Industrial
Solutions

TECHNICAL APPLICATION GUIDE

ReliaGear® LV SG

Low voltage switchgear

by ABB

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Warranty and general information

Hazard classifications
The following important highlighted information appears throughout this document to warn of potential hazards or to call attention to information that clarifies a procedure.

Carefully read all instructions and become familiar with the devices before trying to install, operate, service or maintain this equipment.

DANGER

Danger: Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

Warning: Indicates a hazardous situation that, if not avoided, could result in death or serious injury.

CAUTION

Caution: Indicates that if the hazard is not avoided could result in minor or moderate injury.

NOTICE

Notice: Is used to notify of practices not related to personal injury.

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SACE® Emax 2 Ekip®
ReliaGear® LV SG

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Warranty
This document is based on information available at the time of publication. While efforts have been made to ensure accuracy, the information contained herein does not cover all details or variations in hardware and software, nor does it provide for every possible contingency in connection with installation, operation, and maintenance. Features may be described herein that are not present in all hardware and software systems.

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No warrantees of merchantability or fitness for purpose shall apply. Contact your local sales office if further information is required concerning any aspect of ReliaGear LV SG switchgear and SACE Emax 2 breaker operation or maintenance.

ReliaGear® LV SG
General information

ReliaGear LV SG is the new generation low voltage switchgear platform incorporating the best of both worlds: cutting-edge SACE® Emax® 2 air circuit breaker with SACE Emax 2 Ekip trip unit technology, integrated into the proven AKD switchgear platform, once again, demonstrating the innovation and reliability end users expect from ABB.

ReliaGear LV SG switchgear is manufactured in an ISO 9001 certified ABB facility and built to rigorous standards.

ReliaGear LV SG switchgear meets the demands of industrial, utility and commercial applications. It is designed and tested in accordance with the latest IEEE C37.20.1 standard, CAN/CSA-C22.2 No. 31, and UL 1558 standards (file no. E76012). ReliaGear LV SG has been conformance-tested to ANSI C37.51. Any equipment requiring UL 1558 or CSA labeling will be provided with a cUL label. (A cUL label is a third-party certification that indicates the switchgear is compliant to both ANSI/IEEE and CSA standards.)

ANSI/IEEE standards require that switchgear operates at the ratings of devices installed. Switchgear short circuit ratings are based on two 30-cycle withstand tests with 15-second interval between the two tests, performed at 15 percent power factor and 635 Vac maximum. In addition ANSI/IEEE switchgear thermally qualifies the design through testing, which is inclusive of the UL 1066 Power Air Circuit Breaker. In contrast, switchboards only provide a single 3-cycle withstand test at 20 percent power factor and 600 Vac maximum and do not require thermally tested solutions inclusive of UL1066 or UL489 breakers.

ReliaGear LV SG switchgear is available with the following ratings:
- 600 Vac nominal, 635 Vac maximum
- 8000 amps AC main bus/5000 amps breaker max.
- 50/60 Hz
- 100 kA symmetrical short circuit

ReliaGear LV SG switchgear breaker and auxiliary sections are constructed with 11-gauge frames and are furnished in 15, 22, 30 and 38-inch widths. The switchgear is designed to be operated in ambient temperatures between –30°C and 40°C [-22°F and 104°F]. For installation environment considerations of the SACE Emax 2 circuit breaker, please see 1SXU200040C0201.

Low voltage circuit breakers rated 800/1200/1600/ 2000 amps can be stacked in four-high combinations resulting in optimized floor space. The 11-gauge, bolted modular-designed steel frame permits flexibility in arrangements of breakers and associated components.

ReliaGear LV SG switchgear houses low voltage power circuit breakers, instrumentation, and other auxiliary circuit protective devices in single or multiple source configurations. ReliaGear LV SG switchgear can be applied either as a power distribution unit or as part of a unit substation in indoor or outdoor construction.

A metal breaker cradle is incorporated into the breaker cubicle and includes the safety interlocks, and provisions for accessories such as shutters, position switches, secondary disconnects, and key interlocking.

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01 Cassette construction

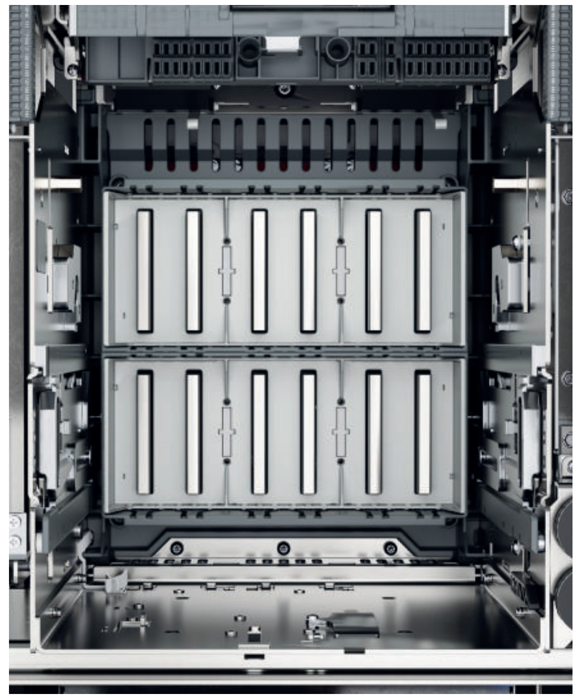
The SACE Emax 2 low voltage power circuit breaker (LVPCB) offers a wealth of protection and communication in a breaker size and weight not seen in previous generations of low voltage switchgear. The circuit breaker's frames have continuous current ratings from 800 A to 5000 A and rating plug values as low as 100 A. Short-circuit ratings are available up to 100 kA, with 65 kA, 85 kA, and 100 kA 30- cycle withstand ratings to match.

The SACE Emax 2 Ekip Touch protection trip units are equipped with a large color touch-screen display which enables safe and intuitive operation. Furthermore the SACE Emax 2 Ekip trip units can be accessed by means of smartphone, tablet or portable PC, thanks to enhanced connectivity capabilities and a full portfolio of commissioning tools. The increased computing power allows to update the circuit breaker maintaining it closed and in service during the operation.

Standard and optional features - for enhanced operation and reliability

Cradle construction
ReliaGear LV SG switchgear has several key components that set it apart from previous low voltage switchgear designs. The ReliaGear LV SG breaker fits into a metal cradle built in to the circuit breaker cubicles, as shown in Figure 01. ReliaGear LV SG breaker cubicle construction uses an unventilated front door that provides closed-door access to breaker status indicators, mechanism operators, trip unit display and keypad, and it allows for true closed-door drawout operation.

The breaker cubicle door has a standard quarter-turn latch and serves as a steel barrier between live parts and the operator. The compartment houses accessories as well as interlocks for the drawout breaker. Accessories include current transformers for discrete metering or protective relaying, drawout position switches and key interlocks.



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01

Repetitive duty
Circuit breakers are designed primarily to perform the function of circuit interruption under short-circuit conditions.

Nevertheless, modern circuit breakers' mechanisms are capable of many operations under full-load operation and in-rush conditions such as those encountered in motor starting applications. Industry standards have been established for maintenance intervals and are indicated in Table 1. With adequate maintenance, SACE Emax 2 will meet all life claims found in the SACE Emax 2 UL catalog Please see 1SXU200040C0201.

SACE Emax 2 breakers have been designed to meet life expectancy claims following a more flexible maintenance schedule. Please see the Installation, operation and maintenance instructions for the installer and the user - SACE Emax 2 E2.2-E4.2-E6.2 for details Please see 1SDH001000R0002.

Power circuit breakers, when operating under usual service conditions, shall be capable of operating the number of times specified in the following table. The operating conditions and the permissible effect of such operations upon the breaker are listed in Table 1 and the footnotes.

For instance, the breaker should be operated with rated control voltage applied. The frequency of operation should not exceed 20 in 10 minutes or 30 in an hour (rectifiers or other auxiliary devices may further limit the frequency of operation).

Servicing consisting of adjusting, cleaning, lubricating, tightening, etc., as recommended by the maintenance manual, is to be done at no greater interval than shown in the column titled “Number of operations between servicing” in Table 1.

No functional parts should require replacement during the listed operations. The circuit breaker should be able to carry its rated continuous current at rated maximum voltage and perform at least one opening operation at rated short-circuit current.

After completion of this series of operations, functional part replacement and general servicing may be necessary. This standard applies to all parts of a circuit breaker that function during normal operation. It does not apply to other parts, such as overcurrent tripping devices that function only during infrequent abnormal circuit conditions.

Table 1: Repetitive duty and normal maintenance (from ANSI C37.16 table 5)

Circuit breaker frame size (amperes)	Number of operations between servicing	Number of operations rated continuous current switching(1)(2)(4)	Number of operations no-load closing and opening(1)	Number of operations in-rush current switching(3)(4)
800	1750	2800	9700	1400
1600	500	800	3200	400
2000	500	800	3200	400
3200	250	400	1100	-
4000	250	400	1100	-
5000	250	400	1100	-

1. Servicing consists of adjusting, cleaning, lubricationg, tightening, etc. as recommended by the manufacturer. When current is interrupted, dressing of contacts may be required as well. The operations listed are on the basis of servicing at intervals of six months or less.

2. With closing and opening currents up to the continuous current rating of the circuit breaker at voltages up to the rated maximum voltage (85% or higher power factor).

3. The number of operations was determined with closing currents up to 100% (80% power factor or higher) of the continuous current rating of the circuit breaker at voltages up to the rated maximum voltage. With closing and opening currents up to 600% (50% power factor or less) of the continuous current rating of the circuit breaker at voltages up to rated maximum voltage, the number of operations shown should be reduced to 10% of the number listed in the column.

4. If a fault operation occurs before the completion of the listed number of operations, servicing is recommended and possible functional part repmacement may be necessary depending on previous accumulated duty, fault magnitude, and expected future operations.

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02 Primary disconnect shutters (locked in the closed position)

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03 Primary disconnect shutters (open position)

Temperature de-rating factors
The continuous current rating of SACE Emax 2 breakers is based on their use in an enclosure at 40° C ambient temperature. SACE Emax 2 breakers must be derated for ambient temperatures above 40° C. (Trip unit ambient is limited to 70° C.)

Table 2: Continuous current de-rating factors

Ambient temperature (°C)	De-rating factor
40	1.00
45	0.94
50	0.88
55	0.83(1)
60	0.77
65	0.71
70	0.65

1. Trip unit maximum

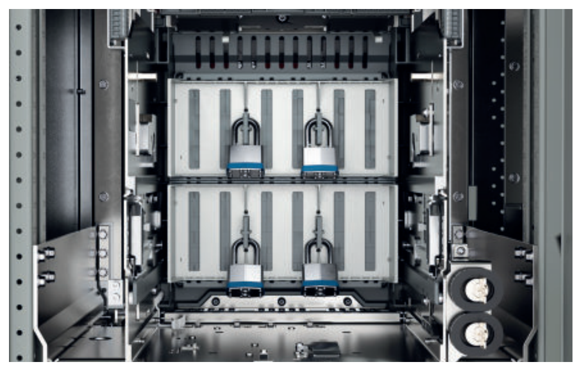
Altitude correction factors
When applying low voltage power circuit breakers at altitudes greater than 6,600 feet, their continuous current rating must be modified due to lower air density at higher altitudes reducing the ability to cool by natural convection. The voltage ratings must also be modified because of the lower dielectric strength of the air. The short-time and short-circuit current ratings are not affected by altitude. However, the short-circuit current ratings shall not exceed that of the voltage class before de-rating.

Table 3: Altitude correction factors (as listed in ANSI C37.13)

Altitude		Rating correction factor	
Meters	Feet	Continuous current	Voltage
2000	6600 (and below)	1.00	1.00
2600	8500	0.99	0.95
3900	13000	0.96	0.80

Humidity
Ferrous parts are zinc-plated for corrosion protection except for some parts made from alloy steels that are inherently corrosion resistant. Current-carrying parts are silver or tin-plated for corrosion protection and to assure electrical continuity. Heaters may be added to indoor sections operating in high humidity environments. Heaters are mounted in the bus/cable compartment in the rear of each section.

Primary disconnect shutters
Shutters, shown closed and locked in Figure 02 and open in Figure 03, are standard accessories for all breaker cubicles. The shutters open when the breaker is racked in from the TEST position to the CONNECT position. The shutters are in the closed position when the breaker is in the TEST and DISCONNECT positions. They can be locked in the closed position (Figure 02) when the breaker is removed from the cubicle, preventing access to the line and load stabs in the breaker cubicle.



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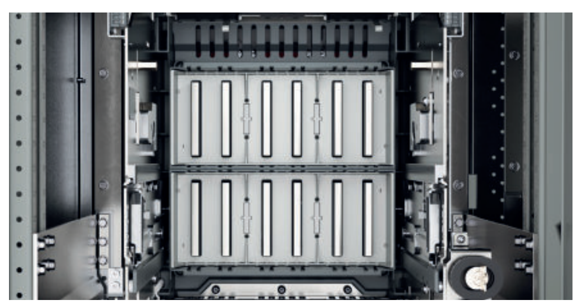

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04 Optional cradle mounted kirk key interlock

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05 Breaker and cradle rejection (respectively)

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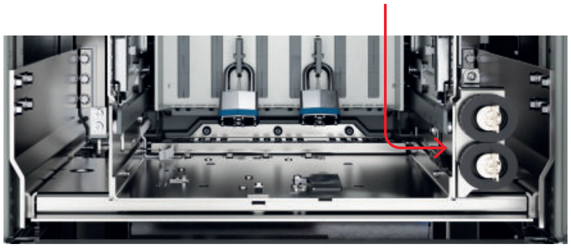
06 Drawout rail padlocked (and close-up)

Kirk key interlocks

Key interlocks can be added to the cradle to mechanically lock the breaker open, in a trip-free position, when the breaker is in the CONNECT position (Figure 04).



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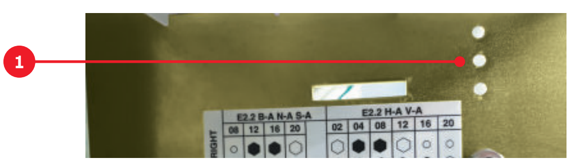
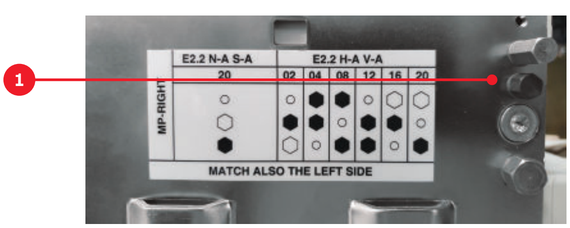
The cradle will accommodate either one or two Kirk key interlocks. Interlocking schemes prevent multiple breakers from being closed at the same time, such as a utility main and emergency generator, or preventing a tie breaker from being closed until a main circuit breaker is opened. Key interlocks are also used to prevent operation of a transformer primary switch unless the main secondary breaker is open. Key interlocks mounted on the breaker cradle stay with the breaker cubicle so that the interlock scheme is maintained even if a spare breaker is inserted into a key interlocked breaker cubicle.

Breaker rating rejection

The cradle also includes rating interlocks to prevent a breaker of incorrect short-circuit rating or continuous current rating from being installed into a cradle (Figure 05). There are four physical envelope sizes for the SACE Emax 2 breaker. The physical size differences will not allow breakers of a different envelope size to fit into an incorrect compartment.



1. Cradle pins (not shown)



1. Breaker pins (shown)

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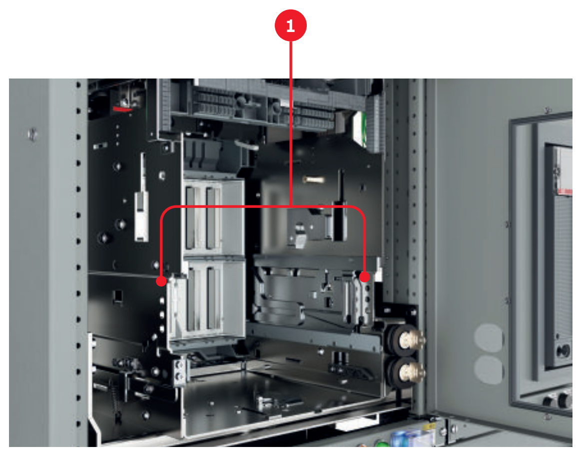
Drawout interlocks

Drawout interlocks are part of the breaker mounted racking mechanism and prevent the breaker from being moved into or out of the CONNECT position unless the circuit breaker is open. Once the breaker has been opened, the racking interlock button can be depressed and racking handle inserted. The interlocks also prevent closing a breaker unless it is in the fully CONNECT or TEST position. A breaker mounted interlock prohibits the breaker from being removed from the cradle while it's spring is charged.

Padlocking provisions

Several types of padlocking provisions are standard on the cradle and breaker. The cradle has provisions for padlocking the shutters in the closed position (Figure 02) and for padlocking access to the racking mechanism (not shown).

The drawout rails have provisions for up to three 8mm padlocks to prevent a circuit breaker from being installed into the cradle (Figure 06). The circuit breaker utilizes the PLC accessory to provide a provision for up to three padlocks of 4mm diameter that will keep the breaker open and mechanically trip free. An optional padlockable cubicle quarter-turn latch is available to prevent unauthorized access to the breaker cubicle.



1. Padlock provisions, padlocks (not shown)

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07 Instrument panel with RELT switch

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08 Secondary disconnects

Door interlock
An optional door interlock can be supplied on the cradle to automatically secure the breaker cubicle door and prevent entry into the breaker cubicle unless the circuit breaker is racked out to the TEST or DISCONNECT position. This interlock can be offered with or without a hidden interlock bypass feature.

Instrument panel
Standard construction includes a grounded steel instrument panel above each circuit breaker (Figure 07). This panel is used for mounting a variety of control circuit components – including fuses for the charge, close, and trip circuits; indicating lights, and the Reduced Energy Let-Thru switch. Control circuit fuses and indicating lamps are replaceable from the front of the panel. The panel is removable to provide access to wiring terminations.

Secondary disconnects
Breaker control circuit devices and trip unit inputs and outputs are connected to the breaker through secondary disconnects mounted on the front of the breaker and cradle (Figure 08).

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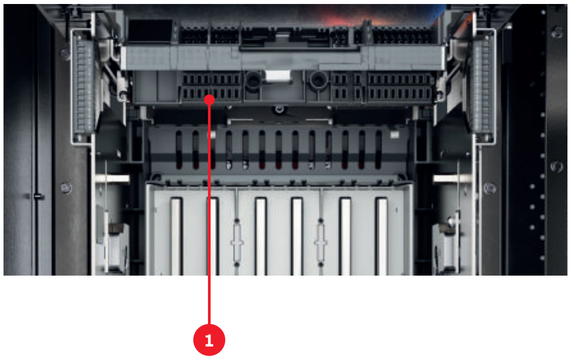

1. Secondary disconnects

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This provides convenient access to the secondary control terminal points for monitoring or troubleshooting. All breaker-mounted accessories have dedicated wiring terminals which reside in the cradle mounted terminal box. Adding accessories to the breaker requires only the installation of the accessory in the breaker and installing a terminal block in the correct location in the cradle mounted terminal box, described in the accessory installation manual.

Current transformers
Relaying class CTs can be supplied for E2.2, E4.2 and E6.2 breakers. The relaying class CTs are located in the breaker cubicle and are mounted on either the three upper primary disconnect stabs or the three lower primary disconnect stabs in the cubicle. Up to three relaying current transformers may be mounted in the breaker cubicle. These CTs are also used for discrete metering purposes.

CT ratios, associated relaying class, and internal winding resistance are shown in Table 4, Table 5 and Table 6.

Table 4: ReliaGear LV SG E1.2 and E2.2 relaying current transformers

Current ratio	Relay class	ANSI metering class @60 Hz					Secondary winding resistance (Ohms @75 °C)	Cat #0173B4776
		B0.1	B0.2	B0.5	B0.9	B1.8		
100:5	-	2.4	1.2	-	-	-	0.0313	P001
150:5	-	1.2	1.2	-	-	-	0.0236	P002
200:5	-	0.6	1.2	2.4	-	-	0.0651	P003
250:5	C10	0.6	0.6	2.4	2.4	-	0.0460	P004
300:5	C10	0.3	0.6	1.2	2.4	-	0.0760	P005
400:5	C20	0.3	0.3	0.6	1.2	2.4	0.1063	P006
500:5	C20	0.3	0.3	0.6	1.2	1.2	0.1394	P007
600:5	C20	0.3	0.3	0.3	0.6	1.2	0.1509	P008
750:5	C20	0.3	0.3	0.3	0.3	0.6	0.1858	P009
800:5*	C20	0.3	0.3	0.3	0.3	0.6	0.2091	P010
1000:5*	C20	0.3	0.3	0.3	0.3	0.3	0.2673	P011
1200:5*	C50	0.3	0.3	0.3	0.3	0.3	0.3480	P012
1500:5*	C50	0.3	0.3	0.3	0.3	0.3	0.3948	P013
1600:5*	C50	0.3	0.3	0.3	0.3	0.3	0.4180	P014
2000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.5109	P015

* Indicated relaying CTs may be used for ground fault protection on main and tie breakers in four-wire, double-ended switchgear applications

Table 5: ReliaGear LV SG E4.2 relaying current transformers

Current ratio	Relay class	ANSI metering mlass @60 Hz					Secondary winding resistance (Ohms @75 °C)	Cat #0275B9440
		B0.1	B0.2	B0.5	B0.9	B1.8		
100:5	-	2.4	2.4	-	-	-	0.0270	P001
150:5	C10	2.4	2.4	-	-	-	0.0321	P002
200:5	C10	0.6	1.2	2.4	2.4	-	0.0465	P003
250:5	C10	0.6	1.2	1.2	2.4	2.4	0.1084	P004
300:5	C20	0.6	0.6	1.2	1.2	2.4	0.1287	P005
400:5	C20	0.3	0.6	0.6	1.2	2.4	0.1702	P006
500:5	C20	0.3	0.3	0.6	0.6	1.2	0.2112	P007
600:5	C50	0.3	0.3	0.3	0.6	0.6	0.2791	P008
750:5	C50	0.3	0.3	0.3	0.3	0.6	0.3146	P009
800:5*	C50	0.3	0.3	0.3	0.3	0.6	0.3344	P010
1000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.4178	P011
1200:5*	C100	0.3	0.3	0.3	0.3	0.3	0.6801	P012
1500:5*	C50	0.3	0.3	0.3	0.3	0.3	0.6435	P013
1600:5*	C50	0.3	0.3	0.3	0.3	0.3	0.6862	P014
2000:5*	C50	0.3	0.3	0.3	0.3	0.3	0.8811	P015
2500:5*	C100	0.3	0.3	0.3	0.3	0.3	1.0872	P016
3000:5*	C50	0.3	0.3	0.3	0.3	0.3	1.1968	P017
3200:5*	C50	0.3	0.3	0.3	0.3	0.3	1.2914	P018

* Indicated relaying CTs may be used for ground fault protection on main and tie breakers in four-wire, double-ended switchgear applications

Table 6: ReliaGear LV SG E6.2 relaying current transformers

Current ratio	Relay class	ANSI metering class @60 Hz					Secondary winding resistance (Ohms @75 °C)	Cat #0275B9556
		B0.1	B0.2	B0.5	B0.9	B1.8		
2000:5	C100	0.3	0.3	0.3	0.3	0.3	0.6875	P001
2500:5*	C100	0.3	0.3	0.3	0.3	0.3	0.8555	P002
3000:5*	C100	0.3	0.3	0.3	0.3	0.3	1.0634	P003
3200:5*	C100	0.3	0.3	0.3	0.3	0.3	1.1332	P004
4000:5*	C50	0.3	0.3	0.3	0.3	0.3	1.0968	P005
5000:5*	C50	0.3	0.3	0.3	0.3	0.3	1.3005	P006

* Indicated relaying CTs may be used for ground fault protection on main and tie breakers in four-wire, double-ended switchgear applications.

ReliaGear LV SG bus options

ReliaGear LV SG bus options are shown in Table 7. All horizontal and vertical bus bars (phase, neutral, and ground) are tin-plated copper. Tin plating is desirable for many industrial applications such as wastewater treatment, pulp and paper, petrochemical and other areas where the environment may be damaging to silver plating. Tin-plated bus can also be used for commercial and utility applications. An optional silver-plated bus may be specified for phase, neutral and ground buses. In all applications, the primary disconnect stabs for drawout breakers are provided with full silver plating. Primary disconnect stabs are removable and replaceable in the breaker cubicle. Uninsulated copper bus is standard in ReliaGear LV SG switchgear, as are insulated runbacks for feeder breakers 2000 A and smaller. Options for insulated horizontal bus, phase-isolated vertical bus, and bus compartment barriers for the phase bus are available as shown in Table 7.

When the insulated/ isolated bus option is specified, all main bus joints are covered with an insulating cap so that only the feeder cable terminations are exposed. Bus compartment barriers provide polyester-glass barriers between the bus compartment and the cable compartment. Additional isolation can be provided in the cable compartment of each vertical section by specifying section barriers.

The section barrier option provides a combination of steel and polyester-glass barriers in the rear of each vertical section. The steel barrier provides isolation between sections in the cable termination area, and the polyester-glass barriers provide isolation in the main bus area. When supplied, the section barrier option prevents exposure to the cable terminations in adjacent vertical sections when performing any operations in the rear of a section.

Table 7: ReliaGear LV SG switchgear bus options

Main bus rating (A)	2000	3200	4000	5000	6000	8000
Vertical bus rating (A)	2000/2500/3200/4000/5000/6000					
Insulated main bus/Isolated vertical bus	×	×	×			
Bus compartment barriers	×	×	×	×	×	×
Section barriers (Rear)	×	×	×	×	×	×
Neutral bus rating (A)	2000/3200/4000/5000/6000/8000					
Ground bus (0.25” x 3” Cu)	1 Bar	1 Bar	1 Bar	1 Bar	2 Bars	2 Bars
Short circuit bracing (kA)	65/85/100/150/200					
30-cycle withstand (kA)	65/85/100					

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09 Infrared feeder stacks

Expansion capabilities
ReliaGear LV SG switchgear is designed to be easily expanded to handle increased loading. It is very common, and advised, to specify fully equipped future breaker cubicles when ordering a substation or lineup. The fully equipped future breaker cubicle contains line and load side primary disconnects, cradle with drawout rails and interlocks, and a cubicle door with a cover over the breaker cutout.

At time of manufacture, the cubicle can also be outfitted with any specified metering, protection, and control devices, or these can be added when the breaker is installed. Adding a new feeder breaker can then be as simple as removing a cover from the cubicle door and installing the breaker.

Standard bus configurations used in ReliaGear LV SG have built-in provisions for future bus extensions. Should the switchgear have no future breaker compartments, additional vertical sections can be mechanically and electrically connected to the ReliaGear LV SG lineup without modifications. ReliaGear LV SG section can also be added to existing GE low voltage switchgear equipment within a limited scope. Please consult your local sales representative to discuss your specific needs.

IR windows
Optional Infrared (IR) Scanning Windows (Figure 9) can be provided in the switchgear rear covers to facilitate the use of IR cameras for performing thermal scans of cable terminations.

Use of the IR windows minimizes exposure to live conductors while performing this preventive maintenance operation. Crystal-type IR windows are used on both indoor NEMA 1 and outdoor NEMA 3R applications. IR windows have a gasketed cover plate secured with tamper-resistant hardware.

Quantity and location of the IR windows are dependent on the breaker stacking arrangement. Typically, one IR window is furnished per feeder breaker, but breaker placement and depth of the rear cable compartment can allow the field of view of the IR window to cover multiple breaker terminations.

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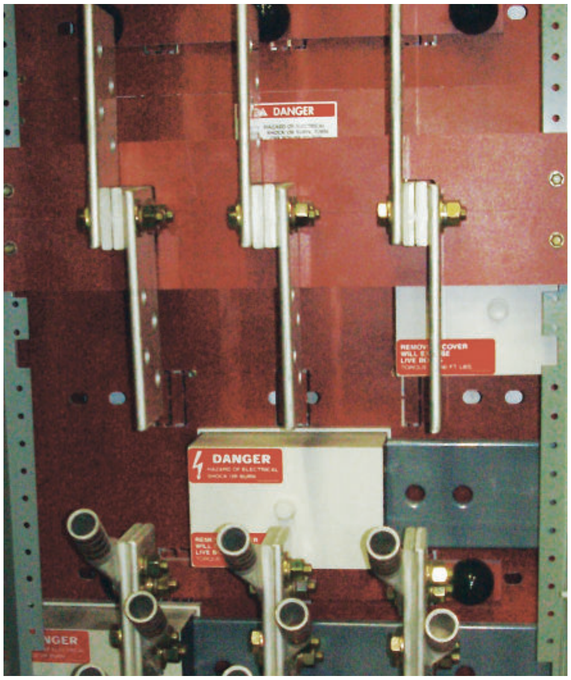
Remote racking
SACE Emax 2 breakers (E2.2, E42 and E6.2) allow provisions to accept a remote racking device that allows the operator or electrician to move the breaker anywhere between the DISCONNECT and CONNECT positions without standing in front of the circuit breaker cubicle. The remote racking device attaches to the breaker without opening the cubicle door. It is powered from any standard 120 Vac receptacle. The control box on the end of the 30-foot cord has switches to control the operation of the remote racking device, allowing the operator to stand outside the arc flash boundary while racking a circuit breaker into or out of its cubicle. For more details, please see 1SDH001564R001.

Cable space
The conduit entrance area meets NEC requirements for cable termination and bending space. Extended depth frame options are available in 7-inch or 14-inch sizes for applications requiring additional cable space. Breaker section widths can also be increased from 22 inches to 30 inches or from 30 inches to 38 inches for additional cable space. An example of available cable terminations is shown in Figure 10.

10 Cable terminations

11 Breaker spreader bar for lifting



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Breaker lifting device
Installed on the top of the switchgear, this rail-mounted hoist provides the means for installing and removing SACE Emax 2 circuit breakers from the switchgear cubicles (Figure 11). The overhead breaker lifting device is standard on outdoor-protected aisle construction and optional on indoor construction. Alternatively, a portable hydraulic breaker lifter may be used to install and remove breakers. Lifting spreaders are provided as a standard accessory for each switchgear lineup. The breaker lifting spreader (Figure 11) is the interface between the cable hook on the breaker lifting device and the circuit breaker. Lifting spreaders are also used with the hydraulic breaker lifter.

Paint finish
The sheet metal parts that form the ReliaGear LV SG switchgear cubicles and sections are protected by a powder coat paint process, which utilizes polyester powder, electrostatically applied to properly prepared parts. Switchgear parts are prepared, coated, and baked on a continuously moving overhead conveyor system to create a textured finish.

The resulting ANSI-61 light gray paint finish far exceeds the requirements of UL1558 and ANSI C37.20.1, which require a minimum 200 hour salt spray test. Parts that have the powder coat applied per this process have passed 1000 hours of neutral salt spray testing per ASTM B-117.

Other testing includes passing 1000 hours in a humidity cabinet, cross hatch adhesion, impact and ductility tests. Meeting or exceeding the UL, ANSI, and ASTM requirements demonstrates that the paint finish on the ReliaGear LV SG switchgear enclosure will be able to provide long service in severe operating environments.

Seismic certification
ReliaGear LV SG switchgear with SACE Emax 2 circuit breakers has been certified in accordance with ICC-ES-AC156 to the requirements of IEEE-693-2018 and CBC-2019/IBC-2018. ReliaGear LV SG switchgear has been certified for use in all IBC-2018 Seismic Use Groups, Occupancy Importance Factors, and Seismic Design Categories, as well as qualified to IEEE- 693 for Moderate and High Seismic Loading conditions.

Outdoor options and features
All outdoor-rated equipment comes standard with hinged aisle doors with rubber gaskets and padlocking provisions, asphalt base undercoating on the exterior bottom, interior lights, space heater in each vertical section, ground-fault circuit interrupter receptacle, light switch, and space heater switch. Outdoor-protected aisle equipment comes standard with an overhead hoist (Figure 12). For outdoor non-walk-in equipment, an optional hydraulic breaker lift may be used.

—
12 Overhead hoist

—
13 Panic door

—
14 Handle with padlock (front view)

—
15 Handle with padlock (side angle)

—
12

—
14

—
15

For ease of breaker installation, outdoor protected-aisle equipment comes standard with double doors on the right side of the equipment aisle (as viewed facing front of the equipment). On longer lineups an additional door is provided on the left side of the equipment.

All aisle doors are padlock capable from the exterior and come standard with panic door latches on the interior (Figure 13). Consult an ABB local sales representative if additional doors or door location modifications are required.

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13

All outdoor switchgear comes standard with hinged rear doors with built-in padlock provisions. For both front and rear doors, use a No. 3 Master padlock (0.281 inches diameter, 0.73 inches high closed [measured inside the lock shank]), or a No. 1 Master padlock (0.312 inches diameter shank, 0.92 inches high closed [measured inside the lock shank]) for locking the handle. (See Figure 14 and Figure 15.)


ID FAN - 2A (2240KW)

SACE Emax 2
Circuit breakers and trip units

The world of the electrical power distribution changes fast and major new trends such as energy efficiency, connectivity and smart grids are now crowding onto the stage. These trends lead to new end user and application demands. To meet these demands, ABB has further improved SACE Emax 2. SACE Emax 2 air circuit breaker is now a multifunctional platform able to manage the next generation of electrical plants such as microgrids, evolving into a true Power Manager.

SACE Emax 2 is the first air circuit breaker that matches all the latest grid requirements. It enables a direct communication to the new energy management cloud-computing platform ABB Ability™ Electrical Distribution Control System. The SACE Emax 2 plug and play accessories paired with cutting edge connectivity capabilities create a next level circuit breaker able to continuously meet the needs of an evolving electrical system.

Thanks to the ABB Ability Marketplace™ offering and the full portfolio of commissioning tools, it is always possible to enhance the device, even when installed. SACE Emax 2 sets a new circuit breaker benchmark for the needs of today and tomorrow.

The SACE Emax 2 system is yet another evolution of ABB core competencies in reliable electric power distribution, circuit protection, and arc flash risk controls. SACE Emax 2 breakers are standard in ReliaGear LV SG low voltage switchgear. These 3-pole breakers are suitable for 240 Vac, 480 Vac, and 600 Vac (nominal Voltage) applications, and they provide advanced circuit protection, limit arc fault energy, and preserve system coordination without sacrificing any of these critical functions. Refer to Table 7 for applicable design and testing standards for SACE Emax 2 breakers.

Table 8: Device standards and references

ANSI certified low voltage power circuit breaker
C37.13
C37.16
C37.17
C37.50
UL1066

SACE Emax 2 devices are 100 percent rated, ANSI, UL rated in drawout designs. All configurations can be manually or electrically operated with multiple and redundant accessories. Table 8 describes SACE Emax 2 short circuit and interrupting ratings for automatic and non-automatic breakers.

Table 9: ANSI/UL1066 LVPCB interrupting ratings

					E1.2			E2.2			E4.2		E6.2
SACE Emax 2 UL1066 performance levels			**B-A**	**N-A**	**S-A**	**S-A**	**H-A**	**V-A**	**S-A**	**H-A**	**V-A**	**H-A**	**V-A**
Continuous current rating Iu @ 40°C		[A]	800	800	250	800	800	250	800	800	800		3200
		[A]	1200	1200	400	1200	1200	800	1600	1600	1600	4000	4000
		[A]			800	1600	1600	1200	2000	2000	2000	5000	5000
		[A]			1200	2000	2000	1600	3200	3200	3200		
		[A]						2000					
Interrupting rating at rated maximum voltage	254 V	[kA]	42	50	65	65	85	100	65	85	100	85	100
	508 V	[kA]	42	50	65	65	85	100	65	85	100	85	100
	635 V	[kA]	42	42	42	65	85	85	65	85	100	85	100
Rated short time current			42	50	50	65	85	85	65	85	100	85	100

Table 10: Non-automatic circuit breaker – ANSI version ratings

SACE Emax 2 UL1066 performance levels			E1.2		E2.2			E4.2			E6.2
			B-A	**N-A**	**N-A**	**S-A**	**V-A**	**S-A**	**H-A**	**V-A**	**L-A**
Continuous current rating Iu @ 40°C		[A]	800	800	2000	800	800	3200	3200	800	3200
		[A]	1200	1200		1600	1600			1600	4000
		[A]				2000	2000			2000	5000
		[A]								3200	
Rated short time current	254 V	[kA]	42	50	50	65	85	65	85	100	100
	508 V	[kA]	42	50	50	65	85	65	85	100	100
	635 V	[kA]	42	42	50	65	85	65	85	100	100

SACE Emax 2 for UL1066				E1.2			E2.2		E4.2			E6.2
		Amps	**800**	**1200**	**<1600**	**1600**	**2000**	**≤2000**	**3200**	**3200**	**4000**	**5000**
Mechanical life with regular ordinary maintenance prescribed by the manufacturer		Cycles	20.000	20.000	25.000	25.000	25.000	20.000	20.000	12.000	12.000	12.000
	Frequency	Cycles/ hour	60	60	60	60	60	60	60	60	60	60
Electrical life with regular ordinary maintenance prescribed by the manufacturer												
	508 V	Cycles	8.000	7.000	15.000	12.000	10.000	10.000	7.000	4.000	4.000	3.000
	635 V	Cycles	8.000	6.500	15.000	10.000	8.000	10.000	7.000	4.000	4.000	2.000
	Frequency	Cycles/ Hour	30	30	30	30	30	20	20	10	10	10

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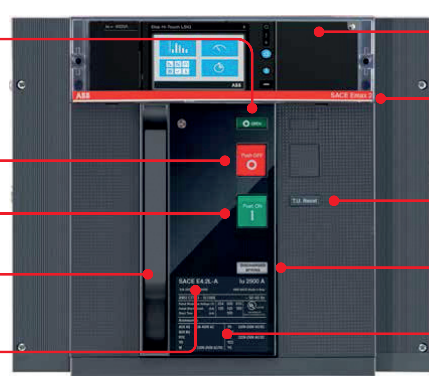
16 SACE Emax 2 features and characteristics

—
17 Circuit breaker label



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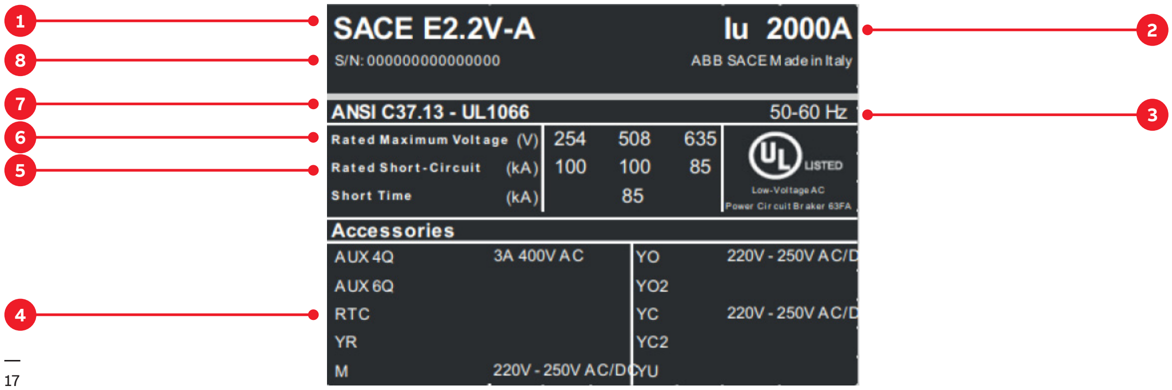
16

—
17 Circuit breaker label

—
18 SACE Emax 2 trip units



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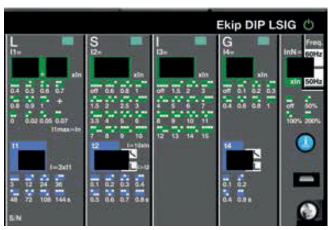
17

1	Type of circuit-breaker
2	Rated current
3	Rated operating frequency
4	Rated voltage of accessories
5	Rated short-circuit breaking capacity
6	Rated service voltage
7	Standards
8	Circuit-breaker serial number



Ekip Dip: The basic trip unit

Ekip Dip LSI
Ekip Dip LSIG

- Overcurrent protection for distribution systems
- Phase and neutral current measurements
- LED trip cause indication
- Optional Ekip Multimeter to display data and measurements

Ekip Hi-Touch: The ultimate trip unit

Ekip Hi-Touch LSI
Ekip Hi-Touch LSIG

- Complete set of protections and measurements
- Dual settings of protection
- Network Analyzer function
- High measurement accuracy of electrical parameters

Ekip Touch: The smart trip unit

Ekip Touch LSI
Ekip Touch LSIG

- Advanced set of protections and measurements, always upgradable and customizable
- Intuitive touchscreen interface

Ekip G: The generator trip unit

Ekip G Hi-Touch LSIG

- Designed for installations with generators such as Genset, cogeneration and paralleling applications
- Dedicated set of generator protections

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18

Overview

Test function
All SACE Emax 2 trip units are equipped with a test port on the front that can be used to carry out circuit breaker tests by connecting one of the following devices:
- Ekip TT to perform trip tests, LED tests and checks for the absence of alarms detected by the watchdog function
- Ekip programming module not only for the trip and LED tests, but also for testing the individual protection functions through the Ekip Connect software interface. Test reports can be saved while utilizing the Ekip Connect software.

In addition, the iTest key allows to run a battery test when the circuit breaker is disconnected.

User interface
Ekip trip units allow to clearly identify the status of the circuit breaker through LEDs activation or an intuitive graphical interface. A password system is used to manage “Read” or “Edit” modes. The default password (00001) can be directly inserted by the user. The protection parameters are settable in “Edit” mode, whereas it is always possible to consult the information in “Read” mode.

Data and measurements
SACE Emax 2 trip units are no longer simply protection devices. The Ekip Dip trip unit measures phase and neutral current with great accuracy, while the other advanced units integrate multimeter and network analyzer functionalities, being also compliant with optional IEC 61557-12 (Class 1 in energy accuracy).

A complete set of information about the circuit breaker and its operation is available for effective fault analysis and preventive scheduling of maintenance.

Communication and connectivity
Ekip Touch and Hi-Touch trip units can be easily integrated into the most modern supervision systems through several communication protocols:
- IEC 61850
- Modbus RS-485
- Profinet
- EtherNet/IP™
- Modbus TCP
- Profibus
- DeviceNet™

Measurements, statuses and alarms can be easily programmed and viewed by remote function, with no need of external interface devices. Moreover, the Ekip Com Actuator module can be installed in the front of the device to remotely control the circuit breaker. Several communication modules with different protocols can be used simultaneously. In addition, up to two modules using the same protocol can be installed to ensure a higher reliability of the installation. The Ekip Com Hub module allows cloud connectivity to ABB Ability™ EDCS platform. The new embedded Bluetooth Low Energy technology makes the circuit breaker easier to be accessed, thus reducing time for commissioning and parameter settings. Ekip Dip and Ekip LCD trip units are not provided with this feature.

Supply
SACE Emax 2 protection trip units are self-supplied through the current sensors installed on the circuit breaker and do not require any external supply devices for basic protection and alarm indication functions. A three-phase current of 100A is sufficient for the activation. All protection settings are stored in non-volatile memory that maintains the information without power supply.
The Ekip Supply module can be easily connected to both direct and alternating current to activate additional functions such as:
- Using the unit when the circuit breaker is opened
- Using additional modules such as Ekip Signalling and Ekip Com
- Connection to external devices such as Ekip Multimeter
- Recording the number of operations
- G protection with values below 100A or 0.2 In
- Zone selectivity (ST, GF and Instentaneous)
- Gext and MCR protection functions

SACE Emax 2 trip units are always supplied with an internal battery that enables the cause of a fault to be indicated after a trip, without limit of time. This battery also ensures the update of time and date, thus guaranteeing the chronology of any events. When the unit switched off, the battery test can be run by simply pressing the iTest key on the front.

Ekip trip unit protection features
Technical characteristics

ABB Code	ANSI/IEEE C37.2 Code	Function	Threshold	Trip time	Excludability	Pre-alarm	Trip curve	Ekip Dip
L	49	Overload protection	I1 = 0.4 - 0.42 - 0.45 - 0.47 - 0.5 - 0.52 - 0.55 - 0.57 - 0.6 - 0.62 - 0.65 - 0.67 - 0.7 - 0.72 - 0.75 - 0.77 - 0.8 - 0.82 - 0.85 - 0.87 - 0.9 - 0.92 - 0.95 - 0.97 - 1 x In	with If = 3 I1, t1 = 3 - 12 - 24 - 36 - 48 - 72 - 108 - 144s [2]	Not allowed for UL	50 ... 90% I1 Step 1%	t = k / I^2	●
		Thermal memory			Not allowed for UL			●
		Tolerance	trip between 1.05 and 1.2 x I1	± 10% If ≤ 6 x In ± 20% If > 6 x In				
S	50TD	Time-delayed overcurrent protection	I2 = 0.6 - 0.8 - 1 - 1.5 - 2 - 2.5 - 3 - 3.5 - 4 - 5 - 6 - 7 - 8 - 9 - 10 x In	with If > I2, t2 = 0.1 - 0.2 - 0.3 - 0.4 - 0.5 - 0.6 - 0.7 - 0.8s	yes	-	t = k	●
		Tolerance	± 7% If ≤ 6 x In ± 10% If > 6 x In	The better of the two data: ± 10% t2 or ± 40 ms				
	51	Time-delayed overcurrent protection	I2 = 0.6 - 0.8 - 1 - 1.5 - 2 - 2.5 - 3 - 3.5 - 4 - 5 - 6 - 7 - 8 - 9 - 10 x In	with If = 10 In, t2 = 0.1 - 0.2 - 0.3 - 0.4 - 0.5 - 0.6 - 0.7 - 0.8s	yes	-	t = k / I^2	●
		Thermal memory			yes	-		
		Tolerance	± 7% If ≤ 6 x In ± 10% If > 6 x In	± 15% If ≤ 6 x In ± 20% If > 6 x In				
I	50	Instantaneous overcurrent protection	I3= 1.5 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - 11 - 12 - 13 - 14 - 15 x In	Instantaneous	yes	-	t = k	●
		Tolerance	± 10%	≤ 30 ms				
G	50N TD	Ground fault protection	I4[1] = 0.1 - 0.2 - 0.3 - 0.4 - 0.6 - 0.8 - 1 x In	with If > I4, t4 = 0.1 - 0.2 - 0.4 - 0.8s	yes	50 ... 90% I4 Step 1%	t = k	●
		Tolerance	± 7%	The better of the two data: ± 10% t4 or ± 40 ms				
	51N	Ground fault protection	I4[1] = 0.1 - 0.2 - 0.3 - 0.4 - 0.6 - 0.8 - 1 x In	with If = 3In, t4 = 0.1 - 0.2 - 0.4 - 0.8s	yes	50 ... 90% I4 Step 1%	t = k / I^2	●
		Tolerance	± 7%	± 15%				

(1) With Vaux all thresholds are available. Without Vaux minimum threshold is limited to: 0.3In (with In = 100A), 0.25In (with In = 400A) or 0.2In (for all other ratings)
(2) The minimum trip time is 1s, regardless of the type of curve set (self-protection)

The tolerances above apply to trip units already powered by the main circuit with current flowing in at least two phases or an auxiliary power supply.
In all other cases the following tolerance values apply

ABB Code	Trip threshold	Trip time
L	Trip between 1.05 and 1.2 x I1	± 20%
S	± 10%	± 20%
I	± 15%	≤ 60ms
G	± 15%	± 20%

ABB Code	ANSI Code	Function	Threshold	Threshold step	Trip time	Time Step
L	49	Overload Protection	I1 = 0.4…1 x In	0.001 x In	with I = 3 I1, t1 = 3...144 s	1s
		Thermal Memory				
		Tolerance	trip between 1.05 and 1.2 x I1		± 10% I ≤ 6 x In / ± 20% I > 6 x In	
S	50TD	Time-delayed overcurrent protection	I2 = 0.6...10 x In	0.1 x In	With I > I2, t2 = 0.05...0.8s	0.01s
	68	Zone selectivity			t2sel = 0.04…0.2s	0.01s
		Start up	Activation: 0.6…10 x In	0.1 x In	Range: 0.1…30s	0.01s
		Tolerance	± 7% I ≤ 6 x In ± 10% I > 6 x In		The better of the two data: +-10% or +-40ms	
	51	Time-delayed overcurrent protection	I2 = 0.6...10 x In	0.1 x In	with I = 10 In, t2 = 0.05...0.8s	0.01s
		Thermal Memory				
		Tolerance	± 7% I ≤ 6 x In ± 10% I > 6 x In		± 15% I ≤ 6 x In ± 20% I > 6 x In	
I	50	Istantaneous overcurrent protection	I3= 1.5...15 x In	0.1 x In	With I > I3, instantaneous	-
		Start up	Activation: 1.5…15 x In	0.1 x In	Range: 0.1…30s	0.01s
		Tolerance	± 10%		≤ 30 ms	
G	50N TD	Ground fault protection	I4(1) = 0.1...1 x In	0.001 x In	with I > I4, t4 = Instantaneous (with Vaux) + 0,1...1 s	0.05s
	68	Zone selectivity			t4sel = 0.04…0,2s	0.01s
		Start up	Activation: 0.2…1 x In	0.02 x In	range: 0.1…30s	0.01s
		Tolerance	± 7%		The better of the two data: ± 10% or ± 40 ms or 50ms with t4 = instantaneous	
	51N	Ground fault protection	I4(1) = 0.1...1 x In	0.001 x In	with I = 4 In, t4 = 0.1…1s	0.05s
		Tolerance	± 7%		± 15%	
IU	46	Current unbalance protection	I6 = 2…90% In unbalance	1%In	with unbalance > I6, t6 = 0.5…60s	0.5s
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / +-100ms (for t≥5s)	
2I	50	Programmable instantaneous overcurrent protection	I31 = 1.5...15 x In (max setting 15kA)	0.1xIn	with I>I31, instantaneous	
		Tolerance	± 10%		≤ 7 ms (2)	
MCR		Closing on short-circuit protection	I3= 1.5...15 x In	0.1 x In	With I > I3, instantaneous Monitor time range: 40…500ms	0.01s
		Tolerance	± 10%		≤ 30 ms	
UV	27	Undervoltage Protection	U8 = 0.5….0.98 x Un	0.001 x Un	with U < U8, t8 = 0.05…120s	0.01s
		Tolerance	± 2%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
MDGF		Modified Differential Ground Fault protection	I41= 0.1…1 x In Max setting 1200A		with I>I41, t41=0.05...0.4s (t=k) with I>I41, t41=0.1...0.4s (t=k)	0.05s
		Tolerance	± 7%		The highest of 15% or 15ms	




Excludability	Excludability trip	Pre-alarm	Trip curve	Ekip Touch	Ekip Hi-Touch	Ekip G Touch	Ekip G Hi-Touch
yes, with rating plug L=off	Not allowed for UL	50...90% I1 step 1%	$t = k / I^2$	●	●	●	●
yes				●	●	●	●
yes	yes	no	t = k	●	●	●	●
yes				●	●	●	●
yes				●	●	●	●
yes	yes	no	$t = k / I^2$	●	●	●	●
yes				●	●	●	●
yes (3)	no	no	t = k	●	●	●	●
yes				●	●	●	●
yes	yes	50...90% I4 step 1%	t = k	●	●	●	●
yes				●	●	●	●
yes				●	●	●	●
yes	yes	50...90% I4 step 1%	$t = k / I^2$	●	●	●	●
yes	yes	no	t = k	●	●	●	●
yes	no	no	t = k	●	●	●	●
yes	no	no	t = k	●	●	●	●
yes	yes	no	t = k	○	●	●	●
yes	yes	50...90% I41 step 1%	t = k $t = k / I^2$	●	●	●	●

ABB Code	ANSI Code	Function	Threshold	Threshold step	Trip time	Time Step
OV	59	Overvoltage protection	U9 = 1.02….1.5 x Un	0.001 x Un	with U > U9, t9 = 0.05…120s	0.01s
		Tolerance	± 2%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
VU	47	Voltage unbalance protection	U14 = 2…90% Un unbalance	1%Un	with unbalance > U14, t14 = 0.5...60s	0.5s
		Tolerance	± 5%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
UF	81L	Underfrequency protection	f12 = 0.9….0.999 x fn	0.001 x fn	with f < f12, t12 = 0.15…300s	0.01s
		Tolerance	± 1% (with fn ±2%)		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
OF	81H	Overfrequency protection	f13 = 1.001….1.1 x fn	0.001 x fn	with f > f13, t13 = 0.15…300s	0.01s
		Tolerance	± 1% (with fn ±2%)		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
RP	32R	Reverse active power protection	P11 = -1…-0.05 Sn	0.001 Sn	with P > P11, t11 = 0.5…100s	0.1s
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
Phase Sequence	47	Cyclical direction of the phases	1-2-3 or 3-2-1			
Power factor	78	3phase Power factor	PF3 = 0.5…0,95	0.01		
LC1/2 Iw1/2		Current threshold	LC1 =50%...100% I1 LC2 =50%...100% I1 Iw1 = 0.1…10 In Iw2 = 0.1…10 In Activation: up/down	1% 1% 0.01 x In		
		Tolerance	± 10%			
S2	50TD	Time-delayed overcurrent protection	I5 = 0.6...10 x In	0.1 x In	With I > I5, t5 = 0.05...0.8s	0.01s
	68	Zone selectivity			t5sel = 0.04…0.2s	0.01s
		Start up	Activation: 0.6…10 x In	0.1 x In	Range: 0.1…30s	0.01s
		Tolerance	± 7% I ≤ 6 x In ± 10% I > 6 x In		The better of the two data: ± 10% or ± 40 ms	
D	67	Directional overcurrent protection (forward &/or backward)	I7 = 0.6...10 x In	0.1 x In	with I > I7, t7 = 0.1...0.8s	0.01s
	68	Zone selectivity			t7sel = 0.1…0.8s	0.01s
		Start up (forward &/or backward)	Activation: 0.6…10 x In	0.1 x In	Range: 0.1…30s	0.01s
		Trip direction	forward &/or backward			
		Minimum angle direction (°)	3.6, 7.2, 10.8, 14.5, 18.2, 22, 25.9, 30, 34.2, 38.7, 43.4, 48.6, 54.3, 61, 69.6			
		Tolerance	± 7% I ≤ 6 x In ± 10% I > 6 x In		The better of the two data: ± 10% or ± 40 ms	
UV2	27	Undervoltage Protection	U15 = 0.5….0.98 x Un	0.001 x Un	with U < U15, t15 = 0.05…120s	0.01s
		Tolerance	± 2%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
OV2	59	Overvoltage protection	U16 = 1.02….1.5 x Un	0.001 x Un	with U > U16, t16 = 0.05…120s	0.01s
		Tolerance	± 2%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
UF2	81L	Underfrequency protection	f17 = 0.9….0.999 x fn	0.001 x fn	with f < f17, t17 = 0.15…300s	0.01s
		Tolerance	± 1% (with fn ±2%)		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	




Excludability	Excludability trip	Pre-alarm	Trip curve	Ekip Touch	Ekip Hi-Touch	Ekip G Touch	Ekip G Hi-Touch
yes	yes	no	t = k	○	●	●	●
yes	yes	no	t = k	○	●	●	●
yes	yes	no	t = k	○	●	●	●
yes	yes	no	t = k	○	●	●	●
yes	yes	no	t = k	○	●	●	●
yes	only signalling	no	-	○	●	●	●
yes	only signalling	no	-	○	●	●	●
yes	only signalling	no	-	●	●	●	●
yes	yes	no	t = k	●	●	●	●
yes	yes			●	●	●	●
yes				●	●	●	●
yes	yes	no	t = k	○	●	○	●
yes				○	●	○	●
yes				○	●	○	●
yes	yes	no	t = k	○	●	○	●
yes	yes	no	t = k	○	●	○	●
yes	yes	no	t = k	○	●	○	●

ABB Code	ANSI Code	Function	Threshold	Threshold step	Tripping time	Time Step
OF2	81H	Overfrequency protection	f18 = 1.001….1.1 x fn	0.001 x fn	with f > f18, t18 = 0.15...300s	0.01s
		Tolerance	± 1% (with fn ±2%)		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
S(V)	51V	Voltage controlled overcurrent protection	I20 = 0.6...10 x In	0.1 x In	With I > I20, t20 = 0.05…30s	0.01s
		Step mode	Ul= 0.2…1 x Un	0.01 x Un		
			Ks= 0.1…1	0.01		
		Linear mode	Ul= 0.2…1 x Un	0.01 x Un		
			Uh= 0.2…1 x Un	0.01 x Un		
			Ks= 0.1…1	0.01		
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
RV	59N	Residual overvoltage protection	U22 = 0.05….0.5 x Un	0.001 x Un	with U > U22, t22 = 0.5…120s	0.01s
		Tolerance	± 5%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
OP	32OF	Active overpower protection	P26 = 0.4…2 Sn	0.001 Sn	with P > P26, t26 = 0.5…100s	0.5s
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
OQ	32OF	Reactive overpower protection	Q27 = 0.4…2 Sn	0.001 Sn	with Q > Q27, t27 = 0.5…100s	0.5s
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
UP	32LF	Active underpower protection	P23 = 0.1...1 x Sn	0.001 x Sn	with P < P23, t23 = 0.5…100s	0.5s
		Start up			range: 0.1…30s	0.01s
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
RQ	40/32R	Loss of field or reverse reactive power protection	Q24 = -1…-0.1 Sn	0.001 Sn	with Q > Q24, t24 = 0.5…100s	0.1s
			Kq = -2…2	0.01		
		Loss of field or reverse reactive power protection	Q25 = -1…-0.1 Sn	0.001 Sn	with Q > Q25, t25 = 0.5…100s	0.5s
			Kq2 = -2…2	0.01		
		Voltage minimum threshold	Vmin. = 0.5...1.2	0.01		
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
S2(V)	51V	Voltage controlled overcurrent protection	I21 = 0.6...10 x In	0.1 x In	With I > I21, t21 = 0.05…30s	0.01s
		Step mode	Ul2= 0.2…1 x Un	0.01 x Un		
			Ks2= 0.1…1	0.01		
		Linear mode	Ul2= 0.2…1 x Un	0.01 x Un		
			Uh2= 0.2…1 x Un	0.01 x Un		
			Ks2= 0.1…1	0.01		
		Tolerance	± 10%		The better of the two data: ± 10% or ± 40 ms (for t<5s) / ± 100 ms (for t≥5s)	
ROCOF	81R	Rate of change of frequency protection	f28 = 0.4….10 Hz/s	0.2 Hz/s	with f > f28, t28 = 0.5...10s	0.01s
		Trip direction	up &/or down			
		Tolerance	± 5%		The better of the two data: ± 20% or ± 200 ms	




Excludability	Excludability trip	Pre-alarm	Trip curve	Ekip Touch	Ekip Hi-Touch	Ekip G Touch	Ekip G Hi-Touch
yes	yes	no	t = k	○	●	○	●
yes	yes	no	t = k	○	○	○	●
				○	○	○	●
				○	○	○	●
yes	yes	no	t = k	○	○	●	●
yes	yes	no	t = k	○	○	●	●
yes	yes	no	t = k	○	○	●	●
yes	yes	no	t = k	○	○	●	●
yes							
yes	yes	no	t = k	○	○	●	●
yes	yes	no	t = k	○	○	○	●
yes							
yes	yes	no	t = k	○	○	○	●
				○	○	○	●
				○	○	○	●
yes	yes	no	t = k	○	○	○	●

ABB Code	ANSI Code	Function	Threshold	Threshold step	Tripping time	Time Step
Synchro-check SC	25	Synchrocheck (Live busbars)	Ulive = 0.5…1.1 Un ΔU = 0.02…0.12 Un Δf = 0.1…1Hz ΔΦ = 5…50° elt	0.001 Un 0.001 Un 0.1Hz 5° elt	Stability voltage time for live state = 100...30000ms Minimum matching Time = 100...3000ms	0.001s 0.01 s
		Tolerance	± 10%			
		Synchrocheck (Live,Dead busbars)	Ulive = 0.5…1.1 Un Udead = 0.02…0.2 Un	0.001 Un 0.001 Un	tref = 0.1…30s	0.1s
		Frequency check off				
		Phase check off				
		Dead bar configuration	Reverse/standard			
		Primary voltage	100...1150	100, 115, 120, 190, 208, 220, 230, 240, 277, 347, 380, 400, 415, 440, 480, 500, 550, 600, 660, 690, 910, 950, 1000, 1150		
		Secondary voltage	100...120	100, 110, 115, 120		
		Tolerance	± 10%			

(1) With Vaux all thresholds are available. Without Vaux minimum threshold is limited to: 0.3In (with In = 100A), 0.25In (with In = 400A) or 0.2In (for all other ratings)
The tolerances above apply to trip units already powered by the main circuit with current flowing in at least two-phases or an auxiliary power supply.
In all other cases the following tollerance values apply:

ABB Code	Trip threshold	Trip time
L	Trip between 1.05 and 1.2 x I1	± 20%
S	± 10%	± 20%
I	± 15%	≤ 60ms
G	± 15%	± 20%
Other protection	± 15%	± 20%

(2) 2I Trip time:
- < 3ms when the fault current is above 18kA
- 7ms (three-phase) or 9ms (single-phase) when the fault current is greater than three times the 2I setting (I31)
- ≤ 15ms when the fault current is lower than three times the 2I setting (I31)

(3) Instantaneous protection can be permanently non-defeatable through the dedicated extracode.

Key:

- not available

● available

○ available with the dedicated software package. The Measuring Package has to be activated first, if not provided by default. For RC protection, Measurement Enabler with voltage sockets and Ekip Supply are needed.

○○ available with Ekip Synchrocheck

	Excludability	Excludability trip	Pre-allarm	Trip curve	Ekip Touch	Ekip Hi-Touch	Ekip G Touch	Ekip G Hi-Touch
	yes	only signalling	no	-	○ ○○	○○	○○	○○
	yes	only signalling	no	-				
	yes							
	yes							
	yes							

Ekip trip unit measurement functions
Technical characteristics

Instantaneous measurements		Displayed with Ekip Multimeter	Parameters	Precision	Standard	Ekip Dip
Currents (RMS)	[A]	•	L1, L2, L3, Ne	1%	IEC 61557-12	●
Ground fault current (RMS)	[A]	•	Ig	2%		●

Record of values: of the parameter for each interval with time-stamping			Parameters	Window	Intervals	
Current: minimum and maximum	[A]	•	I Min, I Max	Fixed, synchronizable by remote	Duration: 5...120min Number of intervals: 24	●

Information on trip and opening data: after a fault with or without auxiliary supply			Parameters			
Type of protection tripped		•	eg. L, S, I, G			●
Fault values per phase	[A]	•	eg. I1, I2, I3, neutral for S protection			●
Time-stamping		•	Date, time and progressive number			●

Maintenance indicators			Parameters			
Information on last 30 trips		•	Type of protection, fault values and time-stamping			●
Information on last 200 events		•	Type of event, time-stamping			●
Number of mechanical operations (1)	[no]	•	Can be associated to alarm			●
Total number of trips	[no]	•				●
Total operating time	[h]	•				●
Wear of contacts	[%]	•	Prealarm >80%, Alarm = 100%			●
Date of maintenance operations performed		•	Last			●
Indication of maintenance operation needed		•				●
Circuit-breaker I.D.		•	Type of circuit breaker, assigned device name, serial number			●

Self-diagnosis			Parameters			
Check of continuity of internal connections		•	Alarm due to disconnection: rating plug, sensors, trip coil	Note: Opening of circuit breaker can be set in the event of alarm		●
Failure of circuit breaker to open (ANSI 50BF)		•	Alarm following non-tripping of protection functions			●
Temperature (T)		•	Pre-alarm and alarm for abnormal temperature			●

(1) with auxiliary supply present

Instantaneous measurements		Parameters	Precision (Class 1)	Ekip Touch (*)	Ekip Hi-Touch	Ekip G Touch (*)	Ekip G Hi-Touch
Currents (RMS)	[A]	L1, L2, L3, Ne	0.5%	●	●	●	●
Ground fault current (RMS)	[A]	Ig	2%	●	●	●	●
Phase-phase voltage (RMS)	[V]	U12, U23, U31	0.5%	○	●	●	●
Phase-neutral voltage (RMS)	[V]	U1, U2, U3	0.5%	○	●	●	●
Phase sequence				○	●	●	●
Frequency	[Hz]	f	0.1%	○	●	●	●
Active power	[kW]	P1, P2, P3, Ptot	1%	○	●	●	●
Reactive power	[kVAR]	Q1, Q2, Q3, Qtot	2%	○	●	●	●
Apparent power	[KVA]	S1, S2, S3, Stot	1%	○	●	●	●
Power factor		total	2%	○	●	●	●
Peak factor		L1, L2, L3, Ne		○	●	●	●

Counters recorded from installation or from the last reset		Parameters	Precision (Class 1)				
Active energy	[kWh]	Ep total, Ep positive, Ep negative	1%	○	●	●	●
Reactive energy	[kVARh]	Eq total, Ep positive, Ep negative	2%	○	●	●	●
Apparent energy	[KVAh]	Es total	1%	○	●	●	●

Network Analyzer		Parameters	Intervals				
Hourly average voltage value	[V] [no]	- Umin= 0.75…0.95 x Un - Umax= 1.05…1.25 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)	t = 5…120min	○	●	○	●
Short voltage interruptions	[no]	- Umin= 0.75…0.95 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)	t <40ms	○	●	○	●
Short voltage spikes	[no]	- Umax= 1,05…1,25 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)	t <40ms	○	●	○	●
Slow-voltage sags and swells	[no]	- Umin1= 0.75…0.95 x Un - Umin2= 0.75…0.95 x Un - Umin3= 0.75…0.95 x Un - Umax1= 1.05…1.25 x Un - Umax2= 1.05…1.25 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)	t = 0.02s…60s	○	●	○	●
Voltage unbalance	[V] [no]	- U neg. seq.= 0.02…0.10 x Un - Events counter (nr. of events day by day in the last year plus the total events in the breaker's lifetime)	t = 5…120min	○	●	○	●
Harmonic analysis		Current and Voltage - up to 50° - Alarm THD: 5…20% - Single harmonic alarm: 3...10% plus a count of minutes the harmonic has been exceeded		○	●	○	●

(*) Precision (Class 1) available with dedicated extracode
With no Class 1, please refer to the following precision values:

Current (RMS)	1%	Frequency	0.2%	Power factor	2%
Ground fault current (RMS)	2%	Active power	2%	Active energy	2%
Phase-phase voltage (RMS)	0.5%	Reactive power	2%	Reactive energy	2%
Phase-neutral voltage (RMS)	0.5%	Apparent power	2%	Apparent energy	2%

Record of values: of the parameter for each interval with time-stamping		**Parameters**	**Window**	**Intervals**	**Ekip Touch**	**Ekip Hi-Touch**	**Ekip G Touch**	**Ekip G Hi-Touch**
Current: minimum and maximum	[A]	I Min, I Max	Fixed synchronizable by remote	Duration: 5...120min Number of intervals: 24	●	●	●	●
Phase-phase voltage: minimum and maximum	[V]	U Min, U max			●	●	●	●
Active power: average and maximum	[kW]	P Avg, P Max			○	●	●	●
Reactive power: average and maximum	[kVAR]	Q Avg, Q Max			○	●	●	●
Apparent power: average and maximum	[KVA]	S Avg, S Max			○	●	●	●

Data logger: record of high sampling rate parameters		**Parameters**				
Currents	[A]	L1, L2, L3, Ne, Ig	○	●	●	●
Voltages	[V]	U12, U23, U31	○	●	●	●
Sampling rate	[Hz]	1200-2400-4800-9600	○	●	●	●
Maximum recording duration	[s]	16	○	●	●	●
Recording stop delay	[s]	0-10s	○	●	●	●
Number of registers	[no]	2 independent	○	●	●	●

Information on trip and opening data: after a fault without auxiliary supply		**Parameters**				
Type of protection tripped		eg. L, S, I, G, UV, OV	●	●	●	●
Fault values per phase	[A/V/Hz W/var]	eg. I1, I2, I3, neutral for S protection V12, V23, V32 for UV protection	●	●	●	●
Time-stamping		Date, time and progressive number	●	●	●	●

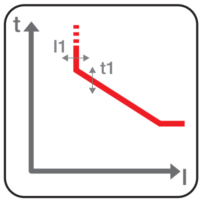
Maintenance indicators		**Parameters**				
Information on last 30 trips		Type of protection, fault values and time-stamping	●	●	●	●
Information on last 200 events		Type of event, time-stamping	●	●	●	●
Number of mechanical operations (1)	[no]	Can be associated to alarm	●	●	●	●
Total number of trips	[no]		●	●	●	●
Total operating time	[h]		●	●	●	●
Wear of contacts	[%]	Prealarm >80% Alarm = 100%	●	●	●	●
Date of maintenance operations performed		Last	●	●	●	●
Indication of maintenance operation needed			●	●	●	●
Circuit-breaker I.D.		Type of circuit breaker, assigned device name, serial number	●	●	●	●

Self-diagnosis	**Parameters**					
Check of continuity of internal connections	Alarm due to disconnection: rating plug, sensors, trip coil	Note: Opening of circuit breaker can be set in the event of alarm	●	●	●	●
Failure of circuit breaker to open (ANSI 50BF)	Alarm following non-tripping of protection functions		●	●	●	●
Temperature (OT)	Prealarm and alarm for abnormal temperature		●	●	●	●

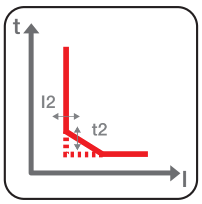
(1) with auxiliary supply present

Key:
- \- not available
- ● available
- ○ available with the dedicated software package

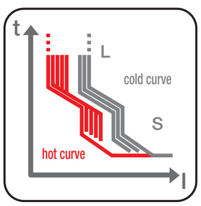
Detailed protection functions
Ekip trip unit



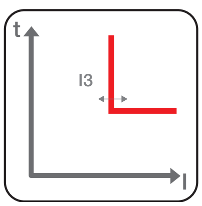
Overload (L - ANSI 49): available with three different types of trip curve:
1. t = k/I² with inverse long time; The thresholds can be fine tuned (for example 1A for circuit-breaker E1.2 1000A) and the timings to the second can be set directly from the display. The settable pre-alarm indicates the set threshold is reached before the protection is tripped.



Time-delayed overcurrent (S - ANSI 51 & 50TD): with constant tripping time (t = k), or with constant specific let-through energy (t = k/I²), this provides 15 current thresholds and 8 curves, for fine adjustment. The function can be excluded by setting the dip switch combination to “OFF”.

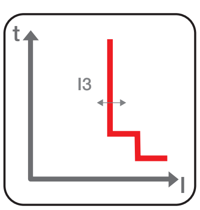


Thermal memory: for L and S protection functions, this is used to protect components, such as transformers, from overheating following an overload. The function, which can be enabled by the Ekip Connect software, adjusts the protection tripping time according to the length of time that has elapsed since the first overload, taking into account the amount of heat generated.

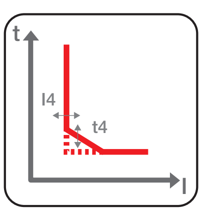


Instantaneous overcurrent (I - ANSI 50): with tripping curve without intentional delay, it offers 15 tripping thresholds and can be excluded by setting the dip switch combination to “OFF”.

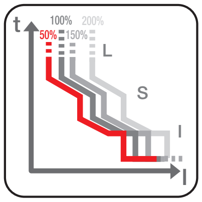
Closing on short-circuit (MCR): the protection uses the same algorithm of the protection I, limiting operation to a settable time window from the closing of the circuit-breaker. The protection can be disabled, also alternatively to protection I. The function is active with an auxiliary supply.



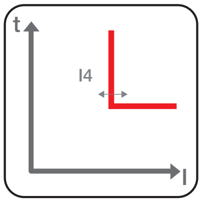
Programmable instantaneous overcurrent (2I - ANSI 50): Second instantaneous tripping curve designed to mitigate against arc flashes (also referred to as RELT - Reduced Energy Let-Through). This protection can be adjusted from 1.5 to 15 x In, with a maximum setting of 18kA. The clearing time of the 2I protection is between 25 and 42ms at 60Hz (+5ms for 50Hz). Easy activation and I/O assignment, including positive feedback, can be implemented using the RELT Ekip Signalling 2K-3 module.



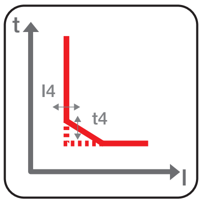
Ground fault (G - ANSI 51N & 50NTD): with tripping time independent of current (t = k) or constant specific let-through energy (t = k/I²). The function can be excluded by setting the dip switch combination to “OFF”.



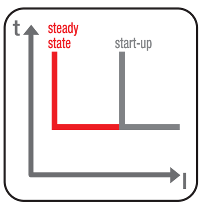
Neutral protection: available at 50 percent, 100 percent or 200 percent of the phase currents, or disabled, it is applied to the overcurrent protections L, S and I.



Instantaneous Ground Fault (G-ANSI 50N): with trip curve without instantaneous delay.

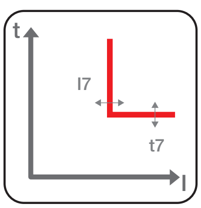


Modified Differential Ground Fault (MDGF): Available (E2.2, E4.2 and E6.2) with the trip time independent of the current (t = k) or constant specific let-through energy ($t = k/I^2$). This protection function is designed for systems with solidly grounded multi-source ground fault schemes (refer to instruction manual 1SDH001330R005). The complete equipment level solution includes third-party phase current transformers, summing current transformers, and a dedicated terminal (please refer to 1SDA114800R1 or 1SDA114798R1).

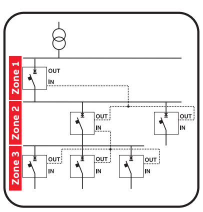


Start-up function: enables protections S, I and G to operate with higher trip thresholds during the starting phase, avoiding untimely trips due to high inrush currents of certain loads (motors, transformers, lamps). The starting phase lasts 100 ms to 30 s and is recognized automatically by the trip unit:

- at the closing of the circuit breaker with a self-supplied trip unit;
- when the peak value of the maximum current exceeds the set threshold (0.1…10 x In) with an externally supplied trip unit; a new start-up is possible after the current falls below the threshold.



Current unbalance (IU – ANSI 46): with constant trip time (t = k), protects from an unbalance between the currents of the single phases protected by the circuit breaker.

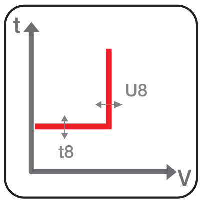


Zone selectivity for S, I and G protections (ANSI 68): can be used to minimize circuit- breaker trip times closer to the fault. The protection is provided by connecting all the zone selectivity outputs of the trip units belonging to the same zone and taking this signal to the trip unit input that is immediately upstream. Each circuit breaker that detects a fault reports it to the circuit breaker upstream; the circuit- breaker thus detects the fault but does not receive any communication from those downstream and opens without waiting for the set delay to elapse. It is possible to enable zone selectivity if the fixed-time curve has been selected and the auxiliary supply is present.

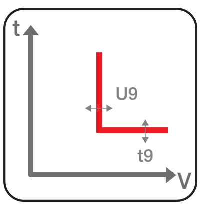
Current thresholds: this function enables four independent thresholds to be indicated in order to enable corrective action implementation before the overload L protection trips the circuit breaker. For example, by disconnecting loads located downstream of the circuit breaker that are controlled by Ekip Signalling.

Advanced protection functions
A different operating mode can be chosen for the following protection function:
1. Active: protection enabled by opening of the circuit- breaker when the threshold is reached;
2. Only alarm: protection active, with only alarm indication when the threshold is reached;
3. Deactivated: protection disabled.

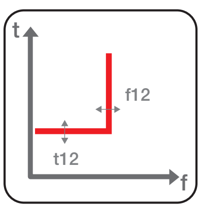
Furthermore, when the voltage and frequency protections are activated, they indicate an alarm status even when the circuit breaker is open so that a fault can be identified before the circuit breaker closes.



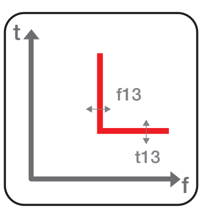
Undervoltage (UV - ANSI 27): with constant trip time (t = k), function is tripped when phase voltage falls below set threshold.



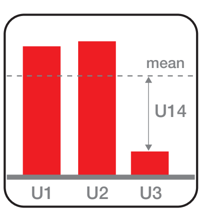
Overvoltage (OV - ANSI 59): with constant trip time (t = k), function is tripped when phase voltage exceeds the set threshold.



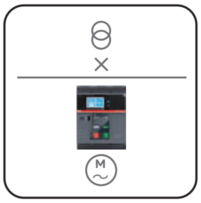
Underfrequency (UF - ANSI 81L): with constant trip time (t = k), function is tripped when network frequency falls below set threshold.



Overfrequency (OF - ANSI 81H): with constant trip time (t = k), function is tripped when network frequency exceeds the set threshold.

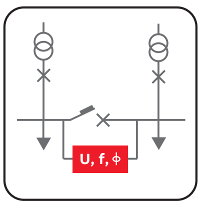


Voltage unbalance (VU – ANSI 47): with constant trip time (t = k), protects against an unbalance between the voltages of the individual phases that are protected by the circuit- breaker.



Reverse active power (RP - ANSI 32R): with constant trip time (t = k), function is tripped when total active power – in the opposite direction of the current - exceeds the set threshold.

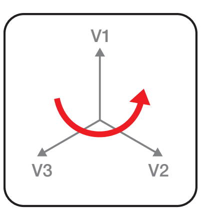
In addition to the protection functions, the following indication and control functions are available to warn the user that a given condition has been reached. The active indications are always shown on the display and are also available by communication on the system bus (with Ekip Com modules) or electrical indication (with Ekip Signalling modules).



Synchrocheck (SC - ANSI 25): the synchronism control function compares the voltages in the modules as well as the frequencies and phases of two circuit breakers to which the circuit breaker is connected. Ekip Touch indicates that conditions have been reached that enable the two lines to be made parallel.
The function is available with two work modes:

- In systems with both busbars supplied, where synchronism is determined by:
  1. voltage of the two half-busbars above the Ulive threshold for the set time
  2. difference of the module of the two voltages below the threshold ΔU
  3. difference in the frequency of the two voltages below the threshold Δf
  4. difference in the phase of the two voltages below the threshold Δ
  5. desirable time for synchronism condition tsyn
  6. circuit breaker open
- In systems with an out-of-service line (dead busbar), where the synchronism condition is determined by the concurrence of the following conditions for the tref set time:
  1. voltage of the active half-busbar above threshold Ulive
  2. voltage of the dead half-busbar below threshold Udead
  3. circuit breaker open

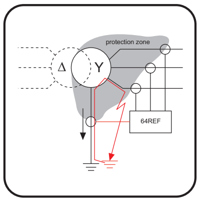
In both cases, synchronism consent is withdrawn when one of the above conditions is missing and it has not been less than 200ms from the change of the circuit- breaker condition (when the relationship has been set).
The indication of reached synchronism is available directly as an electrical indication via a contact that is always supplied with the module. The function can be activated simply by connecting the Ekip Synchrocheck module.



Cyclical direction of the phases (ANSI 47): indicates an alarm through inversion of the phases sequence.

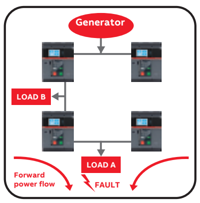
Power factor (ANSI 78): available with a three-phase threshold, warns when the system operates with a power factor that is less than the set power factor.

The following protections are also available:
Second time-delayed overcurrent protection (S2 – ANSI 50TD): in addition to the standard protection S, a second (excludable) time-constant protection is available that enables two independent thresholds to be set in order to ensure precise selectivity, especially in highly critical conditions.



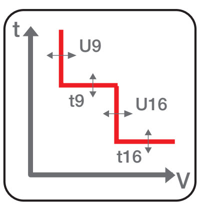
Second protection against ground fault (ANSI 50GTD/51G & 64REF): whereas with Ekip Touch the user has to choose between implementation of the protection G by internal current sensors (calculating the vector sum of the currents) or G ext external toroids (direct measurement of the ground fault current), Ekip Hi-Touch offers the exclusive feature of simultaneous management of both configurations by two independent ground fault protection curves. Owing to this characteristic, the trip unit is able to distinguish a non-restricted ground fault and then activate the opening of SACE Emax 2, from a restricted ground fault, and to thus command the opening of the medium voltage circuit breaker.

Directional overcurrent (D – ANSI 67): the protection is able to recognize the direction of the current during the fault period and thus detect if the fault is upstream or downstream of the circuit-breaker. The protection, with fixed time trip curve (t=k), intervenes with two different time delays (t7bw and t7fw), according to the current direction. In ring distribution systems, this enables the distribution portion to be identified in which the fault occurred and to disconnect it while maintaining the operation of the rest of the installation.

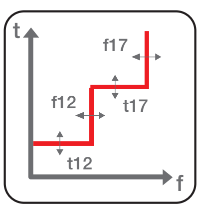


Zone selectivity for protection D (ANSI 68): enables the possibility to interconnect circuit breakers so that, in the event of a fault, the fault area can be rapidly isolated. Disconnection only occurs at the level close to the fault and operation to the rest of the operation continues uninterrupted. The function is particularly useful in ring and grid installations where, in addition to the zone, it is also essential to define the flow direction of the power that supplies the fault. It is possible to enable directional zone selectivity alternatively to the zone selectivity of the protections S and G, and in the presence of an auxiliary supply.

Start-up function for protection D: enables higher trip thresholds to be set at the outgoing point, as available for protections S, I and G.

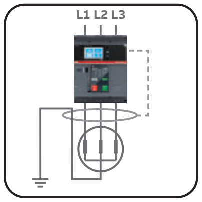


Second protection against undervoltage and overvoltage (UV2 and OV2 – ANSI 27 and 59): enables two minimum and maximum voltage thresholds to be set with different delays in order to be able to discriminate, for example, between voltage dip transients due to the start-up of a motor and an actual fault.

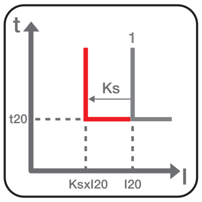


Second protection against underfrequency and overfrequency (UF2 and OF2 – ANSI 81L and 87H): enables two minimum and maximum frequency thresholds to be set simultaneously. For example, only an alarm can be set to be tripped when the first threshold is reached, and the circuit breaker can be set to be opened when the second threshold is reached.

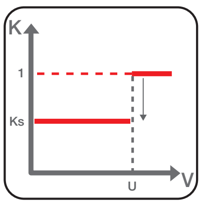
Dual setting of protections: Ekip Hi-Touch can store a set of alternative parameters for all protections. This second series (set B) can replace, if necessary, the default series (set A) by an external command. The command can be given when the network configuration is edited, for example when an emergency source is activated in the system, changing the load capacity and the short-circuit levels. Another typical application is protecting the operator opposite the switchgear against the electric arc. In this case, protection delays are minimized to safeguard the operator (Set A), whereas in the absence of an operator the protections are set to ensure selectivity with the circuit breakers downstream (Set B). It is possible to activate series B by:
- Digital input available with an Ekip Signalling module;
- Communication network, by means of one of the Ekip Com communication modules;
- Directly from the Ekip Hi-Touch display;
- By a settable internal time, after the circuit-breaker has closed.



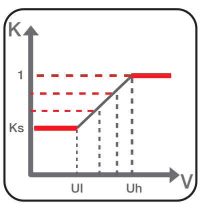
The specific functions for generator protections are described below. For each of these it is possible to choose the operating mode: active, only alarm or deactivated. All the voltage and frequency protections also operate when the circuit- breaker is open, enabling the fault to be identified before the closing of the circuit breaker.



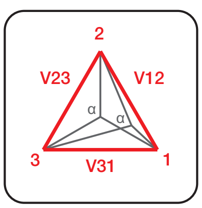
Voltage controlled overcurrent protection (S(V) - ANSI 51V): protection from maximum current with a constant trip time (t = k) that is sensitive to the voltage value. The set current threshold, following a voltage drop, decreases by steps or linearly.



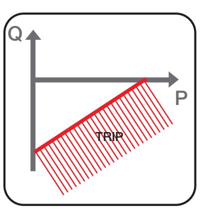
In step mode (controlled mode) the protection is tripped at the set threshold (I20) if the voltage is above U, whereas it is tripped at the lower threshold of the factor Ks (I20 * Ks) if the voltage is below U.



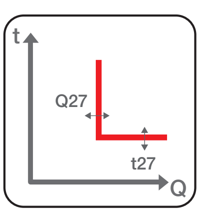
On the other hand, in linear mode (restrained mode) two voltage limits are selected within which the protection is tripped at the set threshold (I20) reduced by the factor K corresponding to the measured voltage. The variation of the factor K is proportional to the voltage, and for voltages greater than the upper threshold (Uh) the threshold I20 works, whereas for voltages below the lower threshold (Ul) the minimum threshold (I20 * Ks) applies.



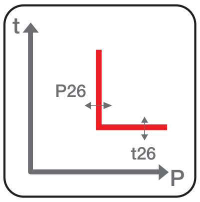
Residual overvoltage (RV – ANSI 59N): with constant trip time (t = k), protects against insulation loss in systems with insulated neutral or with neutral earthed with impedance.



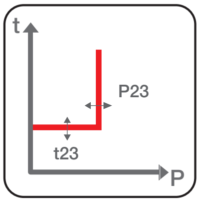
Loss of field or reverse reactive power (RQ – ANSI 40 or 32RQ): with constant trip time (t = k), the circuit breaker tripped when the total reactive power absorbed by the generator exceeds the set threshold. It is possible to select the constant threshold (k=0) or a function of the delivered active power of the generator (k≠0).



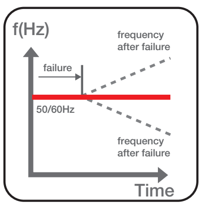
Reactive overpower (OQ – ANSI 32OF): with constant trip time (t = k), the function is tripped when reactive power exceeds the set threshold in the generator to network direction.



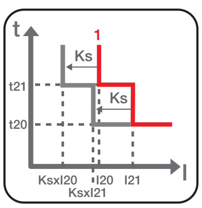
Active overpower (OP – ANSI 32OF): with constant trip time (t = k), the function is tripped when the active power exceeds the threshold set in the delivering direction of the generator.



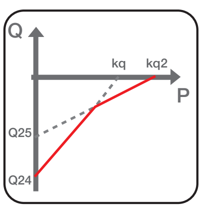
Active underpower (UP – ANSI 32LF): with constant trip time (t = k), the function is tripped when the active power delivered by the generator is lower than the set threshold. It is possible to disable the protection temporarily, to manage the start-up phase, by setting a time window from the closing of the circuit breaker, by using an electrical signal or via incoming communication to a relay.



Rate of change of frequency (ROCOF – ANSI 81R): enables both positive and negative frequency variations to be rapidly detected . The protection is constant and is tripped when the frequency variation in Hz/s is greater than the set threshold.



Second protection against voltage controlled overcurrent protection (S2(V) - ANSI 51V): available in addition to the protection S(V), enables total selectivity to be achieved in all installations.



Second protection against loss of field or reverse reactive power (RQ – ANSI 40 or 32R): enables the generator's de-energization curve to be followed very accurately, thereby avoiding any unnecessary disconnection.

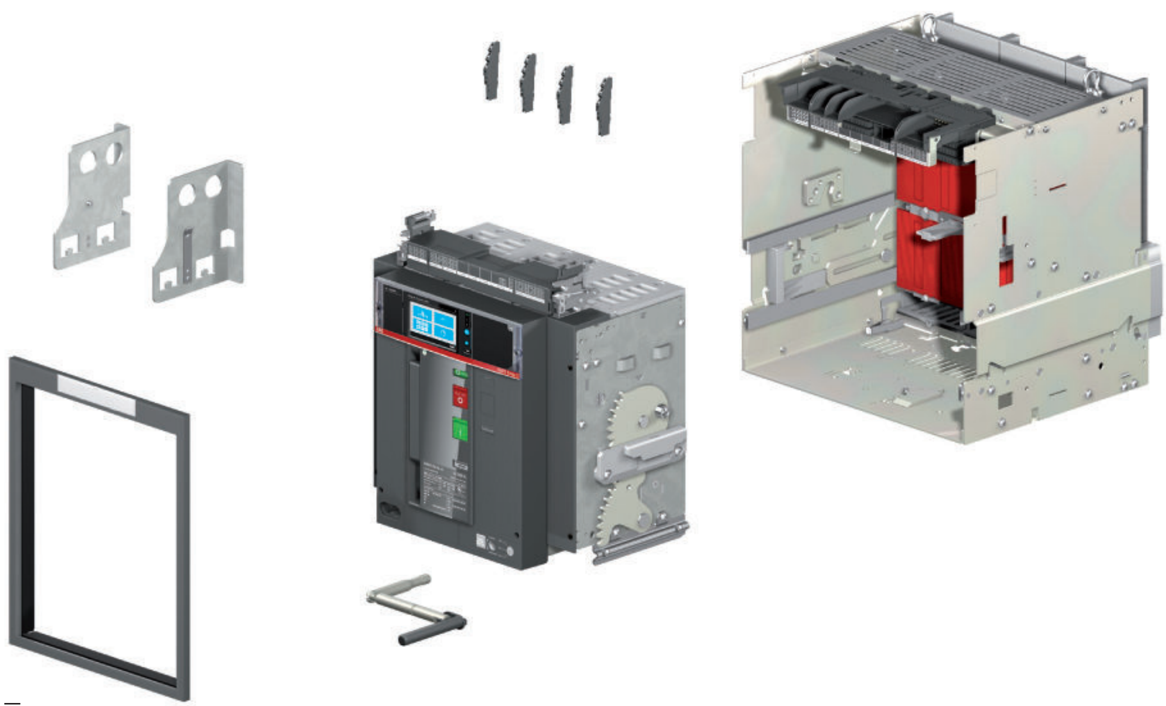
For specific SACE Emax 2 breaker time current curves and coordination with other ABB electrical interruption devices please visit https://partnerhub.connect.abb.com/ to download the Curves application. Curves allows the visualization of the time-current, let-through-energy and peak limitation characteristics of ABB low voltage devices, as well as cables and transformers.

SACE Emax 2 standard features
Breaker and cradle

—
19 Drawout circuit breaker and cradle

The withdrawable versions of SACE Emax 2 automatic circuit- breakers and switch-disconnectors are always supplied as standard with the following accessories:
- Closed circuit-breaker racked-out mechanism lock
- Lifting plates for E2.2 … E2.6 Circuit-breakers
- Lever for racking in and racking out
- Anti-insertion lock
- Four standard open/closed auxiliary contacts - AUX 4Q 400v
- Mechanical signalling of the tripping of the protection trip unit - TU reset
- Contact signalling tripping of Ekip protection trip unit S51 250V

The fixed parts feature:
- IP30 protection for switchgear door
- Anti-insertion lock
- Standard shutter lock – SL



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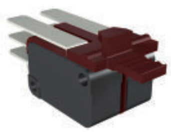
19

SACE Emax 2 circuit breaker accessories

SACE Emax 2 circuit-breakers offer a wide range of accessories developed to satisfy the application and installation requirements of every end user.

	Automatic circuit-breaker		Switch-disconnector	
	E1.2	E2.2 - E4.2 - E6.2	E1.2	E2.2 - E4.2 - E6.2
Signalling				
Standard open/closed auxiliary contacts - AUX 4Q	●●	●●	○○	○○
Open/closed auxiliary contacts - AUX 6Q	-	○○	-	○○
Auxiliary position contacts - AUP	△	△	△	△
Ready to close signalling contact - RTC	○○	○○	○○	○○
TU Reset mechanical signalling of the tripping of protection trip unit - TU Reset	●●	●●	-	-
Contact signalling tripping of Ekip protection trip unit - S51	●●	●●	-	-
Second contact signalling tripping of Ekip protection trip unit - S51/2	-	○○	-	-
Contact signalling loaded springs – S33 M/2 (supplied with Motor)	○○	○○	○○	○○
Control				
Opening and closing release - YO/YC	○○	○○	○○	○○
Second opening and closing release - YO2/YC2	○○	○○	○○	○○
Undervoltage release - YU	○○	○○	○○	○○
Electronic time-delay device for undervoltage release - UVD	○○	○○	○○	○○
Motor - M	○○	○○	○○	○○
Remote reset - YR	○○	○○	-	-
Opening and closing release test unit - YO/YC Test Unit	△	△	△	△
Safety				
Key lock and padlock in open position - KLC and PLC	○○	○○	○○	○○
Key lock and padlock in racked-in / test / racked-out position - KLP and PLP	△	○○	△	○○
Shutter lock - SL	▲	▲	▲	▲
Lock for racking-out mechanism with circuit-breaker in closed position	▲	●●	▲	●●
Lock for racking in / racking out the mobile part when the door is open - DLR	-	△	-	△
Lock to prevent door opening when circuit-breaker is in racked-in / test position - DLP	-	△	-	△
Lock to prevent door opening when circuit-breaker is in closed position - DLC	○○	○○	○○	○○
Anti-insertion lock	●●	●●	●●	●●
Mechanical operation counter - MOC	○○	○○	○○	○○
Protection devices				
Protection device for opening and closing pushbuttons - PBC	○○	○○	○○	○○
IP30 Protection	▲	▲	▲	▲
Interlocks and switching devices				
Mechanical interlock - MI	○○ / △	○○ / △	○○ / △	○○ / △

●● Standard accessory for mobile part
○○ Accessory on request for mobile part
▲ Standard accessory for fixed part
△ Accessory on request for fixed part
* Only closing release YC



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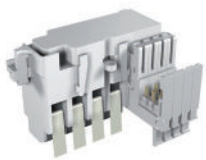
19 A



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19 B

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19 C

Signaling

Open / closed auxiliary contacts - AUX (Fig. 19 A/B/C)

SACE Emax 2 circuit-breakers can be equipped with auxiliary contacts that signal the open or closed status of the circuit-breaker. The first block of four standard contacts is always provided with the automatic circuit-breakers. The switching contacts are available in the following configurations:

Open / closed auxiliary contacts (AUX 4Q)		**E1.2**	**E2.2 ... E6.2**
4 auxiliary contacts	standard	●	●
	digital signals	●	●
	mixed	●	●
Open / closed supplementary auxiliary contacts (AUX 6Q)			
6 auxiliary contacts	standard	-	●
	digital signals	-	●
	mixed	-	●
Maximum number of open / closed auxiliary contacts that can be installed		4	10

		Standard contact	**Contact for digital signals**
Type		changeover contacts	changeover contacts
Minimum load		100mA @ 24V	1mA @ 5V
Breaking capacity			
DC	24V	-	0.1A
	125V	0.3A @ 10ms	-
	250V	0.15A @ 10ms	-
AC	250V	5A @ cosφ 1	-
		5A @ cosφ 0.7	-
		5A @ cosφ 0.3	-
	400V	3A @ cosφ 1	-
		2A @ cosφ 0.7	-
		1A @ cosφ 0.3	-

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Electrical diagram reference: Figures 19, 81, 91 in ABB document 1SXU200040C0201.

Aux 6Q is an alternative to the Ekip signaling 4K module.

Auxiliary position contacts - AUP (Fig. 20 A/B)

When the circuit breaker is a withdrawable version, the position of the mobile part can be signaled electrically by accessorizing the fixed part with one of the following signaling contact units:

Auxiliary position contacts (AUP)		E1.2	E2.2 … E6.2
6 auxiliary contacts	standard	●	-
	digital signals	●	-
5 auxiliary contacts	standard	-	●
	digital signals	-	●
5 supplementary auxiliary contacts	standard	-	●
	digital signals	-	
Maximum number of auxiliary position contacts that can be installed		6	10

—
20 A

—
20 B

		Standard contact	Contact for digital signals
Type		changeover contacts	changeover contacts
Minimum load		100mA @ 24V	1mA @ 5V
Breaking capacity			
DC	24V	-	0.1A
	125V	0.3A @ 0ms	-
	250V	0.15A @ 0ms	-
AC	250V	5A @ cosφ 1	-
		5A @ cosφ 0.7	-
		5A @ cosφ 0.3	-
	400V	2A @ cosφ 0.7	-
		1A @ cosφ 0.3	-

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Electrical diagram reference: Figures 95, 96, 97 in ABB document 1SXU200040C0201.

Ready to close signaling contact - RTC (Fig. 21)

The ready to close signaling contact – RTC – indicates that the circuit-breaker is ready to receive the closing command. The circuit-breaker is ready to close when the following conditions have been met:

- circuit-breaker open
- springs loaded
- no opening command or locks on the opening command
- circuit-breaker reset following tripping of Ekip protection trip unit
- YU energized.

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21

		Standard contact	Contact for digital signals
Type		Switching	
Minimum load		100mA @ 24V	1mA @ 5V
Breaking capacity			
DC	24V	-	0.1
	250V	0.5A @ 0ms / 0.2A 10ms	-
AC	250V	3A @ cosφ 0.7	-

—
Electrical diagram reference: figure 71 in ABB document 1SXU200040C0201.

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22

Mechanical signaling of the tripping of protection trip unit - TU Reset (Fig. 22)
The automatic circuit-breakers are always equipped with a mechanical device that signals the tripping status of the protection trip units. After the Ekip trip unit has tripped due to an electrical fault, the signalling device clearly indicates the tripping status on the front of the circuit- breaker. The circuit-breaker can be reset only after the signaling pushbutton has been restored to its normal operating position. The device conforms to the Ansi 86T standard.
SACE Emax 2 is fitted with the anti-pumping function. With the anti-pumping function the opening order always takes priority over a closing order. Moreover, when the circuit breaker is in open position due to a trip, the anti-pumping function allows the reclosing of the operating mechanism only after a reset of the trip, avoiding improper or accidental closing.

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23

Contact signaling tripping of protection trip unit Ekip – S51 (Fig. 23)
The contact signals the opening of the circuit- breaker after the Ekip protection trip unit has tripped. The circuit-breaker can only be closed after the “TU Reset” tripped trip unit mechanical signalling pushbutton has been restored to its normal operating position.
The switching contact, which is always supplied with the standard version of the automatic circuit-breakers, is also available on request in a version for digital signals (for electrical characteristics, please refer to the RTC contact). It can also be associated with an optional accessory for resetting by remote control - YR. For electromechanical characteristics, please refer to the RTC contact.
For E2.2, E4.2 and E6.2 it is possible to double the signal for the tripping of the Ekip Trip Unit specifying the dedicated code for the S51/2. The S51/2 is an alternative of the YR contact.

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Electrical diagram reference: figure 11 in ABB document 1SXU200040C0201.

Contact signaling loaded springs – S33 M/2
This contact is always supplied with a geared motor; it remotely signals the spring status of the circuit-breaker operating mechanism. It is available in both standard version and version for digital signals.

		Standard contact	Contact for digital signals
Type		changeover contacts	changeover contacts
Minimum load		100mA @ 24V	1mA @ 5V
Breaking capacity			
DC	24V	-	0.1A
	125V	0.3A @ 0ms	-
	250V	0.15A @ 0ms	-
AC	250V	5A @ cosφ 1	-
		5A @ cosφ 0.7	-
		5A @ cosφ 0.3	-
	400V	3A @ cosφ 1	-
		2A @ cosφ 0.7	-
		1A @ cosφ 0.3	-

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Electrical diagram reference: figure 12 in ABB document 1SXU200040C0201.

Control

Opening and closing release- YO/YC (Fig. 24)

The opening and closing releases enable the circuit-breaker to be controlled remotely. Opening is always possible, while closing is available only when the closing springs of the operating mechanism are loaded and the circuit-breakers is ready to close. The releases operate by means of minimum impulse current duration time of 100 ms.

Furthermore, they can operate in permanent service. In this case, if opening command is given by means of the opening release, the circuit-breaker can be closed by de-energizing the opening release and, after a time of at least 30 ms, by controlling the closing.

The circuit breaker operating mechanism has an anti-pumping function that ensures safety and reliability.

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Electrical diagram reference: figures 75, 77 in ABB document 1SXU200040C0201.

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24

Second opening and closing release - YO2/YC2

For certain installations the redundancy of mechanisms and circuit-breaker operating circuits is often requested. To answer these needs, the SACE Emax 2 circuit-breakers can be equipped with double opening release and double closing release. The technical characteristics of the second opening release remain the same as those of the first opening and closing release. A double closing release can be used for E2.2, E4.2 and E6.2 circuit-breakers; a second open release in an alternative to undervoltage release.

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Electrical diagram reference: figures 72, 79 in ABB document 1SXU200040C0201.

General characteristics			
Power supply (Un)		**AC**	**DC**
	24V	●	●
	30V	●	●
	48V	●	●
	60V	●	●
	110V…120V	●	●
	120V…127V	●	●
	220V…240V	●	●
	240V…250V	●	●
Operating limits (IEC60947-2 standards)		YO/YO2: 70%...110% Un YC/YC2: 85%...110% Un	
Inrush power (Ps)		300VA	300W
Continuous power (Pc)		3.5VA	3.5W
Opening time (YO/YO2)			
	E1.2	35 ms	
	E2.2 … E6.2	35 ms	
Closing time (YC/YC2)			
	E1.2	50 ms	
	E2.2 … E6.2	70 ms	

Opening and closing release test unit - YO/YC Test Unit

The opening and closing releases test unit helps ensure that the various version of releases are running smoothly, to guarantee a high level of reliability in controlling circuit-breaker opening.

The test unit ensures the continuity of the opening and closing releases with a rated operating voltage between 24V and 250V (AC and DC), as well as verifies the functions of the opening and closing coil electronic circuit. Continuity is checked cyclically with an interval of 30s between tests. The unit has optic signals via LEDs on the front, which provide the following information:

POWER ON: correct power supply of the YO/YC Test Unit

OPEN ON: coil switch absent, power supply absent or insufficient, interrupted cables

SHORT ON: coil switch failure, short-circuited cables

OPEN and SHORT FLASHING: faulty coil switch or incorrect supply

OPEN and SHORT OFF: correct operation of the coil switch.

Two relays with one change-over area also available on board the unit, to allow remote signalling of the following events:

Failure of a test - resetting takes place automatically when the alarm stops

Failure of three tests - resetting occurs only by pressing the manual RESET on the unit.

Characteristics of device		
Auxiliary power supply		24V...250V AC/DC
Specification of the signalling relays		
	Maximum interruped current	6A
	Maximum interrupted voltage	250V AC

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Undervoltage release – YU (Fig. 25)

The undervoltage release opens the circuit- breaker when there is a significant voltage drop or power failure. It can be used for safe remote tripping, for blocking closing or to control the voltage in the primary and secondary circuits. The power supply for the release is therefore obtained on the supply side of the circuit-breaker or from an independent source. Circuit-breaker closing is permitted only when the release is powered. The undervoltage release is an alternative to as second shunt trip or the anti-racking out device. The circuit-breaker is opened with trip unit power supply voltages of 35-70 percent Un. The circuit-breaker can be closed with a trip unit power supply voltage of 85-110 percent Un.

General characteristics			
Power supply (Un)		AC	DC
	24V	●	●
	30V	●	●
	48V	●	●
	60V	●	●
	110V...120V	●	●
	120V...127V	●	●
	220V...240V	●	●
	240V...250V	●	-
Inrush power (Ps)		300VA	300W
Continuous power (Pc)		3.5VA	3.5W
Opening time (YU)			
	E1.2	30 ms	
	E2.2 … E6.2	50 ms	

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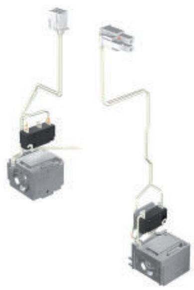
Electrical diagram reference: figure 73 in ABB document 1SXU200040C0201.



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Time-delay device for undervoltage release (UVD) (Fig. 26)
The undervoltage release can be combined with an electronic time-delay device for the circuitbreaker, allowing for delayed external tripping with adjustable preset times. Use of the delayed undervoltage trip unit is recommended to prevent tripping when the power supply network for the trip unit is subject to brief voltage drops or power supply failures. Circuit-breaker closing is inhibited when it is not powered. The time-delay device must be used with an undervoltage release with the same voltage.

General characteristics			
Power supply (UVD)		AC	DC
	24-30V	-	●
	48V	●	●
	60V	●	●
	110-127V	●	●
	220-250V	●	●
Adjustable opening time (YU + D):		0.5-1-1.5-2-3 s	

Resetting remotely- YR
The reset coil YR permits remote resetting of the circuit-breaker after a release has tripped due to an overcurrent condition. It is available for all automatic circuit-breakers, in different voltage supply:

General characteristics			
Power supply (Un)		AC	DC
	24V	●	●
	110V	●	●
	220V	●	●
Operating limits		90%...110% Un	

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Electrical diagram reference: figure 4 in ABB document 1SXU200040C0201.

Motor – M (Fig. 27 A/B)
The motor automatically loads the closing springs of the circuit-breaker. The device, which can be installed from the front, automatically reloads the springs of the operating device when they are unloaded and power is present. In the event no power is present, the springs can be manually loaded by a dedicated lever on the operating device. The motor is always supplied with the limit switch contact S33 M/2 which signals the status of the springs.

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27 A

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27 B

General characteristics			
Power supply (Un)		AC	DC
	24V-30V	●	●
	48V-60V	●	●
	100V...130V	●	●
	220V...250V	●	●
Operating limits (IEC60947-2 standards)		85%...110% Un	
Inrush power (Ps)		300VA E1.2 500VA E2.2 ... E6.2	300W E1.2 500W E2.2 ... E6.2
Inrush time		200ms	
Continuous power (Pc)		100VA E1.2 150VA E2.2 ... E6.2	100W E1.2 150W E2.2 ... E6.2
Charging time			
	E1.2	8 sec	
	E2.2 ... E6.2	7 sec	

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Electrical diagram reference: figure 13 in ABB document 1SXU200040C0201.

Safety

Padlocks - PLC (Fig. 29)
These padlock options allow the circuit-breaker to be kept open by acting directly on the mechanical operating device (opening pushbutton). Three different padlock versions are available:

- Locking device with plastic structure for up to a maximum of three padlocks of 4 mm
- Locking device with metal structure for up to a maximum of two padlocks of 8 mm
- Locking device with metal structure for one padlock of 7 mm or for padlock holders

The padlocks must be supplied by the end user. This device is an alternative to the PBC.

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Key lock in racked-in / test / racked-out position - KLP (Fig. 30)
This device enables the mobile part to be locked in one of the three positions: racked-in, test and racked-out. This device can be supplied with locks with different keys – KLP-D or with the same keys – KLP-S.
A second key lock option can be added for a maximum of two key locks per breaker. Locking in the racked-in, test and racked-out positions can be achieved by using other key locks – KLP-A.
Adapters are offered for acceptance of Ronis, STI, Kirk and Castell locks, which are to be provided by the end user. With the exception of the Castell version, every circuit-breaker can accept up to two key locks. Moreover, it is possible to allow locking only when in the racked-out position with a supplementary accessory.

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Padlock in racked-in / test / racked-out position - PLP (Fig. 31)
This device can hold up to three padlocks of 8 mm in diameter. The structure housing the padlocks can also be used in combination with the 2 lock KLP keylock option. Furthermore, it enables the lock of the moving part in the racked-out position only by means of the supplementary lock in racked-out position. PLP is provided as a standard feature on all ReliaGear LV SG equipment.

Shutter lock – SL
When the mobile part is in the test position, the shutters of the fixed part close, maintaining the insulation distance and physically segregating the live parts of the of the cradle from the internal breaker compartment of the cradle. Using two dedicated mechanisms, the upper and lower shutters can be locked independently of one another. The shutter lock is always supplied with the fixed part of the SACE Emax 2 circuit-breakers and locks the shutters, using a maximum of three padlocks of 4 mm, 6 mm or 8 mm.

— 30

Anti-racking out device / Fail safe - FS
The anti-racking out, or fail safe device prevents the moving part of withdrawable circuit-breakers from being racked out of the cradle when the springs are charged. It is always supplied with the moving part of UL circuit-breakers and switch disconnectors. It is an alternative to the undervoltage coil or second shunt coil.

Protection devices

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Lock for racking-out mechanism with circuit- breaker in closed position (Fig. 32)
All SACE Emax 2 withdrawable circuit-breakers are always supplied with a lock that prevents the mobile part from being racked in and racked out when the circuit- breaker is in the closed position. To rack in the mobile part, the circuit-breaker must be in the open position.

Lock to prevent door opening when the circuit- breaker is in racked-in / test position - DLP (Fig. 33)
This safety device prevents the switchgear door from being opened when the mobile part of the withdrawable version of the circuit-breaker is in the racked-in or test position. This accessory is installed on the left-hand side of the fixed part. It is available for circuit- breakers E2.2, E4.2 and E6.2.

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33

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Anti-insertion lock (Breaker rating rejection)
The withdrawable circuit-breakers are equipped with special locks that allow the mobile part to be inserted only into the corresponding fixed part.

Mechanical operation counter - MOC (Fig. 32)
The number of mechanical operations is often one of the elements that determines the frequency of ordinary maintenance operations on circuit-breakers. With this mechanical operation counter, which is always visible on the front of the circuit-breaker, the user knows how many mechanical operations the device has performed.

Protection device for opening and closing pushbuttons - PBC (Fig. 33)
This accessory is applied to the safety cover of the circuit-breaker and is available in two versions:
- Pushbutton protection device, which blocks operations on both the opening and closing pushbuttons unless the special key is used.
- Padlockable pushbutton protection device, which makes it possible to block either or both pushbuttons and lock the covers in place. It does not trip the breaker as a standard "Padlock device" would.
- PBC is an alternative to PLC padlocks.

IP30 Protection (Fig. 34)
Supplied with every circuit-breaker, the cover frame is installed on the door of the switchgear to achieve IP30 degree of protection on the front part of the circuit-breaker.

Remote Racking Device - RRD
The Remote Racking Device (RRD) operates SACE Emax 2 circuit breakers (E2.2, E4.2 and E6.2) without being in front of the gear. The remote control is connected to the main device through cable that allows the Racking-in/out command from a remote location. The 30 foot cable length guarantees enough distance to remove user from the arc flash boundary of traditional low voltage switchgear. The RRD can only operate with the circuit breaker in open position and discharged springs. The RRD for switchgear has been investigated by UL in accordance with the Standards UL 2876 and CSA-C22.2 (n.14).

General characteristics

Rated service voltage	100...127V AC
	200...240V AC/DC
Frequency	50-60Hz
Rated power	150 W, 120VA
Working and storage temperature range	-5°C...+70°C / 23°F...158°F
Minimum time interval between operation	3 minutes
Maximum operating distance	100m / 33ft
Weight	11Kg / 24.3lb

Ekip trip unit accessories

The electronic trip unit accessories enable utilization of all the potential of Ekip protection trip units in terms of signalling, connectivity, protection functions and testing.

	Electronic trip unit				
	Ekip DIP	**Ekip Touch**	**Ekip Hi-Touch**	**Ekip G Touch**	**Ekip G Hi-Touch**
Power supply					
Ekip Supply	○	○	○	○	○
Battery for Ekip trip units	○	○	○	○	○
Connectivity					
Ekip Com		○	○	○	○
Ekip Com Redundant		○	○	○	○
Ekip Com Actuator	○	○	○	○	○
Ekip Link	○	○	○	○	○
Signalling					
Ekip Signalling 2K		○	○	○	○
Ekip Signalling 3T		○	○	○	○
Ekip Signalling 4K (1)		○	○	○	○
Ekip Signalling 10K	○	○	○	○	○
Ekip Signalling Modbus TCP	○	○	○	○	○
Ekip AUP	○	○	○	○	○
Ekip RTC	○	○	○	○	○
Measurement and Protection					
Measurement Enabler with voltage sockets		○	●	●	●
Measurement Enabler		● (2)			
Ekip Synchrocheck		○	○	○	○
Rating Plug	○	○	○	○	○
Homopolar toroid		○	○	○	○
Toroid for differential protection		○	○	○	○
Current sensor for neutral conductor outside the circuit-breaker	○	○	○	○	○
Displaying and Supervision					
Ekip Multimeter	○	○	○	○	○
Testing and Programming					
Ekip TT	○	○	○	○	○
Ekip T&P: Ekip Programming	○	○	○	○	○

● Standard accessory
○ Accessory on request
(1) Not available for E1.2
(2) Measurements to be activated with the dedicated software package

All accessories are automatically recognized by the Ekip units without the need for any specific configuration. Based on the installation method and connection of the trip units, the electronic accessories can be divided into:

Installation	Modules	Highlights
Terminal box	Cartridge modules: - Ekip Com - Ekip Link - Ekip Signalling 2K - Ekip Signalling 3T - Ekip Supply - Ekip Synchrocheck	- The Ekip Supply module enables the trip units to be supplied with a wide range of control voltages
		- The Ekip supply module must be present for the other modules to be used
		- The Ekip Supply module has a dedicated position in the installation area in the terminal box; the other modules can be installed as desired in the positions available
		- When fitted with the Ekip Supply module, up to 2 additional modules can be installed on E1.2, and up to 3 on E2.2, E4.2 and E6.2
Accessorizing area	Ekip Com Actuator Ekip RTC Ekip AUP Ekip Signalling 4K Rating Plug Battery for Ekip	- These are installed in specific housings from the front of the circuit-breaker
		- For all the trip units with a touch screen interface, an LCD version is available with any adjustment in the protection and measurements functions
		- Thanks to the optional modules Ekip RTC and Ekip AUP, all the Ekip trip units can acquire and monitor the ready to close state and the racked-in/test isolated/racked-out position of the circuit-breaker. The module to acquire the open/closed position is supplied as standard for all Ekip trip units.
		- The Ekip Signalling 4k module increases the remote signalling possibilities for E2.2, E4.2 and E6.2 and can be installed if the Ekip Supply module or another 24V auxiliary power supply is present
Ekip trip unit test port	Ekip TT	- These can be connected to the front test port of the trip units even with the device in operation
		- Compatible also with the Tmax XT range
External	Ekip Multimeter Ekip Signalling 10K Ekip Signalling Modbus TCP	- Ekip Multimeter can supply a 24V DC output to the trip unit it is connected to
		- Several Ekip units and / or Ekip Signalling 10K can be connected at the same time to the same Ekip trip unit
	External neutral sensor	- These are connected to the trip unit by the terminal box of the circuit-breaker

Power supply

Ekip Supply module (Fig. 35)

The Ekip Supply module supplies all Ekip trip units and modules present on the terminal box and of the circuit-breaker with several auxiliary power (in AC or DC) available in the switchgear. The module is mounted in the terminal box and permits the installation of the other advanced modules. It can be field installed at any time.

Two versions are available according to the control voltage available:

- Ekip Supply 110-240V AC/DC
- Ekip Supply 24-48V DC

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	Supply	Ekip Supply	
Ekip Dip	**Nominal voltage**	24-48V DC	110-240V AC/DC
	Voltage range	21,5-53V DC	105-265V AC/DC
	Rated power (including modules)	10W max.	10W max.
	Inrush current	~2A for 20ms	~2A for 20ms
Ekip Touch/ Hi-Touch	**Nominal voltage**	24-48V DC	110-240V AC/DC
	Voltage range	21,5-53V DC	105-265V AC/DC
	Rated power (including modules)	10W max.	10W max.
	Inrush current	~2A for 20ms	~2A for 20ms

Connectivity

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Ekip Com modules (Fig. 36)

The Ekip communication modules enable SACE Emax 2 circuit-breakers to be integrated in an industrial communication network for remote supervision and control of the circuit-breaker. They are suitable for all distribution and generator protection versions of the Ekip Touch and Hi-Touch trip units. Since they are mounted in the terminal box, communication can be maintained with withdrawable circuit-breakers, even while in the racked-out position. Several Ekip Com modules can be installed at the same time, thereby enabling connection to communication systems that use different protocols.
The Ekip Com modules for Modbus RTU, Profibus-DP and DeviceNet™ contain a terminating resistor and dip switch for optional activation to terminate the serial network or bus.
The Profibus-DP module also contains a polarization resistor and dip switch for its activation.
The Ekip Com modules are supplied with auxiliary position contacts Ekip AUP and
ready to close circuit-breaker contacts Ekip RTC.
For industrial applications in which a higher reliability of the communication network is required, the Ekip Com Redundant modules can be installed together with the corresponding Ekip Com modules in order to guarantee a back-up connection to the network.
The following communication protocols are available for Ekip trip units:

Protocol	Ekip Com Module	Ekip Com Redundant Module
Modbus RTU	Ekip Com Modbus RS-485	Ekip Com R Modbus RS-485
Modbus TCP	Ekip Com Modbus TCP	Ekip com R Modbus TCP
Profibus-DP	Ekip Com Profibus	Ekip Com R Profibus
Profinet	Ekip Com Profinet	Ekip Com R Profinet
EtherNet/IP™	Ekip Com EtherNet/IP™	Ekip Com R EtherNet/IP™
DeviceNet™	Ekip Com DeviceNet™	Ekip Com R DeviceNet™
IEC61850	Ekip Com IEC61850	Ekip Com R IEC61850
Cloud connectivity	Ekip Com Hub	–

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Electrical diagram reference: figures from 51 to 57. Redundant version from 61 to 66 in ABB document 1SXU200040C0201.

Ekip Signaling Modbus TCP (Fig. 37)

It is an external signalling unit designed for DIN rail installation. Function of the signalling module is to share, via an Ethernet network with Modbus TCP communication protocol, information about the state of circuit-breakers that might not have the ability to provide such information via Ethernet, and also to allow these circuit-breakers to be operated via remote control.

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Characteristics of output contacts			Number of contacts		
Type		Monostable	Ekip 2K	Ekip 4K	Ekip 10K
Maximum switching voltage		150V DC / 250V AC			
Maximum switching current					
	30V DC	2A			
	50V DC	0.8A	2 output + 2 input	4 output + 4 input	10 output + 11 input
	150V DC	0.2A			
	250V AC	4A			
Contact/coil insulation		1000 Vrms (1min @50Hz)			

Ekip 10K/Ekip signaling Modbus TCP power supply	
Auxiliary supply	24-48V DC, 110-240V AC/DC
Voltage range	21.5-53V DC, 105-265V AC/DC
Rated power	10VA/W
Inrush current	1A for 10ms

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Ekip RTC and Ekip AUP signaling contacts (Fig. 38)

The signalling contacts allow the Ekip trip units to acquire the ready-to-close status of the circuit- breaker, as well as its racked-in, test or racked-out position. These contacts can be optionally installed in the accessories area of SACE Emax 2 equipped with Ekip Dip, Ekip Touch and Ekip Hi-Touch trip units. Ekip Link and Ekip Com modules are always supplied with Ekip RTC and Ekip AUP.

Measurement and protection

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Measurement Enabler module (Fig. 39)
The Measurement Enabler module is supplied with Ekip Touch trip units by default and is installed to the right of the trip unit. This module enables the trip unit to internally measure phase and neutral voltages, as well as power and energy. In particular, the Measurement Enabler module makes the platform always customizable through the activation of dedicated software packages available in the ABB Ability MarketplaceTM. Depending on the functionality desired, a software package may need to be purchased separately. The voltage outlets are installed on the lower terminals by default and can be moved to the upper terminals upon request. No external connection is required, except for rated voltages higher than 690V. In this case, the voltage connection is moved outside the circuit-breaker by using voltage transformers connected to the terminal box. The installation of external outlets does not guarantee Class 1 accuracy.

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Measurement Enabler with voltage sockets (Fig. 40)
This module has the same features as the Measurement Enabler module, but additionally includes voltage sockets that allow direct connection of line voltages higher than 85V. This module is mandatory for Rc protection and is always supplied with Ekip Hi-Touch and Ekip G trip units. On request, it can be also installed with the Ekip Touch version.

Ekip Synchrocheck (Fig. 41)
This module enables the control of the synchronism condition when placing two lines in parallel. The module can be used with distribution and generator protection versions of the Ekip Touch and Hi-Touch trip units with the measurement function enabled.
Ekip Synchrochek measures the voltages from two phases of one line through an external transformer and compares them to the measured voltages at the breaker. An output contact is available, which is activated upon reaching synchronism, and enables the circuit-breaker to be closed by means of wiring with the closing coil.

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Characteristics of output contacts			Number of contacts
Type		Monostable	Ekip Synchrocheck
Maximum switching voltage		150V DC / 250V AC	1 output
Maximum switching current			
	30V DC	2A	
	50V DC	0.8A	
	150V DC	0.2A	
	250V AC	4A	
Contact/coil insulation		1000 Vrms (1min @50Hz)	

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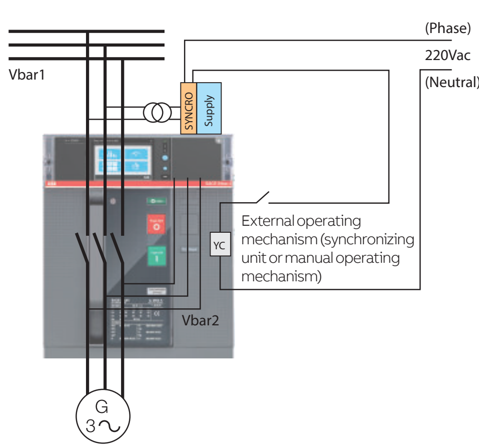
Electrical diagram reference: figure 48 in ABB document 1SXU200040C0201.



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Rating Plug (Fig. 42)
The rating plugs are field interchangeable from the front on all trip units and enable the protection thresholds to be adjusted according to the actual rated current of the system.
This function is particularly advantageous in installations that may require future expansion or in cases in which the power supplied needs to be limited temporarily (e.g. mobile Gen Set).

Circuit-breaker	Rating plugs available
E1.2	400-600-800-1000-1200
E1.2 250	100-200-250
E2.2	400-600-800-1000-1200-1600-2000
E2.2 250	100-200-250
E4.2	400-600-800-1000-1200-1600-2000-2500-3200-3600
E6.2	400-600-800-1000-1200-1600-2000-2500-3200-3600-4000-5000-6000

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Current sensor for neutral conductor outside the circuit-breaker (Fig. 43)
This is only for three-pole circuit-breakers; it enables protection of the neutral conductor to be achieved through connection to the Ekip trip unit. It is supplied on request.

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Electrical diagram reference: figure 27 in ABB document 1SXU200040C0201.

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Dedicated terminal for Modified Differential Ground Fault (MDGF) protection (Fig. 44)
This terminal is needed to realize the MDGF scheme with SACE Emax 2 circuit-breakers. The application needs the mounting of external phase current transformers and summing current transformers. SACE Emax 2 MDGF scheme is compatible with external, cradle and neutral current transformers. External current transformers must have the same rating of the circuit-breaker rating plug. Phase CTs that are compatible with the MDGF system can be found in this tech guide on Tables 4, 5 and 6.

For the complete application wiring diagram, please refer to 1SDM000019A1001.

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External display

Ekip Multimeter (Fig. 45)
Ekip Multimeter is a display unit to be installed on the front of the switchgear for SACE Emax 2 circuit-breakers equipped with Ekip electronic trip units. The device is equipped with a large touch screen display and enables measurements to be displayed with the same levels of precision. If connected to trip units with a display, Ekip Multimeter enables the adjustment of parameters and protection thresholds. Up to 4 Ekip Multimeter devices can be connected at the same time to the same Ekip protection trip unit to display currents, voltage, powers and energy.

Ekip Multimeter can be powered either in direct current or in alternating current. It is equipped with a 24V DC output that supplies the trip unit to which it is connected.

Power supply	24-48V DC, 110-240V AC/DC
Tolerance	21.5-53V DC, 105-265V AC/DC
Rated Power	10VA/W
Inrush current	2A for 20ms

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Testing and programming

Ekip TT testing and power supply unit (Fig. 46)
Ekip TT allows to supply the Ekip trip unit with no need of auxiliary power supply. In this way, the last protection device tripped can be displayed directly on the screen or by the lighting up of corresponding LEDs. Moreover, the unit permits to verify that the circuit-breaker trip mechanism properly works (trip test). Ekip TT can be directly connected through the front test connector of any Ekip trip units of Emax 2 and allows to set all protection functions.

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Ekip Programming Module (Fig. 47)
The Ekip Programming module is used for programming Ekip trip units via USB to a PC using the Ekip Connect software that can be downloaded on-line. This can be useful for uploading/downloading entire sets of parameters for multiple breakers both for set-up as well as for maintenance (for periodic cataloging breaker parameters in case of a catastrophic situation).

Catalog number breakdown

SACE Emax 2 circuit breaker/switch disconnector code

SACE Emax 2 circuit breaker order code explanation

Z	2	H	F	UJ	A	E	4	8	N	B	E	A	A	O	Q	C	E	A
1	2	3	4	5&6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

1 - SACE Emax 2 prefix

A	SACE Emax 2 for ReliaGear LV SWG

2 - Frame

	E1.2	E2.2	E4.2	E6.2
3p	1	2	4	6

3 - Short circuit rating / version

	B	C	N	S	H	V	L	X
kA @ 508V AC	42	-	50	65	85	100	-	-
UL kA @ 635V AC	42	-	50 (1)	65 (1)	85	85/100 (4)	-	-

1) E1.2N = 42kA
2) E1.2N = 50kA
3) E2.2H and E4.2H = 85kA / E6.2H = 100kA
4) E2.V and E4.2V = 85kA / E6.2V = 100kA

4 - Frame rating [A]

	A	C	D	E	F	H	J	K
UL	250	800	1200	1600	2000	3200	4000	5000

5 & 6 - Rating plug [A]

Switch	00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UL	UA	UB	UC	UD	UE	UF	UG	UH	UJ	UK	UL	UN	UQ	UR	US	UT
	100	200	250	400	600	800	1000	1200	1600	2000	2500	3200	3600	4000	5000	6000

7 - Drawout breaker connections

	No lever	With kirk lever
Drawout (less cradle)	A	Y

Z	2	H	F	UJ	A	E	4	8	N	B	E	A	A	O	Q	C	E	A
1	2	3	4	5&6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

8 - Ekip Trip Unit

Switch Disconnector	0			
	Protection Functions	LI	LSI	LSIG
Ekip Trip Unit + Standard 250V Bell Alarm	DIP	A	B	C
	Touch	D	E	F
	Touch + Power Controller (1)	G	H	I
	Hi-Touch	-	J	K
	Hi-Touch + Power Controller (1)	-	L	M
	G Touch	-	-	N
	G Touch + Power Controller (1)	-	-	P
	G Hi-Touch	-	-	Q
	G Hi-Touch + Power Contoller (1)	-	-	R
Ekip Trip Unit + optional 24VDC Bell Alarm	DIP	S	T	U
	Touch	V	W	X
	Touch + Power Controller (1)	Y	Z	1
	Hi-Touch	-	2	3
	Hi-Touch + Power Controller (1)	-	4	5
	G Touch	-	-	6
	G Touch + Power Controller (1)	-	-	7
	G Hi-Touch	-	-	8
	G Hi-Touch + Power Contoller (1)	-	-	9

1) Ekip Power Controller requires the use of Ekip Measuring or Measuring Pro modules

9 - Auxiliary Power Supply (Ekip Supply) and measuring package

	None	0	-
	-	Measuring Package*	1% Accuracy **
	-	1	2
24V - 48V DC Supply	3	4	5
110 -240V AC/DC Supply	6	7	8
Top Supply	-	A	B
External Mtg Cables	-	C	D
Top Supply + 24V DC Supply	-	E	F
Top Supply + 110-240V AC/DC Supply	-	G	H
Ext. Mtg cables + 24V DC Supply	-	J	K
Ext. Mtg cables + 110-240V AC/DC Supply	-	L	M

* Available for Ekip Touch trip units. Provided by default with all the other versions.

** Available for Ekip Touch and Ekip G Touch trip units. Provided by default with all the other versions.

10 - Communication modules

None	**0**	-	-	-	-	-	-
RTC Ekip (24VDC)	**Y**						
Single	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Modbus RS-485	Modbus TCP/IP	Profibus	Profinet	DeviceNet	EtherNet/IP	IEC 61850
Combos	**A**	**B**	**C**	**D**	**E**	**F**	-
	RS-485 + TCP/IP	TCP/IP + Profibus	Profibus + Profinet	Profinet + DeviceNet	DeviceNet + EtherNet/IP	EtherNet/IP + IEC 61850	-
	G	**H**	**J**	**K**	**L**	-	-
	RS-485 + Profibus	TCP/IP + Profinet	Profibus + DeviceNet	Profinet + EtherNet/IP	DeviceNet + IEC 61850	-	-
	M	**N**	**P**	**Q**	-	-	-
	RS-485 + Profinet	TCP/IP + DeviceNet	Profibus + EtherNet/IP	Profinet + IEC 61850	-	-	-
	R	**S**	**T**	-	-	-	-
	RS-485 + DeviceNet	TCP/IP + EtherNet/IP	Profibus + IEC 61850	-	-	-	-
	U	**V**	-	-	-	-	-
	RS-485 + EtherNet/IP	TCP/IP + IEC 61850	-	-	-	-	-
	W	-	-	-	-	-	-
	RS-485 + IEC 61850	-	-	-	-	-	-

Note: not valid with Ekip Dip or Switch Disconnectors

Z	2	H	F	UJ	A	E	4	8	N	B	E	A	A	O	Q	C	E	A
1	2	3	4	5&6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

11 - Redundant communications and additional Ekip modules

None	**0**	-	-	-	-	-	-
Redundant Com.	**2**	**3**	**4**	**5**	**6**	**7**	**8**
	Modbus RS-485	Modbus TCP/IP	Profibus	Profinet	DeviceNet	EtherNet/IP	IEC 61850
Other Modules	**A**	**B**	**C**	**Q**	**W**	**L**	-
	Ekip Link	Synchrocheck	Signalling 2K-1	Ekip Com Hub	Signalling 3T-1	RELT Signalling 2K-3	-
Combos	**D**	**E**	**F**	**R**	**X**	-	-
	Redundant Com + Ekip Link	Redundant Com + Synchrocheck	Redundant Com + Signalling 2K	Redundant Com + Ekip Com Hub	Redundant Com + Signalling 3T-1	-	-
	G	**H**	**J**	**S**	**Y**	-	-
	Ekip Link + Synchrocheck	Synchrocheck + Signalling 2K	Signalling 2K-1 + Signalling 2K-2	Ekip Link + Ekip Com Hub	Ekip Link + Signalling 3T-1	-	-
	K	**V**	**Z**	**1**	**M**	-	-
	Ekip Link + Synchrocheck + Signalling 2K	Ekip Com Hub + Signalling 3T-1	Synchrocheck + Signalling 3T-1	Signalling 2K-1 + Signalling 3T-1	RELT-Ekip Signalling 2K3 + Ekip Link	-	-
	N	**T**	**U**	**9**	**P**		
	Ekip Link + Signalling 2K-1	Synchrocheck + Ekip Com Hub	Signalling 2K-1 + Ekip Com Hub	Ekip Com Hub + Signalling 2K + Signalling 3T-1	RELT-Ekip Signalling 2K3 + Redundant Com		

Note 1: Communication, Synchrocheck, Ekip 2K, Ekip 3T, and Ekip Link are not compatible with Switch Disconnectors
Note 2: Ekip Touch or greater trip unit is required for Communication, Ekip 2K, Ekip 3T, and Synchrocheck modules
Note 3: Redundant Com will match communication module selected in digit 10

12 - Auxilary Contacts (AUX) and Additional Signaling (4K)

None	0			
	-	4 AUX (4Q) 400V(3)	4 AUX (4Q) 24V	4 AUX (2Q+2Q) 24 & 400V
	-	A	B	C
6 AUX (6Q) 400V (1)	D	E	F	G
6 AUX (6Q) 24V (1)	H	J	K	L
6 AUX (3Q+3Q) 400 & 24V (1)	M	N	B	Q
4K Signaling (1)(2)	-	R	S	T

(1) Not compatible with E1.2
(2) Not compatible with Ekip Dip or Switch disconnectors
(3) Provided as standard for all circuit breakers
Note: Options O, D, H and M are for use with switch disconnectors only

13 - Remote Reset (YR), 2nd Bell Alarm (S51/2) and Ready to Close Contacts (RTC)

None	0					
	-	YR 24V AC/DC	YR 110V AC/DC	YR 220V AC/DC	S51/2 250V (1)	S51/2 24V DC (1)
	-	A	B	C	P	Q
RTC 24VDC	D	E	F	G	R	S
RTC 250V AC/DC	H	J	K	L	T	U
Disable Bluetooth + Sealable Cover (2)	M	N	V	W	X	Y
Disable Bluetooth + Sealable Cover (2) + RTC 24VDC	Z	1	2	3	4	5
Disable Bluetooth + Sealable Cover (2) + RTC 250V	6	7	8	9	I	O

(1) Not compatible with E1.2
(2) Disable Bluetooth for Ekip Touch or greater trip unit

14 - Closing Coil (YC) and Redundant Closing Coil (YC2)

None	0										
	24V AC/DC	30V AC/DC	48V AC/DC	60V AC/DC	110-120V AC/DC	120-127V AC/DC	220-240V AC/DC	240-250V AC/DC	380-400V AC	415-440V AC	480-500V AC
YC	A	B	C	D	E	F	G	H	K	L	M
YC + YC2	N	P	Q	R	S	T	U	V	X	Y	Z

Note: YC2 will have the same control voltage as YC1

15 - Opening Coil (YO)

None	0										
	24V AC/DC	30V AC/DC	48V AC/DC	60V AC/DC	110-120V AC/DC	120-127V AC/DC	220-240V AC/DC	240-250V AC/DC	380-400V AC	415-440V AC	480-500V AC
YO	A	B	C	D	E	F	G	H	K	L	M

16 - Undervoltage Release (UVR) or Redundant Opening Coil (YO2)

None	0										
	24V AC/DC	30V AC/DC	48V AC/DC	60V AC/DC	110-120V AC/DC	120-127V AC/DC	220-240V AC/DC	240-250V AC/DC	380-400V AC	415-440V AC	480-500V AC
UVR	A	B	C	D	E	F	G	H	K	L	M
YO2 only	N	P	Q	R	S	T	U	V	X	Y	Z

Z	2	H	F	UJ	A	E	4	8	N	B	E	A	A	O	Q	C	E	A
1	2	3	4	5&6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

17 - Spring Charging Motor (M) and Ekip Com Actuator

None	0					
Ekip Com Actuator	1					
	24-30V AC/DC	48-60V AC/DC	100-130V AC/DC	220-250V AC/DC	380-415V AC	440-480V AC (1)
M with standard aux. for status indication of springs	2	3	4	5	7	8
M with 24V DC aux. contacts for status indication of springs	A	B	C	D	F	G
M with standard aux. for status indication of springs + Ekip Com Actuator	H	J	K	L	N	P
M with 24V DC aux. contacts for status indication of springs + Ekip Com Actuator	Q	R	S	T	U	V

Note: Standard aux = E1.2 = 250V / E2.2 - E6.2 = 400V
(1) not compatible with E1.2

18 - Push Button Locking Options

None	0							
		Push Button Covers (PBC)				**Padlock in Open Position (PLC)**		
		PBC Special Key	**PBC Padlock (4mm)**	**PBC Padlock (7mm)**	**PBC Padlock (8mm)**	**PLC (4mm)**	**PLC (7mm)**	**PLC (8mm)**
		2	3	4	5	6	7	8

19 - Racking Lock Options (1st lock) and Factory Test Report

None	**X**	**Keylock in racked in/out - Same Keys (KLP-S) (1)**	**Keylock in racked in/out - Different Keys (KLP-D) (1)**	**Keylock in racked in/out - Kirk/Ronis/Profulaux provisions (KLP-A) (1)**	**Keylock in racked in/out - Castell provisions (KLP-A) (2)**
	-	A	B	C	D
Padlock in racked in/out position (PLP)	E	F	G	H	J
Factory Test Report	K	M	N	P	Q
PLP + Factory Test Report	R	S	T	U	V

(1) Standard key for Same Key option is #20005. Locks for #20006 - 20009 are available for order as loose accessories.
(2) Two Castell adapters cannot be used at once, but can be used in either position with another type of lock.

20 - 2nd Racking Lock Options, Mechanical Operations Counter (MOC) and Extended Warranty's

None	**X**	**Keylock in racked in/out - Same Keys (KLP-S) (1)**	**Keylock in racked in/out - Different Keys (KLP-D) (1)**	**Keylock in racked in/out - Kirk/Ronis/Profulaux provisions (KLP-A) (1)**	**Keylock in racked in/out - Castell provisions (KLP-A) (2)**
		B	C	D	E
Mechanical Operations Counter (MOC)	A	F	G	H	J
2 Year Extended Warranty	2	N	R	U	Y
4 Year Extended Warranty	4	P	S	V	Z
5 Year Extended Warranty	5	Q	T	W	6
Additional Combinations					
MOC + 2 Year Extended Warranty	K	7	-	-	-
MOC + 4 Year Extended Warranty	L	8	-	-	-
MOC + 5 Year Extended Warranty	M	9	-	-	-

Note: for additional combinations please contact your local ABB sales person

Application data

SACE Emax 2 power circuit breaker selection tables
The tables on the following pages can be used to help determine the correct SACE Emax 2 breaker frame sizes and interrupting ratings based on the system voltage, transformer kVA rating, transformer overload ratings, and transformer impedance.

Main breakers are sized based on either the transformer base kVA or the transformer full load current with fan cooling. The main breaker short circuit rating is based on the transformer base kVA rating, minimum transformer impedance, and the system voltage. Recommended feeder breakers are listed in two columns. Feeder breaker short circuit rating is determined by the combined short circuit current available from the transformer and any contribution from connected motor loads.
The first feeder breaker column provides the breaker designation based on the required short circuit interrupting rating. The breaker in this column has a short time withstand rating less than or equal to the breaker interrupting rating.

The second feeder breaker column lists the feeder circuit breaker with a short time withstand rating equal to its interrupting rating or a “square-rated” breaker. The SACE Emax 2 circuit breaker application guide 1SXU200040C0201 discusses breaker short time withstand and interrupting ratings. To determine the transformer full load current based on the transformer type, kVA, temperature rise, and fan cooling, see Table 11.

Table 11: Transformer full-load current

Transformer type	Self-cooled kVA	Percent increase with fans
Liquid filled 65 °C rise	750-2000	15%
	2500-5000	25%
Liquid filled 55 °C/ 65 °C rise	750-2000	15% (fans) + 12% (65 °C)
	2500-5000	25% (fans) + 12% (65 °C)
Ventilated dry	750-2500	33%
Cast coil	500-2500	40%
	3000-5000	25%

Table 12 shows the breaker description legend, which defines the breaker current and interruption ratings. These breaker descriptions are used in the following breaker selection tables.

Table 12: Breaker description for breaker selection table(1)

Breaker/ cradle size	AIC Rating code 2	Current rating (Max Sensor)
E1.2	B/N/S	800A
E2.2	S/H/V	
E4.2	V	
E1.2	B/N/S	1200A
E2.2	S/H/V	
E4.2	V	
E2.2	S/H/V	1600A
E4.2	V	
E2.2	N/S/H/V	2000A
E4.2	V	
E4.2	S/H/V	3200A
E6.2	V	
E6.2	H/V	4000A
E6.2	H/V	5000A

1. Example: E2.2 S 800A is SACE Emax 2, E2.2 cradle, 800 A, 65 kA interrupting,
65 kA withstand.
2. Refer to Table 8: ANSI/UL1066 LVPCB interrupting ratings.

Table 13: System voltage @600 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 600 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Main breaker [(1)(2)(3)] $I_{CW}>I_{SC}$	Feeder breaker[(5)] $I_{CW}\leq I_{CU}$	Feeder breaker[(5)] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
500	481 with fans: 674	50	1.00	7128	7614	1925	9539	E 2.2 S 800 A	E1.2 B 800 A	E1.2 B 800 A
		100	0.50	7698	8269		10193			
		150	0.33	7909	8512		10437			
		250	0.20	8086	8086		10643			
		500	0.10	8224	8879		10803			
		750	0.07	8271	8934		10858			
		Unlimited	0.00	8367	9046		10970			
750	722 with fans: 1010	50	1.50	9954	10584	2887	13471	E2.2 S 800 A (E2.2 S 1200 A)	E1.2 B 800 A	E1.2 B 800 A
		100	0.75	11103	11892		14779			
		150	0.50	11547	12403		15290			
		250	0.30	11929	12844		15731			
		500	0.15	12232	13197		16083			
		750	0.10	12337	13318		16205			
		Unlimited	0.00	12551	13569		16456			
1000	962 with fans: 1347	50	2.00	12416	13148	3849	16997	E2.2 S 1200 A (E2.2 S 1600 A)	E1.2 B 800 A	E1.2 B 800 A
		100	1.00	14256	15228		19077			
		150	0.67	14996	16077		19926			
		250	0.40	15646	16826		20675			
		500	0.20	16172	17436		21285			
		750	0.13	16356	17649		21498			
		Unlimited	0.00	16735	18092		21941			
1500	1443 with fans: 2021	50	3.00	16496	17351	5774	23124	E2.2 S 1600 A (E2.2 N 2000 A)	E1.2 B 800 A	E1.2 B 800 A
		100	1.50	19909	21168		26941			
		150	1.00	21383	22843		28616			
		250	0.60	22730	24386		30160			
		500	0.30	23857	25689		31462			
		750	0.20	24258	26154		31928			
		Unlimited	0.00	25102	27137		32911			
2000	1925 with fans: 2694	50	4.00	19738	20652	7698	28350	E2.2 N 2000 A (E4.2 S 3200 A)	E1.2 B 800 A	E2.2 S 800 A
		100	2.00	24832	26295		33993			
		150	1.33	27169	28931		36629			
		250	0.80	29382	31453		39151			
		500	0.40	31293	33652		41350			
		750	0.27	31986	34456		42154			
		Unlimited	0.00	33470	36183		43881			

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Main breaker [1][2][3] $I_{CW}>I_{SC}$	Feeder breaker[5] $I_{CW}\leq I_{CU}$	Feeder breaker[5] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
2500	2406 with fans: 3368	50	5.00	22378	23313	9623	32936	E4.2 S 3200 A (E6.2 H 4000 A)	E2.2 S 800 A	E2.2 S 800 A
		100	2.50	29159	30767		40390			
		150	1.67	32435	34438		44060			
		250	1.00	35639	38071		47694			
		500	0.50	38490	41343		50965			
		750	0.33	39545	42562		52184			
		Unlimited	0.00	41837	45229		54852			
3000	2887 with fans: 4041	50	6.00	24568	25504	11547	37051	E4.2 H 3200 A (E6.2 H 5000 A)	E2.2 H 800 A	E2.2 H 800 A
		100	3.00	32991	34702		46249			
		150	2.00	37248	39443		50990			
		250	1.20	41536	44284		55831			
		500	0.60	45461	48773		60320			
		750	0.40	46939	50479		62026			
		Unlimited	0.00	50204	54275		65822			
3750	3608 with fans: 5052	50	7.50	27234	28150	14434	42583	E6.2 H 4000 A (E6.2 H 5000 A)	E2.2 H 800 A	E2.2 H 800 A
		100	3.75	37984	39790		54224			
		150	2.50	43739	46151		60585			
		250	1.50	49772	52919		67353			
		500	0.75	55514	59459		73893			
		750	0.50	57735	62014		76448			
		Unlimited	0.00	62755	67844		82278			
5000	4811 with fans: 6736	50	10.00	30548	31408	19245	50653	E6.2 V 5000 A	E4.2 V 800 A	E4.2 V 800 A
		100	5.00	44756	46626		65871			
		150	3.33	52968	55608		74853			
		250	2.00	62081	65739		84984			
		500	1.00	71278	76142		95387			
		750	0.67	74981	80383		99628			
		Unlimited	0.00	83674	90458		109703		N/A	

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is E2.2, E4.2, or E6.2 to accommodate ground fault CTs for 4-wire modified differential ground fault protection
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.

Table 14: System voltage @480 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 480 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Main breaker [(1)(2)(3)] $I_{cw}>I_{sc}$	Feeder breaker[(5)] $I_{cw} \leq I_{cu}$	Feeder breaker[(5)] $I_{cw}=I_{cu}$ or $I_{cw}>I_{sc}$
500	601 with fans: 842	50	1.00	8910	9518	2406	11923	E2.2 S 800 A (E2.2 S 1200 A)	E1.2 B 800 A	E1.2 B 800 A
		100	0.50	9623	10336		12741			
		150	0.33	9886	10640		13046			
		250	0.20	10108	10898		13303			
		500	0.10	10280	11099		13504			
		750	0.07	10339	11167		13573			
		Unlimited	0.00	10459	11307		13713			
750	902 with fans: 1263	50	1.50	12443	13230	3608	16838	E2.2 S 1200 A (E2.2 S 1600 A)	E1.2 B 800 A	E1.2 B 800 A
		100	0.75	13879	14865		18473			
		150	0.50	14434	15503		19112			
		250	0.30	14911	16055		19664			
		500	0.15	15290	16496		20104			
		750	0.10	15421	16648		20256			
		Unlimited	0.00	15689	16961		20569			
1000	1203 with fans: 1684	50	2.00	15520	16435	4811	21246	E2.2 S 1600 A (E2.2 N 2000 A)	E1.2 B 800 A	E1.2 B 800 A
		100	1.00	17819	19036		23847			
		150	0.67	18745	20096		24907			
		250	0.40	19558	21033		25844			
		500	0.20	20215	21795		26606			
		750	0.13	20444	22062		26873			
		Unlimited	0.00	20918	22615		27426			
1500	1804 with fans: 2526	50	3.00	20620	21689	7217	28905	E2.2 N 2000 A (E4.2 S 3200 A)	E1.2 B 800 A	E1.2 B 800 A
		100	1.50	24886	26460		33677			
		150	1.00	26729	28553		35770			
		250	0.60	28413	30483		37700			
		500	0.30	29822	32111		39328			
		750	0.20	30323	32693		39909			
		Unlimited	0.00	31378	33922		41139			
2000	2406 with fans: 3368	50	4.00	24673	25815	9623	35437	E4.2 S 3200 A (E6.2 H 40)	E1.2 S 800 A	E2.2 S 800 A
		100	2.00	31040	32869		42492			
		150	1.33	33962	36163		45786			
		250	0.80	36727	39316		48938			
		500	0.40	39116	42066		51688			
		750	0.27	39983	43070		52692			
		Unlimited	0.00	41837	45229		54852			

Transformer KVA	Full load current (A)	Primary short sircuit[4] (MVA)	System Z (%)	Available SC Curr. (A), Nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Main breaker (1)(2)(3) $I_{CW}>I_{SC}$	Feeder breaker(5) $I_{CW}\leq I_{CU}$	Feeder breaker(5) $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
2500	3007 with fans: 4210	50	5.00	27972	29141	12028	41170	E4.2 S 3200 A (E6.2 H 5000 A)	E2.2 H 800 A	E2.2 H 800 A
		100	2.50	36449	38459		50487			
		150	1.67	40544	43047		55075			
		250	1.00	44549	47589		59617			
		500	0.50	48113	51678		63706			
		750	0.33	49431	53202		65230			
		Unlimited	0.00	52296	56536		68565			
3000	3608 with fans: 5052	50	6.00	30710	31880	14434	46314	E6.2 H 4000 A (E6.2 H 5000 A)	E2.2 H 800 A	E2.2 H 800 A
		100	3.00	41239	43377		57811			
		150	2.00	46561	49304		63738			
		250	1.20	51920	55355		69789			
		500	0.60	56826	60966		75400			
		750	0.40	58674	63098		77532			
		Unlimited	0.00	62755	67844		82278			
3750	4511 with fans: 6315	50	7.50	34042	35187	18042	53229	E6.2 V 5000 A	E2.2 V 800 A	E4.2 V 800 A
		100	3.75	47479	49737		67779			
		150	2.50	54673	57689		75731			
		250	1.50	62214	66149		84191			
		500	0.75	69393	74324		92366			
		750	0.50	72169	77517		95560			
		Unlimited	0.00	78444	84805		102847		N/A	

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is E2.2, E4.2, or E6.2 to accommodate ground fault CTs for 4-wire modified differential ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.

Table 15: System voltage @240 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 240 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Main breaker [1][2][3] $I_{CW}>I_{SC}$	Feeder breaker[5] $I_{CW}\leq I_{CU}$	Feeder breaker[5] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
500	1203 with fans: 1684	50	1.00	17819	19036	2406	21441	E2.2 S 1600 A (E2.2 N 2000 A)	E1.2 B 800 A	E1.2 B 800 A
		100	0.50	19245	20671		23077			
		150	0.33	19772	21281		23687			
		250	0.20	20215	21795		24201			
		500	0.10	20561	22197		24603			
		750	0.07	20679	22335		24740			
		Unlimited	0.00	20918	22615		25020			
750	1804 with fans: 2526	50	1.50	24886	26460	3608	30068	E2.2 N 2000 A (E4.2 S 3200 A)	E1.2 B 800 A	E1.2 B 800 A
		100	0.75	27757	29730		33338			
		150	0.50	28868	31007		34615			
		250	0.30	29822	32111		35719			
		500	0.15	30580	32991		36600			
		750	0.10	30841	33296		36904			
		Unlimited	0.00	31378	33922		37530			
1000	2406 with fans: 3368	50	2.00	31040	32869	4811	37681	E4.2 S 3200 A (E6.2 H 4000 A)	E1.2 S 800 A	E1.2 S 800 A
		100	1.00	35639	38071		42882			
		150	0.67	37490	40191		45003			
		250	0.40	39116	42066		46877			
		500	0.20	40431	43590		48401			
		750	0.13	40889	44123		48934			
		Unlimited	0.00	41837	45229		50040			
1500	3608 with fans: 5052	50	3.00	41239	43377	7217	50594	E6.2 H 4000 A (E6.2 H 5000 A)	E2.2 H 800 A	E2.2 H 800 A
		100	1.50	49772	52919		60136			
		150	1.00	53458	57107		64324			
		250	0.60	56826	60966		68183			
		500	0.30	59644	64221		71438			
		750	0.20	60646	65385		72602			
		Unlimited	0.00	62755	67844		75061			
2000	4811 with fans: 6736	50	4.00	49346	51630	9623	61252	E6.2 V 5000 A	E2.2 V 800 A	E4.2 V 800 A
		100	2.00	62081	65739		75361			
		150	1.33	67924	72327		81950			
		250	0.80	73454	78631		88254			
		500	0.40	78232	84131		93754			
		750	0.27	79965	86140		95762			
		Unlimited	0.00	83674	90458		100081		N/A	

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is E2.2, E4.2, or E6.2 to accommodate ground fault CTs for 4-wire modified differential ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.

Table 16: System voltage @208 V – Nominal transformer Z (%) = 5.75 ±7.5%; Minimum transformer Z (%) = 5.32

Voltage Rating: 208 V

Transformer KVA	Full load current (A)	Primary short circuit[4] (MVA)	System Z (%)	Available SC curr. (A), nom. Z	Available SC curr. (A), min Z	Motor contribution, 100% motor load (A)	Max. combined fault curr. (A)	Main breaker [1][2][3] $I_{CW}>I_{SC}$	Feeder breaker[5] $I_{CW}\leq I_{CU}$	Feeder breaker[5] $I_{CW}=I_{CU}$ or $I_{CW}>I_{SC}$
500	1388 with fans: 1943	50	1.00	20561	21964	2776	24740	E2.2 S 1600 A (E2.2 N 2000 A)	E1.2 B 800 A	E1.2 B 800 A
		100	0.50	22206	23852		26627			
		150	0.33	22814	24555		27331			
		250	0.20	23325	25148		27924			
		500	0.10	23724	25612		28388			
		750	0.07	23860	25771		28546			
		Unlimited	0.00	24137	26094		28869			
750	2082 with fans: 2915	50	1.50	28714	30530	4164	34694	E2.2 N 2000 A (E4.2 S 3200 A)	E1.2 N 800 A	E1.2 N 800 A
		100	0.75	32028	34303		38467			
		150	0.50	33309	35777		39941			
		250	0.30	34410	37051		41214			
		500	0.15	35285	38067		42231			
		750	0.10	35586	38418		42582			
		Unlimited	0.00	36205	39141		43304			
1000	2776 with fans: 3886	50	2.00	35816	37926	5551	43478	E4.2 S 3200 A (E6.2 H 4000 A)	E1.2 S 800 A	E2.2 S 800 A
		100	1.00	41122	43928		49480			
		150	0.67	43258	46375		51926			
		250	0.40	45134	48537		54089			
		500	0.20	46651	50296		55848			
		750	0.13	47179	50911		56463			
		Unlimited	0.00	48273	52187		57739			
1500	4164 with fans: 5829	50	3.00	47584	50051	8327	58378	E6.2 V 5000 A	E2.2 V 800 A	E4.2 V 800 A
		100	1.50	57429	61061		69388			
		150	1.00	61683	65893		74220			
		250	0.60	65568	70346		78673			
		500	0.30	68820	74102		82429			
		750	0.20	69976	75444		83771			
		Unlimited	0.00	72410	78281		86608			

1. Main breaker sized for transformer base kVA. (Larger main breaker is sized for transformers with dual temperature rise and/or forced air cooling.)
2. Main breaker is E2.2, E4.2, or E6.2 to accommodate ground fault CTs for 4-wire modified differential ground fault protection.
3. Main breaker has 30 cycle withstand rating (ICW) greater than transformer maximum short circuit current (ISC).
4. Equipment ANSI short circuit rating is based on the breaker (main or feeder) with the lowest short circuit rating (ICU).
5. ICW = 30 cycle withstand current rating; ICU = maximum short circuit interrupting rating; ISC = available short circuit current.

SACE Emax 2 low voltage circuit breakers – watts lost

Breaker watts loss values (Table 20) are shown for 100 percent current values. To convert watts loss to BTU/hour, multiply watts by 3.42. Breaker watts loss for lower current values may be estimated by the following formula:

$$W_e = W_{FL} (I/I_{FL})^2$$

where:
We = estimated watts loss at load current
WFL = estimated watts loss at full load current (100 percent of frame rating, see Table 3.7)
I = load current
IFL = full load current (100 percent frame rating)

See the watts loss data in Table 17 for bus in vertical sections.

Table 17: SACE Emax 2 circuit breaker estimated watts loss (per breaker, 3-pole)

Breaker frame size	Breaker type	Breaker envelope	Watts loss
250	S-A	E1.2	14
	V-A	E2.2	22
800	B-A / N-A / S-A	E1.2	118
	S-A	E2.2	73
	H-A / V-A	E2.2	68
	S-A / H-A / V-A	E4.2	58
1200	B-A / N-A / S-A	E1.2	250
	S-A	E2.2	152
	H-A / V-A	E2.2	138
1600	S-A/ H-A / V-A	E2.2	233
	S-A / H-A / V-A	E4.2	189
2000	S-A / H-A / V-A	E2.2	350
	S-A / H-A / V-A	E4.2	279
3200	S-A / H-A / V-A	E4.2	610
	V-A	E6.2	438
4000	H-A / V-A	E6.2	646
5000	H-A / V-A	E6.2	950

Table 18: Low voltage switchgear bussing estimated watts loss (per section, 3-phase)

Section Width (inches)	Main bus rating (A)	Watts loss
15	2000	691
	3200	764
	4000	867
22	2000	743
	3200	1211
	4000	1893
	5000	2014
	6000	2163
	8000	2698
30	2000	802
	3200	1309
	4000	2045
	5000	2211
	6000	2413
	8000	3144
38	2000	648
	3200	1406
	4000	2197
	5000	2613
	6000	3003
	8000	3928

G Protection

ReliaGear LV SG supports the G Protection features of the SACE Emax 2 Ekip trip unit to provide two ground fault solutions for solidly grounded systems requiring ground fault protection. Solidly grounded systems will use either a simple current summation for individual branch feeder circuit breakers or a modified differential scheme for multiple source systems. Ground fault for 3-wire branch circuits is accomplished by summing the phase currents from the integral current sensors on the circuit breaker. Branch circuit breakers serving 4-wire loads require the addition of a neutral current sensor (Rogowski coil) to monitor the load neutral current.

The signal from the neutral Rogowski coil is added to the trip unit summation circuit through the breaker secondary disconnect. Main and tie circuit breakers used on solidly grounded, 3-wire systems (no neutral bus for branch circuit loads) may also use the same summation ground fault protection system. To learn more about the G Protection feature of the SACE Emax 2 Ekip please refer to

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48 Example ground fault diagram

1SXU200040C0201.
Multiple-source systems (or single-source systems with provisions for additional sources) (E2.2, E4.2 and E6.2) with a neutral bus for branch circuit loads require the use of a modified differential ground fault (MDGF) scheme. The modified differential ground fault scheme, shown in Figure 48 for a typical double-ended substation configuration, accommodates neutral-to-ground bonding at each source. The scheme monitors all phase and neutral conductors on all source and tie circuit breakers and accounts for ground current flowing on the neutral bus due to the common neutral connection between sources.

The interconnection of the current sensors also accommodates any neutral load current that may appear on the ground bus. Each source and tie circuit breaker will have three standard 5 A relaying-type current transformers mounted in the breaker cradle and a similar current transformer mounted on the neutral conductor. The secondary of these four current transformers are connected to a summing CT in the breaker section.

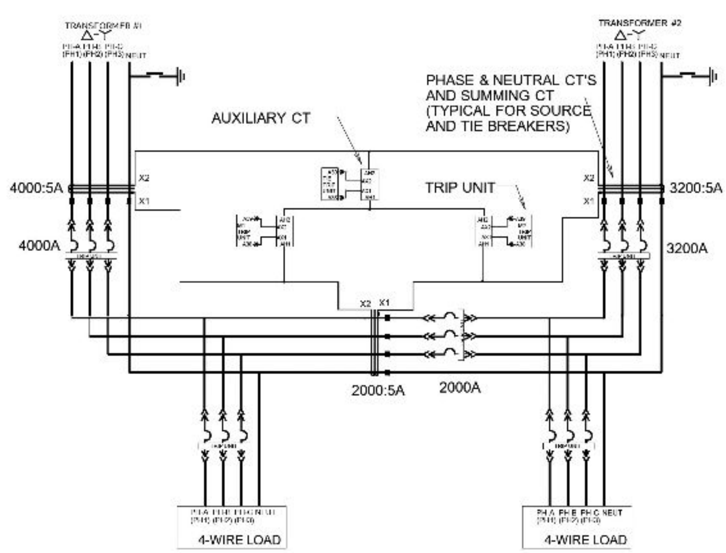
For simplicity, the four phase and neutral current transformers and summing CT are represented by a single current transformer symbol on the three-line diagram (Figure 48.

The secondary of the summing CTs are interconnected to allow unbalanced currents to circulate in the loop. Trip units for the source and tie breakers are connected to the summing CT loop through individual auxiliary current transformers. The summing and auxiliary current transformers are designed to allow a mixture of phase current transformer ratings for the source and tie breakers. For example, in the double-ended substation, below, one main circuit breaker may be rated 4000 A, the other main rated 3200 A and the tie circuit breaker may be rated 2000 A.

The summing and auxiliary CT ratios allow the use of phase and neutral current transformers that match the breaker frame rating rather than requiring all current transformers to have the same primary rating. This solution allows users to optimize the main and tie circuit breakers for their given application. For correct operation of the MDGF protection, the breaker rating, trip plug, compartment/neutral current transformers and auxiliary/summing CT devices will all match for that breaker.

To ensure proper functionality the following wiring limitation are adhered to:
- Phase and neutral current transformers to primary side of summing current transformer wire to be 14 AWG, twisted pair with a maximum one-way length of 30 ft.
- Summing to summing current transformer wiring to be 14 AWG, twisted pair with a maximum loop length of 31,000 ft.
- Auxiliary current transformer to secondary disconnect terminal wiring to be 16 AWG, twisted pair with a maximum one-way length of 49 ft.

For ground faults on branch circuits, the modified differential ground fault scheme will provide backup tripping for the feeder circuit breaker ground fault protection. The source and tie breakers that are connected to the bus with the ground fault will be signaled to trip should the



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feeder breaker fail to clear the ground fault.
The same tripping response applies if the ground fault is ahead of the branch circuit breaker, within the switchgear, or on interconnecting cables or busway for multisource systems that are split into multiple lineups. The faulted bus section will be isolated by tripping the source and tie breakers connected to the bus. Trip unit setup is detailed in MDGF user guide. All of the trip unit ground fault functions can be specified either to trip the circuit breaker or to provide an alarm when a ground fault is sensed. All ground fault tripping is self-powered and requires no shunt trip coil or control power source. Ground fault alarms require either a communication connection to the trip unit or use of the programmable contact on the trip unit and a powered alarm circuit.

Ground detector considerations

High-resistance pulsing ground detection system
This system provides a means for grounding the neutral of a power system, utilizing the "high-resistance" method. It allows the switchgear to operate as an "ungrounded" system but eliminates the danger of high transient overvoltage during certain types of ground faults. For delta systems, a set of grounding transformers is provided for connection of the grounding resistor. Figure 58 shows a typical ground system visualization of the devices and operations in the switchgear.

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— 49 Pulsing high-resistance ground detection interface

The pulsing high-resistance ground detection system uses a voltmeter relay with an adjustable set point to detect abnormal ground current through the grounding resistor.

A green indicating light shows normal conditions, and a red indicating light indicates the presence of a phase-toground fault. Alarm contacts allow remote indication of the ground condition.
The location of the fault is quickly determined using a pulsing current in conjunction with a sensitive clamp-on ammeter, which permits clearing of the ground fault before a second phase-to-ground fault causes an outage. After the fault is located and cleared, the system is reset and ready to detect the next ground fault. The pulsing high-resistance ground detection system can be enhanced by the addition of a current sensor on each feeder breaker, connected to individual ammeters on the switchgear front panel. The ammeter provides visual indication of the faulted feeder when the grounding resistor is being pulsed, avoiding the need for a clamp-on ammeter to detect the faulted feeder in the switchgear.

Ground detection on ungrounded systems
This system provides visual indication of the presence of a phase-to-ground condition on a delta ungrounded system. Ground detection on ungrounded systems consists of one set of three voltage transformers rated for full phase-to-phase voltage on the primary winding and 120 V secondary winding. The primary is connected wye. The secondary connection is dependent on the type of ground indicators and alarm devices used. A loading or stabilizing resistor may be used in the voltage transformer primary connection to ground if ferroresonance with the distributed capacitance of the system is an issue. Ground indication and alarm can be accomplished as described in the following tables.

CAUTION

Caution: A combination of ground indication and metering or relaying on the same set of voltage transformers is not recommended. Metering not only may require different primary and/or secondary connections; It also increases the probability of faults in the secondary circuits with consequent false indications of grounds on the primary system.

Table 19: Operation with lights or voltmeters

Standard	Three 120 V indicating lights with clear lenses (one per phase). Voltage transformers with wye-connected secondaries.
Option	Three voltmeters instead of indicating lights. Voltage transformers with wye-connected secondaries.
Operational description	Assuming rated system voltage on the primary of the voltage transformers, the three lamps would glow about equally at subnormal brilliancy because the voltage across each lamp is 69.3 V. Similarly, each voltmeter would read 69.3 V. If one phase of the system becomes grounded, the voltage transformer on the grounded phase would be short-circuited, and the other two transformers would rise to approximately full phase-to-phase voltage. The lamp on the grounded phase would be dark, and the other two lamps would glow at normal brilliance. Similarly, the voltmeter on the grounded phase would read zero and the other two voltmeters would read 120 V.

Table 20: Operation with alarm relay

Option	An overvoltage relay coil rating of 199 V to 208 V, pickup range of 16 V to 64 V or 70 V to 140 V. Voltage transformers with broken delta-connected secondaries. Note that either indicating lights or voltmeters (Table 3-9) can be used as ground indicators with this option.
Operational description	Operation with the alarm relay is the same as described in Table 18, although the connections are different. Assuming rated system voltage on the voltage transformers' primary, the three secondary voltage vectors add up to zero, resulting in no voltage at the relay. If one phase of the system becomes grounded, the voltage transformer on the grounded phase would be short-circuited and the other two transformers would rise to full phase-to-phase voltage. The secondary voltages would also rise to the phase-to-phase values (120 V). Because these two voltages are in series at an angle of 60° under ground fault conditions, the voltage imposed on the relay is three times the voltage on each voltage transformer secondary under normal conditions (208 V).

Table 21: Operation with test switch

Option	Test switch (for either lamp test or test-forground).
Operational description	The lamp test feature is performed using the normally closed contact of the test switch. The test-for-ground feature is performed using the normally open contact. You must specify which test feature is to be furnished.

Breaker control systems

Accessories for the SACE Emax 2 circuit breaker accommodate control schemes from the very simple to the complex. Electrical safety procedures emphasize the need for controlling breakers from a remote location or control station to keep electricians, operators, and maintenance personnel away from potential arc flash hazards. The need for continuity of service drives designs with multiple sources and automatic transfers to ensure loads remain energized from any available sources.

Switchgear lineups with multiple sources, either double-ended with two utility-fed transformers or a single utility with an emergency generator can be controlled so that a loss of one utility source will cause the main, tie, or generator breakers to open and close, maintaining power to the switchgear buses. Automatic breaker transfer schemes (auto-transfer) can be implemented with discrete relays and hard wiring between source and tie breakers or with programmable logic controllers (PLC) for more complex control sequences. While no single standard auto-transfer scheme will meet all end user needs, the ReliaGear LV SG switchgear and SACE Emax 2 circuit breakers provide flexible equipment configurations, sensing, and controls for almost any requirement. The basic set of components supplied with any auto-transfer scheme include:

- Electrically operated breakers;
- Voltage sensing on the source breakers;
- Lockout for overcurrent trips;
- Breaker position switches;
- Timers;
- An Auto/Manual control selector switch.

Depending on the specific application, additional components may be supplied for bus voltage sensing, synchronism check, generator start/stop signals, open or closed transition return to normal, test switches, and maintenance transfer selector switches.

As a starting point for sequences of operation and typical bills of material, consider 3-breaker (Main-Tie-Main) and 2- breaker (Main-Generator) auto-transfer schemes. Following are descriptions of the 3-breaker and 2-breaker automatic transfer schemes, including basic bills of material, transfer scheme options, sequences of operation, and single-line diagrams.

Main-tie-main (3-breaker) auto-transfer (Figure 3-3)

Basic bill of material:

- Electrically operated main and tie breakers with bell alarm/lockout, drawout position switch, breaker control switch, and indicating lights;
- Line-side voltage transformers on each main breaker;
- Voltage sensing relays on each main breaker – (1) three-phase voltage sensing relay, Device 27, and (1) phase loss/phase unbalance relay, Device 47N – all DIN rail mounted;
- Auto/Manual selector switch, Device 43;
- Electrical interlocking (hardwired) between main and tie breakers – with and without PLC control;
- Delayed auto-return to normal after utility voltage source returns with open transition (break-before-make);
- Options for the basic auto-transfer scheme:
  - Manual transfer (return) to normal with open transition (break-before-make);
  - Delayed auto-return to normal with closed transition (make-before-break) and sync check relay, Device 25;
  - Bus-connected voltage transformers for residual voltage sensing;
  - Test switch to simulate loss of utility voltage;
  - Maintenance transfer trip selector switch (Device 10) to select breaker to trip when all 3 main and tie breakers are closed (system paralleled).

Additional bill of material for PLC/non-PLC control:

- Non-PLC-based transfer;
  - Auxiliary relays for voltage sensing (one per voltage relay), Device 27/47X;
  - Auxiliary relays for bell alarm (one per main and tie breaker), Device 86X;
  - Timers and auxiliary relays for delay on transfer, delay on return, Device 2, 62;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X;
- PLC-based transfer using intelligent platforms of PLC with non-volatile memory (NVM) and backup UPS;
  - Interposing close and trip relays for main and tie breakers (two per main and tie breaker), Device 94, 95;
  - Auxiliary relays for bell alarm (one per main and tie breaker), Device 86X;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X;
  - PLC alarm relay, Device 74;
- Option for PLC-based transfer;
  - Touch-screen interface for timer adjustment and system feedback.

Main-tie-main PLC auto-transfer sequence of operations

1. Each utility has 3-phase undervoltage sensing and phase loss protection;
2. Closed transition return to normal (option) includes synchronism check relay;
3. PLC includes UPS for back-up control power for CPU and I/O;
4. Auto-transfer blocked when any main or bus tie breaker trips on overcurrent (overload, short circuit, ground fault) or when any main or bus tie breaker is racked out of the CONNECT position;
5. Hardwired electrical interlocking between main and bus tie breakers to prevent parallel operation (only 2 of 3 breakers can be closed at any time - standard), unless permitted by sync check relay (optional);
6. Return to normal (both mains closed, bus tie open) after a transfer and utility voltage has been restored will be automatic with time delay and open transition (break-before-make).

Initial Setup
1. Set Auto-Manual switch to Manual position;
2. Close Main1;
3. Close Main2;
4. Bus Tie remains open;
5. Set Auto-Manual switch to Auto position.

Loss of Utility1
1. After preset time delay, verify Utility2 is available;
2. Main1 will open;
3. Bus Tie will close.

Return of Utility1
1. After preset time delay, verify Utility1 is available;
2. Bus Tie will open;
3. Main1 will close (break-before-make).

Loss of Utility2
1. After preset time delay, verify Utility1 is available;
2. Main2 will open;
3. Bus Tie will close.

Return of Utility2
1. After preset time delay, verify Utility2 is available;
2. Bus Tie will open;
3. Main2 will close (break-before-make).

Option for closed transition return to normal (Make- before-break)

Return of Utility1
1. After preset time delay, verify Utility1 is available;
2. Verify Utility1 and Utility2 are in sync;
3. Close Main1;
4. After preset time delay Bus Tie will open (make-before-break).

Return of Utility2
1. After preset time delay, verify Utility2 is available;
2. Verify Utility1 and Utility2 are in sync;
3. Close Main2;
4. After preset time delay Bus Tie will open (make-before-break).

Option for closed transition maintenance transfer (Make-before-break)

In this configuration, Main1 and Main2 are closed, while the Bus Tie is open.

Transfer all loads to main1 (Bus1 and Bus2) without de-energize load (bumpless transfer)
1. Set Trip Selector switch to Trip Main2;
2. Verify Utility1 and Utility2 are in synchronism;
3. Close Bus Tie;
4. After preset time delay, Main2 will open, transferring all loads to Main1 (Bus1 and Bus2).

Return loads to each bus
1. Set Trip Selector switch to Trip Bus Tie;
2. Verify Utility1 and Utility2 are in synchronism;
3. Close Main2;
4. After preset time delay, Bus Tie will open, transferring Bus2 loads back to Main2.

Transfer all loads to main2 (Bus1 and Bus2) without deenergizing load (bumpless transfer)
1. Set Trip Selector switch to Trip Main1;
2. Verify Utility1 and Utility2 are in synchronism;
3. Close Bus Tie;
4. After preset time delay, Main1 will open, transferring all loads to Main2 (Bus1 and Bus 2).

Return loads to each bus
1. Set Trip Selector switch to Trip Bus Tie;
2. Verify Utility1 and Utility2 are in synchronism.
3. Close Main1;
4. After preset time delay, Bus Tie will open, transferring Bus1 loads back to Main1.

Option for test switch to simulate utility failure
In this configuration, Main1 and Main2 are closed, and the Bus Tie open.
1. Transfer to Side2 – Simulates loss of Utility1 and executes automatic transfer as described in Loss of Utility1;
2. Normal – Returns Main1, Main2, and Bus Tie breakers to their normal position based on Open or Close Transition options;
3. Transfer to Side1 – Simulates loss of Utility2 and executes automatic transfer as described in Loss of Utility2.

Option for redundant bus tie breaker (Main-tie-tie-main, Figure 3.4)
1. Redundant bus tie breaker is normally closed and not operated by the PLC;
2. Drawout position switch and bell alarm are provided for inputs to PLC;
3. If redundant bus tie breaker is racked out of the CONNECT position or trips on overcurrent, then the auto transfer will be disabled.

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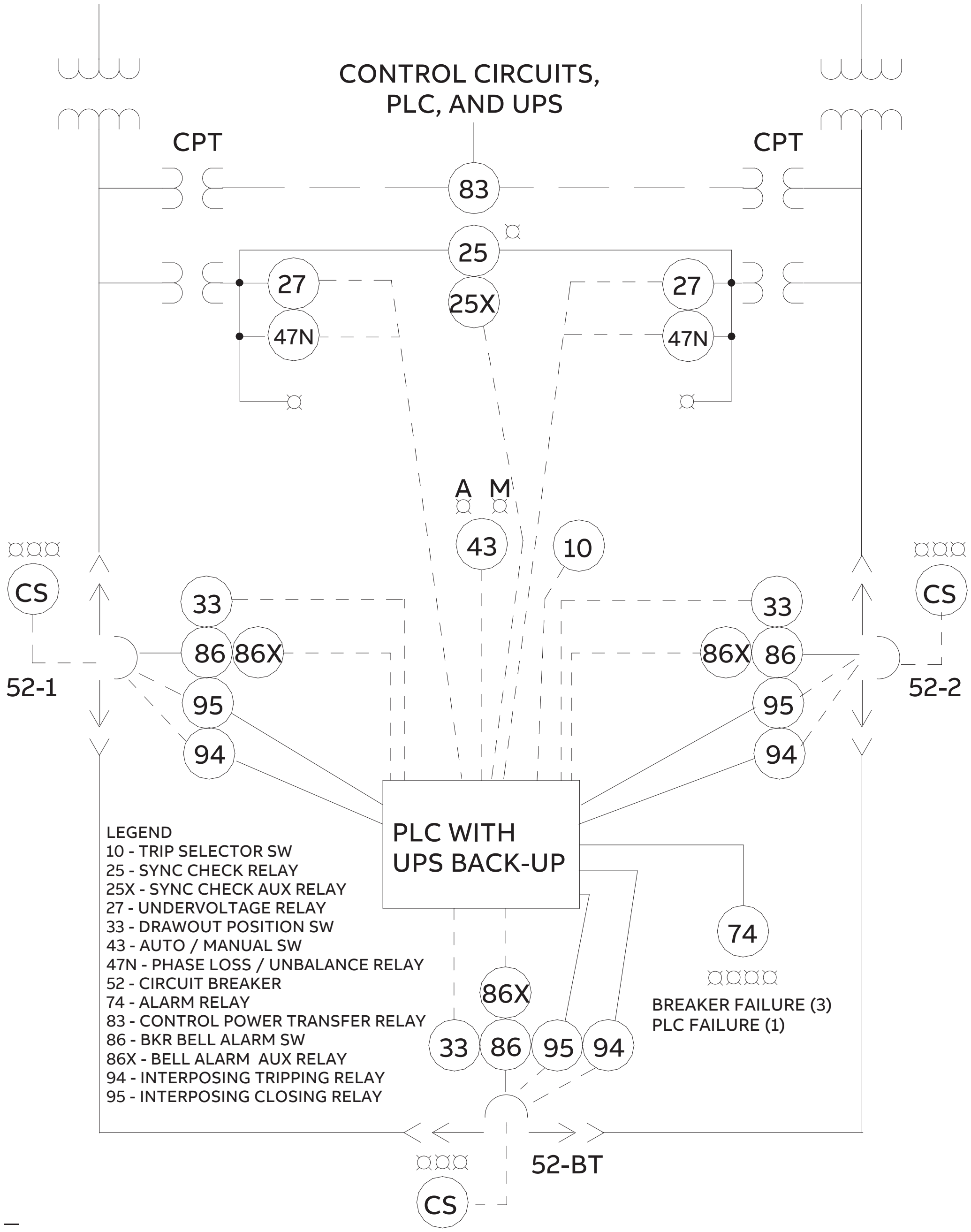
50 Main-tie-main example single-line diagram



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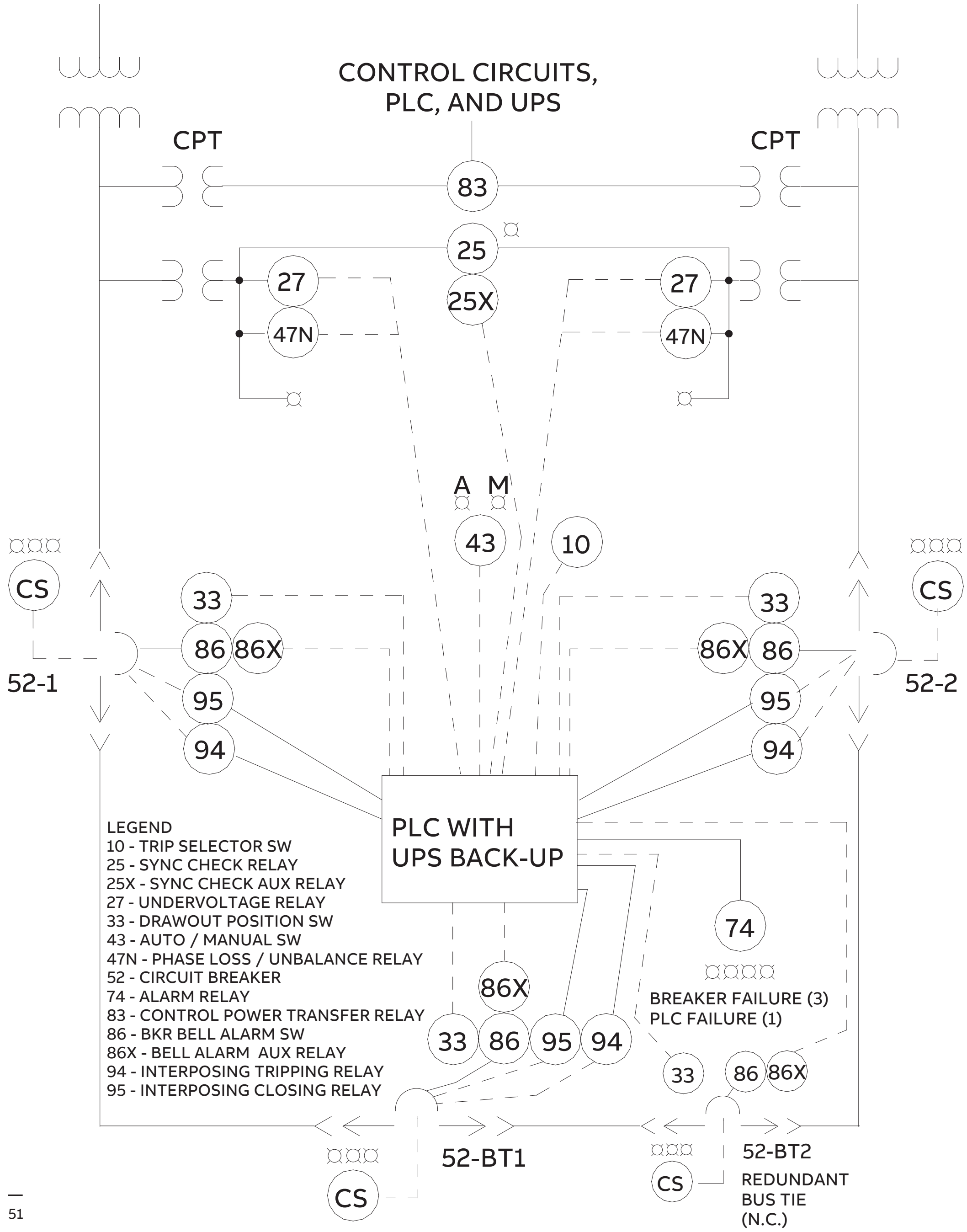
51 Main-tie-tie-main example single-line diagram



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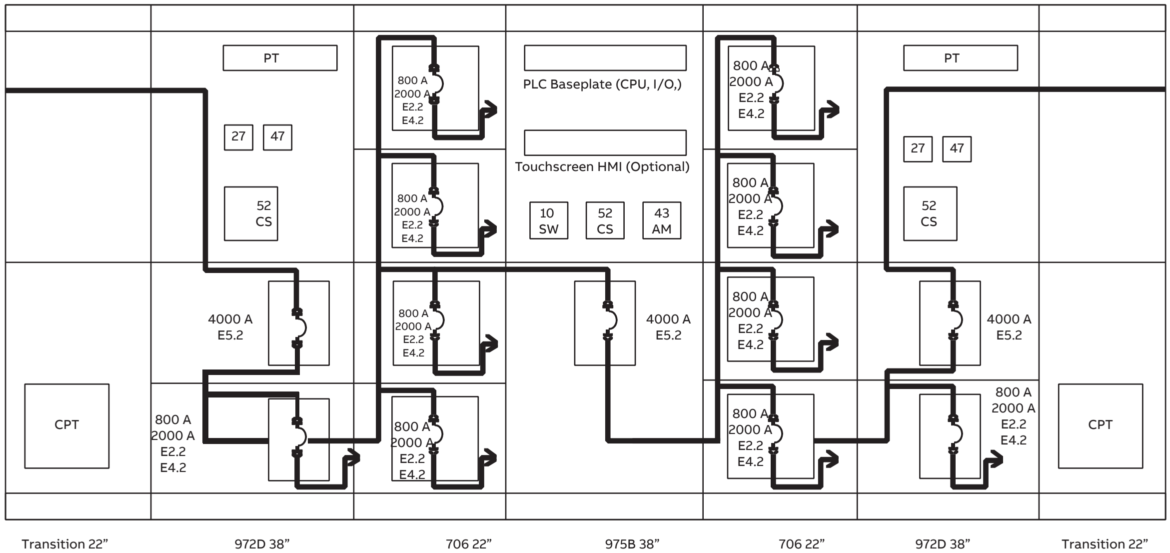
52 4000A Main-tie-main/ Close-coupled to transformer / with transition / Additional feeder sections as required



1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

Main-generator (2-breaker) auto-transfer (Figure 52)

Basic bill of material:

- Electrically operated main and generator breakers with bell alarm/lockout, drawout position switch, breaker control switch, and indicating lights;
- Line-side voltage transformers on the main and generator breaker;
- Voltage sensing relays on the main breaker – (1) three phase voltage sensing relay, Device 27, and (1) phase loss/phase unbalance relay, Device 47N – all DIN rail mounted;
- Voltage and frequency sensing relays on the generator breaker – (1) three-phase voltage sensing relay, Device 27, and (1) single-phase over-/underfrequency relay, Device 81O/U – all DIN rail mounted;
- Auto/Manual selector switch, Device 43
- Electrical interlocking (hardwired) between main and generator breakers – with and without PLC control;
- Delayed auto-return to normal with open transition (break-before-make);
- Generator start/stop signal;
- Options for the basic auto transfer scheme:
  - Manual transfer (return) to normal after utility voltage source returns;
  - Delayed auto-return to normal with closed transition (make-before-break) and sync check relay;
  - Bus-connected voltage transformers for residual voltage sensing;
  - Test switch to simulate loss of utility voltage for generator no-load (start/stop) or full load test (autotransfer).

Bill of material for PLC/non-PLC control

- Non-PLC-based transfer;
  - Auxiliary relays for voltage and frequency sensing (one per voltage relay), Device 27/47X, 27/81X;
  - Auxiliary relays for bell alarm (one per main and generator breaker), Device 86X;
  - Timer and auxiliary relay for delay on transfer, delay on return, Device 2, 62;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X
- PLC-based transfer using intelligent platforms of PLC with non-volatile memory (NVM) and backup UPS;
  - Interposing close and trip relays for main and;
  - generator breakers (two per main and generator breaker), Device 94, 95;
  - Auxiliary relays for bell alarm (one per main and generator breaker), Device 86X;
  - Auxiliary relay for sync check relay (when closed transition is required and sync check relay is provided), Device 25X;
  - PLC alarm relay, Device 74;
- Option for PLC-based transfer;
  - Touchscreen interface for timer adjustment and system feedback.

Main-generator PLC auto transfer sequence of operations

1. Utility source has 3-phase undervoltage sensing and phase loss protection;
2. Generator source has 3-phase voltage sensing and single-phase frequency sensing;
3. Closed transition return to normal (option) includes synchronism check relay;
4. PLC includes UPS for backup control power for CPU and I/O;
5. Auto-transfer blocked when main or generator breaker trips on overcurrent (overload, short circuit, ground fault) or when main or generator breaker is racked out of the CONNECT position;
6. Hardwired electrical interlocking between main and generator breakers to prevent parallel operation (only 1 of 2 breakers can be closed at any time - standard), unless permitted by sync check relay (optional);
7. Return to normal (main breaker closed, generator breaker open) after a transfer and utility voltage has been restored will be automatic with time delay and open transition (break-before-make).

Initial Setup

1. Set Auto-Manual switch to Manual position;
2. Close Utility main breaker (52U);
3. Generator breaker (52G) remains open;
4. Set Auto-Manual switch to Auto position.

Loss of Utility

1. After preset time delay, send start signal to generator;
2. Check for proper voltage and frequency from generator source;
3. After preset time delay with proper voltage and frequency, 52U will open and 52G will close.

Return of Utility

1. Verify utility source is available for preset time delay;
2. 52G will open;
3. After preset time delay, 52U will close (break-beforemake);
4. Remove generator start signal.

Option for closed transition return to normal (Make- before-break)

Return of Utility

1. Verify utility source is available for preset time delay;
2. Verify utility source and generator source are synchronized;
3. 52U will close;
4. After preset time delay, 52G will open (make-beforebreak);
5. Remove generator start signal.

Option for test switch to simulate utility failure

In this configuration, 52U is closed and 52G is open.

1. No Load Test – Sends generator start signal;
2. Normal – Returns 52U and 52G breakers to their normal position based on Open or Close Transition options and removes generator start signal;
3. Full Load Test – Simulates loss of utility source and executes automatic transfer as described in Loss of Utility.

Option for generator cooldown

1. Apply preset time delay after 52G opens before generator start signal is removed.

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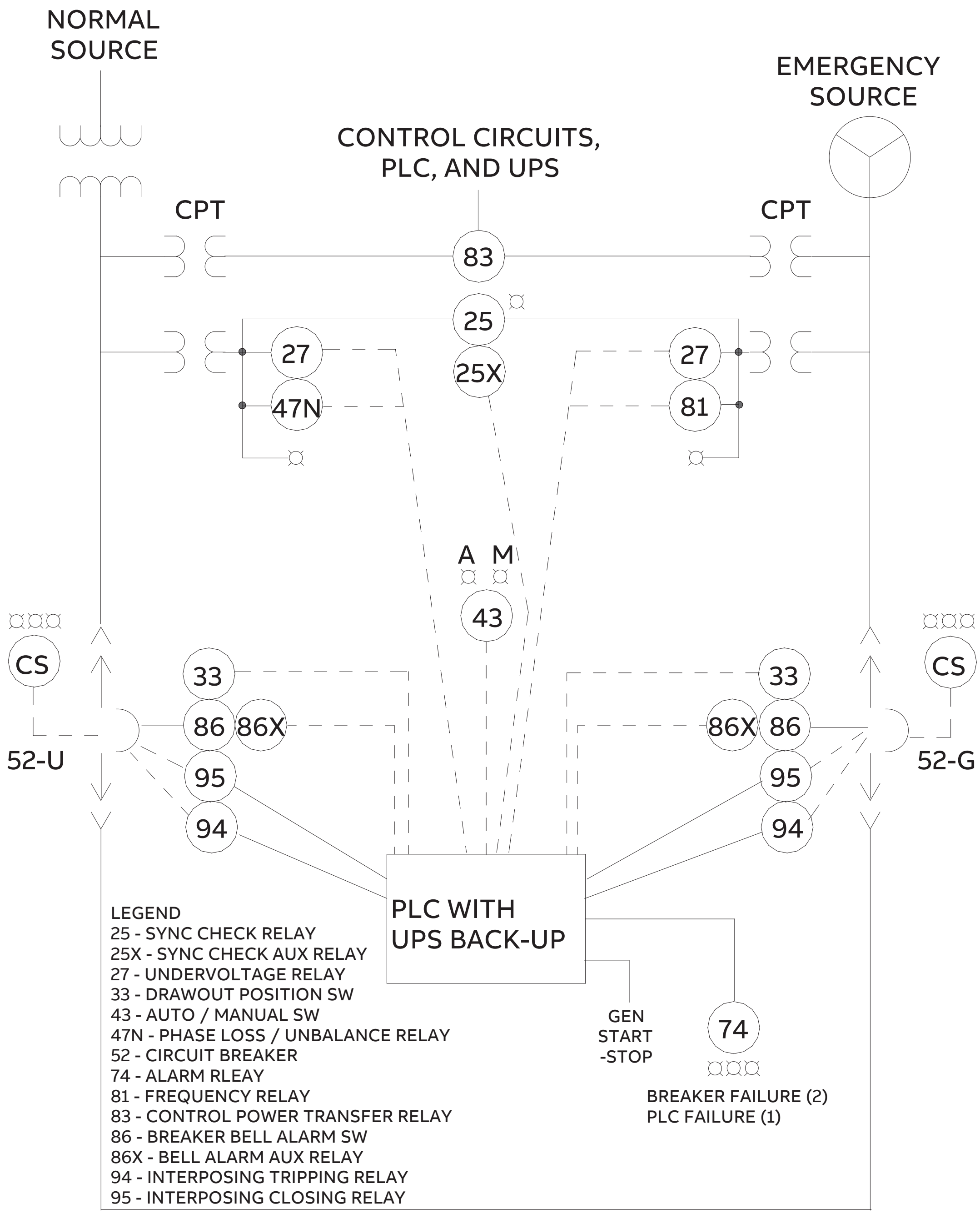
53 Main-generator example single-line diagram



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53

Arc flash risk controls

ReliaGear LV SG switchgear has numerous standard and optional features that can aid in reducing the energy associated with an arc flash or help mitigate the probability of an arc flash incident. Power system design, equipment design, operating procedures, electronics and communications, and new technologies can all be used to address the safety concerns associated with arc flash and shock. It may help if one considers mitigation of the hazards associated with electrical equipment from three perspectives:

- Exposure;
- Probability of an incident during exposure;
- The potential severity of an incident, should it occur.

Power system design

High resistance grounding (HRG) – limits ground fault current to a detectable level (approximately 5 amperes) while minimizing the possibility of the ground fault escalating to a serious phase to phase arcing fault. The neutral grounding resistor and sensing equipment can be located in the low voltage switchgear, and a pulsing circuit can be added to aid in determining the faulted feeder. HRG is widely considered to minimize the probability of serious faults.

Medium voltage interrupter – use of a circuit breaker or other controllable device that can be tripped in the event of an arcing fault between the transformer secondary terminals and the main secondary breaker. Relays, such as the Relion family of relays, may be used for transformer primary and secondary protection and can accept inputs from CTs located on the transformer secondary.

Implemented with Zone Selective Interlock signals from the low voltage trip unit, such a system can provide full selectivity and instant – or near-instant – protection, and arc flash protection for the conductors between the transformer secondary bushings and the main secondary breaker.

This type of protection can reduce the severity of an incident on the primary connections of the equipment or main bus if no secondary main is used.

Switchgear equipment design

Insulated/isolated bus – provides an epoxy coating on the horizontal main bus bars and phase isolation barriers in the vertical bus. The vertical bus system is enclosed with polyester-glass barriers. Bolted bus joints are enclosed with removable bus joint covers. Only cable or busway terminations are visible from the rear of the equipment.

The insulated/isolated bus option is available in sections with 800 A to 4000 A breakers with main bus ratings up to, and including, 4000 A.

Bus compartment barriers – bus ratings above 4000 A and sections containing 5000 A breakers, can be supplied with bus compartment barriers. These polyester-glass barriers are attached to the switchgear frame and provide a separation between the bus compartment (horizontal and vertical buses) and the cable compartment.

As in the insulated/isolated bus option, the only exposed conductors in breaker sections are cable and busway terminations.

Section barriers – provide a combination of steel and polyester-glass barriers between vertical sections in the cable and bus area. Section barriers limit exposure to terminations in adjacent sections when performing maintenance or trouble-shooting work in the rear of a breaker section. Section barriers are particularly important between the section where a main circuit breaker is housed and sections where feeders are housed to ensure that arc plasma on the main bus does not create an arc on the line side of the main circuit breaker where protection may be much slower.

Shutters – provided on all breaker compartments in switchgear lineups. Shutters operate when the breaker is racked into or out of the cubicle. When the breaker is in the DISCONNECT or WITHDRAWN position, the shutters are closed over the primary disconnects. A padlocking feature allows the shutters to be locked in the closed position when the breaker is out of the cubicle.

IR windows – may be supplied on the rear doors of the switchgear for IR camera access. Thermal imaging cable terminations in the rear of each switchgear section do not require opening the rear door when the IR windows are supplied. IR windows are strongly recommended to minimize exposure during IR surveys of cable connections.

Operating the switchgear

Remote control and monitoring – moving operators away from the switchgear to perform monitoring or control functions. Specifying breakers with electric operators (E/O) and shunt trip allows the breaker to be controlled from a location outside the arc flash and arc blast boundaries.

Trip units specified with communication capability can provide information about the circuit (metering data) and the circuit breaker (event information, open/close status, trip unit settings) from a safe location away from the front of the switchgear. A touchscreen monitor can be supplied in a switchgear auxiliary compartment or mounted on a wall and provide convenient single-point access to trip unit information for all breakers in the lineup without approaching each individual breaker cubicle.

Remote racking – inserting and withdrawing the circuit breaker from outside the arc flash boundary. After the circuit breaker has been opened, the operator can attach the remote racking device to the front of the breaker (E2.2, E4.2 and E6.2).

The operator then steps back, up to 30 feet away, from the front of the breaker, sets the controls on the remote racking controller, and proceeds to remotely draw out the breaker from the CONNECT position to the DISCONNECT position.

After the breaker has been removed from the cubicle and any maintenance performed on the breaker, the remote racking device can again be used to remotely rack the breaker back into the CONNECT position. After removing the remote racking device from the front of the breaker, the operator returns to the remote control station and closes the breaker – from a distance outside the arc flash boundary.

Circuit breakers with close coil and shunt trip devices, along with trip unit communication, can provide the ultimate in user remote operation. Using the SACE Emax 2 Ekip Actuator, it is possible to remote open or close the circuit breaker via a communication network. This can be done via the same touchscreen mentioned above, or via an outside control system.

Trip unit electronics
Advances in trip unit technology have made it possible to provide enhanced protection while maintaining the selective tripping functions that switchgear has always been able to provide.

Zone-selective interlocking (ZSI) – digital communication between tiers of circuit breakers to provide increased protection while maintaining selectivity. ZSI allows individual time-delay settings for short time and/or ground fault for “in-zone” and “out-of-zone” faults. An in-zone fault would allow an “unrestrained” (faster) time delay for the upstream (main) breaker, providing better protection for equipment in the zone. An out-of-zone fault would allow the main breaker to operate with a “restrained” (slower) time delay, providing selectivity with the feeder breaker. The feeder breaker initiates the zone selective interlock signal for the out-of-zone fault and clears the fault with minimal service interruption.

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54 "RELT"
system schematic

ZSI can also be executed with breakers in switchboards or motor control centers, improving protection and selectivity for equipment located downstream of the switchgear.

A further enhancement to ZSI is the addition of Instantaneous ZSI, or I-ZSI, to the breaker trip units. I-ZSI allows an upstream breaker (a main breaker, for example) to trip instantaneously for a fault on the switchgear bus or in a breaker cubicle instead of with a delayed long time or short time trip. This provides vastly improved equipment protection by making the main breaker more sensitive to arcing faults, lowering incident energy levels by tripping the main breaker instantaneously while maintaining selectivity with feeder breakers, on a 7x24 basis. DET-760 (Guide to Instantaneous Selectivity) describes ABB instantaneous selective circuit breaker offering. Using this guide, it is possible to design a power distribution system, rated up to 100 kA at 480 V that is 100 percent selective and provides 100 percent instantaneous protection at arcing current levels, 7x24, using the ABB Relion family of relays.

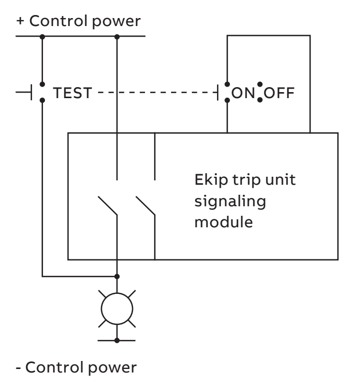
To learn more about the ZSI Protection please see the SACE Emax 2 UL catalog. Please see 1SXU200040C0201.

2I Protection (RELT) – The 2I, also known as RELT, Protection function of the SACE Emax 2 circuit breaker provides a separate, adjustable instantaneous trip function that is enabled by an external command or remote dry contact.

2I instantaneous trip can be enabled whenever an operator must approach the switchgear or any downstream equipment. 2I on the main breaker provides instantaneous overcurrent protection for the switchgear. 2I on a feeder breaker provides instantaneous overcurrent protection for downstream equipment connected to the feeder. The 2I instantaneous function can be adjusted from 1.5 to 15x In, with a maximum of 18kA. The clearing time of the 2I protection is between 25 and 42ms at 60Hz (32-47ms at 50Hz).

2I can affect selectivity so it is normally used only during times when an operator must be in the arc flash boundary. For more details on the protection, please see the SACE Emax 2 UL Catalog.

When provided in ReliaGear LV SG, the 2I Protection utilizes a standard wiring scheme as represented in Figure 54. A Blue LED 3-position switch is used to enable, disable and test the 2I protection. The SACE Emax 2 Ekip trip unit provides positive feedback directly from the the trip unit such that the user is able to verify that the signal was received by the trip unit and the protection is enabled. When the equipment's switch is turned to ON it will illuminated. Additionally, the SACE Emax 2 Ekip trip unit's display will indicate that 2I Protection is ACTIVE. When the switch is turned to OFF the trip unit will return to the normal settings.



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Arc flash relay – For applications of Arc Flash systems by ABB or other manufacturers, contact your ABB Field Application Engineer.

Sizing and dimensional data

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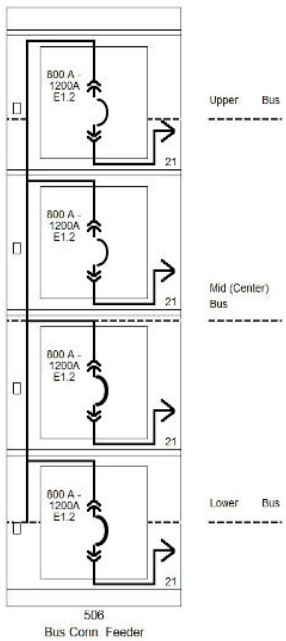
55 Switchgear layout and sizing: 15" section

ReliaGear LV SG switchgear has numerous standard configurations with and without optional features. Figures 55 through 69, show the layouts for these configuration arrangements and dimensions. Utility metering stacks are available as needed. Please consult an ABB local sales representative for end user specific needs.



Offered in 15" section. Upper, Mid, Lower bus positions for horizontal bus (4000 A and lower applications).

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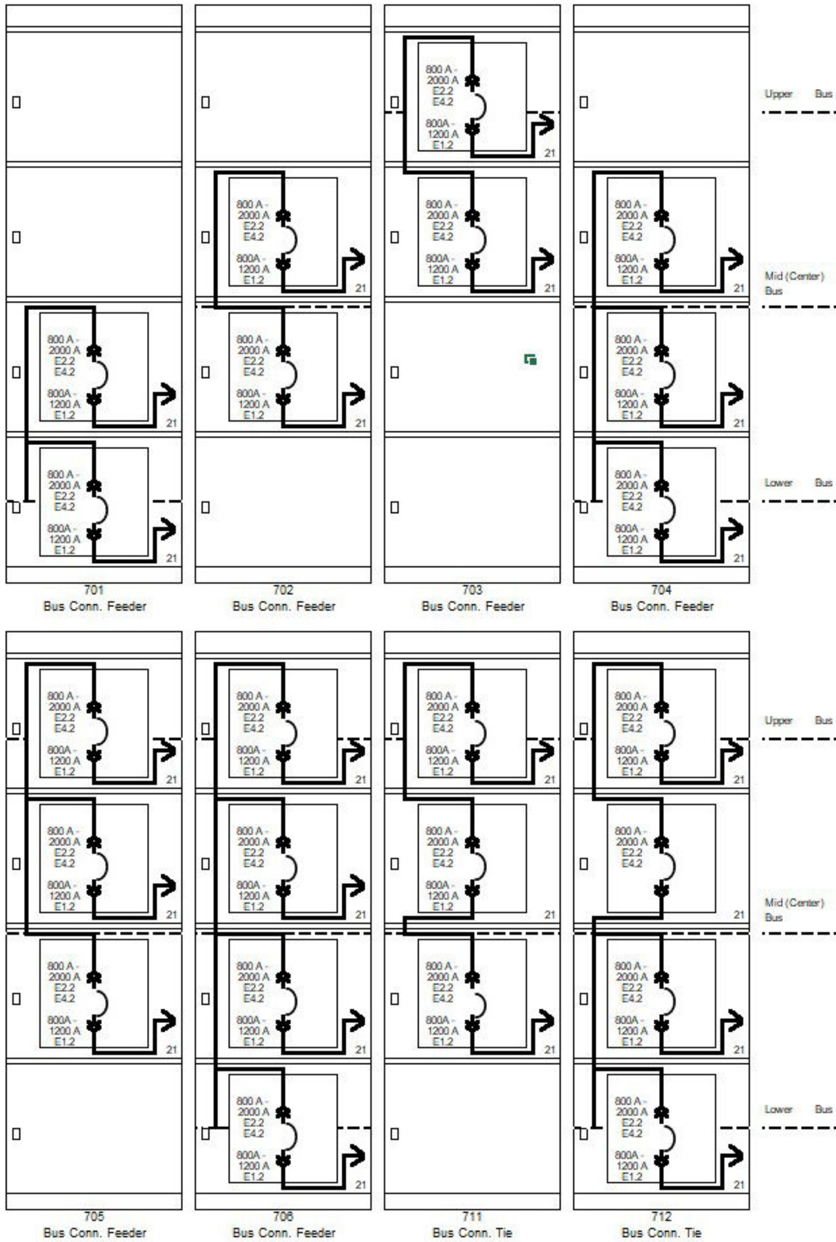
56 Switchgear layout and sizing: 22", 30" and 38" sections continued



Offered in 22", 30", 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway. E1.2 breakers not available in 38" wide sections.

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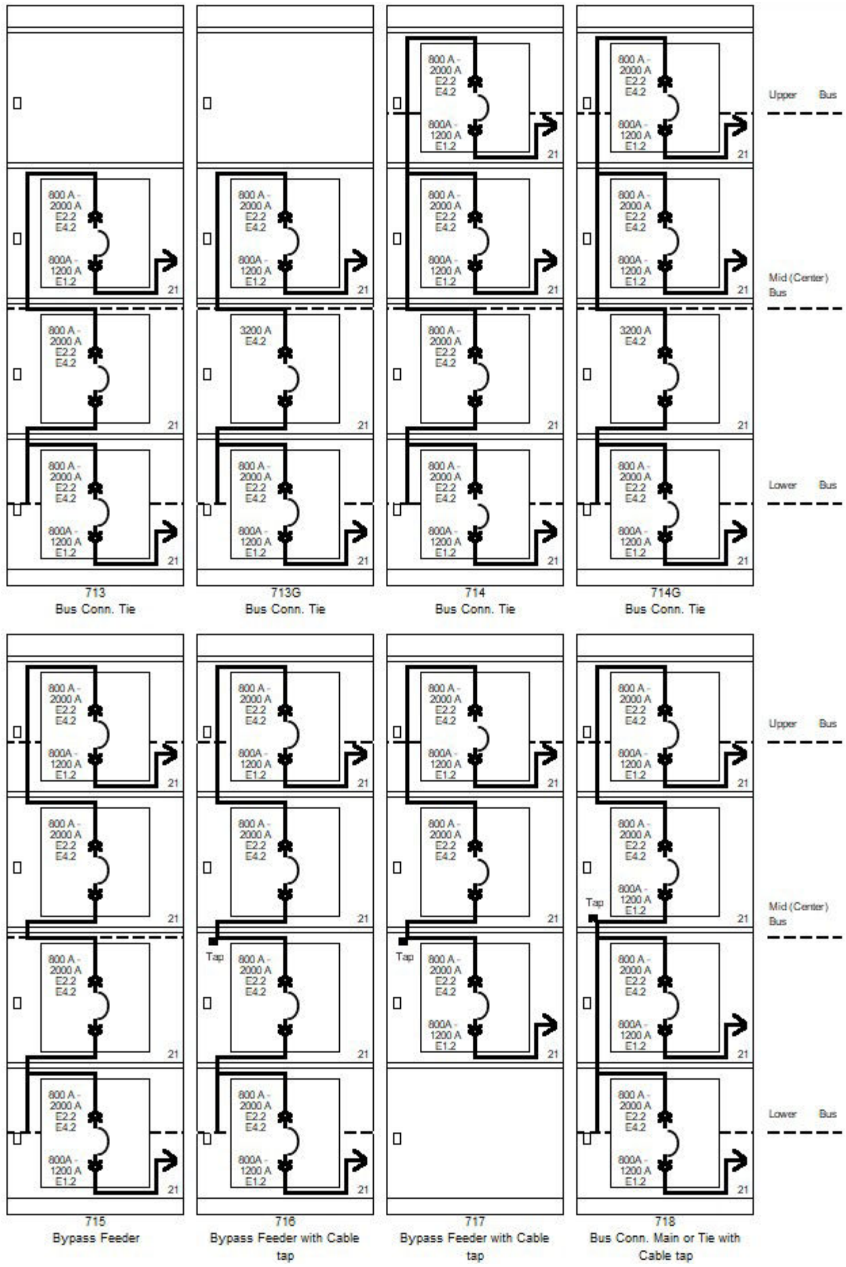
57 Switchgear layout and sizing: 22", 30" and 38" sections continued



Offered in 22", 30", 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway.
Breaker not available in location dedicated for busway. E1.2 breakers not available in 38" wide sections.

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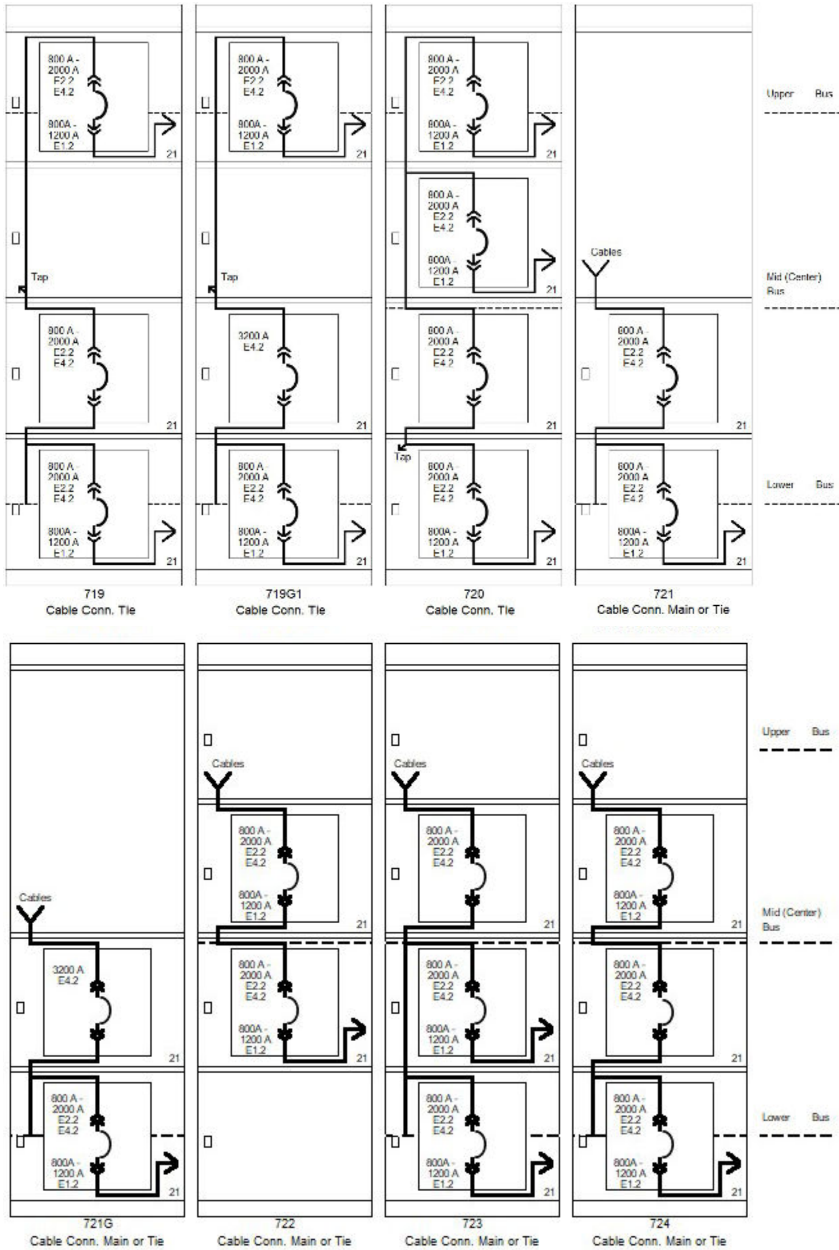
58 Switchgear layout and sizing: 22", 30" and 38" sections continued



Offered in 22", 30", 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway.
Breaker not available in location dedicated for busway. E1.2 breakers not available in 38" wide sections.

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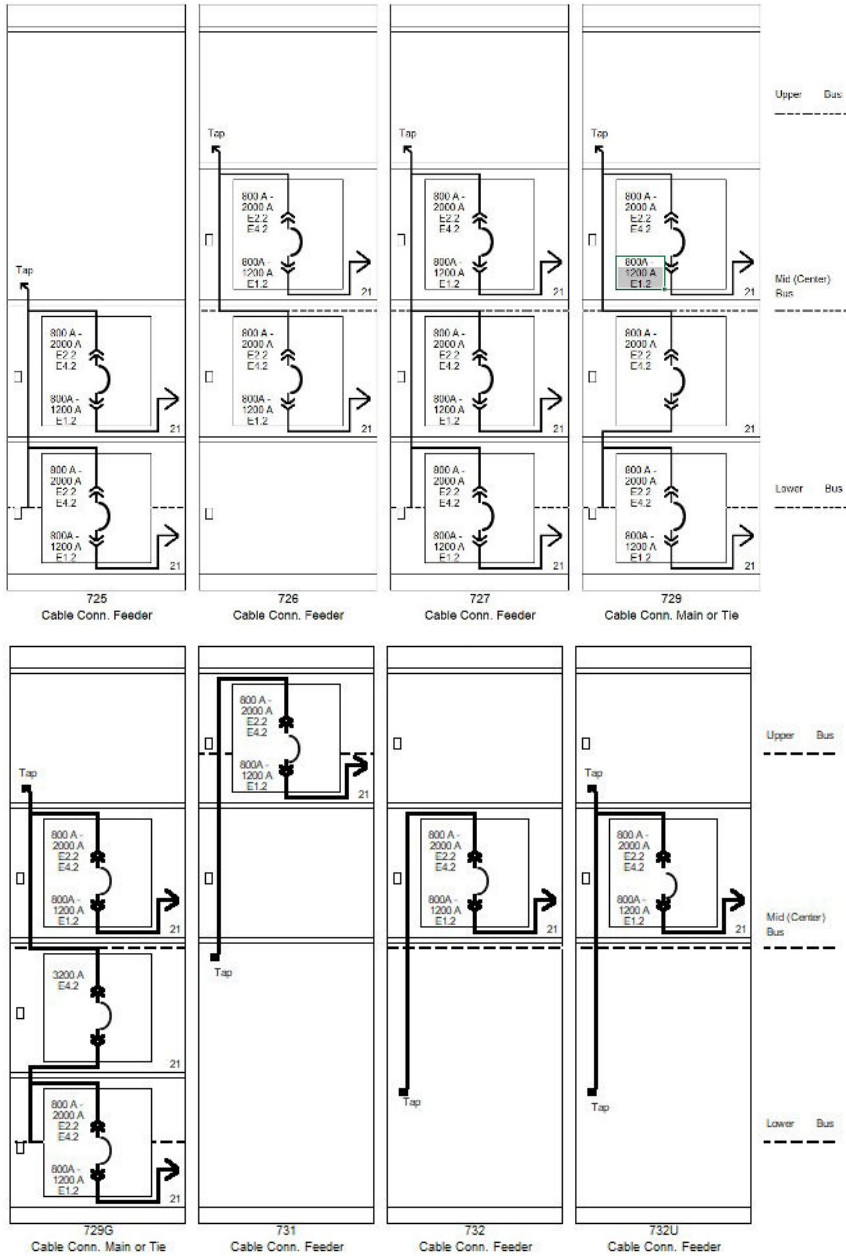
59 Switchgear layout and sizing: 15", 22", 30" and 38" sections continued



Offered in 22", 30", 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway. E1.2 breakers not available in 38" wide sections.

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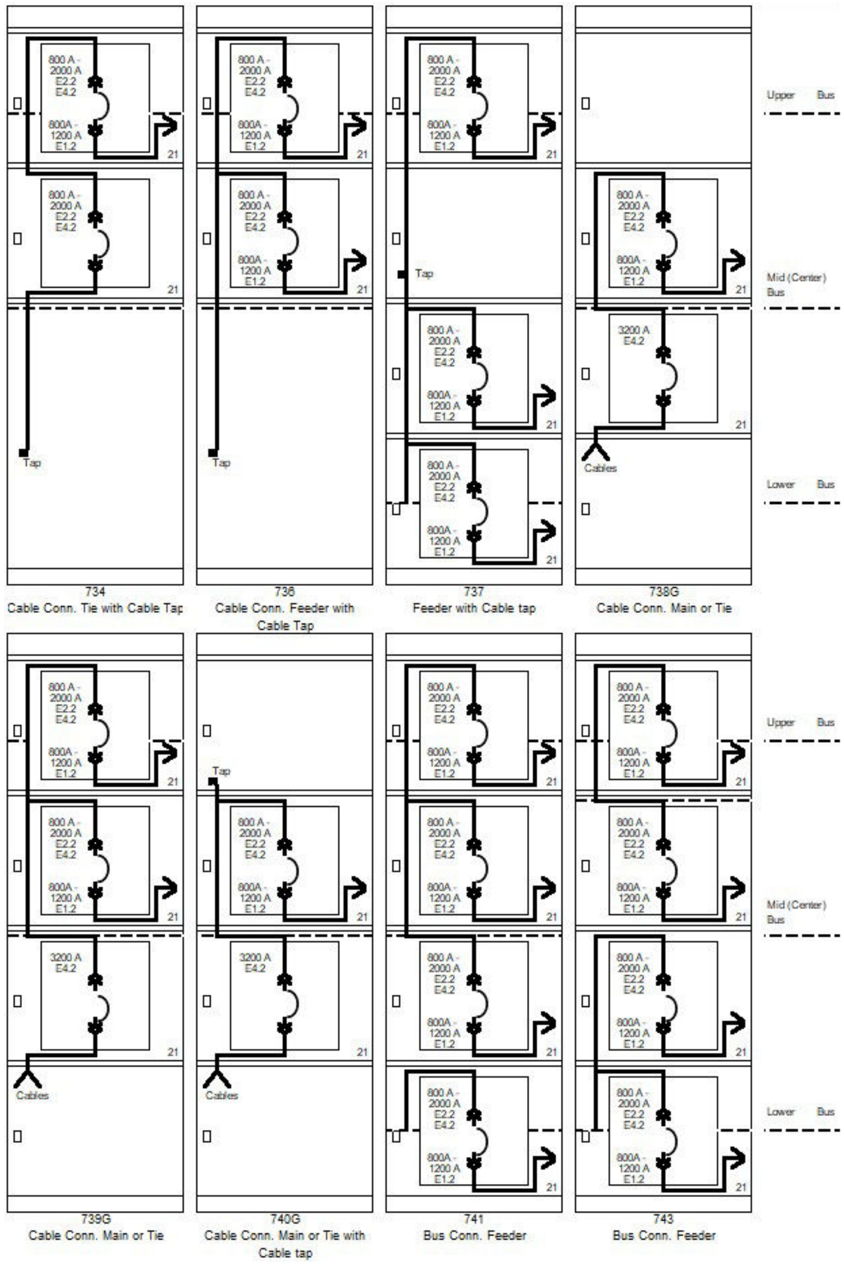
60 Switchgear layout and sizing: 22", 30" and 38" sections continued



Offered in 22", 30", 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway.
Breaker not available in location dedicated for busway. E1.2 breakers not available in 38" wide sections.

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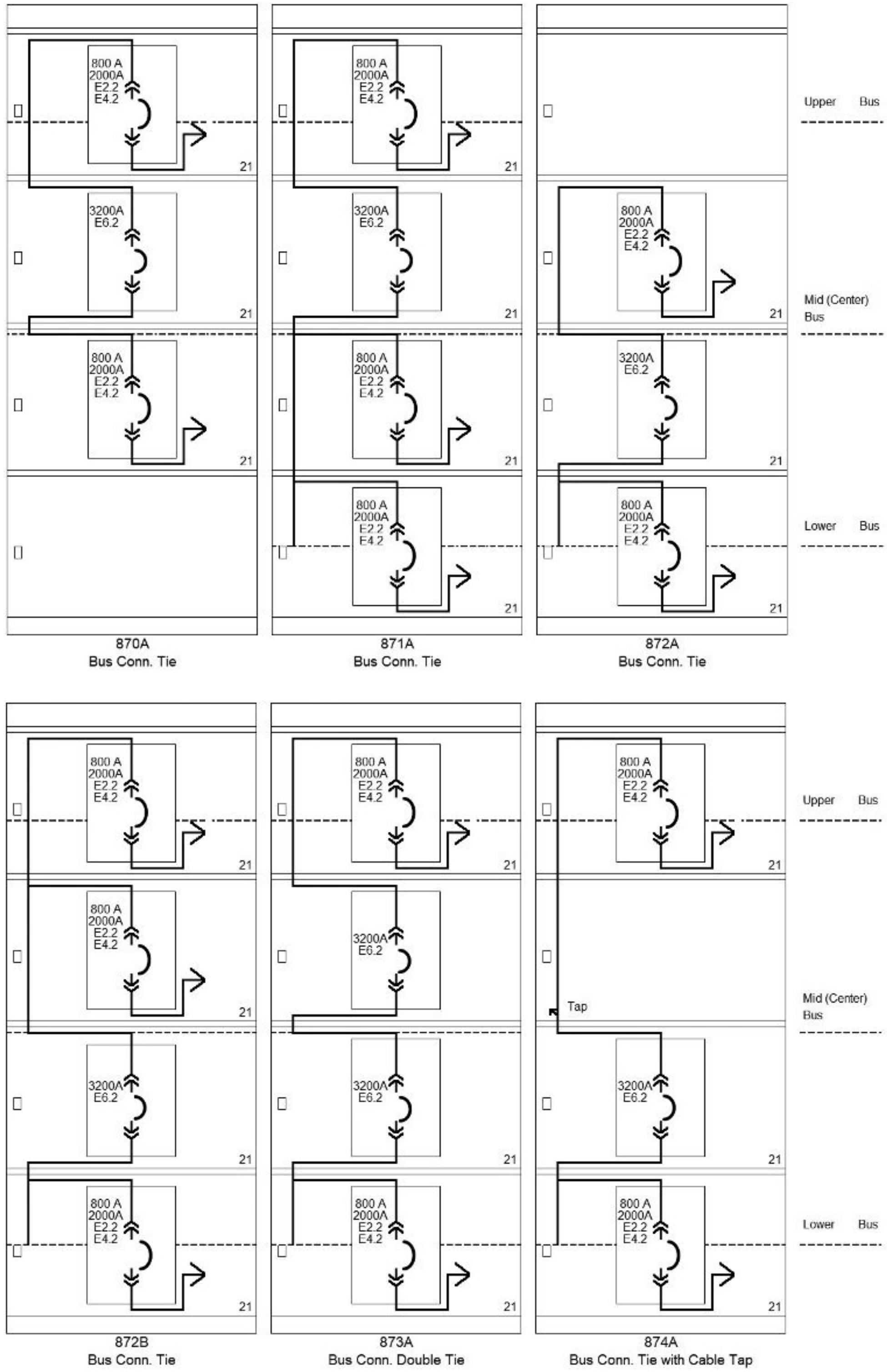
61 Switchgear layout and sizing: 38" sections



Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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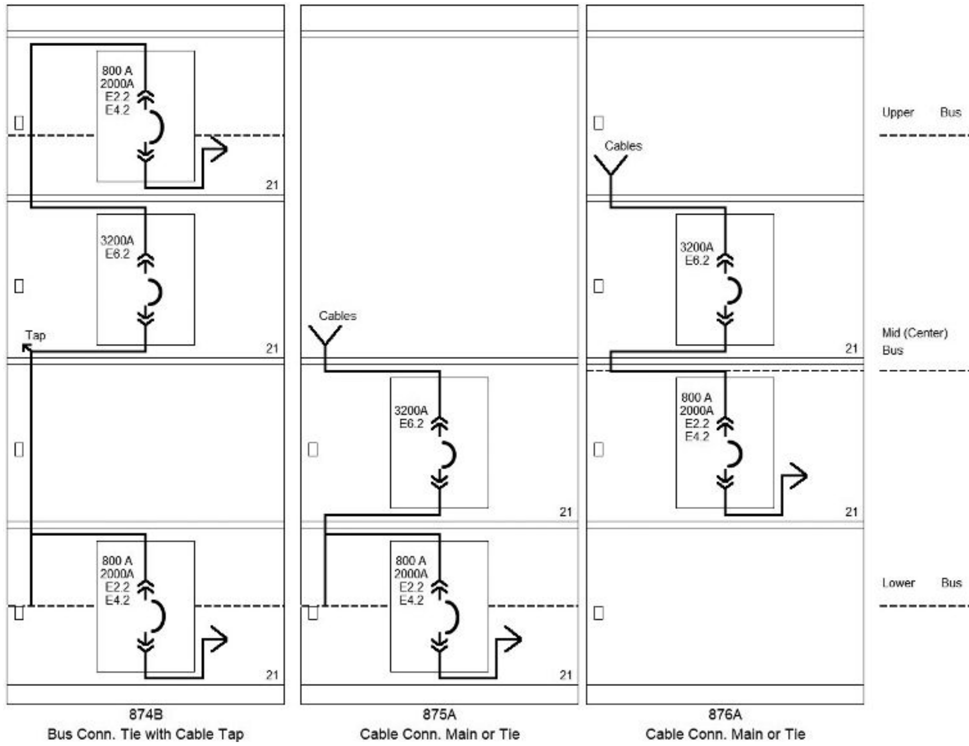
62 Switchgear layout and sizing: 38" sections continued



Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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62

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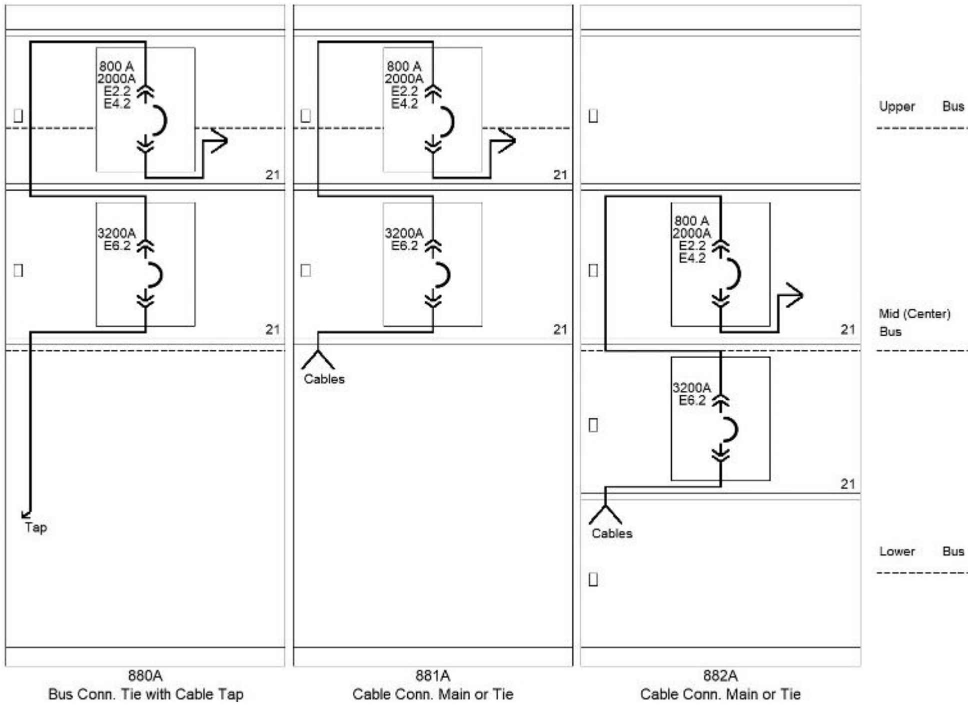
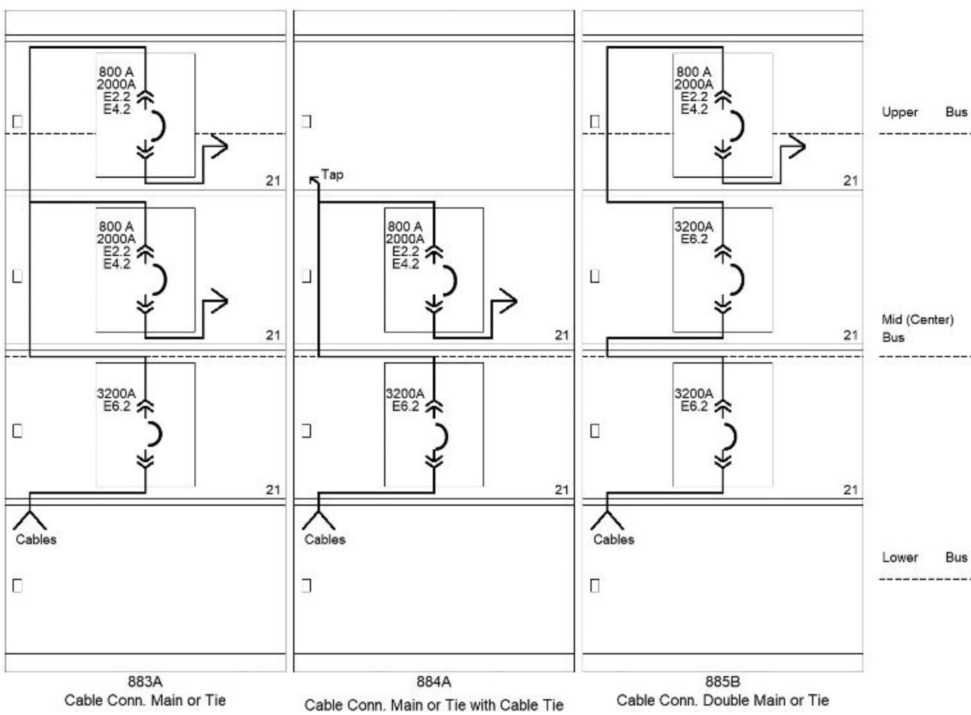
63 Switchgear layout and sizing: 38" sections continued





Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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63

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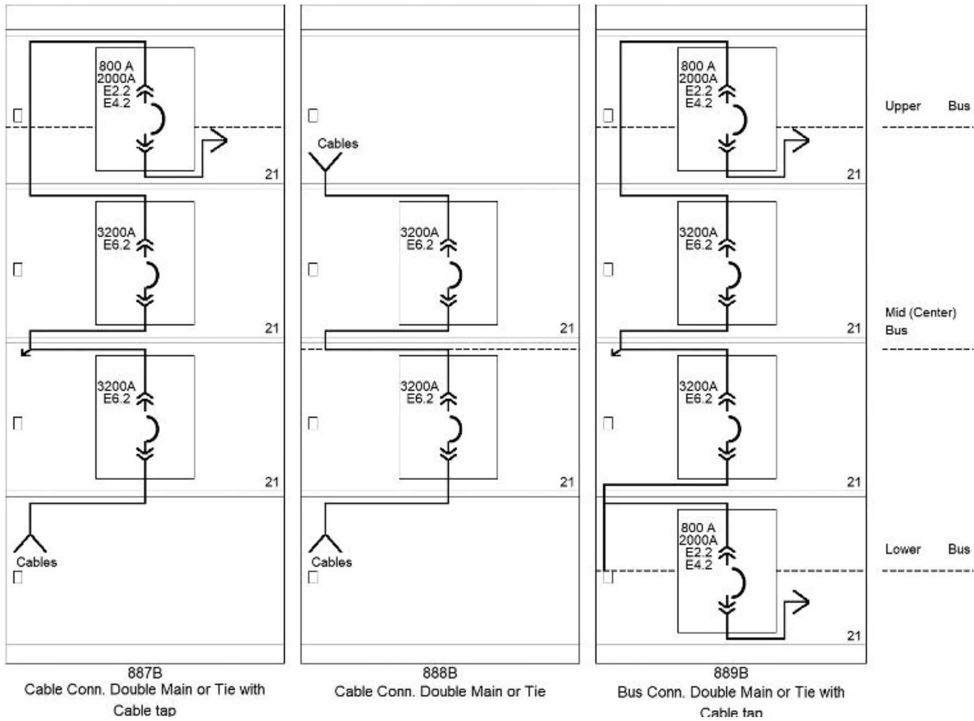
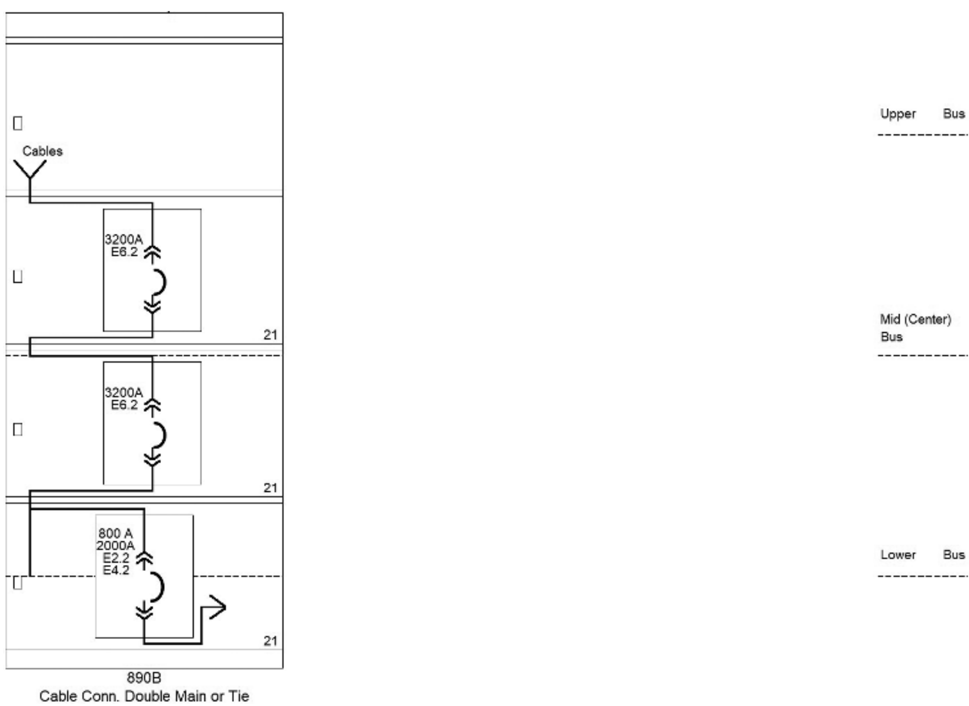
64 Switchgear layout and sizing: 38" sections continued





Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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64

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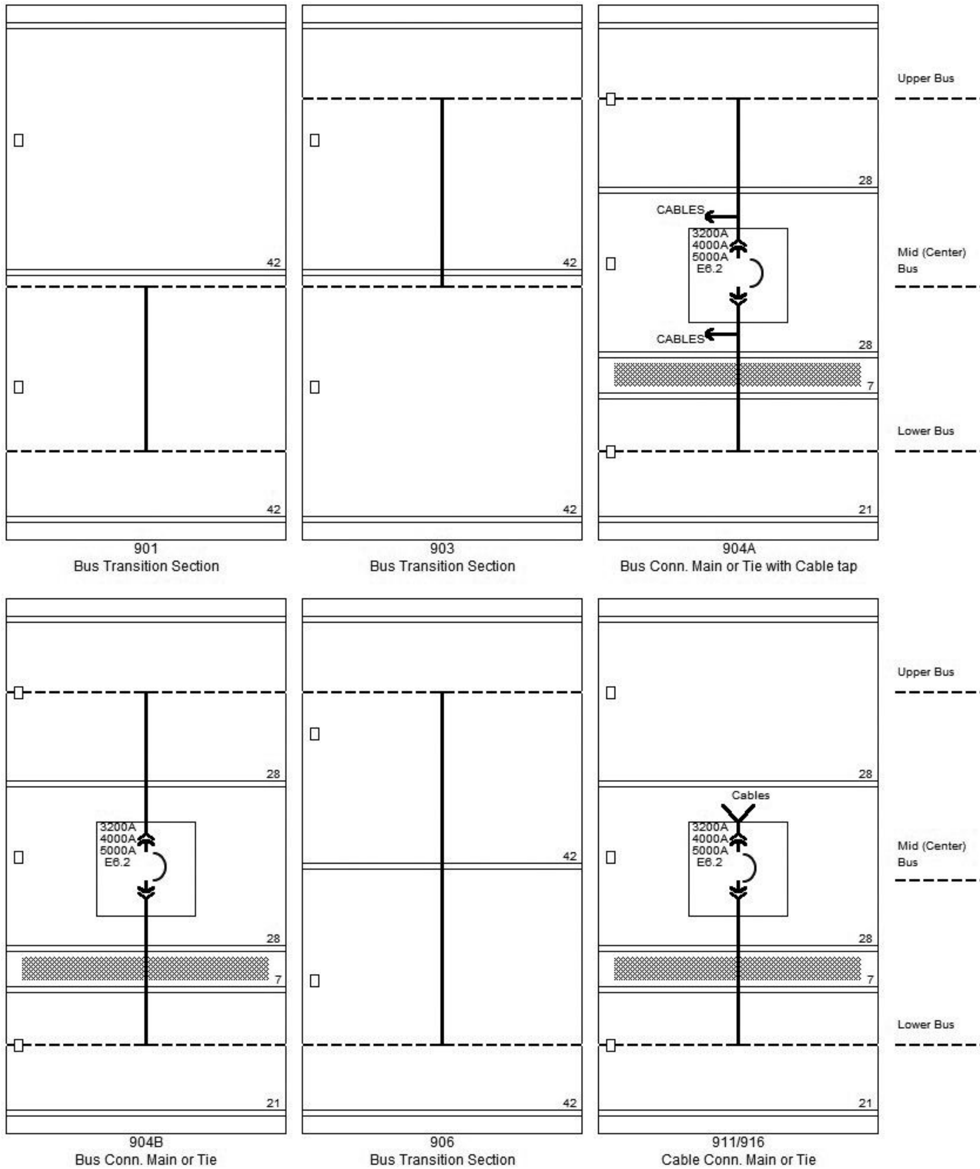
65 Switchgear layout and sizing: 38" sections continued



Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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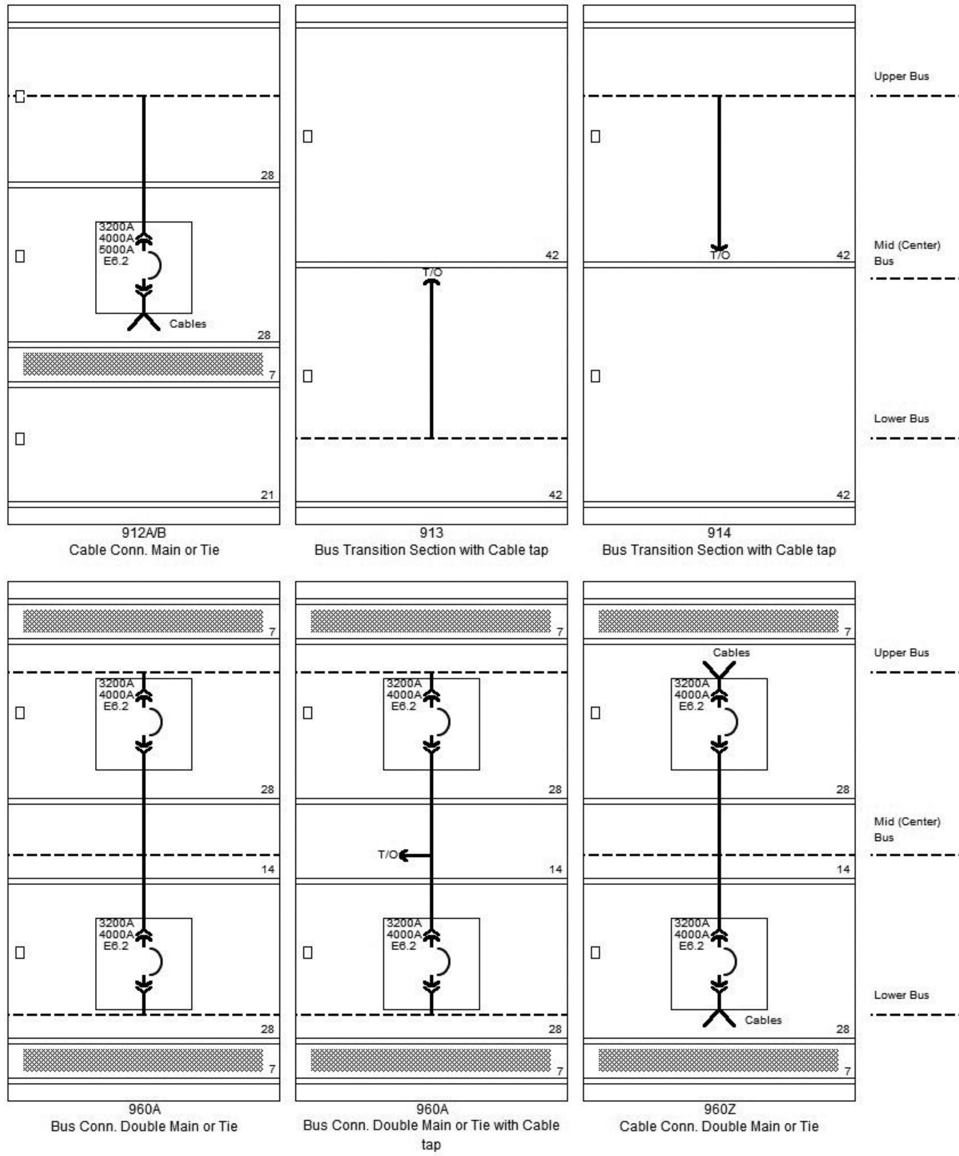
66 Switchgear layout and sizing: 38” sections continued



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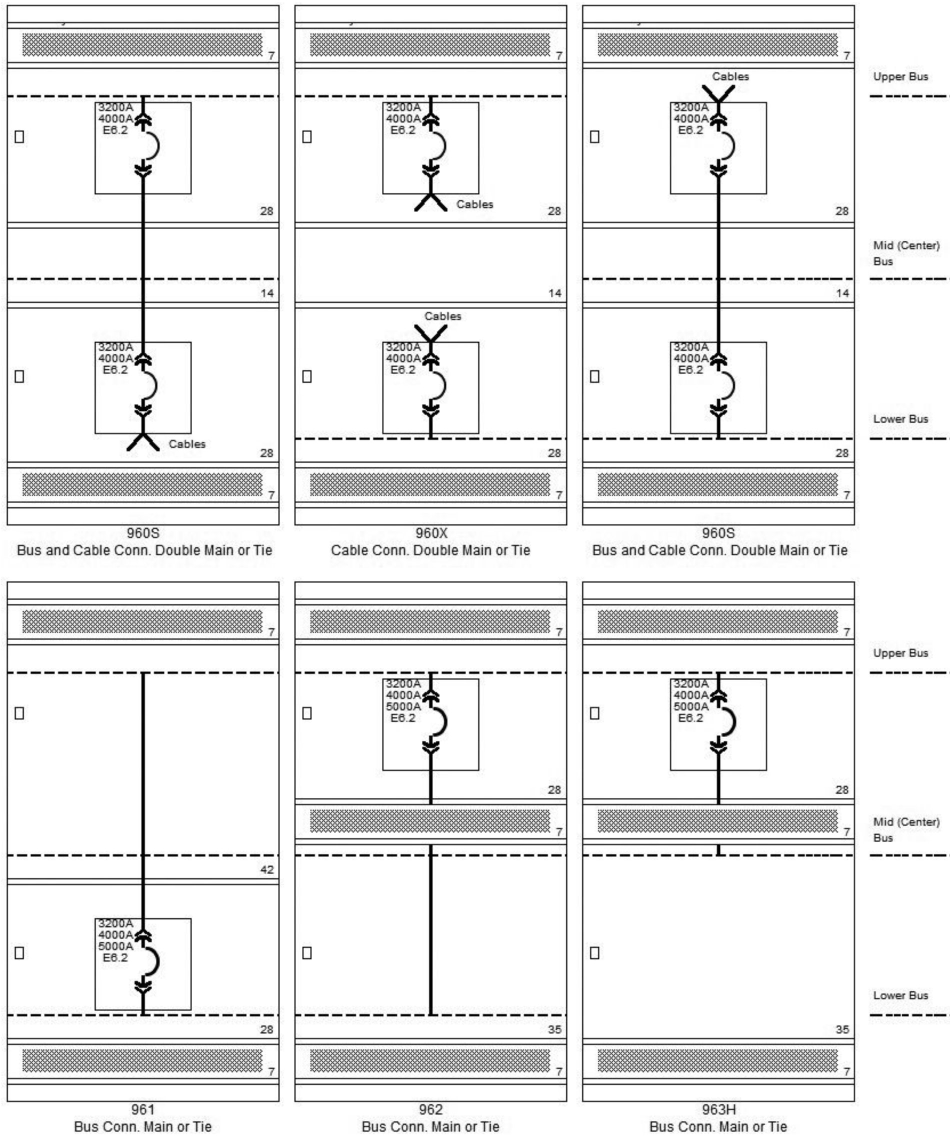
67 Switchgear layout and sizing: 38” sections continued



Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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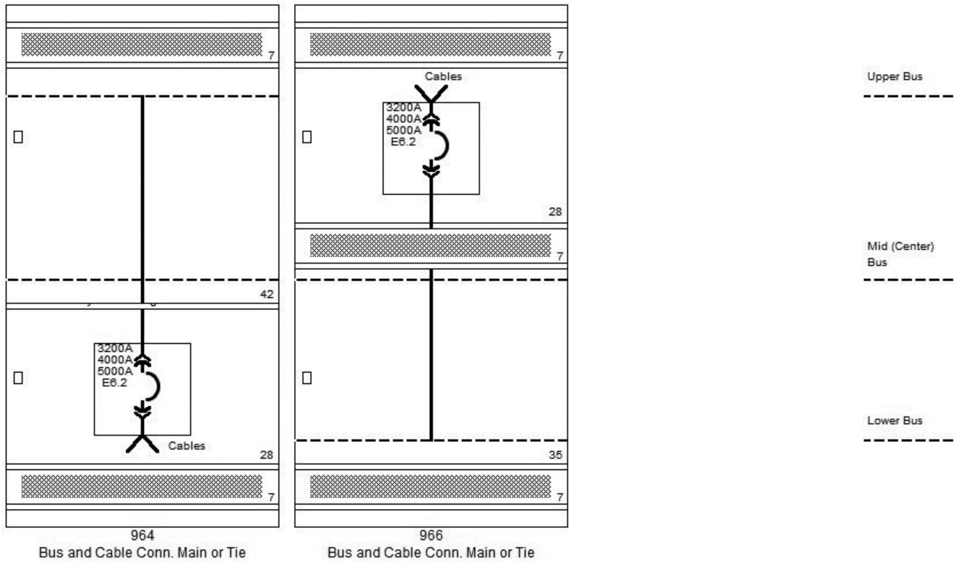
68 Switchgear layout and sizing: 38” sections continued



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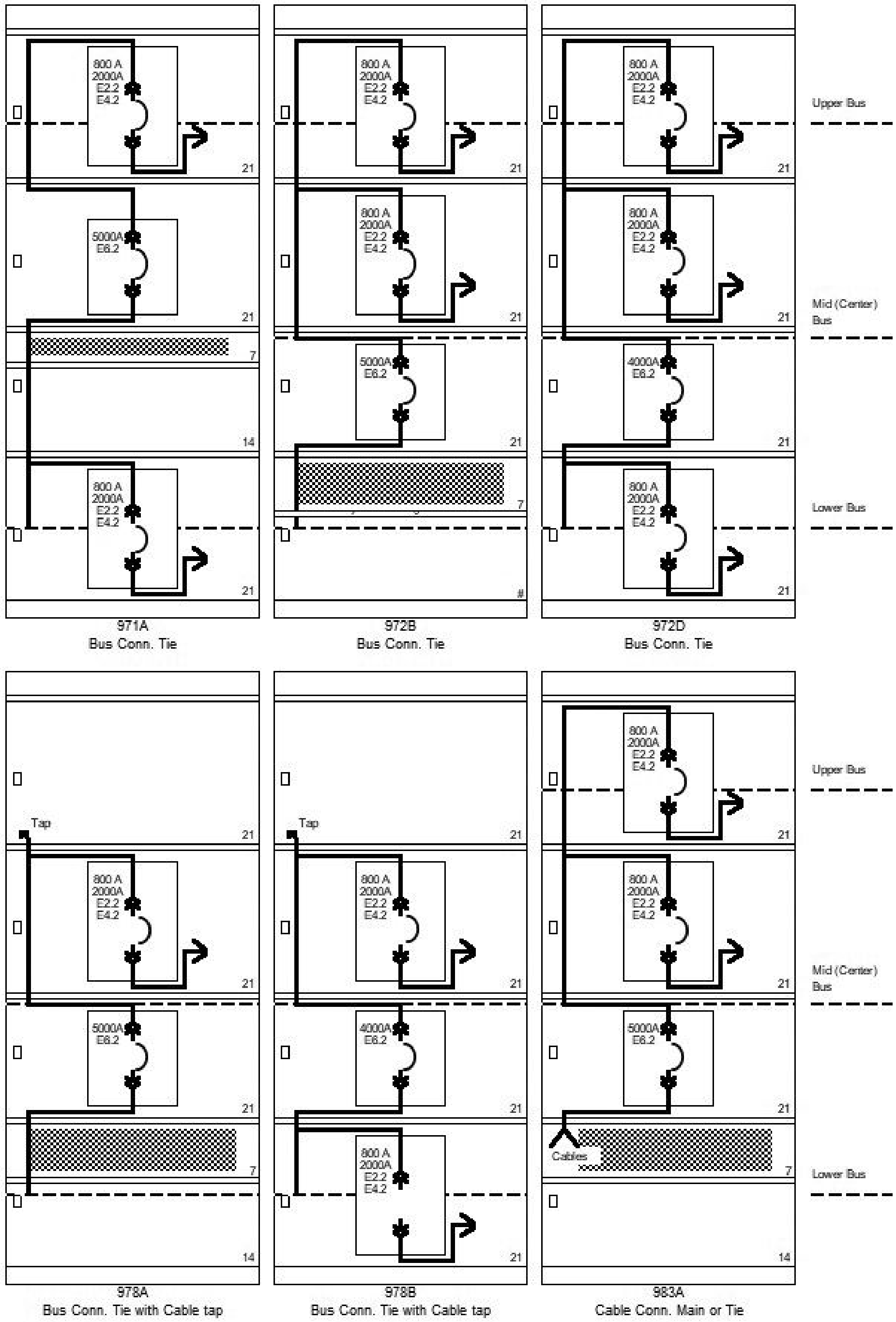
69 Switchgear layout and sizing: 38" sections continued



Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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69

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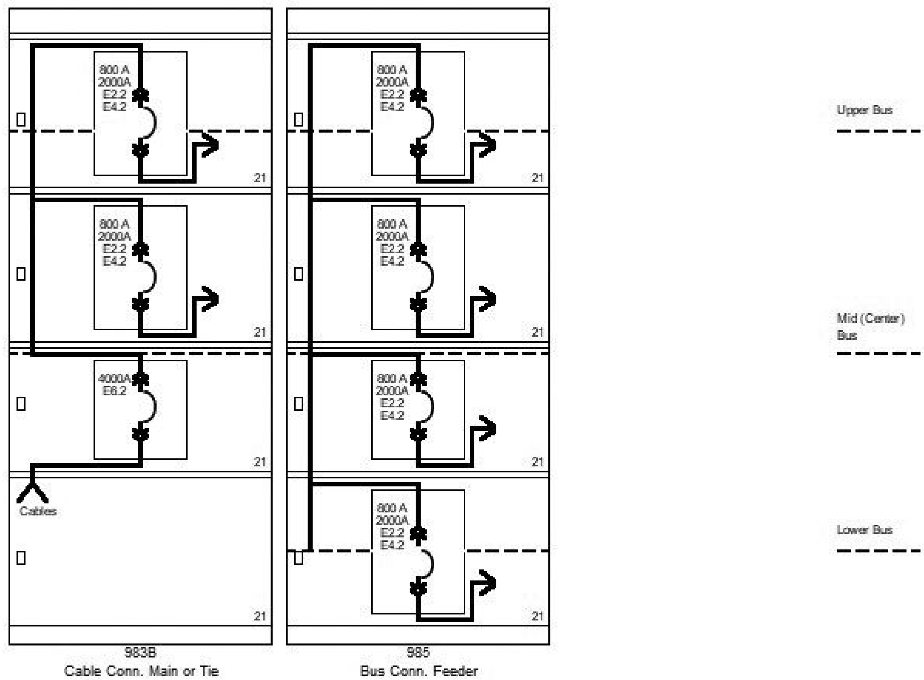
70 Switchgear layout and sizing: 38” sections continued



Offered in 38" sections. Upper, Mid, Lower bus positions for horizontal bus or busway. Breaker not available in location dedicated for busway.

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70

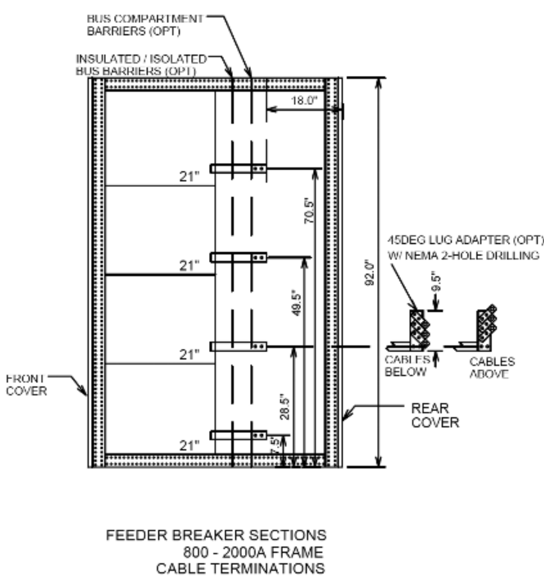
Section views and cable lug landings for feeder breakers and main cable feeds

Cable terminations

Cables used for low voltage power circuit breaker terminations in ReliaGear LV SG must have minimum 90°C insulation while the cable ampacity will be based on a 75°C rating unless detailed otherwise on equipment labeling. This meets the requirements of ANSI C37.20.1, UL1558 and the National Electrical Code. Refer to the example for typical cable ampacities (de-rating factors that may apply are not shown). Figure 79 shows four-high feeder breaker sections and runback locations with and without optional 45° lug adapters for cables above or below.

Cable Size	90°C rating (ref.)	75°C rating (of 90°C cable)
500kcmil	430 Amps	380 Amps
600kcmil	475 Amps	420 Amps

Example (from NEC table 310.16)



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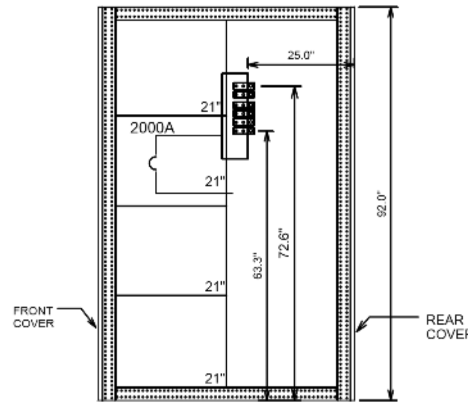
71 Feeder breaker cable termination sections: 800 A – 2000 A breaker

Figure 72 shows a 2000 A main breaker cable feed with cables to the upper primary disconnects and main bus to the lower primary disconnects. The main bus is in the mid or lower bus position.



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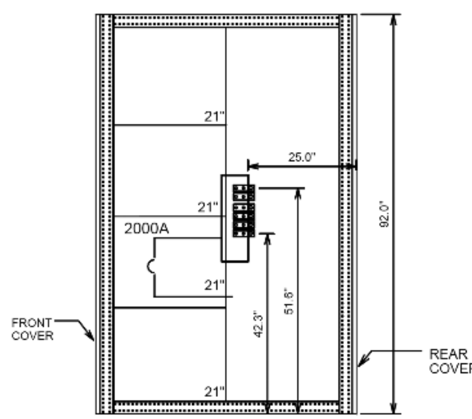
72

72 Main-Tie breaker cable termination sections: 800 A – 2000 A breaker, mid or lower bus

Figure 73 shows a 2000 A main breaker cable feed with cables to the upper primary disconnects and main bus to the lower primary disconnects. The main bus is in the lower bus position.



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73 Main-Tie breaker cable termination sections: 800 A – 2000 A breaker, lower bus

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74 Main-Tie breaker cable termination sections: 3200 A/4000 A breaker

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75 Main-Tie breaker cable termination sections: 3200 A/4000 A breaker

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76 Main-Tie breaker cable termination sections: 3200 A/4000 A breaker

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77 Main-Tie breaker cable termination sections: 5000 A breaker

Figure 74 shows a 3200 A or 4000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper or mid bus position.

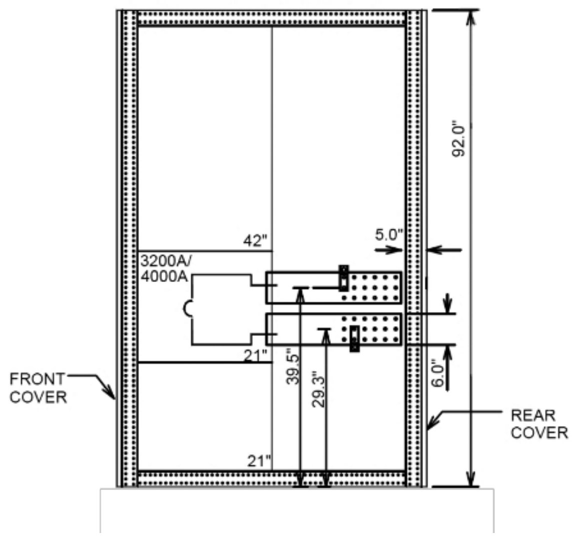

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Figure 75 shows a 3200 A or 4000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the mid or lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position.

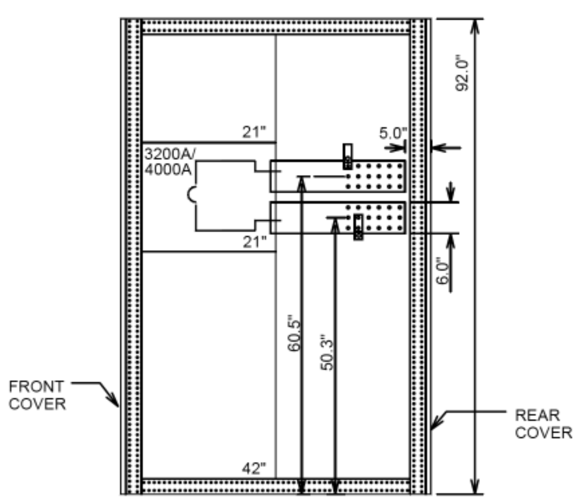

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Figure 76 shows a 3200 A or 4000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position.

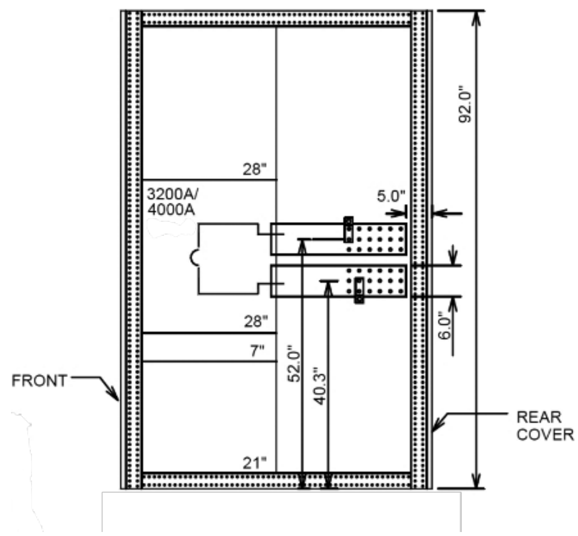

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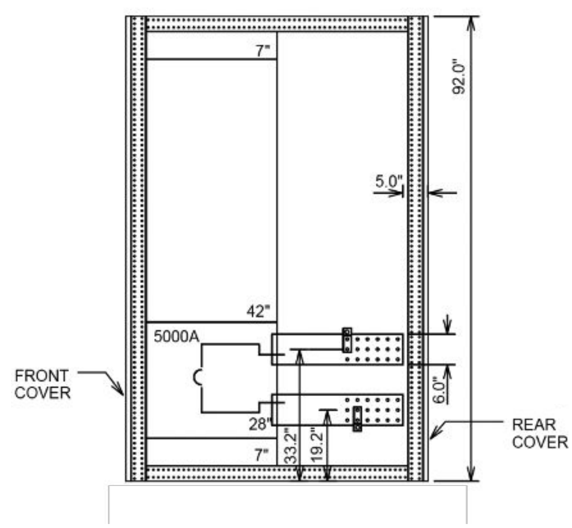
Figure 77 shows a 5000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position.



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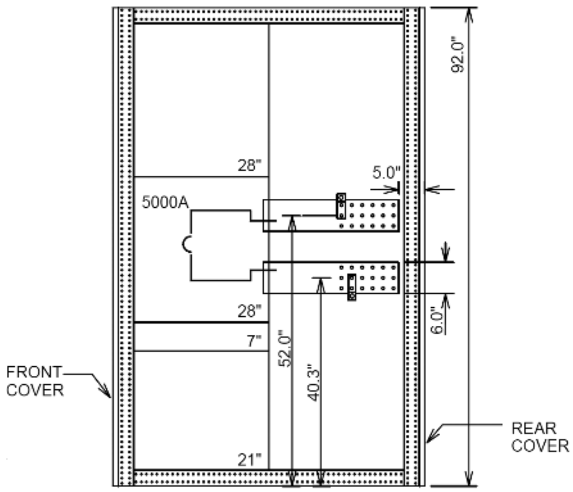
78 Main-Tie breaker cable termination sections: 5000 A breaker

Figure 78 shows a 5000 A main breaker cable feed with cables to the upper or lower primary disconnect. Cables to the upper primary disconnect, main bus in the lower bus position. Cables to the lower primary disconnect, main bus in the upper bus position. Minimum depth is 74“.



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78

Table 22: Feeder breaker cable termination provisions (refer to Figure 5.12)*

Breaker ampere frame	Compression lugs 600 kcmil and smaller NEMA 2-Hole drilling				Clamp (screw) lugs 600 kcmil and smaller NEMA 2-Hole drilling			
	A,B,C-COMP'T		D-COMPT		A,B,C-COMP'T		D-COMPT	
	45° Lug adapter	90° Lug adapter	45° Lug adapter	90° Lug adapter	45° Lug adapter	90° Lug adapter	45° Lug adapter	90° Lug adapter
800 A								
1600 A	8	8	6	8	8	8	3	5
2000 A								

* Maximum quantity of lugs shown. Adapter bars are provided for end user-specified quantity of lugs per breaker.

Table 23: Main cable feed and bus tap-off (refer to Figure 5.13 through Figure 5.19)

Breaker frame/ cable tapoff	Compression lugs 600 kcmil and smaller NEMA 2-Hole drilling			Clamp (screw) lugs 600 kcmil and smaller NEMA 2-Hole drilling		
	Cable feed/Tapoff location			Cable feed/Tapoff location		
	Top	Center	Bottom	Top	Center	Bottom
2000 A	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")	6 (22") 9 (30")
3200 A	12	12	12	11	11	11
4000 A	12	-	12	11	-	11
5000 A	14	-	14	14	-	14

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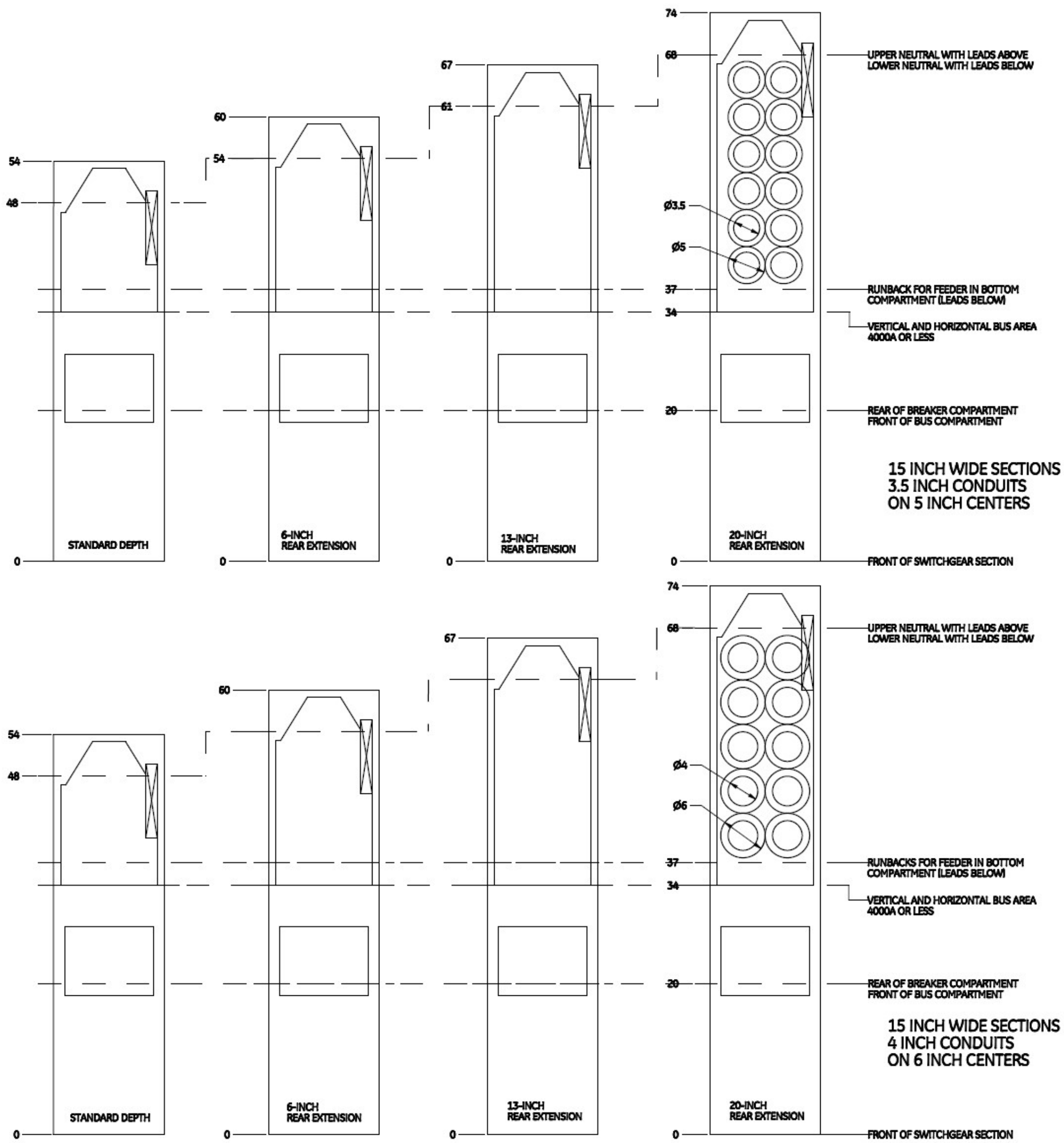
79 Conduit layout: 15-inch sections

Figures 79 through 82 show various layouts for conduit and cable position depending on the section depth and close-coupling options available.



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79

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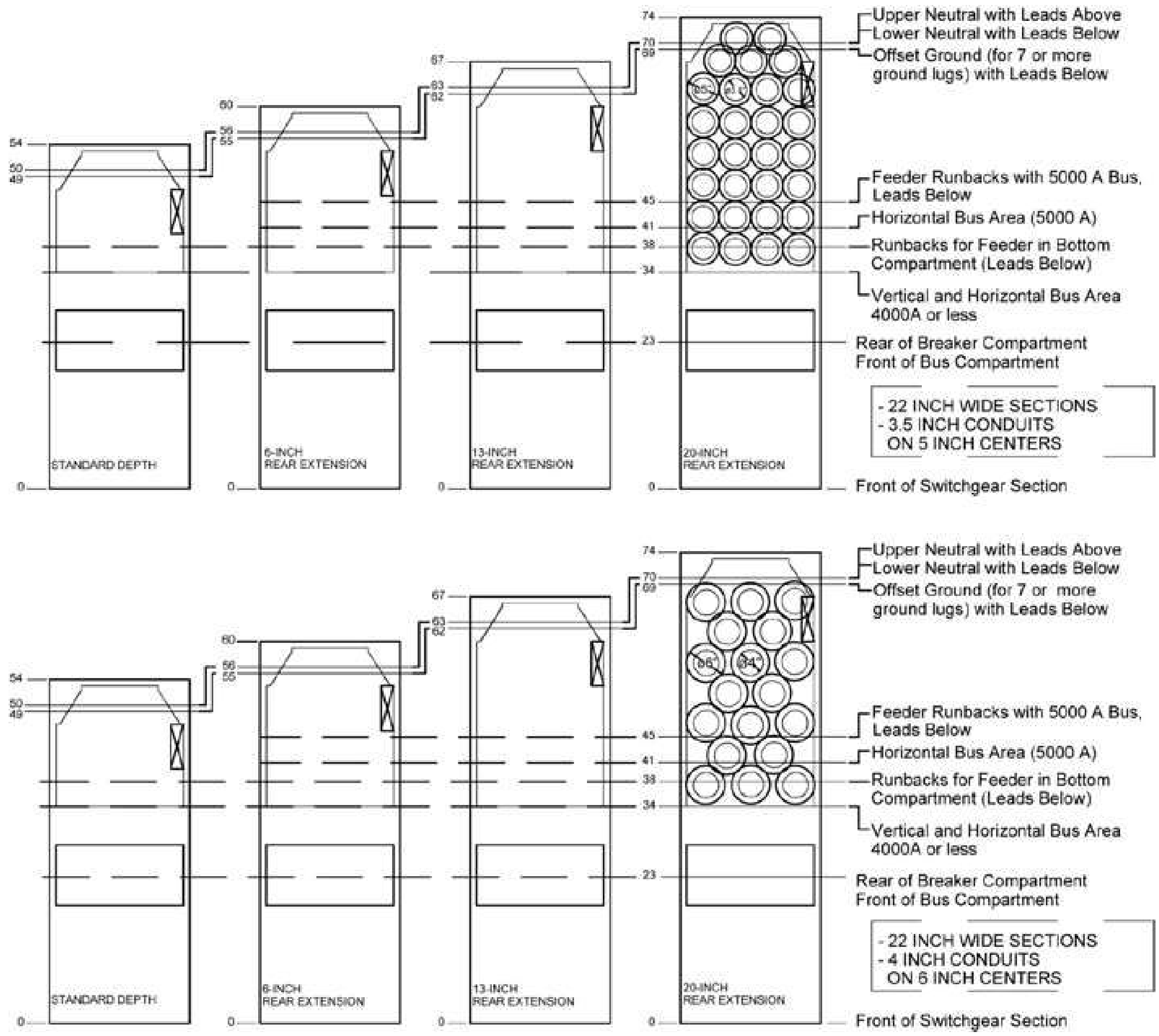
80 Conduit layout: 22-inch sections

Figures 79 through 82 show various layouts for conduit and cable position depending on the section depth and close-coupling options available.



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80

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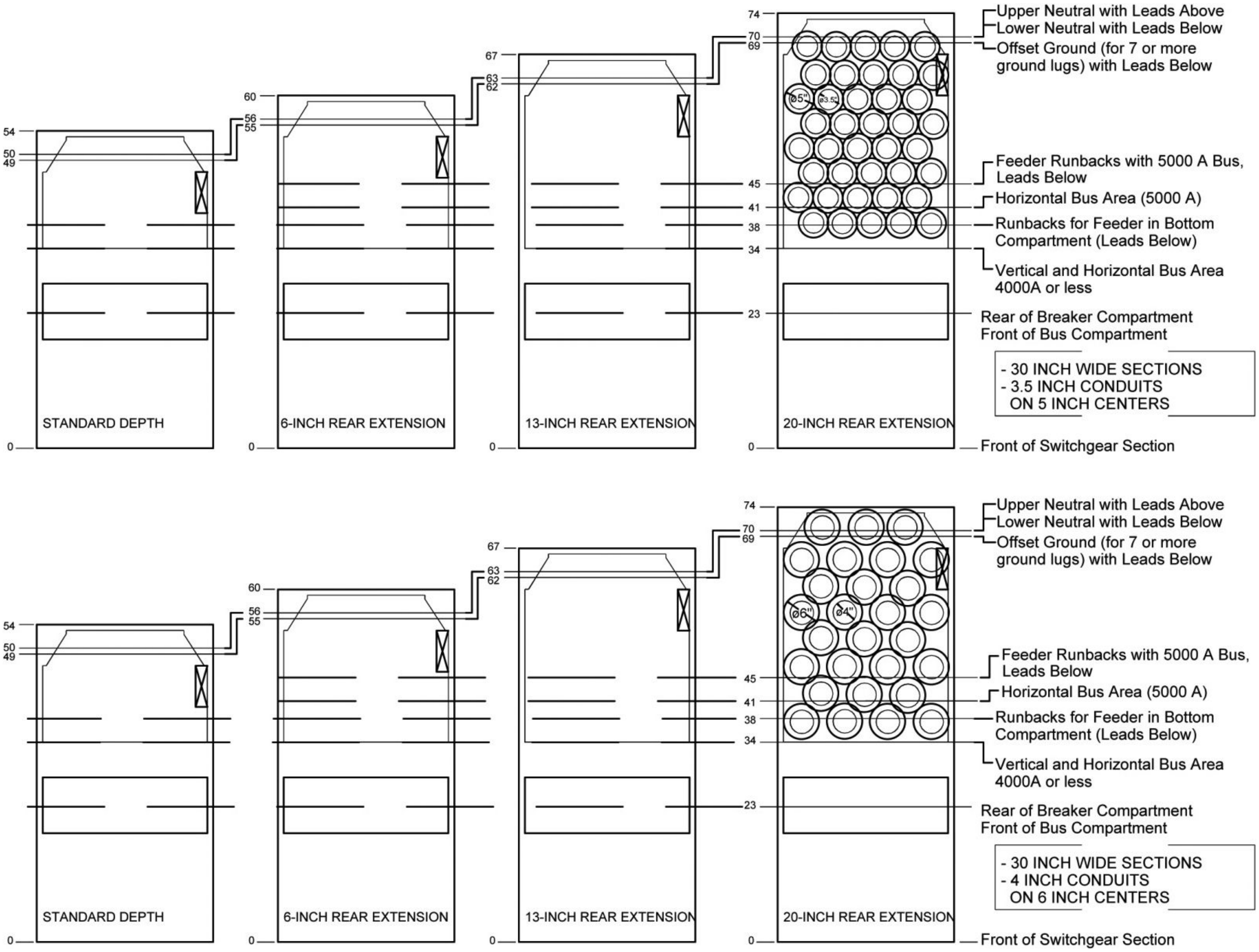
81 Conduit layout:
30-inch sections

Figures 79 through 82 show various layouts for conduit and cable position depending on the section depth and close-coupling options available.



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81

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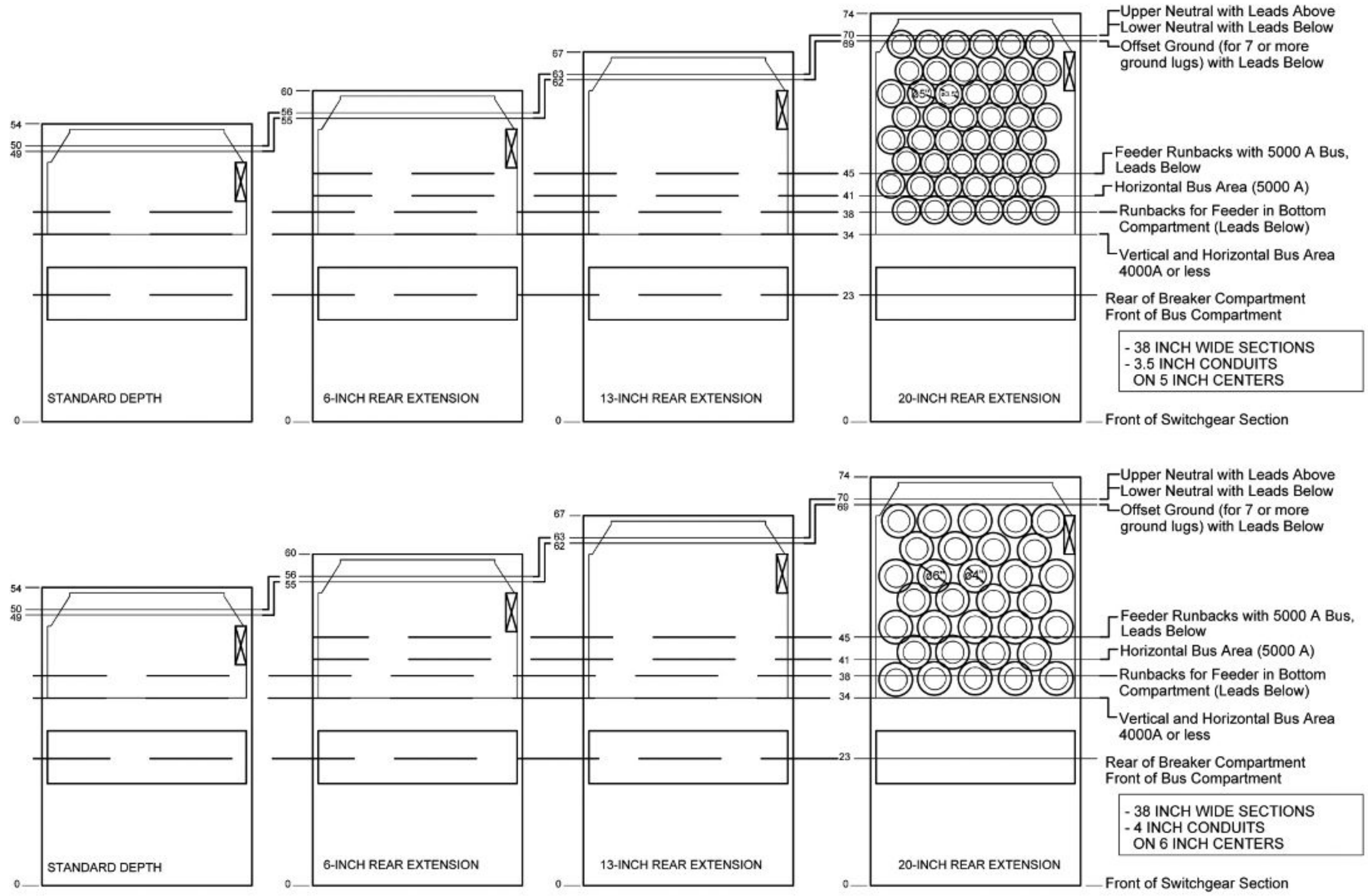
82 Conduit layout:
38-inch sections

Figures 79 through 82 show various layouts for conduit and cable position depending on the section depth and close-coupling options available.



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82

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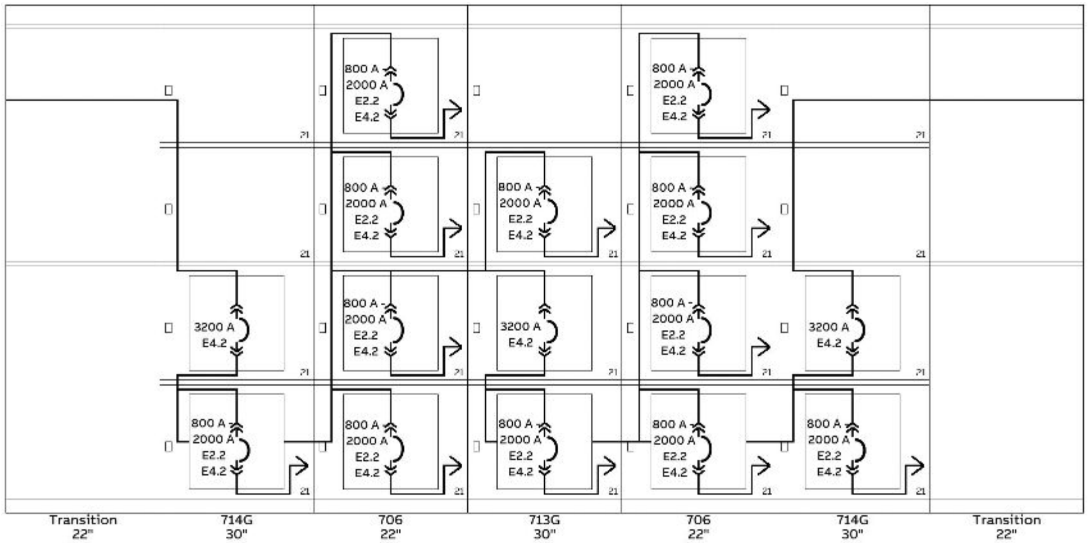
83 Close-coupled to transformer with transition section: Main-Tie-Main

3200 A Main-tie-main / Close-coupled to transformer / With transition / Additional feeder sections as required



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83

Notes:
1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer required with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

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84 Close-coupled to transformer with transition section: Main-Tie-Main and Main-Tie-Tie-Main

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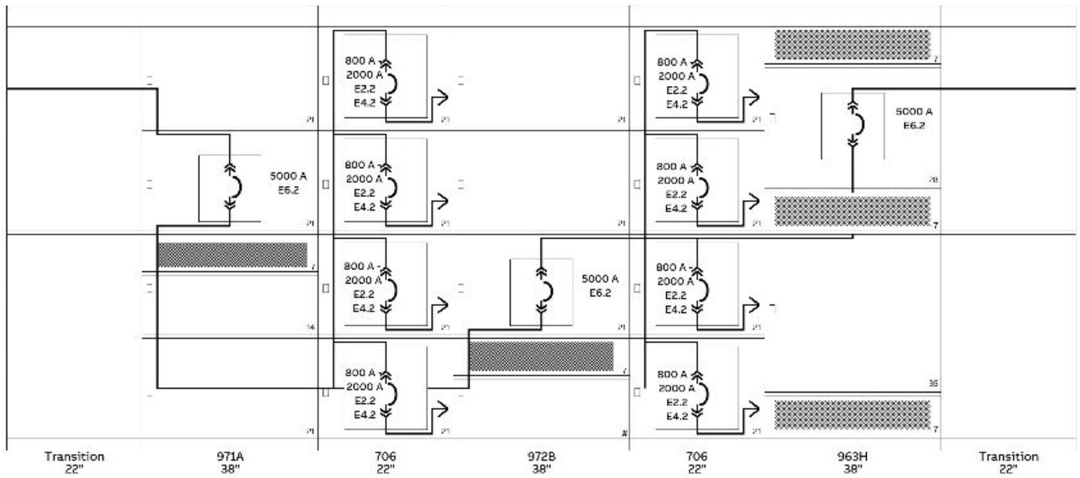
85 Cable or busway connected: Main-tie-tie-main

5000 A Main-tie-main / close-coupled to transformer with transition / additional feeder sections as required



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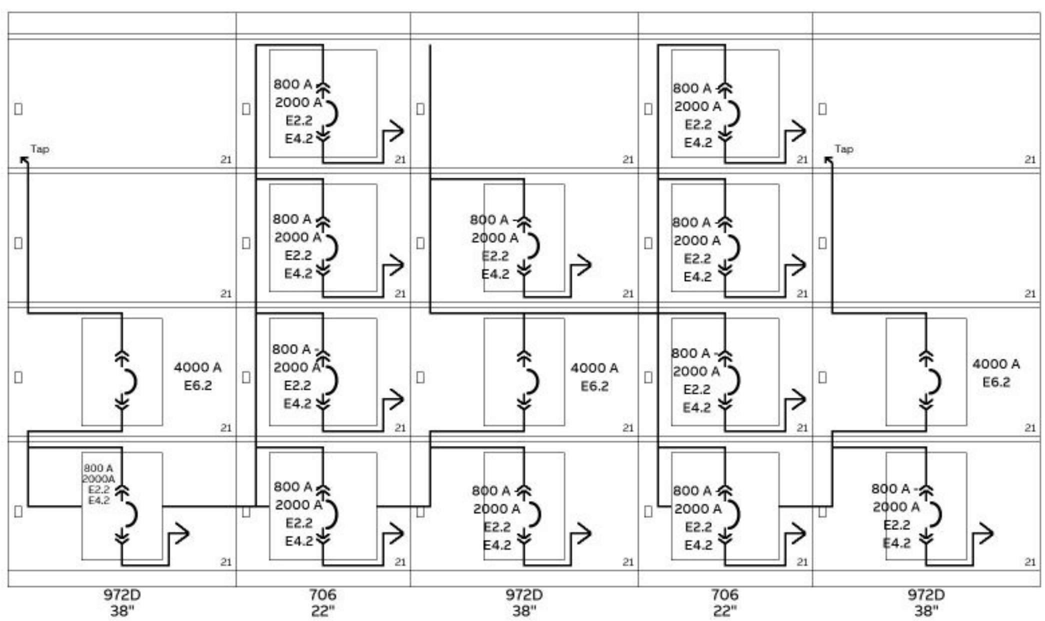
84

Notes:
1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.
2. Transition to transformer required with liquid-filled transformed and recommended with dry type transformers. If transition is not used, then space must be provided in the breaker sections for auxiliary devices (PT, CPT, fuses, meters, etc.).

4000 A Main-tie-main / Cable connected / Additional feeder sections as required



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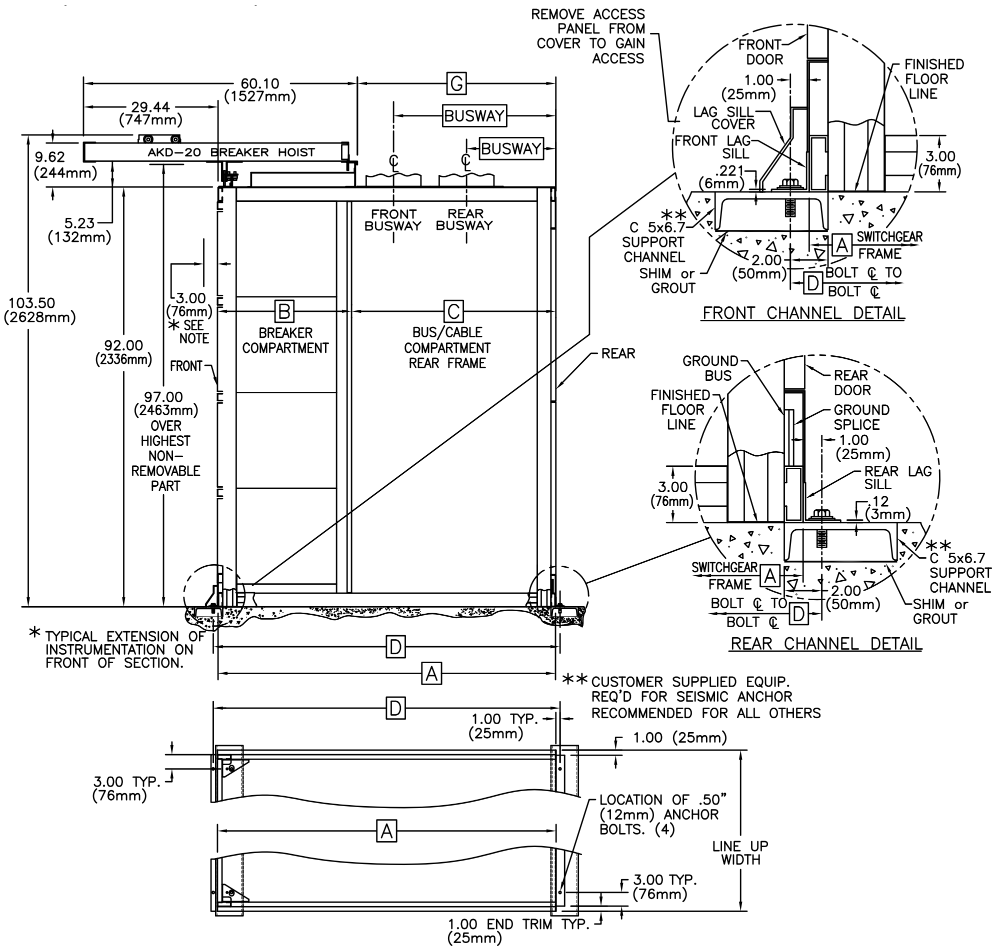
85

Notes:
1. All auxiliary compartments have shallow depths. Device-mounting space on door and rear barrier only.



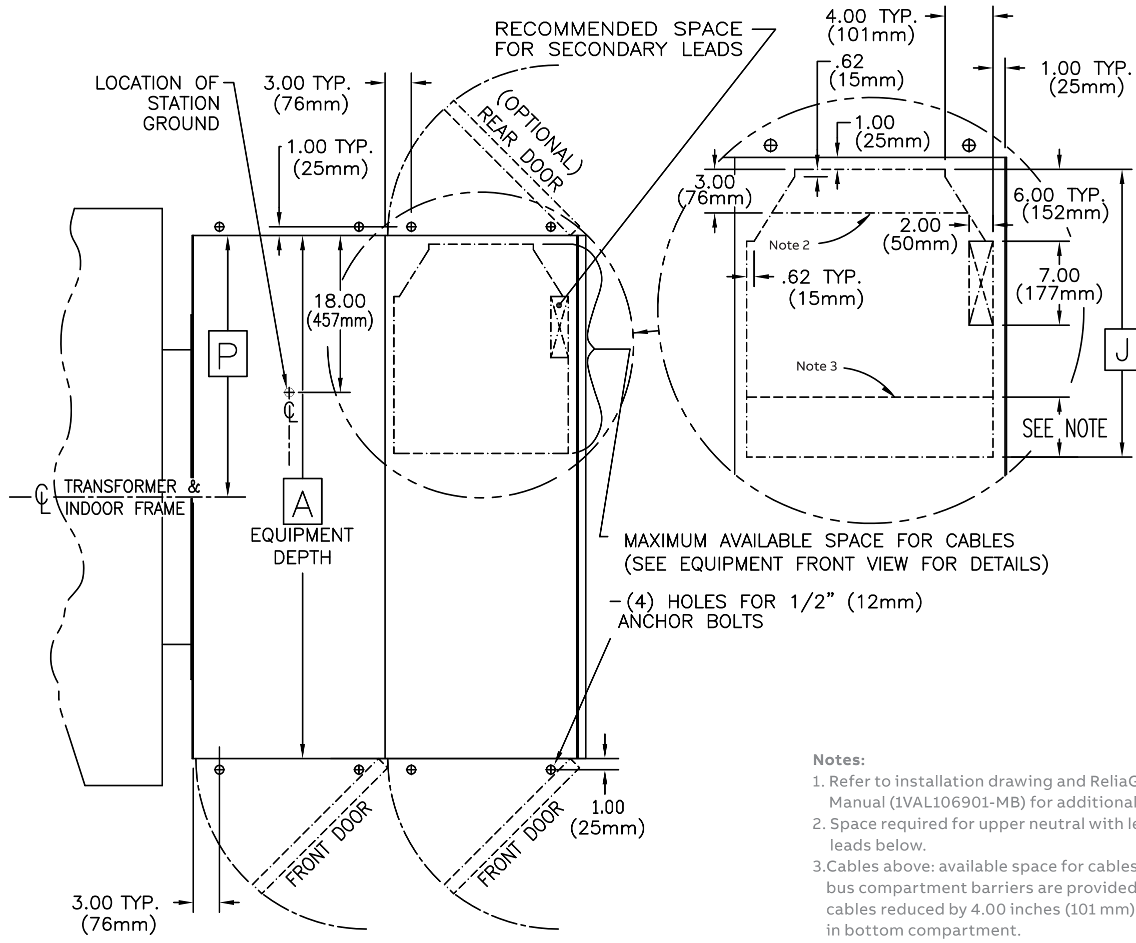
86 NEMA 1 indoor side view and anchoring details[1] – inches (mm)

Busway section width required

Type and amp rating	Min. section width
Spectra 800 A - 3200 A	22.00 in (558 mm)
Spectra 4000 A	30.00 in (762 mm)
Spectra 5000 A	38.00 in (965 mm)
NSP 1200 A - 2500 A	22.00 in (558 mm)
NSP 3200 A	30.00 in (762 mm)
NSP 4000 A – 5000 A	38.00 in (965 mm)

				Busway locations						
				Front					Rear	
A Equipment depth	B Breaker compartment	D Anchor bolt spacing	G Back of hoist to rear frame	Spectra 800 A - 4000 A NSP 1200 A - 3200 A	NSP 4000 A	Spectra 5000 - 6000A	Spectra 800 A - 4000 A	NSP 1200 A -4000 A	Spectra 5000 A	NSP 5000 A
54.00 in (1372 mm)	17.00 in (432 mm)	56.00 in (1422 mm)	23.34 in (593 mm)	12.50 in (317 mm)	12.50 in (317 mm)	-	-	-	-	-
60.00 in (1524 mm)	17.00 in (432 mm)	62.00 in (1575 mm)	29.34 in (745 mm)	21.50 in (546 mm)	19.50 in (495 mm)	23.50 in (596 mm)	9.50 in (241 mm)	12.50 in (317 mm)	11.50 in (292 mm)	-
67.00 in (1701 mm)	17.00 in (432 mm)	69.00 in (1752 mm)	36.34 in (923 mm)	28.50 in (723 mm)	26.50 in (673 mm)	30.50 in (774 mm)	16.50 in (419 mm)	12.50 in (317 mm)	18.50 in (470 mm)	15.88 in (403 mm)
74.00 in (1879 mm)	17.00 in (432 mm)	76.00 in (1930 mm)	43.34 in (1100 mm)	35.50 in (901 mm)	33.50 in (850 mm)	37.50 in (952 mm)	23.50 in (596 mm)	19.50 in (495 mm)	25.50 in (648 mm)	22.88 in (581 mm)

1. Refer to installation drawing and ReliaGear LV SG Installation Manual (1VAL106901-MB) for additional information.
2. End user-supplied equipment required for seismic anchor; recommended for all others.
3. Typical extension of instrumentation on front of section.
4. Uppermost breaker not available when used with a 4 inches subframe or housekeeping pad.



Notes:
1. Refer to installation drawing and ReliaGear LV SG Installation Manual (1VAL106901-MB) for additional information.
2. Space required for upper neutral with leads above, or lower neutral with leads below.
3. Cables above: available space for cables reduced by 5.00 inches (127mm) if bus compartment barriers are provided. Cables below: available space for cables reduced by 4.00 inches (101 mm) if 800 A – 2000 A breaker is located in bottom compartment.

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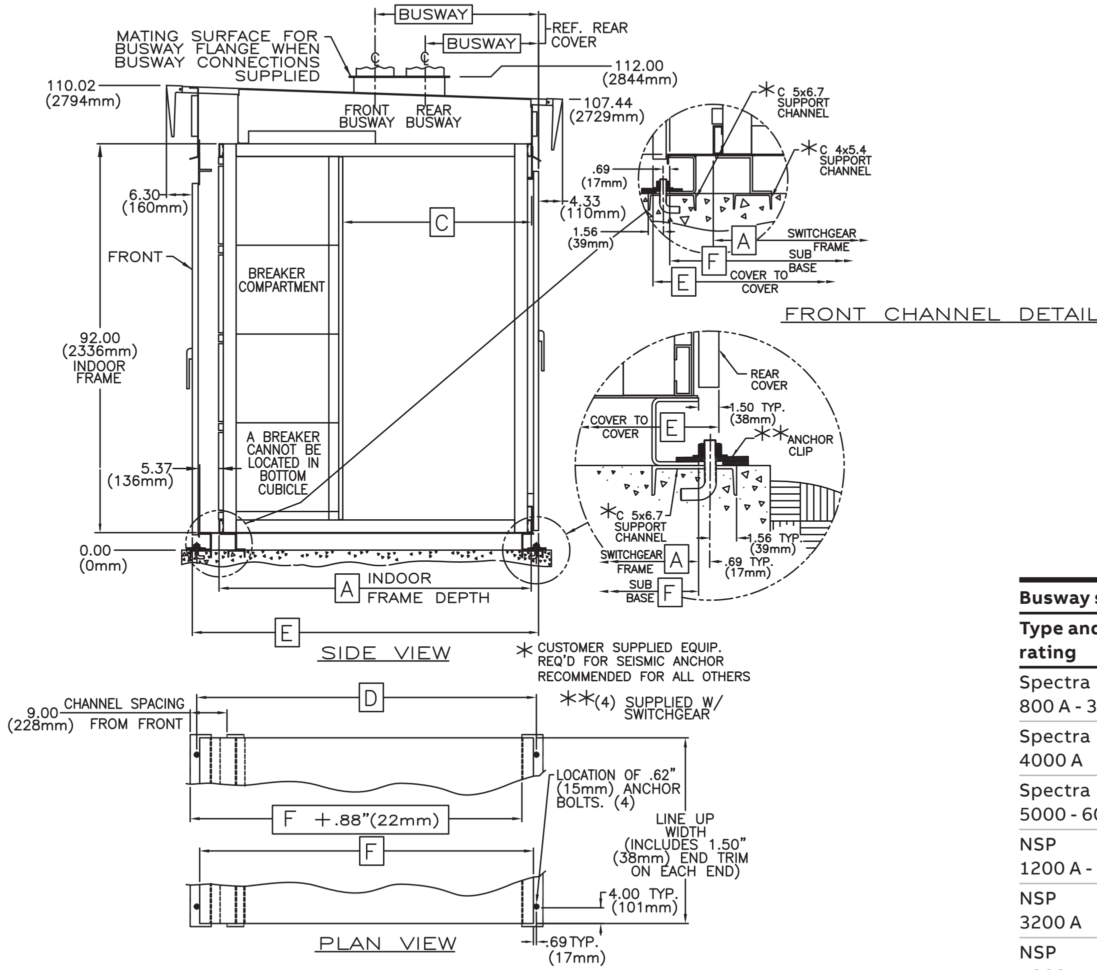
87 NEMA 1 indoor floor plan and cable space details[1] – inches (mm)

A Equipment depth	Direction of cables	J	Rear extension depth	P Transformer ℄ (center line) to rear of switchgear
54 in	Below	19.00 in (482 mm)	-	26.50 in (673 mm)
	Above	24.00 in (609 mm)		
60 in	Below	25.00 in (635 mm)	6.00 in (153 mm)	26.50 in (673 mm)
	Above	30.00 in (762 mm)		
67 in	Below	32.00 in (813 mm)	13.00 in (330 mm)	33.50 in (861 mm)
	Above	37.00 in (940 mm)		
74 in	Below	39.00 in (991 mm)	20.00 in (508 mm)	40.50 in (1029 mm)
	Above	44.00 in (1118 mm)		
67 in 5000A, 6000A, 8000A bus	Below	26.00 in (660 mm)	7.00 in (177 mm)	33.50 in (861 mm)
	Above	31.00 in (787 mm)		
74 in 5000A, 6000A, 8000A bus	Below	33.00 in (838 mm)	14.00 (356 mm)	40.50 in (1029 mm)
	Above	38.00 in (965 mm)		



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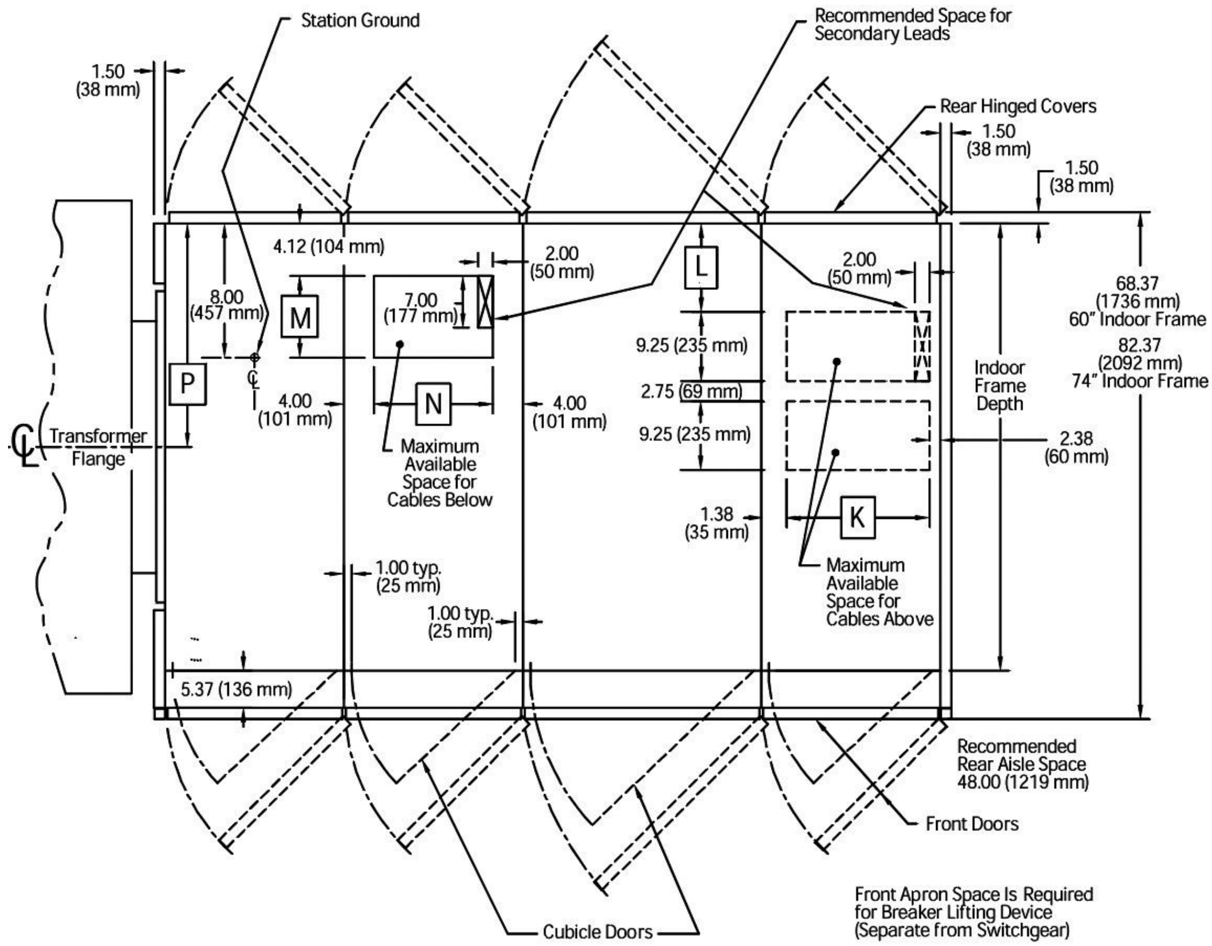
88 NEMA 3R outdoor non-walk-in side view and anchoring details[1] – inches (mm)

Busway section width required	
Type and amp rating	**Min. section width**
Spectra 800 A - 3200 A	24.00 in (609 mm)
Spectra 4000 A	32.00 in (812 mm)
Spectra 5000 - 6000 A	40.00 in (1016 mm)
NSP 1200 A - 2500 A	24.00 in (609 mm)
NSP 3200 A	32.00 in (812 mm)
NSP 4000 A – 5000 A	40.00 in (1016 mm)

				Busway locations			
				Front			**Rear**
A Depth of indoor switchgear	**D Anchor bolt spacing**	**E Depth of outdoor switchgear**	**F Sub base depth**	**Spectra 800 A - 4000 A NSP 1200 A - 3200 A**	**NSP 4000 A**	**Spectra 5000 - 6000 A**	**Spectra 800 A - 4000 A**
60.00 in (1524 mm)	66.38 in (1686 mm)	68.37 in (1736 mm)	65.00 in (1651 mm)	23.00 in (584 mm)	21.00 in (533 mm)	-	11.00 in (279 mm)
74.00 in (1879 mm)	80.38 in (2041 mm)	82.37 in (2092 mm)	79.00 in (2006 mm)	37.00 in (940 mm)	35.00 in (889 mm)	32.00 in (812 mm)	25.00 in (635 mm)

1. Refer to installation drawing and ReliaGear LV SG Installation Manual (1VAL106901-MB) for additional information.
2. End user-supplied equipment required for seismic anchor; recommended for all others.
3. Four (4) anchor clips supplied with switchgear.
4. 5000 A busway to main bus only.
5. Uppermost breaker not available.
6. 800 A – 2000 A breaker may be installed in bottom compartment of 30 inches wide sections.



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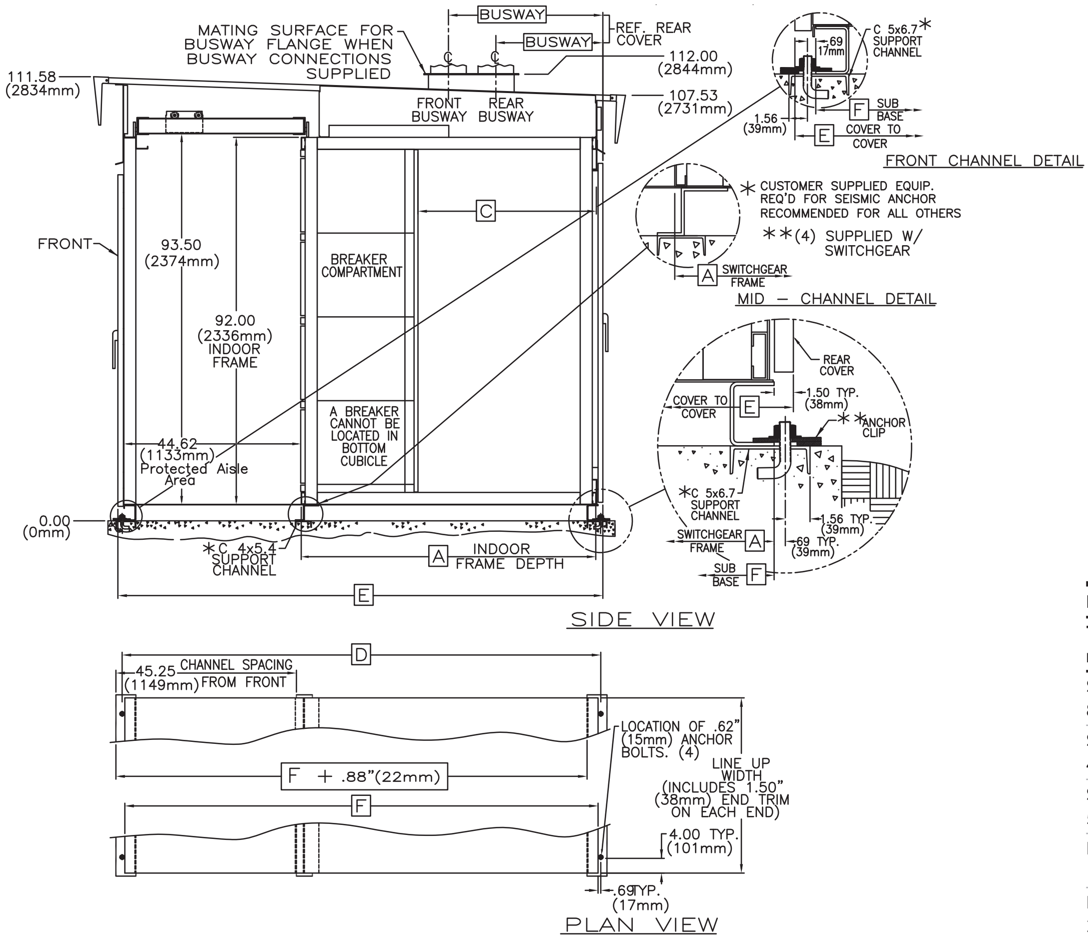
89 NEMA 3R outdoor non-walk-in floor plan and space details(1) – inches (mm)

Section width	K	N
24 in (609 mm)	19.25 in (489 mm)	16.00 in (406 mm)
32 in (812 mm)	27.25 in (692 mm)	24.00 in (609 mm)
40 in (1016 mm)	35.25 in (895 mm)	32.00 in (812 mm)

Indoor frame	L	M	P
60 in (1524 mm)	4.88 in (124 mm)	19.00 in (483 mm)	26.50 in (673 mm)
74 in (1879 mm)[2]	18.88 in (479 mm)	33.00 in (838 mm)	40.50 in (1029 mm)
74 in (1879 mm)[3]	18.88 in (479 mm)	26.00 in (660 mm)	40.50 in (1029 mm)

1. Refer to installation drawing and ReliaGear LV SG Installation Manual (1VAL106901-MB) for additional information.
2. 14 inches rear extension. Main bus ≤ 4000 A.
3. 5000A, 6000A, and 8000A bus without 5000 A breaker, 7 inches rear extension.



Busway section width required	
Type and amp rating	**Min. section width**
Spectra 800 A - 3200 A	22.00 in (558 mm)
Spectra 4000 A	30.00 in (762 mm)
Spectra 5000 A	38.00 in (965 mm)
NSP 1200 A - 2500 A	22.00 in (558 mm)
NSP 3200 A	30.00 in (762 mm)
NSP 4000 A – 5000 A	38.00 in (965 mm)

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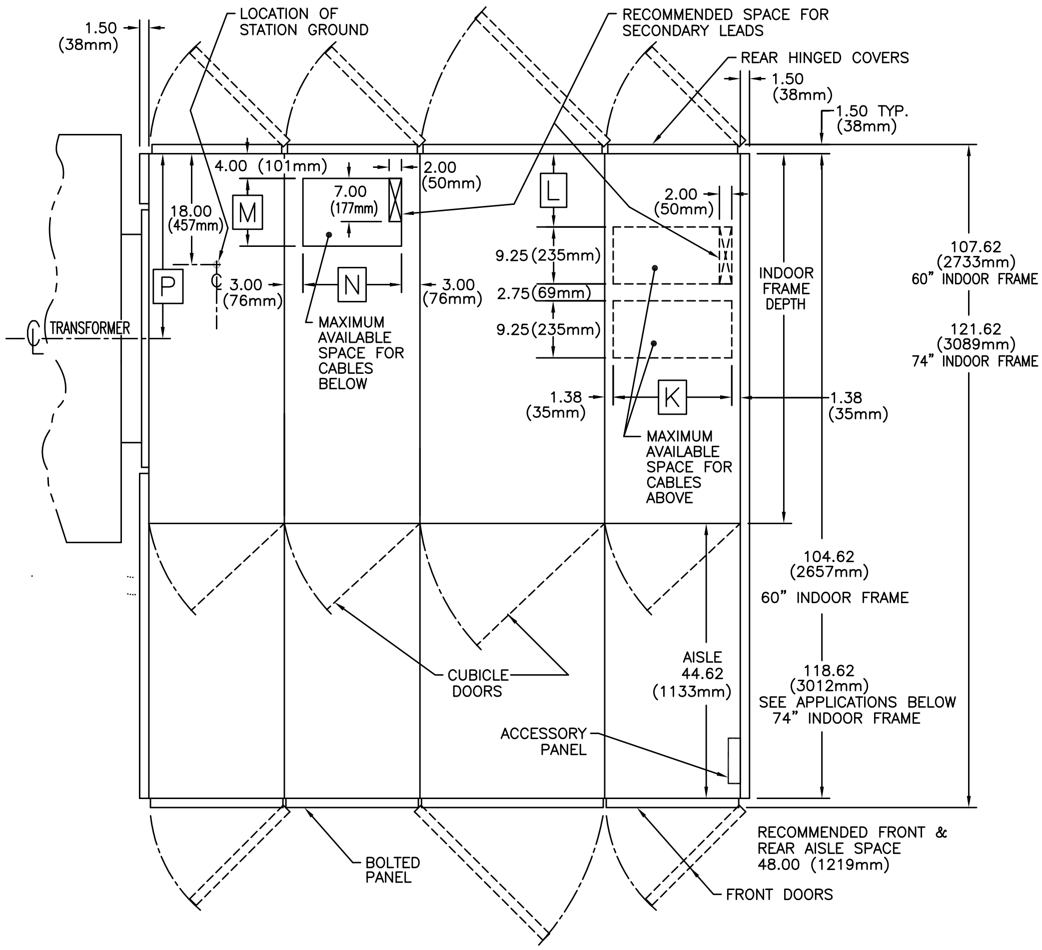
90 NEMA 3R outdoor walk-in protected aisle side view and anchoring details[1] – inches (mm)

A Depth of indoor switchgear	**D Anchor bolt spacing**	**E Depth of outdoor switchgear**	**F Sub base depth**	**Main bus busway locations Front rear spectra**	**Busway locations – Front: Spectra 800 A - 4000 A NSP 1200 A - 3200 A**	**Busway locations – Front: NSP 4000 A**	**Busway locations – Front: Spectra 5000 - 6000 A**	**Busway locations – Rear: Spectra 800 A - 4000 A**
60.00 in (1524 mm)	106.00 in (2692 mm)	107.62 in (2733 mm)	104.62 in (2657 mm)	≤ 4000 A	23.00 in (584 mm)	21.00 in (533 mm)	-	11.00 in (279 mm)
74.00 in (1880 mm)	120.00 in (3048 mm)	121.62 in (3089 mm)	118.62 in (3012 mm)	≤ 4000 A	37.00 in (939 mm)	35.00 in (889 mm)	-	25.00 in (635 mm)
				5000 - 6000 A	37.00 in (939 mm)	35.00 in (889 mm)	37.50 in (952 mm)	25.00 in (635 mm)

1. Refer to installation drawing and ReliaGear LV SG Installation Manual (1VAL106901-MB) for additional information.
2. End user-supplied equipment required for seismic anchor; recommended for all others.
3. Four (4) anchor clips supplied with switchgear.
4. 800 A – 2000 A breaker may be installed in bottom compartment of 30 inches wide sections only.



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91 NEMA 3R outdoor walk-in protected aisle floor plan and cable space details(1) – inches (mm)

Section width	K	N
22.00 in (558 mm)	19.25 in (489 mm)	16.00 in (406 mm)
30.00 in (762 mm)	27.25 in (692 mm)	24.00 in (609 mm)
38.00 in (965 mm)	35.25 in (895 mm)	32.00 in (812 mm)

Indoor frame	L	M	P
60 in (1524 mm)	4.88 in (124 mm)	19.00 in (483 mm)	26.50 in (673 mm)
74 in (1879 mm)[2]	18.88 in (479 mm)	33.00 in (838 mm)	40.50 in (1029 mm)
74 in (1879 mm)[3]	18.88 in (479 mm)	26.00 in (660 mm)	40.50 in (1029 mm)

1. Refer to installation drawing and ReliaGear LV SG Installation Manual (1VAL106901-MB) for additional information.
2. 14 inches rear extension. Main bus ≤ 4000 A.
3. 5000A, 6000A, and 8000A bus without 5000 A breaker, 7 inches rear extension.

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