### Revision

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>07/2016</td>
<td>Initial version</td>
</tr>
<tr>
<td>1</td>
<td>04/2017</td>
<td>Update: Direct interfacing of current and voltage transformers, Table 6 (PR#34101)</td>
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<td></td>
<td></td>
<td>New functions: process command interlocking mode (PR#29902)</td>
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<tr>
<td>2</td>
<td>09/2017</td>
<td>Corrected default of parameter ‘Command release delay time’ (PR#34830)</td>
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<td></td>
<td></td>
<td>560AIR01, 560AIR02, 560BIR01 and 560BOR01 added</td>
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<td>3</td>
<td>03/2018</td>
<td>Added 500CVD21 to chapter ‘Direct interfacing of current and voltage transformers’ (PR#32165)</td>
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<td>04/2018</td>
<td>New layout</td>
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<td>4</td>
<td>02/2019</td>
<td>Parameter ‘Oscillation suppression qualifier’ added to chapter ‘Oscillation suppression’ (PR#40631)</td>
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<td>Added 500CVD90 to chapter ‘Direct interfacing of current and voltage transformers’ (PR#38184)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated chapter ‘Error handling’ (PR#34531, #12254)</td>
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1 Introduction

1.1 About the RTU500 series Function Description

The Function Description consists of several parts:

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<thead>
<tr>
<th>Document identity</th>
<th>Part name</th>
<th>Explanation</th>
</tr>
</thead>
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<tr>
<td>1KGT 150 940</td>
<td>Part 1: Overview</td>
<td>Overview of the RTU500 series and system architecture</td>
</tr>
<tr>
<td>1KGT 150 941</td>
<td>Part 2: Rack mounted solutions</td>
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</tr>
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</tr>
<tr>
<td>1KGT 150 943</td>
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<td>Overview of the RTU500 series rack and DIN rail modules</td>
</tr>
<tr>
<td>1KGT 150 944</td>
<td>Part 5: SCADA functions</td>
<td>Description of the RTU500 series SCADA functions</td>
</tr>
<tr>
<td>1KGT 150 945</td>
<td>Part 6: RTU500 functions</td>
<td>Description of the RTU500 series functions</td>
</tr>
<tr>
<td>1KGT 150 946</td>
<td>Part 7: Archive functions</td>
<td>Description of the RTU500 series Archive functions</td>
</tr>
<tr>
<td>1KGT 150 947</td>
<td>Part 8: Integrated HMI</td>
<td>Description of the RTU500 series Integrated HMI interface</td>
</tr>
<tr>
<td>1KGT 150 948</td>
<td>Part 9: Interfaces and Networks</td>
<td>Description of the RTU500 series Interface and Network functions</td>
</tr>
</tbody>
</table>

Table 1: Parts of the Function Description

1.2 Preface

This document describes the supervisory control and data acquisition (SCADA) functions of RTU500 in monitoring and command direction.
2 SCADA functions in monitoring direction

This document describes the SCADA monitoring functions available for the following I/O modules:

Binary input modules:
- 560BIR01
- 23BE40
- 23BE50
- 520BID01

Analog input modules:
- 560AIR01
- 560AIR02
- 520AID01
- 520PTD01 (PT100 interface)

Multiple I/O modules:
- 540CID01 (binary input, binary output, analog input and command output supervision)

2.1 Processing indications

SCADA functions in monitoring direction can be executed on two types of indications:

- Single point input (SPI)
- Double point input (DPI)

The normal state of a DPI is a non-equivalent bit combination (10 or 01).

Double indications are represented by two sequential bits on the same binary input module. An intermediate state (00) is assigned during runtime of a unit while the unit changes from one position to the other (e.g., an isolator changes from OFF to ON).

The definition of the ON and OFF bit positions can be changed for the entire configuration. If a bit position is changed, this definition is also valid for DCO and RCO commands.
Within an indication module, any type of binary input can be mixed.

However, take into account that a DPI or SPI may be configured to process indications such as pulse counters, digital measured values on bit string inputs. Digital measured values and bit string inputs must be configured to start either at bit position 1 or at bit position 9.

2.1.1 Function distribution

The process data acquisition functions for indications processed by RTU500 can be grouped into functions handled by the following elements:

- I/O controller (IOC) of the binary input modules
- Process data processing (PDP) part of the CMU
- Protocol-specific communication interface part at a CMU

The data processing functions of the communication interface are described in the documentation of the relevant communication protocol.

The following functions are available for binary input boards:

- Read input register (every millisecond)
- Digital filter (contact bouncing)
- Oscillation suppression (signal chattering)
- Time out monitoring for DPI intermediate position
- Store events in FIFO queue with time stamp

The following functions are available for the PDPs of CMUs:

- Intermediate position handling for DPI
- Indeterminate position handling for DPI
- Signal inversion
- Command output response
- Aggregating signal messages
- Transmission to internal communication

2.1.2 Functions of binary input boards

The IOCs of the binary input boards support the indication functions. The configuration parameters for each function are loaded from the PDP part of the CMU during start-up or in the event of a board initialization during runtime. Some parameters apply to all inputs; others can be set for each input individually.

Binary input boards periodically take a reading from all inputs every millisecond, regardless of the specified data point type. The IOCs handle the necessary activities for all 16 bits within that millisecond. The high reading frequency at millisecond intervals allows for the high resolution of events for indications. Each module takes its readings for a block of 16 bits independently from other modules.

2.1.2.1 Blocked

Use the Blocked configuration parameter to specify blocking for a data point. Any data point configured with the Blocked configuration parameter will be blocked from transmission, and PDP will stop reporting any changes related to this data point to the NCC.
2.1.2.2 Digital filter

Use the digital filter configuration parameter to specify the number of milliseconds during which an input has to be stable before it is accepted as a new signal state.

Use the digital filter configuration parameter to prevent ordinary contact bouncing.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI: Digital filter</td>
<td>10 ms</td>
<td>SPI, DPI, DMI, STI, ITI, BSI - PDP parameters</td>
</tr>
</tbody>
</table>

The ‘digital filter’ time specifies the time an input must be stable, before the change is accepted.

Value range: 2 to 255 ms or '-' to disable

If an input channel has changed its state and should be transmitted as an event to the PDP, the time of the last edge before the filter time elapsed is used as the time stamp of the event.
### 2.1.2.3 Oscillation Suppression

Indications, which change their state very often, produce a higher transmission load to NCC.

To prevent permanent transmission. A threshold value for the number of events per time period can be set. If this value is exceeded, the system automatically blocks the corresponding indication.

Use the Maximum chatter frequency configuration parameter to activate or deactivate oscillation suppression for each indication individually.

Maximum chatter frequency is defined as follows:

$$MAX \ CHA\ FREQ = \frac{\text{number of changes}}{\text{second}}$$

The monitoring period is calculated according to the following formula:

$$T_{\text{set}} = \frac{2000}{MAX \ CHA\ FREQ} \ [\text{milliseconds}]$$
RTU500 Series function description part 5: Oscillation suppression for indications

Tosc is the monitoring period. The maximum value is 100 Hz. A typical value is 2 Hz.

The following steps describe a typical monitoring cycle with oscillation suppression:

1. The monitoring period tosc for an indication starts with each leading edge of 0->1.
2. During the monitoring period, the chatter counter register of that indication increments with each leading edge.
3. At the third change within the monitoring period, the binary input board puts the indication into the dynamically blocked state.
4. The binary input board informs PDP by means of an internal event message.
5. The binary input board starts a reset time period (fix to 60 s).
6. If the binary input board detects a new start trigger (leading edge of 0->1) during that reset time period, it restarts the monitoring period tosc.
7. If the state of the indication does not change over the entire reset time period, the binary input board informs PDP by means of an internal event message.

Figure 3: Oscillation suppression

Use the parameter below to set the object state of a blocked indication as invalid (IV) or blocked (BL):

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillation suppression qualifier</td>
<td>Mark as invalid (IV)</td>
<td>RTU - parameters</td>
</tr>
</tbody>
</table>

In case of oscillation suppression the object state is set as selected.
Value range: Mark as invalid (IV), Mark as blocked (BL)
2.1.2.4 Intermediate position handling for DPI

The binary input board handles the two bits of the double point input as follows:

- It transmits any changes to the states of signals received by the DPI to PDP.
- It transmits any intermediate positions (00) to PDP by means of a special status bit.

The binary input board monitors the time window for intermediate position.

The timeout value is loaded as a configuration parameter from PDP. If the DPI does not indicate a new end position before the timeout has expired, the binary input board generates an event message with the following elements:

- the current state of the DPI
- the status of the DPI's intermediate position timeout

2.1.2.5 FIFO storage

To de-couple event bursts from I/O bus transmission etc., the binary input boards store event messages in a FIFO (first in, first out) buffer. The FIFO buffer can store up to 50 event messages.

If the FIFO is full, the binary input board stops the processing of messages. As soon as the FIFO buffer is able to store new messages, the binary input board resumes its activities. Any pending messages are set to Invalid, and a sequence of steps is started to trigger the transmission the current values.

Each event message has a time stamp with a resolution of one millisecond within a minute. PDP expands the time stamp value contained in an event message to absolute time.

2.1.3 PDP functions of the CMU

The binary input board’s FIFO buffer outputs all event messages to PDP. PDP then takes care of any functions specified for the messages it processes.

2.1.3.1 Command output response

For a detailed description of the functionality of a response indication to stop a related command output pulse, refer to the section “Termination of command output by response indication” of this document.

2.1.3.2 Intermediate position suppression for DPI

This function is valid only for double indications (DPI). Fig. 4 shows the handling of intermediate position suppression for DPI within RTU500.

Use the supervision time for intermediate position configuration parameter to specify whether a DPI message should be transmitted as an event. When the indication changes to an intermediate position (00), PDP keeps the first signal change internal. If an abnormal situation occurs, PDP also sends the message of the leading edge to the NCC to allow a more detailed analysis of the unit's error situation.

Use the Supervision time for intermediate position configuration parameter to specify the time period during which RTU500 should inhibit the transmission of the intermediate position (00). If the new state is not indicated to the RTU during that time period, the RTU
generates a DPI telegram with the actual position (normally then 00). The qualifier IV (invalid) remains 0, because this is a valid process information.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPI: Supervision time for midpoint position</td>
<td>30 sec</td>
<td>DPI – PDP parameters</td>
</tr>
</tbody>
</table>

If enabled:
The momentary midposition (00) is suppressed for the supervision time.
Value range: 1 to 255 sec or '-' to disable.

**Supervision time for intermediate position = active**

Normal signal state change
ON -> OFF

Abnormal signal state change
ON -> intermediate -> OFF

Abnormal signal state change timeout

**Supervision time for intermediate position = inactive**

Normal signal state change
ON -> OFF

Abnormal signal state change
ON -> intermediate -> ON

Abnormal signal state change timeout

Figure 4: Intermediate position suppression for double point inputs (DPI)

Figure 5: Intermediate position suppression for double point inputs (DPI)
2.1.3.3 Indeterminate position suppression for DPI

This function is available only for double indications (DPI).

Use the Supervision time for indeterminate position configuration parameter to specify whether a DPI message should be transmitted for the event if the indication changes to the indeterminate position (11). If supervision is enabled, PDP suppresses the signal change to the indeterminate position.

Use the Supervision time for indeterminate position configuration parameter to specify the time period during which RTU500 should inhibit the transmission of the indeterminate position. When the supervision time is over and the DPI is still in the indeterminate position, RTU500 generates a DPI telegram with the indeterminate position value and the qualifier IV (invalid) set to false.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DPI: Supervision time for indeterminate position</td>
<td>3 sec</td>
<td>DPI – PDP parameters</td>
</tr>
</tbody>
</table>

If enabled:
The momentary indeterminate position (11)
is suppressed for the defined time.
Value range: 1 to 255 sec or '-' to disable.

2.1.3.4 Signal inversion

After having a stable indication signal, it is possible to define its logical state, corresponding to the signal voltage level. This function is called a signal inversion.

Use the the Invert the input value configuration parameter to specify signal inversion.

<table>
<thead>
<tr>
<th>INVERSION = NO</th>
<th>INVERSION = YES</th>
</tr>
</thead>
<tbody>
<tr>
<td>logical 0 = OFF</td>
<td>0 V Process Voltage</td>
</tr>
<tr>
<td>logical 1 = ON</td>
<td>Process Voltage 0 V</td>
</tr>
</tbody>
</table>

Table 2: Definition of signal inversion

All other functions are then based on the signal state given by the Invert the input value configuration parameter.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI: Invert the input value</td>
<td>disabled</td>
<td>SPI, DPI, DMI, STI – PDP parameters</td>
</tr>
<tr>
<td>DPI: Invert the input value</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If enabled:
The positive process voltage
will be interpreted as 'Logical Zero'

The definition of the bit position for ON (HIGHER) and OFF (LOWER) can be changed for the entire configuration. If a bit position is changed, this definition is valid for DPI, DCO and RCO commands.
2.1.4 Error handling

2.1.4.1 Failure of binary input boards

Boards can be set to an "out of service" state if one of the following conditions applies:

- The board has never been in service (configuration error).
- The board failed during normal operation (hardware failure, I/O bus failure etc.).
- The board was removed, or rack power is lost.

If a board is set to an "out of service" state, the qualifiers of all configured indications are set to Invalid due to board failure. The RTU500 treats all DPI and SPI messages of that board with qualifiers IV = 1.

Boards can be reverted to a "service active" state during runtime if one of the following conditions applies:

- The board was replaced.
- Rack power is restored.
- The I/O bus is working properly.

When this happens, the following sequence will recover the indications:

1. Normalize the binary input boards.
2. Load all parameters for the configured indications (done by PDP).
3. Read all values (signal states).
4. Reset qualifier IV to 0 and transmit the actual value and qualifier status to NCC.

2.1.4.2 Dynamic qualifier changes

The qualifier status of an indication can change at runtime if one of the following conditions applies:

- The binary input board fails (qualifier IV = 1).
- Oscillation suppression is activated and triggered for that indication.

2.1.4.3 Information Object Qualifier

The following parameter can be used to define the object qualifier of messages of disconnected subordinated devices:

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information object qualifier (usage for disconnected subordinated devices)</td>
<td>Mark as invalid (IV)</td>
<td>RTU - Parameter</td>
</tr>
</tbody>
</table>

Value range: Mark as invalid (IV) / Mark as not topical (NT)
2.2 Processing analog measured information

2.2.1 Analog Measured value Input (AMI) types

Each analog measured value is converted by the analog digital converter (ADC) of the analog input module into a signed integer presentation. Figure 5 shows analog value presentation according to IEC 870-5-101. The 100 % input signal value is represented with 12-bit plus sign. PDP converts the value to a normalized presentation.

---

**ADVICE**

Data points which have not been updated since the RTU started will still be marked as invalid (IV), regardless of the setting of the Information object qualifier parameter.
2.2.2 Measured Floating Point information (MFI) types

The processing of MFI values is the same as with AMI values except that the value representation is a scaled format. The maximum and minimum value of a MFI is configurable.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFI: Scaling minimum value</td>
<td>-100.0</td>
<td>MFI, FSO – PDP parameters</td>
</tr>
<tr>
<td>Minimum value used for scaling.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>This value corresponds to -100% of the internal representation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value range: (-3.4\times10^{38} \ldots 3.4\times10^{38})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MFI: Scaling maximum value</td>
<td>+100.0</td>
<td>MFI, FSO – PDP parameters</td>
</tr>
<tr>
<td>Maximum value used for scaling.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>This value corresponds to +100% of the internal representation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value range: (-3.4\times10^{38} \ldots 3.4\times10^{38})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.3 Function distribution

The process data acquisition functions for analog measured information processed by RTU500 can be grouped into functions handled by the following elements:

- IOC of the analog input board
- Process data processing (PDP) part of the CMU
- Protocol-specific communication interface at a CMU

For a description of the data processing functions of the communication interface, refer to the documentation of the corresponding communication protocol.

The following functions are available for analog input boards:

- Scan analog input cyclically
- Zero value supervision and switching detection
- Smoothing
- Threshold supervision on integrator algorithm
- Periodic update of RTU database
- Store events into FIFO with time stamp

The following functions are available for the PDPs of CMUs:

- Unipolar and Live Zero conversion
- Scaling
- Threshold supervision on absolute threshold value
- Transmission to internal communication

2.2.4 Functions of analog input boards

The IOC of the boards supports the analog measured information functions. The configuration parameters for each function and each AMI / MFI are loaded from PDP during start-up or in the event of a board initialization during runtime.

2.2.4.1 Blocked

Use the Blocked configuration parameter to specify blocking for a data point. Any data point configured with the Blocked configuration parameter will be blocked from transmission, and PDP will stop reporting any changes related to this data point to the NCC.
2.2.4.2 Scan cycle and line frequency interference suppression

The I/O controller of the analog input module scans each channel cyclically.

Beside the information about the configured measuring range the information about the line frequency is required for the A/D-conversion. The scan cycle time is determined by the AC line frequency:

<table>
<thead>
<tr>
<th>Scan cycle time (same for all channels)</th>
<th>Line frequency 50 Hz</th>
<th>Line frequency 60 Hz</th>
<th>Line frequency 16.7 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>580 ms</td>
<td>500 ms</td>
<td>1620 ms</td>
<td></td>
</tr>
<tr>
<td>560AIR01, 560AIR02</td>
<td>486 ms</td>
<td>1395 ms</td>
<td></td>
</tr>
<tr>
<td>540CID01</td>
<td>480 ms or 100 ms for max. 2 channels</td>
<td>400 ms or 100 ms for max 2 channels</td>
<td>1440 ms or 200 ms for max. 2 channels</td>
</tr>
<tr>
<td>520AID01</td>
<td>480 ms</td>
<td>400 ms</td>
<td>1600 ms</td>
</tr>
</tbody>
</table>

The scan frequency is independent from the number of configured channels. The synchronization of the scan cycle with the line frequency is used to increase the line frequency interference suppression of the DC input signal.

### 2.2.4.3 Zero value supervision and switching detection

A low input signal can be forced to 0 %. This allows rejecting noise on the input signal produced by the transducer etc.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero range</td>
<td>±0.25 %</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
</tbody>
</table>

Value range: ±0.1 % - ±5 %

Zero value supervision forces low input signals in the configured range to 0 %

The switching detection is a special function of the analog input boards. It is used to force a value update to PDP if a signal changes only some few percent from/to zero. The function is only active when threshold supervision with integration is selected. The threshold supervision on integrator algorithm would need some cycles before the threshold is exceeded and reported to NCC. This creates a transient situation, e.g. the 380 kV transmission line is switched but the actual current does not change more or less immediately.

Switching detection operates in that form that every time a signal changes to/from 0 % from/to more than ± 2.5 % the new value is transmitted to PDP immediately. If the new value
is below ± 2.5 % an event is not forced. PDP transmits the received value to NCC, regardless of other parameters.

Switching detection is a fixed parameter that cannot be parameterized.

![Diagram showing zero value supervision and switching detection](image)

**Figure 7: Zero value supervision and switching detection**

### 2.2.4.4 Smoothness

Unstable input signals can be smoothed to prevent too many value transmissions.

Use the Smoothing configuration parameter to specify or deactivate smoothing for each input. Use binary factors to specify the smoothing factor.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoothing factor</td>
<td>disabled</td>
<td>AMI, MFI - PDP parameters</td>
</tr>
</tbody>
</table>

Value range: 2, 4, 8, 16, 32, 64, 128 or disabled

Unstable input signals can be smoothed to prevent too many value transmissions.
Processing analog measured information
SCADA functions in monitoring direction

The IOC calculates the new value according to the following formula:

$$MW_{ngl} = \frac{MW - MW_{agl}}{K} + MW_{agl}$$

- $MW_{ngl}$ = new calculated analog measured value
- $MW$ = raw analog measured value (result of A/D conversion)
- $MW_{agl}$ = last calculated value
- $K$ = smoothing factor (1, 2, 4, 8, 16, .. 128)

2.2.4.5 Threshold supervision on integrator algorithm

There are two different methods of threshold supervision within RTUS00:

- Threshold supervision with integration
- Threshold supervision with absolute threshold value

The choice of method depends on the parameter configuration.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition mode</td>
<td>Integrated threshold supervision</td>
<td>AMI, MFI - PDP parameters</td>
</tr>
</tbody>
</table>

Acquisition mode:
- Integrated threshold supervision
- Absolute threshold supervision
- Periodic update
- Integrated threshold + periodic update

The 'Threshold supervision with integration' method uses the analog input boards for threshold supervision. The IOC calculates at each cycle the difference between the last reported analog value and the actual value. The difference is added to the accumulated value in the threshold difference register. If the accumulated deltas exceed the parameterized threshold value, the actual value is stored into the FIFO and reported to PDP. The actual
value will become the last reported value. The threshold difference register is set to zero. The accumulation is done in consideration of the sign of the difference.

Figure 9: Threshold supervision with integration
The threshold difference register is cleared if one of the following conditions applies:

- The value exceeded the threshold value.
- The switching detection supervision was triggered.
- The value passed a monitored limit.

Use the Threshold configuration parameter to specify the threshold value. To be independent of the scan cycle the threshold is calculated on threshold integration per second.

The threshold is rescaled according to the Line frequency configuration parameter:

- 50 Hz: threshold base 1 s = Threshold / 0.58 = 12 %
- 60 Hz: threshold base 1 s = Threshold / 0.5 = 10 %
- 16.6 Hz: threshold base 1 s = Threshold / 1.62 = 25 %

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold</td>
<td>12 %</td>
<td>AMI, MFI - PDP parameters</td>
</tr>
</tbody>
</table>

value range:
1...12% (50Hz)
1...10% (60Hz)
1...25% (16.7Hz)
### Parameter Name and Default

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line frequency</td>
<td>50 Hz</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
</tbody>
</table>

- **Line frequency**: 50 Hz, 60 Hz, 16.7 Hz
- Depending on the line frequency, the scan cycle of the analog input is determined.
- Parameter must be the same for all channels of the analog input module.

### 2.2.4.6 Periodic update of RTU database

If a periodic update of the RTU500 database is required, the analog input boards can be parameterized to periodically transmit the AMI.

Use the Periodic Update configuration parameter to specify the frequency of the database update.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan cycle</td>
<td>8 sec</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
</tbody>
</table>

- **Scan cycle**: 1, 2, 4, 8, 30, 60 sec, only 560MIO10: 100 or 200 msec

### 2.2.5 FIFO storage of the analog input boards

To decouple event bursts from I/O bus transmission etc., events are stored in the FIFOs of the analog input boards. Up to 50 events can be stored within a FIFO. If a FIFO is full when the IOC needs to store new events, the IOC suspends its activities until FIFO storage is available again. Each event has a time stamp with a resolution of 1 ms/min. The absolute time is expanded by PDP.

For each measured value written to the FIFO, the IOC reads the actual time. The actual time quality is equivalent to the scan cycle of the analog input board.

### 2.2.6 PDP functions of the CMU

#### 2.2.6.1 Bipolar, Unipolar, and Live Zero conversion

The input signal type allows specifying unipolar input signals. That means negative values are not allowed. If the value of an input signal defined as unipolar becomes negative (> Zero Value Supervision), RTU500 assigns the 'qualifier invalid' flag (qualifier IV = 1).

Input signals with Live Zero presentation (standard = 4..20 mA) are transformed to the standard presentation of -100 % or 0 %, respectively, up to 100 % by PDP.
Conversion is performed as follows:

- 20 % of the input signal range (default: 4 mA) transform into –100 % or 0 % respectively, of the normalized AMI / MFI value
- 100 % of the input signal range (default: 20 mA) transform into 100 % of the normalized AMI / MFI value

Input signals below 20 % (4 mA) are set to –100 % respectively 0 %. For values < 3.5 mA, the AMI / MFI is indicated to be faulty (qualifier IV=1)

Use the Input signal type configuration parameter to specify the input type (Bipolar, Unipolar or Live Zero).

Use the Input signal range configuration parameter to specify the hardware setting of the analog input boards.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input signal range</td>
<td>20 mA</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
</tbody>
</table>

Select the required input range according to the analog input module variant.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>AMI, MFI – PDP parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input signal type</td>
<td>Bipolar</td>
</tr>
</tbody>
</table>

Input signal types:
- bipolar (e. g. ±20 mA)
- unipolar (e. g. 0... 20 mA)
- live zero (e. g. 4... 20 mA)
- 4... 40 mA

Adjust zero value for live zero signal
- deactivated: 4... 20 mA -> 0... 100%
- activated: 4... 20 mA -> -100... 100%

Figure 10: Example: Unipolar / Bipolar measurement
2.2.6.2 Scaling

PDP converts the value to a normalized AMI or scaled MFI format.

Use the Conversion factor configuration parameter to specify the percentage of the maximum input signal that is defined as 100% of the normalized AMI value or scale maximum MFI value.
2.2.6.3 Threshold supervision with absolute threshold value

There are two methods of threshold supervision within RTU500:

- Threshold supervision with integration
- Threshold supervision with absolute threshold value

The choice of method depends on the parameter configuration. Only one method can be used at a time.

Threshold supervision with an absolute threshold value is carried out in PDP.

In this mode, PDP checks each AMI received from the analog input boards against the last reported value. If the new value exceeds the last reported value plus threshold the received AMI will become the last reported value and is transmitted to NCC.

Use the Threshold configuration parameter to specify the threshold value. The threshold is monitored every nn seconds. Consequently, the analog input board periodically transmits the actual value.

Use the Periodic Update configuration parameter to specify the update frequency.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold</td>
<td>12 %</td>
<td>AMI, MFI - PDP parameters</td>
</tr>
</tbody>
</table>

value range:
1 ... 12% (50Hz)
1 ... 10% (60Hz)
1 ... 25% (16.7Hz)
### 2.2.7 Error handling

#### 2.2.7.1 AMV overflow and/or A/D converter errors

During start-up, and during each conversion, the analog input board checks the functionality of its A/D converter. If an error is detected, the AMIs are marked as invalid. PDP sets qualifier IV to 1 and transmits it to NCC along with the new state.

For AMIs with Live Zero conversion, a value below 3.5 mA is marked as invalid.

#### 2.2.7.2 Failure of analog input boards

Boards can be set to an "out of service" state if one of the following conditions applies:

- The board has never been in service (configuration error).
- The board failed during normal operation (hardware failure, I/O bus failure etc.).
- The board was removed on-line, or sub-rack power is lost.

---

**Figure 14: Threshold supervision with absolute value**

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan cycle</td>
<td>8 sec</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
<tr>
<td>AMI: Scan cycle</td>
<td>sec</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
<tr>
<td>MFI: Scan cycle</td>
<td>unit</td>
<td>AMI, MFI – PDP parameters</td>
</tr>
</tbody>
</table>

Value range seconds [sec] or only with 560MIO10: milliseconds [ms]

- AMI: Fast input scanning
- MFI: Fast input scanning
  - disabled

For 540CID01/560MIO10 only:

The analog input value is read in steps of 100 or 200 ms. Max. 2 analog objects are allowed. Disabled by default.
If a board is set to an "out of service" state, all configured AMIs are set to Invalid. The RTU500 transmits all AMI messages of that board to the NCC with the qualifier IV = 1.

Boards can be reverted to a "service active" state during runtime if one of the following conditions applies:

- The board was replaced.
- Rack power is restored.
- The I/O bus is working properly.

When this happens, the following sequence will recover the AMIs:

- Normalize the binary input boards.
- Load all parameters for the configured indications (done by PDP).
- Read all values (signal states).
- Reset qualifier IV to 0 and transmit the actual value and qualifier status to NCC.

2.2.7.3 Dynamic qualifier changes

The qualifier status of an AMI can change at runtime if one of the following conditions applies:

- The analog input board fails (qualifier IV = 1).
- Live zero supervision detects a current below 3.5 mA (qualifier IV = 1).
- The unipolar value is below –Zero Range (qualifier IV=1).
- The value has an overflow of the ADC signal input (qualifier OV = 1).
- The scaling by means of conversion factor delivers a result >100 % (qualifier OV = 1).

2.3 Processing digital measured values

There are two types of digital measured values:

- Digital measured value input (DMI)
- Step position input value (STI)

RTU500 series is able to read and convert the following bit patterns into a digital measured value:

- 8-bit digital measured value (DMI8)
- 16-bit digital measured value (DMI16)
- 8-bit step position value (STI)

The RTU supports conversion of the following data types:

- Binary data (BIN)
- Binary coded decimals (BCD)
- Gray code (GRAY)

The maximum length of a digital measured value is the word value of 16 bit (= one binary input module). Double word values (32-bit) are not supported.

2.3.1 Digital measured value presentation

Each value type is converted and scaled by PDP.
### 2.3.2 Functions of binary input boards

The IOCs of binary input boards support the digital measured value (DMI) functions. The configuration parameters for each function and each DMI are loaded from PDP during start-up or in the event of a board initialization during runtime.

Binary input boards periodically take a reading from all 16 inputs every millisecond, regardless of the specified data point type. The IOCs handle the necessary activities for all 16 bits within that millisecond.

![Digital measured value presentation](image)

**Figure 15: Digital measured value presentation**
2.3.2.1 Blocked

Use the Blocked configuration parameter to specify blocking for a data point. Any data point configured with the Blocked configuration parameter will be blocked from transmission, and PDP will stop reporting any changes related to this data point to the NCC.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Blocked</td>
<td>disabled</td>
<td>SPI, DPI, AMI, MFI, DMI, STI, ITI, BSI – PDP parameters</td>
</tr>
<tr>
<td>STI: Blocked</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If a process data point is 'blocked', changes are not transmitted to the hosts.

2.3.2.2 Digital filter

Use the digital filter configuration parameter to specify the number of milliseconds during which an input has to be stable before it is accepted as a new signal state.

Use the digital filter configuration parameter to prevent ordinary contact bouncing.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Digital filter</td>
<td>10 ms</td>
<td>SPI, DPI, DMI, STI, ITI, BSI - PDP parameters</td>
</tr>
<tr>
<td>STI: Digital filter</td>
<td>10 ms</td>
<td>SPI, DPI, DMI, STI, ITI, BSI - PDP parameters</td>
</tr>
</tbody>
</table>

The ‘digital filter’ time specifies the time, an input must be stable, before the change is accepted.
Value range: 0 to 255 ms or - to disable

If an input channel has changed its state and should be transmitted as an event to the PDP, the time of the last edge before the filter time elapsed is used as the time stamp of the event.
2.3.2.3 Consistency check

A DMI is a bit pattern with a length of 8 bit or 16 bit. The value is only valid if all binary channels of the DMI are valid and stable for at least the consistency check time. This is given if no input changed for the parameterized consistency check time. Any change on an input channel re-triggers the settling time.

Use the Consistency check time configuration parameter to specify the minimum settling time.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Consistency check time</td>
<td>1 sec</td>
<td>DMI, STI, BSI – PDP parameters</td>
</tr>
</tbody>
</table>

An input value is valid, if there are no changes during the 'Consistency check time'.

Value range:
0.1 to 25.5 seconds
0 or '-' means disabled.
### 2.3.3 FIFO storage of binary input boards

If a DMI has changed and has been stable for at least the consistency time, it is stored into the FIFO and transmitted to PDP.

### 2.3.4 PDP functions of the CMU

PDP receives all events out of the binary input boards FIFO. PDP handles all other functions specified for that DMI.

#### 2.3.4.1 Scaling and format conversion

Use the DMI/STI Value presentation and Input signal type configuration parameters to specify which DMI type is connected to the binary input board.

STI values are always handled as 7-bit signed integer within a range of -63 to +63. For DMI inputs, use the Maximum value configuration parameter to specify the binary value that is converted to 100 % of the scaled DMV value. The binary value of the STI is limited to a range of -63 to +63.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Value presentation</td>
<td>BIN</td>
<td>DMI, STI, DSO – PDP parameters</td>
</tr>
<tr>
<td>STI: Value presentation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following 'value presentations' are supported:

- BIN -> Binary data
- BCD -> Binary coded decimal
- GRAY -> Gray coded
- SBCD -> BCD with sign

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Input signal type</td>
<td>Unipolar</td>
<td>DMI, DSO – PDP parameters</td>
</tr>
<tr>
<td>DMI8: Unipolar: Value range between 0 and 255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bipolar: Value range between -128 and 127</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI16: Unipolar: Value range between 0 and 65635, Bipolar: Value range between -32768 and 32767</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Maximum value (100%)</td>
<td>65535 (DMI16)</td>
<td>DMI, DSO – PDP parameters</td>
</tr>
<tr>
<td></td>
<td>255 (DMI8)</td>
<td></td>
</tr>
</tbody>
</table>

DMI8: Specifies the binary value that is converted to 100 %.

Value range:
- 0 to 255 (BIN/GRAY, unipolar)
- 0 to 99 (BCD, unipolar)
- -128 to 127 (BIN/GRAY, bipolar)
- -79 to 79 (BCD, bipolar).

DMI16: Specifies the binary value that is converted to 100 %.

Value range:
- 0 to 65535 (BIN/GRAY, unipolar)
- 0 to 9999 (BCD, unipolar)
- -32767 to 32767 (BIN/GRAY, bipolar)
- -7999 to 7999 (BCD, bipolar).

#### 2.3.4.2 Signal inversion

Inversion is possible for DMI and STI inputs.
Use the Invert input signal and invert sign of input value configuration parameters to specify a bit inversion of the digital input value. Inversion of the sign bit can be configured independent of the inversion of the value bits.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPI: Invert the input value</td>
<td>disabled</td>
<td>SPI, DPI, DMI, STI – PDP parameters</td>
</tr>
<tr>
<td>DPI: Invert the input value</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If enabled:
The positive process voltage will be interpreted as 'Logical Zero'.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI: Invert the sign of the input value</td>
<td>disabled</td>
<td>DMI, STI – PDP parameters</td>
</tr>
<tr>
<td>STI: Invert the sign of the input value</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If enabled:
The process voltage on the sign-bit is interpreted as a positive value.

<table>
<thead>
<tr>
<th>DMI 8</th>
<th>S</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Input</td>
<td>PV</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
<td>0V</td>
<td>PV</td>
</tr>
<tr>
<td>Invert input value</td>
<td>Invert sign</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>= NO = NO</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>= YES = NO</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>= NO = YES</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>= YES = YES</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

0V = 0V; PV = Process voltage; S = Sign bit

Figure 17: Example: Inversion of DMI8

### 2.3.5 Error handling

#### 2.3.5.1 Failure of binary input boards

Boards can be set to an "out of service" state if one of the following conditions applies:
- The board has never been in service (configuration error).
- The board failed during normal operation (hardware failure, I/O bus failure etc.).
- The board has been removed, or sub-rack power is lost.

If a board is set to an "out of service" state, the configured digital measured values are set to Invalid. All DMI / STI are set faulty. The RTU500 transmits the DMI / STI values of that board to the NCC with the corresponding message and the qualifier IV = 1.

Boards can be reverted to a "service active" state during runtime if one of the following conditions applies:

- The board was replaced.
- Rack power is restored.
- The I/O bus is working properly.

When this happens, the following sequence will recover the DMIs:

1. Normalize the binary input boards.
2. Load all parameters for the configured indications (done by PDP).
3. Read all values.
4. Reset qualifier IV to 0 and transmit the actual value and qualifier status to NCC.

### 2.3.5.2 Dynamic qualifier changes

A DMV can change its qualifier status at runtime if one of the following conditions applies:

- The binary input board fails (qualifier IV = 1).
- The maximum value specified for a DMI input is exceeded (qualifier 0V = 1).
- Any digit of a BCD-coded DMI input has an invalid code > 9 (qualifier IV = 1).

### 2.4 Processing bitstring inputs

RTU500 series is able to read and convert the following bit patterns into a bitstring inputs (BSI):

- 8-bit bitstring (BSI8)
- 16-bit bitstring (BSI16)
- 32-bit bitstring (BSI32)

The maximum length of a bitstring is a word value of 16 bit (= one binary input module). Double word values are not supported.

A 32-bit bitstring input is only supported by selected subdevice communication interfaces.

If an 8-bit pattern is selected the remaining 8 bit of the binary input module can be used for another digital value, for integrated totals or indications.

### 2.4.1 Function distribution

The data acquisition functions for digital measured values processed by RTU500 can be grouped into functions handled by the following elements:

- IOC of the binary input board
- Process data processing (PDP) part of the CMU
- Protocol specific communication interface part at a CMU

The data processing functions of the communication interface is described in the documentation of the specific communication protocol.
The following functions are available for binary input boards:

- Reading input register (every millisecond)
- Digital filter (contact bouncing)
- Consistency check
- Store events in FIFO with time stamp

The following functions are available for the PDPs of CMUs:

- Transmission to internal communication

### 2.4.2 Functions of binary input boards

The IOCs of binary input boards support the bit-string input (BSI) functions. The configuration parameters for each function and each BSI are loaded from PDP during start-up or in the event of a board initialization during runtime.

Binary input boards periodically take a reading all 16 inputs every millisecond, regardless of the specified data point type. The IOCs handle the necessary activities for all 16 bits within that millisecond.

#### 2.4.2.1 Blocked

Use the Blocked configuration parameter to specify blocking for a data point. Any data point configured with the Blocked configuration parameter will be blocked from transmission, and PDP will stop reporting any changes related to this data point to the NCC.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSI: Blocked</td>
<td>disabled</td>
<td>SPI, DPI, AMI, MFI, DMI, STI, ITI, BSI – PDP parameters</td>
</tr>
</tbody>
</table>

If a process data point is ‘blocked’, changes are not transmitted to the hosts.

#### 2.4.2.2 Digital filter

Use the digital filter configuration parameter to specify the number of milliseconds during which an input has to be stable before it is accepted as a new signal state.

Use the digital filter configuration parameter to prevent ordinary contact bouncing.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSI: Digital filter</td>
<td>10 ms</td>
<td>SPI, DPI, DMI, STI, ITI, BSI – PDP parameters</td>
</tr>
</tbody>
</table>

The 'digital filter' time specifies the time, an input must be stable, before the change is accepted.

Value range: 0 to 255 ms or '-' to disable

If an input channel has changed its state and should be transmitted as an event to the PDP, the time of the last edge before the filter time elapsed is used as the time stamp of the event.
SCADA functions in monitoring direction

Processing bitstring inputs

2.4.2.3 Consistency check

A BSI is a bit pattern with a length of 8 bit or 16 bit. The value is only valid if all binary channels of the BSI are valid and stable for at least the consistency check time. This is given if no input changed for the parameterized consistency check time. Any change on an input channel re-triggers the settling time.

Use the Consistency check time configuration parameter to specify the minimum settling time.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSI: Consistency check time</td>
<td>1 sec</td>
<td>DMI, STI, BSI – PDP parameters</td>
</tr>
</tbody>
</table>

An input value is valid, if there are no changes during the ‘Consistency check time’.
Value range:
0.1 to 25.5 seconds
0 or ‘-‘ means disabled.

Figure 18: Digital filter (contact bouncing)
2.4.3 **FIFO storage of binary input boards**

If a BSI has changed and has been stable for at least the consistency time, it is stored into the FIFO and transmitted to PDP.

2.4.4 **Error handling**

2.4.4.1 **Failure of binary input boards**

Boards can be set to an "out of service" state if one of the following conditions applies:

- The board has never been in service (configuration error).
- The board failed during normal operation (hardware failure, I/O bus failure etc.).
- The board has been removed, or rack power is lost.

If a board is set to an "out of service" state, the configured digital measured values are to the invalid state. All BSI are set faulty. The RTU500 transmits the BSI values of that board to the NCC with the corresponding message and the qualifier IV = 1.

Boards can be reverted to a "service active" state during runtime if one of the following conditions applies:

- The board was replaced.
- Rack power is restored.
- The I/O bus is working properly.

When this happens, the following sequence will recover the BSI's:

1. Normalize the binary input board.
2. Load all parameters for the configured indications (done by PDP).
3. Read all values.
4. Reset qualifier IV to 0 and transmit the actual value and qualifier status to NCC.

2.4.4.2 **Dynamic qualifier changes**

The qualifier status of a BSI can change at runtime if the following condition applies:

- The binary input board fails (qualifier IV = 1),

2.5 **Processing integrated totals**

2.5.1 **Types of integrated total values**

There are two types of integrated total values (ITI) defined in RTU500:

- End of period reading counters (EPR)
- Intermediate reading counters (IR)

Both types have only one source and the IR is only an intermediate value of the corresponding EPR. This means that there is one ITI, which is transmitted periodically in fixed periods.
Integrated Total Values with reset to zero at end of period
The IR reading cycle must be 1/n of the end-of-period time, e.g.:
If period = 60 min and n = 5, then IR cycle = 12 min

Figure 19: Integrated total values definition for EPR and IR

2.5.1.1 Presentation of integrated total values

Although the internal value presentation is a 32-bit signed integer, RTU500 series only supports positive ITI values on its local inputs. Therefore, ITI values within the following range are allowed:
• 0 … +2,147,483,647

2.5.2 Function distribution

The process data acquisition functions for ITIs processed by RTU500 can be grouped into functions handled by the following elements:
• IOC of the binary input boards
• Process data processing (PDP) part of the CMU
• Protocol specific communication interface part at a CMU

The data processing functions of the communication interface is described in the documentation of the specific communication protocol.

The following functions are available for binary input module:
• Reading input register (every millisecond)
• Digital filter (contact bouncing)
• Increment integration register
• Freeze integration register into relocation register

The following functions are available for the PDPs of CMUs:
• Freeze and read ITIs periodically
• Transmission to internal communication

2.5.3 Functions of binary input boards

The IOCs of the binary input module support the integrated total functions. The configuration parameters for each function are loaded from PDP during start-up or in the event of a module initialization during runtime. Parameters can be set for each input individually.
Binary input module periodically take a reading from all 16 inputs every millisecond. If the channel is configured for integrated total, a signal change of 0->1 is accepted after digital filtering to be a pulse count and increments the pulse counter register.

Whenever PDP sends a broadcast command to freeze counter values, the binary input module read the actual integration register and store the contents into the relocation register. PDP receives the frozen ITI value from the binary input module.

2.5.3.1 Blocked

Use the Blocked configuration parameter to specify blocking for a data point. Any data point configured with the Blocked configuration parameter will be blocked from transmission, and PDP will stop reporting any changes related to this data point to the NCC.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Blocked</td>
<td>disabled</td>
<td>SPI, DPI, AMI, MFI, DMI, STI, ITI, BSI – PDP parameters</td>
</tr>
</tbody>
</table>

If a process data point is ‘blocked’, changes are not transmitted to the hosts.

2.5.3.2 Digital filter

Use the digital filter configuration parameter to specify the number of milliseconds during which an input has to be stable before it is accepted as a new signal state.

Use the digital filter configuration parameter to prevent ordinary contact bouncing.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Digital filter</td>
<td>10 ms</td>
<td>SPI, DPI, DMI, STI, ITI, BSI - PDP parameters</td>
</tr>
</tbody>
</table>

The ‘digital filter’ time specifies the time an input must be stable, before the change is accepted.

Value range: 2 to 255 ms or ‘-’ to disable

If an input channel has changed its state and should be transmitted as an event to the PDP, the time of the last edge before the filter time elapsed is used as the time stamp of the event.
Figure 20: Digital filter (contact bouncing)

2.5.3.3 Integrated total frequency

The binary input boards can read ITI counter increments with a frequency of max. 120 Hz. The default value is 10 ms (necessary when normal relay contacts are used). The ratio for the 0 and 1 state should be 1:1.

<table>
<thead>
<tr>
<th>Module</th>
<th>Maximum input frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>23BE23</td>
<td>120 Hz</td>
</tr>
<tr>
<td>560BIR01</td>
<td>120 Hz</td>
</tr>
<tr>
<td>23BE40</td>
<td>25 Hz</td>
</tr>
</tbody>
</table>
### 2.5.3.4 Freeze ITI value

PDP forces periodical readings of EPR or IR. At the beginning of a forced reading, PDP sends a broadcast command to all I/O boards: “freeze ITI registers”.

Each binary input board on which ITIs are configured stores the actual content of the Integrated total register to a relocation register as part of the normal signal processing. The Integrated total register continues counting. The frozen values are transmitted to PDP afterwards.

### 2.5.3.5 Reduction factor

If function Reduction factor is enabled, each n-th pulse will be transmitted to PDP to be used in a PLC program.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Reduction factor</td>
<td>disabled</td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

If enabled:

- Each n-th pulse will be reported to the PDV,
- In order to use it in a PLC program.

Notice: The load on the internal bus.

Value range: 1 to 15 (RTU540 MIO: 1 to 65535) or '-' to disable.

**ADVICE**

This increases the load on the I/O bus.

### 2.5.4 PDP functions of the CMU

#### 2.5.4.1 Reading ITI counter values and update ITI status

A reading of ITI counter values is taken for the following periods:

- each configured IR cycle
- each configured EPR period

The frozen ITI values are read from all ITIs which are configured for the actual period. It is not necessary to have all ITIs in the same EPR periods or IR cycles.

There are some qualifier information, which inform the NCC about the quality of the ITI. These qualifiers are updated at each ITI reading.

#### 2.5.4.2 EPR / IR parameters

Use the Acquisition of end of period reading ITI configuration parameter to switch off transmission of EPR readings, or to specify the EPR period in minutes.
Use the End of period wrap around counter configuration parameter to specify that the ITI value is not reset after an EPR reading.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: End of period reading (EPR) cycle</td>
<td></td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

ITI’s are transmitted cyclicly. At the end of a period the ITI’s are set to Zero, if the parameter ‘Wrap around counter’ is not enabled. Value range depends on ‘Unit of EPR cycle’:
- 1..240 minutes
- 1..23 hours
- 1..31 days

<table>
<thead>
<tr>
<th>Parameter name</th>
<th></th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Unit of EPR cycle</td>
<td></td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

Value range minutes [min.], hour or day.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th></th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: End of period wrap around counter</td>
<td>disabled</td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

If enabled:
The ‘end of period reading’ will not reset the counter.

Use the Acquisition of intermediate reading ITI configuration parameter to switch off the transmission of IR readings, or to specify the IR period.

Use the Unit of IR cycle configuration parameter to specify whether IR period is defined in second or minute cycles.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th></th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Intermediate readings (IR) cycle</td>
<td></td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

ITI’s are transmitted cyclicly. An intermediate reading will not reset the counter. Value range depends on ‘Unit of IR cycle’ setting.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th></th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Unit of IR cycle</td>
<td></td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

Value range seconds [sec.] or Minutes [Min.], hour or day

2.5.4.3 CA qualifier flag (Counter was adjusted since last reading)

The CA qualifier flag is set in the following situations:

- The counter is restarted due to RTU500 restart.
- The time changed during the period / cycle (new time synchronization).
- The RTU500 system time has changed due to a new received time base (hard synchronization) and differs more than 5 s from the old system time.

The flag is set in the first telegram of an intermediate value (IR) and in the first telegram of an end of period value (EPR). If the EPR telegram arrives first, the qualifier is not set in the subsequent IR telegram.

2.5.4.4 IV flag (ITI is invalid)

The IV flag is set in the following situation:

- The ITI value is invalid because PDP could not receive the value from the binary input board.
2.5.4.5 **IT flag (Invalid time)**

The IT flag is set in the time information element of the ITI telegram until RTU500 has a valid system time and is synchronized after startup.

2.5.4.6 **Counter Interrogation Group**

The ITI is assigned to a Counter Interrogation Group.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Counter interrogation group</td>
<td>disabled</td>
<td>ITI - PDP parameters</td>
</tr>
</tbody>
</table>

**ADVICE**

Not all protocols are supporting interrogation groups
2.5.4.7 Spontaneous transmission after freeze

After freezing the value is transmitted spontaneously.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITI: Spontaneous transmission after freeze</td>
<td>enabled</td>
<td>ITI – PDP parameters</td>
</tr>
</tbody>
</table>

After freezing the value is transmitted spontaneously.

2.5.5 Error handling

2.5.5.1 Failure of binary input boards

Boards can be set to an "out of service" state if one of the following conditions applies:

- The board has never been in service (configuration error).
- The board failed during normal operation (hardware failure, I/O bus failure etc.).
- The board was removed, or rack power is lost.

If a board is set to an "out of service" state, the configured ITI's qualifiers are set to Invalid due to board failure. The RTU500 transmits all ITI messages of that board to the NCC with an ITI message and the qualifier IV = 1.

Boards can be reverted to a "service active" state during runtime if one of the following conditions applies:

- The board was replaced.
- Rack power is restored.
- The I/O bus is working properly.

When this happens, the following sequence will recover the pulse counter values:

1. Normalize the binary input boards.
2. Load all parameters for the configured channels (done by PDP part of CMU).
3. Read all values and update status.
4. Reset qualifiers IV for affected ITIs to 0.

2.5.5.2 Dynamic qualifier changes

The qualifier status of an integrated total value can change at runtime if the following condition applies:

- The binary input board fails (qualifier IV = 1).

2.6 Binary and analog input boards

2.6.1 Signalization of input board states

An input board can have three states:

- OK: The input board is in operating state.
- Faulty: At least one data point of the input board has configuration errors or is inoperable
- Invalid: The input board is inoperable for one of the following reasons:
  - A power loss has occurred in the rack where the input board is located.
  - The input board is missing.

The state of an input board is signalized in the system diagnosis.
2.6.2 Handling of event queue overflows

Each I/O board contains an event queue to store multiple events like process data changes. These events are read and processed by PDP. In the case of a high load on the peripheral bus or a high process data change rate of the input channels on the I/O board, the I/O board’s event queue may overflow and events may be lost.

PDP is able to detect an I/O board’s event queue overflow. If PDP detects an event queue overflow, it responds by reconfiguring the input board:

- The event queue overflow is signalized in the system diagnosis.
- All data points are set to invalid.
- The input board is normalized.
- All data points on the input board are reconfigured.
- The current values of the data points are read and transmitted to the NCC.

After reconfiguration of the input board, the data points of the input board reflect the current process state.

2.7 Direct interfacing of current and voltage transformers

The current/voltage transformer interfaces 560CVD03, 560CVD11, 500CVD21 and 500CVD90 are used for monitoring input signals from three independent phases with 3- or 4-wire connections.

The following data points are available:

<table>
<thead>
<tr>
<th>Data point</th>
<th>Object type</th>
<th>Unit</th>
<th>560CVD03</th>
<th>560CVD11</th>
<th>500CVD21</th>
<th>500CVD90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage 1-N, 2-N, 3-N</td>
<td>AMI / MFI</td>
<td>V</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Voltage 1-2, 2-3, 3-1</td>
<td>AMI / MFI</td>
<td>V</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Voltage N</td>
<td>AMI / MFI</td>
<td>V</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Voltage Line Unbalance</td>
<td>AMI / MFI</td>
<td>V</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative sequence unbalance</td>
<td>AMI / MFI</td>
<td>V</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero sequence unbalance</td>
<td>AMI / MFI</td>
<td>V</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current 1, 2, 3</td>
<td>AMI / MFI</td>
<td>A</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Current N</td>
<td>AMI / MFI</td>
<td>A</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Current Unbalance</td>
<td>AMI / MFI</td>
<td>A</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>AMI / MFI</td>
<td>Hz</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3: Data points for current/voltage transformer 560CVD03, 560CVD11, 500CVD21, 500CVD90
<table>
<thead>
<tr>
<th>Data point</th>
<th>Object type</th>
<th>Unit</th>
<th>560CVD03</th>
<th>560CVD11</th>
<th>500CVD21</th>
<th>500CVD90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active Power</td>
<td>AMI / MFI</td>
<td>W</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reactive Power</td>
<td>AMI / MFI</td>
<td>Var</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Apparent Power</td>
<td>AMI / MFI</td>
<td>VA</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Power Factor</td>
<td>AMI / MFI</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Total Harmonic Distortion Voltage</td>
<td>AMI / MFI</td>
<td>%</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Total Harmonic Distortion Voltage</td>
<td>AMI / MFI</td>
<td>%</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Total Harmonic Distortion Current</td>
<td>AMI / MFI</td>
<td>%</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phase Angle</td>
<td>AMI / MFI</td>
<td>Degree (°)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Active energy (Total)</td>
<td>ITI</td>
<td>Wh</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparent energy (Total)</td>
<td>ITI</td>
<td>Vah</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active energy (positive)</td>
<td>ITI</td>
<td>+Wh</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Active energy (negative)</td>
<td>ITI</td>
<td>-Wh</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reactive energy (Inductive)</td>
<td>ITI</td>
<td>+Varh</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Reactive energy (Capacitive)</td>
<td>ITI</td>
<td>-Varh</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phase rotation</td>
<td>SPI</td>
<td>-</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Disturbance recorder</td>
<td>FDR</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Transparent data</td>
<td>TDC</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3: Data points for current/voltage transformer 560CVD03, 560CVD11, 500CVD21, 500CVD90

Accumulated values are stored in energy registers of the 560CVD modules as Long integer values. On power up, these values are reset to zero. The accumulated values are cyclically transmitted to RTU500.
• Active energy 3-phase
• Apparent energy 3-phase
• Reactive energy (Inductive) 3-phase
• Reactive energy (Capacity) 3-phase

The current/voltage transformer interfaces 560CVD03 / 560CVD11 / 500CVD21 und 500CVD90 provide measurements of the distortion (THD) for each phase voltage and current waveform. The distortion value is output in the form of a percentage deviation from pure 50 Hz or 60 Hz sine waves, using Fast Fourier Transform algorithm (FFT):

• U1, U2, U3 % THD
• I1, I2, I3 % THD

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Abbreviation</th>
<th>Parameter range / Explanation</th>
<th>Default</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary rated voltage</td>
<td>Upr</td>
<td>10 to 550000</td>
<td>110</td>
<td>V</td>
</tr>
<tr>
<td>Primary rated current</td>
<td>Ipr</td>
<td>0 to 25000</td>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>Voltage measurement range</td>
<td>Umr</td>
<td>0.2 to 1.2</td>
<td>1.2</td>
<td>-</td>
</tr>
<tr>
<td>Current measurement range</td>
<td>Imr</td>
<td>0.01 to 1.2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Nominal frequency</td>
<td>F</td>
<td>50 or 60</td>
<td>50</td>
<td>Hz</td>
</tr>
<tr>
<td>Display Mode</td>
<td></td>
<td>Manual/Scanning Manual</td>
<td>Manual</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4: Table of 560CVD03 configuration parameters

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Abbreviation</th>
<th>Parameter range / Explanation</th>
<th>Default</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary rated voltage</td>
<td>Upr</td>
<td>10 to 550000</td>
<td>110</td>
<td>V</td>
</tr>
<tr>
<td>Primary rated current</td>
<td>Ipr</td>
<td>1 to 5000</td>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>5 to 25000</td>
<td></td>
<td>5</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Voltage measurement range</td>
<td>Umr</td>
<td>0.2 to 1.2</td>
<td>1.2</td>
<td>-</td>
</tr>
<tr>
<td>Current measurement range</td>
<td>Imr</td>
<td>0.01 to 1.2</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Nominal frequency</td>
<td>F</td>
<td>50 or 60</td>
<td>50</td>
<td>Hz</td>
</tr>
<tr>
<td>Neutral current sensing</td>
<td>Io</td>
<td>0 to 1</td>
<td>Calculated</td>
<td>-</td>
</tr>
<tr>
<td>Neutral voltage sensing</td>
<td>Vo</td>
<td>0 to 1</td>
<td>Calculated</td>
<td>-</td>
</tr>
<tr>
<td>Neutral rated voltage</td>
<td>V0 PT</td>
<td>1 to 550000</td>
<td>10</td>
<td>V</td>
</tr>
<tr>
<td>Neutral voltage measurement range</td>
<td>Uomr</td>
<td>0.2 to 1.2</td>
<td>1.2</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 5: 560CVD11 / 500CVD21 configuration parameters
Table 6: 500CVD90 configuration parameters

The measured values (AMI, MFI) are transmitted by the subdevice communication interface. All measured values represent the secondary output of the transformer.

Normalized AMI values are scaled according to following table:

<table>
<thead>
<tr>
<th>Data point</th>
<th>Normalized minimum value (-100 %)</th>
<th>Normalized maximum value (+100 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage 1-N, 2-N, 3-N</td>
<td>- (Upr * Umr) / SQRT(3)</td>
<td>+ (Upr * Umr) / SQRT(3)</td>
</tr>
<tr>
<td>Voltage 1-2, 2-3, 3-1</td>
<td>- Upr * Umr</td>
<td>+ Upr * Umr</td>
</tr>
<tr>
<td>Voltage N</td>
<td>- Upr * Umr</td>
<td>+ Upr * Umr</td>
</tr>
<tr>
<td>Voltage Line Unbalance</td>
<td>- Upr * Umr</td>
<td>+ Upr * Umr</td>
</tr>
<tr>
<td>Current 1, 2, 3</td>
<td>- Ipr * Imr</td>
<td>+ Ipr * Imr</td>
</tr>
<tr>
<td>Current N</td>
<td>- Ipr * Imr</td>
<td>+ Ipr * Imr</td>
</tr>
</tbody>
</table>

Table 7: Scaling of normalized AMI values
### Data point

<table>
<thead>
<tr>
<th>Data point</th>
<th>Normalized minimum value (-100 %)</th>
<th>Normalized maximum value (+100 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Unbalance</td>
<td>- $I_{pr} * I_{mr}$</td>
<td>$+ I_{pr} * I_{mr}$</td>
</tr>
<tr>
<td>Frequency</td>
<td>F-10 %</td>
<td>F+10 %</td>
</tr>
<tr>
<td>Active Power 1-N, 2-N, 3-N</td>
<td>- $U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
<td>$+ U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
</tr>
<tr>
<td>Active Power 1-N, 2-N, 3-N, Total</td>
<td>- $U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
<td>$+ U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
</tr>
<tr>
<td>Reactive Power 1-N, 2-N, 3-N</td>
<td>- $U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
<td>$+ U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
</tr>
<tr>
<td>Reactive Power 1-N, 2-N, 3-N, Total</td>
<td>- $U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
<td>$+ U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
</tr>
<tr>
<td>Apparent Power 1-N, 2-N, 3-N</td>
<td>- $U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
<td>$+ U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
</tr>
<tr>
<td>Apparent Power 1-N, 2-N, 3-N, Total</td>
<td>- $U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
<td>$+ U_{pr} * U_{mr} * I_{pr}$ * $I_{mr} / \sqrt{3}$</td>
</tr>
<tr>
<td>Power Factor 1, 2, 3, Total</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>Total Harmonic Distortion Voltage 1, 2, 3, N</td>
<td>0</td>
<td>+100 %</td>
</tr>
<tr>
<td>Total Harmonic Distortion Current 1, 2, 3, N</td>
<td>0</td>
<td>+100 %</td>
</tr>
<tr>
<td>Angle Phase 1, 2, 3, N</td>
<td>-180°</td>
<td>+180°</td>
</tr>
</tbody>
</table>

Table 7: Scaling of normalized AMI values

Example:

Secondary rated current = 5 A (Value range: 1 A or 5 A)

Current measurement range = 0.5 A (Value range: 0.01 A … 1.20 A)

100 % = 2.5 A (secondary)

<table>
<thead>
<tr>
<th>Tension</th>
<th>Example: 120 V Range=1.0</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower limit</td>
<td>-120 V</td>
<td>-100 %</td>
</tr>
<tr>
<td>Upper limit</td>
<td>+120 V</td>
<td>+100 %</td>
</tr>
</tbody>
</table>

Table 8: Tension scaling

Nominal frequency (560CVD configuration parameter)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Example: 50 Hz Nominal frequency</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal frequency * 90 %</td>
<td>45 Hz</td>
<td>-100 %</td>
</tr>
<tr>
<td>Nominal frequency * 90 %</td>
<td>50 Hz</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 9: Nominal frequency scaling
SCADA functions in monitoring direction

Direct interfacing of current and voltage transformers

SCADA functions in monitoring direction

Direct interfacing of current and voltage transformers

**Nominal frequency scaling**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Example: 50 Hz Nominal frequency</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal frequency * 110 %</td>
<td>55 Hz</td>
<td>+100 %</td>
</tr>
</tbody>
</table>

Table 9: Nominal frequency scaling

The power factor (phases 1, 2, 3, and Total) is also a normalized value:

<table>
<thead>
<tr>
<th>Power factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1,000</td>
<td>-100 %</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>+1,000</td>
<td>+100 %</td>
</tr>
</tbody>
</table>

Table 10: Power factor scaling

Total Harmonic Distortion THD (V and C, Phase 1, 2, 3 and N) is transmitted in percentage as a normalized value:

<table>
<thead>
<tr>
<th>THD</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>100.0 %</td>
<td>+100 %</td>
</tr>
</tbody>
</table>

Table 11: Total Harmonic Distortion (THD) scaling
Figure 22: Power measurement conventions
All energy values are cyclically requested by the RTU500 subdevice communication interface and transmitted as Integrated Total Information (ITI).
### SCADA functions in monitoring direction

#### Logic functions

The logic functions of RTU500 allow deriving virtual process information from process information and system events using logical operations, such as AND, OR, Dynamic OR, or NOR.

- OR groups (>=)
- AND groups (&)
- NOR groups
- Dynamic OR groups
- Security indication
- Security alarm

A group information is a single-point information (SPI) data object. It is calculated from other SPIs or system events (SEV) or in case of a security indication and a security alarm Security Events by logical operations.

A group information data object can be generated from all single-point information SPI and SEV processed in RTU500. Group information can also serve as an input to another group information.

The number of input signals per group information is limited to 32 signals.

Group information output is communicated in the form of an SPI event to the internal communication. Calculation is event-driven, i.e., every change of an input object leads to a recalculation of the derived process information object. Calculation is based on the type of logical function as configured for the selected input objects of the SPI or SEV type.

The time of the input signal forcing the new event message will be used as the time stamp of the event.

#### 2.8 OR group

The output signal of an OR group is set to 1 if at least one input signal is set to 1. The first signal that is set to 1 forces transmission of the OR group signal.

The output signal of an OR group is set to 0 if all input signals are 0. The trailing edge of the last signal that is set to 0 forces transmission of the OR group signal.

#### 2.8.2 AND group

The output signal of an AND group is set to 1 if all input signals are set to 1. The last input signal that is set to 1 forces transmission of the AND group signal.
The output signal of an AND group is set to 0 if at least one input signal is 0. The trailing edge of this signal forces transmission of the AND group signal.

### 2.8.3 NOR group

The output signal of a NOR group is set to 0 if at least one input signal is set to 1. The first signal that is set to 1 forces transmission of the NOR group signal.

The output signal of a NOR group is set to 1 if all input signals are 0. The trailing edge of the last signal that is set to 0 forces transmission of the NOR group signal.

### 2.8.4 DynamicOR group

The output signal of a dynamic OR group is set to 1 every time an input signal is set to 1. Each signal that is set to 1 forces transmission of the OR group signal.

The output signal of a dynamic OR group is set to 0 if all input signals are 0. The trailing edge of the last signal that is set to 0 forces transmission of the OR group signal.

### 2.8.5 Security indication and security alarm functions

These two functions differ from all other logic functions by their input parameters: Generally, these functions use security events as input parameters.

### 2.8.6 Security indication function

If one or more input security events occur, a pulse of approximately 100 ms is generated at the SPI output.

### 2.8.7 Security alarm function

A security alarm is similar to a security indication but differs from it in the following respect: Output is only triggered if an input event has occurred several times within a specified supervision time period. The event count and the supervision time can be configured in RTUtil500.

In the case of redundant CMUs, the current event count and the current elapsed time will be reset if the active CMU fails. It is therefore recommended to monitor the security event #5160 (“RTU restarted”) in order to be able to identify such a situation.

### 2.8.8 Group signal qualifier

A group signal qualifier represents the logical OR of the qualifiers of all input signals of the group information. If the state of one of the inputs does not equal OK, the output of the logic function is set to this state.
3 SCADA functions in command direction

This chapter describes the SCADA functions in command direction for the following modules:

Binary output modules:
- 560BOR01
- 23BA23 (command output supervision)
- 23BA40
- 520BOD01
- 520CSD01 (command output with command output supervision)

Analog output modules:
- 23AA21
- 520AOD01

Multiple I/O modules:
- 540CID01 (binary input, binary output, analog input and command output supervision)

The following output command types are available for the RTU500 series:

- Command Output
  - Single Command Output (SCO)
  - Double Command Output (DCO)
- Regulation Step Command Output (RCO)
- Setpoint Command Output
  - Analog Setpoint Command Output (ASO)
  - Digital Setpoint Command Output (DSO)
- Bit-string Output Command (BSO)

3.1 Function distribution

The task of command output within an RTU500 lies with the installed output boards and, if required, with the command supervision boards 23BA22 or 23BA23.

PDP monitors and coordinates the output boards.

The output boards' IOCs have the following tasks:

- Switching output relays
- Setting the analog output value
- Supervising and monitoring the hardware

During initialization, PDP uploads information on the output configured for, and wired to, each channel to the boards. The format is similar to the format used for input boards.

3.2 Command output and interlocking procedures

Commands for objects can be issued either in a single-step procedure (Direct operate) or – for requests at higher security levels – in a two-step procedure (Select before operate). The two-step procedure significantly decreases the risk of errors in command direction.
### Command output and interlocking procedures

#### SCADA functions in command direction

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select before operate only</td>
<td>disabled</td>
<td>SCO, DCO, RCO, ASO, DSO - PDP parameters</td>
</tr>
</tbody>
</table>

If enabled:
- Only Two Step Commands are accepted.
- The time between 'Select' and 'Execute' must not exceed 20 seconds.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select before operate timeout</td>
<td>20 sec</td>
<td>RTU - parameter</td>
</tr>
</tbody>
</table>

Maximum time a command is selected. With expiration of the timeout, a selection is reset. Value range: 1 to 120 seconds.

If PDP receives a SELECT command, it checks whether the object is available and that there is no reservation for another object exists. If these checks are successful, PDP acknowledges the reservation with a positive confirmation. The reservation is valid for 20 s. Within that time window, PDP should receive either the corresponding EXECUTE command or a DESELECT command. If PDP receives no such command, it clears the reservation of the object.

If PDP receives an EXECUTE command within the allowed time, it checks if the referring object equals the reserved object. If both objects are identical, the command is executed. If the objects differ, PDP rejects the EXECUTE command and sends a negative confirmation. The command procedure is complete once the activation termination for that command is transmitted.

While a command object is selected, no other command objects within the interlocking scope of the selected one can be selected. Other selections will be rejected. If no object is selected, multiple process command objects may be executed in parallel using direct operate procedure.

The scope of command selection interlocking depends on the setting of the Process command interlocking mode configuration parameter.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process command interlocking mode</td>
<td>Interlocking per I/O device, I/O bus and group</td>
<td>RTU - Parameters</td>
</tr>
</tbody>
</table>

Interlocking mode for commands to be used by SCIs, IObus and PLC. Depending on the selection, commands are interlocked against each other within groups or on object level.
- If value ‘Configured’ is selected, ‘1 of n control group’ parameter of command data points are editable to assign commands to project specific ‘1 of n control groups’.
- Selection values ‘with command priority’ allow originators with higher priority (e.g. HCIs with lower host number) to break a selection of a ‘1 of n control group’ by a originator of lower priority.

- Interlocking per I/O device, I/O bus and group (default setting)
  - The selection is interlocked against other commands of the same I/O bus segment and the same command group (possible command groups are object commands, regulation step command, and setpoint commands).
- Interlocking per object / Interlocking per object with command priority
  - The selection is interlocked against the same object only.
- Global / Global with command priority
  - If this mode is selected, only one command can be operated at a time independent of the type of command. As long as a command is in operation any further command operation will be rejected.
• Configured / Configured with command priority
If this mode is selected, process commands can be assigned to 1 out of n control groups (command parameter: 1 out of n control group). The user has now the full flexibility to assign commands to 1 out of n control groups. As long as a command is in operation any further command of the same group will be rejected. Commands not assigned to any configuration are interlocked only on object basis.

• With command priority
Interlocking can be interrupted by a command from an originator (e.g. HCI, PLC, Integrated HMI) of a higher command priority. HCIs with the lowest host numbers have the highest priorities, followed by PLCs, Integrated HMIs and RTU500 series Web servers. Select and execute commands can break the selection.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 of n control group</td>
<td>disabled</td>
<td>SCO, DCO, RCO, ASO, DSO, FSO, BSO – General parameter</td>
</tr>
</tbody>
</table>

Specifies the ‘1 of n control group’ a command is assigned to, if process command interlocking mode ‘Configured’ or ‘Configured with priority’ is selected.
Value range: 1..200, 0 means disabled.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhibit timeout</td>
<td>disabled</td>
<td>RTU - Parameters</td>
</tr>
</tbody>
</table>

Inhibition time specifies how long further commands to the same group are rejected after previous successful execution of a command.
Value range: 1..30 sec, 0 means disabled.

If a process command is rejected because of a selection mismatch or a pending command confirmation, PDP sends a system event SEV#242 .. SEV#260: Process command collision with command of X to the originator of the rejected command. The SEVs contain information about the originator that issued the command causing rejection.

### 3.3 Object command output

The following options are available for object command outputs (SCO or DCO):

• Object command outputs can be wired for 1-pole, 1.5-pole, and 2-pole switching.
• Object command outputs allow additional 1-out-of-n checks (command supervision).
• Object command outputs for 1.5-pole and 2-pole switching allow two-step commands (Select before operate procedure, SBO).
• Object command outputs allow command termination by means of a response indication.
• Object command outputs allow persistent output.

#### 3.3.1 Single-object command output (SCO)

A single-object command has only one output relay. It can be configured as one of the following output types:

• Pulse ON command
• Pulse OFF command
• Persistent output

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCO: Output type</td>
<td>Only On</td>
<td>SCO – PDP parameters</td>
</tr>
</tbody>
</table>

PERSISTENT: The ON will close the relay, the OFF will open it again.
ONLY ON: Only a ON-command is accepted.
ONLY OFF: Only a OFF-command is accepted
Single-object commands can be wired with one relay contact per command (1-pole connection) or with two relay contacts per command (2-pole connection).

Single-object commands are pulse outputs. Use the Command pulse length configuration parameter to specify the command pulse length. Only the configured direction is used for pulse output. The direction not included in the configuration is ignored. A single-object command occupies one relay of a binary output board.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCO: Command pulse length</td>
<td>1 sec</td>
<td>SCO, DCO, RCO - PDP parameters</td>
</tr>
</tbody>
</table>

Execution time of the ONLY ON/ ONLY OFF command. Value range: 0.1 to 25.5 sec, in steps of 100 ms.

Interposing relays

Figure 23: Single-object command definition: Pulse output

Single-object commands are configurable as persistent output. In persistent mode, an ON command switches the relay to persistent ON. The OFF command switches the relay to persistent OFF.

Interposing relays

Figure 24: Single-object command definition: Persistent output

### 3.3.2 Double object command output (DCO)

A double object command has two independent output relays:

- one relay for ON direction
- one relay for OFF direction

Double object commands can be wired with one relay contact per command (1-pole connection) or with two relay contacts per command (2-pole connection).

Double object commands can be pulse outputs. Use the Command pulse length configuration parameter to specify pulse length. Only one channel ON or OFF can be active at the same time. The two relays occupy two consecutive bits within an output board. The ON relay is typically on an odd channel (1, 3, 5 …). The OFF relay is typically on an even channel (2, 4, 6 …).

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCO: Command pulse length</td>
<td>1 sec</td>
<td>SCO, DCO, RCO - PDP parameters</td>
</tr>
</tbody>
</table>

Execution time of the command. Value range: 0.1 to 25.5 sec in steps of 100 ms.
3.3.3 Termination of command output by response indication

The pulse length of an object command can be limited to the runtime of the switching device (e.g., an isolator). PDP uses the new position indication to identify runtime termination. A command release delay time can be specified to prevent the command from stopping before the new position is settled.

Use the Process information configuration parameter to specify the use of a response indication for each object command.

Use the Command release delay time configuration parameter to specify the response delay time. The default value is 200 ms.
3.3.4 Object command output without supervision

The output board takes care of the final output by switching the output relay(s). Binary output boards monitor and check an output using the following methods:

- Reading back the output bit pattern from the relay coil driver
- Supervising the 24 V DC voltage switching the output relays
- Monitoring the output pulse time
- Indicating the command state by LEDs

Fig. 27 shows the generic wiring for object commands (1-pole connection).

2-pole connections require two relays per command direction. The binary output board takes care of switching the relays (e.g., k1 and k9; see Fig. 28).

Configuring 2-pole connections allows the mixed use of object commands and regulation step commands on the same board.
SCADA functions in command direction

Object command output

Figure 27: Process commands without supervision (1-pole connection)

Figure 28: Process commands without supervision (2-pole)

PDP coordinates the command flow on the output board. The interaction is shown in Fig. 29.
If a process command is received to switch the selected output channel, an output request is sent to the assigned output board.
The software on the output board performs the following steps:
1. Verify that no other output is active.
2. Switch the selected output relay.
3. Start the output pulse timer.
4. Transmit a positive acknowledge ("output active") to PDP.
5. Switch off the output relay when pulse time elapses.
6. Transmit "output deactivated" to PDP.

PDP monitors the output commands. If PDP does not receive the acknowledge information within time, it will stop the output by forcing the output board to stop. The binary output board acknowledges "output active" and sends an activation confirmation to the NCC.

RTU560 receives an output command. It checks the command for plausibility and whether no output is active. If both conditions are fulfilled, PDP transmits the command to the relevant binary output board, along with the value of the pulse time parameter.

The binary output board checks the received command. If the condition is fulfilled, it activates an output channel.

The binary output board starts a timer using the received pulse time length and the indicated value of the Output active flag to PDP.

Once the pulse time has elapsed, the binary output board switches off the output channel. The binary output board signals the Output deactivated flag to PDP. PDP receives the Output deactivated signal and resets the Output active flag. PDP is ready to receive a new command.

**3.3.5 1-out-of-n checks for object commands**

To lower the risk of more than one interposing relay being switched at a time when a command is given, a 1-out-of-n check function can be added to an object command.

"Fig. 30: Object command output with supervision (1.5-pole)" and "Fig. 31: Object command output with supervision (2-pole)" show the generic wiring between the output board and the additionally required command supervision board.
SCADA functions in command direction

Object command output

1-out-of-n check circuit
P1 / P2

UD = Process voltage for switching interposing relays

*) = 1.5-pole object command is also possible if only R1 or R2 is wired. The other route may be used for other commands.

To other output boards of the same of the same relay type

Interposing relays

Figure 30: Object command output with supervision (1.5-pole)
**Figure 31: Object command output with supervision (2-pole)**

- UD = Process voltage for switching interposing relays
- *) = only 2-pole object command is possible if wired for 1-out-of-n check.
SCADA functions in command direction

Object command output

1KGT 150 944 V004 1

Figure 32: PDP interaction: Object command output with command supervision

PDP coordinates the two output boards. The interaction is shown in Fig. 32.

When a process command is received, the output relay is first switched with a pulse time signal with a length greater than the configured output pulse length for that channel.

After the output board has acknowledged that the output relay is switched on, the command supervision board is started. The command supervision board checks the output circuit. If the check result is positive, it performs the final output using the configured time for that channel.

The binary output boards 23BA23/ 520CSD01 allows the checking of two different output circuits with different nominal resistances. However, only one channel (P1 or P2) can be active at a time. If the binary output board 23BA23/520CSD01 receives a request to check, and switch, a command on P1 or P2, it performs the following steps:

1. Verify that no other output is active.
2. Select P1 or P2 for checking.
3. Start measuring the resistance on the switched output channel (interposing relay).
4. Compare the measured resistance value against the upper and lower limits defined in the configuration parameters.
5. If the resistance value exceeds the defined limits: Abort all activities and transmit a negative acknowledge.
6. If the result of the resistance check is positive: Switch the auxiliary relays from "TEST" to "SWITCH" position.
7. Start the output pulse by switching the "GO" relays feeding the process voltage to the selected interposing relay.
8. Start the output pulse timer.

RTU560 checks the command for plausibility and whether no output is active. If both conditions are fulfilled, PDP transmits the command to the relevant binary output board, along with a value of the pulse time parameter greater than the configuration value.

PDP sends the Output active signal. PDP starts the command supervision board using a pulse time parameter value. The command supervision board starts a 1-out-of-n check. If the check result is positive, the command supervision board starts the output and the output pulse timer.

Once the pulse time has elapsed, the command supervision board switches off the GO relay. The command supervision board sends the Output deactivated signal to PDP.

PDP sends the Output stop signal to the binary output board. The binary output board switches off the corresponding output channel. The binary output board sends the Output deactivated signal to PDP. PDP resets the Output active flag. PDP is ready to receive a new command.
9 Transmit a positive acknowledge ("command running") to PDP.
10 Switch off the "GO" relay when the pulse time elapsed.
11 Switch the auxiliary relays back to "TEST" position.
12 Transmit "command stopped" to PDP

PDP then stops the output board by a stop command. The PDP part of the CPU monitors the output commands. If it does not receive the acknowledge information within a defined time frame, it will stop the output by forcing the command supervision board to reset and the output board to stop the output.

The mapping of the upper and lower resistance limits to the supervision board and the output board needs to be defined using the relevant configuration parameter for each channel on the command supervision board.

Two command supervision channels (CSC P1 / CSC P2) can be defined on each command supervision board. The binary output board 23BA20 / 520BOD01 allows to select which command supervision channel monitors the board. For 1.5-pole connections, two channels can be selected (relays 1-8 and relays 9-16). Command supervision is valid for all SCO and DCO commands on this board.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check circuit number</td>
<td>1</td>
<td>CSC - General parameter</td>
</tr>
<tr>
<td>Low limit resistance</td>
<td>100 Ohm</td>
<td>CSC - General parameter</td>
</tr>
<tr>
<td>Low limit resistance</td>
<td>100 Ohm</td>
<td>CSC - General parameter</td>
</tr>
<tr>
<td>High limit resistance</td>
<td>10000 Ohm</td>
<td>CSC - General parameter</td>
</tr>
<tr>
<td>High limit resistance</td>
<td>10000 Ohm</td>
<td>CSC - General parameter</td>
</tr>
</tbody>
</table>

A command supervision channel can be configured for any SCO / DCO inside the same RTU.

3.3.6 LOCAL mode on binary output board 23BA22/23BA23

The front panel of the binary output board 23BA22 / 23BA23 includes the LOC push button to activate LOCAL mode. LOCAL mode prevents the board from any active output.

An LED indicates the activity status of the LOCAL mode. To switch from REMOTE to LOCAL mode and vice versa, press the push button twice within 5 seconds. If the push button is pressed once, the LOC LED flashes for five seconds.

While LOCAL mode is active, the binary output board 23BA22 / 23BA23 discards any command and returns negative acknowledgements. The position of the LOCAL / REMOTE switch is sent to the NCC with SEV #64 to #95.
If the LOC push button is pressed twice again, the binary output board 23BA22 / 23BA23 switches back to remote mode and will accept and handle commands in the normal way.

3.3.7 Object command output limitations

Depending on the selected object command output board, the following limitations apply:

<table>
<thead>
<tr>
<th>Module</th>
<th>1-pole without supervision</th>
<th>2-pole without supervision</th>
<th>1.5-pole with supervision</th>
<th>2-pole with supervision</th>
</tr>
</thead>
<tbody>
<tr>
<td>23BA20</td>
<td>X</td>
<td>X</td>
<td></td>
<td>• with 23BA23</td>
</tr>
<tr>
<td>560BOR01</td>
<td>X</td>
<td>X</td>
<td></td>
<td>• with 23BA23</td>
</tr>
<tr>
<td>23BA40</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>520BOD01</td>
<td>X</td>
<td>X</td>
<td>• with 520CSD01</td>
<td>• with 520CSD01</td>
</tr>
<tr>
<td>520CSD01</td>
<td>X</td>
<td>• onboard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>540CID01</td>
<td>X</td>
<td>X</td>
<td>• onboard</td>
<td></td>
</tr>
</tbody>
</table>

3.4 Regulation step command output

The following features / limitations apply to regulation step command output (RCO):
- It can be wired for 1-pole and 1-pole switching.
- It allows one- and two-step commands ("Select before operate" procedure).
- It cannot be wired to a command supervision board.
- It cannot be terminated by a response indication.

Use the command pulse length configuration parameter to specify the pulse length of an object command. The pulse length is the same for both HIGHER and LOWER.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCO: Command pulse length</td>
<td>1 sec</td>
<td>SCO, DCO, RCO - PDP parameters</td>
</tr>
</tbody>
</table>

Execution time of the command.
Value range: 0.1 to 25.5 sec, in steps of 100 ms

The definition of the bit position for ON (HIGHER) and OFF (LOWER) can be changed for the entire configuration. If a bit position is changed, this definition is valid for DPI, DCO and RCO commands.
### 3.4.1 Re-triggering regulation commands

The output pulse length of a regulation command can be expanded if PDP receives the same command within the output pulse time and is able to send it to the output board before the time elapsed. The binary output board restarts the timer.

It is also possible to shorten an output pulse using a new command and the DEACTIVATION flag. If a DEACTIVATION flag is received, execution of the current regulation command is aborted. Support depends on the communication protocol.

![Diagram of re-triggering regulation commands]

Figure 33: Re-triggering / Stopping regulation commands

### 3.4.3 Regulation command output limitations

Depending on the selected output board, the following limitations apply:

<table>
<thead>
<tr>
<th>Module</th>
<th>Regulation command, 1 pole</th>
<th>Regulation command, 2 pole</th>
</tr>
</thead>
<tbody>
<tr>
<td>23BA20</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>560BOR01</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change ON and OFF connection point of DPI, DCO and RCO</td>
<td>disabled</td>
<td>RTU - parameter</td>
</tr>
</tbody>
</table>

Valid for local DPI, DCO and RCO only.

If enabled:

Connection points (CP) for ON and OFF
are changed according to standard:
ON: odd CP = 1, 3, 5, ...
OFF: even CP = 2, 4, 6, ...
### 3.5 Setpoint command output

A setpoint command is specified by an analog or digital setpoint value output. Output is possible with or without strobe.

For a strobe output, the value is valid for the receiving unit during the additional strobe pulse output.

One- or two-step commands are possible.

The following setpoint command types are available:

- Analog output value (ASO / FSO)
  Analog output channel on an analog output board (current or voltage output)
- Digital output value (DSO)
  Digital output on a binary output board

#### 3.5.1 Analog setpoint command output (ASO/ FSO)

Analog setpoint command output (ASO/ FSO) is possible with strobe or without strobe. Strobe output allows triggering of the relevant unit when a new value is received. If no strobe output is required, the setpoint command can be run without strobe.

#### 3.5.2 Bipolar, Unipolar and Live Zero conversion

Analog output boards convert analog output values to analog output signals.

Use the Output signal type configuration parameter to specify unipolar output signals. If this parameter is enabled, negative ASO / FSO values will be set to zero.

PDP transforms output signals with Live Zero presentation (default = 4.20 mA) as follows:

- 0 % of the normalized ASO / FSO value are converted to 20 % of the output signal range (default: 4 mA)
- 100 % of the normalized ASO / FSO value are converted to 100 % of the input signal range (default: 20 mA)
### 3.5.3 Scaling

PDP converts the value of a normalized ASO or scaled FSO.

Use the Conversion factor configuration parameter to specify the percentage of the maximum output signal that is defined as 100% of the normalized ASO value/maximum FSO value.

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion factor</td>
<td>100 %</td>
<td>AMI, MFI, ASO, FSO – PDP parameters</td>
</tr>
</tbody>
</table>

value range: 1 ... 100 %
### Normalized ASO value

![Normalized ASO value diagram]

#### Figure 35: Analog value conversion ASO / FSO

For FSO, use the Maximum float value and Minimum float value configuration parameters to specify the allowed value range (-100 % ... 100 %).

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Default</th>
<th>Parameter location</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSO: Min. float value</td>
<td>-100.0</td>
<td>MFI, FSO – PDP parameters</td>
</tr>
<tr>
<td>This value corresponds to -100% of the internal representation. Value range: -3.4e38 ... 3.4e38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSO: Max. float value</td>
<td>+100.0</td>
<td>MFI, FSO – PDP parameters</td>
</tr>
<tr>
<td>This value corresponds to +100% of the internal representation. Value range: -3.4e38 ... 3.4e38</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 3.5.4 Analog setpoint command output without strobe

The analog output stays stable until a new ASO is received.

#### 3.5.5 Analog setpoint command output with strobe

Use the Strobe (SOC) configuration parameter to specify the corresponding output channel of a binary output board for strobe output.

Use the Pulse length configuration parameter to specify the pulse length of the strobe. The default value is 500 ms.

ASO must be configured to an analog output board.
### 3.5.6 Digital setpoint command output (DSO)

A digital setpoint command output (DSO) is an output of a normalized value on a binary output board. The following types are possible:

- Digital setpoint output 8-bit (DSO8)
- Digital setpoint output 16-bit (DSO16)

The RTU500 supports conversions of the following data types:
• Binary data (BIN)
• Binary coded decimals (BCD)
• Gray code (GRAY)

The maximum length of a digital measured value is a word value of 16 bit (= one binary output board). Double word values are not supported.

### 3.5.7 Digital setpoint value presentation

PDP allows the conversion of digital setpoint values to different data type presentations:

![Diagram](image)

**Conversion by PDP**

| a) | 16 - bit binary data unsigned |
| b) | 15 - bit binary data with sign |
| c) | 8 - bit binary data unsigned |
| d) | 7 - bit binary data with sign |
| e) | 4 - decade BCD unsigned |
| f) | 4 - decade BCD with sign |
| g) | 2 - decade BCD unsigned |
| h) | 2 - decade BCD with sign |
| i) | 16 - bit gray code unsigned |
| j) | 15 - bit gray code with signed |
| k) | 8 - bit gray code unsigned |
| l) | 7 - bit gray code with signed |

[S] = Sign bit / Sign position

Figure 37: Digital setpoint value output (DSO) presentation

### 3.5.7.1 Scaling and format conversion

PDP on the binary output board 23BA20 / 23BA40 converts digital setpoint output from normalized values (+/-100 %) to a bit-pattern output.

Use the DSO value presentation and Output signal type configuration parameter to specify the DSO type connected to the binary output board 23BA20 / 23BA40.

PDP receives the bit pattern of the DMV.

Use the Maximum value configuration parameter to specify the binary value output for 100 % of the DSO value.
3.5.8 Digital setpoint command without strobe

The pulse length of a digital setpoint without strobe signal is fixed to 500 ms.

3.5.9 Digital setpoint command with strobe

Use the Strobe (SOC) configuration parameter to specify the corresponding output channel of a binary output board for strobe output.

Use the Pulse length configuration parameter to specify the pulse length of the strobe. The default value is 500 ms.

DSO must be configured to a binary output board. SOC and DSO8 can be located on the same binary output board.

PDP coordinates the output of the digital output value and the strobe pulse. There is a delay of approx. 50 ms between the output of the digital value and the strobe. This delay allows the value to become stable. The digital outputs are switched off at the end.
3.5.10 Setpoint output limitations

Depending on the selected output board, the following limitations apply:

<table>
<thead>
<tr>
<th>Module</th>
<th>Without strobe</th>
<th>With strobe</th>
</tr>
</thead>
<tbody>
<tr>
<td>23AA21</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>520AOD01</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 12: Analog setpoint output limitations

<table>
<thead>
<tr>
<th>Module</th>
<th>8-bit (DSO8)</th>
<th>16-bit (DSO16)</th>
<th>Without strobe</th>
<th>With strobe</th>
</tr>
</thead>
<tbody>
<tr>
<td>23BA20</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>560BOR01</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>23BA40</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>520BOD01</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>520CSD01</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.6 Bit-string output

3.6.1 Functionality

A bit-string output (BSO) is a persistent output on a binary output board.

The following types are possible:

- Bit-string output 1-bit (BSO1)
- Bit-string output 2-bit (BSO2)
- Bit-string output 8-bit (BSO8)
- Bit-string output 16-bit (BSO16)

Bit-string output values are transparently mapped output channels. The output value is switched on the output board and remains stable until a new value is received from NCC for this output channel.

The maximum length of a digital measured value is a word value of 16 bit (= one binary output board). Double word values are not supported.

3.6.2 Error handling

Failure of output boards

Boards can be set to an "out of service" state if one of the following conditions applies:

- The board has never been in service (configuration error).
- The board failed during normal operation (hardware failure, I/O bus failure etc.).
- The board was removed, or rack power is lost.

If a board is set to an "out of service" state, the configured output channels are set to Faulty due to board failure in the database. The RTU500 indicates that to the NCC with diagnostic message.

Boards can be reverted to a "service active" state during runtime if one of the following conditions applies:

- The board is replaced.
- Rack power is restored.
- The I/O bus is working properly.

If this happens, the following sequence will recover the output channels:

1. Normalize the output board.
2. Load all parameters for configured channels by PDP.
3. Clear faulty state in database and update NCC.

3.6.3 Bit-string output limitations

Depending on the selected output board, the following limitations apply:

<table>
<thead>
<tr>
<th>Module</th>
<th>1-bit</th>
<th>2-bit</th>
<th>8-bit</th>
<th>16-bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>540CID01</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
3.7 Binary output, analog output and command supervision boards

3.7.1 Signalization of output board state

An output board can have one of the following states:

- OK: The output board is in operating state.
- Faulty: At least one data point of the output board has configuration errors or is inoperable.
- Invalid: The output board is inoperable for one of the following reasons:
  - A power loss has occurred in the rack where the output board is located.
  - The output board is missing.

The state of an output board is signalized in the system diagnosis.

3.7.2 Handling of event queue overflows

Each I/O board contains an event queue to store multiple events like output state messages. These events are read and processed by PDP. In the case of a high load on the peripheral bus, the I/O board’s event queue may overflow and events may be lost.

PDP is able to detect an I/O board’s event queue overflow. If PDP detects an event queue overflow, it responds by reconfiguring the output board:

- The event queue overflow is signalized in the system diagnosis.
- All data points are set to invalid.
- The output board is normalized.
- All data points on the output board are reconfigured.
Binary output, analog output and command supervision boards

SCADA functions in command direction
## Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>Alternating Current</td>
</tr>
<tr>
<td>AMI</td>
<td>Analog Measured value Input</td>
</tr>
<tr>
<td>ASO</td>
<td>Analog Setpoint command Output</td>
</tr>
<tr>
<td>BSI</td>
<td>Bit String Input</td>
</tr>
<tr>
<td>BSO</td>
<td>Bit String Output</td>
</tr>
<tr>
<td>CMU</td>
<td>Communication and Data Processing Unit</td>
</tr>
<tr>
<td>CSC</td>
<td>Command Supervision Channel</td>
</tr>
<tr>
<td>DC</td>
<td>Direct Current</td>
</tr>
<tr>
<td>DCO</td>
<td>Double Command Output</td>
</tr>
<tr>
<td>DMI</td>
<td>Digital Measured value Input (8, 16 bit)</td>
</tr>
<tr>
<td>DO</td>
<td>Digital Output</td>
</tr>
<tr>
<td>DPI</td>
<td>Double Point Input</td>
</tr>
<tr>
<td>DSO</td>
<td>Digital Setpoint command Output (8, 16 bit)</td>
</tr>
<tr>
<td>FDR</td>
<td>File transfer directory</td>
</tr>
<tr>
<td>FSO</td>
<td>Floating Setpoint Command Output</td>
</tr>
<tr>
<td>HCI</td>
<td>Human Maschine Interface (here Integrated HMI function of the RTU500 series)</td>
</tr>
<tr>
<td>IOC</td>
<td>I/O Controller (Controller on I/O Board)</td>
</tr>
<tr>
<td>ITI</td>
<td>Integrated Totals Input</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>MAX</td>
<td>Maximum</td>
</tr>
<tr>
<td>MFI</td>
<td>Analog Measured value Floating Input</td>
</tr>
<tr>
<td>Min</td>
<td>Minimum</td>
</tr>
<tr>
<td>MS</td>
<td>Microsoft</td>
</tr>
<tr>
<td>NCC</td>
<td>Network Control Center</td>
</tr>
<tr>
<td>PDP</td>
<td>Process Data Processing</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable Logic Control</td>
</tr>
<tr>
<td>RCO</td>
<td>Regulation step Command Output</td>
</tr>
<tr>
<td>RTU</td>
<td>Remote Terminal Unit</td>
</tr>
<tr>
<td>SBO</td>
<td>Select before Operate</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervision, Control and Data Acquisition</td>
</tr>
<tr>
<td>SCO</td>
<td>Single Command Output</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>SEV</td>
<td>System Event</td>
</tr>
<tr>
<td>SOC</td>
<td>Strobe Output Channel</td>
</tr>
<tr>
<td>SPI</td>
<td>Single Point Input or Single point information</td>
</tr>
<tr>
<td>STI</td>
<td>Step position Input</td>
</tr>
<tr>
<td>TDC</td>
<td>Transparent Data Communication</td>
</tr>
</tbody>
</table>
Note:

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