 Cable is manufactured and tested in accordance with the latest revisions of the following standards and specification:

- UL 1072 - Medium Voltage Power Cables
- ICEA S-93-639 (NEMA WC 74) - 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy
- ICEA S-97-682 (when requested) 5-46 kV Standard for Utility Shielded Power Cable.
- UL 1685 - (AWG 1/0 and larger) - UL Flame Exposure Test
- IEEE 1202 - Flame Test (70,000 BTU/hr Vertical Tray Test)

Certified qualification tests were performed in accordance with the requirements of AEIC CS-8. Cable has fully met the qualification testing requirements of AEIC CS-8.

CONSTRUCTION

Southwire CT1-13ET Type MV-105 Cable offers flexible, easy bending insulation, easy cable preparation, fast stripping thermosetting insulation shield, 105°C continuous operating temperature, 100% shield coverage, and it is triple extruded. Cable is sunlight resistant, suitable for direct burial, and listed for cable tray use in sizes AWG 1/0 and larger. SOLONON® low smoke, non-halogen polyolefin jackets and CPE jackets are available upon request.

• Scope

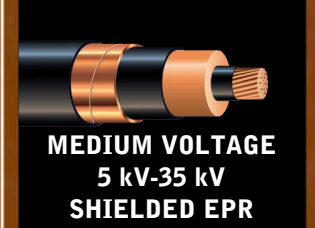
This specification covers single conductor EPR (ethylene propylene rubber) insulated, shielded, thermoplastic jacketed power cable for use in aerial, direct burial, cable trays, conduit, and underground duct installations. This cable is capable of operating continuously at a conductor temperature not in excess of 105°C for normal operation, 140°C for emergency overload conditions, and 250°C for short circuit conditions, and is rated at 15,000 V, 133% insulation level (ungrounded system).

• Standards

The following standards shall form a part of this specification - UL Standard 1072 for Medium Voltage Power Cable and ICEA S-93-639 (NEMA WC 74) 5-46 kV Shielded Power Cable for Use in the Transmission & Distribution of Electric Energy.

• Conductor

The conductor shall be Class B compressed soft or annealed copper in accordance with ASTM specs B3 and B8 and ICEA Part 2, Section 2.1 and 2.5.



WEIGHTS, MEASUREMENTS AND PACKAGING

PRODUCT CODE	SIZE	CONDUCTOR DIAMETER*		0.220" (5.59mm) INSULATION DIAMETER		EXTRUDED INSULATION SHIELD DIAMETER		MINIMUM POINT JACKET THICKNESS		APPROXIMATE OVERALL DIAMETER		APPROXIMATE NET WEIGHT		ALLOWABLE AMPACITIES**	
	AWG or kcmil	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	lbs/1000 ft	kg/km	DUCTS	CONDUIT IN AIR
CT1-13ET-002	2	0.283	7.19	0.773	19.62	0.828	21.02	0.070	1.78	0.995	25.3	641	953	165	165
CT1-13ET-001	1	0.322	8.18	0.813	20.64	0.868	22.03	0.070	1.78	1.035	26.3	719	1070	185	190
CT1-13ET-010	1/0	0.362	9.19	0.853	21.65	0.908	23.05	0.070	1.78	1.075	27.3	819	1219	215	215
CT1-13ET-020	2/0	0.405	10.29	0.893	22.67	0.948	24.07	0.070	1.78	1.115	28.3	930	1384	245	255
CT1-13ET-030	3/0	0.456	11.58	0.943	23.94	0.998	25.34	0.070	1.78	1.165	29.6	1071	1594	275	290
CT1-13ET-040	4/0	0.512	13.00	0.998	25.34	1.053	26.73	0.070	1.78	1.220	31.0	1238	1841	315	330
CT1-13ET-250	250	0.558	14.17	1.053	26.73	1.108	28.13	0.070	1.78	1.275	32.4	1392	2071	345	365
CT1-13ET-350	350	0.661	16.79	1.158	29.40	1.213	30.80	0.070	1.78	1.380	35.0	1772	2637	415	440
CT1-13ET-500	500	0.790	20.07	1.283	32.58	1.338	33.97	0.070	1.78	1.505	38.2	2317	3447	500	535
CT1-13ET-750	750	0.968	24.59	1.470	37.34	1.525	38.74	0.100	2.54	1.755	44.6	3313	4930	610	655
CT1-13ET-100	1000	1.117	28.37	1.615	41.02	1.670	41.02	0.100	2.54	1.900	48.5	4197	6245	690	755

*Minimum diameter per ASTM Standards. Dimensions accuracy $\pm 0.050"$ **Ampacities are based on the NEC® 2008 Edition. Duct ampacities are based on Table 310.77 three conductors in one underground duct, 105°C conductor, 20°C earth ambient temperature. Conduit in air ampacities are based on Table 310.73 three cables in isolated conduit in air, 105°C conductor, 40°C ambient temperature.

CONSTRUCTION (continued)

- Conductor Shield**
 The conductor shall be shielded with an extruded semi-conducting thermosetting polymeric layer over the conductor, applied in tandem with and firmly bonded to the insulation.
- Insulation**
 The insulation shall be EPR (ethylene propylene rubber) meeting the requirements of the referenced standards. The nominal thickness shall be 0.220".
- Insulation Shield**
 The insulation shall be shielded with an extruded layer of semi-conducting thermosetting material which shall be identified as being semi-conducting. Over this layer shall be applied a helically-wrapped 5-mil copper tape with 25% overlap.
- Jacket**
 The cable shall be provided with a SIMpull® jacket of black sunlight resistant PVC conforming to the requirements in ICEA. The average thickness shall be in accordance with Table 7-3 of ICEA. Optional SOLONON® low smoke, non-halogen polyolefin jackets and CPE jackets are available upon request.
- Identification**
 Cable shall be identified by surface printing on jacket.
- Tests**
 Certified qualification tests were performed in accordance with the requirements of AEIC.



Cold ShrinkTM

Silicone Rubber Termination Kits, 5 – 34.5 kV 7640–S, 7650–S and 7660–S Series

Data Sheet

1. Product Description

3MTM Cold ShrinkTM QT–III 7640–S, 7650–S and 7660–S Series Kits contain one piece, skirted, silicone rubber terminations, qualified as IEEE Standard 48–1996 Class 1 for outdoor weather-exposed applications. The termination assemblies consist of a skirted insulator, high dielectric constant (Hi-K) stress control tube, conformable Hi-K stress controlling compound and built-in silicone top seal. The insulator is made of a new dark gray silicone rubber with improved tracking resistant and hydrophobic characteristics.

The complete assembly is prestretched and loaded onto a removable core. The disposable core can be recycled. The kits are designed for terminating jacketed concentric neutral (JCN) and concentric neutral (CN) power cables rated 5 through 34.5 kV.

Kit Contents:

Each kit contains sufficient quantities of the following materials to make one single-phase termination (compression lug is not included in the kit).

- 1 Hi-K, Tracking Resistant, Silicone Rubber Termination
- 2 Strips Sealing Mastic
- 1 Instruction Sheet

Termination Features:

Conforms to IEEE Standard 48–1996 Class 1 requirements for 5, 8.7, 15, 25/28 and 34.5 kV terminations.

One-piece versatile design, allowing quick installation and accommodating a wide range of cable sizes.

Cold ShrinkTM delivery system for easy installation. Simply place termination over prepared cable and unwind core to shrink into place (no force fit required).

Hi-K stress control. Specially formulated high dielectric constant material minimizes surface stress by more uniformly distributing the electrical field over the entire surface of the insulator.

Compact design provides for easier installation in restricted spaces.

Silicone rubber insulators, EPDM stress control tubes, stress controlling compound and silicone sealing compound are compatible with common solid dielectric insulations, such as polyethylene (PE), cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR).

Stress Control

The QT–III controls the electric field stress distribution with special Hi-K materials which are an integral part of the termination. The Hi-K materials, with a dielectric constant (K) of greater than 15, capacitively distribute the field that surrounds the termination.

The stress concentrations in a continuous length of shielded cable are typically 50 V/mil adjacent to the shield to about 70 V/mil at the conductor. The QT–III reduces the cable stresses at the termination to less than those in the continuous shielded portion of the cable.

Electrical flux is refracted to distribute the voltage stress in a controlled manner along the entire termination length extending beyond the cable shield cutoff. By controlling the electric field, the stress concentrations on the termination insulator surface are kept below 15 V/mil at rated voltage. This stress distribution permits high power frequency performance and impulse performance with a compact termination design.

Figure 1 below illustrates an actual computerized stress plot of the QT–III.

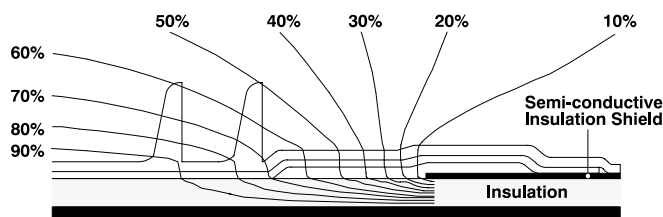


Figure 1

2. Applications

The 7640-S, 7650-S and 7660-S Series QT-III Silicone Cold Shrink™ Terminations are used to terminate Jacketed Concentric Neutral (JCN) and Concentric Neutral (CN) power cables rated 5 – 34.5 kV, having extruded solid dielectric insulation as follows: Polyethylene (high and low density), cross-linked polyethylene (XLP) and ethylene propylene rubber (EPR). The terminations are light weight for either free-hanging or bracket-mounting arrangements. They can be used in both protected and weather exposed

contaminated areas. The amount of airborne contamination determines the operating environment. Operating environments are described as areas having varying degree of airborne contaminant or pollution severity that may, or may not effect the long term performance of terminations. These operating environments are defined as light, medium, heavy and extremely heavy variations of pollution severity. The appropriate termination selection depends on the system voltage and operating environment (*See tables below*).

Recommended Application Guide

Termination Kit	System Voltage	Operating Environment			
		Light	Medium	Heavy	Extremely Heavy
(2 Skirt) 7642-S-2	15 kV	✓	✓	✓	
(4 Skirt) 7652-S-4 — 7656-S-4	15 kV	✓	✓	✓	✓
(8 Skirt) 7663-S-8 — 7666-S-8	15 kV	✓	✓	✓	✓
(4 Skirt) 7652-S-4 — 7656-S-4	25/28 kV	✓	✓	✓	
(8 Skirt) 7663-S-8 — 7666-S-8	25/28 kV	✓	✓	✓	✓
(8 Skirt) 7663-S-8 — 7666-S-8	34.5 kV	✓	✓	✓	★

Recommended operating environments are marked with a check (✓).

★ Consult 3M sales representative.

Pollution Severity Level Guide

Light	Heavy
<ul style="list-style-type: none"> • Areas without industry and with low density housing. • Areas subjected to frequent winds and/or rainfall with low density industry and housing. • Agricultural areas. ☆ • Mountainous areas. <p>All of these regions should be situated at least 7 miles from the coast and should not be exposed to coastal winds. *</p>	<ul style="list-style-type: none"> • High density industrial areas and some urban areas with high density housing, especially those with infrequent rainfall. • Areas subjected to a moderate concentration of conductive dust, particularly industrial smoke producing deposits. • Areas generally close to the coast and exposed to coastal spray or to strong winds carrying sand and salt, and subjected to regular condensation.
Medium	Extremely Heavy
<ul style="list-style-type: none"> • Non polluting industrial areas subject to infrequent rainfall and with average density housing. • Areas subjected to frequent winds and/or rainfall with high density industry and housing. • Areas exposed to wind from the coast but generally over two miles from the coast. 	<ul style="list-style-type: none"> • Usually very limited areas having extremely heavy pollutants from industrial sites especially those located near oceans and subjected to prevailing winds from the sea. • Very small isolated areas where terminations are located immediately adjacent to a pollutant source, especially downwind (cement plants, paper mills, etc.).

☆ Use of fertilizers by spraying, or the burning of crop residues, can lead to a higher pollution level due to dispersal by wind.

* Distances from coast depend on the topography of the coastal area and on the extreme wind conditions.

3. Physical and Electrical Properties

3M Cold Shrink™ QT-III 7640-S, 7650-S and 7660-S Series terminations can be used on cables with a rated maximum operating temperature of 90°C and an overload rating of 130°C. 7640-S, 7650-S and 7660-S Series terminations meet all requirements of IEEE Standard

48-1996, "IEEE Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations" and are designated Class 1 for outdoor weather-exposed locations. The current rating of these terminations meets or exceeds the current rating of the cables on which they are installed.

Typical Dimensions

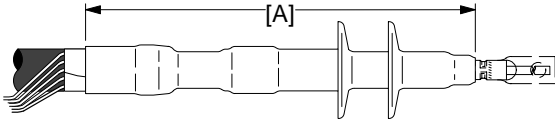
			
Kit Number	Dimension [A] Max.	Wet Creepage Distance Max.	Arcing Distance Max.
7642-S-2	9.8" (249 mm)	13.3" (338 mm)	9.8" (249 mm)

Table 1

Typical Dimensions

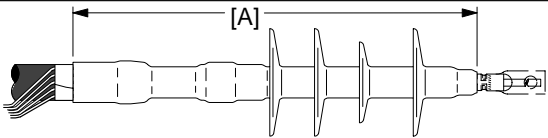
			
Kit Number	Dimension [A] Max.	Wet Creepage Distance Max.	Arcing Distance Max.
7652-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7653-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7654-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7655-S-4	12.25" (311 mm)	18.50" (470 mm)	12.25" (311 mm)
7656-S-4	13.25" (337 mm)	19.50" (495 mm)	13.25" (337 mm)

Table 2

Typical Dimensions

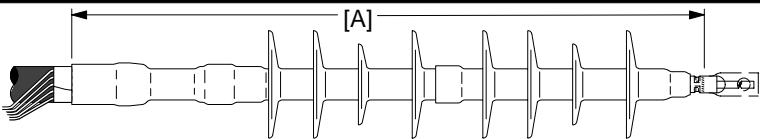
			
Kit Number	Dimension [A] Max.	Wet Creepage Distance Max.	Arcing Distance Max.
7663-S-8	20.50" (521 mm)	33.00" (838 mm)	20.50" (521 mm)
7664-S-8	20.50" (521 mm)	33.00" (838 mm)	20.50" (521 mm)
7665-S-8	20.50" (521 mm)	33.00" (838 mm)	20.50" (521 mm)
7666-S-8	21.50" (546 mm)	34.00" (864 mm)	21.50" (546 mm)

Table 3

A. Typical Physical and Electrical Properties

Silicone Sealing Compound

Hi-K Stress Control Tube

Physical Properties

Test Method	Typical Value*
• Tensile Strength (ASTM D412)	1500 psi
Modulus @ 100% Elongation	160 psi
Modulus @ 300% Elongation	500 psi

Electrical Properties

Test Method	Typical Value*
• Dielectric Constant (K) (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	22
• Dissipation Factor (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	0.10

Hi-K Stress Controlling Compound

Electrical Properties

Test Method	Typical Value*
• Dielectric Constant (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH 100 mil (2,54 mm) thickness	25
• Dissipation Factor (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH 100 mil (2,54 mm) thickness	0.9

Electrical Properties

Test Method	Typical Value*
• Dielectric Strength (ASTM D149) 75 mil (1,90 mm) thickness	300 V/mil

Silicone Rubber Insulator

Physical Properties

Test Method	Typical Value*
• Color	Dark Gray
• Tensile Strength (ASTM D412)	850 psi
Modulus @ 100% Elongation	130 psi
Modulus @ 300% Elongation	400 psi
• Hydrophobic Recovery (3M Test Method No. 406) > 90° Contact Angle	5.0 hrs.

Electrical Properties

Test Method	Typical Value*
• Dielectric Constant (S.I.C.) (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	3.6
• Dissipation Factor (ASTM D150) 60 Hz; @ 1000 V; 23°C (73°F), 50% RH	0.003
• Dielectric Strength (ASTM D149) 75 mil (1,90 mm) thickness	500 V/mil
• Track Resistance (ASTM 2303)) 3.5 kV	5.0 hrs.

* Typical values, not intended for specification purposes.

Termination Selection Guide

Kit Number	Cable Insulation O.D. Range	Conductor Size Range (AWG and kcmil)				
		5 kV 100% 133%	8.7 kV 100% 133%	15 kV 100% 133%	25/28 kV 100% 133%	34.5 kV 100% 133%
7642-S-2	0.64 – 1.08" (16,3 – 27,4 mm)	4/0 – 400 —	3/0 – 300 —	2 – 4/0 (35 – 120 mm ²)	— —	— —
7652-S-4	0.64 – 1.08" (16,3 – 27,4 mm)	4/0 – 400 —	3/0 – 300 —	2 – 4/0 (35 – 120 mm ²)	2 – 1/0 (35 – 50 mm ²)	— —
7653-S-4	0.72 – 1.29" (18,3 – 32,8 mm)	300 – 500 —	250 – 500 —	2/0 – 300 (70 – 150 mm ²)	2 – 4/0 (35 – 120 mm ²)	— —
7654-S-4	0.83 – 1.53" (21,1 – 38,9 mm)	500 – 750 —	350 – 700 —	4/0 – 500 (120 – 240 mm ²)	2/0 – 250 (70 – 150 mm ²)	— —
7655-S-4	1.05 – 1.80" (26,7 – 45,7 mm)	700 – 1500 —	600 – 1250 —	500 – 1000 (240 – 500 mm ²)	250 – 800 (125 – 400 mm ²)	— —
7656-S-4	1.53 – 2.32" (38,9 – 58,9 mm)	1750 – 2000 —	1500 – 2000 —	1250 – 2000 (625 – 1000 mm ²)	900 – 1750 (500 – 800 mm ²)	— —

Table 4

Termination Selection Guide

Kit Number	Cable Insulation O.D. Range	Conductor Size Range (AWG and kcmil)				
		5 kV 100% 133%	8.7 kV 100% 133%	15 kV 100% 133%	25/28 kV 100% 133%	34.5 kV 100% 133%
7663-S-8	0.72 – 1.29" (18,3 – 32,8 mm)	300 – 500 —	250 – 500 —	2/0 – 300 (70 – 150 mm ²)	2 – 4/0 (35 – 120 mm ²)	2 – 2/0 (35 – 70 mm ²)
7664-S-8	0.83 – 1.53" (21,1 – 38,9 mm)	500 – 750 —	350 – 700 —	4/0 – 500 (120 – 240 mm ²)	2/0 – 250 (70 – 150 mm ²)	2 – 4/0 (35 – 120 mm ²)
7665-S-8	1.05 – 1.80" (26,7 – 45,7 mm)	700 – 1500 —	600 – 1250 —	500 – 1000 (240 – 500 mm ²)	250 – 800 (125 – 400 mm ²)	3/0 – 600 (95 – 325 mm ²)
7666-S-8	1.53 – 2.32" (38,9 – 58,9 mm)	1750 – 2000 —	1500 – 2000 —	1250 – 2000 (625 – 1000 mm ²)	900 – 1750 (500 – 800 mm ²)	700 – 1500 (325 – 800 mm ²)

Table 5

4. Specifications

Product

The cable termination must have a voltage class rating equal to or greater than the cable being terminated. The rating shall be 5, 8.7, 15, 25/28 or 34.5 kV as an IEEE Standard 48–1996 Class 1 termination. It must have a maximum continuous operating temperature rating of 90°C, with an emergency overload rating of 130°C. The termination stress control shall be capacitive and constructed of a Hi-K stress control compound and a Hi-K EPDM rubber tube. The installation procedure shall not require using silicone grease. The termination insulator shall be of a skirted design, constructed of tracking resistant silicone rubber, dark gray in color. The termination must be of a prestretched Cold Shrink™ design, installed without the application of a heat source. The

termination kit shall include all materials required (except lug and vinyl tape) and shall accommodate jacketed concentric neutral (JCN) and concentric neutral (CN) cables. The Class 1 termination kits shall be used with listed copper or aluminum compression lugs.

Engineering/Architectural

Terminating of all 5, 8.7, 15, 25/28 and 34.5 kV shielded power cables, shall be performed in accordance with instructions included in the 3M 7640–S, 7650–S and 7660–S Series Cold Shrink™ QT–III silicone rubber termination kits. This shall include all outdoor weather-exposed areas for jacketed concentric neutral (JCN) and concentric neutral (CN) cables. The termination kits shall be used in conjunction with 3M Scotchlok™ 30000 or 40000 Series or 3M SC Series stem connectors.

5. Performance Tests

Typical Results, IEEE Standard 48 Short-Term Test Sequence

Insulation Class Test	15 kV (2 Skirt)		15 / 25 kV (4 Skirt)		34.5 kV (8 Skirt)	
	Require-ments	Results	Require-ments	Results	Require-ments	Results
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV
Power Frequency Voltage 1 min. Dry Withstand	50 kV	85 kV*	50 / 65 kV	95 / 100 kV*	90 kV	125 kV*
Power Frequency Voltage 10 sec. Wet Withstand	45 kV	65 kV*	45 / 60 kV	70 / 75 kV*	80 kV	100 kV*
Power Frequency Voltage 6 hour Dry Withstand	35 kV	75 kV*	35 / 55 kV	85 / 90 kV*	75 kV	115 kV*
Direct Voltage 15 min. Dry Withstand	75 kV	Passed	75 / 105 kV	Passed / Passed	140 kV	Passed
Lightning Impulse Voltage Withstand (BIL)	110 kV	135 kV*	110 / 150 kV	165 / 175 kV*	200 kV	240 kV*
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV

* At higher voltages, flashover occurs without breakdown.

Table 6

Typical Results, IEEE Standard 48 Long-Term Test Sequence

Insulation Class Test	15 kV (2 Skirt)		15 / 25 kV (4 Skirt)		34.5 kV (8 Skirt)	
	Require-ments	Results	Require-ments	Results	Require-ments	Results
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV
Cyclic Aging 30 days, 130°C conductor temperature Power Frequency Voltage Withstand	26 kV	Passed	26 / 43 kV	Passed / Passed	60 kV	Passed
Partial Discharge Extinction Voltage @ 3 pC	13 kV	25 kV	13 / 21.5 kV	25 / 33 kV	30 kV	45 kV
Lightning Impulse Voltage Withstand (BIL)	110 kV	135 kV*	110 / 150 kV	165 / 175 kV*	200 kV	240 kV*

* At higher voltages, flashover occurs without breakdown.

Table 7

Partial Discharge (Corona) Tests

The purpose of corona testing is to ensure that all properly installed terminations operate corona-free at a minimum of 150% of their operating voltage. For the test, an applied test voltage is gradually increased until discharges appear on the test set oscilloscope display. The voltage at which these discharges reach a magnitude of 3 picocoulombs is recorded as the corona starting voltage (CSV). The applied voltage is then lowered until the discharge level drops below 3 picocoulombs, and this is recorded as the corona extinction voltage (CEV).

Power Frequency (AC) Withstand Tests

All 7640-S, 7650-S and 7660-S Series terminations exceed the IEEE Standard 48-1996 requirements for a Class 1 termination.

Lightning Impulse Tests

For these tests a 1.2 x 50 microsecond voltage wave is applied to the termination lug. The testing consists of both positive and negative polarity surges per IEEE Standard 48-1996 BIL requirements. The 7640-S, 7650-S and 7660-S Series terminations exceed these BIL requirements.

Sealing Tests

Termination top and bottom seals are tested by applying 7 psi (0.05 MPa) to the cable conductor strands with the termination submerged in water. Both seals withstand this internal air pressure for 6 hours without leaking.

Environmental Performance

When airborne contaminants are deposited on a termination surface destructive leakage currents can be initiated when the surface becomes wet. Fog and drizzle are worse than rain. Rain tends to wash the pollutants off the termination while fog will wet the pollutants making the surface conductive to varying degrees promoting leakage current formation. This is most typical of hydrophilic surfaces typified by porcelain

(Figure 2). The surface of 3M QT-III silicone insulator is hydrophobic which makes it less likely to erode or track because the surface does not wet readily. (Figure 3). This either prevents or minimizes leakage current formation. On occasion severe environmental conditions can be sustained for long time periods and cause any polymeric surface to lose its hydrophobicity. However, the silicone insulator surface will re-establish its hydrophobic surface within 24 hours. This prevents the surface from becoming increasingly hydrophilic with time, which would result in premature failure or flashover. This unique ability of the QT-III silicone is a major factor to insure long service life.

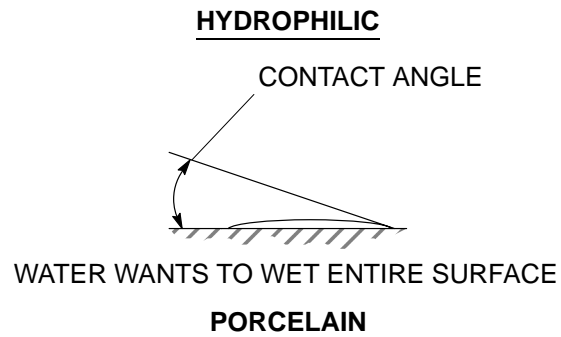


Figure 2

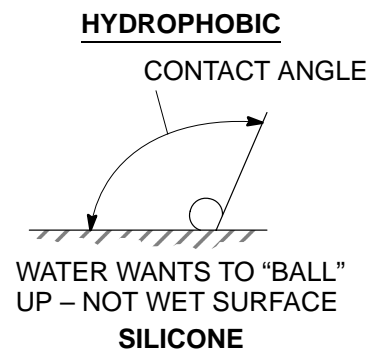


Figure 3

6. Installation Techniques

Detailed instructions are included in each kit to provide the installer with all information required to properly install the appropriately sized 3M 7640-S, 7650-S or 7660-S Series Cold Shrink™ Silicone Rubber Termination. A brief summary of the installation steps for jacketed concentric (JCN) cable is outlined as follows:

1. Prepare cable according to standard procedure.
2. Apply bottom mastic seal (*Figure 4*).

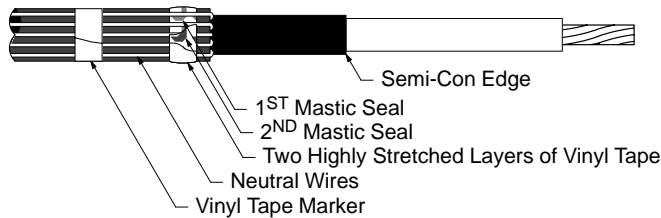
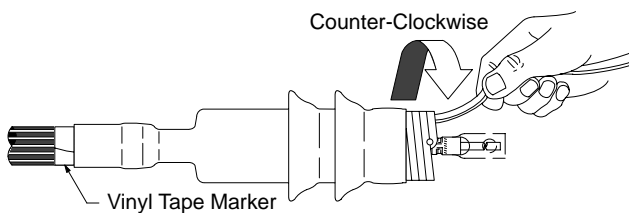


Figure 4

3. Install lug using a listed crimping tool and die.
4. Install termination onto cable and unwind core, allowing termination to shrink into place (*Figure 5*).




NOTE: The material being removed at this step is polypropylene and can be recycled with  waste.

Figure 5

5. Shelf Life

Maximum recommended storage temperature is 43°C (110°F). The termination assemblies are not affected by freezing storage temperatures. Normal stock rotation is recommended. As provided, in the expanded state, 7640-S, 7650-S and 7660-S Series terminations have an on-shelf storage life of three years from the date of manufacture.

6. Field Maintenance

Hypotting

These terminations can be field-tested by using normal cable testing procedures (reference: ANSI/IEEE Standard 400 “Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field”).

Surface Cleaning

QT-III terminations are not harmed by field surface cleaning. Established techniques for cleaning insulators and terminations in extremely contaminated areas such as high pressure water and pulverized corn cobs are acceptable.

7. Availability

3M Cold Shrink™ QT-III 7640-S, 7650-S and 7660-S Series Silicone Rubber Termination kits are available for terminating shielded power cables rated 5 through 34.5 kV. They are available from your local authorized 3M electrical distributor.

'3M', 'Cold Shrink' and 'Scotchlok' are trademarks of 3M.

Important Notice to Purchaser:

All statements, technical information and recommendations related to the Seller's products are based on information believed to be reliable, but the accuracy or completeness thereof is not guaranteed. Before utilizing the product, the user should determine the suitability of the product for its intended use. The user assumes all risks and liability whatsoever in connection with such use.

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Electrical Products Division

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Modular Splicing System

600 A

5, 8, 15 and 25 kV Class

5815 Series

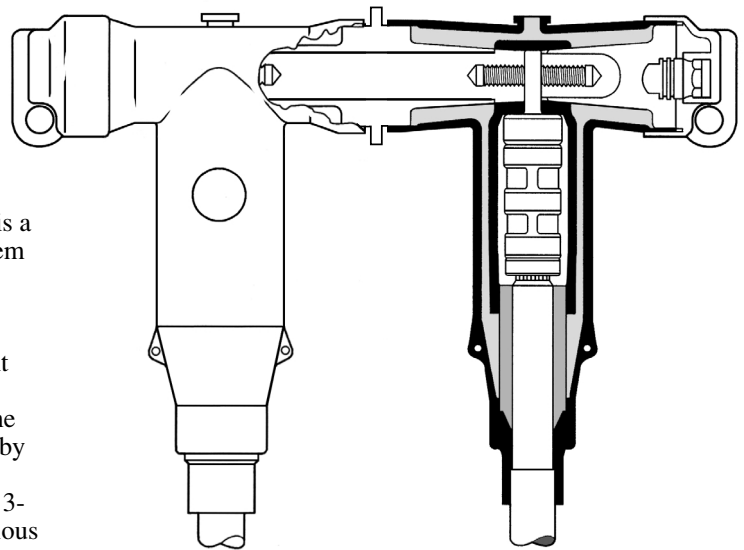
Data Sheet

1.0 Product Description

1.1 General

The 3M™ 5815 Series Modular Splicing System is a fully shielded 600 Amp separable connector system which meets the requirements of ANSI/IEEE Standard 386 – "Separable Insulated Connector Systems." These modular kits are available for splicing, dead-ending and connecting to deadfront apparatus such as transformers, switches and switchgear equipped with 600 Amp bushings. The system has the capability for future modification by simply adding or removing modular components. By combining kits, the system can accommodate 3-way, 4-way, parallel feed, etc. connections in various tap splicing configurations.

The modular kits are designed for use on 5, 8, 15 and 25 kV rated industrial shielded power cables. Kit instructions describe installations for tape shield, wire shield, UniShield®, and jacketed concentric neutral types of solid dielectric cables with extruded semi-conductive insulation shields. A capacitive test point on the insulating plug provides a safe means of testing the circuit without disturbing the bolted connection. The completed installation is fully shielded to provide a complete deadfront connection which is suitable for operation in submerged or direct burial locations.



5815-S (2-way splice)

1.2 Kit Contents

A complete modular splice installation requires one or more splicing kits (base kits) along with an adapter kit for each cable being connected. Each base kit contains the following materials, including silicone lubricant.

Table 1
Base Kit Contents

Kit No.	Tee Module	Connecting Plug	Dead End Plug	Connecting Stud	Kit Instructions
5815-S	2	1	2	2	1
5815-T	1	1	-	1	1
5815-D	1	-	2	1	1
5815-E	1	-	1	1	1

5815-B Series Adapter Kits adapt the splicing kit tee modules to specific cable sizes. The adapter kits include silicone lubricant.

Table 2
Adapter Kit Contents

Kit No.	Kit Contents
5815-B Series Adapter Kit	1 Cable Adapter
	1 Aluminum Compression Connector
	1 Cold Shrink Jacketing Tube
	1 Constant Force Spring
	1 Ground Braid Assembly
	2 Mastic Sealing Strips
	2 Silicone Lubricants
	1 CC-3 Cable Cleaning Pad Kit
	1 Instruction Sheet

A T-Wrench accessory tool is available for use with kits containing Connecting Plug(s), such as the 5815-S and 5815-T Modular Splicing Kits.

Table 3
Accessory

Part No.	Part Name	Description
5815-TW	T-Wrench	T-handled 5/16 inch hex wrench used to install a Connecting Plug into a Tee Module.

1.3 Product Features

The modular Splicing System features include:

- **Modular Design** - allows custom tailoring for various splicing functions and configurations, such as multiple taps, sectionalizing, dead-ending, adding-on, etc.
- **Bolt-together Components** - allows dead-break disconnecting and reuse of the connecting components (connecting plug, dead-end plug, connecting stud, etc.).
- **Molded Conductive Outer Jacket** - provides for a fully shielded dead-front connection which meets the requirements of IEEE Standard 592 – "Exposed Semi-conducting Shields on High-Voltage Cable Joints and Separable Insulated Connectors."
- **Kit Packaging** - designed for industrial use, the kits simplify the selection, ordering and stocking of appropriate system components.
- **Shield Adapter Kits** - cold shrink design for simple shield re-jacketing. Kits provide all of the components necessary for adapting the separable connector to specific cable sizes and shielding types of common industrial power cables.
- **Voltage Test Point** - the dead-end plug provides a high impedance test point for safely checking the de-energized status of the circuit.

2.0 Applications

For connecting 5, 8, 15 and 25 kV shielded power cables to 600 Amp dead-front, dead break installations:

- For splicing – 2-way, 3-way and multiple taps
- For adding-on
- For dead-ending
- For 600 Amp equipment (apparatus) connections
- For shielded solid dielectric (e.g. EPR and XLPE) cables with extruded semi-conductive insulation shield
- For power cable locations: Manhole, Vault, Cabinet, Junction Box, Cable Tray, Direct Burial
- For submerged locations
- For sectionalizing cable systems

3.0 Installation

A torque wrench and one-inch socket is used to tighten the insulating plug through the compression connector within the tee-module body, onto a de-energized 600 A bushing interface. A 3M™ 5815-TW T-wrench is used for installing a connecting plug into a Tee Module, for kits containing a connecting plug (e.g. the 5815-S and 5815-T). Refer to the 5815 Series kit instructions for details.

3.1 Interchangeability

All 3M 5815 Series 600 A Deadbreak Connectors conform to the electrical, mechanical and dimensional requirements of ANSI/IEEE Standard 386. The connectors can be used on any comparably rated bushing interface that also meets the requirements of this standard. In addition, all connecting plugs, dead-end plugs, compression connectors and connecting studs are designed to be interchangeable with those available from other major manufacturers.

4.0 Data

The 3M 5815 Series Modular Splicing System can be used on shielded power cables with a rated operating temperature of 90° C. and an emergency overload rating of 130° C. Connections made with these kits are rated for Voltages up to 25 kV and meet the requirements of ANSI/IEEE 386 for 600 Amp dead-break interfaces.

4.1 Production tests

Test are conducted in accordance with ANSI/IEEE Standard 386:

- Ac 60 Hz 1 Minute Withstand - 40 kV
- Minimum Corona Voltage Level - 19 kV

Tests conducted in accordance with manufacturer's requirements:

- Physical Inspection
- Periodic Dissection
- Periodic Fluoroscopic Analysis

4.2 Grounding

Grounding of the Tee Module and cable metallic shield is performed using the Ground Braid Assembly provided with each 5815-B Series Adapter Kit. The assembly is an integrated design which incorporates both a ground braid for grounding the cable metallic shielding and a ground lead (bleeder wire) for connecting to the Tee Module grounding tabs. A solderless connection is made to the cable metallic shield using a constant force spring.

- Ground Braid: 21,600 circular mils, tinned copper (7 AWG copper equivalent)
- Ground Lead (bleeder wire): 14 AWG solid, tinned copper

The typical fault current performance for the 21,600 circular mils Ground Braid can be plotted as follows:

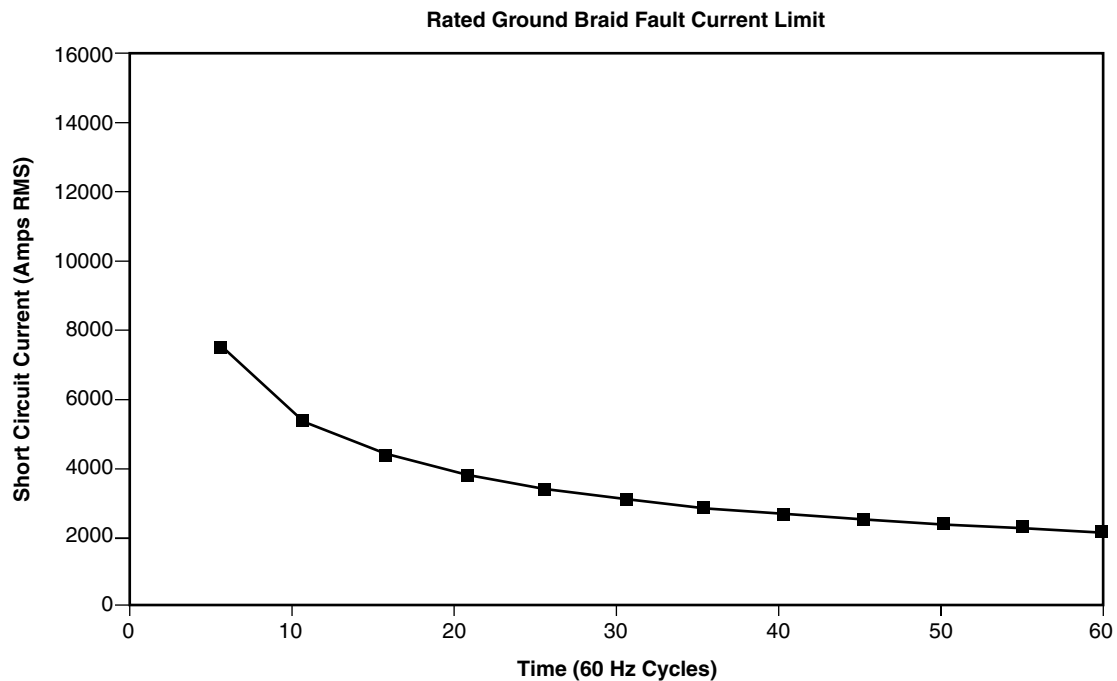


Table 4
Voltage Ratings and Characteristics

Description	kV
Standard Voltage Class	25
Maximum Rating Phase-to-Ground	15.2
ac 60 Hz 1 Minute Withstand	40
dc 15 Minute Withstand	78
BIL and Full Wave Crest	125
Minimum Corona Voltage Level	19

Voltage ratings and characteristics are in accordance with ANSI/IEEE Standard 386.

Table 5
Current Ratings and Characteristics

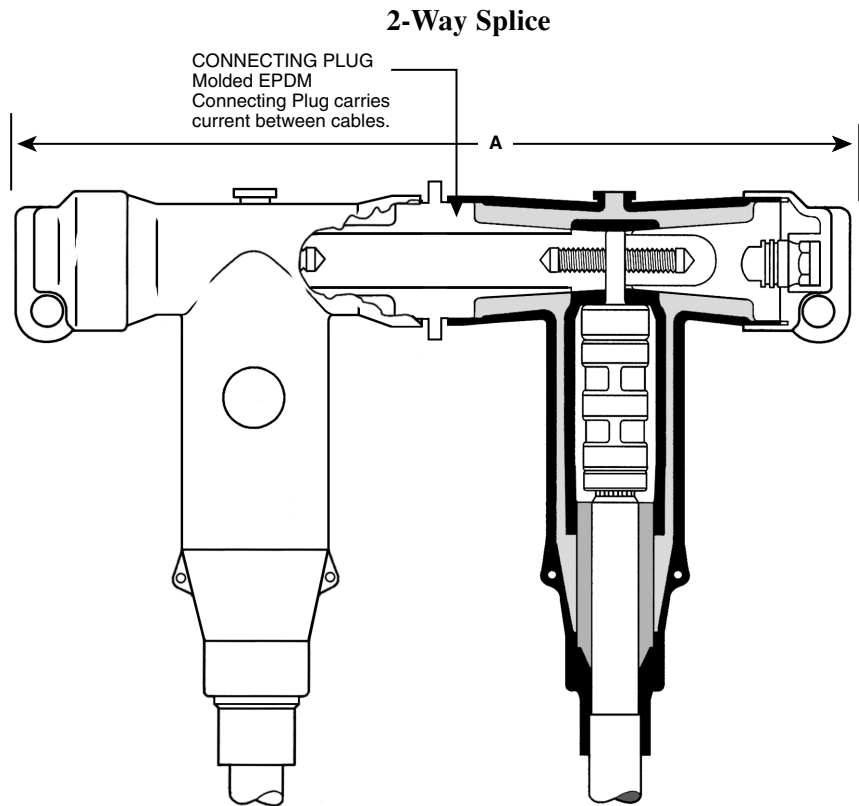
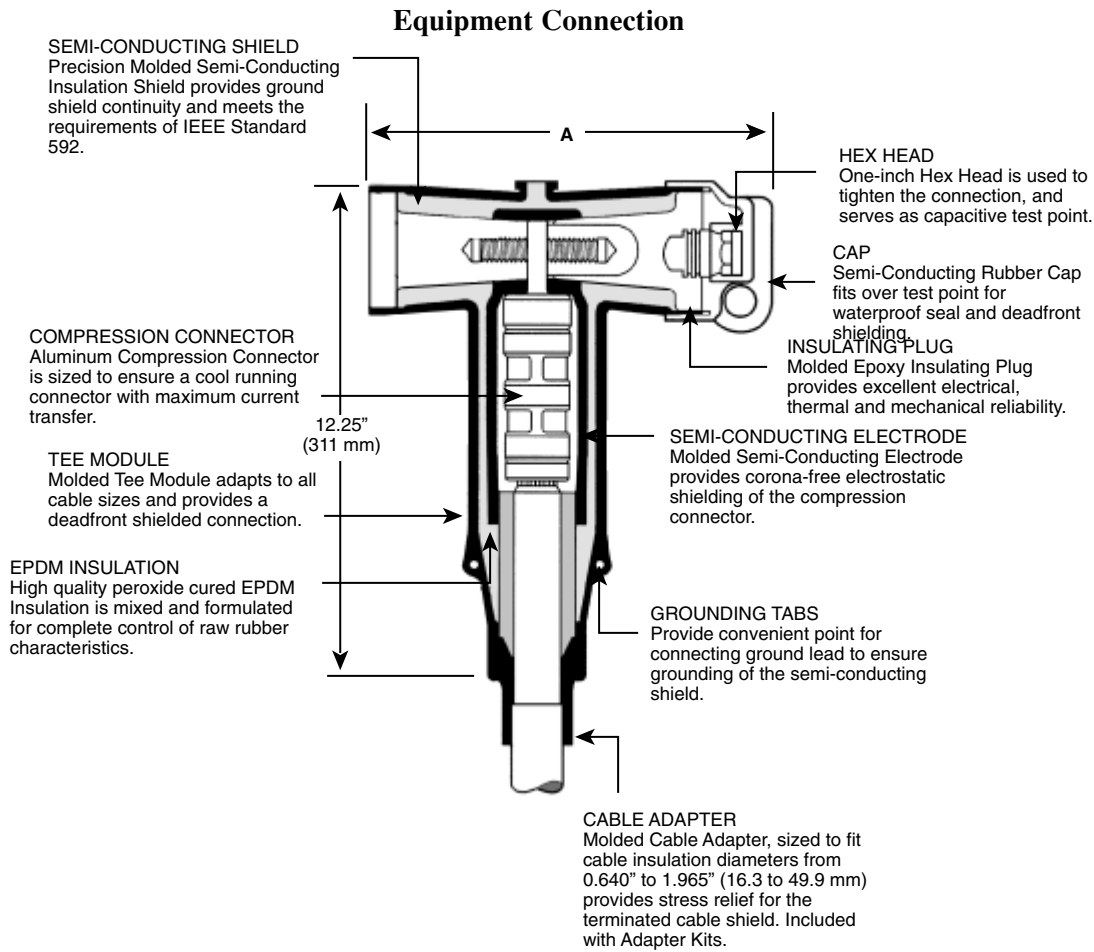
Description (600 A Interface)	Amperes
Continuous	600 A rms
24 Hour Overload	1000 A rms
Short Time	40,000 A rms symmetrical for 0.20 s 27,000 A rms symmetrical for 4.0 s

Current ratings and characteristics are in accordance with ANSI/IEEE Standard 386.

Table 6
Typical Splice Dimensions

Splice Assembly	Dimension "A" (inches/mm)
Dead End	11.10 (282)
2-way Splice	19.80 (503)
3-way Splice	28.10 (714)
4-way Splice	36.30 (922)
Equipment Connection	9.75 (248)

Examples:



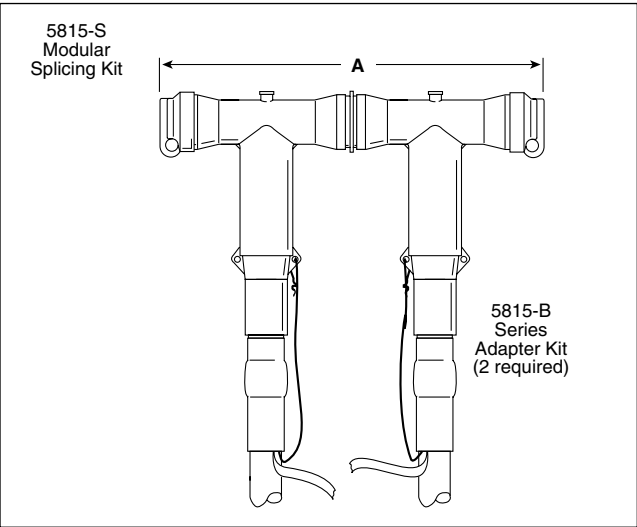
5.0 Ordering Information

Table 7
Base Kit Selection Chart

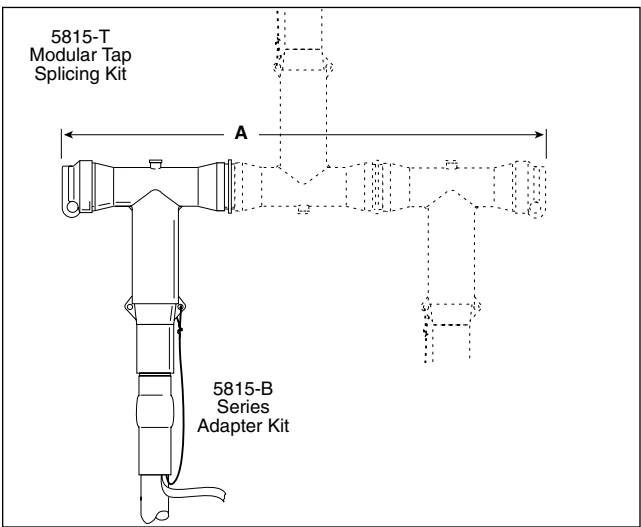
Kit No.	Application	No. of Adapter Kits Required
5815-S	2-way Splice	2
5815-T	Tap Kit (add-on, for adding to 5815-S for 3-way splicing, or for adding another cable to existing installation.	1
5815-D	Dead End Splice (with future add-on capability)	1
5815-E	Equipment Connection (for future 600 Amp apparatus bushing)	1

Table 8
Example: Ordering a Tap or Multi-Tap Splice

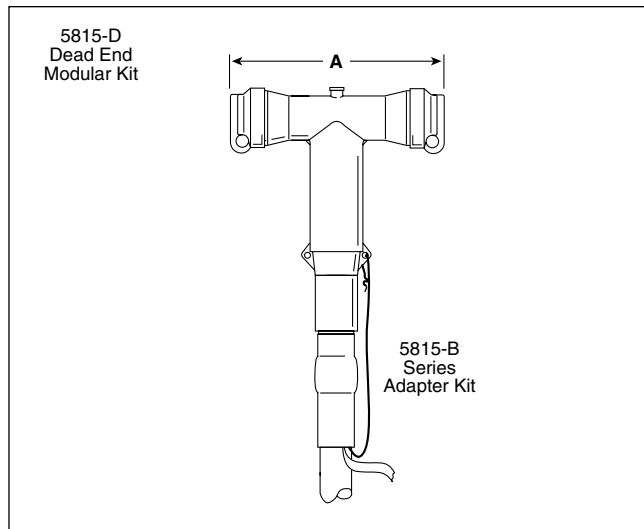
Kit No.	Application	No. of Adapter Kits Required
5815-S + 5815-T	3-way Splice (tee, wye, etc.)	3
5815-S + 5815-T + 5815-T	4-way Splice	4



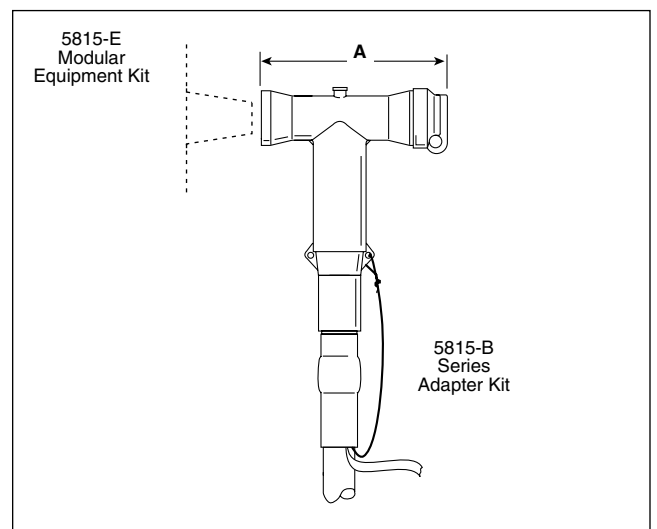
2-way Splice



For connecting to (adding on to) other Modular System Tee Modules



For Dead ending shielded power cable. For future add-on capability with 3M Modular Splicing System



For connecting to 600 Amp apparatus bushing

Adapter Kit Selection Charts (one kit required for each cable being connected)

Table 9
5 & 8 KV Class

NOTE: Final Kit selection is based on CABLE INSULATION DIAMETER.

KIT NO.	INSUL. DIA. RANGE Inches (mm)	5 kV (AWG/kcmil)				8 kV (AWG/kcmil)			
		100% (90 mils)		133% (115 mils)		100% (115 mils)		133% (140 mils)	
		Stranded	Compact /Solid	Stranded	Compact /Solid	Stranded	Compact /Solid	Stranded	Compact /Solid
5815-B1	0.640 – 0.760 (16.3 – 19.3)			2/0	3/0	2/0	3/0		
5815-B2		3/0	4/0						
5815-B5	0.720 – 0.845 (18.3 – 21.5)							2/0	
5815-B6				3/0	4/0	3/0	4/0	3/0	4/0
5815-B7		4/0		4/0	250*	4/0	250*		
5815-B10		250	250						
5815-B12	0.785 – 0.970 (19.9 – 24.6)							4/0	250
5815-B15				250		250		250	
5815-B17		350							
5815-B23	0.910 – 1.065 (23.1 – 27.1)			350		350		350	
5815-B29	0.980 – 1.140 (24.9 – 29.0)	500		500		500			
5815-B35	1.080 – 1.280 (27.4 – 32.5)							500	
5815-B40		750							
5815-B43	1.220 – 1.420 (31.0 – 36.1)			750		750		750	
5815-B45		1000 Al							
5815-B46	1.360 – 1.560 (34.5 – 39.6)			1000 Al		1000 Al		1000 Al	

**NOTE: Check ACTUAL CABLE INSULATION DIAMETER to verify correct kit selection.*

Table 10
15 KV Class

NOTE: Final Kit selection is based on CABLE INSULATION DIAMETER.

KIT NO.	INSUL. DIA. RANGE Inches (mm)	15 kV (AWG/kcmil)			
		100% (175 mils)		133% (220 mils)	
		Stranded	Compact /Solid	Stranded	Compact /Solid
5815-B3	0.640 – 0.760 (16.3 – 19.3)	2	1		
5815-B4		1	1/0*		
5815-B5	0.720 – 0.845 (18.3 – 21.5)	2/0	3/0*		
5815-B8		1/0	2/0		
5815-B9				2	1
5815-B11	0.785 – 0.970 (19.9 – 24.6)			1	1/0
5815-B13				1/0	2/0
5815-B16		3/0	4/0		
5815-B18		4/0	250		
5815-B19				2/0	3/0
5815-B22	0.910 – 1.065 (23.1 – 27.1)			3/0	4/0
5815-B24		250			
5815-B26				4/0	250
5815-B32 5815-B33	0.980 – 1.140 (24.9 – 29.0)	350		250	
5815-B35	1.080 – 1.280 (27.4 – 32.5)	500			
5815-B38				350	
5815-B44	1.220 – 1.420 (31.0 – 36.1)			500	
5815-B48	1.360 – 1.560 (34.5 – 39.6)	750		750	
5815-B49	1.480 – 1.700 (37.6 – 43.2)	1000 Al		1000 Al	

**NOTE: Check ACTUAL CABLE INSULATION DIAMETER to verify correct kit selection.*

Table 11
25 KV Class

NOTE: Final Kit selection is based on CABLE INSULATION DIAMETER.

KIT NO.	INSUL. DIA. RANGE Inches (mm)	25 kV (AWG/kcmil)			
		100% (260 mils)		133% (320 mils)	
		Stranded	Compact /Solid	Stranded	Compact /Solid
5815-B11	0.785 – 0.970 (19.9 – 24.6)	1	1/0		
5815-B14		2	1		
5815-B20	0.910 – 1.065 (23.1 – 27.1)	1/0	2/0		
5815-B21		2/0	3/0		
5815-25				2	1
5815-B27				1	1/0
5815-B28	0.980 – 1.140 (24.9 – 29.0)	3/0	4/0		
5815-B30				1/0	2/0
5815-B31				2/0	3/0
5815-B34		4/0	250*		
5815-B36	1.080 – 1.280 (27.4 – 32.5)			3/0	4/0
5815-B37		250			
5815-B39				4/0	250
5815-B41	1.220 – 1.420 (31.0 – 36.1)	350		350	
5815-B42				250	
5815-B47	1.360 – 1.560 (34.5 – 39.6)	500		500	
5815-B50	1.480 – 1.700 (37.6 – 43.2)	750			
5815-B51	1.640 – 1.840 (41.7 – 46.7)			750	
5815-B52		1000 Al			
5815-B53	1.780 – 1.965 (45.2 – 49.9)			1000 Al	

**NOTE: Check ACTUAL CABLE INSULATION DIAMETER to verify correct kit selection.*

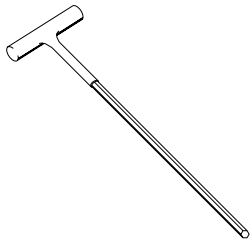


Table 12
Accessory Selection Chart

Part No.	Description
5815-TW	T-Wrench Used to install Connecting Plug into a Tee Module (e.g. with 5815-S and 5815-T Kits)

6.0 Specifications

6.1 Product

Splicing, dead-ending and 600 Amp apparatus connecting of 5, 8, 15 and 25 kV class shielded power cables shall be performed in accordance with the instructions included with the 3M 5815 Series Modular Splicing System Kits. The kit components must be designed according to the specifications of ANSI/IEEE Standard 386 for 600 Amp deadbreak interfaces. The system shall be capable of making dead-end, 2-way, 3-way or multiple tap splices, and of making connections to ANSI/IEEE 386 specified 600 Amp apparatus bushings.

6.2 Engineering/Architectural

The 600 Amp separable insulated connector system shall be rated for continuous operation on single-conductor shielded power cables rated up to 25 kV. The system components shall be designed in accordance with the specifications listed in ANSI/IEEE Standard 386 for 600 Amp deadbreak interfaces. The system shall be made up of specific kits designed for splicing, tapping (adding-on), dead-ending and 600 Amp equipment (apparatus) connecting. Each kit shall contain all of the components necessary for its intended application, except for the connector, cable sizing adapter and shield adapter, which shall be contained in a separate adapter kit. The system shall be capable of making dead-end, 2-way, 3-way or multiple tap splices, and of making connections to ANSI/IEEE 386 specified 600 Amp apparatus bushings.

7.0 Maintenance


The components of the 5815 Series Modular Splicing System are stable under normal storage conditions. Normal storage and stock rotation are recommended. The rubber and molded epoxy components are not impaired by freezing.

8.0 Availability

The 3M 5815 Series Modular Splicing System is available for splicing, tapping (adding-on) and dead-ending of 5, 8, 15 and 25 kV shielded power cables, and for equipment (apparatus) connecting to ANSI/IEEE 386 specified 600 Amp bushings. Separate 5815-B Series Adapter Kits are available to adapt the Modular Splicing Kits to specific cable sizes.

The Modular Splicing Kits are available from your local authorized 3M electrical distributor.

3M is a registered trademark of 3M. UniShield® is a registered trademark of BICC Cables.

Note: The core material being removed from the Cold Shrink Tube is mixed polymers and can be recycled with other waste. 

IMPORTANT NOTICE

Before using this product, you must evaluate it and determine if it is suitable for your intended application. You assume all risks and liability associated with such use.

Warranty; Limited Remedy; Limited Liability. This product will be free from defects in material and manufacture as of the date of purchase. **3M MAKES NO OTHER WARRANTIES INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.** If this product is defective within the warranty period stated above, your exclusive remedy shall be, at 3M's option, to replace or repair the 3M product or refund the purchase price of the 3M product. **Except where prohibited by law, 3M will not be liable for any loss or damage arising from this 3M product, whether direct, indirect, special, incidental or consequential regardless of the legal theory asserted.**

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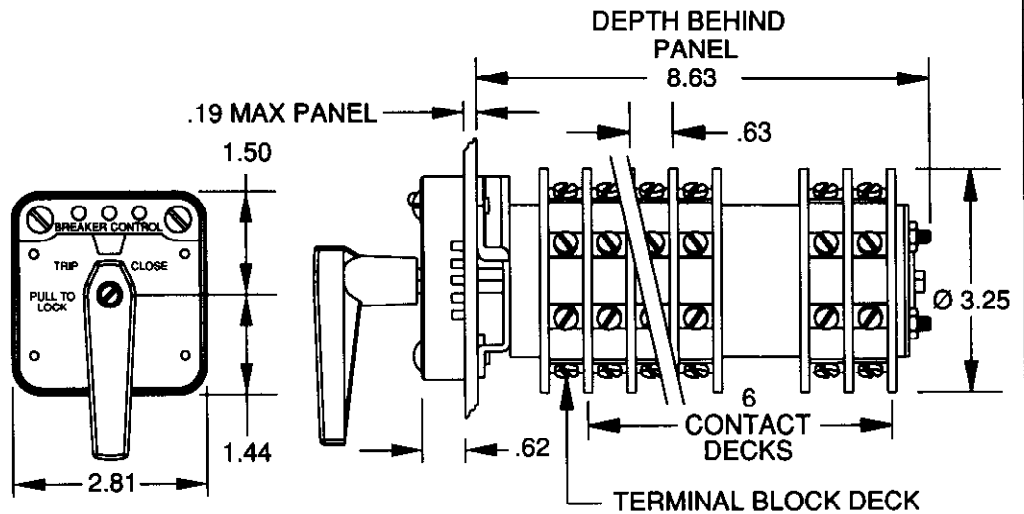
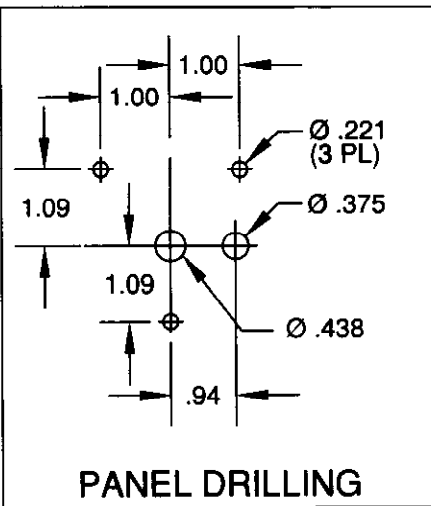
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**ELECTROSWITCH**

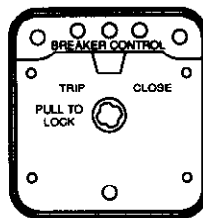
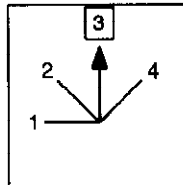
UNIT OF ELECTRO SWITCH CORP.

WEYMOUTH, MASSACHUSETTS 02188

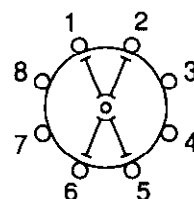
TEL: (781)335-5200 FAX: (781)335-4253

**SERIES 24
CONTROL SWITCH****24PD58D**FILE NO.
E1817420A-120VAC
15A-240VAC
6A-600VAC
3A-125VDC
1A-250VDC20A-600VAC res
15A-600VAC ind
2A-125VDC
2HP-240/480VDC(3) #10-32
MOUNTING SCREWS
SUPPLIED# 8-32 X .25
BD. HD. TERMINAL SCREWS
SUPPLIED UN-ASSEMBLED.**TITLE: BREAKER CONTROL**

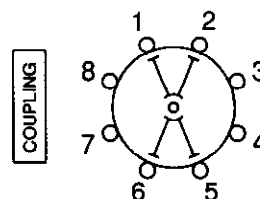
		POSITION				
		PULL TO LOCK	TRIP	(nat)	(nac)	CLOSE
DECK	CONTACTS	3 FROM				
		1	2	2	4	4
1	12    13					X
	16    17					X
2	21    28		X			
	24    25		X			
3	33    34	X				
	37    38	X				
4	41    42			X	X	
	45    46			X	X	
5	52    53				X	X
	56    57				X	X
6	61    62		X	X		
	65    66		X	X		

HANDLE POSITIONS**ENGRAVING CODE**
124C-3B33**ACTION: SPRING RETURN TO POS. 3,
PULL TO LOCK IN POS. 1.**

H	A	B	C	D	E	F	G
●	●	●	●	●	●	●	●
11 ○	12 ●	13 ●	14 ○	15 ○	16 ●	17 ●	18 ○
21 ●	22 ○	23 ○	24 ●	25 ●	26 ○	27 ○	28 ●
31 ○	32 ○	33 ●	34 ●	35 ○	36 ○	37 ●	38 ●
41 ●	42 ●	43 ○	44 ○	45 ●	46 ●	47 ○	48 ○
51 ○	52 ●	53 ●	54 ○	55 ○	56 ●	57 ●	58 ○
61 ●	62 ●	63 ○	64 ○	65 ●	66 ●	67 ○	68 ○

**TERMINALS SUPPLIED
AS SHOWN****CONTACT DECKS**

DECK 1-4 BBM



DECK 5-6 BBM

MADE BY: **DKP**
APPR BY: **WCK**

DATE: 3/20/01

DATE: 3/20/01

SHEET 1 OF 2

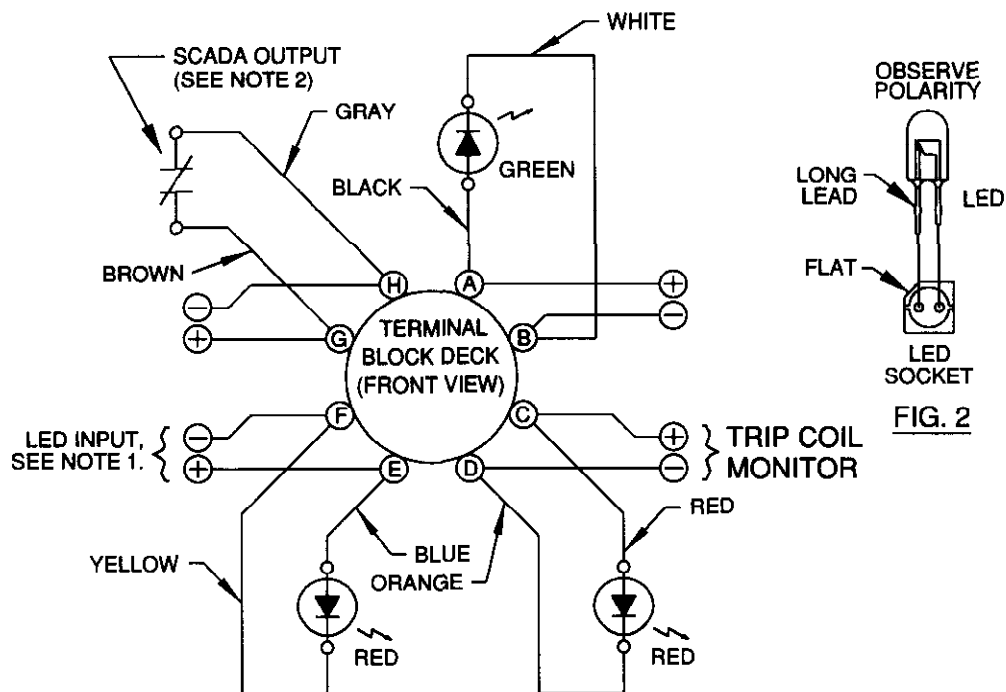
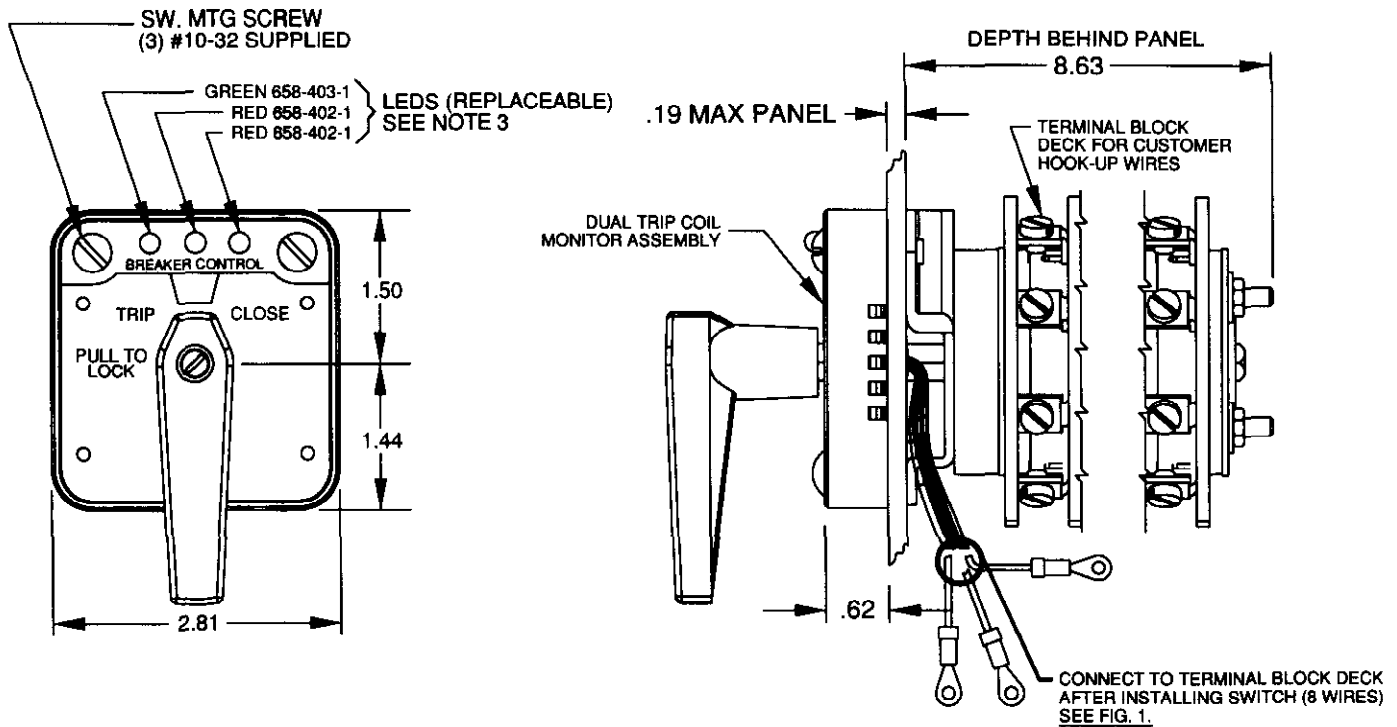
REV
BREV: A/E CN 25973 B/E CN 26551
DKP 4/4/01 PBW BEN 3/8/02 WCK

**ELECTROSWITCH**

UNIT OF ELECTRO SWITCH CORP.

WEYMOUTH, MASSACHUSETTS 02188

TEL: (781)335-5200 FAX: (781)335-4253

**SERIES 24
BREAKER CONTROL
SWITCH****24PD58D****LED VOLTAGE: 37-140 VDC****NOTES:**

1. OPERATING VOLTAGE FOR LED
NAMEPLATE: 37-140 VDC.
2. SCADA OUTPUT IS CONTROLLED
BY TRIP COIL MONITOR. (100 mA MAX)
3. OBSERVE POLARITY WHEN INSERTING
LED IN SOCKET (SEE FIG. 2)
4. FACTORY PIN AT 3.125 FROM HANDLE END.

MADE BY: DKP
APPR BY: WCK

DATE: 3/20/01

DATE: 3/20/01

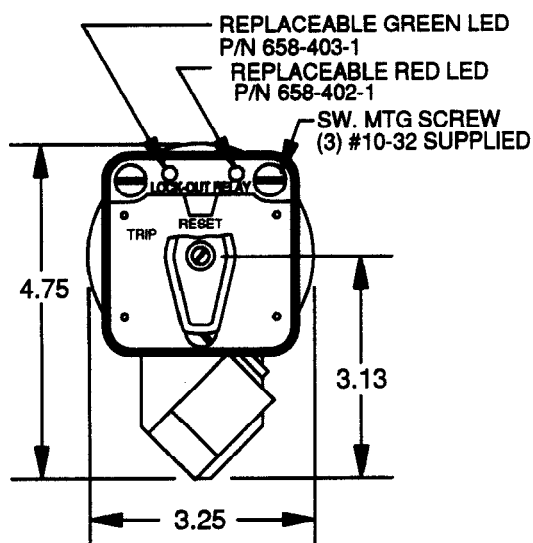
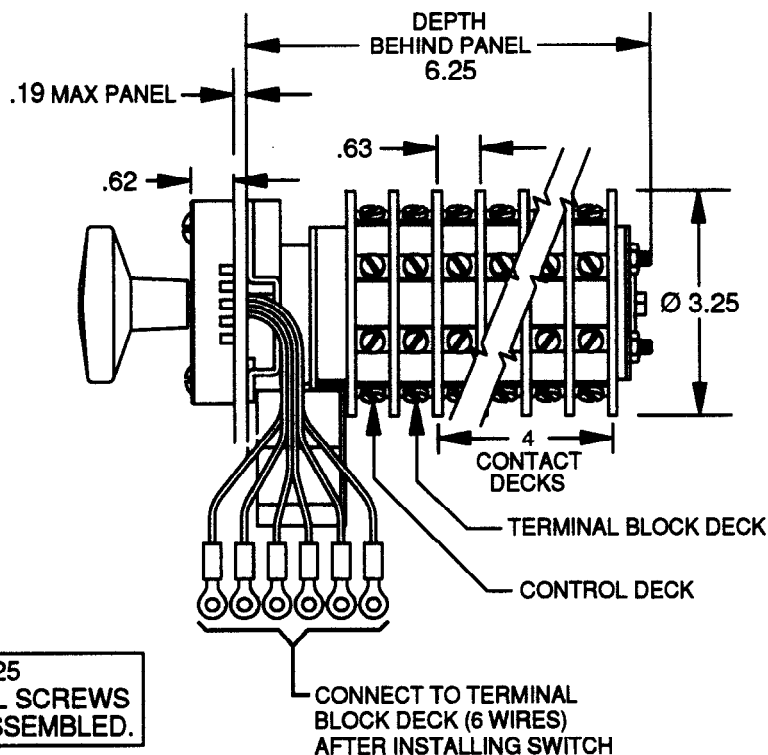
SHEET 2 OF 2

REV
B

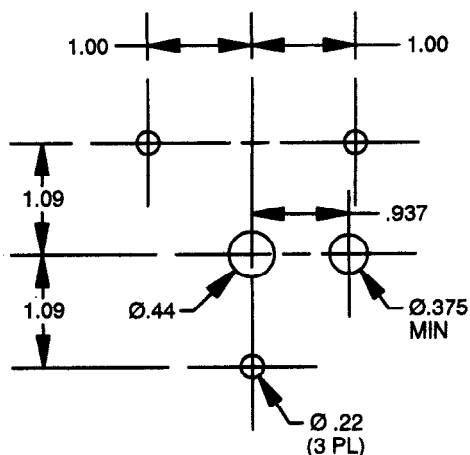
REVISIONS: SEE SHEET 1

**ELECTROSWITCH**UNIT OF ELECTRO SWITCH CORP.
WEYMOUTH MASSACHUSETTS 02188

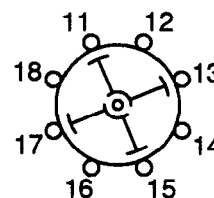
TEL(781)335-5200 FAX(781)335-4253

**SERIES 24P
MANUAL RESET
LOCKOUT RELAY****78PB04D**ENGRAVING CODE
102C-2L22# 8-32 X .25
BD.HD.TERMINAL SCREWS
SUPPLIED UN-ASSEMBLED.**TRIP COIL SPECIFICATIONS**

NOMINAL VOLTAGE:	125 VDC
OPERATING RANGE:	30-140 VDC
THRESHOLD:	16 VDC (MIN)
COIL RESISTANCE:	27.0 Ω
COIL BURDEN:	4.6 AMPS AT 125 VDC

FOR FURTHER INFORMATION REFER TO
TECHNICAL PUBLICATION LOR-1FILE NO.
E8008020A-120VAC
15A-240VAC
6A-600VAC
3A-125VDC
1A-250VDC20A-600VAC res
15A-600VAC ind**PANEL DRILLING DIMENSIONS**

CONTACTS		POSITION	
		TRIP	RESET
DECK 1	11 13		X
	12 18	X	
	15 17		X
	14 16	X	



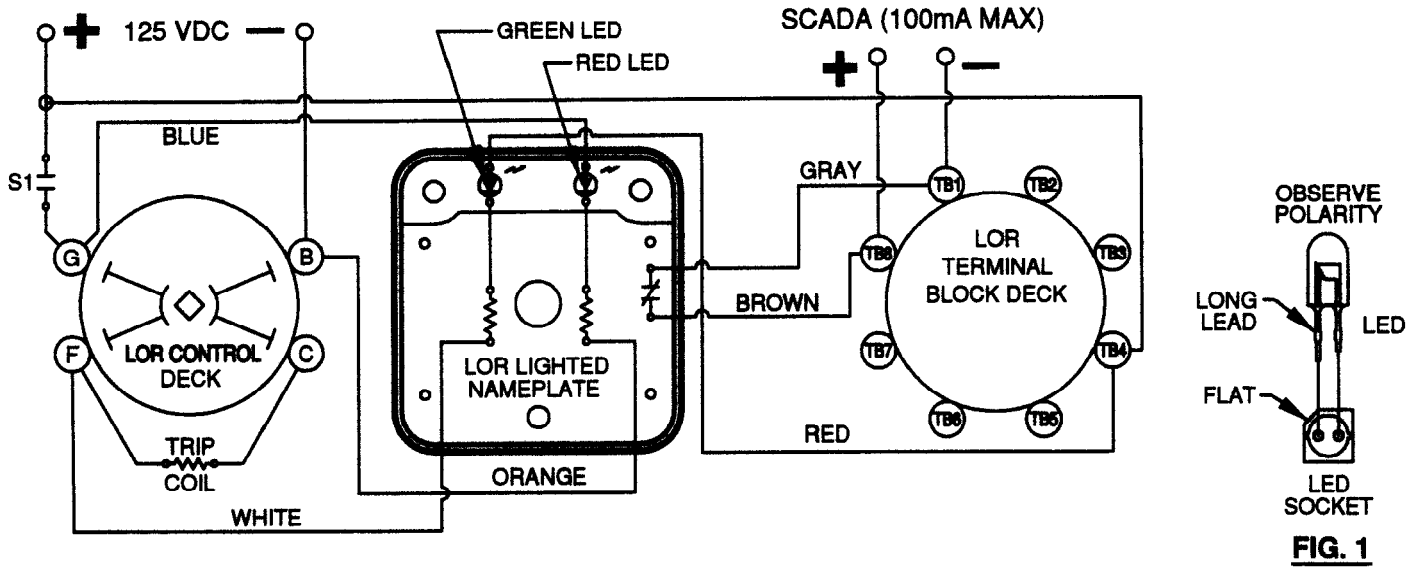
MADE BY: WDS	DATE: 2/25/00
APPR BY: CJL	DATE: 2/25/00

SHEET 1 OF 2

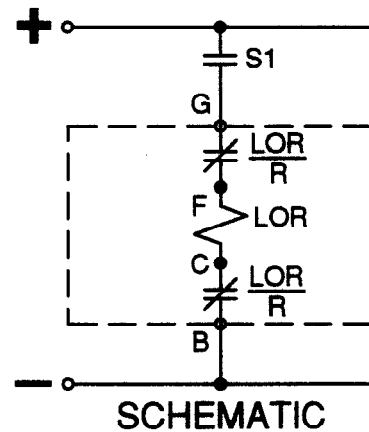
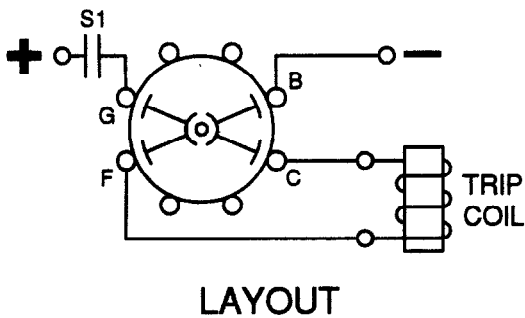
REV
C
 REVISIONS: AIECN# 25634 BIECN# 26551 CIECN# 29185
 WDS 7/5/00 WCK BEN 5/6/02 WCK CMM 11-18-08

**ELECTROSWITCH**UNIT OF ELECTRO SWITCH CORP.
WEYMOUTH MASSACHUSETTS 02188

TEL(781)335-5200 FAX(781)335-4253

**SERIES 24P
MANUAL RESET
LOCKOUT RELAY****78PB04D****NOTES:**

1. OPERATING VOLTAGE FOR LED NAMEPLATE: 37-140 VDC.
2. SCADA OUTPUT IS CONTROLLED BY TRIP COIL MONITOR.
3. OBSERVE POLARITY WHEN INSERTING LED IN SOCKET
(SEE FIG. 1)

CONTROL CIRCUIT

CONTACTS		POSITION	
		TRIP	RESET
CONTROL DECK	B-O-||-||-O-C		X
	F-O-||-||-O-G		X

MADE BY: WDS
APPR BY: CJL
DATE: 2/25/00
DATE: 2/25/00

DWG. NO:
SHEET 2 OF 2

REV 1
C
REVISIONS: SEE SHEET 1



SEL-451-5 Protection, Automation, and Bay Control System

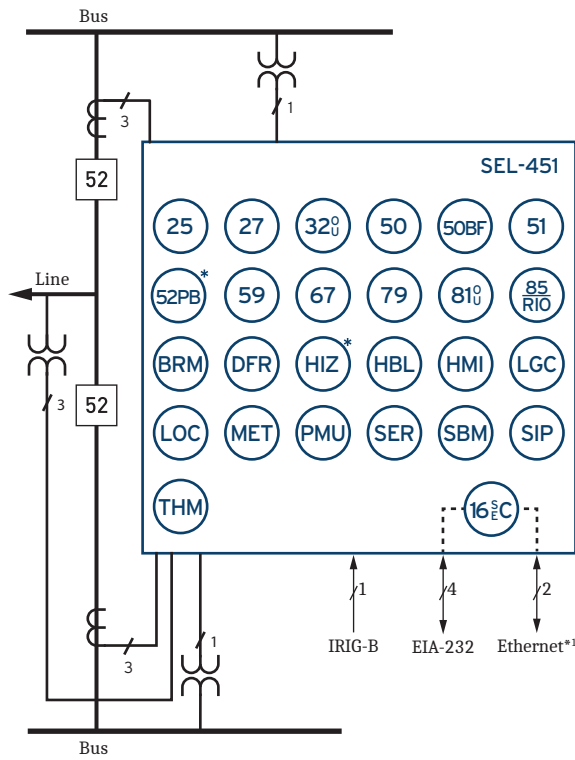


Key Features and Benefits

The SEL-451-5 Protection, Automation, and Bay Control System integrates bay control for breakers and disconnect switches with full automation and protection in one device.

- **Protection.** Customize distribution protection with multiple instantaneous and time-overcurrent elements with SELOGIC® control equations. Best Choice Ground Directional Element® logic optimizes directional element performance and eliminates the need for many directional settings. Provide comprehensive protection for two breakers with one relay.
- **Commissioning.** Rapidly commission your Bay Control with preconfigured bay arrangements. Choose among different bus configurations, including single- and dual-busbar, transfer bus, tie breaker, breaker-and-a-half, ring-bus, double-bus/double-breaker, and source transfer configurations. These bus arrangements allow easy status and control of as many as ten disconnect switches and two breakers. Additional user-selectable bay types are available via ACCELERATOR QuickSet® SEL-5030 Software that can be downloaded at selinc.com.
- **Automation.** Take advantage of enhanced automation features that include 32 programmable elements for local control, remote control, protection latching, and automation latching. Local metering on the large format front-panel LCD eliminates the need for separate panel meters. Serial and Ethernet links efficiently transmit key information, including metering data, protection element and control input/output (I/O) status, IEEE C37.118 Synchrophasors, IEC 61850 Edition 2 GOOSE messages, Sequential Events Recorder (SER) reports, breaker monitor, relay summary event reports, and time synchronization. Apply expanded SELOGIC control equations with math and comparison functions in control applications. Incorporate as many as 1000 lines of automation logic to speed and improve control actions.
- **Software-Invertible Polarities.** Invert individual or grouped CT and PT polarities to account for field wiring or zones of protection changes. CEV files and all metering and protection logic use the inverted polarities, whereas COMTRADE event reports do not use inverted polarities but rather record signals as applied to the relay.
- **Synchrophasors.** Make informed load dispatch decisions based on actual real-time phasor measurements from SEL-451 Relays across your power system. Record streaming synchrophasor data from SEL-451 Relays for system-wide disturbance recording. Control the power system using local and remote synchrophasor data.

- **High-impedance Fault Detection.** The optional high-impedance fault (HIF) detection element operates for small current ground faults typically caused by downed conductors on surfaces such as earth, concrete or other poorly conductive materials. HIF event data are made available in standard COMTRADE format.
- **Ethernet Access.** Access all relay functions with the optional Ethernet card. Interconnect with automation systems by using IEC 61850 Edition 2 or DNP3 protocol directly. Use file transfer protocol (FTP) for high-speed data collection. Connect to substation or corporate LANs to transmit synchrophasors in the IEEE C37.118–2005 format by using TCP or UDP Internet protocols.
- **Parallel Redundancy Protocol (PRP).** Provide seamless recovery from any single Ethernet network failure, in accordance with IEC 62439-3. The Ethernet network and all traffic are fully duplicated with both copies operating in parallel.
- **IEC 61850 Operating Modes.** The relay supports IEC 61850 standard operating modes such as Test, Blocked, On, and Off.
- **IEEE 1588, Precision Time Protocol.** The relay shall support Precision Time Protocol version 2 (PTPv2). PTP provides high-accuracy timing over an Ethernet network.
- **Digital Relay-to-Relay Communications.** Enhanced MIRRORING BITS[®] communications can monitor internal element conditions between bays within a station, or between stations, using SEL fiber-optic transceivers. Send digital, analog, and virtual terminal data over the same MIRRORING BITS channel.
- **Monitoring.** Schedule breaker maintenance when accumulated breaker duty (independently monitored for each pole of two circuit breakers) indicates possible excess contact wear. Electrical and mechanical operating times are recorded for both the last operation and the average of operations since function reset. Two independent DC monitors provide notification of substation battery voltage problems even if voltage is low only during trip or close operations.
- **Breaker Failure.** High-speed (less than one cycle) open-pole detection logic reduces coordination times for critical breaker failure applications. Apply the SEL-451 to supply breaker failure protection for one or two breakers. Logic for breaker failure retrip and initiation of transfer tripping is included.
- **Sequential Events Recorder (SER).** Record the last 1000 events, including setting changes, power-ups, and selectable logic elements.
- **Dual CT Input.** Apply with ring bus, breaker-and-a-half, or other two-breaker schemes. Combine currents within the relay from two sets of CTs for protection functions, but keep them separately available for monitoring and station integration applications.
- **Comprehensive Metering.** Improve feeder loading by using built-in, high-accuracy metering functions. Watt and VAR measurements optimize feeder operation. Minimize equipment needs with full metering capabilities including rms, maximum/minimum, demand/peak, energy, and instantaneous values.
- **High-Accuracy Time-Stamping.** Time-tag binary COMTRADE event reports with real-time accuracy of better than 10 μ s. View system state information to an accuracy of better than 1/4 of an electrical degree.
- **Oscillography and Event Reporting.** Record voltages, currents, and internal logic points at a sampling rate as fast as 8 kHz. Off line phasor and harmonic-analysis features allow investigation of bay and system performance.
- **Reclosing.** Incorporate programmable reclosing of one or two breakers into an integrated substation control system. Synchronism and voltage checks from multiple sources provide complete bay control.
- **Fault Locator.** Efficiently dispatch line crews to quickly isolate line problems and restore service faster.
- **IEC 60255-Compliant Thermal Model.** Use the relay to provide a configurable thermal model for the protection of a wide variety of devices.
- **Rules-Based Settings Editor.** Communicate with and set the relay by using an ASCII terminal, or use QuickSet to configure the SEL-451 and analyze fault records with relay element response.
- **Auxiliary Trip/Close Pushbuttons.** These optional pushbuttons are electrically isolated from the rest of the relay. They function independently from the relay and do not need relay power.
- **Low-Energy Analog (LEA) Inputs.** Reduce costs and save space with as many as six C37.92-compliant LEA voltage inputs.
- **Time-Domain Link (TiDL[®]) Technology.** The relay supports remote data acquisition through use of an SEL-2240 Axion[®]. The Axion provides remote analog and digital data over an IEC 61158 EtherCAT[®] TiDL network. This technology provides very low and deterministic latency over a fiber point-to-point architecture. The SEL-451 relay can receive fiber links from as many as eight Axion remote data acquisition nodes.



ANSI NUMBERS/ACRONYMS AND FUNCTIONS

25	Synchronism Check
27	Undervoltage
32 (O, U)	Over- and Underpower
50	Overcurrent
50BF	Dual Breaker Failure Overcurrent
51	Time-Overcurrent
52PB	Trip/Close Pushbuttons*
59	Overvoltage
67	Directional Overcurrent
79	Autoreclosing
81 (O, U)	Over- and Underfrequency

ADDITIONAL FUNCTIONS

16 SEC	Access Security (Serial, Ethernet)
50G	Best Choice Ground
85 RIO	SEL MIRRORED BITS Communications
BRM	Breaker Wear Monitor
DFR	Event Reports
HBL	Harmonic Blocking
HIZ	High-Impedance Fault Detection Arc Sense™ Technology (AST)*
HMI	Operator Interface
LDE	Load Encroachment
LGC	Expanded SELogic Control Equations
LOC	Fault Locator
MET	High-Accuracy Metering
PMU	Synchrophasors
SBM	Station Battery Monitor
SER	Sequential Events Recorder
SIP	Software-Invertible Polarities
THM	IEC 60255-Compliant Thermal Model
TiDL	Time-Domain Link Remote Data Acquisition

¹Copper or Fiber-Optic * Optional Feature

Figure 1 Functional Diagram



Software-Invertible Polarities Save Commissioning Time and Costs

All signal processing uses the software-inverted polarities for CEV file generation, metering, and protection logic. COMTRADE file generation is isolated from the impacts of the inverted polarities, and records signals as applied to the relay terminals.

The SEL-451 provides multiple directional elements to optimize security and sensitivity. Use ground and negative-sequence directional overcurrent elements to detect high-resistance faults when using communications-assisted tripping schemes.

The SEL-451 includes a number of directional elements for supervision of overcurrent elements. The negative-sequence directional element uses the same patented principle proven in our SEL-351 Relay. This directional element can be applied in virtually any application, regardless of the amount of negative-sequence voltage available at the relay location.

Ground overcurrent elements are directionally controlled by three directional elements working together:

- Negative-sequence voltage-polarized directional element
- Zero-sequence voltage-polarized directional element
- Zero-sequence current-polarized directional element

Our patented Best Choice Ground Directional Element selects the best ground directional element for the system conditions and simplifies directional element settings (you can override this automatic setting feature for special applications).

Communications-Assisted Tripping Schemes

Use communications to improve tripping time for better customer service. The SEL-451 is the ideal relay for use in pilot-based tripping schemes. Enhanced MIRRORING BITS communications with SEL fiber-optic transceivers provide 3–6 ms relay-to-relay transmission time. Among the schemes supported are the following:

- Permissive Overreaching Transfer Tripping (POTT)
- Directional Comparison Unblocking (DCUB)
- Directional Comparison Blocking (DCB)

Use the SELOGIC control equation TRCOMM to program specific elements, combinations of elements, inputs, etc., to perform communications scheme tripping and other scheme functions. The logic readily accommodates the following conditions:

- Current reversals
- Breaker open at one terminal
- Weak-infeed conditions at one terminal
- Switch-onto-fault conditions

Overcurrent Elements

The SEL-451 includes four phase, four negative-sequence, and four ground instantaneous overcurrent elements. The SEL-451 also includes six selectable operating quantity inverse-time overcurrent elements. You can select the operating quantities from the following:

IA, IB, IC, MAX(IA, IB, IC), I1, 3I2, IG

where IA, IB, IC can be fundamental or rms quantities from either circuit breaker or combined currents.

The time-overcurrent curves (listed in *Table 1*) have two reset characteristic choices for each time-overcurrent element. One choice resets the elements if current drops below pickup for one cycle. The other choice emulates the reset characteristic of an electromechanical induction disc relay.

Table 1 Time-Overcurrent Curves

U.S.	IEC
Moderately Inverse	Standard Inverse
Inverse	Very Inverse
Very Inverse	Extremely Inverse
Extremely Inverse	Long-Time Inverse
Short-Time Inverse	Short-Time Inverse

Breaker Failure Protection

Incorporated into the SEL-451 is a full function breaker failure system. Current can be individually monitored in two breakers. High-speed open-pole detection logic allows you to set the pickup current below minimum load for sensitivity without sacrificing high-speed dropout. Even in cases with delayed current zero in the secondary of the CT caused by trapped flux, high-speed detection of circuit breaker opening is achieved. This feature is essential if breaker failure is initiated on all circuit breaker trips. A reset of less than one cycle reduces coordination times, improving stability.

Thermal Overload Protection

The SEL-451 supports three independent thermal elements that conform to the IEC 60255-149 standard. Use these elements to activate a control action or issue an alarm or trip when your equipment overheats as a result of adverse operating conditions.

The SEL-2600 RTD Module provides ambient temperature measurements for the thermal model.

Loss-of-Potential (LOP) Logic Supervises Directional Elements

The SEL-451 includes logic to detect an LOP caused by failures such as blown fuses, which can cause an incorrect operation in directional elements. Simple settings configure the LOP logic to either block or force forward ground and phase directional elements under these conditions. The logic checks for a sudden change in positive-sequence voltage without a corresponding change in positive- or zero-sequence current. Tests and field experience show that this principle is very secure and is faster than the tripping elements.

High-Impedance Fault Detection

High-impedance faults are short-circuit faults with fault currents smaller than what a traditional overcurrent protective relay can detect. The SEL-451 includes logic used to detect HIF signatures without being affected by loads

and 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. As much as 40 minutes of high-impedance fault activity is stored in high-resolution COMTRADE format and a summary of HIF activity is available using ASCII commands. View important high-impedance fault data from available metering commands.

Six Independent Settings Groups Increase Operation Flexibility

The relay stores six settings groups. Select the active settings group by control input, command, or other programmable conditions. Use these settings groups to cover a wide range of control contingencies. Selectable settings groups make the SEL-451 ideal for applications requiring frequent settings changes and for adapting the bay to changing system conditions.

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

Combined Current for Protection Flexibility

In traditional relays, when protecting a line fed from two breakers, such as a breaker-and-a-half system or double-breaker system, you needed to combine the CT inputs before connecting these inputs to the relay. The SEL-451 can accept separate inputs from two separate CTs and mathematically combine the currents. This allows collecting separate current metering and breaker monitor information for each breaker. Breaker monitoring functions for two breakers are done within one relay. Individual breaker currents allow for breaker failure functions on a per-breaker basis within the SEL-451. Breaker diagnostics are reported on a comparative basis allowing for advanced, proactive troubleshooting.

Custom Control Capabilities

Customize control capabilities, adding stability and security to your system.

- Use expanded SELOGIC control equations to create advanced stability enhancements such as VAR-flow controlled time undervoltage load shedding.
- Combine frequency elements with voltage supervision for added security with underfrequency load-shedding systems.

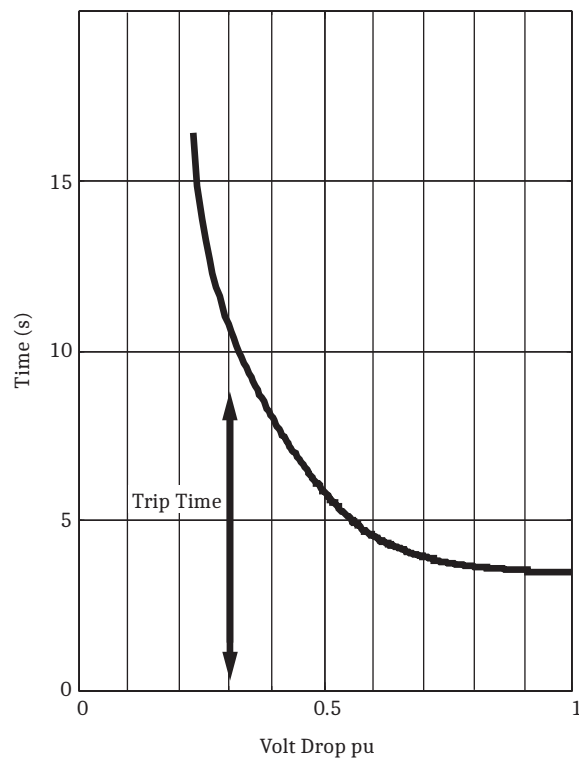


Figure 3 VAR-Flow Controlled Time Undervoltage Load Shedding

Control Inputs and Outputs

The standard SEL-451 includes five independent and two common inputs, two Form A and three Form C standard interrupting outputs, and three Form A high-current interrupting outputs. The following additional I/O boards are currently available.

- Eight independent inputs, 13 standard Form A and two standard Form C contact outputs.
- Eight independent inputs, eight high-speed, high-current interrupting Form A contact outputs.
- Eight independent inputs, 13 high-current interrupting Form A outputs and two standard Form C contact outputs.
- Twenty-four inputs, six high-speed and two standard Form A contact outputs.

Assign the control inputs for protection and control functions, monitoring logic, and general indication. Each control output is programmable using SELOGIC control equations. No additional I/O boards can be added to the 3U chassis; however, one board can be added to the 4U chassis, two I/O boards can be added to the 5U chassis, and four I/O boards can be added to the 8U chassis.

Multifunction Reclosing With Flexible Applications

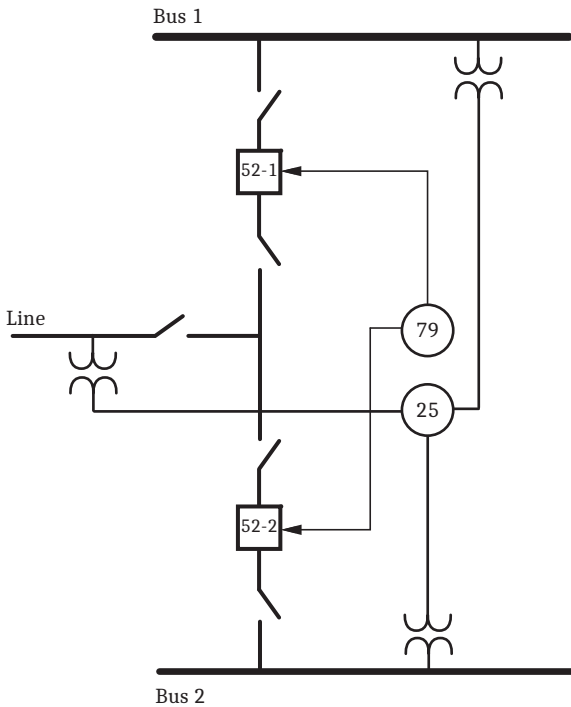


Figure 4 Two-Breaker Reclosing With Synchronism Check

The SEL-451 includes three-pole trip and reclose functions, for either one or two breakers (*Figure 4*). Synchronism check is included for breaker control. Synchronizing and polarizing voltage inputs are fully programmable with Dead Line/Dead Bus closing logic as well as zero-closing-angle logic to minimize system stress upon reclosing. Program as many as four reclose

attempts. Select Leader and Follower breakers directly, or use a SELOGIC control equation to determine reclosing order based on system conditions.

Two-Breaker Control

The SEL-451 contains analog voltage inputs for multiple sources and control inputs to indicate both breaker and disconnect position, as well as the logic required to provide full control for two breakers. This includes separate monitoring functions as well as separate elements for tripping and closing the two breakers to allow for leader/follower operation or other desired control schemes. All analog values are monitored on a per-breaker basis to allow station control access to complete information for individual components of the system.

Backup Protection

Add reliability and dependability by providing independent backup protection without increasing relay count. Use each SEL-451 to provide primary directional overcurrent protection with backup nondirectional overcurrent protection on the adjacent feeder. For additional flexibility, use the available I/O or MIRRORED BITS to switch protection upon loss of one relay.

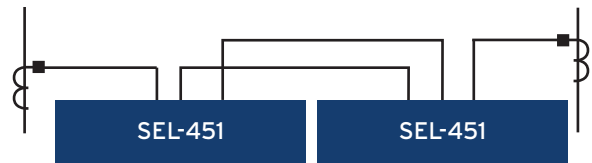


Figure 5 Using Two Cross-Connected SEL-451-5 Relays to Provide Primary and Backup Protection for Two Feeders

Bay Control

The SEL-451 Bay Control provides dynamic bay one-line diagrams on the front-panel screen with disconnect and breaker control capabilities for numerous predefined user-selectable bay types. Additional user-selectable bay types are available via a QuickSet interface that can be downloaded at selinc.com. The bay control is equipped to control as many as 10 disconnects and two breakers, depending on the one-line diagram selected. Certain one-line diagrams provide status for as many as three breakers and ten disconnect switches. Operate disconnects and breakers with ASCII commands, SELOGIC control equations, Fast Operate Messages, and from the one-line diagram. The one-line diagram includes user-configurable apparatus labels and as many as 24 user-definable Analog Quantities.

One-Line Bay Diagrams

The SEL-451 offers a variety of preconfigured one-line diagrams for common bus configurations. Once a one-line diagram is selected, the user has the ability to customize the names for all of the breakers, disconnect switches, and buses. Most one-line diagrams contain analog display points. These display points can be set to any of the available analog quantities with labels, units, and scaling. These values are updated real-time along with the breakers and switch position to give instant status and complete control of a bay. The diagrams below demonstrate some of the preconfigured bay arrangements available in the SEL-451.

The operator can see all valuable information on a bay before making a critical control decision. Programmable interlocks help prevent operators from incorrectly opening or closing switches or breakers. The SEL-451 will not only prevent the operator from making an incorrect control decision, but can notify and/or alarm when an incorrect operation is initiated.

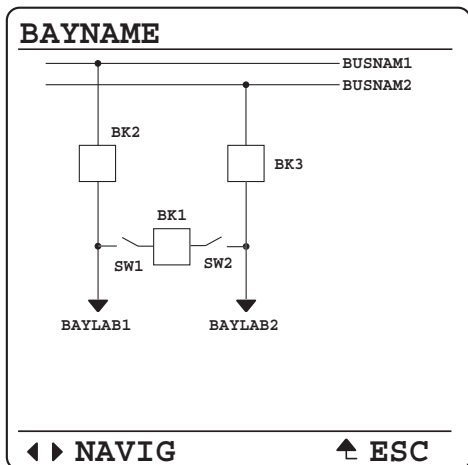


Figure 6 Breaker-and-a-Half

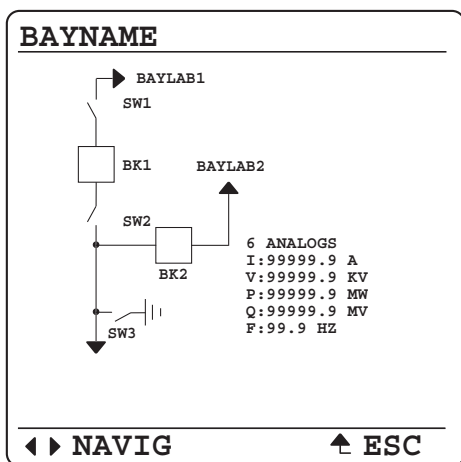


Figure 7 Ring Bus With Ground Switch

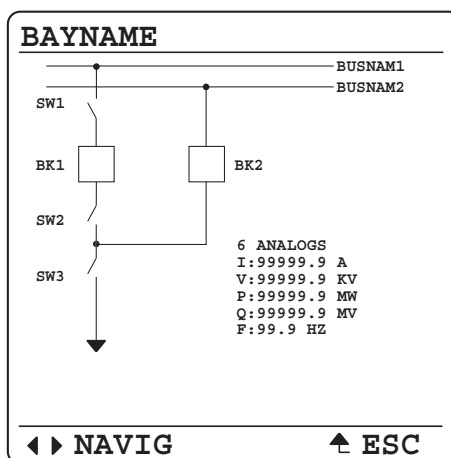


Figure 8 Double Bus/Double Breaker

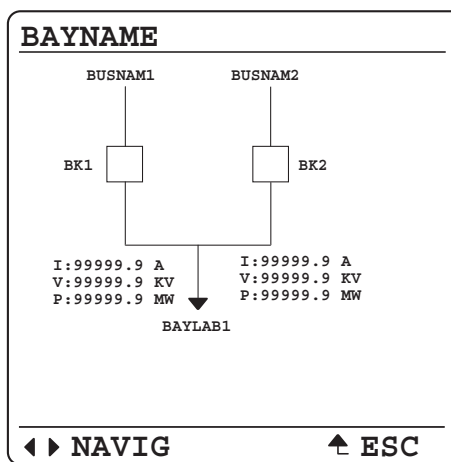


Figure 9 Source Transfer Bus

Circuit Breaker Operations From the Front Panel

Figure 6 through Figure 9 are examples of some of the many selectable one-line diagrams in the SEL-451. The one-line diagram is selectable from the Bay settings. Additional settings for defining labels and analog quantities are also found in the Bay settings. One-line diagrams are composed of the following:

- Bay Names and Bay Labels (Bay Labels available in one-line diagrams 14, 17, 18, and 23. All other one-line diagrams use the Bay Name.)
- Busbar and Busbar Labels
- Breaker and Breaker Labels
- Disconnect Switches and Disconnect Switch Labels
- Analog Display Points

Figure 10 shows the Breaker Control Screens available when the ENT pushbutton is pressed with the circuit breaker highlighted as shown in Figure 10 (a). After pressing the ENT pushbutton with the breaker highlighted

and the LOCAL Relay Word bit asserted, the Breaker Control Screen in Figure 10 (b) is displayed. After entering the screen in Figure 10 (b), the relay performs the circuit breaker operations as outlined in the SEL-451-5

User's Guide. If the LOCAL Relay Word bit is not asserted when the ENT pushbutton is pressed, the screen in Figure 10 (c) is displayed for three seconds, then the bay control displays again the screen in Figure 10 (a).

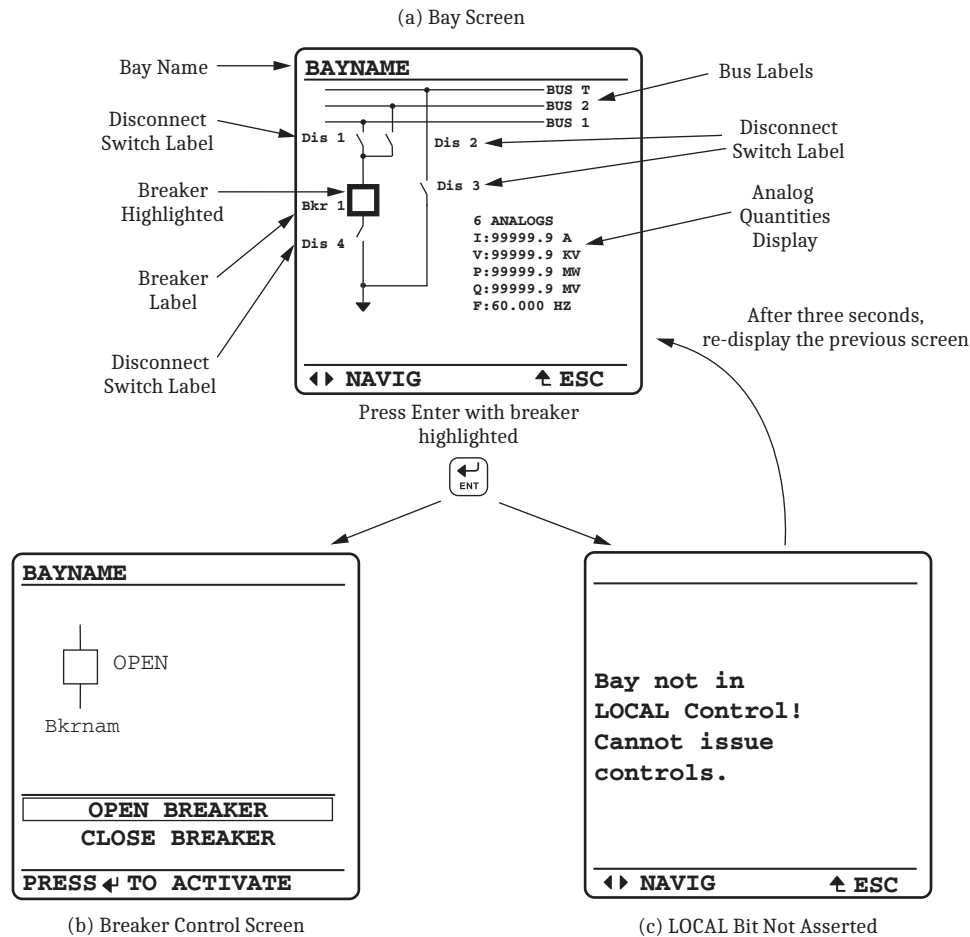


Figure 10 Screens for Circuit Breaker Selection

Rack-Type Breakers Mosaics

The SEL-451 supports the display of rack-type (also referred to as truck-type) circuit breakers. The rack-type breakers have three positions: racked out, test, and racked in. When in the test or racked-in positions, the breaker can be displayed as open or closed. When racked out, there is no breaker open/close display. The rack-type breakers are a display-only functionality and do not impact any circuit breaker control capabilities.

Status-Only Disconnects

The SEL-451 has the ability to designate a disconnect as having control functionality or being status-only. When a disconnect is designated as having control functionality, the disconnect can be selected and controlled from the relay front-panel HMI. When a disconnect is designated

as status-only, the disconnect is displayed in the one-line diagram of the relay front-panel HMI, but it is not selectable when navigating the front-panel HMI. Three-position disconnects are also supported with control/display functionality on a per position basis.

Rules-Based Settings Editor

QuickSet develops settings on- or offline. The system automatically checks interrelated settings and highlights out-of-range settings. Settings are transferred by using a PC communications link with the SEL-451. The QuickSet interface supports Server 2008, Windows® 7 and Windows 8 operating systems, and can be used to open COMTRADE files from SEL and other products. Convert binary COMTRADE files to ASCII format for portability and ease of use. View real-time phasors and harmonic values.

QuickSet Bay Control Settings Interface

There are two ways to enter Bay Control settings by using the QuickSet settings interface. The standard style settings are displayed in traditional form under the Bay Control form. QuickSet also provides an interactive bay control setting entry method. The interactive method works by clicking on the one-line diagram labels. This action automatically displays all the settings for the device selected. This method provides an easy way of organizing and verifying all settings associated with the device.

Figure 11 illustrates the interactive bay control setting form in QuickSet. Click on an apparatus in the one-line diagram, and a form with apparatus-specific settings is displayed.

QuickSet Templates

Use the fully licensed version of QuickSet to create custom views of settings, called Application Designs, to reduce complexity, decrease the chance of errors, and increase productivity.

- Lock and hide unused settings.
- Lock settings to match your standard for protection, I/O assignment, communications, and SELOGIC control equations.
- Enforce settings limits narrower than the device settings.
- Define input variables based on the equipment nameplate or manufacturer's terminology or scaling and calculate settings from these "friendlier" inputs.
- Use settings comments to guide users and explain design reasoning.

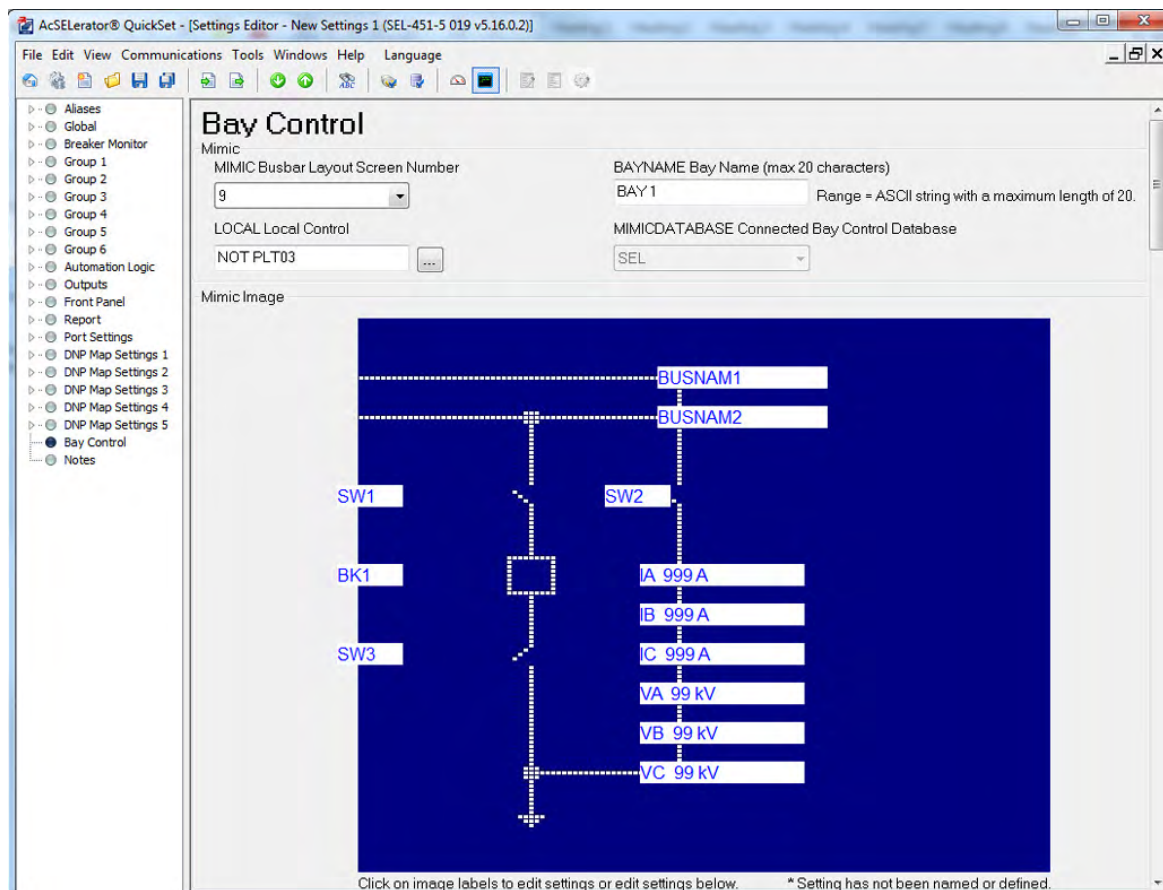


Figure 11 Interactive Bay Control Setting Form

Front-Panel Display

The LCD shows event, metering, settings, and relay self-test status information. The target LEDs display relay target information as described in Figure 12 and explained in Table 2.

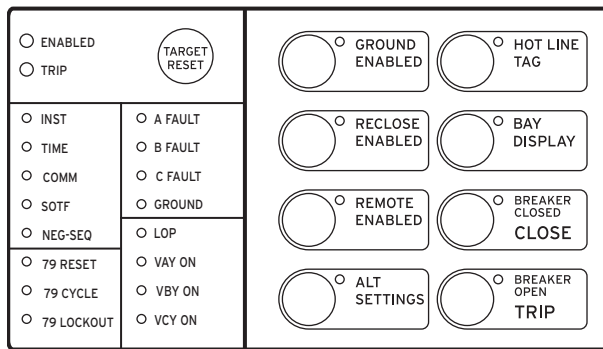


Figure 12 Factory-Default Status and Trip Target LEDs (8 Pushbutton, 16 Target Option)

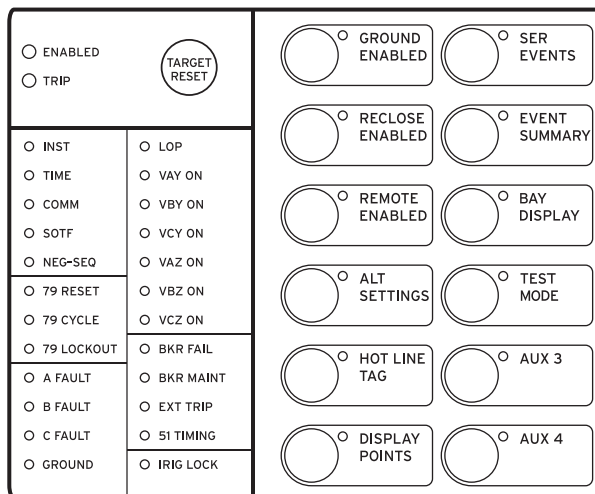


Figure 13 Factory-Default Status and Trip Target LEDs (12 Pushbutton, 24 Target Option)

The LCD is controlled by the navigation pushbuttons (Figure 14), automatic messages the relay generates, and programmable analog and digital display points. The rotating display scrolls through the bay screen, alarm points, display points, and metering screens. Each display remains for an adjustable time (1–15 seconds) before the display continues scrolling. Any message generated by the relay because of an alarm condition takes precedence over the rotating display.

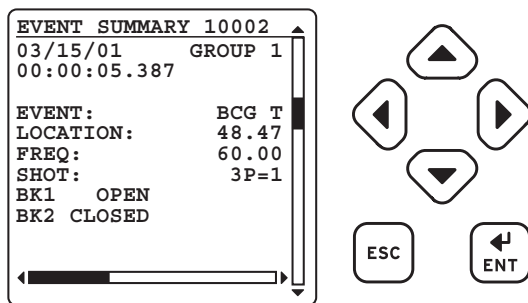


Figure 14 Front-Panel Display and Pushbuttons

Close-up views of the front panel of the SEL-451 are shown in Figure 12, Figure 13, and Figure 14. The front panel includes a 128 x 128 pixel, 3" x 3" LCD screen;

LED target indicators; and pushbuttons with indicating LEDs for local control functions. The asserted and deasserted colors for the LEDs are programmable. Configure any of the direct-acting pushbuttons to navigate directly to an HMI menu item, such as events, bay display, alarm points, display points, or the SER.

Status and Trip Target LEDs

The SEL-451 includes programmable target LEDs, as well as programmable direct-action control pushbuttons/LEDs on the front panel. These LEDs and pushbuttons are shown in Figure 12 and Figure 13. Default Target LED assignments are explained in Table 2.

The SEL-451 features a versatile front panel that you can customize to fit your needs. Use SELOGIC control equations and slide-in configurable front-panel labels to change the function and identification of target LEDs and operator control pushbuttons and LEDs. The blank slide-in label set is included with the SEL-451. Label sets can be printed from a laser printer using templates supplied with the relay or hand labeled on supplied blank labels.

Table 2 Description of Factory-Default Target LEDs

Target LED	Function
ENABLED	Relay powered properly and self-tests okay
TRIP	Indication that a trip occurred
INST	High-speed trip
TIME	Time-delayed trip
COMM	Communications-assisted trip
SOTF	Switch-onto-fault trip
RECLOSER	
79 RESET	Ready for reclose cycle
79 CYCLE	Control in cycle state
79 LOCKOUT	Control in lockout state
PHASE	
A, B, C	Phases involved in fault
GROUND	Ground involved in fault
LOP	Loss-of-potential condition
VOLTAGES	
VAY ON, VBY ON, VCY ON	VY phase filtered instantaneous voltages applied
VAZ ON ^a , VBZ ON ^a , VCZ ON ^a	VZ phase filtered instantaneous voltages applied
BKR FAIL ^a	Breaker Failure trip
BKR MAINT ^a	Breaker maintenance needed
EXT TRIP ^a	External trip detected
51 TIMING ^a	51 element picked up and timing
IRIG LOCKED ^a	IRIG synchronization detected

^a Only available in 24-LED models.

Advanced Display Points

Create custom screens showing metering values, special text messages, or a mix of analog and status information with programmable display points. *Figure 15* shows an example of how display points can be used to show circuit breaker information and current metering. As many as 96 display points can be created. All display points occupy one, and only one, line on the display at all times. The height of the line is programmable as either single or double as shown in *Figure 15*. These screens become part of the autoscrolling display when the front panel times out.

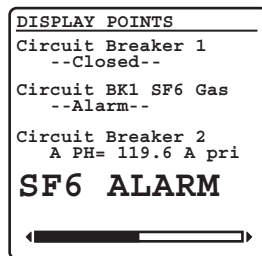


Figure 15 Sample Display Points Screen

Alarm Points

You can display messages on the SEL-451 front-panel LCD that indicate alarm conditions in the power system. The relay uses alarm points to place these messages on the LCD.

Figure 16 shows a sample alarm points screen. The relay is capable of displaying as many as 66 alarm points. The relay automatically displays new alarm points while in manual-scrolling mode and in autoscrolling mode. The alarm point messages are assigned using SER Points settings. The asterisk next to the alarm point indicates an active alarm. The inactive alarms can be acknowledged and cleared using the front-panel navigation buttons.

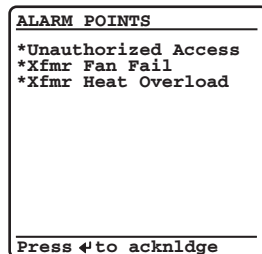


Figure 16 Sample Alarm Points Screen

Auxiliary Trip/Close Pushbuttons and Indicating LEDs

Optional auxiliary trip and close pushbuttons (see *Figure 17*) and indicating LEDs allow breaker control independent of the relay. The auxiliary trip/close pushbuttons are electrically separate from the relay, operating even if the relay is powered down. Make the extra connections at terminals 201 through 208. See *Figure 28* for a rear-panel view. *Figure 18* shows one possible set of connections.

The auxiliary trip/close pushbuttons incorporate an arc suppression circuit for interrupting dc trip or close current. To use these pushbuttons with ac trip or close circuits, disable the arc suppression for either pushbutton by changing jumpers inside the SEL-451. The operating voltage ranges of the breaker CLOSED and breaker OPEN indicating LEDs are also jumper-selectable.



Figure 17 Operator Controls (Auxiliary Trip/Close Model)

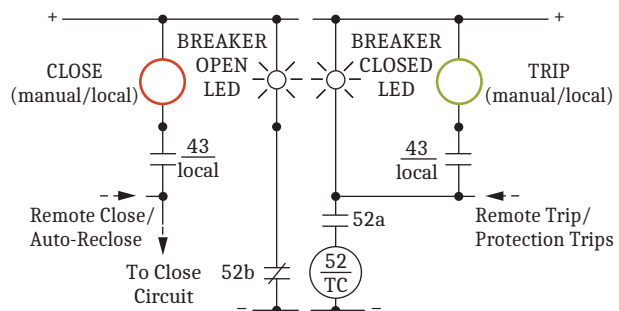


Figure 18 Optional Breaker Trip/Close Control Switches and Indicating Lamps

Monitoring and Metering

Complete Metering Capabilities

The SEL-451 provides extensive metering capabilities as listed in *Table 3*.

Event Reporting and Sequential Events Recorder (SER)

Event Reports and Sequential Events Recorder features simplify post-fault analysis and help improve your understanding of both simple and complex protective scheme operations. These features also aid in testing and troubleshooting bay settings and control schemes. Oscillograms are available in binary COMTRADE and ASCII COMTRADE formats.

Oscillography and Event Reporting

In response to a user-selected internal or external trigger, the voltage, current, 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 an event report is triggered: 8 kHz, 4 kHz, 2 kHz, or 1 kHz resolution analog data. The relay stores from 24 seconds of data per fault at 1 kHz resolution to 3 seconds per fault at 8 kHz resolution. Reports are stored in nonvolatile memory. Settings operational in the relay at the time of the event are appended to each event report.

Event Summary

Each time the SEL-451 generates a standard event report, it also generates a corresponding Event Summary. This is a concise description of an event that includes bay/terminal identification, event date and time, fault location, phase voltages, fault type at time of trip, and trip and close times of day.

With an appropriate setting, the relay will automatically send an Event Summary in ASCII text to one or more relay communications ports each time an event report is triggered.

Sequential Events Recorder (SER)

Use this feature to gain a broad perspective of relay element operation. Items that trigger an SER entry are selectable and can include input/output change of state, element pickup/dropout, recloser state changes, etc. The relay SER stores the latest 1,000 entries.

Voltage Sag, Swell, Interruption Records

The SEL-451 can perform automatic voltage disturbance monitoring for three-phase systems. The voltage sag/swell/interruption (VSSI) recorder uses the VSSI Relay Word bits to determine when to start (trigger) and when to stop recording. The VSSI recorder uses nonvolatile memory, so de-energizing the relay will not erase any stored VSSI data.

The recorded data are available through the VSSI report, which includes date, time, current, voltage, and voltage sag/swell/interruption (VSSI) element status during voltage disturbances, as determined by programmable settings VINT, VSAG, and VSWELL. When the relay is recording a disturbance, entries are automatically added to the VSSI report at one of four rates, depending on the length of the disturbance:

- Once per quarter cycle
- Once per cycle
- Once per 64 cycles
- Once per day

High-Accuracy Time Keeping

Using a combination of IRIG-B and a global positioning satellite, the SEL-451 can time-tag oscillography to within 10 μ s accuracy. This high accuracy can be combined with the high sampling rate of the relay to synchronize data from across the system with an accuracy of better than 1/4 electrical degree. This allows examination of the power system state at given times, including load angles, system swings, and other system-wide events. Triggering can be via external signal (contact or communications port), set time, or system event. Optimal calibration of this feature requires a knowledge of primary input component (VT and CT) phase delay and error.

A single IRIG-B time-code input synchronizes the SEL-451 time to within ± 1 ms of the time-source input. A convenient source for this time code is the SEL-2032 Communications Processor (via Serial Port 1 on the SEL-451).

Precision Time Protocol (PTP) Time Synchronization

In addition to IRIG-B, the relay can be time-synchronized through the Ethernet network by using IEEE 1588 Precision Time Protocol, version 2 (PTPv2). When connected directly to a grandmaster clock providing PTP at

1-second sync intervals, the relay can be synchronized to an accuracy of ± 100 ns. The relay is capable of receiving as many as 32 sync messages per second.

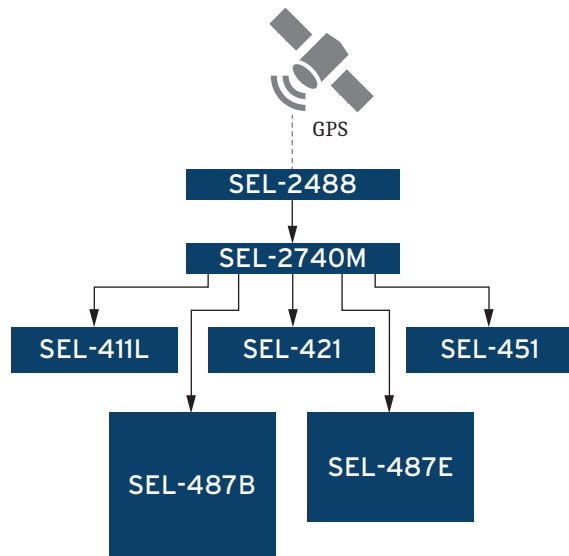


Figure 19 Example PTP Network

SNTP Time Synchronization

Use simple network time protocol (SNTP) to cost-effectively synchronize SEL-451 Relays equipped with Ethernet communication to as little as ± 1 ms with no time-source delay. Use SNTP as a primary time source, or as a backup to a higher accuracy IRIG-B time input to the relay.

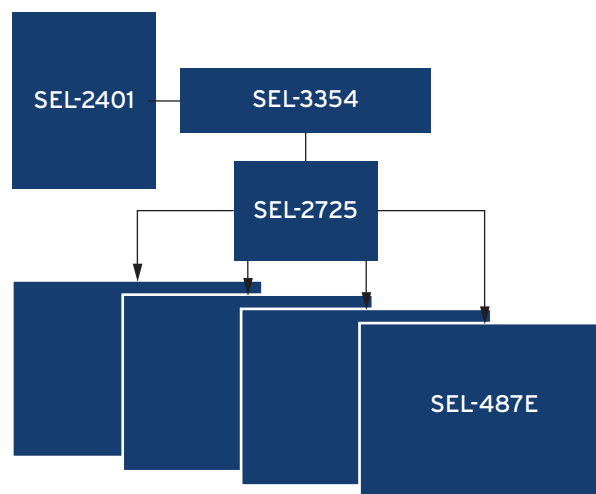


Figure 20 SNTP Diagram

Substation Battery Monitor for DC Quality Assurance

The SEL-451 measures and reports the substation battery voltage for two battery systems. Two sets of programmable threshold comparators and associated logic provide alarm and control of two separate batteries and chargers. The relay also provides dual ground detection. Monitor DC system status alarms with an SEL Communications Processor and trigger messages, telephone calls, or 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. Monitor the substation battery voltage drops during trip, close, and other control operations.

Table 3 Metering Capabilities (Sheet 1 of 2)

Capabilities	Description
Instantaneous Quantities	
Voltages $V_{A,B,C} (Y)$, $V_{A,B,C} (Z)$, $V_{\phi\phi}$, 3V0, V1, 3V2	0–300 V with phase quantities for each of the six voltage sources available as a separate quantity.
Currents $I_{A,B,C} (W)$, $I_{A,B,C} (X)$ I_{AL} , I_{BL} , I_{CL} , (combined currents) I_{GL} , I_{1L} , $3I_{2L}$ (combined currents)	Phase quantities for each of the two current sources available as a separate quantity or combined as line quantities.
Power/Energy Metering Quantities	
MW, MWh, MVAR, MVA, PF, single-phase and three-phase	Available for each input set and as combined quantities for the line.
Demand/Peak Demand Metering	
$I_{A,B,C}$, $3I_2$, $3I_0$	Thermal or rolling interval demand and peak demand.
MW, MVAR, MVA, single-phase	Thermal or rolling interval demand and peak demand.
MW, MVAR, MVA, three-phase	Thermal or rolling interval demand and peak demand.

Table 3 Metering Capabilities (Sheet 2 of 2)

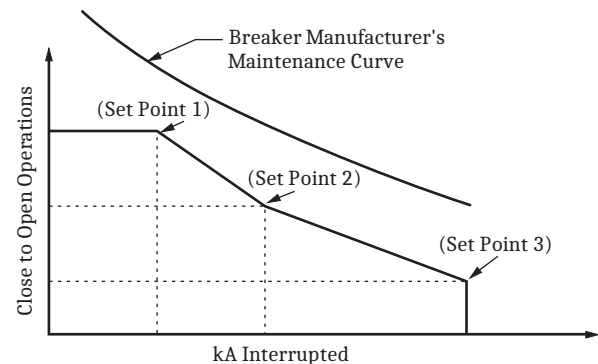
Capabilities	Description
Synchrophasors	
Voltages (Primary Magnitude, Angle) $V_{A,B,C}(Y)$, $V_{A,B,C}(Z)$	Primary phase quantities (kV) for each of the six voltage sources available.
Currents (Primary Magnitude, Angle) $I_{A,B,C}(W)$, $I_{A,B,C}(X)$	Primary phase quantities (A) for each of the six current sources available.
Frequency FREQ dF/dT	Frequency (Hz) as measured by frequency source potential inputs. Rate-of-change of frequency (Hz/s).

Breaker Monitor Feature Allows for Wear-Based Breaker Maintenance Scheduling

Circuit breakers experience mechanical and electrical wear at each operation. Effective scheduling of breaker maintenance takes into account the manufacturer's published data of contact wear versus interruption levels and operation count. The SEL-451 dual breaker monitor feature compares the breaker manufacturer's published data to the integrated actual interrupted current and number of operations.

- Every time the breaker trips, the relay integrates interrupted current. When the result of this integration exceeds the threshold set by the breaker wear curve (*Figure 21*), the bay can alarm via an output contact or the optional front-panel display. With this information, you can schedule breaker maintenance in a timely, economical fashion.

- The relay monitors last and average mechanical and electrical interruption time. You can easily determine if operating time is increasing beyond reasonable tolerance to schedule proactive breaker maintenance. You can activate an alarm point if operation time goes beyond a preset value.
- Breaker motor run time and breaker inactivity are also monitored.

**Figure 21 Breaker Contact Wear Curve and Settings**

Automation

Time-Domain Link (TiDL) Technology

The SEL-451 supports remote data acquisition through use of an SEL Axion with a technology known as TiDL. The Axion provides remote analog and digital data over an IEC 61158 EtherCAT TiDL network. This technology provides very low and deterministic 1.5 ms latency over a point-to-point architecture. The SEL-451 can receive as many as eight fiber links from as many as eight Axion remote data acquisition nodes.

The relay supports a number of fixed topologies. The relay maps the voltage and current inputs from the Axion to existing analog quantities in the SEL-451 based on the connected topology. This limits the number of settings and makes converting an existing system to TiDL easy. *Figure 22* show sample TiDL topologies. The SEL-451-5 Instruction Manual shows all supported topologies.

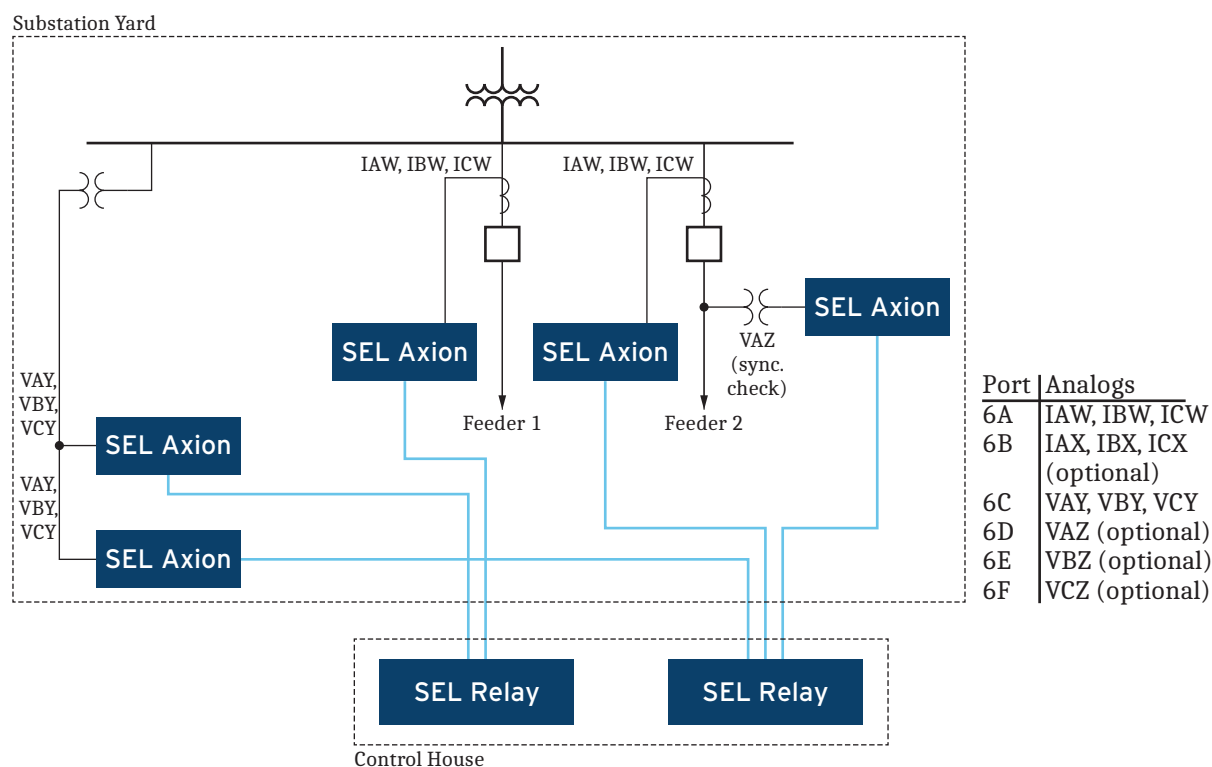


Figure 22 Sample SEL-451 Topology

Flexible Control Logic and Integration Features

The SEL-451 control logic can be used to perform the following:

- Replace traditional panel control switches
- Eliminate remote terminal unit (RTU)-to-bay wiring
- Replace traditional latching relays
- Replace traditional indicating panel lights

Eliminate traditional panel control switches with 32 local control points. Set, clear, or pulse local control points with the front-panel pushbuttons and display. Program the local control points to implement your control scheme via SELOGIC control equations. Use the local control points for such functions as trip testing, enabling/disabling reclosing, and tripping/closing circuit breakers.

Eliminate RTU-to-bay wiring with 32 remote control points. Set, clear, or pulse remote control points via serial port commands. Incorporate the remote control points into your control scheme via SELOGIC control equations. Use remote control points for SCADA-type control operations (e.g., trip, close, settings group selection).

Replace traditional latching relays for such functions as “remote control enable” with 32 latching control points. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the latch control points via control inputs, remote control points, local control points, or any programmable logic condition. The latch control points retain states when the relay loses power.

Replace traditional indicating panel lights and switches with as many as 24 latching target LEDs and as many as 12 programmable pushbuttons with LEDs. Define custom messages (i.e., BREAKER OPEN, BREAKER CLOSED, RECLOSER ENABLED) to report power system or relay conditions on the large format LCD. Control which messages are displayed via SELOGIC control equations by driving the LCD display via any logic point in the relay.

Open Communications Protocols

The SEL-451 does not require special communications software. ASCII terminals, printing terminals, or a computer supplied with terminal emulation and a serial communications port are all that is required. *Table 4* lists a brief description of the terminal protocols.

Table 4 Open Communications Protocol

Type	Description
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 bay 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 communication. Quickly updates SEL-2032 Communications Processors, RTUs, and other substation devices with metering information, bay element, 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 that control operator metering information is not lost while a technician is transferring an event report.
Ymodem	Support for reading event, settings, and oscillography files.
DNP3 Level 2 Outstation	Distributed Network Protocol with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and settings groups.
IEEE C37.118	Phasor measurement protocol.
IEC 61850 Edition 2	Ethernet-based international standard for interoperability between intelligent devices in a substation.

Table 5 SELogic Control Equation Operators

Operator Type	Operators	Comments
Boolean	AND, OR, NOT	Allows combination of measuring units.
Edge Detection	F_TRIG, R_TRIG	Operates at the change of state of an internal function.
Comparison	>, >=, =, <=, <, <>	
Arithmetic	+, -, *, /	Uses traditional math functions for analog quantities in an easily programmable equation.
Numerical	ABS, SIN, COS, LN, EXP, SQRT LOG	
Precedence Control	()	Allows multiple and nested sets of parentheses.
Comment	# (* *)	Provides for easy documentation of control and protection logic.

SELogic Control Equations With Expanded Capabilities and Aliases

Expanded SELOGIC control equations put relay logic in the hands of the engineer. Assign inputs to suit your application, logically combine selected bay 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 (*Table 5*). Any element in the Relay Word can be used in these equations. For complex or unique applications, these expanded SELOGIC functions allow superior flexibility.

Use the relay alias capability to assign more meaningful names to analog and Boolean quantities. This improves the readability of customized programming. Use as many as 200 aliases to rename any digital or analog quantity. The following is an example of possible applications of SELOGIC control equations that use aliases.

```

=>>SET T <Enter>
1: PMV01,THETA
(assign the alias "THETA" to math variable PMV01)

2: PMV02,TAN
(assign the alias "TAN" to math variable PMV02)

=>>SET L <Enter>
1: # CALCULATE THE TANGENT OF THETA
2: TAN:=SIN(THETA)/COS(THETA)
(use the aliases in an equation)

```

Add programmable control functions to your relay and automation systems. New functions and capabilities enable use of analog values in conditional logic statements. The following are examples of possible applications of SELOGIC control equations with expanded capabilities.

- Emulate a motor-driven reclose timer, including stall, reset, and drive-to-lockout conditions (refer to *Figure 23*).
- Scale analog values for SCADA retrieval.
- Initiate remedial action sequence based on load flow before fault conditions.
- Interlock breakers and disconnect switches.

- Restrict breaker tripping in excessive duty situations without additional relays.
- Construct a compensated overvoltage element for open line overvoltage protection.
- Hold momentary change-of-state conditions for SCADA polling.
- Provide a combination of frequency or rate-of-change-of-frequency functions.

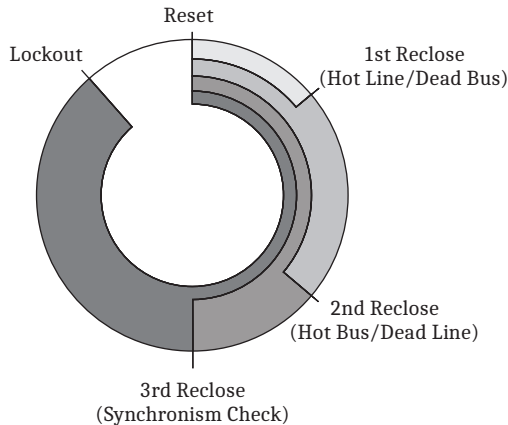


Figure 23 Motor-Driven Reclose Timer

Relay-to-Relay Digital Communications (MIRRORED BITS)

The SEL patented MIRRORED BITS technology provides bidirectional relay-to-relay digital communication (Figure 24). In the SEL-451, MIRRORED BITS can operate simultaneously on any two serial ports for three-terminal power system operation.

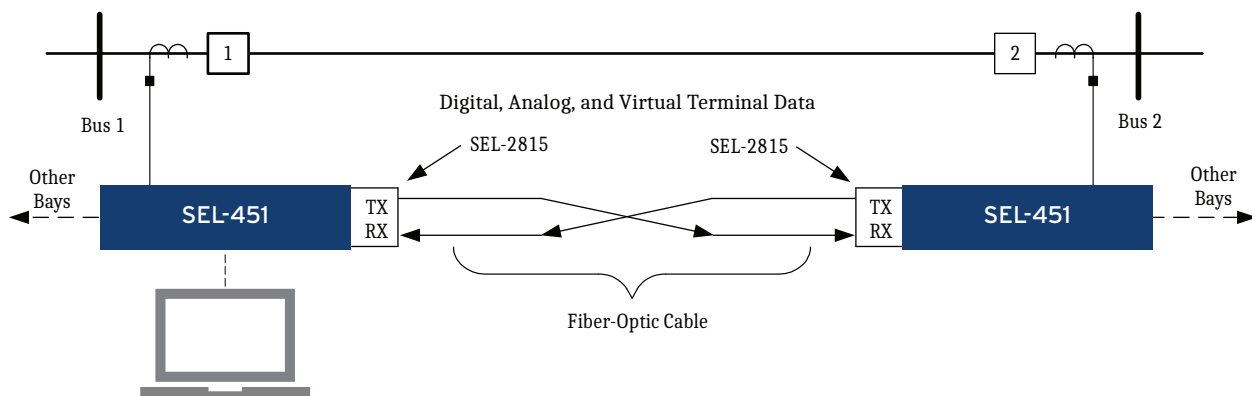


Figure 24 Integral Communication Provides Secure Protection, Monitoring, and Control, as Well as Terminal Access to Both Relays Through One Connection

This bidirectional digital communication creates additional outputs (transmitted MIRRORED BITS) and additional inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS communications mode. Communicated information can include digital, analog, and virtual terminal data. Virtual terminal allows operator access to remote bays through the local bay. These MIRRORED BITS can be used to transfer information between line terminals to enhance coordination and achieve faster tripping. MIRRORED BITS also help reduce total pilot scheme operating time by eliminating the need to close output contacts and debounce contact outputs. Use the dual-port MIRRORED BITS communications capabilities for high-speed communications-assisted schemes applied to three-terminal transmission lines.

Communication

The SEL-451 offers the following serial communication features.

- Four independent EIA-232 serial ports.
- Full access to event history, relay status, and meter information.
- Settings and group switching have three levels of password protection.
- DNP3 Level 2 Outstation.
- Patented SEL Fast Message Interleaving of ASCII and binary data for SCADA communications, including access to SER, relay element targets, event data and more.
- Communication of synchronized phasor measurement data using either SEL Fast Messaging for Synchrophasors or IEEE C37.118–2005 *Standard for Synchrophasors for Power Systems*.

Network Connection and Integration

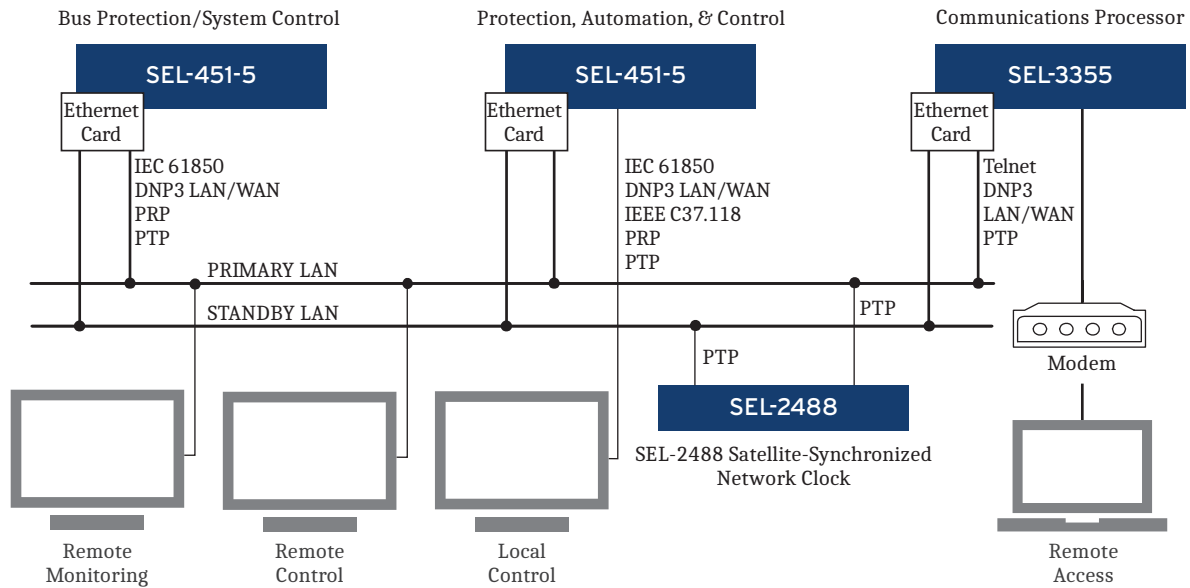


Figure 25 Network Connection and Integration

Connect the SEL-451 to Local Area Networks (LANs) by using the optional Ethernet card. The integrated Ethernet card supports both copper and/or fiber connections with failover protection.

Ethernet Card

The optional Ethernet card mounts directly in the SEL-451. Use popular Telnet applications for easy terminal communications with SEL relays and other devices. Transfer data at high speeds (10 Mbps or 100 Mbps) for fast HMI updates and file uploads. The Ethernet card communicates using File Transfer Protocol (FTP) applications for easy and fast file transfers.

Provide operations with situational awareness of the power system by using IEEE C37.118-2005 Standard for Synchrophasors for Power Systems. Communicate with SCADA and other substation intelligent electronic devices (IEDs) by using DNP3 or IEC 61850 logical nodes and GOOSE messaging.

Choose Ethernet connection media options for primary and standby connections:

- 10/100BASE-T Twisted Pair Network
- 100BASE FX Fiber-Optic Network

Telnet and FTP

Order the SEL-451 with Ethernet communication and use the built-in Telnet and File Transfer Protocol (FTP) that come standard with Ethernet to enhance relay com-

munications sessions. Use Telnet to access relay settings, and metering and event reports remotely using the ASCII interface. Transfer settings files to and from the relay via the high-speed Ethernet port through use of FTP.

IEEE C37.118 Synchrophasors

The latest IEEE Synchrophasor Protocol provides a standard method for communicating synchronized phasor measurement data over Ethernet or serial media. The integrated Ethernet card in the SEL-451 provides two independent connections by using either TCP/IP, UDP/IP, or a combination thereof. Each connection supports unicast or multicast options for serving data to one or multiple clients simultaneously. Each data stream can support data streams at as fast as 60 frames per second.

DNP3 LAN/WAN

The DNP3 LAN/WAN option provides the SEL-451 with DNP3 Level 2 Outstation functionality over Ethernet. Custom DNP3 data maps can be configured for use with specific DNP3 masters. The PTP power profile is also supported over PRP.

Precision Time Protocol (PTP)

An Ethernet card option with Ports 5A and 5B populated provides the ability to accept IEEE 1588 Precision Time Protocol, version 2 (PTPv2) for data time synchronization. Optional PTP support includes both the Default and Power System (C37.238-2011) PTP Profiles.

Parallel Redundancy Protocol (PRP)

This protocol is used to provide seamless recovery from any single Ethernet network failure, in accordance with IEC 62439-3. The Ethernet network and all traffic are fully duplicated with both copies operating in parallel.

HTTP Web Server

When equipped with Ethernet communications, the relay can serve read-only web pages displaying certain settings, metering, and status reports. As many as four users can access the embedded HTTP server simultaneously.

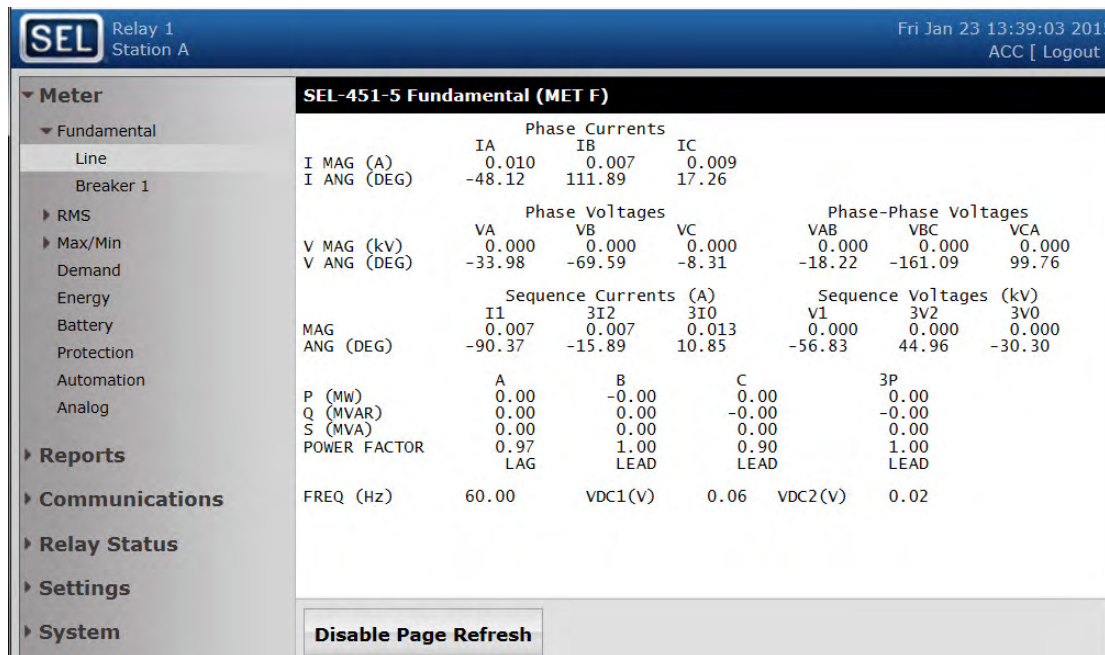


Figure 26 Typical Web Server Default Menu Screen

IEC 61850 Edition 2 Ethernet Communications

IEC 61850 Edition 2 Ethernet-based communications provide interoperability among IEDs within the substation. Logical nodes using IEC 61850 allow standardized interconnection of IEDs from different manufacturers for monitoring and control of the substation. Reduce wiring among various manufacturers' devices and simplify operating logic with IEC 61850. Eliminate system RTUs by streaming monitoring and control information from IEDs directly to remote SCADA client devices.

The SEL-451 can be ordered with embedded IEC 61850 Edition 2 protocol operating on 100 Mbps Ethernet. Use the IEC 61850 Edition 2 Ethernet protocol for relay monitoring and control functions, including the following:

- As many as 128 incoming GOOSE messages. The incoming GOOSE messages can be used to control as many as 256 control bits and 256 analog quantities in the relay with <3 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 and/or analog data. Boolean data are provided with <3 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 Edition 2 Data Server. The SEL-451 is equipped with embedded IEC 61850 Ethernet protocol that provides data according to pre-defined logical node objects. As many as seven 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, outputs or SELOGIC control equations can be monitored using the IEC 61850 data server provided in the relay.
- The SEL-451 supports IEC 61850 standard operating modes such as Test, Blocked, On, and Off.

MMS File Services

This service of IEC 61850 MMS provides support for file transfers completely within an MMS session. All relay files that can be transferred via FTP can also be transferred via MMS file services.

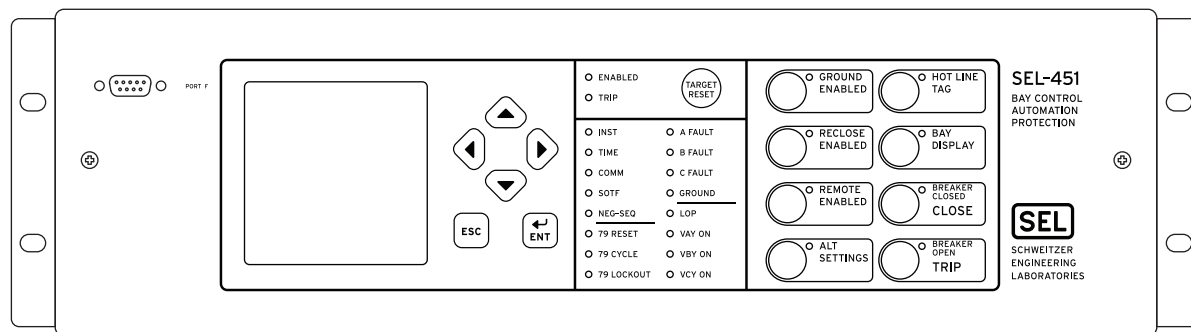
MMS Authentication

When enabled via a setting in the Configured IED Description (CID) file, the relay will require authentication from any client requesting to initiate an MMS session. The client request must be accompanied by the 2AC level password.

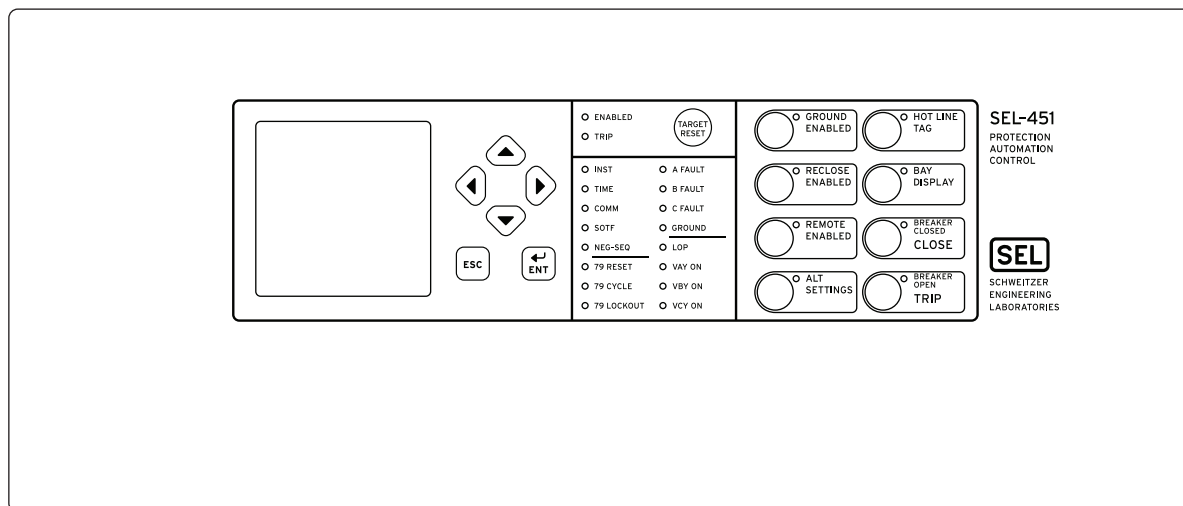
ACSELERATOR Architect

Use ACSELERATOR Architect[®] SEL-5032 Software to manage the logical node data for all IEC 61850 devices on the network. This Windows-based software provides easy-to-use displays for identifying and binding IEC 61850 network data between logical nodes by using IEC 61850-compliant CID files. Architect uses CID files to describe the data the IEC 61850 logical node provides within each relay.

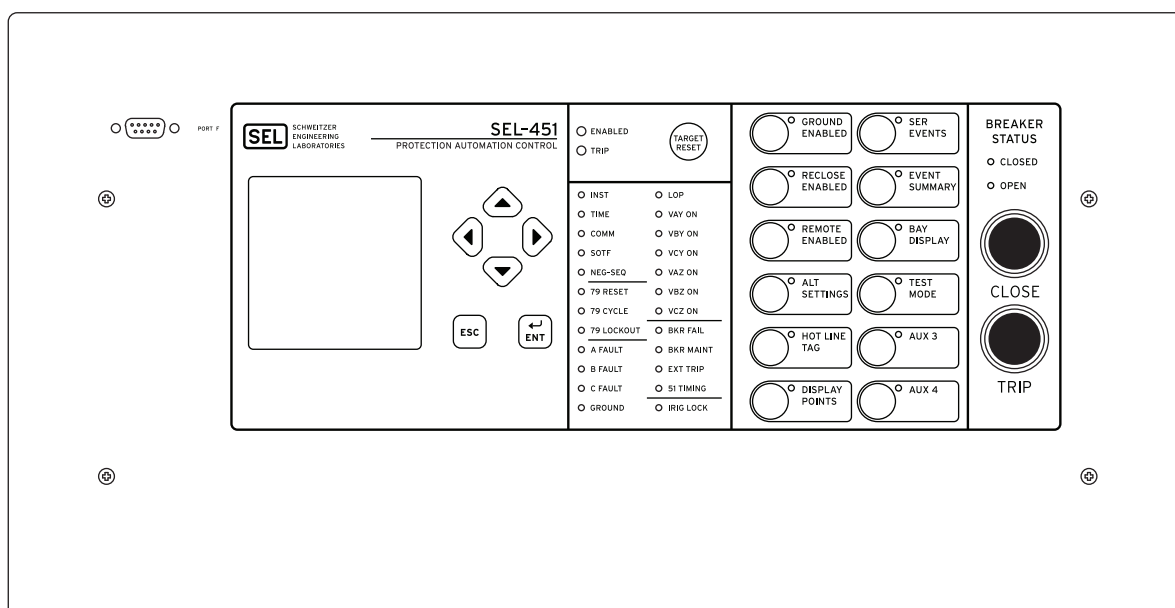
Diagrams and Dimensions



3U Front Panel, Rack-Mount Option With Optional Bay Control Overlay

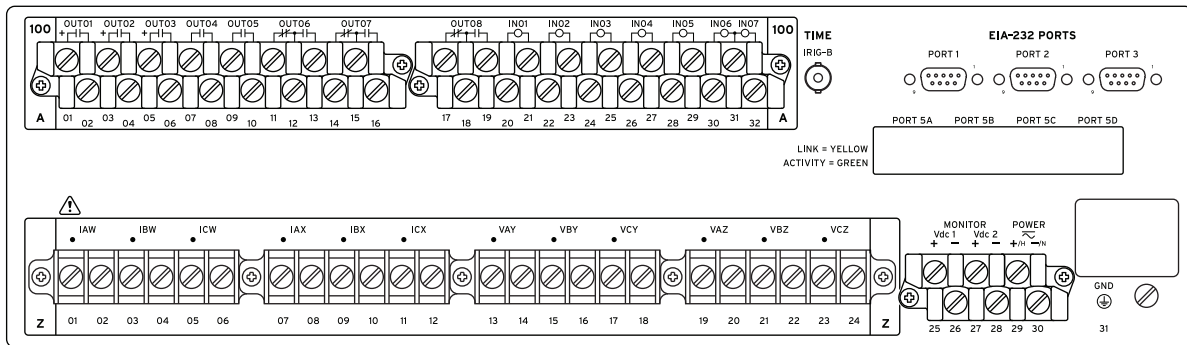


4U Front Panel, Panel-Mount Option



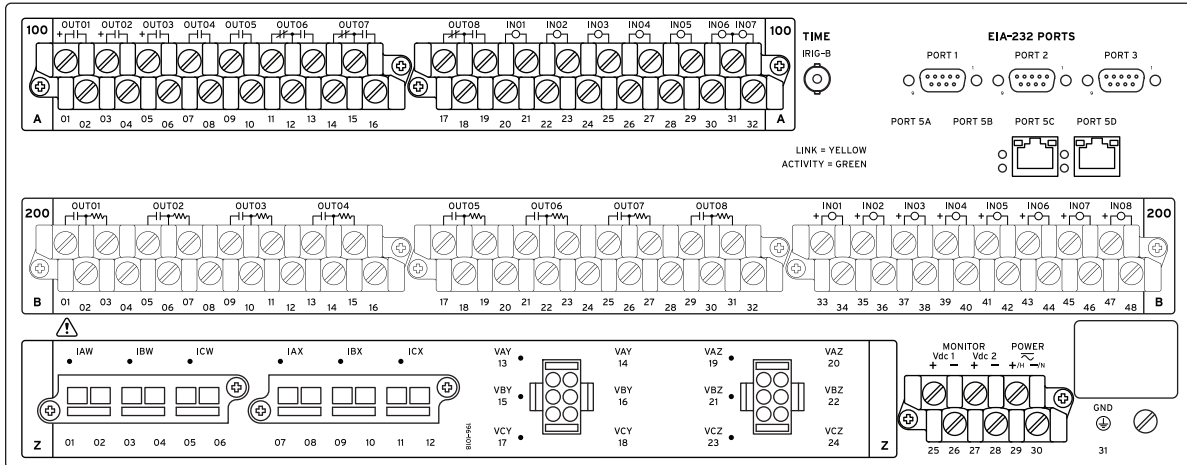
5U Front Panel, Panel-Mount Option With Auxiliary Trip/Close Pushbuttons

Figure 27 Typical SEL-451 Front-Panel Diagrams



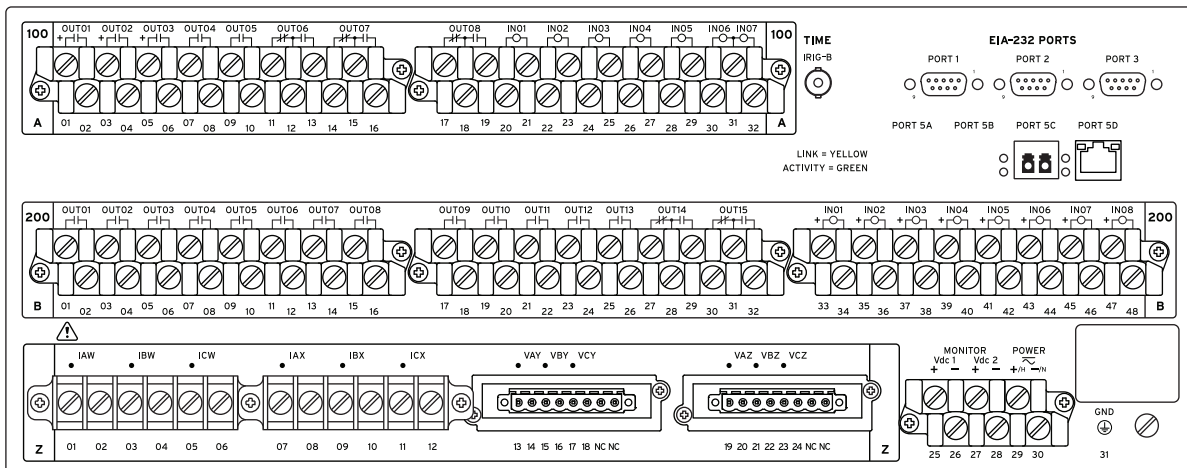
3U Rear Panel, Main Board

I7014c



4U Rear Panel, Main Board, Connectorized® Option, INT5 I/O Board

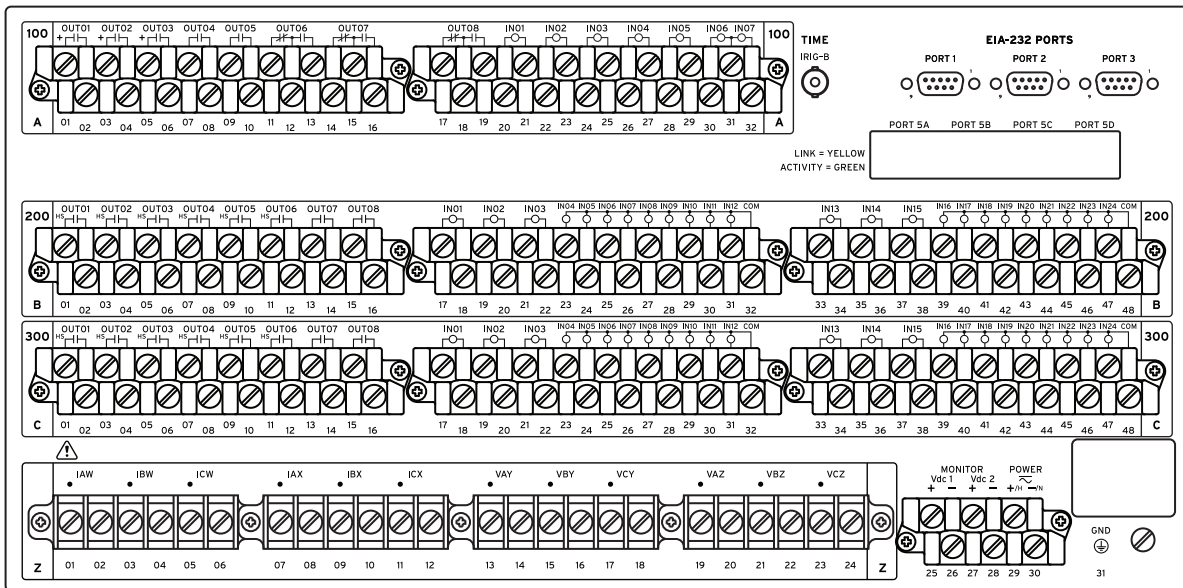
I7015c



4U Rear Panel, Main Board, INT1 I/O Board, LEA Voltage Inputs

I7015c

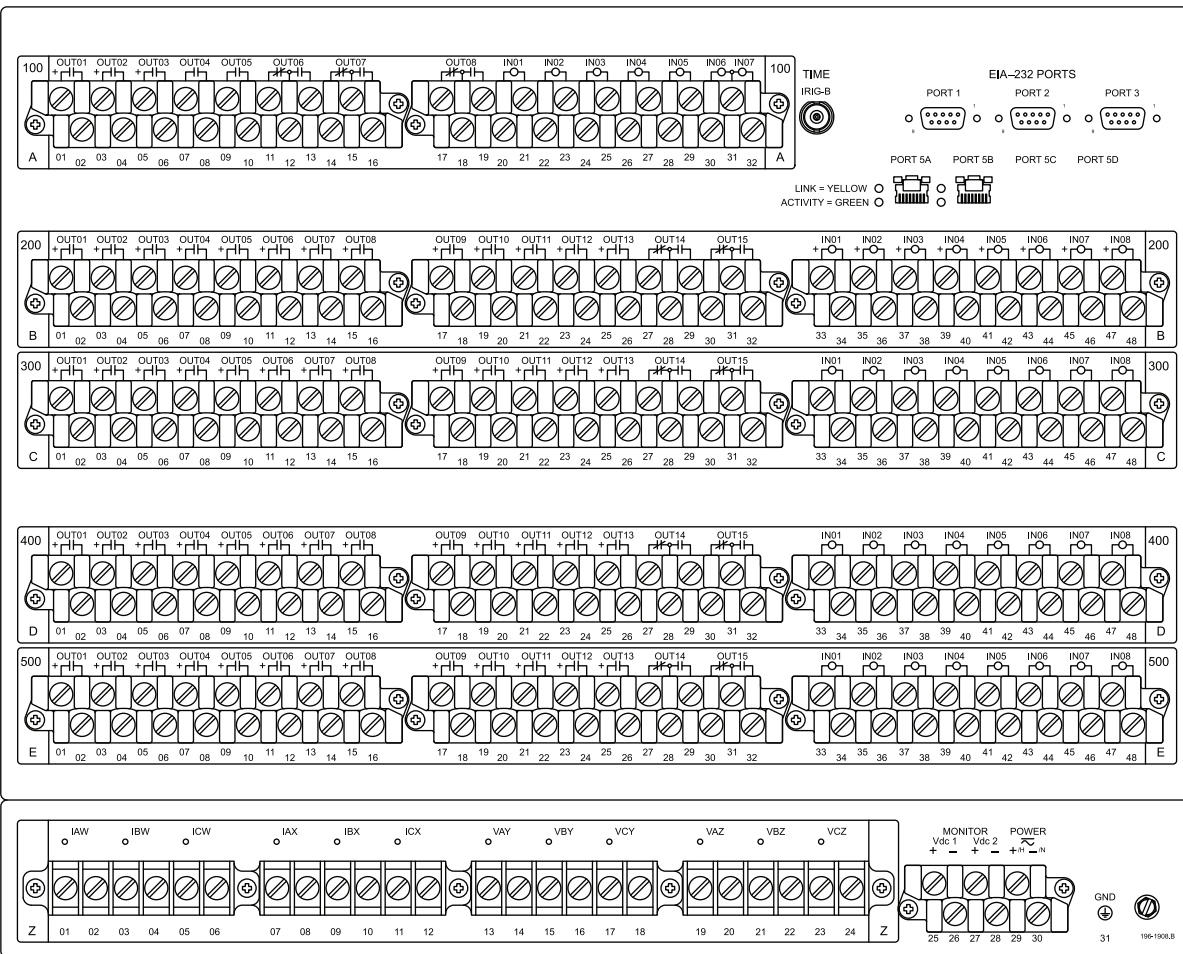
Figure 28 Typical 3U and 4U SEL-451 Rear-Panel Diagrams



5U Rear Panel, Main Board, With Two INT4 I/O Boards

I7016c

Figure 29 Typical 5U SEL-451 Rear-Panel Diagram



I7155a

Figure 30 Typical 8U SEL-451 Rear-Panel Diagram

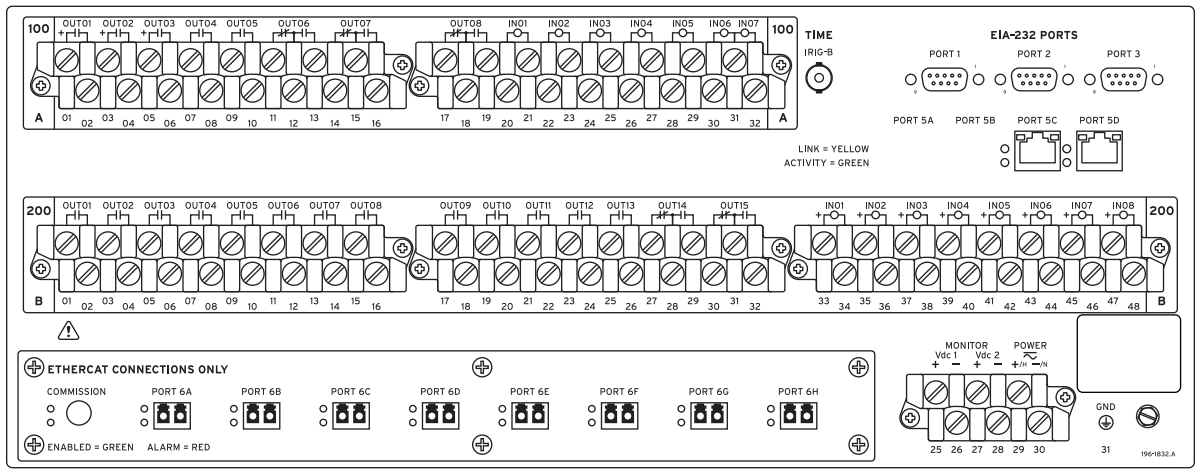
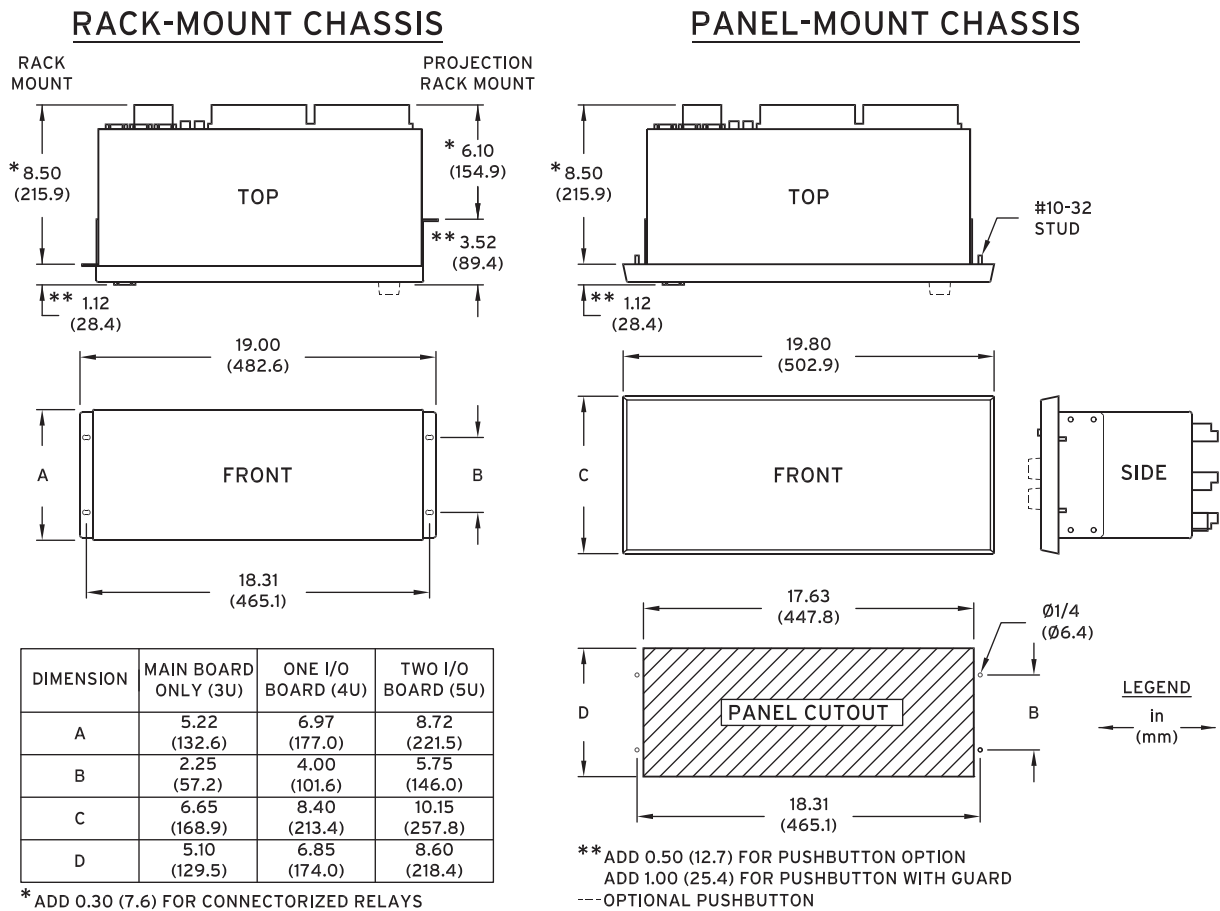
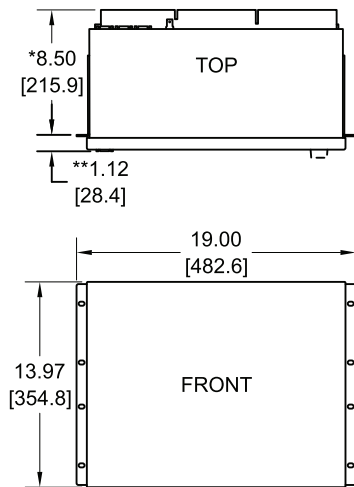
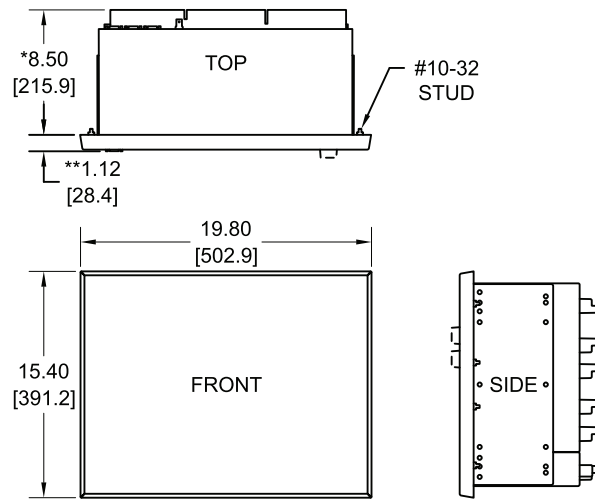


Figure 31 Rear Panel With EtherCAT Board



(Horizontal Mounting Shown; Dimensions Also Apply to Vertical Mounting)

Figure 32 SEL-451 3U, 4U, and 5U Dimensions for Rack- and Panel-Mount Models

RACK-MOUNT CHASSISPANEL-MOUNT CHASSIS

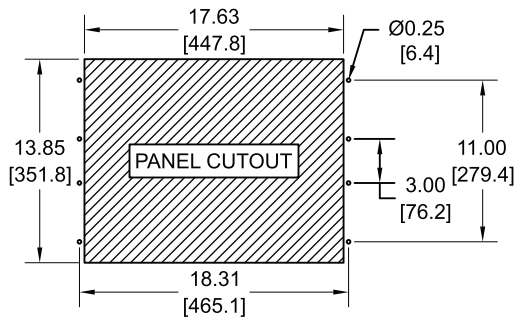
*ADD 0.30 [7.6] FOR CONNECTORIZED RELAYS

--- OPTIONAL PUSHBUTTON

**ADD 0.50 [12.7] FOR PUSHBUTTON OPTION
(ADD 1.00 [25.4] FOR PUSHBUTTON WITH GUARD)

LEGEND

in
[mm]



i9363b

Figure 33 SEL-451 8U Dimensions for Rack- and Panel-Mount Models

Specifications

Note: If the relay is using a remote data acquisition system, such as TiDL, the operating times will be delayed by 1.5 ms. Use caution when setting the relay coordination times to account for this added delay. Element operate times will also have this small added delay.

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B Class A

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 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)

CE Mark

General

AC Analog Inputs

Sampling Rate: 8 kHz

AC Current Input (Secondary Circuits)

Note: Current transformers are Measurement Category II.

Current Rating (With DC Offset at X/R = 10, 1.5 cycles)

1 A Nominal: 18.2 A
5 A Nominal: 91 A

Continuous Thermal Rating

1 A Nominal: 3 A
4 A (+55°C)
5 A Nominal: 15 A
20 A (+55°C)

Saturation Current (Linear) Rating

1 A Nominal: 20 A
5 A Nominal: 100 A

A/D Current Limit

Note: Signal clipping may occur beyond this limit.

1 A Nominal: 49.5 A
5 A Nominal: 247.5 A

One-Second Thermal Rating

1 A Nominal: 100 A
5 A Nominal: 500 A

One-Cycle Thermal Rating

1 A Nominal: 250 A peak
5 A Nominal: 1250 A peak

Burden Rating

1 A Nominal: ≤ 0.1 VA @ 1 A
5 A Nominal: ≤ 0.5 VA @ 5 A

AC Voltage Inputs

Three-phase, four-wire (wye) connections are supported.

Rated Voltage Range: 0–300 V_{L-N}
Ten-Second Thermal Rating: 600 Vac
Burden: ≤ 0.1 VA @ 125 V

LEA Voltage Inputs

Rated Voltage Range: 0–8 V_{L-N}
Ten-Second Thermal Rating: 300 Vac
Input Impedance: 1 MΩ

Common Mode Voltage

Operation: 50 Vac
Without Damage: 300 Vac

Frequency and Rotation

Nominal Frequency Rating: 50 ±5 Hz
60 ±5 Hz
Phase Rotation: ABC or ACB
Frequency Tracking Range: 40–65 Hz
< 40 Hz = 40 Hz
> 65 Hz = 65 Hz
Default Slew Rate: 15 Hz/s

Power Supply

24–48 Vdc

Rated Voltage: 24–48 Vdc
Operational Voltage Range: 18–60 Vdc
Vdc Input Ripple: 15% per IEC 60255-26:2013
Interruption: 20 ms at 24 Vdc, 100 ms at 48 Vdc per IEC 60255-26:2013
Burden: < 35 W

48–125 Vdc or 110–120 Vac

Rated Voltage: 48–125 Vdc, 110–120 Vac
Operational Voltage Range: 38–140 Vdc
85–140 Vac
Rated Frequency: 50/60 Hz
Operational Frequency Range: 30–120 Hz
Vdc Input Ripple: 15% per IEC 60255-26:2013
Interruption: 14 ms at 48 Vdc, 160 ms at 125 Vdc per IEC 60255-26:2013
Burden: < 35 W, < 90 VA

125–250 Vdc or 110–240 Vac

Rated Voltage: 125–250 Vdc, 110–240 Vac
Operational Voltage Range: 85–300 Vdc
85–264 Vac
Rated Frequency: 50/60 Hz
Operational Frequency Range: 30–120 Hz
Vdc Input Ripple: 15% per IEC 60255-26:2013
Interruption: 46 ms at 125 Vdc, 250 ms at 250 Vdc per IEC 60255-26:2013
Burden: < 35 W, < 90 VA

Control Outputs

Standard

Make: 30 A
Carry: 6 A continuous carry at 70°C
4 A continuous carry at 85°C
Is Rating: 50 A
MOV Protection (Maximum Voltage): 250 Vac/ 330 Vdc
Pickup/Dropout Time: ≤ 6 ms, resistive load
Update Rate: 1/8 cycle

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
1 s Rating:	50 A
MOV Protection (Maximum Voltage):	330 Vdc
Pickup Time:	≤ 6 ms, resistive load
Dropout Time:	≤ 6 ms, resistive load
Update Rate:	1/8 cycle

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 cycles in 1 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: Do not use hybrid control outputs to switch ac control signals. These outputs are polarity-dependent.

High-Speed High-Current Interrupting

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 (Maximum Voltage):	250 Vac/330 Vdc
Pickup Time:	≤ 10 μs, resistive load
Dropout Time:	≤ 8 ms, resistive load
Update Rate:	1/8 cycle

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 cycles in 1 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: Per IEC 60255-23:1994, using the simplified method of assessment.

Note: Make rating per IEEE C37.90-2005.

Note: Per IEC 61810-2:2005.

Auxiliary Breaker Control Pushbuttons

Quantity:	2
Pushbutton Functions:	One (1) pushbutton shall be provided to open the breaker. One (1) pushbutton shall be provided to close the breaker.

Resistive DC or AC Outputs With Arc Suppression Disabled

Make:	30 A per IEEE C37.90-2005
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

High-Interrupt DC Outputs With Arc Suppression Enabled

Make:	30 A per IEEE C37.90-2005
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

Breaker Open/Closed LEDs:

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

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.

Control Inputs

Direct Coupled (Use With DC Signals)

INT1, INT5, and INT6 Interface Boards:	8 inputs with no shared terminals
Range:	15–265 Vdc, independently adjustable
Accuracy:	±5% ±3 Vdc
Maximum Voltage:	300 Vdc
Sampling Rate:	2 kHz
Typical Burden:	0.24 W @ 125 Vdc

Optoisolated (Use With AC or DC Signals)

Main Board:	5 inputs with no shared terminals 2 inputs with shared terminals
INT2, INT7, and INT8 Interface Boards:	8 inputs with no shared terminals
INT3 and INT4 Interface Boards:	6 inputs with no shared terminals 18 inputs with shared terminals (2 groups of 9 inputs, with each group sharing one terminal)
Voltage Options:	24 V standard 48, 110, 125, 220, 250 V level sensitive

DC Thresholds

(Dropout thresholds indicate level-sensitive option.)

24 Vdc:	Pickup 19.2–30.0 Vdc
48 Vdc:	Pickup 38.4–60.0 Vdc; Dropout < 28.8 Vdc
110 Vdc:	Pickup 88.0–132.0 Vdc; Dropout < 66.0 Vdc
125 Vdc:	Pickup 105–150 Vdc; Dropout < 75 Vdc
220 Vdc:	Pickup 176–264 Vdc; Dropout < 132 Vdc
250 Vdc:	Pickup 200–300 Vdc; Dropout < 150 Vdc

AC Thresholds

(Ratings met only when recommended control input settings are used)

24 Vac:	Pickup 16.4–30.0 Vac rms
48 Vac:	Pickup 32.8–60.0 Vac rms; Dropout < 20.3 Vac rms
110 Vac:	Pickup 75.1–132.0 Vac rms; Dropout < 46.6 Vac rms
125 Vac:	Pickup 89.6–150.0 Vac rms; Dropout < 53.0 Vac rms
220 Vac:	Pickup 150.3–264 Vac rms; Dropout < 93.2 Vac rms
250 Vac:	Pickup 170.6–300 Vac rms; Dropout < 106 Vac rms
Current Drawn:	< 5 mA at nominal voltage < 8 mA for 110 V option
Sampling Rate:	2 kHz

Communications Ports

EIA-232:	1 Front and 3 Rear
Serial Data Speed:	300–57600 bps

Communications Card Slot for Optional Ethernet Card

Ordering Options:	100BASE-FX Fiber-Optic Ethernet
Fiber Type:	Multimode
Wavelength:	1300 nm
Source:	LED
Connector Type:	LC fiber
Min. TX Power:	–19 dBm
Max. TX Power:	–14 dBm
RX Sensitivity:	–32 dBm
Sys. Gain:	13 dB

Communications Ports for Optional TiDL Interface

EtherCAT Fiber-Optic Ports:	8
Data Rate:	Automatic
Connector Type:	LC fiber
Protocols:	Dedicated EtherCAT
Class 1 LASER/LED	
Wavelength:	1300 nm
Fiber Type:	Multimode
Link Budget:	11 dB
Min. TX Power:	–20 dBm
Min. RX Sensitivity:	–31 dBm
Fiber Size:	50–200 μ m
Approximate Range:	2 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–2 dB/km

Time Inputs

IRIG Input–Serial Port 1

Input:	Demodulated IRIG-B
Rated I/O Voltage:	5 Vdc
Operating Voltage Range:	0–8 Vdc
Logic High Threshold:	≥ 2.8 Vdc
Logic Low Threshold:	≤ 0.8 Vdc
Input Impedance:	2.5 k Ω

IRIG-B Input–BNC Connector

Input:	Demodulated IRIG-B
Rated I/O Voltage:	5 Vdc

Operating Voltage Range:	0–8 Vdc
Logic High Threshold:	≥ 2.2 Vdc
Logic Low Threshold:	≤ 0.8 Vdc
Input Impedance:	50 Ω or > 1 k Ω
Dielectric Test Voltage:	0.5 kVdc

PTP–Ethernet Port 5A, 5B

Input:	IEEE 1588 PTPv2
Profiles:	Default, C37.238-2011 (Power Profile)
Synchronization Accuracy:	± 100 ns @ 1-second synchronization intervals when communicating directly with master clock

Operating Temperature

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20° and above +70°C. Stated temperature ranges not applicable to UL applications.

Humidity

5% to 95% without condensation

Weight (Maximum)

3U Rack Unit:	8.0 kg (17.7 lb)
4U Rack Unit:	9.8 kg (21.6 lb)
5U Rack Unit:	11.6 kg (25.6 lb)
8U Rack Unit:	14.0 kg (32.8 lb)

Terminal Connections

Rear Screw–Terminal Tightening Torque, #8 Ring Lug

Minimum:	1.0 Nm (9 in-lb)
Maximum:	2.0 Nm (18 in-lb)

User terminals and stranded copper wire should have a minimum temperature rating of 105°C. Ring terminals are recommended.

Wire Sizes and Insulation

Wire sizes for grounding (earthing), current, voltage, and contact connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes. The grounding conductor should be as short as possible and sized equal to or greater than any other conductor connected to the device, unless otherwise required by local or national wiring regulations.

Connection Type	Min. Wire Size	Max. Wire Size
Grounding (Earthing) Connection	14 AWG (2.5 mm ²)	N/A
Current Connection	16 AWG (1.5 mm ²)	10 AWG (5.3 mm ²)
Potential (Voltage) Connection	18 AWG (0.8 mm ²)	14 AWG (2.5 mm ²)
Contact I/O	18 AWG (0.8 mm ²)	10 AWG (5.3 mm ²)
Other Connection	18 AWG (0.8 mm ²)	10 AWG (5.3 mm ²)

Type Tests

These tests do not apply to contacts rated for 24 Vdc.

Electromagnetic Compatibility (EMC)

Emissions:	IEC 60255-25:2000
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Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-22-6:2001, 10 Vrms IEC 61000-4-6:2008, 10 Vrms
Electrostatic Discharge Immunity:	IEEE C37.90.3-2001 Levels 2, 4, 8 kV contact; Levels 4, 8, 15 kV air IEC 60255-22-2:2008 IEC 61000-4-2:2008 Levels 2, 4, 6, and 8 kV contact; Levels 2, 4, 8, and 15 kV air

Fast Transient/Burst Immunity:	IEC 60255-22-4:2008 4 kV at 5 kHz and 2 kV at 5 kHz (Comm. Ports) IEC 61000-4-4:2011 4 kV at 5 kHz
Magnetic Field Immunity:	IEC 61000-4-8:2009 1000 A/m for 3 s 100 A/m for 1 min IEC 61000-4-9:2001 1000 A/m
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 60255-11:2008 IEC 61000-4-29:2000
Radiated Digital Radio Telephone RF Immunity:	ENV 50204:1995 10 V/m at 900 MHz and 1.89 GHz
Radiated Radio Frequency Immunity:	IEC 60255-22-3:2007, 10 V/m IEC 61000-4-3:2010, 10 V/m IEEE C37.90.2-2004, 35 V/m
Surge Immunity:	IEC 60255-22-5:2008 IEC 61000-4-5:2005 1 kV line-to-line, 2 kV line-to-earth

NOTE: Cables connected to EIA-232 communications ports shall be less than 10 m in length for Zone A compliance.

Damped Oscillatory Magnetic Field:	IEC 61000-4-10:2001 Severity Level: 100 A/m
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 2.5 kV peak common mode 1.0 kV peak differential mode IEEE C37.90.1-2002 2.5 kV oscillatory 4.0 kV fast transient

Environmental

Cold:	IEC 60068-2-1:2007 16 hours at -40°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25° to 55°C, 6 cycles, 95% humidity
Dry Heat:	IEC 60068-2-2:2007 16 hours at +85°C
Vibration:	IEC 60255-21-1:1988 Severity Level: Class 2 (endurance); Class 2 (response) IEC 60255-21-2:1988 Severity Level: Class 1 (shock withstand, bump); Class 2 (shock response) IEC 60255-21-3:1993 Severity Level: Class 2 (quake response)

Safety

Dielectric Strength:	IEC 60255-5:2000 IEEE C37.90-2005 2500 Vac on contact inputs, contact outputs, and analog inputs 3100 Vdc on power supply
Impulse:	IEC 60255-5:2000 IEEE C37.90-2005 0.5 J, 5 kV
IP Code:	IEC 60529:2001 + CRGD:2003 IP3X

Reporting Functions

High-Resolution Data

Rate:	8000 samples/second 4000 samples/second 2000 samples/second 1000 samples/second
Output Format:	Binary COMTRADE

Note: Per IEEE C37.111-1999 and IEEE C37.111-2013, *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*.

Event Reports

Length:	0.25–24 seconds (based on LER and SRATE settings)
Volatile Memory:	3 s of back-to-back event reports sampled at 8 kHz
Nonvolatile Memory:	At least 4 event reports of a 3 s duration sampled at 8 kHz
Resolution:	8- or 4-samples/cycle

Event Summary

Storage:	100 summaries
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Breaker History

Storage:	128 histories
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Sequential Events Recorder

Storage:	1000 entries
Trigger Elements:	250 relay elements
Resolution:	0.5 ms for contact inputs
Resolution:	1/8 cycle for all elements

Processing Specifications

AC Voltage and Current Inputs

8000 samples per second, 3 dB low-pass analog filter cutoff frequency of 3000 Hz.

Digital Filtering

Full-cycle cosine and half-cycle Fourier filters after low-pass analog and digital filtering.

Protection and Control Processing

Eight times per power system cycle

Control Points

32 remote bits
32 local control bits
32 latch bits in protection logic
32 latch bits in automation logic

Relay Element Pickup Ranges and Accuracies

Instantaneous/Definite-Time Overcurrent Elements

Phase, Residual Ground, and Negative-Sequence

Pickup Range	
5 A Model:	OFF, 0.25–100.00 A secondary, 0.01 A steps
1 A Model:	OFF, 0.05–20.00 A secondary, 0.01 A steps
Accuracy (Steady State)	
5 A Model:	±0.05 A plus ±3% of setting
1 A Model:	±0.01 A plus ±3% of setting
Transient Overreach:	< 5% of pickup
Time Delay:	0.000–16000 cycles, 0.125 cycle steps
Timer Accuracy:	±0.125 cycle plus ±0.1% of setting
Maximum Operating Time:	1.5 cycles

Time-Overcurrent Elements

Pickup Range	
5 A Model:	0.25–16.00 A secondary, 0.01 A steps
1 A Model:	0.05–3.20 A secondary, 0.01 A steps
Accuracy (Steady State)	
5 A Model:	±0.05 A plus ±3% of setting
1 A Model:	±0.01 A plus ±3% of setting

Time-Dial Range	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.05–1.00, 0.01 steps
Curve Timing Accuracy:	±1.50 cycles plus ±4% of curve time (for current between 2 and 30 multiples of pickup)
Reset:	1 power cycle or Electromechanical Reset Emulation time

Harmonic Elements (2nd, 4th, 5th)

Pickup Range:	OFF, 5–100% of fundamental
Pickup Accuracy:	1 A nominal ±5% ±0.02 A 5 A nominal ±5% ±0.10 A
Time-Delay Accuracy:	±0.1% plus ±0.125 cycle

Ground Directional Elements

Neg.-Seq. Directional Impedance Threshold (Z2F, Z2R)

5 A Model:	–64 to 64 Ω secondary
1 A Model:	–320 to 320 Ω secondary

Zero-Seq. Directional Impedance Threshold (Z0F, Z0R)

5 A Model:	–64 to 64 Ω secondary
1 A Model:	–320 to 320 Ω secondary

Supervisory Overcurrent Pickup (50FP, 50RP)

5 A Model:	0.25 to 5.00 A 3I0 secondary 0.25 to 5.00 A 3I2 secondary
1 A Model:	0.05 to 1.00 A 3I0 secondary 0.05 to 1.00 A 3I2 secondary

Directional Power Elements

Pickup Range	
5 A Model:	–20000.00 to 20000 VA, 0.01 VA steps
1 A Model:	–4000.00 to 4000 VA, 0.01 VA steps
Accuracy (Steady State):	±5 VA plus ±3% of setting at nominal frequency and voltage
Time-Delay:	0.00–16000.00 cycles, 0.25 cycle steps
Timer Accuracy:	±0.25 cycle plus ±0.1% of setting

Undervoltage and Overvoltage Elements

Pickup Ranges

300 V Maximum Inputs

Phase Elements:	2–300 V secondary, 0.01 V steps
Phase-to-Phase Elements:	4–520 V secondary, 0.01 V steps

8 V LEA Maximum Inputs

(See *Voltage-Related Settings and LEA Inputs (Group Settings)* on page 14 for information on setting voltage elements when using LEA inputs.)

Phase:	0.05–8.00 V
Phase-to-Phase:	0.10–13.87 V

Accuracy (Steady State)

Phase Elements:	±0.5 V plus ±3% of setting
Sequence Elements:	±0.5 V plus ±5% of setting
Transient Overreach:	< 5% of pickup

Underfrequency and Overfrequency Elements

Pickup Range:	40.01–69.99 Hz, 0.01 Hz steps
Accuracy, Steady State plus Transient:	±0.005 Hz for frequencies between 40.00 and 70.00 Hz
Maximum Pickup/Dropout Time:	3.0 cycles
Time-Delay Range:	0.04–400.0 s, 0.01 s increments
Time-Delay Accuracy:	±0.1% ± 0.0042 s

Pickup Range, Undervoltage Blocking:	20–200 V _{LN} (Wye)
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Pickup Accuracy, Undervoltage Blocking:	±2% ±0.5 V
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Optional RTD Elements (Models Compatible With SEL-2600 Series RTD Module)

12 RTD Inputs via SEL-2600 Series RTD Module and SEL-2800 Fiber-Optic Transceiver

Monitor Ambient or Other Temperatures

PT 100, NI 100, NI 120, and CU 10 RTD-Types Supported, Field Selectable

Pickup Range:	Off, –50 to 250°C, 1°C step
Accuracy:	±2°C

As long as 500 m Fiber-Optic Cable to SEL-2600 Series RTD Module

Breaker Failure Instantaneous Overcurrent

Setting Range

5 A Model:	0.50–50.0 A, 0.01 A steps
1 A Model:	0.10–10.0 A, 0.01 A steps

Accuracy

5 A Model:	±0.05 A plus ±3% of setting
1 A Model:	±0.01 A plus ±3% of setting

Transient Overreach:

< 5% of setting

Maximum Pickup Time:

1.5 cycles

Maximum Reset Time:

1 cycle

Timers Setting Range:

0–6000 cycles, 0.125 cycle steps
(All but BFIDOn, BFISPN)

0–1000 cycles, 0.125 cycle steps
(BFIDOn, BFISPN)

Time-Delay Accuracy:

0.125 cycle plus ±0.1% of setting

Synchronism-Check Elements

Slip Frequency

Pickup Range: 0.005–0.500 Hz, 0.001 Hz steps

Slip Frequency

Pickup Accuracy: ±0.0025 Hz plus ±2% of setting

Close Angle Range:

3–80°, 1° steps

Close Angle Accuracy:

±3° plus ±5% of setting

Load-Encroachment Detection

Setting Range

5 A Model:	0.05–64 Ω secondary, 0.01 Ω steps
1 A Model:	0.25–320 Ω secondary, 0.01 Ω steps
Forward Load Angle:	–90° to +90°
Reverse Load Angle:	+90° to +270°

Accuracy

Impedance Measurement:	±3%
Angle Measurement:	±2°

Timer Specifications

Setting Ranges

Breaker Failure:	0–6000 cycles, 0.125 cycle steps (All but BFIDOn, BFISPN) 0–1000 cycles, 0.125 cycle steps (BFIDOn, BFISPN)
Communications-Assisted Tripping Schemes:	0.000–16000 cycles, 0.125 cycle steps
Pole Open Timer:	0.000–60 cycles, 0.125 cycle steps
Recloser:	1–999999 cycles, 1 cycle steps

Switch-onto-Fault

CLOEND, 52AEND:	OFF, 0.000–16000 cycles, 0.125 cycle steps
SOTFD:	0.500–16000 cycles, 0.125 cycle steps

Synchronism-Check Timers

TCLSBK1, TCLSBK2:	1.00–30.00 cycles, 0.25 cycle steps
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Station DC Battery System Monitor Specifications

Operating Range:	0–350 Vdc
Input Sampling Rate:	DC1: 2 kHz DC2: 1 kHz
Processing Rate:	1/8 cycle
Maximum Operating Time:	≤ 1.5 cycles
Setting Range	
DC Settings:	15–300 Vdc, 1 Vdc steps
AC Ripple Setting:	1–300 Vac, 1 Vac steps
Accuracy	
Pickup Accuracy:	±3% plus ±2 Vdc (all elements but DC1RP and DC2RP) ±10% plus ±2 Vac (DC1RP and DC2RP)

Metering Accuracy

All metering accuracy is at 20°C, and nominal frequency unless otherwise noted.

Currents**Phase Current Magnitude**

5 A Model:	±0.2% plus ±4 mA (2.5–15 A sec)
1 A Model:	±0.2% plus ±0.8 mA (0.5–3 A sec)

Phase Current Angle

All Models:	±0.2° in the current range $0.5 \cdot I_{NOM}$ to $3.0 \cdot I_{NOM}$
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Sequence Currents Magnitude

5 A Model:	±0.3% plus ±4 mA (2.5–15 A sec)
1 A Model:	±0.3% plus ±0.8 mA (0.5–3 A sec)

Sequence Current Angle

All Models:	±0.3° in the current range $0.5 \cdot I_{NOM}$ to $3.0 \cdot I_{NOM}$
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Voltages**300 V Maximum Inputs**

Phase and Phase-to-Phase Voltage Magnitude:	±2.5% ±1 V (5–33.5 V) ±0.1% (33.5–300 V)
Phase and Phase-to-Phase Angle:	±1.0° (5–33.5 V) ±0.5° (33.5–300 V)
Sequence Voltage Magnitude (V1, V2, 3V0):	±2.5%, ±1 V (5–33.5 V) ±0.1% (33.5–300 V)
Sequence Voltage Angle (V1, V2, 3V0):	±1.0° (5–33.5 V) ±0.5° (33.5–300 V)

8 V LEA Maximum Inputs

Phase and Phase-to-Phase Voltage Magnitude:	±0.3% (0.2–0.6 V) ±0.1% (0.6–8.0 V)
Phase and Phase-to-Phase Angle:	±0.5° (0.2–8.0 V)
Sequence Voltage Magnitude (V1, V2, 3V0):	±0.3% (0.2–0.6 V) ±0.1% (0.6–8.0 V)
Sequence Voltage Angle (V1, V2, 3V0):	±0.5° (0.2–8.0 V)

Frequency (Input 40–65 Hz)

Accuracy:	±0.01 Hz
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Power**MW (P), Per Phase (Wye), 3φ (Wye or Delta) Per Terminal**

±1% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (1φ)
±0.7% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (3φ)

MVA (Q), Per Phase (Wye), 3φ (Wye or Delta) Per Terminal

±1% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 0, 0.5 lead, lag (1φ)
±0.7% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 0, 0.5 lead, lag (3φ)

MVA (S), Per Phase (Wye), 3φ (Wye or Delta) Per Terminal

±1% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (1φ)
±0.7% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (3φ)

PF, Per Phase (Wye), 3φ (Wye or Delta) Per Terminal

±1% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (1φ)
±0.7% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (3φ)

Energy**MWh (P), Per Phase (Wye), 3φ (Wye or Delta)**

±1% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (1φ)
±0.7% (0.1–1.2) • I_{NOM} , 33.5–300 Vac, PF = 1, 0.5 lead, lag (3φ)

Synchrophasors**Number of Synchrophasor**

Data Streams:	5
---------------	---

Number of Synchrophasors for Each Stream:

15 Phase Synchrophasors (6 Voltage and 9 Currents)
5 Positive-Sequence Synchrophasors (2 Voltage and 3 currents)

Number of User Analogs for

Each Stream:	16 (any analog quantity)
--------------	--------------------------

Number of User Digitals for

Each Stream:	64 (any Relay Word bit)
--------------	-------------------------

Synchrophasor Protocol:

IEEE C37.118, SEL Fast Message (Legacy)
--

Synchrophasor Data Rate:

As many as 60 messages per second

Synchrophasor Accuracy

Voltage Accuracy:	±1% Total Vector Error (TVE) Range 30–150 V, $f_{NOM} \pm 5$ Hz
Current Accuracy:	±1% Total Vector Error (TVE) Range (0.1–2.0) • I_{NOM} A, $f_{NOM} \pm 5$ Hz

Synchrophasor Data

Recording:	Records as much as 120 s IEEE C37.232, File Naming Convention
------------	--

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SEL SEL-587Z High-Impedance Differential Relay

Bus or Transformer Protection



The SEL-587Z Relay is a flexible high-impedance differential relay that combines time-proven high-impedance analog technology with the advantages of microprocessor technology. Designed primarily as high-impedance bus protection, the relay is also suitable for restricted earth fault applications on transformers with grounded-wye windings. Use the independent overcurrent elements to complement the high-impedance differential elements.

Major Features and Benefits

- **Protection.** Use high-impedance differential elements for fast tripping for in-zone faults, while providing security during heavy through faults and CT saturation. Use familiar high-impedance equations to calculate the voltage-based differential element settings. Save time, money, and panel space because the relay includes the resistors and MOVs required for high-impedance differential protection.
- **Reporting, Monitoring, and Metering.** Simplify fault analysis with event reports and the Sequential Events Recorder. Use a low-set voltage differential element as a CT open-circuit detection function. Validate CT connections by using the metered voltage differential quantities. Interrogate the relay for instantaneous measurements of phase and demand current in transformer applications.
- **Automation, Integration, and Communications.** Use the front- and rear-panel communications ports for system integration, relay settings, and event report retrieval. Modbus RTU, SEL ASCII, and SEL Fast Message protocols are included as standard features of the relay. Use front-panel pushbuttons to save the expense of separately mounted control switches. Use serial port communications for remote control of circuit breakers or other programmable functions.
- **Relay and Logic Settings Software.** ACSELERATOR QuickSet® SEL-5030 Software reduces engineering costs for relay settings and logic programming. The built-in HMI and Control screens provide intuitive displays that help support commissioning and troubleshooting.

Functional Overview

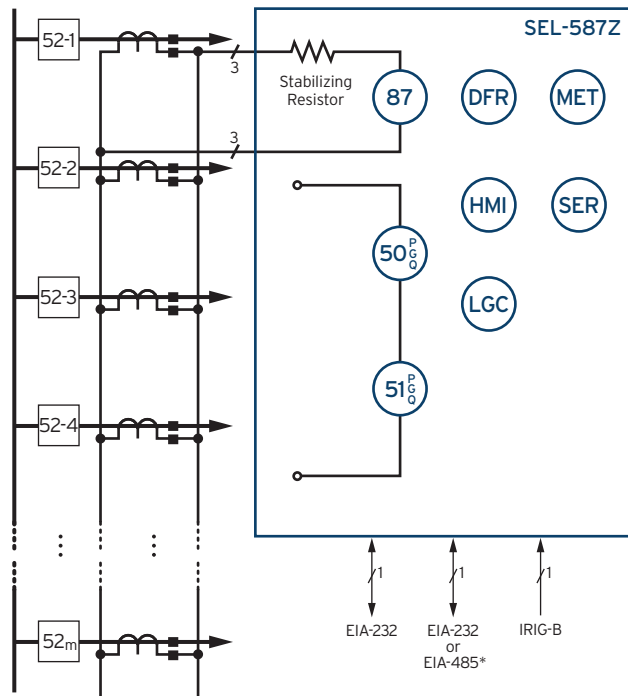


Figure 1 Functional Diagram

ANSI NUMBERS/ACRONYMS AND FUNCTIONS

50 (P, G, Q)	Overcurrent (Phase, Ground, Neg. Seq.)
51 (P, G, Q)	Time-Overcurrent (Phase, Ground, Neg. Seq.)
87	Three-Phase High-Impedance Differential Elements
DFR	Event Reports
LGC	SELogIC Control Equations
HMI	Operator Interface
MET	High-Accuracy Metering
SER	Sequential Events Recorder

* Optional Feature

Protection

Differential Protection

Differential protection is one of the most economical and reliable protection principles available for buses, transformers, and reactors. CT saturation is the most critical design consideration.

Figure 2 shows a through fault, with the direction of current flow in Feeders 1–4 towards the busbar. The sum of the fault current from Feeders 1–4 flows through the CT on Feeder 5, which can result in CT5 saturating.

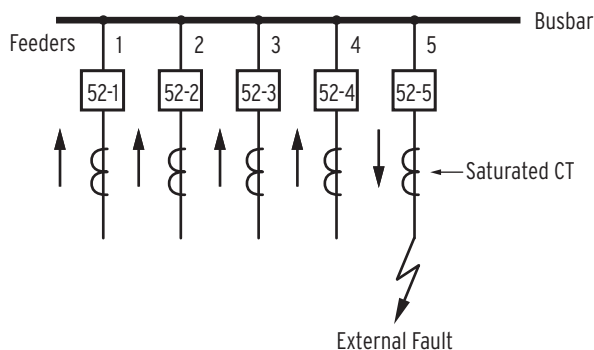


Figure 2 CT Saturation Resulting From a Through Fault

High-impedance differential protection offers immunity against relay misoperation resulting from CT saturation, provided the stabilizing resistor in the circuit has a sufficiently high value. To comply with this requirement, the SEL-587Z uses 2000-ohm resistors, large enough to provide security against CT saturation for through faults. Figure 3 shows typical connections of the lockout contact (86), differential element (87Z), and MOV.

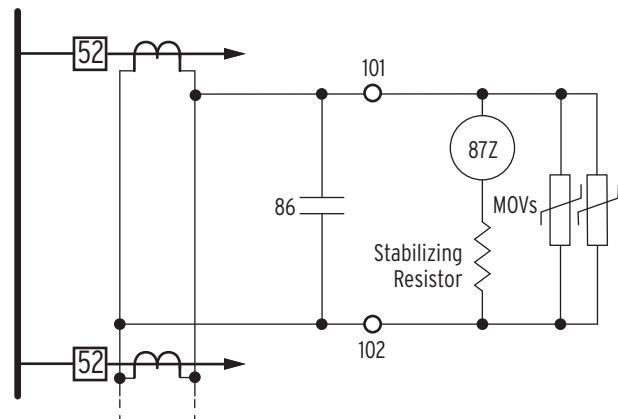


Figure 3 Typical Circuit Connection for High-Impedance Differential Protection

During bus faults, the voltage across the stabilizing resistor can rise to very high values if not limited, as illustrated in *Figure 4*.

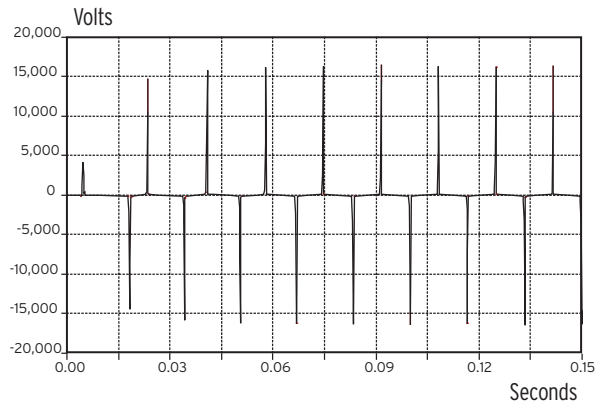


Figure 4 Voltage Without MOV Clamping

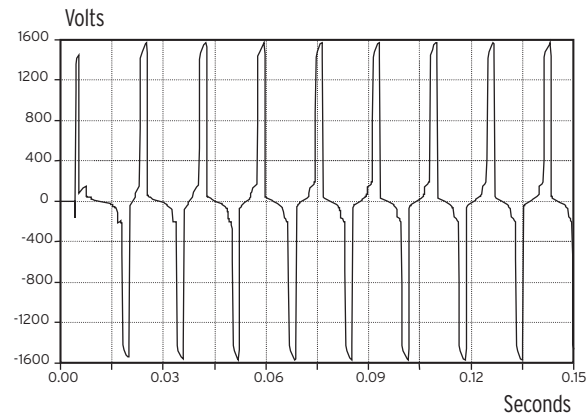


Figure 5 Voltage With MOV Clamping

Figure 5 shows the resultant voltage with a metal oxide varistor (MOV) connected in parallel with the high-impedance elements, clamping the secondary peak voltage to less than 2 kV. The 2000-ohm resistors, combined with suitable MOVs, form the high-impedance input circuit of each phase. For the best performance, select current transformers with fully distributed windings and identical ratio and saturation characteristics.

Bus Protection

Designing bus protection means, as with all protection systems, finding a balance between security and dependability. In a single-zone application, the busbar is the common connection point of all the feeders in the substation. Incorrect bus protection operation affects all the feeders connected to that zone that, at smaller substations, affects each and every customer. Failure of bus protection to operate affects even more customers, because remote protection at adjacent stations must now clear the fault. In addition, high-impedance transformer

grounding practices limit the ground-fault current, necessitating sensitive, phase-segregated protection elements. However, while the ground-fault current is limited, the phase-to-phase current can still be very high, which could result in CT saturation for through faults. The SEL-587Z has three sensitive, independent high-impedance elements, each with two setting levels, providing fast and reliable differential protection.

Transformer Protection

The three independent high-impedance elements are ideal for sensitive restricted earth fault protection on transformers with grounded-wye windings. If both HV and LV windings are wye-connected and grounded, use two high-impedance elements, one on each side of the transformer. Restricted earth fault (REF) protection is not affected by unbalanced load and very seldom by CT saturation for through faults. Although very sensitive, restricted earth fault protection protects only against phase-to-ground faults. To protect against phase-to-phase faults and external phase-to-ground bushing faults, combine the high-impedance elements with instantaneous and time-overcurrent elements. For complete transformer protection that includes percentage differential elements, use the SEL-587 Relay or the SEL-387 Relay with the SEL-587Z.

Overcurrent Protection

The SEL-587Z features overcurrent elements that include maximum-phase, two levels of phase-specific elements, and two levels of negative-sequence and residual overcurrent elements. The relay has six time-overcurrent elements: a maximum-phase element, three phase-specific elements, a negative-sequence element, and a residual element. The overcurrent and high-impedance differential elements are independent and can protect separate equipment.

When you use the SEL-587Z for transformer protection, the instantaneous overcurrent elements provide phase and ground overcurrent protection for bushing faults, while the time-overcurrent elements provide phase and ground protection for coordination with other system protection.

Table 1 Overcurrent Elements Available in the SEL-587Z

Element	Instantaneous	Time-Overcurrent
Maximum-phase	3	1
Phase-specific	6	3
Negative-sequence	2	1
Zero-sequence	2	1

Table 2 Inverse Time-Overcurrent Curves Available in the SEL-587Z

US	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)

Table 2 lists the time-overcurrent curves available in the relay. Each curve has two choices for the reset characteristic. One choice resets the elements if the current drops below pickup for at least one cycle. The other choice causes the relay to emulate the reset characteristic of an electromechanical induction disk relay.

Reporting, Monitoring, and Metering

Event report and Sequential Event Report (SER) features simplify post-fault analysis and improve understanding of simple and complex protection scheme operations. These features also aid in testing and troubleshooting relay settings and protection schemes.

Event Reports

In response to a programmable trigger, the present element status information is recorded in each event report, confirming relay, scheme, and system performance for every fault. A total of 10 events are stored in nonvolatile memory. Decide how much detail you want when you request an event report. You can choose to display a standard event report with 15 cycles of the analog high-impedance differential elements and overcurrent elements, selected Relay Word bits, the inputs and outputs, and the relay settings at 1/4-cycle or 1/8-cycle data resolution.

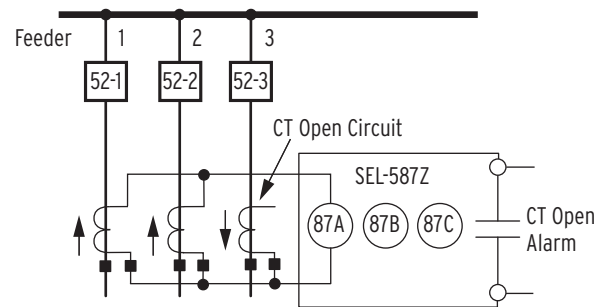
Use event report information in conjunction with the SEL-5601-2 SYNCHROWAVE® Event Software to produce oscillographic type reports suitable for inclusion in analysis documents and reports.

Sequential Events Recorder (SER)

The relay SER stores the latest 512 entries in nonvolatile memory. Use this feature to gain a broad perspective of relay element operation. Events that trigger an SER entry include: input/output change of state and element pickup/dropout. Each entry includes the date, time, differential and current magnitudes, and logic variables. On each processing interval, the relay examines the Relay Word for changes of state in any of the Relay Word elements declared in the SER1, SER2, and SER3 settings. Upon detecting a change of state, the relay adds a row to the SER report. The relay stores the SER report in nonvolatile memory to retain information if a power failure occurs before you can examine the events.

Monitoring

The high-impedance element has two setting levels. By the nature of the high-impedance application, the relay measures only the out-of-balance quantity of the parallel-connected CTs. Detect an open-circuit CT by setting one level to a low value as compared to an out-of-zone fault, and direct the output to an alarm function, as shown in Figure 6. For example, to detect a 40 mA secondary current, set the element to $0.04 \cdot 2000 = 80$ V. Other relay monitoring includes self-tests to continuously track crucial relay subsystems such as RAM, critical RAM, ROM, and EEPROM tests.

**Figure 6 Detecting an Open CT (A-Phase)**

Metering

The SEL-587Z provides three types of metering functions typically used in transformer protection schemes as illustrated in Figure 14. The metering functions are: instantaneous, demand, and peak demand. Metered quantities shown in Table 3 include differential voltages, negative-sequence currents, and zero-sequence (residual) currents.

Use the meter function to detect incorrect CT wiring during testing and installation. Figure 7 is an example of the metering output for the case shown in Figure 6. Differential elements 87B and 87C have values close to zero, but the A element has a value of 73 volts, indicating incorrect CT polarity, ratio, or wiring.

Table 3 Metering Capabilities

Quantities	Description
Voltages 87A, 87B, 87C	Voltage from each differential element
Currents IA, IB, IC, IG (3I ₀), 3I2	Magnitudes and angles for each phase and sequence current
Demand Current IA, IB, IC, IG (3I ₀), 3I2	Magnitudes of each phase and sequence current
Peak demand IA, IB, IC, IG (3I ₀), 3I2	Magnitudes of each phase and sequence current

>> MET <Enter>					
North Busbar		Date: 04/14/01		Time: 17:36:02:616	
Apollo Station					
	87A	87B	87C		
V MAG (V)	73	0.5	0.2		
	IA	IB	IC	IG	312
I MAG (A)	0.1	0.0	0.0	0.01	0.01
I ANG (DEG)	0.01	-119.23	121.12	0.11	0.10

Figure 7 METER Report for an Open CT (A-Phase)

Relay and Logic Settings Software

QuickSet uses the Microsoft Windows operating system to simplify settings and provide analysis support for the SEL-587Z. One can, for instance, open an QuickSet Control screen for intuitive control functions similar to those shown in *Figure 8*.

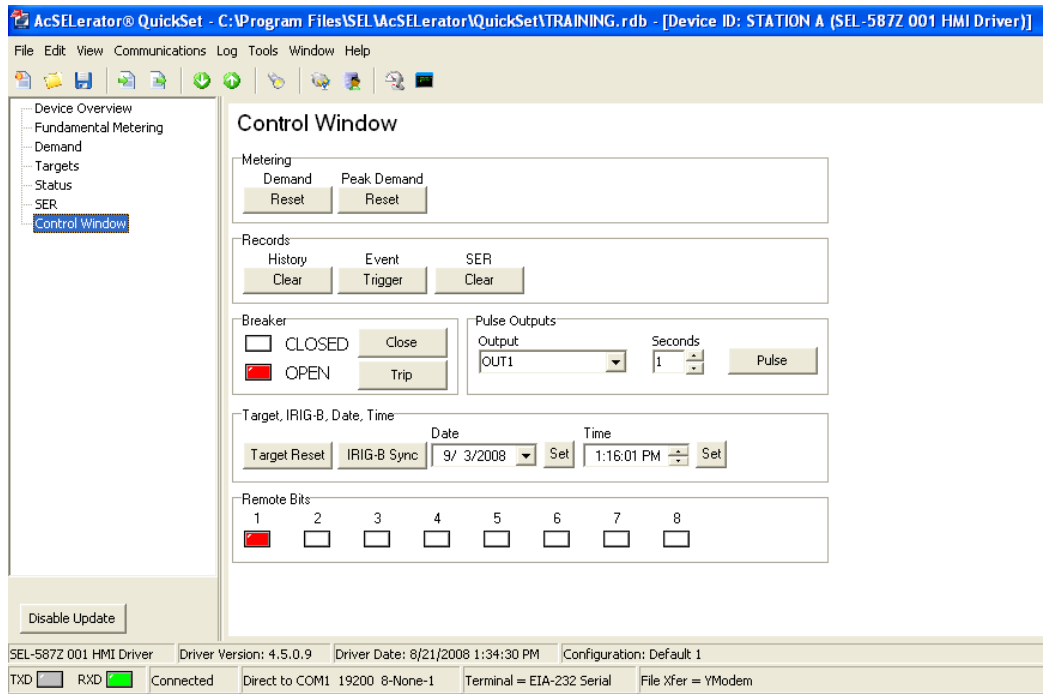


Figure 8 QuickSet Screen Showing SEL-587Z Control Functions

- Use QuickSet to create and manage relay settings:
- Develop settings offline with an intelligent settings editor that only allows valid settings
 - Use online help to assist with configuration of proper settings
 - Organize settings with the relay database manager
 - Load and retrieve settings through use of a simple PC communications link
- Use QuickSet to verify settings and analyze events:
- Analyze power system events with integrated waveform and harmonic analysis tools

- Use QuickSet to aid with monitoring, commissioning, and testing the SEL-587Z:
- Use the HMI to monitor current and voltage information during testing
 - Use the PC interface to remotely obtain power system data
 - Control local and remote bits from the QuickSet control window
 - View the status of all Relay Word bits at once in the Targets display window

Automation, Integration, and Communication

Table 4 Communications Protocols

Type	Description
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	Binary protocol for machine-to-machine communication. Quickly updates SEL-2032/SEL-2030/SEL-2020 Communications Processors, RTUs, and other substation devices with metering information, relay element, 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 to prevent loss of control operator metering information while a technician is 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.
Modbus RTU	Use this protocol to communicate with PLC, HMI, and SCADA systems.

Serial Communication

The SEL-587Z has two independently operated EIA-232 ports: one on the front and a ground-isolated port on the rear of the relay. The rear port can be an EIA-485 port but must be so specified at ordering. The relay needs no special communications software. Use any system that emulates a standard terminal system. Establish communication by connecting computers, modems, protocol converters, printers, an SEL-2032, SEL-2030, or SEL-2020 Communications Processor, SCADA serial port, and/or RTU for local or remote communication. See *Table 4* for a list of available communications protocols.

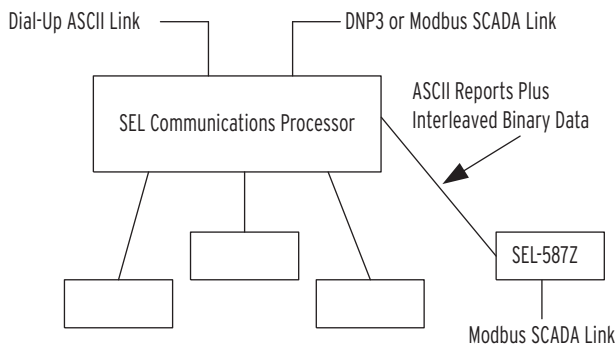


Figure 9 Example Communications System

SEL communications processors often form hubs of star networks, with point-to-point fiber or copper connection between the hub and the SEL-587Z. The communications processor supports external communications links including the public switched

telephone network for engineering access to dial-out alerts and private line connections to your SCADA system.

IRIG-B

The demodulated IRIG-B time-code input synchronizes the SEL-587Z time to within ± 5 ms of the time-source input. SEL-2032, SEL-2030, or SEL-2020 Communications Processors provide convenient sources for this time code.

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Contact your SEL representative for more information on cable availability.

Control Logic and Integration

Use built-in control logic and integration features in the SEL-587Z to economically combine common substation operations. This includes eliminating wiring and replacing traditional panel switches and indicators.

Replace Traditional Panel Control Switches

Eliminate traditional panel control switches with eight 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 perform functions such as a trip test or a breaker trip/close. *Figure 10* shows that you can configure local control switches for ON, OFF, and MOMENTARY functions.

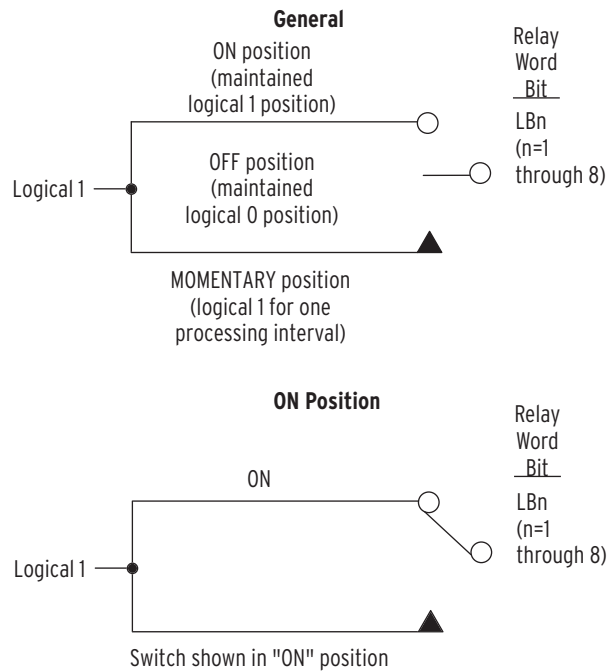


Figure 10 Local Control Switches

Eliminate RTU-to-Relay Wiring

Eliminate RTU-to-relay wiring with eight 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 such as trip, close, and settings group selection. Switch operations are identical as for local switches.

Replace Traditional Indicating Panel Lights

Replace traditional indicating panel lights with eight programmable displays. Define custom messages (e.g., Breaker Open, Breaker Closed) to report power system or relay conditions on the front-panel display.

SELogIC Control Equations

USE SELOGIC control equations to assign relay outputs to any logical combination of relay elements or inputs.

Program SELOGIC control equations by combining relay elements, inputs, and outputs with SELOGIC control equation operators. The state of all logical elements in the relay is reflected by bits from a "Relay Word" table. These logical elements include all current (50/51) and level-detecting elements, timer elements, SELOGIC control equation variables, inputs, outputs, and remote and local bits. You can use any element including input/output, differential, and overcurrent variables in these equations.

SELOGIC control equation operators include OR, AND, invert, and parentheses.

The basic building blocks of SELOGIC control equations are the Relay Word bits. The Relay Word bits are simple digital quantities having a value of either logical 0 or logical 1. The terms "assert" or "asserted" refer to a Relay Word bit that has a value of logical 1 or is changing from logical 0 to logical 1. The terms "deassert" or "deasserted" refer to a Relay Word bit that has a value of logical 0 or is changing from logical 1 to logical 0. Various relay elements assert or deassert Relay Word bits, which the relay uses in fixed internal logic to make decisions, interpret inputs, or drive outputs. You can access these same bits to flexibly define inputs or outputs, specify control variables for internal logic, or create special customized logic by using SELOGIC control equations.

In addition to Boolean logic, ten 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 current element). Assign the timer output to trip logic, event report triggering, or other control scheme logic.

Figure 11 depicts an example breaker failure circuit, configured with relay elements and stored in nonvolatile memory.

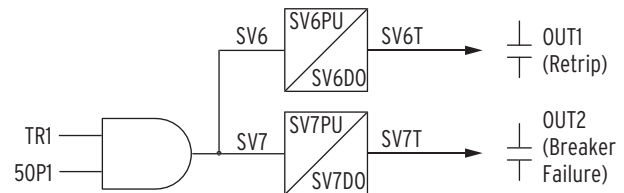


Figure 11 Dedicated Breaker Fail Scheme Created With SELogIC Control Equation Variables/Timers

The following four lines show the SELOGIC control equations to create the breaker fail circuit:

```
SV6 = 50P1*TR1
SV7 = 50P1*TR1
OUT1 = SV6T (retrip)
OUT2 = SV7T (breaker failure trip)
```

Additional Features

Front-Panel Display

The LCD shows event, metering, setting, and relay self-test status information. Use the eight multifunction push-buttons to control this display, showing the messages the relay generates and programmable Display Points. The default display scrolls through any active, nonblank Display Points. Each display remains for two seconds, before scrolling continues. Any message the relay generates because of an alarm condition takes precedence over

the normal default display. Error messages such as a self-test failure appear on the LCD in place of the default display. The {EXIT} pushbutton returns the display to the default display when the relay is displaying some other front-panel function.

When the relay turns on, the LCD scrolls through the current and voltage element displays until the relay is again enabled. When the EN LED indicates the relay is enabled, the LCD scrolls through active Display Points and metering screens.

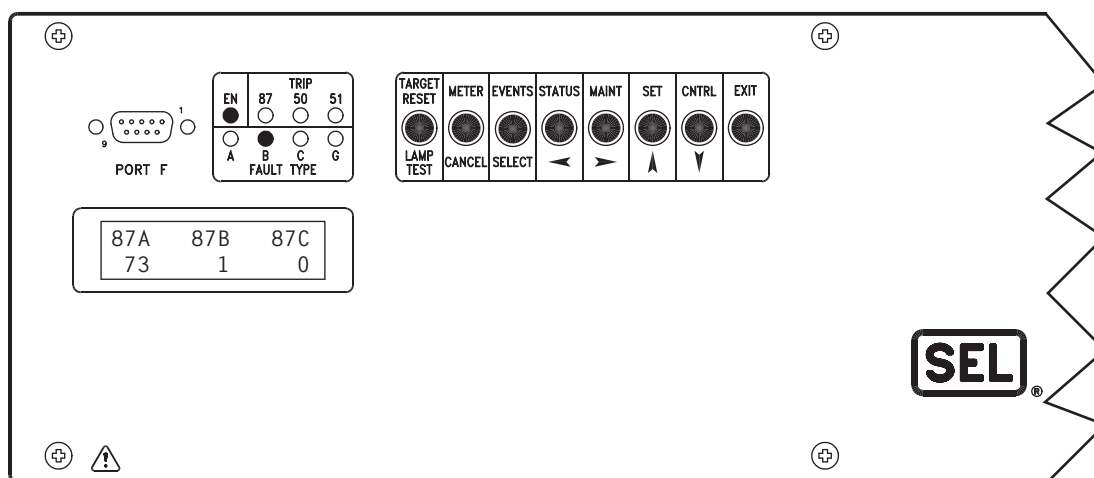


Figure 12 Front-Panel Display

Status and Trip Target LEDs

The SEL-587Z includes eight status and trip target LEDs on the front panel. These targets are shown in *Figure 12* and explained in *Table 5*. The target LEDs indicate conditions that the relay has detected on the power system and how the relay has reacted. Nonvolatile memory stores the states of all eight LEDs. If the relay loses power, the targets will resume their last state when power returns.

Use the SEL ASCII **TAR *n*** command (*n* = row number) to assign relay variables to the LEDs during testing. This provides a visual indication of the status of more than 100 variables in the relay. Local Bit (LB) variables, the equivalent of panel switches, are stored in Row 7 in the relay. For example, assume LB1 and LB6 are asserted. Entering **TAR 7** results in the LED display shown in *Figure 12*.

Table 5 Description of Target LEDs

Target LED	Function
EN	Relay powered up properly, self-tests okay
87	Either Level 1 or Level 2 of the three differential elements asserted
50	Any one of the 13 instantaneous overcurrent elements asserted
51	Any one of the six time-overcurrent elements asserted
A	A-phase overcurrent, time-overcurrent, or differential asserted
B	B-phase overcurrent, time-overcurrent, or differential asserted
C	C-phase overcurrent, time-overcurrent, or differential asserted
G	Any of the three ground elements asserted

Application Examples

Bus Protection

Figure 13 illustrates a typical single-zone, high-impedance bus protection installation. The CTs must have identical ratios and saturation characteristics (C-ratings). Configure the second level of the high-impedance element to an alarm function with a low setting to report on CT open-circuit conditions. Advance warning of an open-circuit CT gives maintenance personnel time to take corrective action that may prevent severe damage to the CT and nearby primary equipment.

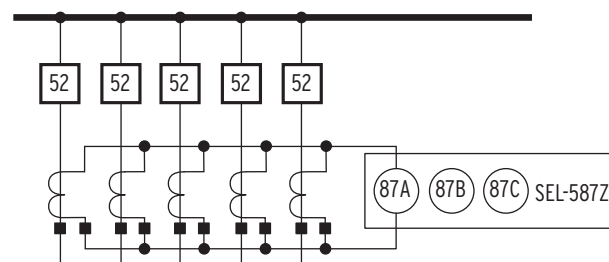


Figure 13 Example Bus Protection (One Phase Shown Connected)

Transformer Protection

Combine the overcurrent elements with the high-impedance differential elements to provide protection for smaller, wye-connected and grounded transformers; see *Figure 14*. The REF CTs must have identical ratios and saturation characteristics.

When you use the SEL-587Z for transformer protection, use the overcurrent elements to provide instantaneous phase and ground overcurrent protection for bushing faults. These elements provide phase and ground time-overcurrent protection for coordination with other system protection.

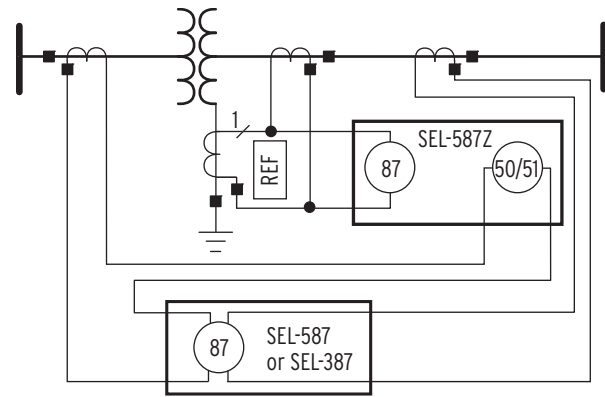


Figure 14 Transformer With Grounded-Wye Connected Winding

Wiring Diagrams

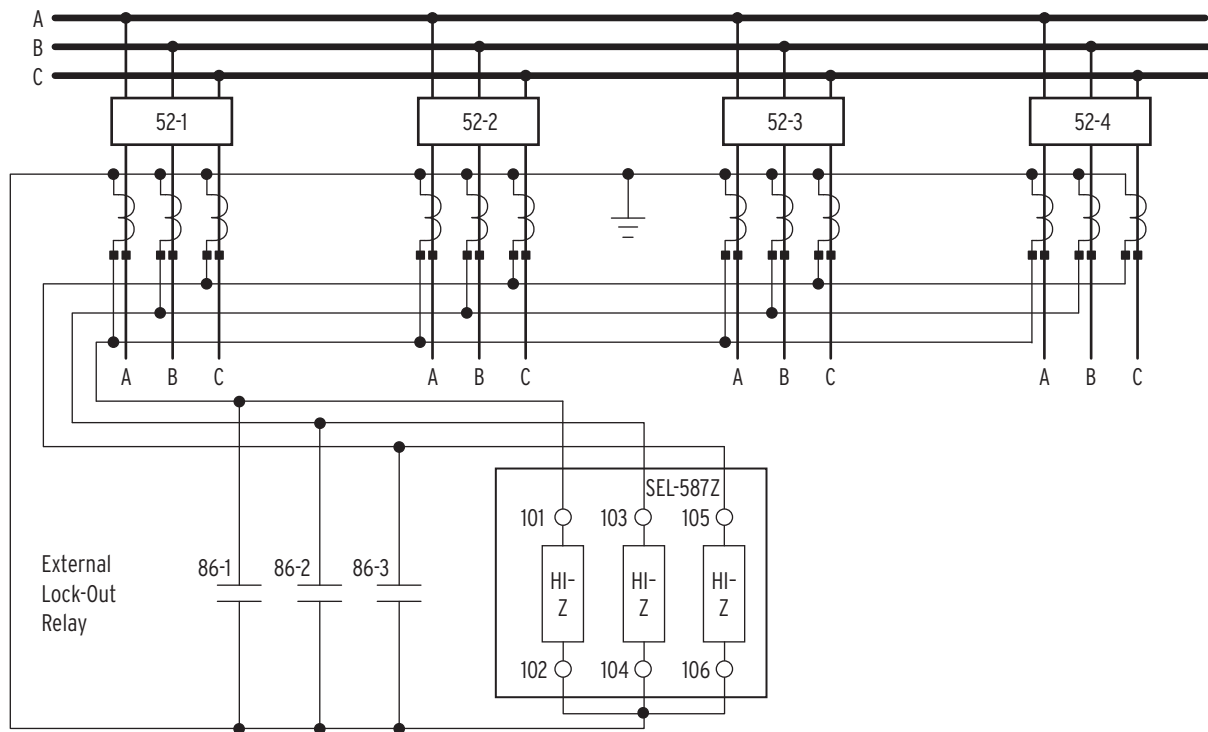


Figure 15 Example AC Connection

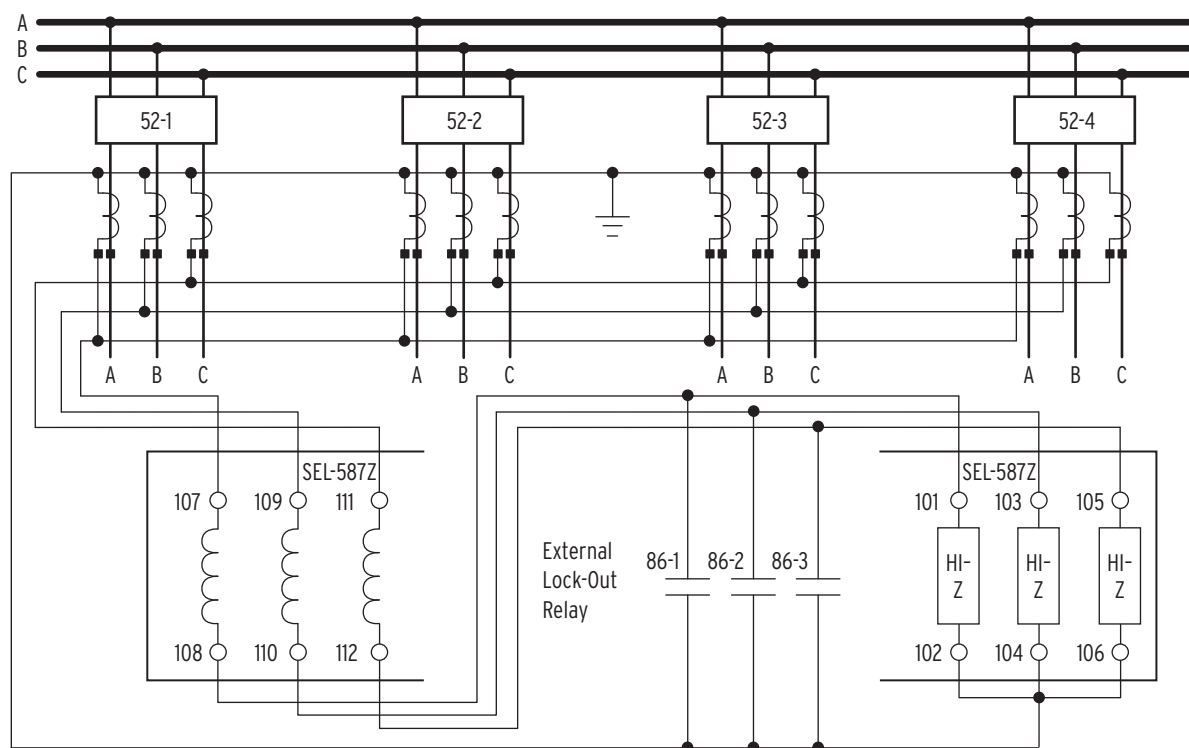


Figure 16 Example AC Connection With 50/51 Overcurrent Element

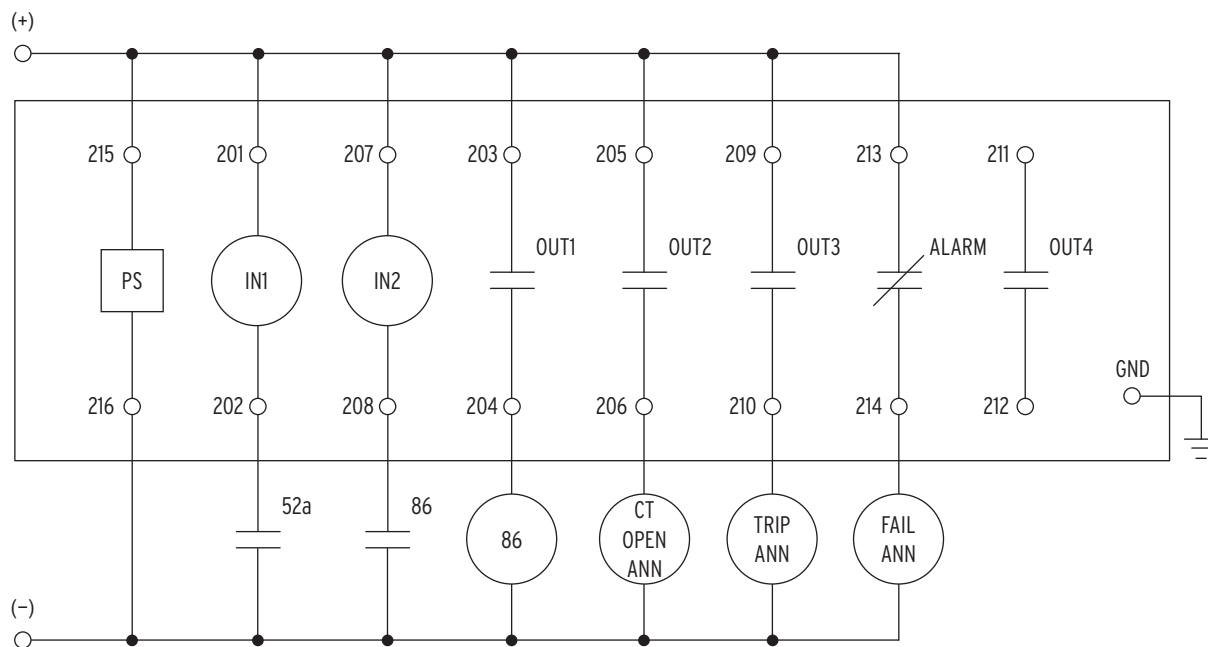
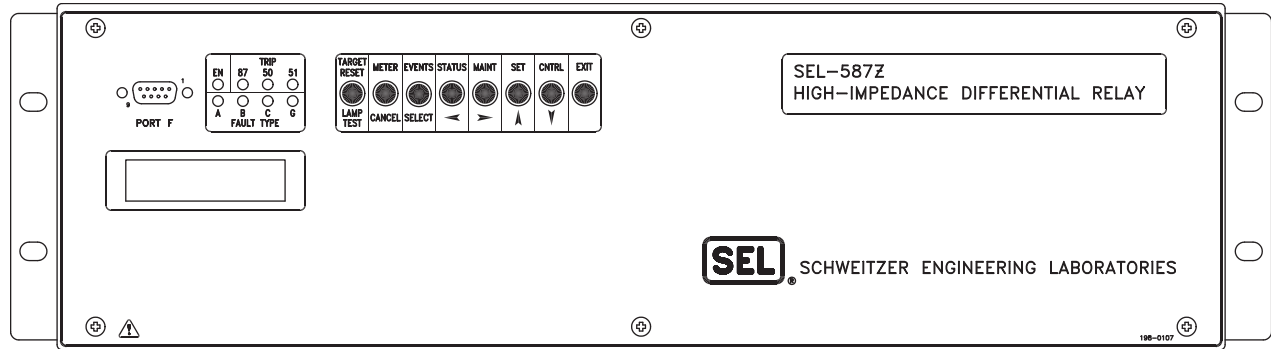


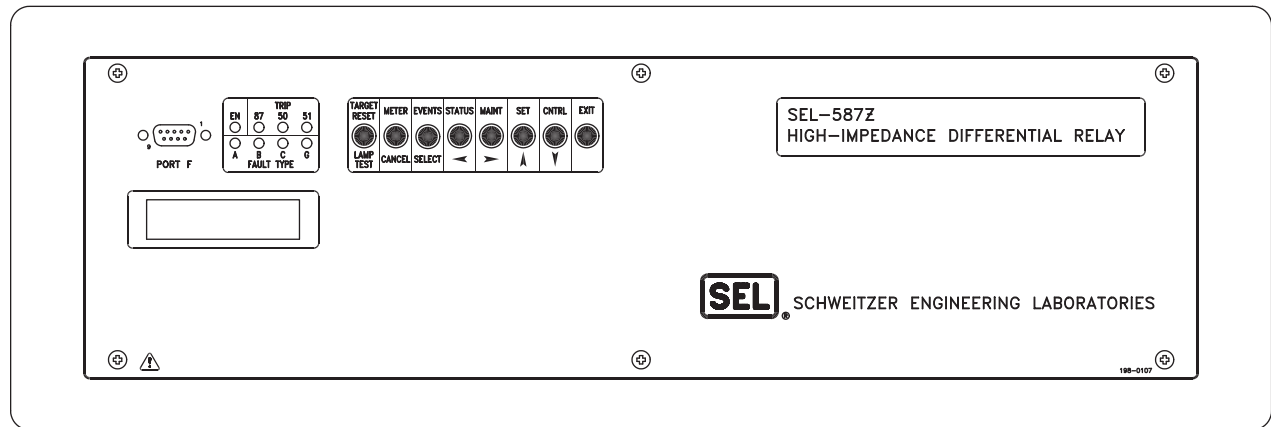
Figure 17 Example DC Connection

Front- and Rear-Panel Diagrams



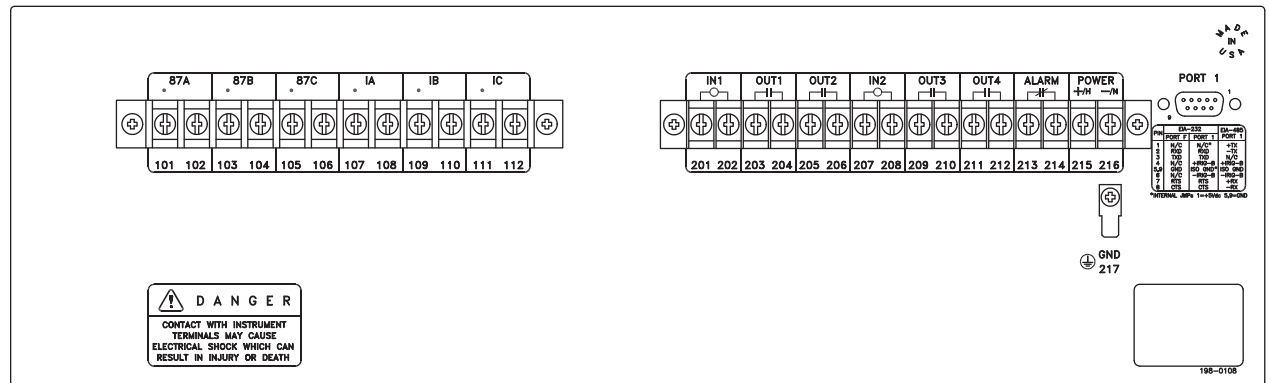
I3483b

Figure 18 Front-Panel Diagram, Rack-Mount Option



I3481b

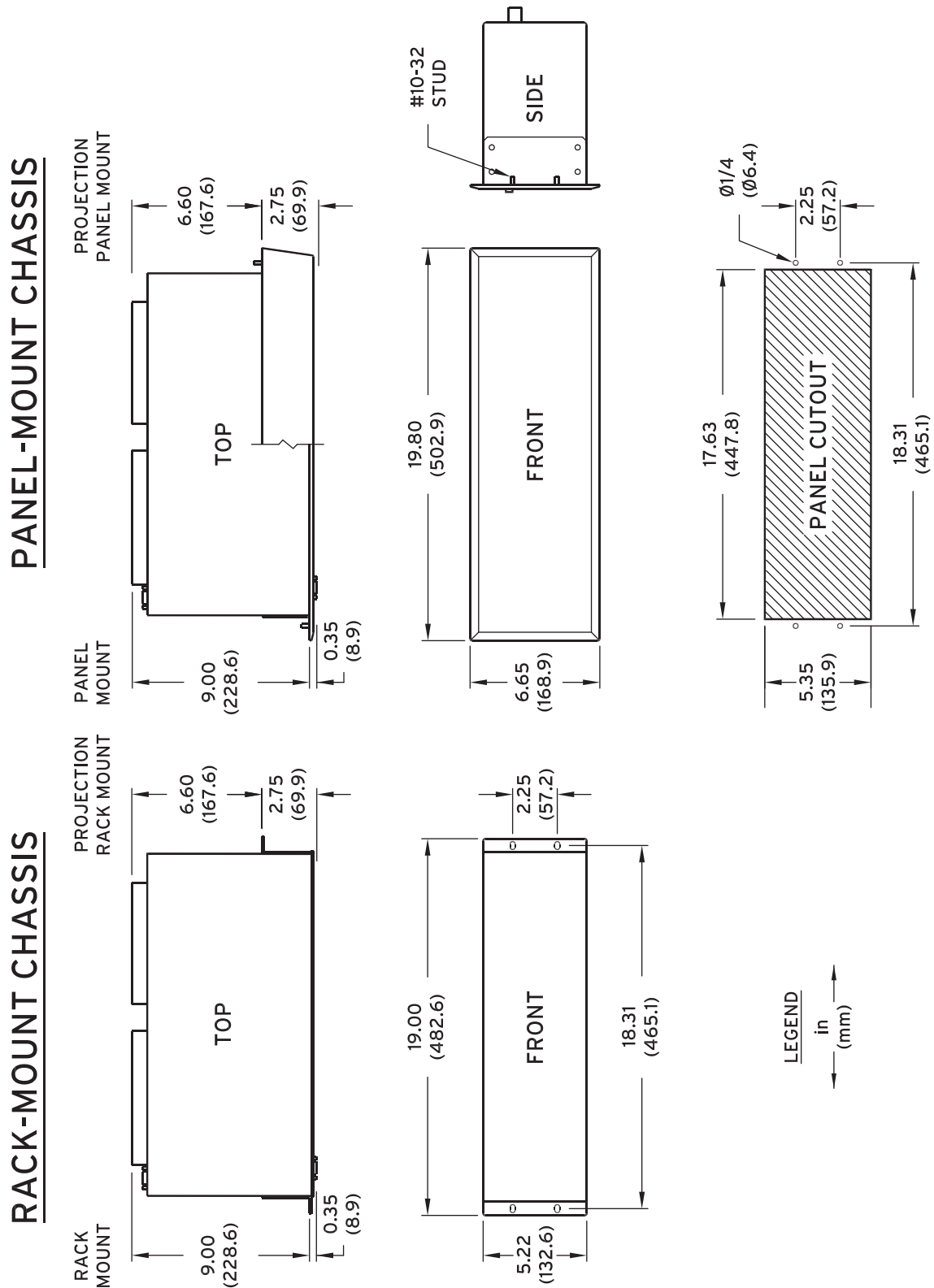
Figure 19 Front-Panel Diagram, Panel-Mount Option



I3482b

Figure 20 Rear-Panel Diagram

Relay Dimensions



i9029c

Figure 21 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

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.

General

Terminal Connections

Rear Screw-Terminal Tightening Torque

Minimum: 1.1 Nm (9 in-lb)

Maximum: 1.3 Nm (12 in-lb)

Terminals or stranded copper wire. Ring terminals are recommended. Minimum wire temperature rating of 90°C at 70°C ambient.

High-Impedance Inputs (87A, 87B, 87C)

200 V nominal: 150 V continuous, linear to 3000 V symmetrical

Burden: 2000 Ω stabilizing resistance

Range: 20–800 V

Metal-oxide varistor clamping voltage: One or two MOV option:
2100 V (8 x 20 μ s)
Four MOV Option:
1500 V (8 x 20 μ s)

Metal-oxide varistor maximum transient energy rating: One MOV–2500 J
Two MOV–5000 J
Four MOV–8400 J

Metal-oxide varistor maximum continuous ac voltage rating: One MOV–750 V
Two MOV–750 V
Four MOV–600 V

AC Current Inputs (IA, IB, IC)

5 A nominal: 15 A continuous, 500 A for 1 s, 625 A for 1 cycle (sinusoidal waveform), linear to 100 A symmetrical

Burden: <0.16 VA @ 5 A, <1.15 VA @ 15 A

Range: 0.5–80 A

1 A nominal: 3 A continuous, 100 A for 1 s, 250 A for 1 cycle (sinusoidal waveform), linear to 20 A symmetrical

Burden: <0.06 VA @ 1 A, <0.18 VA @ 3 A

Range: 0.1–16 A

Note: Use a minimum of C200 CTs or better for high-impedance bus differential applications.

Frequency and Phase Rotation

System Frequency: 50 or 60 Hz

Phase Rotation: ABC or ACB rotation

Power Supply

125/250 V

Range: 85–350 Vdc or 85–264 Vac

Interruption: 100 ms @ 250 Vdc

Ripple: 5%

Burden: <5.5 W, <23 VA

48/125 V

Range: 36–200 Vdc or 85–140 Vac

Interruption: 100 ms @ 125 Vdc

Ripple: 5%

Burden: <5.5 W, <16 VA

24 Vdc

Range: 16–36 Vdc polarity-dependent

Interruption: 25 ms @ 36 Vdc

Ripple: 5%

Burden: <5.5 W

Note: Interruption and Ripple per IEC 60255-26:2013.

Output Contacts

Note: IEEE C37.90-2005 and IEC 60255-27:2013

Standard Outputs (5 contacts, including the alarm contact):

Make (Short Duration Contact Current): 30 Adc
1000 operations @ 250 Vdc
2000 operations @ 125 Vdc

Limited Making Capacity: 1000 W @ 250 Vdc (L/R = 40 ms)

Mechanical Endurance: 10000 operations

Rated Voltage: 24–250 Vdc

Operational Voltage Range: 0–300 Vdc

Operating Time: Pickup \leq 6 ms (resistive load)
Dropout \leq 6 ms (resistive load)

Short Time Thermal Withstand: 50 A for 1 second

Continuous Contact Current: 6 A @ 70°C
4 A @ 85°C

Contact Protection: MOV protection across open contacts
300 Vdc continuous voltage
40 J

Limiting Breaking Capacity/Endurance: 10000 operations
10 operations in 4 seconds, followed by 2 minutes idle

Rated Voltage	Resistive Break	Inductive Break L/R = 40 ms (DC)
24 Vdc	0.75 Adc	0.75 Adc
48 Vdc	0.63 Adc	0.63 Adc
125 Vdc	0.3 Adc	0.3 Adc
250 Vdc	0.2 Adc	0.2 Adc

Optoisolated Inputs

Standard Inputs (2 inputs, Control Voltage Jumpers):

24 Vdc:	pickup 15–30 Vdc
48 Vdc:	pickup 30–60 Vdc
125 Vdc:	pickup 80–150 Vdc
250 Vdc:	pickup 150–300 Vdc

Note: Optoisolated inputs draw approximately 4 mA of current. All current ratings are at nominal input voltages.

Communications Ports

Front Port:	EIA-232
Rear Port (Ground Isolated):	EIA-232* or EIA-485* (*order option)
Baud:	300–38400 bps

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at rear-panel port.

Humidity

5% to 95% without condensation

Altitude

2000 m (6560 feet) AMSL

Operating Temperature

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20°C and above +70°C.

Weight

4.1 kg (9.01 lb)

Routine Dielectric Strength Tests (performed on each manufactured relay)

AC current inputs, optoisolated inputs, and output contacts:	2500 Vac for 10 s
Power supply:	3100 Vdc for 10 s

Type Tests

Product Family Standard(s)

IEC 60255-26:2013

Electromagnetic Compatibility Emissions (EMC)

Conducted Emissions:	FCC 15.107, Class A
Radiated Emissions:	CISPR 22:2008, Class A CISPR 11:2010, Class A FCC 15.109:2014, Class A

Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-26:2013, Section 7.2.8 IEC 61000-4-6:2013 10 Vrms
Electrostatic Discharge Immunity:	IEC 60255-26:2013, Section 7.2.3 IEC 61000-4-2:2008 Levels 2, 4, 6, and 8 kV contact Levels 2, 4, 8, and 15 kV air IEEE C37.90.3-2001 Levels 2, 4, and 8 kV contact Levels 4, 8, and 15 kV air
Electrical Fast Transient Burst Immunity:	IEC 60255-26:2013, Section 7.2.5 IEC 61000-4-4:2012 4 kV @ 5 kHz on power supply and outputs 2 kV @ 5 kHz on communications ports

Power Frequency Immunity:	IEC 60255-26:2013, Section 7.2.9 IEC 61000-4-16:2002 Zone A, applicable to binary input ports only: Differential mode: 150 Vrms Common mode: 300 Vrms
---------------------------	---

Note: Always use multicore screened or twisted pair (screened or unscreened) cables on optoisolated inputs (dc binary inputs).

Power Frequency Magnetic Field Immunity:	IEC 60255-26:2013, Section 7.2.10 IEC 61000-4-8:2009 1000 A/m for 3 s 100 A/m for 60 s
Power Supply Immunity:	IEC 60255-26:2013, Sections 7.2.11, 7.2.12, 7.2.13 IEC 60255-27:2013, Sections 5.1.3, 10.6.6
Radiated Electromagnetic Field Immunity:	IEC 60255-26:2013, Section 7.2.4 10 V/m (unmodulated) at swept frequency, 80 MHz–1 GHz, 1.4–2.7 GHz IEEE C37.90.2-2004 20 V/m (unmodulated) at swept frequency 80 MHz–1 GHz
Surge Immunity:	IEC 60255-26:2013, Section 7.2.7 IEC 61000-4-5:2005 0.5, 1.0, 2.0 kV line-to-line 0.5, 1.0, 2.0, 4.0 kV line-to-earth 0.5, 1.0, 2.0 kV communications ports
Surge Withstand:	IEC 60255-26:2013, Section 7.2.6 IEC 61000-4-18:2006 Power supply, outputs, and inputs 2.5 kV peak common mode 1.0 kV peak differential mode Communications ports 1.0 kV peak common mode IEEE C37.90.1-2012 2.5 kV oscillatory 4.0 kV fast transient

Environmental

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

Safety

Dielectric Strength:	IEC 60255-27:2013; Section 10.6.4.3 IEEE C37.90-2005, Section 8 2.5 kVrms on contact inputs, contact outputs, and analog inputs 3.6 kVdc on power supply
Impulse:	IEC 60255-27:2013; Section 10.6.4.2 0.5 J, 5 kV IEEE C37.90-2005, Impulse section

FCC:	<p>This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions:</p> <p>(1) This device may cause no harmful interference.</p> <p>(2) This device must accept any interference received, including interference that may cause undesired operation.</p> <p>Changes or modifications to this product may void authority to operate this equipment provided in Part 15.</p> <p>Canadian ICES-003: This Class A digital apparatus complies with Canadian ICES-003.</p> <p>Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.</p>
Canadian ICES-003:	<p>This Class A digital apparatus complies with Canadian ICES-003.</p> <p>Cet appareil numérique de la classe A est conforme à la norme NMB-003 du Canada.</p>

Sampling

16 samples per power system cycle

Processing

Differential elements, optoisolated inputs, and contact outputs are processed at 1/8-cycle.

Overcurrent elements are processed at 1/8-cycle.

Metering Accuracy

Instantaneous Currents:

5 A Model: $\pm 2\% \pm 0.10$ A

1 A Model: $\pm 2\% \pm 0.02$ A

Demand Currents:

5 A Model: $\pm 2\% \pm 0.10$ A

1 A Model: $\pm 2\% \pm 0.02$ A

High-Impedance Voltage: $\pm 5\% \pm 2$ V

Differential Element

Pickup Range: 20–800 V

Pickup Accuracy (V secondary):

5 A Model: $\pm 5\% \pm 4$ V

1 A Model: $\pm 5\% \pm 4$ V

Pickup Time (Max): 1.25 cycles

Instantaneous Overcurrent Elements

Pickup Range (A secondary):

5 A Model: 0.5–80.0 A

1 A Model: 0.1–16.0 A

Pickup Accuracy (A secondary):

5 A Model: $\pm 5\% \pm 0.10$ A

1 A Model: $\pm 5\% \pm 0.02$ A

Pickup Time (Typ/Max): 0.75/1.25 cycles

Time-Overcurrent Elements

Pickup Range (A secondary):

5 A Model: 0.5–16.0 A

1 A Model: 0.1–3.2 A

Pickup Accuracy (A secondary):

5 A Model: $\pm 5\% \pm 0.10$ A

1 A Model: $\pm 5\% \pm 0.02$ A

Curves:

U1 =	U.S. Moderately Inverse
U2 =	U.S. Inverse
U3 =	U.S. Very Inverse
U4 =	U.S. Extremely Inverse
U5 =	U.S. Short-Time Inverse
C1 =	IEC Class A (Standard Inverse)
C2 =	IEC Class B (Very Inverse)
C3 =	IEC Class C (Extremely Inverse)
C4 =	IEC Long-Time Inverse
C5 =	IEC Short-Time Inverse

Time-Dial Range

U.S. Curves: 0.50–15.00, 0.01 step

IEC Curves: 0.05–1.00, 0.01 step

Timing Accuracy: $\pm 4\% \pm 2\% \left(\frac{I_{nom}}{I_{sec}} \right) \pm 1.5$ cycles

for current between 2 and 30 multiples of pickup. Curves operate on definite-time for current greater than 30 multiples of pickup or 16 times nominal.

Reset Characteristic:

Induction-disk reset emulation or 1-cycle linear reset

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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This product is covered by the standard SEL 10-year warranty. For warranty details, visit selinc.com or contact your customer service representative.

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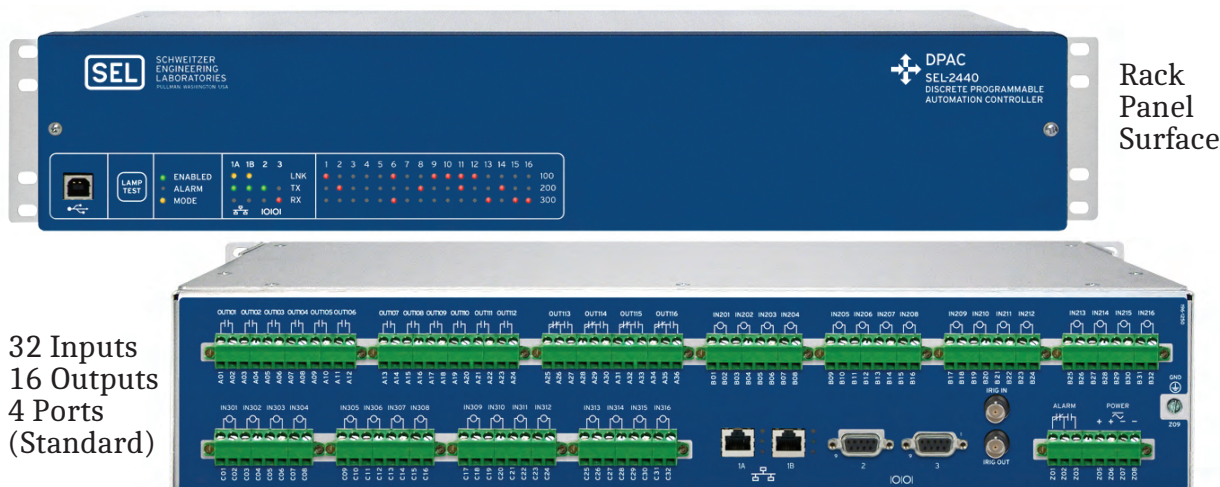


* P D S 5 8 7 Z - 0 1 *



SEL-2440 Discrete Programmable Automation Controller

Complete System for Control and Monitoring



Major Features and Benefits

Fast and Powerful I/O

- Utilize an exceptional and compact combination of inputs, outputs, and communications.
- Analyze system events with inputs and other events timed to the microsecond.
- Synchronize control with outputs that are synchronized to IRIG-B time.
- Perform actions quickly with a processing interval of 2 ms.
- Program new features with logic, latches, timers, counters, edge-triggers, and math functions.
- Ensure safe operation by using an input with logic programmed for local/remote control.

Convenient Maintenance and Support

- LEDs provide status for every I/O point and communications port.
- Removable terminal blocks make installation and replacement quick and efficient.
- Positive retention connectors ensure that connections are not lost due to sagging cables.
- Front-panel management port makes device management convenient.

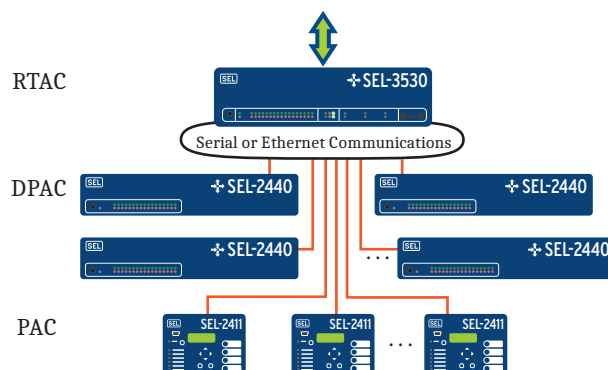
Flexible Communications and Integration

- Communicate with DNP3, Modbus[®], and IEC 61850 protocols over Ethernet and serial connections. Direct and select-before-operate (SBO) outputs are supported.

- Automate systems with flexible communication options that provide easy integration with SCADA.
- Configure easily with preprogrammed register or object maps and front-panel DIP switches.
- Alternatively, configure with ACSELERATOR QuickSet[®] SEL-5030 Software.

SEL Quality, Standards, and Global Support

- Designed and tested for harsh physical and electrical environments.
- Designed and tested to operate with dc grounded batteries and capacitive loads, and to trip breakers and interrupt inductive loads.
- Superior specification compliance, high reliability, low price, and worldwide, ten-year warranty.



Product Summary

The SEL-2440 Discrete Programmable Automation Controller (DPAC) withstands harsh physical and electrical environments and is built and tested to meet mission-critical IEEE and IEC protective relay standards. Apply the DPAC to satisfy stand-alone or distributed input, output, and communications needs. *Figure 1* shows the DPAC functionality.

Functional Diagram

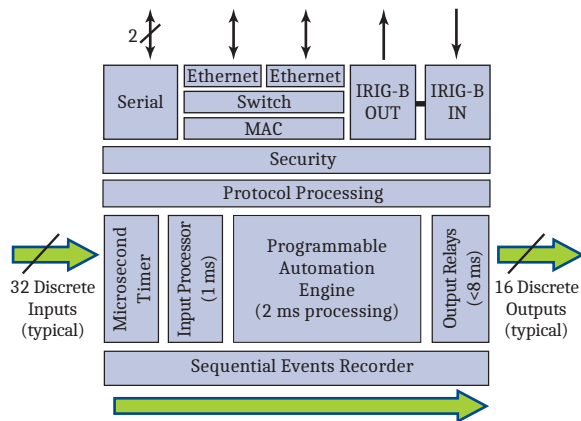


Figure 1 Functional Diagram

Configuration

- **Easy Mode.** Set address and communications parameters with DIP switches.
- **Flexible Mode.** Access additional flexibility using QuickSet software, shown in the following figure.

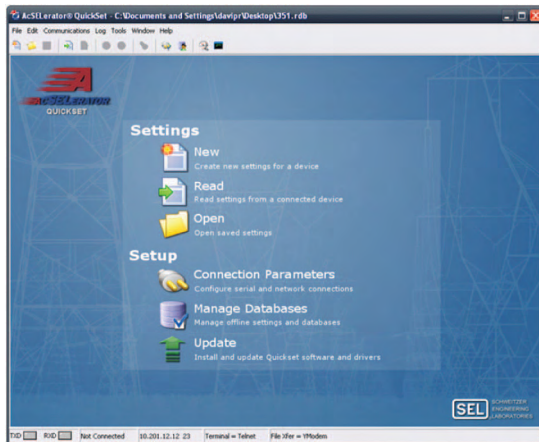


Figure 2 ACSELERATOR QuickSet Launchpad

Inputs/Outputs

DPAC devices can be ordered with different I/O and input voltage ratings as shown in the following tables.

I/O Quantity Options

	Inputs	Outputs
Standard	32	16
Option 1	16	32
Option 2	48	0
Option 3	16	32 (16 Standard and 16 High-Current Interrupting)
Option 4	16	26 (12 Form A, 4 Form C, 10 Fast High-Current Form A)
Option 5	32	10 (10 Fast High-Current Form A)

I/O Input Voltage Options

Digital Input Rating	
24 Vac/Vdc	125 Vac/Vdc
48 Vac/Vdc	220 Vac/Vdc
110 Vac/Vdc	250 Vac/Vdc

Communication and Time

Many communications ports and protocols are provided.

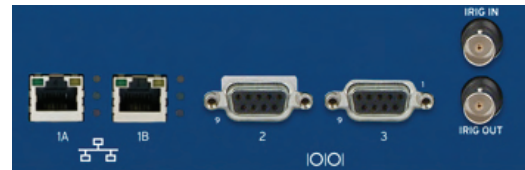


Figure 3 Rear-Panel Communications and IRIG-B Ports

Port	Port Interface
PORT F	USB 2.0 physical interface, serial port (e.g., COM1) software interface
PORT 1	Ethernet with switch/failover (copper or fiber)
PORT 2	Serial (EIA-232, EIA-485, or ST fiber)
PORT 3	Serial (EIA-232)

	Serial	Ethernet
DNP3	Yes	Yes
Modbus	Yes	Yes
IEC 61850		Yes
MIRRORED BITS®	Yes	
SEL Fast Message	Yes	

Input/Output Features

Inputs (Status and Alarms)

Use digital inputs to monitor critical alarms or status points and time-stamp to the microsecond.

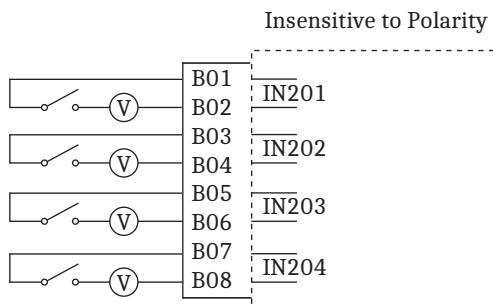


Figure 4 Independent and Isolated Inputs

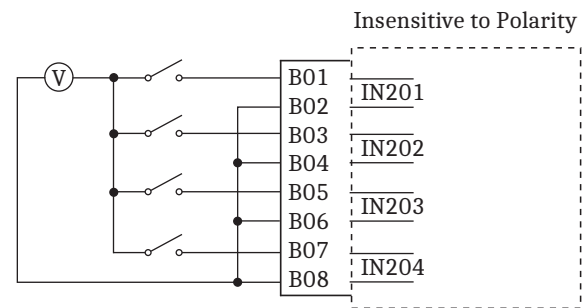


Figure 5 Bussed Inputs

SEL inputs are designed and tested to ensure they operate correctly for dc battery grounds and capacitive discharges.

The bold line in *Figure 6* shows how an earth fault completes the battery path through the input, bypassing the output. If the input is rated for 125 Vdc, the 65 Vdc that the fault causes across the input will assert the input. SEL level-sensitive inputs are designed so that they do not operate for this condition.

The bold line in *Figure 7* shows a discharge path from the wiring capacitance through the input when a knife switch is closed. This discharge can cause a temporary assertion of an input. SEL inputs are designed with debounce timers so that they do not operate for this condition.

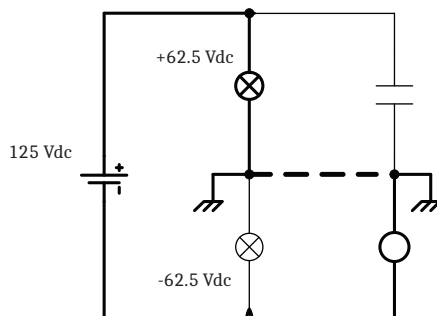


Figure 6 Secure Against DC Grounds

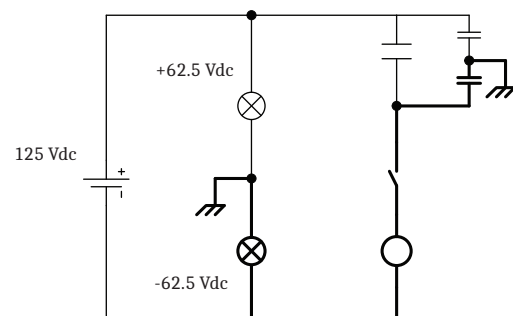


Figure 7 Secure Against Capacitive Discharges

Outputs (Relays)

Outputs are rated for 30 A make and inductive interrupt applications such as trip and close operations and motor control. See the *Output* specifications for more details.

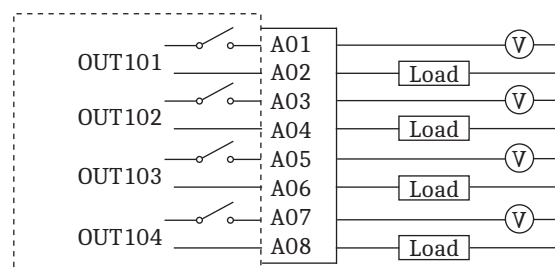
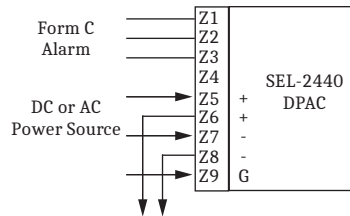


Figure 8 Independent and Isolated Outputs

Power

The **POWER** terminals on the rear panel must connect to 120–230 Vac or 24–250 Vdc with the proper polarity. These terminals are isolated from chassis ground. Extra terminals are provided so power can be daisy-chained from DPAC to DPAC.



IRIG-B

A demodulated IRIG-B input and output are provided so this signal can be daisy-chained between DPAC devices.



Connectors

Removable terminal block connectors make installation and replacement quick and efficient but can result in intermittent or lost connections if positive retention means aren't provided. The following diagram shows one of the pluggable connectors used on the DPAC and points out the retention screws that ensure connections remain in place.

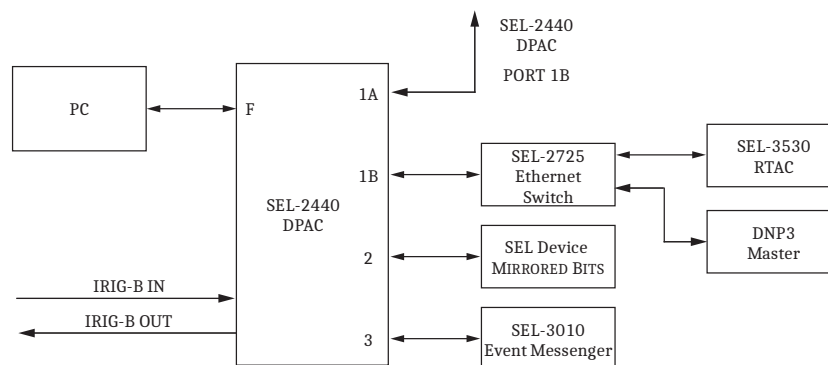


Conformal Coating

The optional conformal coating protects the DPAC printed circuit board from moisture and corrosive elements found in harsh installations. This conformal coating option conforms to Mil-1-46058C Type UR conformal coating requirements.

Communications Ports

A rich collection of communications ports and protocols are available with the DPAC as shown in the following figure, which also includes connection examples.



Automation Features

Flexible Control Logic and Integration Features

Eases Configuration

The DPAC does not require special communications software. Use any system that emulates a standard terminal system for engineering access to the device.

Simplifies Communications

The SEL-2440 is equipped with three independently operated serial ports. Establish communication by connecting computers, modems, protocol converters, printers, an SEL Communications Processor, SCADA serial port, and an RTU for local or remote communication. Apply an SEL communications processor as the hub of a star network, with point-to-point fiber or copper connection between the hub and the SEL-2440.

Supports Standard Protocols

As with most SEL devices, the DPAC comes standard with the communications protocols listed below.

- DNP3
- Modbus
- SEL ASCII
- SEL Compressed ASCII
- SEL Fast Meter
- SEL Fast Operate
- SEL Fast SER
- SEL Fast Message
- SEL MIRRORING BITS

Simplifies SCADA

SEL devices provide proprietary but open, binary “fast” protocols. These protocols are self-describing and are interleaved with ASCII protocols on the same port. Simplify configuration, minimize communications wiring, and improve performance between the DPAC and other devices (e.g., communications processors) with these protocols.

Provides Annunciation

Indicators (LEDs) provide annunciation of I/O status for each input and output. In addition, device status and port activity indicators simplify commissioning and troubleshooting.



Figure 12 Annunciation Indicators

Performs Logic and Math

Eliminate PLCs with Boolean logic, rising/falling edge triggers, and math (+, -, *, /).

Replaces Traditional Latching Relays

Replace as many as 32 traditional latching relays for such functions as “remote control enable” with latches. Program latch set and latch reset conditions with SELOGIC® control equations. Set or reset the nonvolatile latches using optoisolated inputs, Remote Bits, latches, or any programmable logic condition. The latches retain their state when the device loses power.

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. Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.

Eliminates External Counters

Eliminate external counters for custom control schemes with 32 counters, updated every 2 ms processing interval. Each counter element consists of five inputs (preset value; load preset value, count up, count down, and reset to zero) and three outputs (counter value; count as many as preset reached, count down to zero reached).

Eliminates RTU-to-Device Wiring

Eliminate RTU-to-Device wiring with 32 Remote Bits. Set, clear, or pulse Remote Bits using serial or Ethernet 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.

Communications Architectures

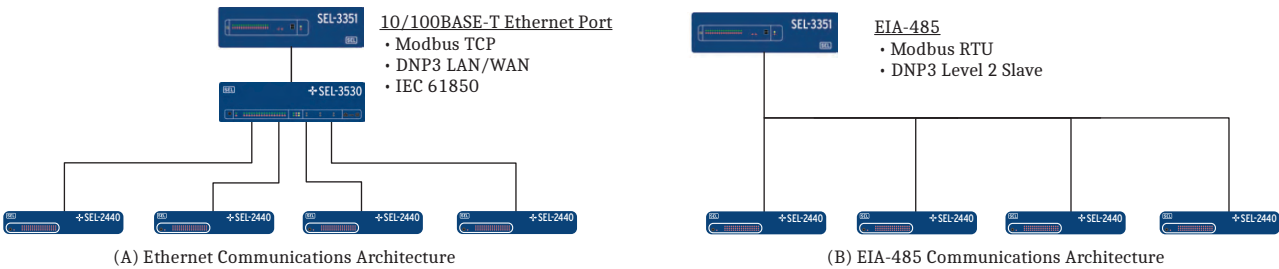


Figure 13 Typical Ethernet and EIA-485 Communications Architectures

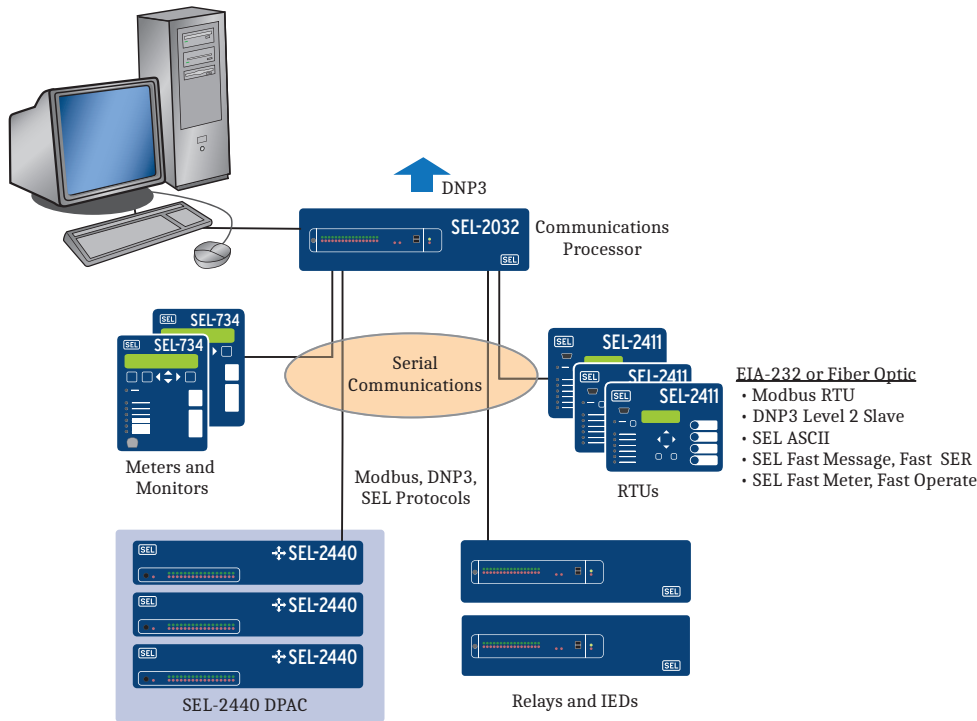


Figure 14 Typical EIA-232 and Fiber-Optic Communications Architecture

Additional Ordering Options

The following options can be ordered for any SEL-2440 model (see the SEL-2440 Model Option Table for details):

Port 2 Physical Interface	Mounting
EIA-232	Rack
EIA-485	Panel
ST fiber	Surface

Front- and Rear-Panel Diagrams

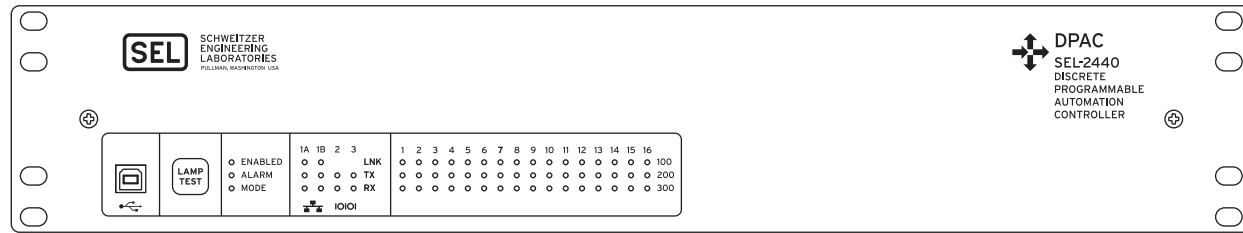


Figure 15 Rack-Mount Drawing

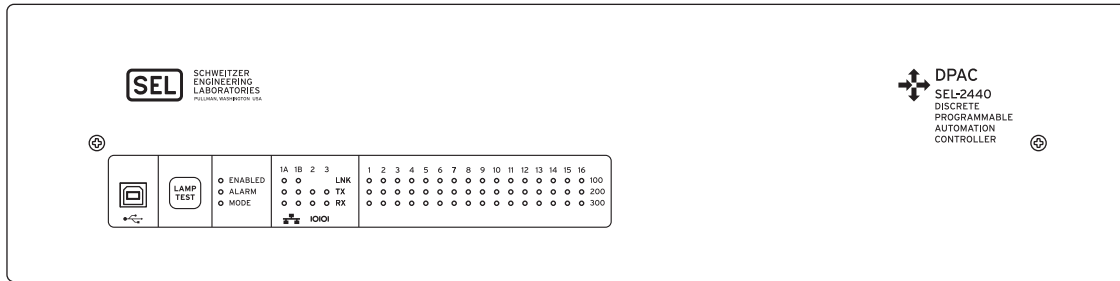


Figure 16 Panel-Mount Drawing

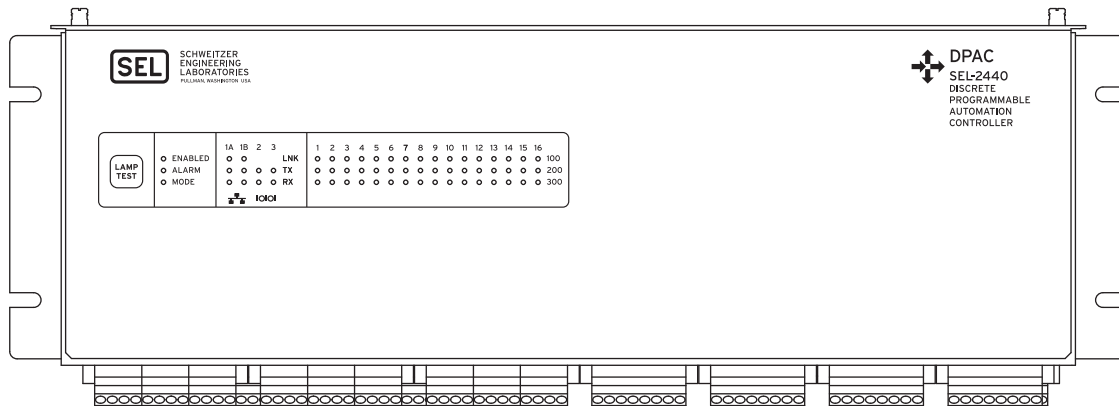


Figure 17 Surface-Mount Drawings

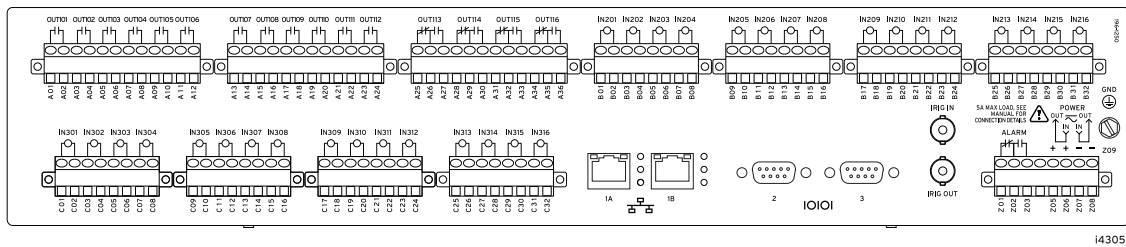
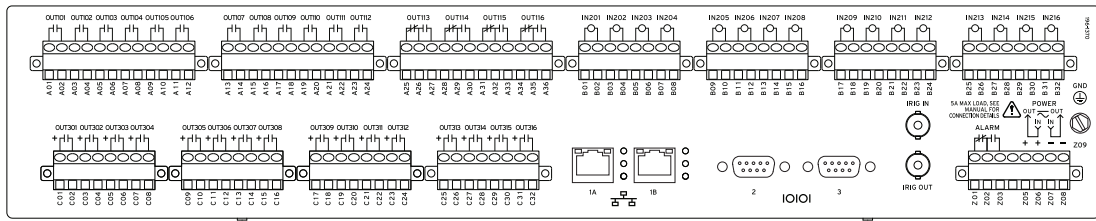


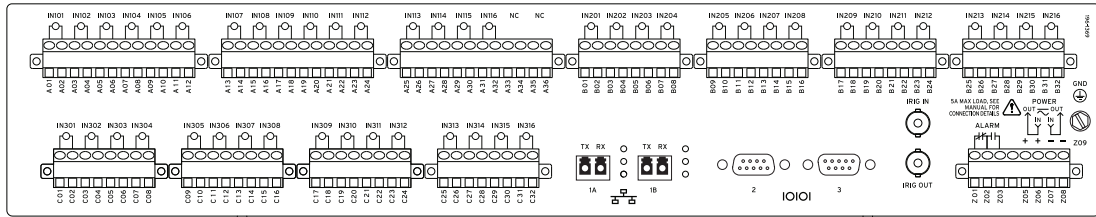
Figure 18 32 Input, 16 Output Rear-Panel Drawing

High-current interrupting outputs are polarity sensitive. This is indicated with a + next to the contact on the overlay to indicate the positive side of the contact.



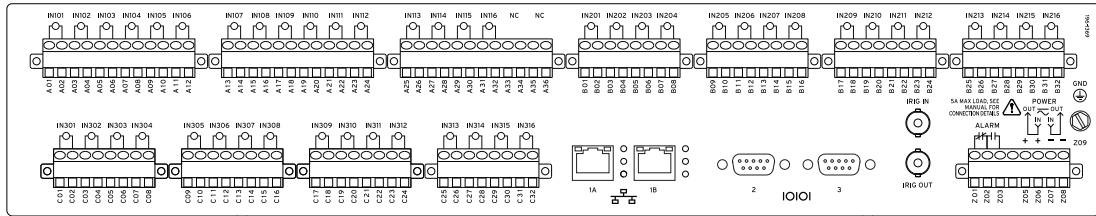
i4961b

Figure 19 High-Current Interrupting Option Rear-Panel Drawing



i4846c

Figure 20 Port 2 EIA-485 and Fiber-Optic Ethernet Option Rear-Panel Drawing



i4875c

Figure 21 48DI Option Rear-Panel Drawing

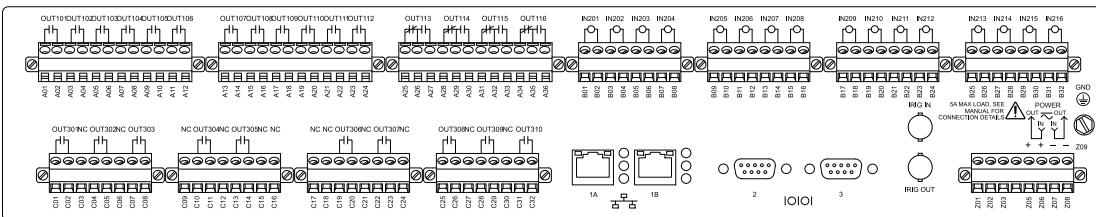


Figure 22 16 Input, 16 Standard Output, and 10 Fast High-Current Output Rear-Panel Drawing

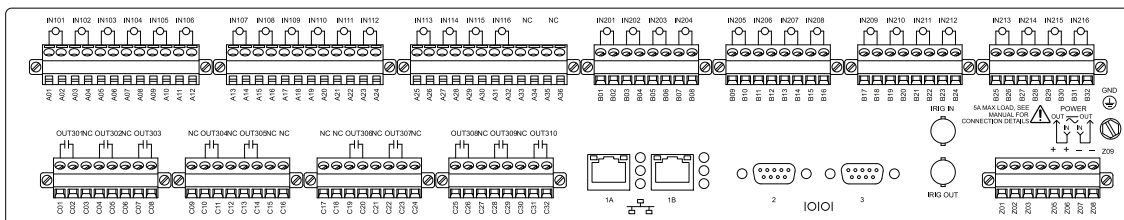
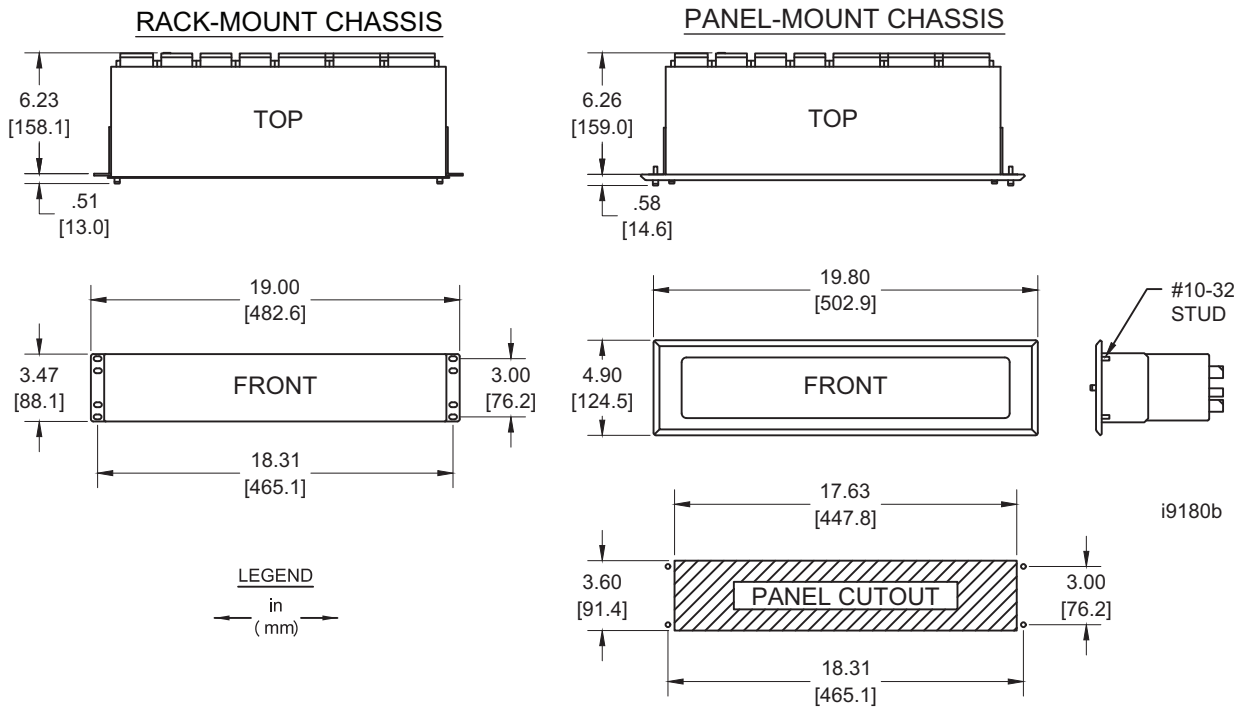
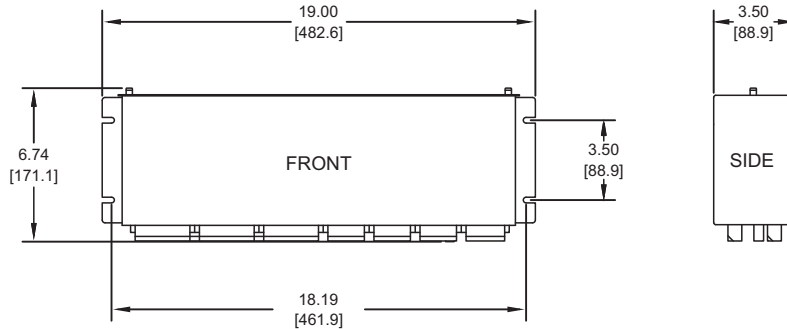


Figure 23 32 Input and 10 Fast High-Current Output Rear-Panel Drawing

Dimensions



SURFACE-MOUNT CHASSIS



i9367a

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards
(File E220228; NRAQ, NRAQ7)

Note: DC output ratings not evaluated by UL61010.

CE Mark

RCM Mark

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.

General

Operating Temperature Range

–40° to +85°C (–40° to +185°F)
(not applicable to UL installations. UL rated 40°C)

When Powered by 24 V, the SEL-2440 Supports the Following Conditions:

70°C: Operate 32 outputs and 2.5 W max on
+5 V pin (Port 2/3)

Conformal Coated: Derate operating temperature by 10°C.

Operating Environment

Pollution Degree: 2
Overvoltage Category: II
Insulation Class: 1
Relative Humidity: 5%–95%, noncondensing
Maximum Altitude: 2000 m

Weight

2.0 kg (4.4 lb)

Inputs

Optoisolated Control Inputs

When Used With DC Control Signals:

250 V	ON for 200–275 Vdc	OFF below 150 Vdc
220 V	ON for 176–242 Vdc	OFF below 132 Vdc
125 V	ON for 100–135.5 Vdc	OFF below 75 Vdc
110 V	ON for 88–121 Vdc	OFF below 66 Vdc
48 V	ON for 38.4–52.8 Vdc	OFF below 28.8 Vdc
24 V	ON for 15–30 Vdc	OFF below 5 Vdc

When Used With AC Control Signals:

250 V	ON for 170.6–275 Vac	OFF below 106 Vac
220 V	ON for 150.3–264 Vac	OFF below 93.2 Vac
125 V	ON for 85–150 Vac	OFF below 53 Vac
110 V	ON for 75.1–132 Vac	OFF below 46.6 Vac
48 V	ON for 32.8–60 Vac	OFF below 20.3 Vac
24 V	ON for 14–27 Vac	OFF below 5 Vac

Current Draw at Nominal
DC Voltage: 2–4 mA (except for 24 V, 8 mA)

Outputs

Mechanical Durability

10 M no-load operations

DC Output Ratings

Standard Output Option

Rated Operational Voltage: 24–250 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
Thermal: 50 A for 1 s
Contact Protection: 360 Vdc, 40 J MOV protection across open contacts

Operating Time (Coil Energization to Contact Closure, Resistive Load): Pickup/Dropout time ≤8 ms typical

Breaking Capacity	24 V	0.75 A	L/R = 40 ms
(10,000 Operations) per	48 V	0.50 A	L/R = 40 ms
IEC 60255-0-20:1974:	125 V	0.30 A	L/R = 40 ms
	250 V	0.20 A	L/R = 40 ms

Cyclic Capacity	24 V	0.75 A	L/R = 40 ms
(2.5 Cycles/Second) per	48 V	0.50 A	L/R = 40 ms
IEC 60255-0-20:1974:	125 V	0.30 A	L/R = 40 ms
	250 V	0.20 A	L/R = 40 ms

High-Current Interrupting Output Option

Rated Operational Voltage: 24–250 Vdc
Rated Voltage Range: 19.2–275 Vdc
Rated Insulation Voltage: 300 Vdc
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.

Fast High-Current Interrupting Output Option

Rated Operational Voltage: 24–250 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
Continuous Carry
(UL/CSA Derating With
All Outputs Asserted): 5 A @ <60°C; 2.5 A 60 to 70°C
Thermal: 50 A for 1 s
Contact Protection: 330 Vdc, 145 J MOV protection across open contacts

Operating Time (Coil Energization to Contact Closure, Resistive Load)

Pickup Time: ~16 µs at 250 Vdc, 22 µs at 125 Vdc, 85 µs at 19.2 Vdc typical (results with 100 kΩ resistive load)

Dropout Time: <8 ms typical

Inductive Breaking Capacity (100,000 Operations)
per IEC 60255-0-20:1974

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

Cyclic Capacity (4 Cycles/Second Followed by 2 Minutes Idle Thermal
Dissipation) per IEC 60255-0-20:1974

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

AC Output Ratings

Standard Output Option

Rated Operational Voltage:	110–240 Vac
Rated Voltage Range:	19.2–264 Vac
Rated Insulation Voltage:	270 Vac
Rated Frequency:	50/60 ± 5 Hz
Utilization Category:	AC-15 (control of electromagnetic loads >72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Contact Protection:	270 Vac, 40 J
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Continuous Carry (UL/CSA Derating With All Outputs Asserted):	5 A @ <60°C; 2.5 A 60–70°C
Operating Time (Coil Energization to Contact Closure):	Pickup/Dropout Time: ≤8 ms

Electrical Durability Make
VA Rating: 3600 VA, $\cos\phi = 0.3$

Electrical Durability
Break VA Rating: 360 VA, $\cos\phi = 0.3$

Fast High-Current Output Option

Rated Operational Voltage:	110–240 Vac
Voltage Range:	19.2–250 Vac
Rated Insulation Voltage:	250 Vdc
Rated Frequency:	50/60 ± 5 Hz
Make:	30 A @ 240 Vac
Utilization Category:	AC-15 (control of electromagnetic loads >72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)
Continuous Carry:	6 A @ 70°C; 4 A @ 85°C
Continuous Carry (UL/CSA Derating With all Outputs Asserted):	5 A @ <60°C; 2.5 A 60 to 70°C
Thermal:	50 A for 1 s
Contact Protection:	250 Vac, 145 J MOV protection across open contacts

Operating Time (Coil Energization to Contact Closure, Resistive Load)

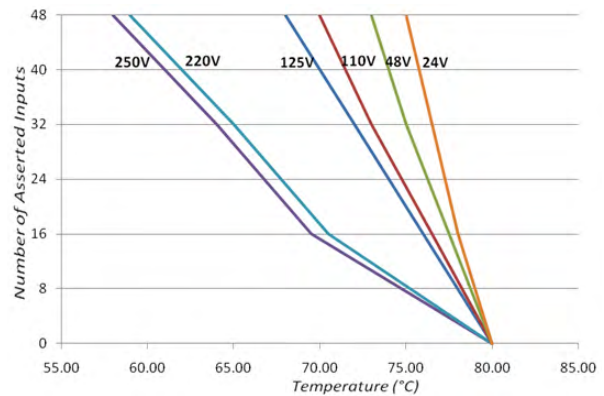
Pickup Time: ~16 μ s at 250 Vac, 22 μ s at 125 Vac, 85 μ s at 19.2 Vac typical (results with 100 k Ω resistive load)

Dropout Time: <8 ms typical

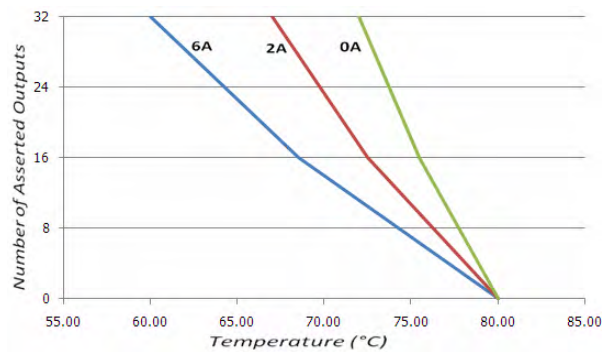
Note: Per IEC 60255-23:1994, using the simplified method of assessment.

Note: Making rating per IEEE C37.90-1989.

48DI Input Derating Curve:



32DO/16DI Output Derating Curve:



Time-Code Input (Demodulated IRIG-B)

On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 k Ω
Accuracy:	microsecond

Time-Code Input (SNTP)

High-Priority Server Accuracy:	±5 ms
Low-Priority Server Accuracy:	±25 ms

Time-Code Output (Demodulated IRIG-B)

On (1) State:	$V_{oh} \geq 2.4$ V
Off (0) State:	$V_{ol} \leq 0.8$ V
Load:	50 Ω

Communications

Communications Ports

USB 2.0 Port:	Port F; front-panel port
Ethernet Ports:	Port 1A, 1B; rear-panel 10/100BASE-T or 100BASE-FX ports
Optional Port:	300–115200 bps Port 2; rear panel available as: EIA-232 with IRIG-B EIA-485 with IRIG-B ST fiber with IRIG-B
EIA-232 Port:	300–115200 bps Port 3; rear-panel port with IRIG-B

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Data Rate:	100 Mbps
Optical Connector Type:	LC
Fiber Type:	Multimode

Link Budget:	16.1 dB
Typical TX Power:	-15.7 dBm
Min RX Sensitivity:	-31.8 dBm
Fiber Size:	50–200 µm
Approximate Range:	~6.4 km
Typical Fiber Attenuation:	-2 dBm/km
Port 2 Serial ST (SEL-2812 Compatible)	
Baud Rate:	300–115200 bps
Wavelength:	850 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	16 dBm
Min TX Power:	-13 dBm
Max TX Power:	-3 dBm
Min RX Sensitivity:	-29 dBm
Fiber Size:	50–200 µm
Approximate Range:	~4 km with 62.5 µm ~1 km with 200 µm
Typical Fiber Attenuation:	-4 dBm/km

Communications Protocols

Modbus Slave (TCP and RTU)
 DNP3 Level 2 Outstation (LAN/WAN and Serial)
 IEC 61850 communications
 FTP
 Telnet
 SEL MIRRORED BITS
 Ymodem file transfer on the front and rear port
 Xmodem file transfer on the front port
 SEL ASCII and Compressed ASCII
 SEL Fast Meter
 SEL Fast Operate
 SEL Fast SER
 SEL Fast Message unsolicited write
 SEL Fast Message read request
 SEL Event Messenger points

Maximum Concurrent Connections

Modbus Slave:	2
DNP3 Level 2 Outstation:	5 ^a
Ethernet FTP:	2
Telnet:	2

^a Maximum in any combination of serial and/or LAN/WAN links.

Power Supply

Input Voltage

Rated Voltage:	24–250 Vdc 110–230 Vac, 50/60 Hz
Voltage Range:	19.2–275 Vdc 85–264 Vac
Inrush Current:	<20 A pk

Power Consumption

AC:	<50 VA
DC:	<20 W

Interruptions:

10 ms @	24 Vdc
25 ms @	48 Vdc
125 ms @	125 Vdc
160 ms @	120 Vac
600 ms @	250 Vdc
1000 ms @	230 Vac

Fuse Rating: 3.15 A, high breaking capacity, time lag T, 250 V (5 x 20 mm, T3.15AH 250 V)

Processing Specifications

Processing Interval:	2 ms
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Product Standards

Electrical Equipment for Measurement, Control, and Laboratory Use:	IEC 61010-1:2013 UL 508:2018 C22.2 No. 61010-1:12 IEC 61010-2-201:2013 UL 61010-2-201:2017 C22.2 No. 61010-2-201:14
Measuring Relays and Protection Equipment:	IEC 60255-26:2013 IEC 60255-27:2013

Type Tests

Note: To ensure good EMI and EMC performance, type tests were performed using shielded copper Ethernet cables with the shell grounded at both ends of the cable. Double-shielded cables are recommended for best EMI and EMC performance.

Environmental Tests

Enclosure Protection:	IEC 60529:1989 + A1:1999 + A2:2013 IP4X Front IP2X Product Note: If rear terminals are accessible during normal use, the product must be mounted in a locked enclosure or restricted area accessible by trained maintenance or operation personnel only.
Vibration Endurance:	Class 2
Response:	Class 2
Shock Withstand:	Class 1
Response:	Class 2
Bump Withstand:	Class 1
Seismic Response:	Class 2
Cold:	IEC 60068-2-1:2007 -40°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 40°C, 93% relative humidity, 4 days
Damp Heat, Cyclic:	IEC 60068-2-30:2005 25°C–55°C, 6 cycles, 95% relative humidity
Dry Heat:	IEC 60068-2-2:2007 85°C, 16 hours

Power Interruption Tests

AC Power:	61000-4-11:2004
DC Power:	61000-4-29:2001

Dielectric Strength and Impulse Tests

Dielectric (HiPot):	IEC 60255-27:2013 IEEE C37.90-2005 3.6 kVdc on power supply 2.5 kVac on contact I/O 1.5 kVac on Ethernet/IRIG IN
Impulse:	IEC 60255-27:2013 5 kV on power supply, contact I/O 2.2 kV on Ethernet

RFI and Interference Tests

EMC Immunity

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 Severity Level: 2, 4, 6, 8 kV contact discharge 2, 4, 8, 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2006 + A1:2007 + A2:2010, 10 V/m IEEE C37.90.2-2004, 20 V/m
Fast Transient, Burst Immunity:	IEC 61000-4-4:2012 4 kV @ 5 kHz on power supply and contact I/O 2 kV @ 5 kHz for communication ports
Surge Immunity:	IEC 61000-4-5:2005 1 kV on power supply, contact I/O 2 kV on power supply, contact I/O, Ethernet and serial ports, IRIG

Surge Withstand Capability:	IEC 61000-4-18:2006 + A1:2010 Severity Level: Power supply and contact I/O 2.5 kV peak common mode 1.0 kV peak differential mode Communications ports 1.0 kV peak common mode IEEE C37.90.1-2012 2.5 kV oscillatory, 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2013 10 Vrms
Power Frequency Magnetic Field:	IEC 61000-4-8:2009 1000A/m for 3 s 100A/m for 1 min
Pulse Magnetic Field:	IEC 61000-4-9:2016 1000 A/m
Damped Oscillatory Magnetic Field:	IEC 61000-4-10:2016 100 A/m

EMC Emissions

Note: Test performed using serial cables with shield grounded at both ends.

Conducted and Radiated Severity Level:	Class A EN 55011:2009 + A1:2010 EN 55022:2010 + AC:2011 EN 55032:2012 + AC:2013 CISPR 11:2009 + A1:2010 CISPR 22:2008 CISPR 32:2015 ANSI C63.4:2014
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Notes

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This product is covered by the standard SEL 10-year warranty. For warranty details, visit selinc.com or contact your customer service representative.

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FT Flexitest™ Switches

Type FT-1, FT-1F, FT-1X & FT-14

Descriptive Bulletin 41-077

Effective April 2010

Supersedes DB 41-077, dated November 2007



Application

ABB Flexitest Switches, Types FT-1 (10 pole, rear connected), FT-1F (10 pole, front connected), FT-1X (10 pole, extended terminals, rear connected), FT-14 (14 pole, rear connected), and associated Test Plugs provide a safe, simple, fast and reliable method to isolate and service installed equipment.

Advantages

FT test switches provide a safe, reliable, and cost-effective means to wire the output of relays, meters, and other associated equipment to external devices for in-service testing. FT test switches have been an industry standard for years.

FT-1 Standard 10 pole, rear connected test switch.

FT-1F Surface mount switch allows the user to make the same connections as with FT-1 but on the front of the switch.

FT-1X Extended length test switch brings the rear terminal connections to the same depth as most panel mounted protective relays and equipment.

FT-14 Provides the same features and reliability as FT-1 but with a maximum of 14 individual poles. Although supplying 40% more capacity than the FT-1, the FT-14 only requires 18% more space.

Safe and Convenient All measurements and tests can be performed at the front of the switchboard without taking any devices out of service.

Flexitest Switches and Test Plugs have all the features necessary for applications involving the measurement of individual currents and voltages to facilitate testing of substation instrumentation and protection devices.

The make-before-break current short circuit feature allows test personnel to quickly and safely isolate equipment from current transformer (CT) circuits.

Voltage measurements can also be made directly on FT Switches without disturbing existing connections. There is a test clip located on the top of each pole that allows connection with standard spring clip test leads.

Fast and Reliable When Test Plugs are used, any number of circuits may be tested in rapid succession. One plug properly connected can test all instruments or meters of a particular type.

Maximum Flexibility Test switches can be assembled in a variety of different arrangements, to match customer requirements.

Test Plugs used in conjunction with FT Switches enable easy measurement, calibration, verification and maintenance of relays, meters and instruments.

Security With the cover in place, a meter seal can be placed through either of the cover studs of any FT Switch to prevent unauthorized access to the switch. As an additional feature, a clear cover is available that can also be installed and locked with the switchblades in the open or closed positions.

Warranty

ALL ABB Substation Automation and Protection test switches and relays are backed by a 12-YEAR warranty. The quality of ABB products comes from years of experience and rigorous quality testing programs.



Specifications

All Flexitest Switches meet or exceed all requirements of ANSI/IEEE Standard C37.90 Class 1E Switches meet IEEE C37.98, C37.105, 323-1983 and 344-1987 Standards. UL, CUL, CSA, and 1E certification are available for most test switches.

Ratings All Flexitest Switches are rated at 600 volts and 30 amps.

Mounting The FT-1, FT-14 and FT-1X Switches are designed for semi-flush mounting on the front of switchboard panels, facilitating inspection and accessibility. The FT-1F is designed for surface mounting and can also be mounted on a unistrut with the use of a unistrut adapter plate. Refer to Figures 11 to 13 beginning on page 28 for the specific outline and drilling plan information of each switch.

Weight Specifications

Device Type	Net Lbs (kg)	Shipping Lbs (kg)	Shipping Container L x W x H in [cm]
FT-1 and FT-1F	1.75 (0.79)	3 (1.4)	7 x 5 x 4 [18 x 13 x 10]
FT-1X	2.7 (1.25)	3.75 (1.7)	7 x 12 x 4 [18 x 30 x 10]
FT-14	3.25 (1.5)	3.25 (1.5)	9 x 5 x 4 [22 x 13 x 10]
Separate Source Test Plug (10 position)	1.5 (0.68)	3 (1.4)	not available
In-Service Series Test Plug (10 position)	1.5 (0.68)	3 (1.4)	not available
Individual Current Circuit Test Plug	0.1 (0.045)	1 (0.45)	not available

Construction The base of all Flexitest Switches is made of a molded thermo-plastic which provides a tough, insulated enclosure. Barriers are molded into the base (front and rear) to separate the switch units from one another. The barriers provide insulation between poles, and also ample wiring space between terminals. The terminals of the FT-1X are extended 8 to 10 inches beyond the switch blades located on the front of the switch.

Cover All Flexitest Switch covers provide a tough insulated enclosure for the switch and are made from a durable plastic material. Covers are fastened to the switches with thumbnuts on either end that can be loosened and tightened by hand, or with a 1/4" nut driver. This is the same size nut driver used on the hex head terminal screws of all Flexitest Switches. All covers have the provision to accept meter seals.

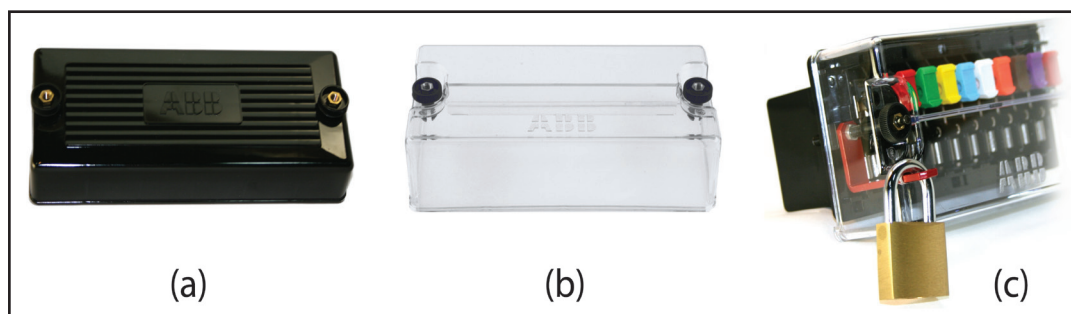


Figure 1. FT Cover selection samples (a) Black; (b) Clear; (c) Lockable

All switches may be purchased with a black opaque cover or a clear cover. The clear cover affords the user the unique option of intentionally leaving switch handles in the open position with the cover in place, maintaining the provision for a meter seal. This allows the user to service electrical equipment while still complying with OSHA tag and lockout procedures. Lockable covers (in black or clear) are also available upon request.

Any cover can be ordered separately to retrofit any existing switch, maintaining the same ease of use and accessibility. See Ordering Information on page 12.

Poles

FT-1, FT-1F and FT-1X switches are available in combinations of 1 to a maximum of 10 individual poles or switch units. FT-14 switches are available in combinations of 1 to a maximum of 14 poles or switch units. Each pole is identified by a letter (A to J or A to N) visible along the top of the base from left to right (front view).

Each individual pole is of a knife blade type. There are two different types of poles, Potential and Current.

Potential poles (P) are configured as single, non-shortening knife blades for use in potential, trip, or control circuits. Current poles are typically configured in sets of two (C-C), for use with current circuits, and consist of a current test jack, a shorting spring, a shorting blade, and a non-shortening blade (see Figure 2). The positions of the short circuit springs are always visible from the front of the switch.

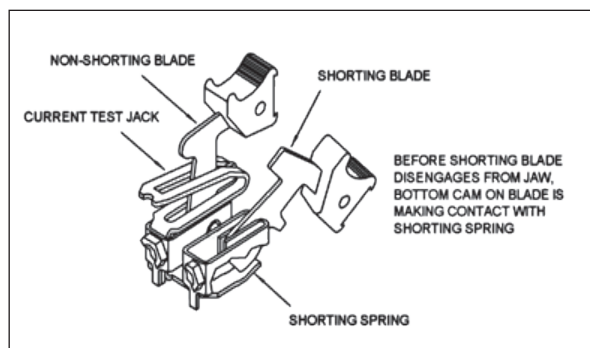


Figure 2. Blade assembly of 2 position pole "C-C" (rear view outside of base)

Switch Handles

Switch handles are made of a molded thermo-plastic material. They are typically black for potential and current circuits, red for trip circuits. In addition to black and red, switch handles are also available in various other colors (brown, purple, green, yellow, blue, white, and orange). Each handle has a dovetail indentation that can hold a circuit identification label.

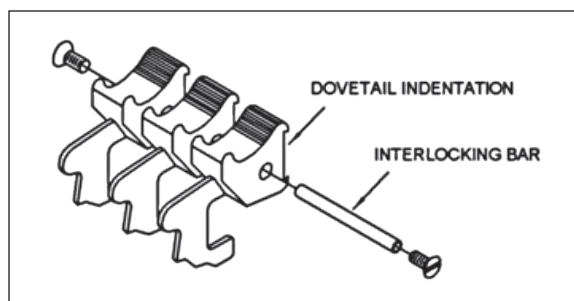


Figure 3. Switch handles with interlocking bar

Knife blade switches can be operated independently, or ganged together with a horizontal interlocking bar to suit testing needs. A hole runs through the middle of each switch handle to allow insertion of interlocking bars that can mechanically tie 2, 3, 4, 5, 6, 8, 10, or 14 switch handles together.

Interlocking Bars are sold separately, see "Test Plug & Accessories – Ordering Information" on page 12.

Terminals

Connection terminals are located at the rear of the switch (except on the front connected FT-1F). Terminal numbers are marked for easy identification along the rear of the switch (1 to 20 on FT-1 and 1 to 28 on FT-14).

Each pair of numbered terminals is associated with a matching pole designated by a letter on the front of the switch, see

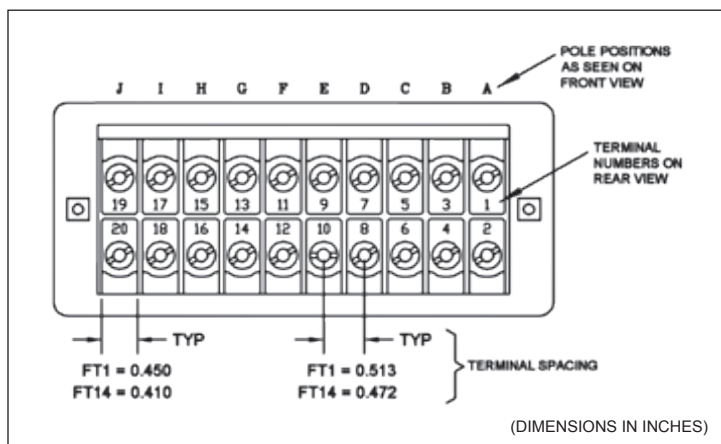


Figure 4. FT Switch terminals, rear view (FT-1 shown)

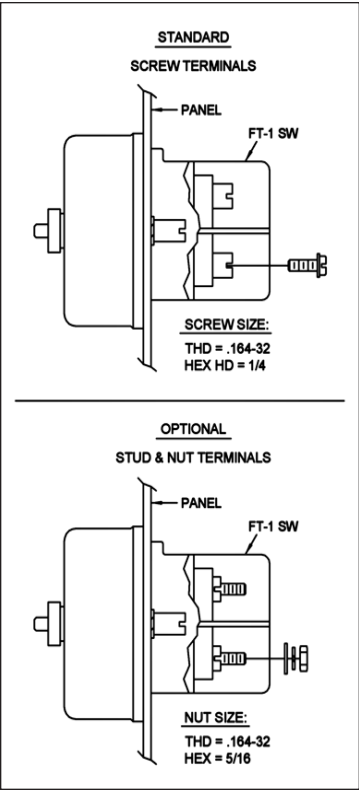


Figure 5. Terminal Connections

Figure 4.

Terminal Connections

All required terminal hardware is supplied with every FT Switch (see Figure 5).

Screw terminals are provided standard with all FT switches. Connections are made with a hex washer head screw - #8 thread size (0.164-32), 1/4" hex head.

Stud and nut terminals are an optional feature. Connections are made with two washers and a nut. A special (5/16") nut driver can be purchased from ABB to connect to stud

Max Lug Size = Yellow 12-10 ga. Ring Terminal



WARNING

terminals, see "Test Plug & Accessories - Ordering Information" on page 12.

Connections to ALL equipment should be made using standard and safe connection practices.

Recommended maximum torque values for all FT-1 & FT-14 terminals is 16 in-lbs. Exceeding this torque may result in damage to terminal threads.

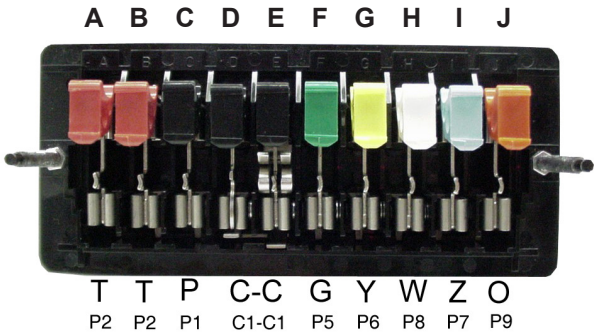
should be connected to equipment that is to be isolated, such as meters and relays.

Switch Arrangement

Pole positions are identified from left to right on the front view of the switch by the letters "A" through "J" or "A" through "N". Individual pole designations are used to identify each pole according to its type or function. In order to develop a complete Switch Arrangement, pole designations should be listed sequentially from left to right to account for every pole position on the switch. Unused poles are identified by the letter X.

Potential Poles P designates a Potential or control circuit with a black handle. Potential poles with other color handles are available by replacing the "P" with the appropriate designation per chart on this page.

Each potential pole can also be described with 2 characters (P1 to P9). P indicates Potential and the second character is a numeric color code for the switch handle.



Potential Pole Designation		Handle Color
P	P1	Black
T	P2	Red
H	P3	Brown
V	P4	Purple
G	P5	Green
Y	P6	Yellow
Z	P7	Blue
W	P8	White
O	P9	Orange

Current Poles **C** designates a single Current circuit, non-shorting pole, with a current test jack and a black handle. Current poles with other color handles are available by replacing the "C" with the appropriate designation per chart on page 6.

Each current pole can also be described with 2 characters (C1 to C9). **C** indicates Current and the second character is a numeric color code for the switch handle.

Current poles typically span more than one pole position. Pole designations **C-C**, **C-C-C**, **C-C-C-C** and **C-C-C-C-C** indicate current shorting poles (make-before-break) with black handles. Note that any

color handle may be selected for any pole position by using the appropriate pole designation, ex: 5-R or C-9-7 (alternately C5-C2 or C1-C9-C7).



WARNING

Current Pole Designation		Handle Color
C	C1	Black
R	C2	Red
3	C3	Brown
4	C4	Purple
5	C5	Green
6	C6	Yellow
7	C7	Blue
8	C8	White
9	C9	Orange

Description of Poles - FT Flexitest Switches

Pole Type	Pole Designation		Handle Color	Description & Schematic Symbol
Potential	P	P1	Black	Potential, non-shorting blade.
	T	P2	Red	
	H	P3	Brown	
	V	P4	Purple	
	G	P5	Green	
	Y	P6	Yellow	
	Z	P7	Blue	
	W	P8	White	
	O	P9	Orange	
Current	L	L1	Black ††	Potential, shorting blade.
	C	C1	Black	Current, non-shorting, with test jack and blade.
	R	C2	Red	
	3	C3	Brown	
	4	C4	Purple	
	5	C5	Green	
	6	C6	Yellow	
	7	C7	Blue	
	8	C8	White	
	9	C9	Orange	
	D	D0	None	Current test jack, no blade.
Current Shorting †	C-C	C1-C1	Black ††	Current shorting (make-before-break), with test jack and blade.
	C-A	C1-A1		Current shorting (make-before-break), with blade only.
	C-B	C1-B0		Current shorting (make-before-break), with stud only.
	C-D	C1-D0		Current shorting (make-before-break), with test jack only.
	C-E	C1-E1		Current shorting (make-before-break), with shorting blade only.
	C-S	C1-S0		Current shorting (make-before-break), with fixed shorting strap.
Miscellaneous	S	S0	None	Fixed shorting strap.
	J	J0	None	Current jaw, no blade.
	N	N0	None	Terminal stud in blade location, no jaw.
	U	U0	None	Stud and test clip in jaw location, no blade.
	X	X0	None	Empty pole position.

Schematic Legend

Non-Shorting Blade
Shorting Blade
Current Test Jack
Shorting Spring
C-C-C

† = Current shorting poles are also available spanning up to 5 positions (ex: **C-C-C-C-C** or alternately C1-C1-C1-C1-C1).

†† = Every color handle is available by substituting appropriate pole color designation in desired location.



FT-1 Configurator

How to use this Site:

[To CONFIGURE: Select Base, Options, Poles & Handles.](#)
[Click Configure... Need to start over? Click Reset.](#)
[To SEARCH: Want to view an existing FT-1 or FT-14 Switch?](#)
[You can search by Code No. or Style No.](#)

Select Base:

☒ Stand Alone FT-1
 ☐ FT-19R Replacement FT-1
 ☐ Front Connected FT-1F
 ☐ FT-14

Letters = Pole Positions
 Numbers = Rear Terminals

Select Options:

Cover:
☒ Black Cover
☐ Clear Cover

Terminals:
☒ Screw Terms.
☐ Stud Terms

Depth:
☒ Standard
☐ Extended (10")

Front View

Select Poles:

Select Handles:

[Find Style No.](#) [Start Over](#)

SEARCH FT-1

☒ By Style No. ☐ By Code No.

SEARCH FT-14

☒ By Style No. ☐ By Code No.

Pole Descriptions

P	Potential
C	Current
D	Test Jack
S	Fixed Strap
X	Empty

C-C	Current Shorting
C-A	
C-B	
C-D	
C-S	

[Configure FT-19R](#)
[Product Literature](#)
[ABB Test Equipment](#)

FT-1 Configurator

ABB has a web based tool to help build any complete FT Switch Arrangement, select options, view schematic details and get Style Number information. The following products can be easily configured:

- FT-1
- Front connected FT-1F
- Extended terminals FT-1X
- Replacement switches for FT-19R
- FT-14 (14 Pole)
- FT19R switch panel assemblies

Please visit ABB's FT-1 Configurator website
@ <http://ft1switch.com/>



FT-1 Configurator

How-to use this Site:

TO CONFIGURE: Select Base, Options, Poles & Handles.
Click Configure... Need to start over? Click Reset.

Select Base:

☒ Stand Alone FT-1
 ☐ FT-19R Replacement FT-1
 ☐ Front Connected FT-1F
 ☐ FT-14

Letters = Pole Positions
 Numbers = Rear Terminals

Select Options:

Cover:

☒ Black Cover
 ☐ Clear Cover

Terminals:

☒ Screw Terms.
 ☐ Stud Terms

Depth:

☒ Standard
 ☐ Extended (10")

Front View

Select Poles:

All

A

B

C

D

E

F

G

H

I

J

Select Handles:

All

Ora

Yel

Blu

Wht

Grn

Blk

Blk

Red

Pur

Brn

Configure

Reset

Find Style No.

Start Over

FT-1

Stand Alone

Data Sheet

Get Data Sheet

Style No:

991A934G01

Code No:

934

Arrangement:

O Y Z W G C-C T V H

No. of Poles:

10

No. of Potentials:

8

No. of Currents:

2

Options:

Black Cover, Screw Terminals

All Switch Arrangements should be checked for adequate current transformer shorting when applied to current transformer circuits.

For a complete listing of available Pole Designations and their description, see below.

Ordering Information - Flexitest Switches

FT-1, FT-1F and FT-1X switches are available in any combination of 1 to 10 poles and FT-14 is available in any combination up to 14 poles. Each different configuration of poles is assigned a unique part number or Style Number by the factory.

All FT switches are ordered by Style Number, see Ordering Information on page 9. The standard FT-1 Style Number defines a unique pole configuration. Adding a prefix and/or suffix to the standard Style Number allows the selection of options for FT-1 as well as the ability to create complete FT-1F and FT-1X Style Numbers. FT-14 Style Numbers are based on a smart part number system

The FT-1 Selection Guide, (Table 1, pages 13-22) and the FT-14 Selection Guide (Table 3, pages 27 & 28) provide a comprehensive listing of existing Style Numbers.

Ordering Examples - “How-To”

The ordering information in Tables 1 and 3 (FT-1 and FT-14 Switch Selection Guides) is organized by number of poles and also by number of potential and current poles. To look up a 10 pole FT-1 switch, go to the 10 pole section of Table 1 and select the desired potential and current pole positions then select the corresponding Style Number.

ex: 10 Poles (6 Potentials, 4 Currents) **P P P P P C-C-C-C** = Style No. 670B197G28

10 Poles (10 Potentials, 0 Currents) **P P P P P P P P P P** = Style No. 129A501G01

An FT-1 switch with black cover and screw terminals will be supplied when ordering the standard Style Number as listed in Table 1, ex: 129A501G01. An optional clear cover will be supplied instead of the black cover by using Style Number prefix “C,” ex: C129A501G01. An FT-1X extended switch with clear cover will be supplied by using prefix “C” and suffix “X10,” ex: C129A501G01X10.

Optional stud and nut terminals are available for all FT switches. Style Number prefix “S” is used for this option, ex: S129A501G01. For optional clear cover with stud and nut terminals use Style Number prefix “CS,” ex: CS129A501G01.

For FT-1, FT-1F, FT-1X, and FT-14 switch requirements not matching an existing Style Number in Tables 1 & 3, select the Style Number that comes closest to the desired configuration and describe the new configuration as similar to the existing Style chosen.

Customers may also place an order by providing a complete Switch Arrangement definition.

ex: **P X P C-C C-C C-C P** (P1 X0 P1 C1-C1 C1-C1 C1-C1 P1).

Reference

- For a breakdown of FT-1 Current and Potential poles by Style Number see Table 2, pages 23 to 26.
- A Typical FT-1 Switch Connection Schematic is given in Figure 14, page 31.
- Refer to page 9 for FT-1, FT-1F, FT-1X and FT-14 Style Number examples, options, and ordering information.



FT Flexitest Switches - Ordering Information

FT-1

10 Pole - Flexitest Switch



- Style Numbers are assigned by the factory. See Tables 1 & 2 (p.13 to p.26).
- Choose from available options by adding Style Prefix as shown.

Example Style Number

1 2 9 A 5 0 1 G 0 1

Style Prefix

- None** = Black cover, screw terminals.
- S** = Black cover, stud & nut terminals.
- C** = Clear cover, screw terminals.
- CS** = Clear cover, stud & nut terminals.
- R** = FT-19R application, screw terminals.
- RS** = FT-19R application, stud & nut terminals.

FT-1X

10 Pole - Extended Terminals



- Style Numbers same as FT-1.
- Choose options (Style Prefix) same as FT-1.
- Choose extended length as shown below.

Example Style Number

1 2 9 A 5 0 1 G 0 1 X 1 0

Style Prefix

Same as FT-1

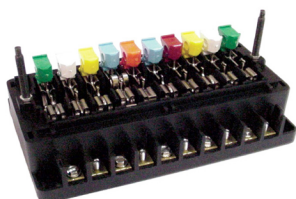
Extended Length

X10 = 10 inches

X08 = 8 inches

FT-1F

10 Pole - Front Connected



- Style Numbers are assigned by the factory. See Tables 1 & 2 (p.13 to p.26).
- Choose from available options by adding Style Prefix as shown.

Example Style Number

F 1 2 9 A 5 0 1 G 0 1

Style Prefix

- F** = Black cover, screw terminals.
- SF** = Black cover, stud & nut terminals.
- CF** = Clear cover, screw terminals.
- CSF** = Clear cover, stud & nut terminals

FT-14

14 Pole Flexitest Switch



(See Table 3, p.27)

FT4 A 14 T 14 C N 4001

Base Type:

FT4 = FT-14

Depth:

A = Standard depth (rear connected)

No. of Poles:

01-14 = Total number of poles used

Terminals:

T = Standard screw terminals

S = Stud & nut terminals

No. of Potentials:

00-14 = Total number of Potential poles

Cover:

C = Clear cover

B = Black cover

Special Features:

N = None

Code No:

4001-4999 = Unique Code Number assigned by the factory,

- For rack mounted assemblies of FT-1 Switches, see Descriptive Bulletin 41-078, FT-19R and FT-19RX Flexitest Switch Assemblies. The typical FT-19R 19" panel can accommodate up to 3 FT-1 switches.
- To build new or view existing FT Switches and FT-19R panels, please visit our interactive FT-1 Configurator website @ <http://ft1switch.com/> (see page 7).



Figure 6. In-Service Series Test Plug

Test Plugs

In-Service Series Test Plug

The "In-Service" Series Test Plug with a maximum of 10 positions is designed to match the pole configurations of specific styles of FT Flexitest devices (either FT-1, FT-1F, FT-1X switches or FT case relays).

This Test Plug is typically used to connect devices measuring the currents and voltages being applied to the switchboard relays, meters and instruments without interrupting or short-circuiting the circuit. Only current test switches with a current jack must be opened before inserting the Series Test Plug. Connections to the test plug must be made before inserting the test plug into an FT switch or relay.



WARNING

Not every switch or relay pole configuration is suitable to accept an In-Service Series Test Plug. For available Styles, see Table 1, page 13, "TEST PLUG" column.

When using an In-Service Series Test Plug for current measurements, connections from the Test Plug to the measuring instruments must be made before inserting the Test Plug in place.



Figure 7. Individual Current Circuit Test Plug

Individual Current Circuit Test Plug

The Individual Current Circuit Test Plug allows in service current measurement with an ammeter. It can be inserted in the current test jack of FT Flexitest devices after opening the knife blade switch. This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and leads carried out through holes in the back of the insulated handle. (See Figures 7 and 8.)

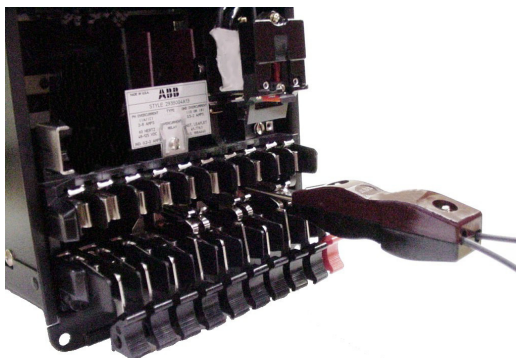


Figure 8. Individual Current Circuit Test Plug inserted in Flexitest Relay Case



WARNING

Connections from the Individual Current Circuit Test Plug to the measuring instrument must be made before inserting the Test Plug in place.

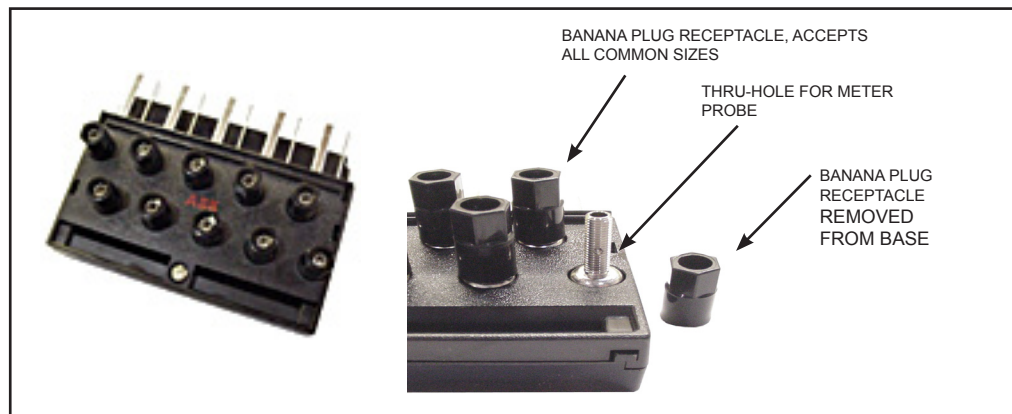


Figure 9. Separate Source Test Plug

The test plug inserts into the current test jack with the red part of the handle facing up allowing the alignment nipple and tab to guide the connector into the test jack.

Separate Source Test Plug

The 10 Position Separate Source Test Plug isolates the external connections from the relay or equipment under test. The test plug accepts all common size banana plugs, ring wire connectors, spade lugs and has a through hole for meter probe or wire connections.

This test plug provides quick circuit testing by fitting into the stationary contact jaws of any Flexitest Type FT Case or Switch. The L-shaped test blades assure quick, accurate alignment between the Test Plug and the stationary contact jaws. The blades connect the relay inputs and outputs to a set of binding banana posts on the top of the Test Plug. An insulated barrier along the bottom of the blades isolates the relay circuits from external connections. Test circuits can then be connected to these binding posts, which are staggered for easy accessibility.



Figure 10. Separate Source Test Plug inserted in Flexitest Relay Case



Before inserting the Separate Source Test Plug into service, all switchblades must be placed in the full open position. In a Flexitest Type FT Case, the plug is inserted in the bottom switch jaw with the binding posts up and in the top test switch jaw with the binding posts down.

Provision is made only on current poles with shorting springs to automatically short-circuit current transformer circuits when the knife switches are opened prior to inserting the Test Plug.

FT Test Kit

The ABB FT test kit comes with a convenient carrying case to hold your hand held meter, test plugs, patch cords, test clips, and test probes in neat order. FT Test Kits can be ordered with your selected quantities of test plugs, patch cords, test clips, and test probes. Patch cords are highly durable and flexible. Contact your local ABB representative for a quotation.

To order the FT Test Kit with items shown shown here, use Style Number 9688A68G18. For more information see "Test Plugs & Accessories - Ordering Information" on page 12.



Test Plugs & Accessories - Ordering Information

Test Plugs		Style Number	
	In-Service Series Test Plug (Order to match Flexitest FT-1 Switch Arrangement or FT Relay Case)	See Table 1 (Page 13)	
	Individual Current Circuit Test Plug - leads not included	7B4618G04	
	Individual Current Circuit Test Plug - leads included ‡	7B4618G05 ‡	
	Separate Source Test Plug (10 position)	1164046	
	Separate Source Test Plug (14 position)	1355D32G04	
Complete FT Test Kit (Includes Red ABB Bag with 12 Year Warranty Logo)		9688A68G18	
	Items in Test Kit 9688A68G18	Rated Voltage	Rated Current
	1 Red 6' safety patch cord with retractable sleeve banana plug on both ends	600 VDC	32A
	1 Black 6' safety patch cord with retractable sleeve banana plug on both ends	600 VDC	32A
	1 Red 10' UTP cable with RJ-45 male connector on both ends.	600V	30A
	1 Red safety plug-on test probe	1000V	10A
	1 Black safety plug-on test probe	1000V	10A
	1 Red safety plug-on alligator test clip	1000V	10A
	1 Black safety plug-on alligator test clip	1000V	10A
	FT Separate Source Test Plug - 1164046	600V	30A
	FT Individual Series Test Plug - 7B4618G04	600V	30A
Covers		FT-1	FT-14
	Standard Cover - BLACK	128A973G01	128A973G03
	Standard Cover - CLEAR	9676A32G01	9676A32G02
	Lockable Cover w/ Locking Bar - BLACK	9669A49G01	9669A49G03
	Lockable Cover w/ Locking Bar - CLEAR	9669A49G02	9669A49G04
	Notched Cover - CLEAR Ø	9654A08G01 Ø	9654A08G03 Ø
	Notched Cover - BLACK Ø	9654A08G02 Ø	9654A08G04 Ø
Interlocking Bars		FT-1	FT-14
	2 Positions	1270547	9669A19G02
	3 Positions	1164048	9669A19G03
	4 Positions	02C9834G03	9669A19G04
	5 Positions	02C9834G04	9669A19G05
	6 Positions	02C9834G06	9669A19G06
	8 Positions	02C9834G07	9669A19G08
	10 Positions	02C9834G05	9669A19G10
	14 Positions	NONE	9669A19G14
Miscellaneous		Style Number	
	FT-1 & FT-14 Nut Driver For Stud & Nut Terminals	877A821G02	
	Unistrut Adapter Plate for Railmount of FT-1F (see Figure 12)	9666A15H01	

‡ = One red and one black lead included, each is 3' safety patch cord with retractable sleeve banana plug connector.

Ø = Bottom end of cover is notched to allow free hanging of identification tags from switch handles.

Table 1 - FT-1 Switch Selection Guide

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
1 0	P	.	.	.	.	.	.	.	.	.	774B542G09	129A062G10
2												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
2 0	.	.	.	.	.	.	.	P	.	P	291B954G15	129A062G10
2 0	.	.	.	P	.	.	P	.	.	.	129A534G01	129A062G10
2 0	P	P	.	.	.	.	.	.	.	.	291B954G13	129A062G10
2 0	T	.	.	.	.	.	.	.	.	T	291B954G14	129A062G10
2 0	T	O	.	.	.	.	.	.	.	.	9688A46G01	129A062G10
2 0	T	T	.	.	.	.	.	.	.	.	291B954G16	129A062G10
2 0	Z	Z	.	.	.	.	.	.	.	.	9676A38G01	129A062G10
0 2	.	.	.	.	.	.	.	C-C	.	.	291B954G12	129A062G01
0 2	.	.	.	.	.	C-C	.	.	.	.	129A531G01	129A062G08
0 2	.	C-C	.	.	.	.	.	.	.	.	498A026G01	129A062G07
0 2	C-C	.	.	.	.	.	.	.	.	.	9689A74G01	129A062G07
3												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
3 0	.	.	.	.	.	.	.	P	P	P	716B871G11	129A062G10
3 0	.	.	.	P	P	P	.	.	.	.	716B871G09	129A062G10
3 0	.	.	.	T	T	T	.	.	.	.	9689A75G01	129A062G10
3 0	.	.	.	Z	Z	Z	.	.	.	.	9688A63G01	129A062G10
3 0	P	.	.	.	P	.	.	.	.	P	716B871G12	129A062G10
3 0	T	Y	O	.	.	.	.	.	.	.	991A939G01	129A062G10
1 2	C-C	.	.	.	.	.	.	.	.	T	9663A78G01	<1>
0 3	.	.	.	C	C	C	.	.	.	.	716B871G10	<1>
4												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
4 0	.	.	.	T	P	T	P	.	.	.	9676A26G01	129A062G10
4 0	.	.	.	T	T	T	P	.	.	.	9676A27G01	129A062G10
4 0	.	.	P	P	P	P	.	.	.	.	129A524G01	129A062G10
4 0	.	.	T	.	T	.	T	.	T	.	291B956G31	129A062G10
4 0	.	.	T	T	T	T	.	.	.	.	1586C39G01	129A062G10
4 0	.	.	T	T	T	T	.	.	.	.	291B956G32	129A062G10
4 0	.	.	Z	Z	Z	Z	.	.	.	.	9689A80G01	129A062G10
4 0	.	P	.	P	.	P	.	P	.	.	9688A64G01	129A062G10
4 0	P	.	.	.	.	.	.	P	P	P	129A506G01	129A062G10
4 0	P	.	.	P	.	.	P	.	.	P	291B956G24	129A062G10
4 0	P	.	.	P	P	P	.	.	.	.	291B956G25	129A062G10
4 0	P	.	.	T	.	.	Y	.	.	Z	9647A17G01	129A062G10
4 0	P	P	.	.	.	.	.	P	P	.	129A538G01	129A062G10
4 0	P	P	P	.	.	.	.	.	.	P	498A022G01	129A062G10
4 0	P	P	P	.	.	.	.	.	.	T	9663A80G01	129A062G10
4 0	P	P	P	P	.	.	.	.	.	.	9672A73G01	129A062G10
4 0	T	.	.	.	.	.	.	P	P	T	763A166G01	129A062G10
4 0	T	.	.	.	.	.	.	T	T	T	498A012G01	129A062G10
4 0	T	.	T	.	.	.	.	T	.	T	862A584G01	129A062G10
4 0	T	T	.	.	.	.	.	P	P	.	991A932G01	129A062G10
4 0	T	T	T	.	.	.	.	.	.	T	1586C39G02	129A062G10

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
4 0	T	T	T	T	.	.	.	.	.	.	9688A79G01	129A062G10
3 1	P	P	C	.	.	.	.	.	.	P	291B956G26	<1>
3 1	P	P	P	S	.	.	.	.	.	.	9688A67G01	<1>
2 2	O	O	C-C	.	.	.	.	.	.	.	9688A25G01	<1>
2 2	P	.	.	.	.	.	.	C-C	.	P	129A507G01	129A062G01
2 2	P	P	.	.	.	.	.	C-C	.	.	291B956G18	129A062G01
2 2	P	P	C-C	.	.	.	.	.	.	.	291B956G30	<1>
2 2	T	.	.	.	.	.	.	C-C	.	P	9671A05G01	129A062G01
2 2	T	T	.	.	.	.	.	C-C	.	.	9676A36G01	129A062G01
2 2	W	W	.	.	.	.	.	C-C	.	.	9688A03G01	129A062G01
1 3	.	.	.	C	C	C	.	.	.	P	291B956G28	<1>
1 3	.	.	.	C-C	C	C	.	.	.	P	991A219G01	<1>
0 4	.	.	.	.	.	C-C	C	C	.	.	291B956G13	129A062G02
0 4	.	C	C	C	C	.	.	.	.	.	291B956G23	<1>
0 4	.	C-A	.	.	.	.	.	C-A	.	.	9666A12G01	<1>
0 4	.	C-C	.	.	.	C-C	.	.	.	.	763A109G01	<1>
0 4	.	C-C	C-C	.	.	.	.	.	.	.	498A027G01	129A062G09
0 4	C	C	C	C	.	.	.	.	.	.	291B956G27	<1>
0 4	C-A	C-A	.	.	.	.	.	.	.	.	9689A12G01	<1>
0 4	C-C	C-C	.	.	.	.	.	.	.	.	291B956G29	<1>
0 4	C-C	C-C	B	.	.	.	.	.	.	.	991A626G01	<1>
0 4	C-C	C-C	C	.	.	.	.	.	.	.	837A087G01	<1>
5												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
5 0	P	P	.	.	.	.	.	P	P	P	129A505G01	129A062G10
5 0	P	P	P	P	P	.	.	.	.	.	291B957G15	129A062G10
5 0	T	T	.	.	.	.	.	T	T	T	9676A37G01	129A062G10
5 0	T	Y	Z	W	P	.	.	.	.	.	9688A55G01	129A062G10
3 2	P	C-C	P	.	.	.	.	.	.	P	129A508G01	129A062G07
3 2	P	P	.	.	.	.	.	C-C	.	P	129A533G01	129A062G01
3 2	P	P	.	.	.	.	.	C-C	.	P	9666A95G01	129A062G01
3 2	P	P	.	.	C-C	.	.	.	.	P	291B957G17	<1>
3 2	P	P	P	C-C	.	.	.	.	.	.	291B957G16	<1>
3 2	T	P	.	.	.	.	.	C-C	.	T	291B957G09	129A062G01
1 4	.	C	C	.	C	.	C	.	.	P	498A002G01	<1>
1 4	C-C	C-C	C	.	.	.	.	.	.	P	9689A54G01	<1>
0 5	C	.	C	.	C	.	C	.	C	.	129A555G01	<1>
6												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
6 0	.	.	.	P	P	P	P	P	P	P	188A416G01	129A062G10
6 0	P	P	.	.	.	.	P	P	P	P	837A889G01	129A062G10
6 0	P	P	.	.	P	P	.	.	P	P	629A568G01	129A062G10
6 0	P	P	P	.	.	.	.	P	P	P	129A504G01	129A062G10
6 0	P	P	P	P	.	.	.	.	P	P	129A550G01	129A062G10
6 0	P	P	P	P	P	P	.	.	.	.	291B958G25	129A062G10
6 0	P	P	T	.	.	.	.	T	T	T	1586C40G01	129A062G10
6 0	T	T	T	T	.	.	.	.	P	P	9683A81G01	129A062G10

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
6 0	T	T	T	T	.	.	.	.	T	T	291B958G33	129A062G10
6 0	T	T	T	T	T	T	.	.	.	.	9676A65G01	129A062G10
6 0	T	Y	O	.	.	.	.	O	Y	T	9688A40G01	129A062G10
6 0	W	W	.	.	P	P	.	.	W	W	9688A04G01	129A062G10
6 0	Y	Y	Y	Y	.	.	.	.	Y	Y	9669A31G01	129A062G10
6 0	Z	Z	Z	P	P	.	.	.	.	P	9666A39G01	129A062G10
4 2	P	.	.	.	.	P	P	C-C	P	.	129A509G01	129A062G01
4 2	P	P	P	P	R-R	.	.	.	.	.	9667A02G01	<1>
4 2	T	T	.	.	.	P	P	.	C-C	.	9672A03G01	<1>
3 3	P	P	.	.	.	.	C	C	C	P	291B958G24	<1>
3 3	P	P	.	.	.	.	C	C-C	P	.	129A543G01	129A062G02
3 3	P	P	P	.	.	.	C	C	C	.	9676A19G01	<1>
2 4	.	.	.	C-C	C-C	P	P	.	.	.	291B958G30	129A062G12
2 4	P	.	.	.	.	C-C	C-C	P	.	.	129A537G01	129A062G02
2 4	P	.	.	.	.	P	C-C	C-C	.	.	291B958G31	<1>
2 4	P	.	.	C	C	C	C	.	.	P	291B958G27	<1>
0 6	.	.	.	C-C	C-C	C-C	.	.	.	.	9672A72G01	<1>
0 6	.	.	.	R-R	7-7	8-8	.	.	.	.	9688A43G01	<1>
0 6	.	.	.	R-R	8-8	7-7	.	.	.	.	9688A30G01	<1>
0 6	.	.	.	8-8	8-8	8-8	.	.	.	.	9689A78G01	292B319G23
0 6	.	.	.	C	C	C	C	C	C	.	188A454G01	<1>
0 6	.	.	.	C-A	C-A	C-A	.	.	.	.	291B958G26	<1>
0 6	.	.	.	C-A	C-A	C-C	.	.	.	.	291B958G29	<1>
0 6	.	.	.	C-B	C-B	C-B	.	.	.	.	498A017G01	<1>
0 6	.	.	.	C-C	C-C	C-C	.	.	.	.	129A516G01	292B319G23
0 6	.	.	.	R-R	R-R	R-R	.	.	.	.	291B958G28	292B319G23
0 6	.	.	C	C	C	C	C	C	.	.	129A523G01	<1>
0 6	.	6-6	.	7-7	.	9-9	.	.	.	.	9666A83G01	<1>
0 6	.	C-C	.	C-C	.	C-C	.	.	.	.	498A014G01	<1>
0 6	.	C-C	C-C	C-C	.	.	.	.	.	.	9683A76G01	<1>
0 6	C	.	C	.	C	.	C	C	C	.	188A304G01	<1>
0 6	C-C	.	.	C-C	.	.	C-C	.	.	.	9689A23G01	<1>
0 6	C-C	C-C	C-C	.	.	.	.	.	.	.	9660A97G01	<1>
7												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
7 0	.	.	.	T	T	T	T	T	T	T	9688A99G01	129A062G10
7 0	.	P	P	P	P	P	P	P	.	.	129A526G01	129A062G10
7 0	P	.	.	P	P	P	.	P	P	P	129A503G01	129A062G10
7 0	P	.	.	P	P	P	P	P	.	P	291B959G19	129A062G10
7 0	P	P	P	.	.	.	P	P	P	P	129A547G01	129A062G10
7 0	P	P	P	.	.	.	P	P	P	P	291B959G30	129A062G10
7 0	P	P	P	P	.	.	P	P	P	.	498A013G01	129A062G10
7 0	P	P	P	P	P	P	.	.	.	T	9663A79G01	129A062G10
7 0	P	P	P	P	P	P	P	.	.	.	291B959G28	129A062G10
7 0	T	.	.	P	P	P	.	P	P	T	763A168G01	129A062G10
7 0	T	T	P	.	.	.	P	P	P	P	291B959G33	129A062G10
5 2	P	C-C	P	.	.	.	P	P	P	.	188A261G01	129A062G07

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
5 2	P	P	.	.	.	C-C	P	P	P	.	129A510G01	129A062G08
5 2	P	P	P	P	P	.	.	.	C-C	.	291B959G27	<1>
5 2	P	P	P	P	P	.	.	C-C	.	.	291B959G18	129A062G01
5 2	T	P	.	.	.	P	P	C-C	T	.	188A622G01	129A062G01
5 2	T	T	.	.	.	R-R	T	T	T	.	9667A17G01	129A062G08
4 3	P	P	C	.	C	.	C	.	P	P	188A477G01	292B319G24
3 4	P	C	C	.	C	.	C	.	P	P	188A618G01	<1>
3 4	P	C-C	.	P	.	C-C	.	P	.	.	9688A83G01	<1>
3 4	P	P	.	.	.	C-C	C-C	P	.	.	129A511G01	129A062G02
3 4	P	P	P	.	.	C-C	C-C	.	.	.	498A008G01	129A062G02
3 4	T	C-C	T	C-C	T	.	.	.	.	.	291B959G26	<1>
3 4	T	T	T	.	.	.	C	C	C	C	291B959G32	<1>
3 4	T	T	T	.	.	C-C	C-C	.	.	.	291B959G20	129A062G02
3 4	T	T	T	.	C-C	.	.	C-C	.	.	9676A79G01	<1>
2 5	C-C	C-C	C-C	T	T	.	.	.	.	.	9682A43G01	<1>
1 6	.	.	.	C-C	C-C	C-C	T	.	.	.	498A003G01	292B319G23
1 6	C-C	C-C	C-C	C-C	.	.	.	T	.	.	9663A77G01	<1>
1 6	P	C-C	C-B	C-B	.	.	.	.	.	.	129A540G01	<1>
1 6	T	.	.	R-R	8-8	7-7	.	.	.	.	991A936G01	<1>
0 7	.	.	C	C-C	C-C	C-C	.	.	.	.	291B959G29	292B319G22
0 7	C-C	C-C	C-C	C	C	.	.	.	.	.	9676A24G01	<1>
8												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
8 0	.	P	P	P	P	P	P	P	P	P	291B960G37	129A062G10
8 0	O	O	O	O	O	O	O	O	.	.	9689A95G01	129A062G10
8 0	P	.	.	P	P	P	P	P	P	P	129A549G01	129A062G10
8 0	P	P	.	P	P	.	P	P	P	P	9689A22G01	129A062G10
8 0	P	P	P	.	.	P	P	P	P	P	719B591G09	129A062G10
8 0	P	P	P	.	P	P	.	P	P	P	291B960G39	129A062G10
8 0	P	P	P	P	.	.	P	P	P	P	129A502G01	129A062G10
8 0	P	P	P	P	.	.	P	P	P	T	129A536G01	129A062G10
8 0	P	P	P	P	P	.	.	P	P	P	129A546G01	129A062G10
8 0	P	P	P	P	P	.	.	P	T	T	719B591G14	129A062G10
8 0	P	P	P	P	P	P	.	.	T	T	9683A80G01	129A062G10
8 0	P	P	P	P	P	P	P	P	.	.	719B591G10	129A062G10
8 0	T	T	.	.	Z	Z	Z	Z	Z	Z	9689A90G01	129A062G10
8 0	T	T	T	.	T	.	O	O	G	G	9689A76G01	129A062G10
8 0	T	T	T	T	.	.	T	T	T	T	9683A10G01	129A062G10
8 0	T	T	T	T	T	.	.	T	T	T	719B591G12	129A062G10
8 0	T	T	T	T	T	T	.	.	T	T	991A937G01	129A062G10
6 2	O	O	C-C	.	.	Z	Z	Z	Z	.	9683A71G01	<1>
6 2	P	P	P	.	.	C-C	P	P	P	P	291B960G26	129A062G08
6 2	P	P	P	P	P	.	.	C-C	P	.	188A632G01	129A062G01
6 2	P	P	P	P	P	P	.	.	C-C	.	291B960G36	<1>
6 2	T	.	.	P	P	P	P	C-C	T	.	763A167G01	129A062G01
6 2	W	W	W	W	W	W	.	.	C-C	.	9689A16G01	<1>
4 4	.	.	P	P	P	C-C	C-C	P	.	.	629A315G01	129A062G02

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
4	4	C-C	C-C	.	.	P	P	P	P	P	719B591G13	<1>
4	4	C-C	C-C	.	P	P	P	P	.	.	719B591G11	<1>
4	4	C-C	C-C	W	W	W	W	.	.	.	9669A32G01	<1>
4	4	P	C-C	P	.	.	P	C-C	P	.	129A512G01	129A062G06
4	4	P	P	.	C	C	C	C	.	P	498A016G01	<1>
4	4	P	P	.	C-C	C-C	.	P	P	.	129A530G01	129A062G12
4	4	P	P	P	P	.	C-C	C-C	.	.	129A544G01	129A062G02
3	5	T	P	.	.	C	C-C	C-C	T	.	291B960G27	292B319G23
2	6	.	C	C	C	C	C	C	.	P	9667A21G01	<1>
2	6	.	C-C	C-C	C-C	.	P	P	.	.	129A521G01	129A062G09
2	6	.	C-C	C-C	C-C	.	T	T	.	.	9683A22G01	129A062G09
2	6	.	C-C	C-C	C-C	P	P	.	.	.	129A525G01	129A062G09
2	6	C-B	C-B	C-B	.	.	P	P	.	.	291B960G38	<1>
2	6	C-C	C-C	C-C	.	.	T	T	.	.	991A938G01	<1>
2	6	T	T	.	.	C-C	C-C	C-C	.	.	9668A69G01	<1>
2	6	Z	Z	.	.	C-C	C-C	C-C	.	.	9688A65G01	<1>
1	7	C	.	.	C-B	C-B	C-B	P	.	.	498A018G01	<1>
1	7	P	.	C	C-C	C-C	C-C	.	.	.	498A019G01	292B319G22
0	8	.	C	C	C	C	C	C	C	.	498A004G01	<1>
0	8	.	C-C	C-C	C-C	C-C	.	.	.	.	129A517G01	292B319G22
0	8	.	C-C	C-C	B	.	C-C	C-C	B	.	498A029G01	<1>
0	8	.	C-C	C-C	B	C-C	C-C	B	.	.	291B960G20	<1>
0	8	.	C-C	C-C	C	C-C	C-C	.	.	.	291B960G33	<1>
0	8	.	R-R	R-R	R-R	R-R	.	.	.	.	9660A84G01	292B319G22
0	8	5-5	.	.	R-R	7-7	8-8	.	.	.	9688A42G01	<1>
0	8	5-5-5-A	.	.	5-5-5-A	.	.	.	.	.	9689A27G01	<1>
0	8	6-6	R-R	5-5	.	.	8-8	.	.	.	9666A78G01	<1>
0	8	C	C	C	C	.	.	C	C	C	188A229G01	<1>
0	8	C-C	.	.	C-C	C-C	C-C	.	.	.	9672A10G01	<1>
0	8	C-C	C-C	C-C	.	.	C-C	.	.	.	1586C41G01	<1>
0	8	C-C	C-C	C-C	C-C	.	.	.	.	.	9689A20G01	<1>
0	8	C-C	C-C	A	.	.	C-C	C-C	A	.	9683A93G01	<1>
0	8	C-C	C-C	A	C-C	C-B	.	.	.	.	837A099G01	<1>
0	8	C-C	C-C	B	.	.	C-C	C-C	B	.	498A025G01	<1>
0	8	C-C	C-C	C	.	.	C-C	C-C	.	.	9666A85G01	<1>
0	8	C-C	C-C	C	C-C	C-B	.	.	.	.	837A098G01	<1>
0	8	D	D	D	C-C	C-C	S	.	.	.	9688A70G01	<1>
9												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
9	0	P	P	.	P	P	P	P	P	P	129A548G01	129A062G10
9	0	P	P	P	P	.	P	P	P	P	129A551G01	129A062G10
9	0	P	P	P	P	.	T	T	T	T	9682A44G01	129A062G10
9	0	P	P	P	P	P	P	P	P	P	9689A21G01	129A062G10
9	0	T	T	T	T	T	T	T	.	O	991A940G01	129A062G10
9	0	T	T	T	T	T	T	T	.	T	9688A45G01	129A062G10
6	3	P	P	P	C	C	C	P	P	P	291B961G23	<1>
6	3	P	P	P	P	.	C	C	C	P	291B961G30	<1>

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
6	3	P	P	P	P	P	.	C	C-C	P	129A552G01	129A062G02
6	3	P	P	P	P	P	.	C-C	C	P	629A483G01	<1>
5	4	P	P	P	P	.	C-C	C-C	P	.	188A633G01	129A062G02
5	4	P	P	P	P	P	.	C-C	C-C	.	291B961G22	<1>
5	4	P	P	P	P	P	C	C	C	C	291B961G28	<1>
5	4	P	P	P	P	P	C-C	C-C	.	.	129A545G01	129A062G02
4	5	P	P	P	P	.	C	C-C	C-B	.	498A028G01	<1>
4	5	P	P	P	P	.	C-C	C-C	E	.	9689A10G01	<1>
3	6	.	T	C-C	T	C-C	T	C-C	.	.	9663A34G01	<1>
3	6	P	C-C	P	C-C	P	C-C	.	.	.	861A551G01	<1>
3	6	P	P	.	C-C	C-C	C-C	P	.	.	129A515G01	292B319G23
3	6	P	P	P	.	C-C	C-C	C-B	.	.	498A024G01	<1>
3	6	P	P	P	C-C	C-C	.	C	C	.	291B961G27	<1>
3	6	P	P	P	C-C	C-C	C-C	.	.	.	291B961G29	292B319G23
3	6	T	T	.	C-C	C-C	C-C	T	.	.	9663A74G01	292B319G23
3	6	T	T	O	.	R-R	8-8	7-7	.	.	9689A56G01	<1>
3	6	T	T	T	.	R-R	8-8	7-7	.	.	9689A57G01	<1>
2	7	P	P	.	C-B	C-B	C-B	S	.	.	291B961G26	<1>
1	8	.	C-C	C-C	C-C	C-C	T	.	.	.	498A009G01	292B319G22
1	8	T	.	C-C	C-C	C-C	C-C	.	.	.	9668A70G01	<1>
0	9	.	C	C-B	C	C-B	C	C-B	.	.	498A023G01	<1>
0	9	C	C-C	C-C	C-C	C-C	.	.	.	.	498A021G01	<1>
0	9	C-C	C-C	C-C	C	.	C-C	.	.	.	9676A25G01	<1>
10												
Poles	A	B	C	D	E	F	G	H	I	J	STYLE NO.	TEST PLUG
10	0	G	G	G	G	G	G	G	G	G	9688A58G01	129A062G10
10	0	G	G	G	G	G	G	G	Y	Y	9689A62G01	129A062G10
10	0	G	G	G	G	G	T	G	T	T	9689A37G01	129A062G10
10	0	G	G	G	G	G	T	T	T	T	9688A57G01	129A062G10
10	0	G	G	G	G	O	O	O	O	O	9666A73G01	129A062G10
10	0	G	G	G	G	Y	Y	Y	Y	Y	9688A26G01	129A062G10
10	0	G	G	G	G	Z	Z	Z	Z	Z	9683A88G01	129A062G10
10	0	G	G	G	G	P	P	T	T	T	9688A56G01	129A062G10
10	0	G	G	G	G	Y	Y	Y	T	T	991A623G01	129A062G10
10	0	G	G	G	G	Y	Y	Y	Y	Y	9683A69G01	129A062G10
10	0	G	G	Y	Y	Y	Y	Y	Y	Y	9682A77G01	129A062G10
10	0	G	O	O	O	O	O	O	O	O	9682A57G01	129A062G10
10	0	G	T	T	G	T	T	T	T	T	9689A65G01	129A062G10
10	0	G	T	T	T	T	T	T	T	G	9682A42G01	129A062G10
10	0	G	T	T	T	T	T	T	T	T	9689A59G01	129A062G10
10	0	G	Y	T	T	T	G	T	T	T	9689A99G01	129A062G10
10	0	O	G	O	P	P	P	P	P	P	9688A13G01	129A062G10
10	0	O	O	O	O	O	O	O	O	O	9672A97G01	129A062G10
10	0	O	O	O	O	O	Y	Y	Y	Y	9688A08G01	129A062G10
10	0	O	O	O	O	O	Z	Z	Z	Z	9666A58G01	129A062G10
10	0	O	O	T	T	T	T	P	P	P	9683A61G01	129A062G10
10	0	O	W	Z	Z	G	W	Y	Y	W	9683A18G01	129A062G10

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
10	0	P	P	G	Y	T	T	T	T	G	G	9669A37G01	129A062G10
10	0	P	P	P	P	G	T	T	P	P	P	9666A50G01	129A062G10
10	0	P	P	P	P	G	T	T	T	P	P	9666A49G01	129A062G10
10	0	P	P	P	P	O	O	O	O	O	O	9666A62G01	129A062G10
10	0	P	P	P	P	P	O	O	T	T		9688A90G01	129A062G10
10	0	P	P	P	P	P	P	P	P	O		991A621G01	129A062G10
10	0	P	P	P	P	P	P	P	P	P	P	129A501G01	129A062G10
10	0	P	P	P	P	P	P	P	P	P	T	774B430G19	129A062G10
10	0	P	P	P	P	P	P	P	P	P	W	991A930G01	129A062G10
10	0	P	P	P	P	P	P	P	P	T	P	9676A88G01	129A062G10
10	0	P	P	P	P	P	P	P	P	T	T	1586C42G23	129A062G10
10	0	P	P	P	P	P	P	P	P	Z	Z	9671A94G01	129A062G10
10	0	P	P	P	P	P	P	T	T	P		9672A77G01	129A062G10
10	0	P	P	P	P	P	P	T	T	T		1586C42G25	129A062G10
10	0	P	P	P	P	P	P	W	P	P		9682A83G01	129A062G10
10	0	P	P	P	P	P	T	P	P	P		1586C42G29	129A062G10
10	0	P	P	P	P	P	T	P	P	T		9676A08G01	129A062G10
10	0	P	P	P	P	P	T	P	T	P		9672A75G01	129A062G10
10	0	P	P	P	P	P	T	P	T	T		1586C42G30	129A062G10
10	0	P	P	P	P	P	T	T	T	P		9672A98G01	129A062G10
10	0	P	P	P	P	P	T	T	T	T		9672A71G01	129A062G10
10	0	P	P	P	P	P	Z	Z	G	T		9688A59G01	129A062G10
10	0	P	P	P	P	P	Z	Z	Z	Z		9671A95G01	129A062G10
10	0	P	P	P	P	T	P	T	P	T		9676A97G01	129A062G10
10	0	P	P	P	P	T	T	T	T	T		1586C42G24	129A062G10
10	0	P	P	P	P	T	T	T	T	T		670B197G21	129A062G10
10	0	P	P	P	P	T	G	T	G	P	P	991A931G01	129A062G10
10	0	P	P	P	P	T	P	P	P	P	P	9688A16G01	129A062G10
10	0	P	P	P	P	T	P	P	P	P	T	9688A96G01	129A062G10
10	0	P	P	P	P	T	P	P	T	P	P	9667A06G01	129A062G10
10	0	P	P	P	P	T	P	T	P	T	P	9682A71G01	129A062G10
10	0	P	P	P	P	T	P	T	T	T	T	1586C42G28	129A062G10
10	0	P	P	P	P	T	T	P	P	P	P	9688A95G01	129A062G10
10	0	P	P	P	P	T	T	T	P	P	P	9676A14G01	129A062G10
10	0	P	P	P	P	T	T	T	T	P	P	9688A28G01	129A062G10
10	0	P	P	P	P	T	T	T	T	T	P	9688A15G01	129A062G10
10	0	P	P	P	P	T	T	T	T	T	T	670B197G26	129A062G10
10	0	P	P	P	P	W	W	T	T	T	T	9683A95G01	129A062G10
10	0	P	P	P	T	P	P	P	P	P	P	9689A79G01	129A062G10
10	0	P	P	P	T	T	P	P	T	T	T	9666A61G01	129A062G10
10	0	P	P	P	T	T	T	T	T	T	P	9672A74G01	129A062G10
10	0	P	P	P	T	T	T	T	T	T	T	9689A32G01	129A062G10
10	0	P	P	T	P	P	P	P	P	P	P	9676A90G01	129A062G10
10	0	P	P	T	P	T	P	P	P	P	P	1586C42G15	129A062G10
10	0	P	P	T	T	P	P	P	P	O	O	9682A45G01	129A062G10
10	0	P	P	T	T	P	P	P	P	P	P	9666A80G01	129A062G10
10	0	P	P	T	T	P	P	T	T	T	T	9689A97G01	129A062G10

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
10	0	P	P	T	T	T	T	P	P	P	P	991A224G01	129A062G10
10	0	P	P	T	T	T	T	P	P	T	T	9652A29G01	129A062G10
10	0	P	P	T	T	T	T	T	P	P	P	9664A98G01	129A062G10
10	0	P	P	T	T	T	T	T	T	P	P	9664A97G01	129A062G10
10	0	P	P	T	T	T	T	T	T	T	T	670B197G24	129A062G10
10	0	P	P	W	W	P	P	P	P	Y	Y	9669A34G01	129A062G10
10	0	P	P	Y	Y	Y	Y	W	W	W	W	9682A76G01	129A062G10
10	0	P	T	P	P	P	P	P	P	P	T	9688A20G01	129A062G10
10	0	P	T	P	P	P	P	P	P	T	T	9688A19G01	129A062G10
10	0	P	T	P	P	T	P	P	T	P	P	9668A27G01	129A062G10
10	0	P	T	P	P	T	T	P	P	T	P	9667A03G01	129A062G10
10	0	P	T	P	T	P	P	T	P	T	P	9670A98G01	129A062G10
10	0	P	T	T	P	P	P	P	P	P	P	9671A69G01	129A062G10
10	0	P	T	T	P	P	P	P	T	T	T	9688A18G01	129A062G10
10	0	P	T	T	T	P	P	T	T	P	P	9676A53G01	129A062G10
10	0	P	T	T	T	T	T	T	T	T	T	9688A17G01	129A062G10
10	0	P	T	W	Z	P	P	T	W	Z	P	9683A97G01	129A062G10
10	0	P	W	T	G	O	Z	T	T	T	T	9688A84G01	129A062G10
10	0	P	Y	P	P	P	P	P	P	P	P	991A229G01	129A062G10
10	0	P	Y	P	Y	P	P	Z	Z	T	T	991A225G01	129A062G10
10	0	P	Y	T	T	T	T	P	P	P	P	991A223G01	129A062G10
10	0	P	Y	T	T	T	T	T	P	P	P	991A228G01	129A062G10
10	0	T	G	T	Z	Z	Z	Z	Z	Z	Z	9688A12G01	129A062G10
10	0	T	O	Y	T	Z	O	O	T	Y	T	9688A44G01	129A062G10
10	0	T	P	P	P	P	P	P	P	P	P	1586C42G31	129A062G10
10	0	T	P	P	P	P	P	P	P	P	T	670B197G36	129A062G10
10	0	T	P	P	P	P	P	P	P	P	W	9664A92G01	129A062G10
10	0	T	P	P	P	P	P	P	P	T	T	9682A59G01	129A062G10
10	0	T	P	P	P	P	T	P	P	P	P	9667A93G01	129A062G10
10	0	T	P	P	P	P	T	T	T	T	P	9682A72G01	129A062G10
10	0	T	P	P	T	P	P	P	P	P	P	9670A35G01	129A062G10
10	0	T	P	P	T	P	P	P	P	T	T	9682A73G01	129A062G10
10	0	T	P	P	T	P	P	T	P	P	P	9670A34G01	129A062G10
10	0	T	P	P	T	P	P	T	P	P	T	9670A97G01	129A062G10
10	0	T	P	T	P	P	P	P	P	P	P	1586C42G06	129A062G10
10	0	T	P	T	P	P	P	P	P	T	T	9682A79G01	129A062G10
10	0	T	P	T	P	P	P	P	T	P	T	1586C42G46	129A062G10
10	0	T	P	T	P	T	P	P	P	P	P	9676A87G01	129A062G10
10	0	T	P	T	P	T	P	T	P	P	P	9676A89G01	129A062G10
10	0	T	P	T	P	T	P	T	P	T	P	9668A54G01	129A062G10
10	0	T	P	T	T	T	P	T	P	T	P	9676A34G01	129A062G10
10	0	T	T	G	G	G	G	G	G	G	G	9689A49G01	129A062G10
10	0	T	T	G	G	G	G	T	T	T	T	9689A50G01	129A062G10
10	0	T	T	G	O	T	T	T	T	T	T	9682A41G01	129A062G10
10	0	T	T	G	T	T	T	T	T	T	T	9676A72G01	129A062G10
10	0	T	T	O	O	Y	Y	T	T	G	G	9688A10G01	129A062G10
10	0	T	T	P	P	P	P	P	P	P	P	1586C42G45	129A062G10

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL	CURRENT												<2>	<3>	<4>	STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J						
10	0	T	T	P	P	P	P	P	P	P	T		9667A78G01		129A062G10		
10	0	T	T	P	P	P	P	P	P	P	W		991A814G01		129A062G10		
10	0	T	T	P	P	P	P	P	P	T	P		9682A70G01		129A062G10		
10	0	T	T	P	P	P	P	P	P	T	T		1586C42G41		129A062G10		
10	0	T	T	P	P	P	P	T	T	P	P		9660A92G01		129A062G10		
10	0	T	T	P	P	P	P	T	T	T	T		991A220G01		129A062G10		
10	0	T	T	P	P	P	T	T	P	P	P		9671A68G01		129A062G10		
10	0	T	T	P	P	T	P	P	P	P	P		9666A93G01		129A062G10		
10	0	T	T	P	P	T	T	P	P	T	T		9667A86G01		129A062G10		
10	0	T	T	P	P	T	T	P	T	T	P		991A221G01		129A062G10		
10	0	T	T	T	G	G	T	P	P	Z	Z		9689A70G01		129A062G10		
10	0	T	T	T	G	Y	Z	Y	O	O	Y		9666A52G01		129A062G10		
10	0	T	T	T	O	O	O	O	O	O	O		9666A45G01		129A062G10		
10	0	T	T	T	O	O	O	O	O	O	O		9682A35G01		129A062G10		
10	0	T	T	T	P	P	P	P	P	P	P		9676A84G01		129A062G10		
10	0	T	T	T	P	P	P	P	T	T	T		9663A25G01		129A062G10		
10	0	T	T	T	P	P	P	T	T	P	P		991A222G01		129A062G10		
10	0	T	T	T	P	P	P	W	P	P	T		991A929G01		129A062G10		
10	0	T	T	T	P	T	T	P	T	T	P		991A230G01		129A062G10		
10	0	T	T	T	P	Y	Y	Y	P	O	P		9682A38G01		129A062G10		
10	0	T	T	T	T	O	O	O	O	O	O		9682A62G01		129A062G10		
10	0	T	T	T	T	P	P	P	P	P	P		670B197G31		129A062G10		
10	0	T	T	T	T	P	P	P	P	T	T		9682A60G01		129A062G10		
10	0	T	T	T	T	P	P	T	T	T	T		9689A31G01		129A062G10		
10	0	T	T	T	T	P	P	W	P	P	P		991A302G01		129A062G10		
10	0	T	T	T	T	T	P	P	P	P	P		9671A13G01		129A062G10		
10	0	T	T	T	T	T	T	G	G	O	O		9682A31G01		129A062G10		
10	0	T	T	T	T	T	T	P	P	P	P		716B562G10		129A062G10		
10	0	T	T	T	T	T	T	P	P	T	P		9666A65G01		129A062G10		
10	0	T	T	T	T	T	T	P	P	Z	Z		9689A69G01		129A062G10		
10	0	T	T	T	T	T	T	T	O	T	T		9689A60G01		129A062G10		
10	0	T	T	T	T	T	T	T	P	P	P		9666A76G01		129A062G10		
10	0	T	T	T	T	T	T	T	T	O	O		9682A66G01		129A062G10		
10	0	T	T	T	T	T	T	T	T	P	P		1586C42G44		129A062G10		
10	0	T	T	T	T	T	T	T	T	T	P		9666A43G01		129A062G10		
10	0	T	T	T	T	T	T	T	T	T	T		129A539G01		129A062G10		
10	0	T	T	T	T	T	T	T	T	T	W		9682A30G01		129A062G10		
10	0	T	T	T	T	T	T	T	T	W	W		9682A67G01		129A062G10		
10	0	T	T	T	T	T	T	T	W	W	W		9682A32G01		129A062G10		
10	0	T	T	T	T	T	T	V	V	V	V		9682A90G01		129A062G10		
10	0	T	T	T	T	T	T	Y	Y	Y	Y		9683A03G01		129A062G10		
10	0	T	T	T	T	T	T	Z	Z	O	O		9682A96G01		129A062G10		
10	0	T	T	T	T	T	T	Z	Z	Z	Z		9672A02G01		129A062G10		
10	0	T	T	T	T	T	Z	Z	Z	Z	Z		9683A06G01		129A062G10		
10	0	T	T	T	T	W	W	W	W	W	W		9682A99G01		129A062G10		
10	0	T	T	T	T	Z	T	T	T	T	T		9664A79G01		129A062G10		
10	0	T	T	T	T	Z	Z	Z	G	G	G		9689A61G01		129A062G10		

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
10	0	T	T	T	T	Z	Z	Z	Z	Z	Z	9688A93G01	129A062G10
10	0	T	T	T	Y	Y	P	P	P	P	P	9676A74G01	129A062G10
10	0	T	T	T	Z	Z	T	T	T	T	T	9664A78G01	129A062G10
10	0	T	T	Y	Y	P	P	P	P	P	P	9676A73G01	129A062G10
10	0	T	T	Y	Y	Z	Z	Z	Z	T	P	9689A08G01	129A062G10
10	0	T	T	Z	Z	P	P	T	G	O	G	9664A88G01	129A062G10
10	0	T	T	Z	Z	T	T	T	T	T	T	9682A29G01	129A062G10
10	0	T	T	Z	Z	T	T	T	T	T	T	9682A37G01	129A062G10
10	0	T	T	Z	Z	Z	Z	Z	Z	Z	Z	9652A26G01	129A062G10
10	0	T	W	P	P	P	P	P	P	P	P	9666A47G01	129A062G10
10	0	T	W	P	W	T	T	W	P	W	T	991A303G01	129A062G10
10	0	T	W	W	W	W	P	P	P	P	P	9682A52G01	129A062G10
10	0	T	Y	Z	P	P	P	P	P	O	O	9666A36G01	129A062G10
10	0	T	Y	Z	T	Y	Z	T	Y	Z	P	9689A40G01	129A062G10
10	0	T	Y	Z	W	G	G	G	G	G	G	9689A36G01	129A062G10
10	0	T	Y	Z	W	G	G	G	G	G	P	9688A54G01	129A062G10
10	0	T	Y	Z	W	P	P	P	G	G	G	9688A52G01	129A062G10
10	0	T	Y	Z	W	P	P	P	P	P	P	9688A53G01	129A062G10
10	0	T	Y	Z	W	T	Y	Z	W	P	P	9666A13G01	129A062G10
10	0	T	Z	P	O	T	G	W	P	O	G	9664A84G01	129A062G10
10	0	W	W	O	O	Y	Y	Z	Z	Y	W	9647A22G01	129A062G10
10	0	W	W	P	P	G	G	P	P	P	P	9669A33G01	129A062G10
10	0	W	W	P	P	P	P	P	P	P	P	991A232G01	129A062G10
10	0	W	W	T	T	T	G	P	P	P	P	9647A21G01	129A062G10
10	0	W	W	T	T	Y	Z	Y	O	O	P	9666A53G01	129A062G10
10	0	W	W	T	T	Y	Z	Y	O	O	Y	9649A37G01	129A062G10
10	0	W	W	W	T	T	T	T	T	T	T	9641A64G01	129A062G10
10	0	W	W	W	W	W	W	W	W	W	T	9646A77G01	129A062G10
10	0	W	W	W	W	W	W	W	W	W	W	9676A93G01	129A062G10
10	0	W	W	W	W	W	Y	Y	Y	Y	Y	9689A63G01	129A062G10
10	0	W	W	W	W	Y	Y	Y	Y	G	G	9688A66G01	129A062G10
10	0	W	Y	Z	Z	Y	Y	G	T	T	T	9683A17G01	129A062G10
10	0	W	Y	Z	Z	Y	Y	O	W	W	W	9683A19G01	129A062G10
10	0	Y	G	Y	G	Y	Y	Y	W	W	W	9688A14G01	129A062G10
10	0	Y	T	G	W	Z	W	T	T	T	P	9666A79G01	129A062G10
10	0	Y	Y	T	T	T	T	T	T	T	T	9666A87G01	129A062G10
10	0	Y	Y	W	W	W	W	W	W	W	W	9688A82G01	129A062G10
10	0	Y	Y	W	W	W	W	Y	Y	Y	Y	9688A73G01	129A062G10
10	0	Y	Y	W	W	Y	Y	W	Y	Y	Y	9688A72G01	129A062G10
10	0	Y	Y	Y	Y	T	T	T	T	T	T	9666A86G01	129A062G10
10	0	Y	Y	Y	Y	W	W	W	W	T	T	9669A41G01	129A062G10
10	0	Y	Y	Y	Y	W	W	W	W	W	W	9688A71G01	129A062G10
10	0	Y	Y	Y	Y	W	W	Y	Y	Y	Y	9689A47G01	129A062G10
10	0	Y	Y	Y	Y	Y	T	T	T	T	T	9688A09G01	129A062G10
10	0	Y	Y	Y	Y	Y	W	W	W	W	W	9688A81G01	129A062G10
10	0	Y	Y	Y	Y	Y	Y	P	P	P	P	9669A38G01	129A062G10
10	0	Y	Y	Y	Y	Y	Y	T	T	P	P	9682A46G01	129A062G10

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
10 0	Y	Y	Y	Y	Y	Y	W	W	W	W	9688A78G01	129A062G10
10 0	Y	Y	Y	Y	Y	Y	W	W	Y	Y	9688A80G01	129A062G10
10 0	Y	Y	Y	Y	Y	Y	T	T	T	T	9689A13G01	129A062G10
10 0	Y	Y	Y	Y	Y	Y	Y	G	G	G	9688A24G01	129A062G10
10 0	Y	Y	Y	Y	Y	Y	Y	T	T	T	9666A90G01	129A062G10
10 0	Y	Y	Y	Y	Y	Y	Y	W	W	W	9688A77G01	129A062G10
10 0	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	9683A01G01	129A062G10
10 0	Y	Y	Z	Z	Z	Z	Z	Z	T	P	9689A09G01	129A062G10
10 0	Z	Z	G	G	G	G	G	G	G	G	9666A77G01	129A062G10
10 0	Z	Z	G	G	G	G	G	W	W	W	9683A75G01	129A062G10
10 0	Z	Z	G	G	G	W	W	W	Y	Y	9683A70G01	129A062G10
10 0	Z	Z	G	G	W	W	W	W	W	W	9688A23G01	129A062G10
10 0	Z	Z	G	G	W	W	Y	Y	Y	Y	9652A27G01	129A062G10
10 0	Z	Z	G	G	W	Y	Y	Y	W	W	9688A74G01	129A062G10
10 0	Z	Z	P	P	P	P	P	P	P	P	9682A65G01	129A062G10
10 0	Z	Z	P	P	W	W	P	P	P	P	991A943G01	129A062G10
10 0	Z	Z	W	W	W	W	W	W	W	W	9688A76G01	129A062G10
10 0	Z	Z	W	W	W	W	W	Y	Y	Y	9683A02G01	129A062G10
10 0	Z	Z	Y	Y	Y	Y	W	W	W	W	9666A92G01	129A062G10
10 0	Z	Z	Y	Y	Y	Y	Y	G	W	W	9663A41G01	129A062G10
10 0	Z	Z	Y	Y	Y	Y	Y	W	W	W	9682A78G01	129A062G10
10 0	Z	Z	Z	O	O	O	O	O	O	O	9688A89G01	129A062G10
10 0	Z	Z	Z	P	P	P	P	P	P	P	9682A89G01	129A062G10
10 0	Z	Z	Z	T	T	T	T	T	T	Z	991A227G01	129A062G10
10 0	Z	Z	Z	Z	O	O	O	O	O	O	9688A88G01	129A062G10
10 0	Z	Z	Z	Z	P	P	P	P	P	P	9682A64G01	129A062G10
10 0	Z	Z	Z	Z	T	T	T	T	T	T	9669A39G01	129A062G10
10 0	Z	Z	Z	Z	Z	O	O	O	O	O	9689A15G01	129A062G10
10 0	Z	Z	Z	Z	Z	Z	O	O	O	O	9688A92G01	129A062G10
10 0	Z	Z	Z	Z	Z	Z	T	T	T	T	9682A19G01	129A062G10
10 0	Z	Z	Z	Z	Z	Z	Z	Z	O	O	9689A91G01	129A062G10
10 0	Z	Z	Z	Z	Z	Z	Z	Z	P	P	9676A81G01	129A062G10
10 0	Z	Z	Z	Z	Z	Z	Z	Z	W	W	9676A91G01	129A062G10
10 0	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	9676A94G01	129A062G10
9 1	C	P	P	P	P	P	P	P	P	P	498A011G01	<1>
9 1	C	T	T	T	T	T	T	T	T	T	1586C42G39	<1>
9 1	O	Y	C	W	G	P	P	T	T	T	9647A19G01	129A062G10
8 2	C-A	P	P	P	P	P	P	P	P	P	714B325G31	<1>
8 2	C-A	T	T	T	T	T	T	T	T	T	9682A80G01	<1>
8 2	C-C	P	P	P	P	P	P	P	P	P	837A665G01	<1>
8 2	C-C	P	P	P	P	T	T	T	T	T	9647A12G01	<1>
8 2	C-C	P	P	T	T	T	T	T	T	T	9647A11G01	<1>
8 2	C-C	T	T	P	P	P	P	P	P	P	9676A86G01	<1>
8 2	C-C	T	T	P	P	T	T	P	P	P	9688A07G01	<1>
8 2	C-C	T	T	T	T	P	P	P	P	P	9647A98G01	<1>
8 2	C-C	T	T	T	T	T	T	P	P	P	9683A72G01	<1>
8 2	C-C	T	T	T	T	T	T	T	T	T	1586C42G20	<1>

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
8 2	C-C	Z	Z	Z	Z	Z	Z	Z	Z	Z	991A944G01	<1>
8 2	O	Y	Z	W	G	C-C	T	V	H	H	991A934G01	<1>
8 2	P	C	C	P	P	P	T	P	P	P	1586C42G32	<1>
8 2	P	P	C-C	P	P	P	P	P	P	P	670B197G33	<1>
8 2	P	P	P	C-C	P	P	P	P	P	P	716B562G21	<1>
8 2	P	P	P	P	P	C-C	P	P	P	P	9689A72G01	<1>
8 2	P	P	P	P	P	P	8-8	Z	Z	Z	9666A28G01	<1>
8 2	P	P	P	P	P	P	C-C	P	P	P	9663A60G01	<1>
8 2	P	P	P	P	P	P	P	C-B	P	P	9666A82G01	<1>
8 2	P	P	P	P	P	P	P	C-C	P	P	129A542G01	129A062G01
8 2	P	P	P	P	P	P	P	C-C	T	T	1586C42G38	129A062G01
8 2	P	P	P	P	P	P	P	P	C-A	A	714B325G30	<1>
8 2	P	P	P	P	P	P	P	P	C-C	C	716B562G26	<1>
8 2	P	P	P	P	P	P	P	P	C-E	E	9682A25G01	<1>
8 2	P	P	P	P	P	P	P	R-R	P	P	9676A15G01	129A062G01
8 2	P	P	P	P	P	T	T	T	C-C	C	991A241G01	<1>
8 2	P	P	P	P	T	T	P	C-C	P	P	716B562G35	129A062G01
8 2	P	P	P	R-R	P	P	P	P	P	P	9682A74G01	<1>
8 2	P	P	P	T	T	T	T	C-C	P	P	9666A42G01	129A062G01
8 2	P	P	P	T	T	T	T	T	C-C	C	991A226G01	<1>
8 2	P	P	R-R	T	P	P	P	P	P	P	9689A25G01	<1>
8 2	P	P	T	T	T	T	T	T	C-C	C	9688A98G01	<1>
8 2	T	P	P	P	P	P	P	C-C	P	P	9672A83G01	129A062G01
8 2	T	P	P	P	P	P	P	C-C	T	T	1586C42G26	129A062G01
8 2	T	T	C-C	P	G	Y	W	Z	O	O	9676A04G01	<1>
8 2	T	T	R-A	T	T	T	T	T	T	T	9689A87G01	<1>
8 2	T	T	R-R	T	T	T	T	T	T	T	991A933G01	<1>
8 2	T	T	T	C-C	P	P	P	P	P	P	9666A69G01	<1>
8 2	T	T	T	S	T	S	O	O	G	G	9689A88G01	<1>
8 2	T	T	T	T	C-C	T	T	T	T	T	1586C42G33	<1>
8 2	T	T	T	T	T	T	5-5	P	P	P	9682A85G01	<1>
8 2	T	T	T	T	T	T	C-A	T	T	T	9688A62G01	<1>
8 2	T	T	T	T	T	T	R-R	T	T	T	9666A34G01	<1>
8 2	T	T	T	T	T	T	T	C-C	T	T	1586C42G47	129A062G01
8 2	T	T	T	T	T	T	T	R-A	T	T	9666A96G01	129A062G01
8 2	T	T	T	T	T	T	T	R-R	T	T	670B197G17	129A062G01
8 2	T	T	T	T	T	T	T	T	C-C	C	9672A89G01	<1>
7 3	P	P	P	P	P	P	C	C-C	P	P	129A553G01	<1>
6 4	6-6	7-7	G	Y	Z	W	O	W	W	W	9666A27G01	<1>
6 4	C	C	P	P	P	P	P	C	C	C	716B562G20	<1>
6 4	C-A	C-A	P	P	P	P	P	P	P	P	714B325G27	<1>
6 4	C-C	C-C	P	P	P	P	P	P	O	O	991A622G01	<1>
6 4	C-C	C-C	P	P	P	P	P	P	P	P	498A015G01	<1>
6 4	C-C	C-C	P	P	P	P	P	P	T	T	1586C42G13	<1>
6 4	C-C	C-C	P	P	P	P	T	T	T	T	9672A80G01	<1>
6 4	C-C	C-C	P	P	P	T	T	T	T	T	991A218G01	<1>
6 4	C-C	C-C	P	P	T	T	T	T	T	T	9676A06G01	<1>

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
6	4	C-C	C-C	T	T	P	P	P	P	P	P	991A334G01	<1>
6	4	C-C	C-C	T	T	T	T	T	T	T	T	9663A31G01	<1>
6	4	C-C	P	P	C-C	P	P	P	P	P	P	716B562G17	<1>
6	4	C-C	P	P	P	P	C-C	P	P	P	P	716B562G19	<1>
6	4	C-C	P	P	P	P	P	P	C-C	P	P	877A077G01	<1>
6	4	C-C	T	T	T	C-C	T	T	T	T	T	9666A97G01	<1>
6	4	C-C-C-A	T	T	T	T	T	T	T	T	T	9683A94G01	<1>
6	4	C-C-C-C	P	P	P	P	P	P	T			1586C42G11	<1>
6	4	C-C-C-C	P	P	P	P	T	T	T			1586C42G12	<1>
6	4	C-C-C-C	T	T	T	T	T	T	T			9672A99G01	<1>
6	4	C-C-C-C	W	W	W	T	T	T	T			9689A38G01	<1>
6	4	C-C-C-E	T	T	T	T	T	T	T			9672A87G01	<1>
6	4	O	O	P	P	P	P	R-6-7-C				9666A37G01	<1>
6	4	P	C-C	C-C	P	P	P	P	P	P	P	716B562G36	<1>
6	4	P	C-C	C-C	T	T	T	T	T	T	T	9682A36G01	<1>
6	4	P	C-C	P	P	P	P	C-C	P			129A513G01	129A062G06
6	4	P	C-C	P	P	P	P	C-C	T			629A735G01	129A062G06
6	4	P	C-C	P	P	P	T	C-C	P			1586C42G22	129A062G06
6	4	P	C-C	P	P	T	T	C-C	T			1586C42G27	129A062G06
6	4	P	C-C-C-C	P	P	P	P	P	P			836A867G01	<1>
6	4	P	P	C	P	C	P	C	P	C	P	991A506G01	292B319G22
6	4	P	P	C-A	C-A	P	P	P	P			714B325G28	<1>
6	4	P	P	C-C	P	P	C-C	P	P			716B562G15	<1>
6	4	P	P	P	C-C	C-C	P	P	P			9689A81G01	129A062G12
6	4	P	P	P	C-C	C-C	T	T	T			9652A30G01	129A062G12
6	4	P	P	P	C-C	P	P	C-C	P			129A520G01	129A062G05
6	4	P	P	P	C-C-C-C	P	P	P	P			991A335G01	<1>
6	4	P	P	P	P	C	C	C	C	P	P	9689A01G01	<1>
6	4	P	P	P	P	C-A	C-A	P	P			714B325G29	<1>
6	4	P	P	P	P	C-C	C-C	P	P			670B197G19	<1>
6	4	P	P	P	P	C-C	P	P	C-C			670B197G34	<1>
6	4	P	P	P	P	P	C-C	C-C	P			129A532G01	129A062G02
6	4	P	P	P	P	P	P	C-A	C-A			714B325G16	<1>
6	4	P	P	P	P	P	P	C-C	C-A			714B325G18	<1>
6	4	P	P	P	P	P	P	C-C	C-C			670B197G28	<1>
6	4	P	P	T	P	P	C-C	C-C	P			9676A09G01	129A062G02
6	4	P	P	T	P	T	P	C-C	C-C			1586C42G14	<1>
6	4	P	T	P	R-C	P	P	R-C	P			9676A71G01	129A062G05
6	4	R-A	R-A	T	T	T	T	T	T			9689A73G01	<1>
6	4	R-R	R-R	O	O	O	O	O	O			9682A98G01	<1>
6	4	R-R	R-R	T	T	T	T	T	T			670B197G25	<1>
6	4	T	P	C	P	C	P	C	P	C	P	670B197G37	292B319G22
6	4	T	P	P	C-C	P	P	C-C	P			9660A91G01	129A062G05
6	4	T	P	P	C-C	T	P	P	C-C			9676A05G01	<1>
6	4	T	P	P	P	P	C-C	C-C	T			849A307G01	<1>
6	4	T	R-E	T	R-E	T	T	T	T			991A231G01	<1>
6	4	T	T	T	R-R	T	T	R-R	T			861A670G01	129A062G05

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
6	4	T	T	T	T	T	T	C-C	C-C			991A235G01	<1>
6	4	T	Y	Z	T	Y	Z	R-6-7-C				9689A42G01	<1>
6	4	Z	Z	O	O	O	O	C-C	C-C			9689A18G01	<1>
5	5	P	P	C	C-C	P	C-C	P	P			670B197G20	<1>
4	6	7-7	7-7	7-7	P	P	O	O				9682A48G01	<1>
4	6	7-7	7-7	7-7	T	T	T	T				9682A49G01	<1>
4	6	7-7	7-7	7-7	Y	Y	Y	Y				9682A50G01	<1>
4	6	8-8	8-8	8-8	W	W	W	W				9682A51G01	<1>
4	6	9-9	9-9	9-9	P	P	P	P				9669A43G01	<1>
4	6	9-9	9-9	9-9	W	W	W	W				9669A36G01	<1>
4	6	C	C	C	C	C	P	P	P	P		774B430G18	<1>
4	6	C	C-C	C-C	C	T	T	T	T			1586C42G21	<1>
4	6	C-C	5-5	R-R	P	P	P	P	P			9666A91G01	<1>
4	6	C-C	C-C	C-C	G	T	T	T				9683A15G01	<1>
4	6	C-C	C-C	C-C	O	O	W	W				9683A21G01	<1>
4	6	C-C	C-C	C-C	O	Y	W	W				9683A20G01	<1>
4	6	C-C	C-C	C-C	P	P	P	P				774B430G20	<1>
4	6	C-C	C-C	C-C	P	P	P	T				1586C42G36	<1>
4	6	C-C	C-C	C-C	P	P	T	T				9671A70G01	<1>
4	6	C-C	C-C	C-C	T	T	P	P				9683A73G01	<1>
4	6	C-C	C-C	C-C	T	T	T	T				774B430G24	<1>
4	6	C-C	C-C	C-C	T	T	W	W				991A238G01	<1>
4	6	C-C	C-C	C-C	Y	Y	Z	Z				991A239G01	<1>
4	6	C-C	C-C	C-C	Z	Z	Y	Y				9666A60G01	<1>
4	6	C-C	P	P	C-C	P	P	C-C				716B562G16	<1>
4	6	C-C	T	P	C-C	C-C	P	T				1586C42G10	<1>
4	6	C-C	C-C	C-C	P	P	P	P				774B430G09	<1>
4	6	C-C	C-C	C-C	P	T	P	T				9676A98G01	<1>
4	6	C-C	C-D	P	L	C-C	T	T				9683A98G01	<1>
4	6	G	G	9-9	9-9	9-9	P	P				9669A42G01	<1>
4	6	L	L	L	L	C-E	C-E	C-E				9660A96G01	<1>
4	6	O	G	T	W	C-C	C-C	C-C				9676A99G01	<1>
4	6	O	O	O	O	C-C	C-C	C-C				9689A14G01	<1>
4	6	O	Y	Y	O	C-C	C-C	C-C				9666A20G01	<1>
4	6	O	Y	Z	8-9	8-6	8-7	P				9683A05G01	292B319G23
4	6	P	C-A	P	C-A	P	C-A	P				9689A04G01	<1>
4	6	P	C-C	C-C	C-C	P	P	P				716B562G37	129A062G09
4	6	P	C-C	C-C	C-C	P	P	P				774B430G10	129A062G09
4	6	P	C-C	P	C-C	P	C-C	P				129A528G01	<1>
4	6	P	G	T	C-C	5-5	R-R	W				9676A58G01	292B319G23
4	6	P	P	C	C	C	C	C	P	P		774B430G21	<1>
4	6	P	P	C	C-C	C-C	C	P	P			714B325G19	<1>
4	6	P	P	C-C	P	P	C-C	C-C				716B562G18	<1>
4	6	P	P	P	6-6	6-6	6-6	P				9664A93G01	292B319G23
4	6	P	P	P	C	C	C	C	C	P		9670A05G01	<1>
4	6	P	P	P	C-A	C-A	C-A	P				9688A22G01	292B319G23
4	6	P	P	P	C-A	P	C-C	C-A				714B325G17	<1>

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
4	6	P	P	P	C-C	C-C	C-C	P				129A514G01	292B319G23
4	6	P	P	P	C-C	C-C	C-C	T				670B197G32	292B319G23
4	6	P	P	P	C-C	C-C	C-C	Z				9671A93G01	292B319G23
4	6	P	P	P	C-C	C-R	C-R	T				1586C42G34	292B319G23
4	6	P	P	P	C-C	P	C-C	C-C				670B197G27	<1>
4	6	P	P	P	G	R-R	R-R	R-R				9688A01G01	<1>
4	6	P	P	P	P	C-A	C-A	C-A				714B325G24	<1>
4	6	P	P	P	P	C-B	C-B	C-B				9666A46G01	<1>
4	6	P	P	P	P	C-C	C-C	C-C				1586C42G05	<1>
4	6	P	P	P	P	C-C	C-C	C-C				670B197G18	<1>
4	6	P	P	P	P	C-C	C-C	C-C				1586C42G37	<1>
4	6	P	P	P	P	P	C-C	C-C				670B197G23	<1>
4	6	P	P	P	P	R-R	R-R	R-R				9660A85G01	<1>
4	6	P	P	P	R-R	R-R	R-R	P				1586C42G03	292B319G23
4	6	P	P	P	R-R	R-R	R-R	W				9688A38G01	292B319G23
4	6	P	P	T	C-C	C-C	C-C	T				1586C42G48	292B319G23
4	6	P	R-R	P	R-R	P	R-R	P				9676A17G01	<1>
4	6	P	T	Z	C-7	8-7	7-C	P				9676A55G01	292B319G23
4	6	P	T	Z	C-8	R-8	7-8	W				9676A68G01	292B319G23
4	6	P	T	Z	W	6-5	8-5	9-5				9689A53G01	<1>
4	6	P	Y	Y	P	C-C	C-C	C-C				9666A55G01	<1>
4	6	P	Y	Z	R-R	6-6	7-6	P				9666A63G01	292B319G23
4	6	P	Y	Z	R-R	6-6	7-7	P				9666A67G01	292B319G23
4	6	R-B	R-B	R-B	T	T	T	T				714B325G20	<1>
4	6	R-R	7-7	C-C	G	Y	T	P				9664A89G01	<1>
4	6	R-R	7-7	C-C	G	Y	W	O				9664A81G01	<1>
4	6	R-R	7-7	C-C	T	G	O	G				9664A87G01	<1>
4	6	R-R	7-7	C-C	T	T	T	P				991A941G01	<1>
4	6	R-R	7-7	C-C	T	Z	P	O				9664A86G01	<1>
4	6	R-R	7-7	C-C	W	P	O	G				9666A88G01	<1>
4	6	R-R	7-7	C-C	W	P	T	G				9664A85G01	<1>
4	6	R-R	7-7	C-C	Y	W	T	G				9666A84G01	<1>
4	6	R-R	R-R	R-R	P	P	P	P				9689A33G01	<1>
4	6	R-R	R-R	R-R	T	T	T	T				9688A11G01	<1>
4	6	T	5-A	T	5-A	T	5-A	T				9689A28G01	<1>
4	6	T	C-C	C-C	C-C	P	P	P				9676A60G01	129A062G09
4	6	T	C-C	T	C-C	T	C-C	T				188A523G01	<1>
4	6	T	C-C	T	C-C	T	C-C	Y				9689A84G01	<1>
4	6	T	O	G	W	R-R	9-9	5-5				9666A72G01	<1>
4	6	T	P	C-C	C-C	C-C	P	P				1586C42G18	<1>
4	6	T	P	P	C-C	C-C	C-C	P				9682A53G01	292B319G23
4	6	T	P	P	P	C-C	C-C	C-C				9664A80G01	<1>
4	6	T	P	P	P	C-C	C-R	C-C				9689A89G01	<1>
4	6	T	P	T	P	C-C	C-C	C-C				9666A94G01	<1>
4	6	T	P	Z	W	R-R	C-C	7-7				9688A87G01	<1>
4	6	T	T	C-C	C-C	C-C	T	T				9667A22G01	<1>
4	6	T	T	P	C-C	C-C	C-C	P				9689A07G01	292B319G23

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
4	6	T	T	P	C-C	C-C	C-C	T				9667A80G01	292B319G23
4	6	T	T	P	P	C-C	C-C	C-C				9672A90G01	<1>
4	6	T	T	T	5-5	5-5	5-5	T				9682A84G01	292B319G23
4	6	T	T	T	5-A	5-A	5-A	T				9689A29G01	292B319G23
4	6	T	T	T	C-C	C-C	C-C	G				9666A59G01	292B319G23
4	6	T	T	T	C-C	C-C	C-C	P				9667A69G01	292B319G23
4	6	T	T	T	C-C	C-C	C-C	T				714B325G32	292B319G23
4	6	T	T	T	C-C	C-C	C-C	W				9676A35G01	292B319G23
4	6	T	T	T	G	C-C	C-C	C-C				9647A23G01	<1>
4	6	T	T	T	P	C-C	C-C	C-C				9676A80G01	<1>
4	6	T	T	T	R-R	R-R	R-R	T				774B430G13	292B319G23
4	6	T	T	T	T	C-C	C-C	C-C				498A010G01	<1>
4	6	T	T	T	T	C-C	C-C	C-C				9676A10G01	<1>
4	6	T	T	T	T	R-R	8-8	7-7				9682A69G01	<1>
4	6	T	T	T	T	R-R	R-R	R-R				9682A39G01	<1>
4	6	T	W	Z	G	R-R	7-7	8-8				9688A41G01	<1>
4	6	T	W	Z	G	R-R	8-8	7-7				9683A07G01	<1>
4	6	T	W	Z	P	R-R	8-8	7-7				991A234G01	<1>
4	6	T	W	Z	R-R	8-8	7-7	P				9683A04G01	292B319G23
4	6	T	Y	P	G	R-R	6-6	C-C				9682A86G01	<1>
4	6	T	Y	Z	8-C	P	R-6-7-C					9689A41G01	<1>
4	6	T	Y	Z	R-R	6-6	7-7	P				9666A44G01	292B319G23
4	6	T	Y	Z	W	C-C	C-C	C-C				9689A06G01	<1>
4	6	W	W	O	O	C-C	C-C	C-C				9666A54G01	<1>
4	6	W	W	O	Y	C-C	C-C	C-C				9666A21G01	<1>
4	6	W	W	W	9-C	9-C	9-C	W				9652A25G01	292B319G23
4	6	W	W	W	W	8-8	8-8	8-8				9682A93G01	<1>
4	6	W	W	W	W	9-9	9-9	9-9				991A624G01	<1>
4	6	W	W	W	W	C-C	C-C	C-C				9688A02G01	<1>
4	6	W	W	Y	O	C-C	C-C	C-C				9647A20G01	<1>
4	6	W	Y	Y	O	C-C	C-C	C-C				9652A28G01	<1>
4	6	Y	T	G	6-6	R-R	5-5	W				9666A66G01	292B319G23
4	6	Y	Y	Y	C-C	C-C	C-C	Y				991A236G01	292B319G23
4	6	Y	Y	Y	R-R	R-R	R-R	Y				9669A30G01	292B319G23
4	6	Z	R-R	Z	R-R	Z	R-R	P				9666A38G01	<1>
4	6	Z	Z	O	O	C-C	C-C	C-C				9689A19G01	<1>
4	6	Z	Z	Z	C-C	C-C	C-C	Z				9672A01G01	292B319G23
4	6	Z	Z	Z	R-R	R-R	R-R	G				9682A82G01	292B319G23
4	6	Z	Z	Z	R-R	R-R	R-R	Z				991A240G01	292B319G23
4	6	Z	Z	Z	W	R-R	6-6	5-5				9689A85G01	<1>
4	6	Z	Z	Z	Z	C-C	C-C	C-C				9676A95G01	<1>
3	7	9-C	6-C	7-C	8	P	G	P				9683A96G01	<1>
3	7	C	Y	Y	Y	C-C	C-C	C-C				9682A97G01	<1>
3	7	C-C	C-C	C-C	C	P	P	P				1586C42G43	<1>
3	7	C-C	P	C-C	P	C-C	P	C				714B325G22	<1>
3	7	L	L	L	U	C-E	C-E	C-E				1485B70G10	<1>
3	7	P	G	T	C-C	5-5	R-R	8				9676A76G01	<1>

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL	CURRENT											<2>	<3>	<4>	STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J					
3	7	P	P	C	C	C	C	C	C	P		716B562G12		<1>		
3	7	P	P	C	C	C	C	C	C	P		129A535G01		292B319G22		
3	7	P	P	C	C	C	C	C	C	T		9672A86G01		292B319G22		
3	7	P	P	P	C	C	C	C	C	C		1586C42G17		<1>		
3	7	P	P	P	C	C	C	C	C	C		9671A26G01		<1>		
3	7	P	P	P	C	B	C	B	C	B	S	716B562G30		<1>		
3	7	P	P	P	C	C	C	C	C	C		1586C42G19		<1>		
3	7	P	P	P	C	C	C	C	C	C		714B325G11		<1>		
3	7	P	P	P	C	C	C	C	C	C		714B325G25		<1>		
3	7	P	P	P	S	C	C	C	C	C		774B430G16		<1>		
3	7	P	P	P	U	C	U	C	U	C	U	1485B70G09		<1>		
3	7	P	T	C	C	C	C	C	C	T		670B197G22		292B319G22		
3	7	R	R	7	7	C	C	C	Y	W	O	9666A89G01		<1>		
3	7	T	O	Y	S	C	8	7	8	5	8	9666A56G01		<1>		
3	7	T	T	C	C	C	C	C	C	T		670B197G35		292B319G22		
3	7	T	T	C	C	C	C	C	C	T		9688A86G01		<1>		
3	7	T	T	T	C	C	5	5	R	R	8	9689A45G01		<1>		
3	7	T	T	T	C	C	C	C	C	C		9663A59G01		<1>		
3	7	T	T	T	C	C	C	C	C	N		291B961G25		<1>		
3	7	T	T	T	C	C	C	C	C	U		1485B70G11		<1>		
3	7	T	T	T	R	R	R	R	R	R		9688A50G01		<1>		
2	8	5	5	5	5	5	5	5	G	G		9683A87G01		<1>		
2	8	6	6	R	R	5	5	8	8	Z	W	9666A64G01		<1>		
2	8	7	7	7	7	7	7	7	W	W		9682A47G01		<1>		
2	8	7	7	7	7	7	7	7	Z	Z		9683A89G01		<1>		
2	8	8	C	8	C	8	C	8	C	P	P	991A237G01		<1>		
2	8	8	C	R	C	5	C	9	C	T	T	9688A85G01		<1>		
2	8	9	9	9	9	9	9	9	G	G		9669A35G01		<1>		
2	8	9	C	6	C	7	C	C	C	T	T	9647A18G01		<1>		
2	8	C	C	C	C	C	C	C	C	P	P	9689A02G01		<1>		
2	8	C	A	P	P	C	C	C	C	C		714B325G21		<1>		
2	8	C	B	C	B	C	B	C	B	P	P	991A942G01		<1>		
2	8	C	C	C	C	C	C	C	C	P	P	837A407G01		<1>		
2	8	C	C	C	C	C	C	C	C	P	T	9672A95G01		<1>		
2	8	C	C	C	C	C	C	C	C	T	P	9676A11G01		<1>		
2	8	C	C	C	C	C	C	C	C	T	T	774B430G22		<1>		
2	8	C	C	C	C	C	C	C	C	W	W	9683A16G01		<1>		
2	8	C	C	C	C	P	C	C	C	C	P	837A664G01		<1>		
2	8	C	C	P	P	C	C	C	C	C		716B562G24		<1>		
2	8	C	C	T	C	C	C	C	C	P		9688A94G01		<1>		
2	8	C	C	T	C	C	C	C	C	T		9667A68G01		<1>		
2	8	C	C	C	B	C	C	C	B	P	P	498A031G01		<1>		
2	8	C	C	C	C	C	C	C	C	P	P	716B562G38		<1>		
2	8	C	C	C	C	C	C	C	C	P	P	714B325G15		<1>		
2	8	C	C	C	C	C	C	C	B	P	P	837A101G01		<1>		
2	8	C	C	C	C	C	C	C	B	T	T	1586C42G42		<1>		
2	8	C	C	C	C	C	C	C	C	P	P	774B430G11		<1>		

POTENTIAL	CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
		A	B	C	D	E	F	G	H	I	J		
2	8	C	C	C	C	C	C	C	C	P	T	1586C42G09	<1>
2	8	C	C	C	C	C	C	C	C	T	P	9671A22G01	<1>
2	8	C	C	C	C	C	C	C	C	T	T	9642A36G01	<1>
2	8	C	C	C	C	P	C	C	C	C	P	9672A94G01	<1>
2	8	C	C	C	C	T	C	C	C	C	T	9676A01G01	<1>
2	8	C	C	C	D	C	C	C	B	P	P	498A032G01	<1>
2	8	C	C	C	D	C	C	C	D	P	P	714B325G13	<1>
2	8	C	C	C	D	C	C	C	D	P	P	774B430G12	<1>
2	8	C	C	C	E	C	C	C	E	T	T	9672A23G01	<1>
2	8	C	C	C	E	T	C	C	C	E	T	9672A88G01	<1>
2	8	C	C	E	C	C	C	C	C	P	P	716B562G39	<1>
2	8	L	C	E	C	E	C	E	C	E	L	9666A23G01	<1>
2	8	O	O	C	C	C	C	C	C	C	C	9682A61G01	<1>
2	8	P	8	8	8	8	8	8	8	8	P	9682A24G01	292B319G22
2	8	P	C	C	C	C	C	C	C	C	P	129A519G01	<1>
2	8	P	C	C	C	C	P	C	C	C	C	716B562G27	<1>
2	8	P	C	C	C	C	C	C	C	P		129A518G01	292B319G22
2	8	P	C	C	C	C	C	C	C	T		1586C42G08	292B319G22
2	8	P	C	C	C	C	C	C	C	T		837A616G01	292B319G22
2	8	P	P	5	5	R	R	6	6	C	C	9682A87G01	<1>
2	8	P	P	9	9	9	9	9	9	9	9	991A625G01	<1>
2	8	P	P	C	C	C	C	C	C	C	C	716B562G25	<1>
2	8	P	P	C	C	C	C	C	C	C	C	9676A96G01	<1>
2	8	P	R	R	8	8	7	7	C	C	P	991A233G01	292B319G22
2	8	P	R	R	R	R	R	R	R	P		9683A99G01	292B319G22
2	8	P	S	P	R	R	R	R	R	C		9676A83G01	<1>
2	8	R	6	7	C	R	6	7	C	O	O	9666A35G01	<1>
2	8	R	B	R	B	R	B	R	B	T	T	714B325G12	<1>
2	8	R	C	R	C	R	C	R	C	T	T	716B562G11	<1>
2	8	R	R	7	7	C	C	9	9	T	G	9664A83G01	<1>
2	8	R	R	7	7	C	C	9	9	T	P	9664A82G01	<1>
2	8	R	R	R	R	R	R	R	R	P	P	9688A91G01	<1>
2	8	R	R	R	R	R	R	R	R	T	T	9666A48G01	<1>
2	8	T	5	5	6	6	7	7	5	5	T	9666A26G01	292B319G22
2	8	T	C	C	C	C	C	C	C	C	P	9671A04G01	<1>
2	8	T	C	C	C	C	C	C	C	C	T	9671A12G01	<1>
2	8	T	C	C	C	C	C	C	C	T		876A157G01	<1>
2	8	T	C	C	C	C	C	C	C	P		670B197G38	292B319G22
2	8	T	C	C	C	C	C	C	C	T		849A513G01	292B319G22
2	8	T	C	C	C	C	C	C	C	Y		9676A75G01	292B319G22
2	8	T	C	C	C	C	C	C	C	P		9666A24G01	<1>
2	8	T	C	C	C	C	C	C	C	P		9689A34G01	<1>
2	8	T	R	R	R	R	R	R	R	T		716B562G28	292B319G22
2	8	T	T	5	5	R	R	8	8	7	7	9682A68G01	<1>
2	8	T	T	9	9	9	9	9	9	9	9	9669A40G01	<1>
2	8	T	T	C	C	C	C	C	C	C	C	1586C42G16	<1>
2	8	T	T	C	C	C	C	C	C	C	C	774B430G28	<1>

Table 1 - FT-1 Switch Selection Guide (continued)

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
2	8	T	T	R-R	8-8	7-7	5-5				991A935G01	<1>
2	8	W	W	C-C	C-C	C-C	C-C				9666A51G01	<1>
2	8	Z	C-C	C-C	C-C	C-C	C-C	Z			9689A77G01	292B319G22
1	9	C	C	C	C	C	C	C	C	P	129A541G01	<1>
1	9	C	C	C	C	C	C	C	C	T	188A286G01	<1>
1	9	C	C	C	C-C	C-C	C-C	P			670B197G16	<1>
1	9	C-C	C-C	C-C	C	C	C-C	P			1586C42G40	<1>
1	9	C-C	C-C	C-C	C	C	C-C	T			1586C42G35	<1>
1	9	P	C-C	C	C-C	C	C-C	C			714B325G23	<1>
1	9	P	C-C	C-B	C	C	C-C	C-B			498A030G01	<1>
1	9	T	8-8	C-C	5-5	R-R	8				9688A48G01	<1>
0	10	5-A	5-A	5-A	5-A	5-A					9689A26G01	<1>
0	10	6-6	6-6	6-6	6-6	6-6					9664A94G01	<1>
0	10	8-8	8-8	8-8	8-8	8-8					9682A94G01	<1>
0	10	C	C	C	C	C	C	C	C	C	129A529G01	<1>
0	10	C	C	C	C	C	C	C	C	C	774B430G17	<1>
0	10	C	C	C	C-C	C-C	C-C	C			9676A18G01	<1>
0	10	C	C	C	C-C	C-C	C-C	C	C		9688A75G01	<1>
0	10	C	C-B	C	C-B	C	C-B	C			716B562G14	<1>
0	10	C	C-C	C-C	C-C	C-C	C				716B562G13	<1>
0	10	C-A	C-A	C-A	C-A	C-A					9689A03G01	<1>
0	10	C-C	5-5	R-R	8-8	8-8					9689A11G01	<1>
0	10	C-C	C-C	C	C	C-C	C-C				714B325G26	<1>
0	10	C-C	C-C	C-C	8-8	8-8					9682A92G01	<1>

POTENTIAL CURRENT	<2> <3> <4>										STYLE NO.	TEST PLUG
	A	B	C	D	E	F	G	H	I	J		
0	10	C-C	C-C	C-C	C-C	8-8					9682A91G01	<1>
0	10	C-C	C-C	C-C	C-C	C	C				774B430G15	<1>
0	10	C-C	C-C	C-C	C-C	C-C					498A020G01	<1>
0	10	C-C	C-C	C-C	C-C	R	R				9676A23G01	<1>
0	10	C-C	C-C	C-C	C-C	C-C					9676A20G01	<1>
0	10	C-C-C-A	C-A	C-A	C-A						9683A92G01	<1>
0	10	C-C-C-A	C-C	C-C	C-A						774B430G14	<1>
0	10	C-C-C-A	C-C	C-C	C-C						1586C42G02	<1>
0	10	C-C-C-B	C-C	C-C	C-B						498A001G01	<1>
0	10	C-C-C-C	C-C	C-C	C-C						714B325G14	<1>
0	10	C-C-C-C	C-C	C-C	C-C						9666A40G01	<1>
0	10	C-C-C-C	C-C	C-C	C-C						774B430G23	<1>
0	10	C-C-C-C	C-C	C-C	C-C	R-R					9666A41G01	<1>
0	10	C-D	C-D	C-D	C-D	C-D					9676A07G01	<1>
0	10	C-E	C-E	C-E	C-E	C-E					714B325G09	<1>
0	10	J	J	J	J	J	J	J	J	J	291B962G31	<1>
0	10	R	R	R	R	R	R	R	R	R	9682A54G01	<1>
0	10	R-6-7-C	R-6-7-C	8-C							9689A43G01	<1>
0	10	R-A	R-A	R-A	R-A	R-A					9689A17G01	<1>
0	10	R-B	R-B	R-B	R-B	R-B					714B325G10	<1>
0	10	R-C	R-C	R-C	R-C	R-C					716B562G09	<1>
0	10	R-R	6-6	7-7	8-8	C-C					9688A51G01	<1>
0	10	R-R	R-R	R-R	R-R	R-R					9663A33G01	<1>

Table 1 Notes:

<1> When a multi-position In-Service Test Plug is not available then the individual current circuit test plug can be used.

<2> A standard FT-1 Switch with screw termination will be supplied when using the Style Number per this table. An optional FT-1 Switch with stud and nut terminals can be supplied at no additional charge provided an "S" prefix is used with FT-1 Switch Style Number (Example: S129A501G01).

<3> A standard FT-1 Switch with black opaque cover will be supplied when using the Style Number per this table. An optional FT-1 Switch with clear cover can be supplied at no additional charge provided a "C" prefix is used with FT-1 Switch Style Number (Example: C129A501G01 or CS129A501G01 for clear cover and stud & nut terminals, per note <2>).

<4> FT-1 Switch styles using the prefix "R" or "RS" can only be used with the FT-19R Assembly (refer to the FT-19R Technical Data and DB 41-078 for more details).

See Ordering Information on page 9.

Table 2 - FT-1 Switch Selection by Style

STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT
129A501G01	10 0	129A550G01	6 0	1586C42G39	9 1	291B958G28	0 6	498A019G01	1 7
129A502G01	8 0	129A551G01	9 0	1586C42G40	1 9	291B958G29	0 6	498A020G01	0 10
129A503G01	7 0	129A552G01	6 3	1586C42G41	10 0	291B958G30	2 4	498A021G01	0 9
129A504G01	6 0	129A553G01	7 3	1586C42G42	2 8	291B958G31	2 4	498A022G01	4 0
129A505G01	5 0	129A555G01	0 5	1586C42G43	3 7	291B958G33	6 0	498A023G01	0 9
129A506G01	4 0	1485B70G09	3 7	1586C42G44	10 0	291B959G18	5 2	498A024G01	3 6
129A507G01	2 2	1485B70G10	3 7	1586C42G45	10 0	291B959G19	7 0	498A025G01	0 8
129A508G01	3 2	1485B70G11	3 7	1586C42G46	10 0	291B959G20	3 4	498A026G01	0 2
129A509G01	4 2	1586C39G01	4 0	1586C42G47	8 2	291B959G26	3 4	498A027G01	0 4
129A510G01	5 2	1586C39G02	4 0	1586C42G48	4 6	291B959G27	5 2	498A028G01	4 5
129A511G01	3 4	1586C40G01	6 0	188A229G01	0 8	291B959G28	7 0	498A029G01	0 8
129A512G01	4 4	1586C41G01	0 8	188A261G01	5 2	291B959G29	0 7	498A030G01	1 9
129A513G01	6 4	1586C42G02	0 10	188A286G01	1 9	291B959G30	7 0	498A031G01	2 8
129A514G01	4 6	1586C42G03	4 6	188A304G01	0 6	291B959G32	3 4	498A032G01	2 8
129A515G01	3 6	1586C42G05	4 6	188A416G01	6 0	291B959G33	7 0	629A315G01	4 4
129A516G01	0 6	1586C42G06	10 0	188A454G01	0 6	291B960G20	0 8	629A483G01	6 3
129A517G01	0 8	1586C42G08	2 8	188A477G01	4 3	291B960G26	6 2	629A568G01	6 0
129A518G01	2 8	1586C42G09	2 8	188A523G01	4 6	291B960G27	3 5	629A735G01	6 4
129A519G01	2 8	1586C42G10	4 6	188A618G01	3 4	291B960G33	0 8	670B197G16	1 9
129A520G01	6 4	1586C42G11	6 4	188A622G01	5 2	291B960G36	6 2	670B197G17	8 2
129A521G01	2 6	1586C42G12	6 4	188A632G01	6 2	291B960G37	8 0	670B197G18	4 6
129A523G01	0 6	1586C42G13	6 4	188A633G01	5 4	291B960G38	2 6	670B197G19	6 4
129A524G01	4 0	1586C42G14	6 4	291B954G12	0 2	291B960G39	8 0	670B197G20	5 5
129A525G01	2 6	1586C42G15	10 0	291B954G13	2 0	291B961G22	5 4	670B197G21	10 0
129A526G01	7 0	1586C42G16	2 8	291B954G14	2 0	291B961G23	6 3	670B197G22	3 7
129A528G01	4 6	1586C42G17	3 7	291B954G15	2 0	291B961G25	3 7	670B197G23	4 6
129A529G01	0 10	1586C42G18	4 6	291B954G16	2 0	291B961G26	2 7	670B197G24	10 0
129A530G01	4 4	1586C42G19	3 7	291B956G13	0 4	291B961G27	3 6	670B197G25	6 4
129A531G01	0 2	1586C42G20	8 2	291B956G18	2 2	291B961G28	5 4	670B197G26	10 0
129A532G01	6 4	1586C42G21	4 6	291B956G23	0 4	291B961G29	3 6	670B197G27	4 6
129A533G01	3 2	1586C42G22	6 4	291B956G24	4 0	291B961G30	6 3	670B197G28	6 4
129A534G01	2 0	1586C42G23	10 0	291B956G25	4 0	291B962G31	0 10	670B197G31	10 0
129A535G01	3 7	1586C42G24	10 0	291B956G26	3 1	498A001G01	0 10	670B197G32	4 6
129A536G01	8 0	1586C42G25	10 0	291B956G27	0 4	498A002G01	1 4	670B197G33	8 2
129A537G01	2 4	1586C42G26	8 2	291B956G28	1 3	498A003G01	1 6	670B197G34	6 4
129A538G01	4 0	1586C42G27	6 4	291B956G29	0 4	498A004G01	0 8	670B197G35	3 7
129A539G01	10 0	1586C42G28	10 0	291B956G30	2 2	498A008G01	3 4	670B197G36	10 0
129A540G01	1 6	1586C42G29	10 0	291B956G31	4 0	498A009G01	1 8	670B197G37	6 4
129A541G01	1 9	1586C42G30	10 0	291B956G32	4 0	498A010G01	4 6	670B197G38	2 8
129A542G01	8 2	1586C42G31	10 0	291B957G09	3 2	498A011G01	9 1	714B325G09	0 10
129A543G01	3 3	1586C42G32	8 2	291B957G15	5 0	498A012G01	4 0	714B325G10	0 10
129A544G01	4 4	1586C42G33	8 2	291B957G16	3 2	498A013G01	7 0	714B325G11	3 7
129A545G01	5 4	1586C42G34	4 6	291B957G17	3 2	498A014G01	0 6	714B325G12	2 8
129A546G01	8 0	1586C42G35	1 9	291B958G24	3 3	498A015G01	6 4	714B325G13	2 8
129A547G01	7 0	1586C42G36	4 6	291B958G25	6 0	498A016G01	4 4	714B325G14	0 10
129A548G01	9 0	1586C42G37	4 6	291B958G26	0 6	498A017G01	0 6	714B325G15	2 8
129A549G01	8 0	1586C42G38	8 2	291B958G27	2 4	498A018G01	1 7	714B325G16	6 4

Table 2 - FT-1 Switch Selection by Style (continued)

STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT
714B325G17	4 6	719B591G12	8 0	9647A17G01	4 0	9664A94G01	0 10	9666A73G01	10 0
714B325G18	6 4	719B591G13	4 4	9647A18G01	2 8	9664A97G01	10 0	9666A76G01	10 0
714B325G19	4 6	719B591G14	8 0	9647A19G01	9 1	9664A98G01	10 0	9666A77G01	10 0
714B325G20	4 6	763A109G01	0 4	9647A20G01	4 6	9666A12G01	0 4	9666A78G01	0 8
714B325G21	2 8	763A166G01	4 0	9647A21G01	10 0	9666A13G01	10 0	9666A79G01	10 0
714B325G22	3 7	763A167G01	6 2	9647A22G01	10 0	9666A20G01	4 6	9666A80G01	10 0
714B325G23	1 9	763A168G01	7 0	9647A23G01	4 6	9666A21G01	4 6	9666A82G01	8 2
714B325G24	4 6	774B430G09	4 6	9647A98G01	8 2	9666A23G01	2 8	9666A83G01	0 6
714B325G25	3 7	774B430G10	4 6	9649A37G01	10 0	9666A24G01	2 8	9666A84G01	4 6
714B325G26	0 10	774B430G11	2 8	9652A25G01	4 6	9666A26G01	2 8	9666A85G01	0 8
714B325G27	6 4	774B430G12	2 8	9652A26G01	10 0	9666A27G01	6 4	9666A86G01	10 0
714B325G28	6 4	774B430G13	4 6	9652A27G01	10 0	9666A28G01	8 2	9666A87G01	10 0
714B325G29	6 4	774B430G14	0 10	9652A28G01	4 6	9666A34G01	8 2	9666A88G01	4 6
714B325G30	8 2	774B430G15	0 10	9652A29G01	10 0	9666A35G01	2 8	9666A89G01	3 7
714B325G31	8 2	774B430G16	3 7	9652A30G01	6 4	9666A36G01	10 0	9666A90G01	10 0
714B325G32	4 6	774B430G17	0 10	9660A84G01	0 8	9666A37G01	6 4	9666A91G01	4 6
716B562G09	0 10	774B430G18	4 6	9660A85G01	4 6	9666A38G01	4 6	9666A92G01	10 0
716B562G10	10 0	774B430G19	10 0	9660A91G01	6 4	9666A39G01	6 0	9666A93G01	10 0
716B562G11	2 8	774B430G20	4 6	9660A92G01	10 0	9666A40G01	0 10	9666A94G01	4 6
716B562G12	3 7	774B430G21	4 6	9660A96G01	4 6	9666A41G01	0 10	9666A95G01	3 2
716B562G13	0 10	774B430G22	2 8	9660A97G01	0 6	9666A42G01	8 2	9666A96G01	8 2
716B562G14	0 10	774B430G23	0 10	9663A25G01	10 0	9666A43G01	10 0	9666A97G01	6 4
716B562G15	6 4	774B430G24	4 6	9663A31G01	6 4	9666A44G01	4 6	9667A02G01	4 2
716B562G16	4 6	774B430G28	2 8	9663A33G01	0 10	9666A45G01	10 0	9667A03G01	10 0
716B562G17	6 4	774B542G09	1 0	9663A34G01	3 6	9666A46G01	4 6	9667A06G01	10 0
716B562G18	4 6	836A867G01	6 4	9663A41G01	10 0	9666A47G01	10 0	9667A17G01	5 2
716B562G19	6 4	837A087G01	0 4	9663A59G01	3 7	9666A48G01	2 8	9667A21G01	2 6
716B562G20	6 4	837A098G01	0 8	9663A60G01	8 2	9666A49G01	10 0	9667A22G01	4 6
716B562G21	8 2	837A099G01	0 8	9663A74G01	3 6	9666A50G01	10 0	9667A68G01	2 8
716B562G24	2 8	837A101G01	2 8	9663A77G01	1 6	9666A51G01	2 8	9667A69G01	4 6
716B562G25	2 8	837A407G01	2 8	9663A78G01	1 2	9666A52G01	10 0	9667A78G01	10 0
716B562G26	8 2	837A616G01	2 8	9663A79G01	7 0	9666A53G01	10 0	9667A80G01	4 6
716B562G27	2 8	837A664G01	2 8	9663A80G01	4 0	9666A54G01	4 6	9667A86G01	10 0
716B562G28	2 8	837A665G01	8 2	9664A78G01	10 0	9666A55G01	4 6	9667A93G01	10 0
716B562G30	3 7	837A889G01	6 0	9664A79G01	10 0	9666A56G01	3 7	9668A27G01	10 0
716B562G35	8 2	849A307G01	6 4	9664A80G01	4 6	9666A58G01	10 0	9668A54G01	10 0
716B562G36	6 4	849A513G01	2 8	9664A81G01	4 6	9666A59G01	4 6	9668A69G01	2 6
716B562G37	4 6	861A551G01	3 6	9664A82G01	2 8	9666A60G01	4 6	9668A70G01	1 8
716B562G38	2 8	861A670G01	6 4	9664A83G01	2 8	9666A61G01	10 0	9669A30G01	4 6
716B562G39	2 8	862A584G01	4 0	9664A84G01	10 0	9666A62G01	10 0	9669A31G01	6 0
716B871G09	3 0	876A157G01	2 8	9664A85G01	4 6	9666A63G01	4 6	9669A32G01	4 4
716B871G10	0 3	877A077G01	6 4	9664A86G01	4 6	9666A64G01	2 8	9669A33G01	10 0
716B871G11	3 0	9641A64G01	10 0	9664A87G01	4 6	9666A65G01	10 0	9669A34G01	10 0
716B871G12	3 0	9642A36G01	2 8	9664A88G01	10 0	9666A66G01	4 6	9669A35G01	2 8
719B591G09	8 0	9646A77G01	10 0	9664A89G01	4 6	9666A67G01	4 6	9669A36G01	4 6
719B591G10	8 0	9647A11G01	8 2	9664A92G01	10 0	9666A69G01	8 2	9669A37G01	10 0
719B591G11	4 4	9647A12G01	8 2	9664A93G01	4 6	9666A72G01	4 6	9669A38G01	10 0

Table 2 - FT-1 Switch Selection by Style (continued)

STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT	STYLE NO.	POTENTIAL CURRENT
9669A39G01	10 0	9676A05G01	6 4	9676A94G01	10 0	9682A74G01	8 2	9683A81G01	6 0
9669A40G01	2 8	9676A06G01	6 4	9676A95G01	4 6	9682A76G01	10 0	9683A87G01	2 8
9669A41G01	10 0	9676A07G01	0 10	9676A96G01	2 8	9682A77G01	10 0	9683A88G01	10 0
9669A42G01	4 6	9676A08G01	10 0	9676A97G01	10 0	9682A78G01	10 0	9683A89G01	2 8
9669A43G01	4 6	9676A09G01	6 4	9676A98G01	4 6	9682A79G01	10 0	9683A92G01	0 10
9670A05G01	4 6	9676A10G01	4 6	9676A99G01	4 6	9682A80G01	8 2	9683A93G01	0 8
9670A34G01	10 0	9676A11G01	2 8	9682A19G01	10 0	9682A82G01	4 6	9683A94G01	6 4
9670A35G01	10 0	9676A14G01	10 0	9682A24G01	2 8	9682A83G01	10 0	9683A95G01	10 0
9670A97G01	10 0	9676A15G01	8 2	9682A25G01	8 2	9682A84G01	4 6	9683A96G01	3 7
9670A98G01	10 0	9676A17G01	4 6	9682A29G01	10 0	9682A85G01	8 2	9683A97G01	10 0
9671A04G01	2 8	9676A18G01	0 10	9682A30G01	10 0	9682A86G01	4 6	9683A98G01	4 6
9671A05G01	2 2	9676A19G01	3 3	9682A31G01	10 0	9682A87G01	2 8	9683A99G01	2 8
9671A12G01	2 8	9676A20G01	0 10	9682A32G01	10 0	9682A89G01	10 0	9688A01G01	4 6
9671A13G01	10 0	9676A23G01	0 10	9682A35G01	10 0	9682A90G01	10 0	9688A02G01	4 6
9671A22G01	2 8	9676A24G01	0 7	9682A36G01	6 4	9682A91G01	0 10	9688A03G01	2 2
9671A26G01	3 7	9676A25G01	0 9	9682A37G01	10 0	9682A92G01	0 10	9688A04G01	6 0
9671A68G01	10 0	9676A26G01	4 0	9682A38G01	10 0	9682A93G01	4 6	9688A07G01	8 2
9671A69G01	10 0	9676A27G01	4 0	9682A39G01	4 6	9682A94G01	0 10	9688A08G01	10 0
9671A70G01	4 6	9676A34G01	10 0	9682A41G01	10 0	9682A96G01	10 0	9688A09G01	10 0
9671A93G01	4 6	9676A35G01	4 6	9682A42G01	10 0	9682A97G01	3 7	9688A10G01	10 0
9671A94G01	10 0	9676A36G01	2 2	9682A43G01	2 5	9682A98G01	6 4	9688A11G01	4 6
9671A95G01	10 0	9676A37G01	5 0	9682A44G01	9 0	9682A99G01	10 0	9688A12G01	10 0
9672A01G01	4 6	9676A38G01	2 0	9682A45G01	10 0	9683A01G01	10 0	9688A13G01	10 0
9672A02G01	10 0	9676A53G01	10 0	9682A46G01	10 0	9683A02G01	10 0	9688A14G01	10 0
9672A03G01	4 2	9676A55G01	4 6	9682A47G01	2 8	9683A03G01	10 0	9688A15G01	10 0
9672A10G01	0 8	9676A58G01	4 6	9682A48G01	4 6	9683A04G01	4 6	9688A16G01	10 0
9672A23G01	2 8	9676A60G01	4 6	9682A49G01	4 6	9683A05G01	4 6	9688A17G01	10 0
9672A71G01	10 0	9676A65G01	6 0	9682A50G01	4 6	9683A06G01	10 0	9688A18G01	10 0
9672A72G01	0 6	9676A68G01	4 6	9682A51G01	4 6	9683A07G01	4 6	9688A19G01	10 0
9672A73G01	4 0	9676A71G01	6 4	9682A52G01	10 0	9683A10G01	8 0	9688A20G01	10 0
9672A74G01	10 0	9676A72G01	10 0	9682A53G01	4 6	9683A15G01	4 6	9688A22G01	4 6
9672A75G01	10 0	9676A73G01	10 0	9682A54G01	0 10	9683A16G01	2 8	9688A23G01	10 0
9672A77G01	10 0	9676A74G01	10 0	9682A57G01	10 0	9683A17G01	10 0	9688A24G01	10 0
9672A80G01	6 4	9676A75G01	2 8	9682A59G01	10 0	9683A18G01	10 0	9688A25G01	2 2
9672A83G01	8 2	9676A76G01	3 7	9682A60G01	10 0	9683A19G01	10 0	9688A26G01	10 0
9672A86G01	3 7	9676A79G01	3 4	9682A61G01	2 8	9683A20G01	4 6	9688A28G01	10 0
9672A87G01	6 4	9676A80G01	4 6	9682A62G01	10 0	9683A21G01	4 6	9688A30G01	0 6
9672A88G01	2 8	9676A81G01	10 0	9682A64G01	10 0	9683A22G01	2 6	9688A38G01	4 6
9672A89G01	8 2	9676A83G01	2 8	9682A65G01	10 0	9683A61G01	10 0	9688A40G01	6 0
9672A90G01	4 6	9676A84G01	10 0	9682A66G01	10 0	9683A69G01	10 0	9688A41G01	4 6
9672A94G01	2 8	9676A86G01	8 2	9682A67G01	10 0	9683A70G01	10 0	9688A42G01	0 8
9672A95G01	2 8	9676A87G01	10 0	9682A68G01	2 8	9683A71G01	6 2	9688A43G01	0 6
9672A97G01	10 0	9676A88G01	10 0	9682A69G01	4 6	9683A72G01	8 2	9688A44G01	10 0
9672A98G01	10 0	9676A89G01	10 0	9682A70G01	10 0	9683A73G01	4 6	9688A45G01	9 0
9672A99G01	6 4	9676A90G01	10 0	9682A71G01	10 0	9683A75G01	10 0	9688A46G01	2 0
9676A01G01	2 8	9676A91G01	10 0	9682A72G01	10 0	9683A76G01	0 6	9688A48G01	1 9
9676A04G01	8 2	9676A93G01	10 0	9682A73G01	10 0	9683A80G01	8 0	9688A50G01	3 7

Table 2 - FT-1 Switch Selection by Style (continued)

STYLE NO.	POTENTIAL CURRENT
9688A51G01	0 10
9688A52G01	10 0
9688A53G01	10 0
9688A54G01	10 0
9688A55G01	5 0
9688A56G01	10 0
9688A57G01	10 0
9688A58G01	10 0
9688A59G01	10 0
9688A62G01	8 2
9688A63G01	3 0
9688A64G01	4 0
9688A65G01	2 6
9688A66G01	10 0
9688A67G01	3 1
9688A70G01	0 8
9688A71G01	10 0
9688A72G01	10 0
9688A73G01	10 0
9688A74G01	10 0
9688A75G01	0 10
9688A76G01	10 0
9688A77G01	10 0
9688A78G01	10 0
9688A79G01	4 0
9688A80G01	10 0
9688A81G01	10 0
9688A82G01	10 0
9688A83G01	3 4
9688A84G01	10 0
9688A85G01	2 8
9688A86G01	3 7
9688A87G01	4 6
9688A88G01	10 0
9688A89G01	10 0
9688A90G01	10 0
9688A91G01	2 8
9688A92G01	10 0
9688A93G01	10 0
9688A94G01	2 8
9688A95G01	10 0
9688A96G01	10 0
9688A98G01	8 2
9688A99G01	7 0
9689A01G01	6 4
9689A02G01	2 8
9689A03G01	0 10

STYLE NO.	POTENTIAL CURRENT
9689A04G01	4 6
9689A06G01	4 6
9689A07G01	4 6
9689A08G01	10 0
9689A09G01	10 0
9689A10G01	4 5
9689A11G01	0 10
9689A12G01	0 4
9689A13G01	10 0
9689A14G01	4 6
9689A15G01	10 0
9689A16G01	6 2
9689A17G01	0 10
9689A18G01	6 4
9689A19G01	4 6
9689A20G01	0 8
9689A21G01	9 0
9689A22G01	8 0
9689A23G01	0 6
9689A25G01	8 2
9689A26G01	0 10
9689A27G01	0 8
9689A28G01	4 6
9689A29G01	4 6
9689A31G01	10 0
9689A32G01	10 0
9689A33G01	4 6
9689A34G01	2 8
9689A36G01	10 0
9689A37G01	10 0
9689A38G01	6 4
9689A40G01	10 0
9689A41G01	4 6
9689A42G01	6 4
9689A43G01	0 10
9689A45G01	3 7
9689A47G01	10 0
9689A49G01	10 0
9689A50G01	10 0
9689A53G01	4 6
9689A54G01	1 4
9689A56G01	3 6
9689A57G01	3 6
9689A59G01	10 0
9689A60G01	10 0
9689A61G01	10 0
9689A62G01	10 0

STYLE NO.	POTENTIAL CURRENT
9689A63G01	10 0
9689A65G01	10 0
9689A69G01	10 0
9689A70G01	10 0
9689A72G01	8 2
9689A73G01	6 4
9689A74G01	0 2
9689A75G01	3 0
9689A76G01	8 0
9689A77G01	2 8
9689A78G01	0 6
9689A79G01	10 0
9689A80G01	4 0
9689A81G01	6 4
9689A84G01	4 6
9689A85G01	4 6
9689A87G01	8 2
9689A88G01	8 2
9689A89G01	4 6
9689A90G01	8 0
9689A91G01	10 0
9689A95G01	8 0
9689A97G01	10 0
9689A99G01	10 0
991A218G01	6 4
991A219G01	1 3
991A220G01	10 0
991A221G01	10 0
991A222G01	10 0
991A223G01	10 0
991A224G01	10 0
991A225G01	10 0
991A226G01	8 2
991A227G01	10 0
991A228G01	10 0
991A229G01	10 0
991A230G01	10 0
991A231G01	6 4
991A232G01	10 0
991A233G01	2 8
991A234G01	4 6
991A235G01	6 4
991A236G01	4 6
991A237G01	2 8
991A238G01	4 6
991A239G01	4 6
991A240G01	4 6

STYLE NO.	POTENTIAL CURRENT
991A241G01	8 2
991A302G01	10 0
991A303G01	10 0
991A334G01	6 4
991A335G01	6 4
991A506G01	6 4
991A621G01	10 0
991A622G01	6 4
991A623G01	10 0
991A624G01	4 6
991A625G01	2 8
991A626G01	0 4
991A814G01	10 0
991A929G01	10 0
991A930G01	10 0
991A931G01	10 0
991A932G01	4 0
991A933G01	8 2
991A934G01	8 2
991A935G01	2 8
991A936G01	1 6
991A937G01	8 0
991A938G01	2 6
991A939G01	3 0
991A940G01	9 0
991A941G01	4 6
991A942G01	2 8
991A943G01	10 0
991A944G01	8 2

Table 3 - FT-14 Switch Selection Guide

POTENTIAL CURRENT	ARRANGEMENT														STYLE NO.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
11 0	T	T	T	T	T	T	T	T	T	T	T	T	T	T	FT4A11T11CN4004
5 6	T	T	T	C-C	C-C	C-C	C-C	Y	Y	.	.	.	.	.	FT4A11T05CN4102
3 8	C-C	C-C	C-C	C-C	C-C	T	T	T	.	.	.	.	.	.	FT4A11T03CN4104
3 8	C-C	C-C	C-C	C-C	C-C	Z	Z	Z	.	.	.	.	.	.	FT4A11T03CN4006
12															
Pole	A	B	C	D	E	F	G	H	I	J	K	L	M	N	STYLE NO.
12 0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	FT4A12T12CN4007
12 0	T	T	T	T	T	T	T	T	T	T	T	T	T	T	FT4A12T12CN4008
6 6	P	P	P	P	R-R	R-R	R-R	R-R	Z	Z	.	.	.	.	FT4A12T06CN4091
4 8	.	C-C	C-C	C-C	C-C	C-C	T	T	T	T	T	.	.	.	FT4A12T04CN4010
4 8	C-C	C-C	C-C	C-C	C-C	T	T	P	P	.	.	.	.	.	FT4A12T04CN4011
4 8	C-C	C-C	C-C	C-C	C-C	Z	Z	Z	Z	.	.	.	.	.	FT4A12T04CN4012
4 8	P	P	P	C-C	C-C	C-C	C-C	T	.	.	.	.	.	.	FT4A12T04CN4076
4 8	T	T	T	W	.	.	C-C	C-C	C-C	C-C	.	.	.	.	FT4A12T04CN4013
0 12	C-C	C-C	C-C	.	C-C	C-C	C-C	.	.	.	.	.	.	.	FT4A12T00CN4079
0 12	C-C	C-C	C-C	C-C	C-C	C-C	C-C	.	.	.	.	.	.	.	FT4A12T00CN4014
13															
Pole	A	B	C	D	E	F	G	H	I	J	K	L	M	N	STYLE NO.
13 0	T	T	T	T	T	T	T	T	T	T	T	T	T	T	FT4A13T13CN4015
9 4	P	P	P	C-C	P	P	P	C-C	P	P	P	.	.	.	FT4A13T09CN4084
0 13	C	.	C-5	C-5	C-5	C-5	C-5	C-5	C-5	C-5	.	.	.	.	FT4A13T00CN4088
14															
Pole	A	B	C	D	E	F	G	H	I	J	K	L	M	N	STYLE NO.
14 0	G	G	G	G	G	G	G	G	G	G	G	G	G	G	FT4A14T14CN4083
14 0	P	P	G	Y	Z	Z	T	T	T	T	T	T	T	T	FT4A14T14CN4017
14 0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	FT4A14T14CN4001
14 0	P	P	P	P	T	T	T	T	T	T	T	T	T	T	FT4A14T14CN4080
14 0	T	P	T	P	T	P	T	P	T	P	T	P	T	P	FT4A14T14CN4066
14 0	T	T	T	T	P	P	P	P	P	P	P	P	P	P	FT4A14T14CN4073
14 0	T	T	T	T	T	T	T	T	T	T	T	T	T	T	FT4A14T14CN4018
14 0	T	Y	Z	T	Y	Y	Z	Z	P	P	P	Y	Y	Y	FT4A14T14CN4071
14 0	W	W	W	W	W	W	W	W	W	W	W	W	W	W	FT4A14T14CN4090
14 0	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	FT4A14T14CN4078
12 2	C-C	P	P	P	P	P	P	T	T	T	T	T	T	T	FT4A14T12CN4085
10 4	T	T	T	T	T	T	T	P	P	C-C	C-C	.	.	.	FT4A14T10CN4086
8 6	C	C	C	C	C	C	P	P	P	P	T	T	T	T	FT4A14T08CN4092
8 6	C-C	C-C	C-C	C-C	P	P	P	P	P	P	P	P	P	P	FT4A14T08CN4067
8 6	C-C	C-C	C-C	C-C	P	P	P	P	T	T	T	T	T	T	FT4A14T08CN4021
8 6	C-C	C-C	C-C	C-C	P	P	P	T	T	T	T	T	T	T	FT4A14T08CN4077
8 6	C-C	C-C	C-C	C-C	T	T	T	T	P	P	P	P	P	P	FT4A14T08CN4022
8 6	C-C	C-C	C-C	C-C	T	T	T	T	T	T	T	T	T	T	FT4A14T08CN4023
8 6	C-C	C-C	C-C	C-C	T	T	T	T	Y	Y	Y	Y	Y	Y	FT4A14T08CN4024
8 6	C-C	C-C	C-C	C-C	T	T	Y	Y	Y	Y	Y	Y	Y	Y	FT4A14T08CN4025
8 6	C-C	C-C	C-C	C-C	Z	Z	Z	Y	Y	Y	Y	Y	Y	Y	FT4A14T08CN4026
8 6	C-C	C-C	C-C	C-C	Z	Z	Z	Z	T	Y	Y	Y	Y	Y	FT4A14T08CN4027

POTENTIAL CURRENT	ARRANGEMENT														STYLE NO.
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	
8 6	C-C	C-C	C-C	C-C	P	P	P	P	T	T	T	T	T	T	FT4A14T08CN4093
8 6	P	P	P	C-C	C-C	C-C	C-C	P	P	P	P	P	P	P	FT4A14T08CN4003
8 6	P	P	P	C-C	C-C	C-C	C-C	P	T	P	P	P	P	P	FT4A14T08CN4028
8 6	T	P	O	O	P	P	P	G	C-C	C-C	C-C	.	.	.	FT4A14T08CN4101
8 6	T	T	C-C	C-C	C-C	W	W	W	W	W	W	W	W	W	FT4A14T08CN4097
8 6	T	T	T	C-C	C-C	C-C	T	T	T	T	T	T	T	T	FT4A14T08CN4030
8 6	T	T	T	C-C	C-C	C-C	W	G	O	Y	Z	.	.	.	FT4A14T08CN4031
8 6	T	T	T	T	C-C	C-C	C-C	T	T	T	T	T	T	T	FT4A14T08CN4032
8 6	T	T	T	T	T	T	T	T	C-C	C-C	C-C	.	.	.	FT4A14T08CN4099
8 6	T	Y	Z	R-R	6-6	7-7	P	P	P	Y	Y	.	.	.	FT4A14T08CN4072
7 7	P	P	P	P	P	P	P	C-C	C-C	C-C	C-C	.	.	.	FT4A14T07CN4033
7 7	P	P	T	T	P	P	P	C-C	C-C	C-C	C-C	.	.	.	FT4A14T07CN4034
6 8	C-C	C-C	C-C	C-C	C-C	P	P	P	P	P	P	P	P	P	FT4A14T06CN4068
6 8	C-C	C-C	C-C	C-C	C-C	P	P	P	P	T	T	.	.	.	FT4A14T06CN4035
6 8	C-C	C-C	C-C	C-C	C-C	T	T	P	P	P	P	P	P	P	FT4A14T06CN4036
6 8	C-C	C-C	C-C	C-C	C-C	T	T	T	T	T	T	T	T	T	FT4A14T06CN4037
6 8	C-C	C-C	C-C	C-C	C-C	T	Y	Y	Y	Y	Y	Y	Y	Y	FT4A14T06CN4038
6 8	C-C	C-C	C-C	C-C	C-C	Z	O	Y	G	P	T	.	.	.	FT4A14T06CN4064
6 8	C-C	C-C	C-C	C-C	C-C	Z	Z	Z	Y	Y	Y	.	.	.	FT4A14T06CN4040
6 8	P	C-C	C-C	C-C	C-C	C-C	P	P	P	P	P	P	P	P	FT4A14T06CN4002
6 8	P	P	O	O	O	O	R-R	6-6	7-7	8-8	.	.	.	.	FT4A14T06CN4043
6 8	P	P	P	C-C	C-C	C-C	C-C	C-C	P	P	P	P	P	P	FT4A14T06CN4044
6 8	P	P	P	P	C-C	C-C	C-C	C-C	C-C	P	P	P	P	P	FT4A14T06CN4065
6 8	P	P	P	P	C-C	C-C	C-C	C-C	C-C	T	T	.	.	.	FT4A14T06CN4045
6 8	P	P	P	P	P	P	P	C-C	C-C	C-C	C-C	.	.	.	FT4A14T06CN4046
6 8	R-R	R-R	R-R	R-R	R-R	P	P	P	P	P	P	P	P	P	FT4A14T06CN4095
6 8	T	C-C	C-C	C-C	C-C	C-C	P	P	P	P	P	P	P	P	FT4A14T06CN4103
6 8	T	C-C	T	C-C	T	C-C	T	C-C	T	C-C	T	T	.	.	FT4A14T06CN4048
6 8	T	P	T	O	O	O	C-C	C-C	C-C	5-5	.	.	.	.	FT4A14T06CN4100
6 8	T	T	C-C	C-C	C-C	C-C	W	W	W	W	.	.	.	.	FT4A14T06CN4096
6 8	T	T	T	C-C	C-C	C-C	C-C	8-8	W	P	P	.	.	.	FT4A14T06CN4049
6 8	T	T	T	C-C	C-C	C-C	C-C	T	T	T	.	.	.	.	FT4A14T06CN4050
6 8	T	T	T	C-C	C-C	C-C	T	C-C	T	T	.	.	.	.	FT4A14T06CN4051
6 8	T	T	T	T	C-C	C-C	C-C	C-C	C-C	T	T	.	.	.	FT4A14T06CN4052
6 8	T	T	T	T	T	T	T	C-C	C-C	C-C	C-C	.	.	.	FT4A14T06CN4053
6 8	T	T	T	T	Z	Z	C-C	C-C	C-C	C-C	.	.	.	.	FT4A14T06CN4054
6 8	T	T	T	Z	Z	Z	C-C	C-C	C-C	C-C	.	.	.	.	FT4A14T06CN4055
6 8	Z	Z	Z	Z	Z	C-C	C-C	C-C	C-C	C-C	T	T	.	.	FT4A14T06CN4074
6 8	Z	Z	Z	Z	Z	Z	C-C	C-C	C-C	C-C	.	.	.	.	FT4A14T06CN4056
5 9	T	P	P	P	P	C-C	C-C	C-C	C-C	C-C	.	.	.	.	FT4A14T05CN4057
4 10	9-9	9-9	9-9	9-9	Z	Z	Z	9-9	9-9	9-9	Z	.	.	.	FT4A14T04CN4058
4 10	C-C	C-C	C-C	C-C	P	T	T	T	C-C	C-C	C-C	.	.	.	FT4A14T04CN4081
4 10	C-R	5-6	C	P	P	C-7	8-9	C	P	P	.	.	.	.	FT4A14T04CN4082
4 10	P	P	C-C	C-C	C-C	C-C	C-C	C-C	P	P	.	.	.	.	FT4A14T04CN4059
2 12	9-9	9-9	9-9	9-9	9-9	Z	9-9	9-9	9-9	Z	.	.	.	.	FT4A14T02CN4060

Table 3 - FT-14 Switch Selection Guide (continued)

POTENTIAL	CURRENT	ARRANGEMENT														STYLE NO.
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
2	12	C	C	C	C	C	C	C	C	C	C	C	P	P		FT4A14T02CN4094
2	12	C-C	C-C	C-C	C-C	C-C	C-C	C-C	C-C	P	P					FT4A14T02CN4098
2	12	C-C	C-C	C-C	C-C	C-C	C-C	C-C	C-C	T	T					FT4A14T02CN4061
2	12	C-C-C-C	C-C	C-C	C-C	C-C	C-C	P	P							FT4A14T02CN4069
2	12	P	C-C	C-C	C-C	C-C	C-C	C-C	P							FT4A14T02CN4075

POTENTIAL	CURRENT	ARRANGEMENT														STYLE NO.
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	
2	12	T	T	C-C	C-C	C-C	C-C	C-C	C-C	C-C						FT4A14T02CN4062
0	14	C-5	C-5	C-5	C	C-5	C-5	C-5	C-5	C						FT4A14T00CN4089
0	14	C-5	C-5	C-5	C-5	C-5	C-5	C-5	C-5							FT4A14T00CN4087
0	14	C-C	C-C	C-C	C-C	C-C	C-C	C-C	C-C	C-C						FT4A14T00CN4063
0	14	C-C	C-C	C-C	C-C	C-C	C-C	C-C	C-C	C-C						FT4A14T00CN4070

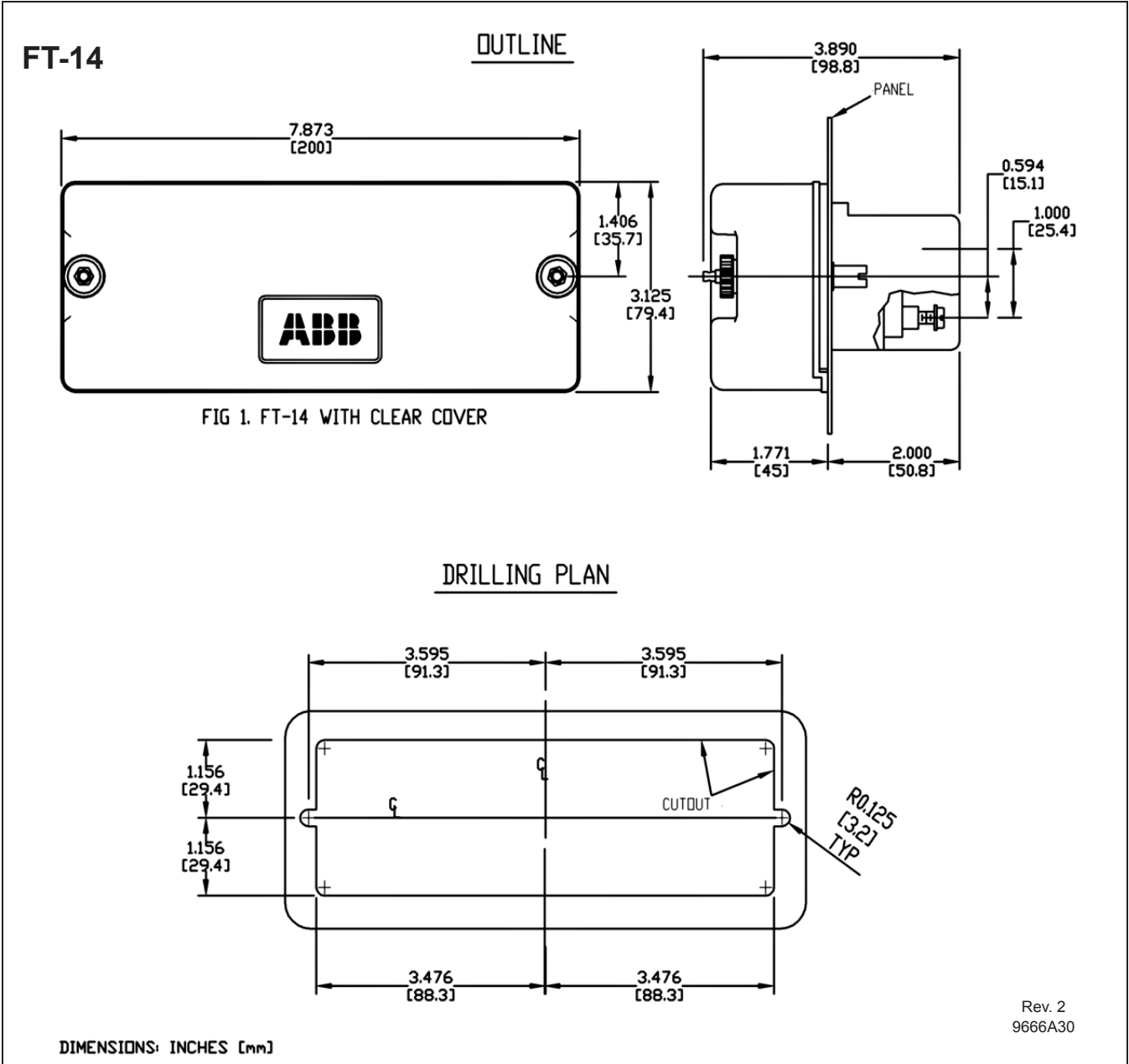


Figure 11. FT-14 Switch Outline and Drilling Plan

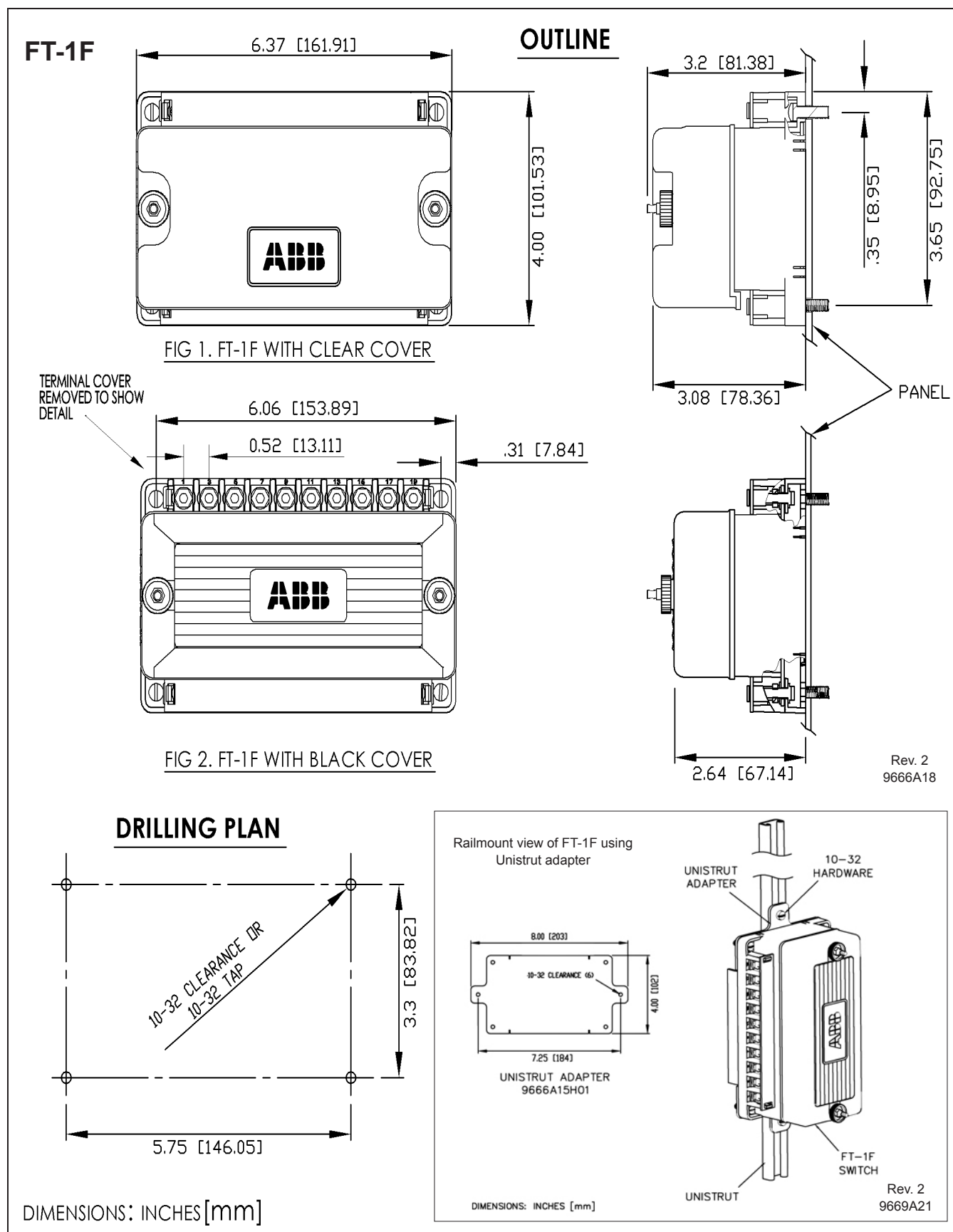
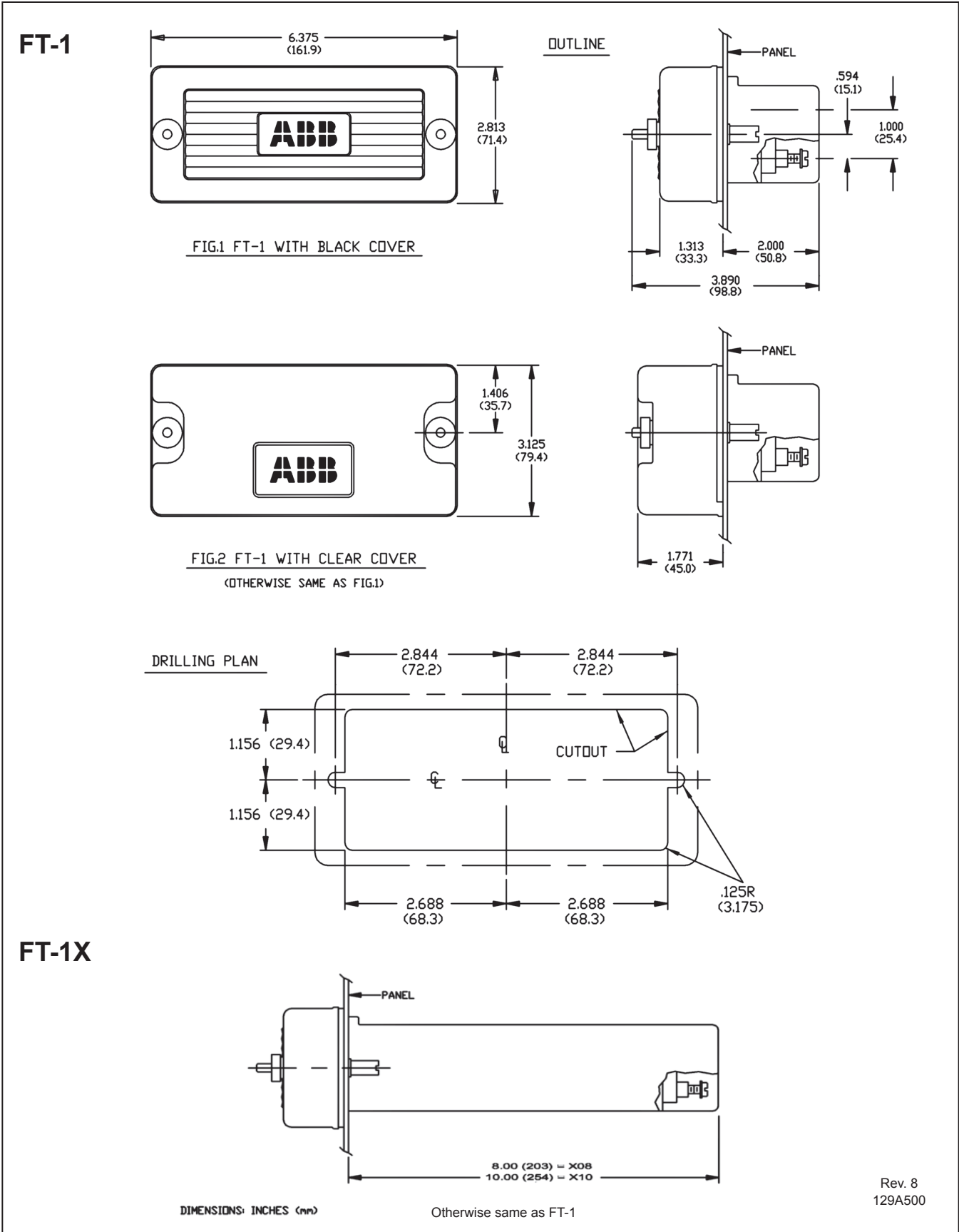


Figure 12. FT-1F Switch Outline and Drilling Plan



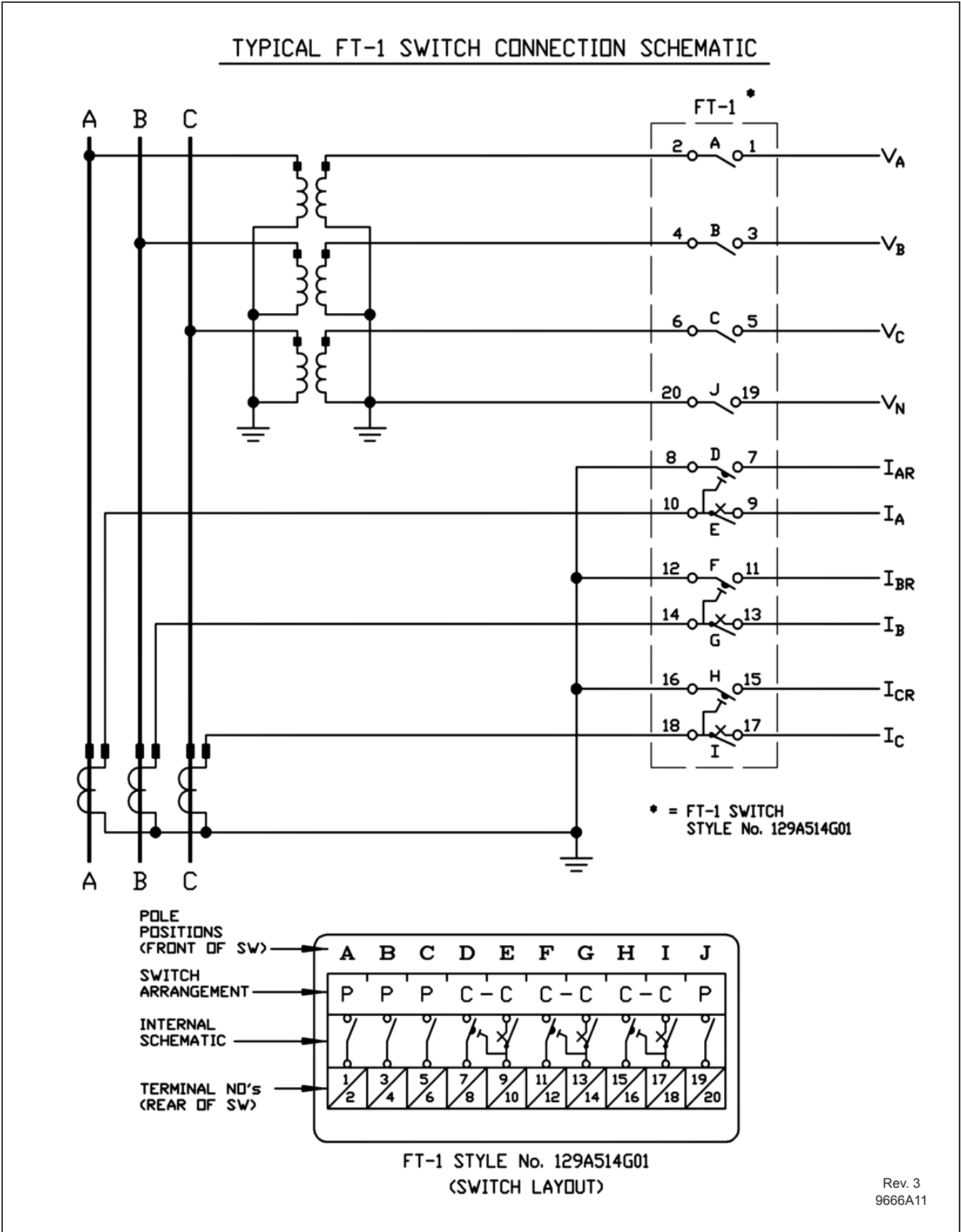


Figure 14. Typical FT-1 Switch Connection Schematic



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Descriptive bulletin

FT Flexitest family

FT-1, FT-1F, FT-1X, FT-14, FT-19R,
FT-19RX, FT-19RS, FT-22RS, & test plugs

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1. Application

ABB Flexitest switches, types FT-1 (10 pole, rear connected), FT-1F (10 pole, front connected), FT-1X (10 pole, extended terminals, rear connected), FT-14 (14 pole, rear connected), and associated Test Plugs, provide a safe, simple, fast and reliable method to isolate, test, and service installed equipment without disturbing the system.

FT-19R, FT-19RX, FT-19RS, and FT-22RS Flexitest switch assemblies for rack and switchboard mounting also permit convenient isolation of switchboard relays, meters, and instruments allowing quick and easy multi-circuit testing by any conventional test method. These assemblies utilize FT-1 and/or FT-14 switches, depending on customer's requirements.



2. The most complete family of test switches

2.1. FT-1 Standard 10 pole, rear connected test switch.

2.2. FT-1F Surface mount switch allows the user to make the same connections as with FT-1 but on the front of the switch.

2.3. FT-1X Extended length test switch brings the rear terminal connections to the same depth as most panel mounted protective relays and equipment for easier and faster access to wiring points. Extended 8 inches or 10 inches depth is available.

2.4. FT-14 Provides the same features and reliability as FT-1 but with a maximum of 14 individual poles. Although supplying 40% more capacity than the FT-1, the FT-14 only requires 18% more space.

2.5. The FT-19R and FT-19RX assemblies accommodate up to three FT-1 switches mounted on a 19" wide, and two-rack unit (2RU), three-rack unit (3RU), or four-rack unit (4RU) high panel suitable for rack or switchboard mounting. These assemblies can be ordered with a full-length clear cover (standard), or optional individual clear covers for each switch.

The FT-19RX extends the rear terminals of the FT-1 switches to the same depth as most 19" rack mounted equipment thereby providing improved access to the rear terminals. FT-19RX two-rack unit assemblies (2RU) allow the user to mount protective relays or other equipment in the racks directly above and below the FT-19RX, optimizing the space in the rack and reducing the amount of wire required.

1 FT-1 | 2 FT-1F | 3 FT-1X | 4 FT-14 | 5 FT-19R 2RU with Full Length Clear Cover

1



2



3



4



5



2.6. FT-19RS assemblies consist of up to two FT-1 switches, two FT-14 switches, or the combination of one FT-1 and one FT-14 switch mounted on a 19" wide, and two-rack unit (2RU), three-rack unit (3RU), or four-rack unit (4RU) high panel suitable for rack or switchboard mounting. Any combination of FT-1 or FT-14 switches styles may be selected with individual black or clear covers. Non-ABB equipment is not included with the assembly (see circle in picture 9 below).

2.7. FT-22RS assemblies consists of up to three FT-1 or two FT-14 switches mounted on a 22" wide, two-rack unit (2RU), three-rack unit (3RU), or four-rack unit (4RU) high mounting panel suitable for rack or switchboard mounting. Any combination of FT-1 or FT-14 switches styles may be selected with individual black or clear covers.

Mounting panels for these assemblies may be of steel or aluminum. Steel panels are commonly available in gray, beige and black; although panel color or finish, as well as panel height, can be customized to meet the user's necessities. The three rack unit (3RU) assembly also allows switches to be positioned off-center, in either low or high upper mounting positions in the rack panel, allowing room for special label requirements, as shown on page 5, figure 7.

6 FT-19 3RU lockable version | 7 FT-19R 3RU with Full Length Clear Cover. Switches mounted in the lower position, with special customer labels | 8 FT-19RX 3RU with Full Length Clear Cover | 9 FT-19RS | 10 FT-22RS



3. Advantages

Flexitest test switches provide a safe, reliable, and cost-effective means to wire the output of relays, meters, and other associated equipment to external devices for in-service testing.

3.1. Safe and convenient

All measurements and tests can be performed at the front of the switchboard, without taking any devices out of service, and without the need to access wiring at the rear of the devices.

Flexitest switches and test plugs have all the features necessary for applications involving the safe measurement and isolation of individual currents, voltages, and digital I/O signals to facilitate testing of substation instrumentation and protection devices.

The make-before-break current shorting feature allows test personnel to quickly and safely isolate equipment from current transformer (CT) circuits.

Voltage measurements can also be made directly on Flexitest switches, without disturbing existing connections. There is a test clip located on the top of each pole that allows connection with standard spring clip test leads.

3.2. Fast and reliable

When test plugs are used, any number of circuits may be tested in rapid succession. One plug properly connected can test all instruments or meters of a particular type.

3.3. Maximum flexibility

Test switches can be assembled in a variety of different arrangements, to match customer requirements. To build new or view existing Flexitest Switches and FT-19R panels, please visit our interactive FT-1 Configurator website at <http://ft1switch.com> (see page 15).

3.4. Security

With the cover in place, a meter seal can be placed through either of the cover studs of any Flexitest switch to prevent unauthorized access to the switch. As an additional feature, a clear cover is available that can also be installed with the switch-blades in the fully open or closed positions. In addition, a barrier has been incorporated into the cover to prevent knife switches from being left partially open. Optional padlocking provisions are available for most covers allowing access to authorized personnel only.

3.5. Quality

With over 50 years of field proven applications, ABB is the test switch manufacturer with the highest quality and largest installed base in North America. ABB's Flexitest test switches have been an industry standard for years.

3.6. Technical and application engineering support

Available 24/7 at +1 800 HELP 365, option 8; or +1 440 585 7804.

4. Specifications

4.1. Certifications

All Flexitest Switches meet or exceed all requirements of ANSI/IEEE Standard C37.90. Class 1E switches meet IEEE C37.98, C37.105, 323-1983 and 344-1987 Standards.

UL and CUL file number E103204, CSA, and 1E certification are available for most test switches. Contact your ABB representative for more details.

4.2. Ratings

All Flexitest switches are rated at 600 Volts AC and 30 Amps.

4.3. Mounting

The FT-1, FT-14, and FT-1X switches are designed for semi-flush mounting on the front of switchboard panels, facilitating inspection and accessibility. The FT-1F is designed for surface mounting and can also be mounted on a unistrut with the use of a unistrut adapter plate. Refer to figures 7 to 9 beginning on page 30 for the specific outline and drilling plan information of each switch.

The FT-19R, FT-19RX, and FT-19RS are designed for mounting on 19-inch rack structures or conventional panels. The FT-22RS are designed for mounting on 22-inch rack structures.

Connections, dimensions and layout are shown on pages 30-37.

Approximate shipping weight and dimensions

Device type	Net lbs (kg)	Shipping lbs (kg)	Shipping container L x W x H in (mm)
FT-1 and FT-1F	1.75 (0.79)	3 (1.4)	4 (100) x 7 (177) x 5 (126)
FT-1X	2.7 (1.25)	3.75 (1.7)	4 (100) x 12 (300) x 7 (177)
FT-14	2.5 (1.5)	3.25 (1.5)	4 (100) x 9 (225) x 5 (126)
FT-19R	7.0 (3.18)	12 (6)	10 (254) x 21 (534) x 10 (254)
FT-19RX	9.0 (4.08)	17 (8)	10 (254) x 21 (534) x 16 (407)
FT-19RS	7.0 (3.18)	12 (6)	10 (254) x 21 (534) x 10 (254)
FT-22RS	7.0 (3.18)	12 (6)	10 (254) x 24 (610) x 10 (254)
Separate Source Test Plug (10 position)	1.5 (0.68)	3 (1.4)	10 (253) x 7 (177) x 5 (126) For up to 4 pieces
In-Service Series Test Plug (10 position)	1.5 (0.68)	3 (1.4)	10 (253) x 7 (177) x 5 (126) For up to 4 pieces
Individual Current Circuit Test Plug	0.1 (0.045)	1 (0.45)	10 (253) x 7 (177) x 5 (126) For up to 30 pieces

4.4. Construction

The base of all Flexitest switches is made of a high grade molded thermo-plastic which provides a tough, insulated enclosure. Barriers are molded into the base (front and rear) to separate the switch units from one another. The barriers provide insulation between poles, and also ample wiring space between terminals. The terminals of the FT-1X are extended either 8 or 10 inches beyond the switch blades located on the front of the switch. The back of the terminals is marked with a white raised 3-D numbering, which allows easier identification of poles and helps prevent inadvertent upside down installation.

4.5. Cover

All Flexitest switch covers provide a tough insulated enclosure for the switch and are made from a durable thermoplastic material. Covers are fastened to the switches with thumbnuts on either end that can be loosened and tightened by hand, or with a 1/4" nut driver. This is the same size nut driver used on the hex head terminal screws of all Flexitest Switches. All covers have the provision to accept meter seals.

All switches may be purchased with a black opaque cover or a clear cover. The clear cover offers the user the unique option of intentionally leaving switch handles in the open position with the cover in place, maintaining the provision for a meter seal. This allows the user to service electrical equipment while still complying with OSHA tag and lockout procedures.

Lockable covers (in black or clear) are also available upon request.

Any cover can be ordered separately to retrofit any existing switch, maintaining the same ease of use and accessibility. See ordering information on page 28.



Figure 1. FT switch terminal numbering, rear view.

FT Cover selection samples (a) Black; (b) Clear; (c) Lockable



4.6. Poles

FT-1, FT-1F and FT-1X switches are available in combinations of 1 to a maximum of 10 individual poles or switch units. FT-14 switches are available in combinations of 1 to a maximum of 14 poles or switch units. Each pole is identified by a letter (A to J or A to N) visible along the top of the base from left to right (front view).

Individual pole designations are used to identify each pole according to its type or function. In order to develop a complete Switch Arrangement, pole designations should be listed sequentially from left to right to account for every pole position on the switch. Unused poles are identified by the letter X.

Each individual pole is of a knife blade type. There are two different types of poles, Potential and Current.

For quick, easy, user friendly configuration of flexitest switches, please visit www.ft1switch.com.

4.6.1. Potential poles

Potential poles (P) are configured as single, non-shorting knife blades for use in potential, trip, or control circuits. P designates a potential, trip, or control circuit with a black handle. Potential poles with other color handles are available by replacing the "P" with the appropriate designation per chart on page 10.

Each potential pole can also be described with 2 characters (P1 to P9). P indicates Potential and the second character is a numeric color code for the switch handle.

4.6.2. Current poles

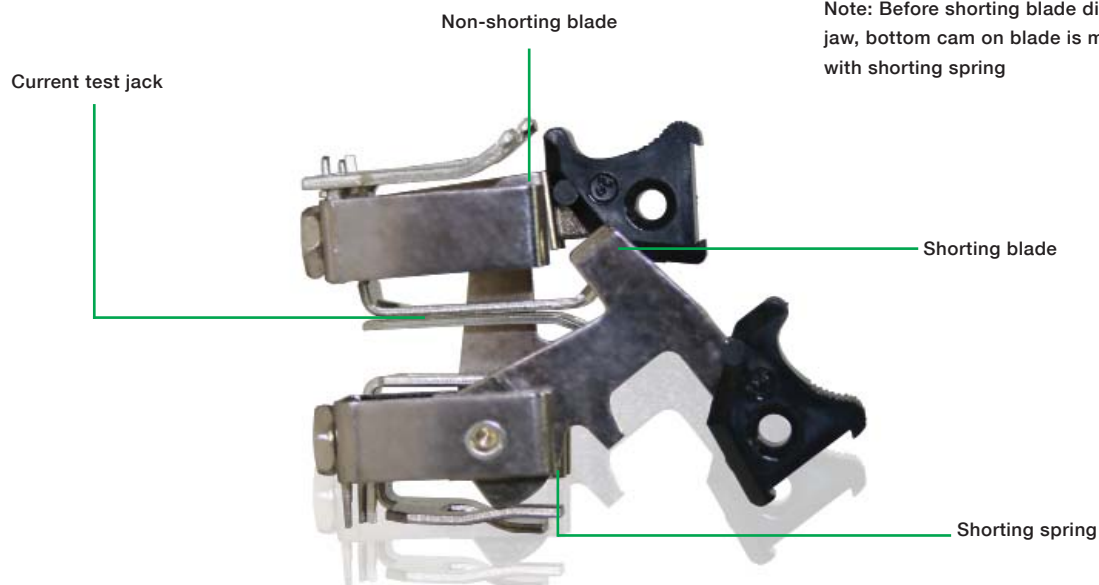
Current poles are typically configured in sets of two (C-C), for use with current circuits, and consist of a current test jack, a shorting spring, a shorting blade, and a non-shorting blade (see Figure 2) The positions of the short circuit springs are always visible from the front of the switch.

C designates a single Current circuit, non-shorting pole, with a current test jack and a black handle. Current poles with other color handles are available by replacing the "C" with the appropriate designation per chart on page 10.

Each current pole can also be described with 2 characters (C1 to C9). C indicates Current and the second character is a numeric color code for the switch handle.

Current poles typically span more than one pole position. Pole designations C-C, C-C-C, C-C-C-C and C-C-C-C-C indicate current shorting poles (make-before-break) with black handles. Note that any color handle may be selected for any pole position by using the appropriate pole designation, ex: 5-R or C-9-7 (alternately C5-C2 or C1-C9-C7).

Figure 2. Blade assembly of 2 position pole "C-C"



Visit www.ft1switch.com to build any complete FT switch arrangement, select options, view schematic details and get style number information.

Pole type	Potential pole designation		Handle color	Description & schematic symbol		Schematic legend
Potential	P	P1	Black	Potential, non-shorting blade		Non-shorting blade
	T	P2	Red			
	H	P3	Brown			
	V	P4	Purple			
	G	P5	Green			Shorting blade
	Y	P6	Yellow			
	Z	P7	Blue			
	W	P8	White			
	O	P9	Orange			
Current	L	L1	Black ^{††}	Potential, shorting blade		Current test jack
	C	C1	Black	Current, non-shorting, with test jack and blade		Shorting spring
	R	C2	Red			
	3	C3	Brown			
	4	C4	Purple			
	5	C5	Green			
	6	C6	Yellow			
	7	C7	Blue			
	8	C8	White			
	9	C9	Orange			
Current Shorting [†]	D	D0	N/A	Current test jack, no switch blade		C-C-C
	C-C	C1-C1	Black ^{††}	Current shorting (make-before-break), with test jack and blade		
	C-A	C1-A1		Current shorting (make-before-break), with standard blade, no current test jack		
	C-B	C1-B1		Current shorting (make-before-break), with stud only, no current jack, no switch blade		
	C-D	C1-D1		Current shorting (make-before-break), with current test jack, no switch blade		
	C-E	C1-E1		Current shorting (make-before-break), with shorting blade, no current test jack		
	C-S	C1-S1		Current shorting (make-before-break), with fixed shorting strap		
	S	S0	None	Fixed shorting strap		
Miscellaneous	J	J0	None	Current jaw, no blade		
	N	N0	None	Terminal stud in blade location, no jaw		
	U	U0	None	Stud and test clip in jaw location, no blade		
	X	X0	None	Empty pole position		

[†] = Current shorting poles are also available spanning up to 5 positions (ex: C-C-C-C-C or alternately C1-C1-C1-C1-C1)

^{††} = Every color handle is available by substituting appropriate pole color designation in desired location



Switch handles with interlocking bar

4.7. Switch handles

Switch handles are made of a molded thermoplastic material. They are typically black for potential and current circuits, red for trip circuits. In addition to black and red, switch handles are also available in various other colors (brown, purple, green, yellow, blue, white, and orange) for simple circuit identification. Each handle has a dovetail indentation that can hold a circuit identification label.

Knife blade switches can be operated independently, or ganged together with a horizontal interlocking bar to suit testing needs. A hole runs through the middle of each switch handle to allow insertion of interlocking bars that can mechanically tie 2, 3, 4, 5, 6, 8, 10, or 14 adjacent switch handles together. Interlocking bars are ordered as a separate line item and installed by the customer ; see “Test plug & accessories – ordering information” on page 28.

4.8. Terminal connections

Connection terminals are located at the rear of the switch (except on the front connected FT-1F). Most Flexitest switch terminals are marked with a white raised 3-D numbering, which allows easier identification of poles along the rear of the switch (1 to 20 on FT-1 and 1 to 28 on FT-14), as shown on Figure 1, page 8). Each pair of numbered terminals is associated with a matching pole designated by a letter on the front of the switch.

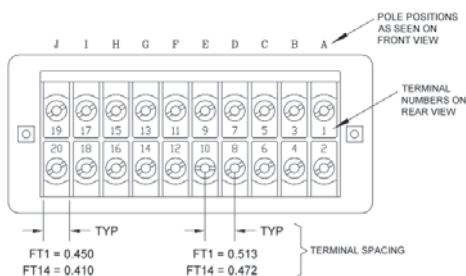


Figure 3. FT Switch terminals, rear view (FT-1 shown)

All required terminal hardware is supplied with every Flexitest switch (see Figure 4).

Screw terminals are provided standard with all Flexitest switches. Connections are made with a hex washer head screw - #8 thread size (0.164-32), 1/4" hex head.

Stud and nut terminals are an optional feature. Connections are made with two washers and a nut. A special (5/16") nut driver can be purchased from ABB to connect to stud terminals, see “Test plug & accessories - ordering information” on page 28.

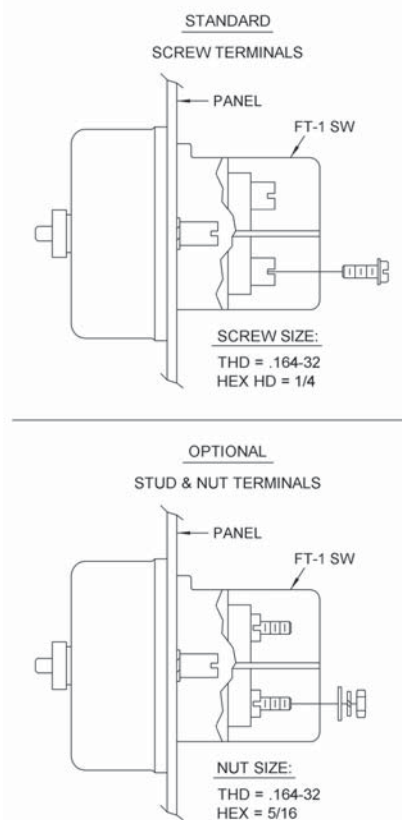


Figure 4. FT Switch terminals, rear view (FT-1 shown)

! Warning

Connections to ALL equipment should be made using standard and safe connection practices.

Recommended maximum torque values for all FT-1 and FT-14 terminals is 16 in-lbs. Exceeding this torque may result in damage to terminal threads.

Even number terminals (bottom row) of Flexitest switches should be connected to voltage transformers and current transformers, while odd number terminals (top row) should be connected to equipment that is to be isolated, such as meters and relays.

Max Lug Size = Yellow 12-10 ga. Ring Terminal

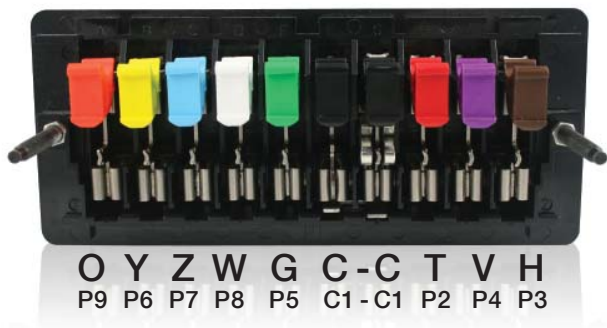


Figure 5. FT Switch arrangement, front view (FT-1 shown)

4.9. Switch arrangement

Pole positions are identified from left to right on the front view of the switch by the letters “A” through “J” or “A” through “N”. Individual pole designations are used to identify each pole according to its type or function. In order to develop a complete Switch Arrangement, pole designations should be listed sequentially from left to right to account for every pole position on the switch. Unused poles are identified by the letter X.

! Warning

All switch arrangements should be checked for adequate current transformer shorting when applied to current transformer circuits.



5. Test plugs



Figure 6. SafePlug with open CT protection

Test plugs used in conjunction with Flexitest switches enable easy measurement, calibration, verification and maintenance of relays, meters and instruments.

5.1. In-Service Series Test Plug

The “In-Service” Series Test Plug with a maximum of 10 positions is designed to match the pole configurations of specific styles of FT Flexitest devices (either FT-1, FT-1F, FT-1X switches or FT case relays).

This test plug is typically used to connect devices measuring the currents and voltages being applied to the switchboard relays, meters and instruments without interrupting or short-circuiting the circuit. Only current test switches with a current test jack must be opened before inserting the Series test plug. Connections to the test plug must be made before inserting the test plug into a Flexitest switch or relay.

Not every switch or relay pole configuration is suitable to accept an In-Service Series Test Plug. For available styles, see table 1, FT-1 switch selection guide 1VAC397062-SG. You may also refer to your ABB representative or ABB FT-1 configurator at www.ft1switch.com.

WARNING

When using an In-Service Series Test Plug for current measurements, connections from the test plug to the measuring instruments must be made before inserting the test plug in place.

5.2. Individual Current Circuit Test Plug

This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and leads carried out through holes in the back of the insulated handle. (See figures 2 and 4 on page 14).

The standard test plug inserts into the current test jack with the red part of the handle facing up allowing the alignment nipple and tab to guide the connector into the test jack.

5.3. SafePlug with open CT protection

The SafePlug is an individual current circuit test plug with open current transformer (CT) protection provides a safe, simple, fast, and reliable method to test and service installed equipment while reducing risks due to operator error, incorrect equipment settings, or deviation from correct test procedures. Its design prevents shock hazards, outages, and erroneous meter readings all associated with open CTs.

If a CT opens during operation, the test plug shorts the CT to protect the operator, typically within 100 microseconds or less (6/1000th of a cycle). At the same time a red LED provides visual indication of the fault.

! Warning

Complete CT secondary circuit connections from the Individual Current Circuit Test Plug to the measuring instrument must be made before inserting the Test Plug in place.

5.4. Separate Source Test Plug

The 10 Position and the 14 Position Separate Source Test Plugs isolate the external connections from the relay or equipment under test. The test plug accepts all common size banana plugs, ring wire connectors, spade lugs and has a through hole for meter probe or wire connections.

This test plug provides quick circuit testing by fitting into the stationary contact jaws of any Flexitest Type FT Case or Switch. The L-shaped test blades assure quick, accurate alignment between the Test Plug and the stationary contact jaws. The blades connect the relay inputs and outputs to a set of binding banana posts on the top of the Test Plug. An insulated barrier along the bottom of the blades isolates the relay circuits from external connections. Test circuits can then be connected to these binding posts, which are staggered for easy accessibility.

Before inserting the Separate Source Test Plug into service, all switchblades must be placed in the full open position. In a Flexitest Type FT Case, the plug is inserted in the bottom switch jaw with the binding posts up and in the top test switch jaw with the binding posts down.

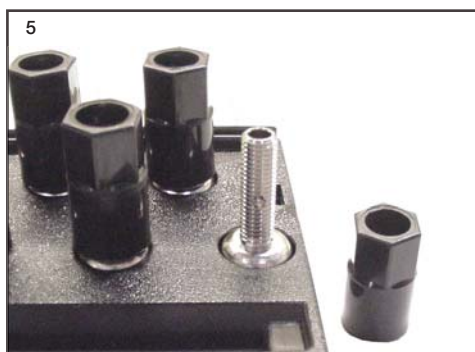
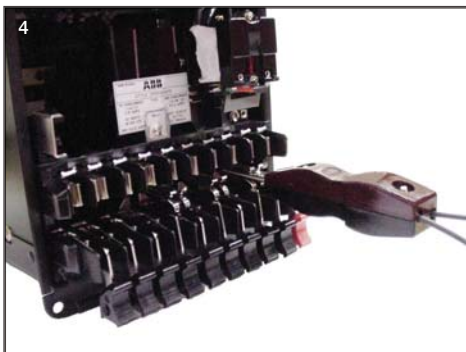
! Warning

Provision is made only on current poles with shorting springs to automatically short-circuit current transformer circuits when the knife switches are opened prior to inserting the Test Plug.

5.5. Flexitest test kit

The ABB Flexitest test kit comes with a convenient carrying case to hold your hand held meter, test plugs, patch cords, test clips, and test probes in neat order. Flexitest Test Kits can be ordered with your selected quantities of test plugs, safety patch cords, test clips, and test probes. Patch cords are highly durable and flexible. Contact your local ABB representative for a quotation. For more information see "Test Plugs & Accessories - Ordering Information" on pages 27-28.

1 In-service Series Test Plug | 2 Individual Current Circuit Test Plug | 3 Separate Source Test Plug | 4 Individual Current Circuit Test Plug inserted in Flexitest relay case | 5 Separate Source Test Plug | 6 FT test kit



6. FT Flexitest switches ordering information

FT-1 Configurator

ABB has a web based tool to help build any complete FT Switch Arrangement, select options, view schematic details and get style number information. We strongly recommend the use of the web based tool for quick, easy, and user-friendly configuration of Flexitest switches.

The following products can be easily configured:

- FT-1 (10 Pole)
- Front connected FT-1F
- Extended terminals FT-1X
- Replacement switches for FT-19R
- FT-14 (14 Pole)
- FT-19R switch panel assemblies
- FT-19RX switch panel assemblies

Please visit ABB's FT-1 Configurator website at www.ft1switch.com.

The screenshot shows the ABB FT-1 Configurator interface. It includes a 'How to use this Site' section, a 'Select Base' dropdown with options like 'Stand Alone FT-1', and a 'Select Options' section with radio buttons for 'Black Cover', 'Clear Cover', 'Screw Terms', 'Stud Terms', 'Standard', and 'Extended (19')'. A central diagram shows a 10-pole switch arrangement with poles labeled A through J. On the right, there are search fields for 'FT-1' and 'FT-14', and a 'Configure FT-19R' button. A 'Pole Descriptions' table is also visible.

This screenshot shows the configuration details for a specific switch. The 'Select Base' dropdown is set to 'Stand Alone FT-1'. The 'Select Options' section shows 'Black Cover' and 'Screw Terms' selected. The 'Front View' diagram shows the switch with colored handles. The 'Select Poles' section shows poles A through J. The 'Select Handles' section shows handles P through S. The 'Configure' button is highlighted. The 'Pole Descriptions' table is also visible.

This screenshot shows the final configuration and reference drawings. The 'Type' is 'FT-1'. The 'Style No.' is '991A34G01'. The 'Code No.' is '934'. The 'Description' is 'Stand Alone 10 Pole Flexitest Switch'. The 'Arrangement' is 'O Y Z W G C C T V H'. The 'Terminal' is 'Screw Terminals'. The 'Terminal Depth' is 'Standard Depth'. The 'Cover' is 'Black'. The 'Pole Positions' diagram shows the switch with poles labeled A through J. The 'Terminal No.' diagram shows the terminal arrangement. The 'Reference Drawings' section is at the bottom.

Flexitest switch ordering information

FT-1
10 pole - Flexitest switch

Style numbers are assigned by the factory.

Choose from available options by adding style prefix as shown.

Individual covers for FT-1 to be used on FT-19R application should be ordered as a separate item. See ordering information table on page 28.

Style prefix

None

=

Black cover, screw terminals.

S

=

Black cover, stud & nut terminals

C

=

Clear cover, screw terminals

CS

=

Clear cover, stud & nut terminals

L

=

Lockable black cover, screw terminals, rear connected

LS

=

Lockable black cover, stud & nut, rear connected

LC

=

Lockable clear cover, screw terminals, rear connected

LCS

=

Lockable clear cover, stud & nut, rear connected

R

=

FT-19R application, screw terminals

RS

=

FT-19R application, stud & nut terminals

Example style number

1 2 9 A 5 0 1 G 0 1

FT-1X
10 pole - extended terminals

Style numbers same as FT-1.

Choose from available options by adding style prefix as shown.

Choose extended length as shown.

Individual covers for FT-1 to be used on FT-19R application should be ordered as a separate item. See ordering information table on page 28.

Style prefix

Example style number

1 2 9 A 5 0 1 G 01

Extended length

Same as FT-1

X10

=

10.25 inches

X08

=

8.25 inches

FT-1F
10 pole - front connected

Style numbers are assigned by the factory.

Choose from available options by adding style prefix as shown.

Example style number

1 2 9 A 5 0 1 G 0 1

Style prefix

F

=

Black cover, screw terminals

SF

=

Black cover, stud & nut terminals

CF

=

Clear cover, screw terminals

CSF

=

Clear cover, stud & nut terminals

LF

=

Lockable black cover, screw terminals, rear connected

LSF

=

Lockable black cover, stud & nut, rear connected

LCF

=

Lockable clear cover, screw terminals, rear connected

LCSF

=

Lockable clear cover, stud & nut, rear connected

FT-14
14 pole Flexitest switch

Base type:
FT4 = FT14

Depth:
A = Standard depth (rear connected)

No. of poles:
01-14 = Total number of poles used

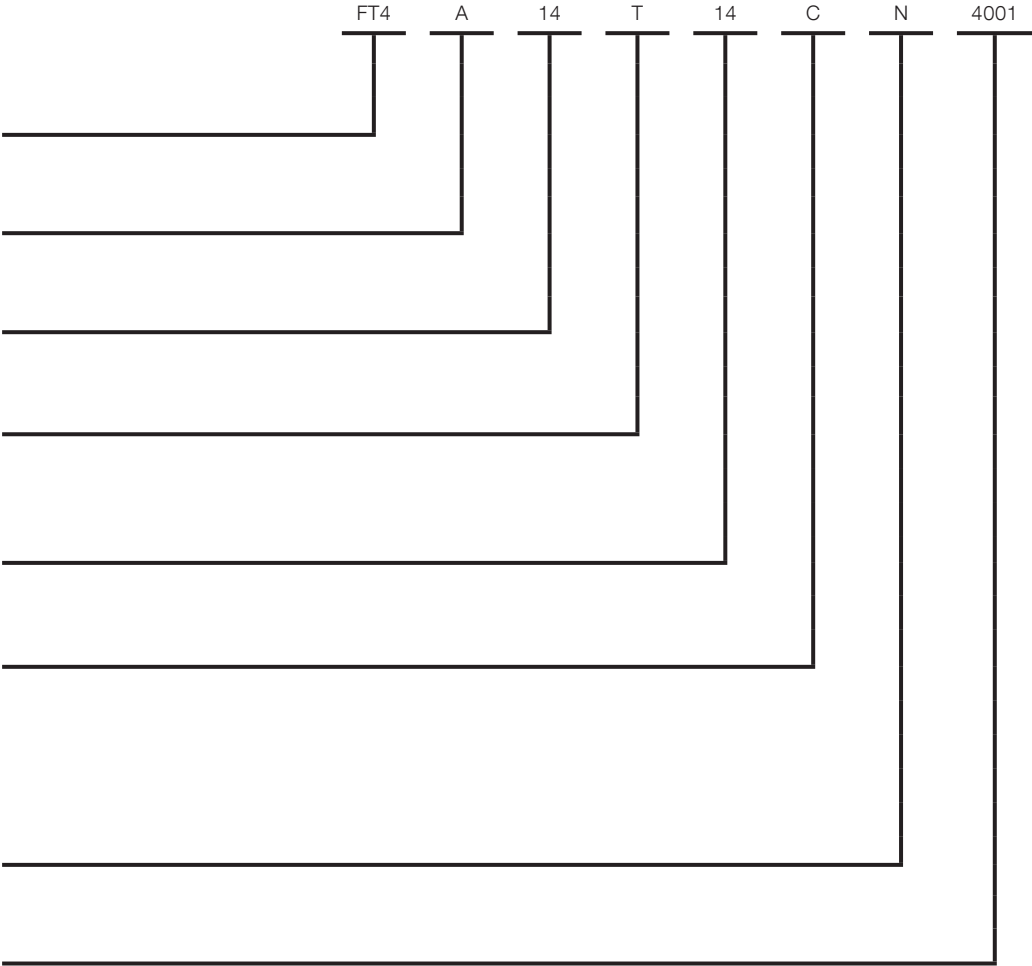
Terminals:
T = Standard screw terminals
S = Stud and nut terminals

No. of potentials:
00-14 = Total number of potential poles

Cover:
C = Clear cover
B = Black cover
L = Lockable clear cover
R = Lockable black cover

Special features:
N = None

Code no.:
4001-4999 = Unique code number assigned by the factory



6.1. FT-1, FT-1F and FT-1X switches are available in any combination of 1 to 10 poles. Each different configuration of poles is assigned a unique part number or style number by the factory. See ordering information chart for FT-1, FT-1X, and FT-1F on pages 16-17.

The standard FT-1 Style Number defines a unique pole configuration with black cover and screw terminals ex: 129A501G01. Adding a prefix and/or suffix to the standard Style Number allows the selection of options for FT-1 as well as the ability to create complete FT-1F and FT-1X style numbers.

Customers may also place an order by providing a complete switch arrangement definition as well as the selected options. ex: P X P C-C C-C C-C P (P1 X0 P1 C1-C1 C1-C1 C1-C1 P1), clear cover, screw terminals.

6.1.1. Terminal connections

An optional FT-1 Switch with stud and nut termination can be supplied at no additional charge. Style Number prefix “S” is used for this option, ex: S129A501G01. For optional clear cover with stud and nut terminals use style number prefix “CS”, ex: CS129A501G01. See pages 16-17 for more ordering details.

6.1.2. Cover

An optional clear cover will be supplied instead of the black cover by using style number prefix “C,” ex: C129A501G01.

6.1.3. Depth

An FT-1X extended switch with black cover will be supplied by using suffix “X08” for 8 inches and “X10” for 10 inches, ex: 129A501G01X08 or 129A501G01X10.

An FT-1X extended switch with clear cover will be supplied by using prefix “C” and suffix “X10”, ex: C129A501G01X10

6.1.4. Front connected

Adding a prefix “F” to the standard style number is used for a front connected FT-1F switch, which allows the user to make the connections on the front of the switch.

6.2. FT-14 switch is available in any combination up to 14 poles. Each different style number is based on a smart part number system. See ordering information chart on page 17.

6.2.1. Terminal connections

A standard FT-14 Switch with screw termination will be supplied when using the normal style number. An optional FT-14 switch with stud and nut termination can be supplied at no additional charge provided when the seventh character on the smart part number is changed from “T” to “S.”

6.2.2. Cover

A standard FT-14 Switch with clear cover will be supplied when using the normal style number. An optional FT-14 switch with black cover can be supplied at no additional charge provided the tenth character in the above styles is changed from “C” to “B”. An optional FT-14 switch with lockable clear or black cover can be supplied at no additional charge provided the tenth character changed from “C” to either “L” (lockable clear) or “R” (lockable black).

6.3 FT-19 and FT-22 test switch assemblies.

The FT-19R and FT-19RX assemblies accommodate up to two FT-1 switches. The FT-19RS and FT-22RS assemblies accommodate up to two FT-1 switches, two FT-14 switches, or the combination of one FT-1 and one FT-14 switch.

Each different style number is based on a smart part number system. See page 20-22 for more ordering details.

6.3.1 Terminal connections

The Flexitest Switches for FT-19R, FT-19RX, FT-19RS, and FT-22RS assemblies can be ordered with standard (# 8) screw terminals or optional stud & nut terminals. The type of terminal connection is represented by the second character of the style number.

6.3.2 Panel height

The 19" as well as 22" wide mounting panel can be ordered in different rack unit (RU) heights: 2RU, 3RU or 4RU. The 3RU assembly is available with switch positions centered, mounted high or mounted low. The 4RU is available with switches mounted low or high.

6.3.3 Panel color & material

Panels are available in the following colors and materials: ANSI 61 gray - steel; ANSI 70 gray - steel; RAL7035 gray - steel; beige - steel; black - steel; Light Sandlewood (RAL1019) - steel; Thunder Blue (textured) - steel ; and brushed finish aluminum.

For visual representation of the panel colors, please visit www.ft1switch.com.

6.3.4 Flexitest switch code numbers (positions A, B, and C)

Each FT-1 switch is identified by a unique three-digit code number. FT-14 switches are identified by a unique four digit code number. These "code numbers" are required for each of the positions in the assembly (positions A, B and C).

To obtain the FT-1 or FT-14 switch style number and the three or four digit code number refer to the ABB FT-1 configurator at www.ft1switch.com or FT switch selection guide (document 1VAC397062-SG). A cover plate will be provided for unused FT-1 or FT-14 switch positions (A, B, or C) by using code number "000" or "0000" respectively.

If a particular arrangement is not listed, contact the ABB Coral Springs factory.

6.3.5 Switch replacement

To add an FT-1 switch in an unused position or to replace a switch in an FT-19R assembly, the required FT-1 switch style(s) will need to be provided. These numbers differ from the individual FT-1 style numbers by including the prefix "R" to represent screw terminals (e.g., R129A501G01) or the prefix "RS" to represent stud type terminals (e.g., RS129A501G01). For FT-19RX assemblies provide the required FT-1 switch style with an "R" or "RS" prefix plus the X08 or X10 length suffix (e.g., R129A501G01X10).

It is not necessary to add "R" prefix to the standard style number of FT-1 or FT-14 switches to be used as replacement on FT-19RS assemblies.

6.3.6 Cover

For FT-19R assemblies, the cover field should be left BLANK to order the unit with the standard full length clear cover. Optional full length black, individual clear, individual black, lockable full length clear or lockable full length black cover can be requested by indicating the assigned letter on the cover field on the smart part number.

The cover field is always required on FT-19RX, FT-19RS and FT-22RS part numbers.

6.3.7 Additional features

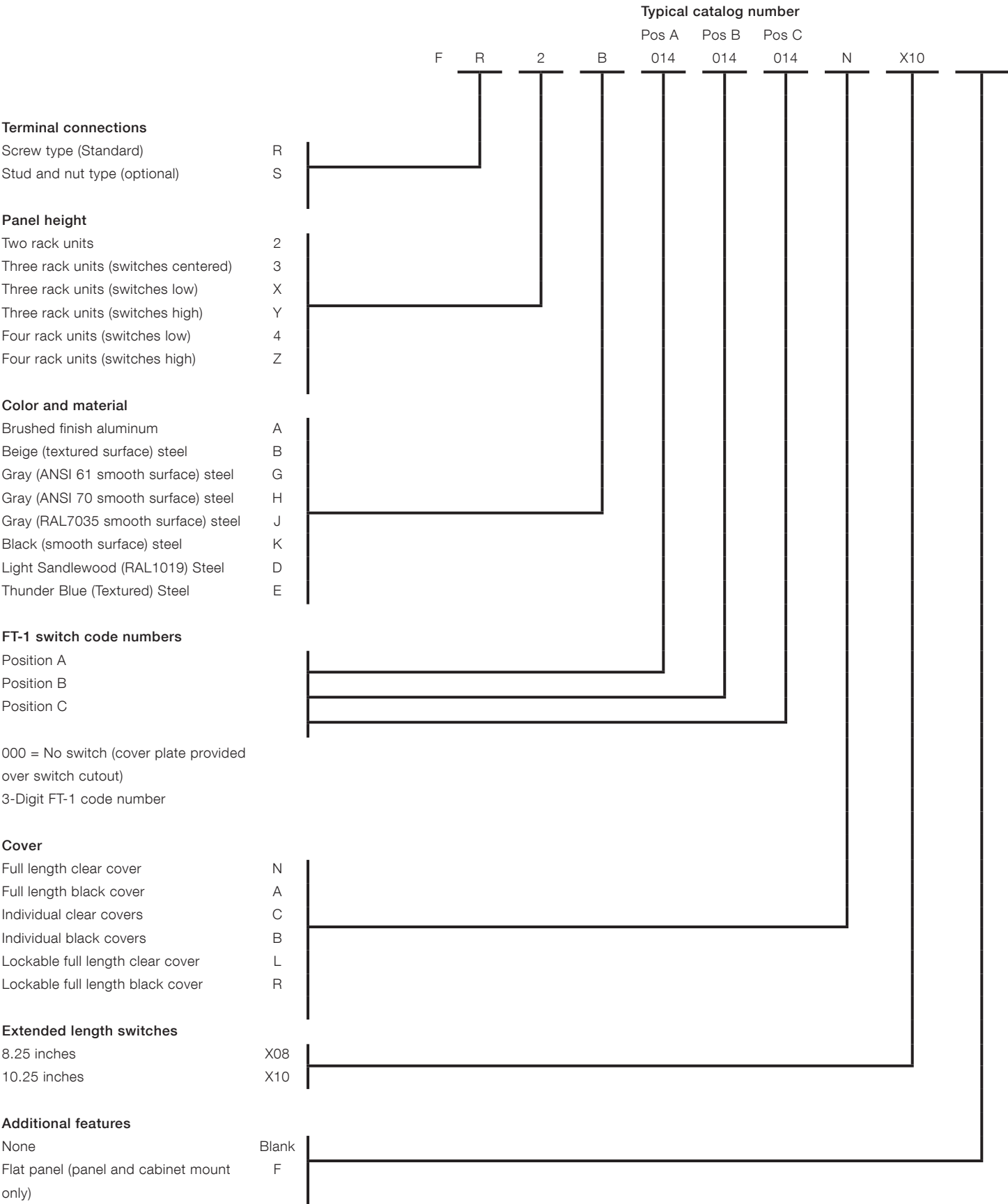
When ordering the "Flat panel" version, please note this is meant for applications where flush panel or cabinet mounting is required.

FT-19R
Flexitest switch assembly

		Typical catalog number							
		F	R	2	B	Pos A	Pos B	Pos C	
						014	014	014	
Terminal connections									
Screw type (Standard)	R								
Stud and nut type (optional)	S								
Panel height									
Two rack units	2								
Three rack units (switches centered)	3								
Three rack units (switches low)	X								
Three rack units (switches high)	Y								
Four rack units (switches low)	4								
Four rack units (switches high)	Z								
Color and material									
Brushed finish aluminum	A								
Beige (textured surface) steel	B								
Gray (ANSI 61 smooth surface) steel	G								
Gray (ANSI 70 smooth surface) steel	H								
Gray (RAL7035 smooth surface) steel	J								
Black (smooth surface) steel	K								
Light Sandlewood (RAL1019) Steel	D								
Thunder Blue (Textured) Steel	E								
FT-1 switch code numbers									
Position A									
Position B									
Position C									
000 = No switch (cover plate provided over switch cutout)									
3-Digit FT-1 code number									
Cover									
Full length clear cover (standard)	Blank								
Full length clear cover (use with additional features only) ¹	N								
Full length black cover	A								
Individual clear covers	C								
Individual black covers	B								
Lockable full length clear cover	L								
Lockable full length black cover	R								
Additional features									
None	Blank								
Flat panel (panel and cabinet mount only)	F								

¹ The cover option "N" only applies when additional features are required.
For special configurations, please contact the factory.

FT-19RX
Flexitest switch assembly



For special configurations, please contact the factory.

FT-19RS and FT-22RS
Flexitest switch assembly

		Typical catalog number					
		Pos A	Pos B	Pos C			
		014	-	N	-	4025	B
Assembly type		S	R	2	B		
19 inch mounting panel	S						
22 inch mounting panel	V						
Terminal connections:							
Screw type (Standard)	R						
Stud and nut type (optional)	S						
Panel height							
Two rack units	2						
Three rack units (switches centered)	3						
Three rack units (switches low)	X						
Three rack units (switches high)	Y						
Four rack units (switches low)	4						
Four rack units (switches high)	Z						
Color and material							
Brushed finish aluminum	A						
Beige (textured surface) steel	B						
Gray (ANSI 61 smooth surface) steel	G						
Gray (ANSI 70 smooth surface) steel	H						
Gray (RAL7035 smooth surface) steel	J						
Black (smooth surface) steel	K						
Light Sandlewood (RAL1019) Steel	D						
Thunder Blue (Textured) Steel	E						
Positions A, B, C							
001-999, A01-Z99 = 3-Digit FT-1 switch code number							
4001-4999 = 4-Digit FT-14 switch code number							
S01-S99 = Special equipment code (see table 1, page 24)							
N = Unused panel position							
000 = No switch (cover plate provided over FT-1 switch cutout)							
4000 = No switch (cover plate provided over FT-14 switch cutout)							
Cover							
Individual clear covers	C						
Individual black covers (standard)	B						
Lockable individual clear cover	L						
Lockable individual black cover	R						
Additional features							
None	Blank						
8.25 inches extended terminals (FT-1 only)	W						
10.25 inches extended terminals (FT-1 only)	X						
Flat panel	F						
8.25 inches extended terminals (FT-1 only), Flat panel	M						
10.25 inches extended terminals (FT-1 only), Flat panel	A						

For special configurations, please contact the factory.

Possible combinations of FT-1 and FT-14 switches on FT-19RS and FT-22RS assemblies, when space for special equipment is not required

Fig.	Pos. A	Pos. B	Pos. C
1	FT1	N	FT1
2	FT14	N	FT14
3	FT14	N	FT1
4	FT1	N	FT14

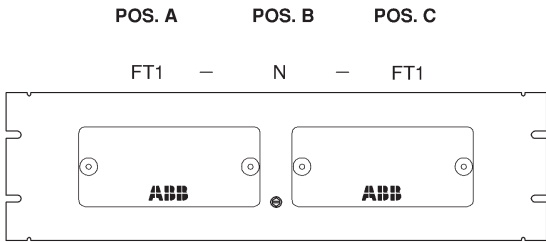


FIGURE 1

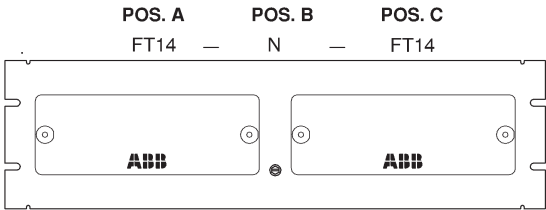


FIGURE 2

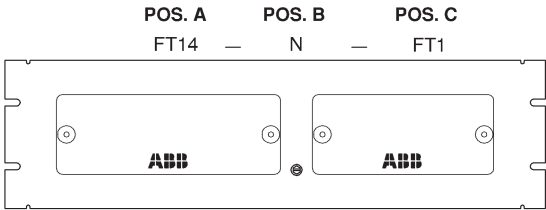


FIGURE 3

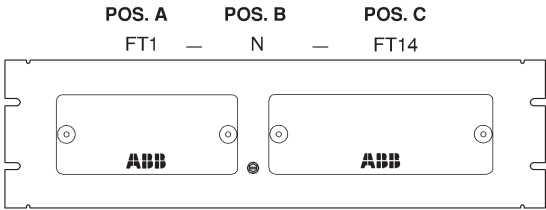


FIGURE 4

Possible configuration of FT-19RS and FT-22RS assemblies, when space for special equipment is required

Fig.	Pos. A	Pos. B	Pos. C
5	FT1	FT1	Sxx
6	FT1	Sxx	FT1
7	Sxx	FT1	FT1

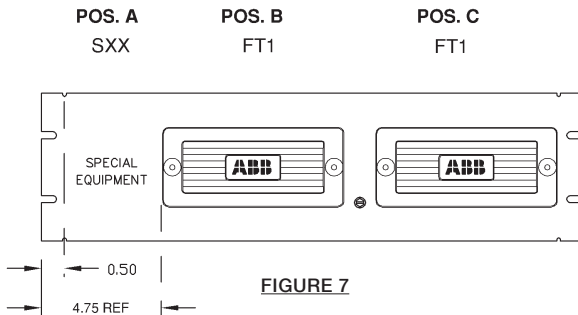
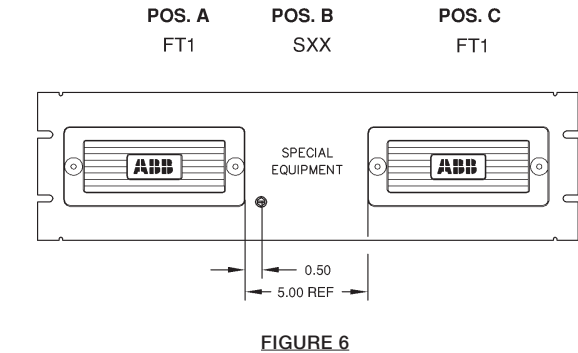
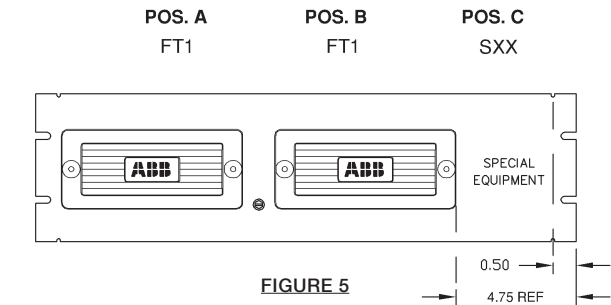


Table 1

AVAILABLE SPECIAL EQUIPMENT CODES

CODE	DETAIL DRAWING	MANUFACTURER	DESCRIPTION
S01	PNL-DRL-S01	—	TOGGLE SWITCH
S02	PNL-DRL-S02	ELECTROSWITCH	SERIES 24 LOCK-OUT RELAY
S03	PNL-DRL-S03	G.E.	GE TYPE SBM CONTROL SWITCH
S24	PNL-DRL-S24	ELECTROSWITCH	SERIES 24 CONTROL TRANSFER SWITCH

Note: Special equipment not included with assembly.

Most popular FT switches

Table 1 - FT-1 Switch selection guide

Poles	Potential	Current	A	B	C	D	E	F	G	H	I	J	Style number	Code	Options	In-Service Test Plug
10	10	0	P	P	P	P	P	P	P	P	P	P	129A501G01	001	Black Cover, Screw Terminals	129A062G10
10	10	0	T	T	T	T	T	T	T	T	T	T	129A539G01	036	Black Cover, Screw Terminals	129A062G10
10	10	0	P	T	T	T	T	T	T	T	T	T	9688A17G01	584	Black Cover, Screw Terminals	129A062G10
10	10	0	P	P	P	P	P	P	P	P	T	T	1586C42G23	212	Black Cover, Screw Terminals	129A062G10
10	10	0	P	P	P	P	T	T	T	P	P	P	9676A14G01	452	Black Cover, Screw Terminals	129A062G10
10	10	0	T	T	P	P	P	P	P	P	P	P	1586C42G45	262	Black Cover, Screw Terminals	129A062G10
10	4	6	P	P	P	C - C	C - C	C - C	C - C	C - C	P	P	129A514G01	014	Black Cover, Screw Terminals	292B319G23
10	4	6	P	C - C	P	C - C	P	C - C	P	C - C	P	P	129A528G01	026	Black Cover, Screw Terminals	NONE
10	4	6	C - C	C - C	C - C	C - C	P	P	P	P	P	P	774B430G20	171	Black Cover, Screw Terminals	NONE
10	4	6	T	T	T	T	C - C	C - C	C - C	C - C	C - C	C	498A010G01	065	Black Cover, Screw Terminals	NONE
10	4	6	P	P	P	P	C - C	C - C	C - C	C - C	C - C	C	670B197G18	119	Black Cover, Screw Terminals	NONE
10	4	6	T	T	T	C - C	C - C	C - C	C - C	C - C	C - C	T	714B325G32	137	Black Cover, Screw Terminals	292B319G23
10	4	6	C - C	C - C	C - C	C - C	T	T	T	T	T	T	774B430G24	183	Black Cover, Screw Terminals	NONE
10	3	7	P	P	C	C - C	C - C	C - C	C - C	C - C	P	P	129A535G01	033	Black Cover, Screw Terminals	292B319G22
10	2	8	P	C - C	C - C	C - C	C - C	C - C	C - C	C - C	P	P	129A518G01	018	Black Cover, Screw Terminals	292B319G22
10	2	8	C - C	C - C	C - C	C - C	C - C	C - C	C - C	P	P	P	837A407G01	083	Black Cover, Screw Terminals	NONE
10	2	8	C - C	C - C	C - C	C - C	C - C	C - C	C - C	T	T	T	774B430G22	173	Black Cover, Screw Terminals	NONE
10	0	10	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C	498A020G01	073	Black Cover, Screw Terminals	NONE
8	0	8	.	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C	129A517G01	017	Black Cover, Screw Terminals	292B319G22
8	0	8	X	R - R	R - R	R - R	R - R	R - R	R - R	R - R	R - R	X	9660A84G01	266	Black Cover, Screw Terminals	292B319G22
6	0	6	.	.	.	C - C	C - C	C - C	C - C	C - C	C - C	C	129A516G01	016	Black Cover, Screw Terminals	292B319G23

Table 2 - FT-14 Switch selection guide

Poles	Potential	Current	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Style number	Code	Options
14	14	0	P	P	P	P	P	P	P	P	P	P	P	P	P	P	FT4A14T14CN4001	4001	Clear Cover, Screw Terminals
14	14	0	T	T	T	T	T	T	T	T	T	T	T	T	T	T	FT4A14T14CN4018	4018	Clear Cover, Screw Terminals
14	6	8	P	P	P	P	P	P	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	FT4A14T06CN4046	4046	Clear Cover, Screw Terminals
14	6	8	P	P	P	C - C	C - C	C - C	C - C	C - C	C - C	P	P	P	P	P	FT4A14T06CN4044	4044	Clear Cover, Screw Terminals
14	6	8	C - C	C - C	C - C	C - C	C - C	C - C	C - C	P	P	P	P	P	P	P	FT4A14T06CN4068	4068	Clear Cover, Screw Terminals
14	6	8	C - C	C - C	C - C	C - C	C - C	C - C	C - C	P	P	P	P	P	T	T	FT4A14T06CN4035	4035	Clear Cover, Screw Terminals
14	6	8	T	T	T	T	C - C	C - C	C - C	C - C	C - C	C - C	C - C	T	T	T	FT4A14T06CN4052	4052	Clear Cover, Screw Terminals
14	4	10	P	P	P	P	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C	FT4A14S04BN4151	4151	Black Cover, Stud Terminals
14	2	12	C - C	C - C	C - C	C - C	C - C	P	P	C - C	C - C	C - C	C - C	C - C	C - C	C	FT4A14S02BN4177	4177	Black Cover, Stud Terminals
14	0	14	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C - C	C	FT4A14T00CN4063	4063	Clear Cover, Screw Terminals
12	4	8	T	P	Z	W	.	R - R	C - C	7 - 7	.	8 - 8	FT4A12T04CN4163	4163	Clear Cover, Screw Terminals			Clear Cover, Screw Terminals	
11	3	8	P	P	P	.	C - C	C - C	C - C	C - C	.	C - C	.	FT4A11S03BN4127	4127	Black Cover, Stud Terminals			Black Cover, Stud Terminals




The above are the most popular FT configurations. For more styles please visit www.ft1switch.com.

Table 3 - FT-19R switch assemblies

Style number	Position A	Position B	Position C	Options
FR3G001001001	001	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR3G171001001	171	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR2G001001001	001	001	001	2RU, Steel, Ansi 61 Gray, Screw Terminals
FR3H014001001	014	001	001	3RU (centered), Steel, Ansi 70 Gray, Screw Terminals
FR3H001001001	001	001	001	3RU (centered), Steel, Ansi 70 Gray, Screw Terminals
FR3G073001001	073	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FRXG001001001	001	001	001	3RU (low), Steel, Ansi 61 Gray, Screw Terminals
FR3G014001001	014	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR3G001001262	001	001	262	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR3G183001262	183	001	262	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR4G001001001	001	001	001	4RU, Steel, Ansi 61 Gray, Screw Terminals
FR3G073212036	073	212	036	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR3G183001001	183	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR4G171001001	171	001	001	4RU, Steel, Ansi 61 Gray, Screw Terminals
FR3G083001001	083	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR3G083452000	083	452	000	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR2G014001001	014	001	001	2RU, Steel, Ansi 61 Gray, Screw Terminals
FR3G036036036	036	036	036	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR2G026001001	026	001	001	2RU, Steel, Ansi 61 Gray, Screw Terminals
FR3G026001026	026	001	026	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR3G171171001	171	171	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals
FR2G001001000	001	001	000	2RU, Steel, Ansi 61 Gray, Screw Terminals
FR2G001000000	001	000	000	2RU, Steel, Ansi 61 Gray, Screw Terminals
FR3H014014014	014	014	014	3RU (centered), Steel, Ansi 70 Gray, Screw Terminals
FR3G026001001	026	001	001	3RU (centered), Steel, Ansi 61 Gray, Screw Terminals


The above are the most popular FT configurations. For more styles please visit www.ft1switch.com.

7. Test plugs & accessories - ordering information

Test Plugs		Style Number	
	In-Service Series Test Plug (Order to match Flexitest FT-1 switch arrangement or FT relay case)	See FT switch selection guide (document 1VAC397062-SG) page 4	
	Standard Individual Current Circuit Test Plug - leads not included	7B4618G04	
	Standard Individual Current Circuit Test Plug - leads included	7B4618G05	
	SafePlug - Individual Current Circuit Test Plug with open CT protection - leads not included	1VAC391001P001	
	SafePlug - Individual Current Circuit Test Plug with open CT protection - leads included	1VAC391001P002	
	Separate Source Test Plug (10 position)	1164046	
	Separate Source Test Plug (14 position)	1355D32G04	
Complete FT test kit (Includes ABB bag)		9688A68G18	
	Items in test kit 9688A68G18	Rated voltage	Rated current
	1 Red 6' safety patch cord with retractable sleeve banana plug on both ends	600 VDC	32A
	1 Black 6' safety patch cord with retractable sleeve banana plug on both ends	600 VDC	32A
	1 Red 10' UTP cable with RJ-45 male connector on both ends.	600V	30A
	1 Red safety plug-on test probe	1000V	10A
	1 Black safety plug-on test probe	1000V	10A
	1 Red safety plug-on alligator test clip	1000V	10A
	1 Black safety plug-on alligator test clip	1000V	10A
	FT separate source test plug - 1164046	600V	30A
	FT individual series test plug - 7B4618G04	600V	30A

Complete FT test kit (includes ABB Bag)

9688A68G24


	Items in test kit 9688A68G24	Rated Voltage	Rated Current
	1 red 6' safety patch cord with retractable sleeve banana plug on both ends	600 VDC	32A
	1 black 6' safety patch cord with retractable sleeve banana plug on both ends	600 VDC	32A
	1 red 10' UTP cable with RJ-45 male connector on both ends	600V	30A
	1 red safety plug-on test probe	1000V	10A
	1 black safety plug-on test probe	1000V	10A
	1 red safety plug-on alligator test clip	1000V	10A
	1 black safety plug-on alligator test clip	1000V	10A
	FT separate source test plug - 1164046	600V	30A
	FT individual current circuit test plug with open CT protection - 1VAC391001P001	600V	20A

Cover

FT-1

FT-14

FT-19R

	Standard individual cover w/ thumb nuts - BLACK	128A973G01	128A973G03	9683A78G03
	Standard individual cover w/ thumb nuts - CLEAR	9676A32G01	9676A32G02	9683A78G01
	Full length cover w/ thumb nuts - BLACK	Not applicable	Not applicable	9676A28G02
	Full length cover w/ thumb nuts - CLEAR	Not applicable	Not applicable	9676A28G01
	Lockable cover w/ thumb nuts & bracket- BLACK	9669A49G01	9669A49G03	Not Applicable
	Lockable cover w/ thumb nuts & bracket - CLEAR	9669A49G02	9669A49G04	Not Applicable
	Lockable full length cover w/thumb nuts & bracket- BLACK	Not applicable	Not applicable	9669A52G02
	Lockable full length cover w/thmb nuts & bracket - CLEAR	Not applicable	Not applicable	9669A52G01

Interlocking bars

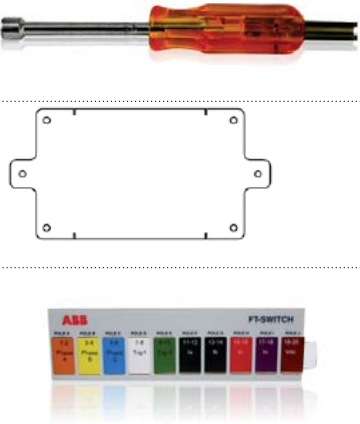
FT-1

FT-14

	2 Positions	1270547	9669A19G02
	3 Positions	1164048	9669A19G03
	4 Positions	02C9834G03	9669A19G04
	5 Positions	02C9834G04	9669A19G05
	6 Positions	02C9834G06	9669A19G06
	7 Positions	Not Applicable	9669A19G07
	8 Positions	02C9834G07	9669A19G08
	10 Positions	02C9834G05	9669A19G10
	14 Positions	Not Applicable	9669A19G14

Miscellaneous

Style number

	FT-1 & FT-14 nut driver For stud & nut terminals	877A821G02
	Unistrut adapter plate for railmount of FT-1F	9666A15H01
	Label Holder Sleeve (gloss polycarbonate) for FT-1 SW *To create and print custom labels, please use the template found on our website www.abb.com/substationautomation under Distribution Automation subheading Test Equipment	1506B81H01

8. Warranty

All ABB Flexitest switches and assemblies are backed by a 12-YEAR warranty. The quality of ABB products comes from years of experience and rigorous quality testing programs.

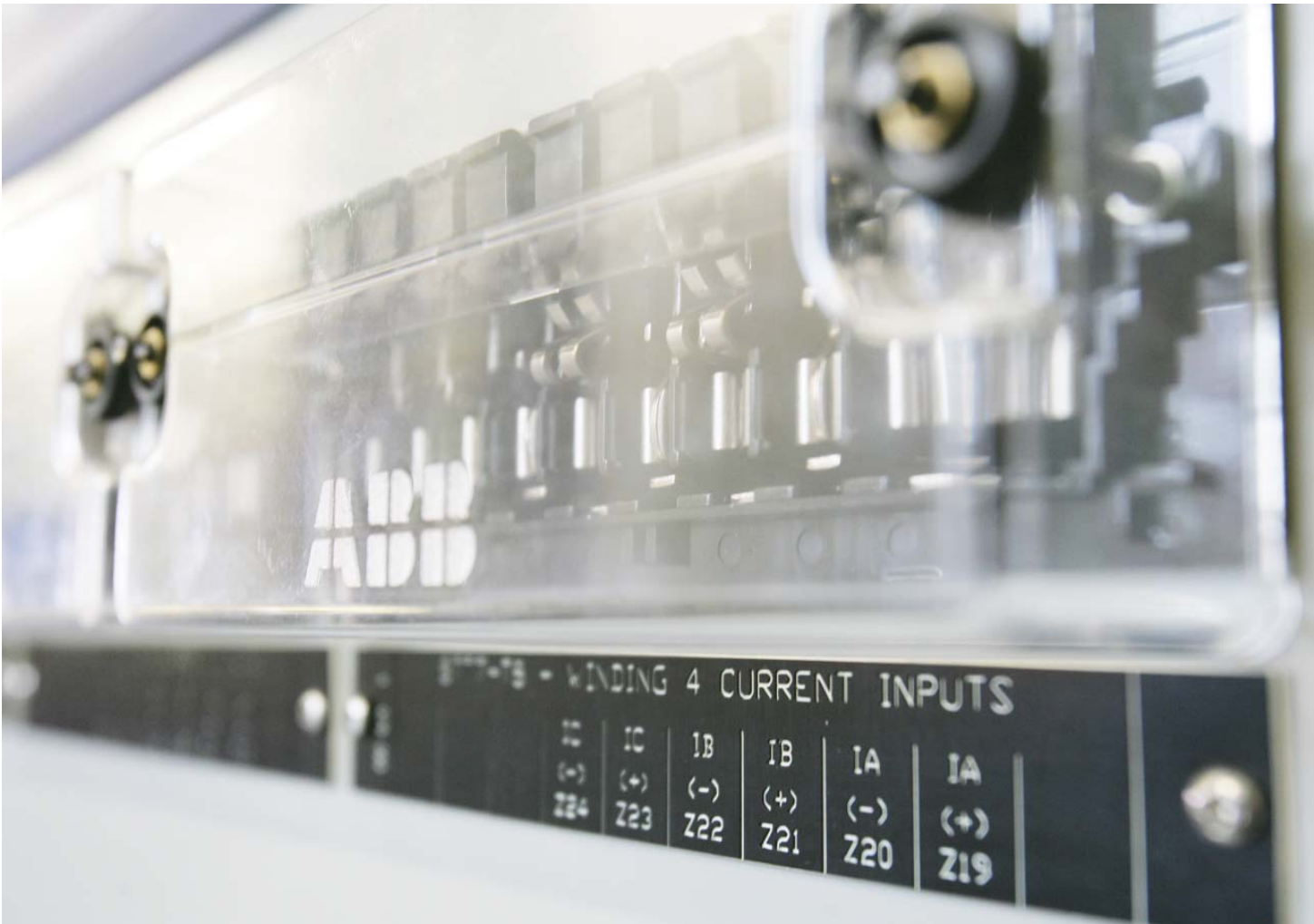
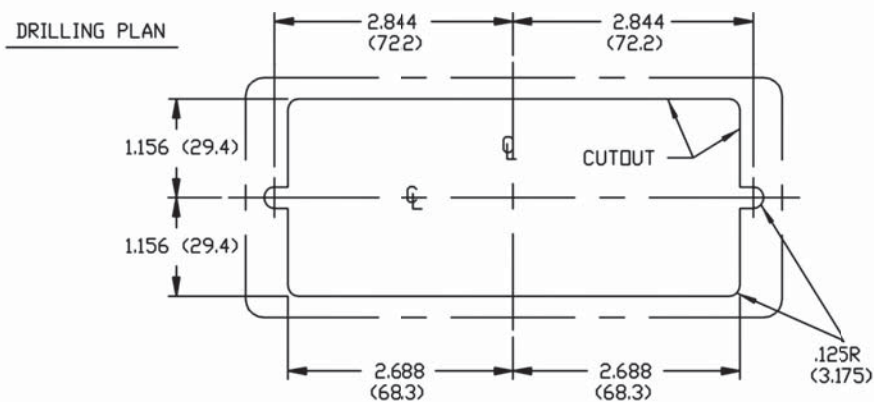
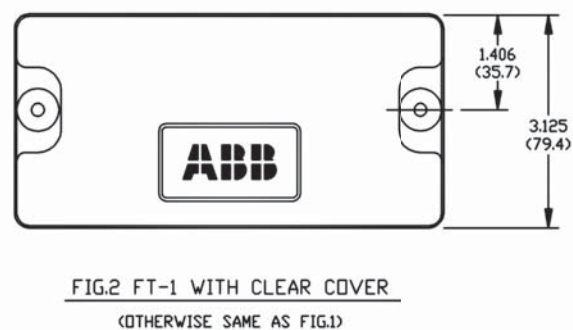
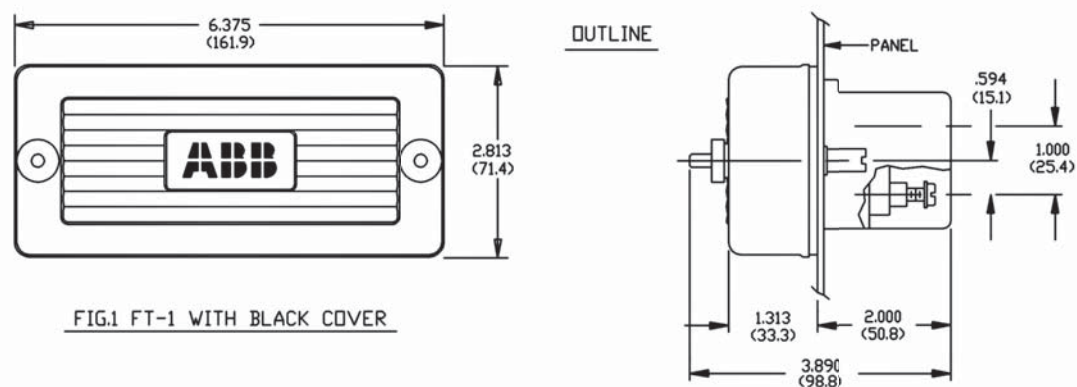
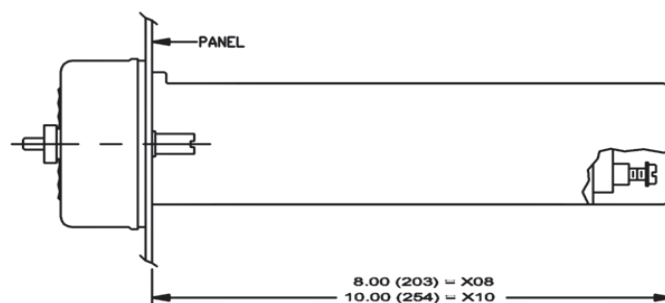


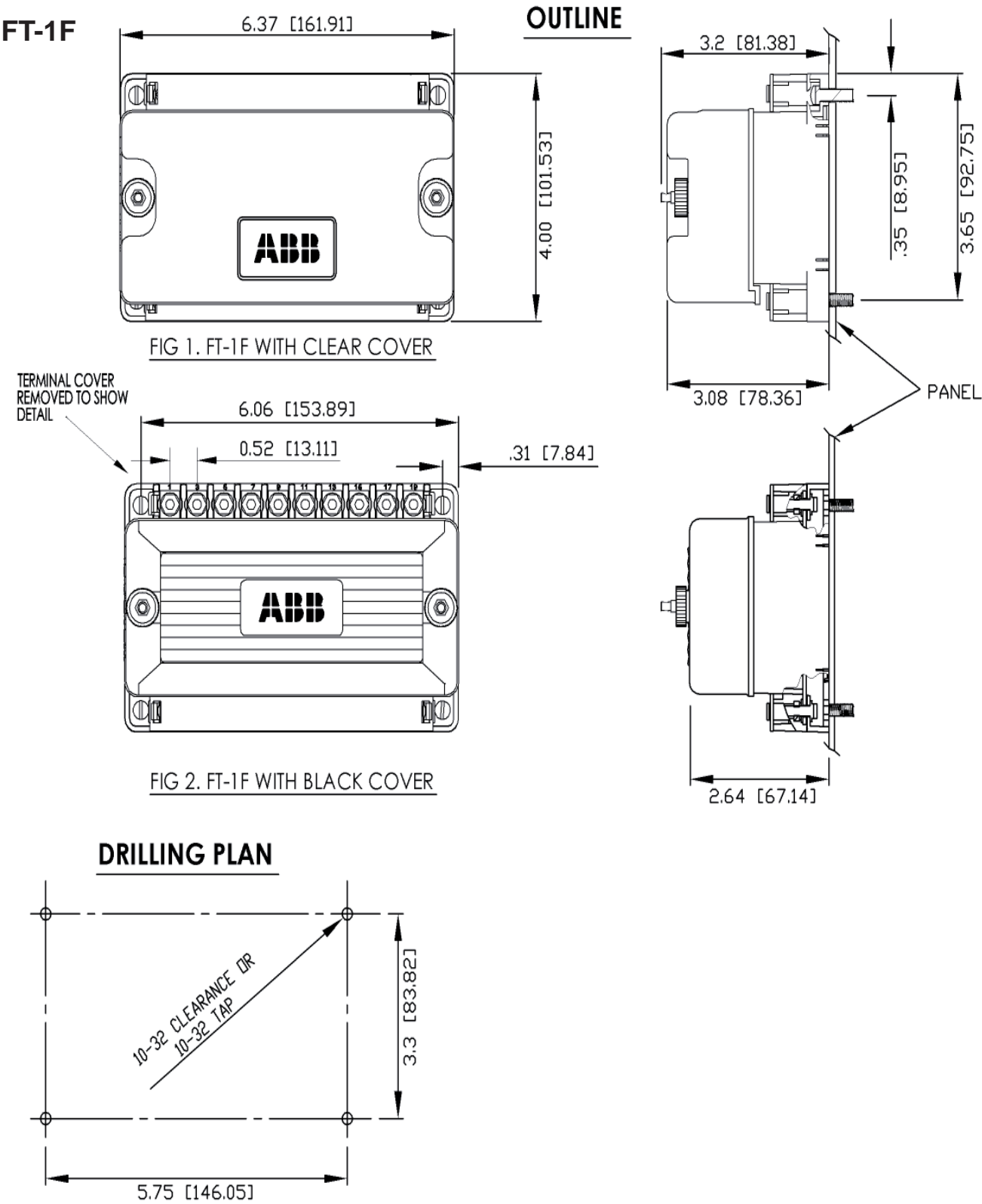
Figure 7 - FT-1 and FT-1X switch outline and drilling plan

FT-1**FT-1X**

DIMENSIONS: INCHES (mm)

Otherwise same as FT-1

Figure 8 - FT-1F switch outline and drilling plan



DIMENSIONS: INCHES[mm]

Figure 9 - FT-14 switch outline and drilling plan

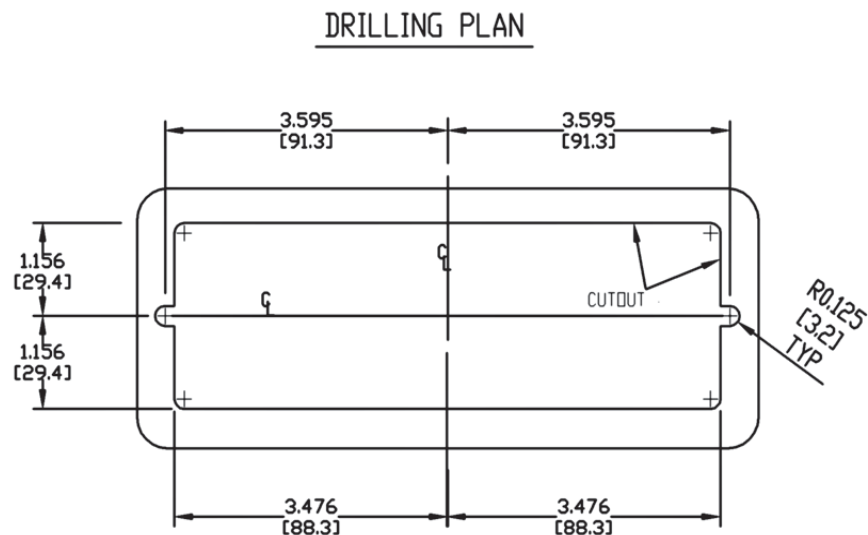
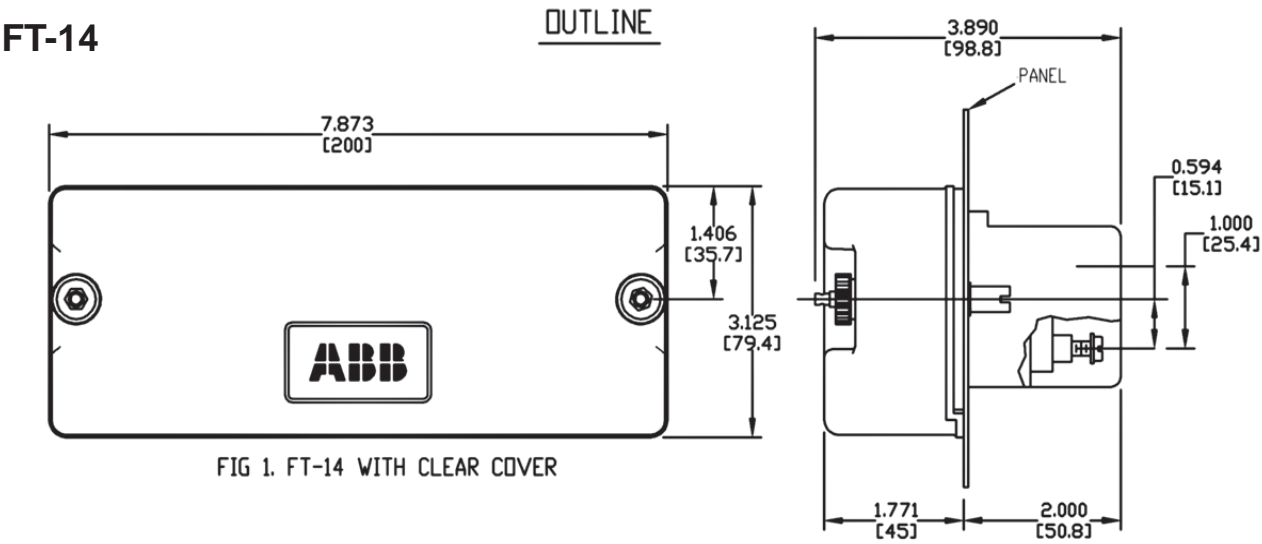


Figure 10 - FT-19R dimensions and layout for rack mounting

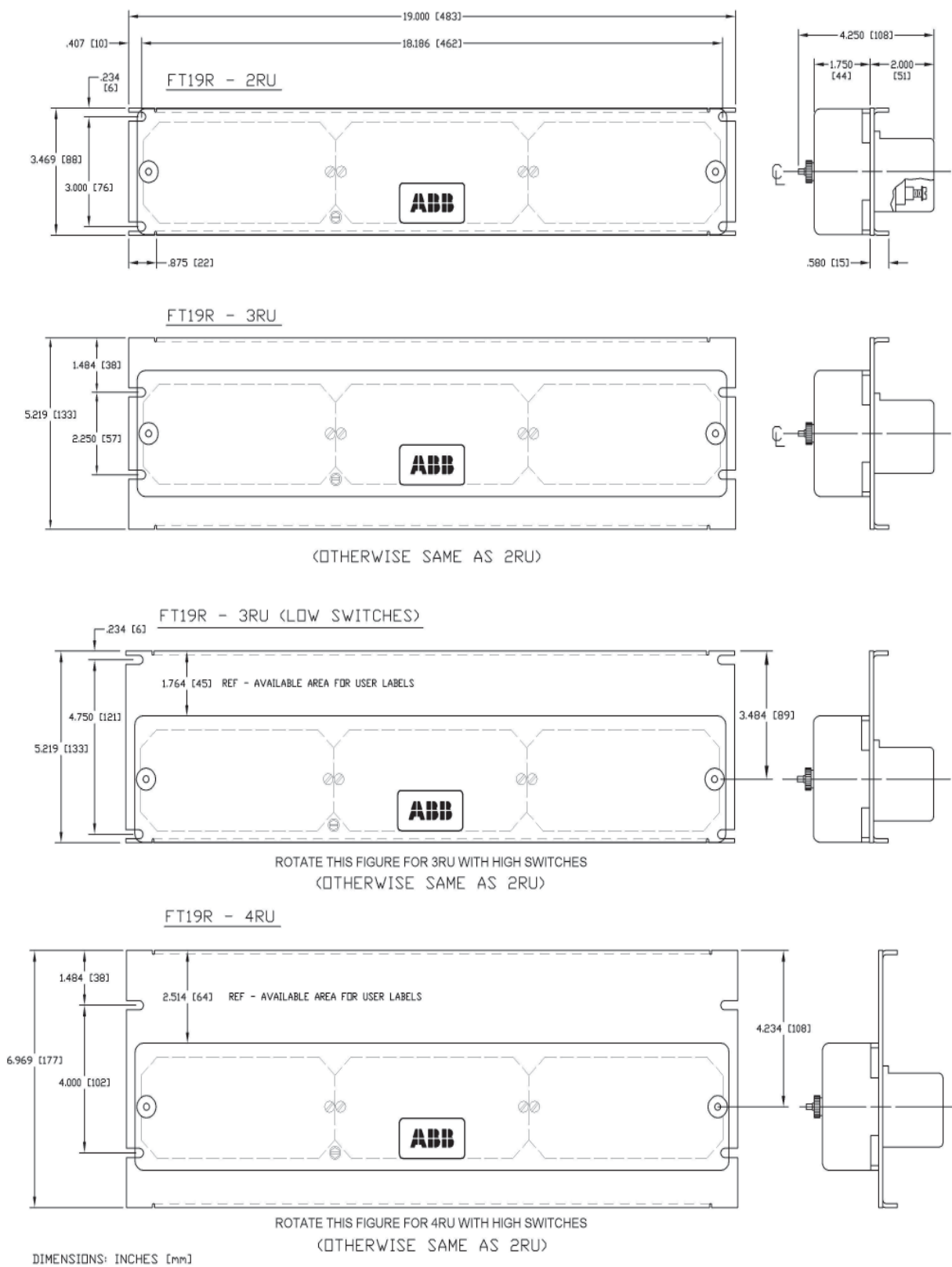
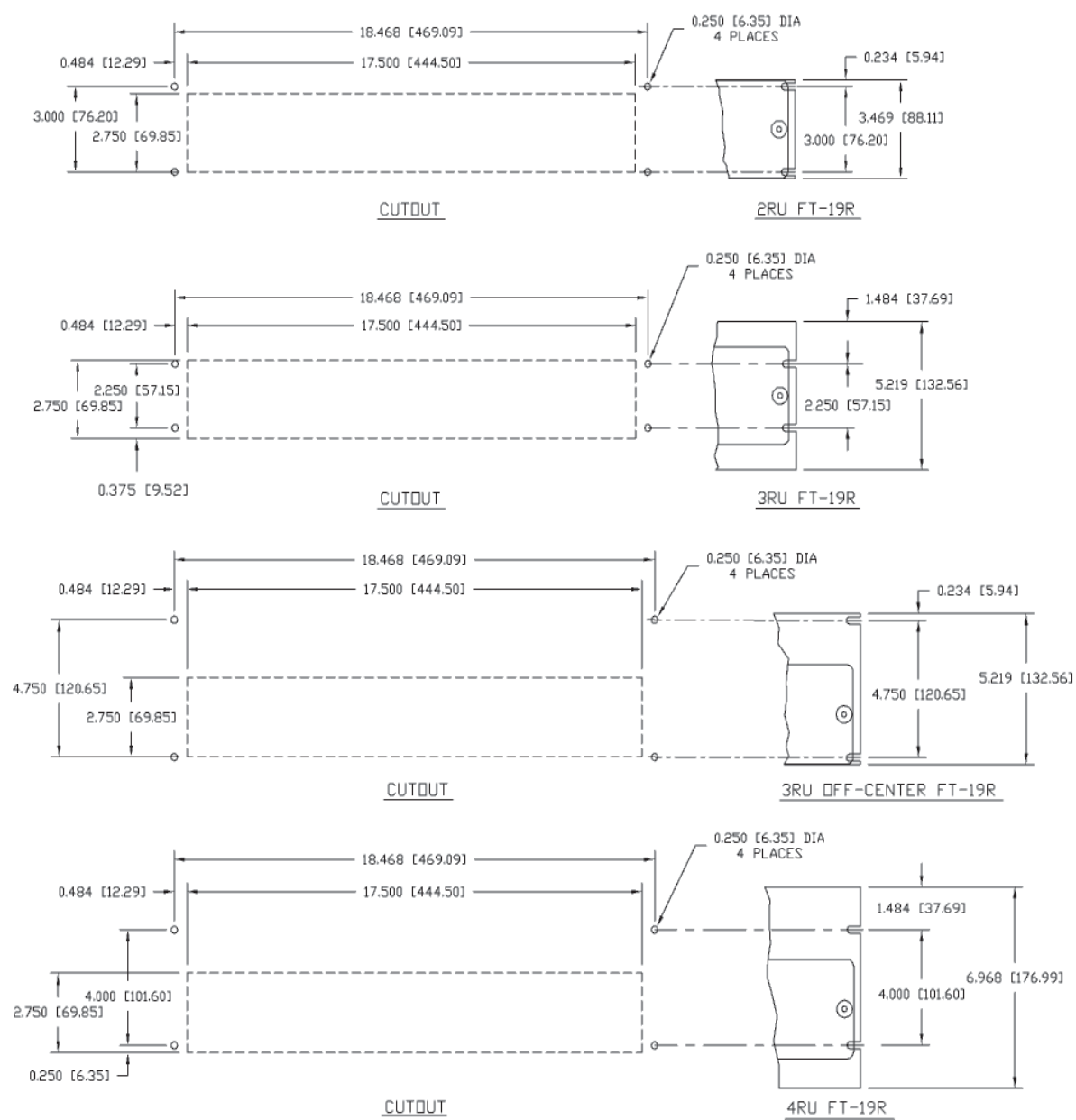


Figure 11 - Outline and drilling plan for FT-19R with flat panels (no rolled edges), rack or flush mounting for panels or cabinets



REF:
DIMENSIONS: INCHES [mm]
ALL FIGURES SHOW FRONT VIEW FT19R PANELS AND CUTOUTS.

Figure 12 - FT-22RS dimensions and layout for rack mounting

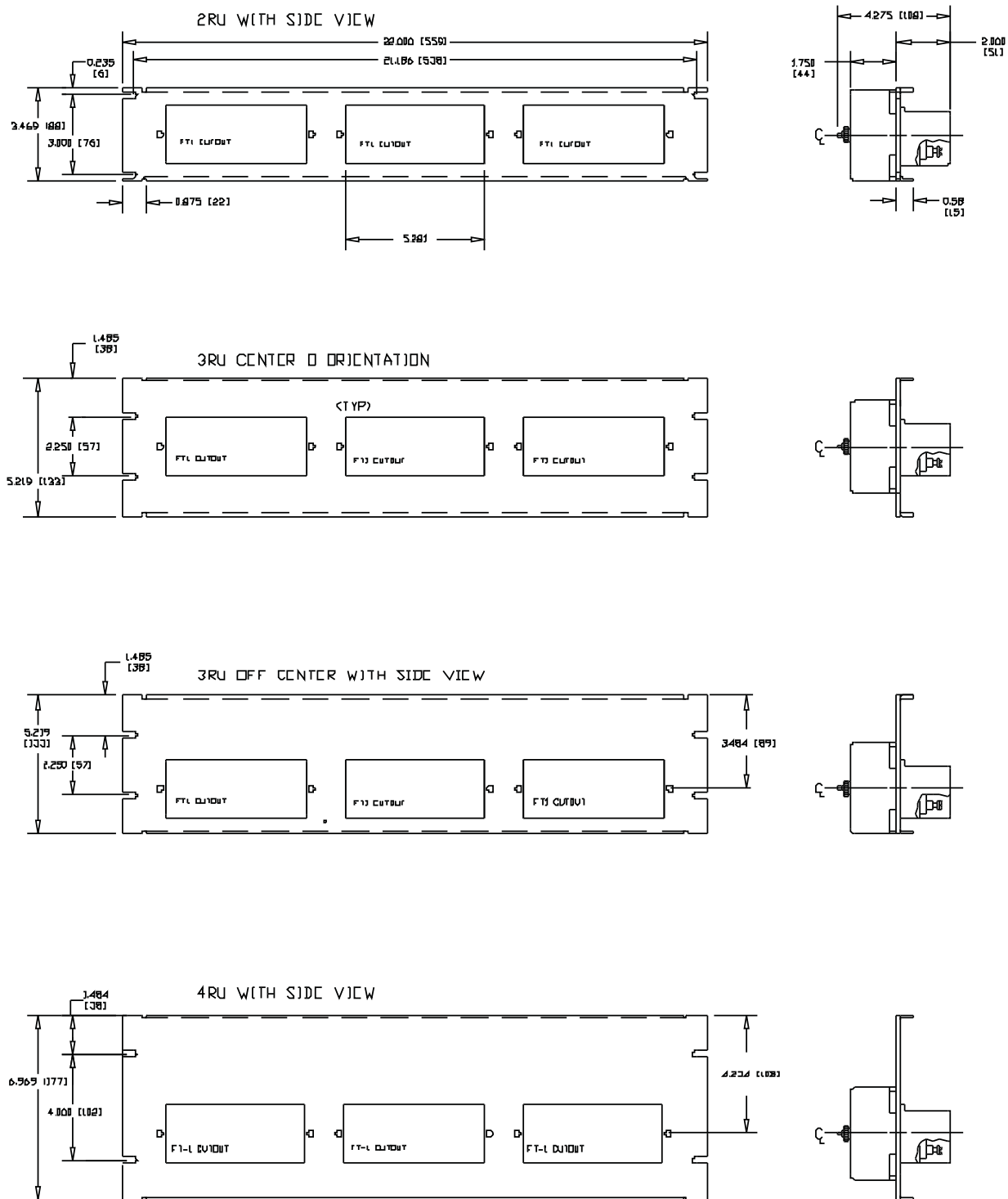


Figure 13 - Outline and drilling plan for FT-22RS with flat panels (no rolled edges), rack or flush mounting for panels or cabinets

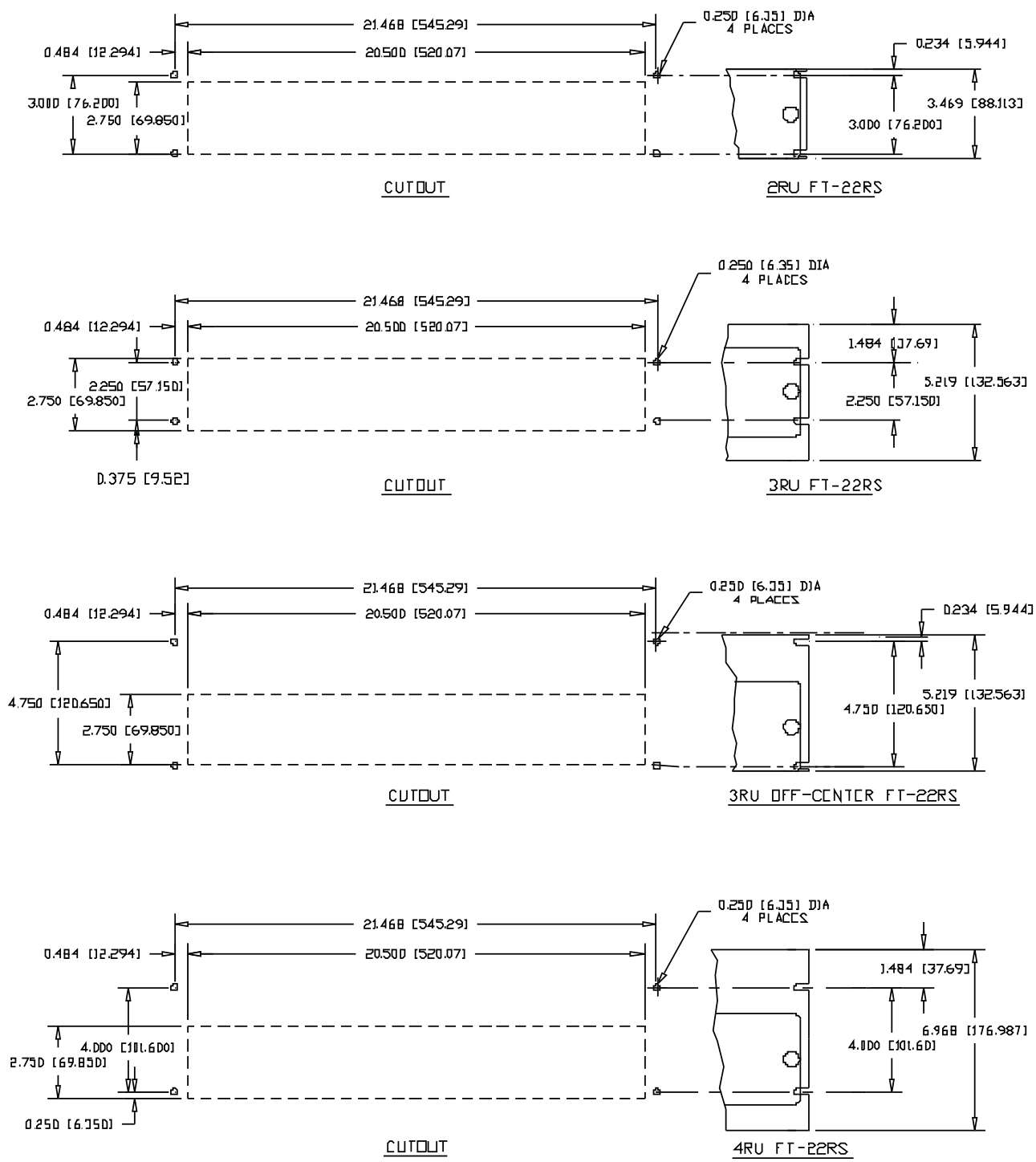
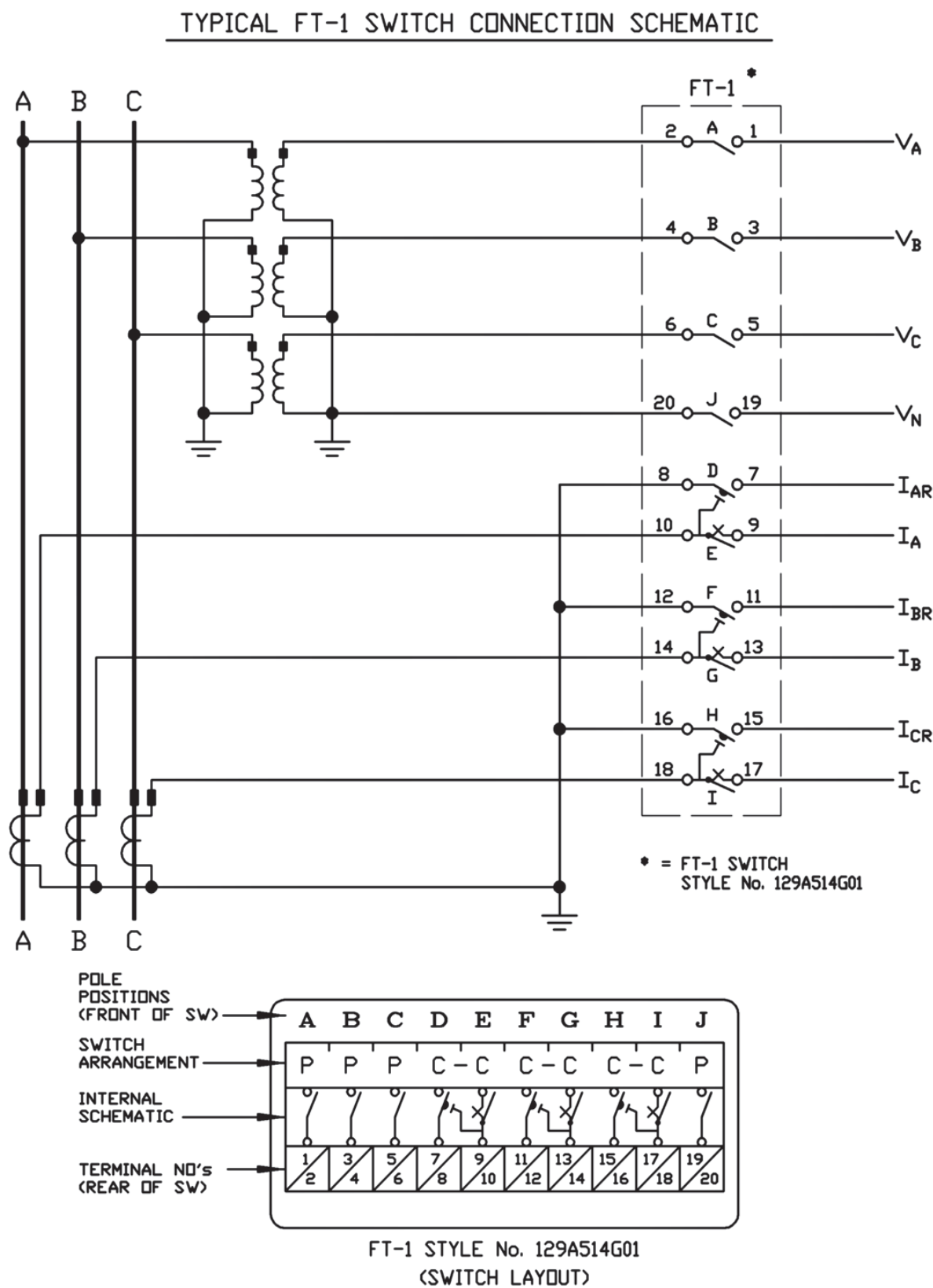


Figure 14- FT-1 switch connection schematic



Notes

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DB 41-077 Rev D March 2012



Main

Range	PowerLogic
Device short name	ION7650
Product or component type	Energy and power quality meter

Complementary

Power quality analysis	harmonic distortion voltage sag and swell detection waveform capture compliance monitoring dip and swell, transient disturbance direction detection programmability (logic and math functions) setpoint learning up to the 63rd harmonic
Device application	Demand and power factor control Co-generation and IPP monitoring Load curtailment Energy pulsing and totalisation Tariff metering Equipment monitoring and control Instrument transformer correction
Type of measurement	Current Voltage Frequency Apparent power total Power factor total Apparent power per phase Power factor per phase Active power total Active power per phase Reactive power total Reactive power per phase
Supply voltage	110...300 V DC 85...240 V AC 47...63 Hz
Network frequency	60 Hz

[In] rated current	5 A
Type of network	3P 1P + N 3P + N
Power consumption in VA	20 VA
Maximum power consumption in VA	45 VA
Display resolution	320 x 240 pixels QVGA
Display type	Backlit LCD
Sampling rate	512 samples/cycle
Measurement current	0...5 A
Input type	Current 0.005...20 A (impedance 0.002 Ohm)
Measurement voltage	100...600 V AC phase to phase 57...347 V AC phase to neutral
Frequency measurement range	42...69 Hz
Number of inputs	8 digital 120 V DC
Measurement accuracy	Current 0.1 % 1...5 A Voltage 0.1 % 57...288 V Energy 0.2 %
Accuracy class	Class 0.2S energy conforming to IEC 62053-22
Number of outputs	3 relay 4 solid state
Communication port protocol	Telnet DNP3 at <= 115.2 kbits/s ION at <= 115.2 kbits/s Modbus at <= 115.2 kbits/s IEC 61850 TCP/IP at 10/100 Mbit/s
Communication port support	RS485 Infrared SUB-D 9: RS232 SC: fiber optic
Data recording	GPS synchronisation Event logs Min/max of instantaneous values Sequence of event recording Time stamping Data logs Trending/forecasting
Transmission rate	<= 115.2 kbits/s 10/100 Mbit/s
Memory capacity	5 MB
Web services	Web server
Tamperproof of settings	Protected by access code
Compatibility code	ION7650

Environment

Electromagnetic compatibility	Electrical fast transient/burst immunity test conforming to IEC 61000-4-4 Electrostatic discharge conforming to IEC 61000-4-2 Susceptibility to electromagnetic fields conforming to IEC 61000-4-3 1.2/50 µs shock waves immunity test conforming to IEC 61000-4-5 Conducted and radiated emissions B conforming to CISPR 22
Mounting mode	Flush-mounted
Mounting support	Enclosure door
Type of installation	Indoor installation
Overvoltage category	III
IP degree of protection	IP30 back: conforming to IEC 60529 IP50 front face: conforming to IEC 60529
Relative humidity	5...95 %
Pollution degree	2
Ambient air temperature for operation	-20...70 °C

Ambient air temperature for storage	-40...85 °C
Operating altitude	0...2000 m
Standards	IEC 61010-1
Width	192 mm
Depth	174 mm
Height	192 mm
Net weight	1.9 kg

Offer Sustainability

Sustainable offer status	Green Premium product
REACH free of SVHC	Yes
EU RoHS Directive	Compliant EU RoHS Declaration
China RoHS Regulation	China RoHS declaration
Environmental Disclosure	Product Environmental Profile
Circularity Profile	End of Life Information
WEEE	The product must be disposed on European Union markets following specific waste collection and never end up in rubbish bins

KEMCO Industries, LLC

Metal Fabrication and Relay Panels

70 Keyes Court • Sanford, FL 32773

(407) 322-1230 Fax: (407) 322-0032

March 23, 2020

Bill of Materials

Quote No.: 37048

Haugland Energy Group, LLC

Cabinet 5, East End Substation

Item	Quantity	Part Number	Description
1	3.00 EA	M7650A0C0B6F1A0A	Schneider ION 7650, 7650-I/10M/1024-EMDM-20MAF PM <i>Mfr.: Schneider Electric USA, Inc.</i>
2	2.00 EA	129A528G01	Test Switch, FT-1, Arranged As (P C-C P C-C P C-C P), Black Cover, Screw Terminals <i>Mfr.: ABB, Inc.</i>
3	7.00 EA	MMLG01	Test Block, Type MMLG, Rack Mount <i>Mfr.: GE Grid Solutions, LLC</i>
4	3.00 EA	24PD58D	Control Switch, Engraving Code 124C-3B33 (Title "BREAKER CONTROL", "TRIP", "CLOSE") <i>Mfr.: Electros witch</i>
5	3.00 EA	78PB04D	Lockout Relay, Series 24, Manual Reset Lockout Relay with Lighted Faceplate (LOR Relay Reset = Green, LOR Tripped = Red) 4 Deck <i>Mfr.: Electros witch</i>
6	3.00 EA	04515625XC0X4H224XX2X	Relay, SEL-451-5, Standard (Replaces SEL-451-2 and SEL-451-4) Firmware, Connectorized® Relay* Connector type, 125-250 Vdc or 110-240 Vac, Horizontal Rack Mount, Keycode 5898 <i>Mfr.: Schweitzer Engineering Laboratories</i>
7	3.00 EA	WA04510BC2A	SEL-WA0451 , Wiring Harness for SEL-451 Relay, 14 AWG Currents, 16 AWG Voltages, 12 foot lengths, Key Code 3837 <i>Mfr.: Schweitzer Engineering Laboratories</i>
8	1.00 EA	CR15I	Receptacle, Duplex, 120 VAC, 15A, Ivory. <i>Mfr.: Hubbell</i>
9	1.00 EA	58 C 7	Cover Plate, for Single Duplex Receptacle, Galvanized, Fits on 2" x 4" Handy Box <i>Mfr.: Thomas & Betts</i>
10	2.00 EA	58361 1/2	Handy Box, 2" x 4", 1-7/8" Depth, 1/2" Knockouts <i>Mfr.: Thomas & Betts</i>
11	1.00 EA	NUD8818/30W	LED Light Fixture, 18", 120V, 11W <i>Mfr.: Nora Lighting</i>
12	1.00 EA	CS115I	Switch, Single Pole, 15A, 120/277 Volts



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Haugland Energy Group, LLC

Cabinet 5, East End Substation

Item	Quantity	Part Number	Description
			<i>Mfr.: Hubbell</i>
13	1.00 EA	58 C 30	Cover Plate, for Single Toggle Switch, Fits on 2" x 4" Handy Box <i>Mfr.: Hubbell</i>
14	2.00 EA	BTC3104	Mechanical grounding lug #4-3/0 awg. <i>Mfr.: Newark Electronics</i>
15	6.00 EA	F30A2S	Fuse Block, Class H, 2 Pole, 250V, 30A <i>Mfr.: Marathon Special Products</i>
16	12.00 EA	NON-10	Fuse, Type NON, Class K5 & H, 125VDC, 10A <i>Mfr.: Bussmann by Eaton</i>
17	16.00 EA	EB25B12	Terminal Block, GE EB-25, 12 Pole, 600V, 30A, Standard Connectors. <i>Mfr.: GE Grid Solutions, LLC</i>
18	1.00 EA	F30A1S	Fuse Block, Class H, 1 Pole, 250V, 30A <i>Mfr.: Marathon Special Products</i>
19	1.00 EA	NON-10	Fuse, Type NON, Class K5 & H, 125VDC, 10A <i>Mfr.: Bussmann by Eaton</i>
20	6.00 EA	CHM3DIU	Fuse Holder, 3 Pole, Midget UltraSafe, 800VAC, 1000VDC, 30A, With Indicator <i>Mfr.: Bussmann by Eaton</i>
21	18.00 EA	NON-5	Fuse, Type NON, Class K5 & H, 125VDC, 5A <i>Mfr.: Bussmann by Eaton</i>
22	1.00 EA	DRS-1215	Rackmount Surge Suppressor, 15 ft. Cord 14 Outlets 3000 Joules <i>Mfr.: Tripp Lite</i>

Metal Fabrication and Relay Panels

70 Keyes Court • Sanford, FL 32773

(407) 322-1230 Fax: (407) 322-0032

March 23, 2020

Bill of Materials

Quote No.: 37048

Haugland Energy Group, LLC

Cabinet 6, East End Substation

Item	Quantity	Part Number	Description
1	2.00 EA	M7650A0C0B6F1A0A	Schneider ION 7650, 7650-I/10M/1024-EMDM-20MAF PM <i>Mfr.: Schneider Electric USA, Inc.</i>
2	1.00 EA	129A528G01	Test Switch, FT-1, Arranged As (P C-C P C-C P C-C P), Black Cover, Screw Terminals <i>Mfr.: ABB, Inc.</i>
3	6.00 EA	MMLG01	Test Block, Type MMLG, Rack Mount <i>Mfr.: GE Grid Solutions, LLC</i>
4	2.00 EA	24PD58D	Control Switch, Engraving Code 124C-3B33 (Title "BREAKER CONTROL", "TRIP", "CLOSE") <i>Mfr.: Electros witch</i>
5	3.00 EA	78PB04D	Lockout Relay, Series 24, Manual Reset Lockout Relay with Lighted Faceplate (LOR Relay Reset = Green, LOR Tripped = Red) 4 Deck <i>Mfr.: Electros witch</i>
6	2.00 EA	04515625XC0X4H224XX2X	Relay, SEL-451-5, Standard (Replaces SEL-451-2 and SEL-451-4) Firmware, Connectorized® Relay* Connector type, 125-250 Vdc or 110-240 Vac, Horizontal Rack Mount, Keycode 5898 <i>Mfr.: Schweitzer Engineering Laboratories</i>
7	3.00 EA	WA04510BC2A	SEL-WA0451 , Wiring Harness for SEL-451 Relay, 14 AWG Currents, 16 AWG Voltages, 12 foot lengths, Key Code 3837 <i>Mfr.: Schweitzer Engineering Laboratories</i>
8	1.00 EA	0587Z0X625H22XX	Relay, SEL-587Z, Standard Firmware, 125/250 Vdc or Vac; 250 Vdc power supply, 5 Amp phase, horizontal rack mount, key code 7890 <i>Mfr.: Schweitzer Engineering Laboratories</i>
9	1.00 EA	24402H12A1A11631	Discrete Programmable Automation Controller (DPAC), SEL-2440, Dual Copper 10/100BASE-T, Standard Connectors, 48 Digital Input, 125 Vdc/Vac Digital Input, Horizontal Rack Mount, Key code 7231 <i>Mfr.: Schweitzer Engineering Laboratories</i>
10	1.00 EA	CR15I	Receptacle, Duplex, 120 VAC, 15A, Ivory.



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Haugland Energy Group, LLC

Cabinet 6, East End Substation

Item	Quantity	Part Number	Description
			<i>Mfr.: Hubbell</i>
11	1.00 EA	58 C 7	Cover Plate, for Single Duplex Receptacle, Galvanized, Fits on 2" x 4" Handy Box <i>Mfr.: Thomas & Betts</i>
12	2.00 EA	58361 1/2	Handy Box, 2" x 4", 1-7/8" Depth, 1/2" Knockouts <i>Mfr.: Thomas & Betts</i>
13	1.00 EA	NUD8818/30W	LED Light Fixture, 18", 120V, 11W <i>Mfr.: Nora Lighting</i>
14	1.00 EA	CS115I	Switch, Single Pole, 15A, 120/277 Volts <i>Mfr.: Hubbell</i>
15	1.00 EA	58 C 30	Cover Plate, for Single Toggle Switch, Fits on 2" x 4" Handy Box <i>Mfr.: Hubbell</i>
16	2.00 EA	BTC3104	Mechanical grounding lug #4-3/0 awg. <i>Mfr.: Newark Electronics</i>
17	6.00 EA	F30A2S	Fuse Block, Class H, 2 Pole, 250V, 30A <i>Mfr.: Marathon Special Products</i>
18	12.00 EA	NON-10	Fuse, Type NON, Class K5 & H, 125VDC, 10A <i>Mfr.: Bussmann by Eaton</i>
19	16.00 EA	EB25B12	Terminal Block, GE EB-25, 12 Pole, 600V, 30A, Standard Connectors. <i>Mfr.: GE Grid Solutions, LLC</i>
20	1.00 EA	F30A1S	Fuse Block, Class H, 1 Pole, 250V, 30A <i>Mfr.: Marathon Special Products</i>
21	1.00 EA	NON-10	Fuse, Type NON, Class K5 & H, 125VDC, 10A <i>Mfr.: Bussmann by Eaton</i>
22	6.00 EA	CHM3DIU	Fuse Holder, 3 Pole, Midget UltraSafe, 800VAC, 1000VDC, 30A, With Indicator <i>Mfr.: Bussmann by Eaton</i>
23	18.00 EA	NON-5	Fuse, Type NON, Class K5 & H, 125VDC, 5A <i>Mfr.: Bussmann by Eaton</i>



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ISO 9001 Certified

Metal Fabrication and Relay Panels

70 Keyes Court • Sanford, FL 32773

(407) 322-1230 Fax: (407) 322-0032

March 23, 2020

Bill of Materials

Quote No.: 37048

Haugland Energy Group, LLC

Cabinet 6, East End Substation

Item	Quantity	Part Number	Description
24	1.00 EA	DRS-1215	Rackmount Surge Suppressor, 15 ft. Cord 14 Outlets 3000 Joules <i>Mfr.: Tripp Lite</i>

Prepared By:

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Proposal Name: East End Substation Restoration & Expansion Project, Phase 2

Quote Name: East End Substation Restoration & Expansion Project, Phase 2

Proposal Number: P-200310-1481378

Quote Number: Q-1595855

Quote Date: April 13, 2020

Through Addenda Number: 0

Sales Representative: Jim Keith

Conditions of Sale

This Quotation is subject to Coordinated Project Terms. See <https://www.schneider-electric.us/en/download/document/0100PL0043>

Quote is valid for 30 days. Quoted lead times are approximate and subject to change.

Schneider Electric reserves the right to amend, withdraw or otherwise alter this submission without penalty or charge as a result of any event beyond its control arising from or due to the current Covid-19 epidemic or events subsequent to this epidemic / pandemic including changes in laws, regulations, by laws or direction from a competent authority.

Clarifications and Exceptions

SECTION 261323 - 15KV GAS INSULATED SWITCHGEAR (GIS) Spec Review

- 1.8 v: The following spare parts have been included in our bid:

- 1) spring charging motor
- 1) motor for disconnect switch
- 1) motor for ground switch
- 1) trip coil
- 1) close coil
- 1) blocking coil disconnect switch
- 1) blocking coil ground switch
- 1) blocking coil circuit breaker TRIP
- 1) diode block
- 1) MCB motor
- 1) MCB controlling
- 1) MCB VT
- 1) filter, 3-phase for VT main winding

- 2.3.A. Quoted as CBGS-0 switchgear, not metal clad; therefore, the PT/CT are not same rating as MV metal clad switch gear. PT and CT is special design for CBGS-0 gear only.
- 2.5.A. Current CBGS-0 of SE only offer under RAL 9002, White color only. Take exception for ANSI 70.
- 2.12. There is standard mimic bus symbol on each switch.
- 2.18. Control selector switch is quoted as remote panel for relay and communication by another group. Switchgear is quoted switchgear only and operating components are included in the corresponding relay/protection panels. All wires are wire out to customer terminal block for other group to use to connect to their remote-control panel.
- 2.20.A. cable /kit/LA is only quoted as provision by others / contractor/distributor to provide this (it is not available to quote).
- 2.21. Take excepting for customer require on rating/ type/ class of CT and PT. Multi ratio CT's are not available in this switchgear. PT is quoted as sensor PT only. See user manual of CBGS-0 product for more detail.
- 2.22.A. Protective Relays shall be included in the pricing for the remote-control/relay panel (quoted by Schneider Electric Energy Automation Division).
- 2.23.A. Metering shall be included in the pricing for the remote-control/relay panel . (quoted by Schneider Electric Energy Automation Division
- 2.25.C. Local Control panel is quoted as a separate device and is not part of the switchgear . (quoted by Schneider Electric Energy Automation Division
- 2.29 FACTORY TESTS is included in our quote. Travel and lodging expenses will be the responsibility of each attendee.
- 3.1.I. Factory trained and certified service personnel to oversee the installation is not included but can be added at a daily rate \$2055/day excluding taxes. Rate is based on Monday through Friday during normal business hours.

Phase 2 Addendum 3 STD-18257-E-600: Rev. 1 date 03.31.2020: drawings review NOTES:

- o Standard SBGS-0 only offers one (1) set of LLI which mounts at switch panel location – See Instruction Bulletin document above for more detail. Take exception to the Second set of LLI
- o Arrestor: SBGS-0 offers a provision for mounting distribution class arrestors only. Provision only is quoted. Arrestors are not included in our quote.
- o Cable lugs termination: Schneider Electric does not offer factory supplied lugs. The cable lug termination must be provided by others in accordance with the requirements of CBGS-0 type switchgear.
- o Fuse Switch which connect the outgoing cable is not part of this quote. It said provided by “WAPA”

PR5 and PR6 remote control/relay panels are included in our quotation as per the below:

- 1) Configuration and testing of 1 x SEL451 for transformer feeder, 4 x SEL 451 for feeder protection and 1 x SEL-0587Z bus bar differential relay - 2 X day Factory acceptance Test (FAT) in Houston plant. FAT is considered to be executed in one single trip by protection engineer - 3.5 X day Site Acceptance Test (SAT) in St Thomas, USVI. SAT is considered to be executed in one single trip by protection engineer.
- 2) It is expected that there is a site SCADA provider who integrates PR5 and PR6 into the overall system and programs/commissions the SEL2440 device and other components to function as intended in the system since there was no sequence of operation or intended functionality included in the contract documents. This is **NOT** included in our quotation.

Seq #	Qty	Product Description
1	1	<p>Designation : CBGS-0 13.8KV 2000A 31.5K</p> <p>Product Details:</p> <p>1 - CBGS-0 TYPE GAS INSULATED SWITCHG+-CBGS-0 TYPE GAS INSULATED SWITCHG+ CBGS-0 Switchgear Assembly Consisting of the following: 5 Section Line-up Lineup Depth : 55.1 in Inches Lineup Width : 139.00 Inches Lineup Height : 92.5 Inches Lineup Weight : 4630.00 LBS Gear Shipped by</p> <p>PHASE TO PHASE VOLTAGE: 13200V SYSTEM: 3 Wire SYSTEM SOURCE GROUND: Ungrounded MAX AVAILABLE FAULT CURRENT: 31.5kA - 2s FREQUENCY: 60Hz PRIMARY BIL: 150 kV DESIGN STANDARD: Not Required NO SEISMIC QUALIFICATION ENCLOSURE TYPE: NEMA 1 FRONT ONLY ACCESS AVAILABLE EXTERIOR PAINT COLOR: RAL9002, White SYSTEM AMPACITY: 2000A SOLIDLY INSULATED COPPER BUS BAR ORIGIN OF CONTROL POWER SOURCE:By Customer SPRING CHARGING MOTOR: 250Vdc DC CONTROL POWER: By Customer AMBIENT AIR: BETWEEN -5 AND 40 DEG C ALTITUDE ABOVE SEA LEVEL: 0 - 3299 ft / 0 - 1005 m GAS EXHAUST: Upwards LATERAL END SHEETS PILOT LIGHT TYPE: LED WIRE MARKERS: Plastic Sleeve TYPE OF CONTROL WIRE: #14 AWG SIS TYPE OF VOLTAGE CIRCUIT WIRE: #14 AWG SIS TYPE OF SECTION INTERCONNECT WIRE: #14 AWG SIS TYPE OF CURRENT WIRE: #12 AWG SIS This product uses shielded insulated elbow style cable connectors of type C specified by CENELEC EN50180 and EN50181 and in IEC 60137. These connectors and surge arrestors are not included and should be provided by the customer --- ---</p> <p>EQUIPMENT NAMEPLATE: Black Surface/White Letters</p> <p>DEVICE NAMEPLATES: Black Surface / White Letters</p> <p>Designation: D-110 CBGS-0 VACUUM CIRCUIT BREAKER - MAIN DEVICE AMPACITY: 2000A INTERRUPTING RATING: 25kA DISCONNECT SWITCH OPERATION TYPE: Motorized GROUND SWITCH OPERATION TYPE: Manual CLOSING COIL: Yes TRIP COIL #1: Yes DISCONNECT AND GROUND SWITCH: Visible indication w camera and USB port SURGE ARRESTER: Distribution Class (1 set) CABLE CROSS SECTION: 750 kcmil LUG TYPE: Through the Bottom CABLES PER PHASE: 3 CURRENT TRANSFORMER TYPE: 3-Phase Single Ratio CT</p>

CT LOCATION: LineSide
CT RATIO: 2000/5 C50-C50-C100
RELAY MANUFACTURER: Schweitzer (SEL)
LOCKOUT RELAY(s) FOR: Bus Differential
(Diff) Relay
VOLTAGE TRANSFORMER:: Cable Side VT

Designation: D-101
CBGS-0 VACUUM CIRCUIT BREAKER - FEEDER
DEVICE AMPACITY: 1200A
INTERRUPTING RATING: 25kA
DISCONNECT SWITCH OPERATION TYPE: Motorized
GROUND SWITCH OPERATION TYPE: Manual
CLOSING COIL: Yes
TRIP COIL #1: Yes
DISCONNECT AND GROUND SWITCH: Visible
indication w camera and USB port
SURGE ARRESTER: Distribution Class (1 set)
CABLE CROSS SECTION: 750 kcmil
LUG TYPE: Through the Bottom
CABLES PER PHASE: 1
CURRENT TRANSFORMER TYPE: 3-Phase Single
Ratio CT
CT LOCATION: LineSide
CT RATIO: 1200/5 C50-C100-C100
RELAY MANUFACTURER: Schweitzer (SEL)
LOCKOUT RELAY(s) FOR: Bus Differential
(Diff) Relay
VOLTAGE TRANSFORMER:: Not Required
LOW VOLTAGE PANEL WITH:
POWER METER

Designation: D-103
CBGS-0 VACUUM CIRCUIT BREAKER - FEEDER
DEVICE AMPACITY: 1200A
INTERRUPTING RATING: 25kA
DISCONNECT SWITCH OPERATION TYPE: Motorized
GROUND SWITCH OPERATION TYPE: Manual
CLOSING COIL: Yes
TRIP COIL #1: Yes
DISCONNECT AND GROUND SWITCH: Visible
indication w camera and USB port
SURGE ARRESTER: Distribution Class (1 set)
CABLE CROSS SECTION: 750 kcmil
LUG TYPE: Through the Bottom
CABLES PER PHASE: 1
CURRENT TRANSFORMER TYPE: 3-Phase Single
Ratio CT
CT LOCATION: LineSide
CT RATIO: 1200/5 C50-C100-C100
RELAY MANUFACTURER: Schweitzer (SEL)
LOCKOUT RELAY(s) FOR: Bus Differential
(Diff) Relay
VOLTAGE TRANSFORMER:: Not Required
LOW VOLTAGE PANEL WITH:
POWER METER

Designation: D-105
CBGS-0 VACUUM CIRCUIT BREAKER - FEEDER
DEVICE AMPACITY: 1200A
INTERRUPTING RATING: 25kA
DISCONNECT SWITCH OPERATION TYPE: Motorized
GROUND SWITCH OPERATION TYPE: Manual
CLOSING COIL: Yes
TRIP COIL #1: Yes
DISCONNECT AND GROUND SWITCH: Visible
indication w camera and USB port

SURGE ARRESTER: Distribution Class (1 set)
CABLE CROSS SECTION: 750 kcmil
LUG TYPE: Through the Bottom
CABLES PER PHASE: 1
CURRENT TRANSFORMER TYPE: 3-Phase Single
Ratio CT
CT LOCATION: LineSide
CT RATIO: 1200/5 C50-C100-C100
RELAY MANUFACTURER: Schweitzer (SEL)
LOCKOUT RELAY(s) FOR: Bus Differential
(Diff) Relay
VOLTAGE TRANSFORMER:: Not Required
LOW VOLTAGE PANEL WITH:
POWER METER

Designation: D-107
CBGS-0 VACUUM CIRCUIT BREAKER - FEEDER
DEVICE AMPACITY: 1200A
INTERRUPTING RATING: 25kA
DISCONNECT SWITCH OPERATION TYPE: Motorized
GROUND SWITCH OPERATION TYPE: Manual
CLOSING COIL: Yes
TRIP COIL #1: Yes
DISCONNECT AND GROUND SWITCH: Visible
indication w camera and USB port
SURGE ARRESTER: Distribution Class (1 set)
CABLE CROSS SECTION: 750 kcmil
LUG TYPE: Through the Bottom
CABLES PER PHASE: 1
CURRENT TRANSFORMER TYPE: 3-Phase Single
Ratio CT
CT LOCATION: LineSide
CT RATIO: 1200/5 C50-C100-C100
RELAY MANUFACTURER: Schweitzer (SEL)
LOCKOUT RELAY(s) FOR: Bus Differential
(Diff) Relay
VOLTAGE TRANSFORMER:: Not Required
LOW VOLTAGE PANEL WITH:
POWER METER

Seq #	Qty	Product Description
2	1	Designation : PR5&PR6 relay panels Product Details: EA scope includes: Manufacturing 2 x 13.2kV relay panel (PR5 and PR6) as provided in the drawing document page6,