SIEMENS

SIPROTEC 5
Point-on-Wave Switching

V8.60 and higher

Manual

C53000-H5040-C082-2

NOTE

For your own safety, observe the warnings and safety instructions contained in this document, if available.

Disclaimer of Liability

Subject to changes and errors. The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

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Version of the product described: V8.60 and higher

Preface

Purpose of the Manual

This manual provides supplementary information about the **Point-On-Wave Switching** function in addition to SIPROTEC 5 device manuals. For other protection, automation, control, and monitoring functions of a specific SIPROTEC 5 device, the corresponding device manual applies.

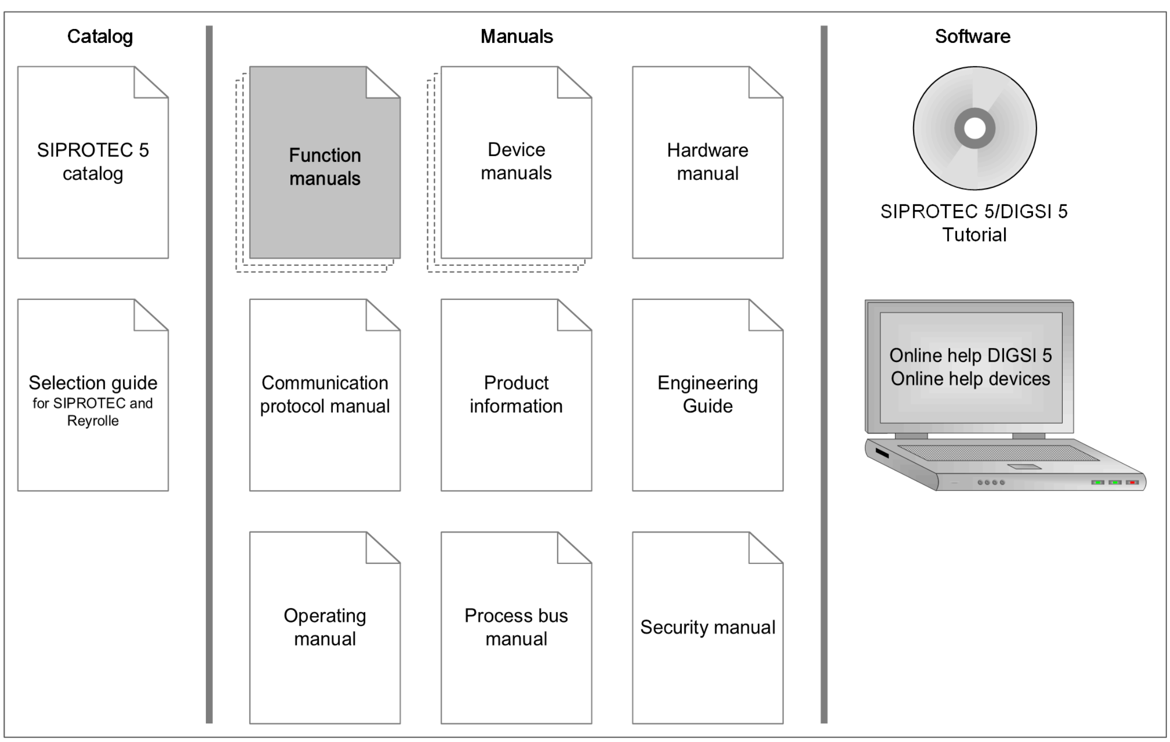
Target Audience

Protection system engineers, commissioning engineers, persons entrusted with the setting, testing and maintenance of automation, selective protection and control equipment, and operational crew in electrical installations and power plants.

Scope

This manual applies to the SIPROTEC 5 device family.

Further Documentation



[dw_Product-overview_SIP5_Function-manual, 2, en_US]

- Function manuals
  Each function manual describes a specific function that can be used in several SIPROTEC 5 devices.

- Device manuals

  Each Device manual describes the functions and applications of a specific SIPROTEC 5 device. The printed manual and the online help for the device have the same informational structure.

- Hardware manual

  The Hardware manual describes the hardware building blocks and device combinations of the SIPROTEC 5 device family.

- Operating manual

  The Operating manual describes the basic principles and procedures for operating and assembling the devices of the SIPROTEC 5 range.

- Communication protocol manual

  The Communication protocol manual contains a description of the protocols for communication within the SIPROTEC 5 device family and to higher-level network control centers.

- Security manual

  The Security manual describes the security features of the SIPROTEC 5 devices and DIGSI 5.

- Process bus manual

  The process bus manual describes the functions and applications specific for process bus in SIPROTEC 5.

- Product information

  The Product information includes general information about device installation, technical data, limiting values for input and output modules, and conditions when preparing for operation. This document is provided with each SIPROTEC 5 device.

- Engineering Guide

  The Engineering Guide describes the essential steps when engineering with DIGSI 5. In addition, the Engineering Guide shows you how to load a planned configuration to a SIPROTEC 5 device and update the functionality of the SIPROTEC 5 device.

- DIGSI 5 online help

  The DIGSI 5 online help contains a help package for DIGSI 5 and CFC.

  The help package for DIGSI 5 includes a description of the basic operation of software, the DIGSI principles and editors. The help package for CFC includes an introduction to CFC programming, basic examples of working with CFC, and a reference chapter with all the CFC blocks available for the SIPROTEC 5 range.

- SIPROTEC 5/DIGSI 5 Tutorial

  The tutorial on the DVD contains brief information about important product features, more detailed information about the individual technical areas, as well as operating sequences with tasks based on practical operation and a brief explanation.

- SIPROTEC 5 catalog

  The SIPROTEC 5 catalog describes the system features and the devices of SIPROTEC 5.

- Selection guide for SIPROTEC and Reyrolle

  The selection guide offers an overview of the device series of the Siemens protection devices, and a device selection table.

Indication of Conformity

This product complies with the directive of the Council of the European Communities on harmonization of the laws of the Member States concerning electromagnetic compatibility (EMC Directive 2014/30/EU), restriction on usage of hazardous substances in electrical and electronic equipment (RoHS Directive 2011/65/EU), and electrical equipment for use within specified voltage limits (Low Voltage Directive 2014/35/EU).

This conformity has been proved by tests performed according to the Council Directive in accordance with the product standard EN 60255-26 (for EMC directive), the standard EN 50581 (for RoHS directive), and with the product standard EN 60255-27 (for Low Voltage Directive) by Siemens.

The device is designed and manufactured for application in an industrial environment.

The product conforms with the international standards of IEC 60255 and the German standard VDE 0435.

Standards

IEEE Std C 37.90

The technical data of the product is approved in accordance with UL.

For more information about the UL database, see *ul.com*

You can find the product with the **UL File Number E194016**.

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Additional Support

For questions about the system, contact your Siemens sales partner.

Customer Support Center

Our Customer Support Center provides a 24-hour service.

Siemens AG
Smart Infrastructure – Digital Grid
Customer Support Center
Phone: +49 911 2155 4466
E-mail: *energy.automation@siemens.com*

Training Courses

Inquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG
Siemens Power Academy TD
Humboldtstrasse 59
90459 Nuremberg
Germany

Phone: +49 (911) 433-7415
Fax: +49 (911) 433-7929
E-mail: *poweracademy@siemens.com*
Internet: *www.siemens.com/poweracademy*

Notes on Safety

This document is not a complete index of all safety measures required for operation of the equipment (module or device). However, it comprises important information that must be followed for personal safety, as well as to avoid material damage. Information is highlighted and illustrated as follows according to the degree of danger:

DANGER

DANGER means that death or severe injury **will** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

WARNING

WARNING means that death or severe injury **may** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid death or severe injuries.

CAUTION

CAUTION means that medium-severe or slight injuries **can** occur if the specified measures are not taken.

✧ Comply with all instructions, in order to avoid moderate or minor injuries.

NOTICE

NOTICE means that property damage **can** result if the measures specified are not taken.

✧ Comply with all instructions, in order to avoid property damage.

NOTE

Important information about the product, product handling or a certain section of the documentation which must be given attention.

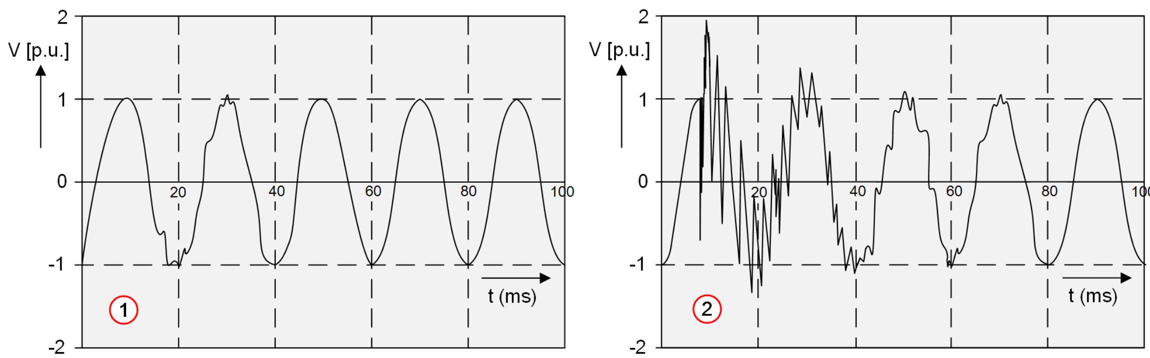
Table of Contents

1 Overview of the Function

1.1 Introduction

The **Point-on-wave switching** function in SIPROTEC 5 is used to reduce increased electrodynamic and dielectric loads which are caused by non-optimal switching of circuit breakers in the network. In extreme cases, these loads reduce the reliability and life of the equipment installed in the network or lead to unnecessary opening operations by the protection device. To avoid effects such as overvoltages and inrush currents, this function can control the closing and opening instants of circuit breakers.

The following figure shows an example of closing for a capacitive load.



[dw_Reduction surge voltages when energizing grounded capacitor bank, 2, en_US]

Figure 1-1 Example of a Closing for a Capacitive Load

(1) Optimized closing instant

(2) Non-optimized closing instant

Table 1-1 Avoided Effects in Different Load Types

Load Type	Switching Operation	Avoided Effect
Inductive load:	Opening	Restriking, overvoltage
Transformer, reactance coil	Closing	Inrush current, overvoltage
Capacitive load:	Opening	Restriking, overvoltage
Capacitor bank, transmission line	Closing	Overvoltage, inrush current

The **Point-on-wave switching** function is always started via a control command, either from the device-internal control function or from an external control function. Protection functions generally directly trip the circuit breaker and have no interaction with the **Point-on-wave switching** function.

1.2 Subfunctions

Control of the Closing and Opening Instants

The desired closing or opening instant is always related to a voltage zero crossing. Depending on the load type, the **Point-on-wave switching** function forwards the received switching command to the trip coil of the circuit breaker depending on the load type with the determined time delay considering the phase relationship. The commands are sent to the 3 phases of the circuit breaker independently of one another.

The following times of the circuit breaker are considered in the time-delay calculation:

- Mechanical operating time (closing and opening time)
- Pre-arcing time for closing operation
- Arcing time for opening operation

Calculation of the Compensated Mechanical Operating Time

The compensated mechanical operating time is used to control the opening or closing instant. The **Point-on-wave switching** function calculates the compensated mechanical operating time using different influencing factors that change the mechanical operating time of the circuit breaker. The influencing factors are as follows:

- Control voltage
- Ambient temperature
- Hydraulic pressure on circuit breakers with hydraulic operating mechanisms

For further information, refer to chapter *1.4.2 Compensation of the Mechanical Operating Times*.

Evaluation of the Switching Accuracy

During the switching operation, the current and voltage signals as well as other switching-accuracy information are recorded, supervised, and logged. The logs and recordings can be downloaded for evaluation purposes. For more information on the switching accuracy, refer to chapter *4.1.4 Switching-Accuracy Supervision* for the **CB opening** function block and to chapter *5.1.4 Switching-Accuracy Supervision* for the **CB closing** function block. For more information on logs and recordings, refer to chapter *7 Recording and Logging*.

Supervision of the Function Availability

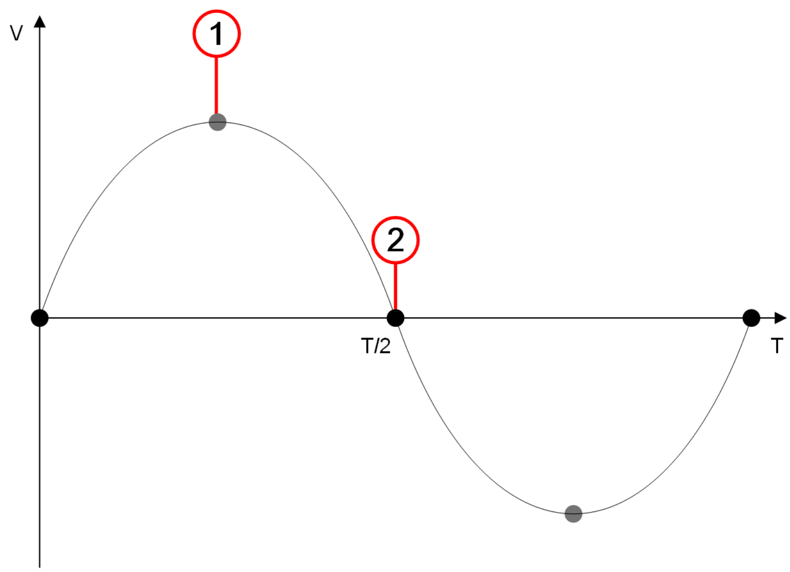
Errors which impair the operation of the **Point-on-wave switching** function or peripheral components such as a failure of a sensor or the control voltage are supervised and reported. For more information on the supervision functions, refer to chapter *3.1.6 Supervision*.

1.3 Influences on Desired Closing and Opening Instants

The desired closing and opening instants depend on the load type. This chapter describes the most important influences.

1.3.1 Capacitive and Inductive Loads

The influences of the load type on the desired closing and opening instants are described using the closing operation as an example.



[dw_Optimum_switching_instants, 2, en_US]

Figure 1-2 Desired Closing Instant in a System with a Grounded Neutral Point

1	Inductive load
2	Capacitive load
V	Voltage across open circuit-break pole
T	Network period

Inductive Load

A reactance coil (inductive load) creates a high resistance. When this reactance coil is energized, large differences of the current in the energizing instant would lead to a strong current increase and would therefore cause high overvoltages. It is therefore best to energize near the current zero crossing, that is, near the maximum voltage.

Capacitive Load

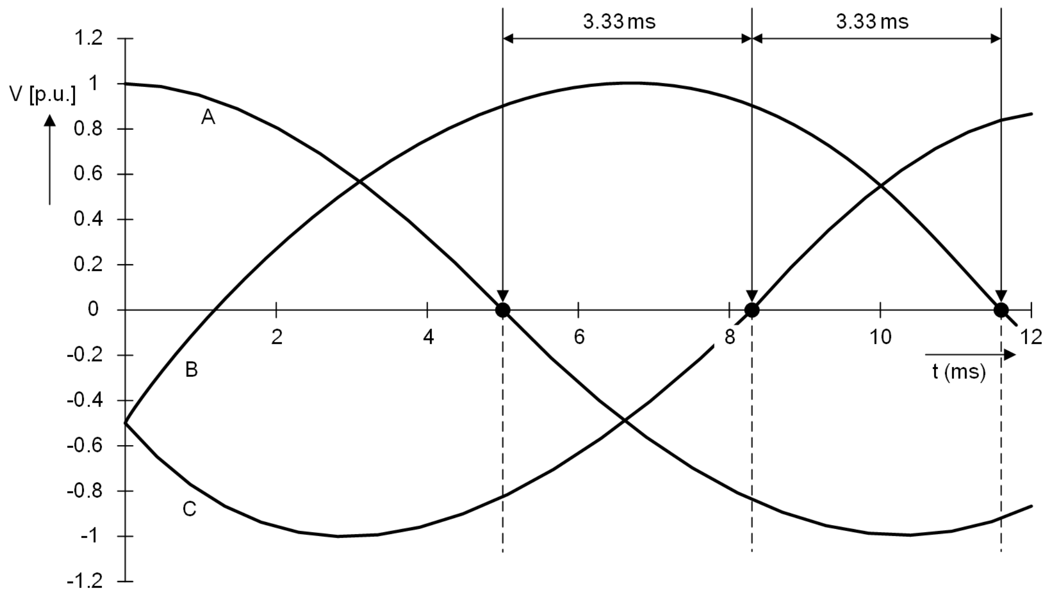
A discharged capacitor (capacitive load) has a low resistance. If this discharged capacitor is energized, strong transient balancing processes such as overvoltages and inrush currents occur when the capacitor is connected near the maximum voltage. To obtain the lowest potential difference upon energizing, the closing operation must occur near the voltage zero crossing.

1.3.2 System Grounding

Another influence on selecting the desired closing and opening instants is whether the system is grounded or isolated. This chapter describes this influence using the energizing of a capacitor bank as an example.

Energizing a Grounded Capacitor Bank

The voltage across the circuit-breaker gap is the decisive factor in selecting the desired closing instant for each phase. Closing each phase leads to a current flow via the ground. The target instant is the voltage zero crossing in each phase and the 3 phases have a time offset by the phase displacement of their zero crossings. In the closing sequence of ACB, the time offset of the closing instants between the phases is 3.33 ms at 50 Hz (2.77 ms at 60 Hz).



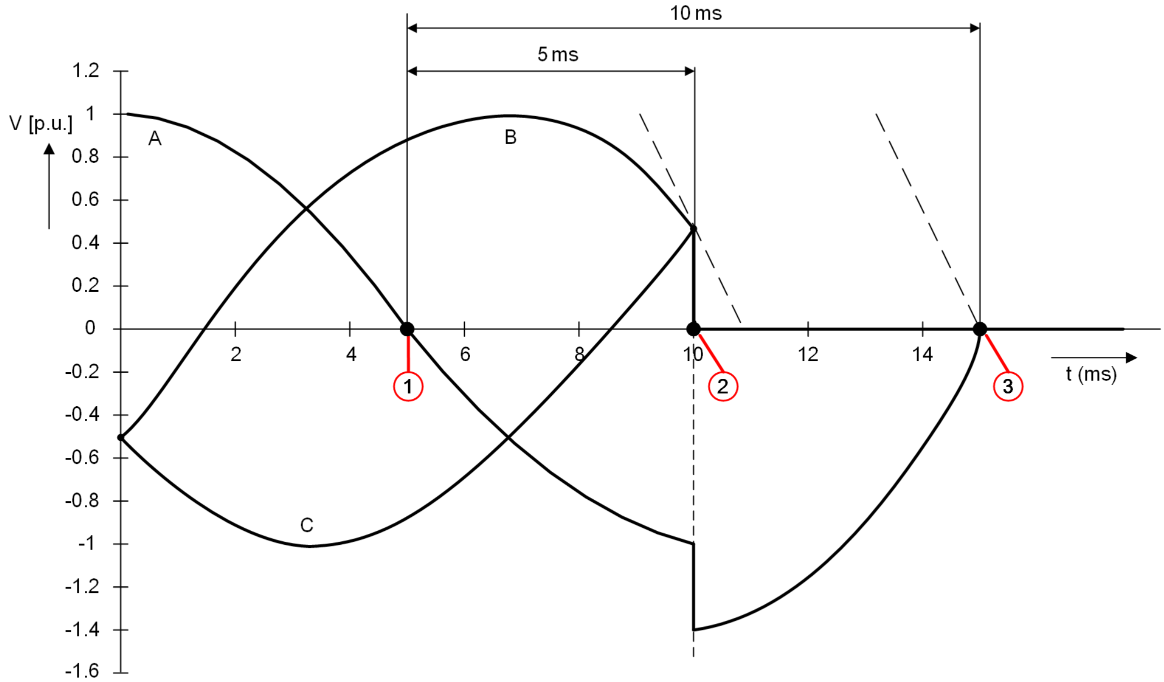
[dw_Closing instants for grounded capacitor bank, 2, en_US]

Figure 1-3 Closing Instants for a Grounded Capacitor Bank (3-Phase, 50 Hz)

Controlled energizing of a grounded capacitor bank reduces overvoltages.

Energizing an Isolated Capacitor Bank

During the energizing of an isolated capacitor bank, energizing the 1st phase does not yet lead to a current flow. With the energization of the 2nd phase, the difference of both voltages is applied to the capacitors. The voltages between the phases must be considered for selecting the optimal closing instant. To avoid the clashing of large voltage differences between the phases to be closed, the first 2 phases are energized at the same time (5 ms at 50 Hz after zero crossing of the reference voltage) when the voltage difference between 2 phases is zero. The 3rd phase is then energized in its voltage zero crossing (10 ms at 50 Hz after zero crossing of the reference voltage).



[dw_Closing instants for isolated capacitor bank, 3, en_US]

Figure 1-4 Closing Instants for an Isolated Capacitor Bank (3-Phase, 50 Hz)

(1) Zero crossing of the reference voltage
(2) Closing instant for phases B and C
(3) Closing instant for phase A

1.4 Properties of the Circuit Breaker

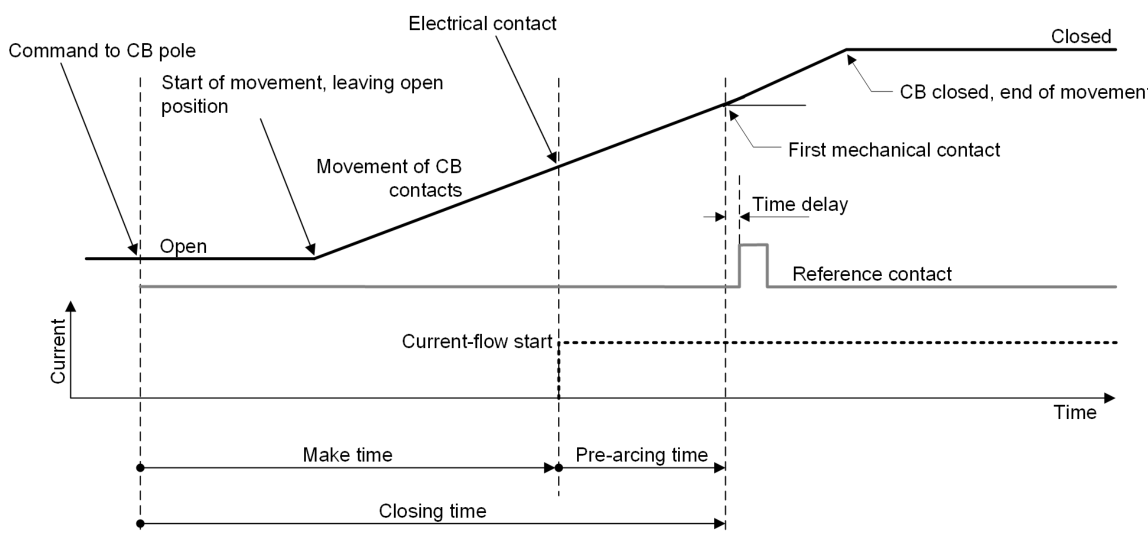
This chapter describes the definitions of the circuit-breaker properties related to the following:

- The closing and opening operations
- The compensation of the mechanical operating times

1.4.1 Definitions of Circuit-Breaker Properties

Circuit-Breaker Closing

Property	Definition
Closing time	The time between the issuing of the electrical command to the circuit-breaker pole concerned and the mechanical contact in this circuit-breaker pole
Make time	The time between the issuing of the electrical command to the circuit-breaker pole concerned and the beginning of the arcing (current-flow start) in this circuit-breaker pole
Pre-arcing time	The time interval in which the arc is active at the circuit-breaker pole concerned



[dw_CB closing, 2, en_US]

Figure 1-5 Diagram for Circuit-Breaker Closing

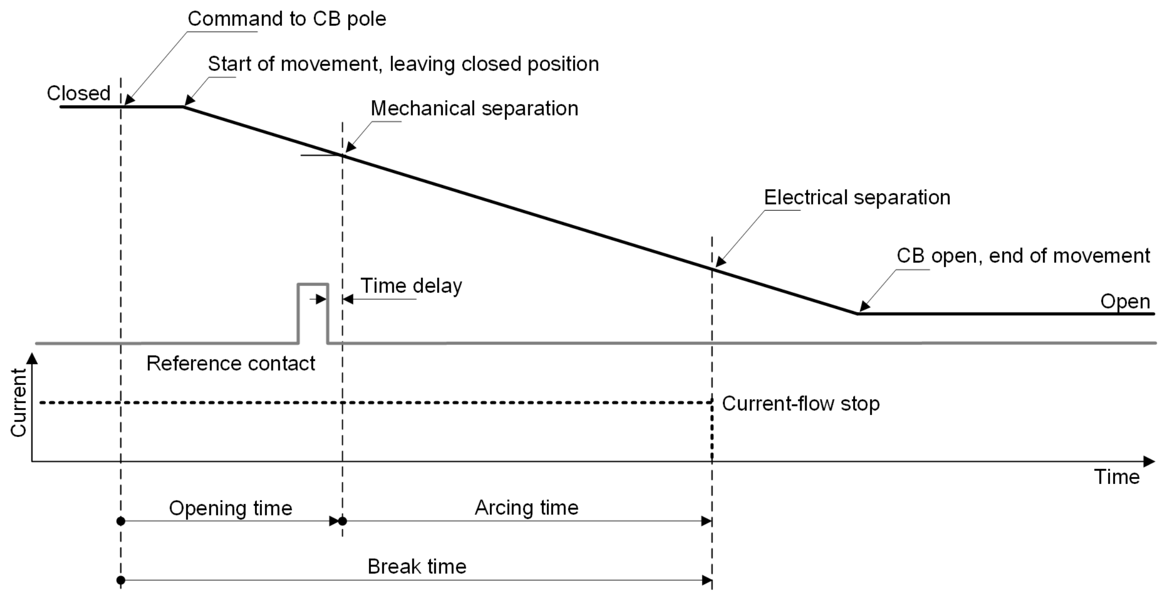
As shown in the preceding figure, the actual time of mechanical contact is obtained via reference contacts of the circuit breaker. Reference contacts can be either specific precise sensors (for example, Hall-effect sensors of Siemens CBs) or the CB auxiliary contacts.

$$\text{Closing time} = \text{Make time} + \text{Pre-arcing time}$$

[fo_Closing time, 2, en_US]

Circuit-Breaker Opening

Property	Definition
Break time	The time between the issuing of the electrical command to the circuit-breaker pole concerned and the arc extinguishing (current-flow end) in this circuit-breaker pole
Opening time	The time between the issuing of the electrical command to the circuit-breaker pole concerned and the mechanical separation in this circuit-breaker pole
Arcing time	The time interval in which the arc is active at the circuit-breaker pole concerned during opening



[dw_CB opening, 2, en_US]

Figure 1-6 Diagram for Circuit-Breaker Opening

As shown in the preceding figure, the actual time of mechanical separation is obtained via reference contacts of the circuit breaker. Reference contacts can be either specific precise sensors (for example, Hall-effect sensors of Siemens CBs) or the CB auxiliary contacts.

$$\text{Break time} = \text{Opening time} + \text{Arcing time}$$

[fo_Break time, 2, en_US]

1.4.2 Compensation of the Mechanical Operating Times

The mechanical operating times (including opening and closing times) of circuit breakers are determined at the factory or on site with a suitable mechanical operating-time measuring device.

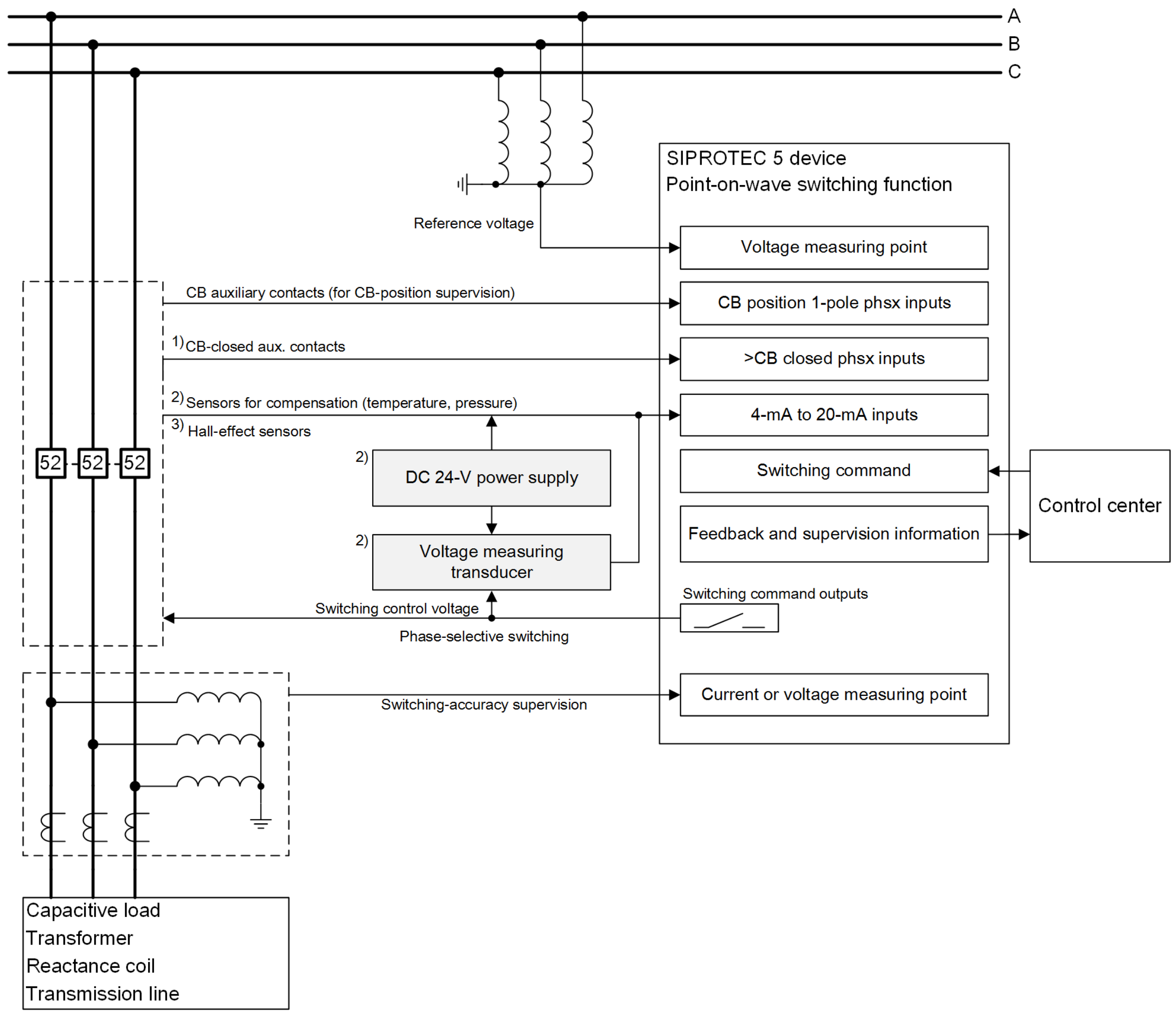
During operation, the mechanical operating times can change with the following factors:

- Control voltage
- Ambient temperature
- Hydraulic pressure for circuit breakers with hydraulic operating mechanisms

The **Point-on-wave switching** function has the option to measure these factors. If the influences of these factors on mechanical operating times are known and relevant, these influences can be compensated via compensation characteristics (linear or used-defined).

For further information on the compensation, refer to chapter *4.1.3 Compensation*.

1.5 Application Environment and Equipment



[dw_Application environment PoW, 3, en_US]

Figure 1-7 Application Environment of the SIPROTEC 5 Device with the Point-on-Wave Switching Function

(1) For Non-Siemens CB, as reference contacts
(2) Optional
(3) For Siemens CB, as reference contacts

The application can comprise the following primary, secondary, and auxiliary equipment, some of which is optional:

- Primary equipment
  - Load to be switched
  - Circuit breaker

- Secondary equipment and circuits
  - Voltage and current transformers
  - SIPROTEC 5 device with the **Point-on-wave switching** function
  - Hall-effect sensors (only for Siemens circuit breaker, as reference contacts)
  - Circuit-breaker auxiliary contacts
  - Switching circuits
  - Sensors (for compensation)
- Auxiliary equipment
  - DC 24-V power supply
  - Voltage measuring transducer

Voltage and Current Transformers

The busbar voltage is usually used as the reference signal for zero-crossing detection. The zero crossing serves as the reference to determine the switching instants.

Currents and voltages at the load side are used to monitor the switching accuracy.

SIPROTEC 5 Device with the Point-on-Wave Switching Function

The **Point-on-wave switching** function can be instantiated in a SIPROTEC 5 device. You can find the device types supporting the **Point-on-wave switching** function in chapter *1.7 Possible Device Types and Device Applications*.

Hall-Effect Sensors (only for Siemens Circuit-Breaker, as Reference Contacts)

In case of Siemens circuit breakers, the mechanical make/break time is detected via Hall-effect sensors with high precision. The Hall-effect sensors are connected to the device via fast measuring-transducer inputs.

In case of non-Siemens circuit breakers, this function is carried out via the 52a auxiliary contact of the circuit breaker.

Circuit-Breaker Auxiliary Contacts

The circuit-breaker auxiliary contacts serve for 2 functionalities. They are connected to the device binary inputs:

- The 52a contacts (CB closed) are used as circuit-breaker reference contacts to detect the mechanical make/break time in case of non-Siemens circuit breakers.
  In case of Siemens circuit breakers, this function is carried out via a fast measuring-transducer input connected to a Hall-effect sensor.
- The 52a and 52b contacts are used for the CB-position supervision.

Switching Circuits and Sensors (for Circuit-Breaker Mechanical Operating-Time Compensation, Optional)

The circuit-breaker switching control voltage level can have an influence on the circuit-breaker switching time. If this influence is known, it can be compensated. To measure the circuit-breaker switching control voltages, external measuring transducers are required (refer to the section *Voltage Measuring Transducer (Optional), Page 19*), which convert the DC voltage into a 4-mA to 20-mA signal. The 4-mA to 20-mA signal is measured via a measuring-transducer input.

For more information about the connection of the CB closing or opening circuit, refer to chapter *Figure A-2*.

Sensors (for Circuit-Breaker Mechanical Operating-Time Compensation, Optional)

Environmental and process conditions can influence the mechanical operating time of the circuit breaker, such as the ambient temperature or the circuit-breaker hydraulic pressure. If the information about the influences on the CB mechanical operating time is known, the influences can be compensated by measuring these influencing conditions via respective sensors.

This functionality is optional.

For more information about the connection to the sensors, refer to chapter *Figure A-4*.

DC 24-V Power Supply (Optional)

An external DC 24-V power supply is required for the following conditions:

- To supply the external sensors and to drive the corresponding 4-mA to 20-mA current loops
- To supply the external voltage measuring transducer

Siemens recommends using the SIPROTEC 7XV5810 wide-range power supply. This power supply is limited to 250 mA. You need to consider the power consumption of the sensors and measuring transducers.

For more information about the connection of the power supply, refer to chapter *Figure A-4*.

The external power supply is only required when any of the following conditions is met:

- Siemens circuit breakers with Hall-effect sensors are used.
- Sensors for the compensation of the circuit-breaker mechanical operating time are used.

Voltage Measuring Transducer (Optional)

If the influence level of the control voltage on the circuit-breaker mechanical operating time shall be compensated, a voltage measuring transducer is required to convert the control voltage to 4-mA to 20-mA current.

For more information about the measuring transducers, refer to chapter *8.3 Required External Components* and for information about the connection to external voltage measuring transducers, refer to chapter *Figure A-10*.

The voltage measuring transducer is only required if this type of compensation needs to be carried out.

1.6 Applications

1.6.1 Reactance Coil

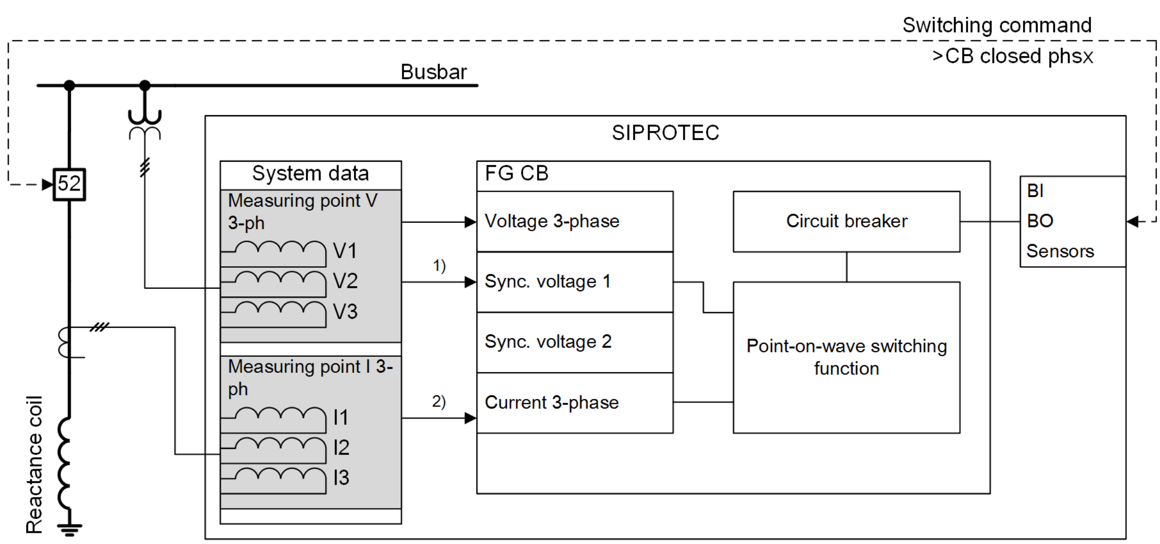
Energization

Energizing a reactance coil can result in large current asymmetry between phases and overvoltage, which might cause the maloperation of protection devices. To avoid this problem, for example, in grounded systems, the **Point-on-wave switching** function can energize the reactance coil at the current zero crossing, that is, at the maximum reference voltage.

De-Energization

During de-energization of a reactance coil, the quickly increased transient recovery voltage can result in overvoltage and restriking. The **Point-on-wave switching** function can decrease the possibility of restriking by controlling the end of the current flow at the current zero crossing. Contact separation takes place earlier by the arcing time.

Single-Line Connections

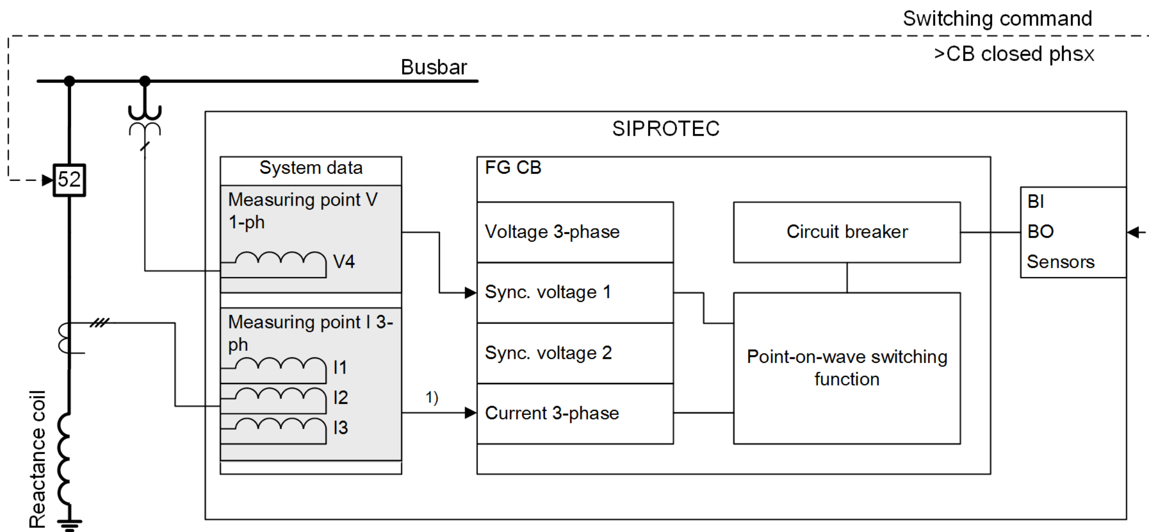


[dw_Shunt reactor, 3-phase VM, 2, en_US]

Figure 1-8 Reactance Coil, 3-Phase Voltage Measurement for Reference Signal

(1) VA or VAB as reference signal

(2) For switching-accuracy supervision



[dw_Shunt reactor,1-phase VM, 2, en_US]

Figure 1-9 Reactance Coil, 1-Phase Voltage Measurement for Reference Signal

(1) For switching-accuracy supervision

Reference-Voltage Connection

A reference voltage must be connected to the **Point-on-wave switching** function for detecting the zero crossing of the power-system voltage. For the reactance coil, a 1-phase or 3-phase busbar voltage can be used as the reference voltage. For more information about the reference-voltage connection via the measuring point **V-3ph** or **V-1ph**, refer to chapter *3.1.3 Reference Signal*.

Switching-Accuracy Supervision

For reactance coils, the 3-phase feeder current is used for the switching-accuracy supervision in the **CB opening** and **CB closing** function blocks.

For more information on switching-accuracy monitoring, refer to chapter *4.1.4 Switching-Accuracy Supervision* for the **CB opening** function block and to chapter *5.1.4 Switching-Accuracy Supervision* for the **CB closing** function block.

1.6.2 Capacitor Bank

Energization

When a discharged capacitor bank which has a low impedance is energized, strong transient balancing processes such as overvoltages and inrush currents occur when it is connected near the maximum voltage. To obtain the lowest potential difference upon energization, the closing operation must occur at the voltage zero crossing.

De-Energization

De-energizing a capacitor bank can cause restriking, which might damage the circuit breaker. The **Point-on-wave switching** function decreases the possibility of restriking.

Single-Line Connections

The single-line connection of the capacitor bank is the same as that of the reactance coil. For further information, refer to chapter *Single-Line Connections, Page 20*.

Reference-Voltage Connection

A reference voltage must be connected to the **Point-on-wave switching** function for detecting the zero crossing of the power-system voltage. For the capacitor bank, a 1-phase or 3-phase busbar voltage can be used as the reference voltage. For more information on the reference-voltage connection via the measuring point **V-3ph** or **V-1ph**, refer to chapter *3.1.3 Reference Signal*.

Switching-Accuracy Supervision

For the capacitor bank, the 3-phase feeder current is used for the switching-accuracy supervision in the **CB opening** and **CB closing** function blocks.

For more information on switching-accuracy supervision, refer to chapter *4.1.4 Switching-Accuracy Supervision* for the **CB opening** function block and to chapter *5.1.4 Switching-Accuracy Supervision* for the **CB closing** function block.

1.6.3 Transformer

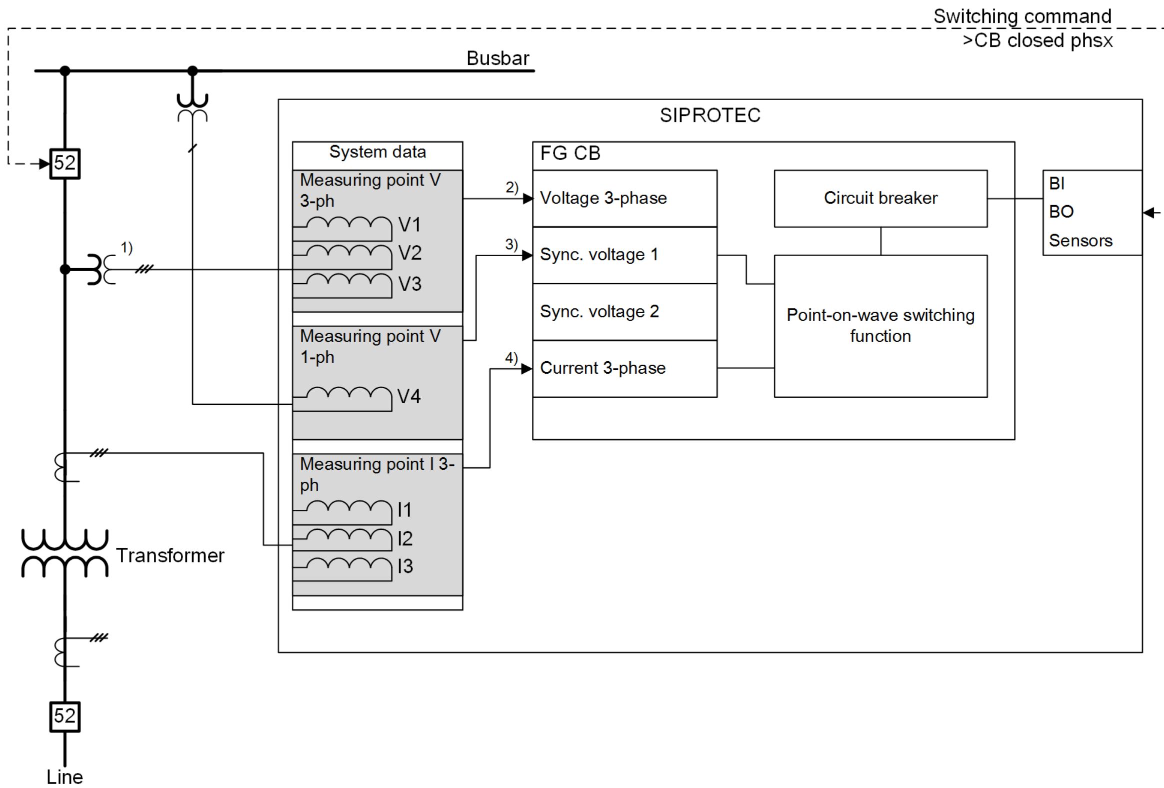
Energization

During energization of transformers, high inrush currents (several times of the rated current) can occur. By reducing the asymmetry of the flux in individual windings of the transformer, the **Point-on-wave switching** function can make sure that the iron core of the transformer would not go in high saturation and therefore reduce the inrush currents.

De-Energization

During de-energization of transformers, the **Point-on-wave switching** function can ensure a defined residual flux pattern by controlling the end of the current flow at the current zero crossing in a grounded system. Contact separation takes place earlier by the arcing time.

Single-Line Connections



[dw_Transformer, 2, en_US]

Figure 1-10 Transformer

(1) The 3-phase voltage measurement can also be on the low-voltage side.
(2) For switching-accuracy supervision of the **CB closing** function block
(3) 1-phase busbar voltage as reference signal
(4) For switching-accuracy supervision of the **CB opening** function block and for recording the inrush current

Reference-Voltage Connection

A reference voltage must be connected to the **Point-on-wave switching** function for detecting the zero crossing of the power-system voltage. For the transformer, a 1-phase busbar voltage is used as the reference voltage. For more information on the reference-voltage connection via the measuring point **V-1ph**, refer to chapter *3.1.3 Reference Signal*.

Switching-Accuracy Supervision

For the transformer, the current or voltage of the circuit breaker is used for the switching-accuracy supervision:

- For the **CB opening** function block, the 3-phase feeder current is used. For more information on the switching-accuracy supervision, refer to chapter *4.1.4 Switching-Accuracy Supervision*.
- For the **CB closing** function block, the 3-phase feeder current is too small to be used for measuring the make time. Therefore, the voltage is used. For more information on the switching-accuracy supervision, refer to chapter *5.1.4 Switching-Accuracy Supervision*.

1.6.4 Transmission Lines

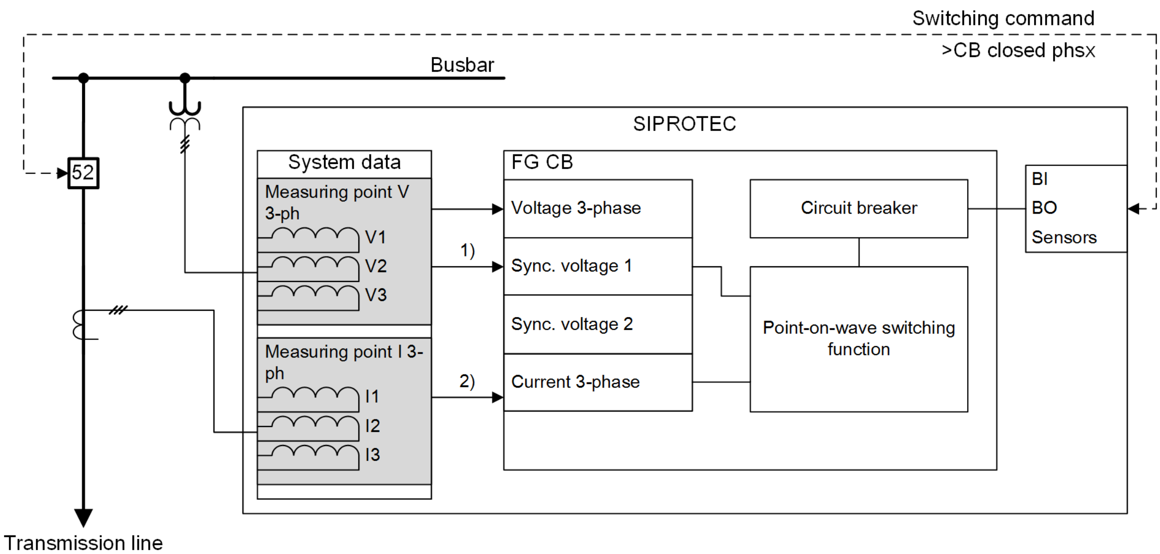
Energization

When an unloaded transmission line or power cable is energized, strong transient balancing processes such as overvoltages and inrush currents occur when it is connected near the maximum voltage. To obtain the lowest potential difference upon energization, the closing operation must occur at the voltage zero crossing.

De-Energization

De-energizing a transmission line or power cable can cause restriking, which might damage the circuit breaker. The **Point-on-wave switching** decreases the possibility of restriking.

Single-Line Connections



[dw_Lines and cables, 2, en_US]

Figure 1-11 Transmission Line

(1) VA or VAB as reference signal

(2) For switching-accuracy supervision

Reference-Voltage Connection

A reference voltage must be connected to the **Point-on-wave switching** function for detecting the zero crossing of the power-system voltage. For the transmission line, a 3-phase busbar voltage is used as the reference voltage. You can find more information about the reference-voltage connection via the measuring point **V-3ph** in chapter *3.1.3 Reference Signal*.

Switching-Accuracy Supervision

For the transmission line, the 3-phase feeder current is used for the switching-accuracy supervision in the **CB opening** and **CB closing** function blocks.

For further information on switching-accuracy monitoring, refer to chapter *4.1.4 Switching-Accuracy Supervision* for the **CB opening** function block and to chapter *5.1.4 Switching-Accuracy Supervision* for the **CB closing** function block.

1.7 Possible Device Types and Device Applications

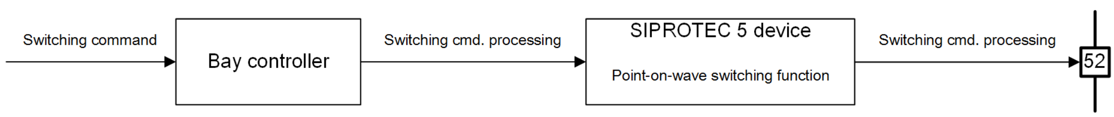
The **Point-on-wave switching** function can be applied in the following SIPROTEC 5 device types: 6MD86, 7SJ85, 7SA87, 7SD87, 7SL87, 7VK87, 7UT85, 7UT86, 7UT87, 6MU85, 7UM85.

3 different device applications are possible:

- Stand-alone point-on-wave (PoW) switching device, via the device type 6MD86
- Bay-control function and point-on-wave switching in one device, via the device type 6MD86
- Protection, bay-control function, and point-on-wave switching in one device, via the preceding listed devices

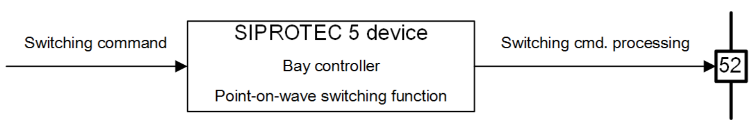
Depending on the condition that the bay-control function and the point-on-wave switching are in separated physical devices or in one physical device, the following device and command processing schemes apply.

- Bay-control function and the point-on-wave switching in 2 separate devices
  The bay controller processes the switching commands to the SIPROTEC 5 PoW-switching device via binary outputs and the SIPROTEC 5 PoW-switching device receives these commands via binary inputs.



[dw_Device scheme independent, 2, en_US]

- Bay-control function and point-on-wave switching in one SIPROTEC 5 device



[dw_Device scheme same device, 2, en_US]

1.8 Point-on-Wave Switching Processing

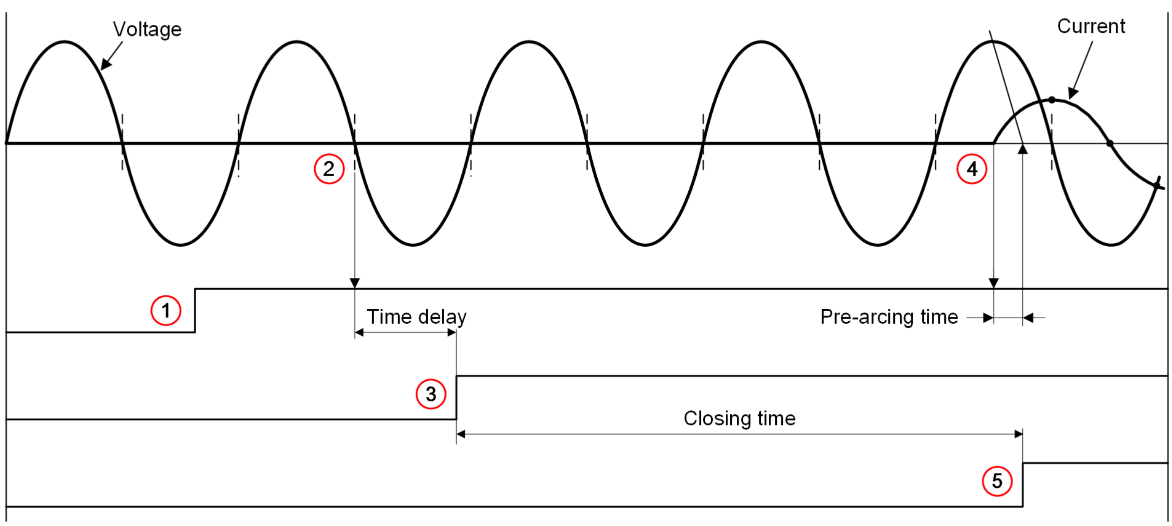
The **Point-on-wave switching** function calculates the switching times for the device binary outputs of each phase based on the relevant settings and on the compensated mechanical operating time.

This chapter describes the switching procedures using the example of closing and opening a grounded reactance coil. The aim is to achieve the start or end of current flow at the maximum voltage.

1.8.1 Closing

The closing operation of the circuit breaker proceeds as follows:

- The **Point-on-wave switching** function receives the closing command.
- The function determines the next voltage zero crossing as a reference instant. This zero crossing is the basis for calculating the switching times for the device binary outputs of all phases.
- At the calculated switching times (individually per phase), the device closes its high-speed contact which will energize the close trip coil.
- With energizing the close trip coil, the circuit-breaker closing time starts.
- The current flow starts at the maximum voltage at the time **closing time – pre-arcing time**.
- The mechanical contact occurs after the closing time.

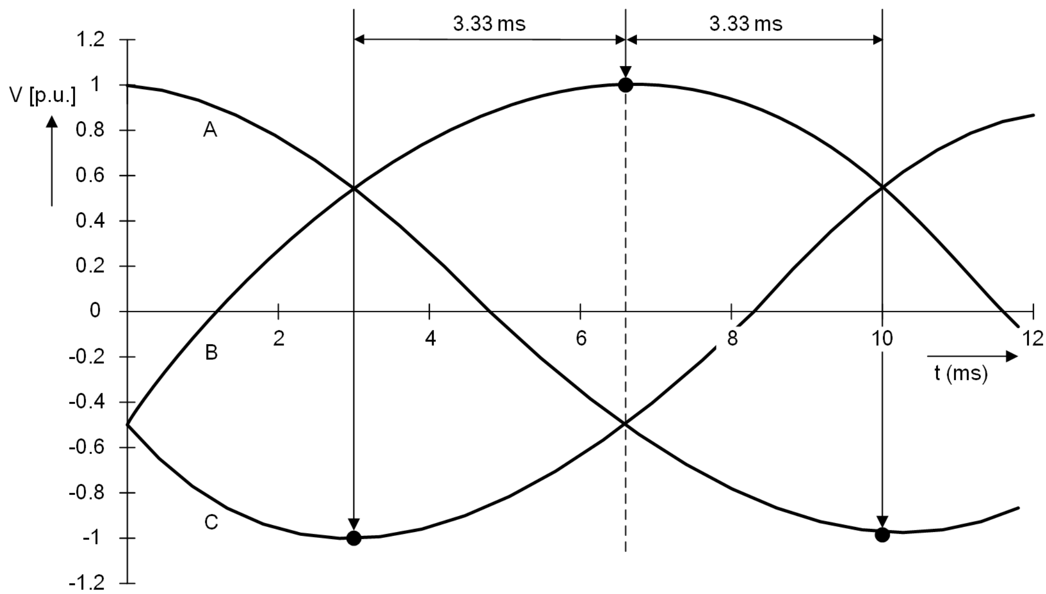


[dw_Sequence of controlled closing operation, 2, en_US]

Figure 1-12 Sequence of a Controlled Closing Operation for a Grounded Reactance Coil

(1)	Close-command reception
(2)	Zero-crossing determination
(3)	Controlled command to the close trip coil
(4)	Start of current flow
(5)	Mechanical contact touch

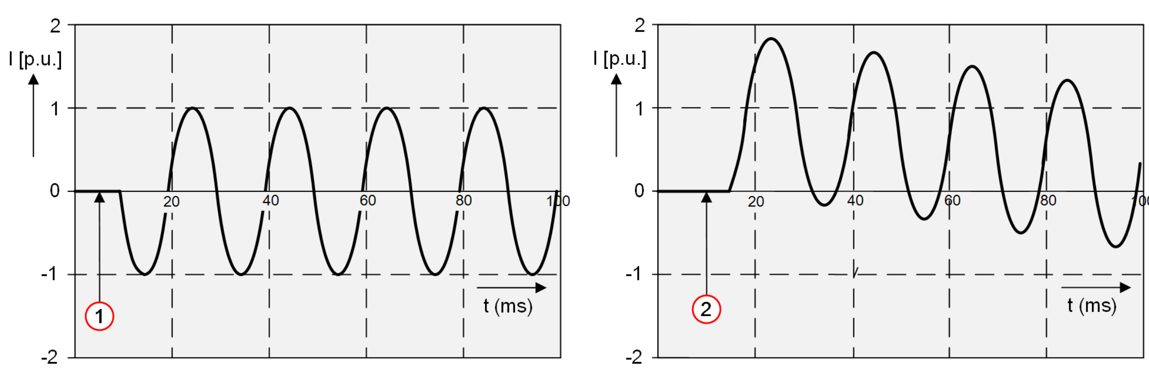
Figure 1-13 shows the 3-phase sequence of the closing operation with a grounded reactance coil. The individual phase voltages have an offset of 120°, that is, of 6.66 ms (50 Hz). This phase displacement is important to ensure that closing occurs at the correct instant for each phase (maximum voltage). If the phases are connected in the sequence of CBA, the offset of the closing instants between the phases is 3.33 ms (50 Hz).



[dw_Closing instants for grounded shunt reactor, 2, en_US]

Figure 1-13 Closing Instants for a Grounded Reactance Coil (3-Phase, 50 Hz)

Controlled energizing of a grounded reactance coil reduces inrush currents for an optimized closing operation, compared with a non-optimized closing operation (see the following figure).



[dw_Reduction of inrush currents when switching on grounded shunt reactor, 2, en_US]

Figure 1-14 Reduction of the Inrush Currents when Switching on a Grounded Reactance Coil

(1) Optimized closing instant
(2) Non-optimized closing instant

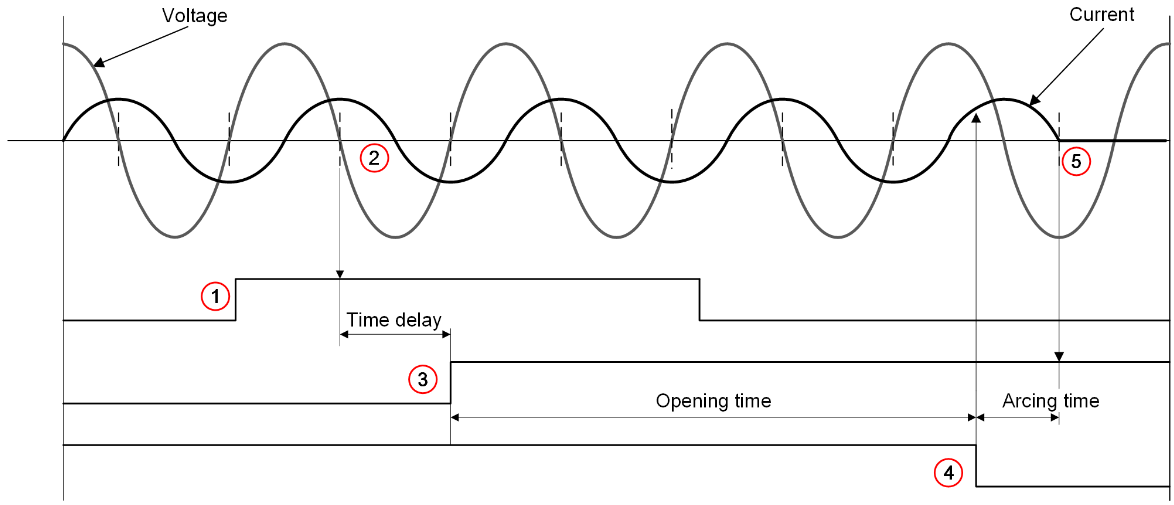
1.8.2 Opening

To reach the end of the current flow in the current zero crossing in a grounded reactance coil, contact separation takes place earlier by the arcing time. The arcing time is a setting in the **Point-on-wave switching** function.

The opening operation of the circuit breaker proceeds as follows:

- The **Point-on-wave switching** function receives the open command.
- The function determines the next voltage zero crossing as a reference instant. This zero crossing is the basis for calculating the switching times for the device binary outputs of all phases.
- At the calculated switching times (individually per phase), the device closes its high-speed contact which will energize the open trip coil.

- With energizing the open trip coil, the circuit-breaker opening time starts.
- The mechanical separation occurs after the opening time has passed and the current still flows because of the arcing.
- The current flow ends after the arcing time has expired at the next current zero crossing (voltage maximum).



[dw_Sequence of controlled opening operation, 2, en_US]

Figure 1-15 Sequence of a Controlled Opening Operation for a Grounded Reactance Coil

(1)	Open-command reception
(2)	Zero-crossing determination
(3)	Controlled command to the open trip coil
(4)	Mechanical contact separation
(5)	End of the current flow

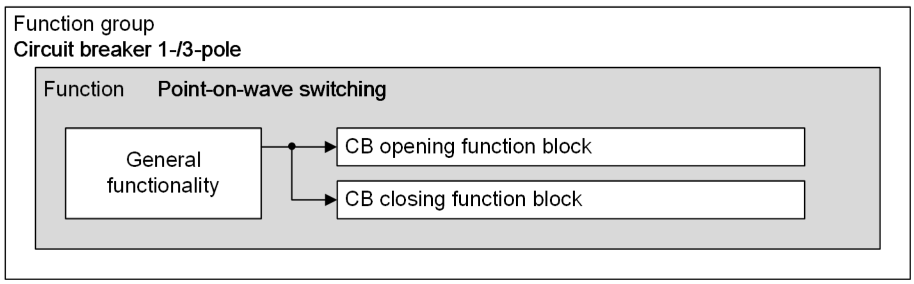
2 Structure and Interfaces of the Function

2.1 Structure and Interface Overview

The **Point-on-wave switching** function can be used in the **Circuit-breaker** function group for 1-pole and 3-pole switching. The function comes factory-set with a **CB opening** function block and a **CB closing** function block. A maximum of 1 **CB opening** function block and 1 **CB closing** function block can be operated simultaneously within the function.

The general functionality includes the zero-crossing detection, supervision, and determination of switching angle and times.

The **CB opening** and **CB closing** function blocks provide subfunctions such as switching-time compensation, switching-time calculation, and switching-accuracy supervision.

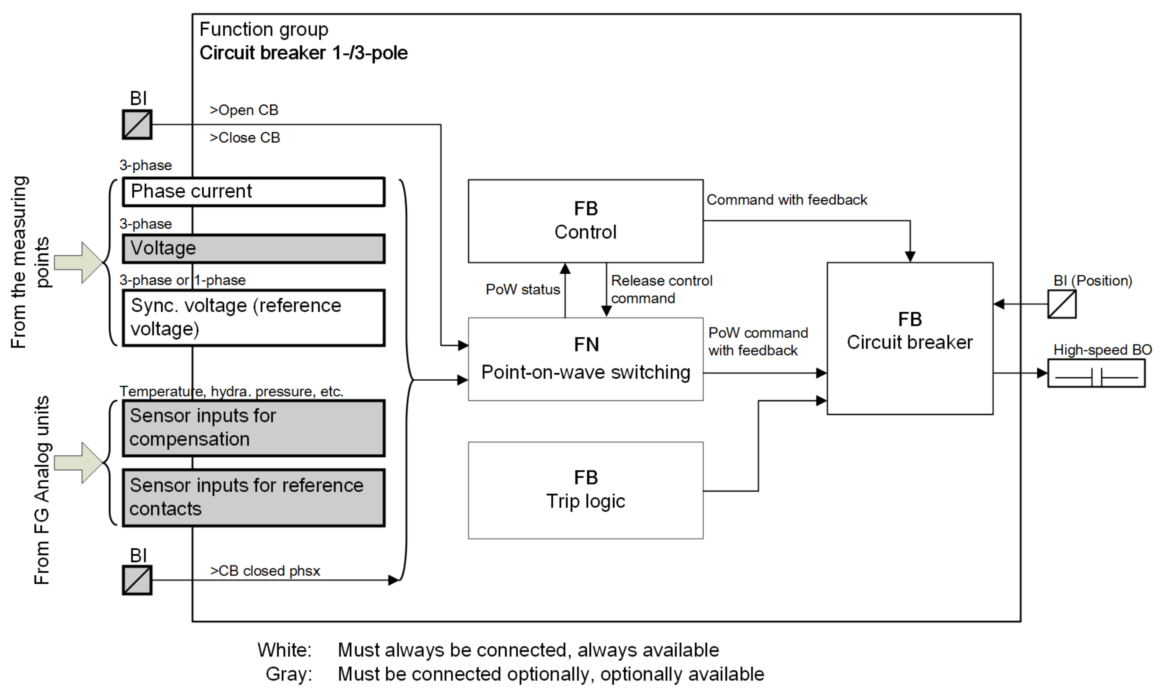


[dw_Structure PoW, 2, en_US]

Figure 2-1 Structure/Embedding of the Function

The detailed function descriptions for the general functionality, the **CB opening** function block, and the **CB closing** function block are provided in the chapters *3 General Functionality*, *4 CB Opening Function Block*, and *5 CB Closing Function Block*.

The following figure gives an overview about the interfaces of the **Point-on-wave switching** function.



[dw_Interfaces PoW, 2, en_US]

The **Point-on-wave switching** function has interfaces with:

- Measuring points

  The **Point-on-wave switching** function obtains the busbar voltage as a reference voltage for zero-crossing detection via the **Sync. voltage** interface from the connected measuring point. You can find more information in chapter *3.1.3 Reference Signal*.

  To obtain the 3-phase current or 3-phase voltage for switching-accuracy supervision, the **Point-on-wave switching** function has an interface with the measuring point **Current 3-phase** or **Voltage 3-phase**.

  For additional information on the measuring points interfaces, refer to chapter *1.6 Applications*.

- FG **Analog units**

  The FG **Analog units** provides the **Point-on-wave switching** function with specific process and environmental data, such as temperature, hydraulic pressure, and reference contact inputs.

- FB **Control** and FB **Circuit breaker** in the FG **Circuit breaker 1-/3-pole**

  The **Point-on-wave switching** function interacts with the FB **Control** and FB **Circuit breaker** to process the switching operations. For further information on the interaction, refer to chapter *2.2 Interaction with the Control and Circuit-Breaker Functionality*.

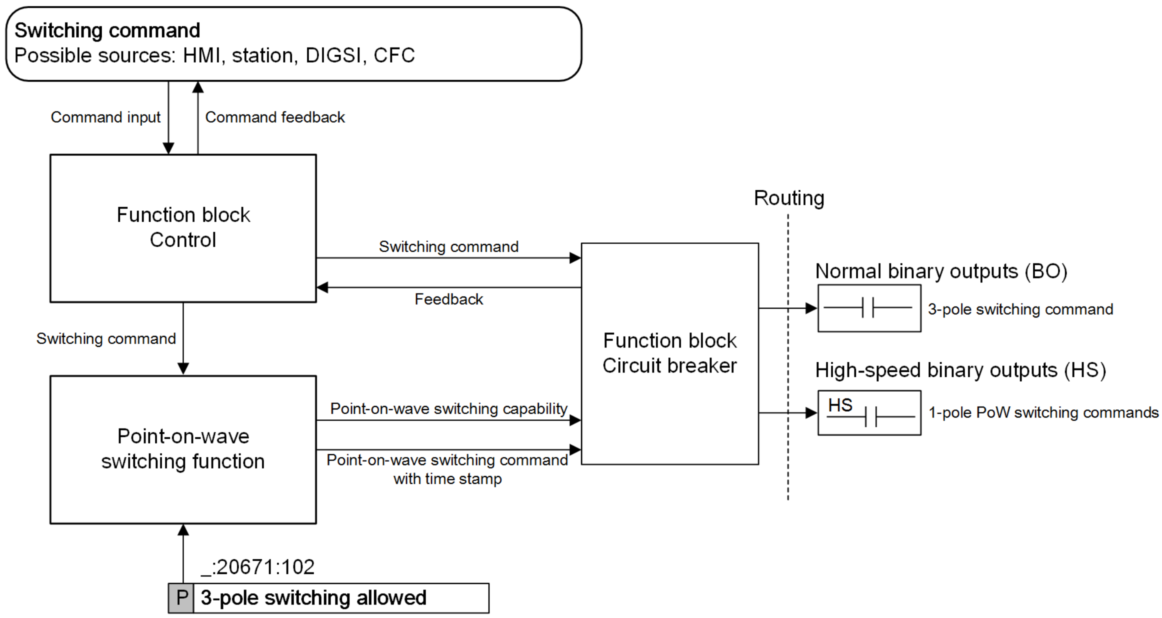
- Binary inputs

  The binary inputs *>Open CB* and *>Close CB* are used to start the point-on-wave switching from externally. For further information on the binary input *>Open CB*, refer to chapter *Start of the Switching Operation, Page 66* or on the binary input *>Close CB*, refer to chapter *Start of the Switching Operation, Page 82*.

  The binary inputs *>CB closed phsA*, *>CB closed phsB* and *>CB closed phsC* are connected to the **CB closed** auxiliary contacts in case of non-Siemens circuit breakers, and are used for the switching-accuracy supervision.

  The binary inputs *Position 1-pole phsA*, *Position 1-pole phsB*, and *Position 1-pole phsC* are connected to the circuit-breaker auxiliary contacts, and are used for circuit-breaker position supervision per circuit-breaker pole. For details, refer to the section *3.1.6.2 Supervision of the Circuit-Breaker Position*.

2.2 Interaction with the Control and Circuit-Breaker Functionality



[dw_Control function blocks PoW, 2, en_US]

Figure 2-2 Interaction with the Control and Circuit-Breaker Functionality

When processing a switching command, the **Point-on-wave switching** function can be in 2 states:

- Point-on-wave switching is possible.
  Point-on-wave switching is possible means that 1-pole point-on-wave switching can work normally, and no supervision error or external blocking is given. The signal *`PoW capability`* indicates if point-on-wave switching is possible or not. For more information about the point-on-wave switching capability, refer to chapter *3.1.7 Determination of the Point-on-Wave Switching Capability*.
- Point-on-wave switching is not possible.

In the 2 different states, the interaction between the **Point-on-wave switching** function and the FBs **Control** and **Circuit breaker** is as follows:

- State 1: Point-on-wave switching is possible
  The FB **Control** sends a switching command to the **Point-on-wave switching** function. The **Point-on-wave switching** function performs the switching-time calculation and sends switching commands with the switching times to the FB **Circuit breaker**. The FB **Circuit breaker** triggers the high-speed relay and sends a positive feedback to the FB **Control**. The FB **Control** then processes the positive feedback and forwards the feedback to the command source.
- State 2: Point-on-wave switching is not possible.
  In this state, the interaction varies according to the setting of the parameter **`3-pole switching allowed`**:
  - If you set the parameter **`3-pole switching allowed`** to ***no***, the switching command is blocked, and the FB **Circuit breaker** sends a negative feedback to the FB **Control**. The FB **Control** then processes the negative feedback and forwards the feedback and cause to the command source.
  - If you set the parameter **`3-pole switching allowed`** to ***yes***, the FB **Circuit breaker** may perform a 3-pole switching and sends a positive feedback to the FB **Control**. The cause why the 1-pole switching is not possible decides, whether a 3-pole switching is performed. For more information, refer to chapter *3.1.6.4 Supervision-Error Reaction*. The FB **Control** then processes the feedback and forwards the feedback and cause to the command source.

2.2.1 Application and Setting Notes

To ensure the accuracy of the switching times, the following signals of the FB **Circuit breaker** must be routed to high-speed outputs:

- *Open cmd. 1-pole phsA*
- *Open cmd. 1-pole phsB*
- *Open cmd. 1-pole phsC*
- *Close cmd. 1-pole phsA*
- *Close cmd. 1-pole phsB*
- *Close cmd. 1-pole phsC*

2.3 Interaction with Further Functions

Automatic Reclosing Function

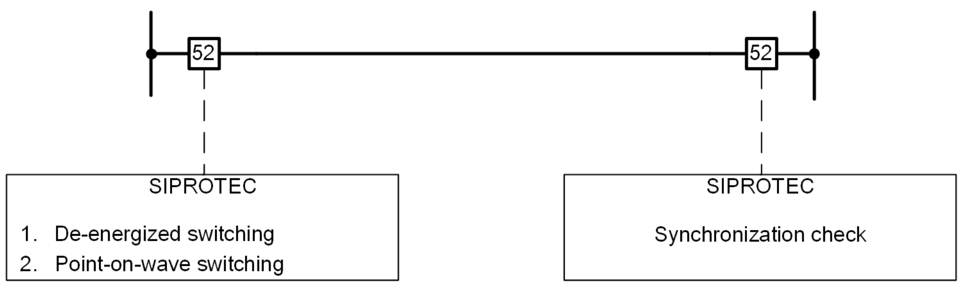
The **Automatic reclosing** function does not cooperate with the **Point-on-wave switching** function. That is, the **Point-on-wave switching** function does not process the closing command of the **Automatic reclosing** function.

However, it must be ensured that the **Point-on-wave switching** function is not blocked by its CB position supervision function when an internal or external automatic reclosing function carries out a 1-pole auto-reclosing cycle. Therefore, a CB position failure is only signaled if the intermediate position is valid for an abnormal time (`CB interm.pos. max. time`). For further information, refer to chapter *3.1.6.2 Supervision of the Circuit-Breaker Position*.

Synchronization Function

The interaction between the **Synchronization** function and the **Point-on-wave switching** function is as follows:

- The **De-energized switching** functionality of the **Synchronization** function can cooperate with the **Point-on-wave switching** function. The following figure shows an application scenario.



[dw_Interact with 25 sync, 2, en_US]

Figure 2-3 Application Scenario

The application scenario is described as follows:

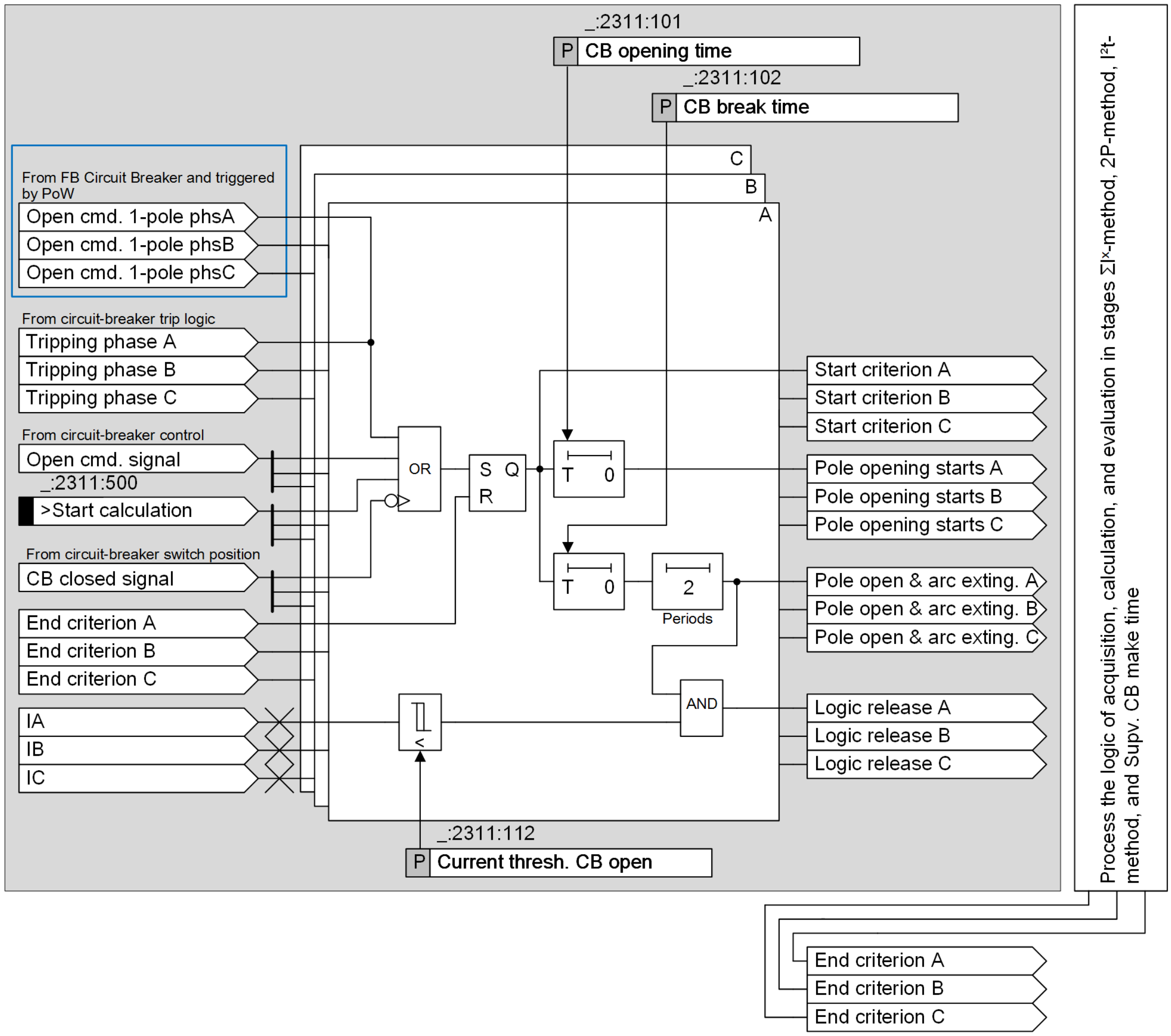
  – For the circuit breaker on the left of the preceding figure, only the **De-energized switching** functionality in the **Synchronization** function is used, which ensures that the voltage is 0 on the line side during switching on.

  – After the check by the **De-energized switching** functionality is completed, the point-on-wave switching is performed to minimize the overvoltage caused by energization.

  – For the circuit breaker on the right, the synchronization check is required.

- The **Synchrocheck** stage in the **Synchronization** function can technically cooperate with the **Point-on-wave switching** function. But this does not lead to a meaningful application.

Circuit-Breaker Wear Monitoring Function



[lo_PoW Interact with CB-wear, 2, en_US]

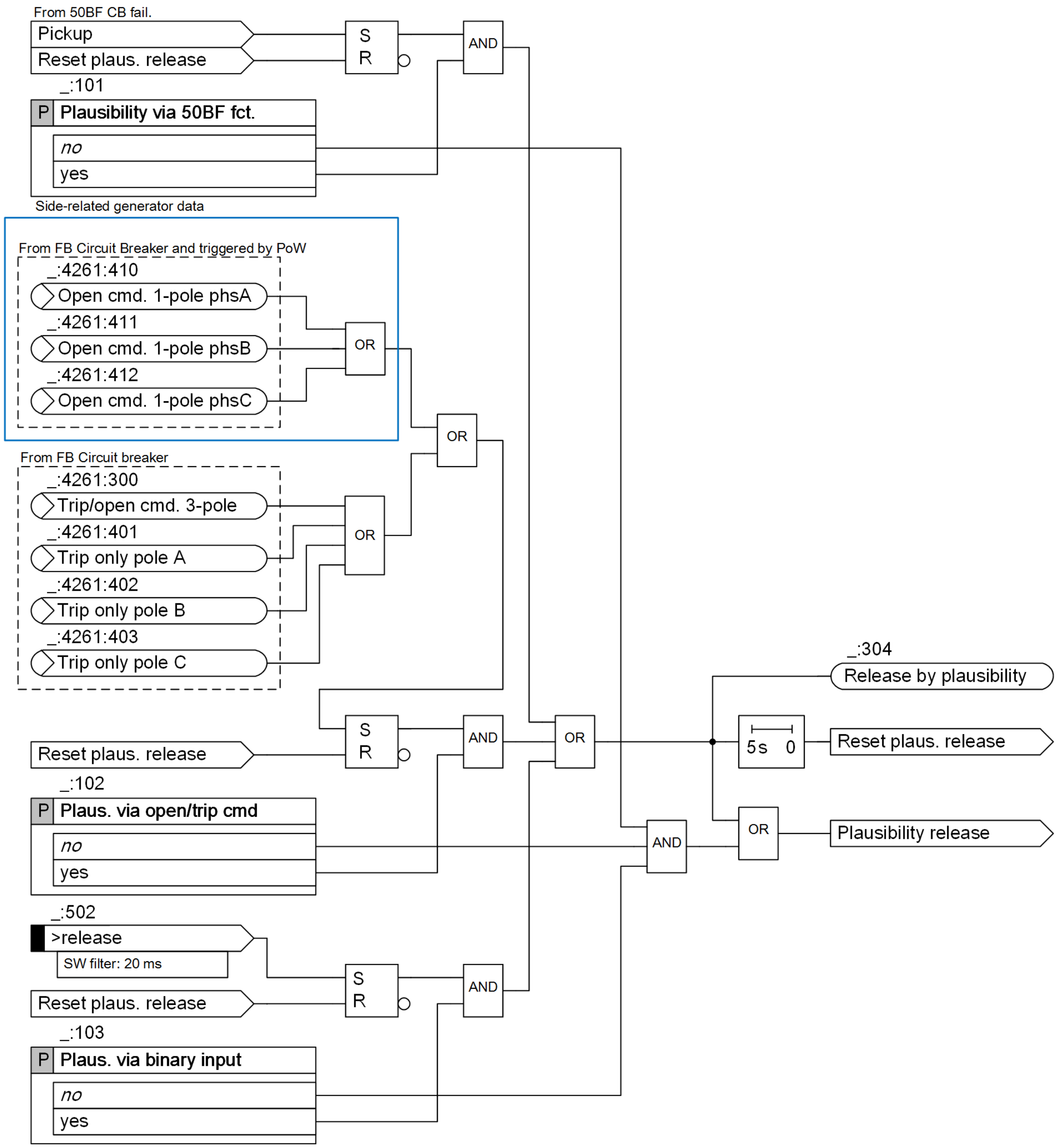
Figure 2-4 Logic Diagram of the Functionality Across Stages of the Circuit-Breaker Wear Monitoring Function

For the **ΣI^x-method** stage, **2P-method** stage, and **I^{2}t-method** stage of the **Circuit-breaker wear monitoring** function, the following phase-selective open commands of the **Point-on-wave switching** function trigger the circuit-breaker wear monitoring:

- *Open cmd. 1-pole phsA*
- *Open cmd. 1-pole phsB*
- *Open cmd. 1-pole phsC*

You can find more information about the **Circuit-breaker wear monitoring** function in the SIPROTEC 5 device manuals.

Circuit-Breaker Restrike Protection Function

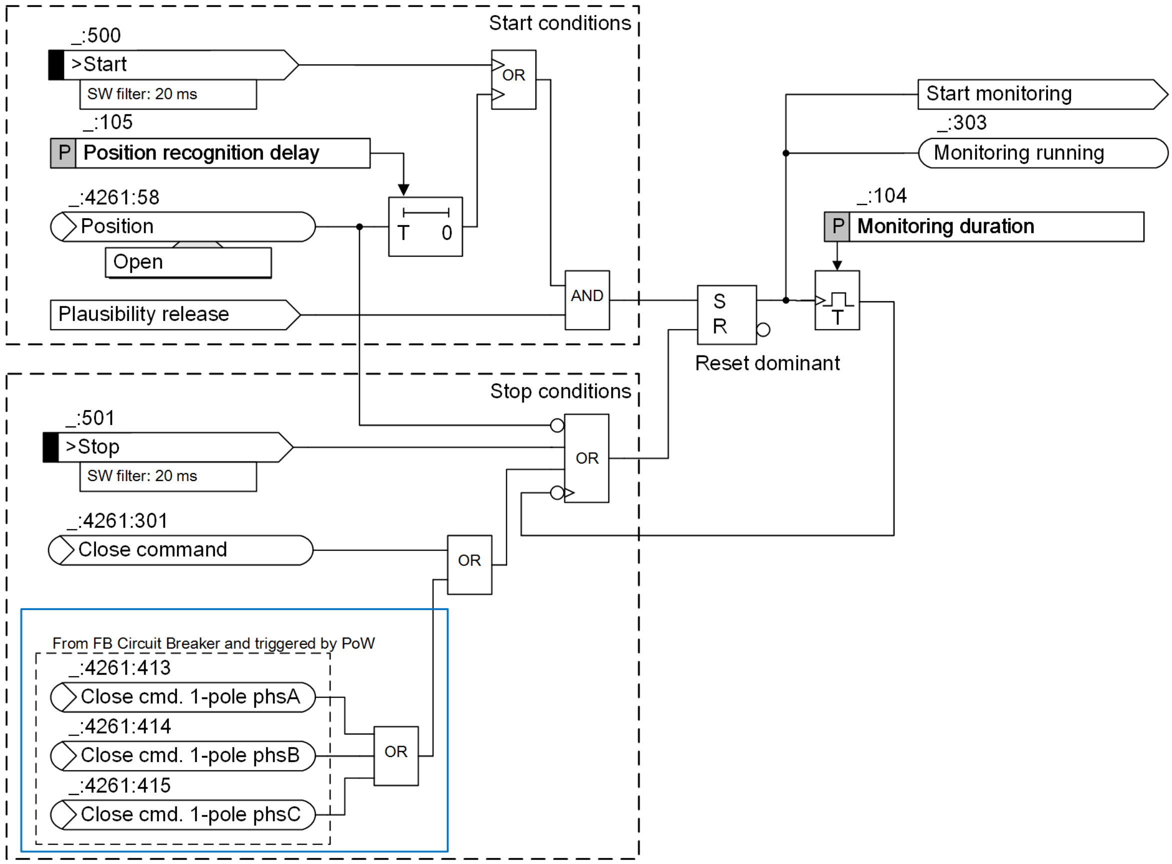


[lo_PoW_Plaus-release_CB-restrike, 2, en_US]

Figure 2-5 Logic Diagram for the Plausibility Release of the Circuit-Breaker Restrike Protection

For the plausibility-release logic of the **Circuit-breaker restrike protection** function, the following phase-selective open commands of the **Point-on-wave switching** function trigger the logic of the open command:

- *Open cmd. 1-pole phsA*
- *Open cmd. 1-pole phsB*
- *Open cmd. 1-pole phsC*



[lo_PoW_Star-stop_CB-strike, 2, en_US]

Figure 2-6 Logic Diagram for Start/Stop Monitoring of the Circuit-Breaker Restrike Protection

For the start/stop monitoring logic of the **Circuit-breaker restrike protection** function, the following phase-selective close commands of the **Point-on-wave switching** function trigger the stop logic:

- *Close cmd. 1-pole phsA*
- *Close cmd. 1-pole phsB*
- *Close cmd. 1-pole phsC*

3 General Functionality

3.1 Description

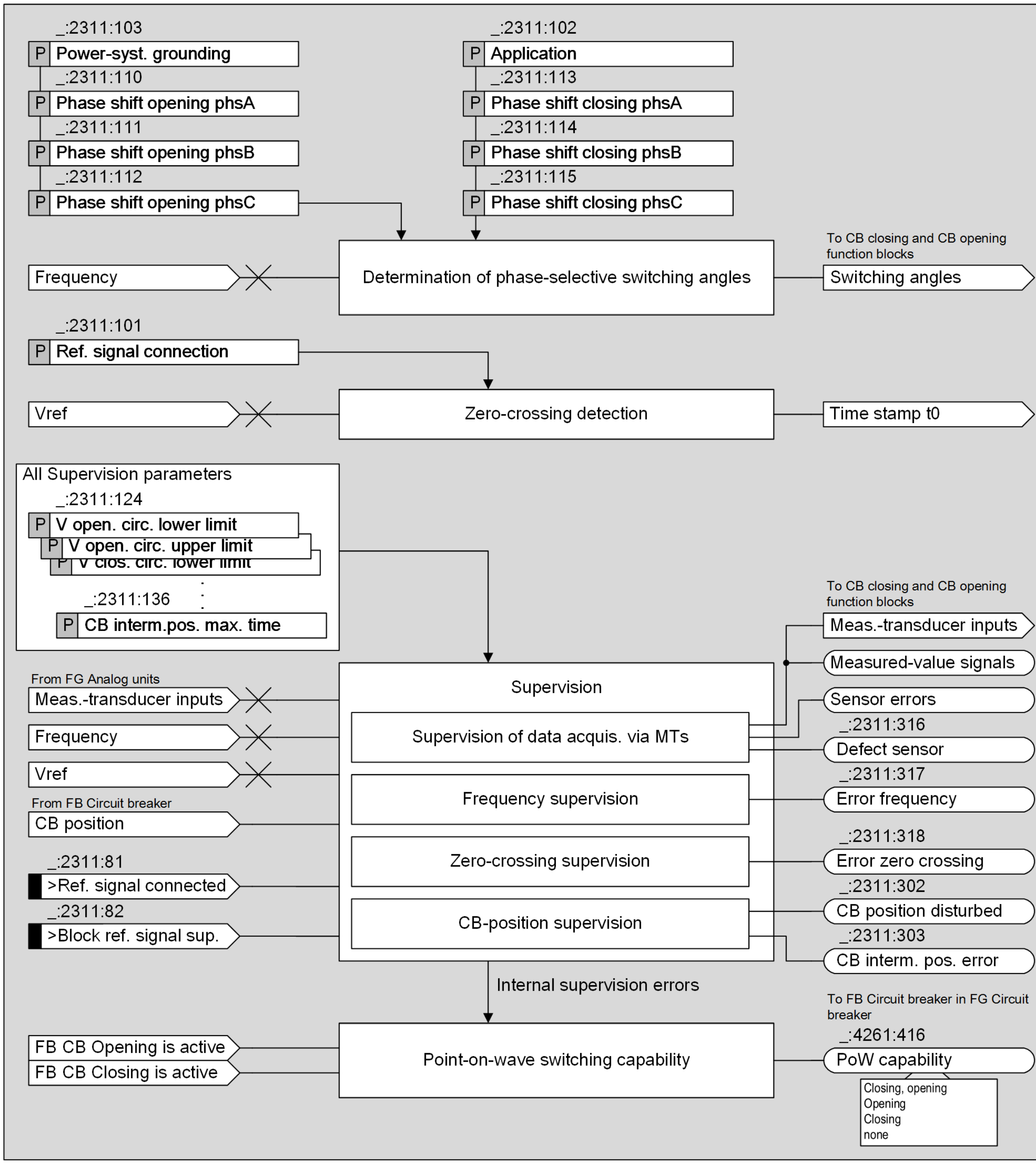
3.1.1 Overview and General Description

Overview

The general functionality provides the following functions:

- Determination of switching angles
- Zero-crossing detection based on the reference signal
- Measuring-transducer configuration for the acquisition of the process and environmental data
- Supervision
- Point-on-wave switching capability

Logic



[lo_PoW FB General, 2, en_US]

Figure 3-1 Logic Diagram of the General Functionality

3.1.2 Determination of Switching Angles

The optimum switching instants depend on the switching application (load type) and the switching direction. A further criterion for selecting the correct switching instant is whether the system is grounded or isolated.

For the calculation of the phase switching times, the voltage of phase A is the internally used reference phase. The time difference for switching the other phases is defined as angle offset to the phase A. These offsets are determined by the settings **Power-syst. grounding** (***grounded*** or ***isolated***) and **Application**.

The following applications can be selected:

- Capacitive load
- Transmission line
- Reactance coil
- Transformer (YNd, Yd)
- User-defined

The following table provides the switching angles of different applications or loads. Each angle in the table means an offset angle to the zero-crossing point of the voltage of phase A.

Table 3-1 Switching Angles of Different Applications or Loads

Application	Switching Direction	Grounding	Phase A	Phase B	Phase C
Capacitive load	Close	Grounded	0°	120 °	60 °
		Isolated	30°	120 °	30°
	Open	Grounded	90 °	210°	150°
		Isolated	90 °	180°	180°
Transmission line	Close	(No influence)	0°	120 °	60 °
	Open	(No influence)	90 °	210°	150°
Reactance coil	Close	Grounded	90 °	210°	150°
		Isolated	60 °	60 °	150°
	Open	Grounded	90 °	210°	150°
		Isolated	90 °	180°	180°
Transformer	Close	Grounded (YNd)	90 °	180°	180°
		Isolated (Yd)	60 °	60 °	150°
	Open	Grounded (YNd)	90 °	210°	150°
		Isolated (Yd)	90 °	180°	180°
User-defined	Close	Grounded	User-defined	User-defined	User-defined
		Isolated	User-defined	User-defined	User-defined
	Open	Grounded	User-defined	User-defined	User-defined
		Isolated	User-defined	User-defined	User-defined

3.1.3 Reference Signal

The busbar voltage is usually used as the reference signal for zero-crossing detection. This voltage is obtained via a measuring point **V-3ph** or **V-1ph**.

- Measuring point **V-3ph**
  If the reference voltage is obtained via a measuring point **V-3ph**, VA or VAB is used as the reference signal:
  - If the voltage connection type is **3 ph-to-gnd voltages**, VA is used.
  - If the voltage connection type is **3 ph-to-ph voltages**, VAB is used.
- Measuring point **V-1ph**
  If the reference voltage is obtained via a measuring point **V-1ph**, the reference signal depends on the routing of the measuring point. As shown in the following figure, VA is selected as reference. Since the zero crossing of VA is always used as the reference of switching angles, if another voltage but not VA is routed, the angle of VA is calculated from the routed voltage. However, Vx, VN, and VN-broken delta are not allowed to be selected as the reference signal.

Voltage-measuring points					
		Base module			
		1B			
		1B1-1B2	1B3-1B4	1B5-1B6	1B7-1B8
Measuring point	Connection type	V 1.1	V 1.2	V 1.3	V 1.4
(All)	(All)	(All)	(All)	(All)	(All)
Meas.point V-3ph 1	3 ph-to-gnd voltages	V A	V B	V C	
Meas.point V-1ph 1					V A
Add new					

[sc_MP V1ph routing, 2, en_US]

Figure 3-2 Routing of Measuring Point V-1ph

The reference voltage must be connected to the voltage interface **Vsync1** of FG **Circuit breaker**. Consequently, you must connect the measuring point that represents the reference voltage to the **Vsync1** interface, as shown in the following figure. **Vsync1** supports both measuring-point types **V-3ph** and **V-1ph**.

Connect measuring points to function group						
	Circuit breaker 1				Line 1	
Measuring point	V	I 3ph	V sync1	V sync2	V 3ph	I line 3ph
(All)	(All)	(All)	(All)	(All)	(All)	(All)
Meas.point I-3ph 1[ID 1]		X				X
Meas.point V-3ph 1[ID 2]	X				X	
Meas.point V-3ph 2[ID 3]			X			

[sc_Ref_V connection in FG CB, 2, en_US]

Figure 3-3 Reference-Voltage Connection in the FG Circuit Breaker

Reference Voltage Only Available Shortly before Switching

A special application scenario is given, when the reference voltage is available only shortly before the point-on-wave switching is initiated. The scenario is described as follows:

- When a request for switching is given to the substation control center (SCC), the voltage is externally connected to the device which contains the **Point-on-wave switching** function.
- The control center performs a plausibility check for the voltage, which takes 1 s to 2 s. If the voltage passes the check, the switching command is forwarded to the device.

If no switching command is initiated, no reference voltage is connected to the device and the device must not perform supervision functions related to the reference voltage. The supervision related to the reference voltage only takes place for the duration when the voltage is connected to the protection device. This application is supported via the following functionality:

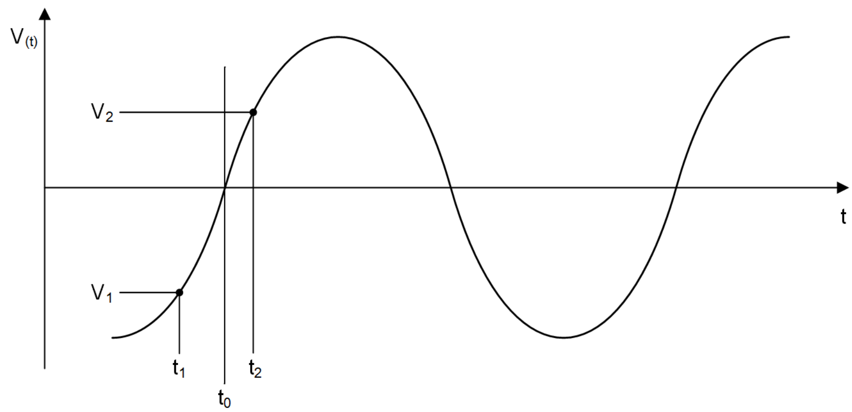
- A parameter **Ref. signal connection** by which the function is informed of the way of the reference-voltage connection
- A binary input signal *>Ref. signal connected* by which the device is informed of the connected reference signal

If you set the parameter **Ref. signal connection** to ***permanently***, the supervision of the reference voltage is always active regardless of the state of the binary input signal *>Ref. signal connected*.

If you set the parameter **Ref. signal connection** to ***before switching***, the supervision of the reference voltage is only carried out after the binary input signal *>Ref. signal connected* is activated.

3.1.4 Zero-Crossing Detection

A reference time is necessary to open or close a circuit breaker at a defined time. The reference time is determined by the zero crossing of the reference voltage signal.



[dw_Zero crossing detection, 2, en_US]

Figure 3-4 Determination of Zero Crossing

The zero-crossing time t_0 is determined accurately with a linear interpolation with one sample before the zero crossing (V_1 at t_1) and one sample after the zero crossing (V_2 at t_2).

$$t_0 = t_1 - V_1 \frac{t_2 - t_1}{V_2 - V_1}$$

[fo_Zero crossing determination, 2, en_US]

The zero-crossing point can be a rising one (from - to +) or a falling one (from + to -).

3.1.5 Measuring-Transducer Configuration for Process and Environmental Data Acquisition

Specific process and environmental data can be relevant to the determination of the circuit-breaker closing and opening time and for the switching-accuracy supervision. This data is acquired via measuring transducers and forwarded to the **CB closing** and **CB opening** function blocks.

The following table describes the process and environmental data that can potentially be acquired via 4-mA to 20-mA measuring transducers.

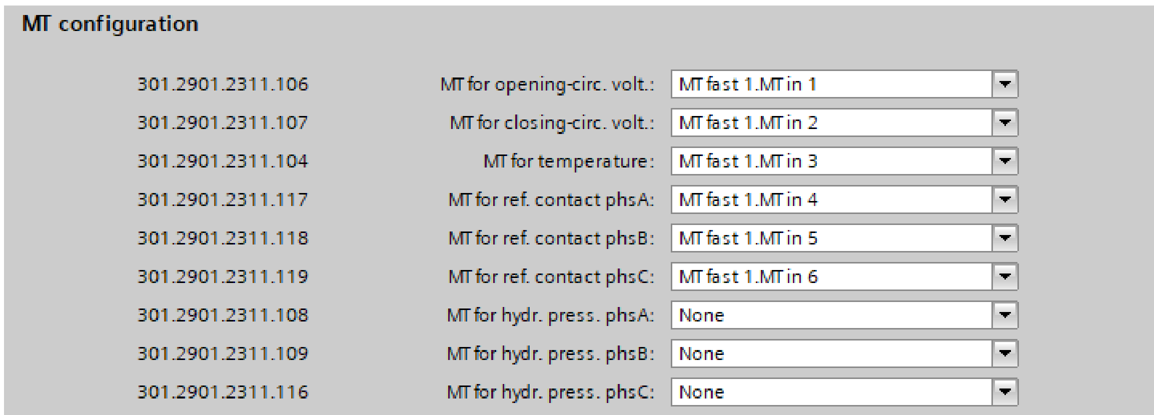
Table 3-2 Process and Environmental Data Potentially Acquired via Measuring Transducers

Data	**No. of Inputs**	**Functionality**
Control voltage of the closing circuit	1 (normal or fast input)	Compensation of process and environmental influences on the mechanical opening/closing time of the circuit breaker. This compensation is optional and only possible if the respective circuit-breaker data is available. For more information, refer to chapter *4.1.3 Compensation*.
Control voltage of the opening circuit	1 (normal or fast input)	
Ambient temperature	1 (normal or fast input)	
Phase-selective hydraulic pressure (optionally, depending on the circuit breaker type)	3 (normal or fast input)	
Siemens circuit-breaker reference contacts (Hall-effect sensor)	3 (fast input required)	Supervision of the actual mechanical opening/closing time of the circuit breaker. In case of non-Siemens circuit breakers, this functionality is carried out via the 52a auxiliary contacts of the circuit breaker. For more information, refer to chapter *4.1.4 Switching-Accuracy Supervision*.

NOTE

To acquire Siemens circuit-breaker reference contacts, you must select fast measuring-transducer inputs (available on the I/O module IO212).

All available measuring transducers by hardware scope are visible in the FG **Analog units**. You can select measuring transducers for different data acquisitions via the corresponding **MT configuration** settings of the **Point-on-wave switching** function. The following figure shows a configuration example.



[sc_MT selection, 2, en_US]

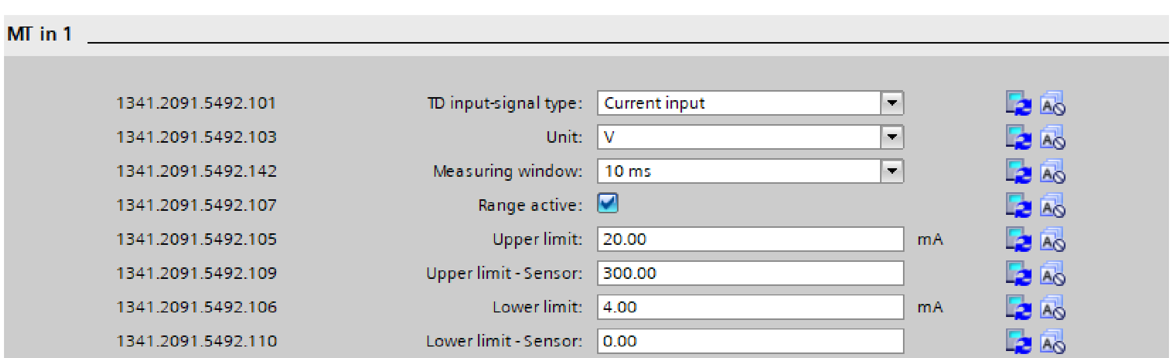
Figure 3-5 Example: Measuring-Transducer Configuration by Using the Module IO212

If one of the **MT configuration** settings is set to ***None***, the corresponding data is not acquired and this data is not available for the subordinate function blocks.

After you assign a measuring transducer for the specific sensor, you must configure the measuring transducer under the function group **Analog units** in DIGSI 5 in the **Settings** folder.

Control-Voltage MT Configuration

With the parameter **`MT for opening-circ. volt.`** or **`MT for closing-circ. volt.`** in the **MT configuration** settings of the **Point-on-wave switching** function, you assign a measuring transducer for the opening-circuit or closing-circuit control voltage. Then you must configure the assigned measuring transducer in the function group **Analog units**. The following figure shows a configuration example.



[sc_MT setting_ctrl volt, 2, en_US]

Figure 3-6 Configuration Example of a Fast Measuring-Transducer Input

In the preceding example, a fast measuring-transducer input is configured, and the relevant parameters are described as follows:

- You must activate the **Range active** parameter. Then the 4 additional parameters **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor** appear.
- For all measuring transducers of the **Point-on-wave switching** function, you must set the **Upper limit** parameter to ***20.00 mA*** and set the **Lower limit** parameter to ***4.00 mA***.
- The parameter **Upper limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Upper limit** setting. The parameter **Lower limit - Sensor** is the calculated measured value if the input current corresponds to the value in the **Lower limit** setting.

  In this configuration, you must set the **Upper limit - Sensor** and **Lower limit - Sensor** parameters to the upper limit and lower limit of the control voltage, with the unit ***V***).

For a normal (speed) measuring-transducer input, the resolution of the scaled values must be set with the **Resolution** parameter. For more information on the measuring-transducer configurations, refer to the chapter **Function-Group Type Analog Units** of the device manual.

For more information on the supervision-related functionality, refer to chapter *3.1.6 Supervision*.

Ambient-Temperature MT Configuration

With the parameter **MT for temperature** in the **MT configuration** settings of the **Point-on-wave switching** function, you assign a measuring-transducer input for the sensor of the ambient temperature at the circuit-breaker installation site. Then you must configure the assigned measuring-transducer input in the function group **Analog units**. For more information on the configuration, refer to section *Control-Voltage MT Configuration, Page 45*.

In this configuration, you must set the **Upper limit - Sensor** and **Lower limit - Sensor** parameters according to the corresponding values of the sensor, with the unit ***°C***.

For more information on the supervision-related functionality, refer to chapter *3.1.6 Supervision*.

Hydraulic-Pressure MT Configuration

With the parameter **MT for hydr. press. phsA**, **MT for hydr. press. phsB**, or **MT for hydr. press. phsC** in the **MT configuration** settings of the **Point-on-wave switching** function, you assign a measuring-transducer input for each sensor of the phase-selective hydraulic pressure of the circuit breaker. Then you must configure the assigned measuring-transducer input in the function group **Analog units**. For more information on the configuration, refer to section *Control-Voltage MT Configuration, Page 45*.

In this configuration, you must set the **Upper limit - Sensor** and **Lower limit - Sensor** parameters according to the corresponding values of the sensor, with the unit ***kPa***.

For more information on the supervision-related functionality, refer to chapter *3.1.6 Supervision*.

Reference-Contact MT Configuration (only for Siemens Circuit Breakers)

With the parameter **MT for ref. contact phsA**, **MT for ref. contact phsB**, or **MT for ref. contact phsC** in the **MT configuration** settings of the **Point-on-wave switching** function, you must assign a fast measuring-transducer input for the phase-selective reference contact input. Then you must configure the assigned fast measuring-transducer input in the function group **Analog units**. For more information on the configuration, refer to section *Control-Voltage MT Configuration, Page 45*.

In the configuration, Siemens recommends the value ***0.02*** for the **Upper limit - Sensor** parameter and the value ***0.00*** for the **Lower limit - Sensor** parameter, with the unit ***A***.

For more information on the supervision-related functionality, refer to chapter *3.1.6 Supervision*.

3.1.6 Supervision

3.1.6.1 Supervision of the Reference Signal

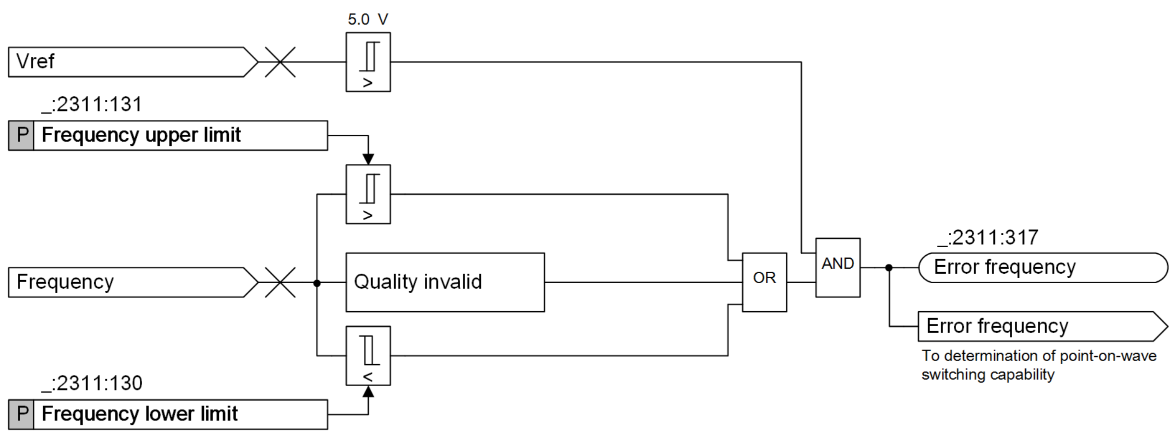
The following supervision functions are available:

- Frequency supervision
- Zero-crossing supervision of the reference phase

Unless otherwise specified, these functions are active if the **Mode** parameter for at least one of the **CB closing** and **CB opening** function blocks is set to ***on*** or ***test***.

Frequency Supervision

The following figure shows the logic of frequency supervision.



[lo_PoW_Supervision_frequency, 2, en_US]

Figure 3-7 Logic Diagram of the Frequency Supervision

If both of the following criteria are met, the signal *Error frequency* is issued:

- The reference voltage is greater than 5.0 V.
  This criterion is used to block the frequency supervision when the reference voltage is too small to calculate an accurate frequency value.
- The frequency is not in the specified range or the quality of the frequency is invalid.

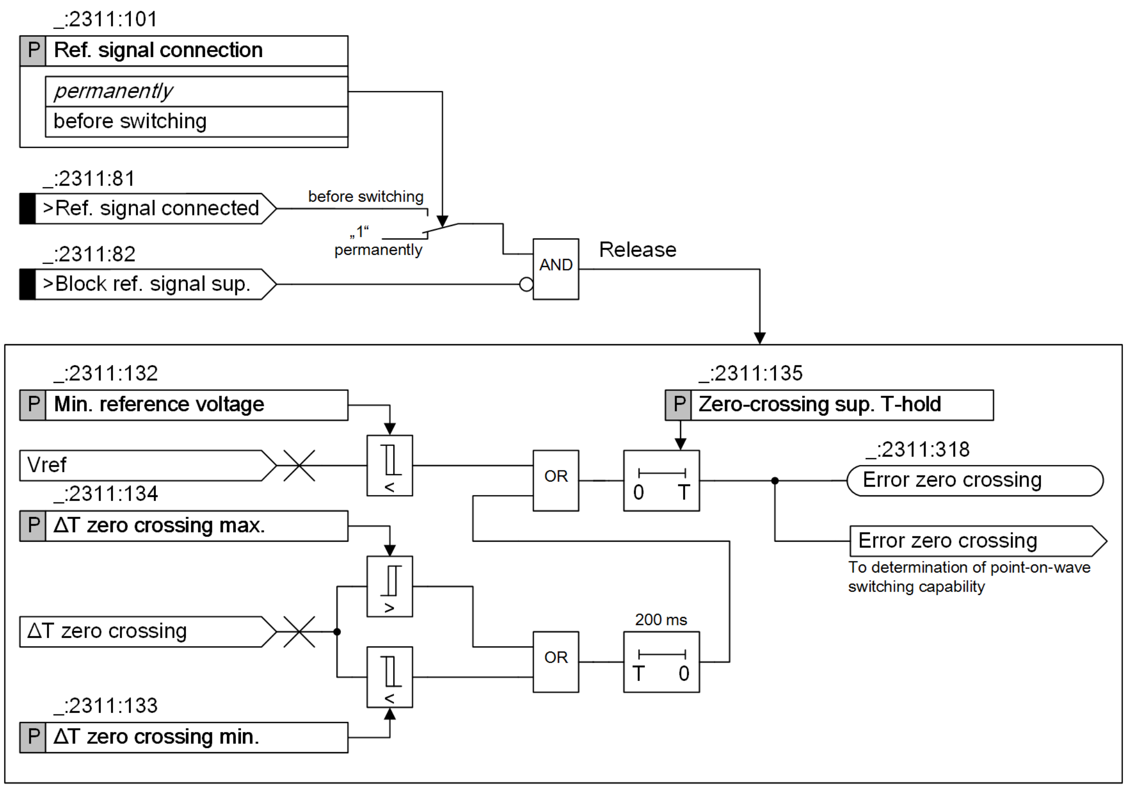
If the signal *Error frequency* is issued, the reaction of the **Point-on-wave switching** function depends on the setting of the **3-pole switching allowed** parameter:

- If the setting of the **3-pole switching allowed** parameter is ***yes***, the **CB closing** and **CB opening** function blocks are still active. Only 3-pole switching can take place.
- If the setting of the **3-pole switching allowed** parameter is ***no***, the **CB closing** and **CB opening** function blocks become inactive.

The error reaction of the **Point-on-wave switching** function on the signal *Error frequency* is also described in chapter *3.1.6.4 Supervision-Error Reaction*.

Zero-Crossing Supervision of the Reference Phase

Figure 3-8 shows the zero-crossing supervision of the reference phase.



[lo_PoW_Supervision_zero crossing, 2, en_US]

Figure 3-8 Logic Diagram of the Zero-Crossing Supervision of the Reference Phase

If at least one of the following criteria is met, the signal *Error zero crossing* is issued:

- The reference voltage is smaller than the threshold **Min. reference voltage**.
- The time between 2 zero crossings is smaller than the threshold **ΔT zero crossing min.** or greater than the threshold **ΔT zero crossing max.** for successive measuring cycles of at least 200 ms.

  For example, very strong harmonics can cause additional zero crossings.

When the preceding criteria are no longer met, the signal *Error zero crossing* is kept for an additional time **Zero-crossing sup. T-hold** before dropout.

The connected reference signal is a precondition for this supervision. If no reference signal is connected, no zero crossing can be detected. Under specific dynamic conditions (for example, switching the busbar or voltage transformer, when the branch disconnectors are open), the reference signal might not be available for a limited time. The supervision must be blocked under such conditions to avoid wrong alarming. Blocking is carried out via the signal *>Block ref. signal sup.*.

A special application scenario is given, when the reference voltage is available only shortly before the point-on-wave switching is initiated. For more information, refer to chapter *Reference Voltage Only Available Shortly before Switching, Page 43*.

If the signal *Error zero crossing* is issued, the reaction of the **Point-on-wave switching** function depends on the setting of the **3-pole switching allowed** parameter:

- If the setting of the **3-pole switching allowed** parameter is ***yes***, the **CB closing** and **CB opening** function blocks are still active. Only 3-pole switching can take place.
- If the setting of the **3-pole switching allowed** parameter is ***no***, the **CB closing** and **CB opening** function blocks become inactive.

3.1.6.2 Supervision of the Circuit-Breaker Position

Unless otherwise specified, this supervision function is active if the **Mode** parameter for at least one of the **CB closing** and **CB opening** function blocks is set to ***on*** or ***test***.

Figure 3-9 shows the possible circuit-breaker-pole positon states if the circuit-breaker position is detected via 2 circuit-breaker auxiliary contacts. The circuit-breaker position can be determined per circuit-breaker pole.

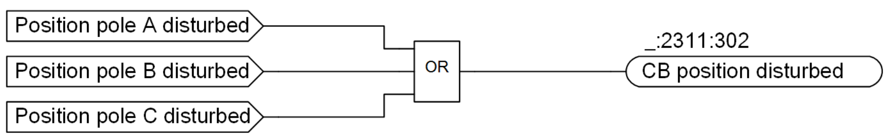
Position 1-pole phsA	301.4261.459	DPC
open		SPS
closed		SPS
intermediate position		SPS
disturbed position		SPS

[sc_CB position, 2, en_US]

Figure 3-9 Possible Circuit-Breaker-Pole States

As shown in the preceding figure, the CB position per pole, including disturbed and intermediate positions, is signaled:

- A disturbed position immediately causes the state *Inactive* of the **CB closing** and **CB opening** function blocks.



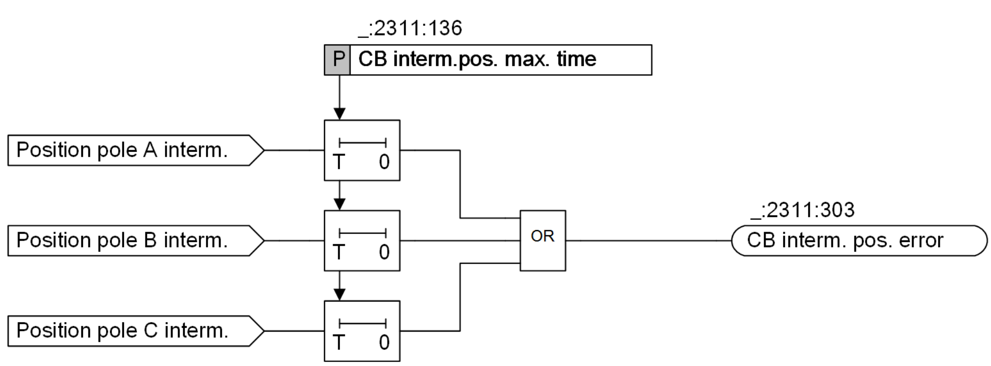
[lo_PoW_CB_disturbed, 2, en_US]

Figure 3-10 Disturbed Position

- An intermediate position is a normal operative condition as long as it disappears after a normal time.

  If an intermediate position of one pole is detected, a settable timer **CB interm.pos. max. time** is started. If the intermediate position is still present after the timer expires, the signal *CB interm. pos. error* is issued and the **CB closing** and **CB opening** function blocks are set to ***Inactive***.

  Via the timer, the condition of a phase-selective auto-reclosing cycle is also handled, since such a cycle must not lead to a supervision signaling.



[lo_PoW_CB_intermediate, 2, en_US]

Figure 3-11 Intermediate Position

3.1.6.3 Supervision of Data Acquisition via Measuring Transducers

To ensure a proper operation of the **Point-on-wave switching** function, acquisition of the process and environmental data is supervised.

The following table describes the process and environmental data acquired via 4-mA to 20-mA measuring transducers and their supervisions.

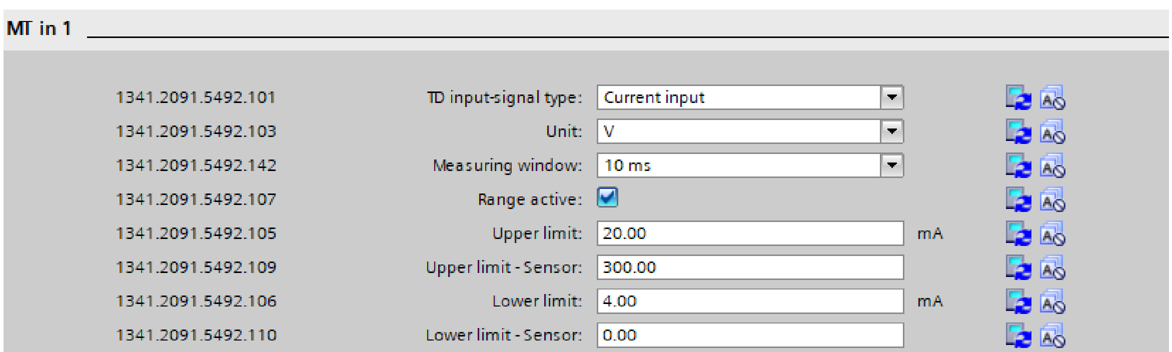
Table 3-3 Process and Environmental Data Acquired via Measuring Transducers and Their Supervisions

Data	Data-Acquisition Supervision
Control voltage of the closing circuit	Data quality is valid, for example, no overflow or broken wire is detected and the voltage is in an allowed range.
Control voltage of the opening circuit	
Ambient temperature	Data quality is valid, for example, no overflow or broken wire is detected.
Phase-selective hydraulic pressure	
Reference contact input	

In case of different supervision errors, 4 types of error reactions are assigned. For further information, refer to chapter *3.1.6.4 Supervision-Error Reaction*.

If the **Mode** parameter is set to ***on*** or ***test*** for at least one of the **CB closing** and **CB opening** function blocks, the supervision functions are active. Otherwise, all supervision functions are deactivated.

By marking the **Range active** check box in the settings for a measuring transducer, the value-range supervision is activated. The valid value range is configured via the parameters **Upper limit**, **Upper limit - Sensor**, **Lower limit**, and **Lower limit - Sensor**, as shown in the following figure.



[sc_MT setting_ctrl volt, 2, en_US]

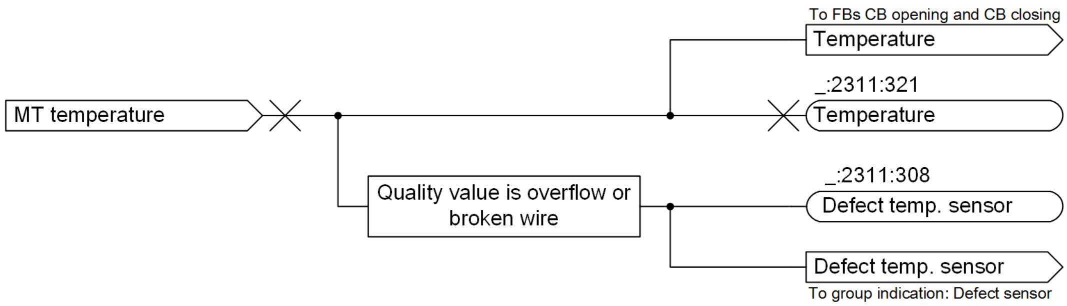
Figure 3-12 Setting of a Measuring Transducer

If the measured sensor value is not in the configured valid value range, the quality of the measured value changes as follows:

- If the measured sensor value exceeds the upper limit, the quality of the measured value is set to overflow.
- If the measured sensor value is below the lower limit, the quality of the measured value is set to broken-wire.

For more information about the parameters, refer to the chapter **Function-Group Type Analog Units** of the device manual.

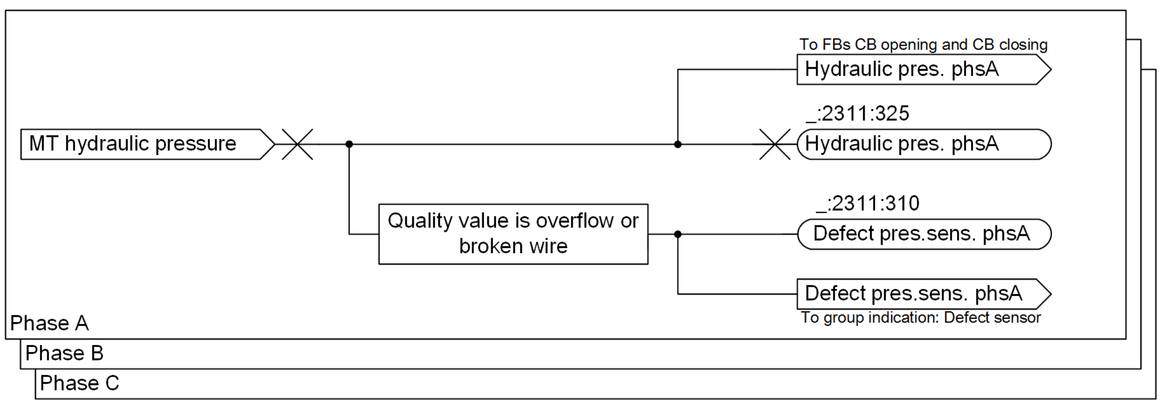
Ambient Temperature



[lo_PoW_Supervision_temperature, 2, en_US]

Figure 3-13 Logic Diagram of the Temperature Supervision

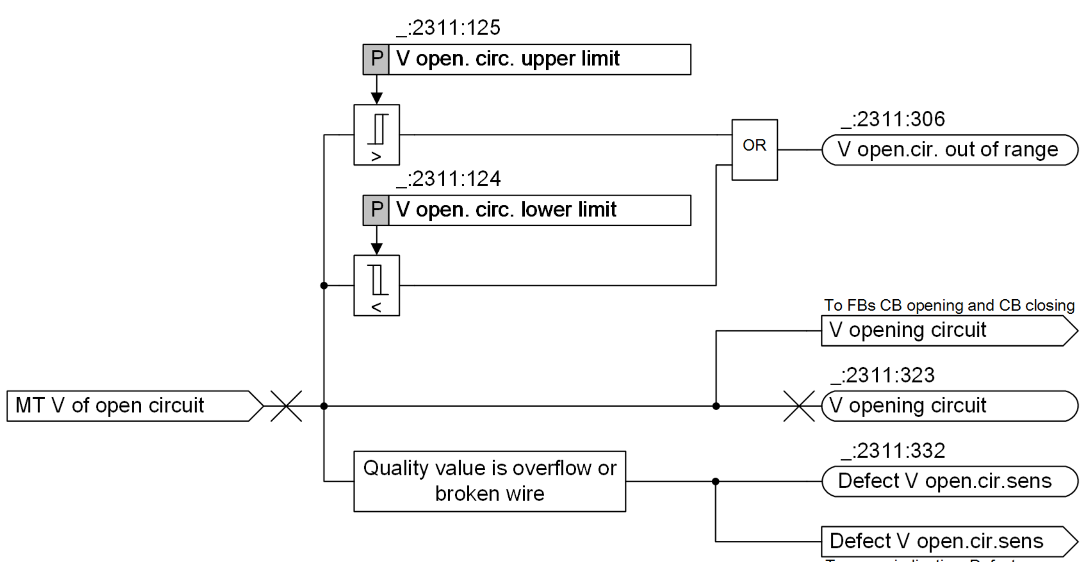
Hydraulic Pressure



[lo_PoW_Supervision_hydraulic_pressure, 2, en_US]

Figure 3-14 Logic Diagram of the Pressure Supervision

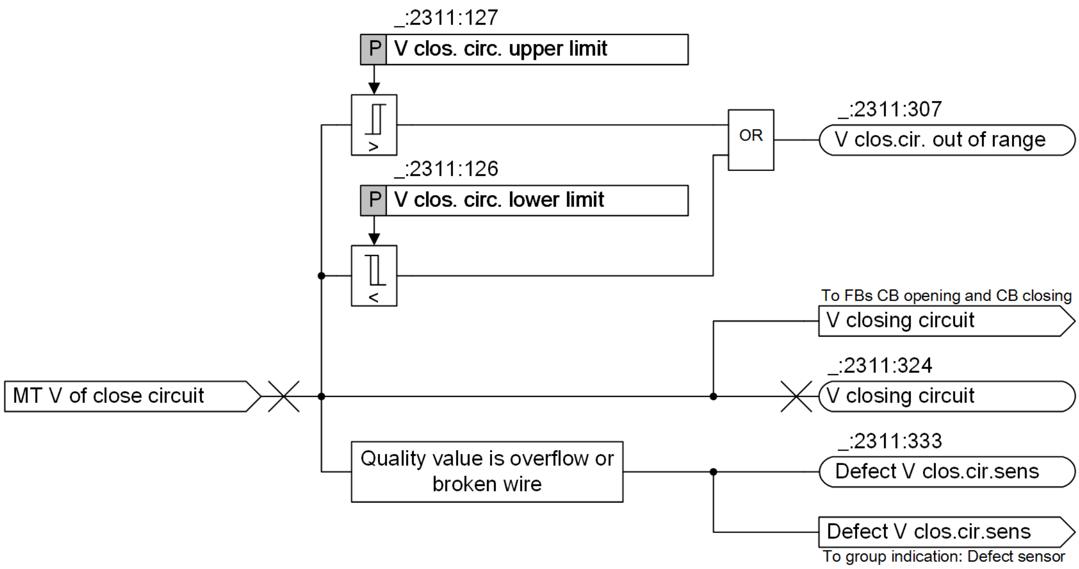
Control Voltage of the Opening Circuit



[lo_PoW_Supervision_V open, 2, en_US]

Figure 3-15 Logic Diagram of the Supervision on the Control Voltage of the Opening Circuit

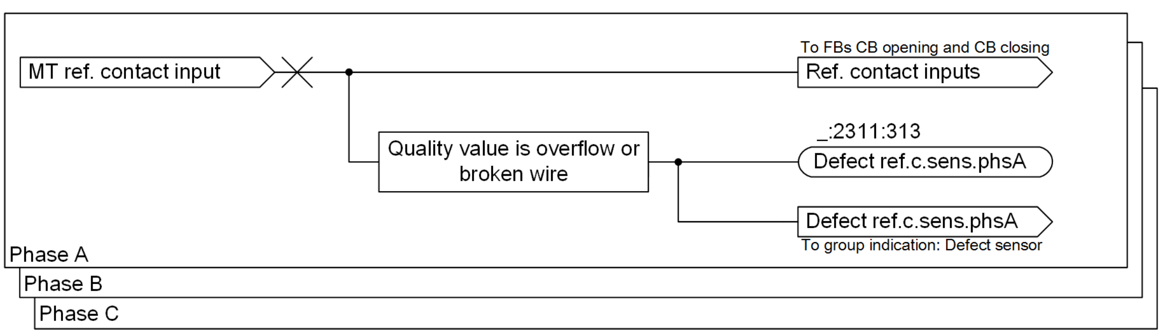
Control Voltage of the Closing Circuit



[lo_PoW_Supervision_V close, 2, en_US]

Figure 3-16 Logic Diagram of the Supervision on the Control Voltage of the Closing Circuit

Reference-Contact Inputs

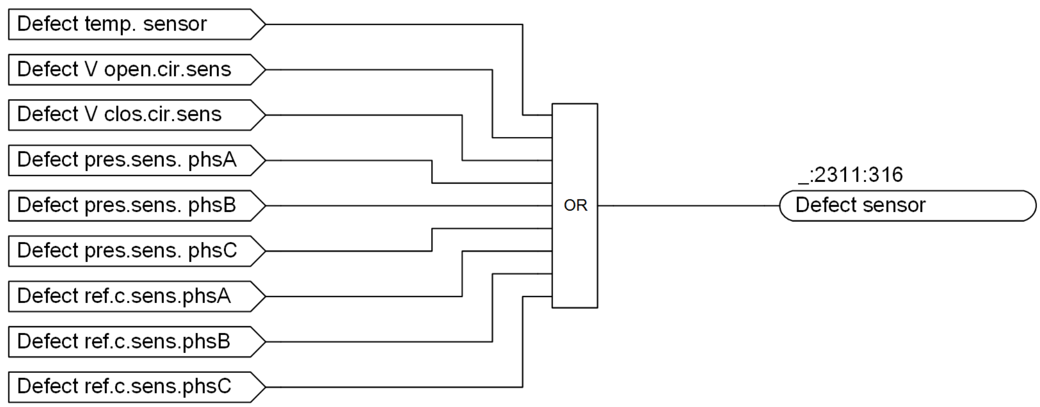


[lo_PoW_Supervision_ref input, 2, en_US]

Figure 3-17 Logic Diagram of the Reference-Contact Inputs

Group Indication: Defect sensor

Each defect of a sensor leads to a group fault indication *Defect sensor*.



[lo_PoW_Supervision_sensor_defect, 2, en_US]

Figure 3-18 Logic Diagram of the Indication Defect sensor

3.1.6.4 Supervision-Error Reaction

When device errors occur and the corresponding supervision functions pick up, this is displayed on the device and also indicated. Device errors can lead to corruption of data and signals. These data and signals are marked and tagged as invalid, so that affected functions automatically go into a secure state. If the supervision functions pick up, this will lead to defined error responses. You can find more information about the device errors and corresponding responses in the chapter **Error Responses and Corrective Measures** in the device manual.

Besides the device errors, the **Point-on-wave switching** function includes the preceding described supervision function. The supervision errors of the supervision functions can be grouped into 4 different supervision error types. *Table 3-4* describes the assignment of the individual supervision errors to the 4 reaction types.

Table 3-4 Assignment of the Individual Supervision Error to the Reaction Type

Error Class	**Type 1**	**Type 2**	**Type 3**	**Type 4**
States of FB CB opening and FB CB closing	**FB inactive** **Health =** ***Alarm***	**FB active** **Health =** ***Warning***	**FB active** **Health =** ***Ok***	**FB inactive** **Health =** ***Ok***
Switching Command Processing	**No switching at all**	**PoW or 3-pole switching**	**Only 3-pole switching**	**No switching at all**
Individual Supervision Error				
Selected reference signal is invalid	x			
3-phase current or voltage for switching monitoring is invalid		x		
V clos.cir. out of range	x[1]	x[2]		
V open.cir. out of range	x[1]	x[2]		
Error zero crossing			x[2]	x[1]
Error frequency			x[2]	x[1]
CB position disturbed				x
CB interm. pos. error				x
Defect V open.cir.sens	x[1]	x[2]		
Defect V clos.cir.sens	x[1]	x[2]		
Defect temp. sensor	x[1]	x[2]		
Defect pres.sens. phsA	x[1]	x[2]		
Defect pres.sens. phsB	x[1]	x[2]		

1 3-pole switching allowed = no

2 3-pole switching allowed = yes

Error Class	Type 1	Type 2	Type 3	Type 4
States of FB CB opening and FB CB closing	**FB inactive** **Health = *Alarm***	**FB active** **Health = *Warning***	**FB active** **Health = *Ok***	**FB inactive** **Health = *Ok***
Switching Command Processing	**No switching at all**	**PoW or 3-pole switching**	**Only 3-pole switching**	**No switching at all**
Individual Supervision Error				
Defect pres.sens. phsC	x[1]	x[2]		
Defect ref.c.sens.phsA		x		
Defect ref.c.sens.phsB		x		
Defect ref.c.sens.phsC		x		

All other existing supervision functions of the protection device operate additionally, as described in the corresponding device manual.

All the supervision errors detected in the general functionality are forwarded to the **CB opening** and **CB closing** function blocks. The **CB opening** and **CB closing** function blocks determine how to process the errors according to *Table 3-4*. You can also see the processing logic in the logic diagram of the specific function block.

3.1.7 Determination of the Point-on-Wave Switching Capability

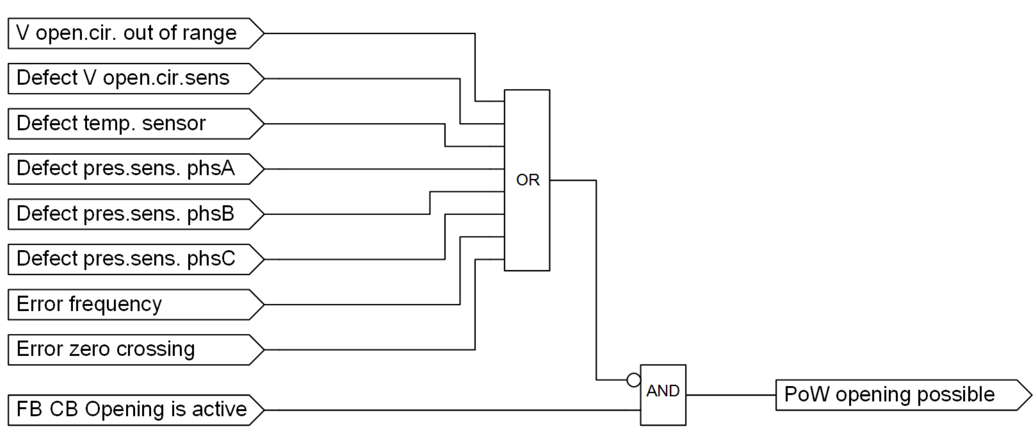
The signal *PoW capability* indicates if the **CB opening** and **CB closing** function blocks are able to carry out point-on-wave switching.

This signal is defined in the IEC 61850 standard for the logical node (function block) **Circuit breaker**. The signal logic is part of the **Point-on-wave switching** function. However, in the user interface, the signal is offered in the **Circuit breaker** function block.

The general function logic issues 2 internal signals *PoW opening possible* and *PoW closing possible* according to the following factors:

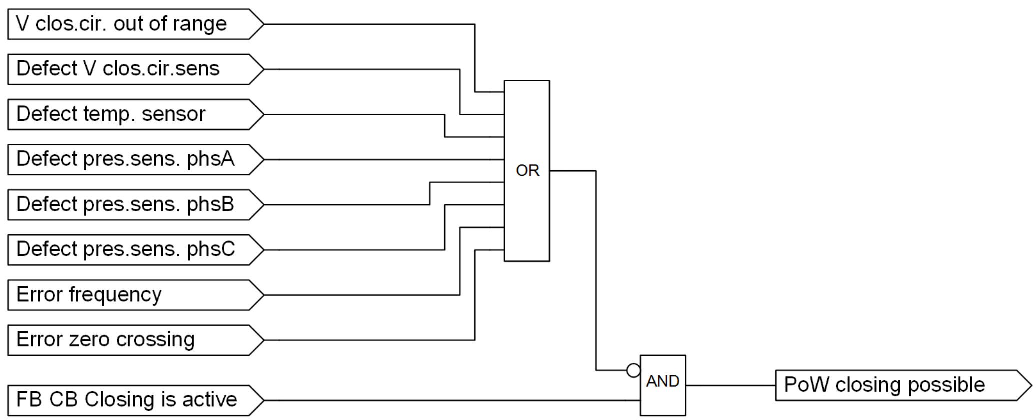
- Availability of the **CB opening** and **CB closing** function blocks
- Mode or behavior status of the function blocks
- Supervision-error reaction

The 2 internal signals are used for determining availability of the **Point-on-wave switching** function.



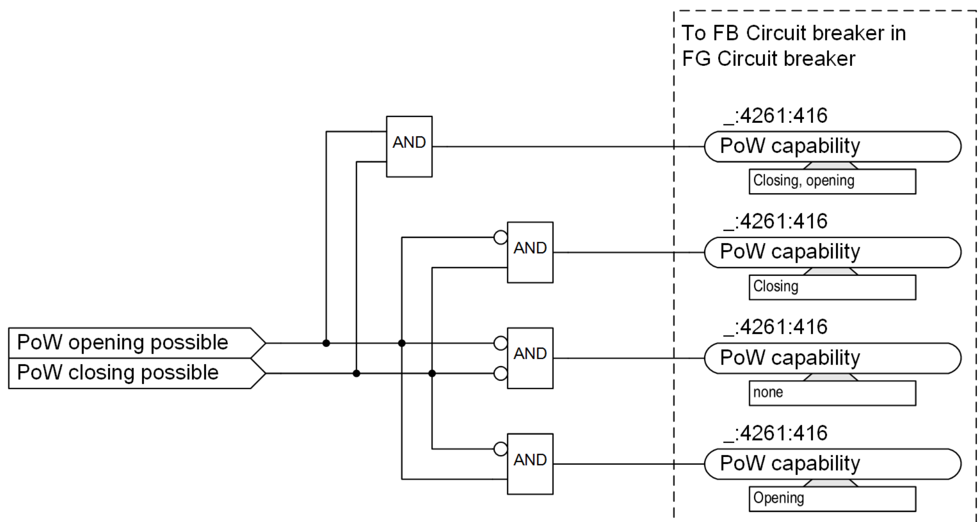
[lo_PoW Opening possible, 2, en_US]

Figure 3-19 Logic Diagram of Issuing the Internal Signal PoW opening possible



[lo_PoW Closing possible, 2, en_US]

Figure 3-20 Logic Diagram of Issuing the Internal Signal PoW closing possible



[lo_PoW Capability, 2, en_US]

Figure 3-21 Logic Diagram of Determining the Point-on-Wave Switching Capability

3.2 Application and Setting Notes

Parameter: Application, Power-syst. grounding

- Default setting (_:2311:102) **Application** = ***Capacitive load***
- Default setting (_:2311:103) **Power-syst. grounding** = ***grounded***

You must set these parameters according to the load that must be switched and according to the network grounding, respectively. You can find more information in *Table 3-1*.

The ***User-defined*** option of the **Application** parameter is used for switching at a customer-specified angle.

Parameter: Phase shift opening phsA, Phase shift opening phsB, Phase shift opening phsC, Phase shift closing phsA, Phase shift closing phsB, and Phase shift closing phsC

For special cases where the predefined switching angles according to the selected load do not fit for any reason, you can select the ***User-defined*** option of the **Application** parameter and set these parameters to define the angles.

If an application is selected, these settings only show the used angles for the application and cannot be changed.

Parameter: Ref. signal connection

- Default setting (_:2311:101) **Ref. signal connection** = ***permanently***

When the reference voltage is always available, you must set the parameter to ***permanently***.

When the reference voltage is available only shortly before the point-on-wave switching is initiated, you must set the parameter to ***before switching***. In this case, the binary input signal *>Ref. signal connected*, which indicates if the reference voltage is available, must be routed and configured.

For more information, refer to section *Reference Voltage Only Available Shortly before Switching, Page 43*.

Parameter: V open. circ. lower limit, V open. circ. upper limit, V clos. circ. lower limit, V clos. circ. upper limit

- Default setting (_:2311:124) **V open. circ. lower limit** = ***0.0 V***
- Default setting (_:2311:125) **V open. circ. upper limit** = ***0.0 V***
- Default setting (_:2311:126) **V clos. circ. lower limit** = ***0.0 V***
- Default setting (_:2311:127) **V clos. circ. upper limit** = ***0.0 V***

With these parameters, you define the limits of the control voltages.

As specified in the IEC standard, the voltage-supervision thresholds are as follows:

- For the closing circuit, a lower limit of 85 % of the rated control voltage and an upper limit of 110 % of the rated control voltage
- For the opening circuit, a lower limit of 70 % of the rated control voltage and an upper limit of 110 % of the rated control voltage

However, the upper limits must be set larger because the voltage is higher in case of loading the battery. Therefore, Siemens recommends the following typical limits:

For the closing circuit, a lower limit of 85 % of the rated control voltage and an upper limit of 120 % of the rated control voltage

For the opening circuit, a lower limit of 70 % of the rated control voltage and an upper limit of 120 % of the rated control voltage

Parameter: `Frequency lower limit`, `Frequency upper limit`

- Default setting (_:2311:130) `Frequency lower limit` = *49.00 Hz* for f_{rated} = 50 Hz
- Default setting (_:2311:131) `Frequency upper limit` = *51.00 Hz* for f_{rated} = 50 Hz

With these parameters, you define the limits of the frequency at which the function works. Siemens recommends using the default settings of these parameters.

Parameter: `ΔT zero crossing min.`, `ΔT zero crossing max.`, `Min. reference voltage`, `Zero-crossing sup. T-hold`

- Default setting (_:2311:133) `ΔT zero crossing min.` = *9.0 ms* for f_{rated} = 50 Hz
- Default setting (_:2311:134) `ΔT zero crossing max.` = *11.0 ms* for f_{rated} = 50 Hz
- Default setting (_:2311:132) `Min. reference voltage` = *15.000 V*
- Default setting (_:2311:135) `Zero-crossing sup. T-hold` = *0.10 s*

Siemens recommends using the default settings of these parameters. If you want to change the values, consider the maximum tolerance of the frequency and reference voltage.

Parameter: `CB interm.pos. max. time`

- Default setting (_:2311:136) `CB interm.pos. max. time` = *5.00 s*

This parameter is a time delay of the signaled intermediate circuit-breaker position (see *Figure 3-11*).

You must set this parameter to be longer than the maximum intermediate time during circuit-breaker switching plus a safety margin. Siemens recommends using the default setting.

Parameter: Measuring-transducer configuration for compensation

- Default setting (_:2311:104) `MT for temperature` = *None*
- Default setting (_:2311:106) `MT for opening-circ. volt.` = *None*
- Default setting (_:2311:107) `MT for closing-circ. volt.` = *None*
- Default setting (_:2311:108) `MT for hydr. press. phsA` = *None*
- Default setting (_:2311:109) `MT for hydr. press. phsB` = *None*
- Default setting (_:2311:116) `MT for hydr. press. phsC` = *None*

The compensation of process and environmental influences on the switching times is optional. It requires the respective circuit-breaker data which must be given by the circuit-breaker manufacturer. If this data is not available, the compensation is not possible.

If you do not use a measuring-transducer input to acquire the process or environmental data, set the corresponding parameter to *None*. Otherwise, specify the measuring transducer ID of the corresponding parameter.

After you select the measuring-transducer inputs, the measured values acquired via the measuring-transducer inputs can be supervised and used for compensation of the corresponding influence. For more information on the supervision, refer to chapter *3.1.6.3 Supervision of Data Acquisition via Measuring Transducers*. For more information on the compensation, refer to chapter *4.1.3 Compensation*.

Parameter: Measuring-transducer configuration for Siemens-CB reference contacts

- Default setting (_:2311:117) `MT for ref. contact phsA` = *None*
- Default setting (_:2311:118) `MT for ref. contact phsB` = *None*
- Default setting (_:2311:119) `MT for ref. contact phsC` = *None*

These settings are only applicable for Siemens circuit breakers with mechanical contact detection via Hall-effect sensors.

To acquire Siemens circuit-breaker reference contacts, you must select the fast measuring-transducer inputs (available on the I/O module IO212).

3.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:2311:102	General:Application		• Capacitive load • Transmission line • Reactance coil • Transformer • User-defined	Capacitive load
_:2311:103	General:Power-syst. grounding		• grounded • isolated	grounded
_:2311:101	General:Ref. signal connection		• permanently • before switching	permanently
Swit. angle Opening				
_:2311:110	General:Phase shift opening phsA		0° to 720°	0°
_:2311:111	General:Phase shift opening phsB		0° to 720°	0°
_:2311:112	General:Phase shift opening phsC		0° to 720°	0°
Swit. angle Closing				
_:2311:113	General:Phase shift closing phsA		0° to 720°	0°
_:2311:114	General:Phase shift closing phsB		0° to 720°	0°
_:2311:115	General:Phase shift closing phsC		0° to 720°	0°
Supervision				
_:2311:124	General:V open. circ. lower limit		0.0 Vto 300.0 V	0.0 V
_:2311:125	General:V open. circ. upper limit		0.0 Vto 300.0 V	0.0 V
_:2311:126	General:V clos. circ. lower limit		0.0 Vto 300.0 V	0.0 V
_:2311:127	General:V clos. circ. upper limit		0.0 Vto 300.0 V	0.0 V
_:2311:130	General:Frequency lower limit		30.00 Hz to 60.00 Hz	49.00 Hz
_:2311:131	General:Frequency upper limit		50.00 Hz to 80.00 Hz	51.00 Hz
_:2311:132	General:Min. reference voltage		0.300 V to 340.000 V	15.000 V
_:2311:133	General:ΔT zero crossing min.		0.0 ms to 50.0 ms	9.0 ms
_:2311:134	General:ΔT zero crossing max.		0.0 ms to 50.0 ms	11.0 ms
_:2311:135	General:Zero-crossing sup. T-hold		0.00 s to 60.00 s	0.10 s
_:2311:136	General:CB interm.pos. max. time		0.00 s to 300.00 s	5.00 s

Addr.	Parameter	C	Setting Options	Default Setting
_:2311:104	General:MT for temperature		Setting options depend on configuration	
_:2311:106	General:MT for opening-circ. volt.		Setting options depend on configuration	
_:2311:107	General:MT for closing-circ. volt.		Setting options depend on configuration	
_:2311:108	General:MT for hydr. press. phsA		Setting options depend on configuration	
_:2311:109	General:MT for hydr. press. phsB		Setting options depend on configuration	
_:2311:116	General:MT for hydr. press. phsC		Setting options depend on configuration	
_:2311:117	General:MT for ref. contact phsA		Setting options depend on configuration	
_:2311:118	General:MT for ref. contact phsB		Setting options depend on configuration	
_:2311:119	General:MT for ref. contact phsC		Setting options depend on configuration	

3.4 Information List

No.	Information	Data Class (Type)	Type
General			
_:2311:500	General:>CB closed phsA	SPS	I
_:2311:501	General:>CB closed phsB	SPS	I
_:2311:502	General:>CB closed phsC	SPS	I
_:2311:81	General:>Ref. signal connected	SPS	I
_:2311:82	General:>Block ref. signal sup.	SPS	I
_:2311:316	General:Defect sensor	SPS	O
_:2311:332	General:Defect V open.cir.sens	SPS	O
_:2311:333	General:Defect V clos.cir.sens	SPS	O
_:2311:308	General:Defect temp. sensor	SPS	O
_:2311:310	General:Defect pres.sens. phsA	SPS	O
_:2311:311	General:Defect pres.sens. phsB	SPS	O
_:2311:312	General:Defect pres.sens. phsC	SPS	O
_:2311:313	General:Defect ref.c.sens.phsA	SPS	O
_:2311:314	General:Defect ref.c.sens.phsB	SPS	O
_:2311:315	General:Defect ref.c.sens.phsC	SPS	O
_:2311:306	General:V open.cir. out of range	SPS	O
_:2311:307	General:V clos.cir. out of range	SPS	O
_:2311:317	General:Error frequency	SPS	O
_:2311:318	General:Error zero crossing	SPS	O
_:2311:302	General:CB position disturbed	SPS	O
_:2311:303	General:CB interm. pos. error	SPS	O
_:2311:328	General:f	MV	O
_:2311:323	General:V opening circuit	MV	O
_:2311:324	General:V closing circuit	MV	O
_:2311:321	General:Temperature	MV	O
_:2311:325	General:Hydraulic pres. phsA	MV	O
_:2311:326	General:Hydraulic pres. phsB	MV	O
_:2311:327	General:Hydraulic pres. phsC	MV	O

4 CB Opening Function Block

4.1 Description

4.1.1 Overview and General Description

Overview

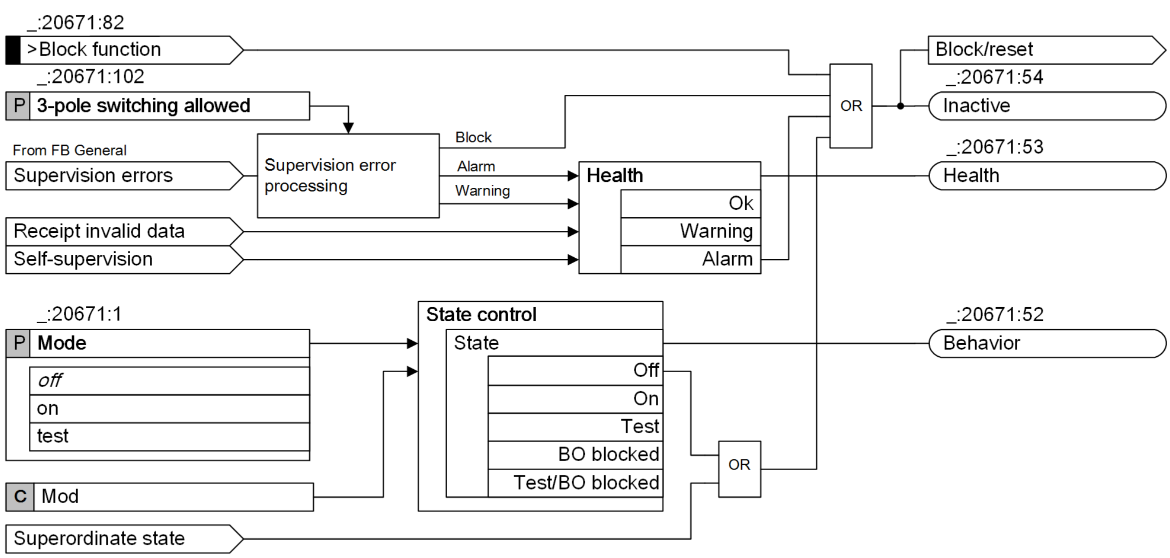
The **CB opening** function block provides the following subfunctions:

- General function-block control
- Start of the switching operation
- Calculation of the opening time stamps and circuit-breaker opening process
- Switching-time compensation
- Switching-accuracy supervision

General Function-Block Control

The function block can be blocked via one of the following options:

- Externally or internally via the binary input signal *>Block function*
- Via errors detected by the supervision in the general functionality
  For more information about the supervision errors and their reactions, refer to chapter *3.1.6.4 Supervision-Error Reaction*.



[lo_PoW_FB open control, 3, en_US]

Figure 4-1 Logic Diagram of the Function-Block Control

If the point-on-wave switching is not possible (for example, blocked by supervision errors) when the **CB opening** function block is triggered, the reaction of the function block depends on the error class and the setting of the **3-pole switching allowed** parameter:

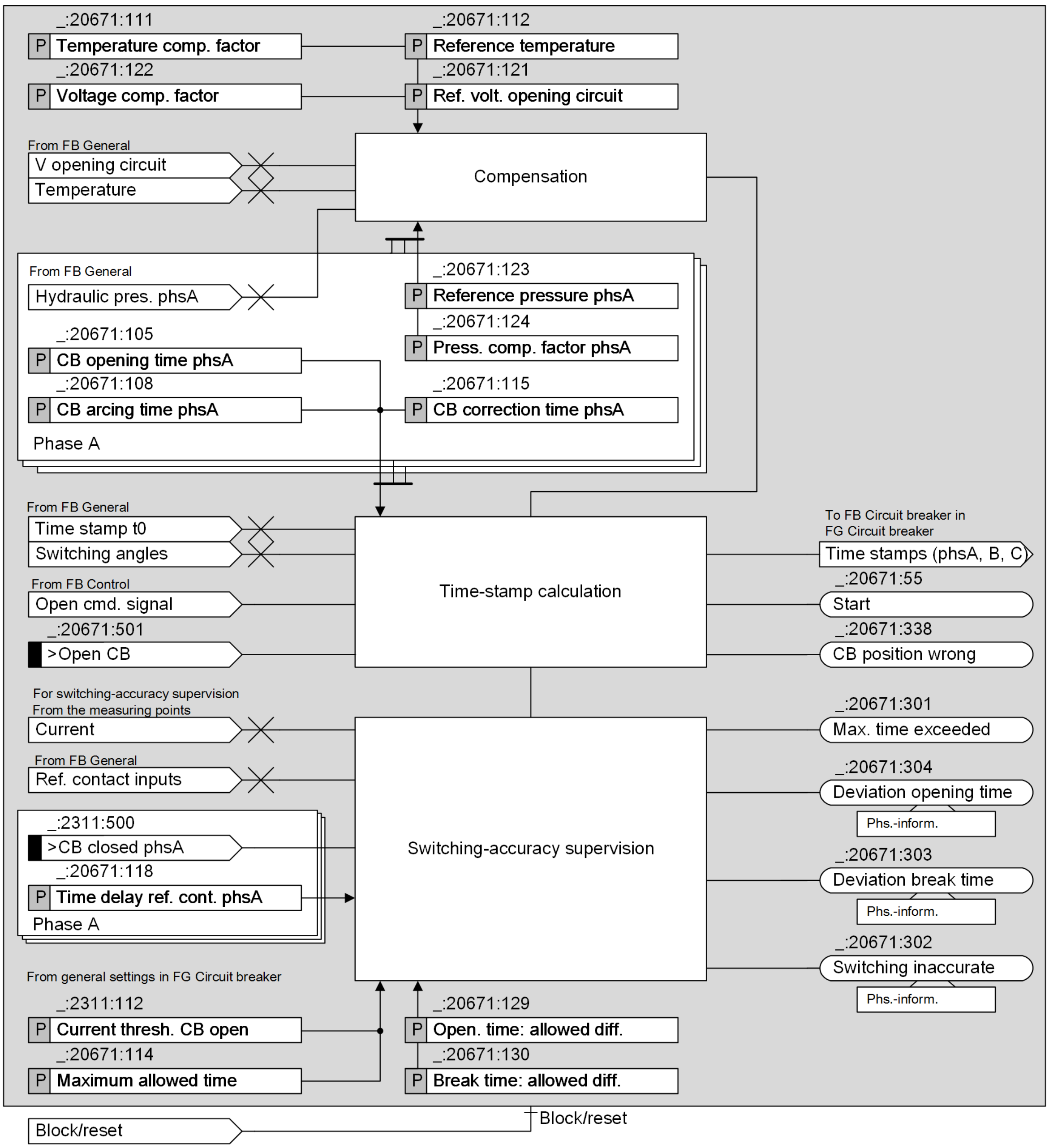
- If the setting of the parameter is ***yes*** and the error class is type 2 or 3, the function block is still active, and only 3-pole switching can take place.
  For more information, refer to chapter *3.1.6.4 Supervision-Error Reaction*.
- If the setting of the parameter is ***no***, the function block becomes inactive, and no switching takes place.

In the following conditions, the **3-pole switching allowed** parameter does not affect the normal 3-pole switching:

- The function block is configured but switched off (**Mode** is ***off***).
- The function block is configured and switched on (**Mode** is ***on*** or ***test***) but blocked by the input signal *>Block function*.

For more information about the reaction to the supervision errors, refer to chapter *3.1.6.4 Supervision-Error Reaction*.

Logic Diagram



[lo_PoW_FB open, 2, en_US]

Figure 4-2 Logic Diagram of the CB Opening Function Block

Start of the Switching Operation

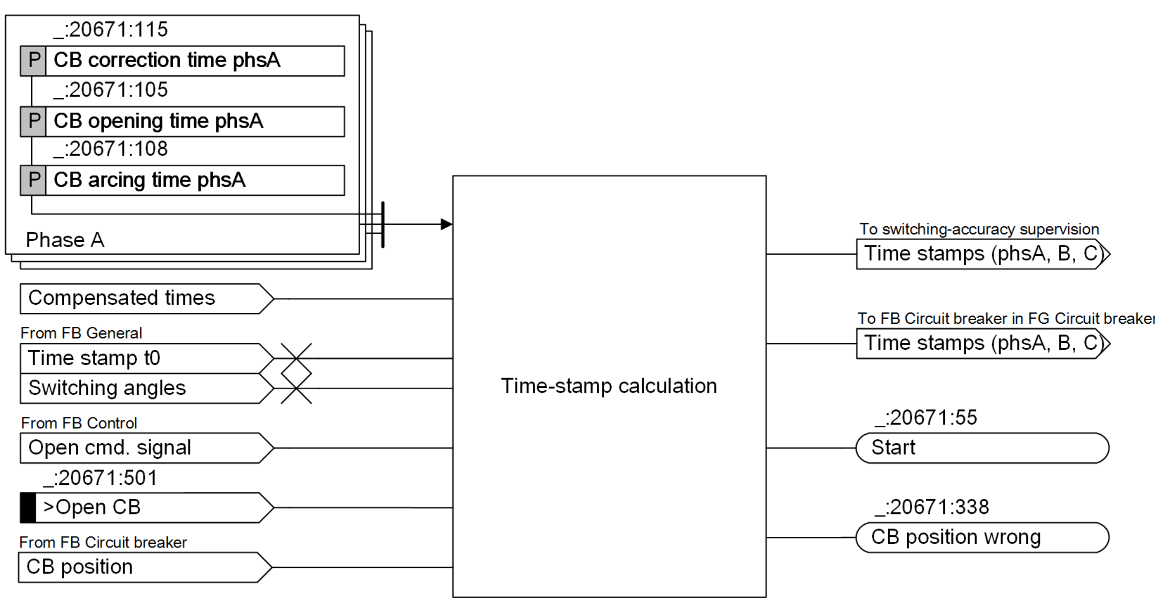
The switching operation can be started via either of the following options:

- Via the open command from the FB **Control**
- Via the binary input signal *>Open CB*
  If the function block is triggered via *>Open CB*, the function block checks the current circuit-breaker position. If the position is intermediate or is already reached, the signal *CB position wrong* is issued, which lasts for 20 ms, and no switching is carried out.

When the function block is triggered, the *Start* signal is issued, which indicates that the point-on-wave switching is in progress. With the *Start* signal, fault logging and recording are initiated.

When the *Start* signal is issued, the timer **Maximum allowed time** is started by which the point-on-wave switching duration is limited, in case that switching is not carried out for any reason. The timer specifies the maximum duration in which the **Point-on-wave switching** function is in progress. If all measured values for switching-accuracy supervision (such as the break times and opening times for phases) are successfully detected before the timer expires, the *Start* signal drops out (the function block is reset) and the timer is reset. Otherwise, after the timer expires, the *Start* signal drops out and the signal *Max. time exceeded* is issued for 20 ms.

4.1.2 Calculation of the Opening Time Stamps and Circuit-Breaker Opening Process



[lo_Timestamp_calcu open, 2, en_US]

Figure 4-3 Logic Diagram of the Opening Time-Stamp Calculation

Based on the following data, the **CB opening** function block calculates the time stamps for the activation of the binary outputs for the different phases:

- Zero-crossing time stamp and switching angles (from FB **General**)
- Compensated circuit-breaker opening time and break time
  The compensated break time is the time between the activation of the binary outputs (command to CB pole) and the end of the current flow.

The compensated circuit-breaker opening time and break time are calculated using the switching-time compensation (refer to chapter *4.1.3 Compensation*) and the **CB data** parameters.

For example, the compensated opening times and break times of phase A is calculated via the following formulas:

$$t_{Open,\ phsA} = t_{Open\ setting,\ phsA} - t_{Corr,\ phsA} + t_{Comp\ (temp)} + t_{Comp\ (volt)} + t_{Comp\ (pressure,\ phsA)}$$

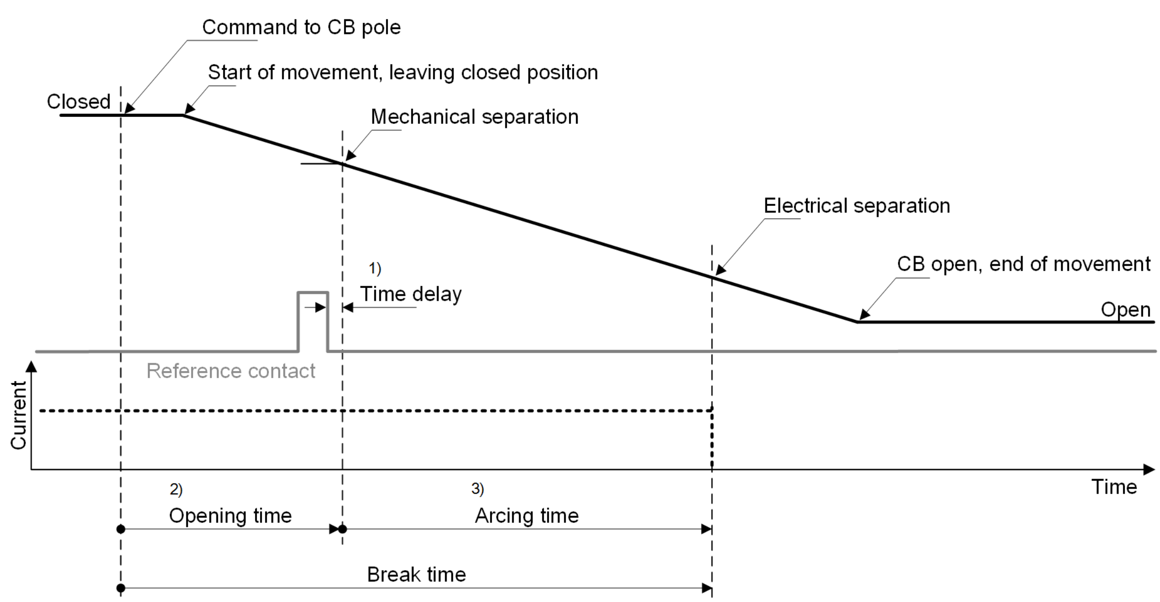
$$t_{Break,\ phsA} = t_{Open,\ phsA} + t_{Arc,\ phsA}$$

[fo_Full compensation per phase, 2, en_US]

Where:

- $t_{Open\ setting,\ phsA}$ is specified by the **CB opening time phsA** parameter.
- $t_{Corr,\ phsA}$ is specified by the **CB correction time phsA** parameter. The automatically calculated optimal opening time can be delayed by the correction time (in ms). This actual opening time can be both before and after the calculated opening time. A positive value generates a later actual time and a negative value generates an earlier actual time.
- $t_{Comp\ (temp)}$, $t_{Comp\ (volt)}$, and $t_{Comp\ (pressure,\ phsA)}$ are the compensated times according to the temperature, control-voltage, and hydraulic-pressure compensation. For further information, refer to chapter *4.1.3 Compensation*.
- $t_{Arc,\ phsA}$ is specified by the **CB arcing time phsA** parameter.

The compensated opening time starts with the command to the circuit-breaker pole. After the mechanical separation, the arcing time starts and ends with the electrical separation. The electrical separation must be completed at the desired switching angle.



[dw_Switching procedure CB open, 2, en_US]

Figure 4-4 Circuit-Breaker Opening Process

(1) With the parameter **Time delay ref. cont. phs*x***, you can adapt the signal of the reference contact to the mechanical separation in an optimal way.

(2) Opening time is calculated based on the parameters **CB opening time phs*x*** and based on the parameters **CB correction time phs*x***. You can find the calculation formula in the preceding description.

(3) Arcing time is specified by the parameters **CB arcing time phs*x***.

4.1.3 Compensation

4.1.3.1 Compensation of the Ambient-Temperature Influence

By measuring the ambient temperature, the **Point-on-wave switching** function can compensate the influence of the ambient temperature on the circuit-breaker switching time.

With the **`Temperature compensat.`** parameter, you can select one of the following compensation capabilities:

- No compensation
- Linear compensation
- Compensation by user-defined characteristic curve (vector)

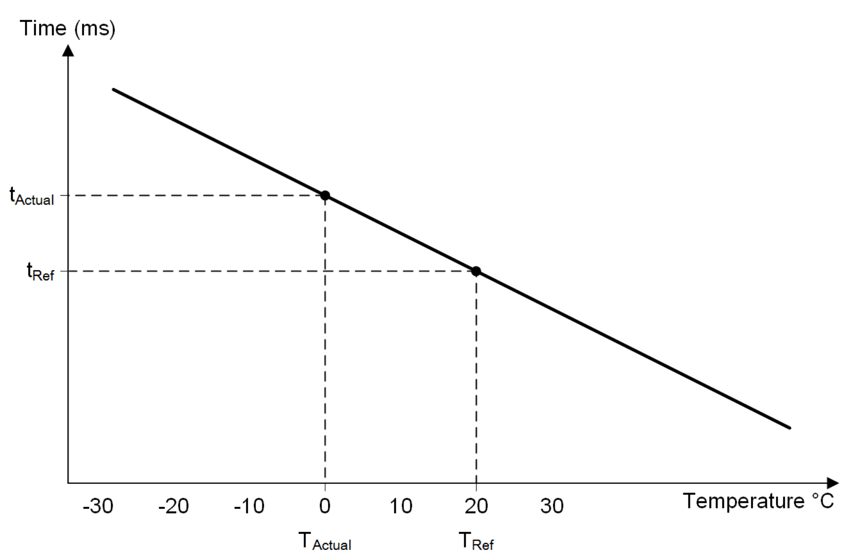
Linear Compensation

In the linear compensation, the compensation time $t_{Comp(temp)}$ is calculated as follows:

$$t_{Comp(temp)} = t_{Actual} - t_{Ref} = (T_{Actual} - T_{Ref}) \cdot K_{Comp(temp)}$$

Where:

- t_{Actual} is the opening time at the currently measured temperature (actual value).
- t_{Ref} is the opening time at the reference temperature.
- T_{Actual} is the currently measured temperature (actual value).
- T_{Ref} is the reference temperature specified by the **`Reference temperature`** parameter.
- $K_{Comp(temp)}$ is the factor specified by the **`Temperature comp. factor`** parameter.



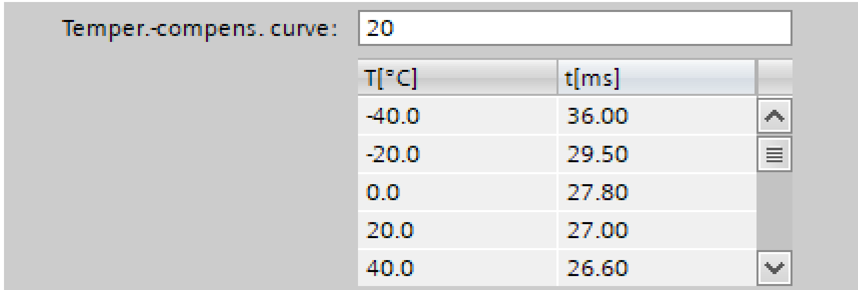
[dw_Opening time acc. temp, 2, en_US]

Figure 4-5 Compensation Characteristic Curve

The slope of the line in the figure is specified by the **`Temperature comp. factor`** parameter, which is usually a negative value.

Compensation by User-Defined Characteristic Curve

With the user-defined characteristic curve of the temperature, you can define the curve point by point using up to 30 value pairs of temperature and time. With the parameter **`Temper.-compens. curve`**, the number of value pairs is configured. The device uses linear interpolation to calculate the characteristic curve from these values.



Temper.-compens. curve: 20

T[°C]	t[ms]
-40.0	36.00
-20.0	29.50
0.0	27.80
20.0	27.00
40.0	26.60

[sc_Curve setting, 2, en_US]

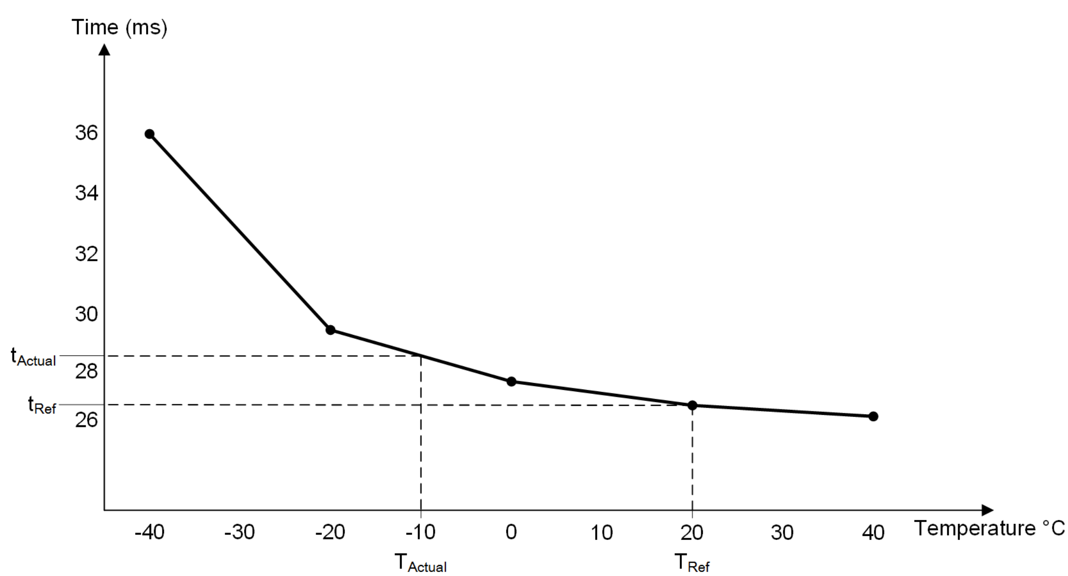
Figure 4-6 Setting Example of the Parameter **`Temper.-compens. curve`**

In this compensation, the compensation time $t_{Comp(temp)}$ is calculated as follows:

$t_{Comp(temp)} = t_{Actual} - t_{Ref}$

Where:

- t_{Ref} is the opening time at the reference temperature (T_{Ref}) specified by the **`Reference temperature`** parameter.
- t_{Actual} is the opening time at the currently measured temperature (T_{Actual}). The time can be obtained from the temperature-compensation curve specified by **`Temper.-compens. curve`**, as shown in *Figure 4-6*.



[dw_Operate time by temp, 2, en_US]

Figure 4-7 Compensation Characteristic Curve

4.1.3.2 Compensation of the Control-Voltage Magnitude Influence

By measuring the control voltage, the **Point-on-wave switching** function can compensate the influence of the control voltage on the circuit-breaker switching time.

With the **`Open.circuit vol.compens.`** parameter, you can select one of the following methods for compensation:

- No compensation
- Linear compensation
- Compensation by user-defined characteristic curve (vector)

Linear Compensation

In the linear compensation, the compensation time $t_{Comp(volt)}$ is calculated as follows:

$t_{Comp(volt)} = (V_{Actual} - V_{Ref}) \cdot K_{Comp(volt)}$

Where:

- V_{Actual} is the currently measured voltage (actual value).
- V_{Ref} is the reference voltage specified by the **Ref. volt. opening circuit** parameter.
- $K_{Comp(volt)}$ is the factor specified by the **Voltage comp. factor** parameter.

Compensation by User-Defined Characteristic Curve

The compensation method is the same as that of the temperature except the following factors:

- The characteristic curve uses pairs of voltage and time.
- t_{Ref} is the opening time corresponding to the reference voltage specified by the parameter **Ref. volt. opening circuit**.

For more information about this compensation function, refer to section *Compensation by User-Defined Characteristic Curve, Page 68*.

4.1.3.3 Compensation of the Hydraulic-Pressure Influence

By measuring the phase-selective hydraulic pressure, the **Point-on-wave switching** function can compensate the influence of the hydraulic pressure on the circuit-breaker switching time per phase.

With the **Hydr. pressure compens.** parameter, you can select whether to perform linear compensation according to the hydraulic pressure.

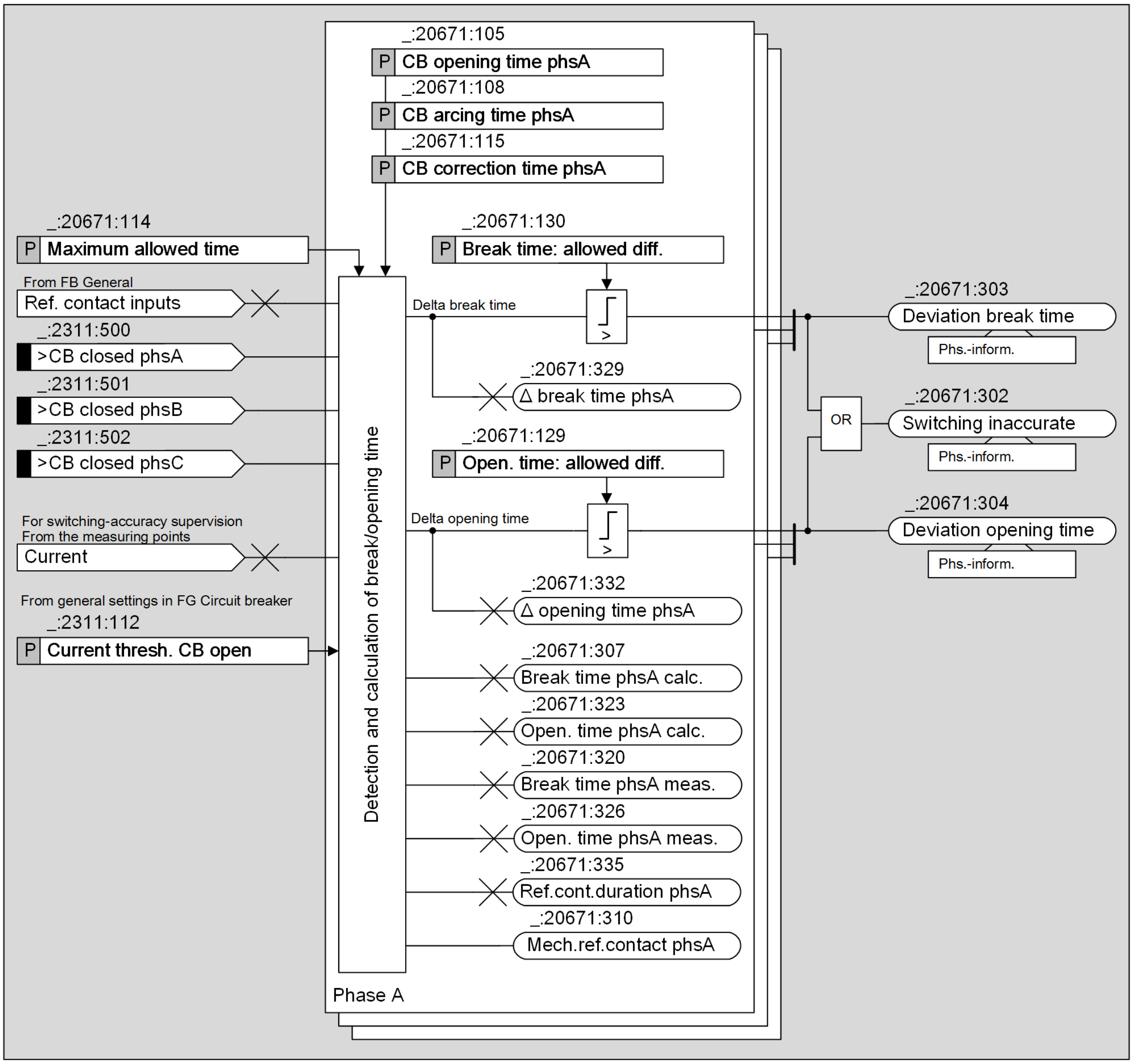
In the linear compensation, the phase-selective compensation time related to the hydraulic pressure is calculated. For example, the formula for calculating the compensation time of phase A $t_{Comp(pressure,\ phsA)}$ is calculated as follows:

$t_{Comp(pressure,\ phsA)} = (P_{Actual} - P_{Ref}) \cdot K_{Comp(pressure,\ phsA)}$

Where:

- P_{Actual} is the actually measured hydraulic pressure of phase A.
- P_{Ref} is the reference hydraulic pressure of phase A, which is specified by the **Reference pressure phsA** parameter.
- $K_{Comp(pressure,\ phsA)}$ is the factor of phase A, which is specified by the **Press. comp. factor phsA** parameter.

4.1.4 Switching-Accuracy Supervision



[lo_PoW_accuracy supervision, 2, en_US]

Figure 4-8 Logic Diagram of the Switching-Accuracy Supervision

Measured Opening and Break Time

- The actual opening time is measured either via the fast measuring-transducer input (Hall-effect sensor measuring transducer, only available for Siemens circuit breakers) or via the binary inputs *>CB closed phsx* connected to the 52a auxiliary contacts.
- The actual break time is calculated based on the phase-current measurement.

The signals *Mech.ref.contact phsA*, *Mech.ref.contact phsB*, and *Mech.ref.contact phsC* indicate the mechanical separation moments of circuit-breaker poles.

Only in the case that the reference contact information is obtained via fast measuring-transducer inputs (with Siemens circuit breakers), the signals *Ref.cont.duration phsA*, *Ref.cont.duration phsB*, and *Ref.cont.duration phsC* indicate the measured duration (pulse) time of the reference contacts, from the rising edge to the falling edge.

Calculated Time Differences

The **Switching-accuracy supervision** function determines the following time differences:

- The time difference between the calculated and the measured opening time per phase
- The time difference between the calculated and the measured break time per phase

Calculated, measured, and delta times are also available as functional values.

If the time difference of the break or opening time exceeds the threshold **Break time: allowed diff.** or **Open. time: allowed diff.**, the signal *Deviation break time* or *Deviation opening time* is issued.

If one of the differences exceeds the threshold, the circuit-breaker switching is considered as inaccurate and the signal *Switching inaccurate* is issued.

4.2 Application and Setting Notes

Start of the Switching Operation

If the bay controller and the **Point-on-wave switching** function are in the same device, the switching operation can be started via the open command from the FB **Control**.

If the bay controller and the **Point-on-wave switching** function are in different devices, the switching operation can be started via the binary input signal *>Open CB*. *>Open CB* can be initiated via a physical binary input or via IEC 61850 GOOSE.

Parameter: 3-pole switching allowed

- Default setting **(_:20671:102) 3-pole switching allowed** = ***no***

When a point-on-wave switching command is given and the function is unable to operate (for example, blocked by supervision) and if no switching operation shall be executed at all, set this parameter to ***no***.

If under this condition 3-pole switching (all poles switched at the same time) shall be carried out, set this parameter to ***yes***.

Parameter: *CB data*

- Default setting **(_:20671:105) CB opening time phsA** = ***0.0 ms***
- Default setting **(_:20671:106) CB opening time phsB** = ***0.0 ms***
- Default setting **(_:20671:107) CB opening time phsC** = ***0.0 ms***
- Default setting **(_:20671:108) CB arcing time phsA** = ***0.0 ms***
- Default setting **(_:20671:109) CB arcing time phsB** = ***0.0 ms***
- Default setting **(_:20671:110) CB arcing time phsC** = ***0.0 ms***
- Default setting **(_:20671:115) CB correction time phsA** = ***0.00 ms***
- Default setting **(_:20671:116) CB correction time phsB** = ***0.00 ms***
- Default setting **(_:20671:117) CB correction time phsC** = ***0.00 ms***

You must set the CB opening time and CB arcing time parameters according to the technical data of the circuit breaker. This data must be obtained from the circuit-breaker manufacturer.

During commissioning, little deviations to the technical data might be detected. Such deviations can be adjusted via the CB correction time parameters.

NOTE

If the real opening time (measured value during commissioning) is greater than the CB opening time parameter, the CB correction time parameter should be a negative value. Otherwise, it should be a positive value.

Parameter: *Compensation data*

- Default setting **(_:20671:131) Open.circuit vol.compens.** = ***no***
- Default setting **(_:20671:113) Temperature compensat.** = ***no***
- Default setting **(_:20671:132) Hydr. pressure compens.** = ***no***
- Default setting **(_:20671:122) Voltage comp. factor** = ***0.000 ms/V***
- Default setting **(_:20671:111) Temperature comp. factor** = ***0.000 ms/K***
- Default setting **(_:20671:124) Press. comp. factor phsA** = ***0.000 ms/kPa***
- Default setting **(_:20671:126) Press. comp. factor phsB** = ***0.000 ms/kPa***

- Default setting **(_:20671:128) Press. comp. factor phsC** = *0.000 ms/kPa*
- Default setting **(_:20671:121) Ref. volt. opening circuit** = *125.0 V*
- Default setting **(_:20671:112) Reference temperature** = *20 °C*
- Default setting **(_:20671:123) Reference pressure phsA** = *500 kPa*
- Default setting **(_:20671:125) Reference pressure phsB** = *500 kPa*
- Default setting **(_:20671:127) Reference pressure phsC** = *500 kPa*

All switching-time compensation functionality is optional. Compensation can only be applied if the influences on the circuit-breaker switching times are known. This data must be obtained from the circuit-breaker manufacturer. If the respective data is not available, compensation is not possible.

If you want to compensate the circuit-breaker switching times according to the CB-switching control voltage or temperature, you must set the **Open.circuit vol.compens.** or **Temperature compensat.** parameter to ***Linear*** or ***user-defined***. The selection between ***Linear*** or ***user-defined*** depends on the characteristic of the compensation data.

If you want to compensate the circuit-breaker switching times according to the phase-selective hydraulic pressure, only the ***Linear*** option is available in the **Hydr. pressure compens.** parameter.

Usually, a lower control voltage, temperature, or hydraulic pressure lead to a longer mechanical operating time. Therefore, the **Voltage comp. factor**, **Temperature comp. factor**, and **Press. com. factor phsx** parameters should be set to negative values to compensate the influences.

For more information about how to set the compensation, refer to chapter *4.1.3 Compensation*.

Opening-Time Detection, Reference Contact

The opening times are detected and measured via the reference contacts. The measured opening times are part of the switching-accuracy supervision (refer to chapter *4.1.4 Switching-Accuracy Supervision*). The type of reference contact depends on the circuit-breaker manufacturer:

- Siemens circuit breaker: a Siemens circuit breaker offers a measuring transducer for a CB-integrated Hall-effect sensor.
  In this case, 3 fast measuring-transducer inputs are required. To configure the measuring-transducer reference contacts, follow chapter *3.1.5 Measuring-Transducer Configuration for Process and Environmental Data Acquisition*.
- Non-Siemens circuit breakers: The CB-closed auxiliary contacts must be used as reference contacts.
  In this case, the input signals *>CB closed phsA*, *>CB closed phsB*, and *>CB closed phsC* must be routed to the physical binary inputs which are wired with the 52a circuit-breaker contacts.

Parameter: *Reference contact*

- Default setting **(_:20671:118) Time delay ref. cont. phsA** = *0.0 ms*
- Default setting **(_:20671:119) Time delay ref. cont. phsB** = *0.0 ms*
- Default setting **(_:20671:120) Time delay ref. cont. phsC** = *0.0 ms*

The setting is the time interval from the opening time of circuit-breaker contact to the falling edge of reference contact input.

Via these settings, the time differences between the reference contacts and the main circuit-breaker contacts are adjusted.

The time differences are determined and stated either:

- During circuit-breaker routine testing by the circuit-breaker manufacturer
  In this case, the times must be part of the circuit-breaker routine test protocol.
- During circuit-breaker commissioning on site, by carrying out switching-time measurements via respective measuring devices

If the signal is later than the opening of the main circuit-breaker contact, the time delay parameter must be set to a negative value.

Parameter: Maximum allowed time

- Default setting **(_:20671:114) Maximum allowed time** = ***0.30 s***

Normally, point-on-wave switching operations should be finished within 100 ms.

Siemens recommends using the default setting of the **Maximum allowed time** parameter.

Parameter: Open. time: allowed diff., Break time: allowed diff.

- Default setting **(_:20671:129) Open. time: allowed diff.** = ***3.0 ms***
- Default setting **(_:20671:130) Break time: allowed diff.** = ***3.0 ms***

The **Open. time: allowed diff.** and **Break time: allowed diff.** parameters represent the difference you accept between the calculated and the actual time. The default settings are the typical values.

Parameter: Current Threshold Circuit Breaker Open

- Default setting **(_:2311:112) Current thresh. CB open** = ***0.10 A***

The **Current thresh. CB open** parameter is available in the general settings of the FG **Circuit breaker**.

With the **Current thresh. CB open** parameter, you specify the current threshold below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the **Current thresh. CB open** parameter so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to ***0.05 A*** for example.

If no special requirements exist, Siemens recommends using the setting value of ***0.10 A***.

Signal: Ref.cont.duration phsA, Ref.cont.duration phsB, Ref.cont.duration phsC

These signals are available only when the parameters **MT for ref. contact phsA**, **MT for ref. contact phsB**, and **MT for ref. contact phsC** are configured for Siemens-CB reference contacts.

The duration times specified by these signals are determined after circuit-breaker manufacturing in the factory and are noted. During commissioning, these duration times are determined again (via the device measurement) and compared to the former values. Therefore, defects in the reference-contact adaption can be found.

4.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:20671:1	Opening:Mode		• off • on • test	off
_:20671:102	Opening:3-pole switching allowed		• no • yes	no
CB data				
_:20671:105	Opening:CB opening time phsA		0.0 ms to 200.0 ms	0.0 ms
_:20671:106	Opening:CB opening time phsB		0.0 ms to 200.0 ms	0.0 ms
_:20671:107	Opening:CB opening time phsC		0.0 ms to 200.0 ms	0.0 ms
_:20671:108	Opening:CB arcing time phsA		0.0 ms to 20.0 ms	0.0 ms
_:20671:109	Opening:CB arcing time phsB		0.0 ms to 20.0 ms	0.0 ms
_:20671:110	Opening:CB arcing time phsC		0.0 ms to 20.0 ms	0.0 ms
_:20671:115	Opening:CB correction time phsA		-20.00 ms to 20.00 ms	0.00 ms
_:20671:116	Opening:CB correction time phsB		-20.00 ms to 20.00 ms	0.00 ms
_:20671:117	Opening:CB correction time phsC		-20.00 ms to 20.00 ms	0.00 ms
Compensation data				
_:20671:131	Opening:Open.circuit vol.compens.		• no • Linear • user-defined	no
_:20671:121	Opening:Ref. volt. opening circuit		20.0 V to 300.0 V	125.0 V
_:20671:122	Opening:Voltage comp. factor		-1.000 ms/V to 1.000 ms/V	0.000 ms/V
_:20671:134	Opening:Voltage-compens. curve		Setting options depend on configuration	
_:20671:113	Opening:Temperature compensat.		• no • Linear • user-defined	no
_:20671:112	Opening:Reference temperature		-60 °C to 100 °C	20 °C
_:20671:111	Opening:Temperature comp. factor		-1.000 ms/K to 1.000 ms/K	0.000 ms/K
_:20671:133	Opening:Temper.-compens. curve		Setting options depend on configuration	
_:20671:132	Opening:Hydr. pressure compens.		• no • Linear	no

Addr.	Parameter	C	Setting Options	Default Setting
_:20671:123	Opening:Reference pressure phsA		100 kPa to 1000 kPa	500 kPa
_:20671:124	Opening:Press. comp. factor phsA		-1.000 ms/kPa to 1.000 ms/kPa	0.000 ms/kPa
_:20671:125	Opening:Reference pressure phsB		100 kPa to 1000 kPa	500 kPa
_:20671:126	Opening:Press. comp. factor phsB		-1.000 ms/kPa to 1.000 ms/kPa	0.000 ms/kPa
_:20671:127	Opening:Reference pressure phsC		100 kPa to 1000 kPa	500 kPa
_:20671:128	Opening:Press. comp. factor phsC		-1.000 ms/kPa to 1.000 ms/kPa	0.000 ms/kPa
Reference contact				
_:20671:118	Opening:Time delay ref. cont. phsA		-50.0 ms to 50.0 ms	0.0 ms
_:20671:119	Opening:Time delay ref. cont. phsB		-50.0 ms to 50.0 ms	0.0 ms
_:20671:120	Opening:Time delay ref. cont. phsC		-50.0 ms to 50.0 ms	0.0 ms
Swit.accuracy sup.				
_:20671:114	Opening:Maximum allowed time		0.00 s to 60.00 s	0.30 s
_:20671:129	Opening:Open. time: allowed diff.		0.0 ms to 20.0 ms; ∞	3.0 ms
_:20671:130	Opening:Break time: allowed diff.		0.0 ms to 20.0 ms; ∞	3.0 ms

4.4 Information List

No.	Information	Data Class (Type)	Type
Opening			
_:20671:82	Opening:>Block function	SPS	I
_:20671:501	Opening:>Open CB	SPS	I
_:20671:54	Opening:Inactive	SPS	O
_:20671:52	Opening:Behavior	ENS	O
_:20671:53	Opening:Health	ENS	O
_:20671:55	Opening:Start	SPS	O
_:20671:338	Opening:CB position wrong	SPS	O
_:20671:310	Opening:Mech.ref.contact phsA	SPS	O
_:20671:311	Opening:Mech.ref.contact phsB	SPS	O
_:20671:312	Opening:Mech.ref.contact phsC	SPS	O
_:20671:301	Opening:Max. time exceeded	SPS	O
_:20671:302	Opening:Switching inaccurate	ACT	O
_:20671:303	Opening:Deviation break time	ACT	O
_:20671:304	Opening:Deviation opening time	ACT	O
_:20671:307	Opening:Break time phsA calc.	MV	O
_:20671:308	Opening:Break time phsB calc.	MV	O
_:20671:309	Opening:Break time phsC calc.	MV	O
_:20671:320	Opening:Break time phsA meas.	MV	O
_:20671:321	Opening:Break time phsB meas.	MV	O
_:20671:322	Opening:Break time phsC meas.	MV	O
_:20671:323	Opening:Open. time phsA calc.	MV	O
_:20671:324	Opening:Open. time phsB calc.	MV	O
_:20671:325	Opening:Open. time phsC calc.	MV	O
_:20671:326	Opening:Open. time phsA meas.	MV	O
_:20671:327	Opening:Open. time phsB meas.	MV	O
_:20671:328	Opening:Open. time phsC meas.	MV	O
_:20671:329	Opening:Δ break time phsA	MV	O
_:20671:330	Opening:Δ break time phsB	MV	O
_:20671:331	Opening:Δ break time phsC	MV	O
_:20671:332	Opening:Δ opening time phsA	MV	O
_:20671:333	Opening:Δ opening time phsB	MV	O
_:20671:334	Opening:Δ opening time phsC	MV	O
_:20671:335	Opening:Ref.cont.duration phsA	MV	O
_:20671:336	Opening:Ref.cont.duration phsB	MV	O
_:20671:337	Opening:Ref.cont.duration phsC	MV	O

5 CB Closing Function Block

5.1 Description

5.1.1 Overview and General Description

Overview

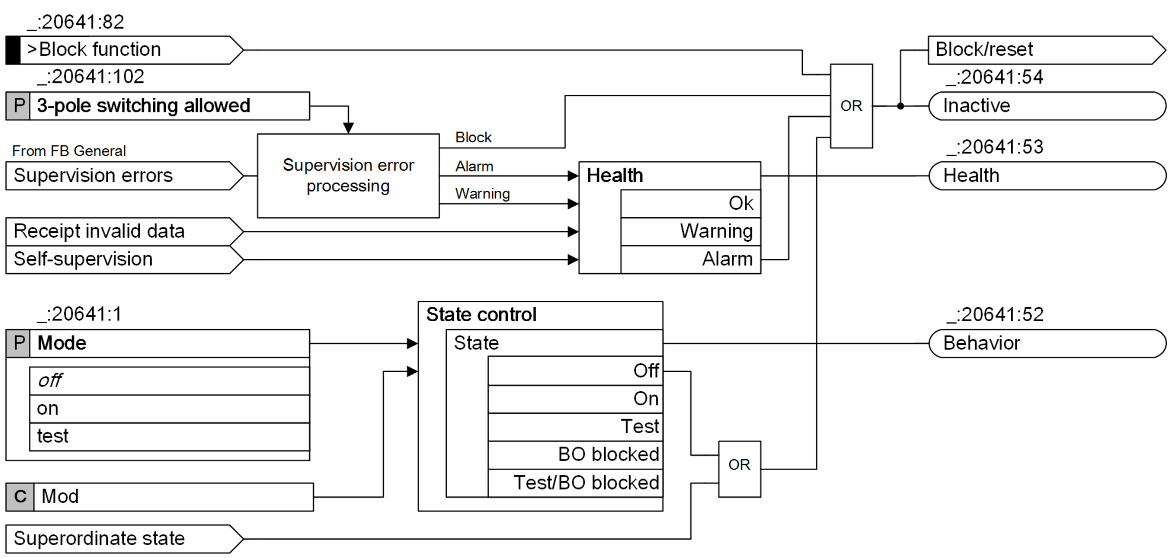
The **CB closing** function block provides the following subfunctions:

- General function-block control
- Start of the switching operation
- Calculation of the closing time stamps and circuit-breaker closing process
- Switching-time compensation
- Switching-accuracy supervision

General Function-Block Control

The function block can be blocked via one of the following options:

- Externally or internally via the binary input signal *>Block function*
- Via errors detected by the supervision in the general functionality
  You can find more information about the supervision errors and their reactions in chapter *3.1.6.4 Supervision-Error Reaction*.



[lo_PoW_FB Close control, 3, en_US]

Figure 5-1 Logic Diagram of the Function-Block Control

If the point-on-wave switching is not possible (for example, blocked by supervision errors) when the **CB closing** function block is triggered, the reaction of the function block depends on the error class and the setting of the **3-pole switching allowed** parameter:

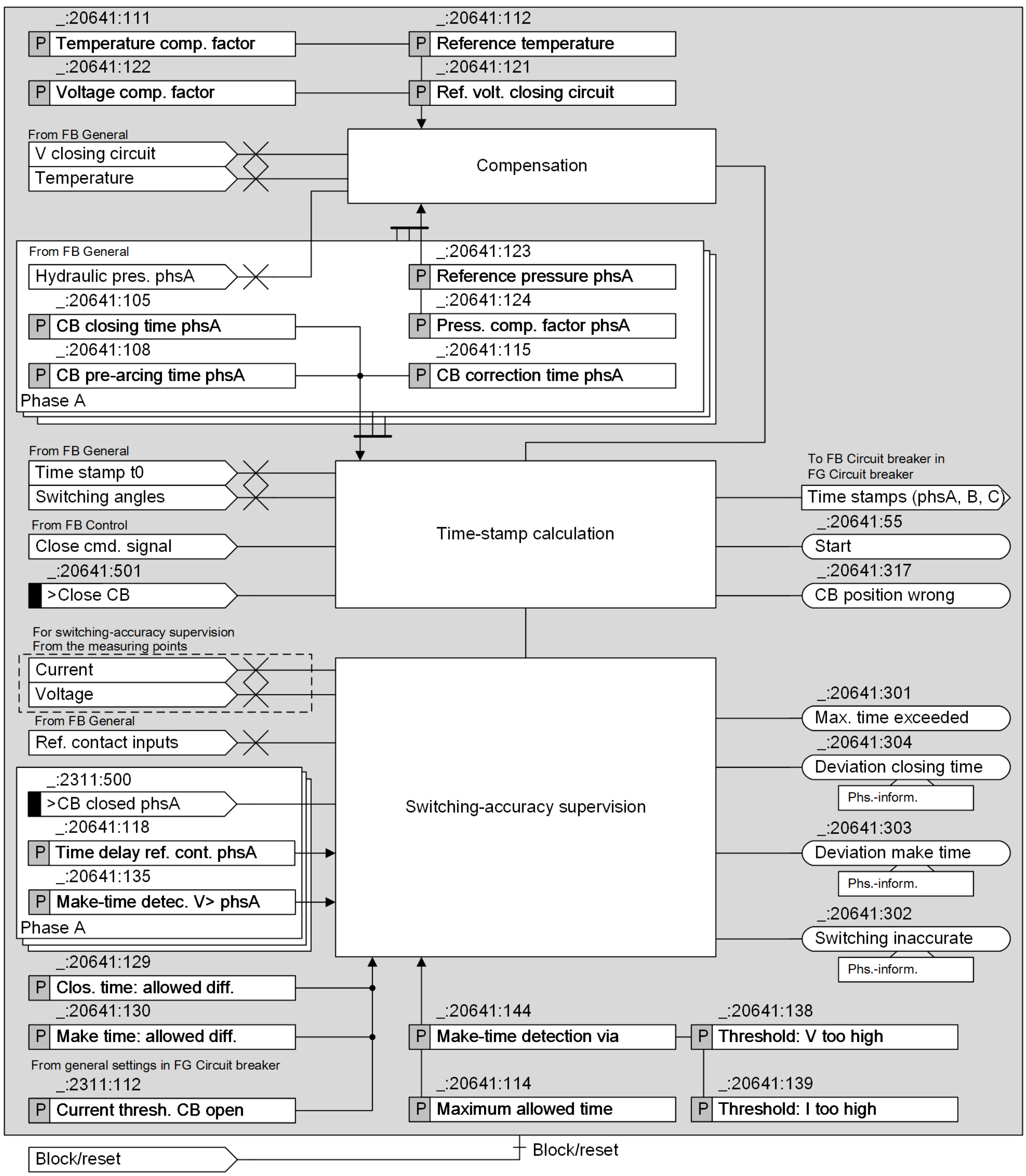
- If the setting of the parameter is ***yes*** and the error class is type 2 or 3, the function block is still active, and only 3-pole switching can take place.
  You can find more information in *3.1.6.4 Supervision-Error Reaction*.
- If the setting of the parameter is ***no***, the function block becomes inactive, and no switching takes place.

In the following conditions, the **3-pole switching allowed** parameter does not affect the normal 3-pole switching:

- The function block is configured but switched off (**Mode** is ***off***).
- The function block is configured and switched on (**Mode** is ***on*** or ***test***) but blocked by the input signal *>Block function*.

You can find more information about the reaction to the supervision errors in chapter *3.1.6.4 Supervision-Error Reaction*.

Logic Diagram



[lo_PoW_FB close, 2, en_US]

Figure 5-2 Logic Diagram of the CB Closing Function Block

Start of the Switching Operation

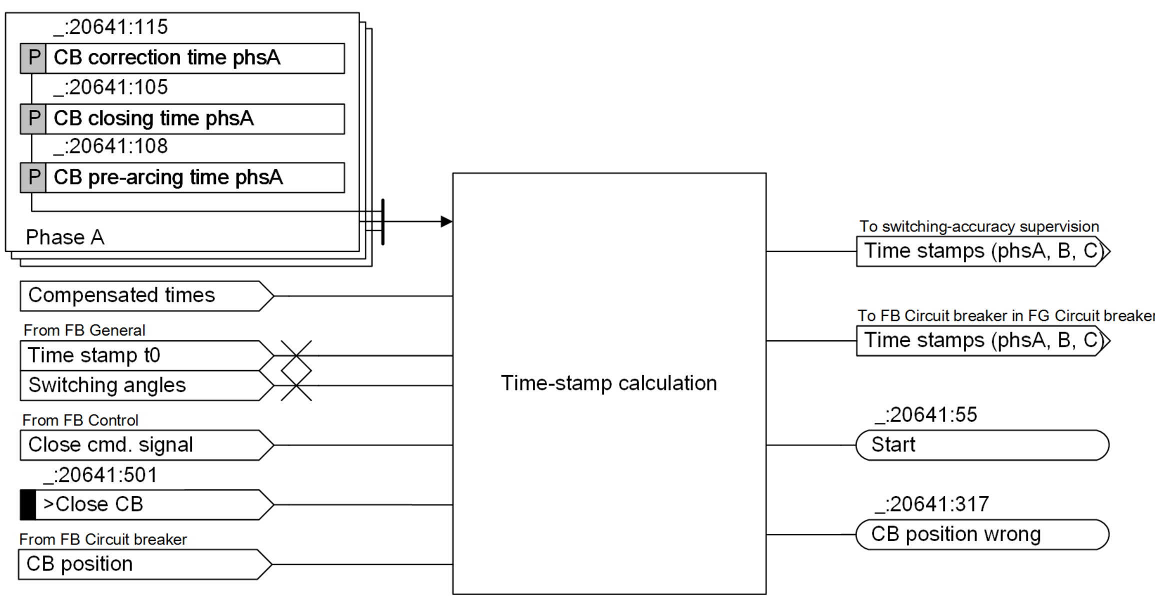
The switching operation can be started via either of the following options:

- Via the close command from the FB **Control**
- Via the binary input signal *>Close CB*
  If the function block is triggered via *>Close CB*, the function block checks the current circuit-breaker position. If the position is intermediate or is already reached, the signal *CB position wrong* is issued, which lasts for 20 ms, and no switching is carried out.

When the function block is triggered, the *Start* signal is issued, which indicates that the point-on-wave switching is in progress. With the *Start* signal, fault logging and recording are initiated.

When the *Start* signal is issued, the timer **Maximum allowed time** is started by which the point-on-wave switching duration is limited, in case that switching is not carried out for any reason. The timer specifies the maximum duration in which the **Point-on-wave switching** function is in progress. If all measured values for switching-accuracy supervision (such as the make times and closing times for phases) are successfully detected before the timer expires, the *Start* signal drops out (the function block is reset) and the timer is reset. Otherwise, after the timer expires, the *Start* signal drops out and the signal *Max. time exceeded* is issued for 20 ms.

5.1.2 Calculation of the Closing Time Stamps and Circuit-Breaker Closing Process



[lo_Time stamp_calcu close, 2, en_US]

Figure 5-3 Logic Diagram of the Closing Time-Stamp Calculation

Based on the following data, the **CB closing** function block calculates the time stamps for the activation of the binary outputs for the different phases:

- Zero-crossing time stamp and switching angles (from FB **General**)
- Compensated circuit-breaker closing time and make time
  The compensated make time is the time between the activation of the binary outputs (command to CB pole) and the start of the current flow.

The compensated circuit-breaker closing and make time is calculated using the switching-time compensation (refer to chapter *5.1.3 Compensation*) and the **CB data** parameters.

For example, the compensated closing time and make time of phase A is calculated via the following formulas:

$$t_{Close,\ phsA} = t_{Close\ setting,\ phsA} - t_{Corr,\ phsA} + t_{Comp\ (temp)} + t_{Comp\ (volt)} + t_{Comp\ (pressure,\ phsA)}$$

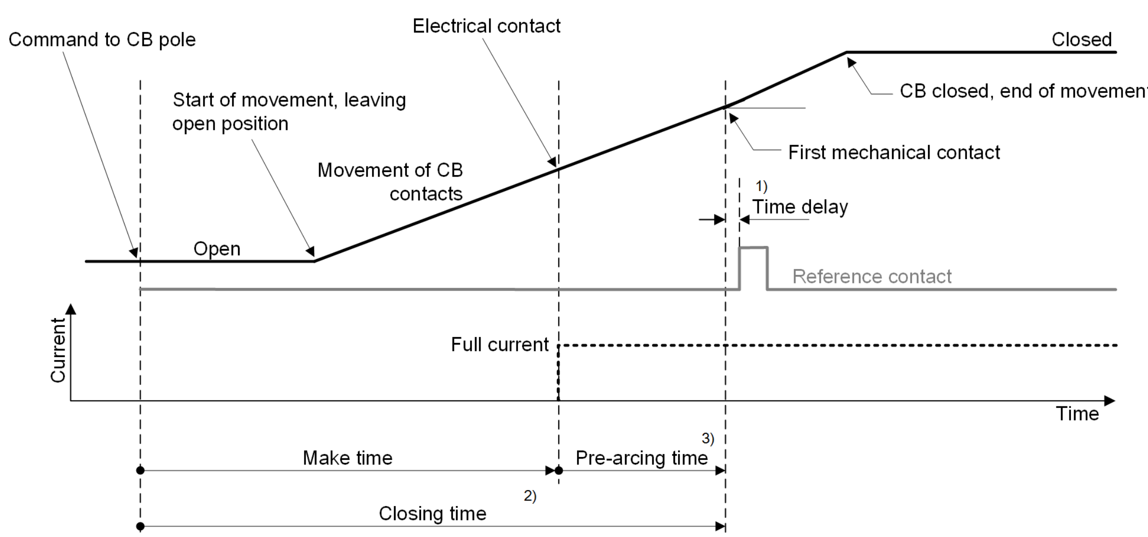
$$t_{Make,\ phsA} = t_{Close,\ phsA} - t_{Pre\text{-}arc,\ phsA}$$

[fo_Full compensation per phase_close, 2, en_US]

With:

- $t_{Close\ setting,\ phsA}$ is specified by the **CB closing time phsA** parameter.
- $t_{Corr,\ phsA}$ is specified by the **CB correction time phsA** parameter. The automatically calculated optimal closing time can be delayed by the correction time (in ms). This actual closing time can be both before and after the calculated closing time. A positive value generates a later actual time and a negative value generates an earlier actual time.
- $t_{Comp\ (temp)}$, $t_{Comp\ (volt)}$, and $t_{Comp\ (pressure,\ phsA)}$ are the compensated times according to the temperature, control-voltage, and hydraulic-pressure compensation. For further information, refer to chapter *5.1.3 Compensation*.
- $t_{Pre\text{-}arc,\ phsA}$ is specified by the **CB pre-arcing time phsA** parameter.

The compensated closing time starts with the command to the circuit-breaker pole. After the electrical contact, the pre-arcing time starts and ends with the mechanical contact. The electric contact must be completed at the desired switching angle.



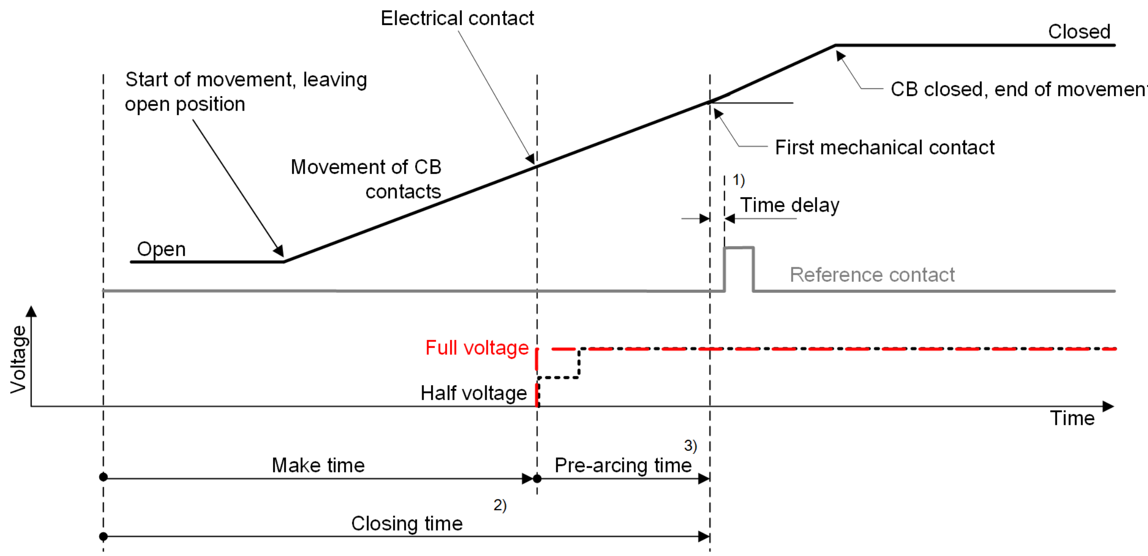
[dw_CB closing_except transformer, 2, en_US]

Figure 5-4 Circuit-Breaker Closing Process for Application Types Except the Transformer

(1) With the parameter **Time delay ref. cont. phs*x***, you can adapt the signal of the reference contact to the mechanical contact in an optimal way.

(2) Closing time is calculated based on the parameters **CB closing time phs*x*** and on the parameters **CB correction time phs*x***. You can find the calculation formula in the preceding description.

(3) Pre-arcing time is specified by the parameters **CB pre-arcing time phs*x***.



[dw_CB closing_voltage, 2, en_US]

Figure 5-5 Circuit-Breaker Closing Process for the Application Type of the Transformer

The descriptions of legends 1, 2, and 3 in this figure are the same as those in the preceding figure.

5.1.3 Compensation

5.1.3.1 Compensation of the Ambient-Temperature Influence

By measuring the ambient temperature, the **Point-on-wave switching** function can compensate the influence of the ambient temperature on the circuit-breaker switching time.

With the **`Temperature compensat.`** parameter, you can select one of the following compensation capabilities:

- No compensation
- Linear compensation
- Compensation by user-defined characteristic curve (vector)

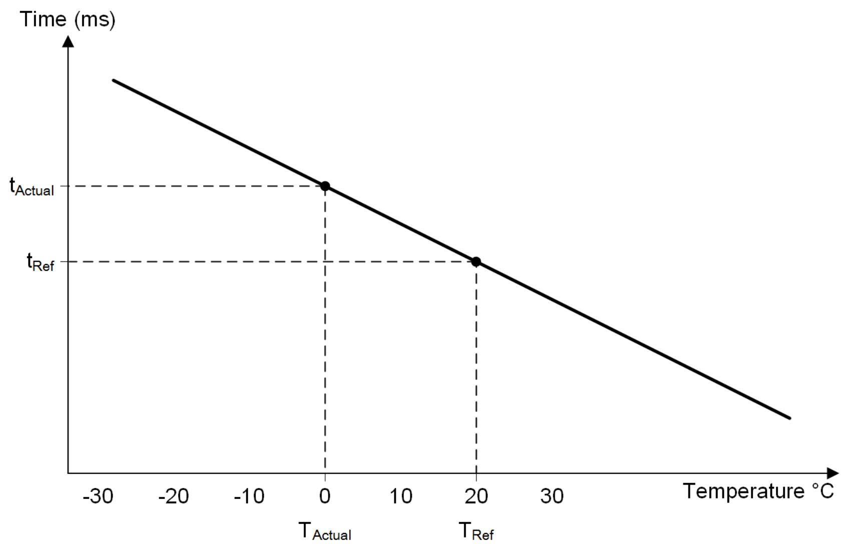
Linear Compensation

In the linear compensation, the compensation time $t_{Comp(temp)}$ is calculated as follows:

$$t_{Comp(temp)} = t_{Actual} - t_{Ref} = (T_{Actual} - T_{Ref}) \cdot K_{Comp(temp)}$$

Where:

- t_{Actual} is the closing time at the currently measured temperature (actual value).
- t_{Ref} is the closing time at the reference temperature.
- T_{Actual} is the currently measured temperature (actual value).
- T_{Ref} is the reference temperature specified by the **`Reference temperature`** parameter.
- $K_{Comp(temp)}$ is the factor specified by the **`Temperature comp. factor`** parameter.



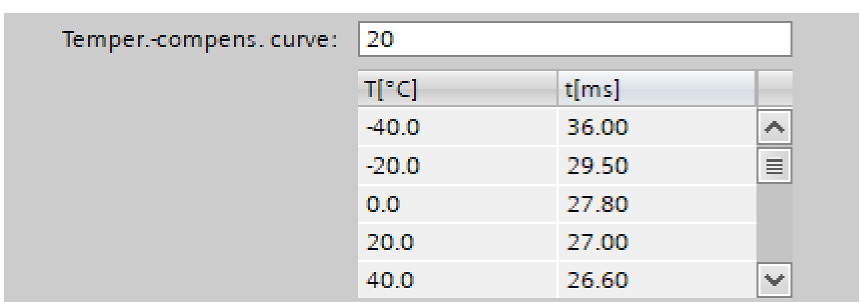
[dw_Opening time acc. temp, 2, en_US]

Figure 5-6 Compensation Characteristic Curve

The slope of the line in the figure is specified by the **`Temperature comp. factor`** parameter, which is usually a negative value.

Compensation by User-Defined Characteristic Curve

With the user-defined characteristic curve of the temperature, you can define the characteristic curve point by point using up to 30 value pairs of temperature and time. With the parameter **`Temper.-compens. curve`**, you can define the number of value pairs. The device uses linear interpolation to calculate the characteristic curve from these values.



[sc_Curve setting, 2, en_US]

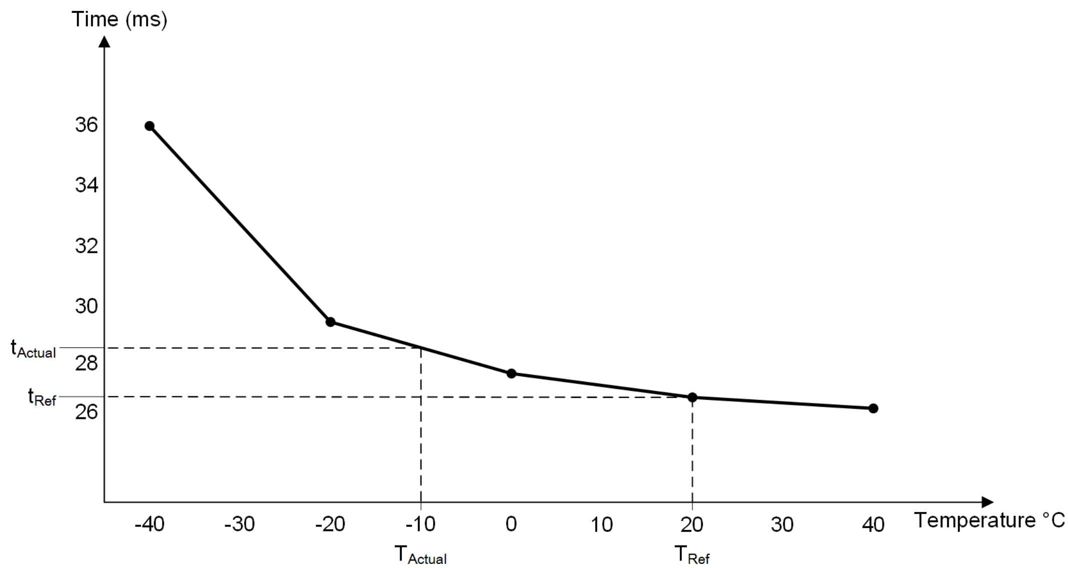
Figure 5-7 Setting Example of the Parameter **`Temper.-compens. curve`**

In this compensation, the compensation time $t_{Comp(temp)}$ is calculated as follows:

$t_{Comp(temp)} = t_{Actual} - t_{Ref}$

Where:

- t_{Ref} is the closing time at the reference temperature (T_{Ref}) specified by the **`Reference temperature`** parameter.
- t_{Actual} is the closing time at the currently measured temperature (T_{Actual}). The time can be obtained from the temperature-compensation curve specified by **`Temper.-compens. curve`**, as shown in *Figure 5-7*.



[dw_Operate time by temp, 2, en_US]

Figure 5-8 Compensation Characteristic Curve

5.1.3.2 Compensation of the Control-Voltage Magnitude Influence

By measuring the control voltage, the **Point-on-wave switching** function can compensate the influence of the control voltage on the circuit-breaker switching time.

With the **`Clos.circuit volt.compens.`** parameter, you can select one from the following compensation capabilities:

- No compensation
- Linear compensation
- Compensation by user-defined characteristic curve (vector)

Linear Compensation

In the linear compensation, the compensation time $t_{Comp(volt)}$ is calculated as follows:

$t_{Comp(volt)} = (V_{Actual} - V_{Ref}) \cdot K_{Comp(volt)}$

Where:

- V_{Actual} is the currently measured voltage (actual value).
- V_{Ref} is the reference voltage specified by the **`Ref. volt. closing circuit`** parameter.
- $K_{Comp(volt)}$ is the factor specified by the **`Voltage comp. factor`** parameter.

Compensation by User-Defined Characteristic Curve

The compensation method is the same as that of the temperature except the following factors:

- The characteristic curve uses pairs of voltage and time.
- t_{Ref} is the closing time corresponding to the reference voltage specified by the parameter **`Ref. volt. closing circuit`**.

For more information on this compensation function, refer to section *Compensation by User-Defined Characteristic Curve, Page 85*.

5.1.3.3 Compensation of the Hydraulic-Pressure Influence

By measuring the phase-selective hydraulic pressure, the **Point-on-wave switching** function can compensate the influence of the hydraulic pressure on the circuit-breaker switching time per phase.

With the **`Hydr. pressure compens.`** parameter, you can select whether to perform linear compensation according to the hydraulic pressure.

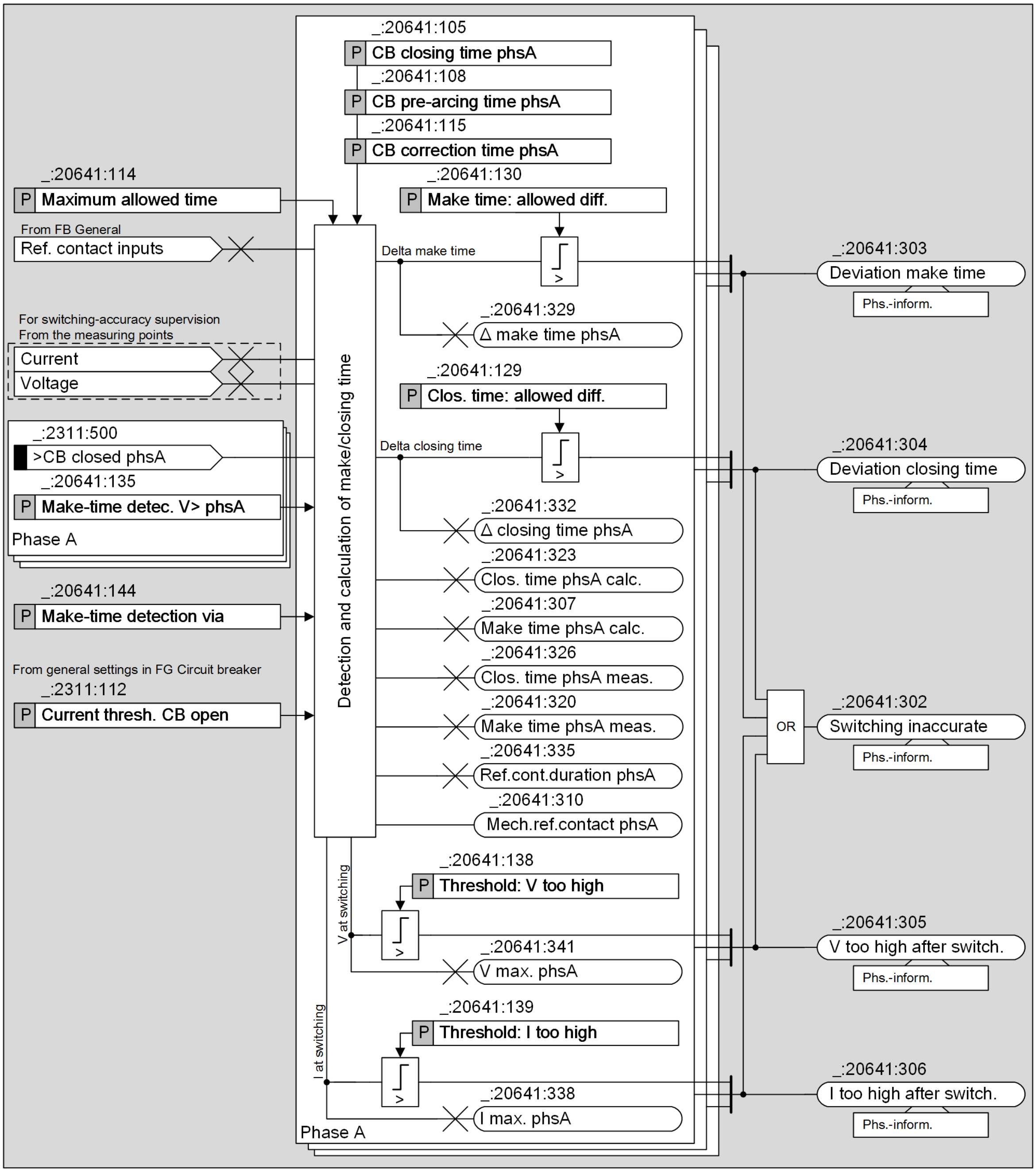
In the linear compensation, the phase-selective compensation time related to the hydraulic pressure is calculated. For example, the formula for calculating the compensation time of phase A $t_{Comp(pressure,\ phsA)}$ is calculated as follows:

$t_{Comp(pressure,\ phsA)} = (P_{Actual} - P_{Ref}) \cdot K_{Comp(pressure,\ phsA)}$

Where:

- P_{Actual} is the actually measured hydraulic pressure of phase A.
- P_{Ref} is the reference hydraulic pressure of phase A, which is specified by the **`Reference pressure phsA`** parameter.
- $K_{Comp(pressure,\ phsA)}$ is the factor of phase A, which is specified by the **`Press. comp. factor phsA`** parameter.

5.1.4 Switching-Accuracy Supervision



[lo_PoW_Accuracy supervision_close, 2, en_US]

Figure 5-9 Logic Diagram of the Switching-Accuracy Supervision

Measured Closing and Make Time

- The actual closing time is measured either via the fast measuring-transducer input (Hall-effect sensor measuring-transducer, only available for Siemens circuit breakers) or via the binary inputs *>CB closed phsx* connected to the 52a auxiliary contacts.
- For reactance coils, capacitor banks, and transmission lines, the actual make time is calculated based on the phase-current measurement.

- For transformers, the actual make time is calculated based on the phase-voltage measurement because the current is too small.

  If the first phase is closed for an isolated transformer, approximately half of the negated voltage is applied to the other phases. Therefore, different thresholds for determining make times are provided via the parameters **Make-time detec. V> phsA**, **Make-time detec. V> phsB**, and **Make-time detec. V> phsC**. The time when the phase-selective voltage exceeds the threshold is determined as the make time.

Whether the phase-current measurement or the phase-voltage measurement is used is determined via the **Make-time detection via** parameter.

The signals *Mech.ref.contact phsA*, *Mech.ref.contact phsB*, and *Mech.ref.contact phsC* indicate the mechanical contact moments of circuit-breaker poles.

Only in the case that the reference contact information is obtained via fast measuring-transducer inputs (at Siemens circuit breakers), the signals *Ref.cont.duration phsA*, *Ref.cont.duration phsB*, and *Ref.cont.duration phsC* indicate the measured duration (pulse) time of the reference contacts, from the rising edge to the falling edge.

Calculated Time Differences

The **Switching-accuracy supervision** function determines the following time differences:

- The difference between the calculated and the measured closing time, per phase
- The difference between the calculated and the measured make time, per phase

Calculated, measured, and delta times are also available as functional values.

If the time difference of the break or closing time exceeds the threshold **Make time: allowed diff.** or **Clos. time: allowed diff.** , the signal *Deviation make time* or *Deviation closing time* is issued.

If one of the differences exceeds the threshold, the circuit-breaker switching is considered as inaccurate and the signal *Switching inaccurate* is issued.

Determination of Maximum Voltage or Current after Circuit-Breaker Closing

Transient phenomena of an inaccurate closing result in higher maximum values of voltage or current. The maximum value in the first period after the closing of the circuit breaker indicates the quality of the closing process.

If the detected maximum voltage exceeds the **Threshold: V too high** or the detected maximum current exceeds the **Threshold: I too high**, the circuit-breaker switching is considered as inaccurate and the signal *Switching inaccurate* is issued.

5.2 Application and Setting Notes

Start of the Switching Operation

If the bay controller and the **Point-on-wave switching** function are in the same device, the switching operation can be started via the close command from the FB **Control**.

If the bay controller and the **Point-on-wave switching** function are in different devices, the switching operation can be started via the binary input signal *>Close CB*. *>Close CB* can be initiated via a physical binary input or via IEC 61850 GOOSE.

Parameter: **3-pole switching allowed**

- Default setting **(_:20641:102) 3-pole switching allowed** = ***no***

When a point-on-wave switching command is given and the function is unable to operate (for example, blocked by supervision) and if no switching operation shall be executed at all, set this parameter to ***no***.

If under this condition 3-pole switching (all poles switched at the same time) shall be carried out, set this parameter to ***yes***.

Parameter: ***CB data***

- Default setting **(_:20641:105) CB closing time phsA** = ***0.0 ms***
- Default setting **(_:20641:106) CB closing time phsB** = ***0.0 ms***
- Default setting **(_:20641:107) CB closing time phsC** = ***0.0 ms***
- Default setting **(_:20641:108) CB pre-arcing time phsA** = ***0.0 ms***
- Default setting **(_:20641:109) CB pre-arcing time phsB** = ***0.0 ms***
- Default setting **(_:20641:110) CB pre-arcing time phsC** = ***0.0 ms***
- Default setting **(_:20641:115) CB correction time phsA** = ***0.00 ms***
- Default setting **(_:20641:116) CB correction time phsB** = ***0.00 ms***
- Default setting **(_:20641:117) CB correction time phsC** = ***0.00 ms***

You must set the CB closing time and CB pre-arcing time parameters according to the technical data of the circuit breaker. This data must be obtained from the circuit-breaker manufacturer.

During commissioning, little deviations to the technical data might be detected. Such deviations can be adjusted via the CB correction time parameters.

NOTE

If the real closing time (measured value during commissioning) is greater than the CB closing time parameter, the CB correction time parameter should be a negative value. Otherwise, it should be a positive value.

Parameter: ***Compensation data***

- Default setting **(_:20641:131) Clos.circuit volt.compens.** = ***no***
- Default setting **(_:20641:113) Temperature compensat.** = ***no***
- Default setting **(_:20641:132) Hydr. pressure compens.** = ***no***
- Default setting **(_:20641:122) Voltage comp. factor** = ***0.000 ms/V***
- Default setting **(_:20641:111) Temperature comp. factor** = ***0.000 ms/K***
- Default setting **(_:20641:124) Press. comp. factor phsA** = ***0.000 ms/kPa***
- Default setting **(_:20641:126) Press. comp. factor phsB** = ***0.000 ms/kPa***
- Default setting **(_:20641:128) Press. comp. factor phsC** = ***0.000 ms/kPa***

- Default setting **(_:20641:121) Ref. volt. closing circuit** = ***125.0 V***
- Default setting **(_:20641:112) Reference temperature** = ***20 °C***
- Default setting **(_:20641:123) Reference pressure phsA** = ***500 kPa***
- Default setting **(_:20641:125) Reference pressure phsB** = ***500 kPa***
- Default setting **(_:20641:127) Reference pressure phsC** = ***500 kPa***

All switching-time compensation functionality is optional. Compensation can only be applied if the influences on the circuit-breaker switching times are known. This data needs to be obtained from the circuit-breaker manufacturer. If the respective data is not available, compensation is not possible.

If you want to compensate the circuit-breaker switching times according to the CB-switching control voltage or temperature, you must set the **Clos.circuit volt.compens.** or **Temperature compensat.** parameter to ***Linear*** or ***user-defined***. The selection between ***Linear*** or ***user-defined*** depends on the characteristic of the compensation data.

If you want to compensate the circuit-breaker switching times according to the phase-selective hydraulic pressure, only the ***Linear*** option is available in the **Hydr. pressure compens.** parameter.

Usually, a lower control voltage, temperature, or hydraulic pressure lead to a longer mechanical operating time. Therefore, the **Voltage comp. factor**, **Temperature comp. factor**, and **Press. com. factor phsX** parameters should be set to negative values to compensate the influences.

For more information on how to set the compensation, refer to chapter *5.1.3 Compensation*.

Closing-Time Detection, Reference Contact

The closing times are detected and measured via the reference contacts. The measured closing times are part of the switching-accuracy supervision (refer to chapter *5.1.4 Switching-Accuracy Supervision*). The type of reference contact depends on the circuit-breaker manufacturer:

- Siemens circuit breaker: a Siemens circuit breaker offers a measuring transducer for a CB-integrated Hall-effect sensor.

  In this case, 3 fast measuring-transducer inputs are required. To configure the measuring-transducer reference contacts, follow chapter *3.1.5 Measuring-Transducer Configuration for Process and Environmental Data Acquisition*.

- Non-Siemens circuit breakers: The CB-closed auxiliary contacts must be used as reference contacts.

  In this case, the binary inputs *>CB closed phsA*, *>CB closed phsB*, and *>CB closed phsC* must be routed to the physical binary inputs which are wired with the 52a circuit-breaker contacts.

Parameter: *Reference contact*

- Default setting **(_:20641:118) Time delay ref. cont. phsA** = ***0.0 ms***
- Default setting **(_:20641:119) Time delay ref. cont. phsB** = ***0.0 ms***
- Default setting **(_:20641:120) Time delay ref. cont. phsC** = ***0.0 ms***

The setting is the time interval from the closing time of circuit-breaker contact to the rising edge of the reference contact input.

Via these settings, the time differences between the reference contacts and the main circuit-breaker contacts are adjusted.

The time differences are determined and stated either:

- During circuit-breaker routine testing by the circuit-breaker manufacturer

  In this case, the times must be part of the circuit-breaker routine test protocol.

- During circuit-breaker commissioning on site, by carrying out switching-time measurements via respective measuring devices

If the signal is later than the closing of the main circuit-breaker contact, the time delay parameter must be set to a negative value.

Parameter: **Maximum allowed time**

- Default setting **(_:20641:114) Maximum allowed time** = ***0.30 s***

Normally, point-on-wave switching operations should be finished within 100 ms.

Siemens recommends using the default setting of the **Maximum allowed time** parameter.

Parameter: **Clos. time: allowed diff. ,Make time: allowed diff.**

- Default setting **(_:20641:129) Clos. time: allowed diff.** = ***3.0 ms***
- Default setting **(_:20641:130) Make time: allowed diff.** = ***3.0 ms***

The **Clos. time: allowed diff.** and **Make time: allowed diff.** parameters represent the difference you accept between the calculated and the actual time. The default settings are the typical values.

Parameter: **Make-time detection via**

The setting of this parameter is related to the setting of the **Application** parameter:

- If the **Application** parameter is set to ***Transformer***, the **Make-time detection via** parameter is read only and is set to ***voltage*** by default.
- If the **Application** parameter is set to ***User-defined***, you can set the **Make-time detection via** parameter to ***voltage*** or ***current***.
- If the **Application** parameter is set to ***Capacitive load***, ***Transmission line***, or ***Reactance coil***, the **Make-time detection via** parameter is read only and is set to ***current*** by default.

Parameter: **Make-time detec. V> phsx**

- Default setting **(_:20641:135) Make-time detec. V> phsA** = ***40.000 V***
- Default setting **(_:20641:136) Make-time detec. V> phsB** = ***40.000 V***
- Default setting **(_:20641:137) Make-time detec. V> phsC** = ***40.000 V***

These parameters are visible only if the **Make-time detection via** parameter is set to ***voltage***.

When a transformer is energized, the make time cannot be detected via a jump in the current, but via a jump in the phase voltage. If the set value is exceeded, the make time is determined.

If the first phase is energized, an inverted voltage of half magnitude of the first phase is applied to the other phases. The magnitude is usually the rated phase voltage. For example, assuming a 100-V rated secondary voltage, the recommended setting is 100 V / $\sqrt{3} \cdot \sqrt{2} \cdot 55$ % (Factor) = 45 V. This factor can be about 55 % to 60 %. If the make time is not detected, these values can be obtained from analysis of a fault record per phase.

Parameter: **Threshold: V too high**

- Default setting **(_:20641:138) Threshold: V too high** = ***120.000 V***

This parameter is visible only if the **Make-time detection via** parameter is set to ***voltage***.

For the application of transformer energization, an inaccurate closing operation causes an overvoltage. This situation can be detected by monitoring the phase voltages. If phase-voltage sample values exceed the **Threshold: V too high** setting, the closing operation is considered as inaccurate.

The **Threshold: V too high** parameter is defined with relation to a phase-to-ground sample value. For example, assuming a 100-V rated secondary voltage, the equivalent value is 100 V / $\sqrt{3} \cdot \sqrt{2}$ = 81.6 V. In this case, the setting value must be greater than 81.6 V as overvoltages can also appear in case of accurate switching operations.

Siemens recommends setting this parameter according to the evaluation of the first switching operations. Till then, the default setting can be applied.

Parameter: **Threshold: I too high**

- Default setting **(_:20641:139) Threshold: I too high** = ***2.000 A***

This parameter is visible only if the **Make-time detection via** parameter is set to ***current***.

For the applications of capacitor-bank, reactance-coil, or transmission-line energization, inaccurate closing operations cause overcurrents. This situation can be detected by monitoring the phase currents. If phase current sample values exceed the **Threshold: I too high** setting, the closing operation is considered as inaccurate.

Siemens recommends setting this parameter according to the evaluation of the first switching operations. Till then, the default setting can be applied.

Parameter: Current Threshold Circuit Breaker Open

- Default setting **(_:2311:112) Current thresh. CB open** = ***0.10 A***

The **Current thresh. CB open** parameter is available in the general settings of the FG **Circuit breaker**.

With the **Current thresh. CB open** parameter, you specify the current threshold below which the circuit-breaker pole or the circuit breaker is recognized as open.

Set the **Current thresh. CB open** parameter so that the current measured when the circuit-breaker pole is open will certainly fall below the parameterized value. If parasitic currents (for example, due to induction) are excluded with the line deactivated, you can make a secondary setting of the value with a high degree of sensitivity, to ***0.05 A*** for example.

If no special requirements exist, Siemens recommends using the setting value of ***0.10 A***.

Signal: Ref.cont.duration phsA, Ref.cont.duration phsB, Ref.cont.duration phsC

These signals are available only when the parameters **MT for ref. contact phsA**, **MT for ref. contact phsB**, and **MT for ref. contact phsC** are configured for Siemens-CB reference contacts.

The duration times specified by these signals are determined after circuit-breaker manufacturing in the factory and are noted. During commissioning, these duration times are determined again (via the device measurement) and compared to the former values. Therefore, defects in the reference-contact adaption can be found.

5.3 Settings

Addr.	Parameter	C	Setting Options	Default Setting
General				
_:20641:1	Closing:Mode		• off • on • test	off
_:20641:102	Closing:3-pole switching allowed		• no • yes	no
CB data				
_:20641:105	Closing:CB closing time phsA		0.0 ms to 200.0 ms	0.0 ms
_:20641:106	Closing:CB closing time phsB		0.0 ms to 200.0 ms	0.0 ms
_:20641:107	Closing:CB closing time phsC		0.0 ms to 200.0 ms	0.0 ms
_:20641:108	Closing:CB pre-arcing time phsA		0.0 ms to 20.0 ms	0.0 ms
_:20641:109	Closing:CB pre-arcing time phsB		0.0 ms to 20.0 ms	0.0 ms
_:20641:110	Closing:CB pre-arcing time phsC		0.0 ms to 20.0 ms	0.0 ms
_:20641:115	Closing:CB correction time phsA		-20.00 ms to 20.00 ms	0.00 ms
_:20641:116	Closing:CB correction time phsB		-20.00 ms to 20.00 ms	0.00 ms
_:20641:117	Closing:CB correction time phsC		-20.00 ms to 20.00 ms	0.00 ms
Compensation data				
_:20641:131	Closing:Clos.circuit volt.compens.		• no • Linear • user-defined	no
_:20641:121	Closing:Ref. volt. closing circuit		20.0 V to 300.0 V	125.0 V
_:20641:122	Closing:Voltage comp. factor		-1.000 ms/V to 1.000 ms/V	0.000 ms/V
_:20641:134	Closing:Voltage-compens. curve		Setting options depend on configuration	
_:20641:113	Closing:Temperature compensat.		• no • Linear • user-defined	no
_:20641:112	Closing:Reference temperature		-60 °C to 100 °C	20 °C
_:20641:111	Closing:Temperature comp. factor		-1.000 ms/K to 1.000 ms/K	0.000 ms/K
_:20641:133	Closing:Temper.-compens. curve		Setting options depend on configuration	
_:20641:132	Closing:Hydr. pressure compens.		• no • Linear	no

Addr.	Parameter	C	Setting Options	Default Setting
_:20641:123	Closing:Reference pressure phsA		100 kPa to 1000 kPa	500 kPa
_:20641:124	Closing:Press. comp. factor phsA		-1.000 ms/kPa to 1.000 ms/kPa	0.000 ms/kPa
_:20641:125	Closing:Reference pressure phsB		100 kPa to 1000 kPa	500 kPa
_:20641:126	Closing:Press. comp. factor phsB		-1.000 ms/kPa to 1.000 ms/kPa	0.000 ms/kPa
_:20641:127	Closing:Reference pressure phsC		100 kPa to 1000 kPa	500 kPa
_:20641:128	Closing:Press. comp. factor phsC		-1.000 ms/kPa to 1.000 ms/kPa	0.000 ms/kPa
Reference contact				
_:20641:118	Closing:Time delay ref. cont. phsA		-50.0 ms to 50.0 ms	0.0 ms
_:20641:119	Closing:Time delay ref. cont. phsB		-50.0 ms to 50.0 ms	0.0 ms
_:20641:120	Closing:Time delay ref. cont. phsC		-50.0 ms to 50.0 ms	0.0 ms
Swit.accuracy sup.				
_:20641:114	Closing:Maximum allowed time		0.00 s to 60.00 s	0.30 s
_:20641:129	Closing:Clos. time: allowed diff.		0.0 ms to 20.0 ms; ∞	3.0 ms
_:20641:130	Closing:Make time: allowed diff.		0.0 ms to 20.0 ms; ∞	3.0 ms
_:20641:144	Closing:Make-time detection via		• current • voltage	current
_:20641:135	Closing:Make-time detec. V> phsA		0.300 V to 340.000 V	40.000 V
_:20641:136	Closing:Make-time detec. V> phsB		0.300 V to 340.000 V	40.000 V
_:20641:137	Closing:Make-time detec. V> phsC		0.300 V to 340.000 V	40.000 V
_:20641:138	Closing:Threshold: V too high		0.300 V to 340.000 V	120.000 V
_:20641:139	Closing:Threshold: I too high	1 A @ 100 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 100 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 50 Irated	0.030 A to 35.000 A	2.000 A
		5 A @ 50 Irated	0.15 A to 175.00 A	10.00 A
		1 A @ 1.6 Irated	0.001 A to 1.600 A	2.000 A
		5 A @ 1.6 Irated	0.005 A to 8.000 A	10.000 A

5.4 Information List

No.	Information	Data Class (Type)	Type
Closing			
_:20641:82	Closing:>Block function	SPS	I
_:20641:501	Closing:>Close CB	SPS	I
_:20641:54	Closing:Inactive	SPS	O
_:20641:52	Closing:Behavior	ENS	O
_:20641:53	Closing:Health	ENS	O
_:20641:55	Closing:Start	SPS	O
_:20641:317	Closing:CB position wrong	SPS	O
_:20641:310	Closing:Mech.ref.contact phsA	SPS	O
_:20641:311	Closing:Mech.ref.contact phsB	SPS	O
_:20641:312	Closing:Mech.ref.contact phsC	SPS	O
_:20641:301	Closing:Max. time exceeded	SPS	O
_:20641:302	Closing:Switching inaccurate	ACT	O
_:20641:303	Closing:Deviation make time	ACT	O
_:20641:304	Closing:Deviation closing time	ACT	O
_:20641:305	Closing:V too high after switch.	ACT	O
_:20641:306	Closing:I too high after switch.	ACT	O
_:20641:307	Closing:Make time phsA calc.	MV	O
_:20641:308	Closing:Make time phsB calc.	MV	O
_:20641:309	Closing:Make time phsC calc.	MV	O
_:20641:320	Closing:Make time phsA meas.	MV	O
_:20641:321	Closing:Make time phsB meas.	MV	O
_:20641:322	Closing:Make time phsC meas.	MV	O
_:20641:323	Closing:Clos. time phsA calc.	MV	O
_:20641:324	Closing:Clos. time phsB calc.	MV	O
_:20641:325	Closing:Clos. time phsC calc.	MV	O
_:20641:326	Closing:Clos. time phsA meas.	MV	O
_:20641:327	Closing:Clos. time phsB meas.	MV	O
_:20641:328	Closing:Clos. time phsC meas.	MV	O
_:20641:329	Closing:Δ make time phsA	MV	O
_:20641:330	Closing:Δ make time phsB	MV	O
_:20641:331	Closing:Δ make time phsC	MV	O
_:20641:332	Closing:Δ closing time phsA	MV	O
_:20641:333	Closing:Δ closing time phsB	MV	O
_:20641:334	Closing:Δ closing time phsC	MV	O
_:20641:335	Closing:Ref.cont.duration phsA	MV	O
_:20641:336	Closing:Ref.cont.duration phsB	MV	O
_:20641:337	Closing:Ref.cont.duration phsC	MV	O
_:20641:338	Closing:I max. phsA	MV	O
_:20641:339	Closing:I max. phsB	MV	O
_:20641:340	Closing:I max. phsC	MV	O
_:20641:341	Closing:V max. phsA	MV	O
_:20641:342	Closing:V max. phsB	MV	O
_:20641:343	Closing:V max. phsC	MV	O

6 Operation Sequence of the Function

6.1 Description

For the **CB opening** and **CB closing** function blocks of the **Point-on-wave switching** function, the general operation sequence is similar. The following describes the sequence of the **CB opening** function block as an example:

- The **CB closing** function block is triggered via an open command or the binary input signal *>Open CB*. Then the *Start* signal is issued to indicate that the **CB closing** function block is in progress. At the same time, the fault recording and a timer **Maximum allowed time** start.
- The **CB closing** function block determines the zero crossing and calculates the desired time stamps for circuit-breaker opening of each pole according to the switching angles.
- The **CB closing** function block transfers the calculated time stamps to the FB **Circuit breaker**. When the desired time stamp is reached, the high-speed relay for circuit-breaker opening of each pole is activated.
- After the high-speed relay is activated, the **CB closing** function block starts to supervise the switching accuracy. The electrical separation time (via current) and mechanical separation time (via the reference contact or auxiliary contact) are determined before the timer **Maximum allowed time** expires.
- If the electrical separation time and mechanical separation time are detected successfully before the timer **Maximum allowed time** expires, the function block decides whether the switching was accurate or not. An inaccurate switching is indicated. All the measured values related to the switching accuracy are written to the fault log.
- If the switching is completed successfully, the *Start* signal drops out. Otherwise, if the timer **Maximum allowed time** expires, the signal *Max. time exceeded* is issued and the switching procedure ends without switching-accuracy information.

7 Recording and Logging

Recording

For the recording of relevant signals, the standard **Fault recorder** function is used. For more information on the **Fault recording** function, refer to the chapter **Fault Recording** of the SIPROTEC 5 device manuals.

The last 128 switching operations can be recorded at the sampling frequency of 4 kHz and if the maximum recoding length is not longer than 250 ms. For lower sampling frequencies, higher numbers or switching operations can also be recorded.

The recording is started and stopped as follows:

- Starting the recording

  The recording is triggered when the **CB opening** or **CB closing** function block issues the *`Start`* signal. Because of the pre-trigger time, the recording also contains the cause of the **Point-on-wave switching** function start (if routed).

- Stopping the recording

  The recording is stopped if one of the following conditions is met:

  – The determination of all relevant times (such as the opening and break times or the closing and make times) is finished.

  – The timer **`Maximum allowed time`** expires.

  – The maximum duration of a recording is reached.

    The maximum duration is specified by a settable parameter **`Maximum record time`**. For more information on this parameter, refer to the chapter **Fault Recording** of the SIPROTEC 5 device manuals. Siemens recommends setting this parameter to 250 ms.

Indication Logging

Indication logs of the **Point-on-wave switching** function are saved in the fault logs of the device.

If the **CB closing** or **CB opening** function block is triggered, a point-on-wave switching log is generated. Each point-on-wave switching log is related to a recording.

The following data is prerouted in the point-on-wave switching log:

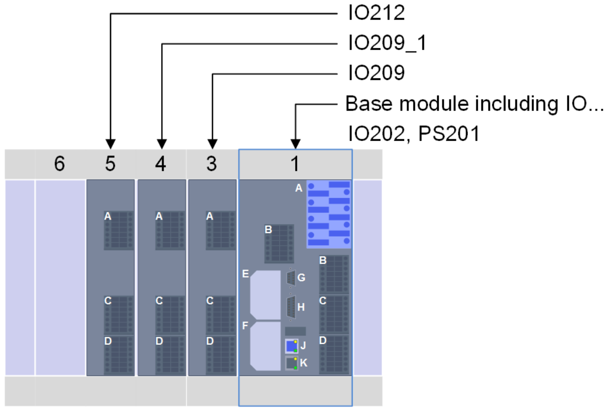
- Selected input and output signals in the general functionality, in the **CB opening** function block, and in the **CB closing** function block
- All measured values that are defined in the general functionality, in the **CB opening** function block, and in the **CB closing** function block
- All the measured times and calculated times which are written into the log at the dropout of the *`Start`* signal

8 Device and External Equipment Requirements

8.1 Required Device Hardware

An overview about the required physical components is provided in chapter *1.5 Application Environment and Equipment*. The following describes the details about the required secondary equipment components.

The following figure provides an example of the device view in DIGSI 5 for using the **Point-on-wave switching** function.



[dw_Stand variant_6M PoW, 2, en_US]

Figure 8-1 Example of the Device View in DIGSI 5

To use the **Point-on-wave switching** function, the following hardware requirements must be met:

- **1/3 base module, mandatory**
  4 voltage terminals and 4 current terminals are generally available in the 1/3 base module of the device. These analog inputs serve for the measurement of the reference voltage and for the supervision of the switching accuracy.
  The 1/3 base module also contains the following elements:
  - Binary inputs and outputs
  - 2 plug-in module slots for protocol communication and 4 normal measuring-transducer inputs (module type ANAI)
  - HMI
  - Power supply
- **IO209 extension module, mandatory**
  1 or 2 IO209 modules are required. Each IO209 module provides 4 high-speed relays.
  - If either controlled opening or controlled closing of the circuit breaker is required, 1 IO209 module is sufficient.
  - If both controlled opening and controlled closing of the circuit breaker are required, 2 IO209 modules are required.
- **IO212 extension module, mandatory in case of Siemens circuit breakers for reference contacts**
  In case of Siemens circuit breakers, the mechanical make/break time is detected via Hall-effect sensors with high precision. The Hall-effect sensors are connected to the device via fast measuring-transducer inputs, which are available on the module IO212. In case of Siemens circuit breakers, IO212 is mandatory.
  IO212 offers 8 fast measuring-transducer inputs, 3 of which are used for the reference contacts.
  In case of non-Siemens circuit breakers, this function is carried out via the 52a auxiliary contacts of the circuit breaker which are connected to normal device binary inputs, for example, available in the 1/3 base module. No IO212 is required for this function.

- **IO212 extension module or ANAI plug-in module, optional**

  To acquire process and environmental data for switching-time compensation, normal or fast measuring-transducer inputs can be applied. Such data is control voltages for opening and closing circuits, ambient temperature, and phase-selective hydraulic pressures. This data acquisition is only meaningful if the influences on the circuit-breaker switching are known.

  The number of required measuring-transducer inputs depends on the process and environmental data to be measured. The maximum scope is as follows:

  – 2 control-voltage inputs

  – 1 temperature input

  – 3 hydraulic-pressure inputs

  If already an IO212 is applied for Siemens circuit-breaker reference contact detection, 5 fast measuring-transducer inputs remain for process and environmental-data acquisition.

  If no IO212 is required for Siemens circuit-breaker reference contact detection, also an ANAI plug-in module can be applied for process and environmental-data acquisition. One ANAI plug-in module provides 4 normal measuring-transducer inputs.

8.2 Application Template and Related Device Hardware

The bay-controller device 6MD86 provides the application template **Point-on-wave switching**.

The device hardware described in the following supports the preroutings of this application template.

The following sections describe an example of a suitable device hardware. The actual scope depends of course on the individual application.

Application-Template Related Device Hardware

The following hardware supports the application template regarding its preroutings:

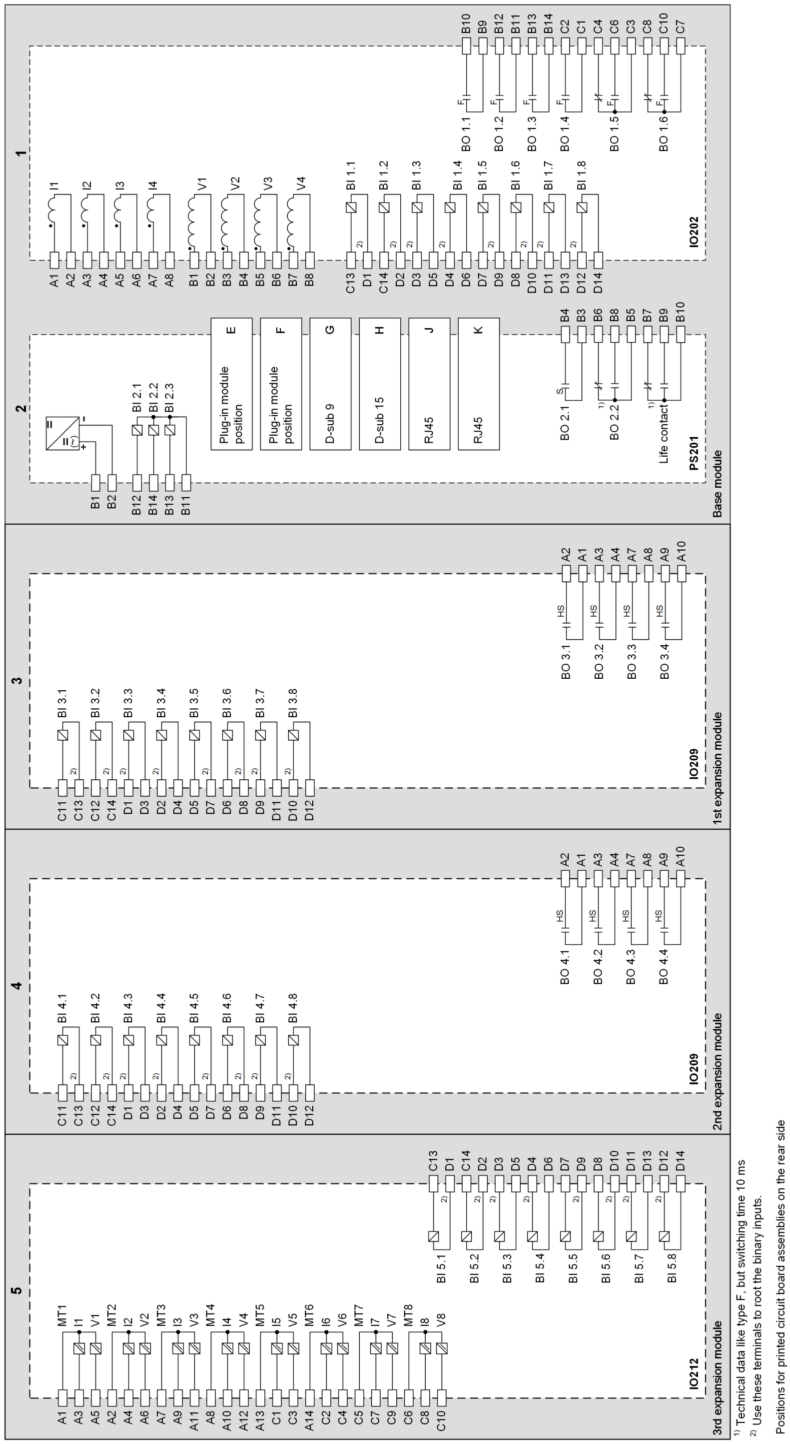
- 1 PS201: 3 binary inputs, 3 binary outputs (including the life contact)
- 1 IO202: 4 current inputs, 4 voltage inputs, 8 binary inputs, 6 binary outputs
- 1 IO212: 8 fast measuring-transducer inputs, 8 binary inputs
- 2 IO209: 16 binary inputs, 8 high-speed binary outputs (HS type)

Therefore, the overall hardware configuration is as follows:

- 35 binary inputs
- 9 standard binary outputs
- 8 high-speed binary outputs
- 4 current inputs and 4 voltage inputs
- 8 fast measuring-transducer inputs

For the device view of the hardware in DIGSI 5, refer to *Figure 8-1*.

The following figure provides the board order and terminals for this device hardware.



[dw_Standard variants PoW, 2, en_US]

Figure 8-2 Board Order and Terminal Overview for the Application-Template Related Device Hardware

Application Template

The bay-controller device 6MD86 provides the application template **Point-on-wave switching**.

The device hardware described in the preceding sections is appropriate for using this application template.

The following table shows the functional scope and the function-point requirements of the application template.

Function	Function Points
Point-on-wave switching (in 6MD86)	200
Circuit breaker	0
Control	0
Analog unit	0

The following tables show the prerouting of the application template. The described preroutings require the I/O modules to be mounted in the described order. If this is not the case, the preroutings must be adjusted accordingly.

Table 8-1 Prerouting Binary Inputs

Binary Input	Signal	Number	Signal Type	Configuration
BI1.1	Circuit breaker 1:Circuit break.:Position 1-pole phsA	301.4261.459	DPC	CH
BI1.2	Circuit breaker 1:Circuit break.:Position 1-pole phsA	301.4261.459	DPC	OH
BI1.3	Circuit breaker 1:Circuit break.:Position 1-pole phsB	301.4261.460	DPC	CH
BI1.4	Circuit breaker 1:Circuit break.:Position 1-pole phsB	301.4261.460	DPC	OH
BI1.5	Circuit breaker 1:Circuit break.:Position 1-pole phsC	301.4261.461	DPC	CH
BI1.6	Circuit breaker 1:Circuit break.:Position 1-pole phsC	301.4261.461	DPC	OH

Table 8-2 Prerouting Output Relays

Binary Output	Signal	Number	Signal Type	Configuration
BO3.1	Circuit breaker 1:Circuit break.:Open cmd. 1-pole phsA	301.4261.410	SPS	U
BO3.2	Circuit breaker 1:Circuit break.:Open cmd. 1-pole phsB	301.4261.411	SPS	U
BO3.3	Circuit breaker 1:Circuit break.:Open cmd. 1-pole phsC	301.4261.412	SPS	U
BO4.1	Circuit breaker 1:Circuit break.:Close cmd. 1-pole phsA	301.4261.413	SPS	U
BO4.2	Circuit breaker 1:Circuit break.:Close cmd. 1-pole phsB	301.4261.414	SPS	U
BO4.3	Circuit breaker 1:Circuit break.:Close cmd. 1-pole phsC	301.4261.415	SPS	U

Table 8-3 Prerouting of Fast Measuring Transducers

Addr.	Parameter	Measuring Transducer
301.2901.2311.106	General:MT for opening-circ. volt.	MT fast 1.MT in 1
301.2901.2311.107	General:MT for closing-circ. volt.	MT fast 1.MT in 2
301.2901.2311.104	General:MT for temperature	MT fast 1.MT in 3
301.2901.2311.117	General:MT for ref. contact phsA	MT fast 1.MT in 4
301.2901.2311.118	General:MT for ref. contact phsB	MT fast 1.MT in 5
301.2901.2311.119	General:MT for ref. contact phsC	MT fast 1.MT in 6

8.3 Required External Components

To implement the **Point-on-wave switching** function, the following external components are required:

- If the switching-time compensation for the switching-circuit control voltage is required, voltage measuring transducers for converting the 0-V to 300-V voltage to the 4-mA to 20-mA current are required. One measuring transducer is required per control-voltage circuit (opening or closing).

  The following 2 types of voltage measuring transducers have been qualified for this:

  - WAGO 857-560 voltage signal conditioner (item number: 857-560), whose current consumption is 46 mA
  - Phoenix Contact MACX MCR voltage transducers for DC voltages (order key: 2906242), whose current consumption is 60 mA

  For more information about the connections with these measuring transducers, refer to chapter *Figure A-10*.

- A 24-V power supply is required:

  - To power the voltage measuring transducers
  - To power the measuring transducers for reference contacts, temperature detection, and hydraulic-pressure detection

  Siemens has qualified the SIPROTEC 7XV5810 wide-range power supply for this application (product number: 7XV5810-0BA00).

  When used together with a Siemens Energy circuit breaker, the shielded twisted pair cable provided by Siemens Energy must be used to connect the external modules to the circuit-breaker control. The modules must be installed close to the SIPROTEC 5 relay in the same control cabinet. The shielding must be grounded at both sides. The maximum permitted length of the unshielded end is 15 cm (see *Figure A-4*). To maintain the warranty for the circuit breaker, commissioning must be performed by a Commissioning Engineer who is certified by Siemens Energy for point-on-wave switching.

Example of the Power Supply for the Measuring Transducers

The current consumptions of measuring transducers are as follows:

- A WAGO transducer: 46 mA
- A Phoenix Contact transducer: 60 mA
- Each measuring transducer for reference contact, temperature detection, or hydraulic-pressure detection: 25 mA

Case	Scenario	Total Maximum Current Consumption	Power-Supply Requirement
Case 1	Siemens circuit breakers: • Point-on-wave switching for opening and closing, with control-voltage compensation • With temperature compensation • Without hydraulic-pressure detection	220 mA, which is the sum of the following values: • 120 mA of 2 Phoenix Contact transducers • 75 mA of 3 MTs for reference contacts • 25 mA of an MT for temperature detection	One SIPROTEC 7XV5810 power supply is sufficient.
Case 2	Siemens circuit breakers: • Point-on-wave switching for opening and closing, with control-voltage compensation • With temperature compensation • With hydraulic-pressure compensation	295 mA, which is the sum of the following values: • 120 mA of 2 Phoenix Contact transducers • 75 mA of 3 MTs for reference contacts • 100 mA of 4 MTs for temperature detection and hydraulic-pressure detection	One SIPROTEC 7XV5810 power supply is not sufficient. A 2nd SIPROTEC 7XV5810 power supply is required.

9 Technical Data

General Device Data

You can find more information about the general device data in the chapter **Technical Data** of the Hardware Manual.

Setting Values for the General Functionality

Phase shift opening phs*x* Phase shift closing phs*x*	0° to 720°	Increments of 1°
V open. circ. lower limit V open. circ. upper limit V clos. circ. lower limit V clos. circ. upper limit	0.0 Vto 300.0 V	Increments of 0.1 V
Frequency lower limit	30.00 Hz to 60.00 Hz	Increments of 0.01 Hz
Frequency upper limit	50.00 Hz to 80.00 Hz	Increments of 0.01 Hz
Min. reference voltage	0.300 V to 340.000 V	Increments of 0.001 V
ΔT zero crossing min. ΔT zero crossing max.	0.0 ms to 50.0 ms	Increments of 0.1 ms
Zero-crossing sup. T-hold	0.00 s to 60.00 s	Increments of 0.01 s
CB interm.pos. max. time	0.00 s to 300.00 s	Increments of 0.01 s

Setting Values for the CB Opening Function Block and CB Closing Function Block

CB opening time phs*x* CB closing time phs*x*	0.0 ms to 200.0 ms	Increments of 0.1 ms
CB arcing time phs*x* CB pre-arcing time phs*x*	0.0 ms to 20.0 ms	Increments of 0.1 ms
CB correction time phs*x*	-20.00 ms to 20.00 ms	Increments of 0.01 ms
Ref. volt. opening circuit Ref. volt. closing circuit	20.0 V to 300.0 V	Increments of 0.1 V
Voltage comp. factor	-1.000 ms/V to 1.000 ms/V	Increments of 0.001 ms/V
Reference temperature	-60 °C to 100 °C	Increments of 1 °C
Temperature comp. factor	-1.000 ms/K to 1.000 ms/K	Increments of 0.001 ms/K
Reference pressure phs*x*	100 kPa to 1000 kPa	Increments of 1 kPa
Press. comp. factor phs*x*	-1.000 ms/kPa to 1.000 ms/kPa	Increments of 0.001 ms/kPa
Time delay ref. cont. phs*x*	-50.0 ms to 50.0 ms	Increments of 0.1 ms
Maximum allowed time	0.00 s to 60.00 s	Increments of 0.01 s

Open. time: allowed diff. Break time: allowed diff. Clos. time: allowed diff. Make time: allowed diff.		0.0 ms to 20.0 ms; ∞	Increments of 0.1 ms
Make-time detec. V> phs*x* Threshold: V too high		0.300 V to 340.000 V	Increments of 0.001 V
Threshold: I too high	1 A @ 100 Irated	0.030 A to 35.000 A	Increments of 0.001 A
	5 A @ 100 Irated	0.15 A to 175.00 A	Increments of 0.01 A
	1 A @ 1.6 Irated	0.001 A to 1.600 A	Increments of 0.001 A
	5 A @ 1.6 Irated	0.005 A to 8.000 A	Increments of 0.001 A

Tolerances

Tolerances of general values	
Switching-time accuracy of switching via high-speed relays	50 μs
Time-stamp accuracy of command signals in recordings and logs	1 ms
Frequency of the reference signal	f_{rated} - 0.20 Hz < f < f_{rated} + 0.20 Hz: ± 5 mHz at V = V_{rated}
	f_{rated} - 3.0 Hz < f < f_{rated} + 3.0 Hz: ± 10 mHz at V = V_{rated}
Tolerances of compensation values	
Phase-selective hydraulic pressure (Via fast measuring-transducer input of 4 mA to 20 mA)	0.5 % of the measuring range[3]
Voltage of the closing or opening circuit (Via fast measuring-transducer input of 4 mA to 20 mA)	0.5 % of the measuring range[3]
Temperature (Via fast measuring-transducer input of 4 mA to 20 mA)	0.5 % of the measuring range[3]
Tolerances of time values in logs and recordings	
Calculated phase-selective break time, opening time, closing time, or make time	20 μs
Measured phase-selective opening time	• From the reference contact via the fast measuring-transducer input: 125 μs • From the auxiliary contact via the binary input: 500 μs
Measured phase-selective closing time	• From the reference contact via the fast measuring-transducer input: 125 μs • From the auxiliary contact via the binary input: 250 μs
Measured phase-selective break time, measuring via current	300 μs
Measured phase-selective make time	• Measurement via current: 300 μs • Measurement via voltage: 350 μs

3 The measuring range is configured in the measuring transducer, from the parameter **Lower limit - Sensor** to the parameter **Upper limit - Sensor**.

Phase-selective reference-contact duration	125 μs
Phase-selective maximum current or voltage	1.5 % of the measured value

A Appendix

A.1 Devices Supporting the Function and Ordering Notes

Devices Supporting the Point-on-Wave Switching Function

The following SIPROTEC 5 protection device types support the **Point-on-wave switching** function:

- Distance and line differential protection, breaker management for 1-pole and 3-pole tripping: 7SA87, 7SD87, 7SL87, 7VK87
- High-voltage bay controller: 6MD86
- Overcurrent protection: 7SJ85
- Transformer differential protection: 7UT85, 7UT86, 7UT87
- Merging unit: 6MU85
- Generator protection: 7UM85

Ordering a Device with the Point-on-Wave Switching Function

To order a device with the **Point-on-wave switching** function, proceed as follows:

✧ Access the SIPROTEC 5 order configurator at *https://w3.siemens.com/smartgrid/global/en/products-systems-solutions/Protection/Pages/protection-relay-configurator.aspx*.

✧ In the order configurator, access the order page of the device.

✧ Select a standard variant.

✧ Select the function-point class for the **Point-on-wave switching** function.
You can use the function-point calculation function to calculate the number of required function points.

✧ Add 1 or 2 IO209 extension modules for high-speed relays.
For each switching direction (closing or opening), one IO209 module is required.

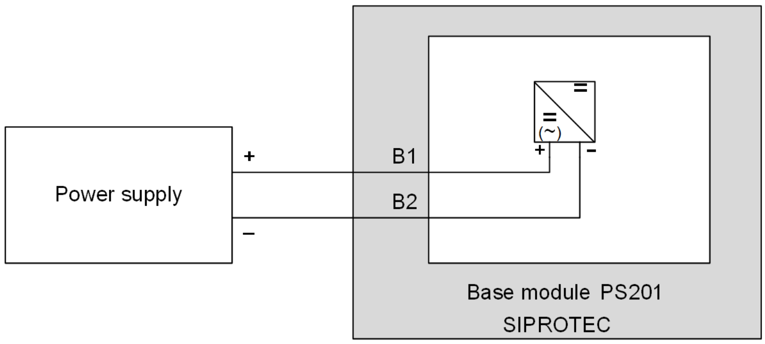
✧ Optionally, add 1 IO212 extension module for fast measuring-transducer inputs if required.
In case of Siemens circuit breakers, the mechanical make/break time is detected via Hall-effect sensors with high precision. The Hall-effect sensors are connected to the device via fast measuring-transducer inputs, which are available on the module IO212. In case of Siemens circuit breakers, IO212 is mandatory.
IO212 offers 8 fast measuring-transducer inputs, 3 of which are used for the reference contacts.
In case of non-Siemens circuit breakers, this function is carried out via the 52a auxiliary contact of the circuit breaker which is connected to normal device binary inputs, for example, available in the 1/3 base module. No IO212 is required for this function.

✧ Add further extension modules or plug-in modules according to your specific configuration.
If non-Siemens circuit breakers are used and the switching-time compensation requires not more than four 4-mA to 20-mA measuring-transducer inputs, a plug-in module ANAI is sufficient instead of the IO212 module.
To acquire process and environmental data for switching-time compensation, normal or fast measuring-transducer inputs can be applied. Such data includes, for example, control voltages for opening and closing circuits, ambient temperature, and phase-selective hydraulic pressures. This data acquisition is only meaningful if the influence factors on the circuit-breaker switching are known.
The number of required measuring-transducer inputs depends on the process and environmental data to be measured. The maximum scope is 2 control-voltage inputs, 1 temperature input, and 3 hydraulic-pressure inputs.
If already an IO212 is applied for Siemens circuit-breaker reference contact detection, 5 fast measuring-transducer inputs remain for process and environmental data acquisition.
If no IO212 is required for Siemens circuit-breaker reference contact detection, also an ANAI plug-in module can be applied for process and environmental data acquisition. One ANAI plug-in module provides 4 normal measuring-transducer inputs.
For more information on the hardware requirements of the **Point-on-wave switching** function, refer to chapter *8.1 Required Device Hardware*.

✧ Configure other device properties, such as communication modules.

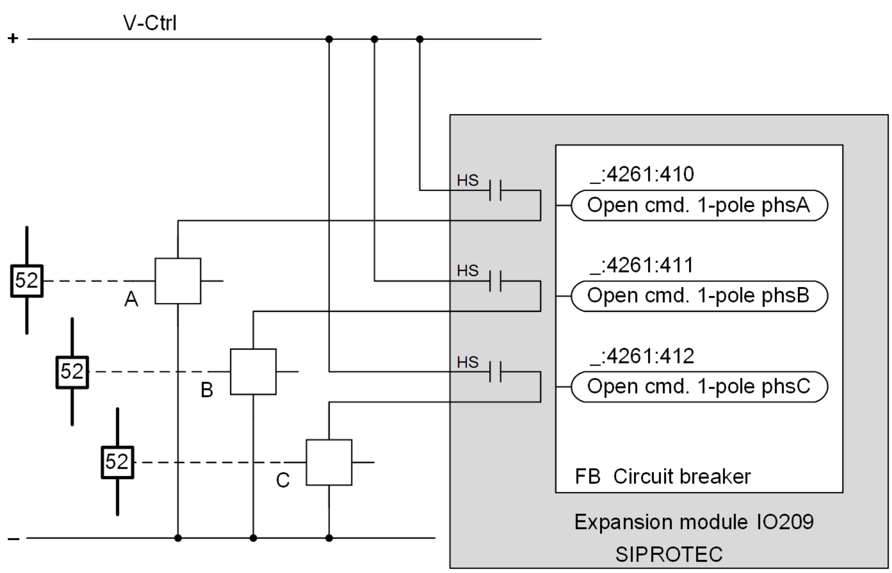
At the end of the configuration process, the product code and a detailed presentation of the configuration result are provided.

A.2 Connection Examples



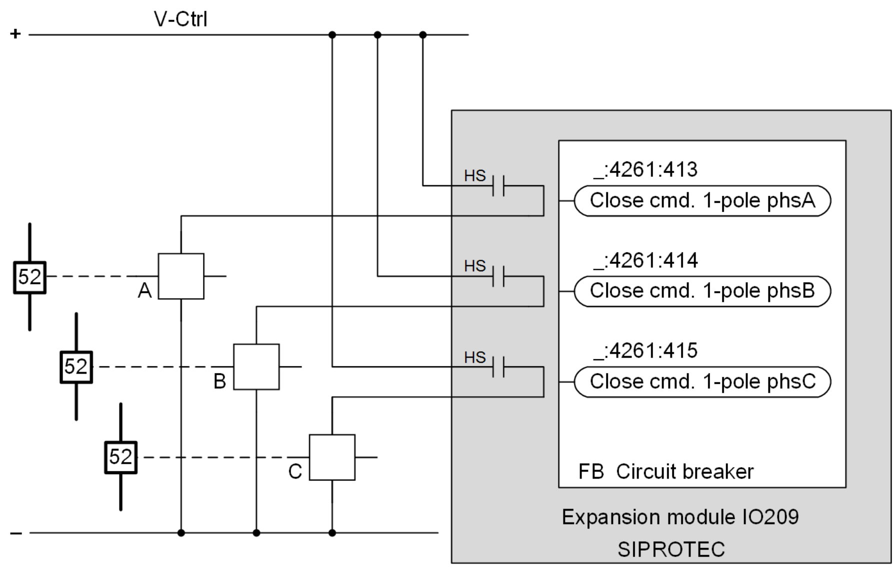
[dw_Power supply PoW, 2, en_US]

Figure A-1 Power-Supply Connection



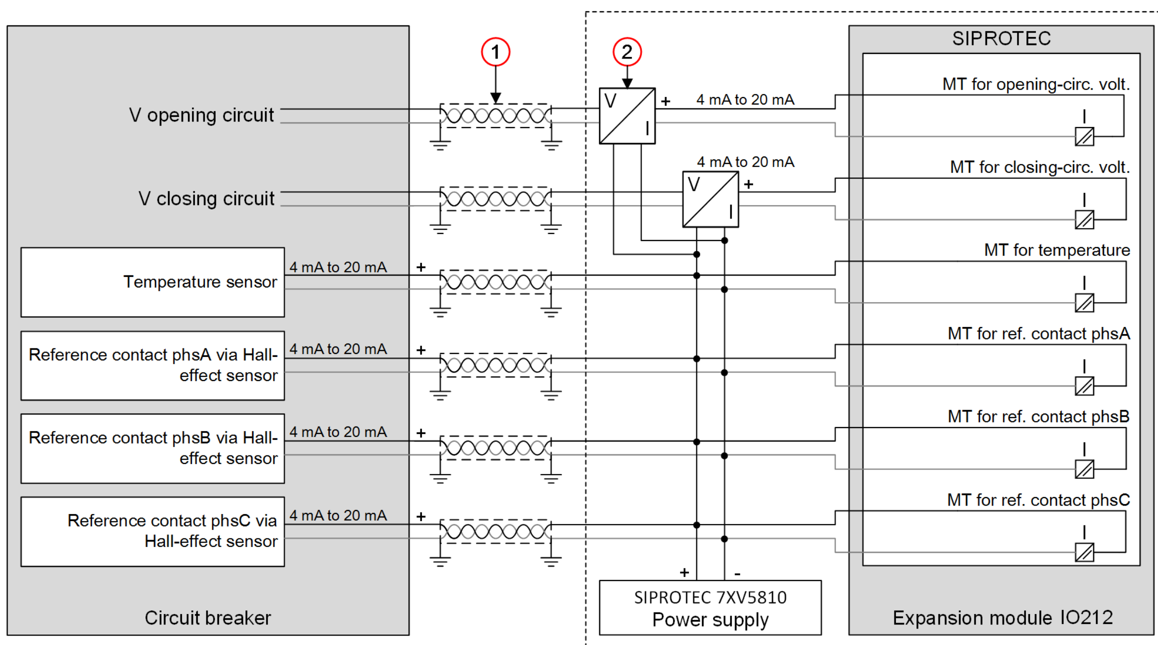
[dw_Opening circuit with HS relay, 2, en_US]

Figure A-2 Circuit-Breaker Opening Circuit Connection for PoW Switching Commands



[dw_Closing circuit with HS relay, 2, en_US]

Figure A-3 Circuit-Breaker Closing Circuit Connection for PoW Switching Commands

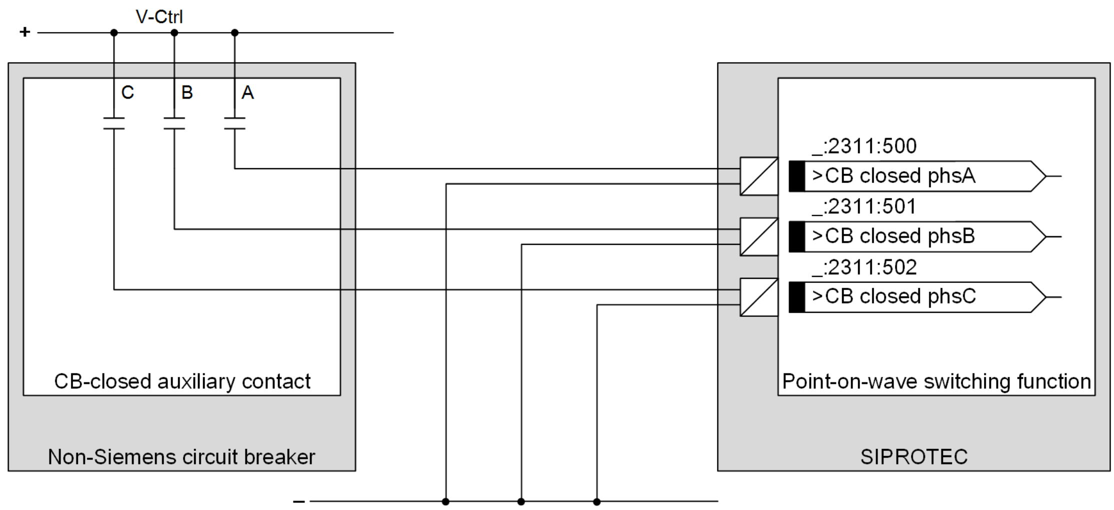


[dw_Sensors and reference contacts, 3, en_US]

Figure A-4 Circuit-Breaker Sensor and Reference-Contact Connection

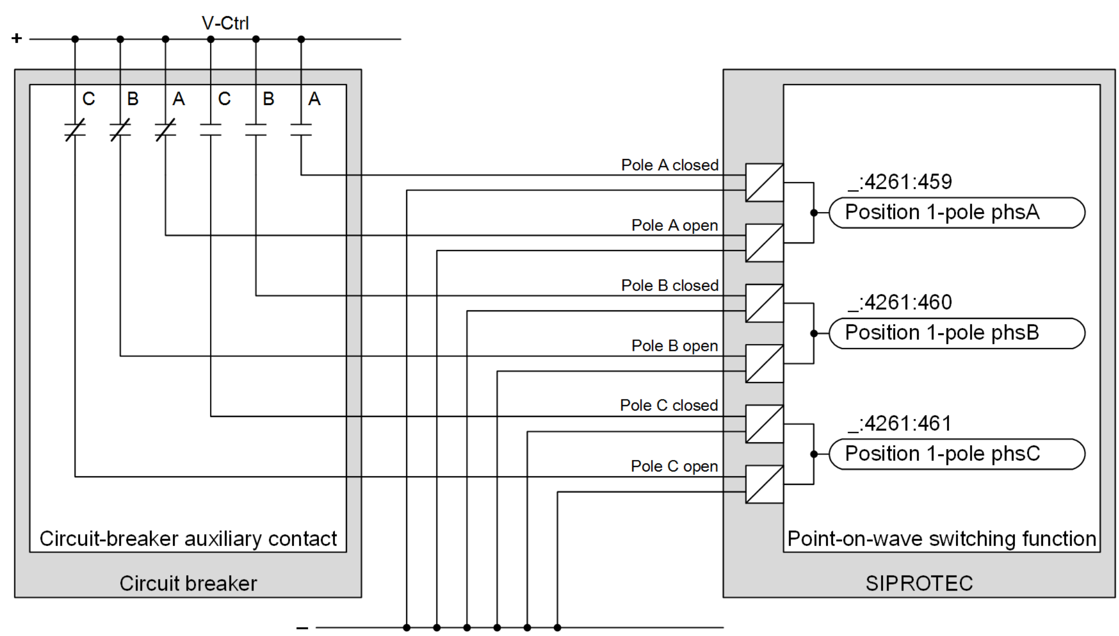
(1) Twisted pair

(2) Voltage measuring transducer, also refer to *Figure A-10*



[dw_Non-siemens CB aux. contacts, 2, en_US]

Figure A-5 Connection of Non-Siemens Circuit-Breaker Auxiliary Contacts for PoW Switching-Accuracy Supervision



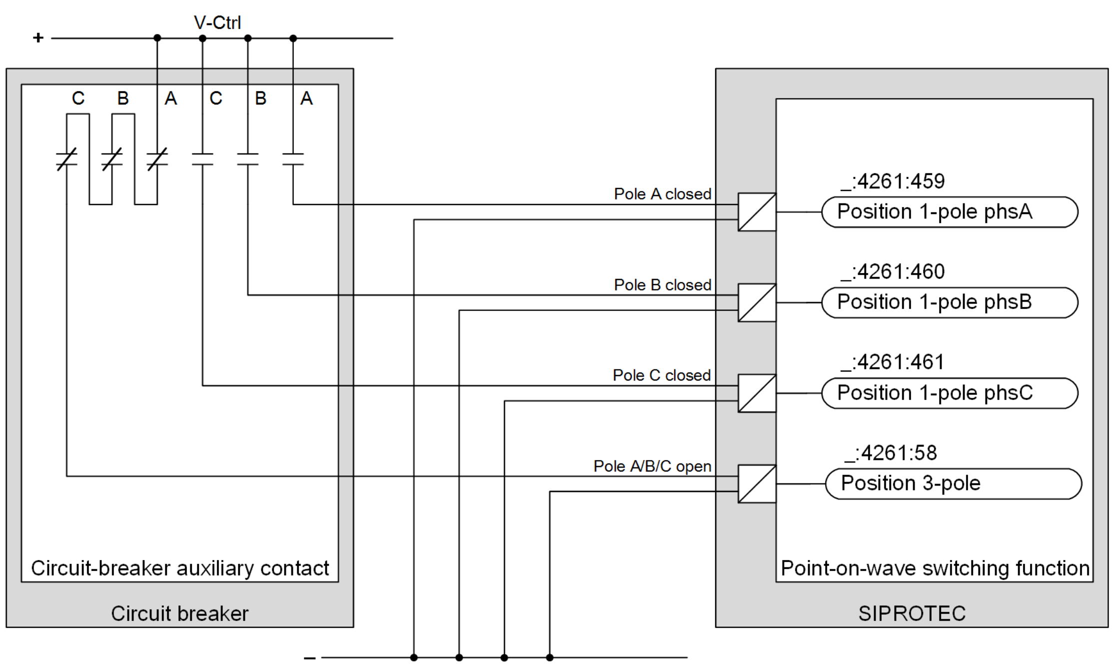
[dw_CB aux. contacts for pos., 2, en_US]

Figure A-6 Connection of Circuit-Breaker Auxiliary Contacts for Circuit-Breaker Position Supervision – Option 1

Information			Source					
			Binary input					
			Base module					
Signals	Number	Type	1.1	1.2	1.3	1.4	1.5	1.6
(All)	(All)	...	...	...	...	...	...	...
Circuit break.	301.4261		*	*	*	*	*	*
>Ready	301.4261.500	SPS						
>Acquisition blocking	301.4261.501	SPS						
>Reset switch statist.	301.4261.502	SPS						
>Reset AcqBlk&Subst	301.4261.504	SPS						
External health	301.4261.503	ENS						
Health	301.4261.53	ENS						
Position 3-pole	301.4261.58	DPC						
Position 1-pole phsA	301.4261.459	DPC	CH	OH				
Position 1-pole phsB	301.4261.460	DPC			CH	OH		
Position 1-pole phsC	301.4261.461	DPC					CH	OH

[sc_Routing example option 1, 2, en_US]

Figure A-7 Information Routing Example for Circuit-Breaker Position Supervision – Option 1



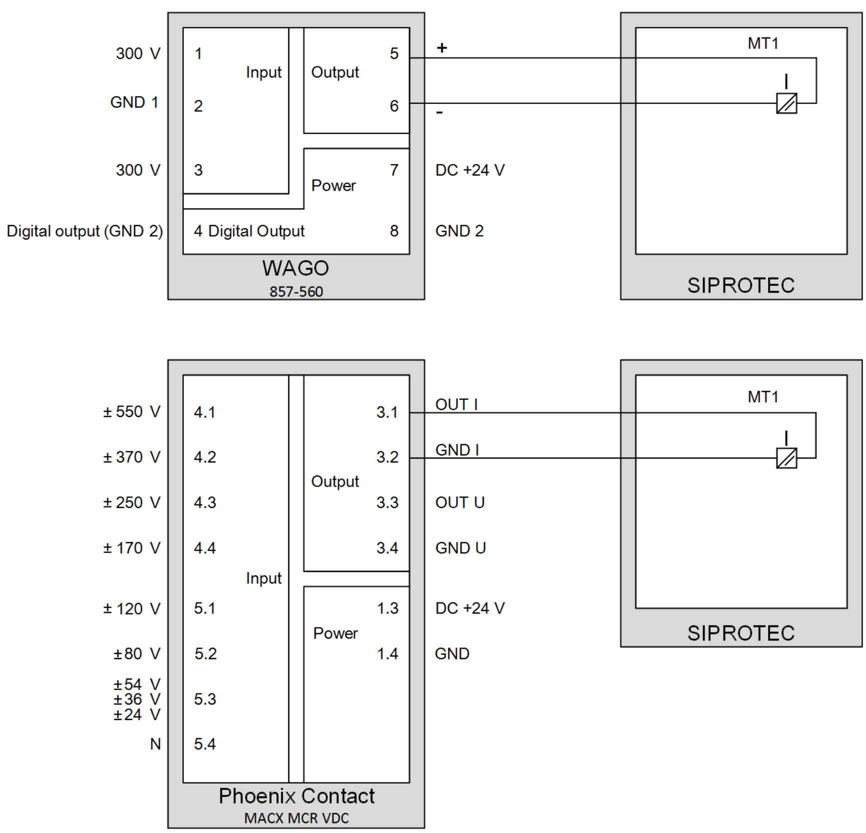
[dw_CB aux. contacts for pos. option 2, 2, en_US]

Figure A-8 Connection of Circuit-Breaker Auxiliary Contacts for Circuit-Breaker Position Supervision – Option 2

Information			Source			
			Binary input			
			Base module			
Signals	Number	Type	1.1	1.2	1.3	1.4
(All)	(All)	...	...	...	...	...
Circuit break.	301.4261		*	*	*	*
>Ready	301.4261.500	SPS				
>Acquisition blocking	301.4261.501	SPS				
>Reset switch statist.	301.4261.502	SPS				
>Reset AcqBlk&Subst	301.4261.504	SPS				
External health	301.4261.503	ENS				
Health	301.4261.53	ENS				
Position 3-pole	301.4261.58	DPC	OH			
Position 1-pole phsA	301.4261.459	DPC		CH		
Position 1-pole phsB	301.4261.460	DPC			CH	
Position 1-pole phsC	301.4261.461	DPC				CH

[sc_Routing example option 2, 2, en_US]

Figure A-9 Information Routing Example for Circuit-Breaker Position Supervision – Option 2



[dw_Connect ext. MT, 2, en_US]

Figure A-10 Connection to External Voltage Measuring Transducers