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BUSBAR TRANSFER FOR ALL INDUSTRIES WITH CRITICAL POWER SUPPLY

SIPROTEC 5 — High Speed Busbar Transfer

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1. Overview and Terminology

The following sections describe the distinction between conventional transfer schemes based on standard control and synchronization functions and the fully integrated High Speed Busbar Transfer (HSBT) implemented as a dedicated SIPROTEC 5 functionality. Key topics include the role of synchrocheck, the application rationale for HSBT, the characteristics of different switching methods, and the influence of motor behavior on transfer strategy selection. A clear separation is made between general power system behavior and device-specific implementation.

Typical Application Areas

Busbar transfer schemes are widely used across industries where supply continuity is critical, including:

- Power generation plants
- Petrochemical and oil & gas facilities
- Pharmaceutical production
- Hospitals and healthcare infrastructure
- Data centers
- Semiconductor manufacturing
- Steel and heavy industry plants

Although all these applications require supply redundancy, the required transfer performance varies significantly. This determines whether a simple Automatic Transfer System (ATS) or a High Speed Busbar Transfer (HSBT) should be applied.



2. Conventional Transfer Logic vs. High Speed Busbar Transfer (HSBT)

2.1 Conventional Transfer Logic (often referred to as ATS function)

Conventional transfer schemes are implemented using standard SIPROTEC 5 control, measurement, and synchronization functions, such as circuit breaker control, voltage supervision, dead bus or dead line detection and synchrocheck. Depending on the selected logic and parameterization, these schemes permit a transfer only after relevant electrical conditions (such as voltage presence, frequency, phase angle, and defined dead times) have been evaluated.

In such schemes, switching speed is determined by the applied checks and logic paths, as well as by the mechanical operating times of the circuit breakers. A short interruption of supply is typically accepted, as the primary objective is controlled and electrically correct closing under defined conditions. These transfer schemes are commonly applied in feeder or busbar transfers initiated by operators, automation or supervisory systems and in installations where continuity requirements are moderate and longer dead times are permissible.

Conventional transfer logic therefore emphasizes controlled and condition checked switching, with flexibility depending on configuration, rather than optimization for minimum interruption time.

Typical Application Areas

- Commercial buildings
- Standard industrial loads
- Backup power switching (utility ↔ generator)
- Non-critical infrastructure



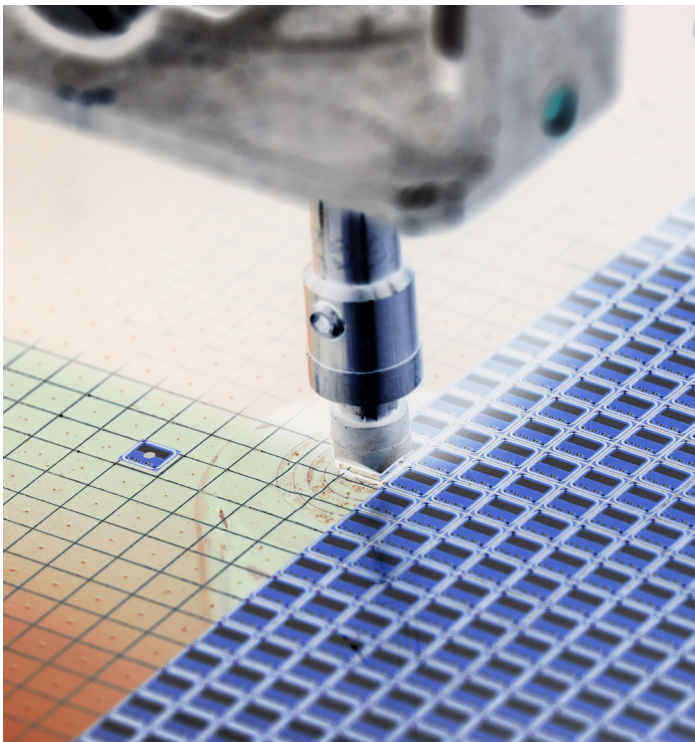
2.2 High Speed Busbar Transfer (HSBT)

High Speed Busbar Transfer (HSBT) is a dedicated SIPROTEC 5 automation function group specifically designed to minimize interruption time during busbar or source transfer. It continuously monitors system conditions and automatically initiates a predefined transfer sequence when configured start criteria are fulfilled.

HSBT supports multiple transfer sequences and switching types that are explicitly designed to operate within narrow time windows and to manage the interaction between the incoming source, the load, and any residual voltage present on the busbar. Depending on the selected switching type, synchronism related conditions may be evaluated, optimized, or deliberately relaxed to achieve the required transfer performance.

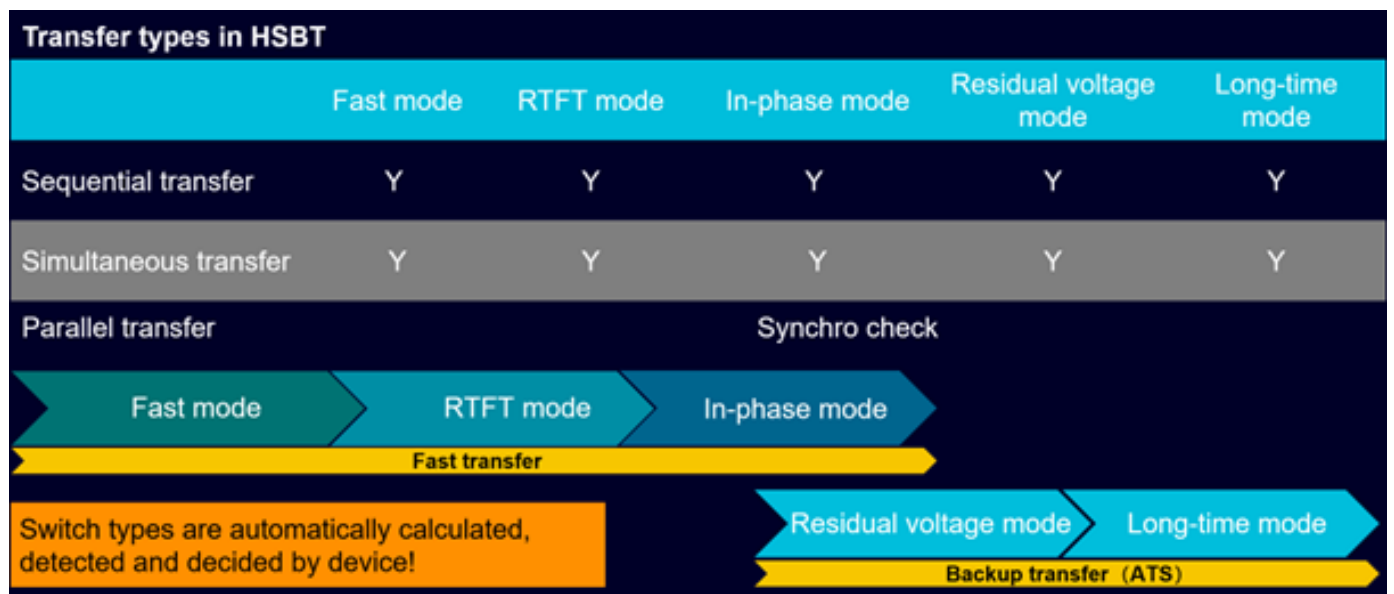
HSBT is typically applied in industrial power systems, auxiliary power systems, and motor dominated installations where supply interruptions of even short duration can lead to process disturbance, motor instability, or loss of production.

The function is implemented with dedicated logic for start detection, transfer sequencing, switching time compensation and result supervision.



2.3 Conceptual Comparison

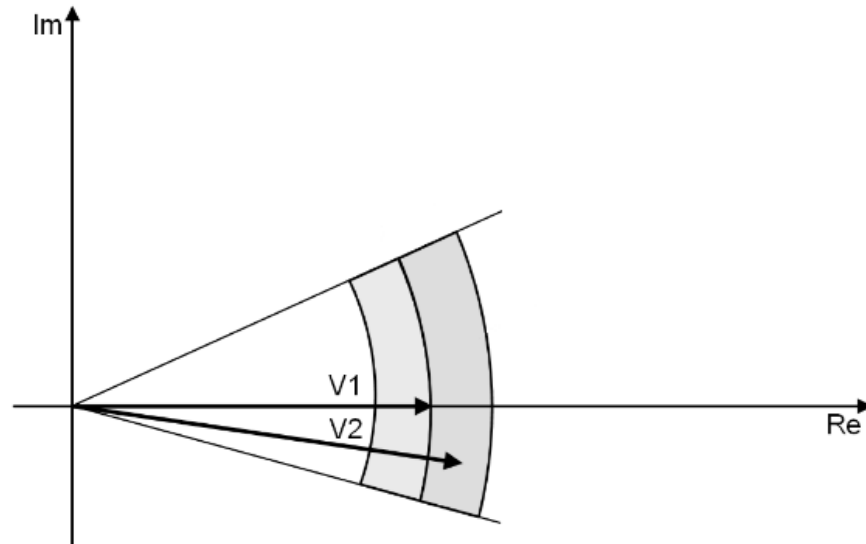
Aspect	Conventional Transfer Logic (ATS)	High Speed Busbar Transfer (HSBT)
Implementation	Standard control and synchronization functions	Dedicated HSBT function group
Primary objective	Controlled, condition-checked switching	Minimum interruption time with defined electrical criteria
Switching speed	Configuration-dependent, typically slower, temporary interruptions (typically 100 ms up to several seconds) are acceptable	Explicitly optimized for fast transfer, Fast transfer times are required (typically <100 ms or even <20 ms) → To maintain motor stability and avoid process trips.
Synchronism evaluation	Typically mandatory before closing	Applied depending on switching type
Typical application focus	General feeders, normal busbar transfer, small motors or static loads where resynchronization is not an issue	Critical and motor-dominated loads



3. Synchrocheck

3.1 Function and Purpose

Synchrocheck is a specific stage of the SIPROTEC 5 synchronization function that provides a closing permission for a circuit breaker when two electrical systems are within predefined limits of voltage magnitude, frequency difference, and phase angle. It ensures that closing takes place only under conditions that limit electrical and mechanical stress.



3.2 Application Scenarios

Synchrocheck is applied whenever a circuit breaker may connect two energized systems, such as during busbar coupling, feeder back feeding, generator connection or manually/automatically initiated transfer operations using conventional control schemes. Its purpose is to prevent unsafe paralleling or excessive transient stress.

3.3 Relationship to HSBT

HSBT does not simply bypass synchronization principles nor is it based solely on the standard synchrocheck stage. Instead, HSBT incorporates its own mode dependent evaluation of system conditions, including phase relationships and residual voltage behavior, depending on the selected switching type. Synchronism related criteria are therefore integrated differently within HSBT rather than eliminated.

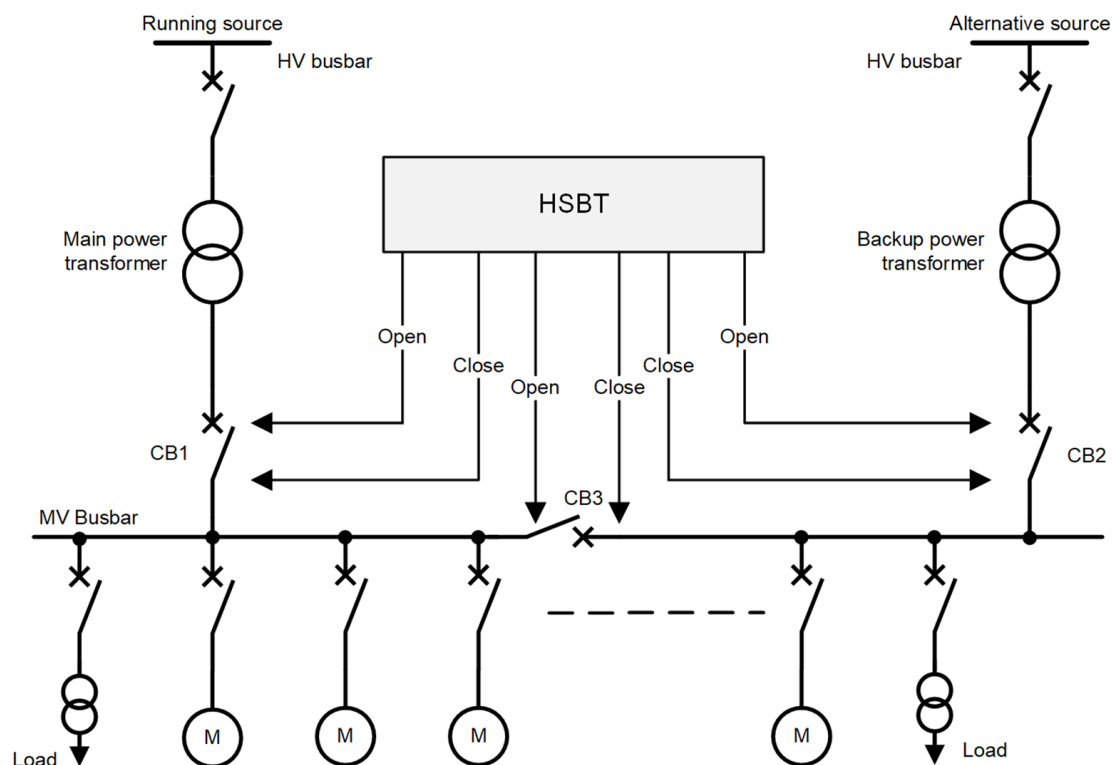


4. High Speed Busbar Transfer (HSBT)

4.1 Application Conditions

HSBT is applied in power systems where permissible interruption times are very short and where waiting for full dead bus conditions or conventional synchronization checks would lead to unacceptable consequences. Typical start criteria include configured detection of faults, undervoltage, underfrequency, unintended circuit breaker opening, or other defined abnormal conditions on the preferred source.

The exact behavior of the transfer depends on the start cause, the configured transfer sequence, the selected switching type, and the measured system conditions at the time of transfer.



4.2 Operational Concept

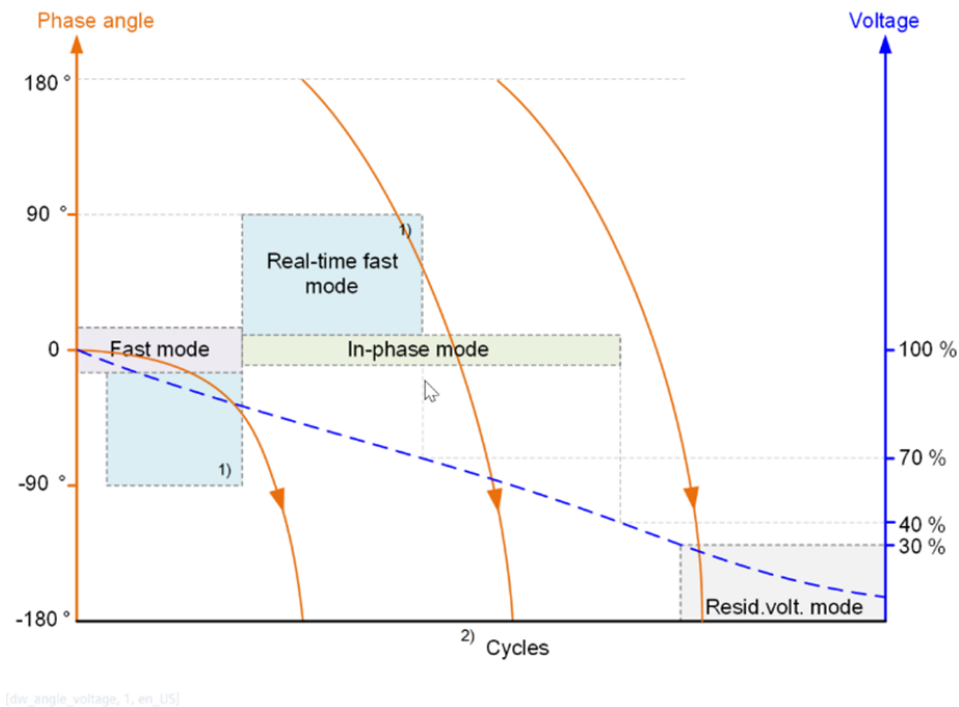
HSBT operates automatically once enabled and continuously evaluates system measurements and circuit breaker states. When a start condition is detected, the function selects and executes the configured transfer sequence and switching type, including compensation for circuit breaker make times and supervision of the transfer result.

The objective of HSBT is to maintain load stability and continuity within defined electrical limits rather than to perform a generic closing operation as fast as possible under all circumstances.



5. HSBT Switching Types

HSBT provides multiple switching types to balance interruption time, electrical stress, and load behavior. The selection of switching type directly determines how voltage phase relationships and residual voltage are treated.



5.1 Fast Switching Type

In the fast switching type the alternative source is closed with minimal delay after loss of the preferred source without waiting for defined synchronism conditions. This enables the shortest transfer times but may result in higher transient electrical and mechanical stress, depending on residual voltage magnitude, phase displacement, and load characteristics.

5.2 Real-Time Fast Switching Type

The real-time fast switching type follows the same objective of minimal interruption time as fast switching but optimizes the exact closing instant based on evaluated voltage waveform conditions. This timing optimization can reduce transient stress compared to standard fast switching while maintaining very short dead times.

5.3 In-Phase Switching Type

In in-phase switching, closing is delayed until a favorable phase angle relationship is detected between the source voltage and the voltage present on the busbar. This results in a longer interruption than fast switching types but significantly reduces transient currents and electromagnetic torque effects, particularly for rotating machines.

5.4 Residual-Voltage Switching Type

Residual-voltage switching uses the predictable decay of voltage on the load side after source disconnection, especially in systems with rotating motors. The closing instant is selected based on the residual voltage characteristics allowing a relatively fast transfer while maintaining acceptable electrical conditions for reconnection.

5.5 Long-Time Switching Type

In long-time switching, closing is delayed until the residual voltage has largely decayed. This results in the longest interruption time but minimizes electrical and mechanical stress and is used where equipment protection has higher priority than supply continuity.

5.6 Switching-Type Overview

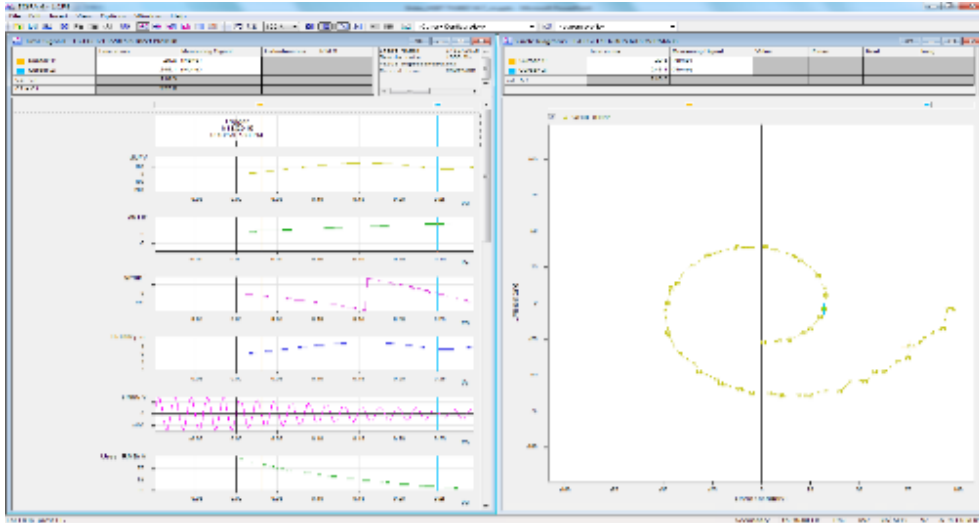
Switching types	Relative speed	Electrical / mechanical stress	Typical use
Fast	Very high	High	Extremely high continuity demand
Real-time fast	Very high	Medium	Optimized fast transfer
In-phase	Medium	Low	Motor-sensitive installations
Residual-voltage	High	Low	Motor-dominated loads
Long-time	Low	Very low	Maximum equipment protection



6. Motor Behavior During Transfer

6.1 Motor Behavior During Supply Interruption

When the supply to a motor is interrupted, the rotor continues to rotate due to mechanical inertia. During this period, an electromotive voltage remains present at the motor terminals. The magnitude, frequency, and phase of this residual voltage are directly related to the instantaneous rotor speed and load conditions and decay over time as the motor slows down.



6.2 Motor Response to Rapid Reconnection

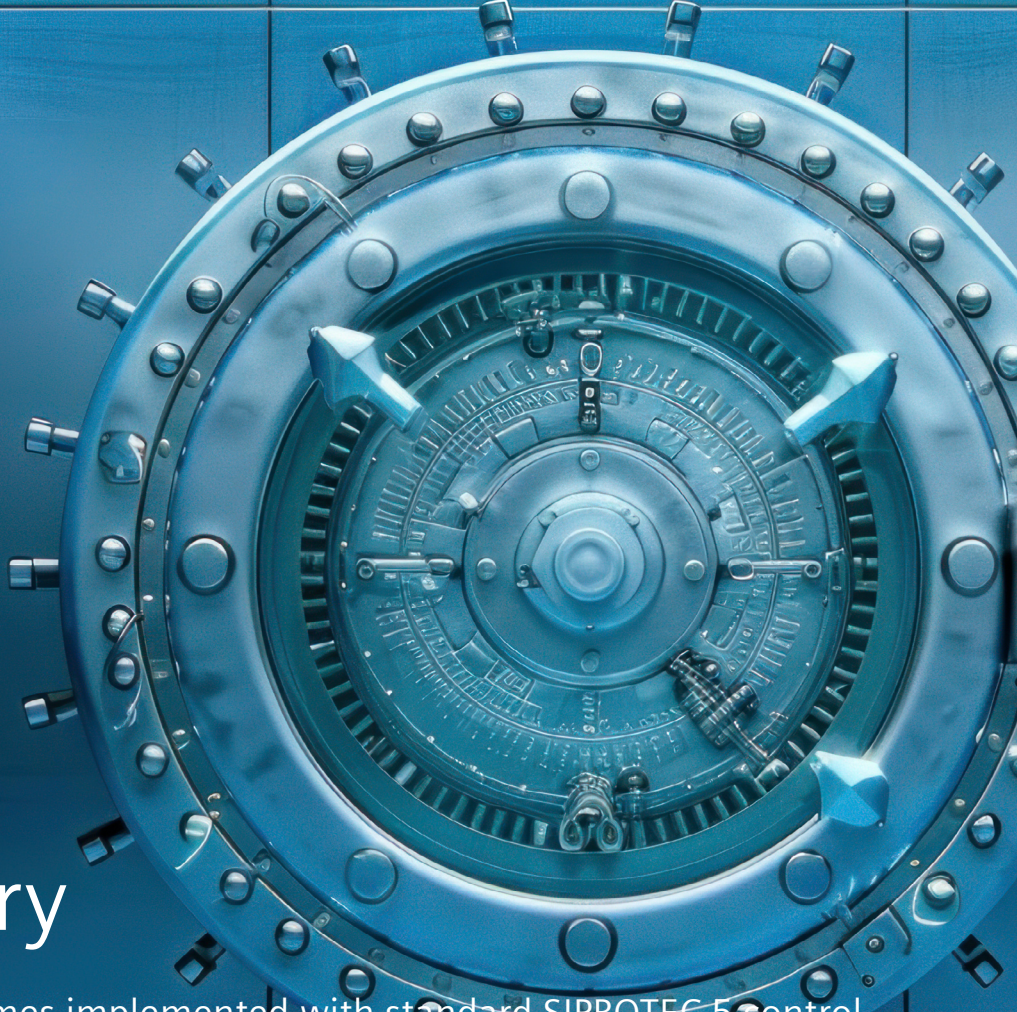
If a new source is connected while the motor is still rotating, the voltage of the incoming source may not coincide with the residual voltage in magnitude or phase. This mismatch can lead to transient currents and electromagnetic torque impulses, which impose mechanical and thermal stress on motor shafts, couplings, and driven equipment.

6.3 Relevance of HSBT Switching Types

Different HSBT switching types exist to manage these effects. In phase and residual voltage switching types reduce stress by aligning the closing instant with favorable voltage conditions. Fast switching types intentionally prioritize minimal interruption time and are therefore used only when process continuity outweighs considerations of reduced mechanical stress.

6.4 Limitations of Conventional Transfer Logic for Motor Loads

Conventional transfer schemes typically involve longer dead times due to synchronization checks or conservative logic. During these dead times, motors may decelerate significantly or stop, leading to a near full restart upon reconnection with high inrush currents. HSBT is designed to reduce or avoid this condition by transferring supplies within time windows that preserve motor rotation where possible.



7. Summary

Conventional transfer schemes implemented with standard SIPROTEC 5 control and synchronization functions provide flexible, condition checked switching, suitable for a wide range of applications. Synchrocheck serves as a defined synchronization stage to control breaker closing between energized systems.

High Speed Busbar Transfer (HSBT) is a dedicated, high performance automation function optimized for minimizing interruption time under defined electrical criteria. It applies different switching types to manage the interaction between sources, residual voltage, and load behavior. In motor dominated systems, the correct selection of HSBT switching type is essential to balance supply continuity with acceptable electrical and mechanical stress.



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