High-speed busbar transfer

HBT

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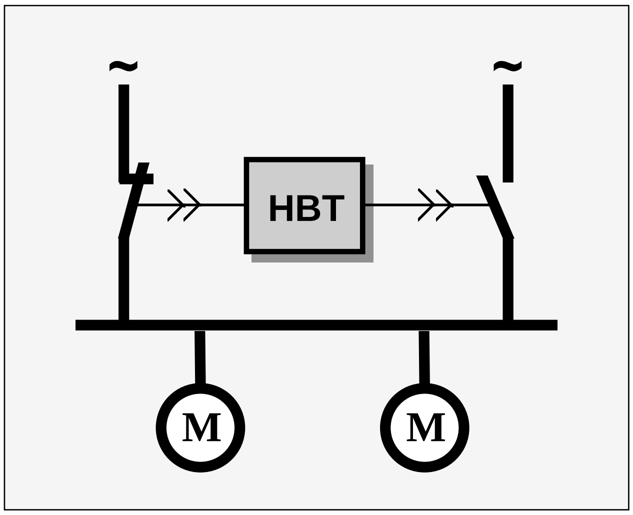

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Main features

Application
- Motor busbars in power plants and industry
- Schemes with two or three circuit-breakers
- User-specific schemes
- Paralleling of asynchronous power systems
- Integrated in control and protection hardware
- Several HBT functions configurable in the same device

Manual transfer
- Transfer initiated manually or by a process signal
- Synchro-check function with adjustable parameters
- Short transfer time
- No-break and with-break transfer modes

Automatic transfer
- Surge-free synchronised transfer in the event of loss of motor supply
- Circuit-breaker closing time taken into account
- Closing command issued within an adjustable angle before the first phase coincidence (fast transfer)
- Circuit-breaker closes at the first phase coincidence (in-phase transfer)
- Automatic transfer below an adjustable minimum voltage (residual voltage transfer)
- Automatic transfer after an adjustable maximum time (long-time transfer)
- Closing enabled up to given limits of amplitude and frequency difference
- Two independent settings for circuit-breaker closing time

Circuit-breaker control
- Control of two circuit-breakers
- Inclusion of bus-tie breaker by configuring two HBT functions
- Supervision of operating status
- Plausibility check
- Supervision of circuit-breaker operating time
- Generation of circuit-breaker closing and opening commands

Hardware
- Microprocessor-based control unit REC316*4. Refer to publication 1MRK511016-Ben for general design and technical data.

Application

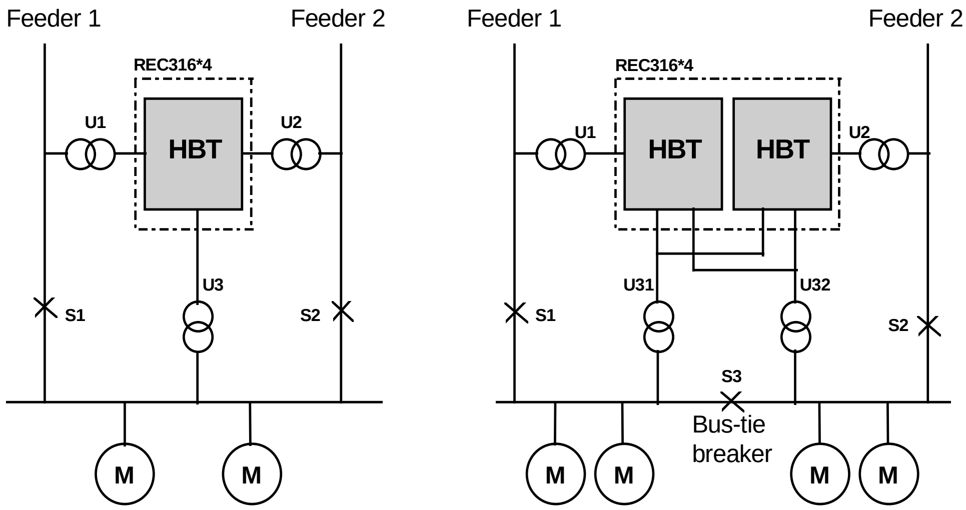

Fig. 1 Standard high-speed bus transfer schemes

High-speed busbar transfer
The purpose of the high-speed busbar transfer system (HBT) is to switch motor busbars over to an intact backup supply should the main supply fail and to switch them back again when the main supply is restored. This function is primarily needed to maintain the supply to essential auxiliaries in power plants and industrial processes.

The transfer is initiated either manually or by a signal generated by the process, e.g. after the generator has been synchronised in the case of power plant auxiliaries. Providing the supplies are in phase, one circuit-breaker is opened and the other closed almost simultaneously.

In the event of a sudden supply failure, because of, for example, a fault on the HV system, the switchover to the backup supply must be performed as quickly and as smoothly as possible to maintain operation and avoid undue stress on the motor shafts. During the period that the supply is interrupted, the slip increases at a rate determined by the moment of inertia and the motor load. The instant at which the close command is issued to the circuit-breaker must therefore take this into account and also the time the circuit-breaker takes to close.

The motors can be switched over at the first phase coincidence or at low rates of slip, before the phase-angle reaches a set maximum. The switchover signal in the event of a sudden supply failure is normally generated by an application-specific logic that evaluates the protection signals and the statuses of the isolators and circuit-breakers. The logic can be implemented in the REC316*4 using the FUPLA function block graphical programming tool.

Should for some reason a fast switchover be impossible, it can be performed either after the motor voltage has fallen below a preset value or after an adjustable time delay. By correspondingly programming an undervoltage function from the REC316*4 software library, the possibility also exists of selectively shedding load before restoring the supply to the motors.

Fig. 1 shows the most common applications of a high-speed bus transfer system.

Paralleling asynchronous power systems
Because of its ability to close a circuit-breaker precisely at the instant when the voltages across it are of equal amplitude and in phase, the HBT function can also be used to connect two power systems in parallel. The paralleling command can be given either manually or by a signal from the power system control centre. The ranges of amplitude and frequency difference within which paralleling is permitted can be determined by the user.

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Functional description

One HBT high-speed bus transfer function is equipped with all the inputs, outputs and function blocks needed to control a single set of busbars with two feeders. An application-specific logic can be added using the FUPLA graphical programming tool (see other relevant documents on Page 8).

The application-specific logic generates the starting signal for the HBT or can enable or disable particular HBT function blocks in relation to the status signals from the switchgear.

- The following function blocks are included in the HBT high-speed busbar system (Fig. 2):
- Manual transfer
- Automatic transfer
- Voltage selection
- Circuit-breaker supervision and control

Manual transfer
Upon receiving a manual switchover command either via the serial bus from the substation control system or an opto-coupler input on the HBT, this function block checks the synchronism of the voltages on the motor busbar and the feeder to be connected to it.

Providing the two are sufficiently closely synchronised, switchover can be performed according to one of two procedures:

- no-break transfer
- with-break transfer

If the ”with-break” transfer mode has been selected, tripping and closing commands are issued to both circuit-breakers at the same time. An adjustable timer enables the closing command to be delayed if necessary. This mode achieves the shortest possible transfer times.

In the case of the no-break transfer mode, the closing command is issued immediately and the tripping command after an adjustable time delay.

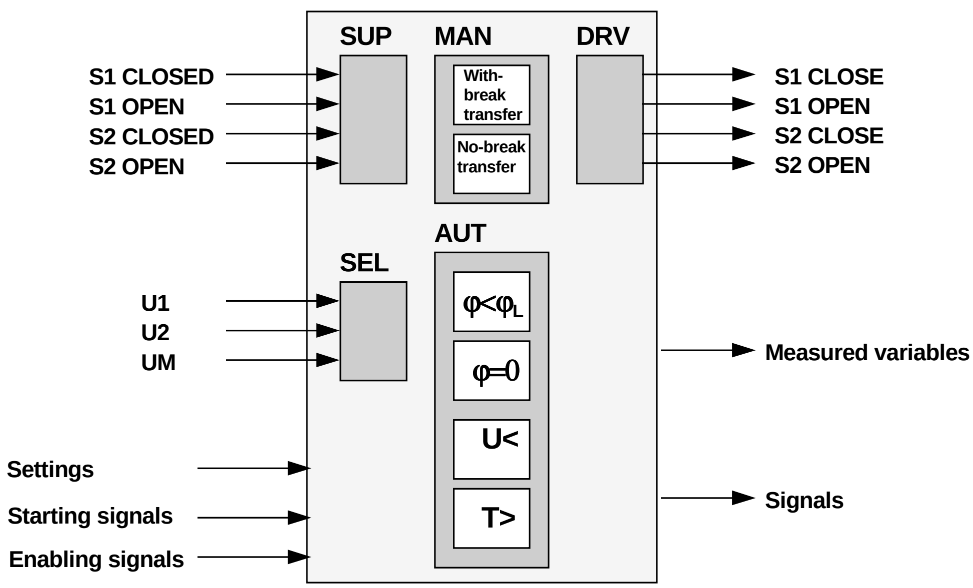

Fig. 2 Block diagram of the HBT function

AUT	Automatic transfer
DRV	Circuit breaker control logic
MAN	Manual transfer
SEL	Voltage selection
SUP	Circuit breaker supervision logic
S1ON, ...	Circuit breaker status signals
U1, U2	Feeder voltages
UM	Motor busbar voltage
$\varphi < \varphi_L$	Adjustable maximum phase angle for closing the breaker
$\varphi = 0$	Circuit breaker closed at first phase coincidence
U<	Transfer by undervoltage function
T>	Transfer by time limit function

Functional description (cont´d)

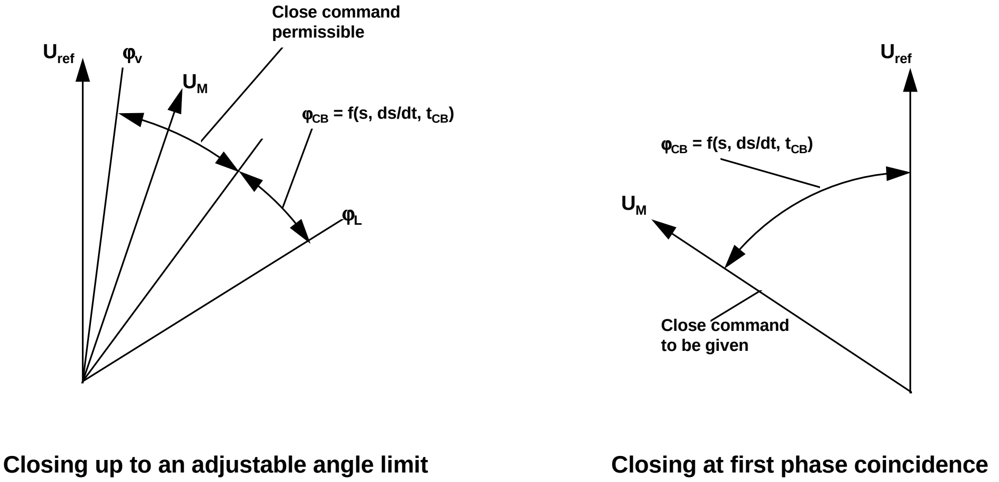

Fig. 3 Vector diagrams of the two complementary algorithms that control automatic transfer after a supply failure

- U_{ref} voltage of the feeder to be connected
- U_M motor bus voltage after tripping the supply
- φ_V phase angle between the motor bus voltage and U_{ref} immediately after tripping the main supply
- φ_{CB} angle corresponding to the circuit breaker closing time
- φ_L max. permissible phase-angle for operating the circuit breaker
- s slip frequency
- t_{CB} circuit breaker closing time

Automatic transfer
This function is intended to respond to a sudden supply failure and will normally be activated, for example, by a protection trip signal, but it can be initiated manually. The function executes two complementary algorithms which can also run in parallel (Fig. 3).

The first algorithm performs a fast switchover within an adjustable phase-angle between the motor voltage and the voltage of the feeder to be connected immediately the supply fails. It is especially suitable for plants with low rates of slip and synchronous feeder voltages before the failure (curve 1 of Fig. 4).

The second algorithm switches over at the first phase coincidence between the motor voltage and the voltage of the feeder to be connected. It always operates correctly regardless of whether the two voltages were synchronised or slipping up to 10 Hz with the motor frequency higher or lower than that of the voltage to be connected. Tests have been successfully carried out with the motor frequency changing at more than 50 Hz per second.

Fig. 4 shows the excursion of the phase-angle between the motor voltage and the voltage of the feeder to be connected in relation to time. It is determined by the initial slip and the rate of change of slip, both of which reflect the prevailing load conditions.

Both algorithms allow for the circuit-breaker closing time, the slip and the rate of change of slip when computing the angular advance for the closing command.

Backup functions
Since they do not have to determine the synchronism of the two circuits to be connected, the measured variables of the backup functions are less complex. Both can be active at the same time:

- Undervoltage
- Limit time

The undervoltage function enables paralleling when the motor busbar voltage falls below a preset value. A typical setting is 30 %.

Paralleling is enabled when the limit time is reached without regard to synchronism.

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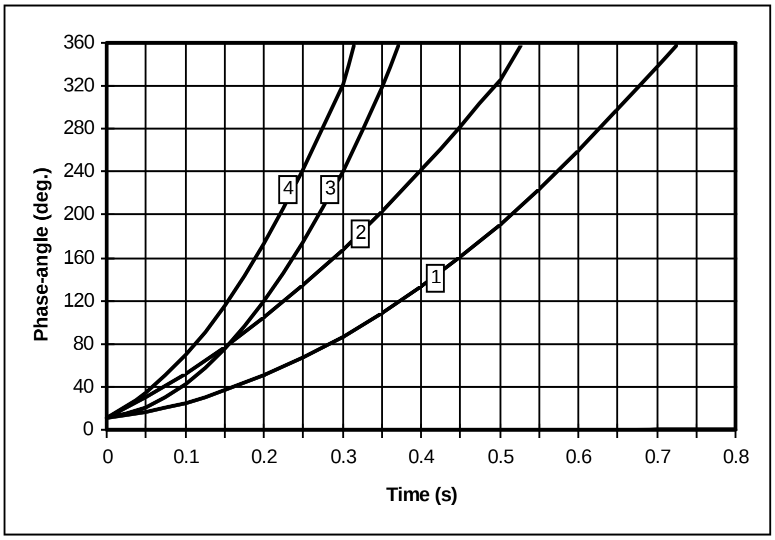

Fig. 4 Excursion of the phase-angle between the motor busbar voltage and the voltage of the feeder to be connected in relation to time after the main supply has been tripped

Curve	Slip before transfer (%)	Rate of change of slip (% per second)
1	0.5	6
2	2	6
3	0.5	25
4	2	25

Voltage selection

This function compares the voltage of the motor busbar with a reference voltage (Fig. 1). If the busbar is being supplied by feeder 1, the reference voltage is U2 (feeder 2) and vice versa. The correct voltage is selected on the basis of the starting signals for manual or automatic transfer.

Circuit-breaker supervision and control

The statuses of the two circuit-breakers are supervised and checked for plausibility. An inadmissible operating condition inhibits the transfer and generates an alarm. The operating times of the circuit-breakers are also supervised.

Example of a high-speed transfer

Fig. 5 shows the waveforms for an automatic switchover of a 6 kV motor busbar. The signals were recorded by the disturbance recorder function of the REC316*4. In this example, the backup supply is connected about 320 ms after the main supply was tripped. This is the time taken for phase coincidence (phase-angle 360°) to occur between the motor bus voltage and the backup feeder (T29 AUX). Main and backup supplies were synchronous before the transfer.

The vertical marker is at 249.5 ms, i.e. the instant at which the close command was issued (Q19 Close). The measured variables to the right are referred to this time. The command was given at a frequency difference of 4 Hz and a rate of change of frequency of 16.5 Hz per second. The HBT function was started about 10 ms after the circuit-breaker opened (HBT start). The internal evaluation was active from the time the starting signal was received to the time the closing command was issued.

Functional description (cont'd)

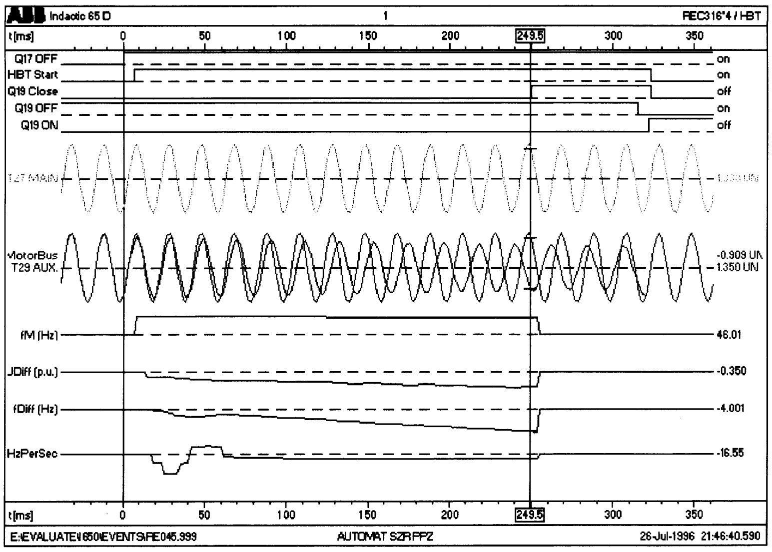

Fig. 5 High-speed transfer of a 6 kV motor busbar

Integration in a Substation Control System

If the HBT function is part of a substation control system (SCS), its operation can be controlled and supervised as follows:

The HBT function can be enabled or disabled directly on the screen of the operator's monitor. The operator also initiates a manual transfer and supervises the status of the HBT function (enabled/disabled/defective) on the screen in a similar manner.

Technical data

(See "Other relevant documents" below for the general REC316*4 data.)

Table 1: Measuring ranges

Rated frequency f_N	50 Hz or 60 Hz
Frequency range	0.8 to 1.04 f_N
Rated input voltage U_N	100 to 130 V or 200 to 260 V

Table 2: REC316*4 inputs and outputs

Voltage inputs	6 on module K41 max. 9 using a user-specific input module (A phase-to-phase measurement is recommended.)
Control outputs	max. 8 for the control of 4 circuit breakers
Optocoupler inputs	max. 32 using four 316DB61 modules, virtually unlimited using RIO 580 modules

Table 3: Parameters

Closing time LS1 and LS2	0 to 150 ms in steps of 1 ms
Live line check	0.5 to 1.2 U_N in steps of 0.1 U_N
CB operating time supervision	50 to 500 ms in steps of 10 ms
Phase compensation for voltages U1 and U2	-180 to 180° in steps of 0.5°
Manual transfer	
Max. duration of the switchover signal	0.02 to 60 s in steps of 0.02 s
Max. voltage difference to enable operation	0.00 to 1.00 U_N in steps of 0.01 U_N
Max. absolute phase difference	0 to 90° in steps of 5°
Max. frequency difference to enable operation	0.05 to 0.4 Hz in steps of 0.05 Hz
Closing command time delay	0 to 200 ms in steps of 10 ms
Tripping command time delay	0 to 200 ms in steps of 10 ms
Automatic transfer	
Time limit for executing synchronous transfer or enabling non-synchronous transfer (T>)	0.1 to 10 s in steps of 0.01 s
Max. voltage difference to enable operation	0.00 to 1.00 U_N in steps of 0.01 U_N
Max. phase-angle before the first phase coincidence for enabling transfer	0° to 90° in steps of 5°
Max. frequency difference to enable operation	0.05 to 10 Hz in steps of 0.05 Hz
Voltage level for enabling non-synchronous transfer	0.1 to 1.0 U_N in steps of 0.1 U_N

Table 4: Accuracy (typical values for a sinusoidal voltage of constant amplitude and frequency)

Phase angle measurement	± 1°
Frequency measurement	± 0.03 Hz
Voltage measurement	±2%
CB closing at 10% slip	phase coincidence ±10°

Ordering information

REC316*4

Ordering code A*B*C*D*U*K*H*E*I*F*J*Q*V*R*W*Y*N*M1 SX900 T***

Functions CTRL AR OCInst OCDT OCINV TH Freq HBT Basic SW

(Refer to 1MRK 511016-Ben for the significance of the codes)

Other relevant documents

Data Sheet REC316*4	1MRK511016-Ben
CAP316	1MRB520167-Ben
Data Sheet RIO 580	1MRB520176-Ben

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