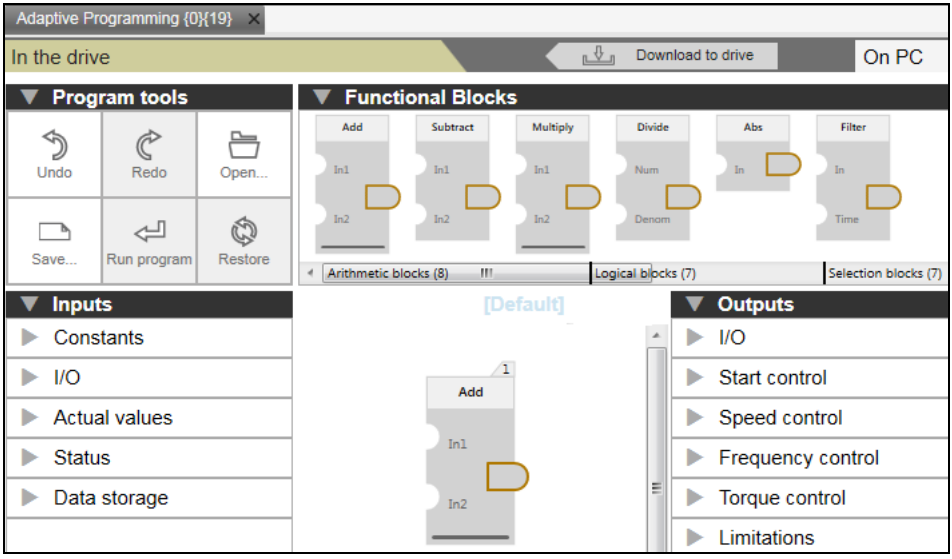
ABB industrial drives

Application guide
Adaptive Programming



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List of related manuals

Drive firmware manuals	Code (English)
ACS880 primary control program firmware manual	*3AUA0000085967*
ACS380 machinery control program firmware manual	*3AXD50000029275*

Option manuals	
Drive composer start-up and maintenance PC tool User's manual	*3AUA0000094606*

You can find manuals and other product documents in PDF format on the Internet. See section *Document library on the Internet* on the inside of the back cover. For manuals not available in the Document library, contact your local ABB representative.

Application guide

Adaptive Programming

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Further information

1

Introduction to the guide

Contents of this chapter

This chapter gives general information on the guide.

Applicability

This guide applies to the following drive programs and software. For version details, see the *Compatibility* list:

- ACS880 primary control program
- ACS380 machinery control program
- Drive composer pro

Compatibility

This guide complies with the following drive application programs in which the Adaptive programming feature is included.

Drive application programs	Version	Other details
ACS880 primary control program	2.20 or later	-
ACS380 machinery control program	1.60 or later	-
Drive composer pro	1.9 or later	Microsoft Windows 7 or newer

Note: The available features may differ depending on both the Drive composer pro and drive versions

Safety instructions

Follow all safety instructions delivered with the drive.

- Read the complete safety instructions before you install, commission, or use the drive. The complete safety instructions are delivered with the drive as either part of the Hardware manual, or, in the case of ACS880 multidrives, as a separate document.
- Read the software function specific warnings and notes before changing the default settings of the function. For each function, the warnings and notes are given in the Firmware Manual in the subsection describing the related user adjustable parameters.

Target audience

This guide is intended for people who design, commission, or operate the drive system.

Purpose of the guide

This guide is used together with the firmware manual of the drive application program.The firmware manual contains basic information on drive parameters including the parameters needed for Adaptive programming.

This guide gives the following information on Adaptive programming:

- what is Adaptive programming
- how to build a adaptive program
- how the function blocks operate
- how to use the system inputs and outputs
- how to use the program states

Contents of the guide

This guide contains the following chapters:

Adaptive programming provides the overview on Adaptive programming.

Using PC tool interface describes the user interface elements for creating an Adaptive program in the PC tool software.

Creating an Adaptive program describes how to create a base program and a sequence program. It also describes how to download the program to the drive.

Program elements describes the function blocks used for Adaptive programming.

Related documents

See the *List of related manuals* on the inside of the front cover.

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Adaptive programming

Contents of this chapter

This chapter provides an overview of Adaptive programming and how to use the Adaptive program.

Overview of Adaptive programming

Adaptive programming is used to customize the operation of a drive in case the drive parameter setting is not sufficient. The Adaptive program is built with standard function blocks included in the drive firmware. The program consists of the following elements:

- A predefined list of inputs for getting information from the drive parameters to use in the Adaptive program.
- A predefined list of outputs that defines parameters where it is possible to write from the Adaptive program.
- A collection of states in which each state has its own block program, including inputs, outputs and state transition elements

Standard function blocks (for example ADD, AND) are used to create an executable Adaptive program. The maximum size of an Adaptive program is approximately 20 standard function blocks, depending on the block types used and the number of predefined inputs and outputs utilized in the program. The standard function blocks available are presented in *Program elements* (page *31*). Numerical function blocks use floating point numbers in the calculations.

Adaptive program is created using the Drive composer pro software with which the program can be downloaded to the drive and started. By default, Adaptive program is started when the drive is powered On, if the program already exists in the drive.

See the below sections on how to use the Adaptive program.

Creating a sequence program

Adaptive program consists of a collection of states for creating a sequence program. When the program is running, there is always one state active and the corresponding program is executed until another state is active. In addition to the states there is also a base program that executes in parallel to the active state.

The state changes are controlled with state transition elements that can be connected to function block outputs. State transition takes place after the full execution cycle of the program during which the value of any corresponding output becomes true. In case multiple state transitions are true during a single execution cycle, then the one that is connected to the smallest numbered block is triggered. See the example program execution.

See also *Creating a sequence program* on page *26* and *Downloading the adaptive program* on page *28*.

Connecting the Adaptive program to a drive application

Adaptive program is connected to a drive application through predefined system inputs and outputs. Drive provides the available inputs and outputs and sets the pointer parameter values accordingly based on the created program.

When the predefined output (value/bit pointer parameter) is written to from the Adaptive program, the parameter is write protected and it is not changed in the parameter table. The control panel and Drive composer pro shows a text in the pointer parameter to indicate that the parameter is connected to the Adaptive program.

Enabling/disabling Adaptive program

The Adaptive program function can be enabled or disabled with the drive parameter *96.70 Disable Adaptive program*.

When Adaptive program is enabled, the program can be put to running mode in the following conditions:

- when drive is powered On
- after a macro/user set is changed
- after a restore operation
- when a clear all and restore to defaults parameter operation (large parameter operations) is done
- when a run command is given from the PC tool.

When Adaptive program is disabled, the situation is similar to a drive without Adaptive program. The following operations are not possible:

- Adaptive program cannot be put to running mode when the drive is powered On
- Adaptive program cannot be edited or put to running mode from Drive composer pro.

Executing the Adaptive program

Adaptive program is executed on firmware time level. The parameter *7.30 Adaptive program status* shows the status of the Adaptive program. The program can be edited only when the drive is in Stopped state. While editing the program, the Start inhibit is On, so that the drive cannot be started.

Note: For time level actual value, refer firmware manual(s) in the *List of related manuals*.

The Adaptive program executes the function blocks in numerical order with all blocks on the same time level. This cannot be changed by the user. The user can only do the following tasks:

- build a program using the standard blocks and connections
- change the numbering of the blocks by moving them to different positions
- select the operation mode of the program (run/edit).

If Adaptive program in the drive is not compatible or corrupted, the fault *64A6h Adaptive program* is activated. The extension code of the fault explains the detail of the problem with the Adaptive program.

Creating a backup/restore

Adaptive program can be saved to the backup file and restored. The program starts automatically after the restore operation, unless the parameter *96.70 Disable Adaptive program* has such a value that after the restore operation the Adaptive program shall not be put to running mode.

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Using PC tool interface

Contents of this chapter

This chapter describes the main user interface elements of PC tool for Adaptive programming.

Adaptive programming user interface

The main user interface of Adaptive programming consists of the following sections:

- *Base and sequence programs*
- *Program tools*
- *Functional blocks*
- *Inputs*
- *Outputs*
- *Sequence states*
- *State transition*.

The working area can be used either with tab or floating window. The selection between tab and floating window can be made using Drive composer pro **View** menu. The figure below shows the user interface with tabbed window.

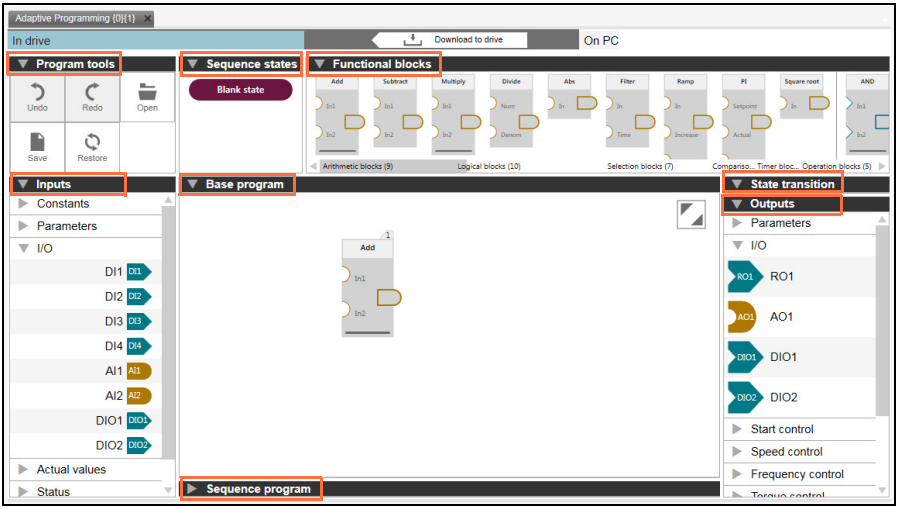

Figure 1. Adaptive programming user interface

Base and sequence programs

There are separate canvases for creating base and sequence programs. The required canvas can be expanded or collapsed. See the above Adaptive programming user interface.

- The base program canvas can be used to create a base program with function blocks. The user can drag and drop the desired function blocks to build a base program. See *Creating a base program* on page *24*.
- The sequence program canvas can be used to create a sequence program. The user can drag and drop the desired amount of states to build a sequence program. See *Creating a sequence program* on page *26*.

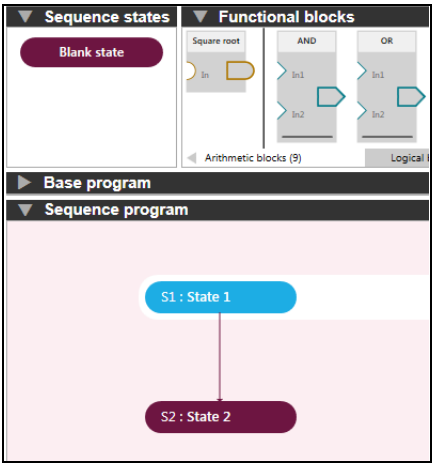

Figure 2. Sequence program user interface

Program tools

The program tools contains the following options:

- Undo: Erases the last change made and reverts it to an older state
- Redo: Reverses the undo or advances to a more current state
- Open: Opens a program from locally saved file
- Save: Saves the active program to a local file (*.dcap* format)
- Restore: Restores the default program.

See *Adaptive programming user interface* on page *16*.

Functional blocks

Functional blocks of Adaptive programming are grouped into categories and are shown on a horizontal shelf. The scroll bar shows category labels and indicates the current view. The blocks are quickly accessible. The user can drag and drop the required blocks to the canvas. See *Adaptive programming user interface* on page *16*.

The functional block consists of the following categories:

- Arithmetic blocks
- Logical blocks
- Selection blocks
- Comparison blocks
- Timer blocks
- Operation blocks.

Inputs

The pre-defined inputs are categorized into groups. Note that the available groups and inputs are dependent on the drive type. Typical examples are:

- Constants
- I/O
- Actual values.

The same input can be used multiple times in the same program. Hovering over an input on the shelf highlights every instance of that input on the canvas, so you can easily locate where the input is used in the program.

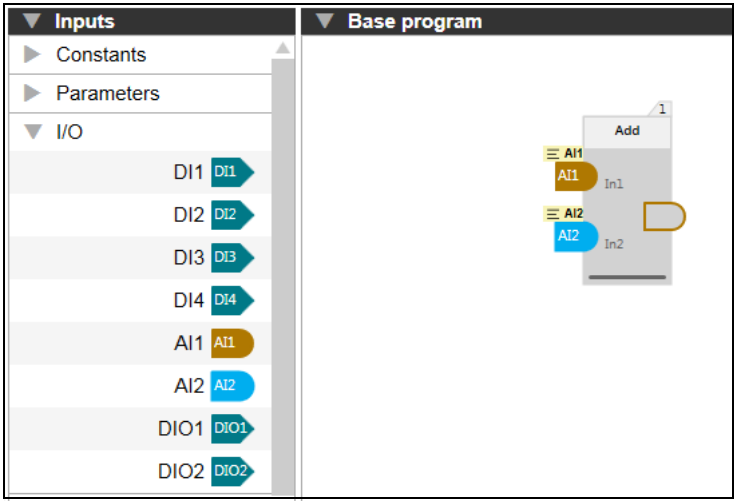

Figure 3. Inputs

Editing the input labels

You can edit the input labels and add a comment.

1. Click DI label in the functional block input.

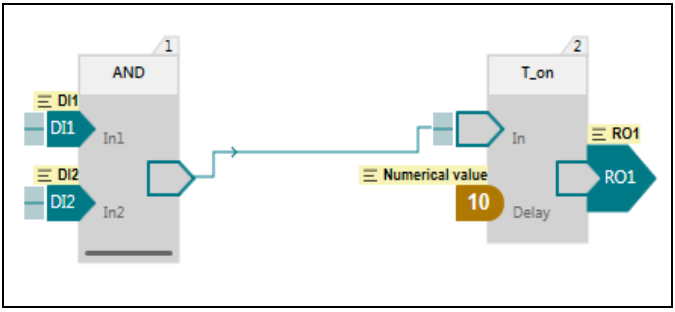

Figure 4. Editing label

2. Edit the label and add the comment as desired.

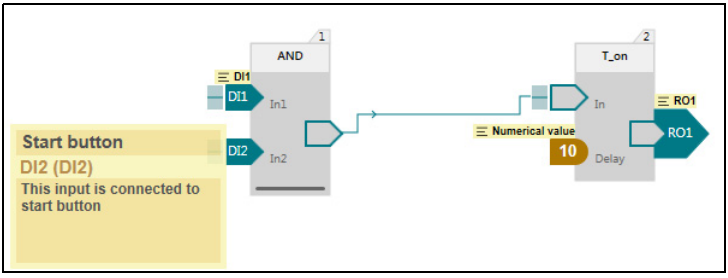

Figure 5. Editing label and comment

For more information on Input descriptions, refer firmware manual(s) in the *List of related manuals*.

Outputs

The pre-defined outputs are categorized into groups. Note that the available groups and outputs are dependent on the drive type. Typical examples are:

- Parameters
- I/O
- Start control
- Speed control.

Each output can be used only once in the program. After you drag and drop an output to the canvas, it is faded on the shelf.

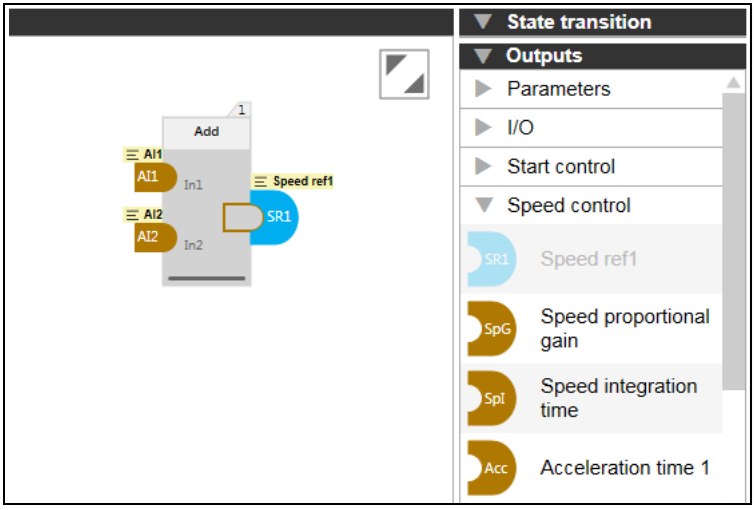

Figure 6. Outputs

For more information on output descriptions, refer firmware manual(s) in the *List of related manuals*.

Sequence states

The sequence states contains a:

- Blank state: adds a new empty state to the sequence program.

  You can drag-and-drop this empty state any number of times to the sequence program canvas and rename the state in the program.

See *Adaptive programming user interface* on page *16*.

State transition

State transition element is used to control the sequence of state transitions when connected to boolean type block outputs. There can be several state transition elements used in a single state.

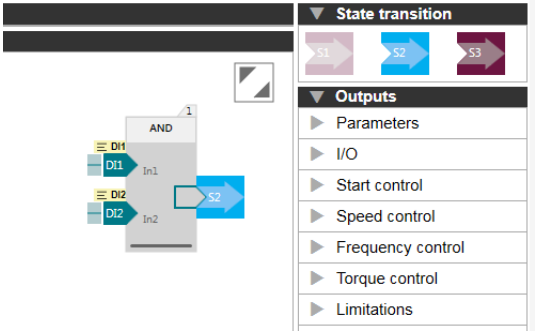

Figure 7. State transition

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Creating an Adaptive program

Contents of this chapter

This chapter describes how to create an Adaptive program and download the program to the drive.

You can do the following:

- Create a base program using function blocks. See *Creating a base program* on page *24*.
- Optionally create a sequence program using states. See *Creating a sequence program* on page *26*.
- Download the program to the drive. See *Downloading the adaptive program* on page *28*.

Creating a base program

To create a base program using function blocks, proceed as follows:

1. Drag-and-drop the desired function blocks to the base program canvas.

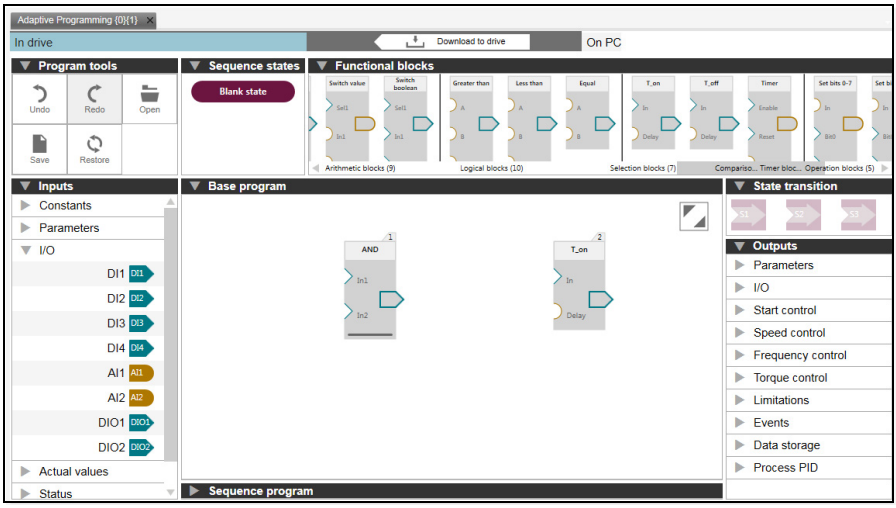


Figure 8. Function block

2. Drag-and-drop the desired inputs from the Inputs categories to the function block(s).

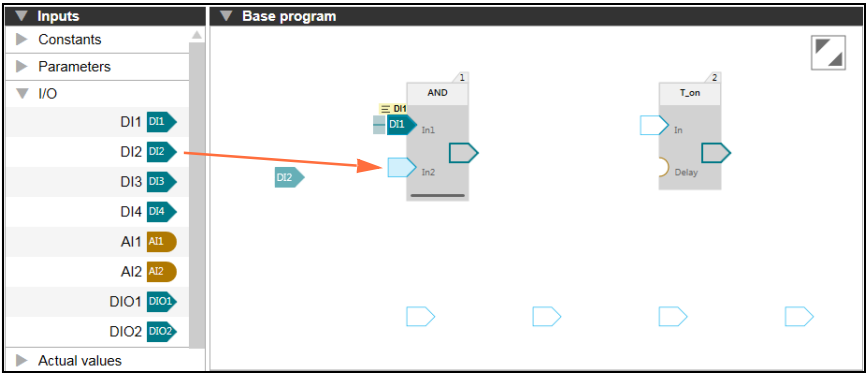


Figure 9. Adding inputs

3. Drag-and-drop the desired connections from the block outputs to other function block(s).

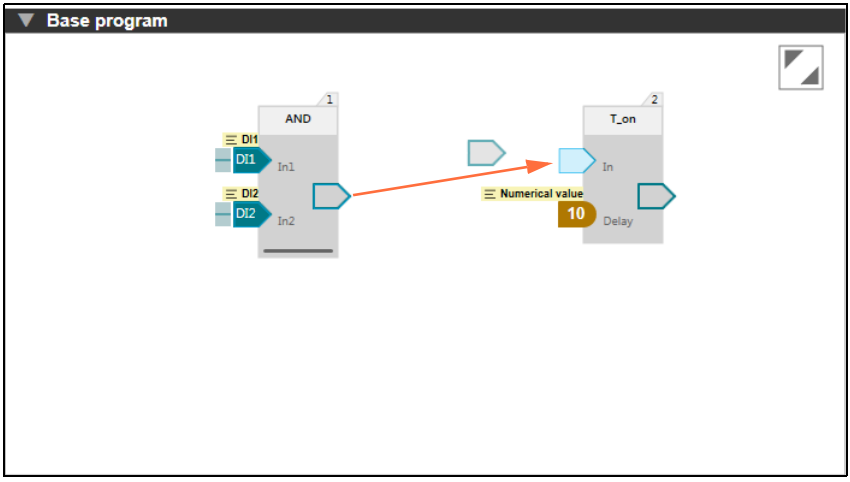


Figure 10. Adding outputs

4. Drag-and-drop the desired output from the Outputs categories to the function block(s).

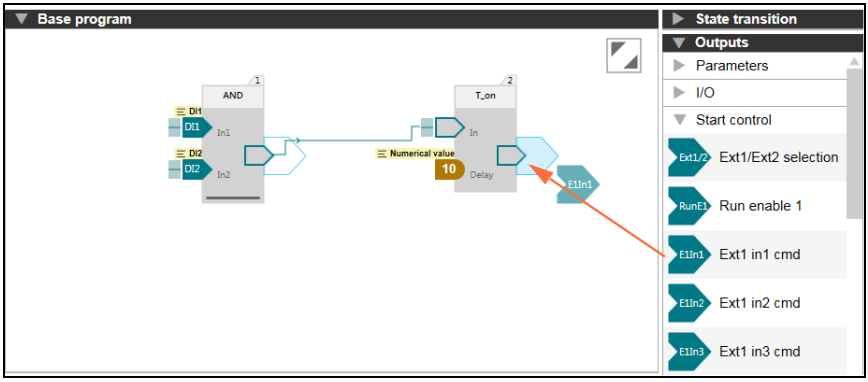


Figure 11. Adding outputs

Similarly, you can create programs as desired by adding multiple function blocks using inputs and outputs.

Creating a sequence program

To create a sequence program using states, proceed as follows:

1. Open the Sequence Program canvas.
2. Drag-and-drop the desired amount of states to the sequence.

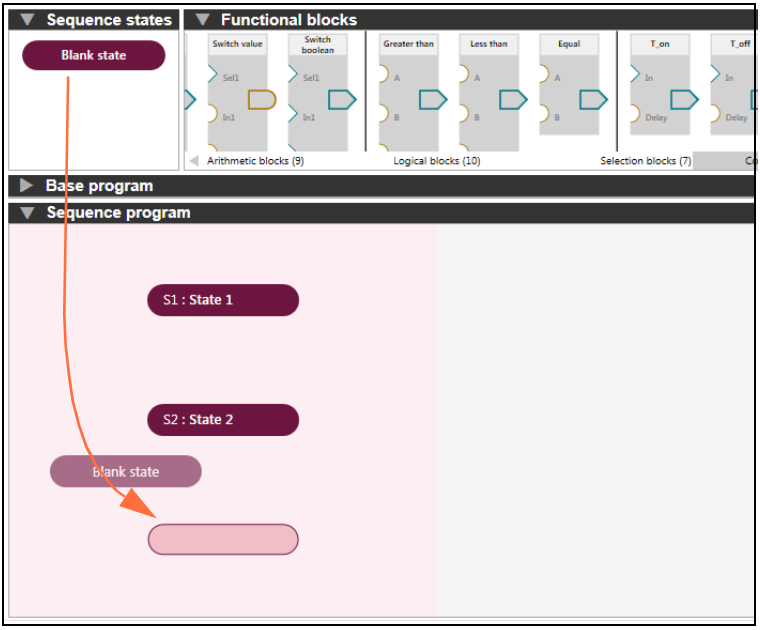


Figure 12. Sequence program states

3. Select the state and create desired block program for each state.

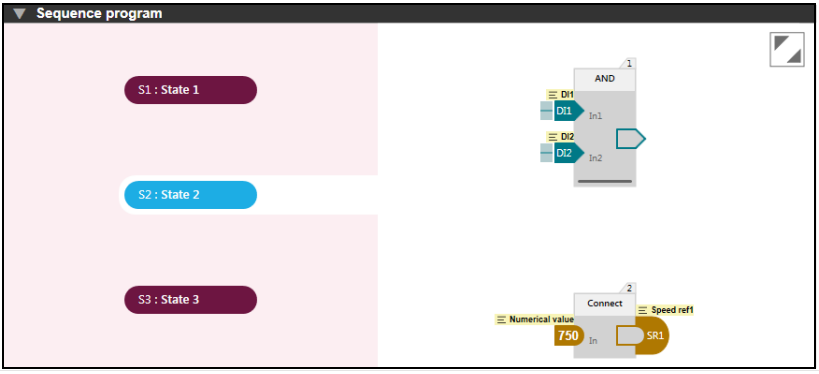


Figure 13. Block program in selected state

4. Drag-and-drop the desired state transitions to each state.

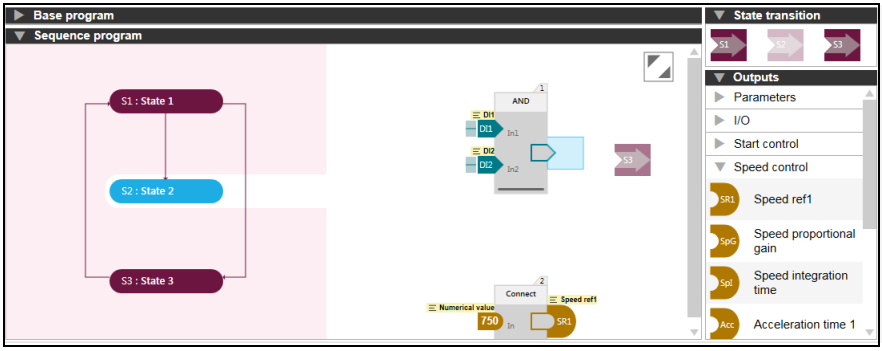


Figure 14. State transitions

Downloading the adaptive program

After creating a base program and optionally a sequence program, you can download the program to a drive and run the program.

1. Click **Download to drive**.

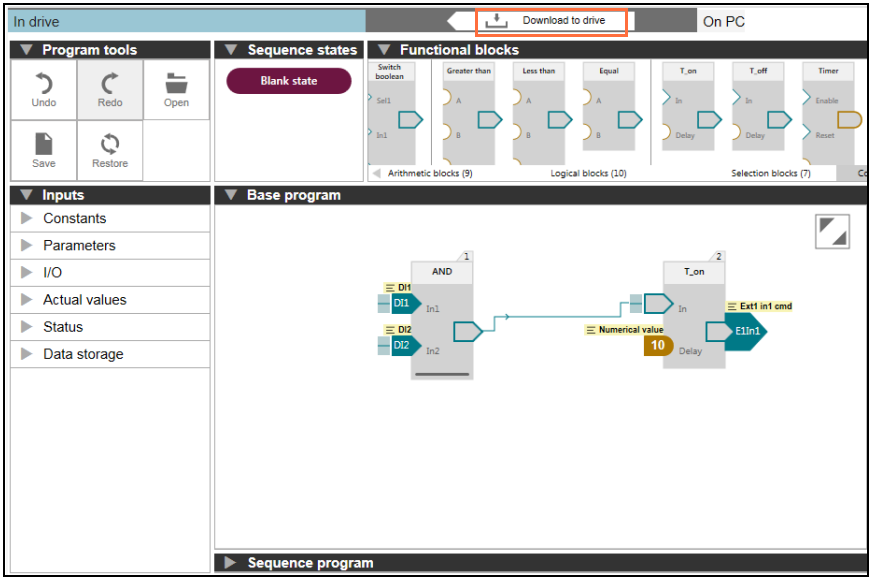


Figure 15. Downloading to drive

The program is downloaded to the drive.

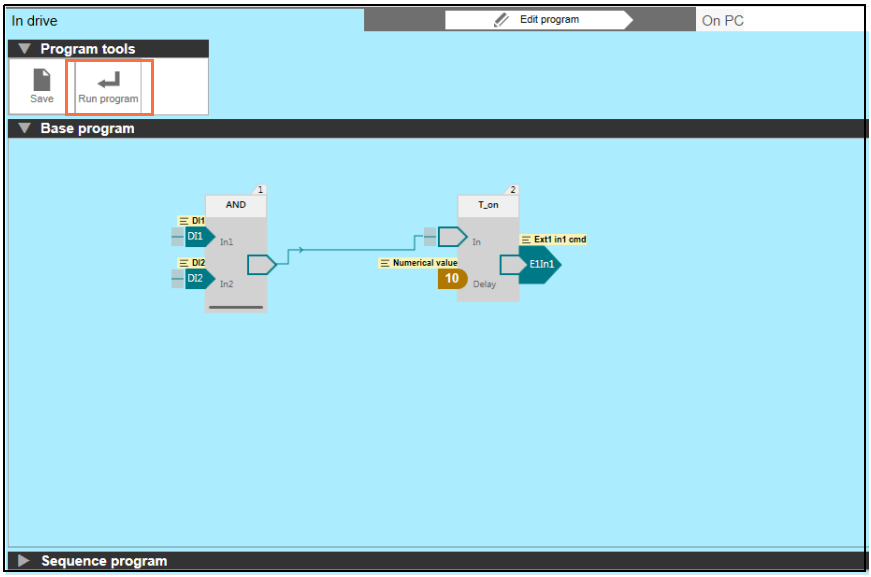


Figure 16. Program downloaded to a drive

2. In the Program tools, click **Run program** to start the program.
3. Open the **Sequence program** canvas to view the sequence program.

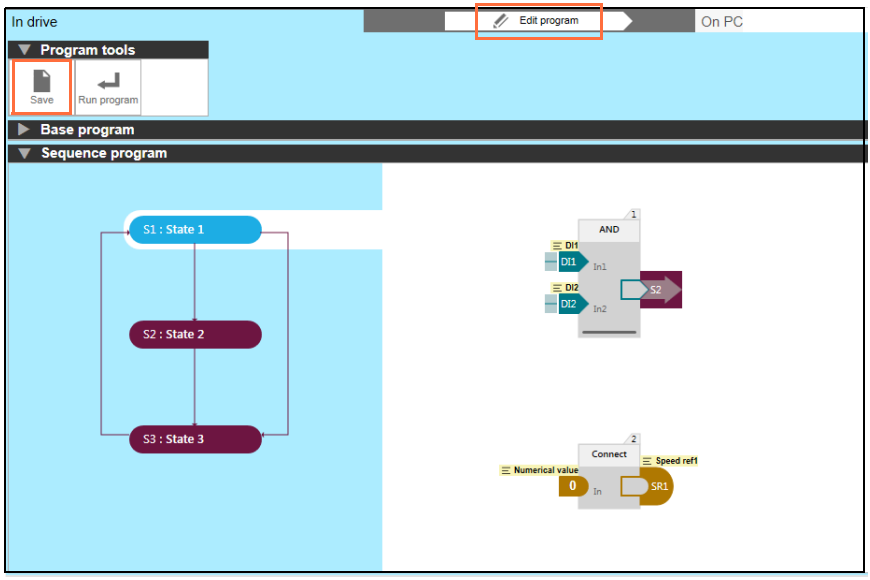


Figure 17. Sequence program

After downloading the program to the drive, you can

- click **Edit program** to stop the program and start editing
  or
- click **Save** to save the adaptive program to a local file (*.dcap* format).

5

Program elements

Contents of this chapter

This chapter describes system inputs, outputs and function blocks available in the master control program for Adaptive programming.

Note: The information in this chapter is drive-specific and should be confirmed from the respective firmware manual(s).

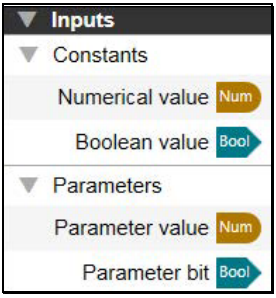
System inputs

The below mentioned system inputs are examples only.

Parameter inputs

System inputs have new type of parameter inputs.

- Boolean parameter input is for reading the value of a bit from a parameter (for example command or status word)
- Numeric parameter input is for reading the value of a parameter.



Constants

Constants consists of Numerical and Boolean constant input values. These constant inputs can be reused in different blocks by changing their values.

For example: Numerical value and Boolean value.

Inputs/outputs

Analog inputs

Analog inputs can be filtered, inverted or scaled with parameter configuration (i.e. not in Adaptive programming).

Analog inputs can be independently set as voltage or current input by a jumper. Each input can be filtered, inverted or scaled.

The drive can be set to perform an action if the value of an analog input moves out of a predefined range.

Digital inputs and outputs

Digital inputs and outputs can be set as either an input or an output.

Digital input/output DIO1 can be used as a frequency input, DIO2 as a frequency output.

For example: AI1, AI2, DI1, DI2, DIO1, DIO2 etc.

Actual values

Basic signals for monitoring the drive.

For example: Motor speed, Output frequency, Motor current and so on.

Status

Drive status word.

Example: Enabled, inhibited, Ready to start etc.

Data storage

Data storage parameters are reserved for data storage. These parameters are unconnected by default and can be used for linking, testing and commissioning purpose.

For example: Data storage 1 real32, Data storage 2 real32 etc.

For more information on Input descriptions, refer *firmware manual(s)* in *List of related manuals*.

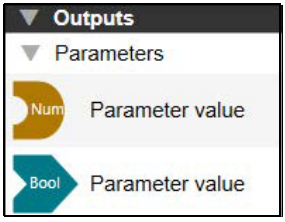
System outputs

The below mentioned system outputs are examples only.

Parameter outputs

System outputs have a new type of parameter outputs.

- Boolean parameter output is for writing a Boolean block output to a parameter. The parameter gets either value one or zero.
- Numerical parameter output is for writing a Numerical block output to a parameter.



You can select the parameter for the input or output either from a list or type the parameter manually.

Reading and writing parameters in the drive

The block output value is written to the parameter only when the value changes. The written parameter values are not saved over power down of the drive.

For efficiency, the parameter reading and writing is made in the internal format. In case of some parameters, it is possible that the block input shows a different value than the corresponding parameter.

I/O

Analog outputs

Analog outputs can be filtered, inverted or scaled with parameter configuration (i.e not in Adaptive programming).

Relay outputs

The signal to be indicated by the outputs can be selected by parameters.

Digital inputs and outputs

Digital input/output DIO1 can be used as a frequency input, DIO2 as a frequency output.

For example: AO1, AO2, RO1, RO2, RO3, DIO1 and DIO2.

Start control

Operating mode

The two external control locations, EXT1 and EXT2, are available. The user can select the sources of the start and stop commands separately for each location.

Run enable

The source of the external run enable signal. If the run enable signal is switched off, the drive will not run.

Fault reset

The drive can automatically reset itself after overcurrent, overvoltage, undervoltage and external faults.

For example: Ext1/Ext2 selection, Run enable 1, Fault reset etc.

Speed control

The output of the speed reference selection block. The motor follows a speed reference given to the drive.

For example: Speed ref1, Speed ref2 and Speed additive 1.

Frequency control

The output of the frequency reference selection block. The motor follows a frequency reference given to the drive. Frequency control is only available in scalar motor control mode.

For example: Frequency ref1, Frequency ref2 etc.

Torque control

The output of the torque reference selection block. Motor torque follows a torque reference given to the drive.

For example: Torque ref1, Torque ref2 and Torque additive 2.

Limitations

Defines the source of maximum torque limit for the drive.

For example: Minimum torque 2 and Maximum torque 2.

Events

Defines the source of external events.

For example: External event 1, External event 2 etc.

Process PID

Selects the source that determines whether process PID parameter set is used.

For example: Set 1 setpoint 1, Set 1 feedback 1, Set 1 tracking mode etc.

For more information on output descriptions, refer *firmware manual(s)* in *List of related manuals*.

Function block specifications

You can adjust the number of inputs by dragging the bottom line in the function block.

Note: Function blocks which do not contain bottom line cannot be adjusted.

Abs

Calculates absolute value.

Output:

Name	Type	Default value
Out	Float	0

Input: 1

Name	Type	Default value	Function
In	Float	0	Block input

Block function

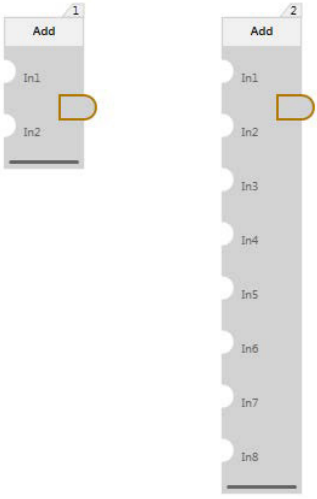
Block calculates absolute value of value in input *In*. Output = I *In* I.

Exceptional cases

Block input is not connected. Input has a default value.

Add

Adds **n** inputs and outputs result.



Output:

Name	Type	Default value
Out	Float	0

Inputs: 2-8

Default inputs: 2

Name	Type	Default value	Function
In1 - In8	Float	0	Provides values to add

Block function

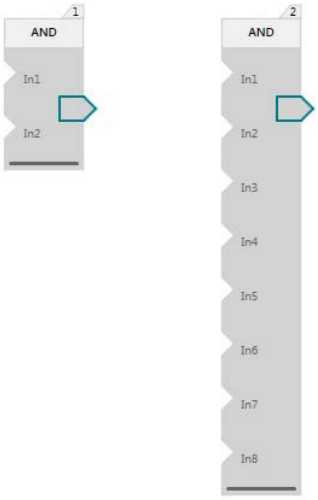
Output = In1 + In2 +...+ In8

Exceptional cases

- Inputs which are not connected are added as default value.
- Overflow to positive side: output is limited to Max float.
- Overflow to the negative side: output is limited to negative Max float.
- Underflow: value 0 is kept at output.

AND

Performs logic *AND*.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 2-8

Default inputs: 2

Name	Type	Default value	Function
In1 - In8	Boolean	N/A	Block inputs

Block function

Function block performs logical conjunction operation with inputs.

Out = In1 & In2 & … & In8.

The truth table of AND operation is below. Example uses two inputs. Same logic can be applied to other inputs. Output is 1 (true) if and only if all inputs have value 1 (true).

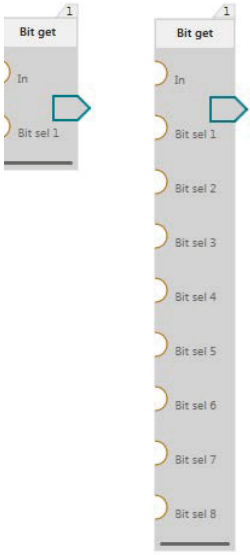
In1	In2	Out
0	0	0
0	1	0
1	0	0
1	1	1

Exceptional cases

- Inputs which are not connected have no effect on the output.
- If some inputs are connected and others are not, only the connected inputs are evaluated.

Bit get

Performs logic OR operation with selected bits from inputs.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 2-9

Name	Type	Default value	Function
In	Float	0	Value to read bits
Bit sel 1 - 8	Float	N/A	Provides number of bits to be selected from input value.

Block function

Basic functionality of the block is to get the value of the defined bit. In case several bits are defined then values of these bits are retrieved and OR operation is executed with these to get the block output value.

Bits 0 - 15 can be selected.

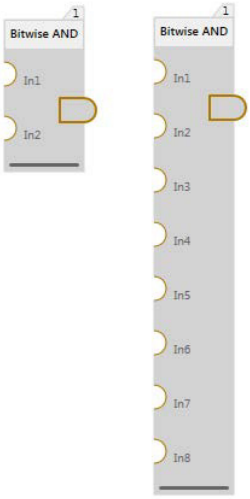
For example, in case only *Bit sel 1* is connected then Out = val1. If *Bit sel 1* and *2* are connected then Out = val1 OR val2, where val1 - value of bit selected by *Bit sel 1* input and val2 - value of bit selected by *Bit sel 2* input.

Exceptional cases

- Bit sel input is not connected. Bit defined by this input is skipped.
- If entered bit sel value > 15, bit 15 is selected.
- If bit sel < 0 then bit 0 is selected.
- If input In is not connected, it gets default value.
- An input In value that is either negative or larger than (2^31)-1 is set to default value 0.

Bitwise AND

ANDs the lowest 16 separate bits of the input values and outputs the combination as float.



Output

Name	Type	Default value
Out	Float	0

Inputs: 2-8

Name	Type	Default value	Function
In1 - In8	Float	N/A	Provides an input value.

Block function

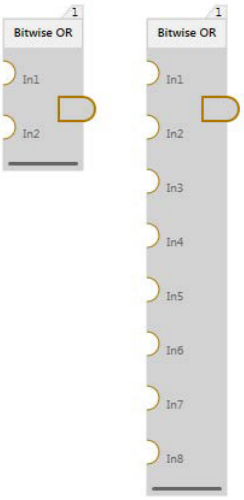
Connected inputs are rounded to the nearest integer after which the AND operation is performed on them. The lowest 16 bits of the result is taken, converted to float and written to output.

Exceptional cases

- An input value that is either negative or larger than (2^31)-1 is set to default value 0.
- If only 1 input is connected then that input is rounded and sent to the output.

Bitwise OR

ORs the lowest 16 separate bits of the input values and outputs the combination as float.



Output

Name	Type	Default value
Out	Float	0

Inputs: 2-8

Name	Type	Default value	Function
In1 - In8	Float	0	Provides an input value.

Block function

Inputs are rounded to the nearest integer after which the OR operation is performed on them. The lowest 16 bits of the result is taken, converted to float and written to output.

Exceptional cases

- An input value that is either negative or larger than (2^31)-1 is set to default value 0.
- If only 1 input is connected then that input is rounded and sent to the output.
- Disconnected inputs have default value 0.

Bitwise XOR

XORs the lowest 16 separate bits of the input values and outputs the combination as float.

Output

Name	Type	Default value
Out	Float	0

Inputs: 2

Name	Type	Default value	Function
In1	Float	0	Provides an input value.
In2	Float	0	Provides an input value.

Block function

Inputs are rounded to the nearest integer after which the XOR operation is performed on them. The lowest 16 bits of the result is taken, converted to float and written to output.

Exceptional cases

- An input value that is either negative or larger than (2^31)-1 is set to default value 0.
- If only 1 input is connected then that input is rounded and sent to the output.

Divide

Divides block inputs.

Output:

Name	Type	Default value
Out	Float	0

Inputs: 2

Name	Type	Default value	Function
Num	Float	0	Dividend
Denom	Float	0	Divisor

Block function

Output = In1 / In2

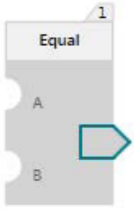
Dividing by zero will set block output to zero.

Exceptional cases

- Inputs which are not connected are assigned with default values.
- Overflow to positive side: output is limited to Max float.
- Overflow to the negative side: output is limited to negative Max float.
- Underflow: value 0 is kept at output.

Equal

Checks if values at inputs are equal.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 2

Name	Type	Default value	Function
A	Float	0	First comparison value
B	Float	0	Second comparison value

Block function

Block compares the whole number parts of numbers in A and B. Behavior of the block can be seen in table below.

Condition	Out
A and B are equal	1
A and B are not equal	0

Inputs are rounded before comparison. Only whole number part of the inputs are compared.

For example, if value 70.5 is in input, it will be compared as 71. If value 70.4 is in input it will be compared as 70. Rounding of negative numbers works as illustrated in the following example. -70.4 rounds to -70. -70.5 rounds to -71.

Exceptional cases

Inputs which are not connected will have a default value.

Filter

Filters input for a defined length of time and then outputs it.

Output:

Name	Type	Default value
Out	Float	0

Inputs: 2

Name	Type	Default value	Function
In	Float	0	Signal to be filtered
Time	Float	0	Filter time constant in seconds

Block function

This block is a single pole low - pass filter. Input signal *In* is filtered using provided time constant *Time*. The following equation is used for internal calculations.

```
Coefficient = TimeLevel / (TimeLevel + Time)
```

```
Out[i] = Coefficient * (In[i] – Out[i - 1]) + Out[i - 1]
```

Where:

Variable	Function
Out [i]	Current calculated output value
Out [i - 1]	Previous output value of the filter from previous time cycle
In [i]	Current input value
Timelevel	Value of timelevel that the program is running at.

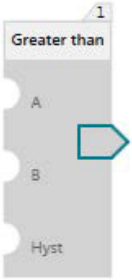
This function is a discrete model for single pole low - pass filter.

Exceptional cases

- Time constant *Time* < timelevel or negative constant is provided. Filter does not filter input signal. Input is written to output unaltered. Time constant is evaluated to 0.
- *In* is not connected - Input gets default value.
- *Time* constant is not connected - assumed to have default value.

Greater than

Comparison block. Compares values at its inputs to see if first value is greater than second. Comparison accuracy is set by the user.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 3

Name	Type	Default value	Function
A	Float	0	Provides first comparison value
B	Float	0	Provides second comparison value
Hyst	Float	0	Value B is subtracted

Block function

Takes two inputs to compare with one another, A and B, and a third input that manipulates input B.

First:

- If A > B, output is set to 1.

Second (if first is not true):

- If A < (B- Hyst) then output is reset to 0.

Third (if neither are true):

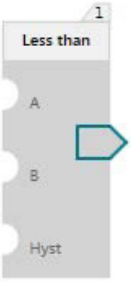
- Previous output value is kept at block output.

Exceptional cases

- When either A or B input is not connected then output is set to default value 0.
- A disconnected Hyst input has value 0.

Less than

Comparison block. Compares values at its inputs to see if first value is smaller than second. Comparison accuracy is set by the user.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 3

Name	Type	Default value	Function
A	Float	0	Provides first comparison value
B	Float	0	Provides second comparison value
Hyst	Float	0	Value that is added to B

Block function

Takes two inputs to compare with one another, A and B, and a third input that manipulates input B.

First

- If A < B, output is set to 1.

Second (if first isn't true)

- If A > (B+ Hyst) then output is reset to 0.

Third (if neither are true)

- Previous output value is kept at block output.

Exceptional cases

- When either A or B input is not connected then output is set to default value 0.
- A disconnected Hyst input has value 0.

Limit

Takes an input that is limited and outputs the value after limiting it.

Output:

Name	Type	Default value
Out	Float	0

Inputs: 3

Name	Type	Default value	Function
In	Float	0	Value to be limited.
Max	Float	3.4028235e+38	Maximum value *In* is limited
Min	Float	- 3.4028235e+38	Minimum value *In* is limited.

Block function

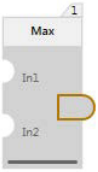
In is written to the output as long as it is within the value range of *Max* and *Min*. When *In* exceeds or falls below the respective limit values, it will first be capped to the appropriate limit value and then written to the output. *In* is evaluated first against *Max*. If *Max* is not limiting, then *In* is evaluated against *Min*.

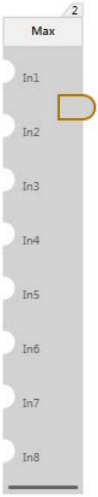
Exceptional cases

- If *In* is not connected then the block output is zero.
- If *Max* or *Min* input is not connected, then the highest and lowest float values are set as the default values for *Max* or *Min*.

Max

Compares **n** inputs and outputs the largest input value.





Output:

Name	Type	Default value
Out	Float	0

Inputs: 2-8

Default inputs: 2

Name	Type	Default value	Function
In1 - In8	Float	0	Provides an input value to compare

Block function

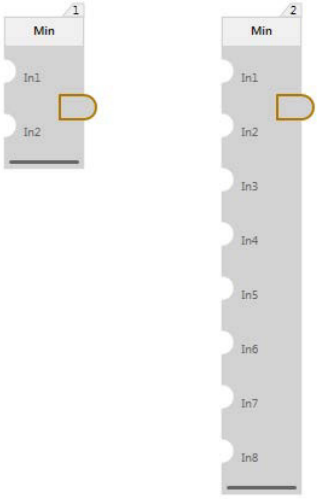
Compares all input values to determine the highest one and outputs it.

Exceptional cases

If some inputs are connected and other inputs are not connected, only the connected inputs are evaluated.

Min

Compares **n** inputs and outputs the smallest input value.



Output:

Name	Type	Default value
Out	Float	0

Inputs: 2-8

Default inputs: 2

Name	Type	Default value	Function
In - In8	Float	0	Provides an input value to be compared

Block function

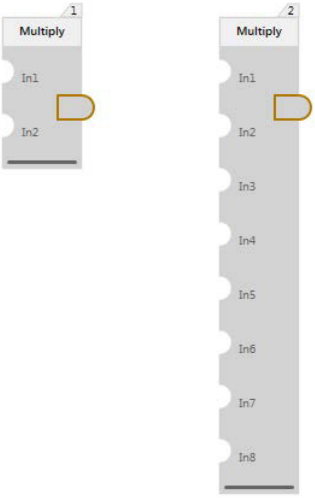
Compares all input values to determine the lowest one and outputs it.

Exceptional cases

If some inputs are connected and others are not connected, only the connected inputs are evaluated.

Multiply

Multiples **n** inputs and outputs the result.



Output:

Name	Type	Default value
Out	Float	0

Inputs: 2-8

Default inputs: 2

Name	Type	Default value	Function
In1 - In8	Float	N/A	Provides values for multiply block to perform multiplication

Block function

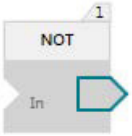
Out = In1 * In2 *...* In8

Exceptional cases

- Inputs which are not connected are not multiplied. If one input is connected, its value is at output.
- All inputs are not connected: output is assigned a default value.
- Overflow to positive side: output is limited to Max float.
- Overflow to the negative side: output is limited to negative Max float.
- Underflow: value 0 is kept at output.

NOT

Inverts value at input.



Output

Name	Type	Default value
Out	Boolean	1

Input: 1

Name	Type	Default value	Function
In	Boolean	0	Block input

Block function

Function block performs inversion.

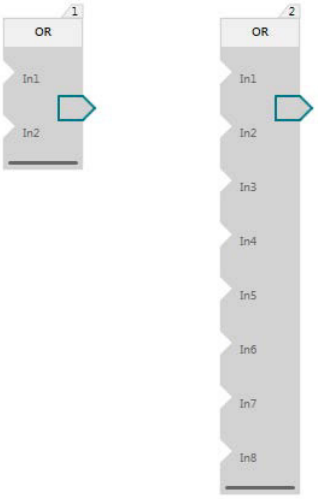
In	Out
0	1
1	0

Exceptional cases

In case a block input is not connected then its value is set to 0 by default.

OR

Performs logic *OR*.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 2-8

Default inputs: 2

Name	Type	Default value	Function
In1 - In8	Boolean	0	Block inputs

Block function

Function block performs logical or operation with inputs. Out = In1 v In2 v … v In8.

The truth table of OR operation is below. Example uses two inputs. Same logic can be applied to other inputs. Output has value 1 when one of the inputs have value 1. Output is 0 if and all inputs have value 0.

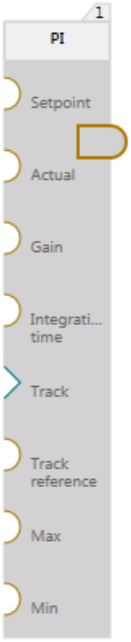
In0	In1	Out
0	0	0
0	1	1
1	0	1
1	1	1

Exceptional cases

If some inputs are connected and others are not, only the connected inputs are evaluated.

PI

PI controller.



Output:

Name	Type	Default value
Out	Float	0

Inputs: 8

Name	Type	Default value	Function
Setpoint	Float	0	Desired output value
Actual	Float	0	Actual output value
Gain	Float	0	Proportional gain (Kp)
Integration time	Float	0	Integration time in seconds (s)
Track	Boolean	0	Enables tracking mode
Track reference	Float	0	Output value in tracking mode
Min	Float	- 3.4028235e+38	Maximum output value
Max	Float	3.4028235e+38	Minimum output value

Block function

Calculates the P and I terms based on error, proportional gain and an integral coefficient. The sum of P and I is written to the output. Sets output to tracking reference value when tracking is enabled and limits the output when needed. In these cases, the I term value is maintained directly in reference to the tracking reference or limit values to provide smooth transfer/anti-windup. PI output continuous changing from track reference value when track is disabled. In the limitation, the value is evaluated first against *Max* limit. If *Max* is not limiting, then the value is evaluated against *Min* limit.

Exceptional cases

- In case a block input is not connected then its value is set to default value.
- When either *Setpoint*, *Actual* or *Gain* are not connected then output is set to 0. When *Track* is enabled and *Track reference* is not connected then output is set to 0.
- When Integration time input is not connected then integral component is reset and PI block functions as a P controller.
- When *Min* or *Max* is not connected, the default values of these inputs are used.

Ramp

Changes the output value to match the input value at a defined rate of change.

Output:

Name	Type	Default value
Out	Float	0

Inputs: 7

Name	Type	Default value	Function
In	Float	0	Reference value to ramp to output
Increase	Float	0	The amount of output increased per second
Decrease	Float	0	The amount of output decreased per second
Track	Boolean	0	Enables tracking mode
Track reference	Float	0	Output value in tracking mode
Max	Float	3.4028235e+38	Maximum value block *output will be limited*
Min	Float	- 3.4028235e+38	Minimum value block output will be limited

Block function

If output value does not equal input reference, then the output value starts changing towards the input value.

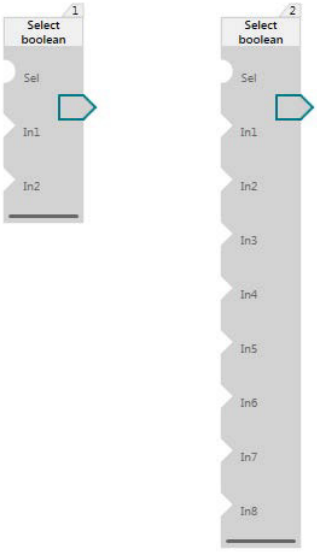
The amount of change per second is defined by the inputs for increasing and decreasing the output. Sets output to track reference value when track is enabled. Output is limited to maximum and minimum limit values. In the limitation, the output is evaluated first against *Max* limit. If *Max* is not limiting, then the output is evaluated against *Min* limit. Ramp output continues changing from tracking reference value when tracking is disabled.

Exceptional cases

- In case a block input is not connected, then its value is set to default value.
- In case, either maximum or minimum limit is disconnected, then their values will be defaulted to the highest and lowest value representable by a float.
- In case, *Increase* or *Decrease* input is disconnected then Output = *In* when trying to ramp with the disconnected input. If the other input is connected then ramping with it behaves as normal.
- In case, *In* input is disconnected then Output = 0.

Select boolean

Outputs the Boolean input value that is selected by the selector input.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 3-9

Default inputs: 3

Name	Type	Default value	Function
Sel	Float	0	Selects input value to connect to output
In1 - In8	Boolean	0	Provides selectable input value for the block.

Block function

This is a selector block that can have different input connected to output. Input to be connected is selected by *Sel* input.

When *Sel* = 1 then Out = *In1*, when *Sel* = 2 Out = *In2* etc.

When *Sel* = 8 Out = *In8*.

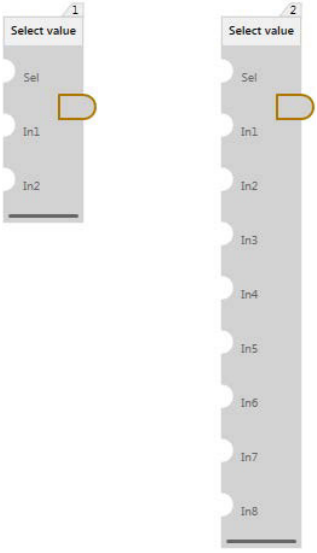
Allowable value range for *Sel* input is 1 <= *Sel* <= 8.

Exceptional cases

- When *Sel* input is out of its allowable range then Out = 0.
- Inputs which are not connected will have a default value.

Select value

Outputs the float input value that is selected by the selector input.



Output

Name	Type	Default value
Out	Float	0

Inputs: 3-9

Default inputs: 3

Name	Type	Default value	Function
Sel	Float	0	Selects input to be connect to output
In1 - In8	Float	0	Provides selectable input value for the block

Block function

This is a selector block that can have different input connected to output. Input to be connected is selected by Sel input.

When, *Sel* = 1 then Out = *In1*, and *Sel* = 2 then Out = *In2* and etc.

When, *Sel* = 8 then Out = *In8*.

Allowable value range for *Sel* input is 1 <= *Sel* <= 8.

Exceptional cases

- When *Sel* input is out of its allowable range then Output = 0.
- Inputs which are not connected will have a default value.

Set bits 0-7

Updates bits 0-7 of the input value.

Output

Name	Type	Default value
Out	Float	0

Inputs: 9

Name	Type	Default value	Function
In	Float	0	Value to be updated
Bit0	Boolean	N/A	Value of bit 0 (lowest)
Bit1	Boolean	N/A	Value of bit 1
Bit2	Boolean	N/A	Value of bit 2
Bit3	Boolean	N/A	Value of bit 3
Bit4	Boolean	N/A	Value of bit 4
Bit5	Boolean	N/A	Value of bit 5
Bit6	Boolean	N/A	Value of bit 6
Bit7	Boolean	N/A	Value of bit 7

Block function

Rounds the float input to closest integer and updates bits 0-7 of the integer value based on the boolean inputs Bit0-Bit7. Takes then the lowest 16 bits of the integer result and converts the value to float and writes it to output.

Exceptional cases

- An input value that is either negative or larger than (2^31)-1 is set to default value 0. Bits 0-7 of the default value are updated.
- If Boolean input is not connected, the value of that bit is not updated.

Set bits 8-15

Update bits 8-15 of the input value.

Output

Name	Type	Default value
Out	Float	0

Inputs: 9

Name	Type	Default value	Function
In	Float	0	Value to be updated
Bit8	Boolean	N/A	Value of bit 8
Bit9	Boolean	N/A	Value of bit 9
Bit10	Boolean	N/A	Value of bit 10
Bit11	Boolean	N/A	Value of bit 11
Bit12	Boolean	N/A	Value of bit 12
Bit13	Boolean	N/A	Value of bit 13
Bit14	Boolean	N/A	Value of bit 14
Bit15	Boolean	N/A	Value of bit 15

Block function

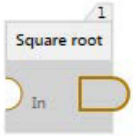
Rounds the float input to closest integer and updates bits 8-15 of the integer value based on the Boolean inputs Bit8-Bit15. Takes then the lowest 16 bits of the integer result and converts the value to float and writes it to output.

Exceptional cases

- An input value that is either negative or larger than (2^31)-1 is set to default value 0. Bits 8-15 of the default value are updated.
- If Boolean input is not connected, the value of that bit is not updated.

Square root

Calculates square root of value at input.



Output

Name	Type	Default value
Out	Float	0

Inputs: 1

Name	Type	Default value	Function
In	Float	0	Block input

Block function

Block calculates square root of input. Out = $\sqrt{In}$

Exceptional cases

- When value at the input is negative (In < 0), then Out = 0

SR

SR trigger is used to store Set value.

Output

Name	Type	Default value
Out	Boolean	0

Input: 2

Name	Type	Default value	Function
Set	Boolean	0	Set input
Reset	Boolean	0	Reset

Block function

This is SR latch. Output keeps it value once set by *Set* input. Value at output is reset to 0 when *Reset* = 1. Value at output depends on previous output value. See truth table.

Previous Out	Reset	Set	Current Out
0	0	0	0
0	0	1	1
x	1	x	0
1	0	0	1
1	0	1	1

Exceptional cases

- If *Set* is not connected, it is assumed to have default value.
- If *Reset* is not connected, it is assumed to have default value.

Subtract

Performs subtract.

Output:

Name	Type	Default value
Out	Float	0

Inputs: 2

Name	Type	Default value	Function
In1	Float	0	Value to subtract from
In2	Float	0	Value to be subtracted

Block function

Output = In1 - In2

Exceptional cases

- In case both inputs are not connected, output has a default value.
- Inputs which are not connected are assigned default value.
- Overflow to positive side: output is limited to Max float.
- Overflow to the negative side: output is limited to negative Max float.
- Underflow: value 0 is kept at output

Switch boolean

Outputs the input Boolean value whose enable value is set first.

Output:

Name	Type	Default value
Out	Boolean	0

Inputs: 3-15

Default inputs: 3

Name	Type	Default value	Function
Sel1 - Sel7	Boolean	0	Selects/deselects input value.
In1 - In7	Boolean	0	Provides selectable input value for the block.
Default	Boolean	0	Default output when Sel is not active for any inputs.

Block function

The value written to the output is “In X” value whose “Sel X” is set first. If no “Sel X” is set then *Default* input is written to the output.

Example:

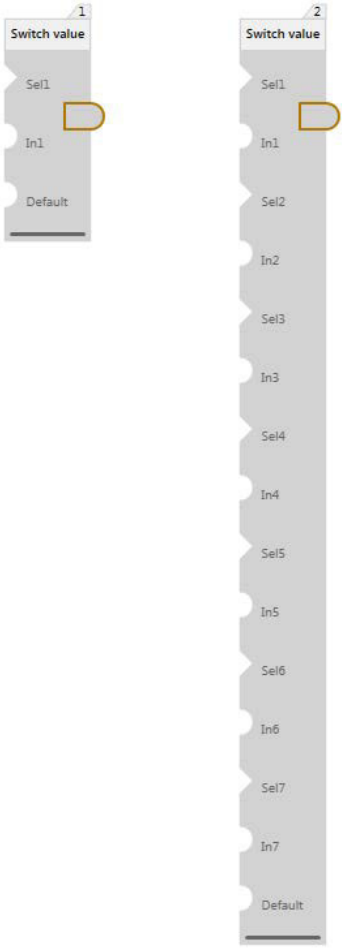
Multiple Sel inputs have value 1. Inputs are evaluated from top to bottom. In case of multiple *In*, Sel pairs *In1, Sel1* is checked first followed by *In2, Sel2* and etc. In case Multiple Sel inputs are 1 the first one will be connected to output. In this example, if both *Sel1* and *Sel 2* are 1 then *In1* is connected to output.

Exceptional cases

Inputs which are not connected will have a default value.

Switch value

Outputs the input float value whose enable value is set first.



Output:

Name	Type	Default value
Out	Float	0

Inputs: 3-15

Default inputs: 3

Name	Type	Default value	Function
Sel1 - Sel7	Boolean	0	Selects/deselects input value
In1 - In7	Float	0	Provides selectable input value for the block
Default	Float	0	Default, that is, connected to output when no Sel is 1

Block function

The value written to the output is “In X” value whose “Sel X” is set first. If no “Sel X” is set, then the *Default* input is written to the output.

Example:

Multiple Sel inputs have value 1. Inputs are evaluated from top to bottom. In case of multiple *In*, Sel pairs *In1*, *Sel1* is checked first followed by *In2*, *Sel2* etc. In case Multiple Sel inputs are 1, the first one will be connected to output. In this example, if both *Sel1* and *Sel2* are 1 then *In1* is connected to output.

Exceptional cases

- Inputs which are not connected will have a default value.

Timer

Runs through states at the speed of timer values defined at the inputs. Outputs the current state. The timers can be paused and the state can be reset.

Output

Name	Type	Default value
Out	Float	1

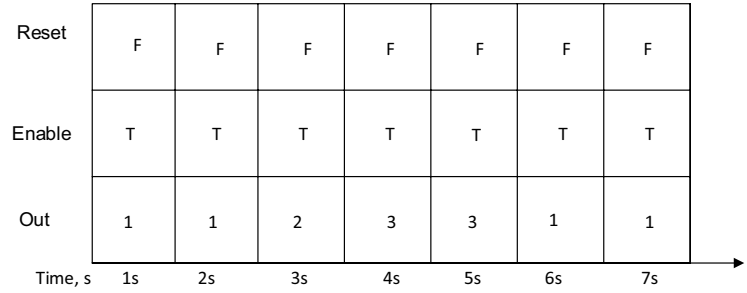
Inputs: 4-10

Default inputs: 4

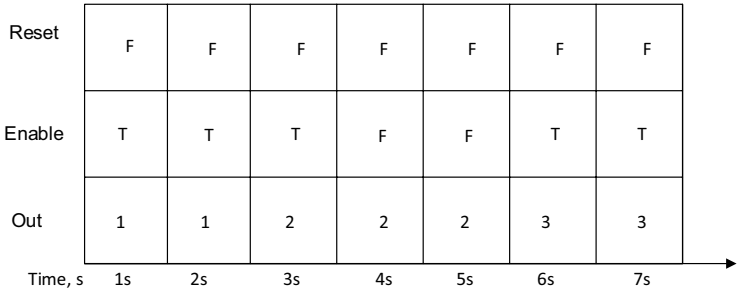
Name	Type	Default value	Function
Enable	Boolean	0	Enables/disables timer.
Reset	Boolean	0	Resets time when rising edge is detected on input.
Time1 - Time8	Float	0	Provides time in state, time value is in seconds.

Block function

Timer block is a state machine that goes through states. The time block stays in each state is specified by time inputs Time1 - Time8. Minimal number of time inputs is 2. When timer starts, it is in state 1 and block output is 1. Timer stays in this state for the time specified in input Time1. When this time is passed, the timer block switches to the next state. This behavior of normal operation is illustrated below. Reset is false, enable is true. Time values Time1 = 2s, Time2 = 1s and Time3 = 2s are used in all examples below.

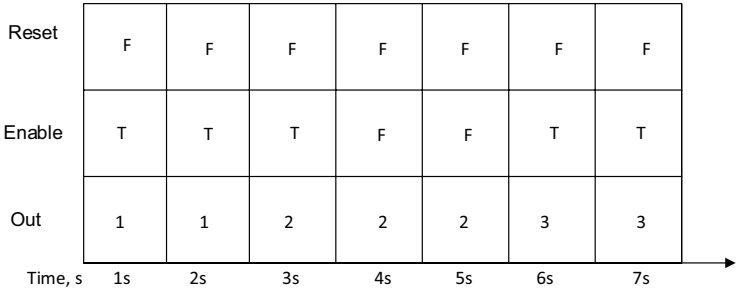


Timer block can be paused by setting enable to false. During which the block stays in the state that it was at the time. When Enable is set to true again, timer resume its work from where it left off. The effect of enable input is illustrated below.

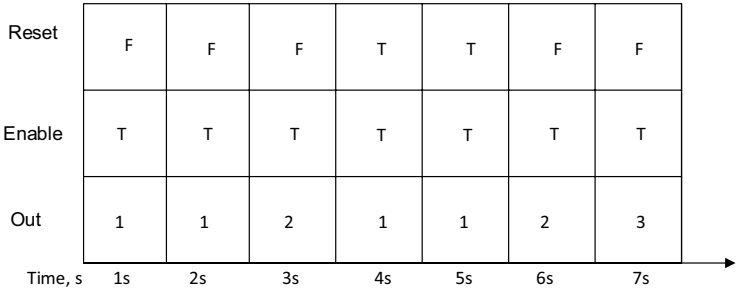


Timer block can be reset using the reset input. When rising edge is detected at the reset input, block goes to state 1 if it is a valid state. If time in state 1 is specified to be less than the time level that the program is running at, timer block will find the next valid state to go to starting from state 1. If all states have delay times that are less than the time level, block will go to state 1. The reset of the timer block happens also in case the block is not enabled.

The reset behavior under normal circumstances is illustrated below. In this example there are 3 time inputs and they all have valid delay times specified.



Block only reacts to rising edge. The reset behavior is illustrated below. The rising edge occurs at time 4s. Reset input is left true but this does not interfere with block operation. At time 5s block is in normal operation mode again.

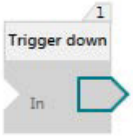


Exceptional cases

- Not connected inputs get default values assigned.
- When specified time in a state is smaller than the value of the time level that the program is running, the state will be skipped.
- When all time inputs have times specified that are smaller than the time level value, the block output is set to default value.

Trigger down

Falling edge detection.



Output

Name	Type	Default value
Out	Boolean	0

Input: 1

Name	Type	Default value	Function
In	Boolean	0	Block input

Block function

Function block performs falling edge detection. Output is 1 when input previous value is 1 and current value is 0. Otherwise output is 0.

Exceptional cases

- If input *In* is not connected, it will get the default value.
- If input *In* has value 0 at the first execution cycle of the block, the output of the block is set to 0.

Trigger up

Rising edge detection.

Output

Name	Type	Default value
Out	Boolean	0

Input: 1

Name	Type	Default value	Function
In	Boolean	0	Block input

Block function

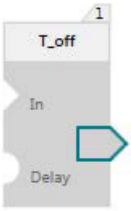
Function block performs rising edge detection. Output is 1 when block input previous value is 0 and current value is 1. Otherwise output is 0.

Exceptional cases

- When input *In* is not connected, it will get the default value.
- If input *In* has value 1 at the first execution cycle of the block, the output of the block is set to 1.

T_off

Turns off the delay.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 2

Name	Type	Default value	Function
In	Boolean	0	Provides boolean value
Delay	Float	0	Provides the time value in seconds to delay outputting 0

Block function

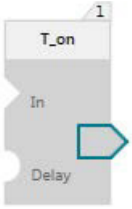
If the value of *In* is 1 then it is written to the output. If the value of *In* is 0 it is written to the output only after a time period is passed which is defined by *Delay*. *Delay* is limited to 2097152 seconds.

Exceptional cases

In case a block input is not connected, then its value is set to default value.

T_on

Turns on the delay.



Output

Name	Type	Default value
Out	Boolean	0

Inputs: 2

Name	Type	Default value	Function
In	Boolean	0	Provides boolean value.
Delay	Float	0	Provides time value in seconds to delay outputting 1.

Block function

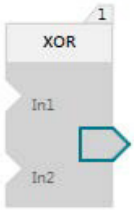
If the value of *In* is 0 then it is written to the output. If the value of *In* is 1, it is written to the output only after a time period is passed which is defined by *Delay*. *Delay* is limited to 2097152 seconds.

Exceptional cases

In case a block input is not connected then its value is set to default value.

XOR

XOR inputs.



Output:

Name	Type	Default value
Out	Boolean	0

Inputs: 2

Name	Type	Default value	Function
In1	Boolean	0	Block input
In2	Boolean	0	Block input

Block function

Function block performs logical XOR operation with inputs.

The truth table of XOR operation:

In1	In2	Out
0	0	0
0	1	1
1	0	1
1	1	0

Output has value 1 when the inputs have different values, otherwise the output is 0.

Exceptional cases

In case a block input is not connected, the default value of the input is used in the operation.

Further information

Product and service inquiries

Address any inquiries about the product to your local ABB representative, quoting the type designation and serial number of the unit in question. A listing of ABB sales, support and service contacts can be found by navigating to www.abb.com/searchchannels.

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