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Secondary Selective Substations with Residual Voltage Based Automatic Transfer

GP 16-12-02

Scope

- 1) [I] This Global Practice (GP) covers the standard design basis of the control system for incoming line (or transformer secondary) circuit breakers, and bus tie circuit breakers, of low-voltage and medium-voltage secondary selective substations with automatic transfer.
 - * [I] When approved by Owner's Engineer, the secondary selective control system in [GP 16-12-03](#) may be used in existing plants where time-based automatic transfer systems are used.
 - * [I] Control of secondary selective substations with manual transfer. Modifications to the control system design given herein will be specified.
 - 4) [I] An asterisk (*) indicates that a decision by Purchaser is required or that additional information is furnished by Purchaser.
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1. Required References

This Section lists Practices and Standards that are generically referenced and assumed to be a part of this document. Unless otherwise specified herein, use the latest edition.

1.1. Global Practices–ExxonMobil Engineering Practices

GP 16-02-01	Power System Design
GP 16-12-03	Secondary-Selective Substations with Time-Based Automatic Transfer

2. Definitions

Term	[I] Description
secondary selective substations	Substations having two busses, each supplied by a normally-closed incoming line circuit breaker and connected together by a normally-open bus tie circuit breaker. Although the name is derived from designs utilizing two transformers, the design is applicable (with appropriate functional deletions) to dual-fed substations without transformers. Figure 4 shows minimum requirements for secondary selective substations with automatic transfer. There are additional protective relaying requirements in GP 16-02-01 which may apply.
series type lockout relay	An auxiliary relay, usually hand reset, whose operating coil is in series with the operating coil of an associated device. Operation of protective relays in the circuit causes the lockout relay and its associated device to operate simultaneously. Contacts of the lockout relay may perform other functions in the circuit including locking out the closing circuits of one or more circuit breakers or contactors.
shunt type lockout relay	An auxiliary relay, usually hand reset, whose operating coil is connected in shunt (parallel) with its control power source and is associated with another device whose coil is similarly connected to the same or a separate control power source. Operation of protective relays in the circuit causes the lockout relay to operate, contacts of which then operate its associated device. Other contacts of the lockout relay may perform other functions in the circuit including locking out the closing circuits of one or more circuit breakers or contactors.

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Term	[I] Description
transformer protection	Typically consists of any of the following, individually or in combination: 1. Three phase overcurrent relays energized from current transformers in the transformer primary bushings or cable ends 2. Fault pressure or Buchholz relays 3. Differential relays
transformer secondary protection	A ground fault relay in the transformer neutral connection or restricted ground fault relaying.

3. Design

3.1. Sequence of Operation

- 1) [O] The control scheme shall provide automatic transfer of the supply to each bus from its incoming line to the other bus. The sequence of the automatic transfer operation shall be as shown in block diagram Figure 1.
- 2) [O], [M] The control scheme shall permit manual switching to remove an incoming line from service or to return an incoming line to service after a transfer. The sequence of the manual switching operation shall be as shown in applicable block diagram Figure 2 or 3.
- 3) * [S] The sequence of manual switching for substations supplied from unsynchronized sources is shown in Figure 3. The control scheme shall not permit paralleling the incoming lines during switching.
- 4) * [O], [M] Synchronized Sources. Figure 2 shows the sequence of manual switching for substations supplied from sources which are always in synchronism or which can be synchronized during the switching operation. A trip-selector switch shall be provided having the following features:
 - a) The switch shall have only three positions, one position for the bus tie breaker and one position for each incoming line breaker.
 - b) The switch shall be arranged so that the selected breaker trips after all three breakers are closed. Incoming lines may thus be momentarily paralleled during switching to prevent interruption of service.

3.2. Instrument Transformers, Relays, and Meters

[O], [R] The arrangement of instrument transformers, relays, and meters shall be per the applicable parts of Figure 4. Figure 4 shows the single-line diagram of a secondary selective substation with automatic transfer having transfer initiation from the source substation and with transformer secondary protection.

3.3. Transfer Initiation From Source Substation

- 1) [O] Intertripping with the source substation initiates automatic transfer of the secondary selective substation whenever one of the supply breakers in the source substation trips. This arrangement eliminates the time delay associated with transfer initiation by undervoltage. Separate 94 auxiliary

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relays shall be provided for each substation when two or more substations are supplied in parallel from a pair of feeders.

- 2) [C] The intertripping shall be combined with the circuit used to trip the primary supply breaker, for substations having transformer protection or transformer secondary protection.

3.4. Transformer and Secondary Protection

* [O], [R] If transformer protection or transformer secondary protection is specified, the protection relays shall actuate a hand-reset lockout relay. Operation of the lockout relay shall lock out the closing circuits of the source breaker and of the incoming line breaker, initiate automatic transfer, and, if the relay is shunt type, initiate tripping of the source breaker.

- 1) If transformer protection utilizes rate-of-rise fault pressure relays equal to GE Model 900-1 or ABB Type SPR, shunt type lockout relays shall be used.
- 2) If the transformer uses surge fault pressure relays of the Buchholz type, series or shunt type lockout relays may be used, but series type is preferred.

3.5. Lockout Relays

- 1) [O] Series type lockout relay shall have the following features:
 - a) Manually reset from exterior of front panel.
 - b) Trip indication, mechanical target type.
 - c) It is preferred that a "healthy trip" pilot light provide simultaneous supervision of the trip initiation circuit as well as of the lockout relay coil, provided there are not sufficient substations supplied by the one source breaker so that total pilot light current could cause false tripping.
- 2) [O] For shunt type lockout relays, relay coil supervision shall be provided by a "healthy trip" pilot light. When two or more substations at one location are supplied in parallel from a pair of feeders, only one shunt lockout relay per source breaker shall be provided at that location. See Figure 6. If these substations operate at different voltages, the lockout relays shall be located in the higher voltage switchgear.
- 3) [S] For either shunt or series type lockout relay, mechanical or electrical means shall be provided and suitably marked to operate the relay manually (thereby tripping the supply breaker and initiating transfer), unless the supply breaker is in the same room.

3.6. Control Power Bus Arrangement

- 1) [R] Arrangement of substation control power busses shall be as shown in Figure 7 or 8 for substations with shunt type lockout relays. For substations with series type lockout relays, bussing shall be per Figure 7 with only 3 branches off bus 3, except a fourth branch is required when synchronizing check facilities are provided.
- 2) [O] Voltage for control power busses shall be supervised by normally energized auxiliary relays located inside the switchgear assembly. Relays shall be suitable for continuous operation at control power bus voltage without tendency to stick in the energized position and shall be time delay on drop-out. Time delay shall be long enough to prevent operation on transient voltage dips. One relay shall be provided for each control power bus, and its coil shall be connected to the bus at the furthest point from the supply connection to the bus. A normally open contact from each relay shall be wired in series and used to actuate a "Loss of Control Power" alarm in the substation alarm panel.

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3.7. Control Circuits

- 1) [R], [I] Control circuits meeting the intent of this Practice are shown in Figures 5 and 6. These schemes are based on the design of switchgear as manufactured in the U.S., and shall be followed for switchgear procured in the U.S. They shall be used as a basis for circuit design of other switchgear. Control schemes implemented in software, using stored-program control devices that function as described in Figures 1 through 3, are acceptable, but require approval of Owner's Engineer.
 - a) * Microprocessor-based schemes shall include a bypass switch, if such a switch is required to permit manual operation of secondary breakers in the event of device failure. Redundancy (e.g., 1oo2 or 2oo3) may be required for some applications. Required level of redundancy will be specified by Owner's Engineer.
 - b) Microprocessor-based schemes shall have device failure ("watchdog") relay outputs connected to a substation alarm system for remote alarm if self-diagnostic failure or error of microprocessor device is detected.
 - c) * The control circuit of Figure 5 is suitable for substations supplied from sources which are always in synchronism or from sources which can be synchronized during manual switching. Modifications to the Figure 5 circuit for substations supplied from sources which cannot be synchronized will be specified.
 - d) * The control circuit of Figure 5 is intended for systems that trip for ground faults. For high-resistance grounded systems, manual- and automatic-transfer blocking is required when ground faults are present on both buses.

3.8. Metering

- 1) [O] Each incoming line shall be provided with a voltmeter to indicate phase-to-phase voltage of one phase.
- 2) [O] Each bus shall be provided with a voltmeter with switch to indicate phase-to-phase voltage of each phase.
- 3) [O] For ungrounded neutral or high impedance grounded neutral substations, the bus voltmeters shall also be switched to indicate the phase-to-ground voltage of each phase to allow detection of grounds on the system.
- 4) [S] If summation CTs are approved for watt-hour demand metering, the main CTs must have a warning nameplate engraved as follows (white letters on red background):

WARNING
BACKFEED PRESENT WHEN OTHER
INCOMER IS CLOSED

3.9. Supervisory Devices

- 1) [O] In addition to standard devices (such as circuit breaker indicating lights and targets), supervisory devices described in Section 3.5 Items 1 and 2 and Section 3.9 Items 2 through 5 shall be provided with the switchgear.
- 2) [O] A white "transfer ready" light shall be provided for each incoming line. The light shall be connected across the contacts of the device or devices that initiate automatic transfer. When

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energized, the light should indicate that the circuit that initiates transfer is ready to operate. When self-supervision circuits indicate that the controlling device has failed, schemes employing microprocessor control shall turn off the transfer ready light(s) and open an alarm contact.

- 3) [O] A latch-check switch, if available, shall be provided on each circuit breaker element used for incoming line and bus tie service. The switch shall indicate that the breaker operating mechanism has reset properly after tripping and will "latch in" when the breaker is closed.
- 4) [O] Latch-check switches on incoming line breakers shall de-energize the breaker "open" indicating light when the breaker mechanism has not reset properly. The tie breaker latch-check switch shall de-energize each "transfer ready" light when the breaker mechanism has not reset properly.
- 5) [O] Latch-check switches on interchangeable breaker elements. When circuit breaker elements for outgoing feeders are interchangeable with incoming line or bus tie breakers, latch-check switches shall be provided on all interchangeable breaker elements. With the breaker element in a feeder position, the switch shall de-energize the breaker "open" indicating light when the breaker mechanism has not reset properly.
- 6) [O], [R] D-C control power for intertrip circuits shall be monitored by a white light or under voltage relay if this loss-of-voltage is not being monitored by other lights or relays in the scheme.

3.10. Panel Arrangement

[O] Arrangements of relays, control devices, and nameplates on switchgear front panels for incoming and bus tie breakers are shown in Figures 10 and 11. These arrangements shall be followed as closely as available panel space allows. All devices shown shall be located on the upper half section of the front panel. Switches and similar devices shall be located at a height convenient for personnel operation.

3.11. Nameplates

- 1) [O] Nameplates shall be provided showing instructions for manual switching to remove an incoming line from service, and to return to normal after an automatic transfer or manual switching. Figure 9 shows a suitable nameplate for substations supplied from synchronized sources.
- 2) [O] Other nameplates shall be mounted on the front of the switchgear panels.
- 3) [O] All nameplates shall be mounted on the front of the switchgear panels.
- 4) [O] In addition to the nameplates specified above, small nameplates shall be provided on the front of the switchgear panels, mounted adjacent to each relay, showing the device function number such as 51-1, 27R-2.

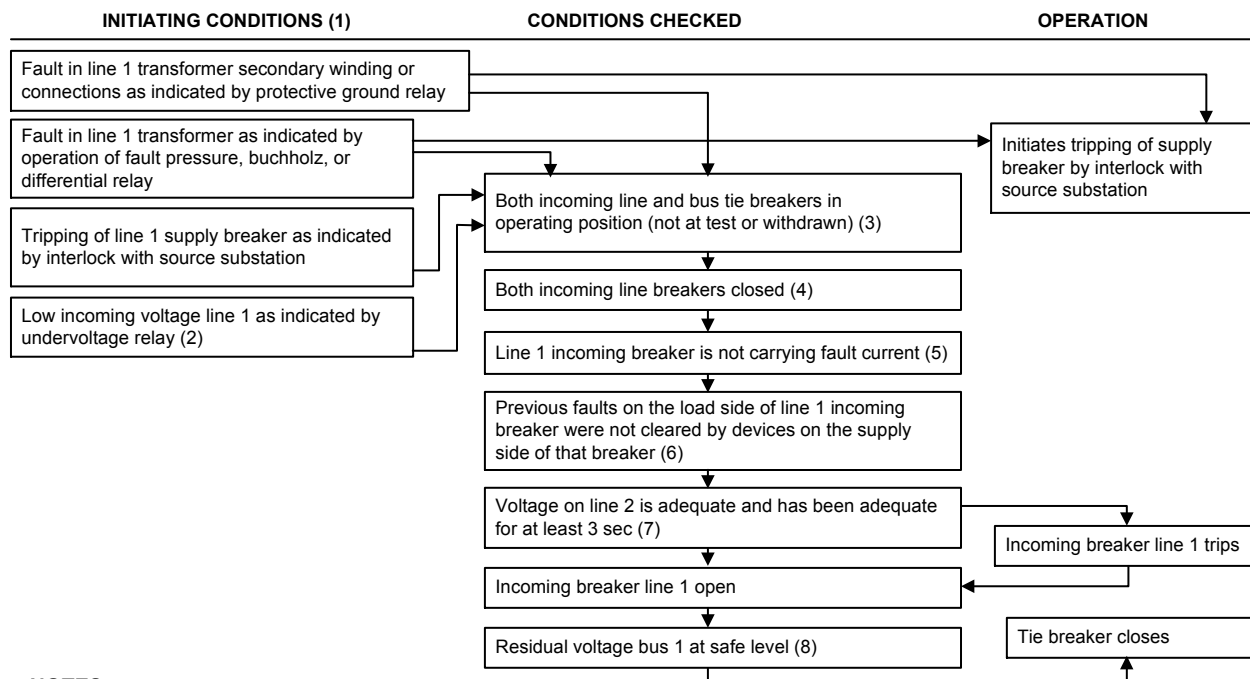
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Figure 1: Sequence of Automatic Transfer Operation



NOTES:

- (1) Transfer initiation on incoming-line undervoltage shall always be provided. One or more of the other initiating conditions may be used as specified.
- (2) Low voltage is 70-80% or less of normal voltage. Relay time at zero voltage usually 0.8-1.5 sec.
- (3) Auto transfer shall be blocked when any of the three breakers is in the test or withdrawn position to prevent:
 - (a) An incomplete transfer as might occur if the tie breaker were at test or withdrawn.
 - (b) A useless operation transferring one bus to the other whose incoming line breaker is at test or withdrawn.
 - (c) A dangerous transfer which would energize a bus which had been deliberately de-energized and whose incoming line breaker is at test or withdrawn.
- (4) Automatic operation of a breaker when in test position which might endanger maintenance personnel.
- (4) Auto transfer shall be blocked when either incoming line breaker is open to prevent:
 - (a) Auto transfer after an incoming line breaker has tripped on overcurrent, to avoid connecting a faulted bus or feeder to the other bus.
 - (b) A dangerous transfer which would energize a bus which had been deliberately deenergized by opening its incoming line breaker.
 - (c) A useless operation transferring one bus to the other whose incoming line breaker is open. If bus (instead of incoming line) potential transformers supply undervoltage relays used to initiate transfer, it must be assured that, when re-energizing a bus, transfer remains blocked long enough for undervoltage relay reset.
- (5) Auto transfer shall be blocked whenever an incoming line breaker is carrying fault current. Low voltage during fault could initiate a transfer which would connect the faulted bus or feeder to the other bus. "50" should be set above the motor backfeed into an incoming line fault, allowing for a-c and d-c decrement; usually 12.5-18A. "50N" should be set below arcing ground fault current, usually 0.5-2A, but above any legitimate neutral current (unless 4CTs used).
- (6) Auto transfer shall be blocked whenever devices on the supply side of an incoming line breaker clear currents caused by faults on the load side of that breaker, to prevent transferring the faulted bus or feeder to the other bus. Transfer shall be blocked until approximately 90% or more of normal voltage is restored after flow of fault current through the incoming breaker stops.
- (7) Auto transfer shall be blocked if supply voltage on the other incoming line at time of transfer is not approximately 90% or more of normal voltage. System disturbances may cause voltage dips on both incoming lines. Since voltage may be restored to one line before the other after a simultaneous dip, transfer shall be blocked for 3 sec to wait for restoration of voltage to other line. This prevents unnecessary transfers when voltage returns to both lines within 3 sec.
- (8) Tie breaker shall not be closed until residual voltage on bus 1 has decayed to or below a specified value, often 25%, or 40% if all motors are suitable for star-delta switching.
- (9) Sequence shown is a transfer of supply of bus 1 from incoming line 1 to bus 2. Substitute 1 for 2 and 2 for 1 to transfer bus 2 to bus 1.