IB-48010 PowLogiC

Residual Bus Automatic Transfer System
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Signal Words

As stated in ANSI Z535.4-2002, § 4.13-4.13.3 the signal word is a word that calls attention to the safety sign and designates a degree or level of hazard seriousness. The signal words for product safety signs are “Danger”, “Warning”, and “Caution”. These words are defined as:

- **DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

- **WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

- **CAUTION** indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

Not stated in ANSI Z535.4-2002, § 4.13-4.13.3 as a signal word but used in this manual is “IMPORTANT”. This is defined as:

- **IMPORTANT** indicates a section of the manual covering a non hazardous situation, but one where Powell feels proper attention is warranted.

Qualified Person

For the purposes of this manual, a qualified person, as stated in NFPA 70®, is one familiar with the construction and operation of the equipment and the hazards involved.

In addition to the above qualifications, one must also be:

1) trained and authorized to energize, deenergize, clear, ground, and tag circuits and equipment in accordance with established safety practices.

2) trained in the proper care and use of personal protective equipment (PPE) such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.

3. trained in rendering first aid if necessary.
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1 - General Information

![WARNING]

The equipment described in this document may contain high voltages and currents which can cause serious injury or death.

The equipment is designed for use, installation, and maintenance by knowledgeable users of such equipment having experience and training in the field of high voltage electricity. This document and all other documentation shall be fully read, understood, and all warnings and cautions shall be abided by. If there are any discrepancies or questions, the user shall contact Powell immediately at 1.800.480.7273.

![WARNING]

Before any adjustment, servicing, part replacement, or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, the power supply must be disconnected. Failure to follow this warning may result in injury or death.

![IMPORTANT]

The information in this instruction bulletin is not intended to explain all details or variation of the PowLogiC Residual Bus Automatic Transfer System, nor to provide for every possible contingency or hazard to be met in connection with installation, testing, operation, and maintenance of the equipment. For additional information and instructions for particular problems, which are not presented sufficiently for the user’s purposes, contact Powell at 1.800.480.7273.
A. SCOPE

This instruction bulletin is intended to assist users in the design and safe operation of the PowLogiC Residual Bus Automatic Transfer System.

B. PURPOSE


The PowLogiC Residual Bus Automatic Transfer System is used in conjunction with switchgear circuit breakers and can be physically mounted either internal to switchgear or in a separate external, wall-mounted enclosure.

This instruction bulletin includes typical design features of the PowLogiC Residual Bus Automatic Transfer System. It should be used in conjunction with reference documents and related circuit breaker, switchgear and accessory equipment instruction bulletins.

This document provides:

1) A description of the operation and some options of the PowLogiC Residual Bus Automatic Transfer System
2) Transfer system control basics
3) Transfer system considerations
4) Typical protection and control relay setting considerations
5) Additional power system design considerations
6) Transfer system alarms
7) Human machine interface recommendations

C. ILLUSTRATIONS

The illustrations within this instruction bulletin are general and may not represent the project construction details of the user's specific equipment and application. For project specifics, refer to pertinent project and equipment documents and drawings.

D. INSTRUCTION BULLETINS AVAILABLE ELECTRONICALLY

For more information visit www.powellind.com. To contact the Powell Service Division call 1.800.480.7273 or 713.944.6900, or email info@powellservice.com.

E. STANDARDS AND CODES

Because of the national standards, local codes, and ordinances vary, the user is responsible for determining the applicable aspects and details of this instruction bulletin.
Ch 2  Safety

A. SAFE WORK CONDITION

The information in part A of this section is quoted from NFPA 70E 2004 - Article 120, 120.1 Establishing an Electrically Safe Work Condition.

120.1 Process of Achieving an Electrically Safe Work Condition

1) Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

2) After properly interrupting the load current, OPEN the disconnecting device(s) for each source.

3) Wherever possible, visually verify that all blades of the disconnecting devices are fully OPEN or that drawout type circuit breakers are withdrawn to the fully disconnected position.

4) Apply lockout/tagout devices in accordance with a documented and established policy.

5) Use an adequately rated voltage detector to test each phase conductor or circuit part to verify they are deenergized. Test each phase conductor or circuit part both phase-to-phase, and phase-to-ground. Before and after each test, determine that the voltage detector is operating satisfactorily.

6) Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

B. SAFETY GUIDELINES

Study this instruction bulletin and all other associated documentation before operating the Residual Automatic Bus Transfer System.

Each user has the responsibility to instruct and supervise all personnel associated with usage, installation, operation, and maintenance of this equipment on all safety procedures. Furthermore, each user has the responsibility of establishing a safety program for each type of equipment encountered.

It is mandatory that the following rules be observed to ensure the safety of personnel associated with usage, installation, operation, and maintenance of these circuit breakers.

The safety rules in this instruction bulletin are not intended to be a complete safety program. The rules are intended to cover only some of the important aspects of personnel safety related to the PowLogiC Residual Bus Automatic Transfer System.

C. GENERAL

1) Only supervised and qualified personnel trained in the usage, installation, operation, and maintenance of the system shall be allowed to work on this equipment. It is mandatory that this instruction bulletin, any supplements, and service advisories be studied, understood, and followed.

2) Maintenance programs must be consistent with both customer experience and manufacturer’s recommendations, including service advisories and instruction bulletin(s). A well-planned and executed routine maintenance program is essential for circuit breaker’s reliability and safety.
3) Service conditions and system applications shall also be considered in the development of safety programs. Variables include ambient temperature; humidity; actual continuous current; thermal cycling; number of operations; interrupting duty; and any adverse local conditions including excessive dust, ash, corrosive atmosphere, vermin, and insect infestations.

D. SPECIFIC

1) DO NOT WORK ON AN ENERGIZED CIRCUIT BREAKER. If work must be performed on a circuit breaker, remove it from service and remove it from the metal-clad switchgear.

2) DO NOT WORK ON A CIRCUIT BREAKER WITH THE CONTROL CIRCUIT ENERGIZED.

3) EXTREME CARE MUST BE EXERCISED TO KEEP ALL PERSONNEL, TOOLS, AND OTHER OBJECTS CLEAR OF MECHANISMS WHICH ARE TO BE OPERATED, DISCHARGED, OR RELEASED. These circuit breakers utilize stored-energy mechanisms. These mechanisms must be serviced only by skilled and knowledgeable personnel capable of releasing each spring load in a controlled manner. Detailed information regarding these mechanisms is found in this instruction bulletin.

4) DO NOT ATTEMPT TO CLOSE THE CIRCUIT BREAKER MANUALLY ON AN ENERGIZED CIRCUIT.

5) DO NOT USE AN OPEN CIRCUIT BREAKER AS THE SOLE MEANS OF ISOLATING A HIGH VOLTAGE CIRCUIT. For complete isolation, the circuit breaker shall be in the disconnected position or shall be withdrawn completely.

6) ALL COMPONENTS SHALL BE DISCONNECTED BY MEANS OF A VISIBLE BREAK AND SECURELY GROUNDED FOR SAFETY OF PERSONNEL PERFORMING MAINTENANCE OPERATIONS ON THE CIRCUIT BREAKERS.

7) Interlocks are provided to ensure the proper operating sequences of the circuit breakers and for the safety of the user. If for any reason an interlock does not function as described, do not make any adjustments, modification, or deform the parts. DO NOT FORCE THE PARTS INTO POSITION. CONTACT POWELL FOR INSTRUCTIONS.

E. SAFETY LABELS

The equipment described in this document has DANGER, WARNING, CAUTION, and instruction labels attached to various locations. All equipment DANGER, WARNING, CAUTION, and instruction labels shall be observed when the medium-voltage controller is handled, operated, or maintained.

![IMPORTANT]

**Warning and Caution labels are located in various places in and on the switchgear and on the circuit breaker removable element. Always observe these warnings and caution labels. Do NOT remove or deface any of these warning/caution labels.**
F. OPERATING SEQUENCE NAMEPLATE

Operating Sequence Nameplate(s) must be thoroughly reviewed and understood before operating the PowLogiC Residual Bus Automatic Transfer System.

G. SAFE USE OF THE TRANSFER SCHEME

This instruction bulletin is intended to assist users in the design and safe operation of the PowLogiC Residual Bus Automatic Transfer System.

Each user has the responsibility to instruct and supervise all personnel using the PowLogiC Residual Bus Automatic Transfer System. Only qualified personnel trained in the use of the PowLogiC Residual Bus Automatic Transfer System should be allowed to operate the equipment.

Because the PowLogiC Residual Bus Automatic Transfer System is a control application used in conjunction with switching equipment, the user must thoroughly understand this instruction bulletin and associated project documents and equipment drawings. Prior to operation, the user must understand the following project and equipment documents:

- PowLogiC PLC ladder logic
- PowLogiC equipment drawings
- PowLogiC operating sequence nameplate(s)
- Switchgear drawings and instruction bulletins
- Circuit breaker drawings and instruction bulletins
- Pertinent project operating sequence documents
- Project specifications
Ch 3 Description

The Figure 1, one-line diagram represents a typical PowLogiC Secondary Selective Substation Residual Bus Automatic Transfer System. The discussions of this document assume upstream three-phase tripping equipment is implemented, thereby inhibiting single-phase conditions. When upstream fuses are applied, additional single-phase considerations must be investigated to prevent single-phasing the downstream bus.

Figures 1 through 9 indicate open-delta potential transformer (PT) configurations. The voltage sensing input for the automatic transfer system must be thoroughly reviewed because electrical systems may be solid or resistance grounded and PT configurations may be wye-wye, delta-wye, etc. Failure to provide adequate initial engineering design, review, and checking may result in non-operation or misoperation of the automatic transfer system.

Automatic transfer systems that include standby generator operation are beyond the scope of this instruction bulletin.

Programmable Logic Controller (PLC) technology is utilized for a modern PowLogiC application solution to complex transfer control. A PLC provides separate control for a more flexible and more robust transfer system with enhanced diagnostic and communications capability. With PLC technology, load shedding and motor reacceleration can be included in the control logic.

When compared with discrete component transfer systems, PLC control modifications typically do not require additional hardware or re-wiring, and troubleshooting is significantly simplified via graphical ladder logic representation on a computer monitor.

To make the transfer system commentaries more easily understood, Figure 3 shows a traditional discrete device transfer configuration and Table A provides a glossary of device nomenclature. When compared with traditional discrete device transfer systems, PLC implementation uses fewer control devices. For equipment and control specifics, refer to the project equipment drawings and PLC ladder logic diagrams.

Figures 1 through 9 show medium voltage and low voltage examples with typical grounding configurations, i.e., solid ground, low resistance ground and high resistance ground.

Operator notification alarms are available for connection to an existing Distributed Control System (DCS) or other remote Human Machine Interface (HMI), cellular phones, pagers, etc. Cellular phone notification may include an electronic speech message, whereas, pagers are limited to text messaging.

A remote HMI, such as a Touchpanel or industrial personal computer (PC), enables an operator to perform manual transfer switching outside equipment arc flash zones, a significant safety advantage.


Using Figures 1 through 13 as references, the discussions investigate transfer control, protection and control settings, system design considerations, alarms, modifications, and HMI recommendations.

Note: To reference equipment and device numbers included in Figures 1 through 13. See Table A Glossary of Applicable Device Numbers and Terms. The glossary lists equipment and device numbers and corresponding descriptions.
Ch 4  Control Basics

A. OVERVIEW

Secondary selective systems provide operational and maintenance flexibility, and enhanced load recovery following a fault or significant voltage depression. Figure 1 shows a typical secondary selective system in the normal operating configuration.

The typical Secondary Selective System normal operating configuration is as follows:

- Breaker 52A racked-in and closed
- Breaker 52B racked-in and closed
- Breaker 52T racked-in and open

PowLogiC transfer systems automatically reestablish power to a main bus following voltage transients.

Some voltage transient examples are:

- Loss of one incoming source at the upstream substation switchgear
- Switching error at an upstream feeder breaker
- Transformer primary feeder cable fault
- Local substation transformer failure
- Incoming circuit breaker line side cable or bus duct failure

Transfer is allowed during stable alternate bus conditions with normal system voltage available to maintain or reaccelerate operating loads. Transfer is blocked during downstream, through fault conditions. Secondary selective system main bus faults are isolated by tripping the incoming breaker and blocking tie breaker closing.

Closed transition (make-before-break) manual transfer operations are permitted for retransfer-to-normal conditions. During plant maintenance, expansions, or modifications, closed transition manual transfer achieves system reconfiguration with minimal or no impact to operating loads.

| CAUTION |
| Do not manually open an incoming breaker to initiate a transfer. Manually opening an incoming breaker isolates and deenergizes one side of the main bus, deenergizes online motors and loads, and “disarms” the automatic transfer system. |

B. PLC INTERPOSING RELAYS

The PowLogiC transfer system uses interposing relays between the PLC contact outputs and breaker close and trip circuits.

C. INSTANTANEOUS BLOCKING RELAYS 50 AND 50G (or 50N)

Incoming breaker phase instantaneous relay 50, transformer neutral instantaneous ground relay 50G, or incoming breaker residual ground relay 50N inhibit transfer during fault conditions and are not part of the breaker protection scheme.

During downstream feeder phase faults, the 50 relay instantaneously blocks transfer until the downstream feeder breaker trips. The 50 relay inhibits transfer during bus phase faults until the incoming breaker 51 relay causes incoming breaker tripping and tie breaker close circuit blocking.
The 50G (or 50N) relay function is similar to the 50 relay blocking operation, except the 50G (or 50N) relay reacts to ground faults. During downstream feeder ground faults, the incoming breaker 50G (or 50N) relay instantaneously blocks transfer until the downstream feeder breaker trips. The 50G (or 50N) relay inhibits transfer during bus ground faults until the incoming breaker 51G (or 51N) relay trips the incoming breaker and blocks tie breaker closing.

D. TIME-OVERCURRENT PROTECTION RELAYS 51 AND 51G (OR 51N)

Incoming breaker 51 relay and 51G (or 51N) relay provide main bus primary protection and feeder breaker failure backup protection. A 51 relay or 51G (or 51N) relay operation trips a lockout relay and the lockout relay (86) trips and blocks closing both an incoming breaker and a tie breaker.

When a 51, 51G (or 51N) relay provides a direct trip command to the breaker trip coil, an additional trip contact can be provided in the 51 and 51G (or 51N) relays for incoming and tie breaker direct trip operation.

E. LOCKOUT RELAYS – RELAYS 86, 86BD, 86T, 86HRG

The PowLogiC automatic transfer system design recommends lockout relays to make operators investigate and resolve a trip condition prior to closing an incoming or tie breaker.

If a lockout relay is tripped following a protection relay operation, facility operating procedures may not allow the operator to close the incoming breaker without approval from electrical personnel.

Some lockout relay applications are as follows:

- 86 - bus fault or downstream feeder breaker failure
- 86BD - bus differential
- 86T - transformer differential
- 86HRG - high resistance ground

F. AUTO/BYPASS SWITCH

The AUTO/BYPASS switch (Device 43) is provided for automatic or manual control of the transfer system. Typically, automatic operation is the preferred method of operation and the AUTO/BYPASS switch is in the AUTO position. During program downloads for logic software changes or enhancements, or for PLC replacement, the PLC can be bypassed and manual control operations implemented. In the BYPASS position, main or tie breaker control is performed manually and automatic transfer is inhibited.

Note: Unless explicitly stated, the discussions assume the AUTO/BYPASS switch is in AUTO.

1) AUTO Position - Normal Operation

In AUTO with PLC logic satisfied, the PLC energizes interposing relays for closing and tripping breaker 52A, breaker 52B, and breaker 52T (see Figures 10, 11, and 12). For detailed close circuit discussions, refer to Ch 4 CONTROL BASICS, G. CLOSE CIRCUIT OPERATION.

CAUTION

Prior to racking-in or racking-out breakers 52A, 52B, or 52T, ensure the AUTO/BYPASS switch is in the BYPASS position. The BYPASS position inhibits the automatic transfer system from issuing a close or trip command to breakers 52A, 52B, or 52T.

2) BYPASS Position - Maintenance

In BYPASS, PLC output close or trip commands to the interposing relays
are inhibited. If non-PLC close circuit permissives, such as 25X, 86, 52/TOC are satisfied, control switch CLOSE operation results in breakers 52A, 52B, or 52T closing (see Figures 10, 11, and 12). For detailed close circuit discussions, refer to Ch 4 CONTROL BASICS, G. CLOSE CIRCUIT OPERATION.

3) BYPASS Alarm

AUTO/BYPASS switch contacts are available for local or remote annunciation. Annunciation is further described in Ch 8 TRANSFER SYSTEM ALARMS.

4) PLC Input Power Failure

Failure of input power to the PLC deenergizes the AUTO/BYPASS auxiliary relay and switches control from the PLC to breaker control switch manual operation. The AUTO/BYPASS switch is a manually operated switch, and during this condition does not change from the AUTO position.

G. CLOSE CIRCUIT OPERATION

Figures 10, 11, and 12 show a basic main or tie breaker close circuit configuration with control permissives as follows:

- PLC in AUTO or BYPASS
- Upstream transfer trip (94)
- Main breaker lockout relay trip (86)
- Main and tie breaker position using breaker auxiliary contacts
- Sync check relay 25 in-phase transfer confirmation
- High-resistance ground lockout (86 HRG)

Note: For specific projects, the detailed project breaker control drawings should be referenced.

1) AUTO/BYPASS Switch - AUTO Mode

In the AUTO mode (the normal operating mode), the AUTO/BYPASS switch is in the AUTO position with the 43/AUTO contacts closed and the 43/BYPASS contacts open. To close the breaker in the AUTO mode, operate the breaker control switch to the CS/C closed position. Separate CS/C closed contacts are input to the PLC and also hard wired in the breaker close circuit.

If PLC logic is satisfied, PLC output contacts and interposing relay contacts close, thereby powering the close circuit to the 43/AUTO contacts. In AUTO, with all other close circuit permissives satisfied (contacts closed), the breaker close coil is energized, and subsequently, the breaker closes.

2) AUTO/BYPASS Switch - BYPASS Mode

In the BYPASS mode, the AUTO/BYPASS switch is in the BYPASS position with 43/BYPASS contacts closed and 43/AUTO contacts open. To close the breaker in the BYPASS mode, operate the breaker control switch to the CS/C closed position. Therefore, the CS/C hard wired contacts in the CLOSE circuit close, 43/BYPASS contacts are closed, and with all other CLOSE circuit permissives satisfied (contacts closed), the breaker CLOSE coil is energized, and subsequently, the breaker closes.

Although separate CS/C contacts to the PLC input may close, the PLC outputs are inhibited from closing in the BYPASS mode and the 43/AUTO contacts are open; hence, in BYPASS, the breaker cannot close from this electrical circuit path.
3) **Upstream 94 Transfer Trip**

When implemented, tripped upstream feeder breaker 94 contacts inhibit incoming breaker close circuit operation. The upstream 94 relay must be reset to confirm trip conditions do not exist. For additional discussions, refer to Ch 4 CONTROL BASICS, H. TRIP CIRCUIT OPERATION.

4) **Lockout Relay 86 Reset**

The 86 relay must be reset to confirm trip conditions do not exist. For additional discussions refer to Ch 4 CONTROL BASICS, E. LOCKOUT RELAYS - RELAYS 86, 86BD, 86T, 86HRG.

5) **25 Sync Check**

Breakers 52A, 52B, and 52T auxiliary “b” contacts and sync check (25) relay contacts are configured to inhibit out-of-phase paralleling of the two incoming sources. In AUTO, the in-phase hard wire contact configuration duplicates the PLC logic and adds backup permissive control. However, in BYPASS, with the PLC in-phase logic bypassed, this hard wire out-of-phase inhibit provides primary permissive control and permits system paralleling by 25 relay confirmation.

**H. TRIP CIRCUIT OPERATION**

The most important consideration about trip circuit operation is “Trip is Trip.” Trip contacts from control or protection devices are always direct connected to the TRIP COIL (see Figure 13). Trip contact examples are control switch CS/T contacts, overcurrent trip contacts, transfer trip 94 contacts, lockout relay 86 contacts, differential protection contacts, etc.

Output contacts from protective devices used for control logic or other non-protection application must be a separate set of dedicated contacts. Protection trip contacts used as an input to a PLC must be a second set of protective device output contacts.

**I. 10-SWITCH - TRIP 52A, TRIP 52T, TRIP 52B**

The 10-Switch is a 3-position selector switch with no OFF position and has the following positions:

- TRIP breaker 52A
- TRIP breaker 52T
- TRIP breaker 52B

The 10-Switch is used for manual operations, such as, maintenance or retransfer to the normal secondary selective configuration. The 10-Switch position shows which breaker will trip when manually paralleling the secondary selective substation incoming sources. The 10-Switch position is pre-selected by the operator before manually, momentarily paralleling the electrical system incoming sources.

As an example, assume an automatic transfer has occurred and breakers 52A and 52T are closed. Returning the system to the normal configuration requires closing breaker 52B and automatically tripping breaker 52T. With the operator pre-selecting the 10-Switch to the TRIP 52T position and closing breaker 52B, the incoming sources are momentarily paralleled and breaker 52T trips.

Unlike typical discrete transfer schemes, PLC logic is configured to inhibit an incoming or tie breaker from closing and immediately tripping because of incorrect 10-Switch selection. Three 10-Switch inhibit conditions are as follows:

- With breakers 52B and 52T closed and the 10-Switch in TRIP 52A position, breaker 52A is inhibited from closing
• With breakers 52A and 52T closed and the 10-Switch in TRIP 52B position, breaker 52B is inhibited from closing.
• With breakers 52A and 52B closed and the 10-Switch in TRIP 52T position, breaker 52T is inhibited from closing.

J. PLC UNDervoltage RELAYS 27, 27I, 27R, 27RI, AND TIMERS

With PLC technology, “A” side and “B” side voltage relays 27, 27I, and 27R and discrete timers 96, 97, and 98 are replaced with voltage transducers and a PLC. Instead of undervoltage relays, a modern equivalent is formed by analog voltage transducers signaling PLC analog sensing inputs and internal logic. This is a particularly convenient replacement for residual undervoltage 27R relay which has a low range set point requirement. Also, PLC timers are inherently abundant, easily accommodating 96, 97, 98 timing function requirements.

Figure 3 shows the discrete device function numbers referenced in the following discussions. When Figure 1 is reviewed, discrete undervoltage relays and discrete timers are replaced by voltage transducers and a PLC.

The following provides a general description of the 27, 27I, 27R, and 27RI permissive/inhibit functions.

• 27 - Transfer system initiator requires depressed incoming source voltage.
• 27I - Incoming breaker close inhibit requires stable incoming voltage. (In discrete automatic transfer systems, the 27I and main breaker auxiliary contact 52AUXa provide a transfer inhibit to confirm stable switchgear voltage before transfer is permitted.)
• 27RI - Transfer permissive requires a stable alternate bus voltage. (This function is not provided in discrete automatic transfer systems.)
• 27R - Final transfer command inhibits transfer until bus voltage is within NEMA MG-1 motor slow transfer or reclosing voltage limits.

For expanded voltage relay discussions, refer to Ch 6 TYPICAL PROTECTION AND CONTROL RELAY SETTING CONSIDERATIONS.

K. INCOMING BREAKER - CLOSE AND TRIP CIRCUITS

Before closing an incoming circuit breaker, the breaker must be in the racked-in position, defined by ANSI as racked onto the bus. A closed truck operated contact (TOC) confirms the breaker is racked onto the bus.

• Breaker 52A truck operated cell switch must be closed before breaker 52A can be closed.
• Breaker 52B truck operated cell switch must be closed before breaker 52B can be closed.
• Breaker 52T truck operated cell switch must be closed before 52T can be closed.

CAUTION

Final voltage settings and time delays must be thoroughly reviewed to comply with project specifics. If upstream transfer and/or motor group reacceleration is implemented, further investigation and review is required to determine final voltage relay time delay settings.
1) **Manually Close an Incoming Breaker**

- Incoming circuit breaker is racked-in (Truck operated cell switch closed)
- Lockout relay 86 is in the RESET position (not tripped)
- No 50 relay or 50G (or 50N) relay transfer blocking operations
- Undervoltage inhibit 27I relay confirms stable incoming source voltage
- Sync-check relay 25 confirms both incoming sources are synchronized, or breaker position auxiliary contact logic confirms not more than one incoming or tie breaker is closed
- With these conditions satisfied, incoming breaker control switch CLOSE operation initiates incoming breaker closing command via PLC and interposing relay logic

Protection tripping devices directly trip the circuit breaker.

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2) **Incoming Breaker Direct Trip Examples**

- Tripping the breaker via the CS/T control switch
- 51 relay or 51G (or 51N) relay fault operation via lockout relay 86 (also trips and blocks closing breaker 52T)
- 87T relay, 63 relay, or 51G relay operation via lockout relay 86T
- PLC and interposing relay trip command

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**L. INCOMING BREAKER - MANUAL TRANSFER CIRCUIT**

Manual transfer is permitted for maintenance or retransfer to normal secondary selective system operation.

1) **Manually Transfer Bus “B” Loads to Bus “A” Example**

- Breaker 52A is racked-in and closed, Breaker 52B is racked-in and closed, Breaker 52T is racked-in and open
- Lockout relay 86-A1 is in the RESET position (not tripped)
- 10-Switch is in the TRIP 52B position
- No 50 relay or 50G (or 50N) relay transfer blocking operations
- Sync-check relay 25 confirms both incoming sources are synchronized
- With these conditions satisfied, breaker 52T control switch manual CLOSE operation initiates breaker 52T closing
- PLC logic via an interposing relay results in breaker 52T closing, momentarily paralleling the system
- After breaker 52T auxiliary contacts confirm the tie breaker 52T is closed, the PLC issues a trip command via an interposing relay to breaker 52B trip circuit
• This results in breaker 52B tripping
• This completes the manual closed transition transfer with bus “B” loads powered by bus “A”

After maintenance upstream of breaker 52B is complete, the switchgear can be returned to the normal configuration via a manual make-before-break transfer operation.

2) Return-to-Normal Operating Conditions Example

• 10-Switch is placed in the TRIP 52T position
• Lockout relay 86-B1 is in the RESET position (not tripped)
• No 50 relay or 50G (or 50N) relay transfer blocking operations
• Relay 27I-B with time delay confirms incoming source “B” voltage is stable
• Breaker 52B truck operated cell switch confirms breaker 52B is racked-in
• Breaker 52B auxiliary contact confirms breaker 52B is open
• Sync-check relay 25 confirms both incoming sources are synchronized
• With these conditions satisfied, breaker 52B control switch CLOSE operation initiates breaker 52B closing
• PLC logic via an interposing relay results in breaker 52B closing, momentarily paralleling the system
• After breaker 52B auxiliary contacts confirm breaker 52B is closed, the PLC issues a trip command via an interposing relay to breaker 52T trip circuit
• This results in breaker 52T tripping
• The manual closed transition transfer is complete with the secondary selective system returned to the normal operating configuration

M. TRANSFER SYSTEM “ARMING” AND AUTOMATIC TRANSFER EXAMPLE

Before automatic transfer can occur, the transfer system must be “armed”.

1) Transfer System “Arming”

• Breaker 52A is racked-in and closed
• Breaker 52B is racked-in and closed
• Breaker 52T is racked-in and open
• PLC AUTO/BYPASS switch is in the AUTO position
• Lockout relays 86-A1 and 86-B1 are in the RESET position
• With these conditions all satisfied, the transfer system is “armed” and ready for transfer. Refer to Ch 5 ADDITIONAL TRANSFER SYSTEM CONSIDERATIONS, J. BUS READY FOR TRANSFER LIGHTS.

2) Loss of Incoming Source “A” After “Arming” Example

• The automatic transfer system is “armed”
• After a delay, 27-A relay initiates a transfer logic command
• Lockout relay 86-A1 is in the RESET position (not tripped)
• No 50 relay or 50G (or 50N) relay transfer blocking operations
• Relay 27RI-B with time delay confirms bus “B” voltage is stable
• Relay 27R-A confirms bus “A” voltage has decremented to acceptable motor reclose voltage magnitudes
• With these conditions satisfied, the PLC via an interposing relay issues a trip circuit command to breaker 52A
• After breaker 52A auxiliary contacts confirm breaker 52A is open, the PLC issues a close command via an interposing relay to breaker 52T close circuit
• This results in breaker 52T closing
• This completes the automatic transfer

3) Return-to-Normal Switchgear Configuration Example

• 10-Switch is placed in the TRIP 52T position
• Lockout relay 86-A1 is in the RESET position (not tripped)
• No 50 relay or 50G (or 50N) relay transfer blocking operations
• Relay 27I-A with time delay confirms incoming source “A” voltage is stable
• Breaker 52A “TOC” contacts confirm breaker 52A is racked-in
• Breaker 52A auxiliary contacts confirm breaker 52A is open
• Sync-check relay 25 confirms both incoming sources are synchronized
• With these conditions satisfied, breaker 52A control switch CLOSE operation initiates breaker 52A closing
• PLC logic via interposing relays results in breaker 52A closing, momentarily paralleling the system
• After 52A auxiliary contacts confirm breaker 52A is closed, the PLC issues a trip command via an interposing relay to breaker 52T trip circuit
• This results in breaker 52T tripping
• The manual closed transition transfer is complete with the secondary selective system returned to the normal operating configuration

N. TIE BREAKER - CLOSE AND TRIP CIRCUITS

Tie breaker 52T close and trip circuit logic is similar to incoming breaker close and trip logic.

1) Manually Close Breaker 52T Example

• Breaker 52T is racked-in and breaker 52T truck operated contacts are closed
• Sync-check relay 25 confirms both incoming sources are synchronized, or breaker position auxiliary contact logic confirms not more than one incoming breaker is closed
• No 50 relay or 50G (or 50N) relay transfer blocking operations
• Lockout relays 86-A1 and 86-B1 are in the RESET position (not tripped)
• 10-Switch is not in the Trip 52T position
• With these conditions satisfied, breaker 52T control switch CLOSE operation initiates breaker 52T closing via PLC and interposing relay logic. If both breakers 52A and 52B are closed, the incoming breaker corresponding to the 10-Switch position will trip

2) Breaker 52T Trip Examples

• Tripping the tie breaker 52T via the control switch
• 51 relay or 51G (or 51N) relay operation via incoming breaker lockout relay 86 (also trips an incoming breaker)
• PLC and interposing relay trip command
O. INHIBIT TIE BREAKER 52T FROM AUTOMATICALLY CLOSING DURING RACKING-IN

Automatic breaker closing during racking-in is a significant safety concern for electrical personnel. This condition could exist if the automatic transfer system is “armed”, the AUTO/BYPASS switch is in AUTO, and breaker 52T is removed for maintenance activities. If 27 relay with time delay detects a loss of incoming source voltage and no transfer inhibits exist, a transfer command is initiated upon racking-in breaker 52T, an incoming breaker trips and breaker 52T automatically closes. This unexpected automatic transfer operation could occur, unless adequate maintenance precautions are performed and a PLC logic inhibit is implemented for this condition. To inhibit breaker 52T from automatically closing during the racking-in operation, the AUTO/BYPASS switch must be in the BYPASS position.

An optional solution is to automatically disable the transfer logic on loss of only one incoming source voltage. Typically, a 60 to 120 second delay can be implemented in PLC logic to “ride through” transient conditions, such as, depressed system voltage during group motor reacceleration periods. The extended time delay allows completion of reacceleration operations, but it is less time than an operator can travel to the switchgear building and perform a racking-in operation.

P. LOSS OF BOTH INCOMING SOURCES

Upon the sudden loss of both incoming sources with both incoming breakers closed, control logic inhibits tripping incoming breakers. Otherwise, operators will be required to visit numerous downstream switchgear buildings and close tripped incoming breakers. This can be a very time consuming task in a major facility. Hence, the momentary or continued loss of both incoming sources at downstream substations should not result in opening breaker 52A or breaker 52B.

![CAUTION]

Prior to racking-in breaker 52T, ensure the AUTO/BYPASS switch is in the BYPASS position. The BYPASS position inhibits the automatic transfer system from issuing a close or trip command to breaker 52T.
**Ch 5 Additional Transfer System Considerations**

**A. UPSTREAM AUTOMATIC TRANSFER SYSTEM**

Upstream medium-voltage switchgear with an automatic transfer system must switch before a downstream substation transfer occurs. An upstream transfer operation reestablishes power to both upstream distribution buses, and makes the transfer operation of multiple downstream switchgear automatic transfer systems unnecessary.

PLC transfer systems easily accommodate additional times delays for upstream transfers without the need for additional timing relays. Providing additional delay with discrete transfer systems may require adding timing relay 98 to increase the time before downstream transfer is initiated.

**B. 25 SYNC-CHECK RELAY AND 25X AUXILIARY RELAY**

The sync-check circuit consists of a 25 sync-check relay with contacts for breaker 52A, breaker 52B, and breaker 52T close circuits. Internal PLC logic for breaker auxiliary contacts permits closing of two breakers, but inhibits all three breakers (52A, 52B, and 52T) from being closed at the same time. However, with the two incoming sources in synchronism, the 25 relay permits momentary paralleling of the incoming sources.

With the AUTO/BYPASS switch in BYPASS, or a PLC failure, breaker auxiliary contact logic can be hard wired in breaker 52A, breaker 52B, and breaker 52T close circuits to inhibit breaker closing without 25 relay permission.

The sync-check relay is not required when both incoming sources originate from the same synchronized upstream substation and the two incoming sources cannot be out of synchronism.

The initial electrical power system configuration may not require a sync-check relay, however, future upstream industrial or utility system modifications or operating procedures may result in out-of-phase source conditions. Including the 25 sync-check relay in the initial transfer system design accommodates future out-of-phase system operating conditions without equipment modification.

**C. BUS DIFFERENTIAL RELAY 87B**

Adding high-impedance bus differential relay 87B to medium voltage switchgear significantly reduces main bus fault clearing time and results in reduced arc flash conditions. Without an instantaneous trip from relay 87B, the 51 and 51G (or 51N) relays must pickup and time out prior to submitting a breaker trip command.

**D. TRANSFORMER DIFFERENTIAL RELAY 87T**

Transformer differential relay 87T downstream zone of protection should not include breaker 52A or breaker 52B load terminals. Including breaker 52A and breaker 52B line terminals in the differential zone allows tripping actions from 87T relay and lockout relay 86T to isolate the faulted transformer. This permits relay 27 to issue a transfer command after time delay.

**E. HIGH RESISTANCE GROUNDING**

High resistance grounding (Figures 5, 8, and 9) inhibits breaker tripping during a line-to-ground fault and requires operator intervention to detect and isolate the fault. If a ground fault exists on only one side of the switchgear, automatic transfer operation is permitted. If a ground exists on both “A” side and “B” side, PLC logic blocks transfer. To achieve this inhibit condition, an interlock, such as, additional 86HRG-A and 86HRG-B relays is required.
F. BREAKER 52T OVERCURRENT PROTECTION RELAYS 51 AND 51G (OR 51N)

When implementing 51 and 51G (or 51N) relays for tie breaker protection, additional breaker 52A and breaker 52B tripping time is required for selectivity with tie breaker 52T.

G. UPSTREAM BREAKER AUXILIARY CONTACT CLOSE PERMISSIVE

Some projects require upstream breaker close confirmation before the downstream incoming breaker can be closed. This is achieved by adding an upstream switchgear feeder breaker auxiliary contact in the downstream incoming breaker close circuit.

H. UPSTREAM SWITCHGEAR FEEDER BREAKER 94 TRANSFER TRIP

For faster system isolation after an upstream feeder circuit breaker trip, include a feeder breaker 94 transfer trip relay to trip the downstream substation incoming main circuit breaker. Implementing a transfer trip achieves faster system fault isolation, and the automatic transfer system operates more quickly because transfer initiation by the 27 undervoltage time delay is not necessary. When applying this optional logic condition, PLC control logic may require modification. This control function is easily accommodated when the upstream and downstream switchgear are inside the same building or in adjacent buildings.

I. DOWNSTREAM SWITCHGEAR 94 TRANSFER TRIP

System tripping can be enhanced by including a transfer trip from the downstream substation switchgear incoming breaker to the upstream feeder breaker trip circuit. This is particularly useful with low resistance grounding and transformer neutral 51G relays at the downstream substation, because the upstream feeder phase protection cannot sense the low magnitude ground fault on the secondary side of the downstream transformer.

Downstream switchgear 86T-A1 and 86T-B1 lockout relays can provide a transfer trip to upstream feeder breaker mounted 94A and 94B high impedance auxiliary relays. Lockout relay 86T-A1 operates relay 94A, and lockout relay 86T-B1 operates relay 94B. Relays 94A and 94B are powered by upstream DC control power. If the distance between lockout relay 86T-A1 and 94A relay is “near” (inside the same building or in adjacent buildings), the lockout relay 86T-A1 contacts could be directly inserted into the upstream switchgear trip and close circuits, eliminating the 94A relay. Likewise, lockout relay 86T-B1 contacts could be directly inserted into the upstream switchgear trip and close circuits, eliminating the 94B relay.

J. BUS READY FOR TRANSFER LIGHTS

When required by project specifications, Bus “A” Ready For Transfer and Bus “B” Ready For Transfer lights may be provided on the breaker 52T front door.
Ch 6 Typical Protection and Control Relay Setting Considerations

A. TRANSFER BLOCKING DURING FAULTS

As previously described, incoming breaker 50 and 50G (or 50N) relays block transfer during feeder or bus faults.

Relay 50 pickup setting should be greater than the motor fault current contribution at the transformer secondary terminals. The 50G (or 50N) relay pickup setting should be slightly greater than the ground pickup setting of the feeder ground protection. The engineer must review this criteria in detail to determine compliance with the specific project requirements and system conditions.

Typically, low voltage switchgear trip units require the addition of 50 and 50G (or 50N) transfer blocking relays because of solid-state trip unit limitation.

When low voltage trip units are used, the engineer should confirm that incoming and tie breaker protection is selective with the downstream low voltage protective devices on motor control centers and panelboards. When the incoming and tie breaker time delay exceeds the time setting capabilities of the low voltage trip unit, replacing the solid-state trip units with 51 and 51G (or 51N) protection relays may be required.

Low voltage power circuit breakers without an integral trip unit are classified as non-automatic, non-U.L. listed circuit breakers and may have a reduced interrupting rating. Consequently, the interrupting rating must be investigated and confirmed adequate for maximum short-circuit conditions.

B. PHASE TIME-OVERCURRENT PROTECTION

Incoming breaker 51 relay provides main bus phase over-current protection and downstream feeder breaker phase failure backup protection. The 51 relay should maintain selectivity with downstream feeder protection, allow large motor starting with one transformer powering the entire switchgear bus, and permit group motor reacceleration.

C. INCOMING BREAKER GROUND PROTECTION

When solid ground system configurations are implemented, incoming breaker 51N residual neutral overcurrent relay should be selective with downstream feeder breaker 50G or 51G relay. If downstream 50G relay or 51G relay is not provided, the 51N setting may not be selective with the downstream phase overcurrent 51 relay.

When low resistance grounded system configurations are implemented, a CT and 51G relay should be provided in the transformer neutral. If a 51N configuration is used, the 51N relay setting should be thoroughly reviewed to ensure the residual neutral ground fault secondary current is adequate for 51N relay sensing. When a more sensitive pickup is needed, a one amp rated relay may be used for the 51N relay application; however, the relay must be suitable for continuous currents greater than one amp.

When low resistance grounded systems are implemented, a practical alternative to the 51N and 50N relay concerns above is the 51G and 50G configuration with a sensing CT in the transformer neutral. Although an additional CT is required, more sensitive current pickup can be achieved.

Transformer neutral 51G-A2 or 51G-B2 relay provides primary protection for ground faults downstream of the incoming breaker and backup protection to the feeder protection relays. Relay 51G-A1 or 51G-B1 trips both the upstream
switchgear feeder breaker and the incoming breaker via an 86T lockout relay. Therefore, the transformer 51G-A1 or 51G-B1 relay must be selective with the incoming breaker ground relay (unless transformer, grounding resistors, switchgear or MCC equipment short time withstand ratings are exceeded).

D. PLOTTING 27 RELAY SETTING ON A TIME CURRENT CURVE

Relay 27 should be selective with the incoming breaker 51 relay. The graphical proof is achieved by plotting the 27 relay setting on a time current curve with the incoming breaker 51 relay, the 50 relay is expected to inhibit a transfer operation. If the 27 relay is not selective with the incoming breaker 51 relay, then the 50 relay is expected to inhibit a transfer operation.

During phase faults, exclusion of the 50 blocking function and a lack of selectivity between the 27 relay and the 51 relay could result in a transfer system operation into a phase fault. A similar discussion applies for 50G and 51G (or 50N and 51N) relays for downstream and bus ground faults.

E. UNDervoltage Transfer Initiator Relay 27

The 27 relay setting should be less than the minimum nominal voltage the upstream substation switchgear expects to experience during normal operation or motor starting voltage depressions.

The 27 relay setting should be made only after performing a thorough review of system operating conditions.

1) System Operating Condition Examples

- Large motor starting voltage drop
- Motor group reacceleration voltage drop
- Motor contactor drop-out time (to inhibit reacceleration timers from operating prior to establishing a healthy bus voltage)

A traditional 27 relay setting is 70% to 80% of system voltage for 1 second.

Incoming breaker protective device tripping characteristics vary, depending on the relay or trip unit characteristic. To minimize fault burning time with downstream definite time devices, definite time (horizontal) characteristics should be investigated for incoming breaker 51 and 51G (or 51N) relays. This is most frequently applicable with low voltage feeder breaker solid state trip units and medium voltage feeder breaker definite time 50GS and 51GS relays.

CAUTION

If the incoming breaker ground relay 51G-A1 or 51G-B1 are not selective, automatic transfer operation may result in breaker 52T closing into a main bus fault.
F. INCOMING SOURCE CLOSE CIRCUIT INHIBIT RELAY 27I

The 27I relay inhibits closing the incoming breaker if the incoming source is not stable.

1) Incoming Source Not Available Examples

- Upstream source bus is not available
- Upstream feeder breaker is switched open
- Upstream feeder fault
- Upstream transformer fault
- Upstream bus duct or cable fault

A traditional 27I relay setting is 90% voltage for 3 seconds.

G. ALTERNATE BUS UNDERVOLTAGE BLOCK TRANSFER PERMISSIVE RELAY 27RI

The healthy bus 27RI relay permissive requires the alternate bus to maintain a stable voltage for several seconds before an automatic or manual transfer is permitted. If the alternate source is not stable, 27RI relay “blocks” transfer to the switchgear alternate bus. When 27RI relay confirms the alternate source voltage is “healthy”, transfer is allowed.

1) Relay 27RI Blocking Examples

- Simultaneous loss of both incoming sources
- Reduced voltage from motor starting or grouped motor reacceleration
- Reduced voltage from system faults

A traditional 27RI relay setting is 90% of system voltage for 3 seconds.
H. RESIDUAL BUS UNDERVOLTAGE RELAY 27R

The 27R residual bus voltage relay monitors the bus voltage and inhibits transfer until the bus voltage is within safe motor transfer or reclosing limits. This inhibits transient torque damage to online motors. A sudden loss of incoming voltage results in bus voltage decrement based on the connected motors open-circuit time constants and the system impedance. Reference [2] within the technical paper “Secondary Selective System Residual Bus Transfer - A Modern Application Approach” indicates the importance of reviewing the motor open-circuit time constant. Refer to Ch 11 REFERENCE, for additional technical paper details.

The application of terminal voltage with motor internal voltage present may result in a transient torque magnitude from 2 to 20 times rated torque. References [10], [11], [12], and [13] within technical paper “Secondary Selective System Residual Bus Transfer - A Modern Application Approach” explains detailed theory and practice of applying reclosing voltage on a de-energized rotating motor. These references reinforce the need for the 27R relays. Refer to Ch 11 REFERENCE for technical paper details.

According to NEMA MG1-1993, paragraph 20.85.1, the slow transfer or reclosing voltage guideline before applying voltage to the motor terminals is a minimum of 1.5 open-circuit time constants. This is approximately 22.3% voltage at the motor terminals.

A traditional 27R relay setting of 20% of nominal motor design voltage complies with the MG1 open-circuit time constant guidance.

Because high inertia loads require more time for the motor internal voltage to decrement, the reclosing criteria must be voltage, not time. This justifies an undervoltage residual bus 27R relay, rather than a discrete timer.

I. UPSTREAM AND DOWNSTREAM TRANSFER SYSTEM TIME DELAYS

If an upstream automatic transfer system is implemented, the downstream transfer system voltage relay pickup and drop out settings and time delays must be thoroughly reviewed. Setting guidance cannot be provided for the additional delay times until process system parameters are thoroughly reviewed.
Ch 7  Additional Power System Design Considerations

A. SWITCHGEAR SHORT-CIRCUIT RATING

Traditionally, the practice of calculating switchgear short-circuit magnitudes was based on one transformer fault contribution and the combined bus “A” and bus “B” motor contributions with breaker 52T closed. Because manual transfer is a make-before-break operation, it is a remote possibility that a feeder fault could occur during the time breakers 52A, 52B, and 52T are momentarily closed. The responsible engineer should thoroughly review this system condition for compliance with, or exception from, operating company, local and national codes and regulations. The engineer should completely understand the applicable risks or liabilities associated with all aspects of the transfer system application. Because of this concern, some manual transfer operations are break-before-make, not make-before-break.

B. TRANSFORMER MEGAVOLTAMPERE (MVA) SIZING CRITERIA

Transformer MVA sizing philosophy should be reviewed for new project preliminary and final loads with one transformer supplying both the bus “A” and bus “B” loads. Loads increase as new projects evolve, and the maximum preliminary loading should be evaluated. During secondary selective substation normal configuration, transformer loading should not exceed the base rating. With one substation transformer supplying the entire load, the transformer extended rating should not be exceeded. The engineer should confirm this operating method complies with project design criteria and operating company policies and guidelines.

C. GROUP MOTOR REACCELERATION

When electrical system disturbances cause process upsets, online motors may “drop out” and slow down. However, the process system has a residual capability that may permit restarting “dropped out” motors, and the possibility of automatically returning to full production without process shutdown or producing “off spec” product. When restarting loads, a priority sequence is required to prevent equipment damage, prohibit safety valves from operating, and maintain “on spec” process production.

When automatically reaccelerating “dropped out” motors, the reacceleration motor groupings are based on priority and the ability to maintain switchgear bus voltages greater than 85% voltage during the reacceleration period. The restarting design should inhibit contactors from “dropping out”, provide adequate motor torque for restarting loads, and prevent stalling online motors.

To determine if group motor reacceleration can return the process to stable “on spec” operation within process system residual parameters, process, mechanical, instrumentation, and electrical engineers must work together to achieve an adequate solution.
**Ch 8  Transfer System Alarms**

The following indicates typical PLC trouble alarms available for a local or remote annunciator or HMI device, such as, a traditional annunciator panel, Touchpanel, Industrial PC, DCS, pagers, cellular phones, etc.

Typically, two separate alarm contacts are available for connection to separate alarm points or one common trouble alarm.

- AUTO/BYPASS switch in BYPASS
- PLC Trouble/Loss of PLC Input Power

The PLC Trouble alarm contacts change state when an internal PLC trouble condition exists or PLC source power is not available.

When requested, user defined optional alarm contacts may be provided in accordance with the users project documents.
Ch 9 Transfer System Modifications

With a PLC based transfer system, logic is easily modified to accommodate unique applications.

A. UNIQUE APPLICATION EXAMPLES

- Three incoming sources and two tie breakers
- Local generation connected to a standby bus
- Load shedding/group motor reacceleration control logic
- Alarm notification to cellular phones, pagers, HMI, DCS, etc. Typically, two separate alarm contacts are available for connection to separate alarm points or one common trouble alarm
- AUTO/BYPASS switch in BYPASS
- PLC Trouble/Loss of PLC Input Power

⚠️ CAUTION

When users desire to modify existing PowLogiC transfer scheme logic, Powell should be consulted because of our familiarity with the transfer logic. When users modify PowLogiC transfer system logic without Powell participation, transfer system non-operation or misoperation may occur because the user may not be completely familiar with all logic conditions and nuances.
Ch 10 Human Machine Interface (HMI) Recommendations

A. LOCAL TOUCHPANEL

As a minimum, a switchgear building Touchpanel should be provided so circuit breaker switching operations are performed outside the arc flash zone. Maintaining a safe distance from the breaker or contactor front door is an operator proactive safety consideration and complies with NFPA 70E, latest edition.

B. LOCAL INDUSTRIAL PC WITH TOUCHPANEL MONITOR

When a local operation requires more than switching control outside the arc flash zone, an Industrial PC with Touchpanel Monitor is recommended. Local data logging, expanded software graphical system capabilities, electronic equipment drawings, instruction manuals, and local maintenance documents can be provided in an Industrial PC with a Touchpanel Monitor.

C. REMOTE MONITORING AND CONTROL

Because most of the cost is included in the microprocessor protective relays, meters, PLC’s, and other communicating intelligent electronic devices, the incremental cost to connect the switchgear building communicating devices for remote monitoring and control is typically very cost effective.

Remote monitoring, breaker control, motor starter control, event recording, and data logging should be implemented via a Modbus TCP/IP data highway to the plant engineers’ office PC, maintenance shop desktop computers, and the control room Distributed Control System.

When a computer network is not implemented, multi-drop (daisy chain) RS-485 configurations can be wired to local and remote HMI’s.
Ch 11 Reference


(Table A) Glossary of Applicable Device Numbers and Terms

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-Switch</td>
<td>Indicates breaker preselected for trip during manual transfer operation</td>
</tr>
<tr>
<td>25</td>
<td>Sync-check relay requires in-phase paralleling of two incoming sources</td>
</tr>
<tr>
<td>25X</td>
<td>Sync-check relay enable (not shown)</td>
</tr>
<tr>
<td>25Y</td>
<td>Synchronizing circuit auxiliary close permissive relay (not shown)</td>
</tr>
<tr>
<td>27</td>
<td>Undervoltage relay for incoming source undervoltage transfer initiator</td>
</tr>
<tr>
<td>27I</td>
<td>Undervoltage relay for incoming source voltage stable</td>
</tr>
<tr>
<td>27R</td>
<td>Bus undervoltage relay less than rotating machinery acceptable residual voltage magnitudes</td>
</tr>
<tr>
<td>27RI</td>
<td>Bus undervoltage relay for stable bus voltage (not shown)</td>
</tr>
<tr>
<td>43</td>
<td>AUTO/BYPASS selector switch</td>
</tr>
<tr>
<td>50</td>
<td>Phase instantaneous relay to block transfer during phase faults</td>
</tr>
<tr>
<td>50G</td>
<td>Instantaneous ground overcurrent relay</td>
</tr>
<tr>
<td>50N</td>
<td>Residual neutral instantaneous relay to block transfer during residual neutral faults</td>
</tr>
<tr>
<td>51G</td>
<td>Ground overcurrent relay</td>
</tr>
<tr>
<td>51N</td>
<td>Residual neutral overcurrent relay</td>
</tr>
<tr>
<td>63</td>
<td>Transformer sudden pressure relay (not shown)</td>
</tr>
<tr>
<td>86</td>
<td>Transfer system lockout relay</td>
</tr>
<tr>
<td>86HRG</td>
<td>High Resistance Ground lockout relay</td>
</tr>
<tr>
<td>86T</td>
<td>Transformer lockout relay (not shown)</td>
</tr>
<tr>
<td>94</td>
<td>High impedance transfer trip auxiliary relay to/from source breaker (not shown)</td>
</tr>
<tr>
<td>96</td>
<td>Time delay relay for the alternate source maintaining healthy voltage</td>
</tr>
<tr>
<td>97</td>
<td>Time delay relay for transfer blocking</td>
</tr>
<tr>
<td>98</td>
<td>Time delay relay for upstream substation transfer</td>
</tr>
<tr>
<td>AUXa</td>
<td>Breaker auxiliary “a” contact (“a” contact is open with breaker in open position)</td>
</tr>
<tr>
<td>TOCa</td>
<td>Truck operated “a” contact (“a” contact is open with breaker in non-connected position)</td>
</tr>
<tr>
<td>TOCb</td>
<td>Truck operated “b” contact (“b” contact is closed with breaker in non-connected position)</td>
</tr>
<tr>
<td>HRG</td>
<td>High Resistance Ground</td>
</tr>
<tr>
<td>LRG</td>
<td>Low Resistance Ground</td>
</tr>
<tr>
<td>LS</td>
<td>Long Time and Short Time Protection Functions</td>
</tr>
<tr>
<td>LSG</td>
<td>Long Time, Short Time, and Ground Protection Functions</td>
</tr>
<tr>
<td>MFR</td>
<td>Multi-Function Relay</td>
</tr>
<tr>
<td>OTS</td>
<td>Overcurrent Trip Switch (Bell Alarm)</td>
</tr>
<tr>
<td>SST</td>
<td>Solid-State Trip</td>
</tr>
<tr>
<td>^</td>
<td>Open-Delta</td>
</tr>
<tr>
<td>Ø - Ø</td>
<td>Phase-to-Phase</td>
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Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
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<tr>
<td>DCS</td>
<td>Distributed Control System</td>
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<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>MVA</td>
<td>MegaVoltAmpere</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer (Industrial)</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Controller</td>
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</tbody>
</table>
Figure 1 - Modern PLC Approach: MV LRG System with Transformer Neutral CT Wired to MFR Ground CT Input

Notes:
1) Provided with PowLogiC Automatic Transfer System
2) Transformer neutral CT is wired to MFR ground CT input for 50G transfer blocking and 51G tripping
Figure 2 - Modern PLC Approach: MV LRG System with Residual CT Connection to MFR for 50N Blocking and 51N Tripping

Notes:
1) Provided with PowLogiC Automatic Transfer System
2) CT wired for residual neutral connection into MFR ground CT input
3) Typically, MFR 50N and 51N pickup is not adequate for the application. The addition of a 1-Amp, 50N/51N residual relay may be required for the “A” side and the “B” side. As an alternate, 51G/A2 and 51G/B2 relays in the transformer neutral may be used (see Figure 3).
Figure 3 - Traditional Discrete Device Approach: MV LRG System
Without Residual Relays for 50G Blocking and 51G Tripping
**Figure 4 - Modern PLC Approach: MV Solid Ground System**

**Notes:**

1) Provided with PowLogiC Automatic Transfer System

2) Typically, 1200/5, 2000/5, or 3000/5 CT’s should be considered for solid ground systems. Confirm CT ratio for each application.
**Figure 5 - Modern PLC Approach: MV HRG System**

**Notes:**
1) Provided with PowLogiC Automatic Transfer System
2) When a high resistance ground exists on both the “A” side and the “B” side, closed transition is inhibited until 86 HRG-A or 86 HRG-B is reset.
3) Disable MFR ground function
**Figure 6 - Modern PLC Approach: LV Solid Ground System with LV Solid-State Trip Unit**

**Notes:**
1. Provided with PowLogiC Automatic Transfer System
2. Typically, 1200/5, 2000/5, or 3000/5 CT should be considered for solid grounding systems. Confirm CT ratio for each application.
Figure 7 - Modern PLC Approach: LV Solid Ground System without LV Solid-State Trip Units

Notes:
1) Provided with PowLogiC Automatic Transfer System
2) Typically, 1200/5, 2000/5, or 3000/5 CT should be considered for solid grounding systems. Confirm CT ratio for each application.
Figure 8 - Modern PLC Approach: LV HRG System with LV Solid-State Trip Units

Notes:
1) Provided with PowLogiC Automatic Transfer System
2) When a high resistance ground exists on both the “A” side and the “B” side, closed transition is inhibited until 86 HRG-A or 86 HRG-B is reset.
Figure 9 - Modern PLC Approach: LV HRG System
without LV Solid-State Trip Units

Notes:
1) Provided with PowLogiC Automatic Transfer System
2) When a high resistance ground exists on both the “A” side and the “B” side, closed transition is inhibited until 86 HRG-A or 86 HRG-B is reset.
3) Disable MFR ground function
Figure 10 - 52A Close Circuit Example

CONTROL POWER

CS/C

PLC

43/BYPASS

AUTO/BYPASS

SWITCH

in AUTO

43/AUTO

52A

TOC_a

94/C

Upstream

Feeder Breaker

Close Confirmation

52B

TOC_b

52B

b

52T

TOC_b

52T

b

25X

86

86HRG-A

86HRG-B

High-Resistance Ground

Lockout

CLOSE

COIL

CC

CONTROL POWER
Figure 11 - 52B Close Circuit Example

CONTROL POWER

CS/C

PLC

43/BYPASS

AUTO/BYPASS SWITCH in AUTO

43/AUTO

52B

TOC_a

52A

TOC_b

52T

TOC_b

52T

TOC_b

94/C

Upstream Feeder Breaker Close Confirmation

86

86HRG-A

86HRG-B

High-Resistance Ground Lockout

CC - CLOSE COIL

CONTROL POWER

25X
Figure 12 - 52T Close Circuit Example
Figure 13 - Trip Circuit Example
IB-48010 PowLogiC

Residual Bus Automatic Transfer System

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