Power steering

Fast power switchover keeps production lines running

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As annoying as a power failure in your home can be, it is rarely dangerous or costly. Not so in industry. Production lines, especially the continuous lines in automotive or semiconductor manufacturing, papermaking, logistics and printing plants, are particularly vulnerable to unexpected power interruption. Here, serious damage can be caused to key production equipment, with economically disastrous results.

To eliminate this risk, ABB developed the High Speed Transfer System, or HSTS. But the HSTS does more than assure an uninterrupted supply of power in the event of actual power failure; its unique ability to anticipate potential power interruptions and respond to voltage sags enables it to switch to an alternative power source in less than 1.5 cycles, providing the highest security for key production equipment.

The HSTS is an ultra-fast transfer switch featuring new power electronics actuators and enhanced control and protection functionality for integration in medium-voltage switchboards. Real-time control and monitoring of the quality of both power supplies is provided by new software, which also activates the circuit-breakers that switch over to the alternative power source in the event of transients or a temporary interruption. Switchover usually takes place in less than 1.5 cycles, a time that most conventional transfer systems cannot match.

> The HSTS has a built-in controller-to-PC connection with user-friendly graphic interface for easy programming and customization of each installation.

This high speed is important, because manufacturing processes depend on a steady supply of power and even short interruptions can be damaging and costly. Due to the profusion of electronic controllers and similarly sensitive equipment on a modern production line, even a temporary voltage disturbance can lead to a total loss of production. Failure of computer-controlled manufacturing systems, for example, can stop production lines and wreck business schedules. Downtime is expensive, and the cost of restoring sensitive production processes whenever the voltage sags can be crippling for a company.

ABB's High Speed Transfer System helps to preserve power quality – and a company's profit margins – by first anticipating voltage sags and then almost instantly switching to a back-up power source.

A success story based on innovation

The HSTS is a good example of the new generation of intelligent ABB devices that have emerged from the marriage of advanced power electronics and control technology, applied in this case to the management and protection of medium-voltage networks.

Its functionality is realized in medium-voltage switchboards 1 through the integration of vacuum circuit-breakers with fast-acting magnetic-drive operating mechanisms and the control architecture and software algorithm developed for the new-generation switchbay control unit, REF542*plus*.

Vacuum CBs with fast magnetic actuator

In 1997 ABB introduced a new series of medium-voltage circuit-breakers with a magnetic drive in place of the usual spring-based operating mechanism [1]. The magnetic actuator's small number of parts and simple mechanics facilitate a more compact design and allow a greater number of mechanical operations. Field experience soon showed this solution to be much more reliable than its predecessor.

1 Switchgear with integrated High Speed Transfer System and fast VM1 T circuit-breakers

Another advantage of the magnetic actuator is the coil current controllability it allows – an important characteristic considering the dynamics involved in fast switching. Thanks to all of these features, the type VM1 T vacuum circuit-breaker with magnetic-drive operating mechanism is capable of extremely short operating times and exhibits highest reliability.

Notwithstanding the demands high-speed switching makes on its components, the fast VM1 T circuit-breaker has a lifetime of 20,000 C-O operations for the same ratings as the standard version of the breaker and with the same high reliability.

REF542*plus* and SUE 3000 controllers

REF542*plus* is the second generation of controllers to be developed as part of ABB's integrated approach to switchbay control and protection, with features especially important for applications in medium-voltage switchboards and for remote control. It consists of a control unit (CORE) and a remote human-machine interface. The modular control unit is based on a DSP microprocessor with dedicated measurement and protection functionality and a micro-controller architecture that allows fully programmable logic.

An advantage of REF542*plus* CORE units is that they can work together with other CORE units to solve complex HSTS control tasks in which speed and accuracy are extremely important.

> REF542*plus* controllers monitor the feeders for power supply disturbances and initiate all C/O commands to the circuit-breakers.

The new calculation capability and increased bandwidth enable power quality control and protection functions, switchgear supervision and substation control to be fully integrated. State-of-the-art telecommunications technology, which is essential for the remote supervision of switchbays, is also an integral part of the controller.

Supervising the smooth transfer of power in less than 30 ms is the SUE 3000. This new-generation control unit is based on REF542*plus* architecture and benefits from the company's extensive experience in high-speed transfer applications.

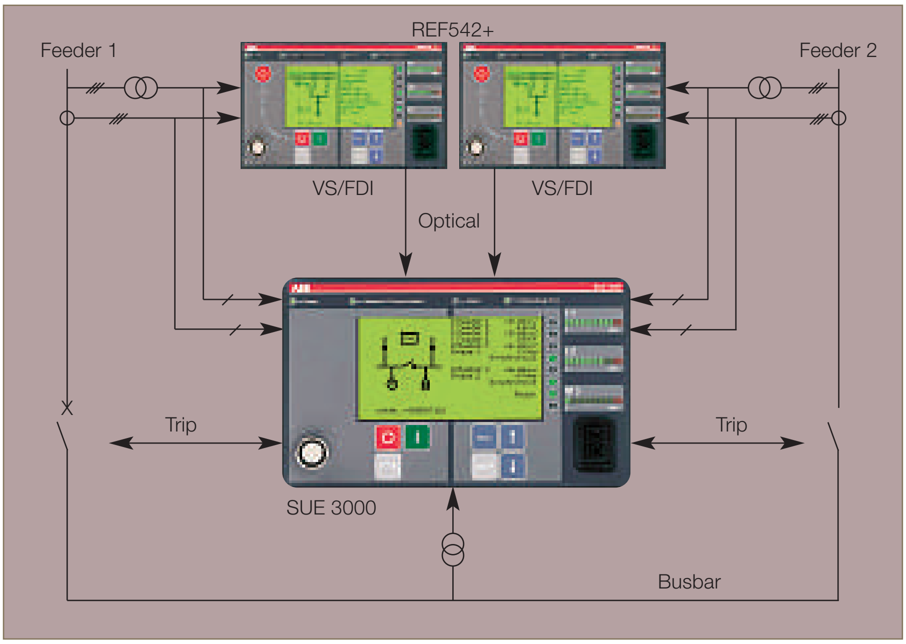
Summing up, the REF542*plus* controller automatically supervises the operational status, makes protection and reconfiguration decisions in real time and, finally, drives the devices that operate the breakers with the speed and sequence required to minimize transients and prevent interruption of the power supply.

System configurations

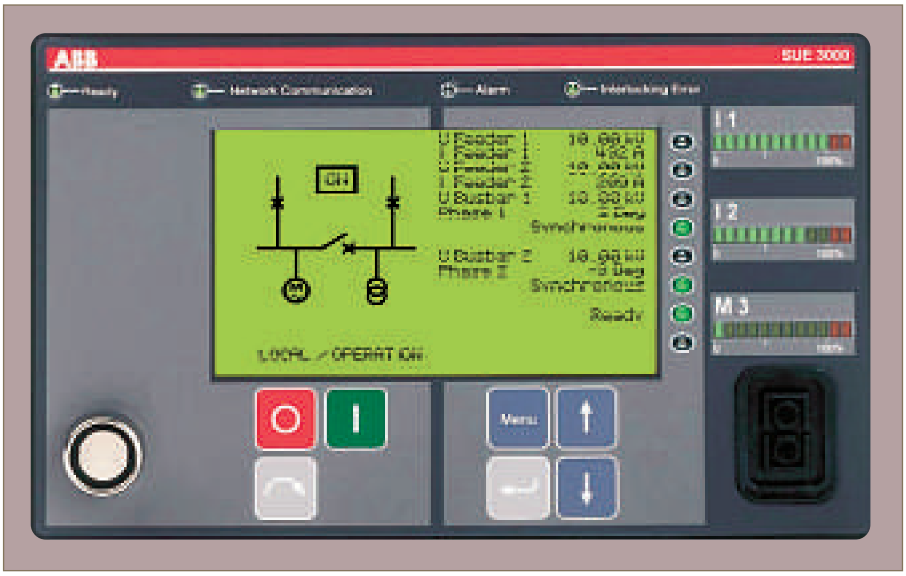
The transfer system is designed for easy installation. A high-performance, built-in controller-to-PC connection with user-friendly graphic interface ensures easy programming, allowing the customization of each installation.

There are two typical installation configurations [2]:

2 HSTS architecture in a two-breaker configuration



3 Configuration with three circuit-breakers, displayed on the HSTS controller, SUE 3000



- *Two-breaker configuration:* A main feeder (eg, feeder 1 in 2) normally supplies power to the installation busbar (breaker closed; the other feeder's breaker is open). If a voltage dip/loss is detected in feeder 1, the HSTS transfers the load to the standby feeder (feeder 2) in less then 30 ms.
- *Three-breaker configuration:* In this case, the load is split into two busbar sections to provide redundancy, the bus-tie being normally open and the two feeder breakers closed 3. A disturbance in one of the two feeders causes that feeder's breaker to open and the bus-tie to close, so that power is supplied to the installation busbar through the alternative feeder.

Two REF542*plus* controllers, connected to the SUE 3000 control unit by an optical link, monitor the feeders for power supply disturbances and initiate all C/O commands to the circuit-breakers.

Types of transfer

The type of transfer that takes place depends upon how it is initiated (manually, by local or remote control, or externally via the protection system) and on the parameters involved, ie the voltage, frequency, phase angle of the two power sources.

Fast transfer: After it has been checked that the main and standby feeders are synchronized and in phase, the 'open' and 'close' commands are given simultaneously to the circuit-breakers involved, whereupon transfer takes place without interruption, within 1.5 cycles 4.

Transfer at 1st phase coincidence: If the two supply networks are not in synchronism at the moment of initiation, a 'transfer at the 1st phase coincidence' will take place. This means that the 'open' command is given at once and the standby network is connected at the point of minimum difference between the standby and busbar voltage 5. The average transfer time is approximately 250 to 500 ms, the actual value depending solely on the residual voltage behavior of the load.

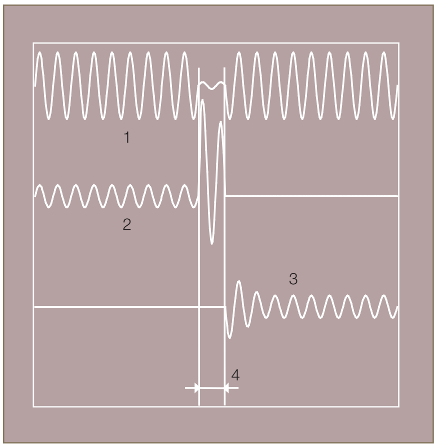
Residual voltage transfer: This comes into play when the criteria for a fast transfer operation are not met and a transfer at 1st phase coincidence is not feasible. First the supply breaker is opened, and then the decay on the busbar is monitored. When a preset residual voltage value has been reached the standby feeder is closed. This ensures that the maximum possible voltage difference between the busbar and standby network (in the case of phase opposition) does not exceed a defined value, thereby limiting the torque surge acting on the installation motors when the busbar is connected to the standby network.

Time-controlled transfer: This kind of transfer is initiated if the busbar voltage cannot be monitored. The standby feeder is closed after a fixed time, which can be preset. This time must always be longer than the maximum transfer time in the case of a residual voltage transfer so as to ensure that the voltage falls below the residual voltage value.

Where the HSTS wins

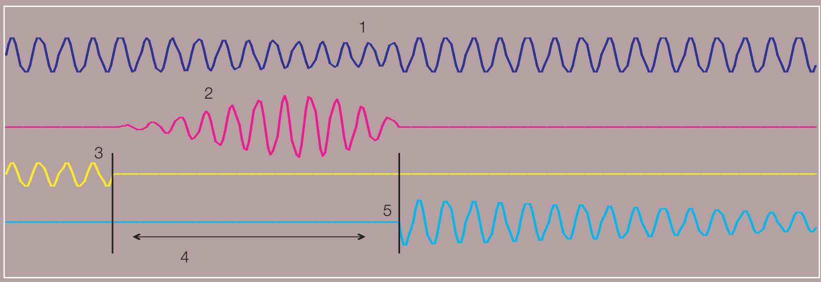
While line failure is neither a common nor a frequent problem, it can occur where even advanced power distribution infrastructures exist. Data from surveys of distribution networks' power quality performance [3] show that the average customer minutes loss

4 Fast transfer waveforms with synchronized feeders



1 = Busbar voltage
2 = Main feeder current before transfer
3 = Standby feeder current after transfer
4 = Dead time

5	Transfer at first phase coincidence. If the two supply networks are not synchronized, the standby feeder is connected 250 to 500 ms after the command to open the main feeder breaker is given.



1 = Busbar voltage
2 = Differential voltage ($U_{bb} – U_{standby}$)
3 = Main feeder current before transfer
4 = Dead time
5 = Standby feeder current after transfer

(CML) in the industrialized world lies in the tens to hundreds of minutes/customer/year range, with 1 to 5 events/customer/year; the majority of these originate in medium-voltage networks.

Most large factories or manufacturing plants with sensitive processes now have two independent power supply lines and automatic transfer systems as an insurance against power interruption. If the primary power supply fails, the switchgear cuts in and switches to the secondary supply. However, these systems can be slow to react and do not normally respond to voltage sags or potential interruption.

ABB's High Speed Transfer System offers customers speedy protection against power interruption and preservation of power quality [4].

Due to the short operating times, the phase angle between the busbar and the alternative power supply shifts only very slightly in the event of disturbance and the two remain synchronized.

> Automatic load transfer in less than 1.5 cycles avoids costly downtime and enhances the protected busbar's power quality.

Also, since a full sized circuit-breaker is used, no additional breaker is needed for the feeder protection. With a full short-circuit rating of up to 25 kA (breaking current) and a rated current of 1250 A, the circuit-breakers are suitable for standard protection as well as HSTS applications.

Power quality plus

Through the integration of new power electronics actuators and enhanced control and protection, ABB's High Speed Transfer System offers a genuinely high-value system for better power supply management. The HSTS is the answer to problems stemming from momentary/sustained interruptions and, thanks to the ultra-fast transfer, voltage sags, for critical loads.

Automatic load transfer to an undisturbed power supply in less then 1.5 cycles avoids costly downtime and enhances the protected busbar's power quality, while at the same time providing full short-circuit protection.

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