OSCAT Basic Documentation

Franz Höpfinger

2022-2026, Meisterschulen am Ostbahnhof - München

Contents

1. OSCAT Basic Library Documentation

Welcome to the OSCAT Basic Documentation.

The OSCAT library is an Open Source library for automation technology according to IEC61131-3.

Please select a topic from the navigation.

Download documentation as PDF

2. Buffer Management

This section contains 12 modules.

2.0.1 Type Function : BOOL

Input PT	POINTER TO BYTE (address of the Buffer)
SIZE	UINT (size of the buffer)
Output	BOOL (Returns TRUE)
The function _BUFFER_CLEAR initialize any array of Byte with 0. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys is the call	_BUFFER_CLEAR(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

Example:
`_ARRAY_CLEAR(ADRs(bigarray), SIZEOF(bigarray)) initialized bigarray with 0.`

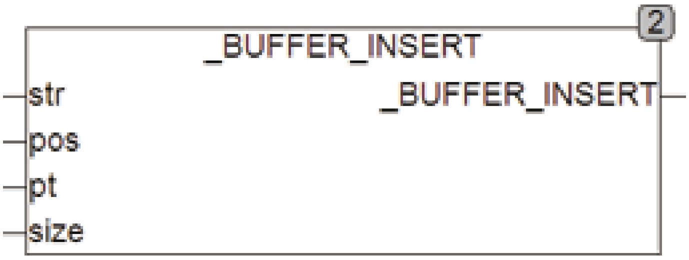
2.0.2 Type Function : BOOL

Input PT	POINTER TO BYTE (address of the Buffer)
SIZE	UINT (size of the buffer)
INIT	BYTE (initial value)
Output	BOOL (Returns TRUE)
The function _BUFFER_INIT initializes any array of Byte with value INIT. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_BUFFER_INIT(ADR(Array), SIZEOF(Array), INIT), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

Example:
`_BUFFER_INIT(ADR(bigarray), SIZEOF(bigarray),3) initializes bigarray with 3.`

2.0.3 _BUFFER_INSERT

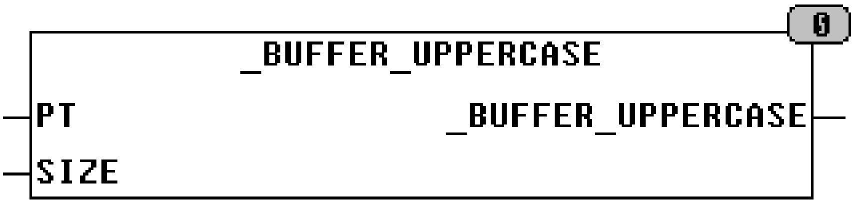
Type Function	INT
Input STR	STRING (string to be copied)
POS	INT (position from which the string is copied into the buffer)
PT	POINTER TO BYTE (address of the Buffer)
SIZE	UINT (size of the buffer)
Output	INT (position in buffer post included string
The function _BUFFER_INSERT copies a string in any array of Byte and moves the rest of the array to the length of the string. The string is stored from any position POS in the buffer. The first element in the array has the position number 0. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_BUFFER_INSERT(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function returns the string copied from the buffer as STRING. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
`_BUFFER_INSERT(STR, POS, ADR(bigarray), SIZEOF(bigarray))`

2.0.4 _BUFFER_UPPERCASE

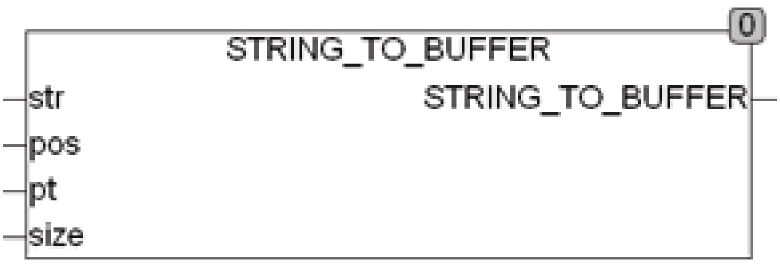
Type Function	BOOL
Input PT	POINTER TO BYTE (address of the Buffer)
SIZE	UINT (size of the buffer)
Output	BOOL (Returns TRUE)
The function _BUFFER_UPPERCASE interprets each byte in the buffer as ASCII characters and converts it to uppercase . When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_BUFFER_INIT(ADR(Array), SIZEOF(Array), INIT), where array is the name of the array to be manipulated. ADR is a standard function, which identifies the Pointer the array and SIZEOF is a standard function, which determines the size of the array. The function only returns TRUE. By the Pointer given array is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
`_BUFFER_UPPERCASE(ADR(bigarray), SIZEOF(bigarray))`

2.0.5 _STRING_TO_BUFFER

Type Function	INT
Input STR	STRING (string to be copied)
POS	INT (position from which the string is copied into the buffer)
PT	POINTER TO BYTE (address of the Buffer)
SIZE	UINT (size of the buffer)
Output	INT (returns the position in buffer post the imported string
	)
The function _STRING_TO_BUFFER copies a string in any array of Byte . The string is stored from any position POS in the buffer. The first element in the array has the position number 0. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_STRING_TO_BUFFER(STR, POS, ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function returns the string copied from the buffer as STRING. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

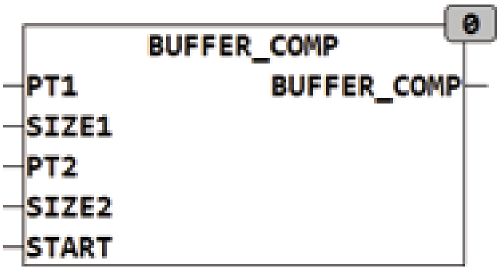


Example:
`_STRING_TO_BUFFER(STR, POS, ADR(bigarray), SIZEOF(bigarray))`

2.0.6 BUFFER_COMP

Type Function	INT

Input PT1	POINTER (address of the first Buffer)
Size1	INT (size of the first buffer)
PT2	POINTER (address of the second Buffer)
SIZE2	INT (size of the second buffer)
START	INT (search begin from start)
Output	INT (position found)
	The function BUFFER_COMP checks whether the content of the array PT2 occurs in the array PT1 from position START. If PT2 is found in PT1, so the function returns the position in PT1, starting from 0. If PT2 is not found in PT1, −1 is returned. BUFFER_COMP can also be used for comparison of two equally sized arrays.
When called, a Pointer to the array and its size in bytes is passed to the function. In CoDeSys the call reads	BUFFER_COMP(ADR(BUF1), SIZEOF(BUF1), ADR(BUF2), SIZEOF(BUF2)), where BUF1 and BUF2 are the names of the arrays to be manipulated. ADR() is a standard function which indentifies the Pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function only returns TRUE. The array specified by the Pointer is manipulated directly in memory. This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

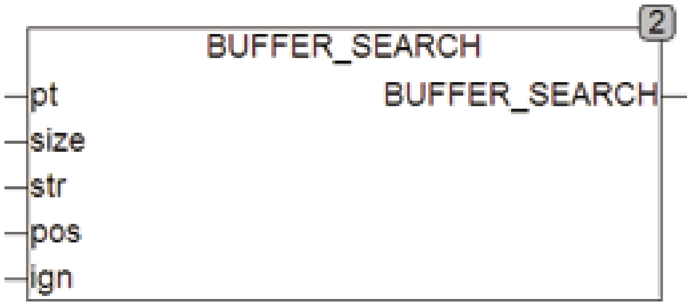


Example:
```
BUFFER_COMP(ADR(BUF1), SIZEOF(BUF1), ADR(BUF2), SIZEOF(BUF2))
```

2.0.7 BUFFER_SEARCH

Type Function	INT
Input PT	POINTER (address of the Buffer)
SIZE	UINT (size of the buffer)
STR	STRING (search string)
POS	INT (from the position being sought)
IGN	BOOL (Search is case-sensitive)
Output	INT (position of the string was found)
The function BUFFER _ SEARCH search any array of Bytes on the contents of a string and reports the position of the first character of	BUFFER_SEARCH (ADR (Array), SIZEOF (ARRAY), STR, POS, IGN), where ARRAY is the name of the array. ADR() is a standard function which

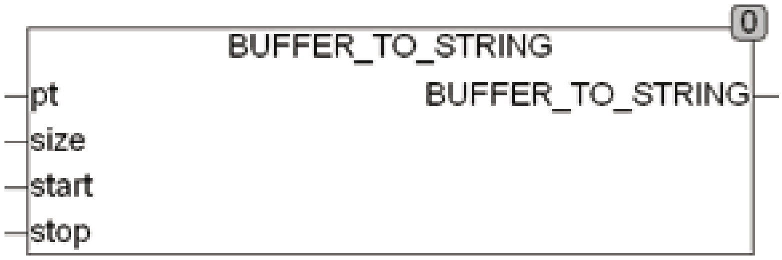
the string in the array when a matching is found. The Buffer is searched from any position POS. The first element in the array is at position number 0. When called, a Pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function returns the string copied from the buffer as STRING. This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied. If IGN = TRUE both upper- and lowercase letters are found as a match, while STR must be present in uppercase letters. If IGN = FALSE case sensitive is searched.



Example:
`BUFFER_SEARCH(ADR(aArray), SIZEOF(Array), 'FIND', 0, TRUE) Locates 'FIND', 'Find', 'find' .... in the array. Example: BUFFER_SEARCH(ADR(Array), SIZEOF(ARRAY), 'FIND', 0, FALSE) Only finds 'FIND' in the array.`

2.0.8 BUFFER_TO_STRING

Type Function	STRING
Input PT	POINTER TO BYTE (address of the Buffer)
SIZE	UINT (size of the buffer)
START	UINT (position from which the String will be from the buffer
	copied)
STOP	UINT (end of Strings in the buffer)
Output	STRING (a string that was copied from the buffer)
The function BUFFER_To_STRING extracts a String from any array of Byte. The String is copied from any position START from the buffer and ends at the STOP position. The first element in the array is at position number 0. When called aPointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	BUFFER_TO_STRING (ADR (Array), SIZEOF (ARRAY), START, STOP), ARRAY is the name of the array. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function returns the string copied from the buffer as STRING. This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied. Example: BUFFER_TO_STRING(ADR(Array), SIZEOF(ARRAY), START, STOP)


0
BUFFER_TO_STRING
pt
size
start
stop
BUFFER_TO_STRING

3. Data Types

3.0.1 CALENDAR

***.UTC**	DT	Universal world time
***.LDT**	DT	Local time
***.LDate**	DATE	Local date
***.LTOD**	TOD	Local time of day
***.YEAR**	INT	Local year
***.MONTH**	INT	Local months
***.DAY**	INT	Local days
***.WEEKDAY**	INT	Local weekday
***.OFFSET**	INT	Offset of local time to universal time in minutes
***.DST_EN**	BOOL	Daylight saving time Enable
***.DST_ON**	BOOL	Daylight saving time is On
***.NAME**	STRING (5)	Time zone name
***.LANGUAGE**	INT	Language (See Language Setup)
***.LONGITUDE**	REAL	Longitude of the place
***.LATITUDE**	REAL	Latitude of the place
***.SUN_RISE**	TOD	Time of sunrise (LTC)
***.SUN_SET**	TOD	Time of sunset (LTC)
***.SUN_MIDDAY**	TOD	World time when the Sun stands in the south (LTC)
***.SUN_HEIGTH**	REAL	the highest altitude of the sun on the horizon
***.SUN_HOR**	REAL	Horizontal solar altitude in degrees from north
***.SUN_VER**	REAL	Vertical position of the sun above the horizon
***.NIGHT**	BOOL	TRUE if night
***.HOLIDAY**	BOOL	TRUE if holiday
***.HOLY_NAME**	STRING (30)	Name of the holiday
***.WORK_WEEK**	_ INT	current work week

A variable type CALENDAR can be used for to provide modul wide calendar data. In the section date and time functions are various functions to update the calendar continuously.

3.0.2 The COMPLEX structure can present complex numbers.

***.RE**	(Real part of a complex number)

*.IM	Imaginary part of a complex number)

3.0.3 This structure defines different languages as String Constants. The variable LANGUAGE of the global variables list provides itself in the library.

*. DEFAULT	INT: = 1 defines the default Language	
*.LMAX	INT:= 3	specifies how many languages are available
*.WEEKDAYS	ARRAY[1..3, 1..7] OF STRING(10):= ' Monday','Tuesday'	
*.WEEKDAYS2	ARRAY[1..3, 1..7] OF STRING(2):=	
*.MONTHS	ARRAY[1..3, 1..12] OF STRING(10):= 'January','February',	
*.MONTHS3	ARRAY[1..3, 1..12] OF STRING(3):=	
*.DIRS	ARRAY[1..3,0..15] OF STRING(3):=	'N','NNE','NE','ENE','E',

(1 = English, 2 = German, 3 = French)

The Default Language is always used when the language 0 is called. If the language setting > 0 then the corresponding language is selected.

Language setting: 0 (the default language specified in DEFAULTis used
(1 = English, 2 = German 3 = French)
other languages are defined by expanding the structure CONSTANTS_LANGUAGE.
'Wednesday','Thursday','Friday','Saturday','Sunday','Monday',
'Tuesday','Wednesday','Thursday','Friday','Saturday','Sunday';
'Mo','Tu','We','Th','Fr','Sa','Su',
'Mo','Di','Mi','Do','Fr','Sa','So';
'March','April','May','June','July','August','September','October', 'November','December',
'January','February','March','April','May','June','July','August',
'September','October','November','December';
'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec',
'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','October','Nov','Dec';
'ESE','SE','SSE','S','SSW','SW','WSW','W','WNW','NW','NNW'
'N','NNE','NO','ENE','O','OSO','SO','SSO','S','SSW','SW','WSW'
'W','WNW','NW','NW';

3.0.4 CONSTANTS_LOCATION

*.DEFAULT	INT:= 1	
*.LMAX	INT:= 3	indicates how many places are defined.
*.LANGUAGE	ARRAY[1..5] of INT := 2,2,3,2,2;	

This structure defines location-dependent constants. The variable LOCATION of the global variable list places it in the library.

(1 = Germany, 2 = Austria, France 3 =, 4 = Belgium-German,
5 = Italy, South Tyrol).
for each location, the language is defined.

3.0.5 CONSTANTS_MATH

***.PI**	REAL:= 3.14159265358	Circle number PI
***.PI2**	REAL:= 6.28318530717	Circle number PI * 2
***.PI4**	REAL:= 12.566370614359	Circle number PI * 4
***.PI05**	REAL:= 1.5707963267949	Circle number PI / 2
***.PI025**	REAL:= 0.785398163397448	Circle number PI / 4
***.PI_INV**	REAL:= 0.318309886183791	1 / PI
***.E**	REAL:= 2.718281828459045235	Euler's constant e
***.E_INV**	= 0.367879441171442	1 / e
***.SQ2**	REAL:= 1.4142135623731	Root of 2
***.FACTS**	ARRAY[0..12] of DINT	Faculties 0-12

This structure defines mathematical constants. The variable MATH from the global variables list places it in the library.

3.0.6 This structure defines physical constants. The structure PHYS of the global variable list places it in the library.

***.C**	REAL:= 299792458	Speed of light in m/s
***.E**	REAL:= 1.60217653E-19	Elementary charge in coulombs = A * s
***.G to REAL**	= 9.80665	Gravitational acceleration in m / s ²
***.T0**	REAL:= −273.15	absolute zero in °C
***.RU**	REAL:= 8.314472	Universal gas constant in J / (mol * K)
***.PN**	REAL:= 101325	Normal pressure Pa

3.0.7 This structure defines location-dependent constants. The variable SETUP the global variables list places it in the library.

***.EXTENDED_ASCII**	BOOL:= TRUE extends the ASCII character set to	special characters eg ÄÖÜ
***.CHARNAME[1..4]**	STRING(253) stores Unicode character names	
***.MTH_OFS**	ARRAY[1..12] OF INT:= 0, 31, 59, 90, 120, 151, 181, 212,	243, 273, 304, 334;
***.DECADES**	ARRAY[0..8] OF REAL:= 1,10,100,1000,10000,100000,	

MTH_OFS is used in various date functions, the array represents the respective current day offset for the months of the year. The 1 February of a year eg is the day 31 + 1
1000000,10000000,100000000;

3.0.8 The structure ESR_DATA is used for Error and Status Reporting modules.

***.TYP**	BYTE	Data Type
***.ADRESS**	STRING(10)	Adress designation

***.DS**	DT	Date / time stamp
***.TS**	TIME	Timestamp in milliseconds
***.DATA**	ARRAY[0..7] OF BYTE	Data packet

3.0.9 FRACTION

***.NUMERATOR**	INT	Numerator of the fraction (numerator)
***.DENOMINATOR**	INT	Denominator of the fraction (Denumerator)

The data type FRACTION can be used to represent a fraction .

3.0.10 HOLIDAY_DATA

***.NAME**	STRING(30)	Name of the holiday
***.DAY**	SINT	Day of public holiday
***.MONTH**	SINT	Month of the holy day
***.USE**	SINT	activates the holyday (0=off, 1=on)

The structure HOLIDAY_DATA is used to define and describe holidays.

The structure is used by modules Calendar_calc and HOLYDAY by using a array of type HOLYDAY_DATA for definition of the annual holydays

There are 3 different types of definitions:

Day 1-.31, MONTH 1..12, USE 1 (public holiday on a fixed date)

DAY ±X , MONTH, 0, USE 1 (holiday is X days before or after Easter)

Day 1..31, MONTH 1..12, USE −7 ..- 1 (public holiday on a weekday before a date, herein is −1 Monday and −7 Sunday.

Example:

Examples:

(NAME:= ‘New Year’, Day:= 1, MONTH:= 1, USE:= 1) holiday with a fixed date USE = 1 means it is active.

(NAME:= ‘New Year’, Day:= 1, MONTH:= 1, USE:= 1) holiday with a fixed date USE = 0 means it is not active.

(NAME:= ‘Karfreitag’, DAY:= −2, MONTH:= 0, USE: = 1) holiday with a fixed offset from Easter Sunday, in this case, the Good Friday 2 days before Easter Sunday.

(NAME:= ’Buss und Bettag “, DAY:= 23, MONTH:= 11, USE: = −3) holiday on the last Wednesday before the 23.11.yyyy of a year.

examples of holyday definitions:

Array of Bavarian Holidays

HOLIDAY_DE: ARRAY [0..29] OF HOLIDAY_DATA:= (name:= ‘New Year’, day:= 1, month: = 1, use: = 1).

(Name:= ‘Three Kings’, Day:= 6, month:= 1 use:= 1),
(Name: = ‘Good Friday’, day:= −2, month: = 0, use: = 1),
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1),
(Name:= ‘Easter Monday’, day:= 1, month:= 0, use:= 1),
(Name:= ‘Labor Day’, day:= 1, month:= 5, use:= 1),
(Name:= ‘Ascension’, day:= 39, month:= 0, use:= 1),
(Name:= ‘Pentecost’, day:= 49, month:= 0, use:= 1)
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1)
(Name:= ‘Corpus Christi’, day:= 60, month:= 0, use:= 1)
(Name:= ‘Peace of Augsburg’, day:= 8, month:= 8, use:= 0)
(Name:= ‘Assumption’, day:= 15, month:= 8, use:= 1)
(Name:= ‘Day of German Unity’, day:= 3, month:= 10, use:= 1)
(Name:= ‘Reformation’, day:= 31, month:= 10, use:= 0)

(Name:= ‘All Saints’ Day:= 1, month:= 11, use:= 1)
(Name:= ‘Buss und Bettag’, day:= 23, month: = 11, use:= 0)
(Name:= ‘1. Christmas Day’, day:= 25, month:= 12, use:= 1)
(Name:= ’2. Christmas day ’, day:= 26, month: = 12, use:= 1)
Array of Austrian Holidays
HOLIDAY_AT: ARRAY [0..29] OF HOLIDAY_DATA:= (name:= ‘New Year’, day:= 1, month:= 1, use:= 1).
(Name:= ‘Three Kings’, Day:= 6, month:= 1 use:= 1),
(Name: = ‘Good Friday’, day:= −2, month: = 0, use: = 1),
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1),
(Name:= ‘Easter Monday’, day:= 1, month:= 0, use:= 1),
(Name:= ‘Ascension’, day:= 39, month:= 0, use:= 1),
(Name:= ‘Pentecost’, day:= 49, month:= 0, use:= 1)
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1)
(Name:= ‘Corpus Christi’, day:= 60, month:= 0, use:= 1)
(Name: =’’, day: = 8, month: = 8, use: = 0)
(Name:= ‘Assumption’, day:= 15, month:= 8, use:= 1)
(Name:=’’, day:= 3, month:= 10, use:= 0)
(Name:=’’, day:= 31, month:= 10, use:= 0)
(Name:= ‘All Saints’ Day:= 1, month:= 11, use:= 1)
(Name:= ‘Immaculate Conception’, day:= 8, month:= 12, use:= 1)
(Name:= ‘1. Christmas Day’, day:= 25, month:= 12, use:= 1)
(Name:= ’2. Christmas day ’, day:= 26, month: = 12, use:= 1)
French Holidays
HOLIDAY_FR: ARRAY [0..29] OF HOLIDAY_DATA := (name: = ‘Nouvel an’, day:= 1, month:= 1, use:= 1)
(Name:= ‘St Valentine’, day:= 14, month:= 2, use:= 0)
(Name:= ‘Vendredi Saint (alsace)’, day:= −2, month:= 0, use:= 0)
(Name:= ’Dimanche de Pâques “, day:= 0, month:= 0, use:= 1)
(Name:= ‘Lundi de Pâques’, day:= 1, month:= 0, use:= 1)
(Name:= ‘Jeudi de Ascension’, day:= 39, month:= 0, use:= 1)
(Name:= ‘dimanche de Pentecôte’, day:= 49, month:= 0, use:= 1)
(Name:= ‘jeudi de la Trinité’, day:= 60, month:= 0, use:= 0)
(Name:= ’Fête du Travail “, day:= 1 month:= 5, use:= 1)
(Name:= ‘Victoire 1945’, day:= 8, month:= 5, use:= 1)
(Name:= ‘Prise de la Bastille’, day:= 14, month:= 7, use:= 1)
(Name:= ’15 Août 1944 ’, day:= 15, month:= 8, use:= 1)
(Name:= ‘Halloween’, day:= 31, month:= 10, use:= 0)
(Name:= ‘Armistice 1918’, day:= 11, month:= 11, use:= 1)
(Name:= ‘Noël’, day:= 25, month:= 12, use:= 1)
(Name:= ‘Saint Etienne (Alsace)’, day:= 26, month:= 12, use:= 0)
(Name:= ‘Fête de la musique’, day:= 21, month:= 6, use:= 0)
Belgium german language
HOLIDAY_BED: ARRAY [0..29] OF HOLIDAY_DATA:= (Name:= ‘New Year’, day:= 1, month:= 1, use:= 1)
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1),
(Name:= ‘Easter Monday’, day:= 1, month:= 0, use:= 1),
(Name:= ‘Labor Day’, day:= 1, month:= 5, use:= 1),
(Name:= ‘Ascension’, day:= 39, month:= 0, use:= 1),
(Name:= ‘Pentecost’, day:= 49, month:= 0, use:= 1)
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1)
(Name:= ‘national day’, day:= 21, month:= 7, use:= 1)
(Name:= ‘Assumption’, day:= 15, month:= 8, use:= 1)
(Name:= ‘All Saints’ Day:= 1, month:= 11, use:= 1)
(Name:= ‘DG holiday’, day:= 15, month:= 11, use:= 1)
(Name:= ‘Christmas Eve’, day:= 24, month:= 12, use:= 1)
(Name:= ‘1. Christmas Day’, day:= 25, month:= 12, use:= 1)
(Name:= ’2. Christmas day ’, day:= 26, month: = 12, use:= 1)
(Name:= ‘New Year’, day:= 31, month:= 12, use:= 1);
South Tyrol, italy
HOLIDAY_DE: ARRAY [0..29] OF HOLIDAY_DATA:= (name:= ‘New Year’, day:= 1, month:= 1, use:= 1).
(Name:= ‘Three Kings’, Day:= 6, month:= 1 use:= 1),

(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1),
(Name:= ‘Easter Monday’, day:= 1, month:= 0, use:= 1),
(Name:= ‘tday to be exempted in Italy’, day:= 25, month:= 4, use:= 1)
(Name:= ‘Labor Day’, day:= 1, month:= 5, use:= 1),
(Name:= ‘Pentecost’, day:= 49, month:= 0, use:= 1)
(Name:= ‘Easter Sunday’, day:= 0, month:= 0, use:= 1)
(Name:= ‘Day of the Republic of Italy’, day:= 2, month:= 6, use:= 1)
(Name:= ‘Assumption’, day:= 15, month:= 8, use:= 1)
(Name:= ‘All Saints’ Day:= 1, month:= 11, use:= 1)
(Name:= ‘Immaculate Conception’, day:= 8, month:= 12, use:= 1)
(Name:= ‘Christmas Eve’, day:= 24, month:= 12, use:= 1)
(Name:= ‘1. Christmas Day’, day:= 25, month:= 12, use:= 1)
(Name:= ‘2. Stephen day’, day:= 26, month:= 12, use:= 1); *)

3.0.11 The structure of REAL2 simulates on systems without LREAL a floating point value double precision. but with restrictions and only with special functions.

***.R1**	REAL	Roughly double the number of
***. RX**	REAL	Fine part of the double number

3.0.12 The structure for SDT defines a structured time-date format.

***.YEAR**	INT	Year
***.MONTH**	INT	Month
***. DAY**	IN T	Day
***. HOUR**	INT	Hours
***. MINUTE**	INT	Minutes
***. SECOND**	INT	Seconds
***. MS**	INT	Milliseconds

WEE *. KDAY: INT Week (1 = Monday, 7 = Sunday)

3.0.13 TIMER_EVENT

***.TYP**	BYTE	Event Type
***.CHANNEL**	BYTE	Channel
***.DAY**	BYTE	Day or days
***.START**	TOD	Start time
***.DURATION**	TIME	Duration
***.LAND**	BYTE	Logical AND
***.LOR**	BYTE	Logical OR
***.LAST**	DT	last activity of the event

The structure TIMER_EVENT defines and stores defaults for timers and events.

3.0.14 The Structure VECTOR_3 stores the three vectors of a three-dimensional vector space.

***.X**	REAL	component in x direction
***.Y**	REAL	Component in Y - direction
***.Z**	REAL	Component in Z - direction

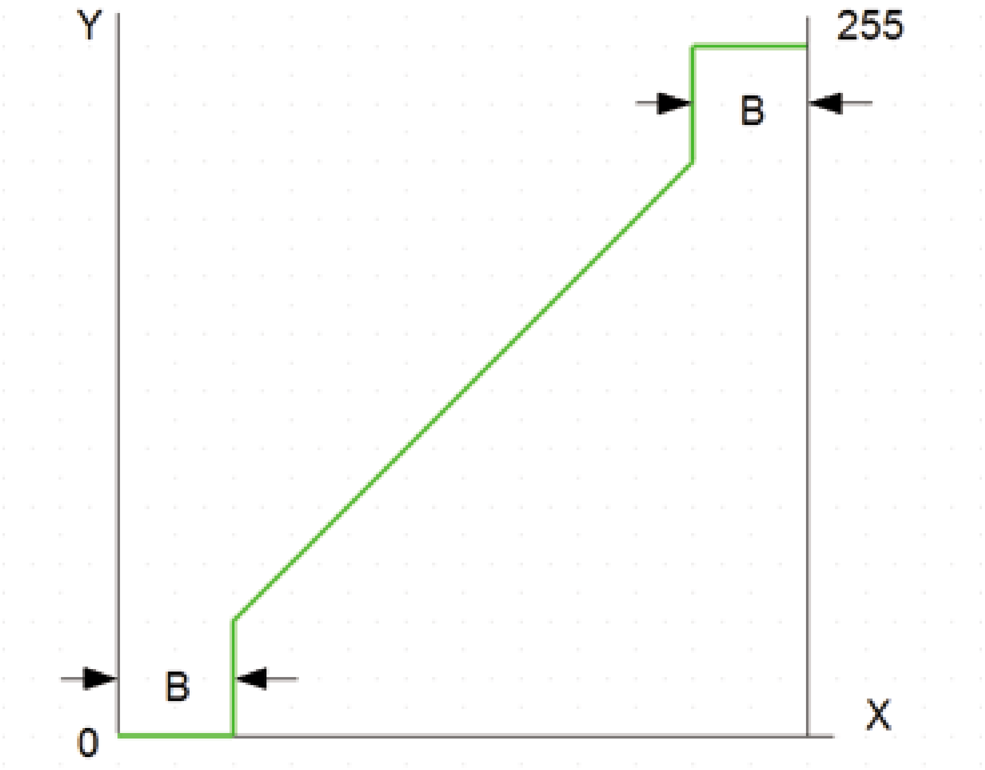
4. Engineering

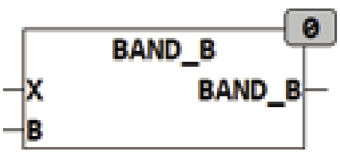
4.1 Engineering / Control

This section contains 68 modules.

4.1.0.1 Type Function: BYTE

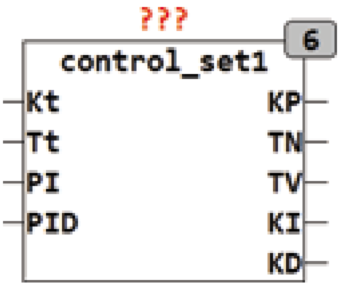
Input X	BYTE (input value)
B	BYTE (limit area)
Output	BYTE (output value)
	BAND_B hides at the input areas 0..255 the areas 0..B and 255-B.. 255, in this areas the output is 0 respectively 255.





4.1.0.2 Type Function module

Input KT	REAL (critical gain)
TT	REAL (Period of the critical Vibration)
PI	BOOL (TRUE if parameters for PI controller are determined)
PID	BOOL (TRUE if parameters for PID controller)
Output KP	REAL (variable gain KP)
TN	REAL (past set time of the integrator)
TV	REAL (retention time of the differentiator)
CI	REAL (Gain of the integrator)
KD	REAL (Gain of Differentiator)
	CONTROL_SET1 calculate setting parameters for P, PI and PID controller according to the Ziegler-Nichols method. Here it indicates the critical gain KT, and the period of the critical vibration TT. The parameters are determined by the controller operated as a P-controller and the gain is ramped up while committed to a continuous oscillation with a constant amplitude. The corresponding values of KT and TT are then determined. Disadvantage of this method is not any real control loop can be moved to the stability limit, and so the process very long time for slow control loops such as room arrangements.
	The default values of the tuning rules are defined in Setup variables and can be changed by the user. The following table shows the default values
Setup P_K	REAL:= 0.5 (default value KP for P controller)
PI_K	REAL:= 0.45 (default value KP for PI controller
PI_TN	REAL:= 0.83 (default value of TN for PI controller)
PID_K	REAL:= 0.6 (default value KP for PID controller)
PID_TN	REAL:= 0.5 (default value of TN for PID controller)
PID_TV	REAL:= 0.125 (default value TV for PID controller)

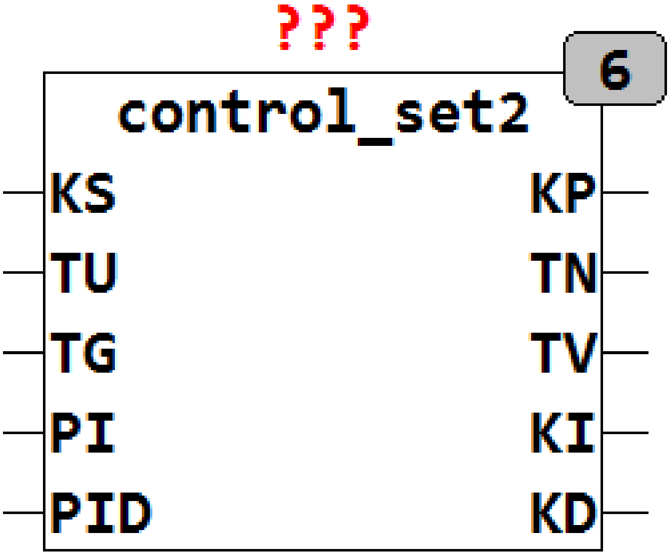


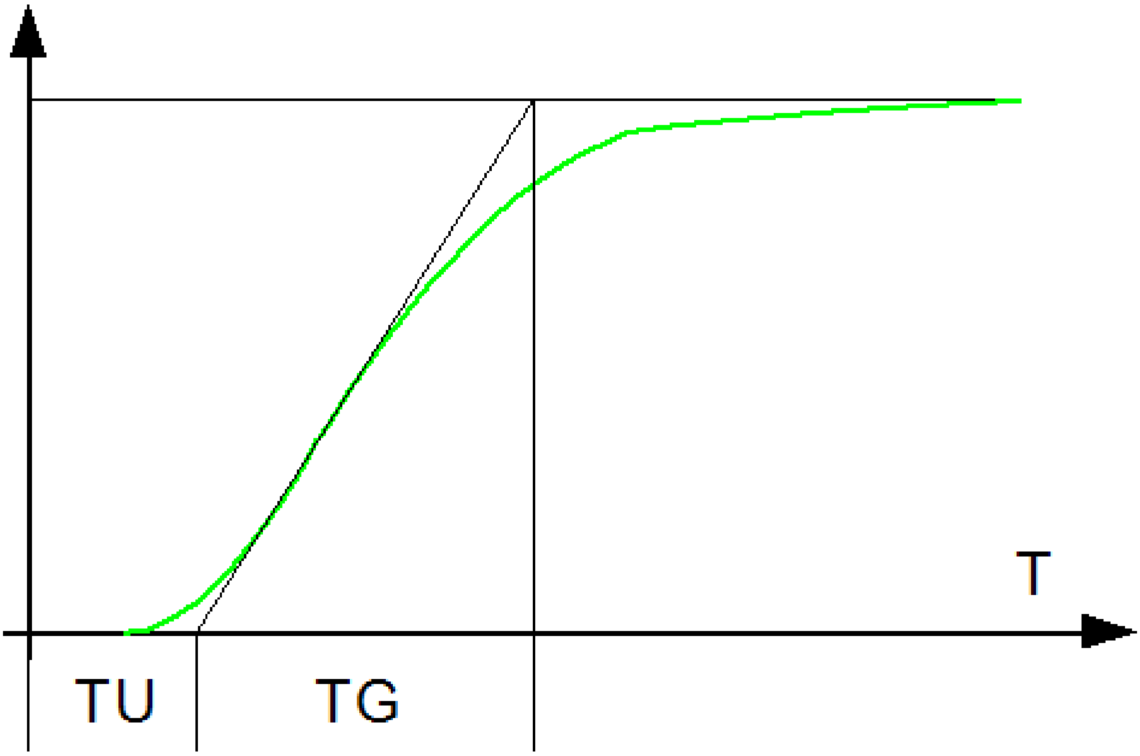
Controller Type	PI	PID	KP	TN	TV
P Controller	0	0	P_K * KT		
PI Control	1	0	PI_K * KT	PI_TN * TT	
PID Controller	0	1	PID_K * KT	PID_TN * TT	PID_TV * TT

Controller Type	PI	PID	KP	TN	TV
P Controller	0	0	P_K = 0.5		
PI Control	1	0	PI_K = 0.45	PI_TN = 0.83	
PID Controller	0	1	PID_K = 0.6	PID_TN = 0.5	PID_TV = 0.125

4.1.0.3 Type Function module

Input KT	REAL (critical gain)
TT	REAL (Period of the critical Vibration)
PI	BOOL (TRUE if parameters for PI controller are determined)
PID	BOOL (TRUE if parameters for PID controller)
Config P_K	REAL:= 0.5 (default value KP for P controller)
PI_K	REAL:= 0.45 (default value KP for PI controller
PI_TN	REAL:= 0.83 (default value of TN for PI controller)
PID_K	REAL:= 0.6 (default value KP for PID controller)
PID_TN	REAL:= 0.5 (default value of TN for PID controller)
PID_TV	REAL:= 0.125 (default value TV for PID controller)
Output KP	REAL (variable gain KP)
TN	REAL (past set time of the integrator)
TV	REAL (retention time of the differentiator)
CI	REAL (Gain of the integrator)
KD	REAL (Gain of Differentiator)
	CONTROL_SET2 calculated setting parameters for P, PI and PID controller according to the Ziegler-Nichols method. Here, the delay time TU and compensatory time TG is given. The parameters are determined by the step response of the controlled system is measured. TU is the time after which the output of the system 5% of its maximum value reached added. TG is the time at the turn of the tangent of the controlled system. KS actual value is the controlled / manipulated variable change.
The following chart shows the determination of TU and TG with the inflection tangent method	
The default values of the tuning rules are defined in Config variables and can be changed by the user. The following table shows the Default Values	



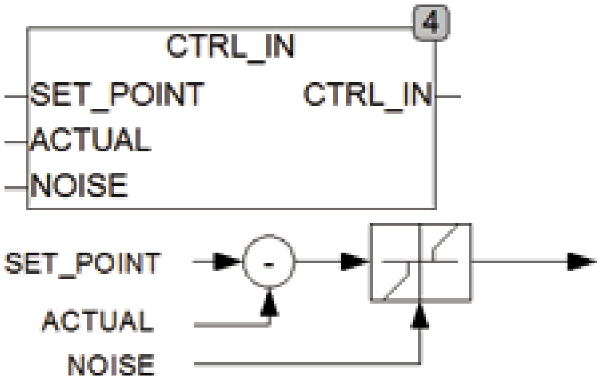


Controller Type	PI	PID	KP	TN	TV
P Controller	0	0	P_K * TG / TU / KS		
PI Control	1	0	PI_K * TG / TU / KS	PI_TN * TU	
PID Controller	0	1	PID_K * TG / TU / KS	PID_TN * TU	PID_TV * TU

Controller Type	PI	PID	KP	TN	TV
P Controller	0	0	P_K = 1.0		
PI Control	1	0	PI_K = 0.9	PI_TN = 3.33	
PID Controller	0	1	PID_K = 1.2	PID_TN = 2	PID_TV = 0.5

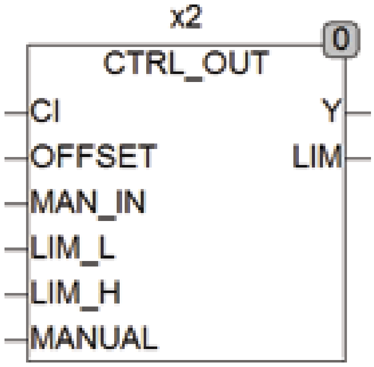
4.1.0.4 CTRL_IN

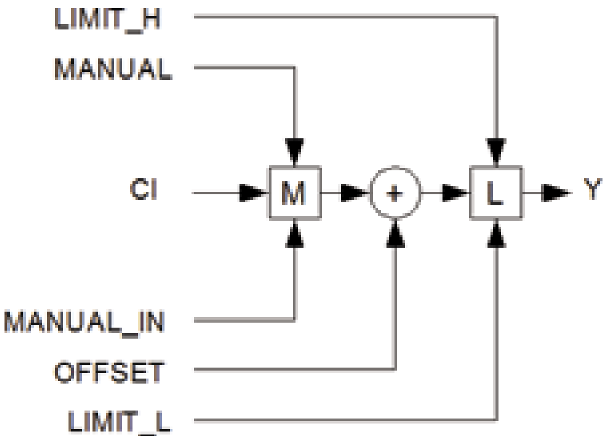
Type Function	REAL
Input SET_POINT	REAL (default)
ACTUAL	REAL (process value)
NOISE	REAL (threshold)
Output	REAL (Process deviation)
	CTRL_IN calculates the process deviation (SET_POINT _ ACTUAL) and passes them at the output. If the difference is less than the value at the input NOISE of the output remains at 0. CTRL_IN can be used to build own rule modules.
Block diagram of CTRL_IN	



4.1.0.5 Type Function module

Input CI	REAL (input from controller)
OFFSET	REAL (output offset)
MAN_IN	REAL (Manual input)
LIM_L	REAL (lower output limit)
LIM_H	REAL (upper output limit)
MANUAL	BOOL (switch for manual operation)
Output Y	REAL (Control signal)
LIM	BOOL (TRUE if control signal reaches a limit)
	CTRL_OUT adds to the CI input the value of OFFSET and returns the result to Y if MANUAL = FALSE. If MANUAL is TRUE at output Y the input value of MAN_IN + OFFSET is issued. Y is always limited to the boundaries defined by LIM_L and LIM_H. If Y reaches one of the limits, then the output LIM is TRUE. CTRL_OUT can be used to build own rule modules.
Block diagram of CTRL_OUT	

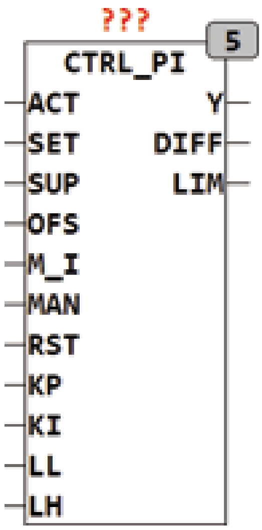


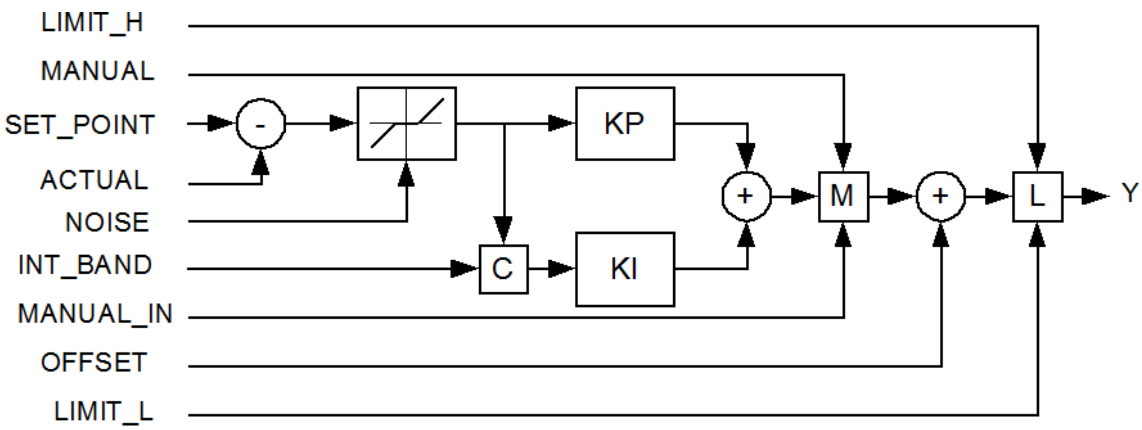


4.1.0.6 Type Function module

Input ACT	REAL (value measured by the way)
SET	REAL (default)
SUP	REAL (noise reduction)
SFO	REAL (offset for the output)
M_I	REAL (input value for manual operation)
MAN	BOOL (switch to manual mode, MANUAL = TRUE)
RST	BOOL (asynchronous reset input)
KP	REAL (proportional part of the controller)
KI	REAL (integral part of the controller)
LL	REAL (lower output limit)
LH	REAL (upper output limit)
Output Y	REAL (output of the controller)
DIFF	Real (deviation)
LIM	BOOL (TRUE if the output has reached a limit)
CTRL_PI is a PI controller with dynamic anti-wind-up and manual control input. The PI controller operates according to the formula	

	Y = KP * DIFF + KI * INTEG(DIFF) + OFFSET
	where DIFF = SET_POINT - ACTUAL
In manual mode (manual = TRUE) is	Y = MANUAL_IN+ OFFSET
ACT is the measured value for the controlled system and set the setpoint for the controller. The input values of LH and LL limit Output value Y. With RST the internal integrator may be set to 0 any time. The output LIM signals that the controller has reached the limit of LL or LH. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The Default Values of the input parameters are predefined as follows	KP = 1, KI = 1, LIMIT_L = −1000 and LIMIT_H = +1000. With the input SUP a noise reduction is set, the value on input SUP determines at which control difference the controller turns on. With SUP is avoided that the output of the controller varies continously. The value at the input SUP should be in dimension that it suppresses the noise of the controlled system and the sensors. If the input to SUP is set to 0.1, the controller is only at deviations greater than 0.1 active. At the output DIFF the measured and through a Noise Filter (DEAD_BAND) filtered control deviation is available. DIFF is normally not required in a controlled system but can be used to influence the control parameters. The input OFS is added as the last value to output, and is used to compensate mainly of noise, whose effect can be estimated on the loop.
	The controller works with a dynamic air- Up that prevents that the integrator, when reaching a output limit and further deviation, continues to run unlimited and affects the properties usually negative. In the introduction chapter of the control technology, more details can be found on anti-wind-up.
The following graph illustrates the internal structure of the controller	

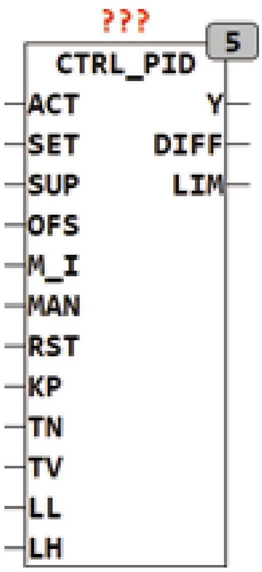


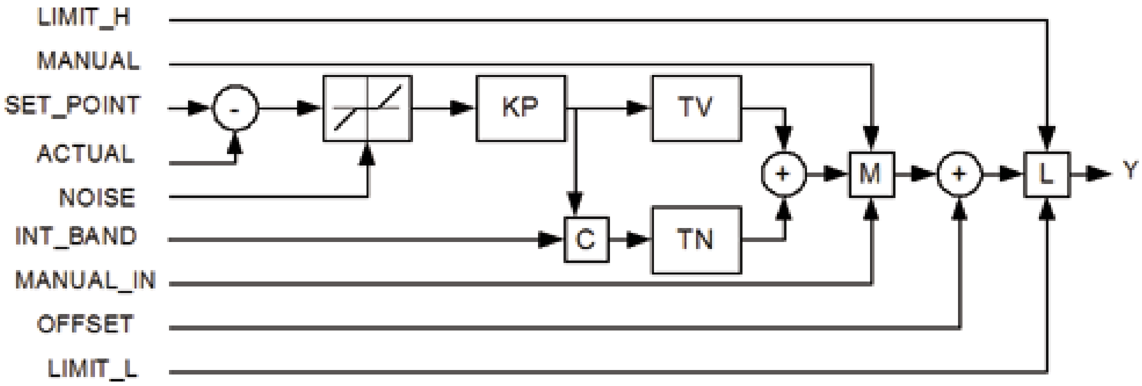


4.1.0.7 Type Function module

Input ACT	REAL (value measured by the way)
SET	REAL (default)
SUP	REAL (noise reduction)
SFO	REAL (offset for the output)
M_I	REAL (input value for manual operation)
MAN	BOOL (switch to manual mode, MANUAL = TRUE)
RST	BOOL (asynchronous reset input)
KP	REAL (controller gain)
TN	REAL (reset of the controller)
TV	REAL (derivative of the controller)
LL	REAL (lower output limit)
LH	REAL (upper output limit)
Output Y	REAL (output of the controller)
DIFF	Real (deviation)
LIM	BOOL (TRUE if the output has reached a limit)
CTRL_PID is a PID controller with dynamic anti-wind up and manual control input. The PID controller operates according to the formula	
	Y = KP * (DIFF + 1/Tn * INTEG(DIFF) + TV *DERIV(DIFF)) + OFFSET
	where DIFF = SET_POINT - ACTUAL
In manual mode (manual = TRUE) is	Y = MANUAL_IN+ OFFSET
ACT is the measured value for the controlled system and SET is the setpoint for the controller. The input values of LH and LL limit the output value Y. With RST, the internal integrator will always set to 0. The output	KP = 1, TN = 1, TV = 1, LIMIT_L = −1000 and LIMIT_H = +1000. With the input SUP a noise reduction is set, the value on input SUP determines at which control difference, the controller turns on. With SUP is avoided that the output

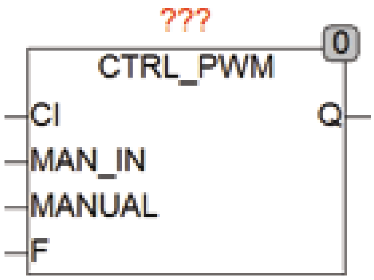
LIM signals that the controller has reached the limit of LL or LH. The PID controller operates free-running and uses the trapezoidal rule to calculate with highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	of the controller wobbles. The value at the input SUP should be in dimension that it suppresses the noise of the controlled system and the sensors. If the input to SUP is set to 0.1, the controller is only at deviations greater than 0.1 active. The ouput DIFF passes the measured and through a noise filter (DEAD_BAND) filtered control deviation. DIFF is normally not required in a controlled system but can be used to influence the control parameters. The input OFS is added as the last value to output, and is used to compensate mainly of noise, whose effect can be estimated on the loop.
	The controller works with a dynamic air- Up that prevents that the integrator, when reaching a output limit and further deviation, continues to run unlimited and affects the properties usually negative. In the introduction chapter of the control technology, more details can be found on anti-wind-up.
The control parameters are given in the form of KP, TN and TV, and if there are parameters KP, KI and KD they can be converted using the following formula	
	TN = KP/KI und TV = KD/KP
The following graph illustrates the internal structure of the controller	
	In the following example, a PID controller is shown whose SET_POINT is generated by module TUNE2 using buttons. Output DIFF is passedto a module PARSET2 which changes the parameters KP, TN, and TV depending on the deviation at the output of DIFF.

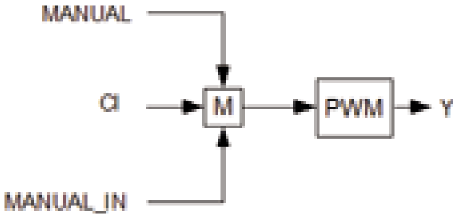


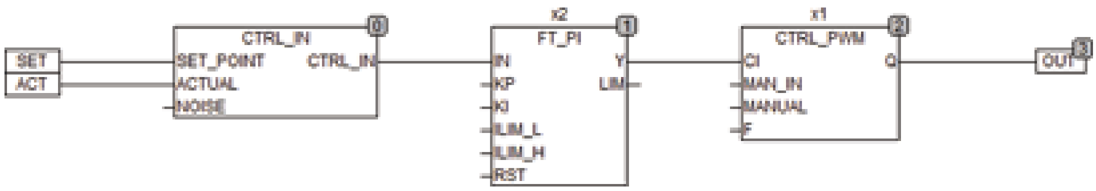


4.1.0.8 CTRL_PWM

Type	Function module
Input CI	REAL (input from controller)
MAN_IN	REAL (Manual input)
MANUAL	BOOL (switch for manual operation)
F	REAL (frequency of the output pulses in Hz)
Output Q	BOOL (control signal)
	CTRL_PWM converts the input value of CI (0 .1) in a pulse width modulated output signal Q. When MANUAL is TRUE at the output Q the input value of MAN_IN is passed. CTRL_OUT can be used to build own rule modules.
Block diagram of CTRL_PWM	
The following example shows a PI controller with PWM output	

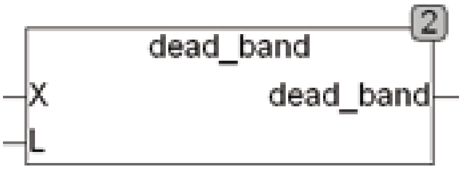


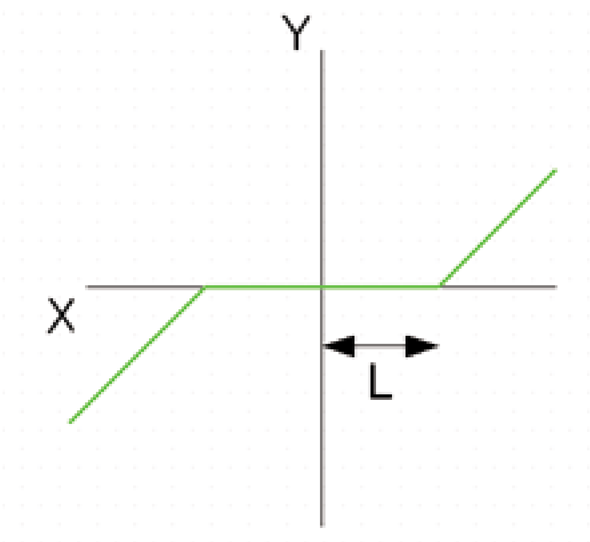




4.1.0.9 DEAD_BAND

Type	Function
Input X	REAL (input)
L	REAL (Lockout Value)
Output	REAL (output value)
	DEAD_BAND is a linear transfer function with dead zone. The function moves the positive part of the curve to -L and the negative part of the curve by +L. DEAD_BAND is used to filter a quantization noise and other noise components from a signal. DEAD_BAND, for example, is used in control systems in order to prevent that the controller permanently switches in small increments, while the actuator is overstressed and worn out.
	DEAD_BAND = X - SGN(X)*L if ABS(X)> L if ABS(X) > L
	DEAD_BAND = 0 if ABS(X) <= L

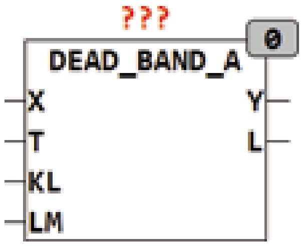


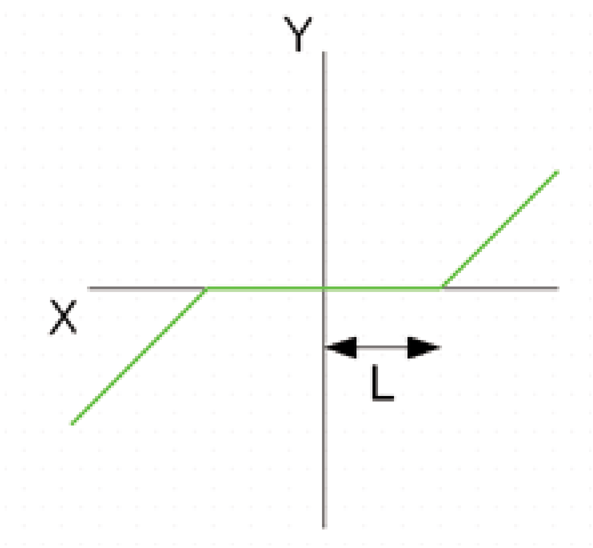


4.1.0.10 Type Function module

Input X	REAL (input)
T	TIME (time delay of the lowpass)
KL	REAL (gain of the filter)
LM	REAL (maximum value of the HF amplitude)
Output Y	REAL (output value)
L	REAL (amplitude of high frequency)
	DEAD_BAND_A is a self adapting linear transfer function with dead zone. The function moves the positive part of the curve to -L and the negative part of the curve by +L. DEAD_BAND_A is used to filter the noise components at the origin of a signal.

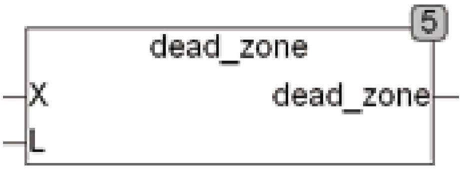
	DEAD_BAND_A, for example, used in control systems in order to prevent that the controller permanently switches in small increments, while the actuator is overstressed and worn out.
	The size L is calculated by filtering the HF cpmponents of the input signal X using a low pass with time constant T and the dead zone L calculated from the amplitude of the HF portion. The sensitivity of the device can be changed via the parameter KL. KL is predefined to 1 and can be unconnected. Reasonable values for KL are between 1 - 5.
	L = HF_Amplitude(effective) *KL.
	So that the module will remain stable even under extreme operating conditions, the input LM is limited by of the maximum value of L.
	DEAD_BAND = X - SGN(X)*L if ABS(X)> L if ABS(X) > L
	DEAD_BAND = 0 if ABS(X) <= L

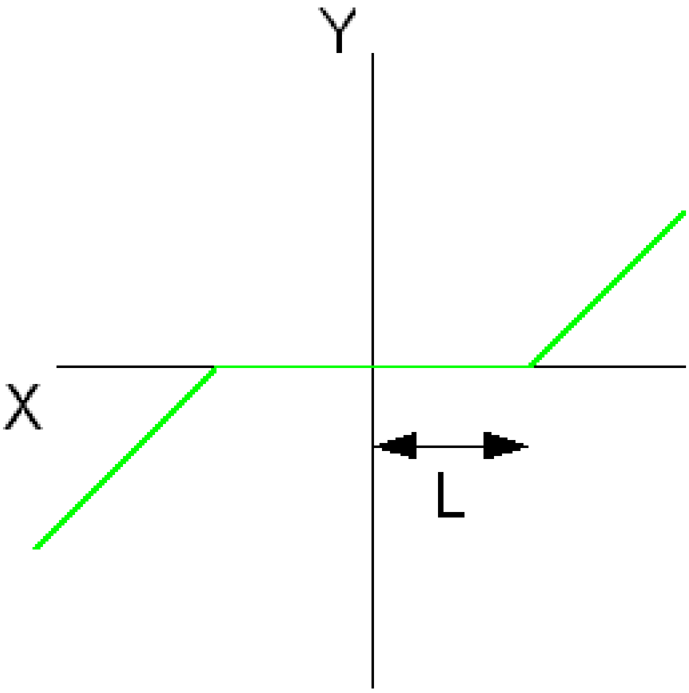




4.1.0.11 Type Function: REAL

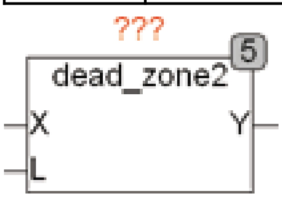
Input X	REAL (input)
L	REAL (Lockout Value)
Output	REAL (output value)
	DEAD_ZONE is a linear transfer function with dead zone. The output equals the input signal when the absolute value of the input is greater than L.
	DEAD_ZONE = X if ABS(X) > L
	DEAD_ZONE = 0 if ABS(X) <= L

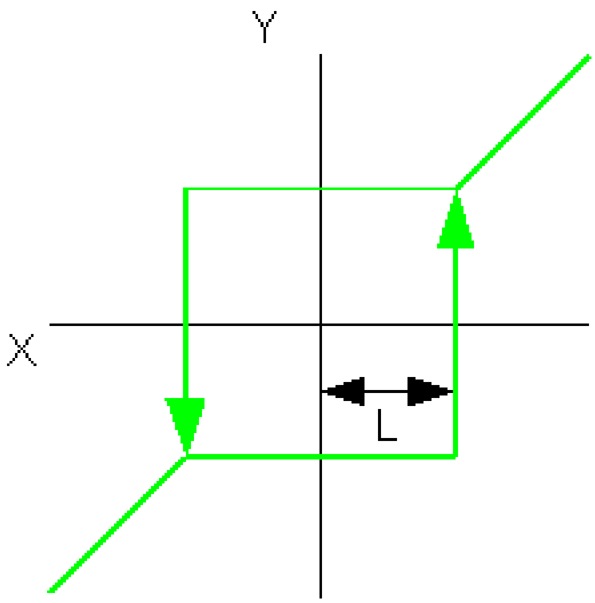




4.1.0.12 Type Function module

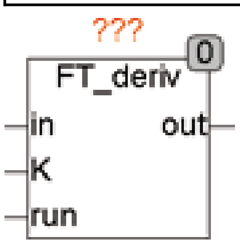
Input X	REAL (input)
L	REAL (Lockout Value)
Output Y	REAL (output value)
	DEAD_ZONE2 is a linear transfer function with dead zone and hysteresis. The output equals the input signal when the absolute value of the input is greater than L.
	DEAD_ZONE2 = X if ABS (X) > L
	DEAD_ZONE2 = + / - L if ABS (X) <= L





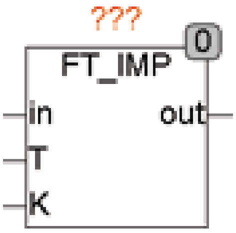
4.1.0.13 FT_DERIV

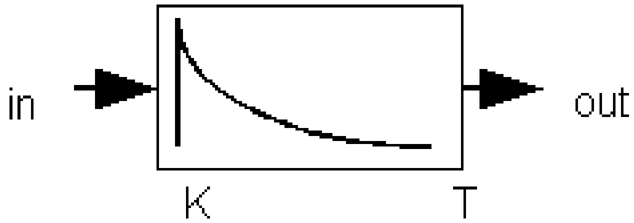
Type	Function module
Input IN	REAL (input signal)
K	REAL (multiplier)
RUN	BOOL (enable input)
Output OUT	REAL (derivation of the input signal K *X/ ∆ T)
	FT_DERIV is a D-link, or LZI-transfer element, which has a differentiating transfer behavior. At the output of FT_DERIV the derivative is over time T in seconds. When the input signal increases in one second from 3 to 4 then the output 1 * K (K * ∆ X / ∆ T = 1 * (4-3) / 1 = 1
	In other words, the derivative of the input signal, the instantaneous slope of the input signal. With the input RUN the FT_DERIV can be enabled or disabled. FT_DERIV works internally in microseconds and fulfill also the requirements of very fast PLC controller with cycle times under a millisecond.
Structure diagram	



4.1.0.14 Type Function module

Input IN	REAL (input signal)
T	TIME (time constant)
K	REAL (multiplier)
Output OUT	REAL (High pass with time constant T)
	FT_IMP is a high-pass filter with time constant T and multiplier K. An abrupt change at the input is visible at the output, but after the time T the value is already smoother by 63% and after 3 * T by 95%. Thus, after an abrupt change of the input signal from 0 to 10, the output passes 10 at the beginning and reduces after 1* T to 3.7 and after 3 * T to 0.5 and then gradually to 0.
Structure diagram	



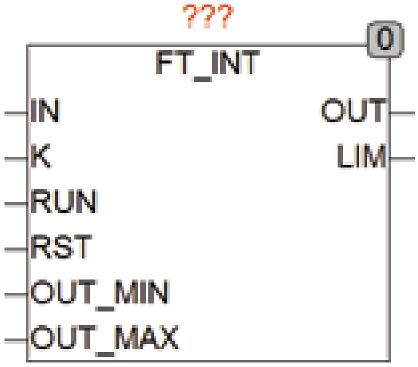


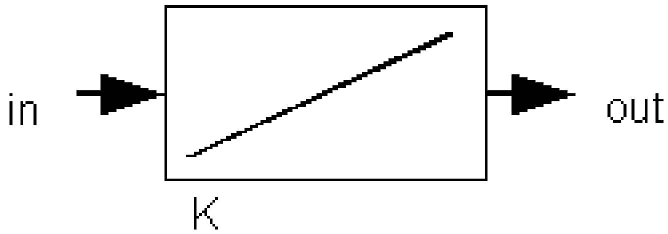
4.1.0.15 Type Function module

Input IN	REAL (input signal)
K	REAL (multiplier)
RUN	BOOL (enable input)
RST	BOOL (Reset input)
OUT_MIN	REAL (lower output limit)
OUT_MAX	REAL (upper output limit)
Output OUT_MAX	REAL (upper output limit)
LIM	BOOL (TRUE if the output is at a limit)
	FT_INT is an integrator module which provides the integral of the input signal at the output. The input K is a multiplier for the output signal. Run switches the integrator on if TRUE and off when FALSE. RST (reset) sets the output to 0. The inputs OUT_MIN and OUT_MAX serve upper and lower limits for the output of the integrator. FT_INT works internally in microseconds and is thus fulfill also the requirements very fast PLC controller with cycle times under one millisecond.

| | A fundamental problem with integrator is the resolution.The output of type real has a resolution of 7-8 points. This will result in a calculated integration step of 1 at an output value of more than one hundred

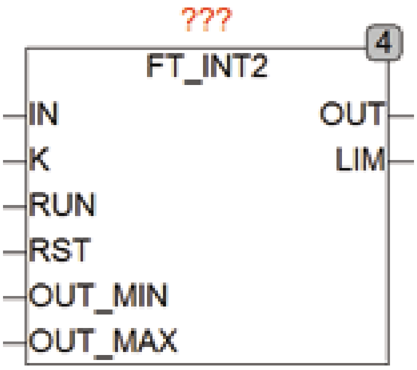
million (1E8). Thus the step can not be added up because it falls below the resolution limit of a maximum of 8 points in type Real. This limitation is important when using FT_INT. | | | For example, an input signal of 0.0001 would be at a sampling time of 1 millisecond and a baseline of 100000 to add a value of 0.0001 * 0.001 seconds = 0.000001 to the baseline of 100000, which inevitably results in the value of 100000 again, because the resolution of the data type Real can only collect up to 8. This should be considered especially if FT_INT should serve as a utility meter or similar applications. | | **Structure diagram** | |





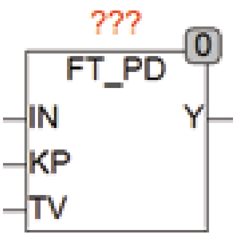
4.1.0.16 Type Function module

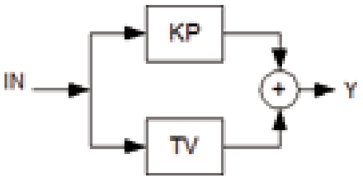
Input IN	REAL (input signal)
K	REAL (multiplier)
RUN	BOOL (enable input)
RST	BOOL (Reset input)
OUT_MIN	REAL (lower output limit)
OUT_MAX	REAL (upper output limit)
Output OUT_MAX	REAL (upper output limit)
LIM	BOOL (TRUE if the output is at a limit)
	FT_INT2 is an integrator module which calculates internal with double-precision and ensures a resolution of 14 decimal places. This makes it suitable to use FT_INT2 unlike FT_INT, for power meters and similar applications.
	For example, an input signal of 0.0001 results in a sampling time of 1 millisecond and an output value of 100000 a value of 0.0001 * 0.001 seconds = 0.000001. To be added to the baseline of 100000, which results inevitably reflect the value of 100000 because the resolution of the data type Real can only collect up to 8. FT_INT2 solves this problem by calculating internal with double-precision (14 decimal places) and adds even the smallest input values so that no information is lost.



4.1.0.17 Type Function module

Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
TV	REAL (reset time of the differentiator in seconds)
Output Y	REAL (output of the controller)
FT_PD is a PD controller, the following formula works	
	Y = KP * (IN + DERIV(IN))
	FT_PD can be used in conjunction with the modules CTRL_IN and CTRL_OUT to establish a PD controller.
The following graph illustrates the internal structure of the controller	

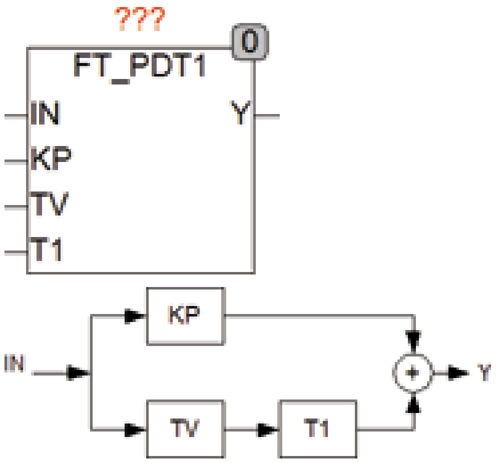




4.1.0.18 Type Function module

Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
TV	REAL (reset time of the differentiator in seconds)
T1	REAL (T1 of the PT1 element in seconds)
Output Y	REAL (output of the controller)

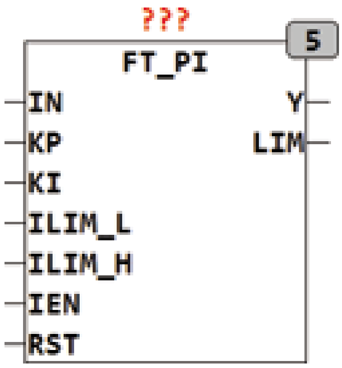
FT_PDT1 is a PD controller with a T1 link in the D-term. The device operates as follows	
	Y = KP * (IN + PT1(DERIV(IN))
	FT_PDT1 can be used in conjunction with the modules CTRL_IN and CTRL_OUT and other regulatory technical modules to build complex control circuits.
Internal structure of the block	

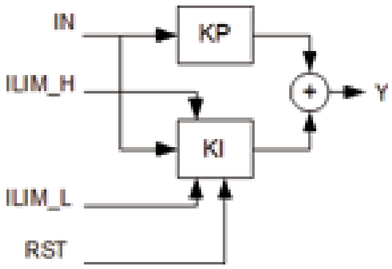


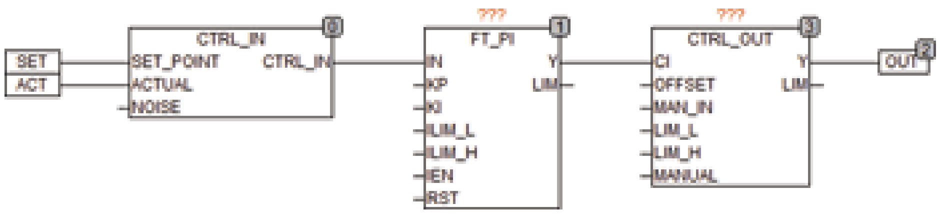
4.1.0.19 Type Function module

Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
KI	REAL (integral part of the controller)
ILIM_L	REAL (lower limit of the integrator output)
ILIM_H	REAL (upper limit of the integrator output)
IEN	BOOL (Enable for Integrator)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output of the controller)
LIM	BOOL (TRUE if the output has reached a limit)
FT_PI is a PI controller which works following the formula	
	Y = KP * IN + KI * INTEG(IN)
The input values ILIM_H and ILIM_L limits the working area of the internal integrator. With RST, the internal Integrator can always be set to 0. The output LIM indicates that the Integrator has reached one of the limits ILIM_L oe ILIM_H. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	KP = 1, CI = 1, ILIM_L= −1E38 and ILIM_H = +1E38.

Anti Wind-Up	Control modules with Integrator tend to the so-called Wind-Up Effect. A Wind-Up means that the integrator module continuously run again because, for example, the control signal Y is at a limit and the system can not compensate the deviation, which then leads to subsequent transition into the control range until a long and time-consuming dismantling of the integrator value and the scheme only respond delayed. Since the integrator is only necessary to compensate the deviation for all other control units, and the range of the integrator should be limited with the values of ILIM. The Integrator then reaches a limit and stops remaining at the last valid value. For other wind- Up Action, the Integrator can be controlled with the input IEN = FALSE any time separately, the Integrator only runs when IEN = TRUE.
The following graph illustrates the internal structure of the controller	
	FT_PI can be used in conjunction with the modules CTRL_IN and CTRL_OUT to build a PI controller.



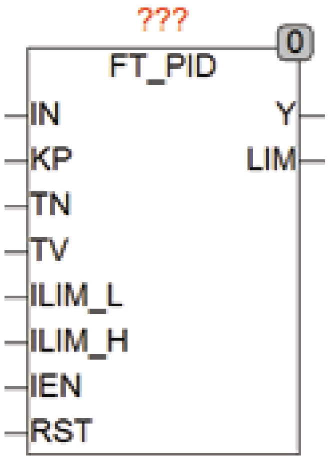


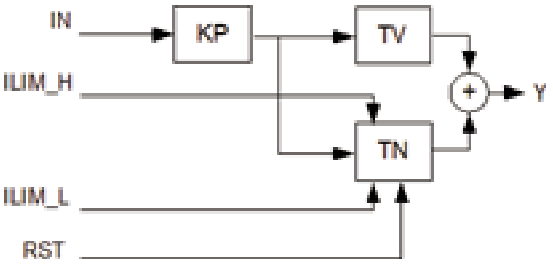


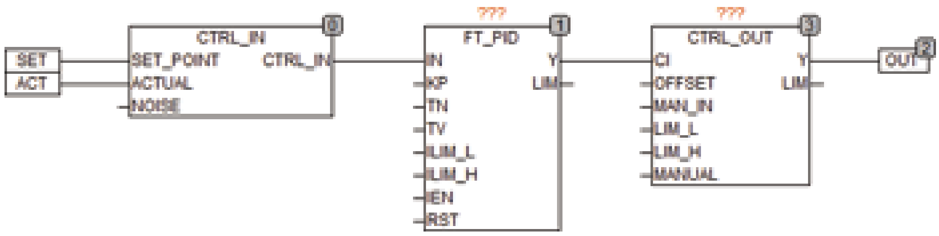
4.1.0.20 Type Function module

Input IN	REAL (input value)
KP	REAL (controller gain)

TN	REAL (past set time of the controller in seconds)
TV	REAL (derivative of the controller in seconds)
ILIM_L	REAL (lower limit of the integrator output)
ILIM_H	REAL (upper limit of the integrator output)
IEN	BOOL (Enable for Integrator)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output of the controller)
LIM	BOOL (TRUE if the output has reached a limit)
FT_PID is a PID controller of the following formula works	
	Y = KP * (IN + 1/TN * INTEG(IN) + TV *DERIV(IN))
The control parameters are given in the form of KP, TN and TV, and if there are parameters KP, KI and KD they can be converted using the following formula	
	TN = KP/KI und TV = KD/KP
The input values ILIM_H and ILIM_L limit the working area of the internal integrator. With RST, the internal integrator will always set to 0. The output LIM signals that the integrator runs one of the limits or ILIM_L ILIM_H. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	KP = 1, TN = 1s, TV = 1s, ILIM_L =−1E38 and ILIM_H = +1 E38.
Anti Wind-Up	Control modules with Integrator tend to the so-called Wind-Up Effect. A Wind-Up means that the integrator module continuously run again because, for example, the control signal Y is at a limit and the system can not compensate the deviation, which then leads to subsequent transition into the control range until a long and time-consuming dismantling of the integrator value and the scheme only respond delayed. Since the integrator is only necessary to compensate the deviation for all other control units, and the range of the integrator should be limited with the values of ILIM. The Integrator then reaches a limit and stops remaining at the last valid value. For other wind- Up Action, the Integrator can be controlled with the input IEN = FALSE any time separately, the Integrator only runs when IEN = TRUE.
The following graph illustrates the internal structure of the controller	
	FT_PD can be used in conjunction with the modules CTRL_IN and CTRL_OUT to establish a PD controller.



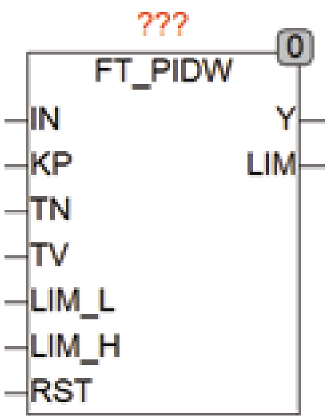


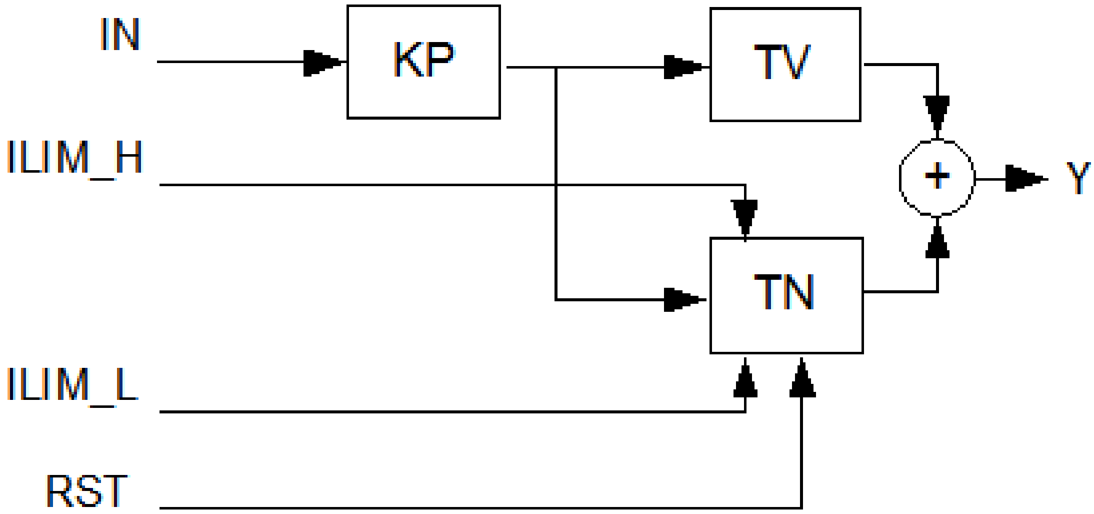


4.1.0.21 Type Function module

Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
TN	REAL (past set time of the controller in seconds)
TV	REAL (derivative of the controller in seconds)
LIM_L	REAL (lower limit of the integrator output)
ILIM_H	REAL (upper limit of the integrator output)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output of the controller)
LIM	BOOL (TRUE if the output has reached a limit)
FT_PIDW is a PID controller with Anti Wind- Up Hold works according to the following formula	
	Y = KP * (IN + 1/TN * INTEG(IN) + TV *DERIV(IN))
The control parameters are given in the form of KP, TN and TV, and if there are parameters	

KP, KI and KD they can be converted using the following formula	
	TN = KP/KI und TV = KD/KP
The input values LIM_H and LIM_L limit the range of the output Y. With RST, the internal Integrator can always be set to 0. The output LIM indicates that the Output Y runs to one of the limits LIM_L orL IM_H. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	KP = 1, TN = 1s, TV = 1s, ILIM_L =−1E38 and ILIM_H = +1 E38.
Anti Wind-Up	Control modules with Integrator tend to the so-called Wind-Up Effect. A Wind-Up means that the integrator module continuously run again because, for example, the control signal Y is at a limit and the system can not compensate the deviation, which then leads to subsequent transition into the control range until a long and time-consuming dismantling of the integrator value and the scheme only respond delayed. Since the integrator is only necessary to compensate the deviation for all other control units, and the range of the integrator should be limited with the values of ILIM.
	The module FT_PIDW has a so-called Wind-Up-Hold which freezes the integrator after reaching for an output limit (LIM_L, LIM_H) on the last value and thus a Wind-Up prevents.
The following graph illustrates the internal structure of the controller	
	FT_PD can be used in conjunction with the modules CTRL_IN and CTRL_OUT to establish a PD controller.

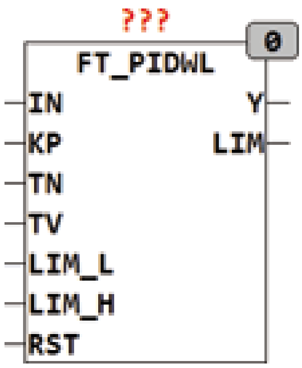


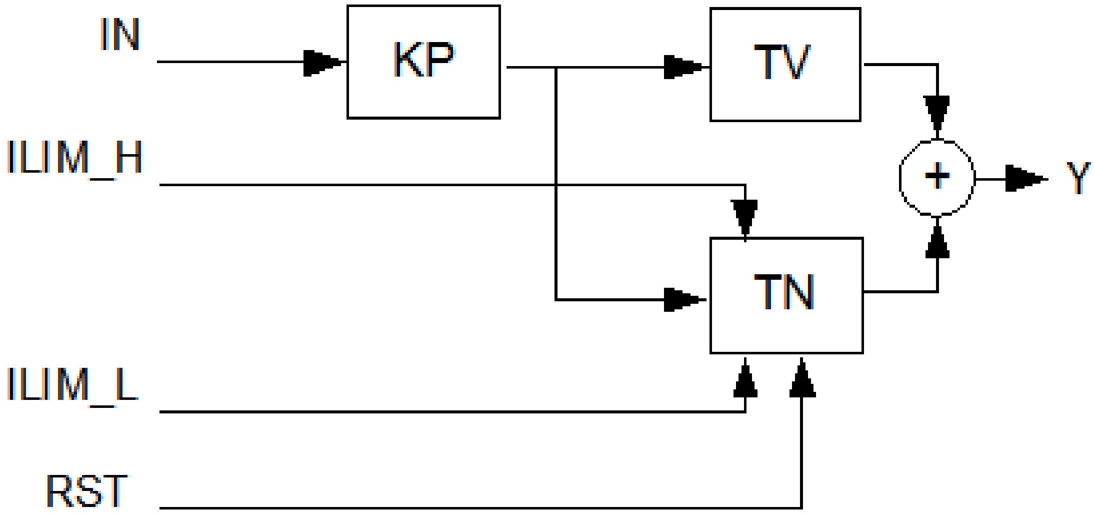


4.1.0.22 FT_PIDWL

Type	Function module
Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
TN	REAL (past set time of the controller in seconds)
TV	REAL (derivative of the controller in seconds)
LIM_L	REAL (lower limit of the integrator output)
ILIM_H	REAL (upper limit of the integrator output)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output of the controller)
LIM	BOOL (TRUE if the output has reached a limit)
FT_PIDWL is a PID controller with dynamic Wind- Up reset and works according to the following formula	
	Y = KP * (IN + 1/TN * INTEG(IN) + TV *DERIV(IN))
The control parameters are given in the form of KP, TN and TV, and if there are parameters KP, KI and KD they can be converted using the following formula	
	TN = KP/KI und TV = KD/KP
The input values LIM_H and LIM_L limit the range of the output Y. With RST, the internal Integrator can always be set to 0. The output LIM indicates that the Output Y runs to one of the limits LIM_L orL IM_H. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	KP = 1, TN = 1s, TV = 1s, ILIM_L =−1E38 and ILIM_H = +1 E38.

Anti Wind-Up	Control modules with Integrator tend to the so-called Wind-Up Effect. A Wind-Up means that the integrator module continuously run again because, for example, the control signal Y is at a limit and the system can not compensate the deviation, which then leads to subsequent transition into the control range until a long and time-consuming dismantling of the integrator value and the scheme only respond delayed. Since the integrator is only necessary to compensate the deviation for all other control units, and the range of the integrator should be limited with the values of ILIM.
	The module FT_PIW has a so-called dynamic-wind Up Reset which resets reaching a limit (LIM_L, LIM_H) the the Integrator to a value corresponding of the output limit. After reaching a Limits the controller re-enters the work area must the Integrator are not first or Down-integrated, and the controller is ready for use without delay. The dynamic Anti-Wind Up Method is that in most cases without drawbacks preferred method, because it does not negatively affect the control and prevents the disadvantages of Wind_Up .
The following graph illustrates the internal structure of the controller	
	FT_PD can be used in conjunction with the modules CTRL_IN and CTRL_OUT to establish a PD controller.

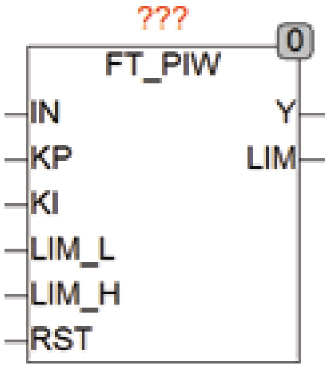


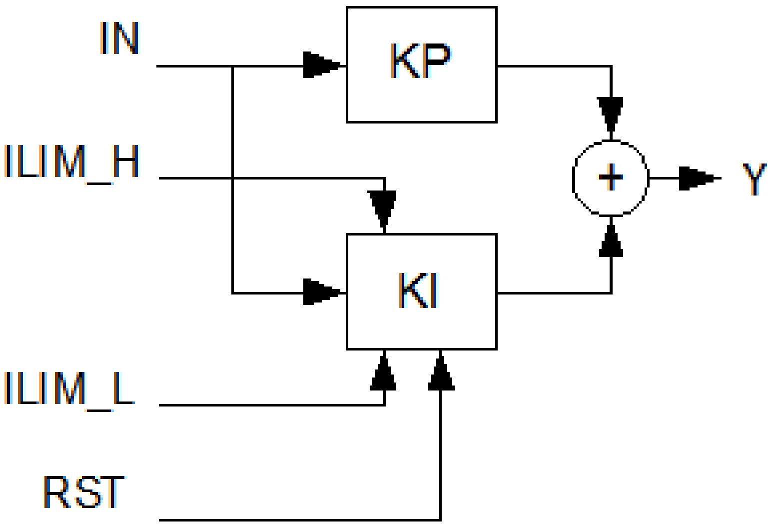


4.1.0.23 Type Function module

Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
KI	REAL (integral part of the controller)
LIM_L	REAL (lower limit of the integrator output)
ILIM_H	REAL (upper limit of the integrator output)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output of the controller)
LIM	BOOL (TRUE if the output has reached a limit)
FT_PIDW is a PID controller with Anti Wind- Up Hold works according to the following formula	
	Y = KP * IN + KI * INTEG(IN)
The input values LIM_H and LIM_L limit the range of the output Y. With RST, the internal Integrator can always be set to 0. The output LIM indicates that the Output Y runs to one of the limits LIM_L orL IM_H. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	KP = 1, CI = 1, ILIM_L= −1E38 and ILIM_H = +1E38.
Anti Wind-Up	Control modules with Integrator tend to the so-called Wind-Up Effect. A Wind-Up means that the integrator module continuously run again because, for example, the control signal Y is at a limit and the system can not compensate the deviation, which then leads to subsequent transition into the control range until a long and time-consuming dismantling of the integrator value and the scheme only respond delayed. Since the

	integrator is only necessary to compensate the deviation for all other control units, and the range of the integrator should be limited with the values of ILIM.
	The module FT_PIDW has a so-called Wind-Up-Hold which freezes the integrator after reaching for an output limit (LIM_L, LIM_H) on the last value and thus a Wind-Up prevents.
The following graph illustrates the internal structure of the controller	
	FT_PIW can used together with the modules CTRL_IN and CTRL_OUT to build complex controllers.

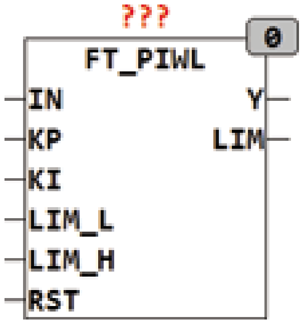


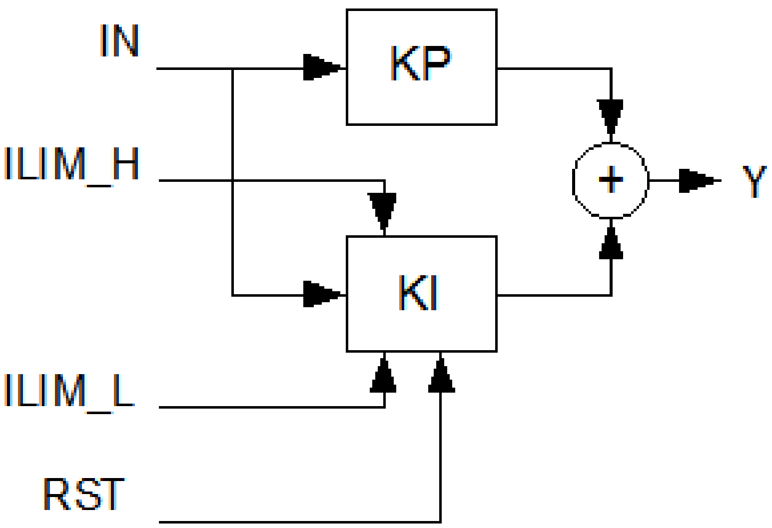


4.1.0.24 Type Function module

Input IN	REAL (input signal)
KP	REAL (proportional part of the controller)
KI	REAL (integral part of the controller)
LIM_L	REAL (lower limit of the integrator output)
ILIM_H	REAL (upper limit of the integrator output)
RST	BOOL (asynchronous reset input)

Output Y	REAL (output of the controller)
LIM	BOOL (TRUE if the output has reached a limit)
FT_PIWL is a PI controller with dynamic anti-wind Up and works according the following formular	
	Y = KP * IN + KI * INTEG(IN)
The input values LIM_H and LIM_L limit the range of the output Y. With RST, the internal Integrator can always be set to 0. The output LIM indicates that the Output Y runs to one of the limits LIM_L orL IM_H. The PI controller is free running and uses the trapezoidal rule to calculate the integrator for the highest accuracy and optimal speed. The default values of the input parameters are predefined as follows	KP = 1, CI = 1, ILIM_L= −1E38 and ILIM_H = +1E38.
Anti Wind-Up	Control modules with Integrator tend to the so-called Wind-Up Effect. A Wind-Up means that the integrator module continuously run again because, for example, the control signal Y is at a limit and the system can not compensate the deviation, which then leads to subsequent transition into the control range until a long and time-consuming dismantling of the integrator value and the scheme only respond delayed. Since the integrator is only necessary to compensate the deviation for all other control units, and the range of the integrator should be limited with the values of ILIM.
	The module FT_PIWL has a so-called dynamic-wind Up Reset which resets reaching a limit (LIM_L, LIM_H) the Integrator to a value corresponding of the output limit. After reaching a Limits the controller re-enters the work area must the Integrator are not first or Down-integrated, and the controller is ready for use without delay. The dynamic Anti-Wind Up Method is that in most cases without drawbacks preferred method, because it does not negatively affect the control and prevents the disadvantages of Wind_Up .
The following graph illustrates the internal structure of the controller	
	FT_PIWL can used together with the modules CTRL_IN and CTRL_OUT to build complex controllers.

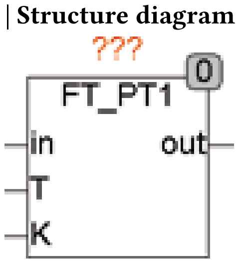


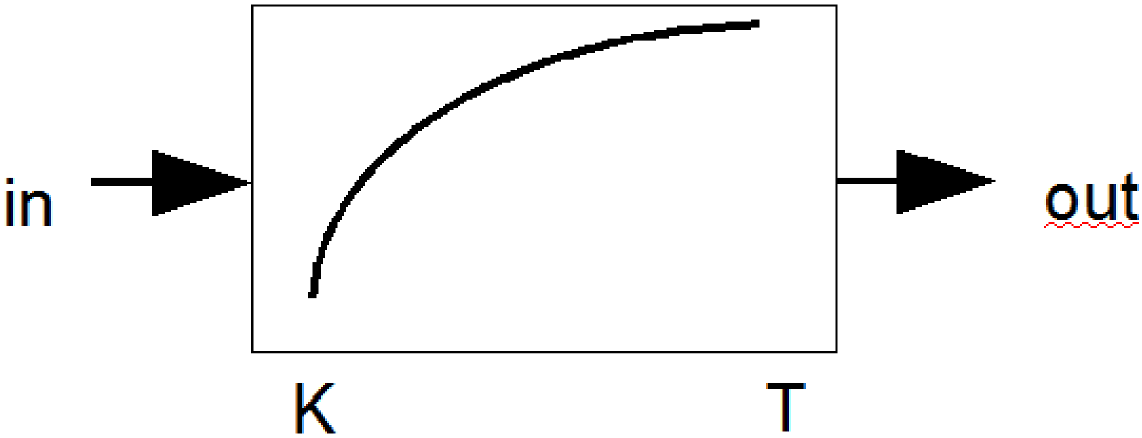


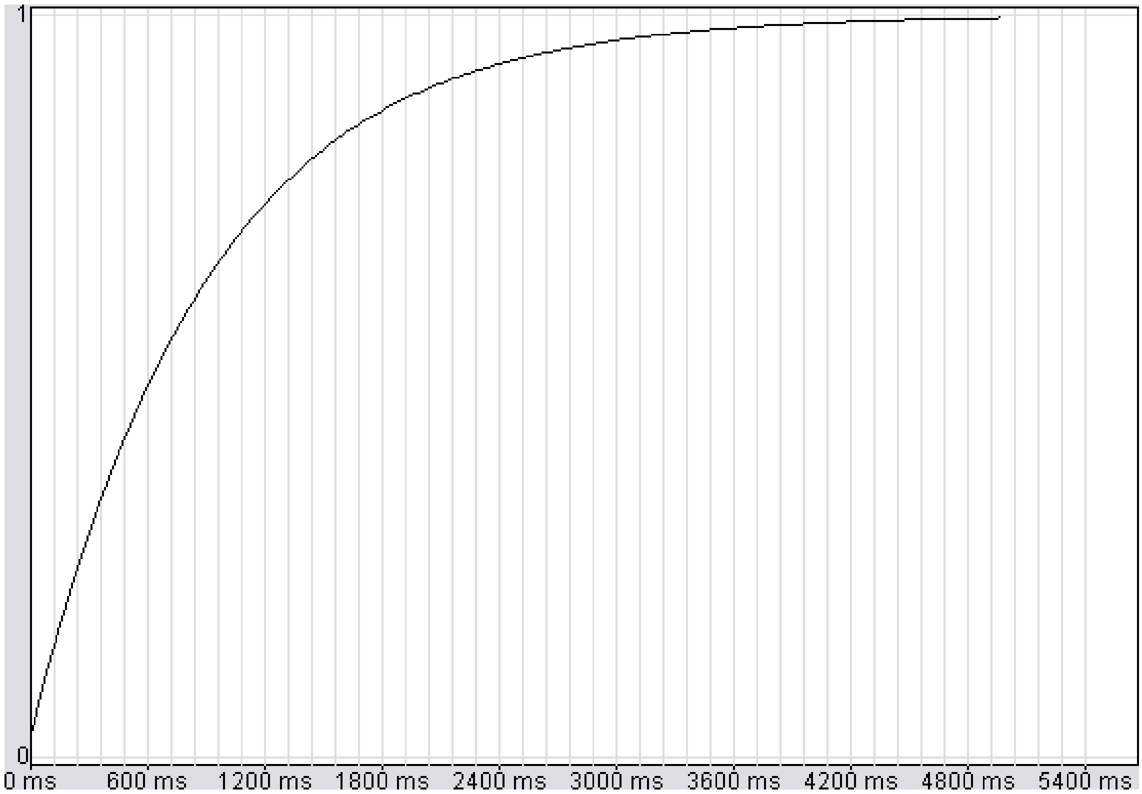
4.1.0.25 Type Function module

Input IN	REAL (input signal)
T	TIME (time constant)
K	REAL (multiplier)
Output OUT_MAX	REAL (upper output limit)
	FT_PT1 is an LZI- Transmission link with a proportional transfer behavior 1 Order, even as a low pass filter 1 order referred to. The multiplier K sets the gain (multiplier) is fixed and T is the time constant. A change at the input is attenuated at the output visible. The output signal increases within T to 63% of the input value and after 3 * T to 95% of input values. Thus, after an abrupt change of the input signal of 0 to 10 at the time of the initial input change 0, increasing to 1 at T * 6.3 and after 3 * T 9.5 and then approaches asymptotically the value 10. The first time the output OUT to the IN input value is initialized to a defined starting performance guarantee. If the input T of T#0s is equal to the output OUT = K * IN.

| **Structure diagram** | | | | Step response for T = 1, K = 1 |



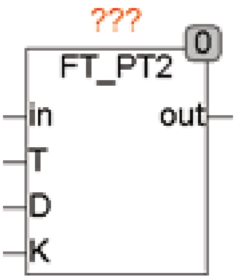


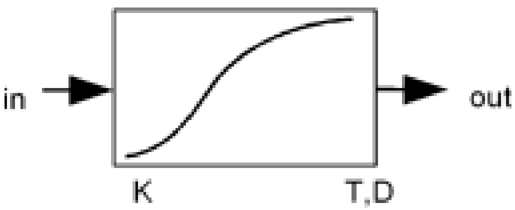


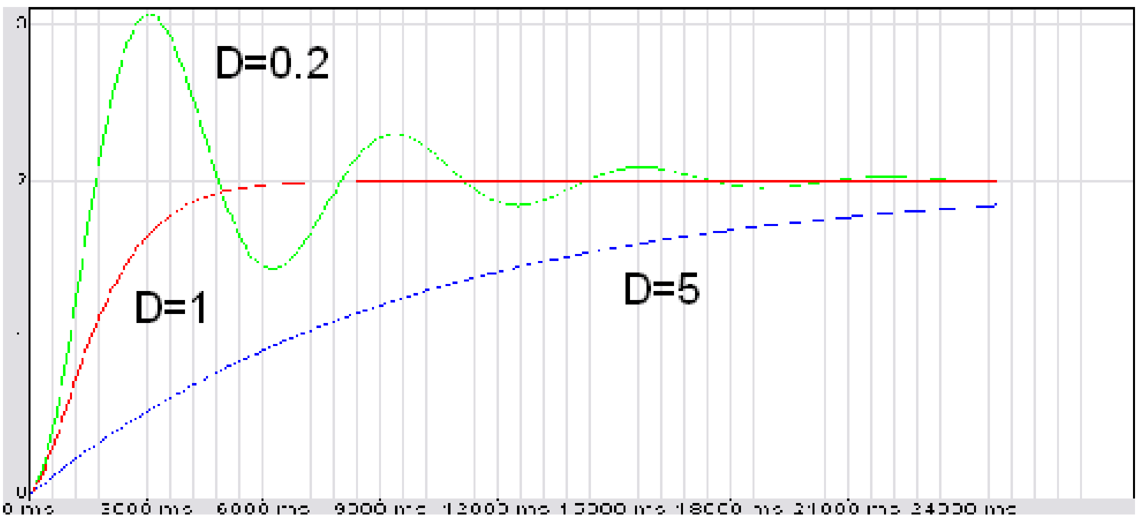
4.1.0.26 Type Function module

Input IN	REAL (input signal)
T	REAL (time constant)
D	REAL (damping)
K	REAL (multiplier)
Output OUT_MAX	REAL (upper output limit)
	FT_PT2 is an LZI transfer module having a second transfer characteristic proportional order, even as a low pass filter 2 order known. The multiplier K sets the gain (multiplier), T and D the time constant and the damping. If the input T of T#0s is equal to the output OUT = K * IN.

The corresponding functional relationship in the time windows is given by the following differential equation	
	T² * OUT''(T) + 2 * D* T * OUT'(T) + OUT(T) = K * in(T).
Structure diagram	
	Step response for T = 1, K = 2, D = 0,2 / 1 / 5

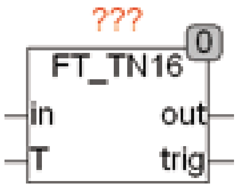






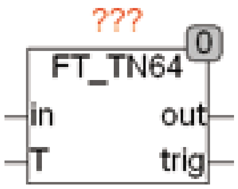
4.1.0.27 Type Function module

Input IN	REAL (input signal)
T	REAL (delay time)
Output OUT_MAX	REAL (upper output limit)
	FT_TN16 delays an input signal by an adjustable time T and scanned it in time T 16 times. After each update of the output signal OUT, TRIG is TRUE for one cycle.
	T16INOUT1514012



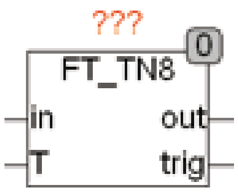
4.1.0.28 Type Function module

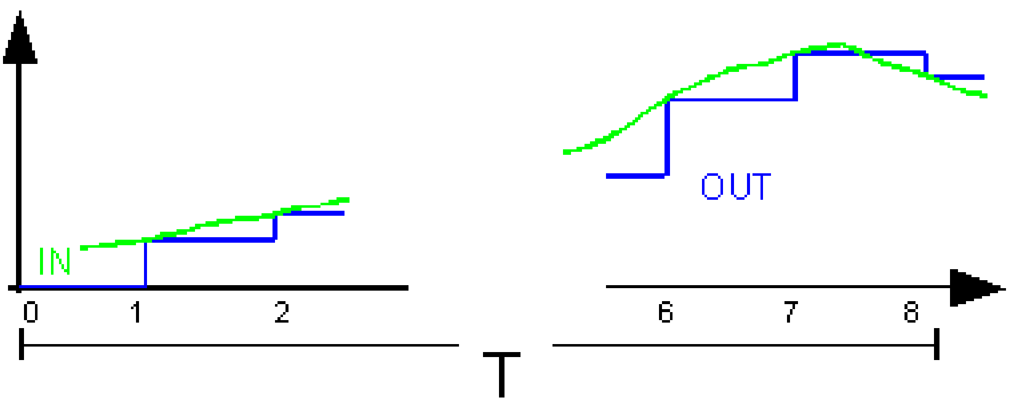
Input IN	REAL (input signal)
T	REAL (delay time)
Output OUT_MAX	REAL (upper output limit)
	FT_TN64 delays an input signal by an adjustable time T and scans it in time T 64 times. After each update of the output signal OUT, TRIG is TRUE for one cycle.
	T64INOUT6362012



4.1.0.29 Type Function module

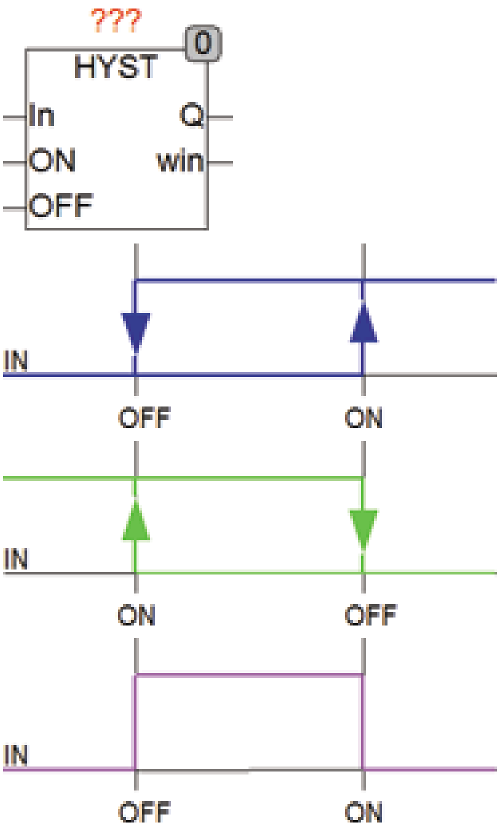
Input IN	REAL (input signal)
T	REAL (delay time)
Output OUT_MAX	REAL (upper output limit)
	FT_TN8 delays an input signal by an adjustable time T and scanned it in time T by 8 times. After each update of the output signal OUT, TRIG is TRUE for one cycle.





4.1.0.30 Type Function module

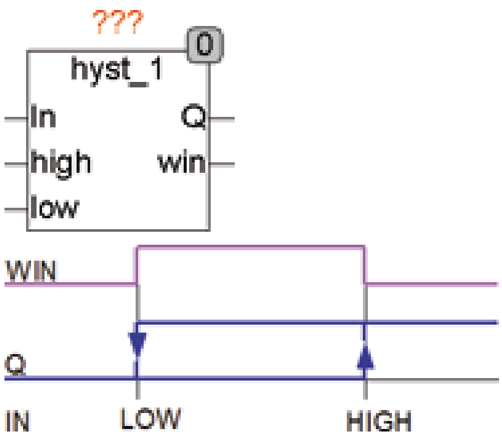
Input IN	REAL (input value)
ON	REAL (upper threshold)
OFF	REAL (lower threshold)
Output Q	BOOL (output)
WIN	BOOL (shows that lies in between ON and OFF)
	HYST is a standard Hysteresis module, its function depends on the input values ON and OFF.
	Is ON > OFF then the output TRUE if IN > ON and is FALSE when IN < OFF.
	Is ON < OFF then the output TRUE if IN < ON and is FALSE when IN > OFF.
	The output WIN is TRUE if IN is between ON and OFF, is IN is out of range ON - OFF WIN gets FALSE.

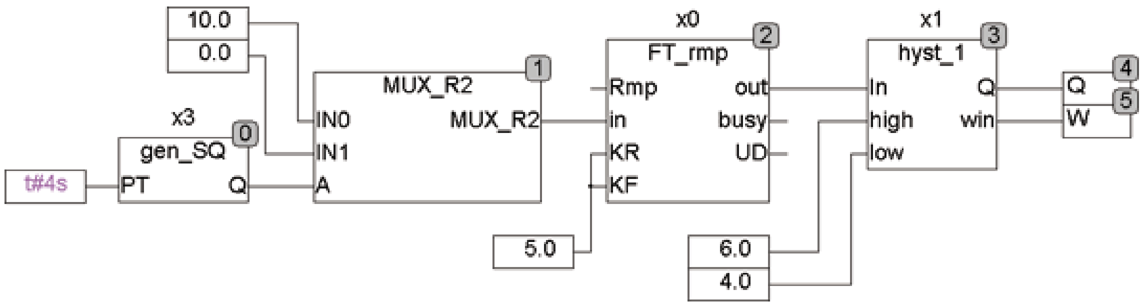


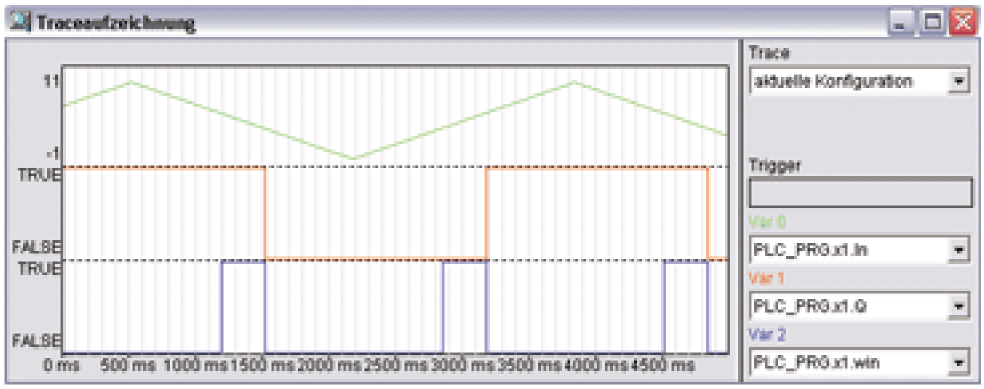
4.1.0.31 Type Function module

Input IN	REAL (input value)
HIGH	REAL (upper threshold)
LOW	REAL (lower threshold)
Output Q	BOOL (output)
WIN	BOOL (shows that IN in between LOW and HIGH)

	HYST_1 is a hysteresis module that works with upper and lower limit. The output Q is only true if the input signal at IN has exceeded the value HIGH. It is then held true until the input signal falls below LOW and Q gets FALSE. A further output WIN indicates whether the input signal is between LOW and HIGH.
	The following example shows a triangular wave generator with downstream hysteresis hysteresis module HYST_1.
	The green line shows the input signal, red is the output hysteresis and blue the WIN.



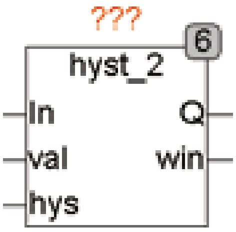


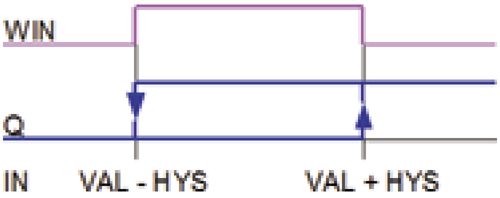


4.1.0.32 Type Function module

Input IN	REAL (input value)
VAL	REAL (mean of the hysteresis)
HYS	REAL (width of hysteresis)
Output Q	BOOL (output)
WIN	BOOL (shows that IN is in between LOW and HIGH)

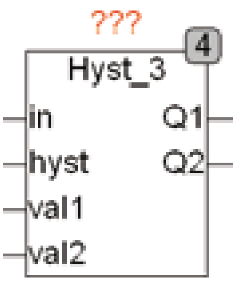
	HYST_2 hysteresis is a module for the logic thresholds by a mean and a hysteresis is defined. The lower threshold value is VAL - HYS / 2 and the upper threshold for VAL + HYS / 2
	A detailed description of the hysteresis and an application example, see HYST_1.

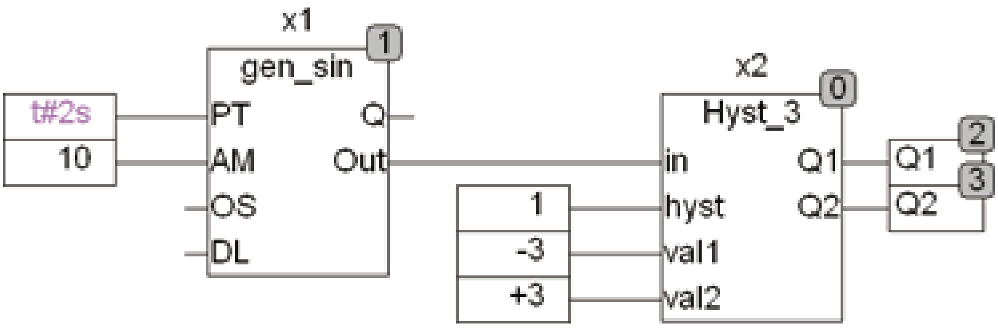


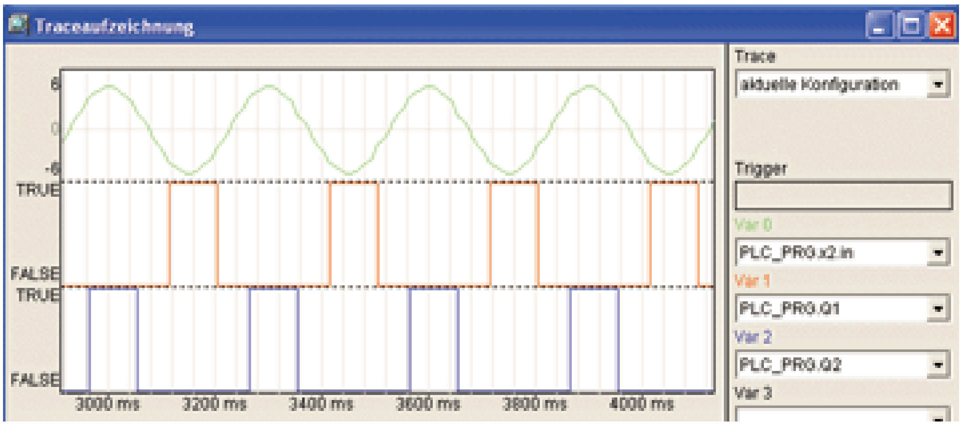


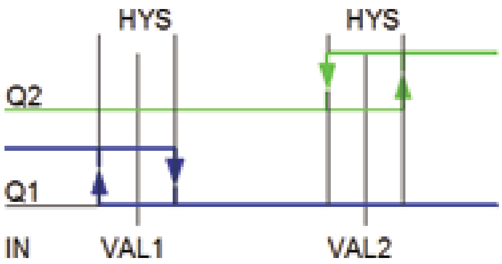
4.1.0.33 Type Function module

Input IN	REAL (input value)
HYST	REAL (width of hysteresis)
VAL1	REAL (mean of the hysteresis 1)
VAL2	REAL (mean of the hysteresis 2)
Output Q1	BOOL (Output 1)
Q2	BOOL (Output 2)
	HYST_3 is a three-point controller. The three-point controller consists of two hysteresis. Q1 is a hysteresis with val1 as the threshold and HYST as hysteresis. Q1 is TRUE when IN is less than VAL1 - HYST / 2 and FALSE when IN is greater than VAL1 + HYST / 2 . Q2 is analogous to val2. The three-point controller is used at all when motorized valves are controlled, which then be controlled with Q1r fo on and Q2 for off. If the value of IN between val1 and val2 both outputs are FALSE and the engine still stops.
Following Example shows the waveform of a 3-point controller	



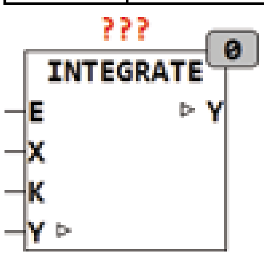






4.1.0.34 Type Function module

Input E	BOOL (Enable Input, Default = TRUE)
X	REAL (input)
K	REAL (Integration value in 1/s)
I / O Y	REAL (IntegratorOutput)
	INTEGRATE is a Integrator which integrates the value of X to an external value Y. The integrator operates when E = TRUE, the internal Default of E = TRUE.

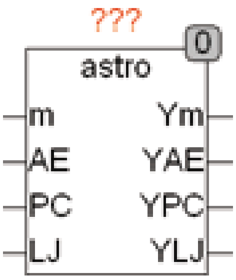


4.2 Engineering / Conversion

This section contains 42 modules.

4.2.0.1 Type Function module

Input M	REAL (distance in meter)
AE	REAL (distance in astronomical units)
PC	REAL (distance in parsecs)
LJ	REAL (distance in light years)
Output YM	REAL (distance in meters)
YAE	REAL (distance in astronomical units)
YPC	REAL (distance in parsecs)
YLJ	REAL (distance in light years)
	The module ASTRO converts various distance units commonly used in astronomy. Normally, only the input to be converted is occupied and the remaining inputs remain free. However, if several inputs loaded with values, the values of all inputs are converted accordingly and then summed.
	1 AE = 149,597870 * 109 m
	1 PC = 206265 AE
	1 LJ = 9,460530 * 1015 m = 63240 AE = 0,30659 PC

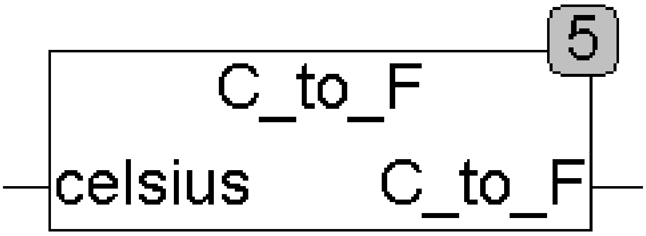


4.2.0.2 Type Function

Input BFT	INT (wind force on the Beaufort scale)
Output MS	REAL (Wind speed in meters / second)
	BFT_TO_MS calculete wind speeds on the Beaufort scale in meters per second.
The calculation is done using the formula	
	BFT_TO_MS = 0.836m/s * B^3/2

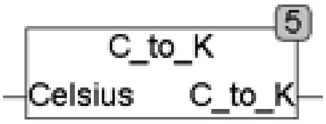
4.2.0.3 Type Function: REAL

Input CELSIUS	REAL (temperature in ° C)
Output	REAL (temperature in Fahrenheit)
	C_TO_F converts a temperature reading from Celsius to Fahrenheit.



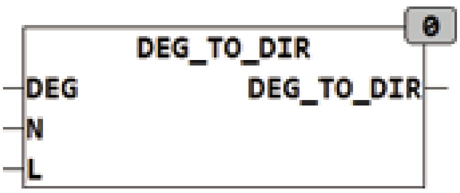
4.2.0.4 Type Function: REAL

Input CELSIUS	REAL (temperature in ° C)
Output	REAL (temperature in Kelvin)
	C_TO_K converts a temperature reading from Celsius to Kelvin.



4.2.0.5 Type Function: STRING(3)

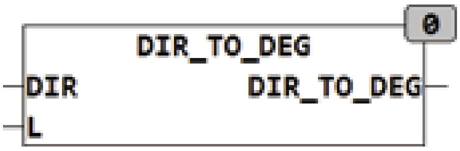
Input DEG	INT (direction in degrees)
N	INT (Maximum length of string)
L	INT (language: see language definition)
Output	STRING(3) (compass readings)
DEG_TO_DIR calculates a direction (0 .360 degrees) into to compass readings. At the input DEG the direction in degrees is available (0 = North, 90 = East, 180 = South and 270 = West). The output represents the direction as String NNE. With the input N the maximum length of the direction indication is limited. When N = 1, only in the 4 cardinal directions N, E, S, W dissolved. If N = 2 between each another direction is inserted	NE, SE, SW, NW. At N = 3 are also directions as NNO ... are dissolved, with N = 3 a total of 16 directions are evaluated. The input L allows the switching of the languages defined in the language setup. 0L = 0 means Default Language, a number > 0 is one of the predefined languages. more info about the pre-defined data types can be found at CONSTANTS_LANGUAGE.



4.2.0.6 Type Function: INT

Input DIR	STRING(3) (direction in compass readings)
L	INT (language selection)
Output	INT (direction in degrees)
	DIR_TO_DEG converts a NNE direction in the form to degrees. It will be up to 3 points evaluated, corresponding to a resolution of 22.5°. The output

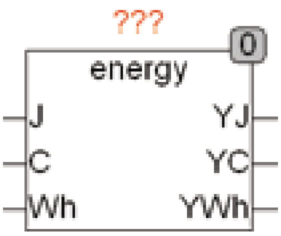
	is integer. The input must be in capital letters and East must be marked with O or E. The string NO is converted to 45°. L specifies the used language, for detailed information see data type CONSTANTS_LANGUAGE.
The cardinal points are	0° = North, 90° = East, 180° = South, 270° = West. The conversion is done according to the following table:



N	0°	NNO, NNE	23°	NO	45°	ONO, ENE	68°
O	90°	OSO, ESE	113°	SO, SE	135°	SSO, SSE	158°
S	180°	SSW	203°	SW	225°	WSW	248°
W	270°	WNW	293°	NW	315°	NNW	338°

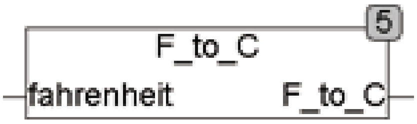
4.2.0.7 Type Function module

Input J	REAL (Joule)
C	REAL (calorie)
WH	REAL (Watt hours)
Output YJ	REAL (Joule)
YC	REAL (calorie)
YWH	REAL (Watt hours)
	The module converts ENERGY in different, in practice common units of energy. Normally, only the input to be converted is occupied and the remaining inputs remain free. However, if several inputs loaded with values, the values of all inputs are converted accordingly and then summed.
	1 J = 1 Ws (Watt * Seconds) = 1 Nm (Newton * meters)
	1 C = 4,1868 J = 1,163 * 10 −3 Wh (watt * hours)
	1 Wh = 3,6 * 103 J = 860 C



4.2.0.8 F_TO_C

Type Function	REAL
Input FAHRENHEIT	REAL (temperature value in Fahrenheit)
Output	REAL (temperature in °C)
	F_TO_C converts a temperature reading from Fahrenheit in Celsius.



4.2.0.9 Type Function: REAL

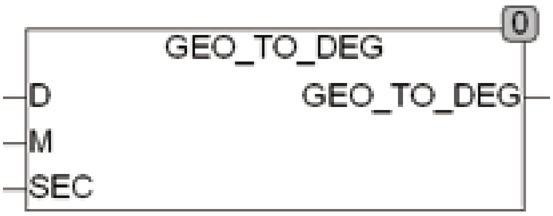
Input F	REAL (frequency in Hz)
Output	REAL (frequency in Hz)
	F_TO_OM calculates the angular frequency omega of the frequency in Hz

4.2.0.10 Type Function: REAL

Input F	REAL (frequency)
Output	TIME (period)
	F_TO_PT converts a frequency value of Hz in the corresponding period.

4.2.0.11 Type Function: REAL

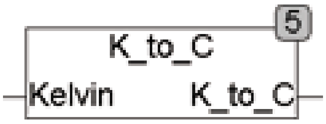
Input D	INT (angle in degrees)
M	INT (arc minutes)
SEC	REAL (arc seconds)
Output	REAL (angle specified in decimal degrees)
	GEO_TO_DEG calculates an angle expressed in degrees from the input data level. Minutes, seconds.
	GEO_TO_DEG (2,59,60.0) is 3.0 degrees



4.2.0.12 K_TO_C

Type Function	REAL
Input KELVIN	REAL (temperature value in Kelvin)

Output	REAL (temperature in °C)
	K_TO_C converts a temperature reading from Kelvin in Celsius.



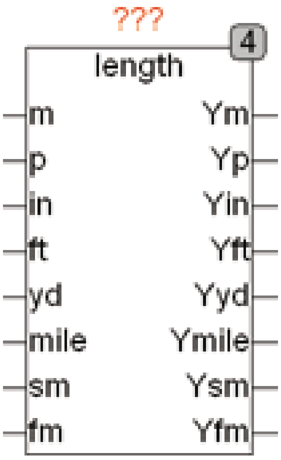
4.2.0.13 KMH_TO_MS

Type Function	REAL
Input KMH	REAL (speed in m/s)
Output	TIME (speed in km/h)
KMH_TO_MS converts value to a speed of kilomter per Hour in meters per second. KMH_TO_MS	= KMH / 3.6

4.2.0.14 LENGTH

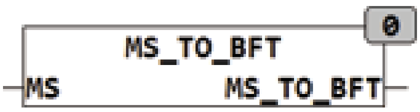
Type	Function module
Input M	REAL (Meter)
P	REAL (Typographic point)
IN	REAL (Inch)
FT	REAL (Foot)
YD	REAL (Yard)
MILE	REAL (Mile)
SM	REAL (International nautical mile)
FM	REAL (Fathom)
Output YM	REAL (Meter)
YP	REAL (Typographic point)
YIN	REAL (Inch)
YFT	REAL (Foot)
YYD	REAL (Yard)
YMILE	REAL (Mile)
YSM	REAL (International nautical mile)
YFM	REAL (Fathom)
	The module LENGTH converts different in common used units for units of length. Normally, only the input to be converted is occupied and the remaining inputs remain free. However, if several inputs loaded with values, the values of all inputs are converted accordingly and then summed.

	1 P = 0.376065 mm (unit from the printing industry)
	1 IN = 25,4 mm
	1 FT = 0,3048 m
	1 YD = 0,9144 m
	1 MILE = 1609,344 m
	1 SM = 1852 m
	1 FM = 1,829 m



4.2.0.15 MS_TO_BFT

Type	Function
Input MS	INT (force on the Beaufort scale)
Output MS	REAL (Wind speed in meters / second)
	MS_TO_BFT converts wind speeds of meters per second in the Beaufort scale.
The calculation is done using the formula	
	MS_TO_BFT = (MS * 1.196172)^2/3



4.2.0.16 MS_TO_KMH

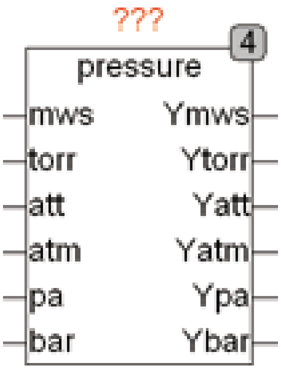
Type Function	REAL
Input MS	REAL (speed in km/h)
Output	REAL (speed in m/s)
	MS_TO_KMH calculates a speed value of meters/second to kilometers/hour to.
MS_TO_KMH	= MS * 3.6

4.2.0.17 OM_TO_F

Type Function	REAL
Input OM	REAL (angular frequency omega)
Output	REAL (frequency in Hz)
	OM_TO_F calculates the frequency in Hz of the angular frequency Omega.

4.2.0.18 PRESSURE

Type	Function module
Input MWS	REAL (water column in meters)
TORR	REAL (Torr respectively mercury column in mm)
ATT	REAL (technical atmosphere)
ATM	REAL (atmospheric physics)
PA	REAL (Pascal)
BAR	REAL (Bar)
Output YMWS	REAL (water column in meters)
YTORR	REAL (Torr respectively mercury column in mm)
Yatt	REAL (technical atmosphere)
Yatm	REAL (atmospheric physics)
YPA	REAL (Pascal)
Ybars	REAL (Bar)
	The module PRESSURE converts different, in practice common units, for pressure. Normally, only the input to be converted is occupied and the remaining inputs remain free. However, if several inputs loaded with values, the values of all inputs are converted accordingly and then summed.
	1 MWS = 1 meter of water = 0.0980665 Bar
	1 Torr = 1 mm Hg = 0.133322 bar = 101325/760 Pa
	1 ATT = 1 kp / cm ² = 0.980665 bar
	1 ATM = 1.01325 Bar
	1 PA = 1 N / m²
	1 BAR = 105 Pa

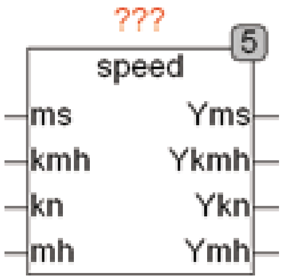


4.2.0.19 PT_TO_F

Type Function	REAL
Input PT	TIME (period in seconds)
Output	REAL (frequency in Hz)
	PT_TO_F expects a period of seconds in the appropriate frequency to frequency in Hz.

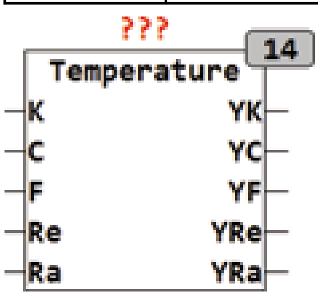
4.2.0.20 Type Function module

Input MS	REAL (meters / second)
KMH	REAL (kilometers / hour)
CN	REAL (knots = miles / hour)
MH	REAL (miles / hour)
Output YMS	REAL (meters / second)
YKMH	REAL (Kilometers / hour)
YKN	REAL (knots = miles / hour)
YMH	REAL (miles / hour)
	The module SPEED converts various common units in the units for speed. Normally, only the input to be converted is occupied and the remaining inputs remain free. However, if several inputs loaded with values, the values of all inputs are converted accordingly and then summed.
	1 ms = meters / second = 3.6 km / h
	1 kmh = kilometers / hour = 1 / 3, 6 m / s
	1 knot = knot = 1 nautical mile / hour = 0.5144 m / s
	Mh = 1 mile per hour = 0.44704 m / s



4.2.0.21 Type Function module

Input K	REAL (Kelvin temperature scale for)
C	REAL (Temperature scale to Celsius)
F	REAL (Fahrenheit temperature scale)
RE	REAL (after Reaumur temperature scale)
RA	Real (after Rankine temperature scale)
Output YK	REAL (according to Kelvin temperature scale)
YC	REAL (Temperature scale to Celsius)
YF	REAL (Fahrenheit temperature scale)
YRE	REAL (after Reaumur temperature scale)
YRA	Real (after Rankine temperature scale)
	The module TEMP converts different, in practice common used units for temperature. Normally, only the input to be converted is occupied and the remaining inputs remain free. However, if several inputs loaded with values, the values of all inputs are converted accordingly and then summed.
	1 K = 273.15 °C
	1 °C = 273.15 K
	1 °F = °C * 1.8 + 32
	1 Re = °C * 0.8
	1 Ra = K * 1.8

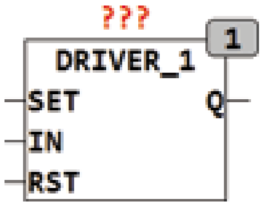


4.3 Engineering / automation

This section contains 38 modules.

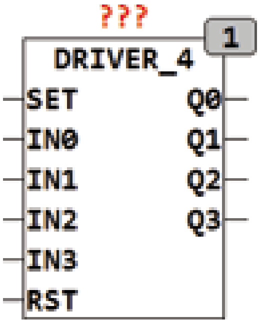
4.3.0.1 Type Function module

Input SET	BOOL (asynchronous set input)
IN	BOOL (switch input)
RST	BOOL (asynchronous reset input)
Output Q0	BOOL (output)
	DRIVER_1 a driver module whose output Q can be set by the input IN is when TOGGLE_MODE = FALSE. The output is then held to TRUE until it is either set to FALSE by an asynchronous reset (RST) or until expiry of the maximum switching time (TIMEOUT). Further impulses at the input IN thereby extend the TRUE period by the output whereas each rising edge at the IN the Timeout begins again. If TOGGLE_MODE = TRUE, the output Q switches with each rising edge on the IN state between TRUE and FALSE. Also in TOGGLE_MODE the TIMEOUT limits the maximum TRUE phase at the output Q. TIMEOUT is set to T#0s (Default) Then no Timeout active. The asynchronous SET and RST inputs sets the output Q to TRUE or FALSE. The module DRIVER_4 provides the same functionality with 4 switching outputs.
Setup TOGGLE_MODE	BOOL (mode of the input IN)
TIMEOUT	TIME (maximum duty cycle of the outputs)



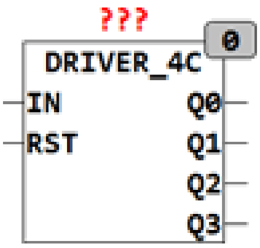
4.3.0.2 DRIVER_4

Type	Function module
Input SET	BOOL (asynchronous set input)
IN0...IN3	BOOL (switching inputs)
RST	BOOL (asynchronous reset input)
Output Q0 .. Q3	BOOL (outputs)
	DRIVER_1 is a driver module whose outputs Q can be switched by the inputs IN. a detailed description of the module can be read under DRIVER_1. DRIVER_4, as opposed to DRIVER_1 has 4 switching outputs, but otherwise has the same functionality.
Setup TOGGLE_MODE	BOOL (mode of the input IN)
TIMEOUT	TIME (Maximum Ontime of outputs)



4.3.0.3 Type Function module

Input IN	BOOL (switch input)
RST	BOOL (asynchronous reset input)
Output Q0 .. Q3	BOOL (outputs)
	DRIVER_4C is a driver circuit whose output states are switched with a rising edge of IN. The output states are predefined in the Setup array SX and may be changed at any time by the user. The array SX [1..6] defines the output states for each switching state SN individually bitwise. Bit 0 of an element switch Q0, Bit1 turns Q1, Bit2 Q2 and Bit3 Q3, the upper 4 bits are respectively ignored. The array is initialized with Bit0 = TRUE for SN = 1, bit 1 for SN = 2. Bit2 for SN = 3 and Bit3 for SN = 4. Thus, the output go through the sequence (0000,0001,0010,0100,1000,0000) for (Q3, Q2, Q1, Q0) . If the element SX[SN] is of array 0 so the SN will automatically jump back to 0, so that an empty element terminates the sequence. At the end of the timeout the module automatically jumps back into the condition SN = 0. The timeout is only active if the variable TIMEOUT > t#0s is.
Setup TIMEOUT	TIME (Maximum Switch of the module)
SX	ARRAY [1..7] OF BYTE:= 1,2,4,8,0,0,0;
	(Default setting of the switching sequence)



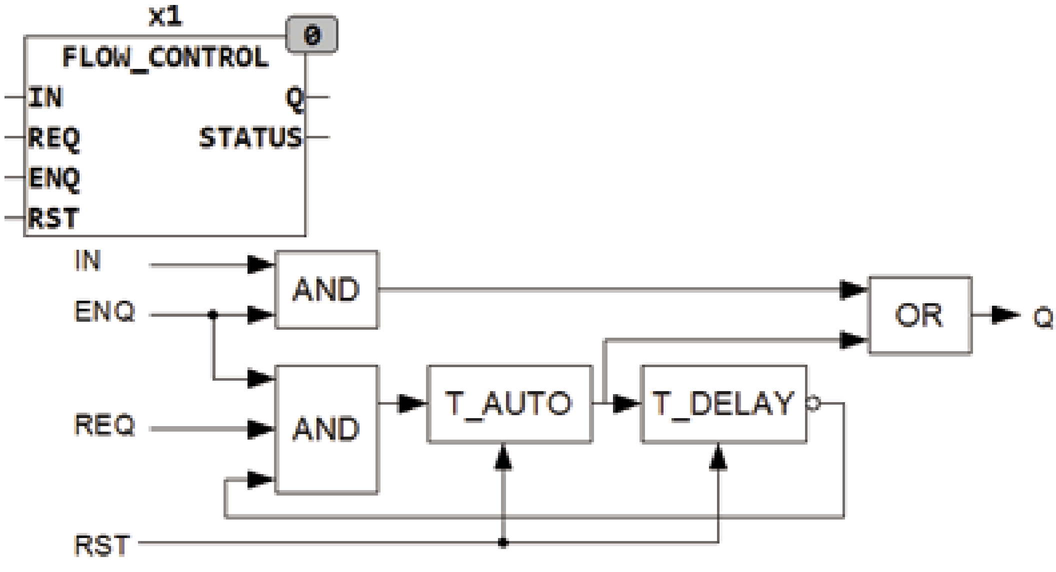
Example:

```
SX = 1,3,7,15,7,3,1 generates the following sequence: Q3,Q2,Q1,Q0 =
0000,0001,0011,0111,1111,0111,0011,0001,0000,......
```

4.3.0.4 Type Function module

Input IN	BOOL (control input)
REQ	BOOL (Request for automatic mode)
ENQ	BOOL (Enable for output Q)
RST	BOOL (asynchronous reset input)
Output Q	BOOL (switching output for valve)

STATUS	BYTE (ESR compliant status output)
	FLOW_CONTROL switches a valve at the output Q when the input IN = TRUE. In addition, the valve can also be switched via the input RE. REQ = TRUE turns the valve on for the time T_AUTO and will be locked for the time T_DELAY. after the time T_DELAY the valve can be turned on again on REQ. During this lock period T_DELAY the valve may be controlled by the input IN. An ESR compatible status output STATUS indicates the status of the module. Both the REQ and IN can only switch the output Q when the input ENQ is set to True.
Status = 100	Ready
Status = 101	Valve on by a TRUE at IN
Status = 102	Valve on by a TRUE at REQ
Status = 103	Reset is executed
The diagram illustrates the structure of inferential FLOW_CONTROL	
Setup T_AUTO	TIME (valve switch time in automatic mode)
T_DELAY	TIME(valve disable Time in automatic mode)

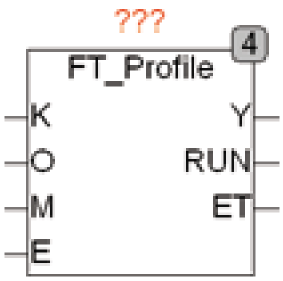


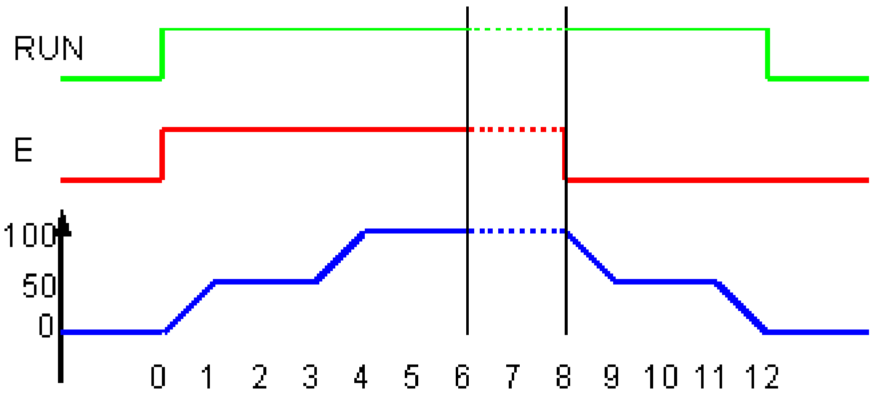
4.3.0.5 Type Function module

Input K	REAL (multiplier)
O	REAL (offset)
M	REAL (time multiplier)
E	BOOL (start signal)
Output Y	REAL (signal output)

RUN	BOOL (TRUE, if the output signal is generated)
ET	TIME (time since start of the initial profile)
Setup VALUE_0	REAL (output value of the output to start)
TIME_1	TIME (time when the ramp reaches VALUE_1)
VALUE_1	REAL (value of the ramp at the time TIME_1)
TIME_2	TIME (time when the ramp reaches VALUE_2)
VALUE_2	REAL (value of the ramp at the time TIME_2)
TIME_3	TIME (time when the ramp reaches VALUE_3)
VALUE_3	REAL (value of the ramp at the time TIME_3)
TIME_10	TIME (time when the ramp reaches VALUE_10)
VALUE_10	REAL (value of the ramp at the time TIME_10)
TIME_11	TIME (time when the ramp reaches VALUE_11)
VALUE_11	REAL (value of the ramp at the time TIME_11)
TIME_12	TIME (time when the ramp reaches VALUE_12)
VALUE_12	REAL (value of the ramp at the time TIME_12)
TIME_13	TIME (time when the ramp reaches VALUE_13)
VALUE_13	REAL (value of the ramp at the time TIME_13)
	FT_PROFILE generates a time-dependent output signal. The output signal is defined by time - value pairs. FT_PROFILE generate a output signal Y by the value pairs are connected by ramps. A typical application for FT_PROFILE is to generate a temperature profile for a furnace, but also every application which requires a time-dependent control signal provides an application. The time-dependent output signal is initiated by a rising edge at E and then runs automatically. After the pair of values (TIME_10, VALUE_10) the output signal remains to VALUE_10, until the input E = FALSE. With an edge to E the signal can be started and additionally, the input E will also used to extend the signal indefinitely. This makes it possible to create a course to the value VALUE_3, to stretch it with E and after the falling edge of E again to create a course back to baseline. With the inputs K, M and O, the output signal can be stretched and scaled dynamically.
	Y = value generated * K + O
	The input M is used for stretching of the signal over time. The actual time course is consistent with the defined time course through the setup over time multiplied by M. In order to ensure linear ramp, a time extension by M works only after completion of an edge. The output RUN is set with a rising edge of E to TRUE and is only after the time profile FALSE again. At the output of ET, the time elapsed since start time can be read.

The following graphs show the output for the values	
	VALUE_0 = 0
	TIME_1, VALUE_1 = 1s, 50
	TIME_2, VALUE_2 = 3s, 50
	TIME_3, VALUE_3 = 4s, 100
	TIME_10, VALUE_10 = 6s, 100
	TIME_11, VALUE_11 = 7s, 50
	TIME_12, VALUE_12 = 9s, 50
	TIME_13, VALUE_13 = 10s, 0
	The graphs represent the output of both phase 3 is stretched by E, and without stretching.

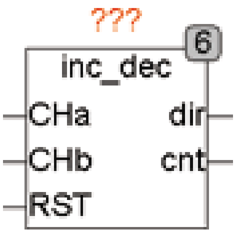


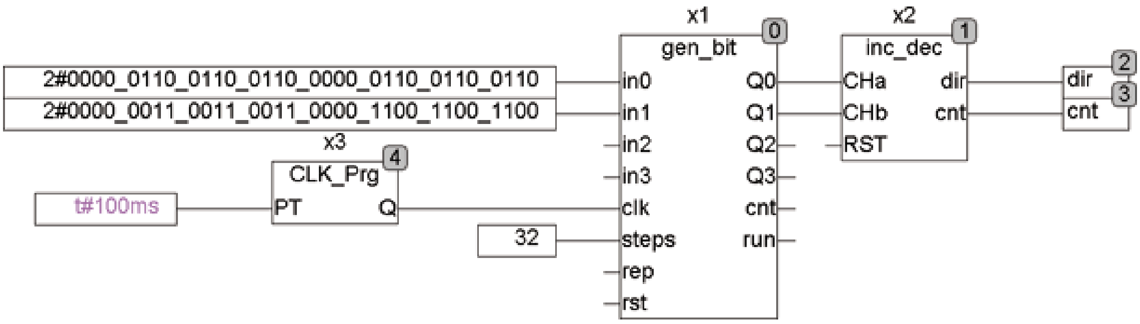


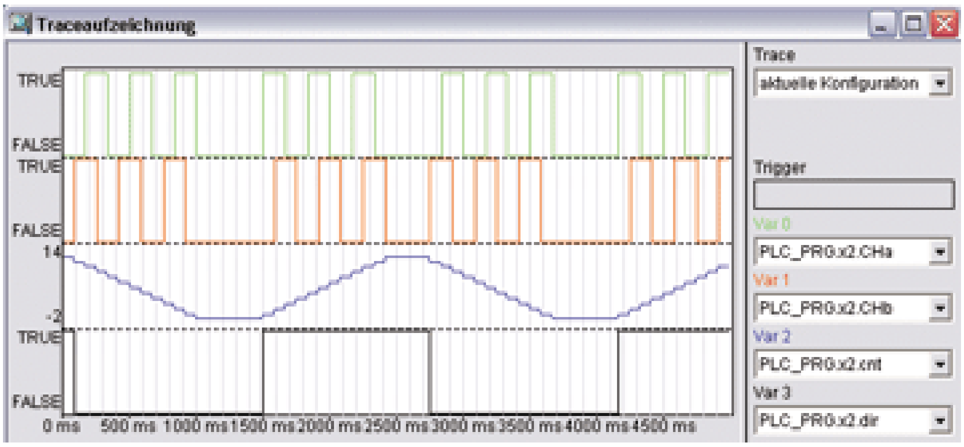
4.3.0.6 Type Function module

Input CHA	BOOL (channel A of sender)
CHB	BOOL (channel B of sender)
RST	BOOL (Reset)
Output DIR	BOOL (rotation)
CNT	INT (counter value)
	INC_DEC is a decoder for incremental encoder. Encoder (rotation encoder) deliver two overlapping pulses, channel A and channel B. By the two channels, the direction and angle of rotation is decoded. INC_DEC detect each edge of the encoder, so 4 times the resolution is achieved. The output DIR shows the direction of rotation, and at the output CNT is an integer value provided, which outputs the number of counted pulses.

	For a full rotation of an encoder with 100 pulses CNT counts to 400, because each edge is counted at both channels, so 4 times the resolution is achieved. A RST input allows any time to set the counter to 0. The counter counts up when DIR = TRUE, and down if DIR = FALSE.
	In the following Example a pattern generator GEN_BIT is used to simulate a rotary encoder, which is always makes just 3 steps clockwise and 3 counterclockwise . In the Trace RECORDING is shown how the INC_DEC split the movement in 12 steps and decodes the direction.

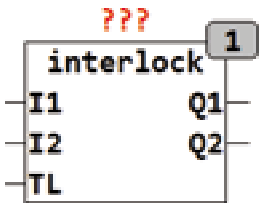


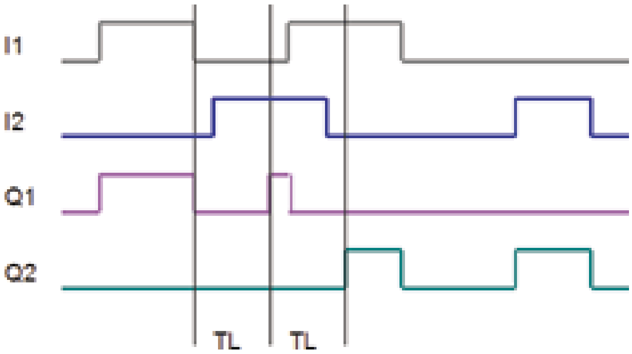




4.3.0.7 Type Function module

Input I1	BOOL (input 1)
I2	BOOL (input 2)
TL	TIME (lock time)
Output Q1	BOOL (output 1)
Q2	BOOL (output 2)
	The module INTERLOCK has 2 inputs I1 and I2 which passes to each of the outputs Q1 and Q2. Q1 and Q2, however, are interlocked so that only one output is set to TRUE. The time TL sets a dead time between the two outputs. An output can only be true if the other output was at least for the time TL FALSE.

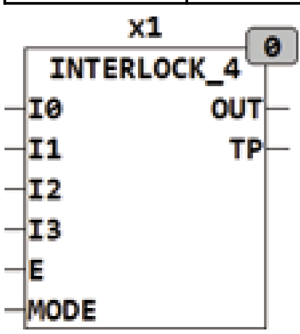




I1	I2	Q1	Q2
0	0	0	0
0	1	0	1
1	0	1	0
1	1	0	0

4.3.0.8 Type Function module

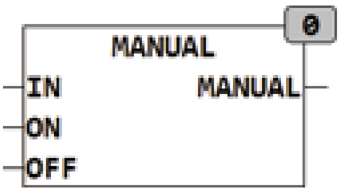
Input I0	BOOL (Input 0)
I1	BOOL (input signal 1)
I2	BOOL (input signal 2)
I3	BOOL (input signal 3)
E	BOOL (Enable Input)
MODE	INT (operating mode)
Output OUT	BOOL (output)
TP	BOOL (TRUE if the departure has changed)
	INTERLOCK_4 stores the 4 input values I0..I3 in the bits (0..3) of the output OUT. With every change of the output the output TP is for one cycle TRUE so that additional modules can be triggered for processing. If the input E = FALSE, all outputs remain to 0 or FALSE. The input MODE adjust the different operating modes of the module.

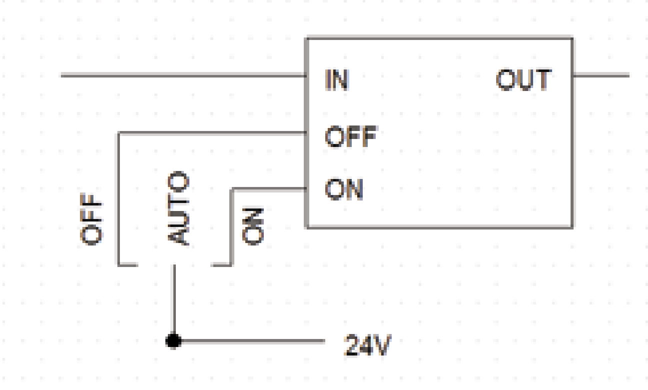


MODE	Meaning
0	Inputs are directly passed to the output byte.z.B. I0, I2 = TRUE OUT = 2#0000_0101
1	Only the input with the highest input number is issued, the others are ignored.z.B. I0,I1,I2 = TRUE: OUT = 2#0000_0100
2	Only the most recently activated input is passed.
3	An enabled input disables all other inputs.

4.3.0.9 MANUAL

Type Function	BOOL
Input IN	BOOL (Input)
ON	BOOL (manual mode on)
OFF	BOOL (manual mode off)
Output	BOOL (output)
	MANUAL can override an input signal IN with TRUE or FALSE.
	The typical use of MANUAL by means of a switch with 3 positions (OFF, AUTO, ON) where the connections are OFF at OFF and On at On and AUTO of the switch remains open.
The following diagram shows the possible connection of a switch with 3 positions	

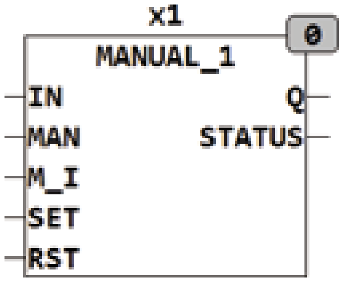




IN	ON	OFF	Q	
0	0	0	0	
1	0	0	1	
-	-	1	0	Manual operation position OFF
-	1	0	1	Manual operation position ON

4.3.0.10 MANUAL_1

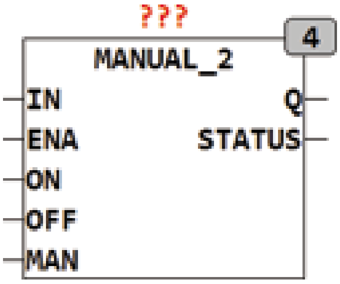
Type	Function module
Input IN	BOOL (Input)
MAN	BOOL (manual override)
M_i	BOOL (signal level in manual mode)
SET	BOOL (Asynchronous set in manual mode)
RST	BOOL (Asynchronous reset for manual operation)
Output Q	BOOL (output)
STATUS	BYTE (ESR compliant status output)
	MANUAL_1 can override a digital signal in the manual mode. As long as MAN = FALSE the output Q follows the input IN directly. Once MAN = TRUE, the output follows the state of the input M_I. With the inputs of SET and RST in manual mode, an asynchronous set and clear the output can be produced. SET and RST are active only during manual operation. Is in manual mode at SET or RST a rising edge, the output follows not longer the input M_I but remains on the state of the rising edge of SET (output = TRUE) or RST (output = FALSE). Once the input MAN is back on FALSE the output Q follows the input IN again.



4.3.0.11 MANUAL_2

Type	Function module
Input IN	BOOL (Input)
ENA	BOOL (block Enable Input)
ON	BOOL (Forces the output to TRUE)
OFF	BOOL (Forces the output to FALSE)
MAN	BOOL (starting mode in manual mode)
Output Q	BOOL (output)
STATUS	BYTE (ESR compliant status output)
	MANUAL_2 , a digital signal and override switches between manual and automatic operation. The module is designed so that a 3-position switch switches between off and auto. In the automatic the signal mode is set to IN, in the case of enforced off, the OFF is set to TRUE and in the case of enforced on, tho ON set to TRUE. If the two inputs ON and OFF are FALSE switch the input IN directly to the output Q. However, are both inputs ON and OFF simultaneously set to TRUE, the state of the input MAN is switched to the output. The input MAN can also be used to define a priority for ON or OFF which passes the value of the MAN is always on the output if both inputs ON and OFF are simultaneously

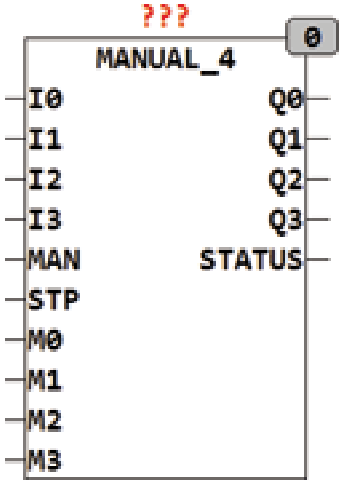
	true. Is the input ENA set to FALSE, the output is always set to FALSE, the module is disabled. The following table defines the operating modes of the module. The STATUS output is ESR compatible and reports on the status of the module to corresponding ESR components.



IN	ENA	ON	OFF	MAN	Q	STATUS	
-	L	-	-	-	L	104	Disabled
X	H	L	L	-	X	100	Auto Mode
-	H	H	L	-	H	101	forceHigh
-	H	L	H	-	L	102	forceLow
-	H	H	H	X	X	103	Manual Input
-	H	H	H	L	L	103	ForcewithPriorityfor OFF
-	H	H	H	H	H	103	ForcewithPriorityfor ON

4.3.0.12 MANUAL_4

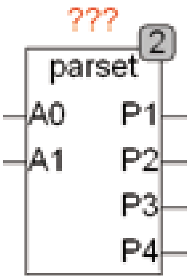
Type	Function module
Input I0..I3	BOOL (inputs)
MAN	BOOL (manual override)
M0..M3	BOOL (input signals in manual mode)
STP	BOOL (Asynchronous Step in manual mode)
Output Q0..Q3	BOOL (output signals)
STATUS	BYTE (ESR compliant status output)
	MANUAL_4 can override 4 digital signal in manual mode. As long as MAN = FALSE the outputs Q follows direct the input I. As soon as the inputs MAN = TRUE, the outputs follow the states of the inputs M. The STP input follow is in manual mode, a rotating set of outputs are generated. STP is active only during manual operation. When in manual operation of STP registered a rising edge, then the outputs follow not the inputs MX but are switched cyclically with STP. At the first rising edge of STP, only the output Q0 gets active and the next edge of STP the module switch to the output Q1 and so on. Once the input MAN goes back to FALSE the outputs Q follows again the input I. The ESR compliant status output passes the switching states.



STATUS	Condition
100	Automatic Mode MAN = FALSE, Q0 = I0, Q1 = I1, Q2 = I2, Q3 = I3
101	Manual Mode MAN = TRUE, Q0 = M0, Q1 = M1, Q2 = M2, Q3 = M3
110,111,112,113	Step Mode for Output Q0, Q1, Q2, Q3

4.3.0.13 Parset

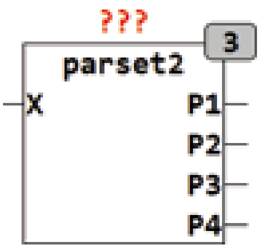
Type	Function module
Input A0	BOOL (selection input 0)
A1	BOOL (selection input 1)
Output P1	REAL (parameter 1 out)
P2	REAL (Parameter 2 Output)
P3	REAL (Parameter 3 Output)
P4	REAL (Parameter 4 Output)
	Parset selects from up to 4 sets of parameters each one and returns the values at the outputs P1 to P4. The values for the parameter sets are defined with the setup variables. If the TC setup variable to a value > 0 is set, the outputs do not change abruptly to a new value, but run in a ramp to the new value so that the final value is reached after time TC. This allows the smooth transition between different sets of parameters. The choice of parameters is controlled by inputs A0 and A1.
Setup X01, X11, X21, X31	REAL (values for parameters P1)
X02, X12, X22, X32	REAL (values for parameters P2)
X03, X13, X23, X33	REAL (values for parameters P3)
X04, X14, X24, X34	REAL (values for parameters P4)
TC	TIME (ramp time to a new value of the)



A1,A0	P1	P2	P3	P4
00	X01	X02	X03	X04
01	X11	X12	X13	X14
10	X21	X22	X23	X24
11	X31	X32	X33	X34

4.3.0.14 PARSET2

Type	Function module
Input X	REAL (input)
Output P1	REAL (parameter 1 out)
P2	REAL (Parameter 2 Output)
P3	REAL (Parameter 3 Output)
P4	REAL (Parameter 4 Output)
	Parset selects from up to 4 sets of parameters one and returns the values at the outputs P1 to P4. The values for the parameter sets are defined with the setup variables. If the TC setup variable to a value > 0 is set, the outputs do not change abruptly to a new value, but run in a ramp to the new value so that the final value is reached after time TC. This allows the smooth transition between different sets of parameters. The choice of parameters is the controlled variable X and the thresholds L1 to L3 set.
Setup X01, X11, X21, X31	REAL (values for parameters P1)
X02, X12, X22, X32	REAL (values for parameters P2)
X03, X13, X23, X33	REAL (values for parameters P3)
X04, X14, X24, X34	REAL (values for parameters P4)
L1, L2, L3	REAL (Limits for the parameter switching
TC	TIME (ramp time at the outputs P)

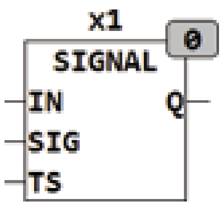


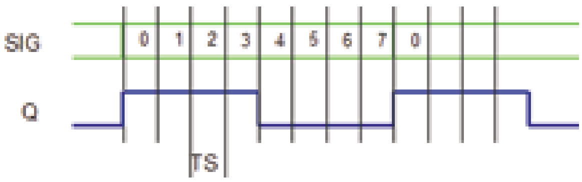
X	P1	P2	P3	P4

X < L1	X01	X02	X03	X04
L1 < X < L2	X11	X12	X13	X14
L2 < X < L3	X21	X22	X23	X24
X >= L3	X31	X32	X33	X34

4.3.0.15 Type Function module

Input IN	BOOL (enable input)
SIG	BYTE (Bitpattern)
TS	TIME (switching time)
Output Q	BOOL (output)
	SIGNAL generates an output signal Q that corresponds to the bit pattern in SIG. This is Bitpattern is passed in TS long steps. By different bit patterns in SIG, various output signals are generated. If the input IN connected to TRUE, the module begins to put on output Q in accordance with the SIG provided Bitpattern . By adapting the Bitpattern different output signals are generated. A Pattern of 10101010, generates an output signal with 50% Duty Cycle and a frequency that is 1/2*S. A Pattern 11110000 by contrast, generates an output signal of 50% and a frequency of 1/8*TS. The start of an output signal is random. The Bit sequence starts at any bit when the input IN goes to TRUE. If at the input TS no time given then the module internally uses a default of 1024ms per cycle (a cycle is the cycle of all 8 bits of a sequence). Typical applications for SIGNAL is the signal generation for sirens or signal lamps.
	The following graph illustrates the functioning of signal for
SIG = 2#1111_0000	

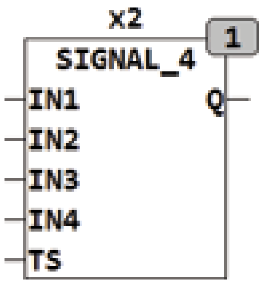


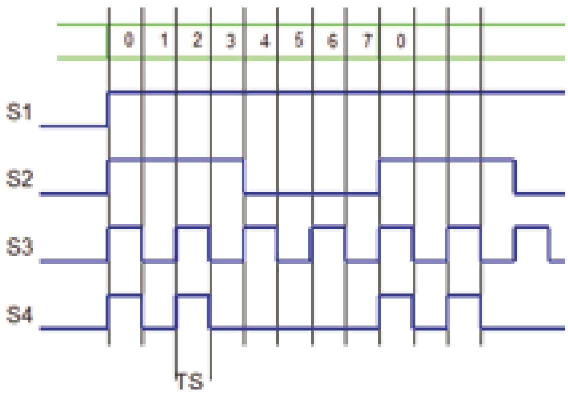


4.3.0.16 Type Function module

Input IN1..IN4	BOOL (input for Bitpattern S1..S4)
TS	TIME (switching time)
Output Q	BOOL (output)
	SIGNAL_4 generates an output signal Q that is equivalent the one of 4 Bitpattern (S1.. S4). This is Bitpattern is passed in TS long steps. The inputs IN1..IN4 inputs are prioritized. A TRUE at IN1

	overrides all other inputs, IN2 overwrite IN3 and IN4 has the lowest priority. A detailed description of the function of SIGNAL_4 is under SIGNAL. The 4 different Bitpattern are in setup variables are in S1.. S4 and can be adjusted by the user at any time.
The module has the following default by Bitpattern, but can be changed by the user if required	
	S1 = 2#1111_1111
	S2 = 2#1111_0000
	S3 = 2#1010_1010
	S4 = 2#1010_0000
Setup S1.. S4	BYTE (Bitpattern S1 .. S4)

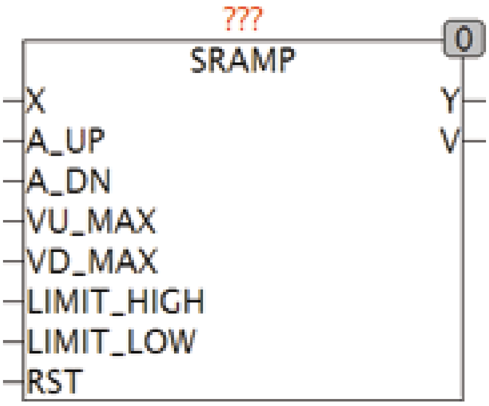


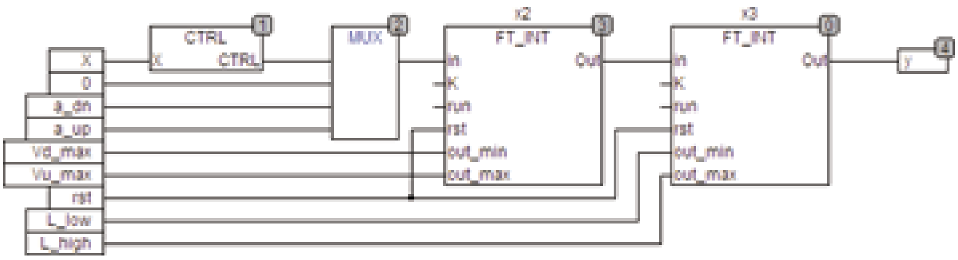


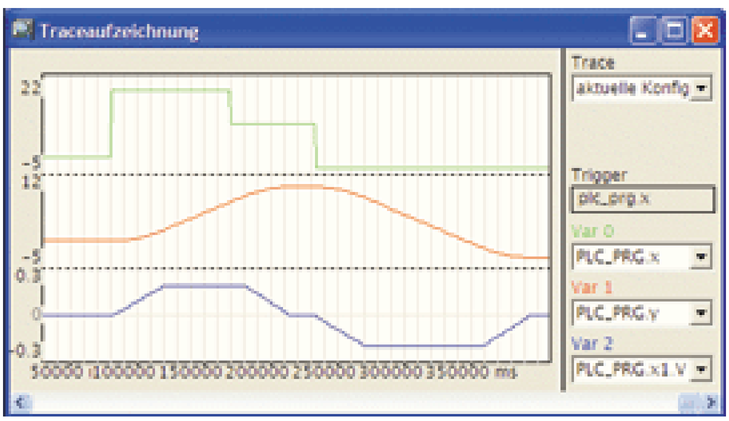
4.3.0.17 SRAMP

Type	Function module
Input X	REAL (input)
A_UP	REAL (Maximum acceleration Up)
A_DN	REAL (Maximum acceleration down)
VU_MAX	REAL (Maximum speed Up)
VD_MAX	REAL (Maximum Speed Down)
LIMIT_HIGH	REAL (Output Limit High)
LIMIT_LOW	REAL (Output Limit Low)
RST	BOOL (Asynchronous Reset)

Output Y	REAL (output signal)
V	REAL (current speed of the output signal)
	SRAMP generates an output signal which is is limited by the adjustable parameters. The output follows the input signal and is limited by maximum speed (VU_MAX and VD_MAX), upper and lower limit (LIMIT_LOW and LIMIT_HIGH), and maximum acceleration (A_UP and A_DN). SRAMP is used to drive motors, for example. The output V passes the current speed of the output.
	In following diagram, the internal process of SRAMP is shown. A ramp generator X2, sets the speed of the output change, and a second ramp generator X3 controls the output.
	The Trace Recording shows an example of SRAMP. The input (green) increases from 0 to 20 and then immediately to 10 while the output increases with the maximum acceleration to maximum speed. Then is shown that the Input during the course may change. In this example, it slowed down in time, so that the output stops exactly at 10. After reaching the end value 10 of the input switches to −3 and the output Y follows accordingly.
	The input values for A_UP and VU_MAX must be specified with a positive sign, A_DN and VD_MAX need a negative sign.

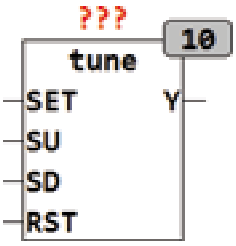






4.3.0.18 Type Function module

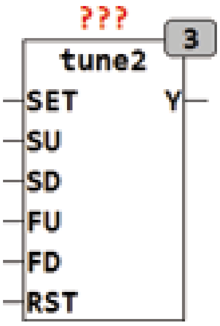
Input SET	BOOL (Asynchronous set input)
SU, SD	BOOL (inputs for up and down)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output signal)
	TUNE sets, using up and down buttons, an output signal Y. By corresponding setup variables, the increment will be programmed individually. An upper and lower limit for the output Y can be specified by LIMIT_L and LIMIT_H . with the buttons SU and SD up or down steps are generated. If a key is held down longer than the time T1, then the output Y is continuously adjusted up or down. The speed, which with the output is adjusted here, is given by S1. S1 and S2 indicate the units per second. Is a button held down longer than the time T2, the device automatically switches to a second speed S2. With the inputs RST and SET the output can at any time be adjusted by RST_VAL resp. SET_VAL to a predetermined value.
Setup SS	REAL (step size for small step)
SS	REAL (step size for small step)
Limit_H	REAL (upper limit)
RST_VAL	REAL (initial value after reset)
RST_VAL	REAL (initial value after reset)
T1	TIME (time after the first ramp starts)
T1	TIME (time in which the second ramp starts)
S1	REAL (speed for first ramp)
S2	REAL (speed for second ramp)



4.3.0.19 Type Function module

Input SET	BOOL (Asynchronous set input)
SU, SD	BOOL (inputs for up and down in small increments)
FU, FD	BOOL (inputs for up and down in large increments)
RST	BOOL (asynchronous reset input)
Output Y	REAL (output signal)
	TUNE2 sets an output signal Y using up and down buttons. By corresponding setup variables, the step size for small and large steps are programmed individually. An upper and lower limit for the output Y can be specified by LIMIT_L and LIMIT_H . with the SU and SD keys small steps can be generated up or down. The buttons FU and FD respectively produce large steps at the output Y. If a key is held down longer than TR,

	then the output Y continuously adjusted up or down. The speed which with the output here is adjusted, is for the two pairs of keys S1 and S2 set individually. S1 and S2 indicate the units per second. S1 is the speed of the button SU and SD, and S2 according to FU and FD. With the inputs of the RST and SET the Output can be set at any time, on a value predetermined by RST_VAL SET_VAL.
Setup SS	REAL (step size for small steps)
FS	REAL (step size for big steps)
SS	REAL (step size for small step)
Limit_H	REAL (upper limit)
RST_VAL	REAL (initial value after reset)
RST_VAL	REAL (initial value after reset)
TR	TIME (time in which the ramp starts)
S1	REAL (speed for small ramp)
S2	REAL (speed for large ramp)

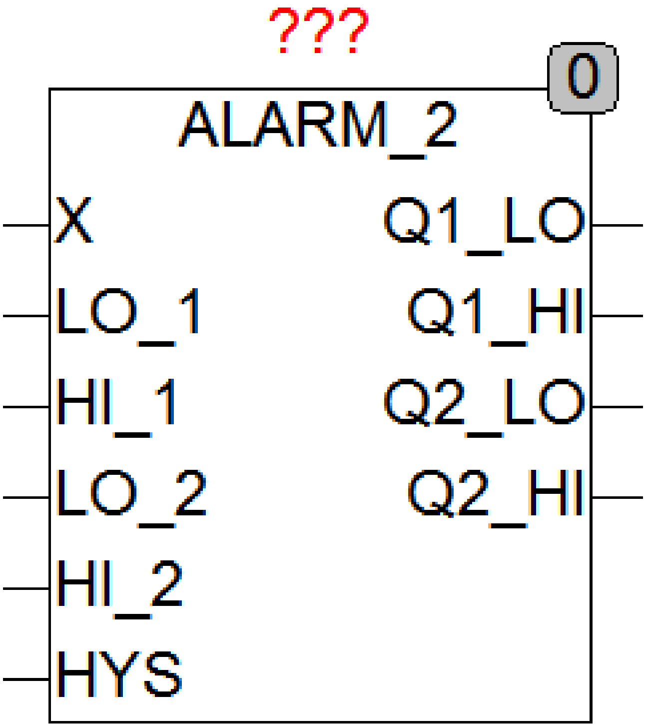


4.4 Engineering / measurements

This section contains 34 modules.

4.4.0.1 Type Function module

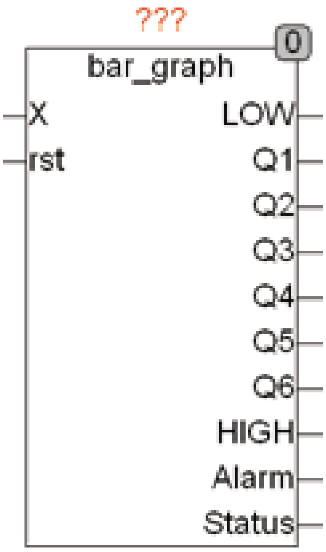
Input X	REAL (input)
RST	BOOL (reset input for alarm output)
Output LOW	BOOL (TRUE, if X < TRIGGER_LOW)
	ALARM_2 examine whether X exceeds up the limits HI_1 or HI_2 and relies on the outputs Q1_HI or Q2_HI TRUE. If the limits LO_2 or LO_1 are below, it set Q1_LO or Q2_LO to TRUE. The outputs will remain TRUE as the corresponding limit over-or under-rature. To prevent a flutter of the outputs alternatively a Hysteresis HYS may be set. HYS is set to a value > 0, then the corresponding output is set only when the limit is exceeded or below by more than HYS/2. Accordingly, the input X is the limit by more than HYS/2 on or before exceeding the corresponding outputs are deleted.
	ALARM_2 for example, with HI_1 and LO_1 can control the level of a liquid container and with HI_2 and LO_2 trigger an alarm when a critical level is exceeded or below.

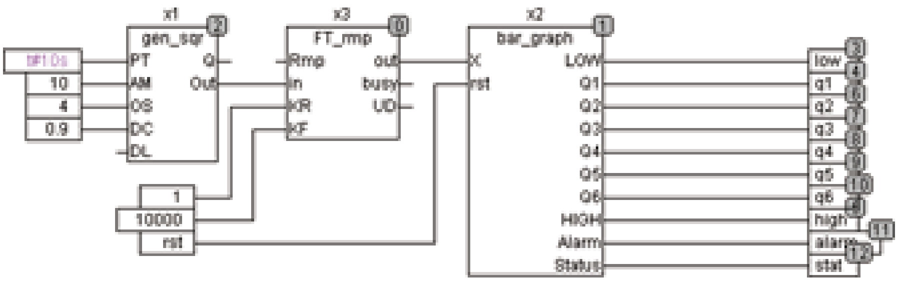


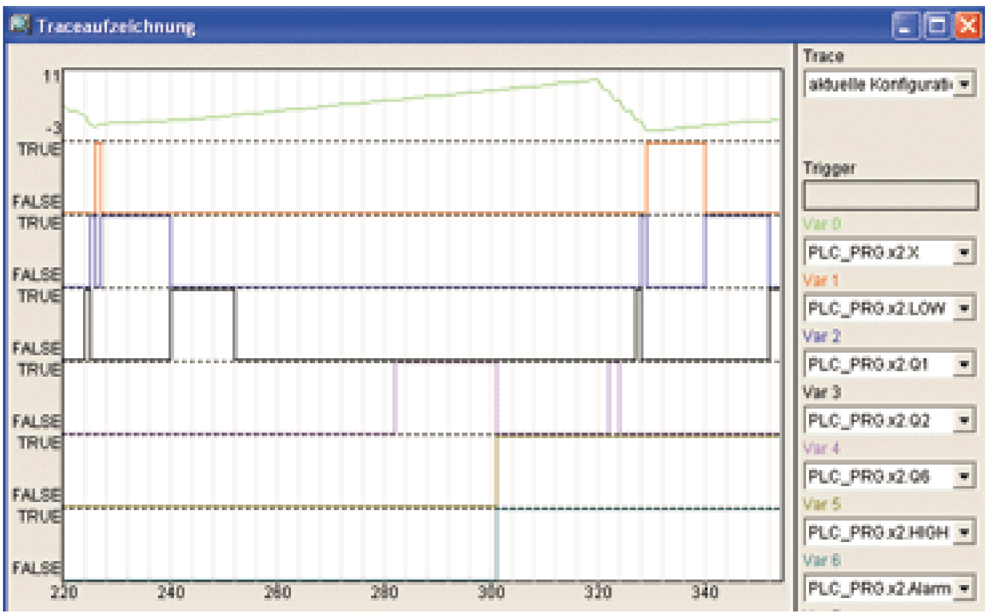
4.4.0.2 Type Function module

Input X	REAL (input)
RST	BOOL (reset input for alarm output)
Output LOW	BOOL (TRUE, if X < TRIGGER_LOW)
Q1 .. Q6	BOOL (trigger output)
HIGH	BOOL (TRUE if X >= TRIGGER_HIGH)
ALARM	BOOL (alarm output)
STATUS	Byte (ESR status output)
Setup TRIGGER_LOW	REAL (trigger threshold for LOW Output)
TRIGGER_HIGH	REAL (trigger threshold for High Output)
ALARM_LOW	BOOL (Enable Alarm Low Output)
ALARM_HIGH	BOOL (Enable Alarm High Output)
LOG_SCALE	BOOL (output is logarithmic if TRUE)
	BAR_GRAPH is a level Detector, which activates depending on the input value an output. The threshold for the LOW and HIGH Outputs can be set by the setup variables TRIGGER_LOW and TRIGGER_HIGH. LOW is TRUE if X is less than TRIGGER_LOW and HIGH is true if X is greater or equal than TRIGGER_HIGH. If the setup variables ALARM_LOW and / or ALARM_HIGH set to TRUE, the output ALARM set to TRUE if the value will be lower than TRIGGER_LOW or exceed of TRIGGER_HIGH , and the output LOW or HIGH and ALARM remains TRUE until the

	input RST is TRUE and the alarm is reseted. The outputs Q1 to Q6 divide the area between between TRIGGER_LOW and TRIGGER_HIGH in seven equal areas. If the setup variable LOG_SCALE is set, the area between TRIGGER_LOW and TRIGGER_HIGH is divided logarithmically.
	The output Status is an ESR compliant output and forwards states and alarms to ESR components.
The following example shows a signal characteristic of n Bar_Graph	



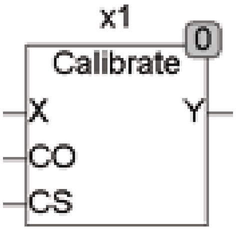




Status	
110	Input is between Trigger_Low and Trigger_High.
111	Input lower than Trigger_Low , Output LOW is TRUE
112	Input higher than Trigger_High , Output HIGH is TRUE.
1	Input lower than Trigger_low and Alarm_Lowis TRUE
2	Input higher than Trigger_high and Alarm_High is TRUE

4.4.0.3 Type Function module

Input X	REAL (input)
CO	BOOL (pulse for storing the offset)
CS	BOOL (pulse for storing the gain factor)
Output Y	REAL (Calibrated output signal)
Setup Y_OFFSET	REAL (Y value in which the offset is set)
Y_SCALE	REAL (Y value in which the amplification factor
	is set)
	CALIBRATE serves for calibrating an analog signal. In order to allow a calibrating two reference values (Y_OFFSET and Y_SCALE) must be set by double-clicking on the icon of the module. Y_OFFSET is the starting value at which the offset is set by a pulse at CO and Y_SCALE is the value at which the gain is determined. A calibration can only be successful if the first offset and gain are then calibrated.



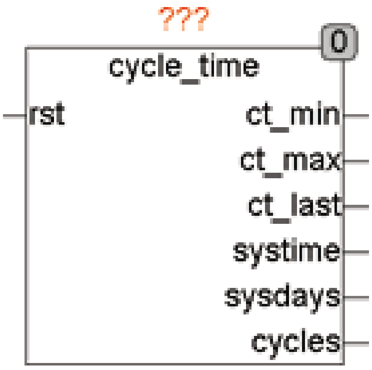
Example:

Example : An input signal of 4..20 mA can be calibrated at the temperature values from 0 .. 70 ° C. Therefore the setup variables Y_OFFSET = 0 and Y_SCALE = 70 are set. Then the sensor is placed in ice water and after the response of the sensor, a pulse at the input C0 is triggered to initiate a calculation of the correction value for offset and store it internally . Next, then the sensor is applied with 70 ° C and after the response a pules is triggered on the CS input, which calculates in the module a gain factor that is stored internally. The calibration values are permanently stored. That means, they are also not lost when a reset is executed, or turn off the power to the PLC.

4.4.0.4 Type Function module

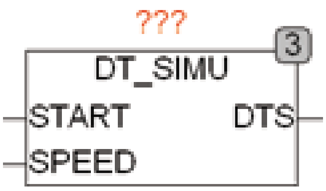
Input RES	BOOL (Reset)
Output CT_MIN	TIME (minimum measured cycle time)
CT_MAX	TIME (maximum measured cycle time)
CT_LAST	TIME (recently measured cycle time)
SYSTIME	TIME (duration since last start)

SYSDAYS	INT (number of days since last start)
CYCLES	DWORD (number of cycles since the last start)
	CYCLE_TIME monitors the cycle time of a PLC and provides the user with a range of information about cycle times and run times. The total number of cycles is also measured. Hereby, the user can, for example ensure that a function is called every 100 cycles. Control modules can report errors if the cycle time is too long and therefore the control parameters can not be guaranteed.



4.4.0.5 Type Function module

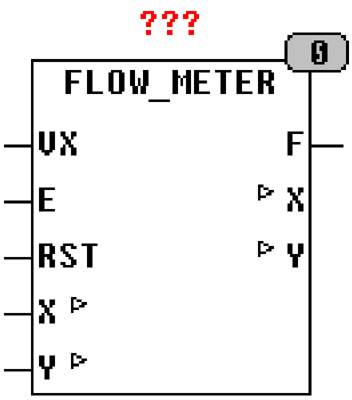
Input	START DT (start DATETIME)
SPEED	REAL (speed for the output DTS)
Output DTS	DT (Simulated DATE TIME)
	DT_SIMU simulates on output DTS a date value that starts with the initial value of START and continues with the speed SPEED. If SPEED intthe input value not used, the device operates with the internal standard value 1.0 and the DTS output is running forward at 1 second/second. With the input SPEED at the output DTS an arbitrarily fast or slow clock can be simulated. The module can be used in the simulation environment to simulate an RTC and also adjust the speed of the RTC for testing. If the input SPEED = 0, the output DTS at each PLC cycle is further increased by a second.



4.4.0.6 FLOW_METER

Type	Function module
Input VX	REAL (volume per hour)
E	BOOL (Enable Input)
RST	BOOL (Reset input)
I / O X	REAL flow rate fractional part)
Y	UDINT (flow rate integer part)
Output F	REAL (actual flow)

	The function module FLOW_METER determines the flow rate per unit of time and count quantities. FLOW_METER determines the flow rate from the input VX and E. The module supports two operating modes are determined by the variable setup PULSE_MODE. If PULSE_MODE = TRUE is the volume flow and the amount determined by is added at each rising edge at E, the value of VX upon itself. If the PULSE_MODE = FALSE the input VX is interpreted as flow per unit time and is added up as long as E = TRUE. Using the input RST, the internal counter can be always set to zero. X and Y are external to be declared variables and can be declared retentive / permanent to be permanent in case of power failure. The module provides the instantaneous flow value F as the Real in accordance to the unit connected to VX. If a value at VX is applied eg. in liters / hour so is the measured value at the output F in l / h. The output F is set at the constant intervals UPDATE_TIME. The outputs X and Y make up the over time accumulated measure values where X in REAL represent in the decimal point and Y in UDINT the integer part. A count of 234.111234 is represented by 0.111234 at X and a value of 234 at Y. If for count only a REAL is used then the resolution (for Real to IEEE32), is only 7-8 position . The above described method can provide more than 9 digits before the decimal point (2^32-1) and at least 7 digits after the decimal point. Since in this case X is always smaller than 1, Y can be used for output without decimal places. The two variables X and Y must be declared external and can, as the following example, also be secured against power failure.
SETUP PULSE_MODE	BOOL (pulse counter when TRUE)
UPDATE_TIME	TIME (measuring time for F)

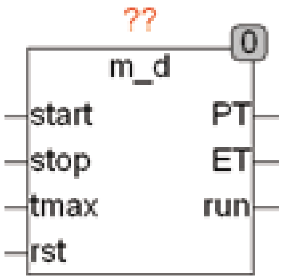


Example:
VX := 4 m^3/h; PULSE_MODE := FALSE; UPDATE_TIME := T#100ms; The device measures the flow in m^3/h and counts the flow as long as the input E is TRUE. The output F shows (4.0m^3/h) as long as E is TRUE, otherwise it shows (0.0). The value of F is re-calculated every 100 milliseconds. Example2: VX := 0,024 l/Puls; PULS_MODE := TRUE; UPDATE_TIME := T#1s; In this example, the flow at the output F is displayed in l/h and with each rising edge at E the counter is increased by 0.024 l.

4.4.0.7 Type Function module

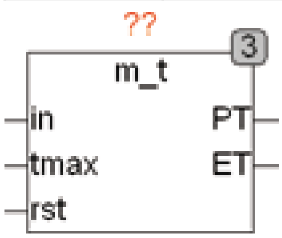
Input START	BOOL (input)
STOP	BOOL (input)
TMAX	TIME (Timeout für ET)
RST	BOOL (Reset input)
Output PT	TIME (elapsed time)

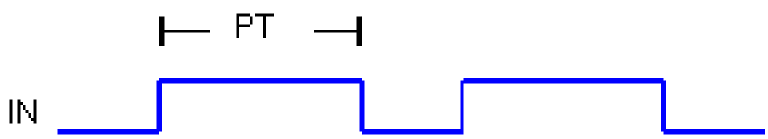
ET	TIME (Elapsed time since last rising edge)
RUN	BOOL (TRUE if measure processes)
M_D measures the time between a rising edge of START and a rising edge on STOP. PT is the result of the last measurement. Output ET is the elapsed time since the last rising edge of START. M_d requires a rising edge to start the measurement. If at the first call already START is TRUE, it is not seen as a rising edge. Even if STOP is TRUE, a rising edge of START is not counted. Only when all start conditions (STOP = FALSE, RST	= FALSE and rising edge at START) are present, the output RUN gets TRUE and a measurement is started. With TRUE at the input RST, the outputs can always be reset to 0. If ET reaches the value of TMAX, automatically a reset is generated in the module to reset all outputs to 0. TMAX is internally assigned with default value of T#10d and normally can be unconnected. TMAX serves to define a maximum value range for PT. The output RUN is TRUE if is a measurement is processed.



4.4.0.8 Type Function module

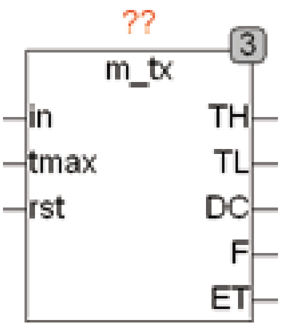
Input IN	BOOL (Input)
TMAX	TIME (Timeout für ET)
RST	BOOL (Reset input)
Output PT	TIME (measured pulse duration from the rising to the falling edge)
ET	TIME (Elapsed time since last rising edge)
	M_T measures the time how long IN was TRUE. PT is the time from the rising edge of signal IN to the falling edge of the IN signal. The Output ET passes the elapsed time since the last rising edge to falling edge. As long as the input signal is FALSE, ET = 0. M_T requires a rising edge to trigger the measurement. If at the first call IN is already TRUE, it is not seen as a rising edge. For more examples, see the description of M_TX. With TRUE at the input RST, the outputs can always be reset to 0. If ET reaches the value of TMAX, automatically a reset is generated in the module to reset all outputs to 0. TMAX is internally assigned with default value of T#10d and normally can be unconnected.





4.4.0.9 M_TX

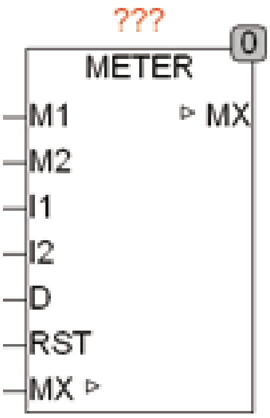
Type	Function module
Input IN	BOOL (Input)
TMAX	TIME (Timeout für ET)
RST	BOOL (Reset input)
Output TH	TIME (Ontime the input signal)
TL	TIME (Off time of the input signal)
DC	REAL (duty cycle / Duty Cycle the input signal)
F	REAL (the input signal frequency in Hz)
ET	TIME (Elapsed time during the measurement)
	M_TX determined from the input signal IN the time which the signal IN was TRUE (TH) and the time the signal was set to FALSE (TL). The times of TH and TL are only measured after a rising or falling edge. If IN is at the first call of the module already high, this is not seen as a rising edge. From the measured values of TH and TL the Duty Cycle and the frequency in Hz are calculated. A Duty Cycle of 0.4 means the signal was 40% TRUE and 60% FALSE. Output ET of type TIME is started with each rising edge at 0 and runs up until the next rising edge it starts again at 0. With a TRUE at the input RST, the outputs can be reset at any time to 0. The input TMAX sets, after which the elapsed time at ET, the outputs automatically are reseted. TMAX is internally assigned a default value of T#10d and can normally be left open. The input TMAX is primarily used to reset in the absence of input signal for a defined time the outputs. An example of a possible application is to measure the speed of a wave, indicating absence of the sensor signals to the speed (frequency) 0. TMAX is used with caution because, for example, a TMAX of 10 seconds at the same time limits the smallest measurable frequency to 0.1 Hz.

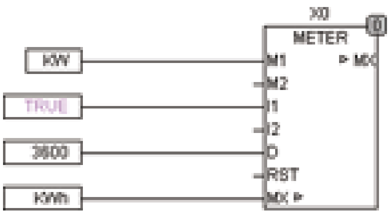


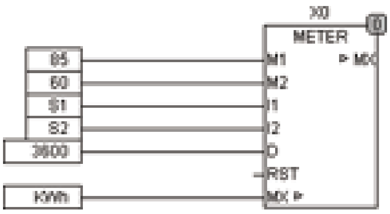
4.4.0.10 Type Function module

Input M1	REAL (consumption value of 1)
M2	REAL (consumption value of 2)
I1	BOOL (enable input 1)
I2	BOOL (enable input 2)
D	REAL (divider for the output)
RST	BOOL (Reset input)
I / O MX	REAL (consumption value)
	METER is a meter, the two independent inputs (M1 and M2) are added up over time. The counting is controlled the inputs I1 and I2. With the reset input RST the counter can be

	reset at any time. The value of M1 is added to the output value per second as long as I1 is TRUE analogous the value of M2 is added per second to output value if I2 is TRUE. If I1 and I2 TRUE, the value of M1 + M2 is added per seconds once to the output. The input D Splits the output MX. Thus i.e. watt-hours can be counted instead of watt-seconds. The module uses internally the OSCAT specific data type REAL2 which allows a resolution of 15 digits. This the module can capture smallest consumption levels at the inputs of M1 and M2 with short cycle times and add them up to high overall values at the output MX. The resolution of the block can be determined as follows. MX is defined as I/O and must be placed on an external variable of type REAL. The external variable can be declared as retentive and/or persistent in order to obtain the value in case of power failure.
	MX/10^15 corresponds to the minimum resolution at the inputs M1 and M2.







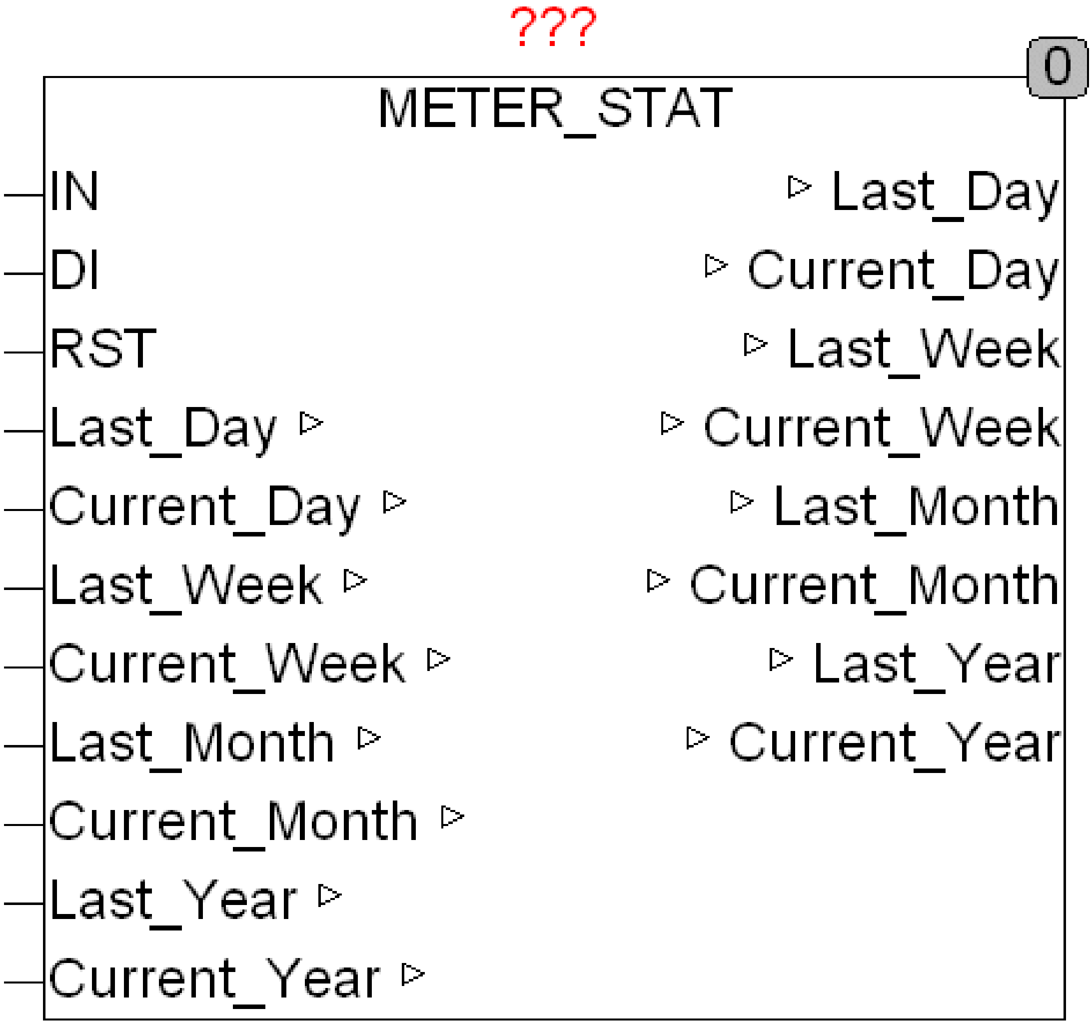
Example:

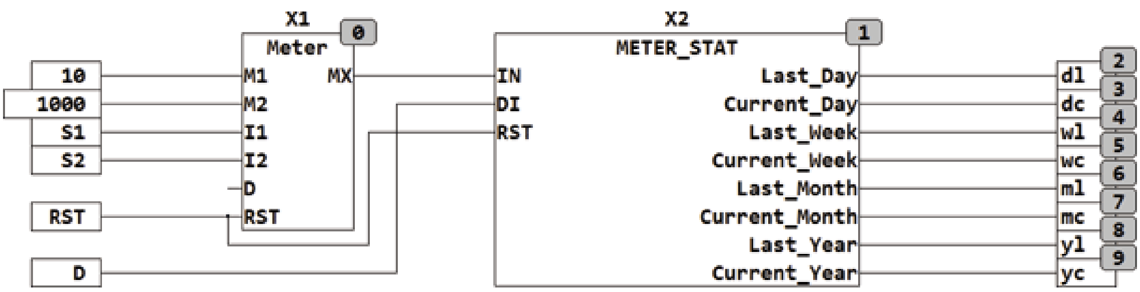
```
Example  : MX = 10E6    the utility meter is at 10 MWh M1 = 0.09 Watt   Current
consumption is 0.1 watts D = 3600       Output operates in Wh (Watt hours) Cycle time is
10ms In this example, at each cycle a value of 0.09[W] * 0.01[S]/3600 = 2.5E-7[Wh] on
the output MX is added. This represents a change in the 14 decimal place of the output.
example 1 power consumption meter: The power consumption counter of kilowatt second
counts the input M1. By the input D the output is divided by 3600, so that the output
displays kilowatt hours. Example 2   Consumption calculation for a 2 stage burner: In
this example, the output of level 1 (M1) 85KW and stage 2 (M2) 60KW. The inputs S1 and
S1 (I1 and I2) are TRUE, if the corresponding level is running. By the constant 3600 at
D, the output is divided by 3600, so kilowatt hours are shown.
```

4.4.0.11 Type Function module

Input IN	REAL (input signal)
DI	DATE (date input)
RST	BOOL (Reset input)

I / O LAST_DAY	REAL (consumption value of the previous day)
CURRENT_DAY	REAL (consumption value of the current day)
LAST_WEEK	REAL (consumption value over the past week)
CURRENT_WEEK	REAL (consumption value of the current week)
LAST_MONTH	REAL (consumption value of the last month)
CURRENT_MONTH	REAL (consumption of the current month)
LAST_YEAR	REAL (consumption value of last year)
Current_year	REAL (consumption value of the current year)
	METER_STAT calculates the consumption of the current day, week, month and year and shows the value of the last corresponding period. The accumulated consumption value is at the IN input, while at the DI input is applied the current date. With the RST input, the counter can be reset at any time. For ease of storage in the persistent and retentive memory, the outputs are defined as I / O.
The following example shows the application of METER_STAT with the module METER	

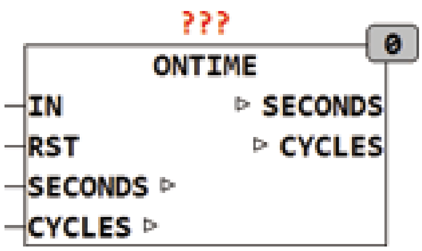




4.4.0.12 Type Function module

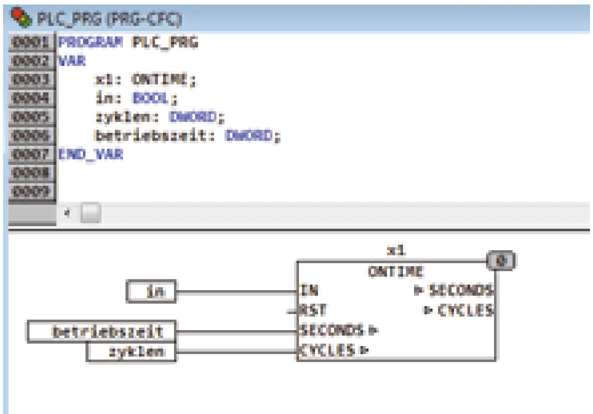
Input IN	BOOL (Input)
RST	BOOL (Reset input)
Output SECONDS	UDINT (operating time in seconds)
CYCLES	UDINT (switch cycles of the input IN)
	ONTIME is an hour meter. It is summed up the entire time that the signal IN was since the last RESET to TRUE. Additionally, the number of the total on/off cycles is determined. The output values are of type UDINT. With the input RST, the

	output values will be reset at any time. The output values are not stored in variables of the module, but are applied externally attached and connected over IO (Pointer). This has the distinct advantage that as desired by the user the variables can be determined as RETAIN or PERSISTENT. It is thus possible to store old operating hours and restore it later, for example, at CPU change.
	The declaration of the variables at the inputs SECONDS and CYCLES must be of type UDINT and can either be created as a VAR, VAR RETAIN or VAR RETAIN PERSISTENT.
	The declaration of the variables for the operating time and cycles must be UDINT type and can be alternatively RETAIN or PERSISTENT.
	VAR RETAIN PERSISTENT
Betriebszeit_in_Sekunden	UDINT;
Cycles	UDINT;
	END_VAR
The following table explains, RETAIN and PERSISTENT	
	Type variables Retain and Persistent retain their value during download, online change and reset. In a cold reset or reset source, lose these variables the values. The user can save, but the values in the file system or network, and to restore itself, eg after changing the CPU.



x = Wert bleibt erhalten - = Wert wird neu initialisiert

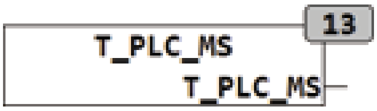
nach Online-Befehl	VAR	VAR RETAIN	VAR PERSISTENT	VAR RETAIN PERSISTENT VAR PERSISTENT RETAIN
Reset	-	x	-	x
Reset Kalt	-	-	-	-
Reset Ursprung	-	-	-	-
Laden (=Download)	-	-	x	x
Online Change	x	x	x	x



4.4.0.13 Type Function: DWORD

Output	DWORD (SPS Timer in milliseconds)
	T_PLC_MS returns the current internal PLC time in milliseconds. This has nothing to do with a possibly existing clock (real time module), but is the internal Timer of a PLC, which is used as a time reference.
The source code of the module has the following characteristics	
FUNCTION T_PLC_MS	DWORD
	VAR CONSTANT
DEBUG	BOOL := FALSE;
N	INT := 0;
OFFSET	= 0;
	END_VAR
	VAR
TEMP	DWORD := 1;
	END_VAR
T_PLC_MS	= TIME_TO_DWORD(TIME());
	IF DEBUG THEN
T_PLC_MS	= SHL(T_PLC_US,N) OR SHL(TEMP,N)-1 + OFFSET;
	END_IF;
	In normal operation, the module reads the function TIME() the internal Timer of the PLC, and returns it. The internal Timer the PLC according to IEC standard has one millisecond resolution.
	Another feature of T_PLC_MS is a debug mode, which allows to test the overflow of the internal PLC Timers and verify the developed software shure. The internal Timer of any PLC has, independent of manufacturer and type of implemen-

	tation, after a fixed time an overflow. That means that it is running against .. FF FFFF (highest value of the corresponding type can be stored) and then starts again at 000..0000. At standard PLC Timers is the overflow time 2^32 −1 milliseconds, which is about 49.71 days. Since this Timer is implemented in a hardware, it initial value can not be set, so that after starting the PLC it always starts at 0 and runs up to the maximum value . After reaching the maximum value, the infamous Timer Overflow arises, which causes fatal consequences in the application software , but can only be tested extremely difficult.
	T_PLC_MS offers several ways to test the overflow and time-dependent software. With the constant DEBUG, the test mode is switched on and then, using the constants N and offset , starts the timer at a certain level, thus specifically the overflow can be tested without waiting the 49. Offset definces which ist addeed to the value of the internal Timer . With the constant N is determined by how many bits of the internal Timer Value is shifted to the left, while the lower N bits are filled with 1. With N thus the speed of the internal Timers can be increased by factors of 2,4,8,16 and so on.
	T_PLC_US thus offers all possibilities to test time-dependent software, both for the problem of overflow, and for very slow time-dependent functions.
	The constant DEBUG, N and OFFSET were intentionally not implemented as inputs of the function to avoid accidental misuse.



4.4.0.14 Type Function: DWORD

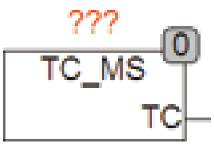
Output	DWORD (SPS Timer in microseconds)
	T_PLC_US returns the current internal PLC time in microseconds. This has nothing to do with a possibly existing clock (Real Time Module), but is the internal Timer of a PLC that is used as a time reference.
The source code of the module has the following characteristics	
FUNCTION T_PLC_US	DWORD
	VAR CONSTANT
DEBUG	BOOL := FALSE;
N	INT := 0;

OFFSET	= 0;
	END_VAR
	VAR
TEMP	DWORD := 1;
	END_VAR
T_PLC_US	= TIME_TO_DWORD(TIME())*1000;
	IF DEBUG THEN
T_PLC_US	= SHL(T_PLC_US,N) OR SHL(TEMP,N)-1 + OFFSET;
	END_IF;
	In normal operation, the module reads the function TIME() the internal Timer of the PLC. Since the internal Timer of the PLC works according to IEC standard with 1 millisecond resolution, the read value is multiplied by 1000 to deliver the value in micro-seconds back. This function was created for compatibility reasons in that way, to provide microseconds timer for controls, that has a resolution no better than milliseconds, which can then be used in other modules. If the existing PLC supports microseconds, this function can easily be adjusted only at this point and the accuracy changes by this simple patch for all the modules that call this feature. The software remains portable and future proof. Already, virtually all PLC controllers support a resolution in microseconds. This will however not be read using standard routines, but provided vendor specific and non-standard. The module T_PLC_US provides so an appropriate interface to these vendor-specific timers.
	Another feature of T_PLC_US is a Debug Mode, which allows to produce the overflow of the internal PLC Timers and test the software developed right shure. The internal Timer of any PLC has, independent of manufacturer and type of implementation, after a fixed time an overflow. That means that it is running against FF..FFFF (highest value of the corresponding type can be stored) and then starts again at 000..0000. At standard PLC Timer is the overflow time 2^32 −1 milliseconds, which is about 49.71 days. Since this Timer is implemented in a hardware, it initial value can not be set, so that after starting the PLC it always starts at 0 and runs up to the maximum value. After reaching the maximum value, the infamous Timer Overflow arises, which causes fatal consequences in the application software , but can only be tested extremely difficult.
	T_PLC_US offers several ways to test the overflow and time-dependent software. With the constant

	DEBUG, the test mode is switched on and then, using the constants N and offset , starts the timer at a certain level, thus specifically the overflow can be tested without waiting the 49. Offset definces a value which is added to the value of the internal Timer . With the constant N is determined by how many bits of the internal Timer Value is shifted to the left, while the lower N bits are filled with 1. With N thus the speed of the internal Timers can be increased by factors of 2,4,8,16 and so on.
	T_PLC_US thus offers all possibilities to test time-dependent software, both for the problem of overflow, and for very slow time-dependent functions. The constant DEBUG, N and OFFSET were intentionally not implemented as inputs of the function to avoid accidental misuse.

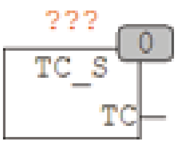
4.4.0.15 Type Function module

Output TC	DWORD (last cycle time in milliseconds)
	TC_MS determines the last cycle time, that is the time since the last call of the module has passed. The time comes in milliseconds.



4.4.0.16 Type Function module

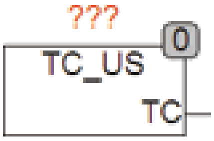
Output TC	REAL (last cycle time in seconds)
	TC_S determines the last cycle time, that is the time since the last call of the module has passed. The time will be delivered in seconds, but has an accuracy in microseconds. The module calls the function T_PLC_US(). T_PLC_US () returns the internal PLC Timer in microseconds with a step width of 1000 microseconds. If a higher resolution is required the function T_PLC_US() has to be adjusted to the appropriate system.



4.4.0.17 Type Function module

Output TC	DWORD (last cycle time in milliseconds)
	TC_US determines the last cycle time, that is the time since the last call of the module has passed. The time comes in milliseconds. The module calls the function T_PLC_US().

	T_PLC_US () returns the internal PLC Timer in microseconds with a step width of 1000 microseconds. If a higher resolution is required the function T_PLC_US() has to be adjusted to the appropriate system.

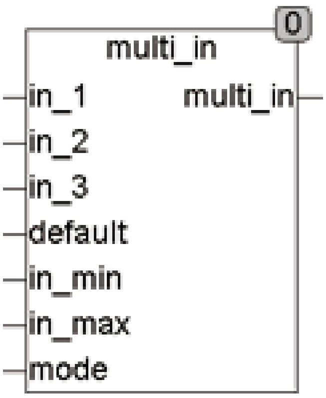


4.5 Engineering / sensor

This section contains 20 modules.

4.5.0.1 MULTI_IN

Type Function	REAL
Input IN_1	REAL (input 1)
IN_2	REAL (input 2)
IN_3	REAL (input 3)
DEFAULT	REAL (default value)
IN_MIN	REAL (lower limit for inputs)
IN_MAX	REAL (upper limit for inputs)
MODE	Byte (selection of the operating mode)
Output	REAL (output)
	MULTI_IN is a sensor interface that accepts up to 3 sensors to check for errors, and depending on the input mode, an output value is calculated.
	Regardless of the mode input values that are greater than IN_MAX or less than IN_MIN be ignored. If no calculation is possible as defined by mode, the input Default is used as a output value. Multi_in is used when different sensors measures the same value and high security and reliability is required. A possible application is to measure the outside temperature at various points and the surveillance on cable or sensor failure.

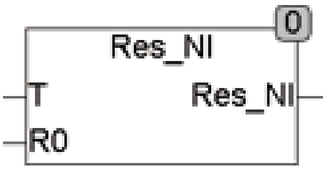


Mode	Function
0	MULTI_in = average of the inputs in_1.. 3
1	MULTI_in = input in_1

2	MULTI_in = input in_2
3	MULTI_in = input in_3
4	MULTI_in = Default Input
5	MULTI_in = smallest value of the inputs in_1.. 3
6	MULTI_in = largest value of the inputs in_1 .. 3
7	MULTI_in = mean value of the inputs in_1..3
>7	MULTI_in = 0

4.5.0.2 RES_NI

Type Function	REAL
Input T	REAL (temperature in °C)
R0	REAL (resistance at 0° C)
Output	REAL (resistance)
	RES_NI calculated the resistance of a NI-resistance sensor from the input values T (temperature in°C) and R0 (resistance at 0°C).
The calculation is done using the formula	
	RES_NI = R0 + $AT + BT^2$+C*T4
	A = 0.5485
	B = 0.665E-3
	C = 2.805E-9
	The calculation is suitable for temperatures from −60.. +180 °C.



Auszug aus DIN 43760 für Ni100

°C	R	°C	R	°C	R	°C	R	°C	R
-60	69,5	-10	94,6	40	123,0	90	154,9	140	190,9
-55	71,9	-5	97,3	45	126,0	95	158,3	145	194,8
-50	74,3	0	100,0	50	129,1	100	161,8	150	198,7
-45	76,7	5	102,8	55	132,2	105	165,3	155	202,6
-40	79,1	10	105,6	60	135,3	110	168,8	160	206,6
-35	81,6	15	108,4	65	138,5	115	172,4	165	210,7
-30	84,2	20	111,2	70	141,7	120	176,0	170	214,8
-25	86,7	25	114,1	75	145,0	125	179,6	175	219,0
-20	89,3	30	117,1	80	148,3	130	183,3	180	223,2
-15	91,9	35	120,0	85	151,6	135	187,1		

4.5.0.3 RES_NTC

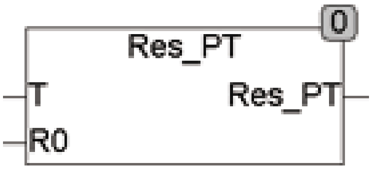
Type Function	REAL
Input T	REAL (temperature in °C)

RN	REAL (resistance at 25°C)
B	REAL (characteristic value of the sensor)
Output	REAL (resistance)
	RES_NTC calculated the resistance of an NTC resistance sensor from the input values T (temperature in °C) and RN (resistance at 25°C). The input value B is a constant value which must be read in the data sheets of that sensor. Typical values are at NTC sensors 2000 - 4000 Kelvin.
The calculation is done using the formula	
	The formula provides a sufficient accuracy for small temperature ranges, eg 0-100°C. For wide temperature ranges the formula according to Steinhart is more suitable.

$$R_\mathrm{H} = R_\mathrm{N} \cdot \mathrm{e}^{b\left(\frac{1}{T}-\frac{1}{T_\mathrm{N}}\right)}$$

4.5.0.4 Type Function: REAL

Input T	REAL (temperature in °C)
R0	REAL (resistance at 0° C)
Output	REAL (resistance)
	RES_PT calculates the resistance of a PT resistance sensor from the input values T (temperature in °C) and R0 (resistance at 0°C).
The calculation is done using the formula	
	for temperatures > 0 °C
	RES_PT = R0 * (1 + $AT + BT^2$)
	and for temperatures below 0 ° C
	RES_PT = R0 * (1 + $AT + BT^2$ + C*(T-100)*T^3
	A = 3.90802E-3
	B = −5.80195E-7
	C = −427350E-12
	The calculation is suitable for temperatures from −200.. +850°C.

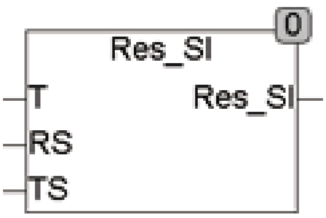


Auszug aus DIN 43760 für Pt100

°C	R	°C	R	°C	R	°C	R	°C	R	°C	R
-200	18,49	-100	60,25	0	100,00	100	138,50	200	175,84	300	212,02
-195	20,65	-95	62,28	5	101,95	105	140,39	205	177,68	305	213,80
-190	22,80	-90	64,30	10	103,90	110	142,29	210	179,51	310	215,57
-185	24,94	-85	66,31	15	105,85	115	144,17	215	181,34	315	217,35
-180	27,08	-80	68,33	20	107,79	120	146,06	220	183,17	320	219,12
-175	29,20	-75	70,33	25	109,73	125	147,94	225	184,99	325	220,88
-170	31,32	-70	72,33	30	111,67	130	149,82	230	186,82	330	222,65
-165	33,43	-65	74,33	35	113,61	135	151,70	235	188,63	335	224,41
-160	35,33	-60	76,33	40	115,54	140	153,58	240	190,45	340	226,17
-155	37,63	-55	78,32	45	117,47	145	155,45	245	192,26	345	227,92
-150	39,71	-50	80,31	50	119,40	150	157,31	250	194,07	350	229,67
-145	41,79	-45	82,29	55	121,32	155	159,18	255	195,88	355	231,42
-140	43,87	-40	84,27	60	123,24	160	161,04	260	197,69	360	233,17
-135	45,94	-35	86,25	65	125,16	165	162,90	265	199,49	365	234,91
-130	48,00	-30	88,22	70	127,07	170	164,76	270	201,29	370	236,65
-125	50,06	-25	90,19	75	128,98	175	166,61	275	203,08	375	238,39
-120	52,11	-20	92,16	80	130,89	180	168,46	280	204,88	380	240,13
-115	54,15	-15	94,12	85	132,80	185	170,31	285	206,67	385	241,86
-110	56,19	-10	96,09	90	134,70	190	172,16	290	208,45	390	243,59
-105	58,22	-5	98,04	95	136,60	195	174,00	295	210,24	395	245,31

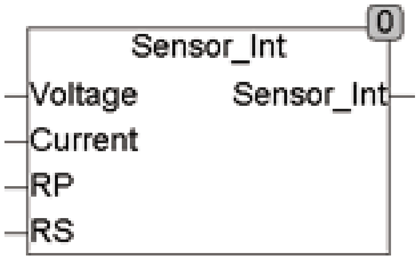
4.5.0.5 Type Function: REAL

Input T	REAL (temperature in °C)
RS	REAL (Resistance at TS °C)
TS	REAL (temperature at RS)
Output	REAL (resistance)
	RES_SI calculates the resistance of a SI-resistance sensor from the input values T (temperature in °C) and RS, resistance at TS in °C. In contrast to the modules RES_NI and RES_PT which R0 is given at 0°C, the resistance specified for RS for SI sensors at different temperatures (eg 25°C for KTY10). Therefore, the module has an input for RS and another for TS.
The calculation is done using the formula	
	RES_SI = RS + A*(T-TS) + B*(T-TS)²
	A = 7.64E-3
	B = 1.66E-5
	The calculation is suitable for a temperature range of −50 .. +150°C.



4.5.0.6 Type Function: REAL

Input VOLTAGE	REAL (measured in volts)
CURRENT	REAL (Current measured in amperes)
RP	REAL (parallel parasitic resistance in ohms)
RS	REAL (serial parasitic resistance in ohms)
Output	REAL (resistance of the sensor)
	SENSOR_INT calculate the sensor resistance, taking into account the parasitic resistances, which usually affect the measurement. The A / D converter measures either current at a fixed voltage or voltage at a fixed current. The resulting resistance is not only the resistance of the sensor, but is composed of the resistance of the sensor and two parasitic resistances RS and RP. Since the parasitic resistances remain constant, they can be compensated and the real resistance of the sensor can be calculated.
	RPRSRXABBetween the terminals A and B measured resistance (measured by current and voltage) is a total resistance of the sensor resistance in parallel to the parasitic resistance RP and the line resistance RS. RS and RP, are compensated the real resistance RX is calculated. The modules can TEMP_ then be calculated as the exact temperature.



4.5.0.7 Type Function: REAL

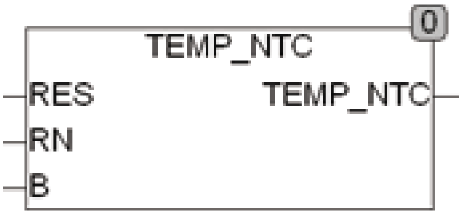
Input RES	REAL (resistance in ohms)
R0	REAL (resistance at 0° C)
Output	REAL (measured temperature)
	RES_NI calculates the temperature of a NI-resistance from the RES sensor input values (measured resistance value) and R0 (resistance at 0°C).
The calculation is suitable for a temperature range of −60.. +180 ° C and made by the following formal	
	RES_NI = R0 + $AT + BT^2$+C*T4
	A = 0.5485; B = 0.665E-3; C = 2.805E-9

Auszug aus DIN 43760 für Ni100

°C	R	°C	R	°C	R	°C	R	°C	R
-60	69,5	-10	94,6	40	123,0	90	154,9	140	190,9
-55	71,9	-5	97,3	45	126,0	95	158,3	145	194,8
-50	74,3	0	100,0	50	129,1	100	161,8	150	198,7
-45	76,7	5	102,8	55	132,2	105	165,3	155	202,6
-40	79,1	10	105,6	60	135,3	110	168,8	160	206,6
-35	81,6	15	108,4	65	138,5	115	172,4	165	210,7
-30	84,2	20	111,2	70	141,7	120	176,0	170	214,8
-25	86,7	25	114,1	75	145,0	125	179,6	175	219,0
-20	89,3	30	117,1	80	148,3	130	183,3	180	223,2
-15	91,9	35	120,0	85	151,6	135	187,1		

4.5.0.8 Type TEMP_NTC

Input RES	REAL (measured resistance in ohms)
RN	REAL (resistance of the sensor at 25°C)
B	REAL (specification of the sensor)
Output	REAL (measured temperature)
	TEMP_NTC calculates from the measured resistance and the parameters of the sensor, the measured temperature. RN is the resistance of the sensor at 25°C, and B depends on the sensor and the specification of the sensor.
The module calculates the temperature according to the following formula	



$$T = \frac{b \cdot T_{\mathrm{N}}}{b + \ln\left(\frac{R_{\mathrm{H}}}{R_{\mathrm{N}}}\right) \cdot T_{\mathrm{N}}}$$

4.5.0.9 Type Function: REAL

Input RES	REAL (measured resistance in ohms)
R0	REAL (resistance at 0° C)

Output	REAL (measured temperature)
	TEMP_PT calculates the temperature of a PT-resistance from the RES sensor input values (measured resistance value) and R0 (resistance at 0°C). If the inputs has a temperature outside the range of −200.. + 850°C, at the output the temperature output +10000.0°C is passed.
The calculation is done using the formula	
	for temperatures > 0 °C
	RES_PT = R0 * (1 + $AT + BT^2$)
	and for temperatures below 0 ° C
	RES_PT = R0 * (1 + $AT + BT^2$ + C*(T-100)*T^3
	A = 3.90802E-3; B = −5.80195E-7; C = −427350E-12

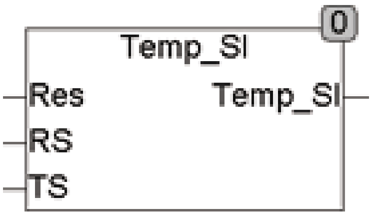
Auszug aus DIN 43760 für Pt100

°C	R	°C	R	°C	R	°C	R	°C	R	°C	R
-200	18,49	-100	60,25	0	100,00	100	138,50	200	175,84	300	212,02
-195	20,65	-95	62,28	5	101,95	105	140,39	205	177,68	305	213,80
-190	22,80	-90	64,30	10	103,90	110	142,29	210	179,51	310	215,57
-185	24,94	-85	66,31	15	105,85	115	144,17	215	181,34	315	217,35
-180	27,08	-80	68,33	20	107,79	120	146,06	220	183,17	320	219,12
-175	29,20	-75	70,33	25	109,73	125	147,94	225	184,99	325	220,88
-170	31,32	-70	72,33	30	111,67	130	149,82	230	186,82	330	222,65
-165	33,43	-65	74,33	35	113,61	135	151,70	235	188,63	335	224,41
-160	35,33	-60	76,33	40	115,54	140	153,58	240	190,45	340	226,17
-155	37,63	-55	78,32	45	117,47	145	155,45	245	192,26	345	227,92
-150	39,71	-50	80,31	50	119,40	150	157,31	250	194,07	350	229,67
-145	41,79	-45	82,29	55	121,32	155	159,18	255	195,88	355	231,42
-140	43,87	-40	84,27	60	123,24	160	161,04	260	197,69	360	233,17
-135	45,94	-35	86,25	65	125,16	165	162,90	265	199,49	365	234,91
-130	48,00	-30	88,22	70	127,07	170	164,76	270	201,29	370	236,65
-125	50,06	-25	90,19	75	128,98	175	166,61	275	203,08	375	238,39
-120	52,11	-20	92,16	80	130,89	180	168,46	280	204,88	380	240,13
-115	54,15	-15	94,12	85	132,80	185	170,31	285	206,67	385	241,86
-110	56,19	-10	96,09	90	134,70	190	172,16	290	208,45	390	243,59
-105	58,22	-5	98,04	95	136,60	195	174,00	295	210,24	395	245,31

4.5.0.10 Type Function: REAL

Input RES	REAL (measured resistance in ohms)
RS	REAL (resistance at 0°C)

TS	REAL (temperature is defined in RS)
Output	REAL (measured temperature)
	TEMP_SI calculates the temperature of a resistor sensor input values from the RES (resistance in ohms) and RS, Resistance at TS in °C. It is specified in contrast to the modules TEMP_NI and TEMP_PT with their R0 at 0°, the resistance RS is given in SI sensors at different temperatures (eg 25° C for KTY10). Therefore, the module has an input for RS and another for TS.
The calculation is done using the formula	
	RES_SI = RS + A*(T-TS) + B*(T-TS)²
	A = 7.64E-3; B = 1.66E-5
	The calculation is suitable for temperatures from −50.. +150 °C.

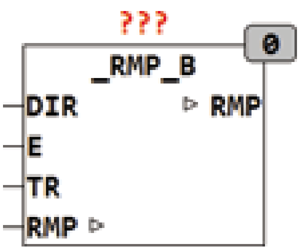


4.6 Engineering / signal generators

This section contains 30 modules.

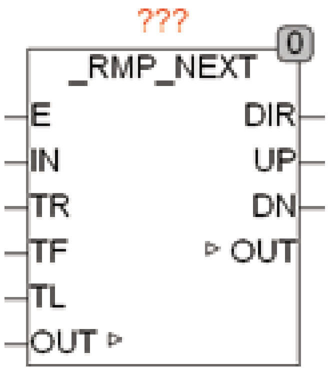
4.6.0.1 Type Function module

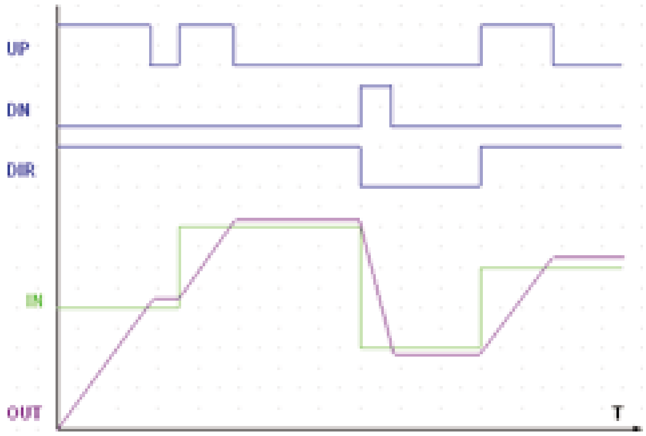
Input DIR	BOOL (Direction, TRUE means Up)
E	BOOL (Enable Input)
TR	TIME (time to run a full ramp)
I / O RMP	BYTE (output signal)
	_RMP_B Is an 8-bit ramp generator. The ramp is generated in an externally declared variable. The ramp is rising when DIR = TRUE and falling if DIR = FALSE. Reaching a final value of the ramp, the generator remains at this value. With the input E the ramp can be stopped at any time, when E = TRUE the ramp runs. The input TR shows the time which is needed to cycle through 0-255 or the other way around.



4.6.0.2 _RMP_NEXT

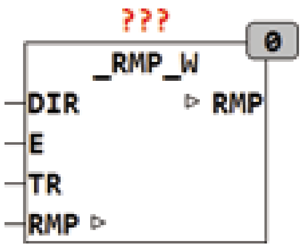
Type	Function module
Input E	BOOL (Enable Input)
IN	BOOL (input)
TR	TIME (rise time for ramp from 0..255)
TF	TIME (fall time for ramp 255..0)
TL	TIME (lock time between a change of direction)
I / O	I/O
OUTPUT DIR	BOOL (direction of change in IN)
UP	BOOL (signals a rising ramp)
DN	BOOL (signals a falling ramp)
	RMP_NEXT follows at the output OUT to the input signal IN with the in TR and TF defined rising or falling flanks. Unlike RMP_SOFT the flank of RMP_NEXT runs until it underrun or overrun the endpoint and is therefore suitable for control tasks. Changing the value of IN so a rising ramp with TR or a falling flank with TF starts at the output OUT until the value of OUT has overrun or underrun the IN. The output then remains at this value. The outputs of UP and DN shows just whether a rising or a falling edge are created. The output DIR indicates the direction of change at IN, if IN is not changed, the output remains at the last state. The lock time TL determines the delay time between the direction reversal.
The following graph shows the waveform at OUT when changing the input signal at IN	





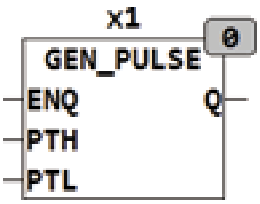
4.6.0.3 Type Function module

Input DIR	BOOL (Direction, TRUE means Up)
E	BOOL (Enable Input)
TR	TIME (time to run a full ramp)
I / O RMP	WORD (output signal)
	_RMP_B Is an 16-bit ramp generator. The ramp is generated in an externally declared variable. The ramp is rising when DIR = TRUE and falling if DIR = FALSE. Reaching a final value of the ramp, the generator remains at this value. With the input E the ramp can be stopped at any time, when E = TRUE the ramp runs. The input TR shows the time which is needed to cycle through 0-65535 or the other way around.



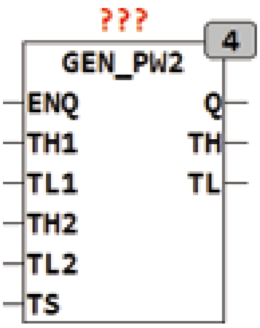
4.6.0.4 Type Function module

Input ENQ	BOOL (Enable Input)
PTH	TIME (pulse duration HIGH)
PTL	TIME (pulse duration LOW)
Output Q	BOOL (output)
GEM_PULSE generates at the output Q, an output signal which sets in the time of PTH to TRUE and then set for PTL to LOW. The generator will start after ENQ = TRUE always with a rising edge at Q, and remains for the time PTH to TURE. As long as ENQ = TRUE continuous pulses at the output Q are generated. Is one of the times (PTH, PTL) or both equal to 0 the time will limit to one PLC cycle. GEN_PULSE (ENQ	= TRUE, PTH: = T # 0s, PTL: = T # 0s) generates an output signal which has one cycle TRUE and one cycle FALSE. The Default ENQ value is TRUE.



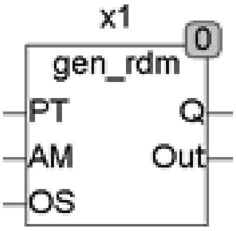
4.6.0.5 Type Function module

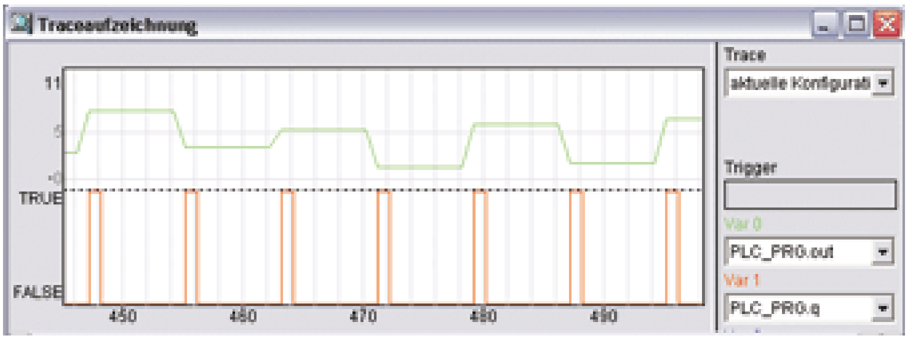
Input ENQ	BOOL (Enable Input)
TH1	TIME (set time HIGH when TS = LOW)
TL1	TIME (set time LOW when TS = LOW)
TH2	TIME (set time HIGH when TS = HIGH)
TL2	TIME (set time LOW when TS = HIGH)
TS	BOOL (selection for the end times)
Output Q	BOOL (binary output)
TL	TIME (elapsed time when Q = FALSE)
TH	TIME (elapsed time when Q = TRUE)
	GEN_PW2 generates an output signal with a definable time TH? for HIGH and TL for LOW. Using the input TS is switched between two sets of parameters (TL1, TH1 and TL2, TH2). On startup or after a ENQ = TRUE, the module begins with the LOW phase at the output.



4.6.0.6 Type Function module

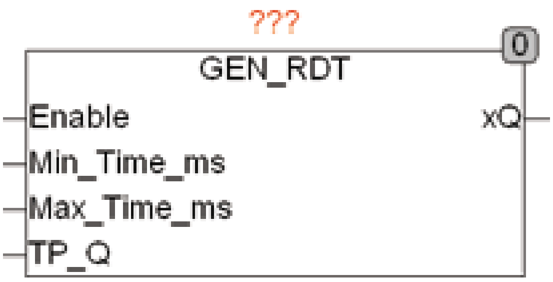
Input PT	TIME (period time)
AM	REAL (signal amplitude)
OS	REAL (signal offset)
Output Q	BOOL (binary output)
OUT	REAL (analog output signal)
	GEN_RDM is a random signal generator. It generates the output OUT a new value in PT intervals. The output Q is TRUE for one cycle when the output OUT has changed. The input AM and OS set the amplitude and the offset for the output OUT. If the inputs OS and AM are not connected, then the default values are 0 and .
	The following example shows a trace recording of the input values PT = 100ms, AM = 10 and OS = 5. The output values generated every 100 ms in the range of 0 .. 10.





4.6.0.7 Type Function module

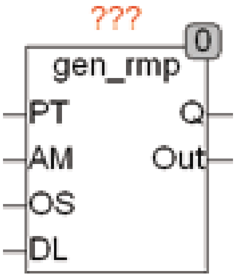
Input ENABLE	BOOL (enable input)
MIN_TIME_MS	TIME (Minimum cycle time)
MAX_TIME_MS	TIME (maximum cycle time)
TP_Q	TIME (pulse width of the output pulse to XQ)
Output XQ	BOOL (binary output)
	GEN_RDT generates pulses with a defined pulse width and random spacing. The output pulses with the pulse width TP_Q be generated at random intervals TX. TX fluctuates randomly between time MIN_TIME_MS and MAX_TIME_MS. The module generates output pulses at XQ only when the ENABLE input is TRUE.

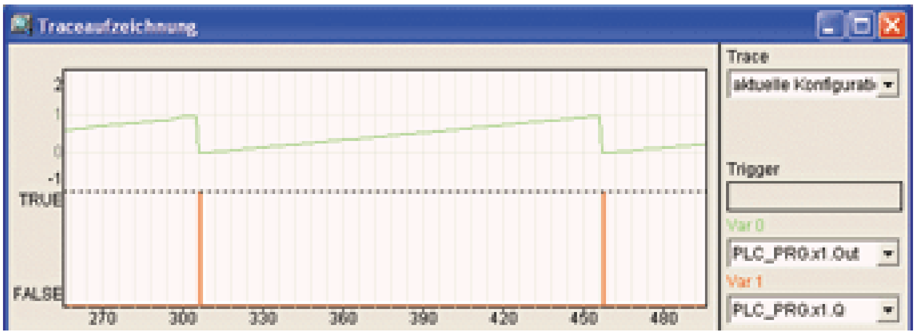


4.6.0.8 Type Function module

Input PT	TIME (period time)
AM	REAL (signal amplitude)
OS	REAL (signal offset)
DL	REAL (signal delay 0..1 * PT)
Output Q	BOOL (binary output)
OUT	REAL (analog output)

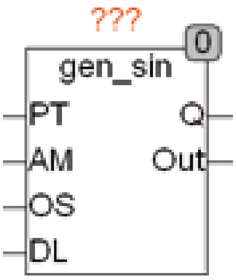
	GEN_RMP is a sawtooth generator. It generates a ramp at the output OUT with the duration of PT and repeats this continuously. The output Q is for exactly one cycle TRUE when the ramp starts at the output OUT. The input AM and OS set the amplitude and the offset for the output OUT. If the inputs OS and AM are not connected the default values are 0 and 1. The output OUT then generates a sawtooth signal of 0 .. 1. The input DL can move the output up to a period (PT) and is used to produce multiple shifted signals to each other. A 0 at the input DL means no displacement. A value between 0 and 1 shifts the signal by up to a period.
	The following example shows a trace recording of the input values PT = 10s, AM = 1 and OS = 0

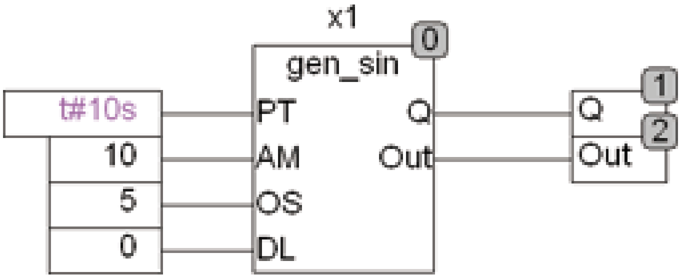


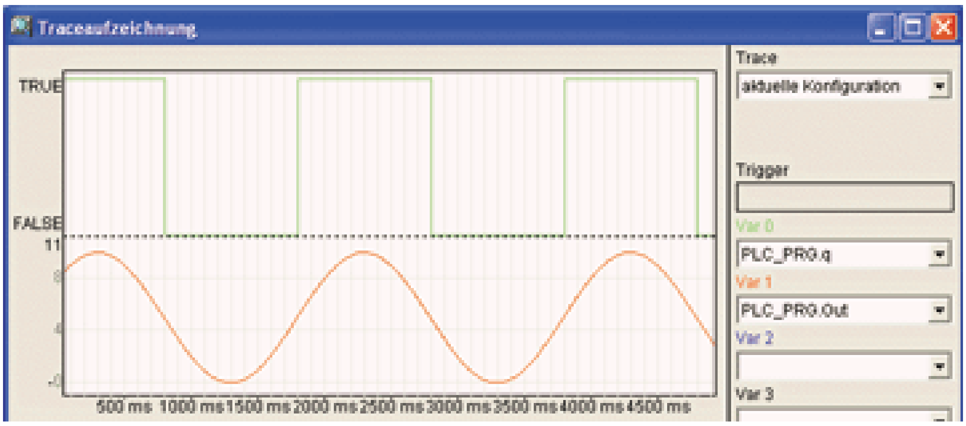


4.6.0.9 Type Function module

Input PT	TIME (period time)
AM	REAL (signal amplitude)
OS	REAL (signal offset)
DL	REAL (signal delay 0..1 * PT)
Output Q	BOOL (binary output)
OUT	REAL (analog output)
	GEN_SIN is a sine wave generator with programmable period, adjustable amplitude and signal offset. A special feature is a adjustable delay so that with multiple generators overlapping signals can be generated. A Binary Output Q passes a logical signal, which is generated phase equal to the sine signal. The input DL is a delay for the output signal. The Delay is specified with DL * PT. A DL of 0.5 delays the signal by half a period.
	The following example shows GEN_SIN with a trace recording of the sine signal and the binary output Q.
	The above example generates a sine wave with 0.1 Hz (PT = 10 s) and a lower peak value of 0 and upper peak value of 10.

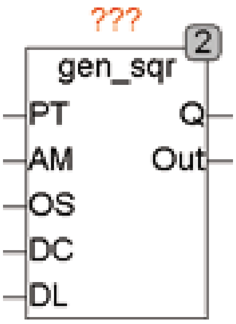


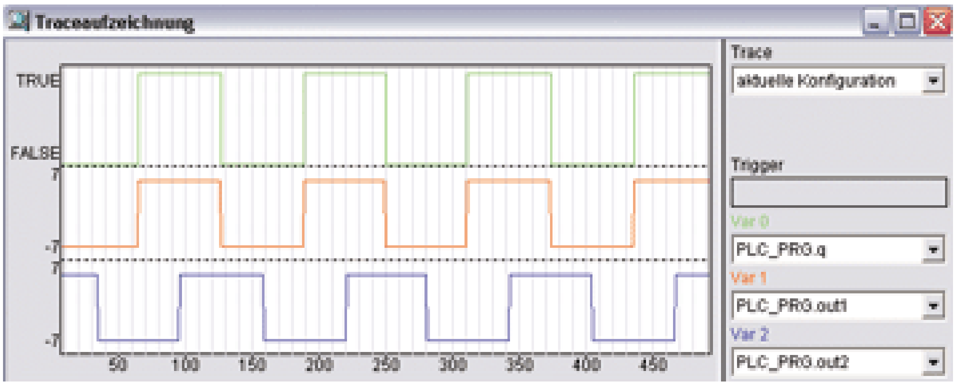


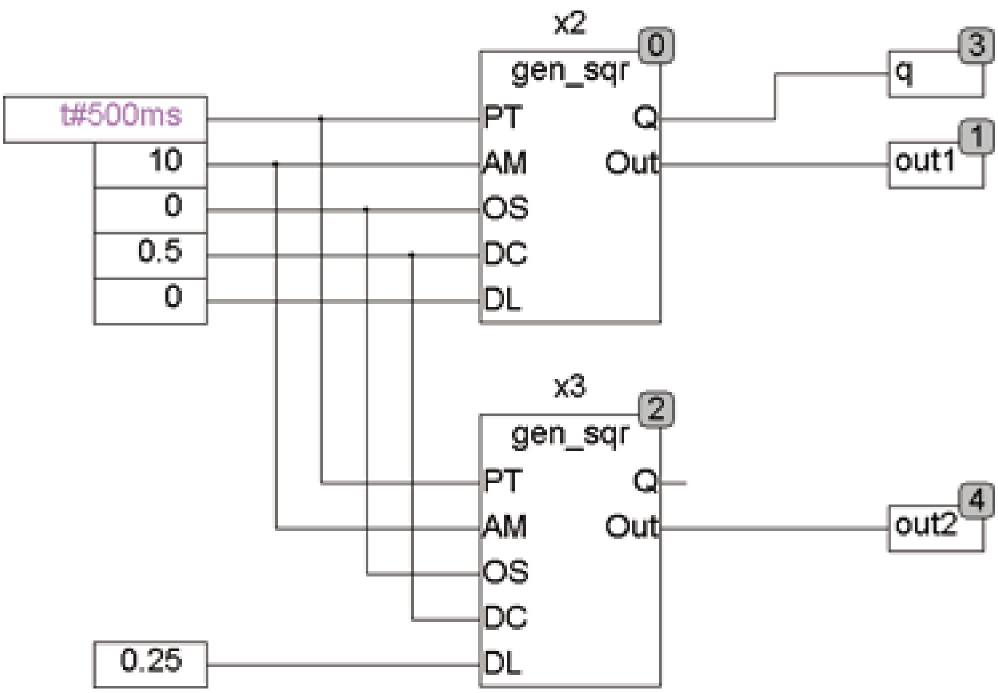


4.6.0.10 Type Function module

Input PT	TIME (period time)
AM	REAL (signal amplitude)
OS	REAL (signal offset)
DC	REAL (duty cycle 0..1)
DL	REAL (signal delay 0..1 * PT)
Output Q	BOOL (binary output)
OUT	REAL (analog output)
	GEN_SQR is a sqare wave generator with programmable period, adjustable amplitude and signal offset and duty cycle DC (Duty Cycle). A special feature is a adjustable delay so that with multiple generators overlapping signals can be generated.
	The following Example shows 2 GEN_SQR, one runs with a delay of 0.25 (¼ period). In the trace record clearly shows the signal of the first generator and the delayed signal of the second generator.



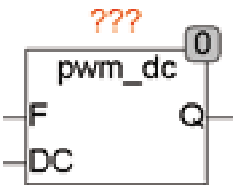


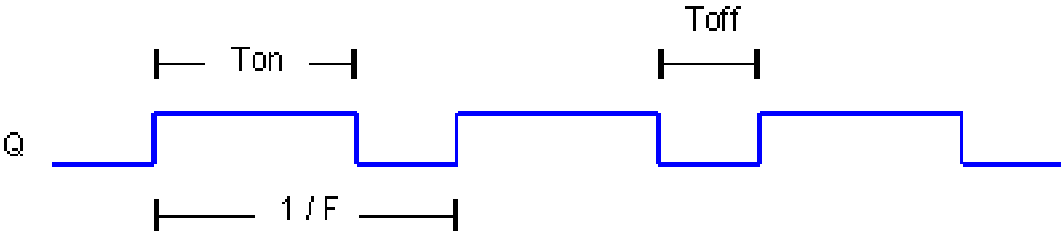


4.6.0.11 PWM_DC

Type	Function module
Input F	REAL (output frequency)
DC	REAL (duty cycle 0..1)
Output Q	BOOL (output)
	PWM_DC is a Duty - cycle modulated frequency generator. The generator generates a fixed frequency F with a duty cycle (TON / TOFF) which can be modulated (adjusted) by the input DC. A value of 0.5 at the input DC generates a duty cycle of 50%.

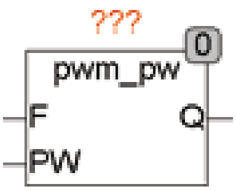
	The following image shows an output signal with a duty - cycle 2 / 1, which corresponds to a DC (ratio) of 0.67.

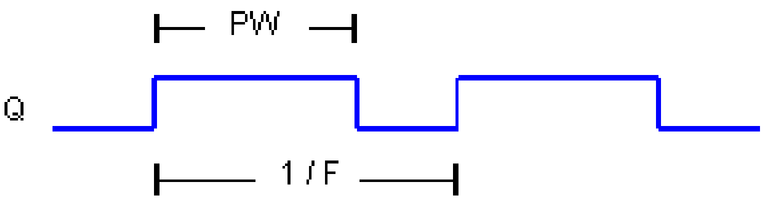




4.6.0.12 Type Function module

Input F	REAL (output frequency)
PW	TIME (pulse duration high)
Output Q	BOOL (output)
	PWM_PW is a pulse width modulated frequency generator. The generator generates a fixed frequency F with a duty cycle (TON / TOFF) which can bemodulated (set) by the input PW. The input passes the time before the signal remains TRUE.

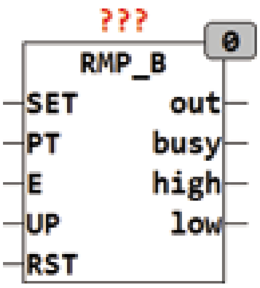


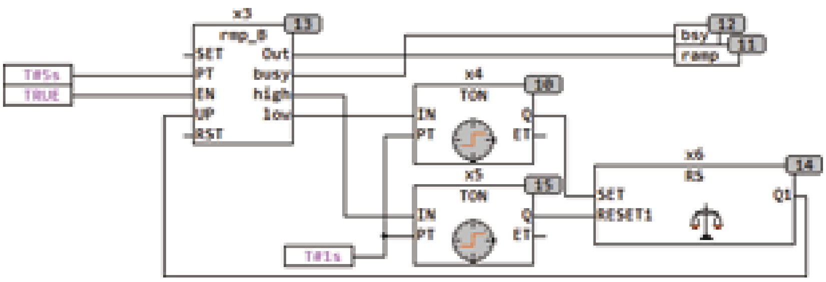


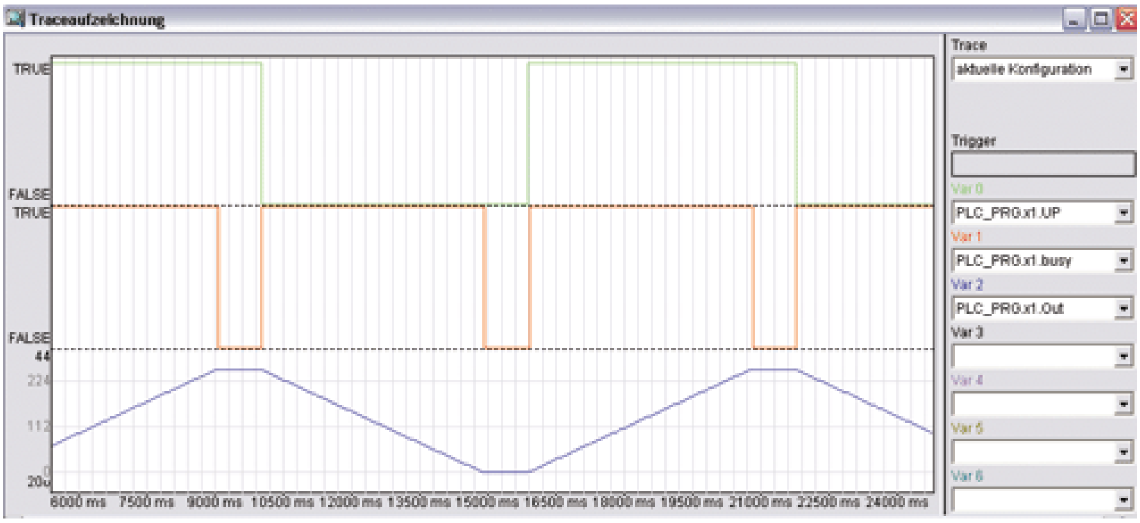
4.6.0.13 Type Function module

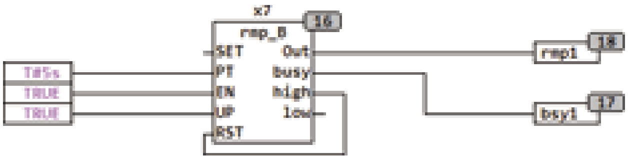
Input SET	BOOL (set input)
PT	TIME (duration of a ramp 0..255)
E	BOOL (enable input)
UP	BOOL (direction UP = TRUE means Up)
RST	BOOL (Reset input)
Output	I/O
BUSY	BOOL (TRUE, when ramp is running)

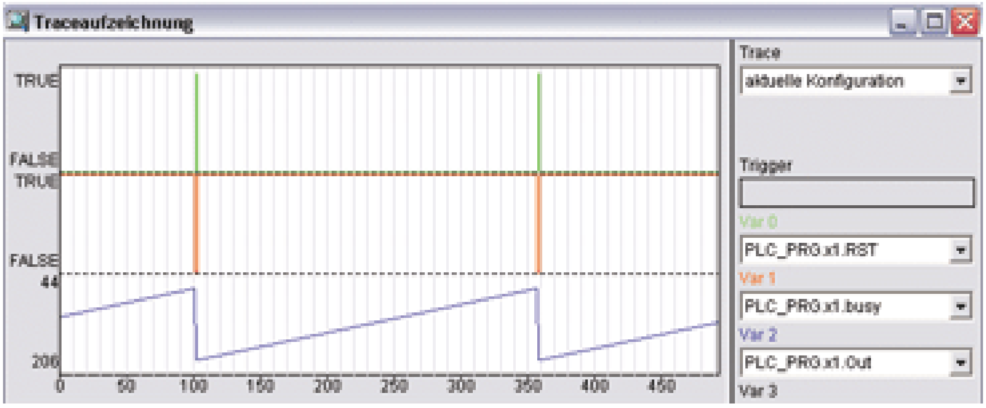
HIGH	BOOL (maximum output value is reached)
LOW	BOOL (Minimum output value is reached)
	RMP_B is a ramp generator with 8 bits (1 byte) resolution. The ramp of 0..255 is divided into a maximum of 255 steps and go through, in a time of PT once complete. An enable signal E switches the ramp generator on or off. An asynchronous reset sets each time the output to 0, and a pulse at the SET input sets the output to 255. With a UD input, the direction OPEN (UD = TRUE) or down (UD = FALSE) is set. The output of BUSY = TRUE indicates that a ramp is active. BUSY = FALSE means the output is stable. The outputs HIGH and LOW are TRUE, if the output OUT reaches the lower or upper limit (0 and 255).
	At setting of PT has to be noted, that a PLC with 5ms cycle time needs 256*5 = 1275 milliseconds for a ramp. If the time PT is made shorter than the cycle time multiplied by 256, the edge is translated in correspondingly larger steps. The ramp is constructed in this case with less than 256 steps per cycle. PT may be T#0s, then the output switched between minimum and maximum value back and forth.
	The following example shows an application of RMP_B. The outputs HIGH and LOW triggers both NTSC (X4, X5) 1 second delayed, and switch with the RS Flip Flop (X6) the UP input of the Ramps generators in order. The result is a ramp of 5 seconds, followed by an break of 1 second and then the reverse gradient of 5 seconds and then a break of 1 second. In the Trace the history of the signals can be seen.
Timing diagram for Up / Down Ramp	
	Another example shows the use of a sawtooth RMP_B.
Timing diagram for sawtooth	





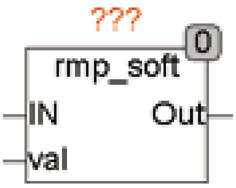


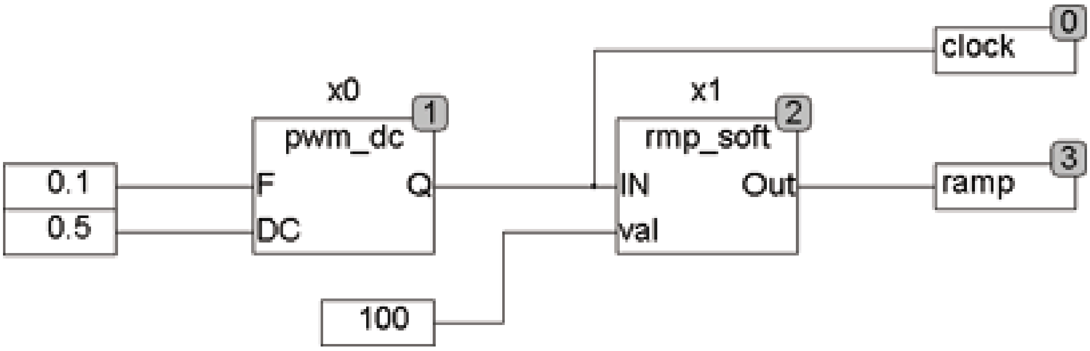


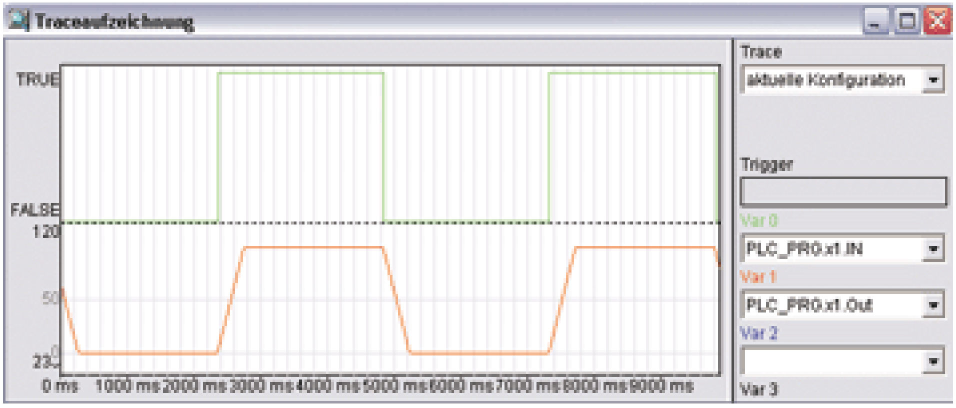


4.6.0.14 RMP_SOFT

Type	Function module
Input IN	BOOL (enable input)
VAL	Byte (maximum output value)
Output	I/O
	RMP_SOFT smooths the ramp of an input signal VAL. The signal Out follows the input signal VAL, where increase time as well as fall time can be limited by PT_ON and PT_OFF . The rise time and fall time of the ramps are defined by setup parameter in the module RMP_SOFT. The setup time PT_ON specifies how long the ramp takes of 0..255. A ramp that is limited by the VAL, is accordingly shorter. PT_OFF defines accordingly the falling ramp. If the input IN is set to FALSE, VAL corresponds to a value of 0, so by switching the input IN between 0 and VAL it can be switched.
Setup PT_ON	TIME (rise time, Default is 100 ms)
PT_OFF	TIME (fall time; Default is 100 ms)







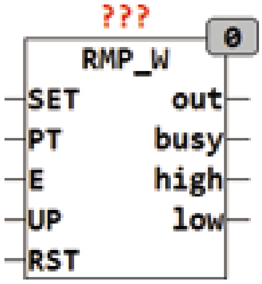
Example:

Example:

4.6.0.15 RMP_W

Type	Function module
Input SET	BOOL (set input)
PT	TIME (duration of a ramp 0..65535)
E	BOOL (enable input)
UP	BOOL (direction UP = TRUE, means UP)
RST	BOOL (Reset input)
Output	I/O
BUSY	BOOL (TRUE, when ramp is running)
HIGH	BOOL (maximum output value is reached)
LOW	BOOL (Minimum output value is reached)
	RMP_W is a ramp generator with 16-bit (2 bytes) resolution. The ramp of 0.. 65535 is divided into a maximum of 65536 steps and run in a time of PT once complete. An enable signal E switches the ramp generator on or off. An asynchronous reset sets each time the output to 0, and a pulse at the Set input sets the output to 65535. With the UD input, the direction UP (UD = TRUE) or DOWN (UD = FALSE) is defined. The output of BUSY = TRUE indicates that a ramp is active. BUSY = FALSE means the output is stable. The

	outputs HIGH and LOW gets TRUE, the output OUT reaches the lower or upper limit (0 and 65535).
	At setting of PT is to be noted that a PLC with 5 ms cycle time needs 65536*5 = 327 seconds for a ramp. If the PT is the time defined shorter than the cycle time 65536, the edge is translated in correspondingly larger steps. The ramp is constructed in this case with less than 256 steps per cycle. PT may be T#0s, then the output switched between minimum and maximum value back and forth.
	For a detailed description, see the module RMP_B. The function is absolutely identical except that the output OUT 8-bit wide instead of 16 bit.

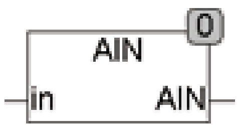


4.7 Engineering / signal processing

This section contains 82 modules.

4.7.0.1 Type Function

Input IN	DWORD (input from the A / D converter)
Output	REAL (output value)
Setup BITS	Bytes (number of bits, 16 for a complete word)
SIGN	Byte (Sign Bit, 15 for Bit 15)
LOW	REAL (minimum value of output)
High	REAL (largest value of output)
	Analog inputs of A / D converters generally provide a WORD (16 bit) or DWORD (32 bit), but they do not even usually 16 bit or 32 bit resolution. Furthermore A/D converter digitizing a fixed input range (z as −10 .. + 10 V), which for example, the digital values 0 .. 65535 (In 16-bit). The AIN function is configured by setup parameters and calculates the output values of the A/D converter according to, so that after the AIN module a REAL value is available, which corresponds to the real measured value. Furthermore, the module can extract and convert a Sign- Bit at any point. By double-clicking on the module, several setup variables can be defined. Bits defines how many bits of the input DWORD to be processed. For a 12 bit converter, this value is 12. Then only the bits 0 - 11 are scored. Sign defines whether a sign bit is present and where it is found in the input word. Sign = 255 means that no sign bit is present and 15 means that bit 15 in the DWORD contains the sign. The default value for SIGN is 255. LOW and HIGH define the smallest and largest output value. If a Sign- Bit is defined (SIGN < 255), then LOW and HIGH must be positive. Without Sign- Bit they can be either positive or negative.



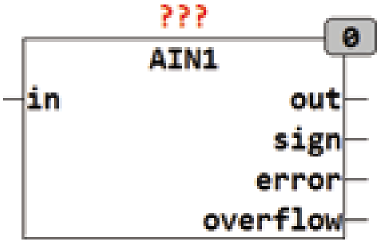
Example:

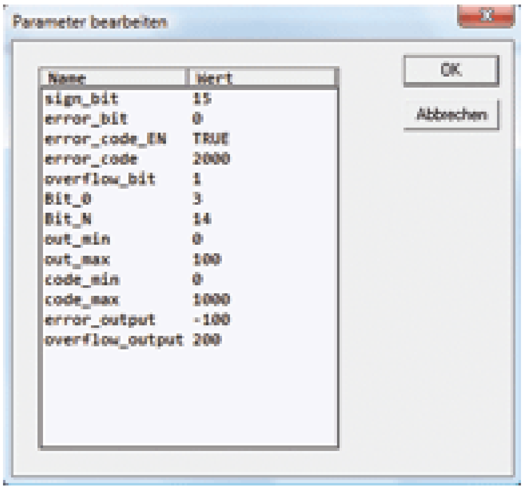
Example: A 12-bit A/D converter without a sign and input range from 0-10 is defined as follows: Bits = 12, Sign = 255, LOW = 0, HIGH = 10 A 14-bit A/D converter with 14 bits with sign and input range −10 - +10 is defined as: Bits = 14, Sign = 14, Low = 0, HIGH = +10. A 24-bit A/D converter without sign and a input range −10 - +10 is defined as: Bits = 24, Sign = 255, LOW =- 10, HIGH = +10.

4.7.0.2 Type Function module

Input IN	DWORD (input from the A / D converter)
Output OUT	REAL (output value)
SIGN	BOOL (sign)
ERROR	BOOL (Error Bit)
OVERFLOW	BOOL (Overflow Bit)
Setup SIGN_BIT	INT (bit number of the sign)
ERROR_BIT	INT (bit number of error bits)
ERROR_CODE_EN	BOOL (evaluation of the Error A code)
ERROR_CODE	DWORD (error code of the input IN)
OVERFLOW_BIT	INT (bit number of Overflow Bits)
OVERFLOW_CODE_EN	BOOL (Overflow code evaluation enabled)
OVERFLOW_CODE	DWORD (Overflow Code of input IN)
BIT_0	INT (least significant bit number of data bits)
BIT_N	INT (most significant bit number of data bits)
OUT_MIN	REAL (input value at CODE_MIN)
OUT_MAX	REAL (output value at CODE_MAX)
CODE_MIN	DWORD (Minimum input value)
CODE_MAX	DWORD (maximum input)
ERROR_OUTPUT	REAL (output value ERROR)
OVERFLOW_OUTPUT	REAL (output value of OVERFLOW)
	AIN1 sets the digital output value of an A/D converter into a corresponding REAL value to the measured value. The device can be adjusted by setup variables to a variety of digital converters.
	A SIGN_BIT determines at which bit the D/A converter transmit the sign. When this variable is not defined or set to a value greater than 31 no sign is evaluated. The content of the SIGN_BIT appears at the output of SIGN. When a ERROR_BIT is specified, the contents of Error Bits is displayed at the output ERROR. Some A/D converter supply instead of a Error Bit a fixed output value which is out of the specified range and is thus an error signaling. The setup variable ERROR_CODE specifies the corresponding Error Code and with the ERROR_CODE_EN the evaluation of error_code is defined. If ERROR = TRUE, at the output OUT the value of ERROR_OUTPUT is issued. Using the OVERFLOW_BITS an over-range of the D/A converter is signaled and issued at the output OVERFLOW. Using the Setup variables OVERFLOW_CODE_EN and OVERFLOW_CODE it can query a certain code at the input IN and in the presence of this code, the Overflow Bits are set. Using CODE_MIN CODE_MAX in addition to OVERFLOW_BIT

	specifies an allowable range for the input data. Over-or under-steps this area will also set the OVERFLOW output. In an overflow the output value OVERFLOW_OUTPUT is at the output OUT. The setup variables BIT_0 BIT_N determine how the measured value by the D/A converter is provided. With Bit_0 set is defined at which bit the data word begins and with BIT_N at which the bit data word ends. In the example above, the data word is transferred from bit 3 - bit 14 (Bit 3 = bit 0 of data word and bit 14 = bit 12 of data word). The received data word is converted according to the setup variables CODE_MIN, CODE_MAX and OUT_MIN, OUT_MAX and, if a sign is present and if SIGN = TRUE, the output value OUT is inverted.





4.7.0.3 Type Function

Input IN	REAL (input value)
Output	DWORD (output word to the A/D converter)
Setup BITS	Bytes (number of bits, 16 for a complete word)
SIGN	Byte (Sign Bit, 15 for Bit 15)
LOW	REAL (smallest value of the input)
HIGH	REAL (largest value of input)
	Inputs of D/A converters typically require a WORD (16 bit) or DWORD (32 bit), but they do not have usually 16 bit or 32 bit resolution. D/A converter normally generate a fixed output range (ie −10 .. + 10 V) which is represented, for example, with the digital values 0 .. 65535 (In 16-bit). The function AOUT is configured by setup parameters and calculates the input values (IN) to accordingly, so that after the module AOUT is a digital value available at the output of the D/A converter generates a value that is the REAL value IN matches. Furthermore, the module can insert a Sign- Bit anywhere if the D/A converter need a Sign- Bit. By double-clicking on the module, several setup variables can be defined. Bits define how many Bits the D/A converter can handle. For a 12 bit

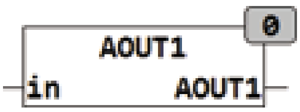
	converter, this value is 12. Then only the bits 0 - 11 are scored. Sign defines whether a sign bit is needed and where to place in the source DWORD. Sign = 255 means that no sign bit is needed, and 15 means Bit 15 in the DWORD contains the sign. LOW and HIGH define the smallest and highest input value. If a Sign-Bit is defined (SIGN< 255), then LOW and HIGH must be positive. Without Sign-Bit they can be either positive or negative.

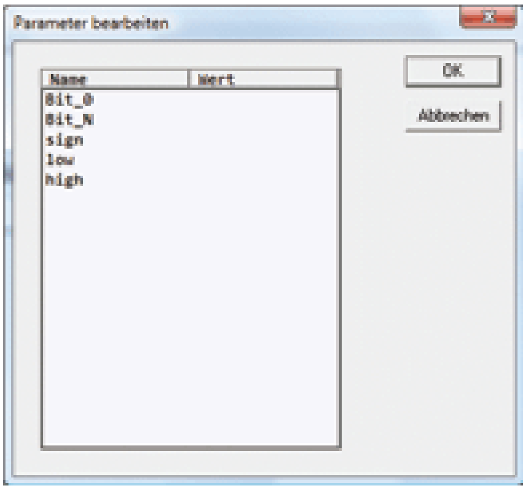
Example:

Examples : A 12-bit D/A converter without a sign and output range from 0-10 is defined as follows: Bits = 12, Sign = 255, LOW = 0, HIGH = 10 A 14-bit D/A converter with 14 bits with sign and output range −10 - +10 is defined as: Bits = 14, Sign = 14, Low = 0, HIGH = +10. A 24-bit D/A converter without a sign and output range from −10 - +10 is defined as follows: Bits = 24, Sign = 255, LOW = −10, HIGH = +10

4.7.0.4 Type Function

Input IN	REAL (input value)
Output	DWORD (output word to the A/D converter)
Setup BIT_0	INT (position of the lowest significant bit of data word)
BIT_N	INT (position of the most significant bits of data word)
SIGN	INT(Sign Bit, 15 for Bit 15)
LOW	REAL (smallest value of the input)
HIGH	REAL (largest value of input)
	AOUT1 generates from the REAL input value IN a digital output value for D/A converter or other modules of digital data. Using Setup variables, the digital output value can be adapted to different needs. The IN input value is converted using the information in LOW and HIGH and with the length specified in BIT_0 and BIT_N, and made available at the output. BIT_0 specifies the position of the lowest significant data bits (Bit0) in the output data and BIT_N specifies the position of the most significant data bits in the output data. The length of the data area is automatically calculated by BIT_N - BIT_0 + 1. When the position of a sign bit is specified with SIGN the sign of the input value is copied to the specified position of SIGN in the output data.



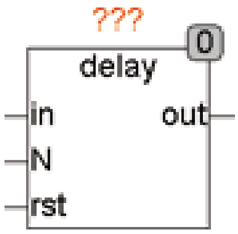


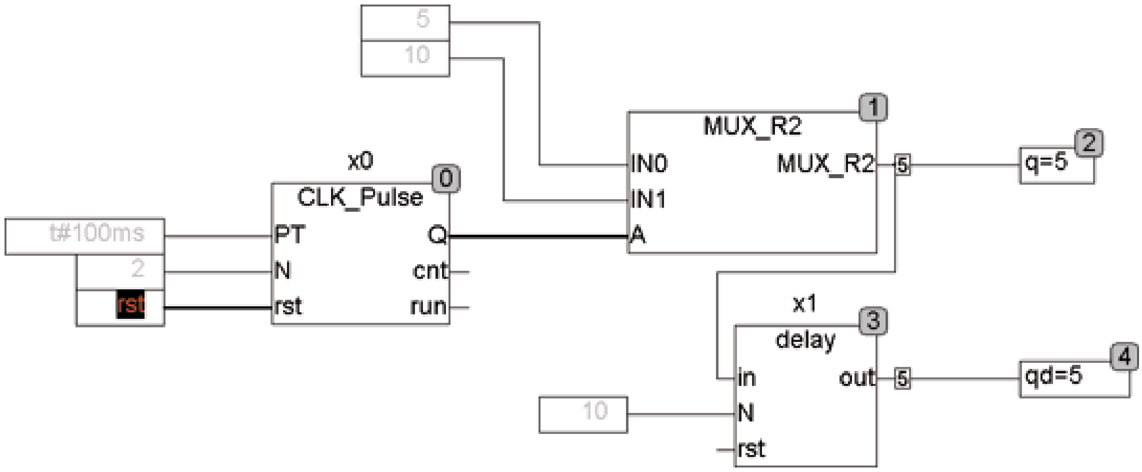
4.7.0.5 Type Function

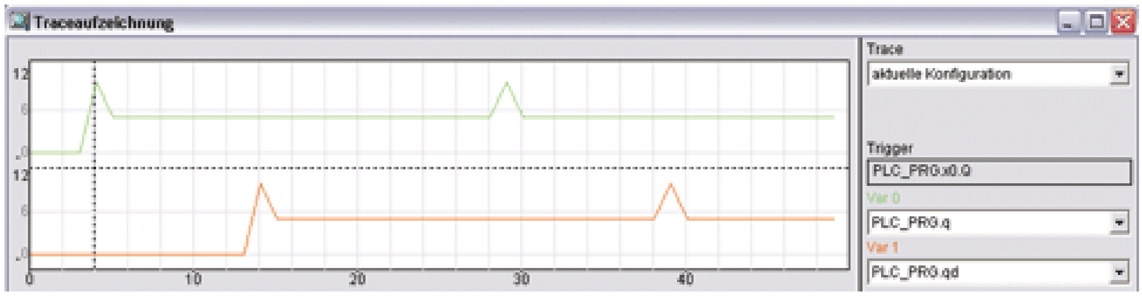
Input IN	BYTE (input)
LOW	REAL (initial value at X = 0)
HIGH	REAL (initial value at X = 255)
Output	REAL (output value)
	BYTE_TO_RANGE convert a BYTE value to a REAL. An input value of 0 corresponds to the REAL value of LOW and an input value of 255 corresponds to the input value of HIGH.
To convert a BYTE value of 0 .255 to a percent of 0 .100 the module is called, as follows	
	BYTE_TO_RANGE (X,0,100)

4.7.0.6 Type Function module

Input IN	REAL (input value)
N	INT (number of delay cycles)
RST	BOOL (asynchronous reset)
Output OUT	REAL (delayed output value)
	DELAY delays an input signal (IN) for N cycles. The input RESET is asynchronous, and may delete the Delay buffer.
	The Example shows a generator that produces pulses of 5 to 10 and a Delay, that generates a 10 cycles delay.

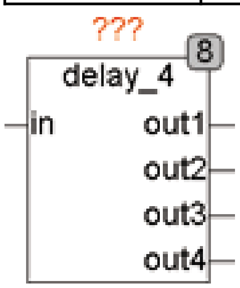


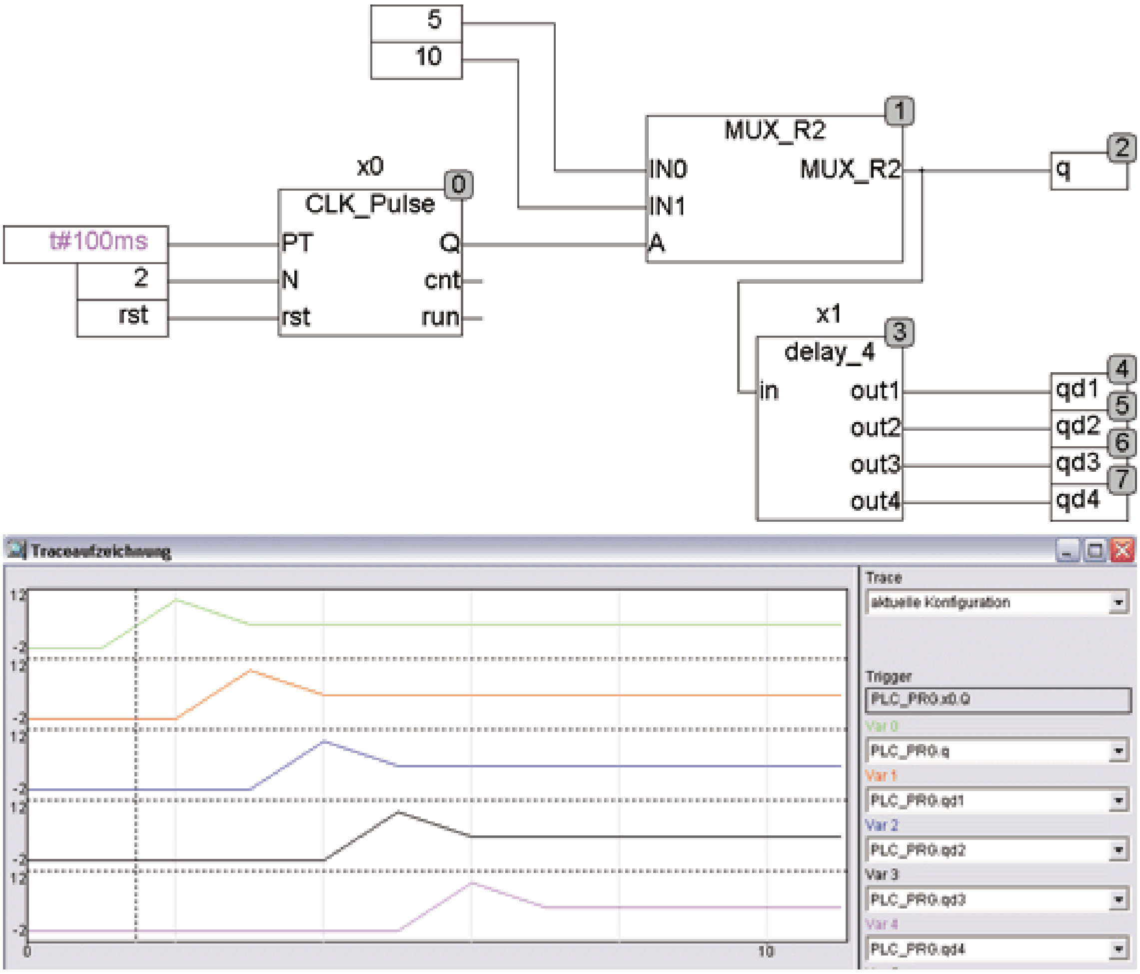




4.7.0.7 Type Function module

Input IN	REAL (input value)
Output OUT1	REAL (by 1 cycle delayed output value)
OUT2	REAL (by 2 cycles delayed output value)
OUT3	REAL (by 3 cycles delayed output value)
OUT4	REAL (by 4 cycles delayed output value)
	DELAY_4 delays an input signal by a maximum of 4 cycles. The outputs Out 1..4 passes the last 4 values. Out1 is delayed by one cycle, Qut2 by 2 cycles and Out3 by 3 cycles and Out4 by 4 cycles.



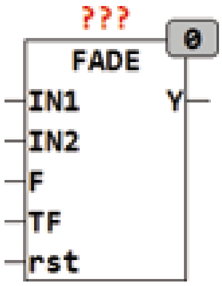


Example:
Example :

4.7.0.8 Type Function module

Input IN1	REAL (input value of 1)
IN2	REAL (input value 2)
F	BOOL (select input TRUE = IN2)
TF	TIME (Transition period)
RST	BOOL (Asynchronous Reset)
Output Y	REAL (baseline)
	FADE is used to switch between 2 inputs IN1 and IN2 with a soft transition. The switching time is specified as TF. An asynchronous reset (RST) resets the module without delay to IN1 if F = FALSE or IN2 when F = TRUE. A switching operation is triggered by a change in the value of R. Then it switches within the time TF between the two inputs. The switchover will mix the two entrances during the changeover. At the beginning of switching at the output are at 0% of the new value and 100% of the old value passsed. after half the transfer time (TF/2) the output has 50% each of the two input

	values (Y = in1* 0.5 + in2 * 0.5). after the time TF is then the new output value to 100% available.
During the switching of the output Y is	
	Y = TU/TF * IN1 + (1 - TU/TF) * IN2.
	TU is the time elapsed since the start of the switchover.
	Since the output of FADE is dynamically calculated, the device can also be used to switch dynamic signals. The switch is divided into up to 65,535 steps, which can be limited by the cycle time of the PLC. A PLC with a cycle time of 10ms and a TF of a second is only in 1s/10ms = 100 steps to change channels.



4.7.0.9 Type Function: DWORD

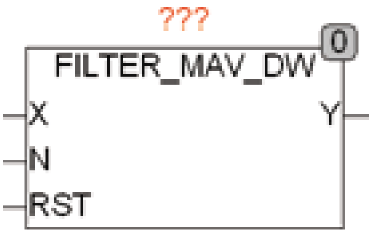
Input X	DWORD (input)
T	TIME (time constant of the filter)
Output Y	DWORD (filtered value)
	FILTER_DW is a filter of the first degree for 32-bit DWORD data. The main application is the filtering of sensor signals for noise reduction. The basic functionality of a filter of the first degree can be found in the module FT_PT1.

4.7.0.10 FILTER_I

Type Function	INT
Input X	INT (input)
T	TIME (time constant of the filter)
Output Y	INT (filtered value)
	FILTER_I is a filter of the first degree for 16-bit INT data. The main application is the filtering of sensor signals for noise reduction. The basic functionality of a filter of the first degree can be found in the module FT_PT1.

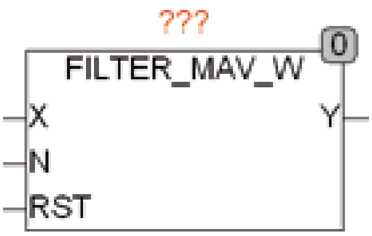
4.7.0.11 FILTER_MAV_DW

Type Function	DWORD
Input X	DWORD (input)
N	UINT (number of assigned values)
RST	BOOL (asynchronous reset input)
Output Y	DWORD (filtered value)
	FILTER_MAV_DW is a filter with moving average. The filter with moving average (also Moving Average Filter called) the average of N successive readings is output as an average.
Y	= (X0 + X1 + ... + Xn-1) / N
	X0 is the value of X in the current cycle, X1 is the value in the previous cycle, etc. The number of values over which the average has to be calculated is specified at the input N. The range of values of N is between 1 and 32



4.7.0.12 Type Function: WORD

Input X	WORD (input)
N	UINT (number of assigned values)
RST	BOOL (asynchronous reset input)
Output Y	WORD (filtered value)
	FILTER_MAV_W is a filter with moving average. The filter with moving average (also Moving Average Filter called) the average of N successive readings is output as an average.
Y	= (X0 + X1 + ... + Xn-1) / N
	X0 is the value of X in the current cycle, X1 is the value in the previous cycle, etc. The number of values over which the average has to be calculated is specified at the input N. The range of values of N is between 1 and 32



4.7.0.13 Type Function: WORD

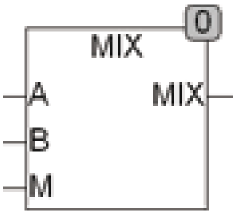
Input X	WORD (input)
T	TIME (time constant of the filter)
Output Y	WORD (filtered value)
	Output The main application is the filtering of sensor signals for noise reduction. The basic functionality of a filter of the first degree can be found in the module FT_PT1.

4.7.0.14 Type Function: REAL

Input X	DWORD (input)
W	array [0...15] of real (weighting factors)
RST	BOOL (asynchronous reset input)
Output Y	REAL (filtered value)
	FILTER_WAV is a filter with a weighted average. (Also called FIR filter) the filter with a weighted average of individual values in the buffer are evaluated with different weights.
Y	= X0 * W0 + X1 * W1 + ...+ X15 * W15
	X0 is the value of X in the current cycle, X1 is the value in the previous cycle, etc. The factors W are passed as the input array W. In applying the FIR filter hast to be ensured that appropriate factors are used for weighting. The application makes sense only if these factors are determined by appropriate methods or design software.

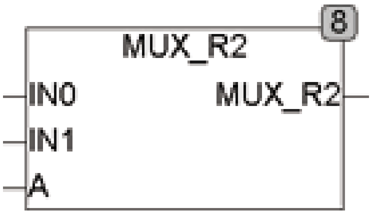
4.7.0.15 Type Function: REAL

Input A	REAL (input value of 1)
B	REAL (input value 2)
M	REAL (ratio)
Output	REAL (value from the mixing ratio M between A and B)
	MIX provides at the output a mixed ratio M value, mixed from values A and B. The input M passes the proportion of B in the range 0..1.
	MIX = (M-1)$A + M$B



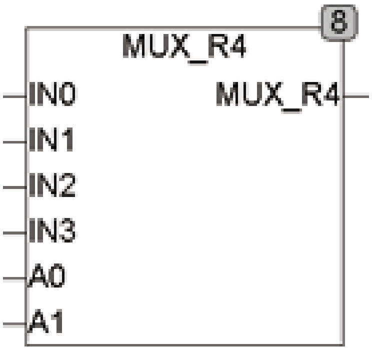
4.7.0.16 MUX_R2

Type	Function
Input IN0	REAL (input 0)
IN1	REAL (input value of 1)
A	BOOL (address input)
Output	REAL (IN0 if A = 0, IN1 if A = 1)
	MUX_R2 selects one of two input values. The function returns the value of IN0, if A = 0 and the value of IN1, if A = 1



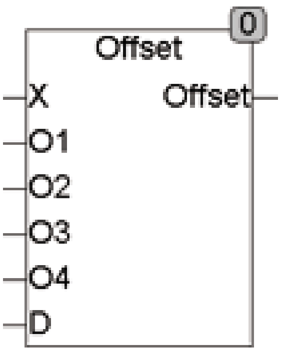
4.7.0.17 MUX_R4

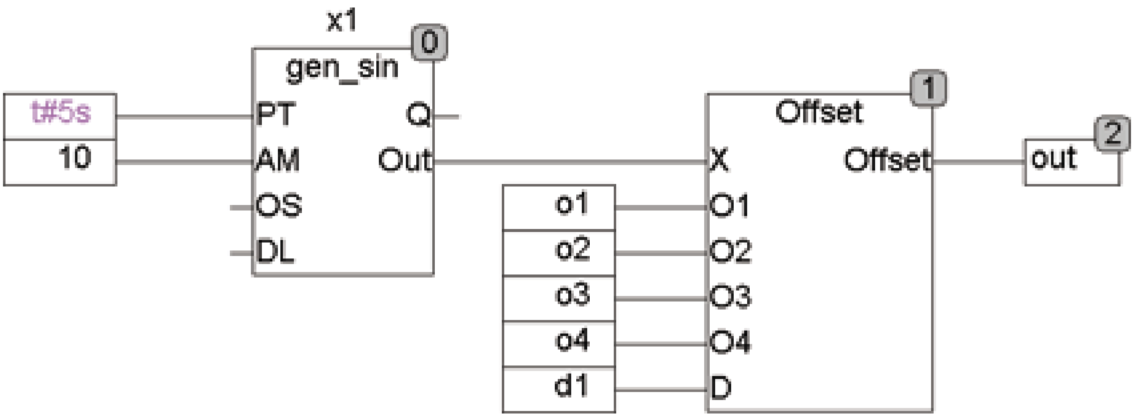
Type	Function
Input IN0	REAL (input 0)
IN1	REAL (input value of 1)
IN2	REAL (input 0)
IN3	REAL (input value of 1)
A0	BOOL (address input bit 0)
A0	BOOL (address input bit 0)
Output	REAL (IN0 if A0 = 0 and A1 = 0, IN3 if A0 = 1 and A3 = 1)
	MUX_R4 selects one of 4 input values.
Logical connection	IN0 if A0 = 0 & A1 = 0,
	IN1 if A0 = 1 & A1 = 0;
	IN2 if A0 = 0 & A1 = 1;
	IN3 if A0 = 1 & A1 = 1;

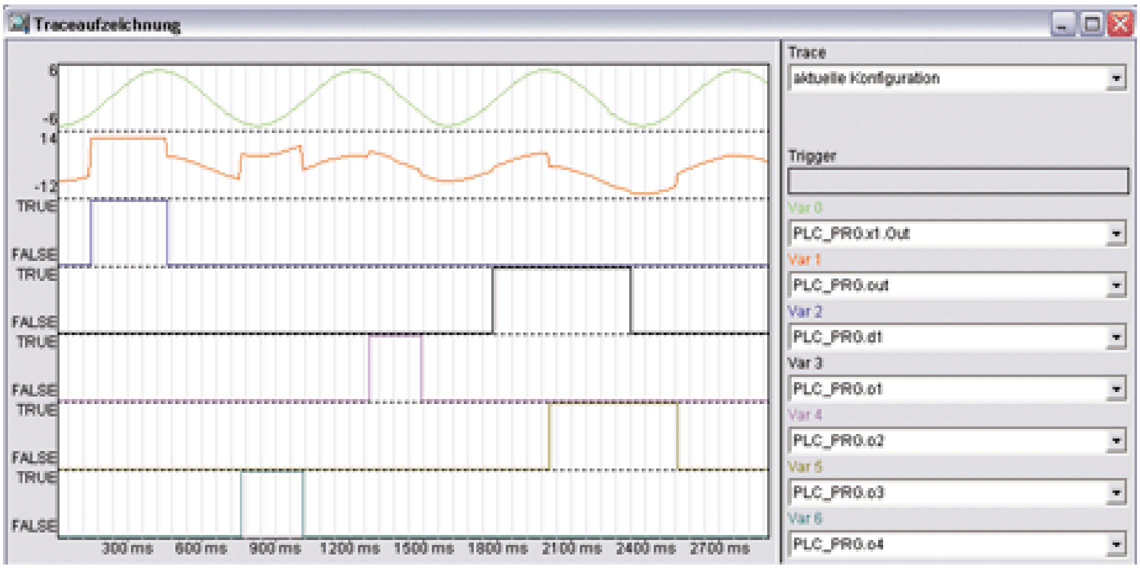


4.7.0.18 OFFSET

Type	Function
Input X	REAL (input)
O1	BOOL (Enable Offset 1)
O2	BOOL (Enable Offset 2)
O3	BOOL (Enable Offset 3)
D	BOOL (EnableDefault)
Output	REAL (output value with offset)
Setup Offset_1	REAL (offset that is added when O1 = TRUE)
Offset_2	REAL (offset that is added when O2 = TRUE)
Offset_3	REAL (offset that is added when O3 = TRUE)
Offset_4	REAL (offset is added if O4 = TRUE)
Default	REAL (This is used instead of X, if D = TRUE)
	The function Offset addes different offsets to an input signal depending on the binary value of O1.. O4. The offsets can be added individually or simultaneously. With the input D a Default value instead of the input X can be switched to the adder. The offset and Default value be defined through the setup variables.
The following example illustrates the operation of offset	



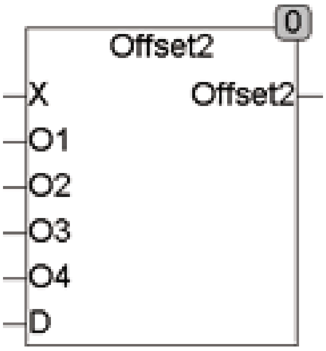




4.7.0.19 OFFSET2

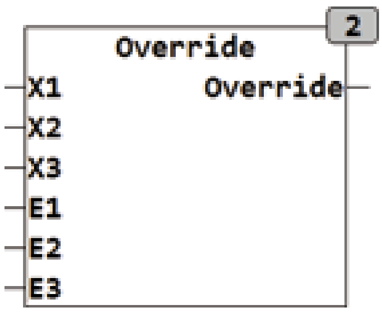
Type	Function
Input X	REAL (input)
O1	REAL (Enable Offset 1)
O2	REAL (Enable Offset 2)
O3	REAL (Enable Offset 3)
D	BOOL (EnableDefault)
Output	REAL (output value with offset)
Setup Offset_1	REAL (offset that is added when O1 = TRUE)
Offset_2	REAL (offset that is added when O2 = TRUE)
Offset_3	REAL (offset that is added when O3 = TRUE)
Offset_4	REAL (offset is added if O4 = TRUE)
DEFAULT	REAL (This is used instead of X, if true)
	The function Offset2 adds an offset to an input signal depending on the binary value of O1.. O4. If more offsets are selected simultaneously, then the offset with the highest numbers added up and the others ignored. If O1 and O3 are simultaneously

	TRUE, then Offset_3 is added and not Offset_1. With the input D a default value instead of the input X can be switched to the adder. The offset and Default value be defined through the setup variables.
	For further explanation and an example, see Offset, which has very similar functionality. Offset2 only adds only one (the one with the highest number) offset, while Ofset simultaneously adding all the selected.



4.7.0.20 OVERRIDE

Type	Function
Input X1	REAL (input signal 1)
X2	REAL (Input signal 2)
X3	REAL (input signal 3)
E1	BOOL (Enable Signal 1)
E2	BOOL (Enable Signal 2)
E2	BOOL (Enable Signal 3)
Output	REAL (output value
	OVERRIDE supplies at the output Y the input value (X1, X2, X3), whose absolute value is the largest of all. The inputs X1, X2 and X3 may each individually be enabled with the inputs E1, E2 and E3. if one of the input signals E1, E2 or E3 to FALSE, the corresponding input X1, X2 or X3 is not considered. One of many possible applications of OVERRIDE is for example, the query of three sensors with the highest value overrides the others. With the inputs of E in the diagnosis case, each sensor can be queried individually, or a defective sensor can be switched off.

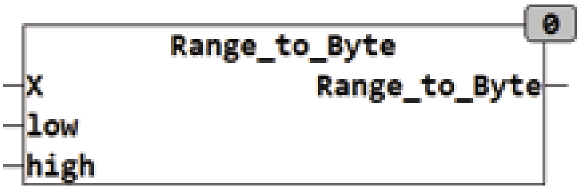


Example:

```
OVERRIDE(10,-12,11, TRUE, TRUE, TRUE) = -12 OVERRIDE(10,-12,11, TRUE, FALSE, TRUE) = 11
OVERRIDE(10,-12,11, FALSE, FALSE, FALSE) = 0
```

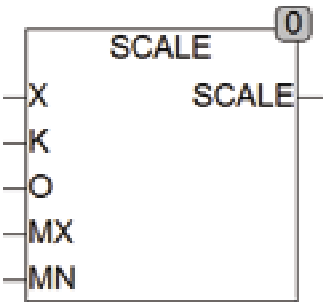
4.7.0.21 RANGE_TO_BYTE

Type	Function
Input X	REAL (input)
LOW	REAL (Lower Range limit)
HIGH	REAL (upper limit)
Output	BYTE (output value)
	RANGE_TO_BYTE converts a real value in a BYTE value. An input value of X corresponds to the value of LOW is converted it into an output value of 0 and an input value X of the input value corresponds to HIGH is converted into an output value of 255. The input X is limited to the range from LOW to HIGH, an overflow of the output BYTE can therefore not happen.



4.7.0.22 SCALE

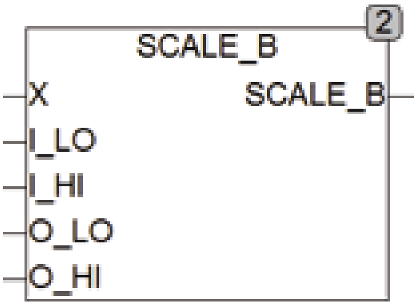
Type Function	REAL
Input X	Byte (input)
K	Byte (multiplier)
O	REAL (offset)
MX	REAL (maximum output value)
MN	REAL (minimum output value)
Output	REAL (output value)
	SCALE multiplies the input X with K, and adds the offset O. The calculated value will be limited to the values of MN and MX and the result is passed to output.
	SCALE = LIMIT(MN, X * K + O, MX)



4.7.0.23 SCALE_B

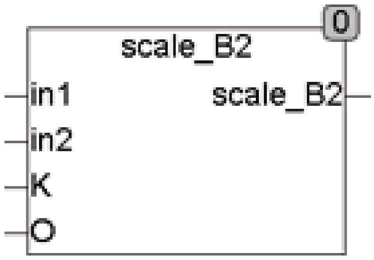
Type Function	REAL
Input X	DWORD (input)
I_LO	DWORD (min input value)

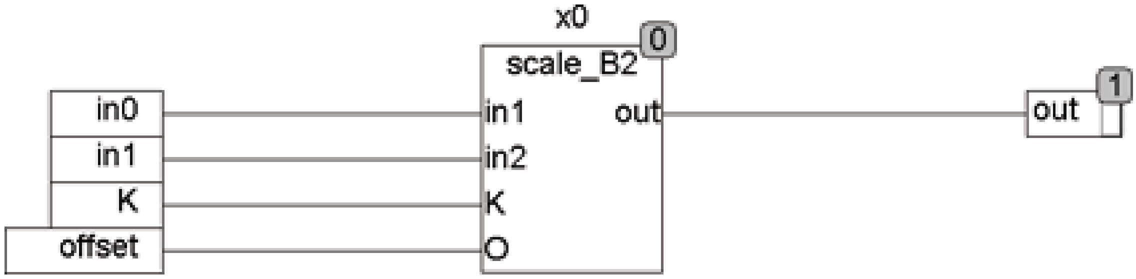
I_HI	DWORD (max input value)
O_LO	REAL (min output value)
O_HI	REAL (output value max)
Output	REAL (output value)
	SCALE_B scales an input value BYTE and calculates an output value in REAL. The input value X is limited here to I_LO and I_HI. SCALE_D (IN, 0, 255, 0, 100) scales an input with 8-bit resolution on the output 0..100.

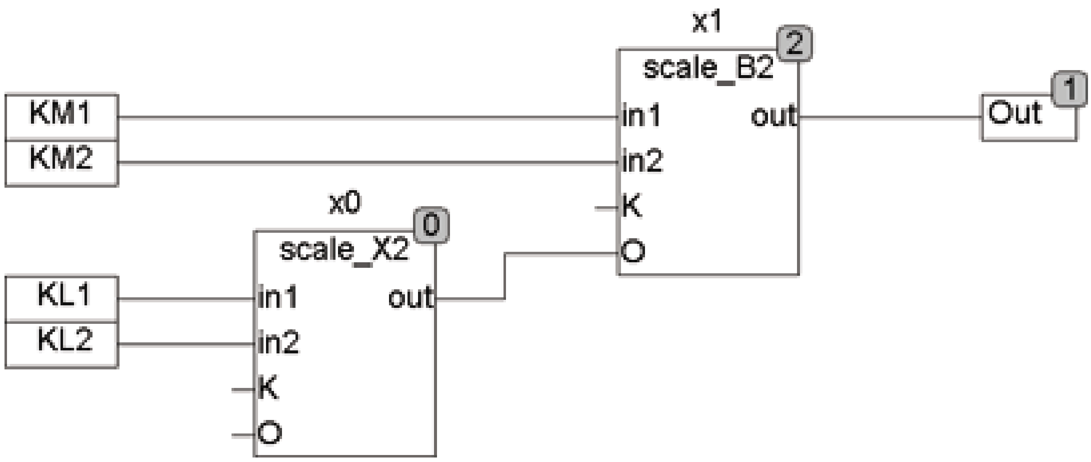


4.7.0.24 SCALE_B2

Type Function	REAL
Input IN1	Byte (input value 1)
IN2	Byte (input value 2)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
Setup IN1_MIN	REAL (lowest value for IN1)
IN1_MAX	REAL (highest value for IN1)
IN2_MIN	REAL (lowest value for IN2)
IN2_MAX	REAL (highest value for IN2)
	SCALE_B2 calculates from the input value IN and the setup values IN_MIN and IN_MAX an internal value, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN1 = 0 means IN1_MIN is taken into account, IN1 = 255 means IN1_MAX is considered. K is not connected then the first multiplier
Out =	(in1 * (IN1_MAX − IN1_MIN) / 255 + IN1_MIN + in2 *
(IN2_MAX −	IN2_MIN) / 255 + IN2_MIN) * K + O
	SCALE_B2 can be used, for example, to calculate total air quantities in ventilation systems. Also, wherever there are controlled mixers used and the resulting total amount has to be calculated.







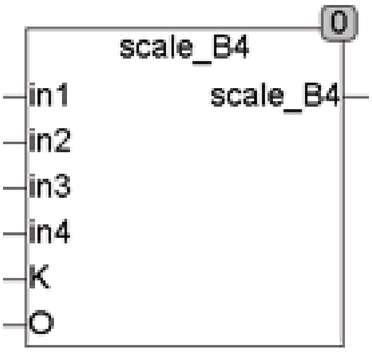
Example:

Example: IN0 is an air valve, which controls the air volume between 100m³/h and 600m³/h for the setting values IN0 - Controls (0-255). IN1 is an exhaust device that the exhaust air from 0m³/h to 400 m³/h for the control values IN1 controls 0- 255. The setup values for this application are: IN0_MIN = 100, IN0_MAX = 600, IN1_MIN = 0, IN1_MAX = −400. The resulting total air volume for K = 1 and O = 0 (no multiplier and no offset) then varies from −300 (IN0 = 0 and IN1 = 255) to +600 (IN0 = 255 and IN1 = 0). For an input value IN0 = 128 (flap 50%) and IN1 = 128 (fan at 50%) is the output value 250m³ - 200m³ = 50 m³. The input offset can also be used to cascade modules.

4.7.0.25 SCALE _ B4

Type Function	REAL
Input IN1 .. IN4	Byte (input values)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
Setup IN1_MIN	REAL (lowest value for IN1)
IN1_MAX	REAL (highest value for IN1)
IN2_MIN	REAL (lowest value for IN2)
IN2_MAX	REAL (highest value for IN2)

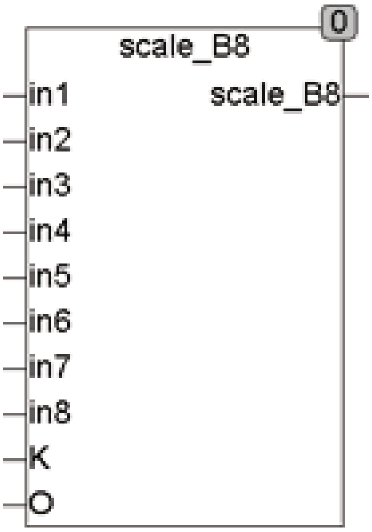
IN3_MIN	REAL (lowest value for IN3)
IN3_MAX	REAL (highest value for IN3)
IN4_MIN	REAL (lowest value for IN4)
IN4_MAX	REAL (highest value for IN4)
	SCALE_B4 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = 0 means IN_MIN is included, IN = 255 means IN_MAX is not considered. If K is not connected, then the multiplier is 1
OUT	= (in1 * (IN1_MAX – IN1_MIN) / 255 + IN1_MIN
	1. in2 * (IN2_MAX – IN2_MIN) / 255 + IN2_MIN
	1. in3 * (IN3_MAX – IN3_MIN) / 255 + IN3_MIN
	1. in4 * (IN4_MAX – IN4_MIN) / 255 + IN4_MIN) * K + O
	SCALE_B4 can ie be used for calculation total air quantities in ventilation systems, or wherever controlled mixers are used and the resulting total needs to be calculated.. More detailed explanations you can find at SCALE_B2.



4.7.0.26 SCALE_B8

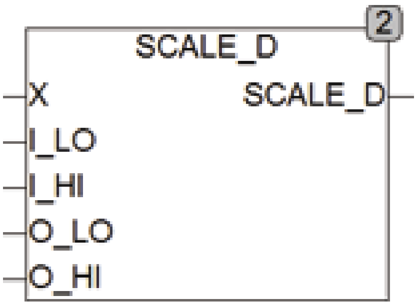
Type Function	REAL
Input	IN1 .. 8 bytes (input values)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
Setup IN_MIN	REAL (lowest value for IN)
IN_MAX	REAL (highest value for IN)
	SCALE_B8 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = 0 means IN_MIN is included, IN = 255 means IN_MAX is not considered. K is not connected then the first multiplier
OUT	= (in1 * (IN1_MAX – IN1_MIN) / 255 + IN1_MIN
	1. in2 * (IN2_MAX – IN2_MIN) / 255 + IN2_MIN
	1. in3 * (IN3_MAX – IN3_MIN) / 255 + IN3_MIN
	1. in4 * (IN4_MAX – IN4_MIN) / 255 + IN4_MIN

	1. in5 * (IN5_MAX – IN5_MIN) / 255 + IN5_MIN
	1. in6 * (IN6_MAX – IN6_MIN) / 255 + IN6_MIN
	1. in7 * (IN7_MAX – IN7_MIN) / 255 + IN7_MIN
	1. in8 * (IN8_MAX – IN8_MIN) / 255 + IN8_MIN) * K + O
	SCALE_B8 can be used, for example,to calculate total air quantities in ventilation systems, or wherever controlled mixers are used and the resulting total needs to be calculated . More detailed explanations you can find at SCALE_B2.



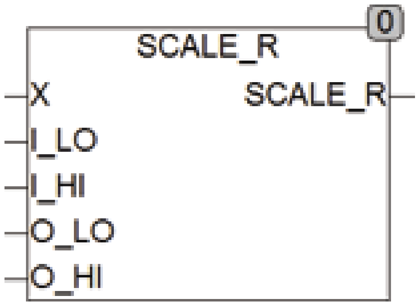
4.7.0.27 SCALE_D

Type Function	REAL
Input X	DWORD (input)
I_LO	DWORD (min input value)
I_HI	DWORD (max input value)
O_LO	REAL (min output value)
O_HI	REAL (output value max)
Output	REAL (output value)
	SCALE_D scales an input value DWORD and calculates an output value in REAL. The input value X is limited here to I_LO and I_HI. SCALE_D (IN, 0, 8191, 0, 100) scales an input with 14 bit resolution to the output 0..100. SCALE_D can also be negative and have a negative slope work at output values, and the values I_LO and I_HI must always be specified that ILO < I_HI is.



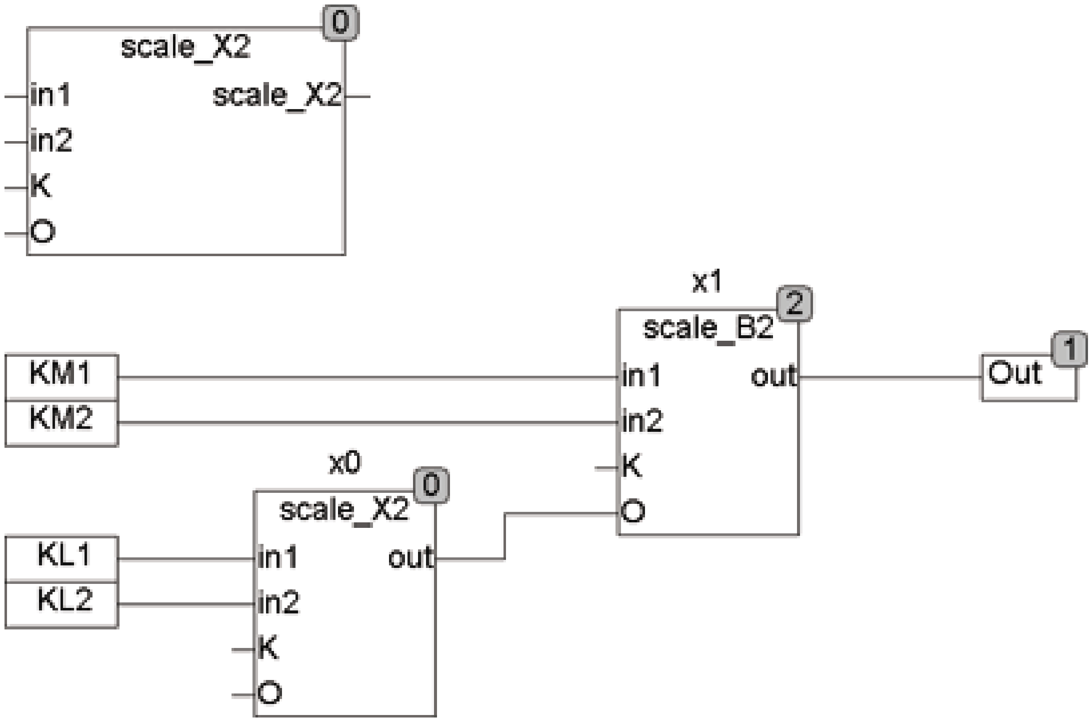
4.7.0.28 SCALE_R

Type Function	REAL
Input X	REAL (input)
I_LO	REAL (min input value)
I_HI	REAL (input value max)
O_LO	REAL (min output value)
O_HI	REAL (output value max)
Output	REAL (output value)
	SCALE_R scales an input value REAL and calculates an output value in REAL. The input value X is limited here to I_LO and I_HI. SCALE_D (IN,4,20,0,100) scales an input with 4 .. 20mA to the output 0..100. SCALE_R can also be negative output values and work with a negative slope, the values I_LO and I_HI but must always be specified that ILO < I_HI.



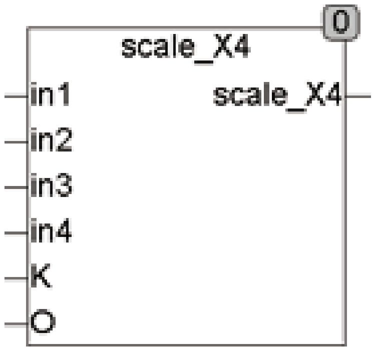
4.7.0.29 SCALE_X2

Type	Function
Input IN1 .. 2	BOOL (input values)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
Setup IN_MIN	REAL (lowest value for IN)
IN_MAX	REAL (highest value for IN)
	SCALE_X2 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = FALSE means IN_MIN is included, IN = TRUE means IN_MAX is considered. The sum is multiplied by K and offset O is added. K is not connected then the first multiplier
	SCALE_X2 can be used, for example, to calculate total air quantities in ventilation systems, or wherever controlled flaps are used and the resulting total needs to be calculated. By the input offset, SCALE_X2 can easily be cascaded with other SCALE modules.
	In following Example, two motor flaps KM1 and km² with 2 on/off flaps are connected KL1 and KL2 and the resulting amount of air is calculated.



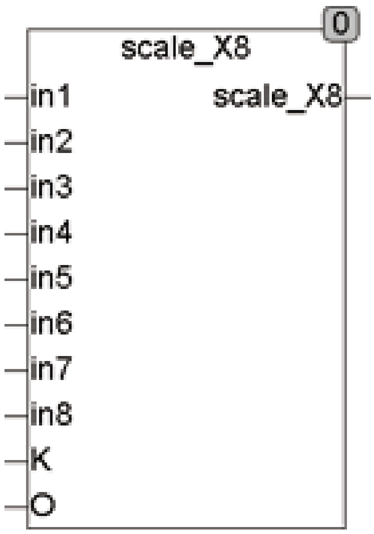
4.7.0.30 SCALE_X4

Type Function	REAL
Input IN1 .. 4	BOOL (input values)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
Setup IN_MIN	REAL (lowest value for IN)
IN_MAX	REAL (highest value for IN)
	SCALE_X4 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = FALSE means IN_MIN is included, IN = TRUE means IN_MAX is considered. The sum is multiplied by K and offset O is added. K is not connected then the first multiplier
	SCALE_X4 can be used, for example, to calculate total air quantities in ventilation systems, or wherever controlled flaps are used and the resulting total needs to be calculated. By the input offset, SCALE_X2 can easily be cascaded with other SCALE modules. Further explanation and examples, see SCAE_X2.



4.7.0.31 Type Function: REAL

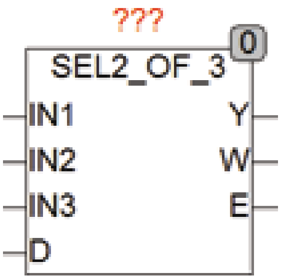
Input IN1 .. 8	BOOL (input values)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
Setup IN_MIN	REAL (lowest value for IN)
IN_MAX	REAL (highest value for IN)
	SCALE_X8 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = FALSE means IN_MIN is included, IN = TRUE means IN_MAX is considered. The sum is multiplied by K and offset O is added. K is not connected then the first multiplier
	SCALE_X8 can be used, for example, to calculate total air quantities in ventilation systems, or wherever controlled flaps are used and the resulting total needs to be calculated. By the input offset, SCALE_X2 can easily be cascaded with other SCALE modules. Further explanation and examples, see SCAE_X2.



4.7.0.32 Type Function: REAL

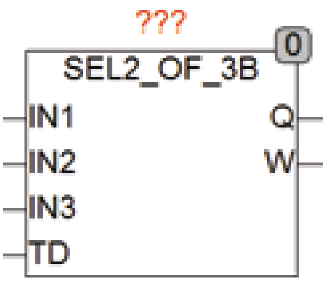
Input IN1	REAL (input value of 1)

IN2	REAL (input value 2)
IN3	REAL (input value 3)
D	REAL (tolerance)
Output Y	REAL (baseline)
W	INT (warning)
E	BOOL (Error Output)
	SEL2_OF_3 evaluates 3 inputs (IN1 .. IN3) and checks whether the deviation of the input value is less than or equal to D. The average of the three inputs is output at output Y. The individual inputs are only considered if they are not further away from another input than D. If the mean value of only 2 inputs, the number of unrecognized input is passed at W. If W = 0, all 3 inputs are considered. If all 3 inputs vary more than D, the output is set to W = 4 and the output E = TRUE. The output Y is not changed in this case and remains at the last valid zero. “
	A typical application for the module is the acquisition of 3 sensors which measures the same process variable in order to reduce measurement error as measured by different measures or broken wire.



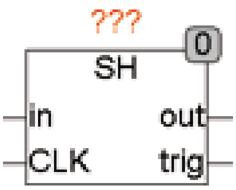
4.7.0.33 Type Function: BOOL

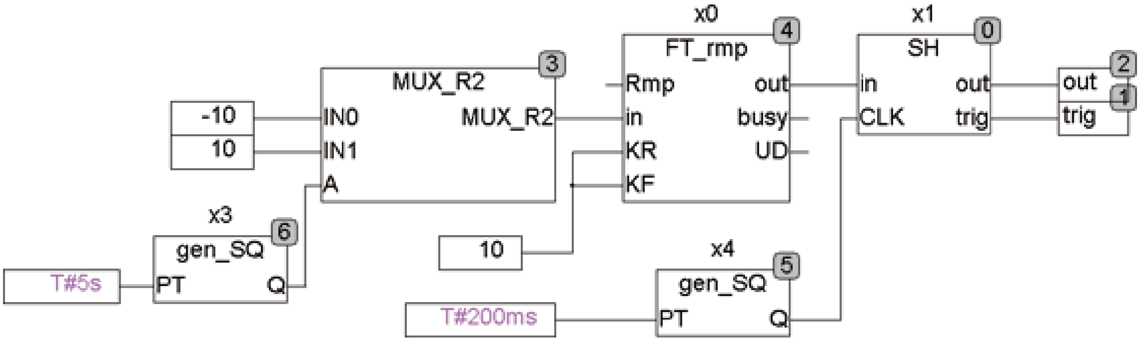
Input IN1	BOOL (input 1)
IN2	BOOL (input 2)
IN2	BOOL (input 2)
TD	TIME (Delay for output for W)
Output Q	BOOL (output)
W	BOOL (warning)
	SEL2_OF_3B evaluates 3 redundant binary inputs and provides the value, that at least 2 of the 3 inputs have, at output Q. If one of the three inputs has a different value than the other two, the output W is set as a warning. A response delay TD can be defined for the output W that at different timing while switching the inputs the Output W does not respond.

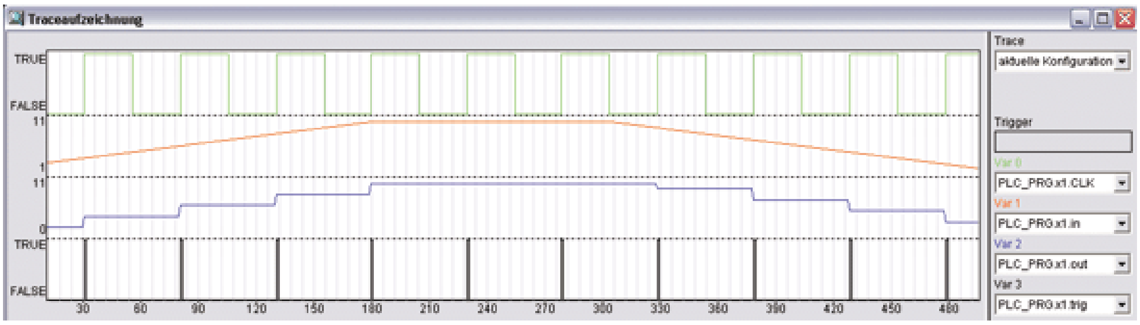


4.7.0.34 SH

Type	Function module
Input IN	REAL (input signal)
CLK	BOOL (clock input)
Output OUT_MAX	REAL (upper output limit)
TRIG	BOOL (Trigger Output)
	SH is a Sample and Hold module. It saves on each rising edge of CLK, the input signal IN at the output OUT. After each update of TRIG OUT is TRUE for one cycle.
The following Example explains the function of SH	



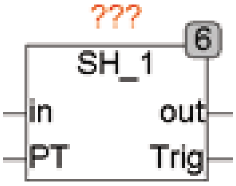


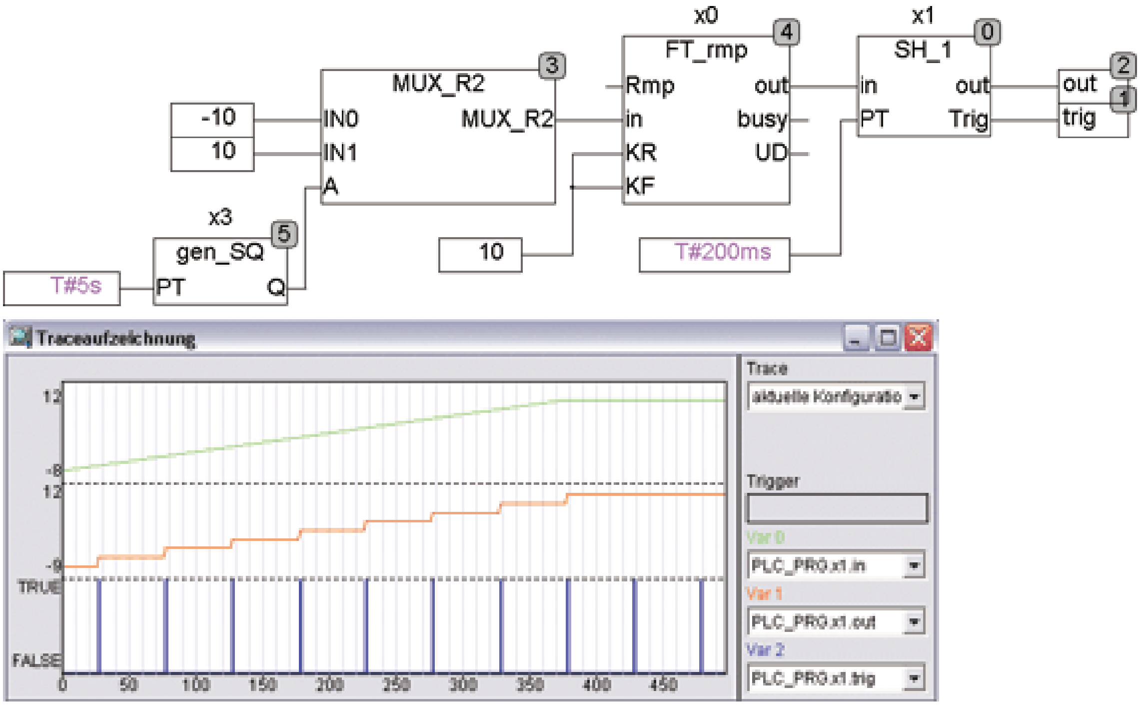


4.7.0.35 SH_1

Type	Function module
Input IN	REAL (input signal)
PT	TIME (sampling time)
Output OUT_MAX	REAL (upper output limit)
TRIG	BOOL (Trigger Output)

	SH_1 is a Sample and Hold module with adjustable sampling time. It stores all the PT, the input signal IN at the output OUT. After each update of OUT, TRIG remains TRUE for one cycle.
The following Example illustrates how SH_1 works	

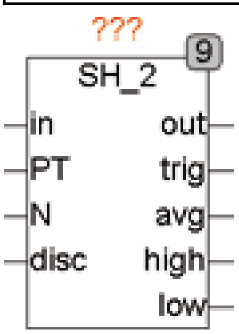


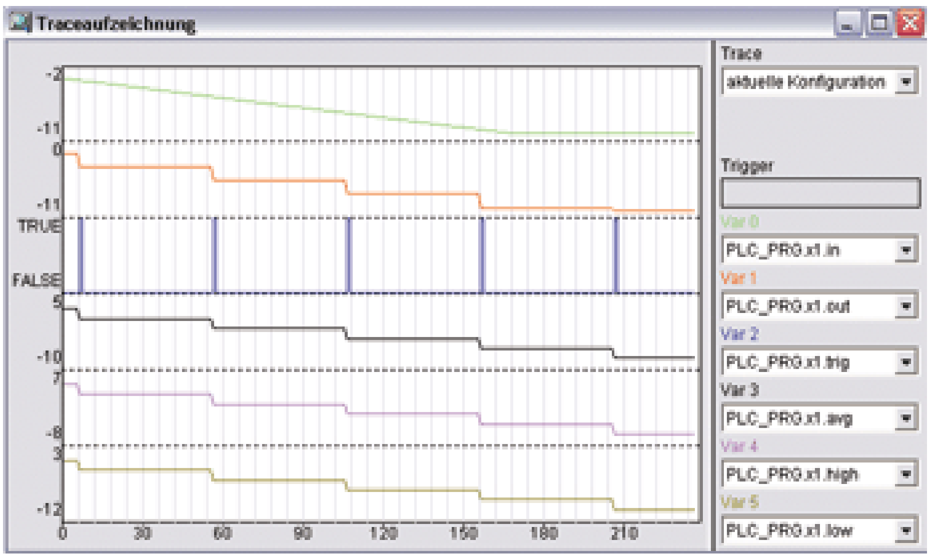


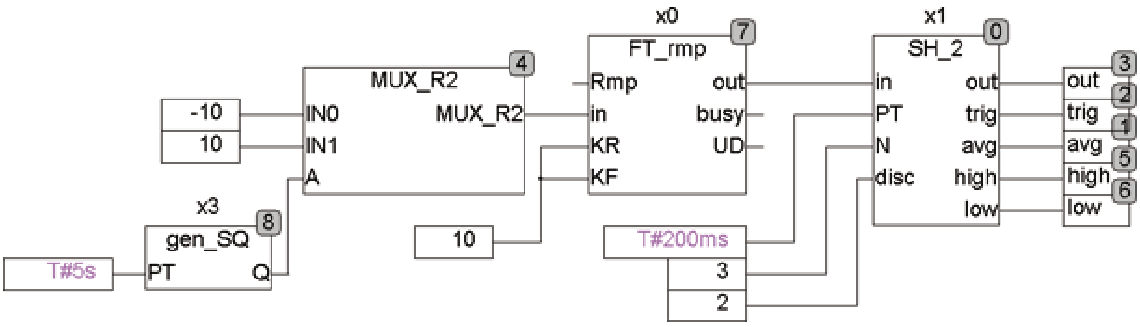
4.7.0.36 SH_2

Type	Function module
Input IN	REAL (input signal)
PT	TIME (sampling time)
N	INT (number of Samples of Statistics)
DISC	INT (discard DISC values)
Output OUT_MAX	REAL (upper output limit)
TRIG	BOOL (Trigger Output)
AVG	REAL (average)
HIGH	REAL (maximum)
LOW	REAL (minimum)
	SH_2 is a Sample and Hold module with adjustable sampling time. It stores all the PT, the

	input signal IN at the output OUT. After each update of OUT, TRIG remains TRUE for one cycle. In addition to the function of a Sample and Hold module SH_2 already offers integrated functionality with respect to the statistics. With the input of N can be specified on how many Samples (16 maximum), a average, minimum and maximum value can be formed. As a further feature, from N Samples smallest and largest values can be ignored for statistics, which can be very useful to ignore extremes. The input value DISC = 0 means use all Samples , a 1 means ignore the lowest value, 2 means ignore the lowest and highest value etc. For example, if N = 5 and DISC = 2, then 5 Samples are collected, the lowest and highest value are discarded and on the remaining 3 Samples the average, minimum and maximum value is formed.
The following example illustrates how SH_2 works	

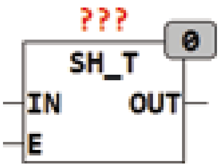


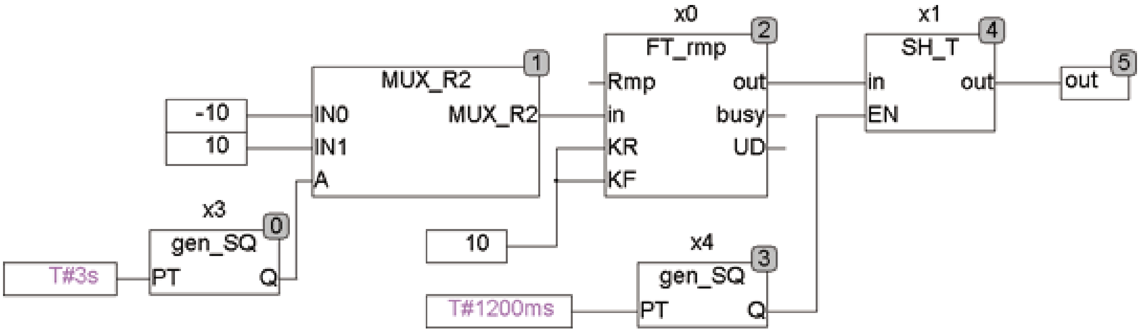


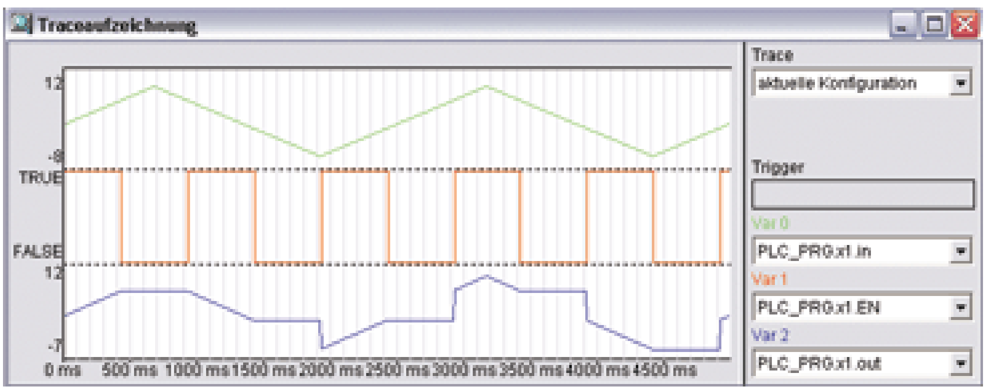


4.7.0.37 SH_T

Type	Function module
Input IN	REAL (input signal)
E	BOOL (enable Signal)
Output OUT_MAX	REAL (upper output limit)
	SH_T is a transparent Sample and Hold module. The input signal is provided at the output, as long as E is TRUE. With a falling edge of E, the value stored in the output OUT and will stay here until E return TRUE, and thus is switched back to OUT.
	The following example illustrates the operation of SH_T

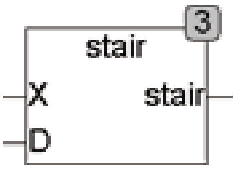


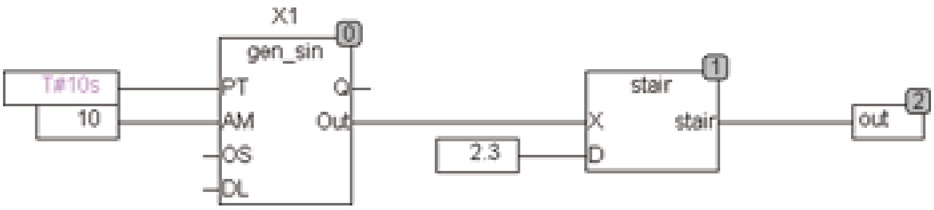


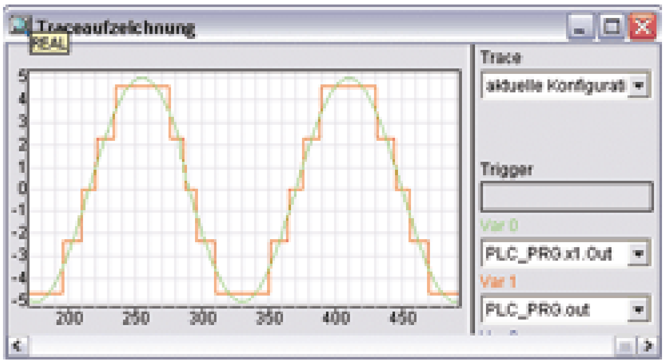


4.7.0.38 Type Function

Input X	REAL (input)
D	REAL (step size of the output signal)
Output	REAL (output)
	The Output of STAIR follows the input signal X with a step function. The height of the steps is given by D. If X = 0, then the output directly follows the input signal. STAIR is not suitable for filtering of input signals, because if the input fluctuates by a step , the output switches between two adjacent values back and forth. For this purpose we recommend the use of Stair2 that works with a Hysteresis and avoids unstable conditions.
The following example illustrates the operation of STAIR	



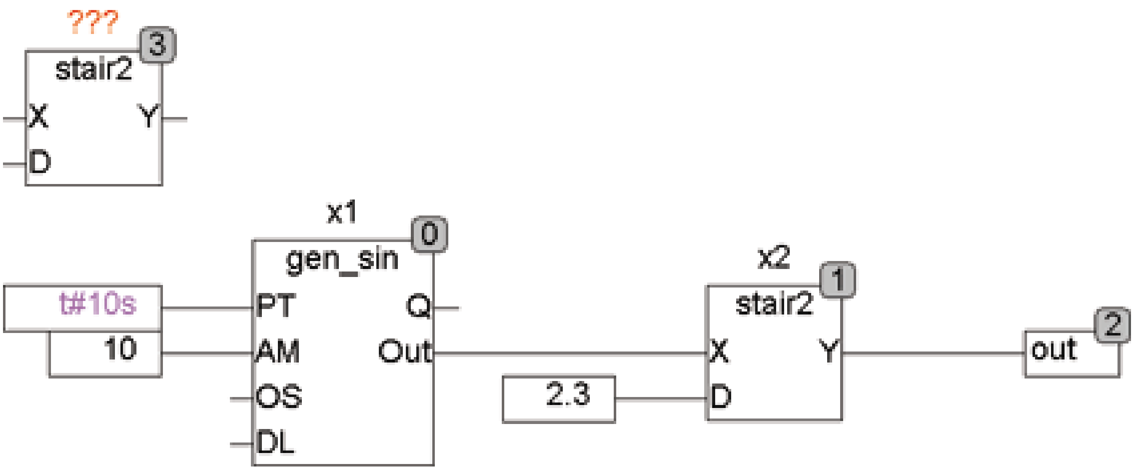


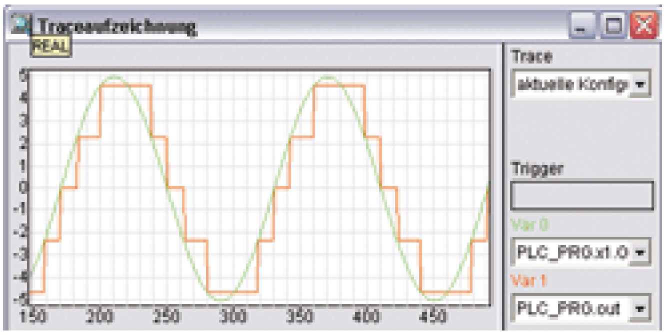


4.7.0.39 STAIR2

Type	Function module
Input X	REAL (input)
D	REAL (step size of the output signal)
Output Y	REAL (output signal)
	The output signal from STAIR2 follows the input signal X with a step function. The height of the steps is given by D. If D = 0, then the output directly follows the input signal. The signal follows the steps but with a hysteresis of D so that a noisy

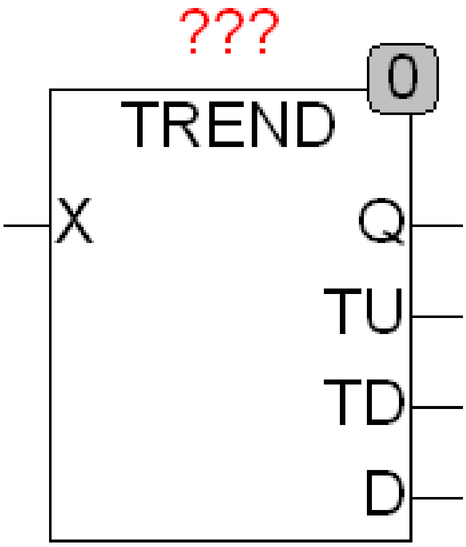
	input signal can not trigger jumps between step values. STAIR2 is also suitable as an input filter.
The following example illustrates the operation of STAIR2	





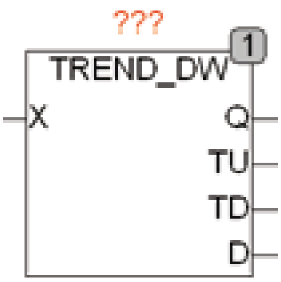
4.7.0.40 TREND

Type	Function module
Input X	REAL (input)
Output Q	BOOL (X ascending = TRUE)
TU	BOOL (TRUE if the input X increases)
TD	BOOL (TRUE if input X reduces)
D	REAL (deltas of the input change)
	TREND monitors the input X and time at the output Q to see if X increases (Q = TRUE) or X decrease (Q = FALSE). If X does not change, Q remains at its last value. If X increases, the output TU gets for one cycle to TRUE and at the output D the result X - LAST_X is displayed. If X is less than LAST_X so TD gets TRUE for one cycle and the output D is LAST_X - X passed. LAST_X is an internal value of the module and is the value of X in the last cycle.



4.7.0.41 Type Function module

Input X	DWORD (input signal)
Output Q	BOOL (X ascending = TRUE)
TU	BOOL (TRUE if the input X increases)
TD	BOOL (TRUE if input X reduces)
D	DWORD (Delta of the input change)
	TREND_DW monitors the input X and time at the output Q to see if X increases (Q = TRUE) or X decrease (Q = FALSE). If X does not change, Q remains at its last value. If X increases, the output TU gets for one cycle to TRUE and at the output D the result X - LAST_X is displayed. If X is less than LAST_X so TD gets TRUE for one cycle and the output D is LAST_X - X passed. LAST_X is an internal value of the module and is the value of X in the last cycle.



5. Introduction

Welcome to the Introduction section of the OSCAT Basic library.

6. Introduction Baustein Template

6.0.1 Conventions

6.0.2 Demo programs

The OSCAT Network Library contains components and functions that deal with the issue of file-handling and ethernet communications, and sometimes require enhanced base knowledge . In order to allow the user easy access are possible, for many theme demo programs are prepared. The demo programs are in network.lib in the folder "DEMO" included. If they are used, the needed programs should be copied to your project and then can be adjusted to your needs. Some modules require the disclosure of its own specific parameters so that they are fully functional. The Codesys and Beckhoff library demo programs are hidden because they would otherwise occupy resources needlessly. BASE64_DEMO CSV_PARSER_BUF_DEMO CSV_PARSER_FILE_DEMO DLOG_FILE_CSV DLOG_FILE_CSV_FTP_DEMO DLOG_FILE_CSV_SMTP_DEMO DLOG_FILE_HTML_DEMO DLOG_FILE_XML_DEMO DLOG_RRD_DEMO DNS_DYN_DEMO DNS_REV_DEMO DNS_SNTP_SYSLOG_DEMO FILE_BLOCK_DEMO FTP_CLIENT_DEMO GET_WAN_IP_DEMO HTTP_DEMO INI_PARSER_BUF_DEMO INI_PARSER_FILE_DEMO IP2GEO_DEMO IRTRANS_DEMO MB_CLIENT_DEMO MB_SERVER_DEMO MD5_CRAM_AUTH_DEMO NET_VAR_MASTER_DEMO NET_VAR_SLAVE_DEMO RC4_CRYPT_DEMO SHA_MD5_DEMO SMTP_CLIENT_DEMO SPIDER_DEMO TELNET_LOG_DEMO TELNET_PRINT_DEMO TN_VISION_DEMO_1 TN_VISION_DEMO_2 YAHOO_WEATHER_DEMO WORLD_WEATHER_DEMO

6.0.3 Disclaimer

The software modules included in the OSCAT library are offered with the intent to serve as a template and guideline for software development for PLC according to IEC61131-3. A functional guarantee is not offered by the programmers and is excluded explicitly. As the software modules included in the library are provided free of charge, no warranty is provided to the extent permitted by law. As far as it is not explicitly arranged in written form, the copyright owners and/ or third parties provide the software modules "as is", without any warranty, explicit or implicit, including, but not limited to; market maturity or usability for a particular purpose. The full risk and full responsibility concerning quality, absence of errors and performance of the software module lie with the user. Should the library, or parts of it, turn out to contain errors, the costs for service, repair and/or correction must be assumed by the user. Should the entire library, or parts of it, be used to create user software, or be applied in software projects, the user is liable for the absence of errors, performance and quality of the application. Liability of OSCAT is explicitly ruled out. The OSCAT library user has to take care, through suitable tests, releases and quality assurance measures, that possible errors in the OSCAT library cannot cause damage. The present license agreements and disclaimers are equally valid for the software library, and the descriptions and explanations given in this manual, even when this is not mentioned explicitly.

6.0.4 Global constants

SETUP	
	SETUP defines general basic settings. The settings are defined in the TYPE definition CONSTANTS_SETUP.
LOCATION	
	LOCATION defines location settings, including but also definitions holiday. The settings are defined in the TYPE definition CONSTANTS_LOCATION.
String_Length	INT: = 250

	String_Length is by default 250 characters, and is used by STRING function to avoid a range overflow when processing STRINGS. STRING_LENGTH shall also determine within the OSCAT LIB the maximum length, which can lead to high memory consumption when heavily used. If in a Application short STRINGS must be processed, the length may be reduced accordingly on these SETUP constant STRING. We recommend to define STRINGS within the application with the aid of this constant. STRINGS, if longer than 80 characters, may need to increase this constant at a value to 255.
New_string	STRING(String_Length).
	WIth this definition the newly defined STRING automatically defines the length of STRING_LENGTH and can be changed globally if needed.
LIST_LENGTH	INT := 250.
	LIST_LENGTH is by default 250 characters and sets the size of lists.

OSCAT The library tries to avoid global variables, an attempt to be easily integrated into other environments. Global variables are not necessary for function and exchange of data between devices. The setup and configuration is fully implemented within the modules to ensure high modularity and portability. For physical and mathematical constants we decided for reasons of clarity to use global constants. MATH : MATH defined mathematical constants. The constants are defined in the TYPE definition CONSTANTS_MATH. PHYS : PHYS defines physical constants. The constants are defined in the TYPE definition CONSTANTS_PHYS. LANGUAGE : LANGUAGE defines language. The settings are defined in the TYPE definition CONSTANTS_LANGUAGE.

6.0.5 Intended Use

The software modules included in the OSCAT library and described in this documentation were exclusively developed for professionals who have had training in PLC. The users are responsible for complying with all applicable standards and regulations which come into effect with the use of the software modules. OSCAT does not refer to these standards or regulations in either the manual or the software itself.

6.0.6 Complex numbers are shown with the defined type COMPLEX.

The type COMPLEX consists of a real part and an imaginary part, both components are of type REAL. The complex number Z of type COMPLEX consists of: *.RE Real part of type REAL. *.IM Imaginary part of the type REAL.

6.0.7 Floating point numbers are stored in the format REAL. A common data format according to IEC754 used a 24 bit wide mantissa and an 8-bit exponent. This results in an accuracy of 7-8 digits. Usually this is for applications in control technology more than sufficient, but in certain cases can lead to a problem. A typical case can which be solved with single-precision only inadequate is a consumption meter. If you want to several Mwh (megawatt hours) of total consumption adding up, taking a smallest power of 1 mW (milliwatt) at a distance of 10ms fairs and so you need a resolution of 3.6 * 10^{7} (equivalent 10MWs) and it would be a do add up 1* 10_{-5} W's. To do this it requires a resolution of 12 digits.

The solution implemented by OSCAT is REAL Double precision and has a resolution of about 15 digits. The implemented data type REAL2 consists of R1 and RX, RX is here the value saved the first 7-8 points as Real and the rest in one real R1. This data type has the advantage that no conversion of REAL2 to REAL is needed, rather, the RX is rather part of single REAL value.

6.0.8 Vectors are mapped to the defined type VEKTOR_3.

The type VEKTOR_3 consists of 3 components X, Y and Z, all components are of type REAL. The vector of type vector V consists of: V.X X component of the type REAL. V.Y Y component of the type REAL. V.Z Z component of the type REAL.

6.0.9 The time and date functions of the library OSCAT depend on the target system implemented so that they take into account the differences in the implementation of date / time types of the individual systems. For example, on the UNIX systems CoDeSys implements the UNIX TIME DATE, which means that the data type TD is mapped in seconds as of 1.1.1970-00:00 as 32-bit value. In STEP7, however, the data type TD in seconds is shown as 1.1.1990. The range of time / date functions in CoDeSys systems 01.01.1970 - 31.12.2099 and in STEP7 systems 01.01.1990 - 31.12.2099. The limitation of the range on the year 2099 is mainly due to the fact that in 2100 will be not a leap year.

Furthermore, the date and time functions are in accordance with the ISO8601 (international standard for numeric date functions). Here, for example, the implementation of the days with 1 = Monday and 7 = Sunday is prescribed.

6.0.10 In the field of process control modules for the construction of controllers and controlled systems are provided. Where possible, the modules measures the cycle time and calculate the output change with the current cycle time. This process has and advantage to a process over a fixed cycle time, that control systems of different speeds can be processed within the same task. Another advantage is the fact that at low priority Tasks the cycle time can vary and a controller with fixed cycle time inaccurate output values generates. The user should ensure with use of the set, that the cycle time of the task is in accordance with the requirements of the process.

Overview of the control circuit elements: Wind-Up: The wind- Up effect effects all controllers with I component. Thus real controller have a restricted control area the Integrator would always grow, reaching large control differences and output limits. If after some time the process value exceeds the nominal value would have to wait until the Integrator reduces its high value. This is an undesirable and inappropriate behavior of the controller. The controller would suspend for the time of Integrator required to reduce its high value, which would, the longer the longer the controller is in the limitation. Therefore at regulators with I-share anti wind-up measures are necessary. The simplest measure to prevent the wind Up is the integrator to reach a Limits to stop and return to work until the area with the last value of the Integrator continue working. This method has the disadvantage that changes in the control deviation during the output is limited, continues to perform in unnecessarily high values of the integrator. Modules in the library are working with the procedure marked with a W at the end. A sophisticated anti- Wind-Up Measure is a process that the output value of the integrator limits to a value and together with the other control rules exactly leads to the output limit. This method has the advantage that at entering the work area the controller can be operational immediately and can respond without time delay. Modules in the library working with this better method are marked with a WL at the end.

TYPE	Name	Parameter	Transfer function	Calculation
P	Proportional element	KP	KP	Y = X * KP
I	Integrator	KI		Y = Ya + X * KI * ΔT
D	Differentiator	KD		Y = KD * ΔX / ΔT

PT1	1st order low pass	T1	KP / (1 + T1s)	
PT2	2nd order low pass	T1, T2		
PI	PI element	KP, KI	KP (1 + 1/TNs)	Y = Ya + KP ((1 + ΔT/ TN)X - Xa)
PD	PD-element	KP, KD	KP (1 + TDs)	
PDT1	PD element, delayed	KP, TV, T1	KP (1 + TVs/(1+T1s))	
PID	PID-element	KP, TN, TV	KP (1 + 1/TNs + TVs	
PIDT1	PID element delayed	KP, TN, TV, T1	KP (1 + 1/TNs + TVs/ (1+T1s))	

6.0.11 The following modules are designed and harmonized to each other that a modular structure of a shutter controller can be reached. This modular system allows quick and easy setup from simple to complex blind controllers which are aligned to the application. The system can also be expanded at any later time, allowing any expansion of the functions. Applications include all types of blinds, shutters, and all types of shading devices. The modules are designed so they can be easily connected in series and the order of the wiring at the same time determines the priority of the functions. The signals UP and DN for manual operation, and the guidelines for angle and position in the automatic mode (PI and AI) are passed from module to this module, which ensures a simple signal path and a clear structure. A special feature is that the signals UP and DN if both are true simultaneously switch to automatic mode.

All modules have the inputs UP and DN with which the manual upd and down command is received and by QU and QD is passed on to the next module. If both inputs UP and DN set to TRUE then the relevant modules switch to automatic mode and evaluate the inputs PI and AI (position and angle) for input from the blind. If both inputs UP and DN set to TRUE then the relevant modules switch to automatic mode and evaluate the inputs AI and PI (position and angle for input from the blind. By order of the modules also the priority of the individual functions are determined and can easily changed by users . Future or custom features can be turned on in this way quickly and easily into the existing modules without having to modify the existing programming. The STATUS output passes ESR compliant messages about the state of the module. When there are no messages available each module passes the input adjacent S_IN status messages on to the STATUS output. Summary of the Blind status messages:

STATUS	Module	Description
111	SECURITY	Safe position in case of fire
112	SECURITY	Security position at wind
113	SECURITY	Safety position at ALARM
114	SECURITY	Door contact safety position
115	SECURITY	Security position in the rain
1	ACTUATOR	Error UP and DOWN simultaneously
120	ACTUATOR	Up motion
121	ACTUATOR	down motion
121	CONTROL	Up moving position

122	CONTROL	Down moving position
123	CONTROL	UP moving angle
124	CONTROL	Down moving angle
121	CONTROL_S	Up motion
122	CONTROL_S	down motion
123	CONTROL_S	Auto positioning
127	CONTROL_S	Lockout Time
128	CONTROL_S	Calibration
129	CONTROL_S	Extend mode
130	INPUT	Standby
131	INPUT	Manual Timeout
132	INPUT	Manual Up
133	INPUT	Manual Down
134	INPUT	SingleClick up
135	INPUT	SingleClick Down
136	INPUT	Forced position
137	INPUT	Double click 1
138	INPUT	Double click 2
141	NIGHT	Night position active
Night position active	SHADE	Active shading
160-175	SCENE	active scene
178	SET	Set operation
179	SET	Restore operation

6.0.12 Introduction

The lists described here are stored lists STRING (LIST_LENGTH), the elements of the list begin with the sign SEP followed by the element. The elements can contain all Strings allowable characters, and can also be an empty string. An empty list is represented by the string '', the string contains no elements. The length of a list is defined by the is the number of items in the list, an empty list has lengths 0. The functions for processing lists uses I/O variables, so that the long lists must note be copied at every function call into the memory. The separation character SEP of the lists can be freely determined by the user and is passed to the functions at the input SEP. The separation character is always only a single character and can be any valid character in a string. In the following examples '§' is used as the separation character. Empty list: '' List with an empty element: '§' List of 2 items '§1§NIX' List with 6 elements one of which is empty '§1§§33§/§1§2'

6.0.13 License Terms

The use of the OSCAT library is free of charge and it can be utilized for private or business purposes. Distribution of the library is expressly encouraged; however, this has to be free of charge and contain a reference to our webpage WWW.OSCAT.DE. If the library is offered in electronic form for download or distributed on data carriers, it has to be ensured that a clearly visible reference to OSCAT and a link to WWW.OSCAT.DE are included accordingly.

6.0.14 Other

All legally binding regulations can be found solely in chapter 1 of the user manual. Deduction or acquisition of legal claims based on the content of the manual, apart from the provisions stipulated in chapter 1, is completely ruled out.

6.0.15 OSCAT is for “ Open Source Community for Automation Technology “.

OSCAT created a Open Source Library referenced to the IEC61131-3 standard, which can be dispensed with vendor-specific functions and therefore ported to all IEC61131-3-compatible programmable logic controllers. Although trends for PLC in the use of vendor-specific libraries are usually solved efficiently and these libraries are also provided in part free of charge, there are still major disadvantages of using it:

6.0.16 Registered trademarks

All the trademarks used in this description are applied without reference to their registration or owner. The existence of such rights can therefore not be ruled out. The used trademarks are the property of their respective owners. Therefore, commercial use of the description, or excerpts of it, is not permitted.

6.0.17 Releases

This manual is updated by OSCAT continuously. It is recommended to download the latest version of the OSCAT manual under WWW.OSCAT.DE . Here the most current Manual is available for download. In addition to the Manual OSCAT prepared a detailed revision history. The OSCAT revisionhistory lists all revisions of individual modules, with amendments and at what release the library of this component is included.

6.0.18 Support

Support is given by the users in the forum WWW.OSCAT.DE. A claim for support does not exists, even if the library or parts of the library are faulty. The support in the forum under the OSCAT is provided for users voluntarily and with each other. Updates to the library and documentation are usually made available once a month on the home page of OSCAT under WWW.OSCAT.DE. A claim for maintenance, troubleshooting and software maintenance of any kind is generally not existing from OSCAT. Please do not send support requests by email to OSCAT. Requests can be processed faster and more effectively when the inquiries are made in our forum.

6.0.19 Test environment

The OSCAT library is designed with CoDeSys and tested on different systems. The test environment consists of the following systems: We are constantly striving OSCAT the library to also test in other test environments.

7. List Processing

This section contains 16 modules.

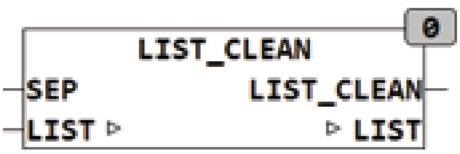
7.0.1 LIST_ADD

Type Function	BOOL
Input SEP	BYTE (separation sign the list)
INS	STRING (New Item)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	BOOL (TRUE)
	LIST_ADD adds another element to the end of a list. The list consists of Strings (elements) that begin with the separation character SEP.

Example:
`LIST_ADD('&ABC&23&&NEXT', 38, 'NEW') = '&ABC&23&&NEXT&NEW'`

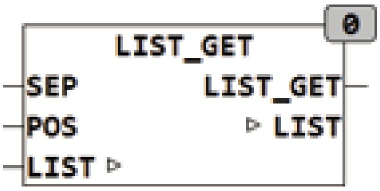
7.0.2 LIST_CLEAN

Type Function	BOOL
Input SEP	BYTE (separation sign the list)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	BOOL (TRUE)
	LIST_CLEAN cleans a list of empty elements. The list consists of Strings (elements) that begin with the separation character SEP.
	LIST_CLEAN('&ABC$23&&NEXT', 38) = '&ABC&23&NEXT'
	LIST_CLEAN('&&23&&NEXT&', 38) = '&23&NEXT'
	LIST_CLEAN('&&&&', 38) = ''



7.0.3 LIST_GET

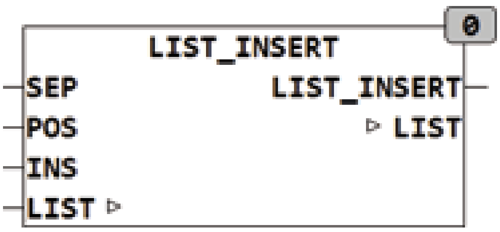
Type Function	STRING(LIST_LENGTH)
Input SEP	BYTE (separation sign the list)
POS	INT (position of list element)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	STRING (String output)
	LIST_GET delivers the item at the position POS from a list. The list consists of Strings (elements) that begin with the separation character SEP. The first element of the list has the position 1.



Example:
```
LIST_GET('&ABC&23&&NEXT', 38, 1) = 'ABC' LIST_GET('&ABC&23&&NEXT', 38, 2) = '23'
LIST_GET('&ABC&23&&NEXT', 38, 3) = '' LIST_GET('&ABC&23&&NEXT', 38, 4) = 'NEXT'
LIST_GET('&ABC&23&&NEXT', 38, 5) = '' LIST_GET('&ABC&23&&NEXT', 38, 0) = ''
```

7.0.4 LIST_INSERT

Type Function	BOOL
Input SEP	BYTE (separation sign the list)
POS	INT (position of list element)
INS	STRING (New Item)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	BOOL (TRUE)
	LIST_INSERT puts an element at the position POS in a list. The list consists of Strings (elements) that begin with the separation character SEP. The first element of the list is at position 1. If a position greater than the last element of the list is given, empty elements are added to the list until INS is at its normal position at the end of the list. If POS = 0, the new element will be placed to the top of the list.



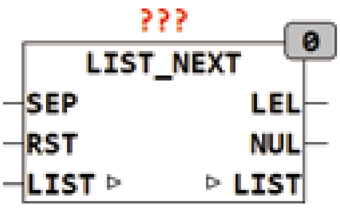
Example:
```
LIST_INSERT('&ABC&23&&NEXT',38,0,'NEW')= '&NEW&ABC&23&&NEXT'
LIST_INSERT('&ABC&23&&NEXT',38,1,'NEW')= '&NEW&ABC&23&&NEXT'
LIST_INSERT('&ABC&23&&NEXT',38,3,'NEW')= '&ABC&23&NEW&&NEXT'
LIST_INSERT('&ABC&23&&NEXT',38,6,'NEW')= '&ABC&23&&NEXT&&NEW'
```

7.0.5 LIST_LEN

Type Function	INT
Input SEP	BYTE (separation sign the list)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	INT (number of items in the list)
	LIST_LEN determines the number of items in a list.
	LIST_LEN('&0&1&2&3', 38) = 4
	LIST_LEN('',21) = 0

7.0.6 LIST_NEXT

Type Function	STRING
Input SEP	BYTE (separation sign the list)
RST	BOOL (Asynchronous Reset)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output LEL	STRING(LIST_LENGTH) (list item)
NUL	BOOL (TRUE if list is executed or empty)
	LIST_NEXT always delivers the next item from a list. The list is a STRING whose elements are separated with the character SEP. The first element of the list has the position 1. After the first call to LIST_NEXT or a reset, at output LEL the first element of the list is passed. For each subsequent call the module returns the next element of the list. When the end of the list is reached, an empty string Issued and set the output NUL = TRUE. With the command RST = TRUE, the list can be edited again and again.



Example:

Example of application: FUNCTION_BLOCK testll VAR_INPUT s1 : STRING(255); END_VAR VAR Element: array [0..20] OF STRING(LIST_LENGTH) ; list_n : LIST_NEXT; pos : INT; END_VAR pos := 0; list_n(LIST := s1, SEP := 44); WHILE NOT list_n.NUL and pos <= 20 DO element[pos] := list_n.LEL; list_n(list := s1); pos := pos + 1; END_WHILE;

7.0.7 LIST_RETRIEVE

Type Function	STRING

Input SEP	BYTE (separation sign the list)
POS	INT (position of list element)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	STRING(LIST_LENGTH) (string output)
	LIST_RETRIEVE passes the item at the position POS from a list and deletes the corresponding item in the list. The list consists of Strings (elements) that begin with the separation character SEP. The first element of the list is at position 1. The function returns an empty string if no element is at the position POS.

Example:

```
Example : LIST_RETRIEVE('&ABC&23&&NX&, 38, 1) = 'ABC'   LIST = '&23&&NX&'
LIST_RETRIEVE('&ABC&23&&NX', 38, 2) = '23'    LIST = '&ABC&&NX'
LIST_RETRIEVE('&ABC&23&&NX', 38, 3) = ''  LIST = '&ABC&23&NX'
LIST_RETRIEVE('&ABC&23&&NX', 38, 4) = 'NEXT'    LIST = '&ABC&23&'
LIST_RETRIEVE('&ABC&23&&NX', 38, 5) = ''  LIST = '&ABC&23&&NX'
LIST_RETRIEVE('&ABC&23&&NX', 38, 0) = ''   LIST = '&ABC&23&&NX'
```

7.0.8 LIST_RETRIEVE_LAST

Type Function	STRING(LIST_LENGTH)
Input SEP	BYTE (separation sign the list)
I / O LIST	STRING(LIST_LENGTH) (input list)
Output	STRING(LIST_LENGTH) (string output)
	LIST_RETRIEVE_LAST passes the last item from a list and deletes the corresponding item in the list. The list consists of Strings (elements) that begin with the separation character SEP.

8. Logic

8.0.1 CRC_CHECK

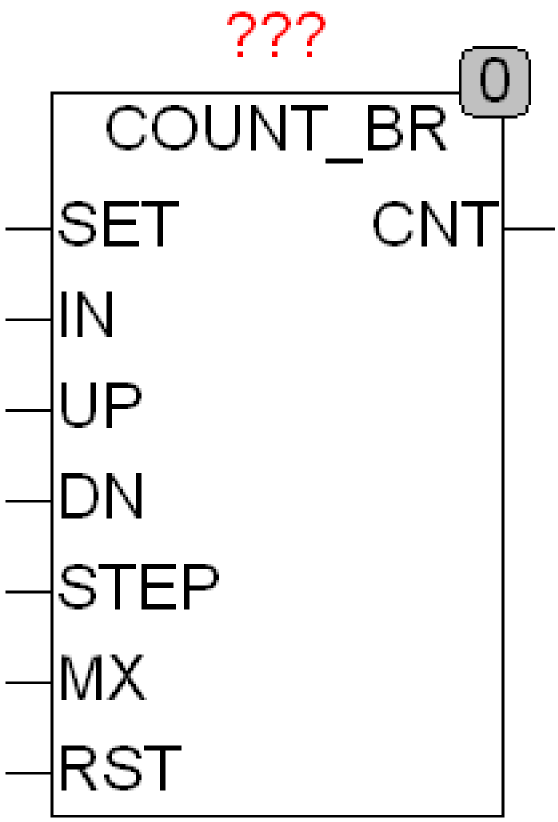
The module CRC_CHECK was removed from the library because the functionality can be fulfilled in their entirety, with the module CRC_GEN. Usually CRC_GEN generates a checksum which is is appended to the original message . If we now build again the checksum of the message with an attached checksum then the new checksum 0. With some specific CRC's where this is not the case, the checksum will be created once again after receive of a message. The checksum is build about all the transferred databytes without checksum and then is compared with the transmitted checksum.

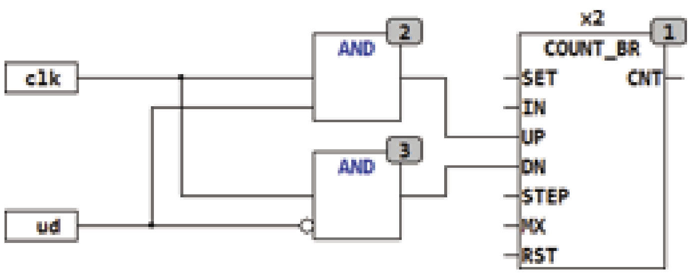
8.1 Logic / FF edge triggered

This section contains 26 modules.

8.1.0.1 COUNT_BR

Type	Function module
Input SET	BOOL (Asynchronous Set)
IN	BYTE (default value for set)
UP	BOOL (forward switch edge-triggered)
DN	BOOL (reverse switch edge-triggered)
STEP	BYTE (increment of Counters)
MX	BYTE (maximum value of the Counters)
RST	BOOL (asynchronous reset)
Output CNT	BYTE (output)
	COUNT_BR is a byte count from 0 to MX and starts again at 0. The counter can, using two edge-triggered inputs UP and DN, both forward and backward counting. when reaching a final value 0 or MX it counts again at 0 or MX. The STEP input sets the increment value of the counter. With a TRUE at input SET the counter is set to present value at the IN input. A reset input RST resets the counter at any time to 0.
If the independent inputs UP and DN with CLK and a control input UP/DN should be replaced, id can be done using two AND gates at the inputs	
	COUNT_BR may work with individual step width at UP or Down command, it is important to note that the counter behaves as if it internally counts the number of STEP steps forward or backward.





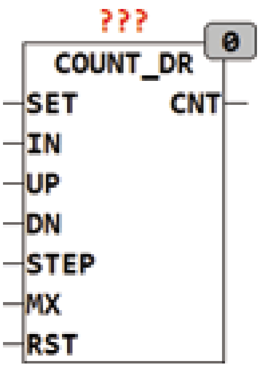
Example:

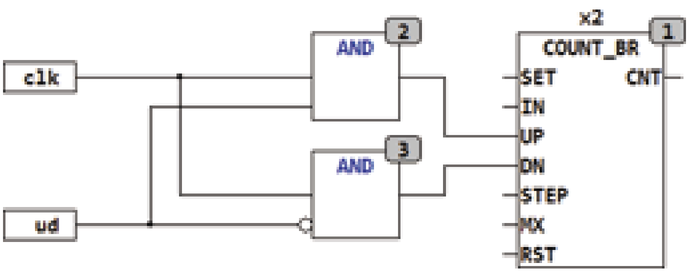
Example: MX = 50, STEP = 10 The counter will work as follows: 0,10,20,30,40,50,9,19 ,...... Is 50 achieved in this example, it is recognized as a maximum value and it continues counting from 0. Internally, it looks like this: 50,0,1,2,3,4,5,6,7,8,9 exactly 50 + 10 if after 50 the 0 comes back. The implementation of a counter 0 .. 50 in increments of ten is as follows: MX = 59, STEP = 10 results in 0,10 ...50,0,10 the transition from 50 to 0 is then exactly 10 steps.

	SET	IN	UP	DN	STEP	RST	CNT
Reset	-	-	-	-	-	1	0
Set	1	N	-	-	-	0	N
up	0	-	↑	0	N	0	CNT + N
down	0	-	0	↑	N	0	CNT - N

8.1.0.2 COUNT_DR

Type	Function module
Input SET	BOOL (Asynchronous Set)
IN	DWORD (default value for set)
UP	BOOL (forward switch edge-triggered)
DN	BOOL (reverse switch edge-triggered)
STEP	DWORD (increment of Counters)
MX	DWORD (maximum value of the Counters)
RST	BOOL (asynchronous reset)
Output CNT	DWORD (output)
	COUNT_DR is a DWORD (32-bit) counter with counts from 0 to MX and then begins again at 0. The counter can, using two edge-triggered inputs UP and DN, both forward and backward counting. when reaching a final value 0 or MX it counts again at 0 or MX. The STEP input sets the increment value of the counter. With a TRUE at input SET the counter is set to present value at the IN input. A reset input RST resets the counter at any time to 0.
If the independent inputs UP and DN with CLK and a control input UP/DN should be replaced, id can be done using two AND gates at the inputs	

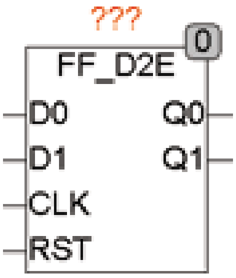




	SET	IN	UP	DN	STEP	RST	CNT
Reset	-	-	-	-	-	1	0
Set	1	N	-	-	-	0	N
up	0	-	↑	0	N	0	CNT + N
down	0	-	0	↑	N	0	CNT - N

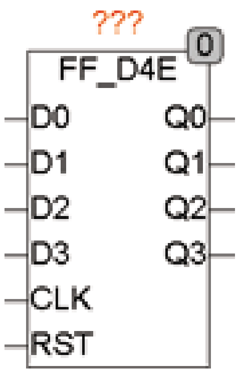
8.1.0.3 Type Function module

Input D0	BOOL (Data 0 in)
D1	BOOL (Data 1 in)
CLK	BOOL (clock input)
RST	BOOL (asynchronous reset)
Output Q0	BOOL (Data 0 out)
Q1	BOOL (Data 1 out)
	FF_D2E is a 2-bit edge-triggered D-Flip-Flop with asynchronous reset input. The D-Flip-Flop stores the values at the input D at a rising edge at the CLK input.
	D1D0CLKRSTQ1Q0



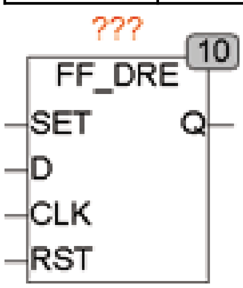
8.1.0.4 Type Function module

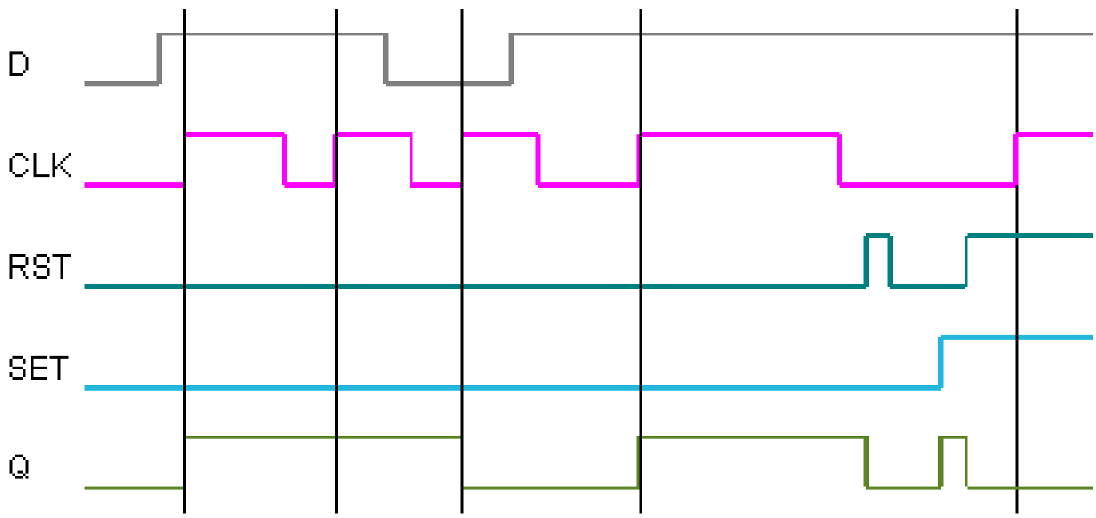
Input D0	BOOL (Data 0 in)
D1	BOOL (Data 1 in)
D2	BOOL (Data 2 in)
D3	BOOL (Data 3 in)
CLK	BOOL (clock input)
RST	BOOL (asynchronous reset)
Output Q0	BOOL (Data 0 Out)
Q1	BOOL (Data 1 Out)
Q2	BOOL (Data 2 Out)
Q3	BOOL (Data 3 Out)
	FF_D2E is a 4-bit edge-triggered D-Flip-Flop with asynchronous reset input. The D-Flip-Flop stores the values at the input D at a rising edge on CLK. Detailed information can be found in the block FF_D2E.



8.1.0.5 Type Function module

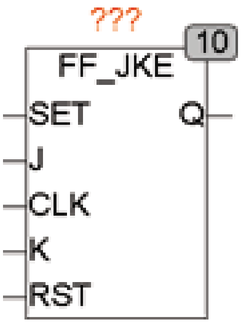
Input SET	BOOL (Asynchronous Set)
D	BOOL (Data in)
CLK	BOOL (clock input)
RST	BOOL (asynchronous reset)
Output Q	BOOL (Data Out)
	FF_DRE is a edge-triggered D-Flip-Flop with Asynchronous Set and Reset input. A rising edge at CLK stores the input D to output Q. A TRUE on the SET or RST input resets or clears the output Q at any time regardless of CLK. The reset input has priority over the input set. If both are active (TRUE) are reset is processed and SET is ignored.





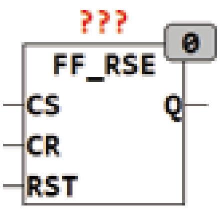
8.1.0.6 Type Function module

Input SET	BOOL (Asynchronous Set)
J	BOOL (clock synchronous Set)
CLK	BOOL (clock input)
K	BOOL (clock synchronous reset)
RST	BOOL (asynchronous reset)
Output Q	BOOL (output)
	FF_JKE is an edge-triggered JK-flop-flop with asynchronous Set and Reset inputs. The JK-Flip-Flop sets the output Q when with a rising edge of the CLK the Input J is TRUE. Q is FALSE when on a rising clock edge the input K is TRUE. If the two inputs J and K on a rising clock edge are TRUE, the output will be negated. It switches the output signal in each cycle.
	DCLKRSTQSET



8.1.0.7 Type Function module

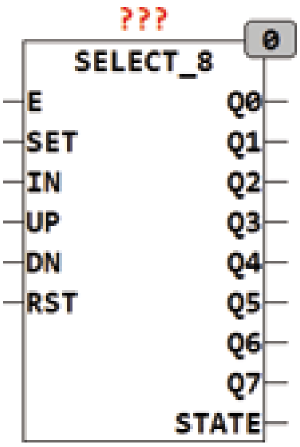
Input CS	BOOL (edge-sensitive Set)
CR	BOOL (edge-sensitive reset)
RST	BOOL (asynchronous reset)
Output Q	BOOL (output)
	FF_RSE an edge-triggered RS flip-flop. The output Q is set by a rising edge of CS and cleared by a rising edge on CR. If both edges (CS and CR) rise at the same time, the output is set to FALSE. An asynchronous reset input RST sets the output at any time to FALSE.



8.1.0.8 Type Function module

Input E	BOOL (Enable for outputs)
SET	BOOL (Asynchronous Set)
IN	BYTE (default value for set)
UP	BOOL (forward switch edge-triggered)

DN	BOOL (reverse switch edge-triggered)
RST	BOOL (asynchronous reset)
Output Q0 .. Q7	BOOL (outputs)
STATE	BYTE (status output)
	SELECT_8 set only one output to TRUE as long as E = TRUE. The active output Q0..Q7 can be selected by the SET input and the value at the input IN. A TRUE at SET and a value of 5 at the input IN set the output Q5 to TRUE while all other outputs are set to FALSE. A TRUE at the input RST set output Q0 to TRUE. With inputs UP is switched from an output Qn to Qn +1, while the input DN switches an output Qn to Qn-1. The input EN must be TRUE so that an output is TRUE, if EN is FALSE, all outputs are FALSE. A FALSE at E does not affected the function of other inputs. Thus, even with a FALSE at input EN can be switched up or down with UP or DN . The inputs UP and DN are edge-triggered and respond to the rising edge. The state output always shows which output is currently selected.

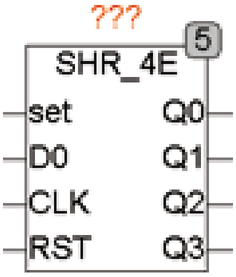


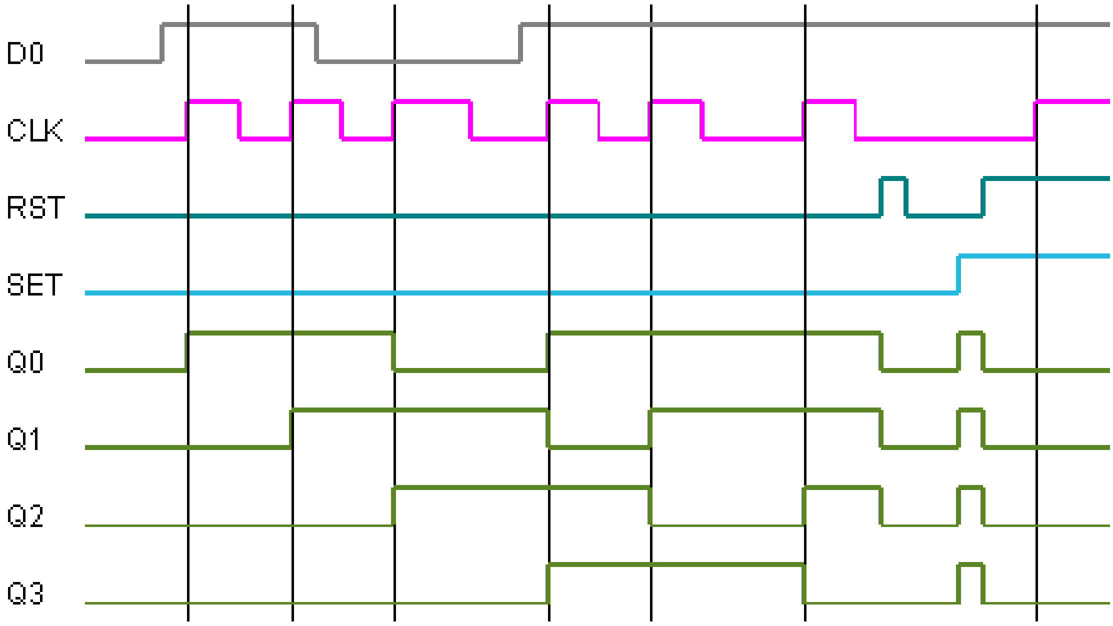
	E	SET	IN	UP	DN	RST	Q	STATE
Reset	X	-	-	-	-	1	Q0 if EN=1	0
Set	X	1	N	-	-	0	QN if EN=1	N
up	X	0	-	↑	0	0	QN+1 if EN=1	N + 1
down	X	0	-	0	↑	0	QN-1 if EN=1	N - 1

8.1.0.9 Type Function module

Input SET	BOOL (Asynchronous Set)
D0	BOOL (Data Input)
CLK	BOOL (clock input)
RST	BOOL (asynchronous reset)
Output Q0	BOOL (Data Out 0)
Q1	BOOL (Data Out 1)
Q1	BOOL (Data Out 1)
Q3	BOOL (Data Out 3)

	SHR_4E is a 4-bit shift register with asynchronous set and reset input. A rising edge at CLK, Q2 is moved to Q3, then moves the Q1 to Q2, Q0 to Q1 and D0 to Q0. With a TRUE on the Set input, all outputs (Q0.. Q3) are set to TRUE and with RST are all set to FALSE.

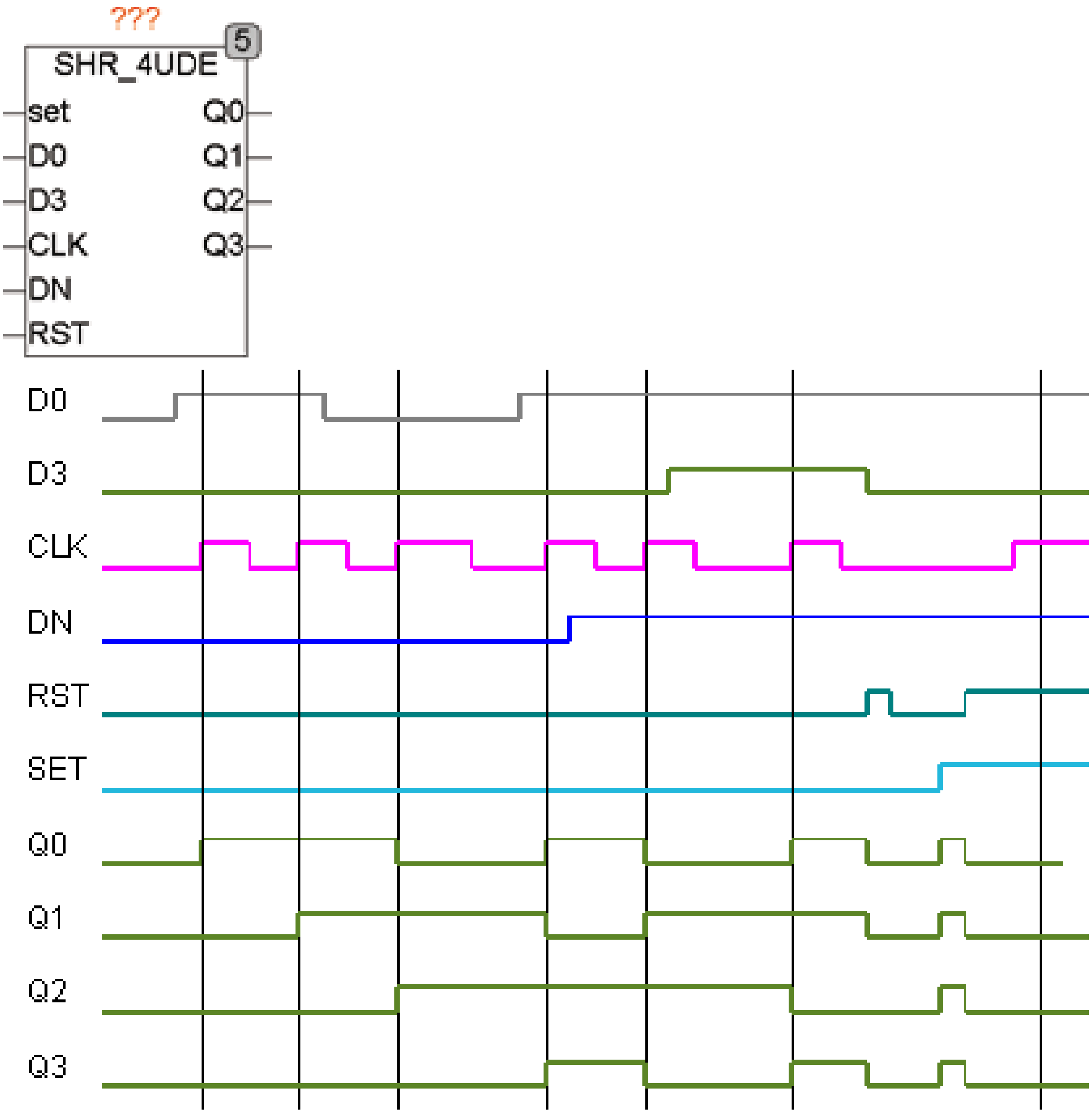




8.1.0.10 Type Function module

Input SET	BOOL (Asynchronous Set)
D0	BOOL (Data Input Bit 0)
D3	BOOL (Data Input Bit 3)
CLK	BOOL (clock input)
DN	BOOL (control input Up / Down TRUE = D own)
RST	BOOL (asynchronous reset)
Output Q0	BOOL (Data Out 0)
Q1	BOOL (Data Out 1)
Q1	BOOL (Data Out 1)
Q3	BOOL (Data Out 3)
	SHR_4UDE is a 4-bit shift register with Up / Down sliding directions. A rising edge at CLK, Q2 is moved to Q3, then moves the Q1 to Q2, Q0 to Q1 and D0 to Q0. The shift direction can be reversed with a TRUE at the input DN, then the D3 is pushed to Q3 - to

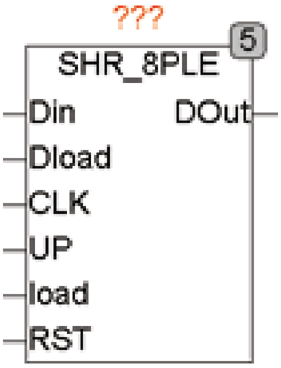
	Q2 - to Q1 - to Q0. With a TRUE on the Set input, all outputs (Q0.. Q3) are set to TRUE and with RST all the inputs are set to FALSE.



8.1.0.11 Type Function module

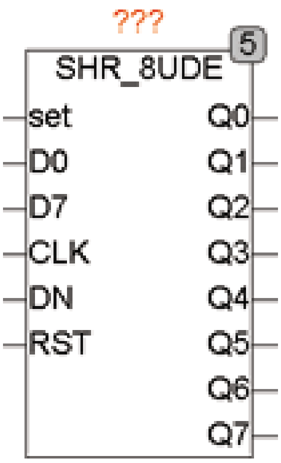
Input DIN	BOOL (Shift Data Input)
Dload	Byte (data word for parallel Load)
CLK	BOOL (clock input)
UP	BOOL (control input Up / Down, TRUE = Up)
LOAD	BOOL (control input for loading the register)
RST	BOOL (asynchronous reset)
Output DOUT	BOOL (Data Out)
	SHR_8PLE is an 8 bit shift register with parallel Load and asynchronous reset. The shift direction can be reversed with the input of UP. When UP = 1, bit 7 is first pushed on DOUT and when UP = 0, bit 0 is first pushed to DOUT. For Up -Shift Bit 0 is

	loaded with DIN and Down - Shift Bit 7 is loaded with DIN. At the input DLOAD one byte of data occures, which with parallel Load (LOAD = 1 and rising edge on CLK) Is loaded into internal registers. In the case of parallel Load is first a shift done and then loaded the register. An RST can always delete the register asynchronously. A detailed description of a shift register, see the module SHR_4E.



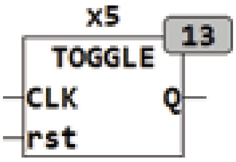
8.1.0.12 Type Function module

Input SET	BOOL (Asynchronous Set)
D0	BOOL (Data Input Bit 0)
D3	BOOL (Data Input Bit 3)
CLK	BOOL (clock input)
DN	BOOL (control input Up / Down, TRUE = Down)
RST	BOOL (asynchronous reset)
Output Q0 .. Q7	BOOL (Data Out)
	SHR_8UDE is an 8 bit shift register with Up /Down sliding direction. A rising edge at CLK, the data Q0 are be pushed to Q7 one step. Q0 is then loaded with D0. The shift direction can be reversed with a TRUE at the input DN. Then D7 is pushed to Q6, Q5, Q4, Q3, Q2, Q1, Q0 and Q7 is loaded with D7. With a TRUE on the Set input, all outputs (Q0.. Q3) set to TRUE and RST all outputs are set to FALSE. Further explanation of shift registers, see SHR_4E and especially at the module SHR_4UDE, which has the same function for 4 bits as SHR_8UDE for 8 bits.



8.1.0.13 TOGGLE

Type	Function module
Input CLK	BOOL (clock input)
RST	BOOL (asynchronous reset)
Output Q	BOOL (output)
	TOGGLE is a edge-triggered Toggle Flip -Flop with asynchronous reset input. The TOGGLE Flip Flop invertes output Q on a rising edge of CLK. The output changes on each rising edge of CLK his condition.

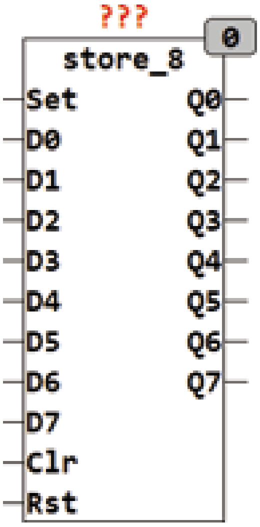


8.2 Logic / FF pulse triggered

This section contains 2 modules.

8.2.0.1 Type Function module

Input SET	BOOL (Asynchronous Set)
D0..D7	BOOL (Data Input Bit 0..7)
CLR	BOOL (gradual reset input)
RST	BOOL (Asynchronous set input)
Output Q0..Q7	BOOL (event outputs)
	STORE_8 is an 8-event memory. A TRUE one of the inputs D0..D7 sets the corresponding output Q0 .. Q7. The asynchronous set and reset inputs (SET, RST) set all outputs simultaneously to TRUE or FALSE. IF during a reset one of the inputs TRUE after the reset, the corresponding output is immediately set to TRUE. If edge-triggered inputs are required, use TP_R modules before of the module STRORE_8. This allows the user to use both edge triggered as well as condition-triggered inputs simultaneously. Input CLR clears with a rising edge on CLR only one event, beginning with the highest priority output that is just TRUE. If with CLR a output Q has cleared which input Q is TRUE, so the output D will be set to TRUE at the next cycle.



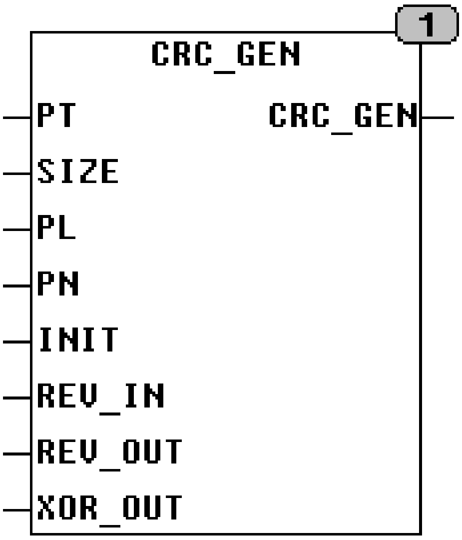
8.3 Logic / Others

This section contains 6 modules.

8.3.0.1 CRC_GEN

Type Function	DWORD
Input PT	POINTER TO ARRAY OF BYTE (data package)
SIZE	UINT (size of the Arrays)
Output	DWORD (calculated CRC checksum)
CRC_GEN generates a CRC check sum of an arbitrarily large array of Bytes. When the function is called a Pointer is passed on the processed array and its size in bytes. In CoDeSys the call reads	CRC_GEN(ADR(array), SIZEOF(Array),...), where array is the name of the processed array. ADR is a standard function, the Pointer the array is determined and SIZEOF is a standard function, which determines the size of the array. The polynomial can be any polynomials up to a maximum of 32 bits in length. A polynomial $X^3 + X^2 + 1$ is represented by 101 ($1X^3 + 1X^2 + 0+X^1 + 1X^0$). *The most significant bit, in this case 1*X^3 is not specified in the polynomial, because it is always one. It can process up polynomials to X^{32} (CRC 32). By the value INIT, the CR can be passed a starting value. Usually are here are 0000 and FFFF. The appropriate start value is the standard in the literature, “Direct Initial Value”. The input XOR_OUT determines with which bit sequence with the checksum at the end of XOR is associated with. The inputs and REV_IN REV_OUT set the bit sequence of data. If REV_IN = TRUE, each byte with LSB beginning is processed, if REV_IN = FALSE with MSB is started. REV_OUT = TRUE turns the bit corresponding sequence to the checksum. The module requires a minimum length of the processed data of 4 bytes, and is limited up only by the maximum array size.

	The CRC further down in the following table provides detailed information on common CRC's and the setup data for CRC_GEN. Due to the number of possible and even common CRC's, it is not possible for us to show a complete list.
For further research, the website http	//regregex.bbcmicro.net/crc-catalogue.htm is recommended.
Online test calculations are possible for the following Java Tool	http://zorc.breitbandkatze.de/crc.html
Common CRC'S AND polynomials	
Setup PL	UINT (length of the polynomial)
PN	DWORD (polynomial)
INIT	DWORD (INIT data)
REV_IN	BOOL (input data bytes invert)
REV_OUT	BOOL (invert output data)
XOR_OUT	DWORD (Last XOR of the output)



CRC	PL	PN [Hex]	INIT [Hex]	REV IN	REV OUT	XOUT [Hex]
CRC-3/ROHC	3	3	7	T	T	0
CRC-4/ITU	4	3	0	T	T	0
CRC-5/EPC	5	9	9	F	F	0
CRC-5/ITU	5	15	0	T	T	0
CRC-5/USB	5	5	1F	T	T	1F
CRC-6/DARC	6	19	0	T	F	0
CRC-6/ITU	6	3	0	T	T	0
CRC-7	7	9	0	F	F	0
CRC-7/ROHC	7	4F	7F	T	T	0

CRC-8	8	7	0	F	F	0
CRC-8/DARC	8	39	0	T	T	0
CRC-8/I-CODE	8	1D	FD	F	F	0
CRC-8/ITU	8	7	0	F	F	55
CRC-8/MAXIM	8	31	0	T	T	0
CRC-8/ROHC	8	7	FF	T	T	0
CRC-8/WCDMA	8	9B	0	T	T	0
CRC-10	10	233	0	F	F	0
CRC-11	11	385	1A	F	F	0
CRC-12/3GPP	12	80F	0	F	T	0
CRC-12/DECT	12	80F	0	F	F	0
CRC-14/DARC	14	805	0	T	T	0
CRC-15	15	4599	0	F	F	0
CRC-16/LHA	16	8005	0	T	T	0
CRC-16/CCITT-AUG	16	1021	1D0F	F	F	0
CRC-16/BUYPASS	16	8005	0	F	F	0
CRC-16/CCITT-FALSE	16	1021	FFFF	F	F	0
CRC-16/DDS	16	8005	800D	F	F	0
CRC-16/DECT-R	16	589	0	F	F	1
CRC-16/DECT-X	16	589	0	F	F	0
CRC-16/DNP	16	3D65	0	T	T	FFFF
CRC-16/EN13757	16	3D65	0	F	F	FFFF
CRC-16/GENIBUS	16	1021	FFFF	F	F	FFFF
CRC-16/MAXIM	16	8005	0	T	T	FFFF
CRC-16/MCRF4XX	16	1021	FFFF	T	T	0
CRC-16/RIELLO	16	1021	B2AA	T	T	0
CRC-16/T10-DIF	16	8BB7	0	F	F	0
CRC-16/TELEDISK	16	A097	0	F	F	0
CRC-16/USB	16	8005	FFFF	T	T	FFFF
CRC-16/CCITT-TRUE	16	1021	0	T	T	0
CRC-16/MODBUS	16	8005	FFFF	T	T	0
CRC-16/X-25	16	1021	FFFF	T	T	FFFF
CRC-16/XMODEM	16	1021	0	F	F	0
CRC-24/OPENPGP	24	864CFB	B704CE	F	F	0
CRC-24/FLEXRAY-A	24	5D6DCB	FEDCBA	F	F	0
CRC-24/FLEXRAY-B	24	5D6DCB	ABCDEF	F	F	0

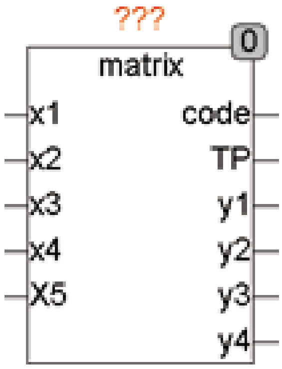
CRC-32/PKZIP	32	04C11DB7	FFFFFFFF	T	T	FFFFFFFF
CRC-32/BZIP2	32	04C11DB7	FFFFFFFF	F	F	FFFFFFFF
CRC-32/CASTAGNOLI	32	1EDC6F41	FFFFFFFF	T	T	FFFFFFFF
CRC-32/D	32	A833982B	FFFFFFFF	T	T	FFFFFFFF
CRC-32/MPEG2	32	04C11DB7	FFFFFFFF	F	F	0
CRC-32/POSIX	32	04C11DB7	0	F	F	FFFFFFFF
CRC-32/Q	32	814141AB	0	F	F	0
CRC-32/JAM	32	04C11DB7	FFFFFFFF	T	T	0
CRC-32/XFER	32	AF	0	F	F	0

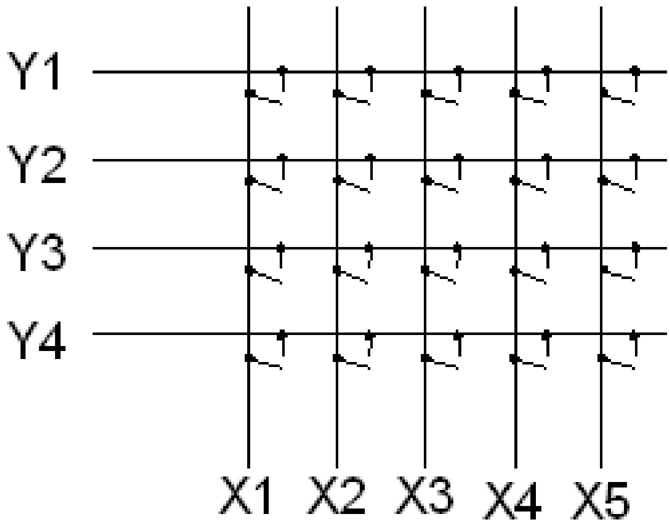
8.3.0.2 MATRIX

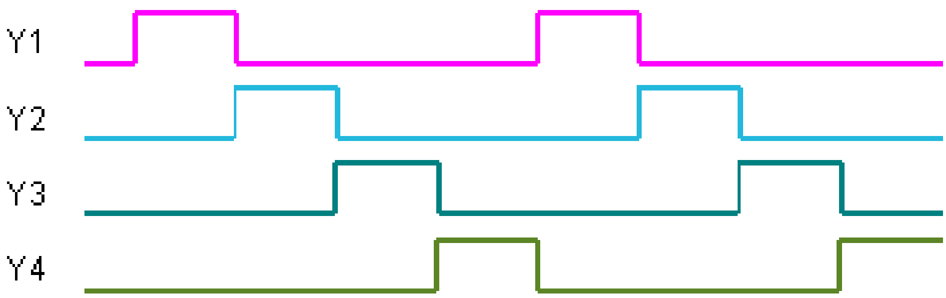
Type	Function module
Input X1 .. X5	BOOL (line inputs)
Output CODE	Byte (output for key code)
TP	BOOL (TP is TRUE for one cycle when a new Key code is present)
Y1 .. Y4	BOOL (line outputs)
MATRIX is a matrix keyboard controller for up to 4 columns and 5 rows. With each PLC cycle on the MATRIX column switch the output further for a column so that the lines Y1 to Y4 are queried one by one. For each column, the row inputs X1 to X5 are queried and if a button is pressed, the corresponding key code is displayed on the output. The output of TP is a cycle set to TRUE if the output CODE indicating a new value. If the setup variable RELEASE is set to TRUE, then for pressing and releasing a button each sent a key code. If RELEASE is set to FALSE, a key code is generated only when a button is a pressed. The key code of the output is as follows	
The matrix controller is wired as follows	
	This simple circuit can analyze up to 20 (4 * 5) keys. However, it should be noted here that only in cases a number of keys can be pressed simultaneously. The controller can handle with this circuit, several buttons in a column in any doubt, but not when keys are pressed simultaneously on different columns. The wiring may be extended by each button is decoupled via diodes, and thus the influence of different columns to one another is prevented. In the circuit with diodes, any number of keys at a time and be evaluated safely. The outputs of the matrix controller continuously scan the rows of the keyboard matrix. On every

	PLC cycle one line is read. If in a row more keys have been pressed or changed, the changes are displayed as codes of the following cycles. The module stores the individual key codes and gives each cycle consisting of only one code so that no code can be lost.

| **The following timing diagram shows the scanning of rows of keys** | | | **Setup RELEASE** | BOOL (a key code when you press and release of a key generated) |





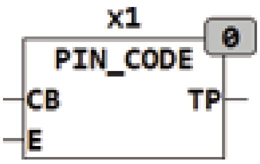


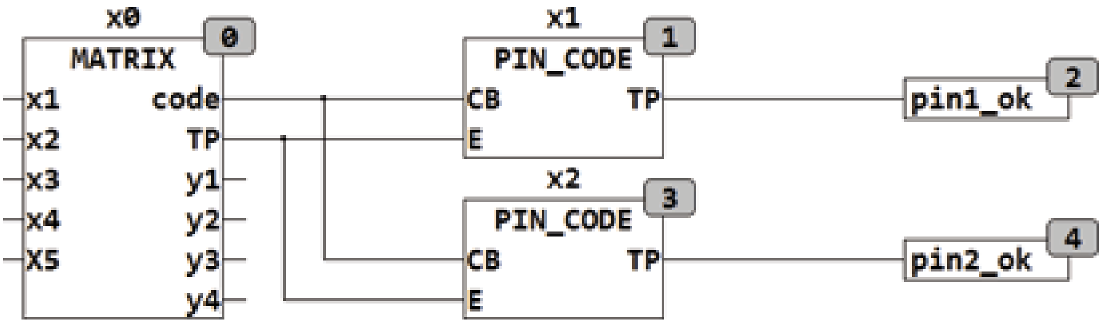
Bit	CODE Output
7	1 when key is pressed, 0 when key is released
6	Line number Bit 2
5	Line number Bit 1
4	Line number Bit 0
3	Always 0

2	Row number Bit 2
1	Row Number Bit 1
0	Row Number Bit 0

8.3.0.3 PIN_CODE

Type	Function module
Input CB	BYTE (input)
E	BOOL (Enable Input)
Output	TP (Trigger Output)
	PIN_CODE checks a stream of bytes for the presence of a specific sequence. If the sequence is found, this is indicated by a TRUE at output TP.
	In the following example, two modules PIN_CODE be used to decode two CODE_SEQUENCES of a matrix keyboard.
SETUP PIN	STRING(8) (String to be tested)



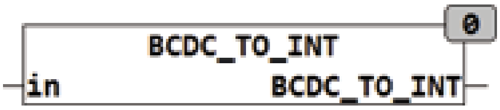


8.4 Logic / gate logic

This section contains 76 modules.

8.4.0.1 Type Function: INT

Input IN	BYTE (BCD coded input)
Output	INT (output value)
	BCDC_TO_INT converts a BCD coded input BYTE in an integer value.

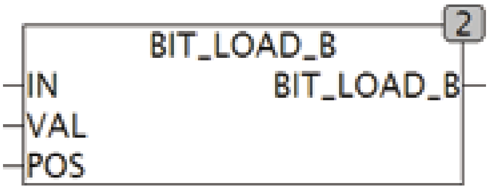


8.4.0.2 Type Function: INT

Input IN	DWORD (input)
Output	INT (number of bits which have value TRUE (1) in IN)
	BIT_COUNT determines the number of bits in IN, which have the value TRUE (1). The input IN is DWORD and can also process the types Byte and Word.

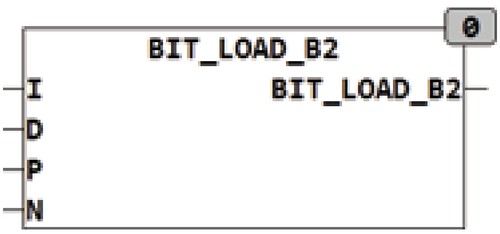
8.4.0.3 Type Function: BYTE

Input IN	BYTE (input)
VAL	BOOL (value of bits to be loaded)
POS	INT (position of the bits to be loaded)
Output	BYTE (output)
	BIT_LOAD_B copies the bit at VAL to the bit in the position N in byte IN. The least significant bit B0 is described by the position 0.



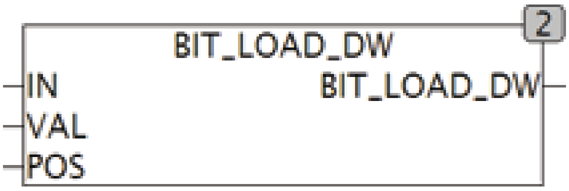
8.4.0.4 Type Function: BYTE

Input I	BYTE (input value)
D	BOOL (value of bits to be loaded)
P	INT (position of the bits to be loaded)
N	INT (number of bits that are loaded from position P)
Output	BYTE (output)
	BIT_LOAD_B2 can set or delete multiple bits in a byte at the same time. The position is indicated with 0 for Bit0 and 7 for Bit7. N specifies how many bits from the specified location can be changed. If N = 0, no bits are changed. If the P and N is specified that the bits to be written goes over the highest bit (bit 7), so it starts again at bit 0.
	BIT_LOAD_B2(2#1111_0000, TRUE, 1, 2) = 2#1111_0110
	BIT_LOAD_B2(2#1111_1111, FALSE, 7, 2) = 2#0111_1110



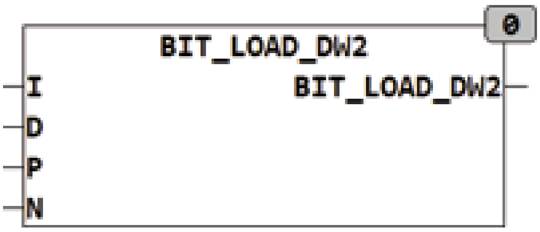
8.4.0.5 Type Function: DWORD

Input IN	DWORD (input)
VAL	BOOL (value of bits to be loaded)
POS	INT (position of the bits to be loaded)
Output	DWORD (output)
	BIT_LOAD_DW copies the VAL bit at the input to the bit in position N in DWORD IN. The least significant bit B0 is described by the position 0.



8.4.0.6 Type Function: DWORD

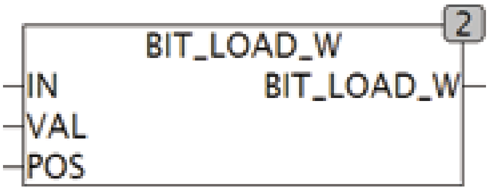
Input I	DWORD (input value)
D	BOOL (value of bits to be loaded)
P	INT (position of the bits to be loaded)
N	INT (number of bits that are loaded from position P)
Output	DWORD (output)
	BIT_LOAD_DW2 can set or delete multiple bits in a byte at the same time. The position is indicated with 0 for Bit0 and 31 for Bit 31. N specifies how many bits from the specified location can be changed. If N = 0, no bits are changed. If P and N is specified that the bits to be written goes over the highest bit (bit 31), so it starts again at bit 0.



Example:
Examples, see BIT_LOAD_B2

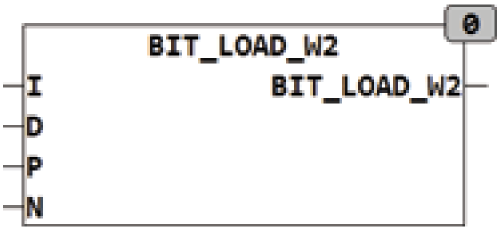
8.4.0.7 Type Function: WORD

Input IN	WORD (input)
VAL	BOOL (value of bits to be loaded)
POS	INT (position of the bits to be loaded)
Output	WORD (output)
	BIT_LOAD_W copies the bit at input VAL to the bit in position N in WORD IN. The least significant bit B0 is described by the position 0.



8.4.0.8 Type Function: WORD

Input I	WORD (input value)
D	BOOL (value of bits to be loaded)
P	INT (position of the bits to be loaded)
N	INT (number of bits that are loaded from position P)
Output	WORD (output)
	BIT_LOAD_W2 can set or delete multiple bits in a WORD at the same time. The position is indicated with 0 for Bit 0 and 15 for Bit 15. N specifies how many bits from the specified location can be changed. If N = 0, no bits are changed. If P and N is specified that the bits to be written goes over the highest bit (bit 15), so it starts again at bit 0.



Example:

Examples, see BIT_LOAD_B2

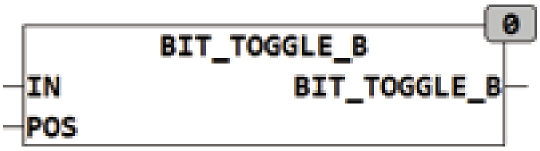
8.4.0.9 Type Function: BOOL

Input IN	DWORD (input)
N	INT (number of bits 0..31)
Output	BOOL (output bit)
	BIT_OF_DWORD extracts a bit of the DWORD at the input IN.
	Bit0 für N=0, Bit1 für N=1 and so on.

8.4.0.10 Type Function: BYTE

Input IN	BYTE (input data)
POS	INT (Position)
Output	BYTE (output byte)

	BIT_TOGGLE_B inverts a specified bit at IN.
	BIT_TOGGLE_W(2#0000_1111, 2) = 2#0000_1011
	BIT_TOGGLE_W(2#0000_1111, 7) = 2#1000_1111



8.4.0.11 Type Function: DWORD

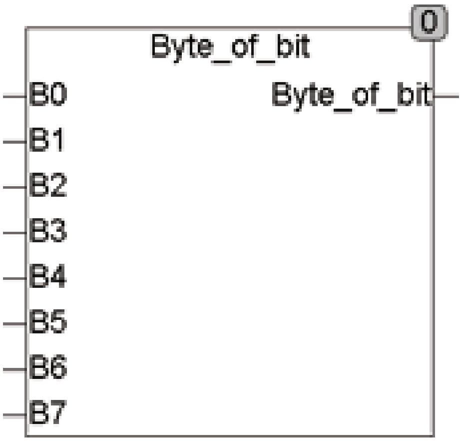
Input IN	DWORD (input data)
POS	INT (Position)
Output	DWORD (output byte)
	BIT_TOGGLE_DW inverts a specified bit at IN.
	BIT_TOGGLE_DW(2#0000_1111, 2) = 2#0000_1011
	BIT_TOGGLE_DW(2#0000_1111, 7) = 2#1000_1111

8.4.0.12 Type Function: WORD

Input IN	WORD (input data)
POS	INT (Position)
Output	WORD (output byte)
	BIT_TOGGLE_W inverts a specified bit POS at IN.
	BIT_TOGGLE_W(2#0000_1111, 2) = 2#0000_1011
	BIT_TOGGLE_W(2#0000_1111, 7) = 2#1000_1111

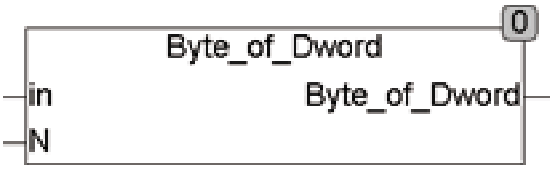
8.4.0.13 Type Function: BYTE

Input B0 .. B7	BOOL (input bits)
Output	BYTE (output byte)
	BYTE_OF_BIT uses one byte of 8 individual bits (B0 .. B7) together.



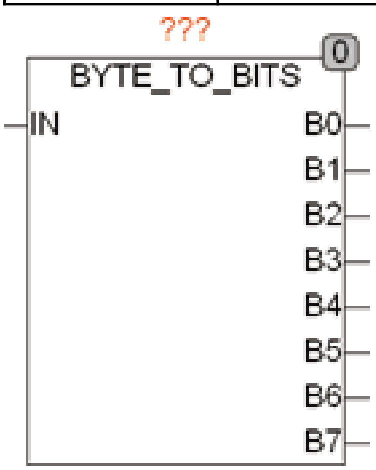
8.4.0.14 Type Function: BYTE

Input IN	DWORD (DWORD input)
Output	BYTE (output byte)
	BYTE_OF_DWORD extracts a byte (B0 .. B3) a DWORD. The individual bytes are selected with 0-3 at the input IN.



8.4.0.15 Type Function module

Input IN	BYTE (input byte)
Output B0 .. B7	BOOL (output bits)
	BYTE_TO_BITS split a byte (IN) into its individual bits (B0 .. B7). The input IN is defined as a DWORD to handle either byte, word, or DWORD at the input. If a Word or DWORD used at the input, only the bits 0th .7 are processed. A DWORD can then, using the default command SHR , be shifted by 8 bits to the right and then the next byte can be processed.

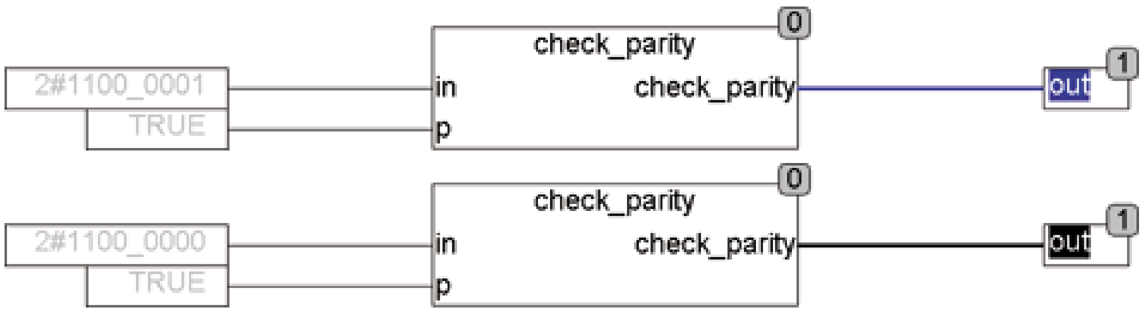


8.4.0.16 BYTE_TO_GRAY

Type Function	BYTE
Input IN	BYTE (input byte)
Output	Byte (value in Gray code)
	BYTE_TO_GRAY converts a byte value (IN) in the Gray code.

8.4.0.17 CHECK_PARITY

Type Function	BOOL
Input IN	BYTE (input byte)
P	BOOL (Parity-Bit)
Output	BYTE (output is TRUE in even parity)
	CHECK_PARITY checks an input byte IN and an associated paritybit P to even parity. The output is TRUE if the number of bits in the byte IN have the value TRUE together with the parity-bit results is an even number.



Example:
Example for output = TRUE: Example output = FALSE:

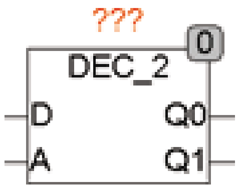
8.4.0.18 CHK_REAL

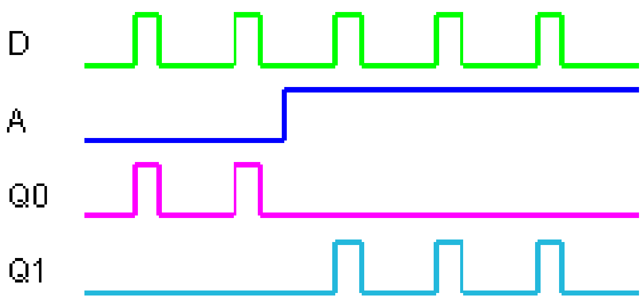
Type Function	BYTE
Input X	REAL (value to be tested)

Output	BYTE (return value)
	CHK_REAL reviewes X for valid values.
The return values are	
#00	valid floating-point
#20	1. Infinity
#40	• Infinity
#80	NAN
	For more information see the IEEE754 floating point specification.

8.4.0.19 Type Function module

Input D	BOOL (input bit)
A	BOOL (address)
Output Q0	BOOL (TRUE if A=0)
Q1	BOOL (TRUE if A=1)
	DEC_2 is a 2-bit decoder module. If A=0, the input D is passed to output Q0. If A=1, so D is set to Q1. In other words, Q0=1 if D=1 and A=0
Logical connection	Q0 = D & /A; Q1 = D & A

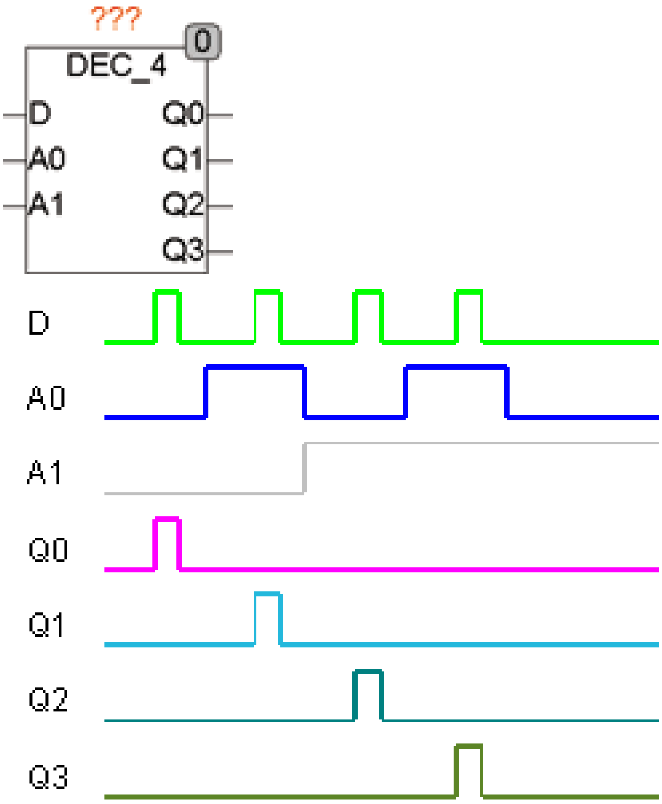




8.4.0.20 Type Function module

Input D	BOOL (input bit)
A0	BOOL (address bit0)
A1	BOOL (address bit1)

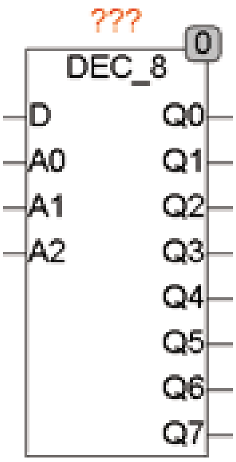
Output Q0	BOOL (TRUE with A0=0 and A1=0)
Q1	BOOL (TRUE if A0=1 and A1=0)
Q2	BOOL (true when A0=0 and A1=1)
Q2	BOOL (true when A0=0 and A1=1)
	DEC_4 is a 4-bit decoder module. If A0=0 and A1=0, the input D is passed to output Q0. If A0=1 and A1=1, the input D is passed to output Q3. In other words, Q0=1, if D=1 and A0=0 and A1=0.
Logical connection	Q0 = D & / A0 & / A1
	Q1 = D & A0 & /A1
	Q2 = D & /A0 & A1
	Q3 = D & A0 & A1

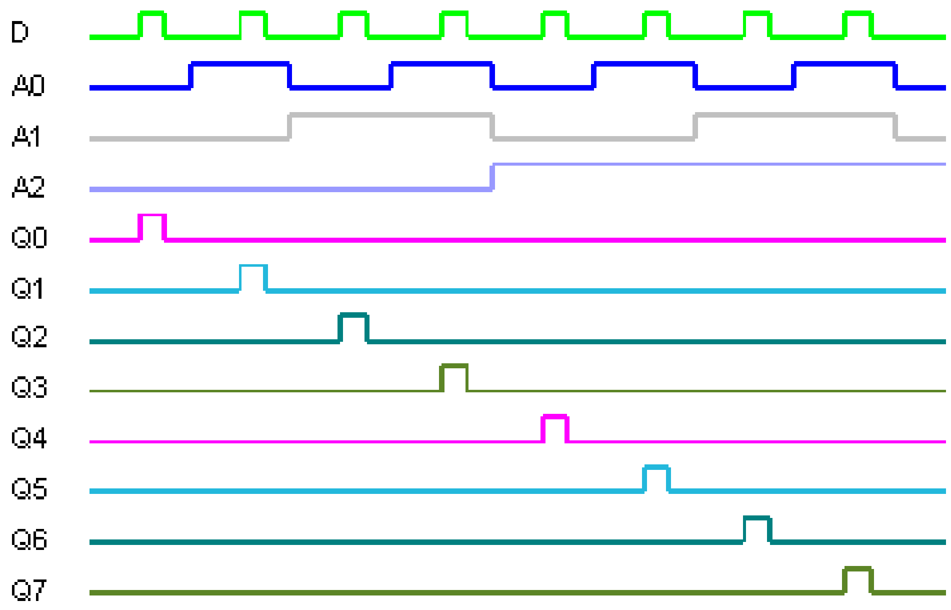


8.4.0.21 Type Function module

Input D	BOOL (input bit)
A0	BOOL (address bit0)
A1	BOOL (address bit1)
A2	BOOL (address bit 2)
Output Q0	BOOL (TRUE with A0 = 0 and A1 = 0 and A2 = 0)
Q1	BOOL (TRUE = 1 with A0 and A1 = 0 and A2 = 0)
Q2	BOOL (true when A0 = 0 and A1 = 1 and A2 = 0)

Q3	BOOL (TRUE with A0 = 1 and A1 = 1 and A2 = 0)
Q4	BOOL (TRUE with A0 = 0 and A1 = 0 and A2 = 1)
Q5	BOOL (TRUE with A0 = 1 and A1 = 0 and A2 = 1)
Q6	BOOL (TRUE with A0 = 0 and A1 = 1 and A2 = 1)
Q7	BOOL (TRUE with A0 = 1 and A1 =1 and A2 = 1)
	DEC_8 is an 8-bit decoder module If A0 = 0 and A1 = 0 and A2 = 0, the D input is pased to output Q0, if A0 = 1 and A1 = 1 and A2 = 1 the D is connected to Q3. In other words, Q0 = 1 if D = 1 and A0 = 0 and A1 = 0 A2 = 0.
The following diagram illustrates the logic of the module	
Logical connection	
Q0 = D & /A0 & /A1 & /A2	Q1 = D & A0 & /A1 & /A2
Q2 = D & /A0 & A1 & /A2	Q3 = D & A0 & A1 & /A
Q4 = D & /A0 & /A1 & A2	Q5 = D & A0 & /A1 & A2
Q6 = D & /A0 & A1 & A2	Q7 = D & A0 & A1 & A2



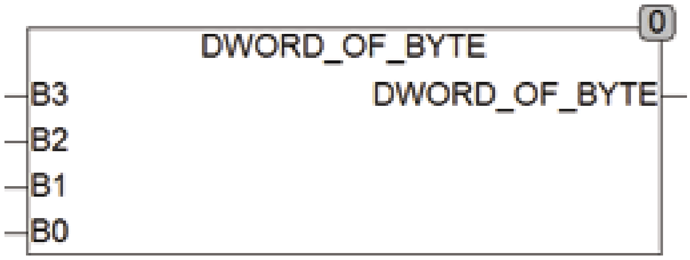


8.4.0.22 Type Function: REAL

Input X	DWORD (input)
Output	REAL (output value)
	DW_TO_REAL copies the bit pattern of a DWORD (IN) to a REAL. These bits are copied without regard to their meaning. The function REAL_TO_DW is the inverse so that the conversion of REAL_TO_DW and then DW_TO_REAL result in the output value. The IEC standard DWORD_TO_REAL function converts the value of the DWORD to a REAL value.

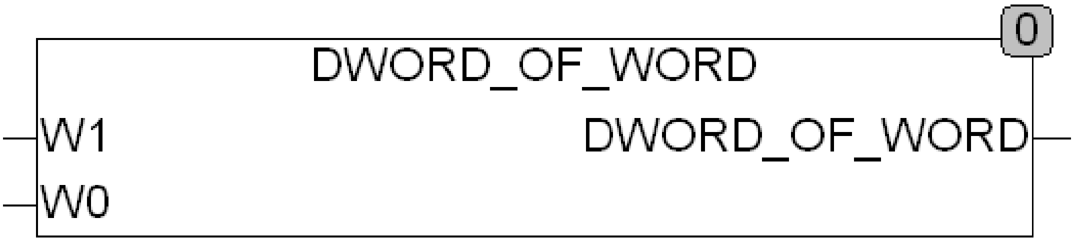
8.4.0.23 Type Function: DWORD

Input B3	Byte (input byte 3)
B2	Byte (input byte 2)
B1	Byte (input byte 1)
B0	Byte (input byte 0)
Output	DWORD (DWORD result)
	BYTE_OF_BIT creates from 4 individual bits (B0 .. B3) a DWORD.
A DWORD is composed as follows	B3-B2-B1-B0.



8.4.0.24 DWORD_OF_WORD

Type Function	DWORD
Input W1	WORD (Input WORD 1)
W0	WORD (Input WORD 0)
Output	DWORD (DWORD result)
	DWORD_OF_WORD creates from 2 separate WORDS W0 und W1 a DWORD.
A DWORD is composed as follows	W1-W0.

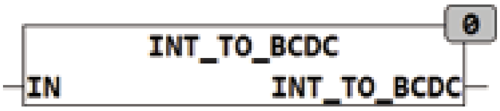


8.4.0.25 Type Function

Input IN	BYTE (Gray coded value)
Output	Byte (Binary Value)
	GRAY_TO_BYTE converts a Gray-coded value (IN) in a byte.

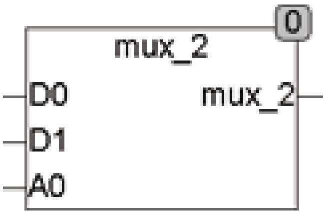
8.4.0.26 Type Function: BYTE

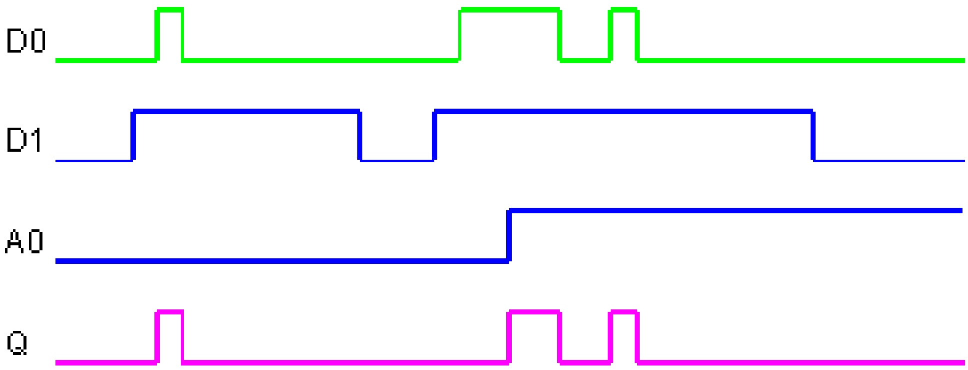
Input IN	INT (input)
Output	BYTE (BCD coded output value)
	INT_TO_BCDC converts the input value IN to a BCD coded output value.



8.4.0.27 MUX_2

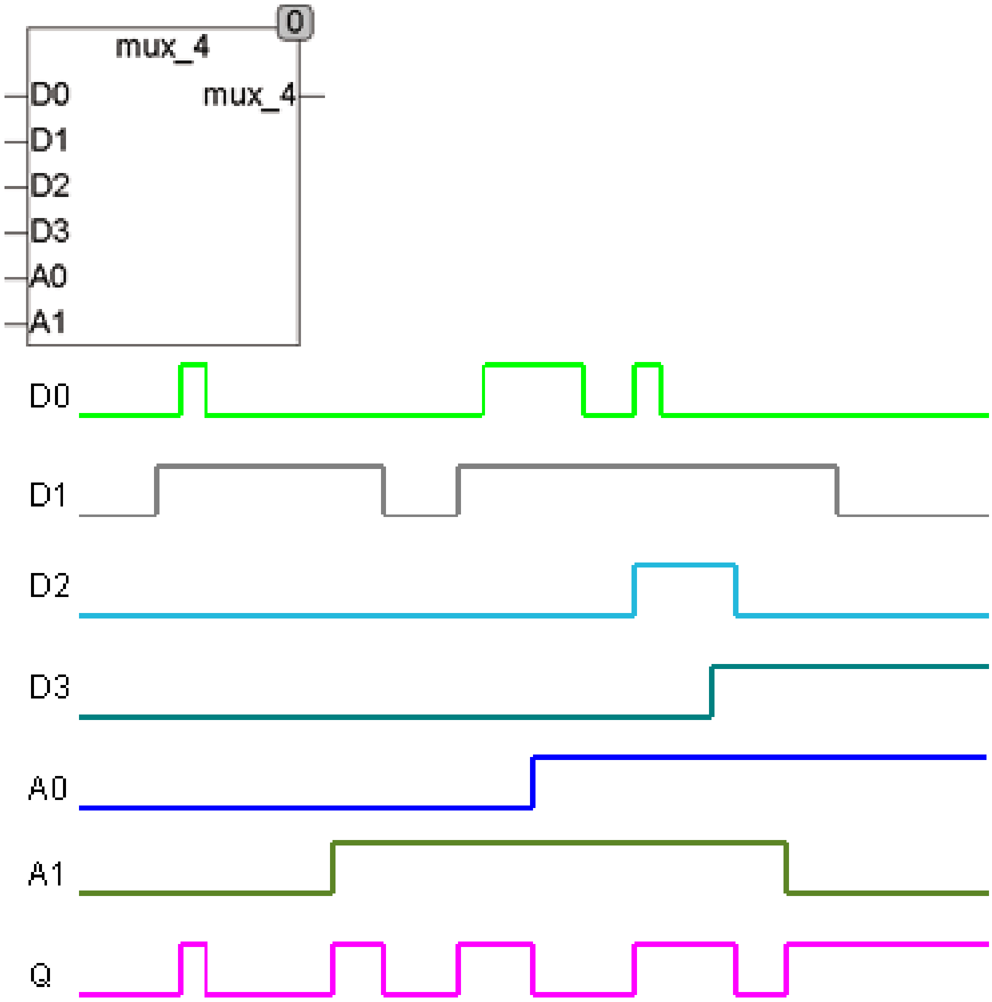
Type Function	BOOL
Input D0	BOOL (Bit 0)
D1	BOOL (Bit 1)
A0	BOOL (address)
Output	BOOL (D0, when A0 = 0 and D1, when A0 = 1)
	MUX_2 is a 2-bit Multiplexer. The output corresponds to D0 when A0 = 0 and it corresponds to D1, if A0 = 1
Logical connection	MUX_2 = D0 & /A0 + D1 & A0





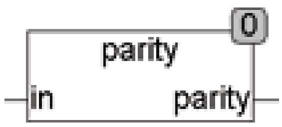
8.4.0.28 MUX_4

Type Function	BOOL
Input D0	BOOL (input 0)
D1	BOOL (input 1)
D2	BOOL (input 2)
D3	BOOL (Input 3)
Output	BOOL (D0, if A0 = 0 and A1 = 0, etc. ..)
	MUX_4 is a 4-bit Multiplexer. The output corresponds to D0 when A0 = 0 and A1 = 0 It corresponds to D3, if A0 = 1 and A1 = 1.
Logical connection	MUX_4 = D0 & /A0 & /A1 + D1 & A0 & /A1
	1. D2 & /A0 & A1 + D3 & A0 & A1



8.4.0.29 PARITY

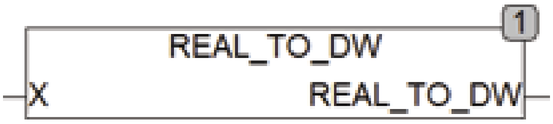
Type Function	BOOL
Input IN	BYTE (BYTE input)
Output	BOOL (output is TRUE if parity is even)
	PARITY calculates even parity over the input byte IN. The output is TRUE if the number of true bits in the byte (IN) is odd.



8.4.0.30 REAL_TO_DW

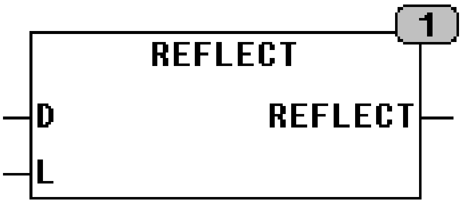
Type Function	DWORD
Input IN	REAL (input)
Output	DWORD (output value)

	REAL_TO_DW copies the bit pattern of a REAL (IN) in a DWORD. These bits are copied without regard to their meaning. The function REAL_TO_DW is the inverse so that the conversion of REAL_TO_DW and then DW_TO_REAL result in the output value. The IEC standard function REAL_TO_DWORD converts the REAL value to a fixed numerical value and is rounded at the lowest point of the DWORD.



8.4.0.31 REFLECT

Type Function	DWORD
Input D	DWORD (input)
L	INT (number of bits to be rotated)
Output	DWORD (output value)
	REFLECT reverses the order specified by the number of L BitsBits in a DWORD. The most significant bits than specified by the length L remain unchanged.



Example:
`REVERSE(10101010 00000000 11111111 10011110, 8)`
results 10101010 00000000 11111111 01111001 Example: REVERSE(10101010 00000000 11111111 10011110, 32) results 01111001 11111111 00000000 01010101 the following example in ST would reverse all the bytes in a DWORD X, but the byte order remains: FOR i := 0 TO 3 DO REVERSE(X, 8); ROR(X,8); END_FOR

8.4.0.32 REVERSE

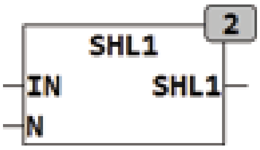
Type Function	BYTE
Input IN	BYTE (BYTE input)
Output	BYTE (Byte Output)
	REVERSE reverses the order of the bits in a byte. Bit7 of IN becomes bit 0, bit 6 to bit 1, etc.

Example:
`REVERSE(10011110) = 01111001`

8.4.0.33 Type Function: DWORD

Input IN	DWORD (input data)

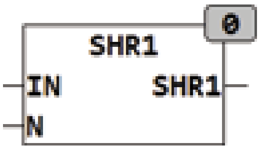
N	INT (number of bits to be shifted)
Output	DWORD (Result)
	SHL1 shifts the input DWORD for N bits to the left and fills the right N bits with 1. In contrast to the IEC standard function SHL, which filles when pushing with zeros, at SHL1 is filled with ones.



Example:
`SHL1(11110000,2) results 11000011`

8.4.0.34 Type Function: DWORD

Input IN	DWORD (input data)
N	INT (number of bits to be shifted)
Output	DWORD (Result)
	SHR1 pushes the input to N bits to the right and fills the left N bits with 1's. In contrast to the IEC standard function SHL, which filles when pushing with zeros, at SHR1 is filled with ones.



Example:
`SHR1(11110000,2) results 11111100`

8.4.0.35 Type Function: WORD

Input IN	WORD (input data)
Output	WORD (result)
	SWAP_BYTE exchanges the High and Low Bytes in a WORD.

Example:
`SWAP_BYTE(16#33df) = 16#df33.`

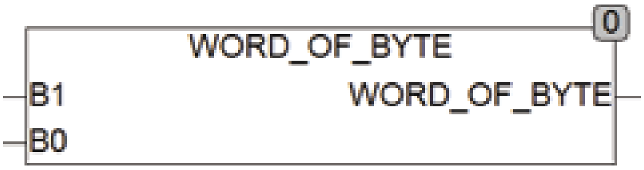
8.4.0.36 Type Function: DWORD

Input IN	DWORD (input data)
Output	DWORD (Result)
	SWAP_BYTE2 reverses the order of bytes in a DWORD.

Example:
`SWAP_BYTE2(16#33df1122) = 16#2211df33.`

8.4.0.37 Type Function: WORD

Input B1	Byte (input byte 1)
B0	Byte (input byte 0)
Output	Word (Word Score)
	WORD_OF_BYTE composes a Word of 2 separate bytes B0 and B1.



8.4.0.38 Type Function: WORD

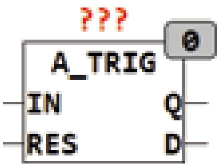
Input IN	DWORD (DWORD input)
Output	WORD (output WORD)
	WORD_OF_DWORD extracts a word (W0 .. W1) from a DWORD.

8.5 Logic / generators

This section contains 48 modules.

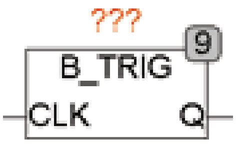
8.5.0.1 Type Function module

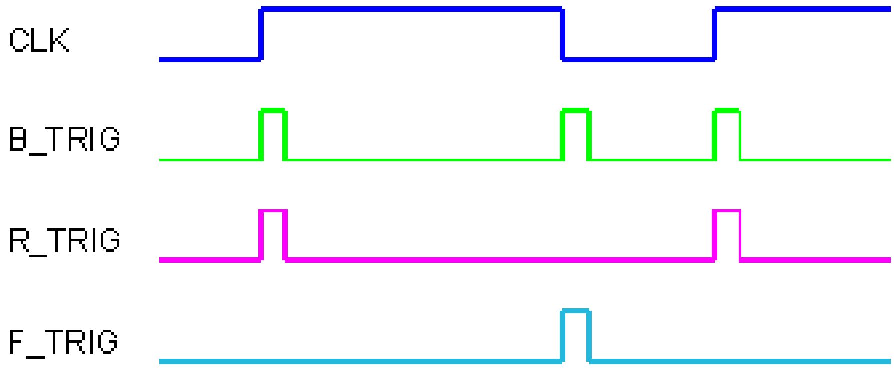
Input IN	REAL (input signal)
RES	REAL (input change)
Output Q	BOOL (output)
D	REAL (last change of the input signal)
	A_TRIG monitors an input value on change and every time when the input value changes by more than RES, the module generates an output pulse for a cycle so that the new value can be processed. At the same time, the device remembers the current input value with which it compares with the input IN at the next cycle. At the output D the difference between IN and the stored value is displayed.



8.5.0.2 Type Function module

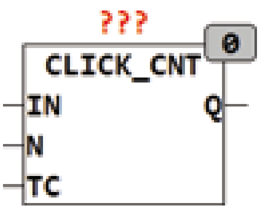
Input CLK	BOOL (Input signal)
Output Q	BOOL (output)
	The function module B_TRIG generates after a change of edge on the CLK input an output pulse for exactly one PLC cycle. In contrast to the two standard modules R_TRIG and F_TRIG that produce only at falling or rising edge of a pulse, B_TRIG generates at falling and rising edge of an output pulse.

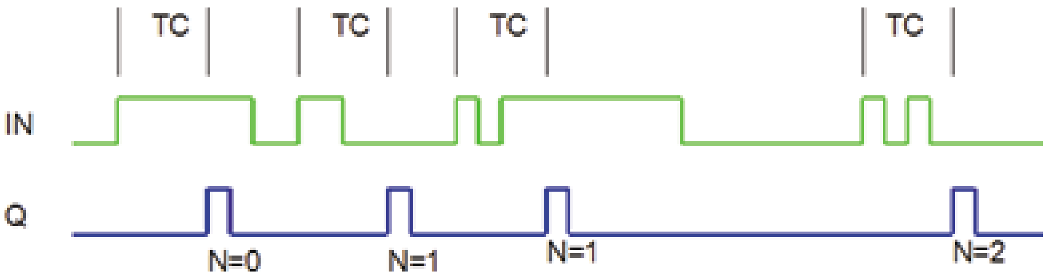




8.5.0.3 Type Function module

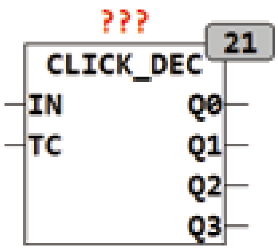
Input IN	BOOL (Input)
N	INT (number ofclicks) to decode
TC	TIME (time in which the clicks must take place)
Output Q	BOOL (output)
	CLICK_CNT determines the number of pulses within the unit time TC. at input IN. A rising edge at IN will start an internal timer with time TC. During the course of Timers the module counts the falling edges of IN and reviewes after the expiry of the time TC whether N pulses are within the time TC. Just when exactly N pluses within TC will happen, the output Q is set for a PLC cycle to TRUE. The module decodes also N = 0, which corresponds to a rising edge but not falling edge within TC.

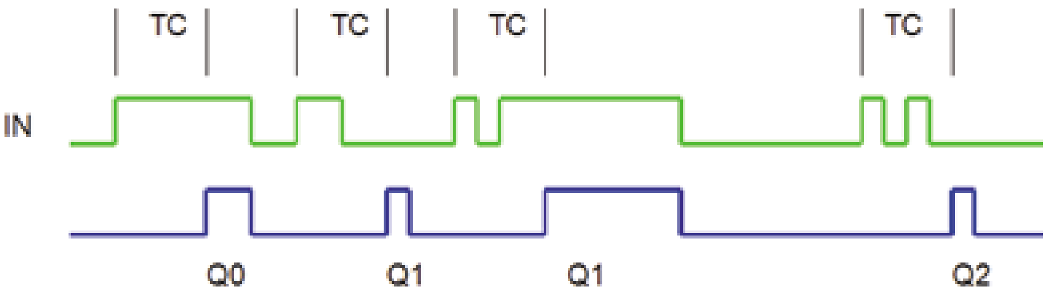




8.5.0.4 Type Function module

Input IN	BOOL (Input)
TC	TIME (time in which the clicks must take place)
Output Q0	BOOL (output signal rising edge
	without falling edge)
Q1	BOOL (output signal of a pulse within TC)
Q2	BOOL (output signal for two pulses within TC)
Q3	BOOL (output signal for three pulses within TC)
	CLICK_DEC decodes multiple keystrokes and signals to different outputs the number of pulses. An input signal without falling edge within TC is issued at Q0 and remains TRUE until IN goes on FALSE. A pulse followed by a TRUE is output to Q1 and so on. Is a pulse registered within TC which is followed by the state FALSE, then TRUE appear at the corresponding output for a PLC cycle.

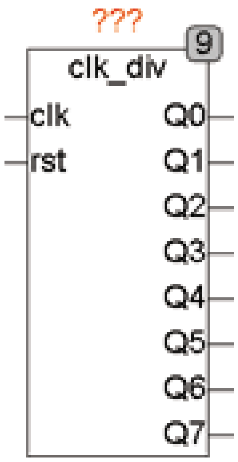


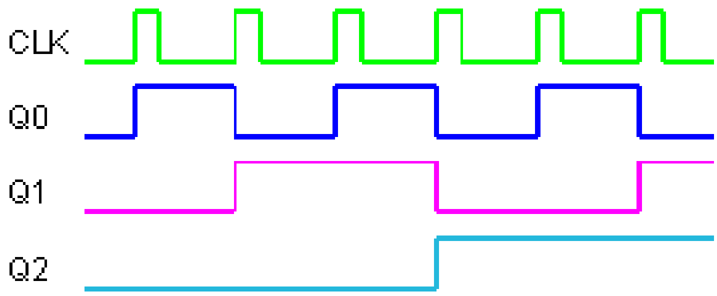


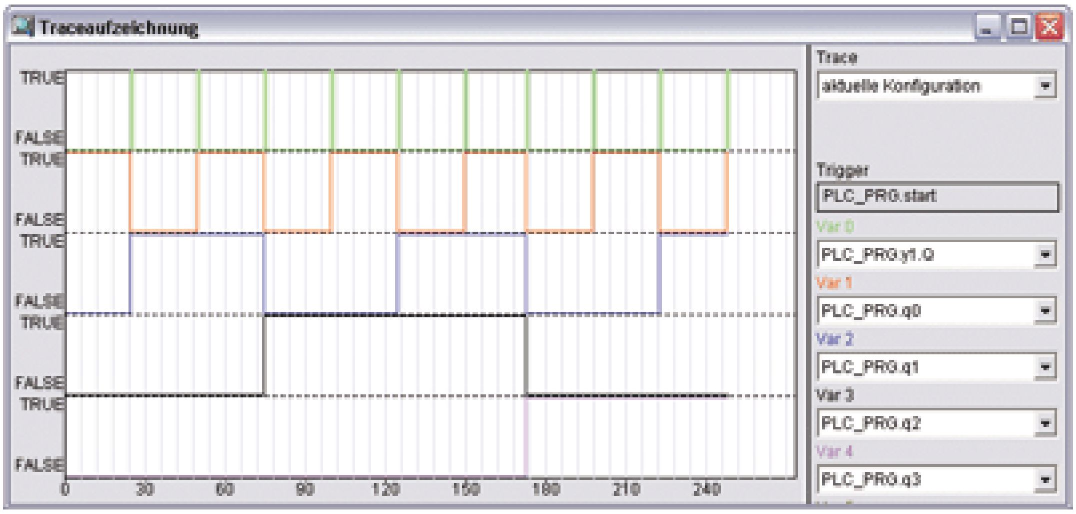
8.5.0.5 Type Function module

Input CLK	BOOL (Clock Input)
RST	BOOL (Reset input)
Output Q0	BOOL (divider output CLK / 2)
Q1	BOOL (divider output CLK / 4)
Q2	BOOL (divider output CLK / 8)

Q3	BOOL (divider output CLK / 16)
Q4	BOOL (divider output CLK / 32)
Q5	BOOL (divider output CLK / 64)
Q6	BOOL (divider output CLK / 128)
Q7	BOOL (divider output CLK / 256)
	The function module CLK_DIV is a divider module and devides the input signal CLK into 8 levels each divided by 2, so that at the output Q0 is half the frequency of the input CLK with 50% duty cycle available. The output Q1 is the halved frequency of Q0 available and so on, until at Q7 the input frequency is divided by 256. A reset input RST sets asynchronous all outputs to FALSE. CLK is allowed to make only one cycle to TRUE, if CLK does not this, CLK musst provided over TP_R.
The following example is a test circuit with a start signal via ENI / ENO realized functionality. Figure 2 shows a corresponding trace recording of the circuit	

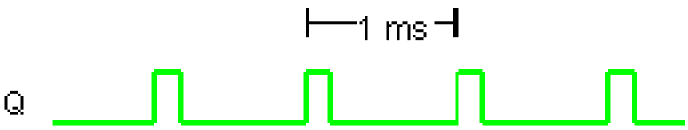






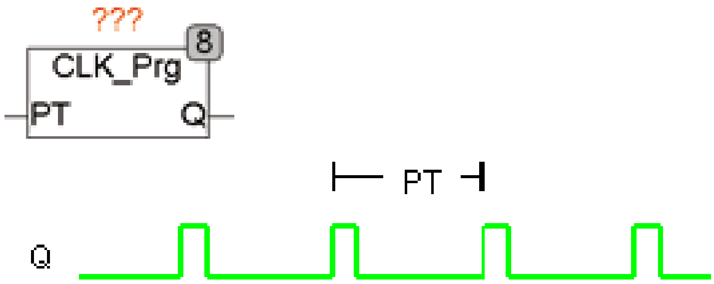
8.5.0.6 Type Function module

Input N	INT (Clock Divider)
Output Q	BOOL (clock output)
	CLK_N generates a pulse every X milliseconds, based on the PLC internal 1 ms reference. The pulses are exactly one PLC cycle length and are generated every 2^N milliseconds.
	The period is 1 ms for N = 0, 2ms for N = 1, 4ms, for N=2
	CLK_N replaces the modules CLK_1ms, CLK_2ms, CLK_4ms and CLK_8ms from older libraries.
The following picture shows the output signal for N=0	



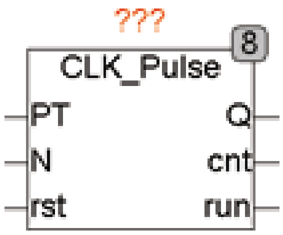
8.5.0.7 Type Function module

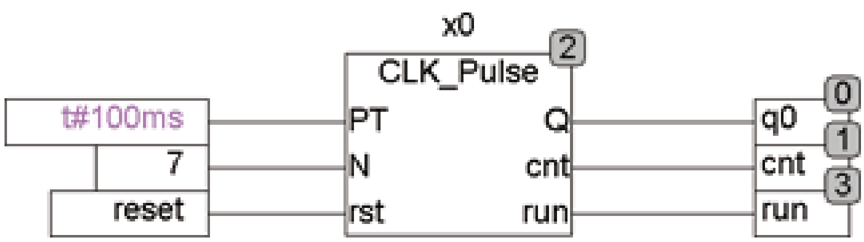
Input PT	TIME (cycle time)
Output Q	BOOL (clock output)
	CLK_PRG generates clock pulses with a programmable period PT. The output pulses are only one PLC cycle.

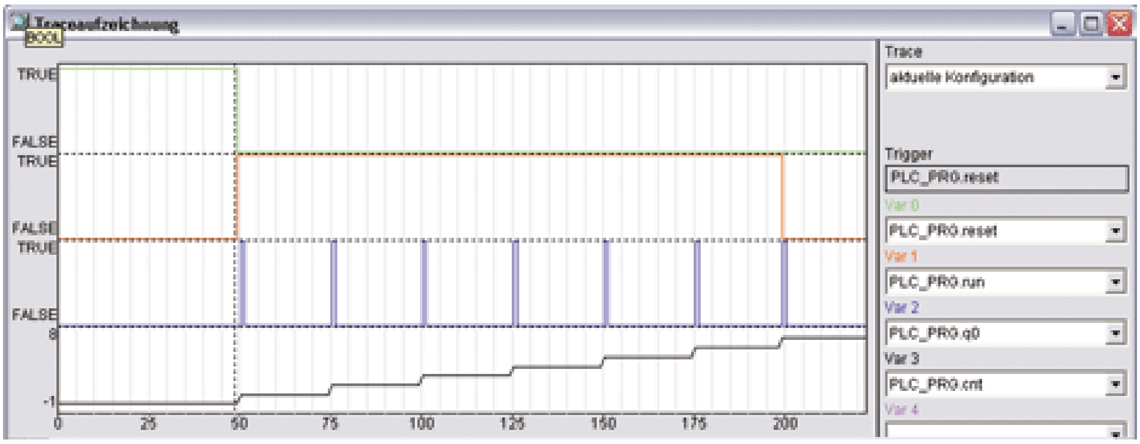


8.5.0.8 Type Function module

Input PT	TIME (cycle time)
N	INT (number of pulses to be generated)
RST	BOOL (Reset)
Output Q	BOOL (clock output)
CNT	INT (counter of output pulses)
RUN	BOOL (TRUE, if pulse generator is running)
	CLK_PULSE generates a defined number of clock pulses with a programmable duty cycle. PT defines the duty cycle and N is the number of generated pulses. WIth a reset input RST, the generator can be restarted at any time. The output CNT counts the pulses generated and RUN = TRUE indicates that the generator currently generate pulses. An input value N = 0 generates an infinite pulse series, the maximum number of pulses is limited to 32767.
	The following example shows an application of CLK_PULSE for the production of 7 pulses with a duty cycle of 100 ms.
	The trace recording, shows how the RESET (green) is inactive and thus RUN (red) is active. The generator generates then 7 pulses (blue), as specified at the input N. The output CNT counts from 1 on the first pulse to 7 by the last pulse. After the end of the sequence RUN is inactive again and the cycle is complete until it is started by a new reset.

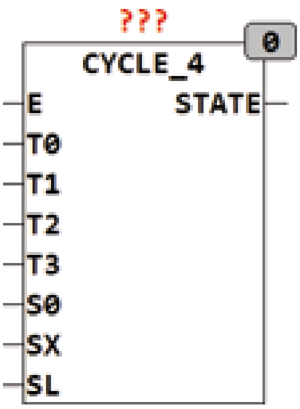






8.5.0.9 Type Function module

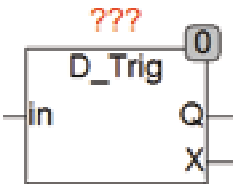
Input E	BOOL (Enable Input)
T0 _ T3	TIME (run time of each States)
S0	BOOL (continuous cycle Enable)
SX	INT (State if SL = TRUE)
SL	BOOL (asynchronous Load input)
Output STATE	INT (status output)
	CYCLE_4 generates theStates 0..3 if E = TRUE . The duration of each State can be determined by the time constraints T0..T3. The input SL starts when TRUE from a predetermined STATE SX. The input E has the internal Default = TRUE, so that it can also be left open. After a rising edge on E the module always starts with STATE = 0, and if E = FALSE, the output STATE remains at 0. With the input of S0 the cyclic mode is turned on, if S0 = FALSE the module stops at State = 3, if S0 = TRUE, the device begins to State 3 again with State 0.

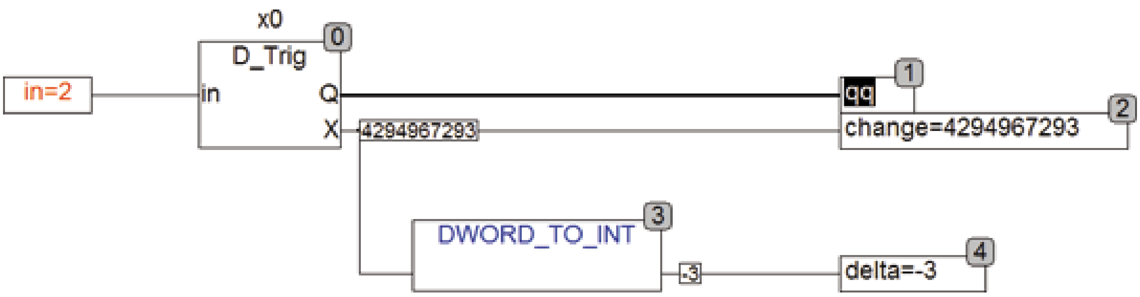


8.5.0.10 Type Function module

Input IN	DWORD (input signal)
Output Q	BOOL (output)
X	DWORD (change of the input signal)

	The function module D_ TRIG generates after a change at the input IN an output pulse for exactly one PLC cycle. The module works similar to the standard function blocks R_TRIG and F_TRIG and the library module B_TRIG. While B_TRIG, R_TRIG and F_TRIG monitor a Boolean input, the module D_TRIG triggers on any change in the DWORD-input IN. If the input value has changed, the output Q for a PLC cycle is set to TRUE and the output X indicates how much has changed in the IN input. The input and output are of type DWORD. The input can also process WORD and BYTE types. With output X it should be noted that DWORD is unsigned and therefore a change of −1 at the input is not −1, but the number 2^32-2 at the output. With the standard function DWORD_TO_INT the output X can be converted to an integer, which displays also negative changes correctly.
The following example shows the application of D_TRIG when the input changes value from 5 to 2	

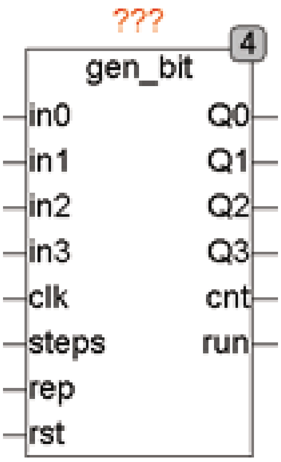


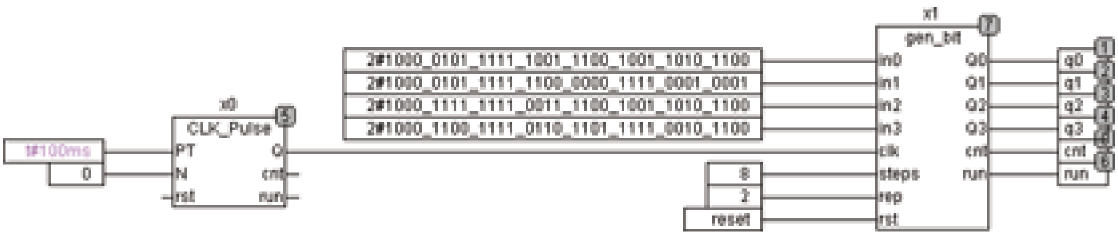


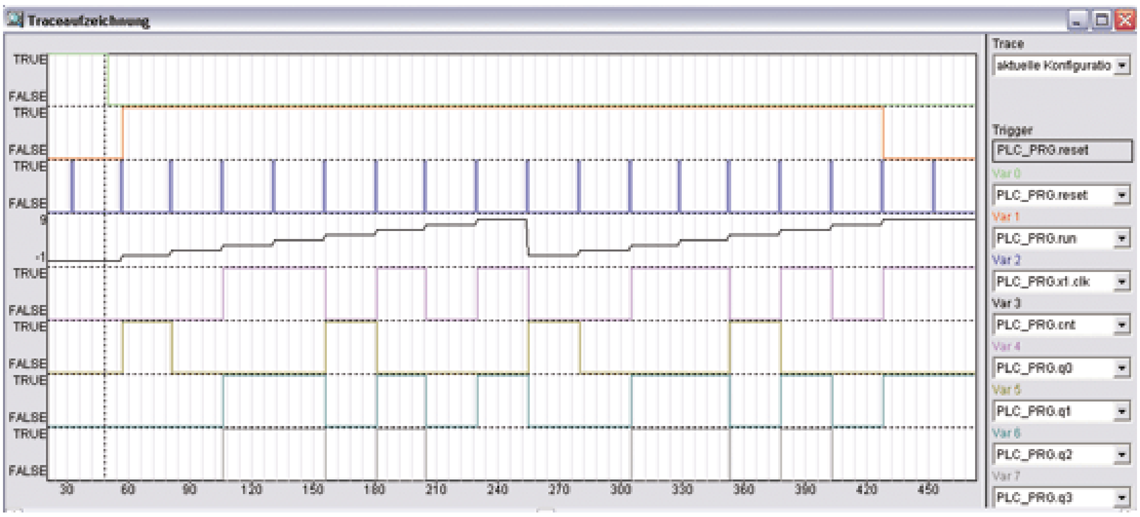
8.5.0.11 Type Function module

Input IN0	DWORD (bit sequence for Q0)
IN1	DWORD (bit sequence for Q1)
IN2	DWORD (bit sequence for Q1)
IN3	DWORD (bit sequence for Q1)
CLK	BOOL (clock input)
STEPS	INT (number of generated clocks)
REP	INT
RST	BOOL
Output Q0	BOOL (bit sequence Q0)
Q1	BOOL (bit sequence Q1)

Q2	BOOL (bit sequence Q2)
Q3	BOOL (bit sequence Q3)
CNT	INT (number of output bits already generated)
RUN	BOOL (TRUE if the sequencer is running)
	GEN_BIT is a fully programmable pattern generator. At the inputs in0 .. IN7 are the bit patterns at the input CLK in each case as a DWORD and passed by each clock pulse to the outputs Q0 .. Q3 starting from bit 0 of ascending. After the first clock pulse at the input CLK the output Q0 has bit 0 of IN0 , at Q1 is bit 0 of In1 ... on Q7 is bit 0 of IN3. After the next clock pulse at the CLK input, the bit 1 of the inputs IN is passed to the outputs Q and so on, until the sequence is completed. The input STEPS determines how many bits of the input DWORDS be passed to the outputs. The input REP determines how often this sequence is repeated. If the input set to 0, the sequence is repeated continuously. An asynchronous reset can always reset the sequencer. The outputs CNT and RUN indicate which bit is currently passed to the output and whether the sequencer is running, or the sequence (RUN inactive) has finished. After the sequences have expired the last bit patterns remains on the outputs available until a reset restarts the generator.





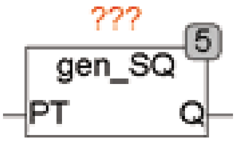


Example:

Example: In this example, the lowest 8 bits (bits 0 .. 7) at the inputs IN are pushed to the outputs Q. The sequence begins with bit 0 and ends at bit 7 (8 Steps are defined by the input 8). This sequence is repeated 2 times (2 repetitions at the input REP) and then stopped. The Trace Recording shows the reset signal becoming inactive (green), which starts the generator and after the first clock pulse passes bit 0 to the outputs.

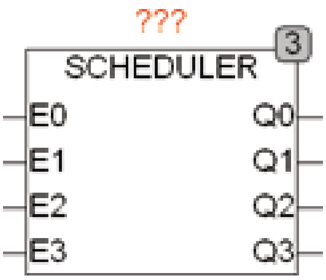
8.5.0.12 Type Function module

Input PT	TIME (period time)
Output Q	BOOL (output)
	Gen_SQ is a generator with programmable period time and a fixed duty cycle of 50%. The input PT defines the period time and the output Q passes the output signal.
	PTQ



8.5.0.13 SCHEDULER

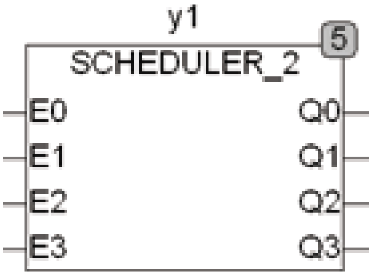
Type	Function module
Input E0..3	BOOL (release signal for Q0..3)
Output Q0..3	BOOL (output signals)
	SCHEDULER is used to call time dependent program parts. For example, complex calculations that are needed only rarely, can be called at fixed intervals. The outputs Q? of the module will be active only for one cycle and release the execution of the program part. The setup time T? specify at which intervals the outputs are enabled. SCHEDULER checks per CPU cycle only one output, so that in maximum one output per cycle can be active. In the extreme case when all call times T? are T#0s, in each cycle one output should be set, so that first Q0, then Q1, etc. to Q3 are set and then again to start Q0. The call times can therefore up to 3 CPU cycles and differ from the predetermined value T? .
Setup T0..3	TIME (cycle time)



8.5.0.14 Type Function module

Input E0..3	BOOL (release signal for Q0..3)
Output Q0..3	BOOL (output signals)

	SCHEDULER_2 activates depending on the setup variables C? And O? The outputs Q?. SCHEDULER_2 can an output Q? All C? cycles enable, to launch the program items with different cycle times. An optional setup parameters O? is used to a time offset of O? to define cycles for the corresponding output to a simultaneous turn of the outputs in the first cycle to prevent.
Setup C0 .. 3	UINT (The output Q? is activated the C? cycles)
O0 .. 3	UINT (delay for the outputs)

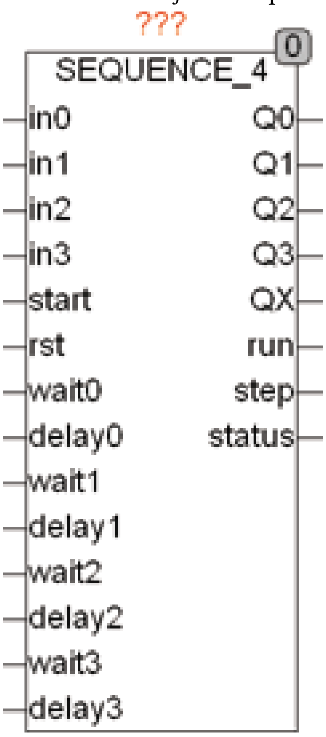


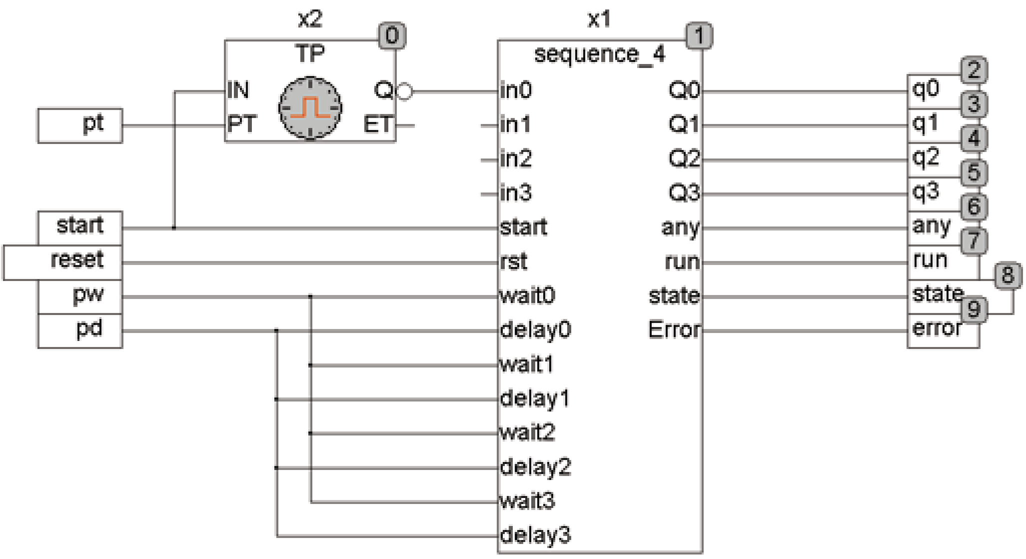
8.5.0.15 Type Function module

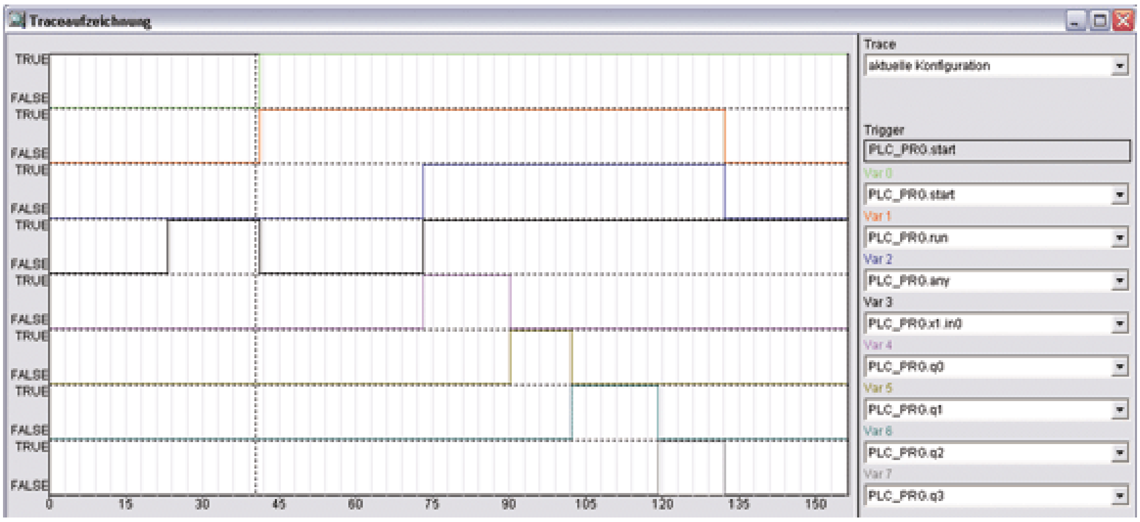
Input IN0 .. 3	BOOL (enable signal for Q0..3)
START	BOOL (starting edge for the sequencer)
RST	BOOL (asynchronous reset input)
WAIT 0..3	TIME (wait for the input signal to 0..3)
DELAY 0..3	TIME (delay time until the input signal IN0..3 is being tested)
Output Q 0..3	BOOL (control outputs)
QX	BOOL (TRUE if one of the outputs Q0..Q3 is active)
RUN	BOOL (RUN is TRUE if the sequencer is running)
STEP	INT (indicates the current step)
STATUS	BYTE (to ESR compliant status output)
	SEQUENCE_4 is a 4-bit sequencer with control inputs. After a rising edge on START, RUN gets TRUE and the sequencer waits for the time Wait0 for a TRUE signal at the input IN0. After the signal on IN0 is TRUE, the output Q0 is set and waits the time Delay0. After the interval Delay0 in the next cycle the module waiting the time wait1 for an input signal at in1 and Q0 remains TRUE, until Q1 is set. The whole procedure is repeated until all 4 cycles have elapsed. If during the waiting time wait0..3 the corresponding input gets not true, an error is set, by corresponding Error Number at the output STATUS it is displayed, and depending on the setup variable STOP_ON_ERROR the sequencer is stopped or not. The STATUS output is 110 for waiting to the start signal, and 111 for pass through. It show the sequence with 1 .. 4 errors. A Error = 1 means that the signal at the input in0 gets not active, a 2 corresponds to in1 etc. The outputs RUN and STEP indicate whether the sequencer is running and in which cycle it is at the moment. The output QX is TRUE, if one of the outputs Q0..Q3 are TRUE.

| | An asynchronous reset input can always reset the sequencer. This reset input can also be connected with a output Q0..Q3 to stop the sequencer before the full sequence. The sequencer can be started at any time with a rising edge on the START input, again and again. This is true, even if he has not completed a sequence. | | | If not a edge examination of one or more inputs IN are required, they may simply be left open, because the default value for this input is TRUE. | | | The initial state is compatible and ESR shows a value of 1-4 indicates that an error has occurred. An error occurs if the corresponding input signal to

IN does not occur during the waiting period. | | | Error = 1 means that in0 is not within the waiting time has become active. Error 2 .. 4 corresponds to inputs 1 .. 3. | | | A status value of 110 means on hold and 111 means that just a sequence is running. |





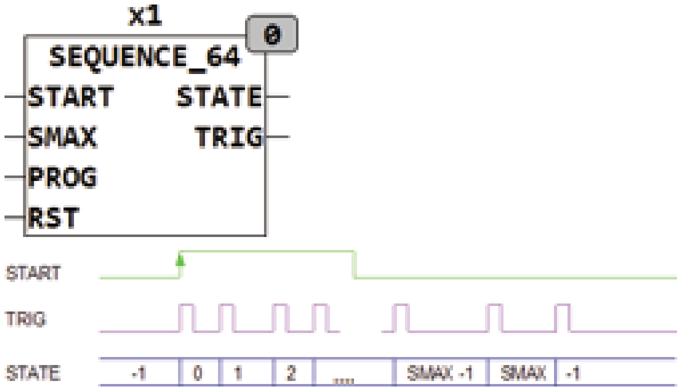


Example:

```
In the following  Example  is  the sequencer is started with a rising edge.
Simultaneously, a pulse generator TP starts with 2 seconds, and that was the starting
trigger with 2 seconds delay to the input IN0. The sequencer sets just after the start
pulse, the output signal RUN and then waits for a maximum of 5 seconds on a signal to
IN0. The rising edge of IN0 that is generated after 2 seconds of TP, Q0 is set and a
delay for 1 second is waited. This the first step is finished and the remaining steps
are executed without waiting for an input signal in 1..3. The default values for the
inputs IN are TRUE when they are unconnected. The trace record shows the start signal
(green) and the RUN signal (red). After 2 seconds, the rising edge is putted on the
input in0 and then on the output signals Q0..3 and QX. The signal QX (blue) is active if
one of the output signals is active and the RUN signal (red) is active from start to
finish.
```

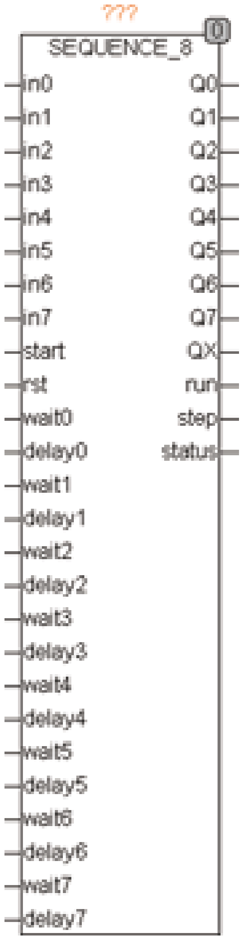
8.5.0.16 Type Function module

Input START	BOOL (rising edge starts the sequence)
	SMAX INT (last State the sequence)
PROG	ARRAY [0..63] OF TIME (duration of the individual states)
RST	BOOL (asynchronous reset input)
Output STATE	INT (State Output)
TRIG	BOOL (Indicates changes with condition TRUE)
	SEQUENCE_64 generates a time sequence of up to 64 states. In the resting state the output STATE is set to −1, thereby demonstrating to that the module is not active. A rising edge at START starts the sequence and the output switches to 0. After the waiting time PROG[0] the module switch next to STATE = 1, waits the time PROG[1], switches to STATE = 2, etc. .. until the output STATE reached the value of SMAX. After the waiting time PROG[SMAX], the device returns to the idle state (STATE = −1). A change to a new state STATE trigger of the output TRIG with a TRUE for one PLC cycle. With TRIG easily downstream modules can be controlled. With the input RST, the device can also be reset in the initial state at any time during the process of a sequence.
signal diagram of SEQUENCE_64	



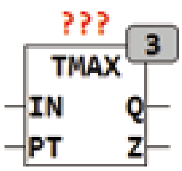
8.5.0.17 Type Function module

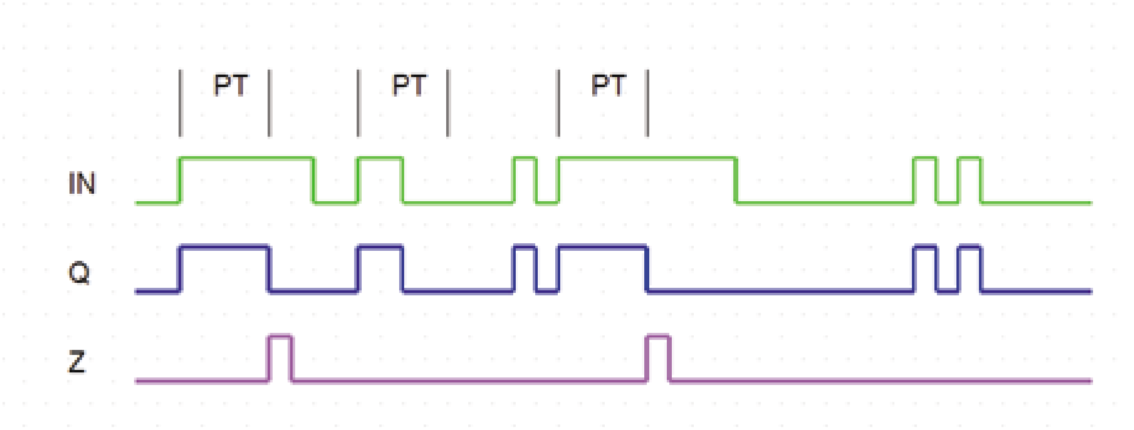
Input IN0..7	BOOL (enable signal for Q0..7)
START	BOOL (starting edge for the sequencer)
RST	BOOL (asynchronous reset input)
WAIT 0..7	TIME (wait for the input signal to 0..7)
DELAY 0..7	TIME (delay time until the input signal IN0..7 tested)
Output Q 0..7	BOOL (control outputs)
QX	BOOL (TRUE if one of the outputs Q0.. Q7 is active)
RUN	BOOL (RUN is TRUE if the sequencer is running)
STEP	INT (indicates the current step)
STATUS	BYTE (0 if no error, else > 0)
	A functional description of SEQUENCE_8 can be found at SEQUENCE_4. SEQUENCE_8 function is identical with SEQUENCE_4. He has 8 instead of 4 channels. SEQUENCE_8 is used in the OSCAT library module Legionella.



8.5.0.18 Type Function module

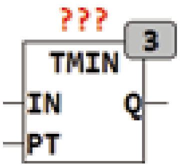
Input IN	BOOL (Input)
PT	TIME (switch off delay)
Output Q	BOOL (output)
Z	BOOL (Trigger Output)
	TMAX limits the duration of the output pulse to the time PT. The output Q follows the input IN, as long as the TRUE time of IN is shorter than PT. If IN is longer than PT to TRUE, the output pulse is shortened. Whenever an output changes by a timeout to FALSE, the output Z is set to TRUE for a cycle.

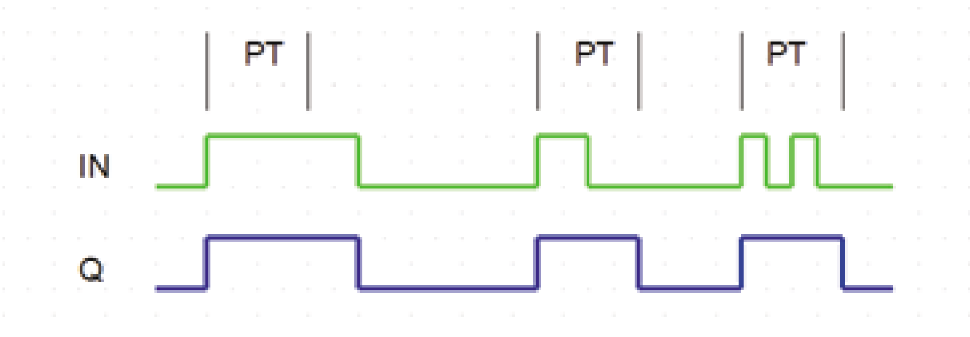




8.5.0.19 Type Function module

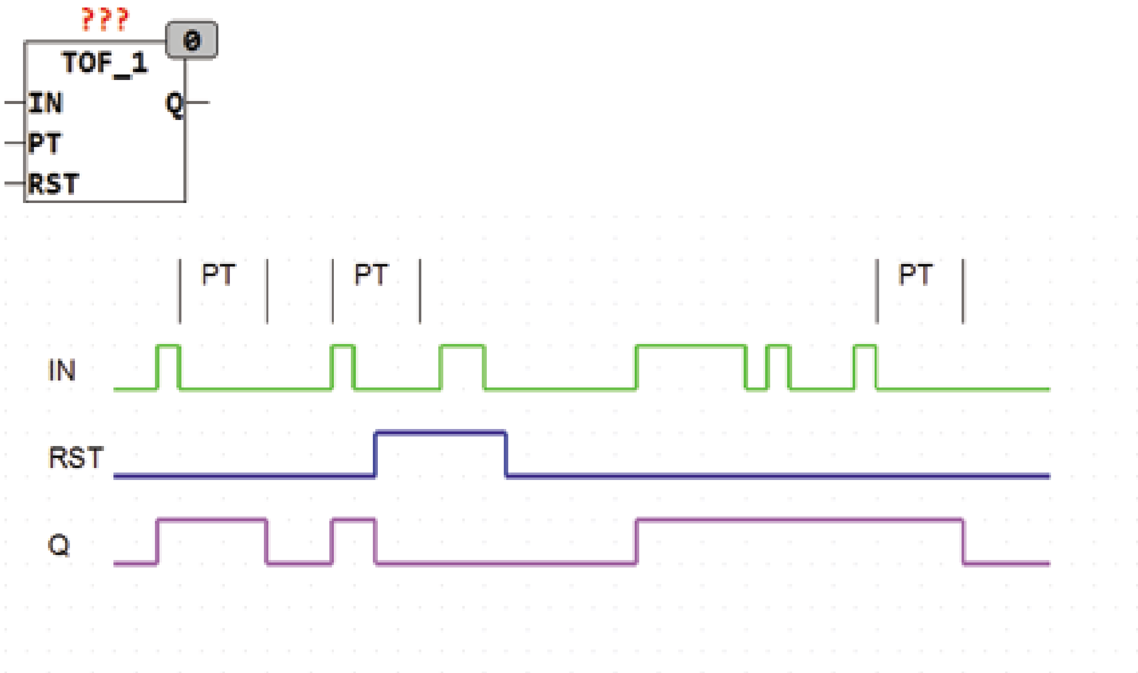
Input IN	BOOL (Input)
PT	TIME (switch off delay)
Output Q	BOOL (output)
	TMIN ensures that the output pulse Q is at least PT is set to TRUE, even if the input pulse at IN is shorter than PT. otherwise the output Q follows the input IN.





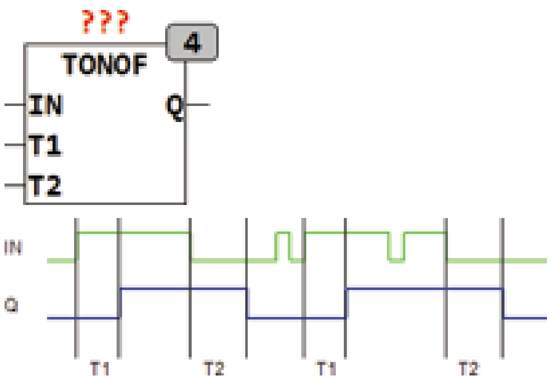
8.5.0.20 Type Function module

Input IN	BOOL (Input)
PT	TIME (switch off delay)
RST	BOOL (asynchronous reset)
Output Q	BOOL (output)
	TOF_1 extended an input pulse at IN by the time PT. TOF_1 has the same functionality as TOF from the standard LIB, but with an additional asynchronous reset input.



8.5.0.21 Type Function module

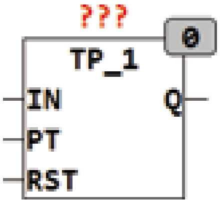
Input IN	BOOL (Input)
T1	TIME (ON Delay)
T2	TIME (OFF Delay)
Output Q	BOOL (output pulse)
	TONOF creates a ON delay T1 and an OFF delay T2
	The rising edge of the input signal IN is delayed by T1 and the falling edge of IN is delayed by T2.

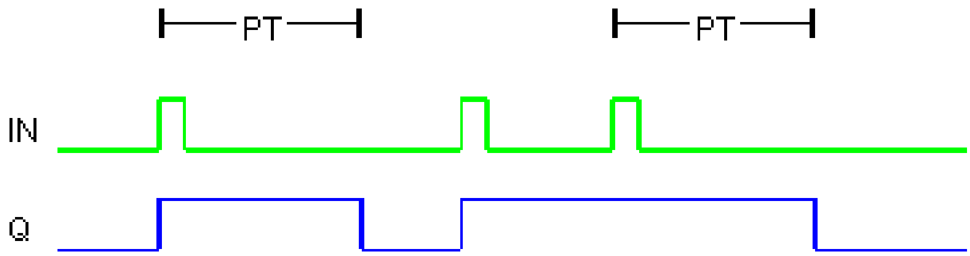


8.5.0.22 Type Function module

Input IN	BOOL (Input)
PT	TIME (pulse duration)
RST	BOOL (asynchronous reset)
Output Q	BOOL (output pulse)

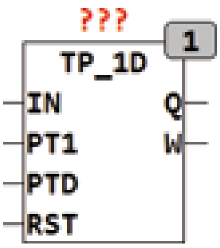
	TP_1 is an edge-triggered pulse generator which generates a rising edge at IN an output pulse at Q with the duration of PT. During the output pulse an another rising edge to IN is created, the output pulse will be extended so that after the last rising edge of output for the duration of PT remains TRUE. The module can be reset at any time with a TRUE at the RST input.
Timing of TP_1	





8.5.0.23 Type Function module

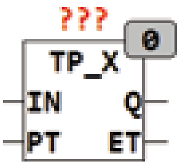
Input IN	BOOL (Input)
PT1	TIME (pulse duration)
PTD	TIME (Delay can be generated by new pulse)
RST	BOOL (asynchronous reset)
Output Q	BOOL (output pulse)
	TP_1D is an edge-triggered pulse generator which generates at a rising edge at IN an output pulse at Q with the duration of PT1. During the output pulse an another rising edge to IN is created, the output pulse will be extended so that after the last rising edge of output for the duration of PT remains TRUE. After the end of the pulse duration PT1 the module block the output for the time PTD. A new impulse can be restarted only after the time PTD. The module can be reset at any time with a TRUE at the RST input. The output W shows that the module in the waiting cycle, and as long as W = TRUE, no new impuls can start.

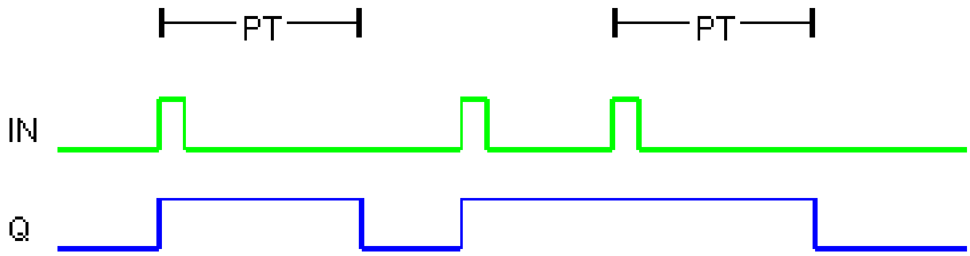


8.5.0.24 Type Function module

Input IN	BOOL (Input)
PT	TIME (pulse duration)

Output Q	BOOL (output pulse)
ET	TIME (Count the elapsed time of the output pulse)
	TP_X is a multiple triggerable pulse generator. In contrast to the standard module TP this template can be triggered multiple times and thus the output pulse can be extended. The output Q remains after the last trigger event (rising edge of IN) at ON, for the period of PT. While Q is true, by a further edge at the IN the Timer can be triggered again and the output pulse can be extended. In contrast to TOF, at TP_X the time PT is measured as of the last rising edge, regardless of how long IN remains at TRUE. This means that the output Q, after the time PT, is measured from the last rising edge of IN moves to FALSE, even when the input IN is TRUE.
Timing of TP_X	



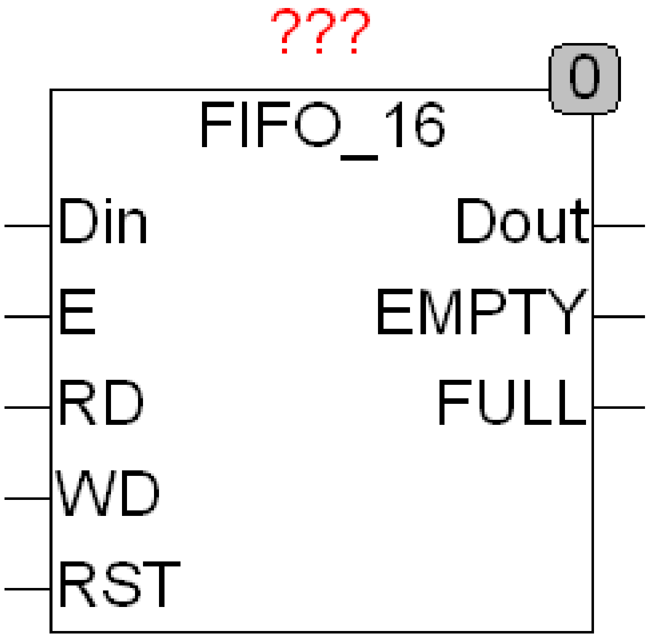


8.6 Logic / memory

This section contains 8 modules.

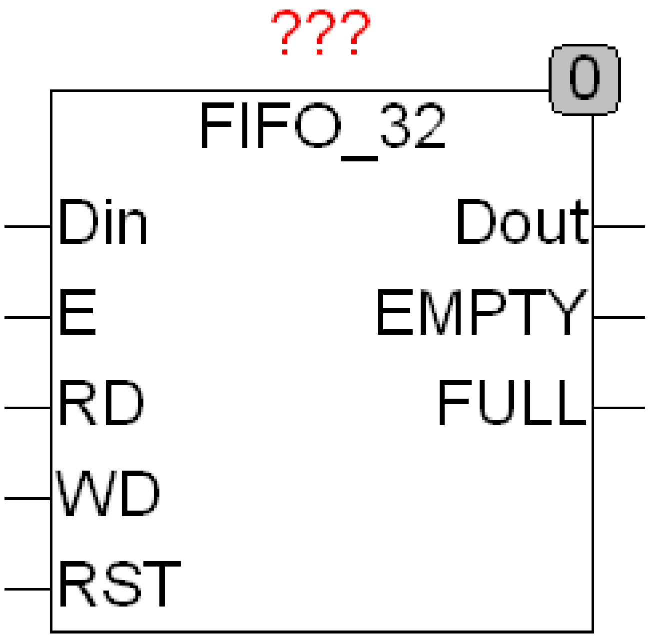
8.6.0.1 Type Function module

Input DIN	DWORD (data input)
E	BOOL (enable input)
RD	BOOL (read command)
WD	BOOL (write command)
RST	BOOL (Reset input)
Output DOUT	DWORD (data output)
EMPTY	BOOL (EMPTY = TRUE means that memory is empty)
FULL	BOOL (FULL = TRUE means: memory is full)
	FIFO_16 is a First-In First-Out Memory with 16 memory locations for DWORD data. The two outputs EMPTY and FULL indicate when the memory is full or empty. The RST input clears the entire contents of the memory. The FIFO is described by DIN, by put a TRUE to the input WD, and a true-pulse on the input E. A read command is executed by TRUE to RD and TRUE to E. Reading and writing can be performed simultaneously in one cycle. The module reads or writes in each cycle as long as the corresponding command (RD, WD) is set to TRUE.



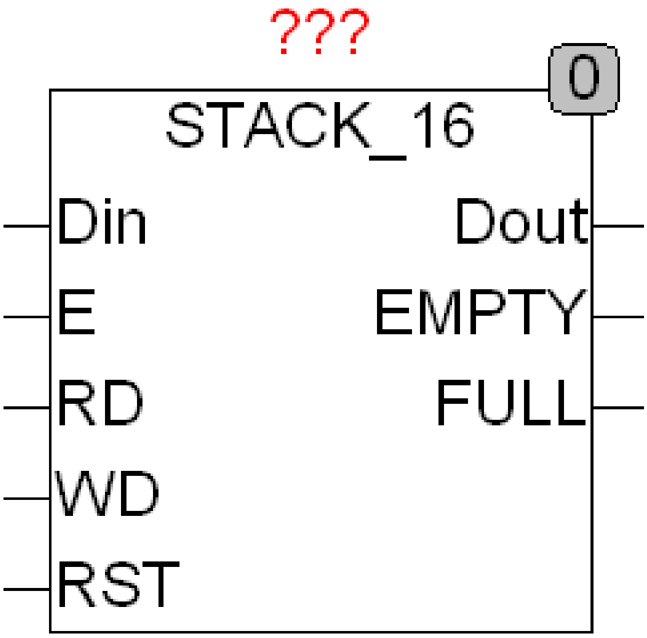
8.6.0.2 Type Function module

Input DIN	DWORD (data input)
E	BOOL (enable input)
RD	BOOL (read command)
WD	BOOL (write command)
RST	BOOL (Reset input)
Output DOUT	DWORD (data output)
EMPTY	BOOL (EMPTY = TRUE means that memory is empty)
FULL	BOOL (FULL = TRUE means: memory is full)
	FIFO_32 is a First-In First-Out Memory with 32 memory locations for DWORD data. The two outputs EMPTY and FULL indicate when the memory is full or empty. The RST input clears the entire contents of the memory. The FIFO is described by DIN, by put a TRUE to the input WD, and a true-pulse on the input E. A read command is executed by TRUE to RD and TRUE to E. Reading and writing can be performed simultaneously in one cycle. The module reads or writes in each cycle as long as the corresponding command (RD, WD) is set to TRUE.



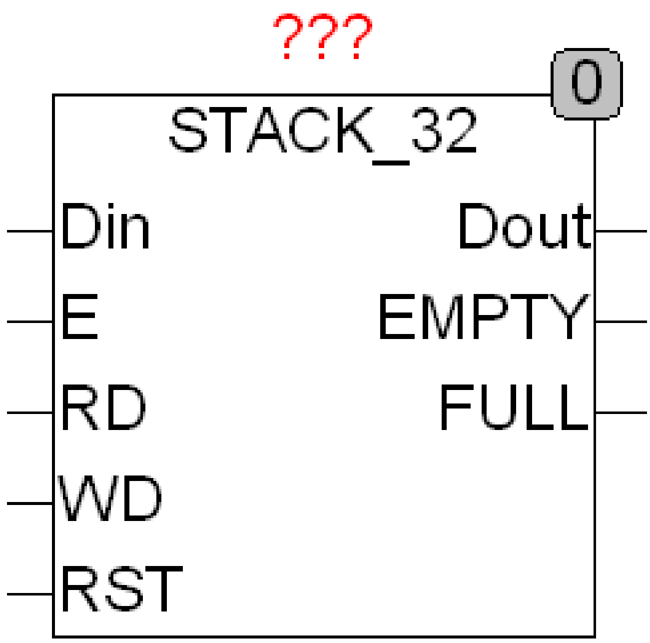
8.6.0.3 STACK_16

Type	Function module
Input DIN	DWORD (data input)
E	BOOL (enable input)
RD	BOOL (read command)
WD	BOOL (write command)
RST	BOOL (Reset input)
Output DOUT	DWORD (data output)
EMPTY	BOOL (EMPTY = TRUE means that memory is empty)
FULL	BOOL (FULL = TRUE means: memory is full)
	STACK_16 is a stack (STACK) with 16 memory locations for DWORD data. The two outputs EMPTY and FULL indicate when the memory is full or empty. The RST input clears the entire contents of the memory. The FIFO is set with DIN, by setting a TRUE to the input WD, and true to the input E. A read command is executed by TRUE to RD and TRUE to E. Reading and writing can be performed simultaneously in one cycle. The module reads or writes in each cycle as long as the corresponding command (RD, WD) is set to TRUE.



8.6.0.4 Type Function module

Input DIN	DWORD (data input)
E	BOOL (enable input)
RD	BOOL (read command)
WD	BOOL (write command)
RST	BOOL (Reset input)
Output DOUT	DWORD (data output)
EMPTY	BOOL (EMPTY = TRUE means that memory is empty)
FULL	BOOL (FULL = TRUE means: memory is full)
	STACK_32 is a stack (STACK) with 32 memory locations for DWORD data. The two outputs EMPTY and FULL indicate when the memory is full or empty. The RST input clears the entire contents of the memory. The FIFO is set with DIN, by setting a TRUE to the input WD, and true to the input E. A read command is executed by TRUE to RD and TRUE to E. Reading and writing can be performed simultaneously in one cycle. The module reads or writes in each cycle as long as the corresponding command (RD, WD) is set to TRUE.

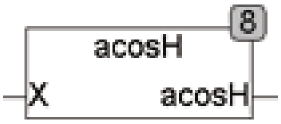

???
0
STACK_32
Din
Dout
E
EMPTY
RD
FULL
WD
RST

9. Mathematical

This section contains 132 modules.

9.0.1 ACOSH

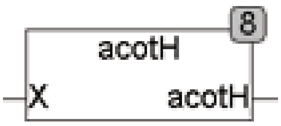
Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
ACOSH calculates the arcus hyperbolic cosine of the following formula	



$$ACOSH = \ln\left(X + \sqrt{X^2 - 1}\right)$$

9.0.2 ACOTH

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
Acoth calculates the arc cotangent hyperbolic with following formula	



$$acoth = \frac{1}{2}\ln\left(\frac{(x+1)}{(x-1)}\right)$$

9.0.3 AGDF

Type Function	REAL
Input X	REAL (input)
Output	REAL (Gundermann inverse function)
	AGDF calculates the inverse Gundermann function.
The calculation is done using the formula	

$$agdf = \ln\left(\frac{1+\sin(X)}{\cos(X)}\right)$$

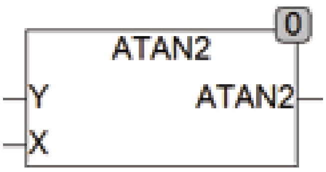
9.0.4 ASINH

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
ASINH calculate the arc hyperbolic sine by the formula	

$$asinh = \ln\left(X + \sqrt{X^2+1}\right)$$

9.0.5 ATAN2

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
	ATAN2 calculates the angle of coordinates (Y, X) in RAD. The result is between $-\pi$ and $+\pi$



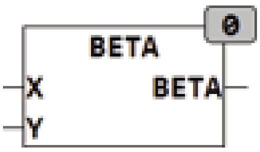
9.0.6 ATANH

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
ATANH calculates the Arcus Hyperbolic tangent as follows	

$$atanh = \frac{1}{2}\ln\left(\frac{(1+x)}{(1-X)}\right)$$

9.0.7 Type Function: REAL

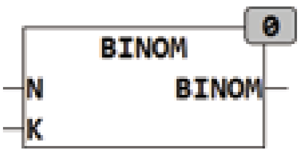
Input X	REAL (input)
Y	REAL (input value)
Output	REAL (output value)
	BETA computes the Euler Beta function.



$$B(x,y) = \int_0^1 t^{x-1}(1-t)^{y-1}\,\mathrm{d}t$$

9.0.8 Type Function: DINT

Input N	INT (input value)
K	INT (input value)
Output	DINT (output value)
	BINOM calculates the binominal coefficient N over K for integer N and K.

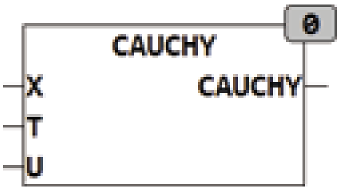


$$\binom{n}{k} = \frac{n!}{k! \cdot (n-k)!}$$

9.0.9 CAUCHY

Type Function	REAL
Input X	REAL (input)
T	REAL (input)
U	REAL (input)
Output	REAL (output value)

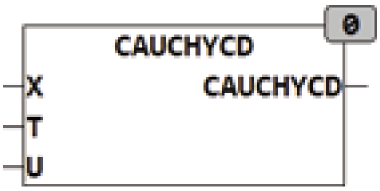
	CAUCHY calculates the density function for Cauchy.



$$f(x) = \frac{1}{\pi} \cdot \frac{s}{s^2 + (x - t)^2}$$

9.0.10 Type Function: REAL

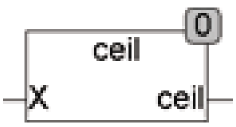
Input X	REAL (input)
T	REAL (input)
U	REAL (input)
Output	REAL (output value)
	CAUCHYCD calculated the distribution function after Cauchy.



$$F(x) = \frac{1}{2} + \frac{1}{\pi} \cdot \arctan\left(\frac{x - t}{s}\right)$$

9.0.11 Type Function: INT

Input X	REAL (input)
Output	INT (output value)
	The CEIL function returns the smallest integer value greater or equal than X.

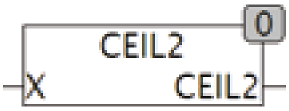


Example:
```
CEIL(3.14) = 4 CEIL(-3.14) = -3 CEIL(2) = 2
```

9.0.12 Type Function: DINT

Input X	REAL (input)
Output	DINT (output value)

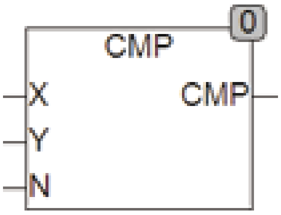
	The function returns the smallest integer value CEIL2 greater or equal to X.



Example:
`CEIL2(3.14) = 4 CEIL2(-3.14) = -3 CEIL2(2) = 2`

9.0.13 Type Function: BOOL

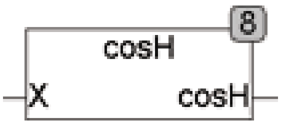
Input X, Y	REAL (input)
N	INT (number of digits to be compared)
Output	BOOL (result)
	CMP compares two REAL values if the first N points are equal.



Example:
```
CMP(3.140,3.149,3) = TRUE   CMP(3.140,3.149,4) = FALSE CMP(0.015,0,016,1) = TRUE
CMP(0.015,0,016,2) = FALSE
```
In the CMP function note that the dual coding of numbers a 0.1 in the decimal system can not necessarily always displayed as 0.1 in the binary system. Rather, it may happen that represented something less than 0.1 or greater because the resolution is not the number in binary coding allows exactly one 0.1. For this reason, the function can not detect for 100% the difference of 1 in the last position. In addition, note that a data type REAL with 32 bit has only a resolution of 7 - 8 decimal places.

9.0.14 COSH

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
COSH calculates the hyperbolic cosine using the formula	



$$\cosh = \frac{e^{X} + e^{-X}}{2}$$

9.0.15 COTH

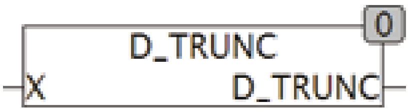
Type Function	REAL

Input X	REAL (input)
Output	REAL (output value)
COTH calculates the hyperbolic cotangent by the following formula	
	For input values larger than 20 or less than −20 COTH provides the approximate value +1 or −1 corresponding to an accuracy better than 8 digits and is thus below the resolution of type REAL.

$$\coth = \frac{e^{2X} + 1}{e^{2X} - 1}$$

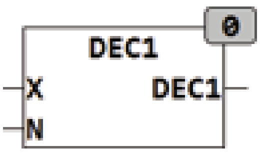
9.0.16 Type Function: DINT

Input X	REAL (input)
Output	DINT (output value)
	D _TRUNC returns the integer value of a REAL value as DINT. The IEC routine TRUNC() does not supports on all systems a TRUNC to DINT so that we have rebuilt this routine for compatibility. Unfortunately, even REAL_TO_DINT does not give on all systems the same result. D_TRUNC reviewes what result the IEC functions provides, and uses the appropriate function to deliver a useful result.
	D_TRUNC(1.6) = 1
	D_TRUNC(-1.6) = −1



9.0.17 Type Function: INT

Input INT	X (number of values X can be)
N	INT (the variable which is incremented)
Output	INT (Return Value)
	DEC1 counts the variable X from N-1 to 0 and then starts again at N-1, so that exactly N different starting values are generated at N-1 through 0.

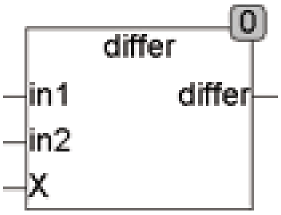


9.0.18 DEG

Type Function	REAL
Input Rad	REAL (angle in radians)
Output	REAL (angle in degrees)
	The function converts an angle value from radians to degrees. This takes into account the input may be not larger than 2.π. If RAD is greater than 2π, the equivalent to 2π is deducted until the input RAD is between 0 and 2π.
DEG(π) = 180 Grad,	DEG(3π) = 180 Grad
DEG(0) = 0 Grad,	DEG(2π) = 0 Grad

9.0.19 DIFFER

Type Function	BOOL
Input IN1	REAL (value 1)
IN2	REAL (value 2)
X	REAL (minimum difference in1 to in2)
Output	BOOL (TRUE if in1 and in2 differ by more than x from each other)
	The function DIFFER is TRUE if in1 and in2 differ by more than X from each other.

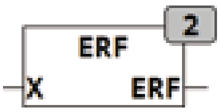


$$differ = |(in1 - in2)| > X$$

Example:
`Differ(100, 120, 10) returns TRUE Differ(100,110,15) returns FALSE`

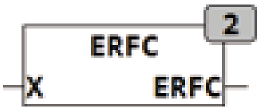
9.0.20 Type Function: REAL

Input X	REAL (input)
Output	REAL (result)
	The ERF function calculates the error function of X. The error function is calculated using an approximation formula, the maximum relative error is smaller than 1,3 * 10-4 .



9.0.21 Type Function: REAL

Input X	REAL (input)
Output	REAL (result)
	The function ERFC calculates the inverse error function of X.



9.0.22 Type Function: BOOL

Input in	DINT (input)
Output	BOOL (TRUE, if in straight)
	The function EVEN = TRUE if the input IN is even and FALSE for odd IN.

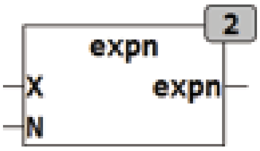
Example:
`EVEN(2) is TRUE EVEN(3) returns FALSE`

9.0.23 Type Function: REAL

Input X	REAL (input)
Output	REAL (exponential base 10)
	The function Exp10 returns the exponential base 10
	Exp10 (2) = 100
	EXP10(0) = 1
	EXP10(3.14) = 1380.384265

9.0.24 Type Function: REAL

Input X	REAL (input)
N	INT (exponential)
Output	REAL (result X^N)
	EXPN calculates the exponential value of X^N for integer N. EXPN is especifically written for PLC without Floating Point Unit and is about 30 times faster than the IEC standard function EXPT(). Note the special case of the 0^0 defined mathematically as a 1 and is not a 0.
EXPN(10,-2) = 0.01	EXPN(1.5,2) = 2.25
	EXPN(0,0) = 1



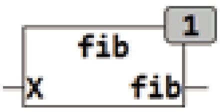
9.0.25 Type Function: DINT

Input X	INT (input)
Output	DINT (Faculty of X)
	The function FACT calculates the factorial of X.
	It is defined for input values from 0 .. 12. For values less than zero and greater than 12 is the result −1. For the factorial of larger numbers, the GAMMA function is suitable.
For natural numbers X	X! = 123...*(X-1)*X, 0! = 1
	Faculties of negative or non-whole numbers are not defined.

Example:
`1! = 1 2! = 1*2 = 2 5! = 1*2*3*4*5 = 120`

9.0.26 Type Function: DINT

Input X	INT (input)
Output	DINT (Fibonacci numbers)
FIB calculate the Fibonacci number The Fibonacci number is defined as follows	
	FIB(0) = 0, FIB(1) = 1, FIB(2) = 1, FIB(3) = 2, FIB(4) = 3, FIB(5) = 5 .....
	The Fibonacci number of X is equal to the sum of the Fibonacci numbers of X-1 and X-2. The function can compute the Fibonacci numbers up to 46, if X < 0 or greater than 46, the function returns −1.



9.0.27 Type Function: INT

Input X	REAL (input)
Output	INT (output value)
	The FLOOR function returns the greatest integer value less or equal to X.

Example:
`FLOOR(3.14) = 3 FLOOR(-3.14) = -4 FLOOR(2) = 2`

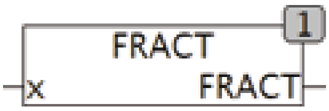
9.0.28 Type Function: DINT

Input X	REAL (input)
Output	DINT (output value)
	The function floor2 returns the largest integer value less or equal than X back.

Example:
`FLOOR2(3.14) = 3 FLOOR2(-3.14) = -4 FLOOR2(2) = 2`

9.0.29 Type Function: REAL

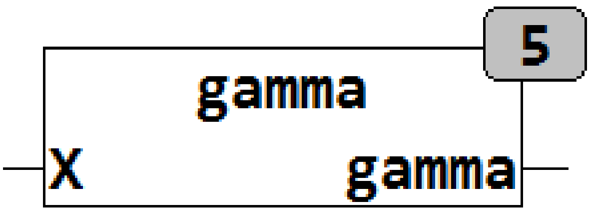
Input X	REAL (input)
Output	REAL (fractional part of X)
	The function Fract returns the fractional part of X .



Example:
`FRACT(3.14)`
results 0.14. For X greater than or less than +/- 2.14 * 10^9 Fract always provides a zero return. As the resolution of a 32bit REAL is a maximum of 8 digits, from numbers larger or smaller than +/- 2.14 * 10 9 no fractional part can be determined, because this part can also not be stored in a REAL variable.

9.0.30 GAMMA

Type Function	REAL
Input X	REAL (input)
Output	REAL (Gamma function)
	The function GAMMA calculates the gamma function after approximation of NEMES.
	The gamma function can be used for Integer X as replacement for the Faculty.



$$GAMMA(x) = \sqrt{\frac{2\pi}{x}} * \left(\frac{1}{e}\left(x + \frac{1}{12x - \frac{1}{10x}}\right)\right)$$

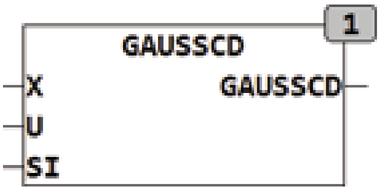
9.0.31 GAUSS

Type Function	REAL
Input X	REAL (input)
U	REAL (locality of the function)
SI	REAL (Sigma, spreading the function)
Output	REAL (Gaussian function)
The function calculates the Gaussian normal distribution using the following formula	
	The normal distribution is the density function normally distributed random variables. With the parameters U = 0 and SI = 1, it follows the standard normal distribution.

$$gauss = \frac{1}{SI * \sqrt{2\pi}} * e^{-\frac{1}{2} * \left(\frac{X-U}{SI}\right)^2}$$

9.0.32 GAUSSCD

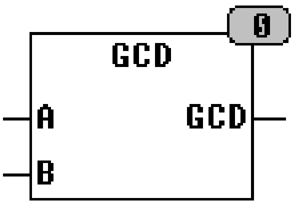
Type Function	REAL
Input X	REAL (input)
U	REAL (locality of the function)
SI	REAL (Sigma, spreading the function)
Output	REAL (Gaussian distribution function)
The function GAUSSCD calculated the distribution function for normal distribution using the following formula	
	The normal distribution is the density function normally distributed random variables. With the parameters U = 0 and SI = 1, it follows the standard normal distribution. The distribution function (Cumulative Distribution Function).



$$gausscd = \frac{1}{2} erf\left(\left(X - U\right) * SI * \sqrt{\pi}\right)$$

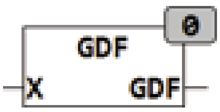
9.0.33 GCD

Type	Function
Input A	DINT (input value A)
B	DINT (input value B)
Output	INT (Greatest common divisor)
	The GCD function calculates the greatest common divisor (GCD) of A and B.



9.0.34 GDF

Type Function	REAL
Input X	REAL (input)
Output	REAL (Gundermann function)
	GDF calculate the Gundermann function.
The calculation is done using the formula	
	The result of GDF is between -π/2 and + π/2
	GDF(0) = 0



$$gdf = 2\,atan\left(e^{X}\right) - \frac{\pi}{2}$$

9.0.35 GOLD

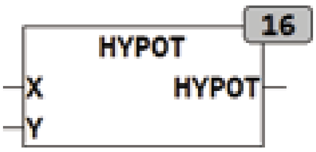
Type Function	REAL

Input X	REAL (input)
Output	REAL (result of the Golden function)
	GOLD calculates the result of the golden feature. GOLD (1) gives the golden ratio, and GOLD (0) returns 1. GOLD (X) * GOLD (-X) is always 1. GOLD (X) is the positive result of the quadratic equation and -GOLD(-X) is the negative result of the quadratic equation.
The calculation is done using the formula	

$$gold = \frac{(X + \sqrt{X^2 + 4})}{2}$$

9.0.36 HYPOT

Type Function	REAL
Input X	REAL (X - value)
Y	REAL (Y - value)
Output	REAL (length of the hypotenuse)
	The Mortgage function calculates the hypotenuse of a right triangle, by the theorem of Pythagoras.

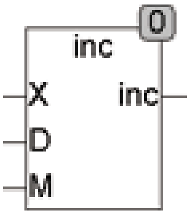


$$hypot = \sqrt{x^2 + Y^2}$$

9.0.37 Type Function: INT

Input X	INT (input)
D	INT (value to be added to the input value)
M	INT (maximum value for the output)
Output	INT (output value)
	INC adds to the input X the Value D and ensures that the output INC is not does not exceed the value of M. If the result from the addition of X and D is greater than M, then it starts again at 0. The feature is especially useful when addressing arrays and buffers. Even the positioning of absolute encoders it can be used. INC can be used to decrementieren with a negative D, while INC will ensure that the result is not below zero. If subtract 1 from zero INC starts again at M.
INC	= X + D, because D can take the maximum value M.

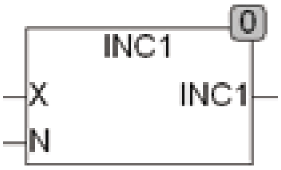
	If INC > M so INC starts again at 0.
	If INC < 0 so INC starts again at M



Example:
`INC(3, 2, 5) ergibt 5 INC(4, 2, 5) ergibt 0 INC(0,-1,7) ergibt 7`

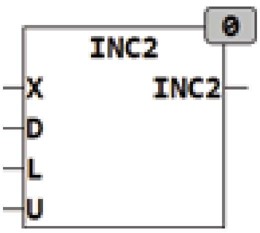
9.0.38 Type Function: INT

Input X	INT(number of values X can be)
	N INT(the variable that is incremented)
Output	INT (Return Value)
	INC1 count the variable X from 0.. N-1 and then starts again from 0, so that exactly N different values are produced starting from 0.



9.0.39 Type Function: INT

Input X	INT (input)
D	INT (value to be added to the input value)
L	INT (lower limit)
U	INT (upper limit)
Output	INT (output value)
	INC2 addes valued D to the input X and ensures that the output INC does not exceed the value U (upper limit) or under-run the value L (low limit). If the result from the addition of X and D is larger than U so it begins again with L. It is ensured that at negative D when reaching L counted again at U on. The feature is especially useful when addressing arrays and buffers. Even the positioning of absolute encoders it can be used. INC2 can be used to decrementieren with a negative D, while INC2 will ensure that the result is not below zero.
INC2	= X + D, where L <= INC2 <= U.

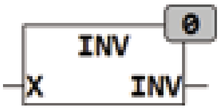


Example:

```
INC2(2, 2, -1, 3) result -1 INC2(2, -2, -1, 3) result 0 INC2(2, 1, -1, 3) result 3
INC2(0, -2, -1, 3) result 3
```

9.0.40 INV

Type Function	REAL
Input X	REAL (input)
Output	REAL (1 / X)
INV calculates the inverse of X	



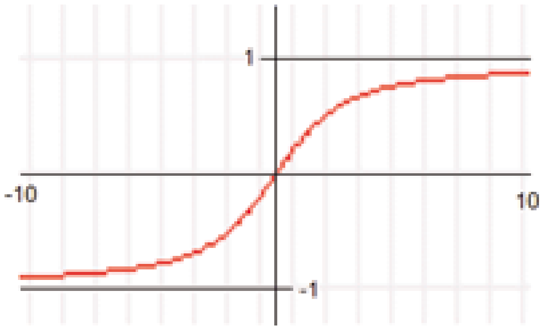
$$INV = \frac{1}{X}$$

9.0.41 LAMBERT_W

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
	The LAMBERT_W function is defined for x > = −1/e. When the value is below the range the is result −1000. The range of LAMBERT_W function is >= −1.

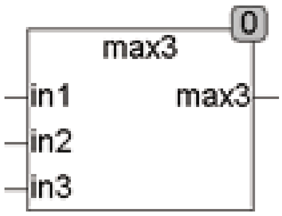
9.0.42 LANGEVIN

Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
	The The Langevin Function is very similarto sigmoid function, but more slowly approaching the limits. In contrast to the sigmoid are the values at −1 and +1. The Langevin function is mainly at CPUs without floating point unit much faster than the Sigmoid function.
The following chart shows the progress of the Langevin function	



9.0.43 MAX3

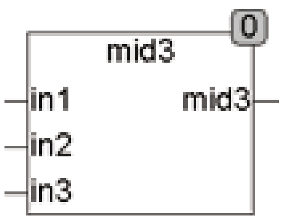
Type Function	REAL
Input IN1	REAL (input 1)
IN2	REAL (input 2)
IN3	REAL (input 3)
Output	REAL (maximum of 3 inputs)
	The function MAX3 delivers the maximum value of 3 inputs. Basically, the in standard IEC61131-3 contained function MAX should be equipped with a variable number of inputs. However, since in some systems the MAX function is supported only two inputs, the function MAX3 is offered.



Example:
`MAX3(1,3,2) = 3.`

9.0.44 MID3

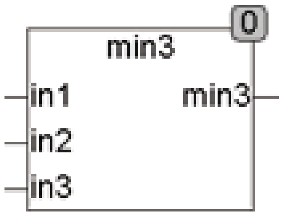
Type Function	REAL
Input IN1	REAL (input 1)
IN2	REAL (input 2)
IN3	REAL (input 3)
Output	REAL (mean value of the 3 inputs)
	The function MID3 returns the average value of 3 inputs, but not the mathematical average.



Example:
`MID3(1,5,2) = 2.`

9.0.45 MIN3

Type Function	REAL
Input IN1	REAL (input 1)
IN2	REAL (input 2)
IN3	REAL (input 3)
Output	REAL (Minimum 3 inputs)
	The function MIN3 returns the minimum value of 3 inputs. Basically, the function MIN in standard functionality IEC61131-3 should have a variable number of inputs. However, since in some systems the function MIN supportes only two inputs, the function MIN3 is available.



Example:
`MIN3(1,3,2) = 1.`

9.0.46 MODR

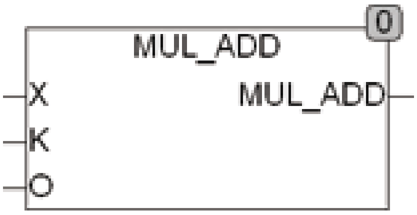
Type Function	REAL
Input IN	REAL (Dividend)
DIVI	REAL (divisor)
Output	REAL (remainder of division)
	The function MODR returns the remainder of a division similar to the standard MOD function, but for REAL numbers. MODR internally uses the data format of type DINT. This may come to an overflow because DINT can store a maximum of +/-2.14 * 10^{9} The range of MODR is therefore limited to +/- 2.14 * 10 9. For DIVI = 0 the function returns 0.
	MODR(A, M) = A - M * FLOOR2(A / M).

Example:
`MODR(5.5, 2.5) result 0.5.`

9.0.47 MUL_ADD

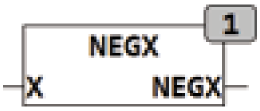
Type Function	REAL

Input X	REAL (input)
K	REAL (multiplier)
O	REAL (offset)
Output	REAL (output value)
	MUL_ADD multiplies the input value X with K and adds O.
	MUL_ADD = X * K + O. MUL_ADD (0.5, 10, 2) is 0.5 * 10 + 2 = 7



9.0.48 NEGX

Type Function	REAL
Input X	REAL (input)
Output	REAL (-X)
	NEGX returns the negated input value (-x).



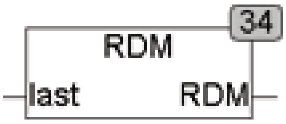
9.0.49 RAD

Type Function	REAL
Input DEG	REAL (angle in degrees)
Output	REAL (angle in radians)
	The RAD function converts an angle value from degrees to radians. Taking into account that the DEG will not be greater than 360. If DEG is greater than 360, 360 is to be subtracted as long as DEG is again between 0-360 °.
RAD(0) = 0	RAD(180) = π RAD(360) = 0 RAD(540) = π

9.0.50 RDM

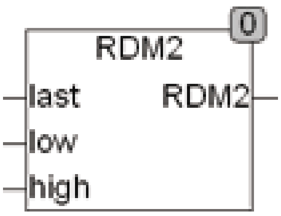
Type Function	REAL
Input LAST	REAL (last calculated value)
Output	REAL (random number between 0 and 1)

	RDM calculates a pseudo- random number. This is the PLC's internal Timer read and converted into a pseudo-random number. Because RDM's is written as a function and not as a function module, it can not save data between 2 calls and should therefore be used with caution. RDM is only called once per cycle, it produces reasonable good results. But when it is repeatedly called within a cycle, it delivers the same number, most likely because of the PLC timer is still on the same value. If the function is repeatedly used within a cycle, so it must be passed with each call a different number of starts (LAST). It shall be called only once per cycle, is sufficient to call RDM(0). As a starting number for each call, the last calculated number of RDM can be used. Supplied by RDM random numbers between 0 and 1, which does not contain 1 (0 <=random number < 1)



9.0.51 RDM2

Type Function	INT
Input LAST	INT (last calculated value)
LOW	INT (lowest generated value)
HIGH	INT (highest generated value)
Output	INT (random number between LOW and HIGH)
	RDM2 generates an integer random value in the range from LOW to HIGH, where LOW and HIGH are being included in the range of values. If the function is used only once per cycle, the input value LAST can remain at 0. The function RDM2 used the PLC internal time base to generate the random number. Since RDM2 uses LAST, an integer which represents the final result between LOW and HIGH, it can lead to a situation, in which the result RDM2 always produces the same result, as long as PLC Timer does not change in a cycle. This most often happens, if the result is identical to the start value. Since then, the same start value will be reused within the same cycle again, and the result is the same. This occurs more often, depending on, if the specific area of LOW and HIGH is smaller for the result. One can avoid this effect easily by using as a starting value of loop counter which definitely uses each time a new value, or better yet add a loop counter with the final result used as initial value.



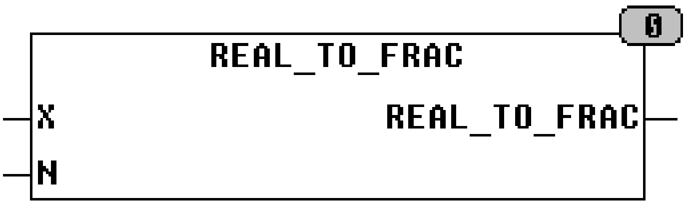
9.0.52 RDMDW

Type Function	DWORD
Input LAST	DWORD (last calculated value)
Output	DWORD (Random Pattern)

	RDMDW charges pseudo - random number with 32 bits in length in the format DWORD. This is the PLC's internal timer that is read and is transferred into a pseudo random number. Since RDMDW as a function and was not written as a function module, it can not save data between 2 calls and should therefore be used with caution. If RDMDW called only once per cycle, it produces reasonable good results. But when it is repeatedly called within a cycle, it delivers the same number, most likely because of the PLC timer is still on the same value. If the function is repeatedly used within a cycle, so it must be passed with each call a different number of starts (LAST). If it be called only once per cycle, it is sufficient to call RDMDW(0). As a starting number for each call, the last number accounted by RDMDW be used. That result from RDMDW is a random 32-bit wide bit pattern.

9.0.53 REAL_TO_FRAC

Type Function	FRACTION
Input X	REAL (input)
N	INT (maximum value of the denominator)
Output	FRACTION (output value)
	REAL_TO_FRAC converts a floating point number (REAL) in a fraction. The function returns the data type is a FRACTION of the structure with 2 values. With the input X, the maximum size of the counter can be specified.
Data type FRACTION	
***.NUMERATOR**	INT (Numerator of the fraction)
***.DENOMINATOR**	INT (Denominator of the fraction)

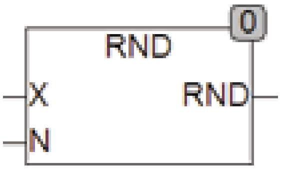


Example:
`REAL_TO_FRAC(3.1415926, 1000)`
results 355 / 113. 355/133 gives the best approximation for the denominator < 1000

9.0.54 RND

Type Function	REAL
Input X	REAL (input)
N	integer (number of digits)
Output	REAL (rounded value)
	The function R ND rounds the input value IN to N digits. Follows the last point a number that is greater than 5, the last digit is rounded up. RND internally uses

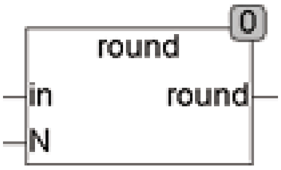
	the standard function TRUNC() which converts the input value to an INTEGER type DINT. This may come as an overflow because DINT can store in maximum +/-2.14*10^9. The range of the RND is therefore limited to +/-2.14*10^9 . See also the ROUND function which rounds the input value to N decimal places.



Example:
`RND(355.55, 2) = 360 RND(3.555, 2) = 3.6 ROUND(3.555, 2) = 3.56`

9.0.55 ROUND

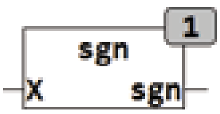
Type Function	REAL
Input IN	REAL (input value)
N	integer (number of decimal places)
Output	REAL (rounded value)
	The function ROUND rounds the input value IN to N digits. Follows the last digit a digit greater than 5 the last digit is rounded up. ROUND internally uses the standard function TRUNC() which converts the input value to an INTEGER type DINT. This may come as an overflow because DINT can store in maximum +/-2.14*10 9. The range of ROUND is therefore limited to +/- 2.14 * 10 9.



Example:
`ROUND(3.555, 2) = 3.56`

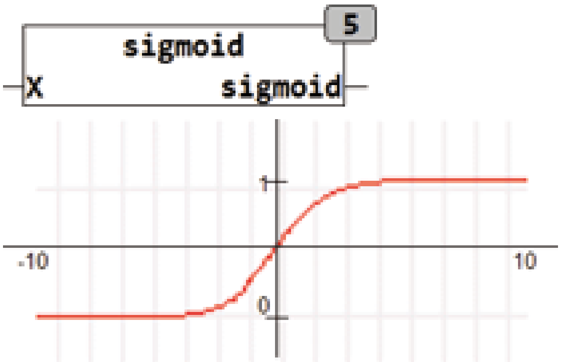
9.0.56 Type Function: INT

Input X	REAL (input)
Output	INT (Signum the input X)
	The function SGN calculates the Signum of X.
	SGN = +1 if X > 0
	SGN = 0 if X = 0
	SGN = −1 if X < 0



9.0.57 Type Function: INT

Input X	REAL (input)
Output	REAL (result of Sigmoid)
The Sigmoid is also named Gooseneck - function and described by the following equation	
	SIGMOID = 1 / (1 + EXP(-X))
	The Sigmoid is often used as activation function. By its behavior the Sigmoid is qualified for soft switching transitions.
The following chart illustrates the progress of the Sigmoid	



9.0.58 Type Function: BOOL

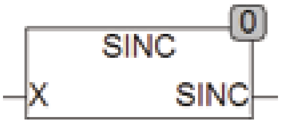
Input IN	DINT (input)
Output	BOOL (TRUE if the input is negative)
	The function SIGN_I returns TRUE if the input value is negative. The input values are of type DINT.

9.0.59 Type Function: BOOL

Input IN	REAL (input)
Output	BOOL (TRUE if the input is negative)
	The SIGN_R function returns TRUE if the input value is negative. The input values are of type REAL.

9.0.60 SINC

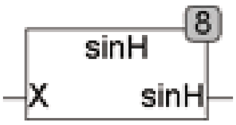
Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
	SINC calculates the sine Kardinalis or the gap function.
	Mit SINC(0) = 1.



$$\sinh = \frac{\left(e^{X} - e^{-X}\right)}{2}$$

9.0.61 SINH

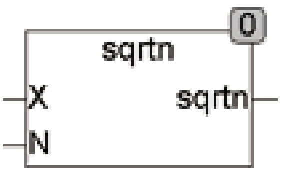
Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
SINH calculates the sinus Hyperbolic according the following formula	



$$\sinh = \frac{\left(e^{X} - e^{-X}\right)}{2}$$

9.0.62 SQRTN

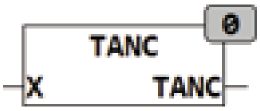
Type Function	REAL
Input X	REAL (input)
N	INT (input value)
Output	REAL (output value)
SQRTN calculates the N-fold root of X as follows	



$$sqrtn = \sqrt[N]{X}$$

9.0.63 TANC

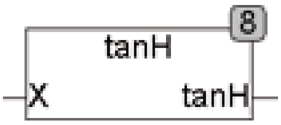
Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
TANC TANC function calculates the following formula	
	with TANC(0) = 1.



$$tanc = \frac{\tan(X)}{X}$$

9.0.64 TANH

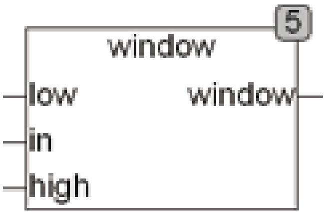
Type Function	REAL
Input X	REAL (input)
Output	REAL (output value)
TANH calculates the Tangent Hyperbolic according to the following formula	



$$\tanh = 1 - \frac{2}{e^{-2} + 1}$$

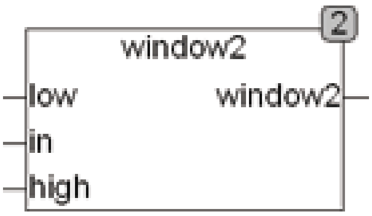
9.0.65 WINDOW

Type Function	BOOL
Input LOW	REAL (lower limit)
IN	REAL (input value)
HIGH	REAL (upper limit)
Output	BOOL (TRUE, if in < HIGH and in > LOW)
	The WINDOW function tests whether the input value is within the limits defined by the LOW and HIGH.
	WINDOW is exactly TRUE if IN < HIGH and IN > LOW.



9.0.66 Type Function: BOOL

Input LOW	REAL (lower limit)
IN	REAL (input value)
HIGH	REAL (upper limit)
Output	BOOL (TRUE, if in <= HIGH and in >= LOW)
	The WINDow2 function tests whether the input value IN <= HIGH and IN >= LOW. In contrast to the function WINDOW which returns TRUE if the IN is within the limits LOW and HIGH WINDOW2 supplies FALSE if IN is outside the limits LOW and HIGH .

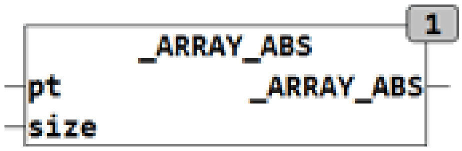


9.1 Mathematical / Array

This section contains 36 modules.

9.1.0.1 _ARRAY_ABS

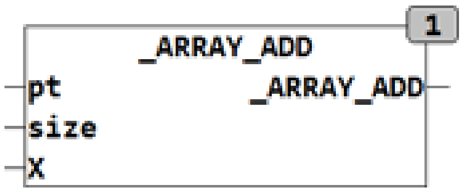
Type Function	BOOL
Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
Output	BOOL (TRUE)
The function _ARRAY_ABS calculates the elements of an arbitrary array Of REAL in an absolute value. When called, a pointer to the array and its size in bytes is transferred to the function. Under CoDeSys the call reads	_ARRAY_ABS(ADR(Array), SIZEOF(array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.
Call	_ARRAY_ABS(ADR(bigarray), SIZEOF(bigarray))



Example:
```
[0,-2,3,-1-5]   is converted to [0,2,3,1,5]
```

9.1.0.2 _ARRAY_ADD

Type Function	BOOL
Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
X	REAL (added value)
Output	BOOL (TRUE)
The function _ARRAXY_ADD adds to each element of an arbitrary array of REAL value X. When called a Pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_ARRAY_ADD(ADR(Array), SIZEOF(Array), X), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.
Call	_ARRAY_ADD(ADR(bigarray), SIZEOF(bigarray), X)

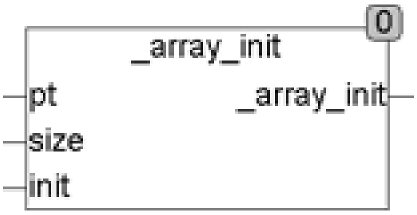


Example:
```
[0,-2,3,-1-5]   [0,-2,3,-1-5], X = 3 is converted into [3,1,6,2,-2]
```

9.1.0.3 _ARRAY_INIT

Type Function	BOOL
Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
INIT	REAL (initial value)
Output	BOOL (TRUE)
The function _ARRAY_INIT initializes an arbitrary array of REAL with an initial value. When called, a pointer to the array and its size in bytes is transferred to the function. Under CoDeSys the call reads	_ARRAY_INIT(ADR(Array), SIZEOF(Array), INIT), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size

	of the array. The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
`_ARRAY_INIT(ADR(bigarray), SIZEOF(bigarray), 0) initialized bigarray with 0.`

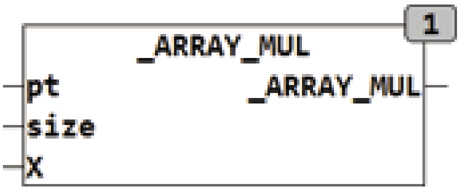
9.1.0.4 Type Function: REAL

Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (median of the array)
The function _ARRAY_MEDIAN calculates the median value of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_ARRAY_MEDIAN(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the median value the array referenced by the pointer is sorted in the memory and remains after function end sorted. The function _ARRAY_MEDIAN thus changes the contents of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.
	If an array is processed, which should not be changed, so it has to be copied to a temporary array before handing over the Pointer and calling the function.

Example:
`_ARRAY_MEDIAN(ADR(bigarray), SIZEOF(bigarray)) Median Value:`
The median is the middle value to a sorted set of values. Median of (12, 0, 4, 7, 1) is 4 After running the function the array remains sorted in memory (0, 1, 4, 7, 12). If the array contains an even number of elements the median is the average of the two middle values of the array.

9.1.0.5 _ARRAY_MUL

Type Function	BOOL
Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
X	REAL (multiplier)
Output	BOOL (TRUE)
The function _ARRAY_MUL multiply each element of an arbitrary array of REAL with the value X. When called a Pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	_ARRAY_MUL(ADR(Array), SIZEOF(Array), X), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.
Call	_ARRAY_MUL(ADR(bigarray), SIZEOF(bigarray), X)



Example:

```
[0,-2,3,-1-5], X = 3 is converted into [0, -6,9,-3,-15]
```

9.1.0.6 _ARRAY_SHUFFLE

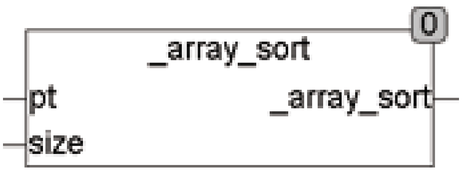
Type Function	BOOL
Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	BOOL (result TRUE)
The function _array _ SHUFFLE exchanges the elements of an arbitrary array Of REAL at random. When called, a Pointer to the array and its size in bytes is transferred to the function. Under CoDeSys is the call	_ARRAY_SHUFFLE(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. The array referenced by the Pointer is manipulated directly in memory and is available directly after exit the function. The function _ARRAY_SHUFFLE thus changes the contents of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.
	If an array is processed, which should not be changed, so it has to be copied to a temporary

	array before handing over the Pointer and calling the function.
Output array	(0,1,2,3,4,5,6,7,8,9)
Results	(5,0,3,9,7,2,1,8,4,6)
	The result is not repeatable, the function returns after each call or even restart a new order.

Example:
`_ARRAY_SHUFFLE (ADRs(bigarray), SIZEOF(bigarray))`
A call of the function _ARRAY_SHUFFLE could change an array as follows. Since the function uses a pseudo random algorithm each time the result is different, the results are not reproducible, even through a restart of the program or the programmable logic control (plc).

9.1.0.7 Type Function: BOOL

Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	BOOL (TRUE)
The function _array_SORT sorts an arbitrary array of REAL in ascending order. When called, a pointer to the array and its size in bytes is transferred to the function. Under CoDeSys the call is	_ARRAY_SORT(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array.
	The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

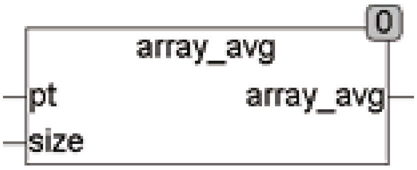


Example:
`_ARRAY_SHUFFLE (ADRs(bigarray), SIZEOF(bigarray))`

9.1.0.8 Type Function: REAL

Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (mean value of the array)

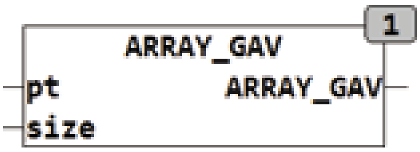
The function _ARRAY_AVG calculates the median value of an arbitrary array ofREAL. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_AVG(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_AVG does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
`ARRAY_AVG(ADR(bigarray), SIZEOF (bigarray))`

9.1.0.9 Type Function: REAL

Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (mean value of the array)
[fuzzy] The function _ARRAY_GAV calculates the median value of an arbitrary array of REAL. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_GAV(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_GAV does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

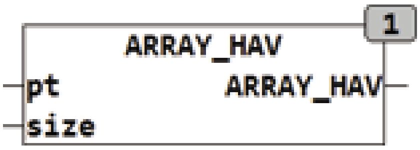


Example:
`ARRAY_GAV(ADR(bigarray), SIZEOF(bigarray))`

9.1.0.10 Type Function: REAL

Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (mean value of the array)

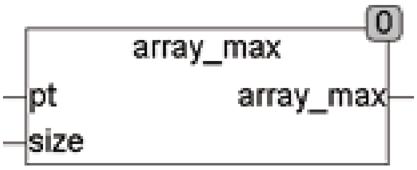
The function _ARRAY_HAV calculates the harmonic median value of an arbitrary array of REAL. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_HAV(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_HAV does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
`ARRAY_HAV(ADR(bigarray), SIZEOF (bigarray))`

9.1.0.11 Type Function: REAL

Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (maximum value of the array)
The function _ARRAY_REAL calculates the maximum value of an arbitrary array of-REAL. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_MAX(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_MAX does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

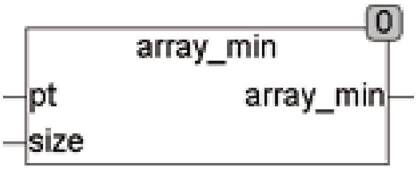


Example:
`ARRAY_MAX(ADR(bigarray), SIZEOF(bigarray))`

9.1.0.12 ARRAY_MIN

Type Function	REAL
Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)

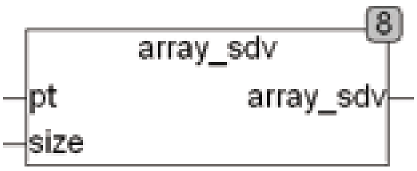
Output	REAL (minimum value of the array)
The function ARRAY_MIN calculates the minimum value of any array of REAL. When called the function passed a Pointer to the array and its size in bytes. Under CoDeSys the call reads	ARRAY_MIN(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY _ MIN does not change the contents of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
`ARRAY_MIN(ADR(bigarray), SIZEOF(bigarray))`

9.1.0.13 Type Function: REAL

Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (standard deviation of the array)
The function _ARRAY_SDV calculates the standard deviation (Standard Deviation) value of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_SDV(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_SDV does not change the contents of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

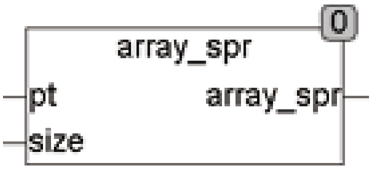


Example:
`ARRAY_SDV(ADR(bigarray), SIZEOF(bigarray))`

9.1.0.14 ARRAY_SPR

Type Function	REAL
Input PT	Pointer (Pointer to the array)

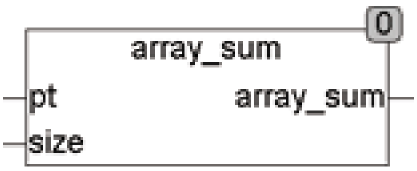
SIZE	UINT (size of the array)
Output	REAL (dispersion of the array)
The function ARRAY_SPR determines the dispersion of an arbitrary array of REAL. The dispersion is the maximum value in the array minus the minimum value of the array. When called, a Pointer to the array and its size in bytes is transferred to the function. Under CoDeSys the call reads	ARRAY_SPR(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_SPR does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
```
ARRAY_SPR(ADR(bigarray), SIZEOF(bigarray)) = maximumvalue(bigarray) -
minimalvalue(bigarray)
```

9.1.0.15 Type Function: REAL

Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (sum of all values of the array)
The function _ARRAY_SUM calculates the sum of all values of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_SUM(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_SUM does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
```
ARRAY_SUM(ADR(bigarray), SIZEOF(bigarray))
```

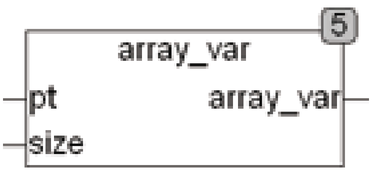
9.1.0.16 Type Function: REAL

Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (development trend of the array)
The function _ARRAY_TREND calculates the trend development of all values of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_TREND(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the trend, the array referenced by the pointer is scanned directly in memory. The function ARRAY_TREND does not change the content of the array. This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied. The trend is determined by subtract the average of the lower half of the values of the array from the average of the values of the upper half of the array.

Example:
```
[fuzzy] ARRAY_AVG(ADR(bigarray), SIZEOF (bigarray))
```

9.1.0.17 Type Function: REAL

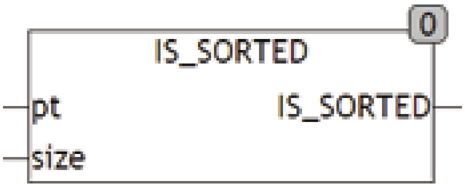
Input PT	Pointer (Pointer to the array)
SIZE	UINT (size of the array)
Output	REAL (variance of the array)
The function _ARRAY_VAR calculates the variance of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads	ARRAY_VAR(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function, which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_VAR does not change the content of the array.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



Example:
```
ARRAY_VAR(ADR(bigarray), SIZEOF(bigarray))
```

9.1.0.18 Type Function: BOOL

Input PT	Pointer (pointer to the array)
SIZE	UINT (size of the array)
Output	BOOL (TRUE)
The function IS_SORTED checks whether any array of REAL is sorted in ascending order. When called, a pointer to the array and its size in bytes is transferred to the function. Under CoDeSys the call is	_ARRAY_SORT(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array.
	The function returns TRUE if the array is sorted in ascending order.
	This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.



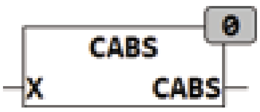
Example:
`IS_SORTED(ADR(bigarray), SIZEOF(bigarray))`

9.2 Mathematical / Complex

This section contains 52 modules.

9.2.0.1 Type Function: REAL

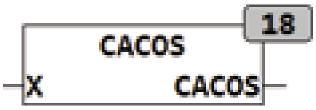
Input X	COMPLEX (Input)
Output	REAL (result)
	CABS calculates the length of the vector of a complex number The absolute value is also module or Magnitude mentioned.
	CABS = SQRT(X.RE² + X.IM²)



9.2.0.2 CaCO

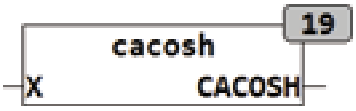
Type Function	COMPLEX
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	Cacos calculates the arc cosine of a complex number

	The range of values of the result is between [0, π] for the real part and [-∞, +∞] for the imaginary part.



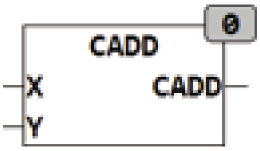
9.2.0.3 CACOSH

Type Function	COMPLEX
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CACOSH calculates the arc hyperbolic cosine of a complex number
	[fzy] The range of values of the result is between [- [illegible] ,+ [illegible]] For the imaginary part.



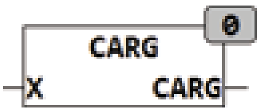
9.2.0.4 Type Function: COMPLEX

Input X	COMPLEX (Input)
Y	[COMPLEX(../../Data Types/complex.md) (Input value)
Output	COMPLEX (result)
	CADD adds two complex numbers X and Y.



9.2.0.5 CARG

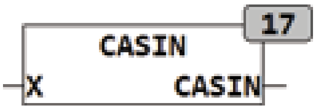
Type Function	REAL
Input X	COMPLEX (Input value)
Output	REAL (result)
	CARG calculates the angle of a complex number in the coordinate system.
	The range of values of the result is between [-π , +π].



9.2.0.6 CASIN

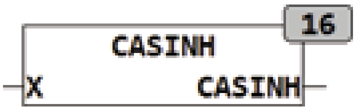
Type Function	COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CASIN calculates the arc sine of a complex number
	The range of values of the result is between [-π/2,+π/2] For the imaginary part.



9.2.0.7 CASINH

Type Function	COMPLEX
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CASINH calculates the arc hyperbolic sine of a complex number
	[fzy] The range of values of the result is between [- π ,+ π] For the imaginary part.

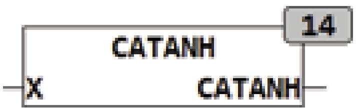


9.2.0.8 CATAN

Type Function	COMPLEX
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	ATAN calculates the arc tangent of a complex number
	The range of values of the result is between [-π/2,+π/2] For the imaginary part.

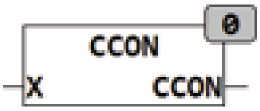
9.2.0.9 CATANH

Type Function	COMPLEX
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CATANH calculates the arc hyperbolic tangent of a complex number
	The range of values of the result is between [- π/2,+π/2] for the imaginary part.



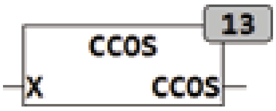
9.2.0.10 Type Function: COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CCON calculated the conjugation of a complex number
	CCON.RE = X.RE
	CCON.IM = -X.IM



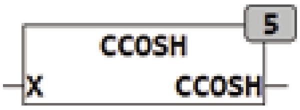
9.2.0.11 Type Function: COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CCOs calculates the cosine of a complex number



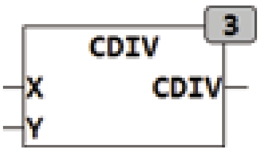
9.2.0.12 Type Function: COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CCOSH calculates the hyperbolic cosine of a complex number



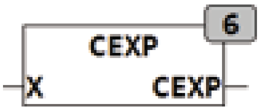
9.2.0.13 Type Function: COMPLEX

Input X	COMPLEX (Input)
Y	[COMPLEX(../../Data Types/complex.md) (Input value)
Output	COMPLEX (result)
	CDIV dividing two complex numbers X / Y.



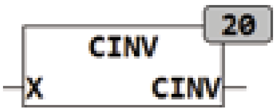
9.2.0.14 Type Function: COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CEXP calculates the complex exponent to base E, CEXP = E^X.



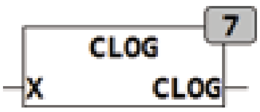
9.2.0.15 Type Function: COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CINV calculated the reciprocal of a complex number, CINV = 1/X



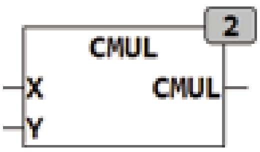
9.2.0.16 CLOG

Type Function	COMPLEX
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CLOG calculates the natural logarithm of a complex number raised to E.
	CLOG(X) = LOG(e)(X).



9.2.0.17 Type Function: COMPLEX

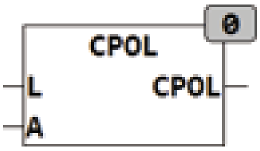
Input X	COMPLEX (Input)
Y	[COMPLEX(../../Data Types/complex.md) (Input value)
Output	COMPLEX (result)
	CMUL Multiplies two complex numbers X and Y.



9.2.0.18 Type Function: COMPLEX

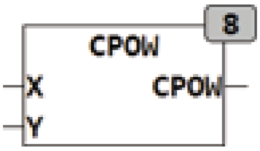
Input L	REAL (Length or Radius)
A	REAL (Angle value)

Output	COMPLEX (result)
	CPOL produces a complex number in polar form. The input values of L and A specify the length (radius) and the angle.



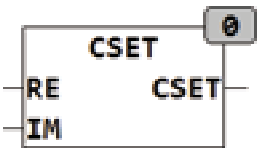
9.2.0.19 Type Function: COMPLEX

Input X	COMPLEX (Input)
Y	COMPLEX (input value of 2)
Output	COMPLEX (result)
	CPOW calculates the power of two Complex numbers, CPOW = X^Y.



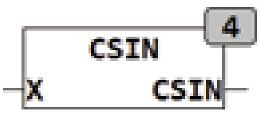
9.2.0.20 Type Function: COMPLEX

Input RE	COMPLEX (Real input)
IM	REAL (Imaginary input)
Output	COMPLEX (result)
	CSET generated from the two input components RE and IM is a complex number of type COMPLEX.



9.2.0.21 Type Function: COMPLEX

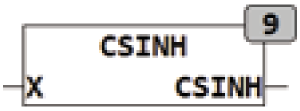
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	Csin calculates the sine of a complex number



9.2.0.22 Type Function: COMPLEX

Input X	COMPLEX (Input)

Output	COMPLEX (result)
	CSINH calculates the hyperbolic sine of a complex number

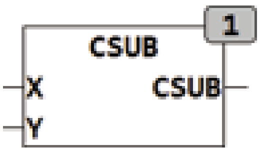


9.2.0.23 Type Function: REAL

Input X	COMPLEX (Input)
Output	REAL (result)
	CSQRT calculates the square root of a complex number

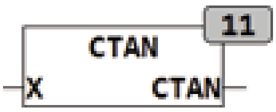
9.2.0.24 Type Function: COMPLEX

Input X	COMPLEX (Input)
Y	[COMPLEX(../../Data Types/complex.md) (Input value)
Output	COMPLEX (result)
	CSUB Subtracts two complex numbers, Csub = X - Y.



9.2.0.25 Type Function: COMPLEX

Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CTAN calculates the tangent of a complex number



9.2.0.26 Type Function: COMPLEX

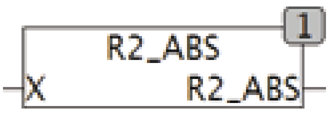
Input X	COMPLEX (Input)
Output	COMPLEX (result)
	CTANH calculates the hyperbolic tangent of a complex number

9.3 Mathematical / Double Precision

This section contains 10 modules.

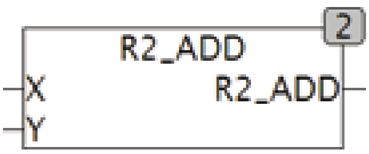
9.3.0.1 R2_ABS

Type Function	REAL2
Input X	REAL2 (Input)
Output	REAL2 (result double-precision)
	R2_ABS returns the absolute value of x in double precision.



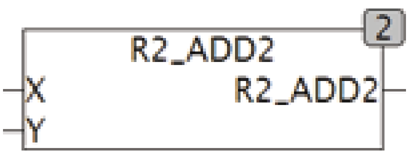
9.3.0.2 R2_ADD

Type Function	REAL2
Input X	REAL2 (Input)
Y	REAL (value to be added)
Output	REAL2 (result double-precision)
	R2_ADD adds to a double-precision value X is a single-precision value Y. The result has again double precision.



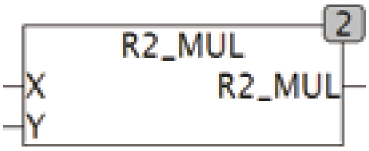
9.3.0.3 R2_ADD2

Type Function	REAL2
Input X	REAL2 (Input)
Y	REAL2 (value to be added)
Output	REAL2 (result double-precision)
	R2_ADD2 adds to a double precision value X to another double-precision value Y. The result has again double precision.



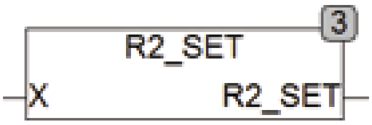
9.3.0.4 R2_MUL

Type Function	REAL2
Input X	REAL2 (Input)
Y	REAL (multiplier)
Output	REAL2 (result double-precision)
	R2_MUL multiplies a double precision value X with a single-precision Y. The result has again double precision.



9.3.0.5 R2_SET

Type Function	REAL2
Input X	REAL (Input)
Output	REAL2 (result double-precision)
	R2_SET sets a double precision value to the input value x with single precision.

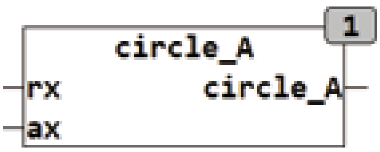


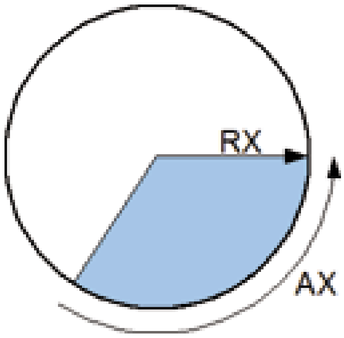
9.4 Mathematical / Geometry

This section contains 16 modules.

9.4.0.1 Type Function

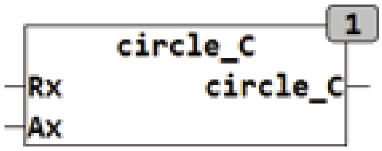
Input RX	REAL (circle radius)
RX	REAL (circle radius)
Output	REAL (area of circle segment)
	CIRCLE_A calculates the area of a circle segment with the angle AX and radius RX. If the angle is set AX = 360 so the circle area is calculated.

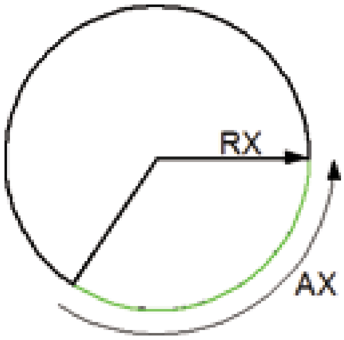




9.4.0.2 Type Function

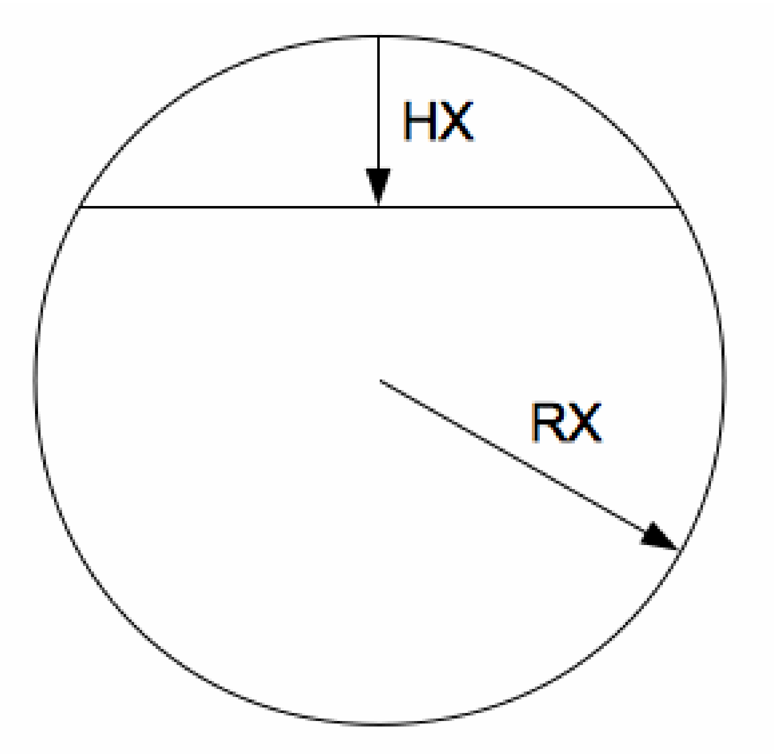
Input RX	REAL (circle radius)
RX	REAL (circle radius)
Output	REAL (arc length or circumference)
	CIRCLE_C calculates the arc length of an arc with the angle AX and radius RX. If the angle is set AX = 360 so the circumference is calculated.





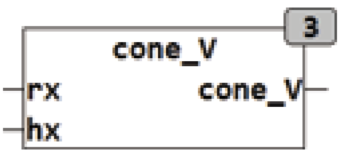
9.4.0.3 CIRCLE_SEG

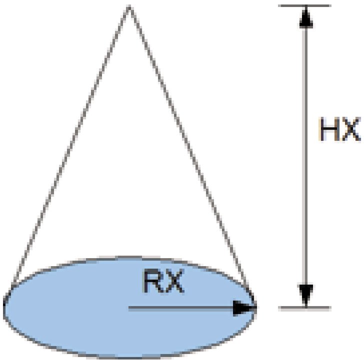
Type Function	REAL
Input RX	REAL (Circle radius)
HX	REAL (Height of Sektantlinie)
Output Real	(Area of segment)
	CIRCLE_SEG calculates the area of a circle segment is enclosed by a Sektantlinie and the circle.



9.4.0.4 Type Function

Input RX	REAL (radius of base)
HX	REAL (height of cone)
Output	REAL (volume of the cone)
	KONE_V calculated the volume of a cone with the radius RX and height HX.



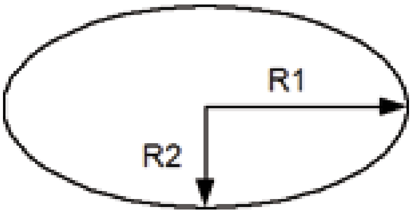


9.4.0.5 Type Function

Input R1	REAL (radius 1)
R2	REAL (radius 2)
Output	REAL (area of the ellipse)
	ELLIPSE_A calculates the area of an ellipse that is defined by the radii R1 and R2.

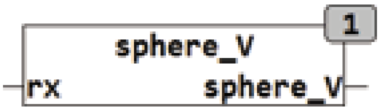
9.4.0.6 Type Function

Input R1	REAL (radius 1)
R2	REAL (radius 2)
Output	REAL (circumference of the ellipse)
	ELLIPSE_C calculates the circumference of an ellipse that is defined by the radii R1 and R2.



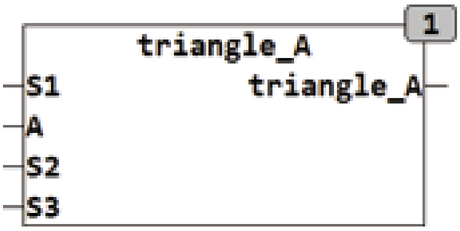
9.4.0.7 Type Function

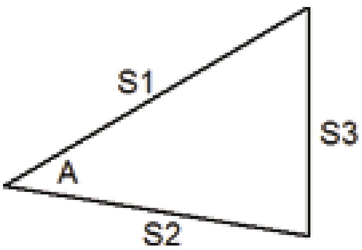
Input RX	REAL (radius)
Output	REAL (volume of ball)
	SPHERE_V calculates the volume of a sphere with a radius of RX.



9.4.0.8 Type Function

Input S1	REAL (side 1)
A	REAL (angles between page 1 and page 2)
S2	REAL (side length 2)
S3	REAL (side length 3)
Output	REAL (area of the triangle)
	TRIANGLE_A calculates the area of any triangle. The triangle can be defined by either through 2 pages and the pages spanned by the angles 1 and 2 (S1, S2 and A), or if A = 0 then the area is calculated from three sides (S1, S2 and S3).



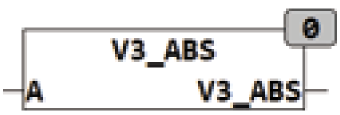


9.5 Mathematical / Vektormathematik

This section contains 28 modules.

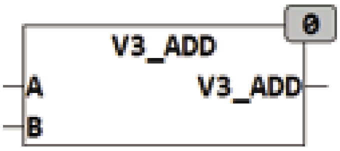
9.5.0.1 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	REAL (Absolute length of the vector)
	V3_ABS calculates the absolute value (length) of a vector in a three-dimensional coordinate system.
	V3_ABS(3,4,5) = 7.071...



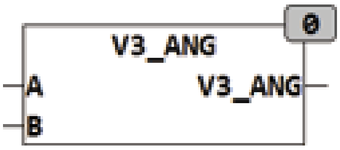
9.5.0.2 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
B	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)
	V3_ADD adds two three dimensional vectors.
	V3_ADD([3,4,5],[1,2,3]) = (4,6,8)



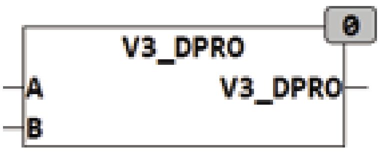
9.5.0.3 V3_ANG

Type	Function
Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
B	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	REAL (angle in radians)
	V3_ANG calculates the angle between two three dimensional vectors
	V3_ANG([1,0,0],[0,1,0]) = 1,57.. (π / 2)



9.5.0.4 Type Function

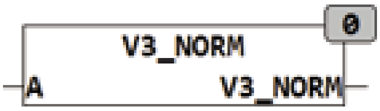
Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
B	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	REAL (Scalar Product)
	V3_DPRO calculates the scalar product of two-dimensional vectors.
	V3_DPRO([1,2,3],[3,1,2]) = 11
	The scalar product is calculated from A.X*B.X + A.Y*B.Y + A.Z*B.Z



9.5.0.5 Type Function

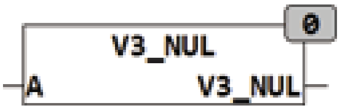
Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)

	V3_NORM generates from any one-dimensional vector a vector Normalized to length 1 with the same direction. A vector of length 1 is called unit vector
	V3_NORM(3,0,0) = (1,0,0)



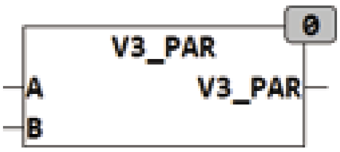
9.5.0.6 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	BOOL (TRUE if vector is a zero vector)
	V3_NUL checks if the vector A is a zero vector. A vector is then a zero vector if all the components (X, Y, Z) are zero.
	V3_NUL(0,0,0) = TRUE



9.5.0.7 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
B	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	BOOL (TRUE if the two vectors are parallel)
	V3_PAR will be TRUE if the two vectors A and B are parallel. A zero vector is parallel to any vector because it has no direction. Two vectors A and B in opposite directions are parallel.
	V3_PAR([1,1,1],[2,2,2]) = TRUE
	V3_PAR([1,1,1],[−1,-1,-1]) = TRUE
	V3_PAR([1,2,3],[0,0,0]) = TRUE
	V3_PAR([1,2,3],[1,0,0]) = FALSE

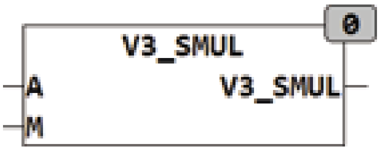


9.5.0.8 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)
	V3_REV generates a vector with the same amount of A but with opposite direction. A - V3_REV(A) = 0.
	V3_REV(1,2,3) = (-1,-2,-3)

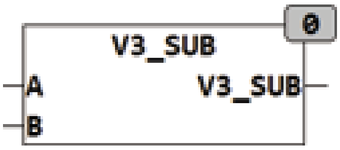
9.5.0.9 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
M	REAL (scalar multiplier)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)
	V3_SMUL multiplies a three-dimensional vector A with scalar M.
	V3_SMUL([1,2,3],10) = (10,20,30)



9.5.0.10 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
B	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)
	V3_SUB Subtracts the vector B of A
	V3_SUB([3,3,3],[1,2,3]) = (2,1,0)
	V3_SUB([1,2,3],[1,-2,-3]) = (0,4,6)

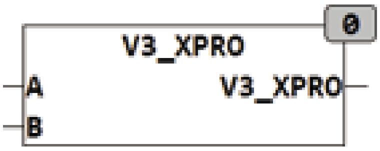


9.5.0.11 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	REAL (angle to the X-axis)
	V3_XANG calculates the angle between the X-axis of the coordinate system and a three-dimensional vector A in radians
	V3_XANG(1,2,3) = 1.300..

9.5.0.12 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
B	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)
	V3_XPRO calculates the cross product of two-dimensional vectors A and B
	V3_XPRO([1,2,3],[2,1,2]) = (1,4,-3)

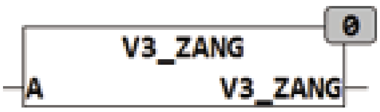


9.5.0.13 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	REAL (angle to the y-axis)
	V3_YANG calculates the angle between the Y-axis of the coordinate system and a three-dimensional vector A in radians
	V3_YANG(1,2,3) = 1.006..

9.5.0.14 Type Function

Input A	VECTOR_3 (vector with the coordinates X, Y, Z)
Output	REAL (angle to the Z-axis)
	V3_ZANG calculates the angle between the Z-axis of the coordinate system and a three-dimensional vector A in radians
	V3_ZANG(1,2,3) = 0.640..



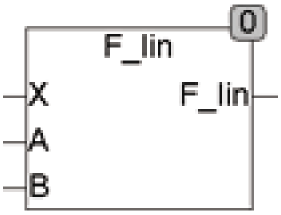
9.6 Mathematical / functions

This section contains 22 modules.

9.6.0.1 Type Function: REAL

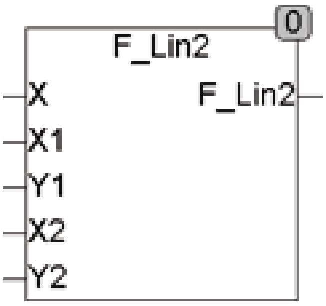
Input X	REAL
A	REAL
B	REAL
Output	REAL (F_LIN = A*X + B)

	The function F_LIN returns the Y value of a linear equation.
	F_LIN = A*X + B



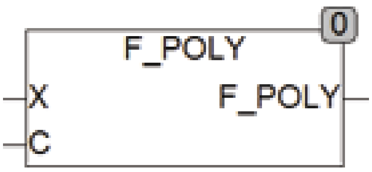
9.6.0.2 Type Function: REAL

Input X	REAL
X1, Y1	REAL (first coordinate)
X2, Y2	REAL (second coordinate)
Output	REAL (value on the line passing through the above 2 points defined.)
	The function F_LIN2 returns the Y value of a linear equation.
	The straight line here is defined by the specification of two coordinate points (X1, Y1, X2, Y2).



9.6.0.3 Type Function: REAL

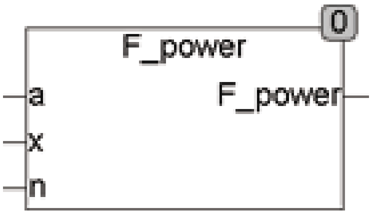
Input X	REAL (input)
C	ARRAY[0..7] of REAL (polynomial coefficients)
Output	REAL (result of the polynomial equation)
	F_POLY calculates a polynomial of 7th degree.
	F_POLY = C[0] + C[1] * $X^{1 + C[2] * X}$2 + ...C[7] * X^7



9.6.0.4 Type Function: REAL

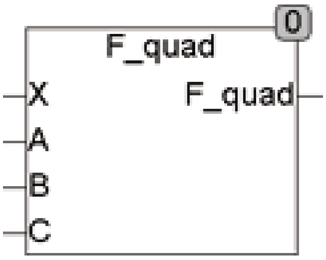
Input A	REAL

X	REAL
N	REAL
Output	REAL (result of the equation F_POWER = A * X^N)
	F_Power calculate the power function according to the equation F_POWER = A * Xn .



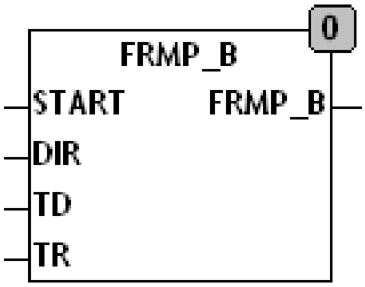
9.6.0.5 Type Function: REAL

Input X	REAL
A, B, C	REAL
Output	REAL (F_QUAD = A * X² + B * X + C)
	F_QUAD calculates the result of a quadratic equation using the formula f_QUAD = A * X ² + B * X + C.



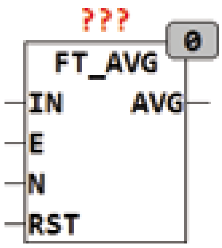
9.6.0.6 FRMP_B

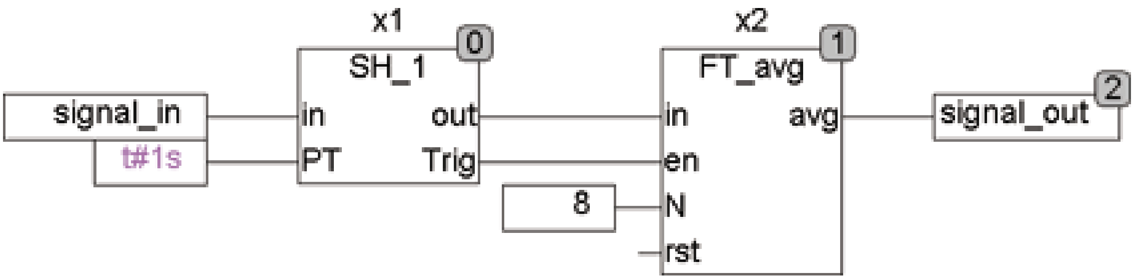
Type Function	BYTE
Input START	BYTE (start value)
DIR	BOOL (direction of the ramp)
TD	TIME (Elapsed time)
TR	TIME (rise time for ramp from 0..255)
Output	BYTE (output)
	FRMP_B calculates the value of a ramp at a given time TD. The module ensures that no buffer overrun or underrun can take place at the output. The output value is limited in all cases to 0 .. 255. TR sets the time for a full ramp 0 .. 255 and TD is the elapsed time. If DIR = TRUE, a rising ramp is calculated and if DIR = FALSE a falling edge. With the start value an edge can be calculated from any starting point.



9.6.0.7 Type Function module

Input IN	REAL (input signal)
E	BOOL (enable input)
N	INT (number of values over which the average is calculated)
RST	BOOL (Reset input)
Output	REAL (moving average over the last N values)
	The function module FT_AVG calculates a moving average over each of the last N values. By the input RST, the stored values can be deleted. N is defined from 0 .. 32. N = 0 means that the output signal = input signal. N = 5 is the average over the last 5 values. The average is calculated over a maximum of 32 values. With input E can be control when the input is read. This allows a simple way to connect a sample and a hold module, such as SH_1 with FT_AVG can be linked. The first call to FT_AVG the buffer load the input signal to avoid that a Ramp-up takes place.
	The following example reads SH_1 once a second the input value Signal_In and passes these values once per second to FT_AVG, which then forms out of the last 8 values the mean value.

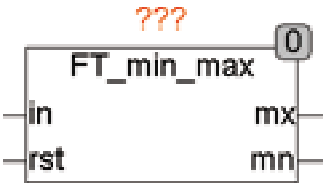




9.6.0.8 Type Function module

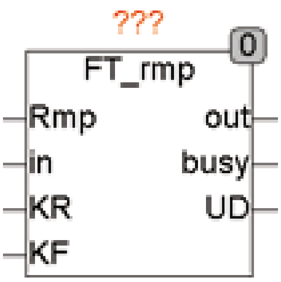
Input IN	REAL (input signal)
RST	BOOL (Reset input)

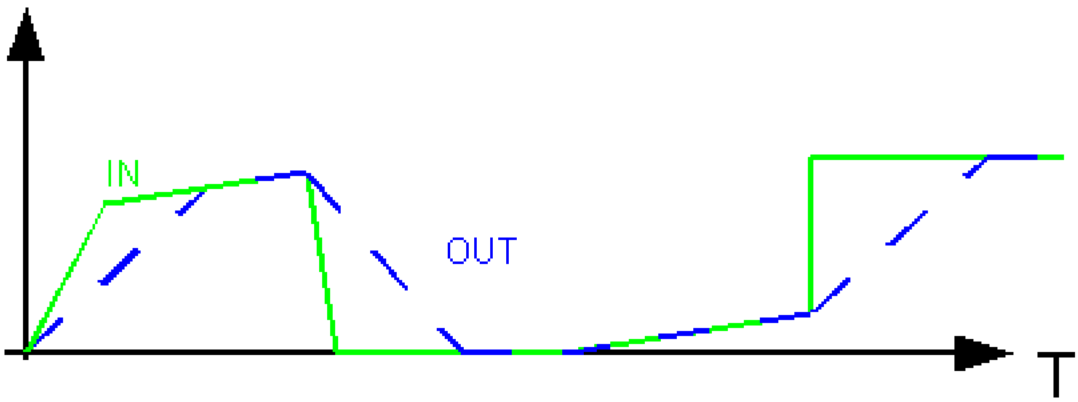
Output MX	REAL (maximum value of the input signal)
MN	REAL (minimum value of the input signal)
	FT_MIN_MAX stores the minimum and maximum value of an input signal IN and provides these two values at the outputs of MN and MX until cleared by a reset. A reset sets MN and MX on the reset applied input values.



9.6.0.9 Type Function module

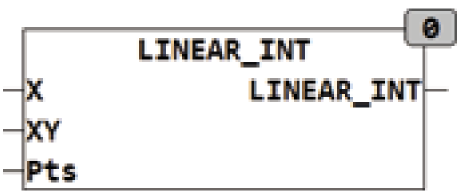
Input RMP	BOOL (Enable Signal)
IN	REAL (input signal)
KR	REAL (rate of increase in 1 / seconds)
TV	REAL (speed of the drop in 1 / seconds)
Output OUT_MAX	REAL (upper output limit)
BUSY	BOOL (Indicates if the output rises or falls)
UD	BOOL (TRUE, when output is rising and false if Output drops)
	The output OUT follows the input with a linear ramp with defined rise and fall speed (KR and KF). K = 1 means that the output increases with 1 unit per second, or falls. The K factor must be greater than 0. The output of UD is TRUE if the output is rising and FALSE if it drops. When the output reaches the input value is BUSY FALSE, otherwise BUSY is TRUE and indicates that a rising or falling ramp is active.
	The output follows the input signal as long as the rise and fall speed of the input signal is smaller than that by KR and KF defined maximum increase or decrease speed. Changing the input signal faster, the output runs at the speed of KR or KF after the input signal. The ramp generation is real-time, which means that FT_RMP calculates every time where the output should be and sets this value to the output. The main change is therefore dependent on the cycle time and is not in equal steps. If a ramp out of sheer same steps are required, are the modules RMP_B and RMP_W are available. The module is only active when the input RMP = TRUE.
The following chart shows the profile of the output as a function of an input signal	





9.6.0.10 LINEAR_INT

Type	Function
Input X	REAL (input)
XY	ARRAY [1..20,0..1] (Ascending sorted values pairs)
PTS	INT (number of pairs of values)
Output	REAL (output)
	LINEAR_INT is a linear interpolation module. A characteristic is described by a maximum of 20 coordinate values (X, Y) and is cut up to 19 linear segments. The definition of the coordinate values is passed in an array which describes the characteristic with individual X, Y describes value pairs. The value pairs must be sorted by the x_value. If an X value is called outside range which is described by the value pairs, then the first respective last linear segment is extrapolated and the corresponding value Issued. To keep the number of definition points flexible, at the input PTS is given the number of points. The possible score is in the range from 3 to 20, wherein each individual dot is shown with X-and Y-value.



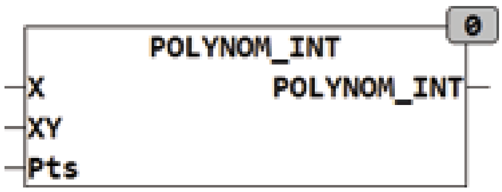
Example:

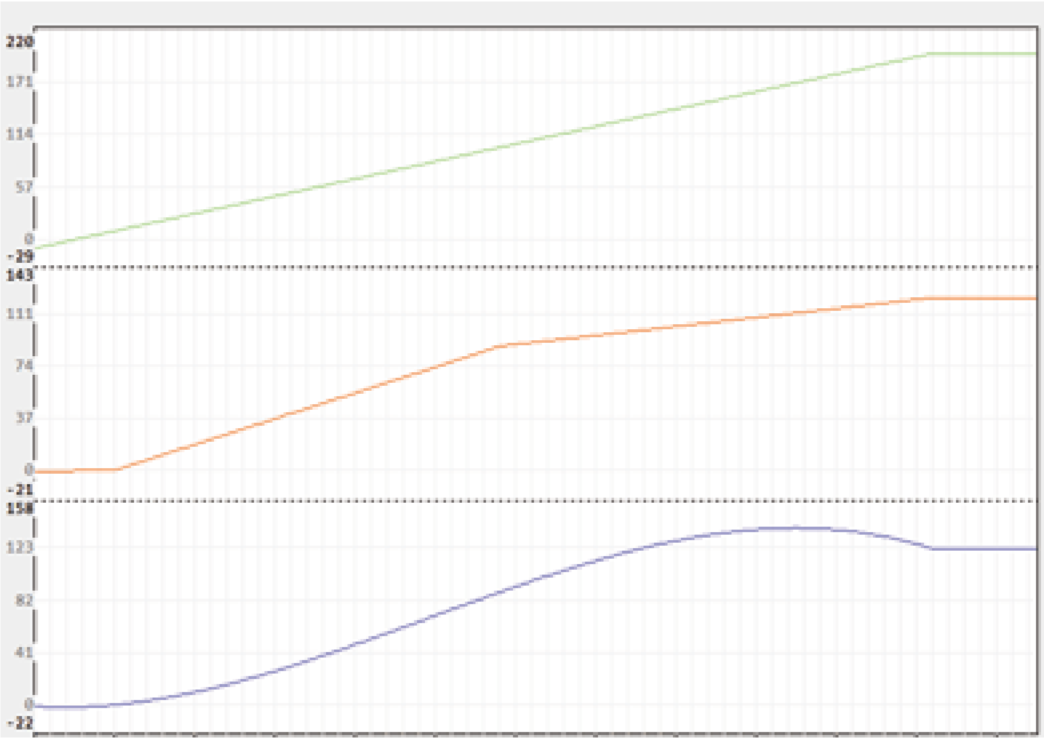
```
VAR EXAMPLE : ARRAY[1..20,0..1] := -10,-0.53, 10,0.53, 100,88.3, 200,122.2; END_VAR
```

for the above definition, the following results are valid: LINEAR_INT (0, EXAMPLE, 4) = 0; LINEAR_INT (30.0, EXAMPLE, 4) = 20.0344; LINEAR_INT (66.41, EXAMPLE, 4) = 55.54229; LINEAR_INT (66.41, EXAMPLE, 4) = 55.54229;

9.6.0.11 POLYNOM_INT

Type	Function
Input X	REAL (input)
XY	ARRAY [1..5,0..1] (Ascending sorted values pairs)
PTS	INT (number of pairs of values)
Output	REAL (output)
	POLYNOM_INT interpolates a number of pairs of values with a polynomial of N times degree. The number of pairs is PTS, and N is the number of pairs of values (PTS). Any characteristic is described by a maximum of 5 coordinate-values (X, Y) and internally described by a polynomial. The definition of the coordinate values is passed in an array which describes the characteristic with individual X, Y describes value pairs. The value pairs must be sorted by the x_value. If an X value is queried outside the described range by value-apairs, so that is calculated according to the determined polygon. It is noted, that here can occur oscillations above and below the area of definition by a polynomial of higher degree , and calculated values mostly are not useful in this area. Before the application of a polynomial it is essential for this purpose to read the basics, for example, in Wikipedia. To keep the number of definition points flexible, at the input PTS is given the number of points. The possible score is in the range from 3 to 5, wherein each individual dot is shown with X-and Y-value. A Polynomial with more than 5 points leads to an increased tendency to oscillate and is for this reason refused.
The following example shows the definition for the array XY and some values	
	VAR





Example:

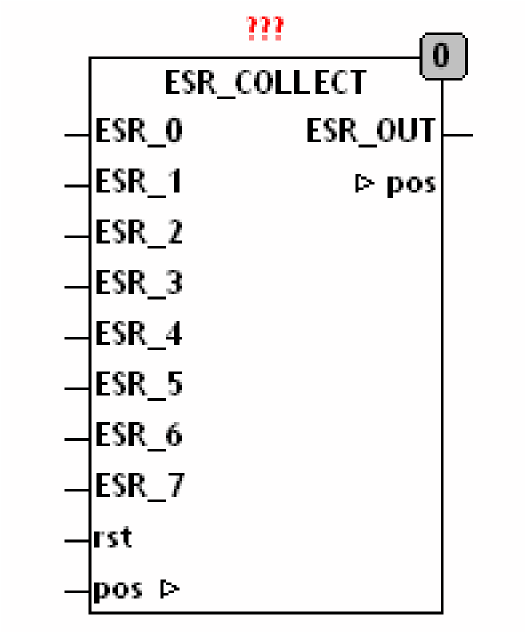
`EXAMPLE : ARRAY[1..5,0..1] := -10,-0.53, 10,0.53, 100,88.3, 200,122.2; END_VAR for the above definition, the following results are valid: POLYNOM_INT(0, example, 4) = -1.397069; POLYNOM_INT(30.0, example, 4) = 11.4257; POLYNOM_INT(66.41, example, 4) = 47.74527; POLYNOM_INT(800.0, example, 4) = -19617.94; When the results of the example is clearly seen that the value of -19617.94 for the input X = 800 makes no sense, since it is outside the defined range of -10 to +200. The following trace recording shows the variation of output to input. Here, clearly, the overshoot of the polygon with respect to a linear interpolation can be seen. Green = input X, Red = linear interpolation, Blue = polynomial interpolation.`

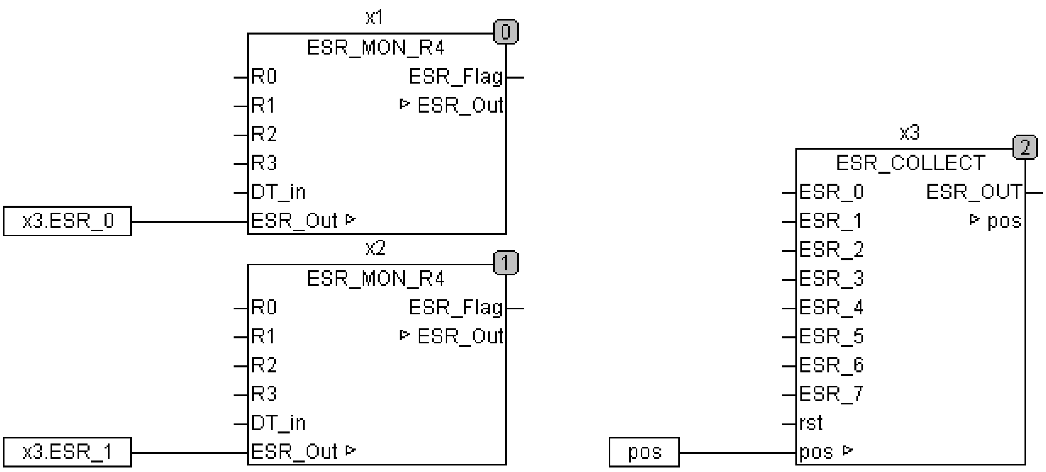
10. Other

This section contains 12 modules.

10.0.1 ESR_COLLECT

Type	Function module
Input ESR_0.. 7	ESR_DATA (ESR inputs)
RST	BOOL (asynchronous reset input)
Output ESR_OUT	ESR_DATA (Array with the ESR protocol)
IN/OUT POS	INT (Position of of latest ESR protocol in the array)
	ESR_COLLECT collects ESR data from up to 8 ESR modules and stores the log in an array. The output POS indicates the position at which in the array ESR_OUT is currently the last message is ESR. Collects the module more than 64 messages so the messages are discarded and restarted at position 0. With the asynchronous reset input, the device can be reset at any time. By resetting, all the collected data will be deleted and the pointer is moved to -1. The module collects data in the output array ESR_OUT and moves POS the last position of the array that contains data. When there are no messages POS remains to -1. If the output data are read, the variable POS has to be set to -1, or if only readed a part POS can be set to the last valid value.
	The following example demonstrates how ESR_COLLECT is connected with ESR modules.
The output ESR_OUT is made up as follows	
The ESR data includes the following	
ESR_DATA .TYP	Data type, see table above
ESR_DATA .ADRESS	up to 10 characters long String Identifier
ESR_DATA .DS	Date stamp of type TIME DATA
ESR_DATA .TS	Timestamp of type TIME (PLC Timer)
ESR_DATA .DATA	up to 8 bytes of data block



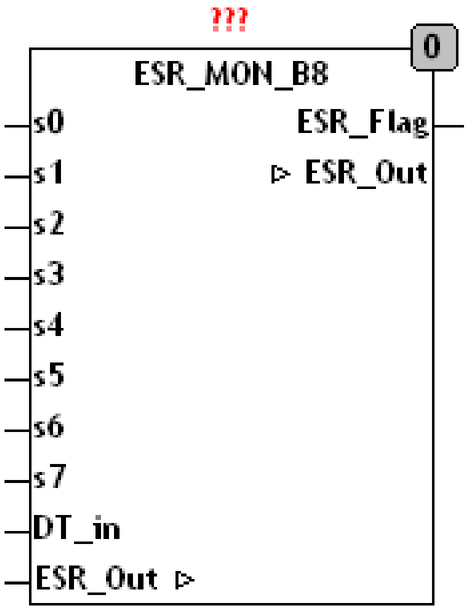


.TYPE	.ADRESS	.DS	.TS	.DATA [0..7]	
1	Label	Date	TIME	Status, 1 Byte	ESR Error
2	Label	Date	TIME	Status, 1 Byte	ESR Status
3	Label	Date	TIME	Status, 1 Byte	ESR Debug
10	Label	Date	TIME	notused	Boolean input lowtransition
11	Label	Date	TIME	notused	Boolean input hightransition
20	Label	Date	TIME	Byte 0 - 3 Real Value	Real Valuechange

10.0.2 ESR_MON_B8

Type	Function module
Input S0..7	BOOL (signal input)

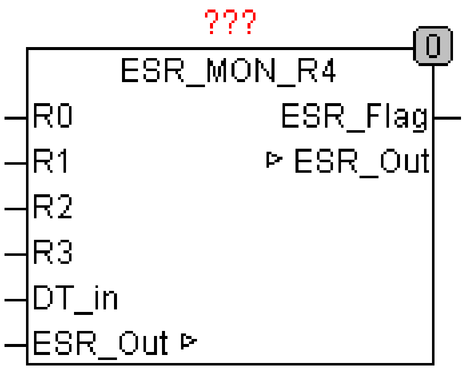
DT_IN	DATE_TIME (time-date-input stamp for time-stamp)
Output ESR_FLAG	BOOL (TRUE, if ESR data are available)
IN/OUT ESR_OUT	ESR_Data (ESR_data ouput)
Setup A0..7	STRING(10) (designation of the inputs)
	ESR_MON_B8 monitors up to 8 binary signals to change, and provides them with a timestamp and a name. The collected messages are buffered and passed to a protocol module on ESR_OUT. The output ESR_FLAG is set to TRUE when messages are present.
The ESR data at the output consist of the following items	
.TYPE	11 rising edge , 10 falling edge
.ADRESS	Byte address of ISR data recording
.LINE	Line number (input) of the ESR data recording
.DS	Date stamp of type DATE_TIME
.DT	Timestamp of type TIME (PLC- Timer)
.Data	Data block blank of 8 bytes
	An application example for the module is in the description of ESR_COLLECT.



10.0.3 ESR_MON_R4

Type	Function module
Input R0.. 3	REAL (signal input)
DT_IN	DATE_TIME (time-date-input stamp for time-stamp)

Output ESR_FLAG	BOOL (TRUE, if ESR data are available)
IN/OUT ESR_OUT	ESR_Data (ESR_data ouput)
Setup A0..3	STRING(10) (signal address of the inputs)
A0..3	STRING(10) (signal address of the inputs)
	ESR_MON_R4 monitors up to 4 analog signals for changes and provides them with a time s stamp and the address of the input signal. The collected messages are buffered and passed to a protocol module on ESR_OUT. The output ESR_FLAG is set to TRUE when messages are present. A change of an input is recorded only when the input has changed more than the in threshold S predetermined value.
.TYPE	20 Floating point
.ADRESS	Byte address of ISR data recording
.LINE	Line number (input) of the ESR data recording
.DS	Date stamp of type DATE_TIME
.DT	Timestamp of type TIME (PLC- Timer)
.Data	Data Block 4 byte real value
	An application example for the module is in the description of ESR_COLLECT.

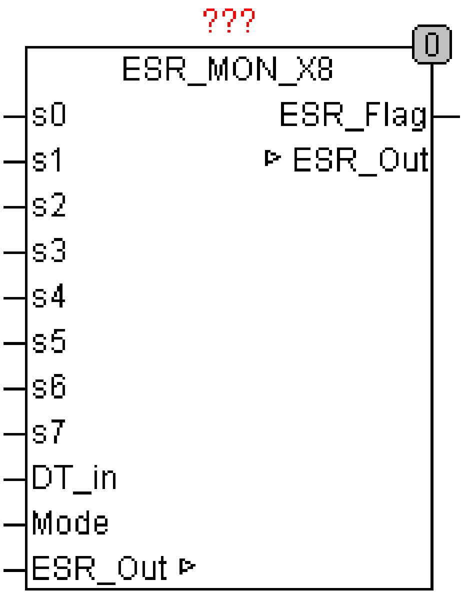


10.0.4 ESR_MON_X8

Type	Function module
Input S0..7	Byte (status Inputs)
DT_IN	DATE_TIME (time-date-time stamp for input)
Mode	Byte (designate the type of processing of messages)
Output ESR_FLAG	BOOL (TRUE when messages are present)
IN/OUT ESR_OUT	array [0..7] of ESR_DATA (collected messages)
Setup A0..7	STRING (10) (signal address of the inputs)
	ESR_MON_X8 collects status messages of up to 8 ESR compatible modules, provides them with a Timestamp , date stamp , input number and

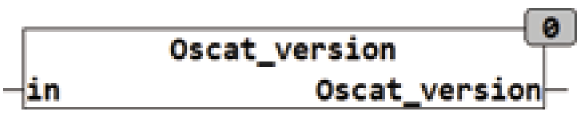
	a module address. The collected messages are buffered and passed to a protocol module. If messages for transmission are present, this is indicated by the signal ESR_FLAG. At input DT_IN the current time, which is used for the timestamp of the messages should be provided. The MODE input determines which status messages should be passed.
	When the MODE input is not wired, automatically all messages are processed.
The ESR data at the output consist of the following items	.TYP 1 = error, 2 = State, 3 = Debug . ADRESS Byte address of ESR data recording .LINE Line number (input) of the ESR data recording .DS Date stamp of type DATE_TIME .DT Timestamp of type TIME (PLC Timer) .Data Data Byte 0 contains the status message

| | An application example for the module is in the description of ESR_COLLECT. |



10.0.5 Type Function: DWORD

Input IN	BOOL (if TRUE the module provides the release date)
Output	(Version of the library)
	OSCAT_VERSION iprovides if IN = FALSE the current version number as DWORD. If IN is set to TRUE then the release date of the current version as a DWORD is returned.

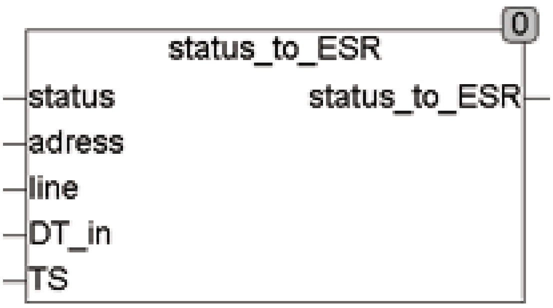


Example:

```
OSCAT_VERSION(FALSE) = 201 for version 2.60 DWORD_TO_DATE(OSCAT_VERSION (TRUE)) =
2008-1-1
```

10.0.6 STATUS_TO_ESR

Type Function	ESR_DATA
Input STATUS	BYTE (status byte)
ADRESS	Byte (address, bytes)
LINE	Byte (input number)
DT_IN	DATE_TIME (time-date-input)
TS	TIME (time for timestamp)
Output	ESR_DATA (ESR data block)
	STATUS_TO_ESR generates a record from the input values.
	A STATUS in the range between 1.. 99 is an error message and will be marked as Type 1. Status 100 .. 199 is characterized as type 2 and 200 .. 255 is marked as Type 3 (Debug I nformation).
The ESR data at the output consist of the following items	
.TYPE	1 = error, 2 = State, 3 = Debug
.ADRESS	Byte address of ISR data recording
.LINE	Line number (input) of the ESR data recording
.DS	Date stamp of type DATE_TIME
.DT	Timestamp of type TIME (PLC-timer)
.Data	Data block of 8 bytes

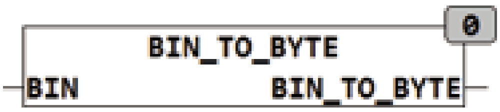


11. String

This section contains 150 modules.

11.0.1 Type Function: BYTE

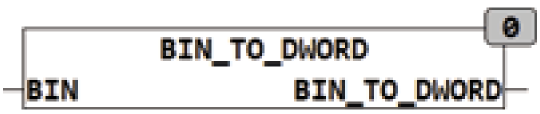
Input BIN	STRING (12) (Octal string)
Output	BYTE (output value)
	The function BIN_TO_BYTE converts a binary encoded string in a BYTE value. There, this method only binary characters are '0 'and '1' is interpreted, others in BIN occurring characters are ignored.



Example:
`BIN_TO_BYTE ('11 ') result 3.`

11.0.2 Type Function: DWORD

Input BIN	STRING (40) (Octal string)
Output	DWORD (output value)
	The function BIN_TO_DWORD converts a binary encoded string in a BYTE value. There, this method only binary characters are '0 'and '1' is interpreted, others in BIN occurring characters are ignored.



Example:
`BIN_TO_DWORD ('11 ') result 3.`

11.0.3 Type Function : STRING

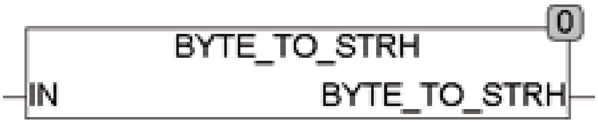
Input IN	BYTE (input)
Output	STRING (8) (result STRING)
	BYTE_TO_STRB convert a byte into a fixed-length STRING. The output string is exactly 8 characters long and is the bitwise notation of the value of IN. The output string consists of the characters '0 'and '1'. The least significant bit is right in the STRING. If a STRING is required with less than 8 characters, it can be truncated with the standard function RIGHT () accordingly. The call RIGHT(BYTE_TO_STRB (X),4) results in a STRING with four characters that correspond to the content of the lowest 4 bits of X.

Example:

```
BYTE_TO_STRB(3) = '00000011 '
```

11.0.4 BYTE_TO_STRH

Type Function	STRING
Input IN	BYTE (input)
Output	STRING(2) (result STRING)
	BYTE_TO_STRH converts a byte into a fixed-length STRING. The output string is exactly two characters long and is the hexadecimal notation of the value of IN. The output string consists of the characters '0 '.. '9' and 'A' .. 'F'. The least significant sign is right in the STRING.



Example:

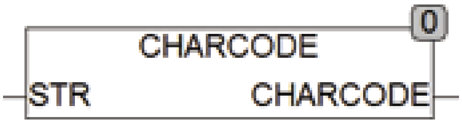
```
Example  :  BYTE_TO_STRH(15) = '0F'
```

11.0.5 Capitalize

Type Function	STRING
Input STR	STRING (String input)
Output	STRING (result STRING)
	CAPITALIZE converts all first letter on STR in capital letters . During conversion, the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE, all characters of the extended ASCII character set to be considered in accordance with ISO 8859-1.
	Capitalize('peter pan') = 'Peter Pan'

11.0.6 Type Function : BYTE

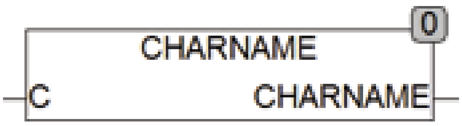
Input STR	STRING(10) (String input)
Output	BYTE (character code)
	CHARCODE returns the byte code of a Named Characters. A List the Codes with Name located under the function charName. If no character known, for the name in STR 0 is returned. If STR consists of only one character, then the code of this character returned. CHARCODE uses the global variables SETUP.CHARNAMES which include the list of names with codes.



Example:
`CHARCODE('euro') = 128 and corresponds to the character € CHARCODE(',') = 44`

11.0.7 CHARNAME

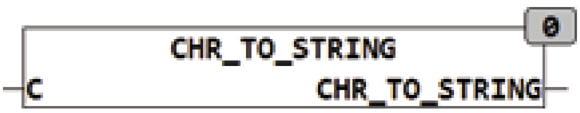
Type Function	STRING(10)
Input C	BYTE (character code)
Output	STRING (character name)
	CHARNAME determines the character name for a character code.



Example:
`CHARNAME(128) = 'euro'`
If no name is known for a code, the code is returned as a single character. For the Code 0 an empty string is returned. CHARNAME uses the global variables SETUP.CHARNAMES which includes the list of names with codes.

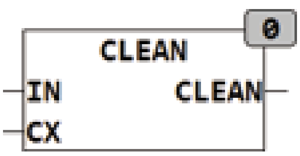
11.0.8 Type Function : STRING

Input C	Byte (input value)
Output	STRING (result STRING)
	CHR_TO_STRING forms a ASCII characters from a byte and returns it as a one-character string.



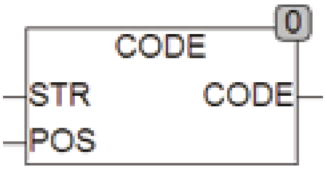
11.0.9 Type Function : STRING

Input IN	STRING (input)
CX	STRING (All characters are not to be deleted)
Output	STRING (result STRING)
	CLEAN removes all characters from a string that are not included in the string CX.
	CLEAN('Nr.1 23#', '0123456789 ') = '123'



11.0.10 Type Function : BYTE

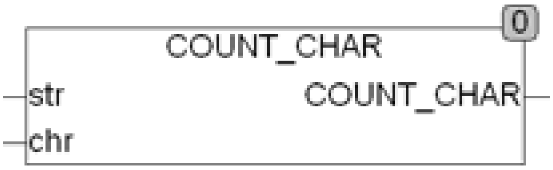
Input STR	STRING (string)
INT	POS (position at which the character is read)
Output	BYTE (code of the character at position POS)
	CODE determines the numerical code for a character at the position POS in STR. Is CODE called with a position with less than 1 or greater than the length of STR, 0 is returned.



Example:
`CODE('ABC 123',4) = 32`
(The character '' is encoded with the value of 32).

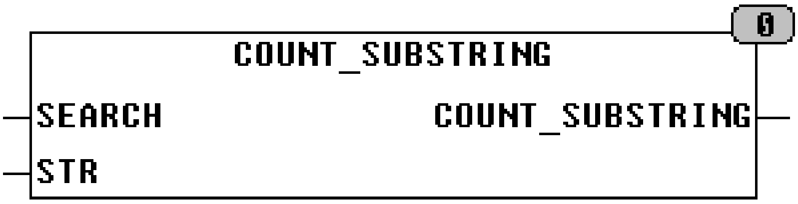
11.0.11 Type Function : STRING

Input STR	STRING (string)
CHR	Byte (search characters)
Output	STRING (result STRING)
	COUNT_CHAR determines how often the sign of CHR in the string STR occurs. To search for special characters and control characters, the search character CHR is specified as BYTE.



11.0.12 COUNT_SUBSTRING

Type Function	INT
Input SEARCH	STRING (string to be examined)
STR	STRING (search string)
Output	INT (number of localities)
	COUNT_SUBSTRING determined how many times a substring occurs in the string STR SEARCH.



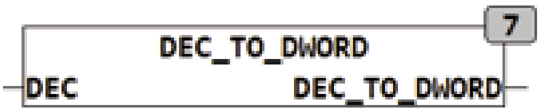
11.0.13 Type Function: BYTE

Input DEC	STRING(10) (decimal-encoded string)
Output	BYTE (output value)
	The function DEC_TO_BYTE converts a decimal encoded string into a byte value. Here only decimal characters '0 '.. '9' are interpreted, others in DEC occurring characters are ignored .

Example:
`DEC_TO_BYTE('34 ') is 34.`

11.0.14 DEC_TO_DWORD

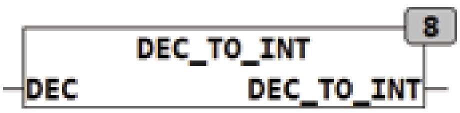
Type Function	DWORD
Input DEC	STRING(20) (decimal-encoded string)
Output	DWORD (output value)
	The function DEC_TO_DWORD converts a decimal encoded string into a byte value. Here only decimal characters '0 '.. '9' are interpreted, others in DEC occurring characters are ignored .



Example:
`DEC_TO_DWORD('34 ') is 34.`

11.0.15 Type Function: INT

Input DEC	STRING(10) (decimal-encoded string)
Output	INT (output value)
	The function DEC_TO_INT converts a decimal encoded string into a byte value. Here only decimal characters '0 '.. '9' and '-' are interpreted, others in DEC occurring characters are ignored .

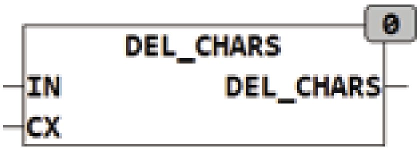


Example:

`DEC_TO_INT ('-34') is -34.`

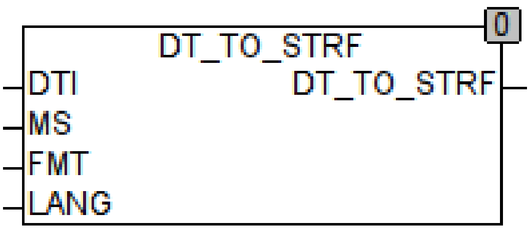
11.0.16 Type Function : STRING

Input IN	STRING (input)
CX	STRING (All characters which are to be deleted)
Output	STRING (result STRING)
	DEL_CHARS deletes all characters from a string which are contained in the string CX.
	CLEAN('Nr.1 23#', ' #ABCDEFG') = 'Nr.123'



11.0.17 DT_TO_STRF

Type Function	STRING
Input DTI	DT (Date and time input value)
MS	INT (ms input)
FMT	STRING (default format for output)
LANG	INT (default language)
Output	STRING (result string)
	DT_TO_STRF converts a DATETIME value into a formated string. At the input DTI the convertible DATETIME value appears and with the string FMT the appropriate output format is determined. The input LANG determines the language to be used (0 = LANGUAGE_DEFAULT, 1 = English and 2 = German). The language settings are made in the relevant paragraph of the global constants and can be adapted or modified. In addition to the date and time at the input of MS also milliseconds can be processed.
The generated string matches the string FMT where in the string all characters '#' followed by a capital letter are replaced with the corresponding value. The following table defines the format characters	



Example:

```
DT_TO_STRF(DT#2008-1-1, 'Datum '#C. #F #A', 2) = '1. Januar 2008'
DT_TO_STRF(DT#2008-1-1-13:43:12, '#J #M:#Q am #C. #E #A', 2) = 'Di 13:43 am 1. Jan 2008'
```

#A	4 digit year number (2008)
#B	2-digit year number, eg (08)
#C	Month 1-2 digits (1,12)
#D	Month 2 digits (1, 12)
#E	Month 3 letters (Jan)
#F	Months written out (January)
#G	Day 1 or 2 digits (1, 31)
#H	Day 2-digit (01, 31)
#I	Week as a number (1 = Monday, 7 = Sunday)
#J	Week 2 letters (Mo)
#K	Week written out (Monday)
#L	AM or PM in American date formats
#M	Hour in 24 hour format 1-2 digits (0, 23)
#N	Hour in 24 hour format 2 digits (00, 23)
#O	Hours in 12 hours Format 1 - 2 digits (1, 12)
# P	Hour in 12 hour format 2 digits (01, 12)
#Q	Minutes 1-2 digits (0, 59)
#R	Minutes 2 digits (00, 59)
#S	Seconds 1-2 digits (0, 59)
#T	Seconds 2 digits (00, 59)
#U	Milliseconds 1-3 digits (0, 999)
#V	Milliseconds 3 digits (000, 999)
#W	Day 2 digits but pre-padded with blank (' a' .. '31 ')
#X	Month 2 digits but pre- padded with blank (' 1' .. '12 ')

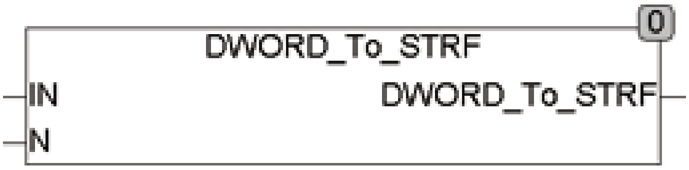
11.0.18 Type Function : STRING

Input IN	DWORD (input value)
Output	STRING(32) (result STRING)
	DWORD_TO_STRB converts a DWORD, Word or byte in a STRING of fixed length. The output string is exactly 32 characters long and is the bitwise notation of the value of IN. The output string consists of the characters '0 'and '1'. The least significant bit is left in the string. DWORD_TO_STRB can handle input formats, Byte, Word and DWORD types. The output is independent of the input type is always a STRING of 32 characters. If a shorter string is needed, it can be cut with the standard function RIGHT() accordingly. The call RIGHT(DWORD_TO_STRB(X),8) results to a string of 8 characters to the contents of the lower bytes of X.

Example:
```
Example  : DWORD_TO_STRB(127) = '00000000000000000000000001111111'
```

11.0.19 Type Function: STRING

Input IN	DWORD (input value)
N	Int (length of the result string)
Output	STRING (result STRING)
	DWORD_TO_STRF converts a DWORD, Word or byte in a STRING of fixed length. The output string is exactly N digits, with leading zeros inserted or leading digits truncated. The maximum permitted length N is 20 digits.



Example:
```
DWORD_TO_STRF(5123, 6) = '005123'
DWORD_TO_STRF(5123, 3) = '123'
```

11.0.20 Type Function : STRING

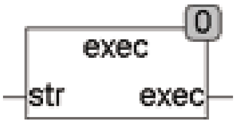
Input IN	DWORD (input value)
Output	STRING(8) (result string)
	DWORD_TO_STRH converts a DWORD, Word or byte in a STRING of fixed length. The output string is exactly 8 characters long and is the hexadecimal notation of the value of IN. The output string consists of the characters ’0 ’.. ‘1’ and ’A ’.. ‘F’. The least significant hexadecimal character is right in the string. DWORD_TO_STRH can process input as byte, word and DWORD types. The output is independent of the input type is always a STRING of 32 characters. If a shorter string is needed, it can be cut with the standard function RIGHT() accordingly. The call RIGHT(DWORD_TO_STRH(X),4) results to a string of 4 characters to the contents of the lower 2 bytes of X.

Example:
```
DWORD_TO_STRH(127) = '0000007F'
```

11.0.21 Type Function: STRING

Input STR	STRING (input STRING)
Output	STRING (result STRING)

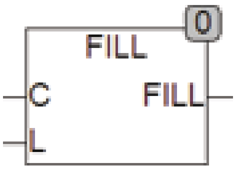
	The function EXEC calculates mathematic expressions and results a string. The expression can only be a simple expression with an operator and without brackets. For errors, such as a divide by zero EXEC provides the return string 'ERROR'.
The valid operators are	+, - *, /, ^, SIN, COS, TAN, SQRT.
	REAL as numbers and integer numbers are allowed.



Example:
`EXEC('3^2') = '9' EXEC('4-2') = '2'`

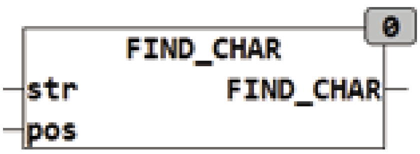
11.0.22 Type Function: STRING

Input C	BYTE (Character Code)
L	INT (length of string)
Output	STRING (result STRING)
	FILL creates a string consisting of the symbol C with the length L.
	FILL(49,5) = '11111'
	The FILL function evaluates the Global Setup constant STRING_LENGTH and limits the maximum length L of the string to STRING_LENGTH.



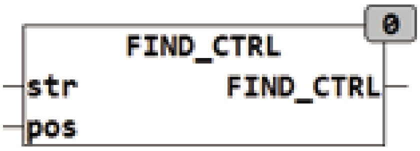
11.0.23 Type Function: INT

Input STR	STRING (input STRING)
POS	INT (start position)
Output	INT (pos of first character that is not a control character)
	FIND_CHAR searches the string STR starting at position POS and returns the position at which the first character is not a control character. Control characters are all characters whose value is less than 32 or 127. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE. If EXTENDED_ASCII = FALSE characters of the extended character set with a value > 127 interpreted as control characters.



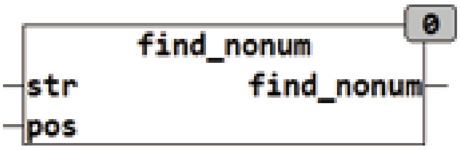
11.0.24 Type Function: INT

Input STR	STRING (input STRING)
POS	INT (start position)
Output	INT (the first character is a control character)
	FIND_CTRL searches the string str starting at position POS and returns the position at which the next control character is. Control characters are all characters whose value is less than 32 or 127.



11.0.25 Type Function: INT

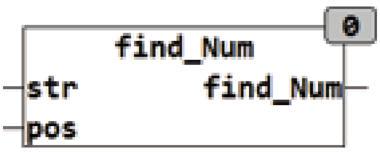
Input STR	STRING (String input)
POS	INT (position at which the search begins)
Output	INT (The first character that is not a number or point)
	The function FIND_NONUM searches STR from the starting position POS from left to right and returns the first position which is not a number.
	Numbers are the letters “0..9” and “.”



Example:
```
FIND_NONUM('4+33',1) = 2
```

11.0.26 Type Function: INT

Input STR	STRING (String input)
POS	INT (position at which the search begins)
Output	INT (position of first character that is a number or point)
	The function searches FIND_NUM STR from position POS from left to right and returns the first position that is a number.
	Numbers are the letters “0..9” and “.”



Example:
```
FIND_NONUM('4+33',1) = 1
```

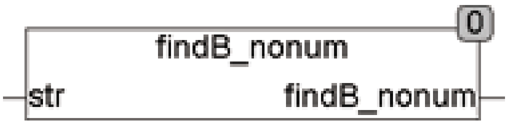
11.0.27 Type Function: INT

Input STR1	STRING (String input)
STR1	STRING (String input)
Output	INT (position of last occurrence of STR2 in STR1)
	The function FINDB searched for the presence of STR2 in STR1 and returns the last position of STR2 in STR1.
	If STR2 is not found, a 0 is returned.

Example:
`FINDB('abs12fir12bus12', '12') = 14`

11.0.28 Type Function: INT

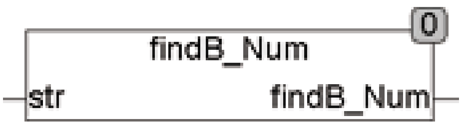
Input STR	STRING (String input)
Output	INT (position of the last letter that is not a number)
	The function FINDB_NONUM STR searches from right to left and returns the last position which is not a number.
	Numbers are the letters “0..9” and “.”



Example:
`FINDB_NONUM('4+33+1') = 5`

11.0.29 Type Function: INT

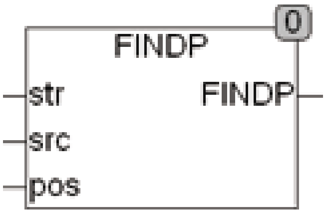
Input STR	STRING (String input)
Output	INT (of the last character, which is a number or point)
	The function FINDB_NUM searches STR from right to left and returns the last position that is a number.
	Numbers are the letters “0..9” and “.”



Example:
`FINDB_NUM('4+33+1hh') = 6`

11.0.30 Type Function: INT

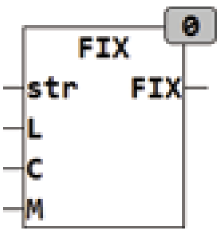
Input STR	STRING (String input)
SRC	STRING (search string)
POS	INT (from the position being sought)
Output	INT (position of the first letter of the found string)
	FINDP searches in a string STR starting at position POS for a string SRC. If SRC found in the string so the position of the first character of SRC in STR is returned. If the string starting at position POS is not found, an 0 is returned. If an empty string is specified as the search string, the module delivers the result 0.



Example:
`FINDP('ein Fuchs ist ein Tier','ein',1) = 1; FINDP('ein Fuchs ist ein Tier','ein',2) = 15; FINDP('ein Fuchs ist ein Tier','ein',16) = 0;`

11.0.31 Type Function: STRING

Input STR	STRING (String input)
L	INT (fixed-length od output string)
C	BYTE (padding character when padding)
M	INT (mode for padding)
Output	STRING (string of fixed length N)
	FIX creates a string of fixed length N. The string STR at the input is truncated to the length N respective filled with the fill character C. If the string STR is shorter than the length L to be created, will the string be filled depending on M, with the fill character C. If M = 0, the padding at the end of the string is appended, if M = 1, the padding is attached the beginning and when M = 2, the string is centered between fill character. If the number of the necessary padding is odd and if M = 2, the fill at the end has a fill character more than at the beginning. The FIX function evaluates the Global Setup string_length constant and limits the maximum length L of the string to string_length.



11.0.32 Type Function: REAL

Input FLT	STRING(20) (floating point)
Output	REAL (REAL value of the floating point)

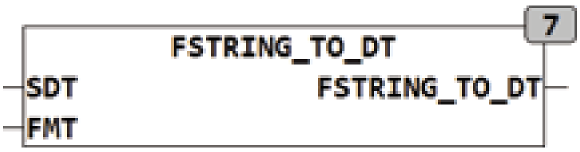
	FLOAT_TO_REAL converts a string- floating point number into a data type REAL. While the conversion characters "." or ',' interpreted as a comma and 'E' or 'e' as the separator of the exponent. The characters '–0123456789' are evaluated and others in FLT occurring characters are ignored.

11.0.33 Type Function: BYTE

Input IN	STRING(12) (String input)
Output	BYTE (Byte value)
FSTRING_TO_BYTE converts a formatted string into a byte value. It supports following input formats	
	2#0101 (binary), 8#345 (octal), 16#2a33 (hexadecimal) and 234 (decimal).

11.0.34 Type Position: DT

Input SDT	STRING(60) (String input)
FMT	STRING(60) (formatting)
Output	DT (identified date and time)
	FSTRING_TO_DT convert a formatted string to a DATETIME value. Useing the string FMT a format is given for decoding. The character '#' followed by a letter defines the information to be decoded.



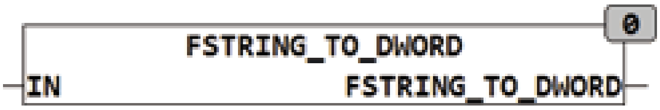
Example:

```
FSTRING_TO_DT('25. September 2008 at 10:01:00', '#D. #N #Y ** #h:#m:#s')
FSTRING_TO_DT('13:14', '#h:#m')
```

#Y	Year in the spelling in 08 or 2008
#M	Month in the spelling of 01 or 1
#N	Month in the spelling of 'Jan' or 'January' (Big and small letters are ignored)
#D	Day in the spelling of 01 or 1
#h	Hour in the spelling of 01 or 1
#m	Minute in the spelling of 01 or 1
#s	Second in the spelling of 01 or 1

11.0.35 Type Function: DWORD

Input IN	STRING(40) (String input)
Output	DWORD (32bit value)
FSTRING_TO_DWORD converts a formatted string to a 32bit Value. It supports following input formats	
	2#0101 (binary), 8#345 (octal), 16#2a33 (hexadecimal) and 234 (decimal).



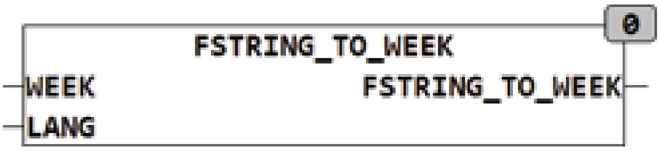
11.0.36 Type Function: INT

Input MTH	STRING(20) (String input)
LANG	INT (language)
Output	INT (month number 1..12)
	FSTRING_TO_MONTH determines from a string containing a month name or abbreviation the value of the month. The function can handle both the month names and abbreviations as input as well as a number of the month.
	FSTRING_TO_MONTH('Januar',2) = 1
	FSTRING_TO_MONTH('Jan',2) = 1
	FSTRING_TO_MONTH('11',0) = 11
	The input LANG selects the used language, 0 = the default in the Setup , 1 = English .... more info about the language settings, see the chapter Data Types.

11.0.37 Type Function: BYTE

Input WEEK	STRING(60) (String input)
LANG	INT (language)
Output	BYTE (Bitpattern of week days)
	FSTRING_TO_WEEK decode a list of days on the form 'MO,TU,3'in a Bitpattern (bit6 = MO...Bit0 = So) For the evaluation each of the first two letters of the list elements are evaluated, the rest are ignored. If the string contains spaces they will be removed. The days of the week can be present in both upper-or lowercase. LANG specifies the language used, 1 = English, 2 = German, 0 is the default language defined in the setup.
	Mo = 1; Di, Tu = 2; We, Mi = 3; Th, Do = 4; Fr = 5; Sa = 6; So, Su = 7

	Since the function evaluates only the first two characters, the weekdays may also be spelled out (Monday) format.
	As an alternative form, the weekday can be specified as number 1..7.
	The list includes the weekdays unsorted and separated by commas.
	FSTRING_TO_WEEK ('Mo,Tu,Sa',2) = 2#01100010.



11.0.38 Type Function: INT

Input WDAY	STRING(20) (String input)
LANG	INT (language)
Output	INT (weekday)
	FSTRING_TO_WEEKDAY decodes a weekday in the form 'MO' to an integer, 1 = MO ... 7 = Sun. For the analysis the first two letters of the string WDAY are evaluated, all others are ignored. If the string contains spaces they will be removed. The days of the week can be present in both upper-or lowercase. Since the function evaluates only the first two characters, the weekdays may also be spelled out (Monday) format.
	Mo = 1; Di, Tu = 2; We, Mi = 3; Th, Do = 4; Fr = 5; Sa = 6; So, Su = 7
	As an alternative form, the weekday can be specified as number 1..7. LANG specifies the used language, 1 = English, 2 = German, 0 = defined default language in the Setup.

11.0.39 Type Function: BYTE

Input HEX	STRING(5) (hex string)
Output	BYTE (output value)
	The function converts a hexadecimal string HEX_TO_BYTE in a BYTE value. Here only hexadecimal characters '0'..'9', 'a..f' and 'A'.. 'F' are interpreted, others occurring in HEX characters are ignored.

Example:
`HEX_TO_BYTE('FF') is 255.`

11.0.40 Type Function: DWORD

Input HEX	STRING(20) (hex string)
Output	DWORD (output value)
	The function HEX_TO_DWORD converts a hexadecimal string in a DWORD value. Here only hexadecimal characters ‘0’..‘9’, ‘a..f’ and ‘A’.. ‘F’ are interpreted, others occurring in HEX characters are ignored.

Example:
`HEX_TO_DWORD('FF') is 255.`

11.0.41 IS_ALNUM

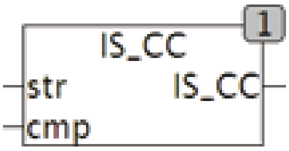
Type Function	BOOL
Input STR	STRING (String input)
Output	BOOL (TRUE if STR contains only letters or numbers)
	IS_ALNUM test if in the string STR are only letters or numbers. If an incorrect, non-alphanumeric character is found the function returns FALSE. STR contains only letters or numbers, the result is TRUE. Letters are the characters A..Z and a..Z, and numbers are the signs 0..9. In examining the Global Setup constant EXTENDED_ASCII is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE.

11.0.42 IS_ALPHA

Type Function	BOOL
Input STR	STRING (String input)
Output	BOOL (TRUE if STR contains only letters)
	IS_ALPHA tests whether the string STR contains only letters. If an incorrect, non-alphanumeric character is found the function returns FALSE. If only letters are included in STR is the result of TRUE. Letters are the characters A..Z and a..z. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE.

11.0.43 IS_CC

Type Function	BOOL
Input STR	STRING (String input)
CMP	STRING (comparison characters)
Output	BOOL (TRUE if STR contains only those listed in the STRING CMP
	contains)
	IS_CC tests whether the string in STR only the in STR listed characters are included. If another character is found the function returns FALSE.



Example:
`IS_CC('3.14', '0123456789.') = TRUE IS_CC('-3.14', '0123456789.') = FALSE`

11.0.44 Type Function: BOOL

Input STR	STRING (String input)
Output	BOOL (TRUE if STR contains only control characters)
	IS_CTRL tests whether the string STR are only control characters included. If another character is found the function returns FALSE. If in STR are only control characters included, the function returns TRUE. Control characters are the characters with the decimal 0..31 and 127

11.0.45 IS_HEX

Type Function	BOOL
Input STR	STRING (String input)
Output	BOOL (TRUE if STR contains only hexadecimal)
	IS_HEX tests whether the string STR contains only hexadecimal characters are. If another character is found the function returns FALSE. If in STR are only hexadecimal characters included, the function returns TRUE. The hexadecimal character are characters with the decimal code 0..9, a..f. and A..F.

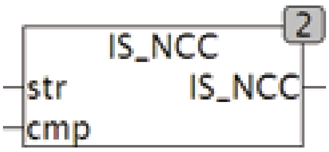
11.0.46 IS_LOWER

Type Function	BOOL

Input STR	STRING (String input)
Output	BOOL (TRUE if str contains only lowercase letters)
	IS_LOWER tests whether the string STR only lowercase letters are included. If anything other than a small letter found the function returns FALSE. If in STR are only lowercase letters included, the function returns TRUE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE.

11.0.47 IS_NCC

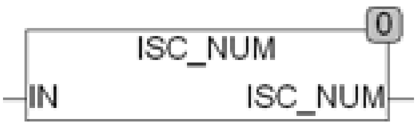
Type Function	BOOL
Input STR	STRING (String input)
CMP	STRING (comparison characters)
Output	BOOL (TRUE if STR none of the character listed in the STRING CMP
	contains)
	IS_NCC tests whether the string STR none of the in STR listed characters are included. Is a character of CMP found in STR, the function returns FALSE.



Example:
`IS_NCC('3.14', ',-+()') = TRUE IS_NCC('-3.14', ',-+()') = FALSE`

11.0.48 IS_NUM

Type Function	BOOL
Input STR	STRING (String input)
Output	BOOL (TRUE if STR does not contain capital letters)
	IS_NUM tests whether the string STR contains only numbers. If another character is found the function returns FALSE. If in STR are only numbers included, the function returns TRUE. Numbers are the character 0..9.



11.0.49 IS_UPPER

Type Function	BOOL
Input STR	STRING (String input)
Output	BOOL (TRUE if STR contains only capital letters)
	IS_UPPER checks if in the string STR all capital letters are included. If an incorrect, non capital character is found the function returns FALSE. If in STR are only capital letters included, the function returns TRUE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE.

11.0.50 Type Function: BOOL

Input IN	BYTE (characters)
Output	BOOL (TRUE IN a sign of a..z, A..Z or Umlaut) is
	ISC_ALPHA tests whether the character IN is an alphabetic character. If IN is a sign A..Z, a..z or any umlaut, the function returns TRUE, if not the function returns FALSE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE.
The following Table Explains the code	

Code	EXTENDED_ASCII = TRUE	EXTENDED_ASCII = FASLE
0..64	FALSE	FALSE
65..90	TRUE	TRUE
91..96	FALSE	FALSE
97..122	TRUE	TRUE
123..191	FALSE	FALSE
192..214	TRUE	FALSE
215	FALSE	FALSE
216..246	TRUE	FALSE
247	FALSE	FALSE
248..255	TRUE	FALSE

11.0.51 ISC_CTRL

Type Function	BOOL
Input IN	BYTE (characters)
Output	BOOL (TRUE IN a sign is 0..9)
	ISC_CTRL tests whether a sign IN is a control character, if IN is a controll character, the function returns TRUE, if not the function returns FALSE. Control characters are all characters with code < 32 or 127.

11.0.52 ISC_HEX

Type Function	BOOL
Input IN	BYTE (characters)
Output	BOOL (TRUE IN a sign is 0..9)
	ISC_HEX tests whether a sign IN is a hex character, If IN is a sign 0..9, A..F, a..f the function returns TRUE if the function returns FALSE.
	The signs are 0..9 are the codes (48..57)
	The characters A..F are the codes (65..70)
	The characters a..f are the codes (97..102)

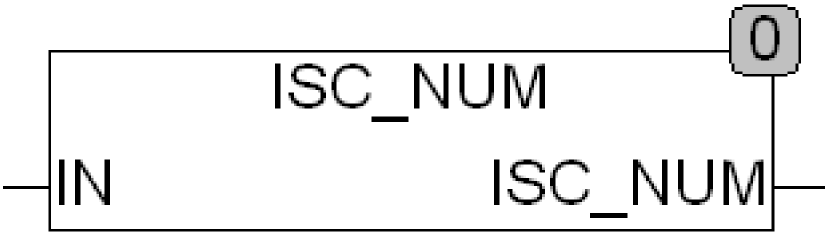
11.0.53 Type Function: BOOL

Input IN	BYTE (characters)
Output	Type
	ISC_LOWER tests whether a sign IN is a lower-case letter, If IN is a lower case the function returns TRUE, else the function returns FALSE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1.
The following Table discusses the character codes	

Code	EXTENDED_ASCII = TRUE	EXTENDED_ASCII = FASLE
0..96, 123..223, 247, 255	FALSE	FALSE
97..122	TRUE	TRUE
224..246	TRUE	FALSE
248..254	TRUE	FALSE

11.0.54 Type Function: BOOL

Input IN	BYTE (characters)
Output	Type
	ISC_NUM tests whether a sign IN is a number, if IN is a character 0..9, the function returns TRUE, if not the function returns FALSE. The character 0..9 are codes (48..57)



11.0.55 ISC_UPPER

Type Function	BOOL
Input IN	BYTE (characters)
Output	Type
	ISC_UPPER tests whether a sign IN is a captial letter, if IN is a capital letter, the function returns TRUE, if not the function returns FALSE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with ISO 8859-1.
The The following table describes the character codes	

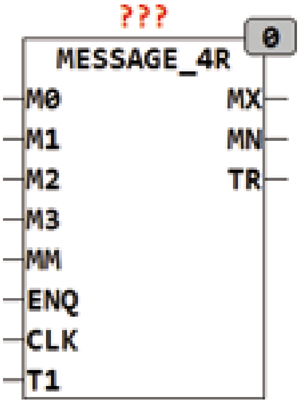
Code	EXTENDED_ASCII=TRUE	EXTENDED_ASCII = FASLE
0..64,91..191,215, 223..255	FALSE	FALSE
65..90	TRUE	TRUE
192..214	TRUE	FALSE
216..222	TRUE	FALSE

11.0.56 LOWERCASE

Type Function	STRING
Input STR	STRING (String input)
Output	STRING (STRING in lowercase)
	The function LOWERCASE converts the String STR to lower case. During conversion, the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE extended ASCII character set are evaluated according to ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE. A detailed description of the code change is found in the function TO_LOWER.

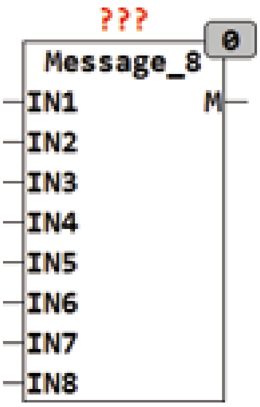
11.0.57 Type Function module

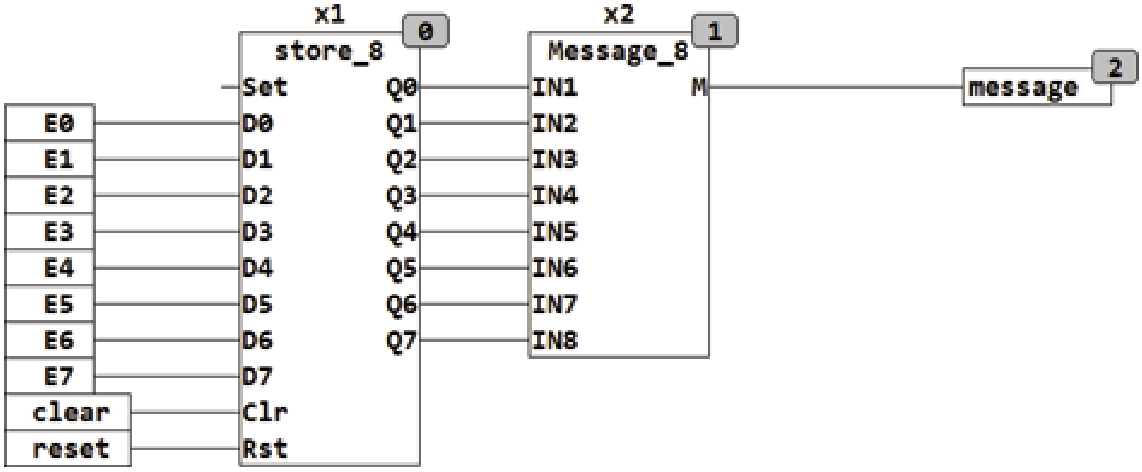
Input M0	. M3 STRING(string_length) (Information)
MM	INT (message appears maximum)
ENQ	BOOL (enable input)
CLK	BOOL (input to the next turn)
T1	TIME (time for automatic advance)
Output MX	STRING(string_length) (output string)
MN	INT (currently active message)
TR	BOOL (Trigger Output)
	MESSAGE_4R provides at the output MX up to 4 messages. There is only one available of up to 4 entries at MX. The number of messages can be limited to the input of MM. MM is set to 2 then only the messages M0.. M2 passed to output after each other. MM is not set then all messages will be issued M0..M3. With each rising edge of CLK, the next message is written to MX, if CLK remains at TRUE so after the time T1 the next message is passed automatically, until CLK is FALSE again. If the enable-input ENQ is set to FALSE, at the output MX '' is passed and the module has no function. The output MN indicates what message is just passed at the output MX. The output TR is always for one cycle TRUE if the message at the output MX has changed, it serves to control given modules to process the messages.



11.0.58 MESSAGE_8

Type	Function module
Input IN1..IN8	BOOL (select inputs)
Output M	STRING (String output)
	MESSAGE_8 generates an output of 8 messages on M. If none of the inputs IN1..IN8 are TRUE,the output to M is an empty string, otherwise one of the stored in S1..S8 messages is passed. The module passes the message with the highest priority. IN1 has the highest priority and IN8 the lowest. MESSAGE_8 can be used in conjunction with the module STORE_8 to save and view events.
	In the following example, up to 8 fault events (E0..E7)
	are stored, and in each case the highest priority message is shown at the output of M MESSAGE_8. With the CLEAR input last message can be deleted by triggering and the next pending message is passed. WITH the RESET input all pending error messages can be cleared.
Setup S1..S8	STRING(default message)





11.0.59 Type Function: STRING

Input STR	STRING (String input)
Output	STRING (input string read backwards)
	MIRROR reads the string STR reverse and passes the characters in reverse order.

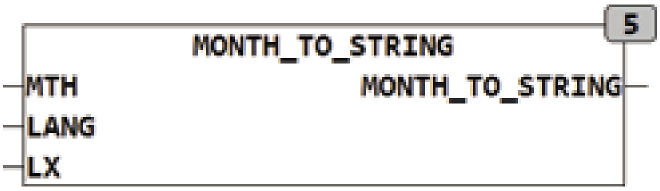
Example:

```
MIRROR ('This is a test') = 'tset a si siht'
```

11.0.60 MONTH_TO_STRING

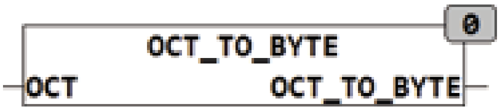
Type Function	STRING (10)
Input MTH	INT (Month 1..12)
LANG	INT (Language 0 = Default)
LX	INT (length of string)
Output	STRING (10) (output value)
MONTH_TO_STRING convert a month number to its equivalent string. The input MTH passes the month	1 =January, 12 = December. The input LANG chooses the language: 1 = English and 2 = German. LANG = 0 used as Default the language specified in the Global Setup variable LANGUAGE_DEFAULT. The input LX sets the length of the string to be generated: 0 = full month name, 3 = 3-letter abbreviation, all other values at the input LX are undefined.
	The strings produced by the module, and the supported languages are defined in the Global Constants and can be expanded and changed.
	MONTH_TO_STRING(1,0,0) = 'January'
	dependent on the global constant LANGUAGE_DEFAULT

	MONTH_TO_STRING(1,2,0) = ‘Januar’
	MONTH_TO_STRING(1,2,3) = ‘Jan’



11.0.61 OCT_TO_BYTE

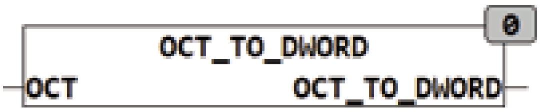
Type Function	BYTE
Input OCT	STRING (10) (Octal string)
Output	BYTE (output value)
	The function OCT_TO_BYTE converts an octal encoded string into a byte value. Only the octal characters are ’0 ’..‘7’ are interpreted, others in HEX occurring characters are ignored.



Example:
`OCT_TO_BYTE('11') results 9.`

11.0.62 OCT_TO_DWORD

Type Function	DWORD
Input OCT	STRING(20) (Octal string)
Output	DWORD (output value)
	The function OCT_TO_DWORD converts an octal encoded string into a byte value. Only the octal characters are ’0 ’..‘7’ are interpreted, others in HEX occurring characters are ignored.

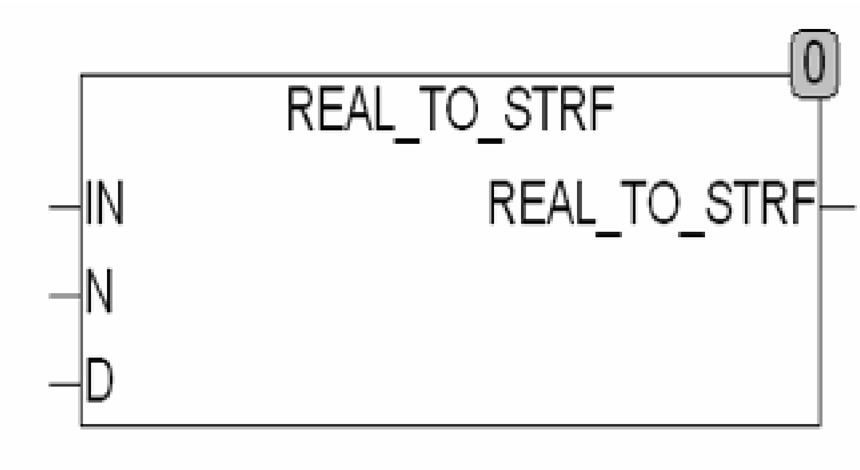


Example:
`OCT_TO_DWORD ('11 ') result 9.`

11.0.63 REAL_TO_STRF

Type Function	STRING(20)
Input IN	REAL (input value)
N	INT (number of decimal places)
D	STRING(1) (decimal punctuation character)
Output	STRING (String output)

	REAL_TO_STRF converts a REAL value to a string with a fixed number of decimal N. At the conversion entirely in a normal number format XXX.NNN is converted. At the conversion IN is rounded to N digits after the decimal point and then converted into a String to the format XXX.NNN. When N = 0, the REAL number is rounded to 0 digits after the decimal point and the result is passed as an integer without a point and decimal places. If the number IN is less than, as with N decimal places can be captured, a zero is passed. The decimal places are always filled up to N digits with zeros. The maximum string length is 20 digits. The D input determines which character represents the decimal point.



Example:
```
REAL_TO_STRF(3.14159,4,'.') = '3.1416' REAL_TO_STRF(3.14159,0,'.') = '3'
REAL_TO_STRF(0.04159,3,'.') = '0.042' REAL_TO_STRF(0.001,2',') = '0,00'
```

11.0.64 REPLACE_ALL

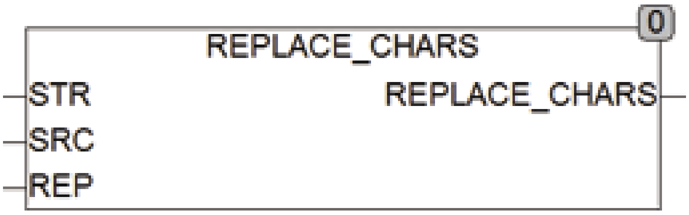
Type Function	STRING
Input STR	STRING (String input)
SRC	STRING (search string)
REP	STRING (String replacement)
Output	STRING (String output)
	REPLACE_ALL replaces all occurring strings SRC in the string STR with REP. An empty string SRC gives no results.

Example:
```
REPLACE_ALL('123BB456BB789BB','BB','/') = '123/456/789/'
REPLACE_ALL('123BB456BB789BB','BB','') = '123456789'
```

11.0.65 REPLACE_CHARS

Type Function	STRING

Input STR	STRING (String input)
SRC	STRING (search strings)
REP	STRING (surrogate)
Output	STRING (String output)
	REPLACE_CHARS replaces all the characters STR in String SRC with the characters at the same place in REP.



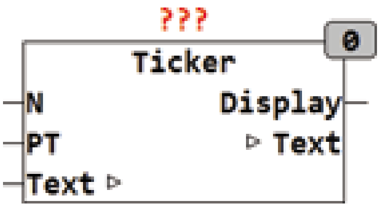
Example:
`REPLACE_CHARS('abc123', '0123456789', ABCDEFGHIJ') = 'abcABC'`

11.0.66 REPLACE_UML

Type Function	STRING
Input STR	STRING (String input)
Output	STRING (String output)
	REPLACE_UML replaces umlauts with a combination of two characters so that the result contains no more umlauts. The large and small letters are considered here. If a word is all upper case and is an umlaut is mentioned, this is replaced by a capital letter followed by a lowercase letter, in the case of a ß which has no capitals there will always be replaced with two small letters. If the function REPLACE_UML is used on a uppercase word, then it must be ensured using the function UPPERCASE() that all capital letters that the lower case are again converted to uppercase.
	Ä > Ae, Ö > Oe, Ü > Ue, ä > ae, ö > oe, ü > oe, ß > ss.

11.0.67 Type Function module

Input N	INT (length of the display Strings)
PT	TIME (slide delay, Default = T#1s)
I / O TEXT	STRING (String input)
Output DISPLAY	STRING (String output)
	TICKER generate at the output DISPLAY a running script. At the output DISPLAY a substring of text with the length N is output. DISPLAY is passed to output in a time frame of PT and starts at each pass from one place to the left of the input string TEXT. The scrolling text is generated only when N < than the length of TEXT. If N >= length of text then the String TEXT is directly represented at the output of DISPLAY.



11.0.68 Type Function: BYTE

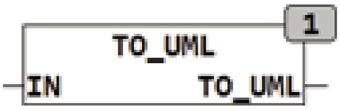
Input IN	BYTE (Characters to be converted)
Output	BYTE (converted characters)
	To_lower converts individual characters to lowercase. During conversion, the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE, all characters of the extended ASCII character set to be considered in accordance with ISO 8859-1.
The following Table discusses the conversion code	

Code	EXTENDED_ASCII = TRUE	EXTENDED_ASCII = FALSE
0..64	0..64	0..64
65..90	97..122	97..122
91..191	91..191	91..191
192..214	224..246	192..214
215	215	215
216..222	248..254	216..254
223..255	223..255	223..255

11.0.69 Type Function: STRING(2)

Input IN	BYTE (Characters to be converted)
Output	STRING (2) (converted characters)
	TO_UML converts individual characters of the character set to greater than 127 in a combination of two letters. It is here the extended ASCII character set ISO 8859-1 (Latin1).
It will be converted the following characters	
Ä >> Ae	ä >> ae Ö >> Oe ö >> oe Ü >> Ue ü >> ue
	ß >> ss

	All other characters are returned as a string with the character IN.



11.0.70 Type Function: BYTE

Input IN	BYTE (Characters to be converted)
Output	BYTE (converted characters)
	To_upper converts some characters to uppercase. During conversion, the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE, all characters of the extended ASCII character set to be considered in accordance with ISO 8859-1.
The following Table discusses the conversion code	

Code	EXTENDED_ASCII = TRUE	EXTENDED_ASCII = FALSE
0..64	0..64	0..64
65..90	97..122	97..122
91..191	91..191	91..191
192..214	224..246	192..214
215	215	215
216..222	248..254	216..254
223..255	223..255	223..255

11.0.71 Type Function: STRING

Input STR	STRING (String input)
Output	STRING (STR without spaces)
	The TRIM function removes all spaces from STR.

Example:
```
TRIM('find BX12') = 'findBX12'
```

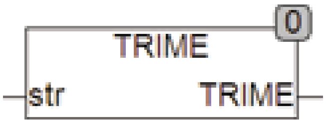
11.0.72 Type Function: STRING

Input STR	STRING (String input)
Output	STRING (STR without double spaces)
	The function TRIM1 replaces multiple spaces with one space. Spaces at the beginning and the end of STR will be deleted completely.

Example:
`TRIM1(' find  BX12 ') = 'find BX12'`

11.0.73 Type Function: STRING

Input STR	STRING (String input)
Output	STRING (output string)
	The TRIME function removes spaces at the beginning and the end of STR. Spaces within the string are ignored, even if they occur repeatedly.



11.0.74 Type Function: STRING

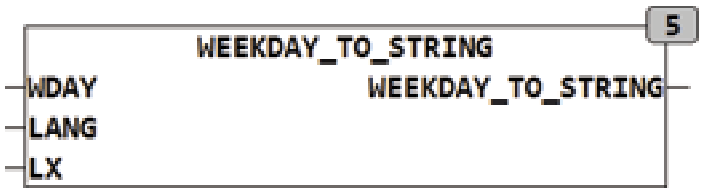
Input STR	STRING (String input)
Output	STRING (STRING in uppercase)
	The function UPPERCASE converts all letters of STR in uppercase. During conversion, the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE, all characters of the extended ASCII character set to be considered in accordance with ISO 8859-1. Umlauts like Ä, Ö, Ü are considered only if the global constant EXTENDED_ASCII = TRUE. A detailed description of the code change is found in the function TO_UPPER.

Example:
`UPPERCASE('find BX12') = FIND BX12`

11.0.75 Type Function: STRING (10)

Input WDAY	INT (weekday 1..7)
LANG	INT (Language 0 = Default)
LX	INT (length of string)
Output	STRING (10) (output value)

WEEKDAY_TO_STRING converts a weekday in the corresponding string. The input WDAY indicates the corresponding day of the week	1 = Monday and 7 = Sunday. The input LANG chooses the language: 1 = English and 2 = German. LANG = 0 used as Default the language specified in the Global Setup variable LANGUAGE_DEFAULT. [fzy] The input LX sets the length of the string to be generated: 0 = full month name, 3 = 3-letter abbreviation, all other values at the input LX are undefined.
	The strings produced by the module, and the supported languages are defined in the Global Constants and can be expanded and changed.
	WEEKDAY_TO_STRING(1,0,0) = ' Monday '
	dependent on the global constant LANGUAGE_DEFAULT
	WEEKDAY_TO_STRING(1,2,0) = ' Monday '
	WEEKDAY_TO_STRING(1,0,2) = ' Mon '

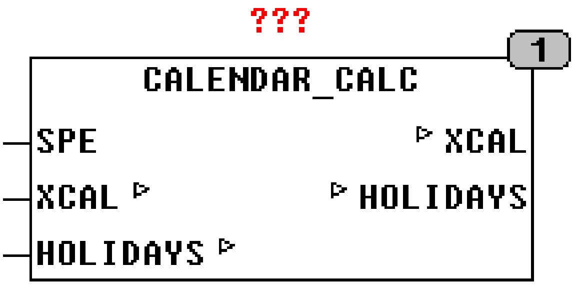


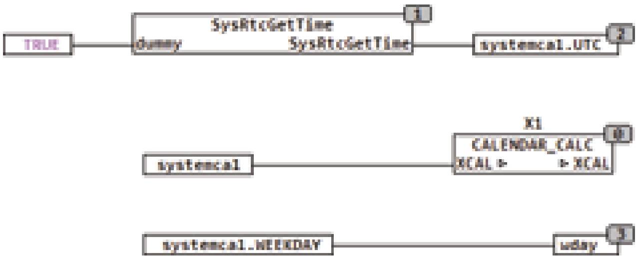
12. Time&Date

This section contains 109 modules.

12.0.1 CALENDAR_CALC

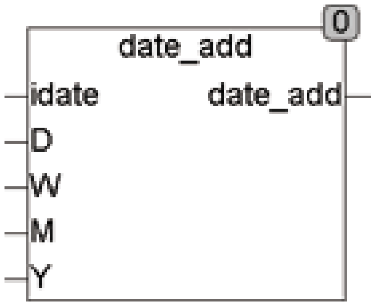
Type	Function module
Input SPE	BOOL (TRUE calculates the current sun position)
I / O XCAL	CALENDAR (external variables)
HOLIDAYS	HOLIDAY_DATA (holiday list)
	CALENDAR_CALC automatically calculates all the values in a CALENDAR structure based on the value of the type UTC in the structure. XCAL is a Pointer an external or global variable of type CALENDAR. CALENDAR_CALC can thus deliver calendar values based on the structure XCAL throughout the module. CALENDAR_CALC determines at each change of the value UTC in XCAL automatically all other values in the structure. Alone the value of UTC in a structure must be fed by the RTC module. The definition of the structured type CALENDAR you can find in section data structures. The continuous calculation of the sun position can weigh heavily on a PLC without FPU, which is why the current sun position is calculated only once every 25 seconds if SPE = TRUE. This corresponds to an accuracy of 0.1 degrees which is quite sufficient for normal applications. If SPE is FALSE, the position of the sun is not calculated. By an external array HOLIDAYS of type HOLYDAY_DATA, the user can specify specific holidays according to his needs, for more information on the definition of public holidays see the module data structures.
	If several structures of the type CALENDAR are required (for example, or various local and UTC times) then more modules CALENDAR_CALC can be used with different structures of TYPE CALENDAR in accordance .
	The following example shows how the module SYSRTCGETTIME reads the RTC of the CPU and writes the current time in SYSTEMCAL.UTC. CALENDAR_CALC checks every cycle if the value in .UTC has changed and if so it calculates the other values of the structure automatically. The output WDAY shows how the structure reads data for further processing. CALENDAR_CALC accounts of the setup data from the data structure (OFFSET DST_EN, LONGITUDE, LATITUDE).
	In the external array HOLIDAYS up to 30 holidays can be defined. For examples, see the description of the data type HOLIDAY_DATA. This array of HOLIDAY_DATA must be defined outside of the module and be pre-assigned as a variable with the holiday dates.





12.0.2 Type Function

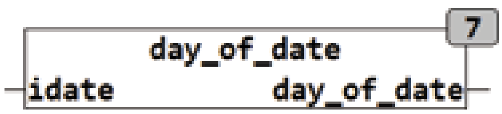
Input IDATE	DATE (date)
D	INT (days to be added)
W	INT (weeks to be added)
M	INT (months to be added)
Y	INT (years to be added)
Output	DATE (result date)
	The function DATE_ADD add days, weeks, months, and add years to a date. First the module adds the specified days and weeks, then months and finally the years.
	The input values can be both positive as well be negative. So it can also be subtracted from a date.
	Note that especially for negative input values the sum of negative values, i.e. −3000 days does not run below 1.1.1970 because this would have an overflow of data type DATE and undefined values are obtained.



Example:
`DATE_ADD(1.1.2007,3,1,-1,-2) = 11/12/2005`
adds additional 3 days and 1 week and then draws 1 month and 2 years from.

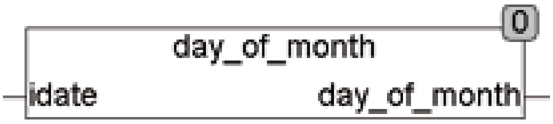
12.0.3 Type Function: DINT

Input IDATE	DATE (date)
Output	DINT (day in month of inout date)
	The function calculates the DAY_OF_DATE day since 1.1.1970. The result of the function is of type DINT because the entire DATE Range Includes 49,710 days.



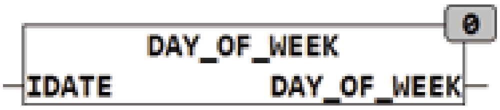
12.0.4 Type Function: INT

Input IDATE	DATE (date)
Output	INT (day in month of input date)
	The DAY_OF_MONTH function calculates the day of the month from the input date IDATE.



12.0.5 Type Function: INT

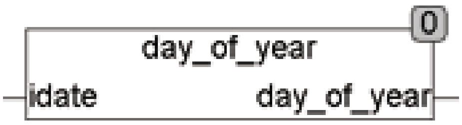
Input IDATE	DATE (date)
Output	INT (month in the year of the input date)
	The function calculates the DAY_OF_WEEK week from the date of receipt IDATE.
	Monday = 1 .. Sunday = 7 The calculation is done in accordance with ISO8601.



Example:
`DAY_OF_WEEK(D#2007-1-8) = 1`

12.0.6 Type Function: INT

Input IDATE	DATE (date)
Output	INT (day of the year of input date)
	The DAY_OF_YEAR function calculates the day of the year from the input date IDATE. Leap years are taken into account according to the Gregorian calendar. The function is defined for the years 1970 - 2099.



Example:
`DAY_OF_YEAR(31.12.2007) = 365 DAY_OF_YEAR(31.12.2008) = 366`

12.0.7 Type Function: TIME

Input IN	REAL (number of days with decimal places)
Output	TIME (TIME)
	The function DAY_TO_TIME calculates a value (TIME) from the input value in days as REAL.

Example:
`DAY_TO_TIME(1.1) = T#26h24m`

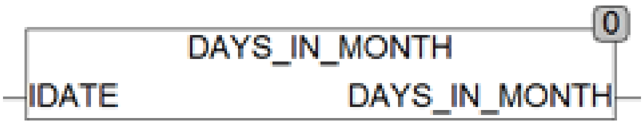
12.0.8 Type Function: DINT

Input DATE_1	DATE (Date1)
DATE_2	DATE (date2)
Output	DINT (difference of the two input dates in days)
	The function DAYS_DELTA calculates the difference between two data in days.

Example:
`DAYS_DELTA(10.1.2007, 1.1.2007) = -9 DAYS_DELTA(1.1.2007, 10.1.2007) = 9`
The result of the function is of type DINT because the entire DATE Range Includes 49,710 days.

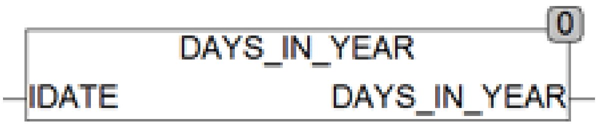
12.0.9 Type Function: INT

Input IDATE	DATE (current date)
Output	INT (number of days of current month)
	The days_in_month function calculates the number of days in the current month.



12.0.10 Type Function: INT

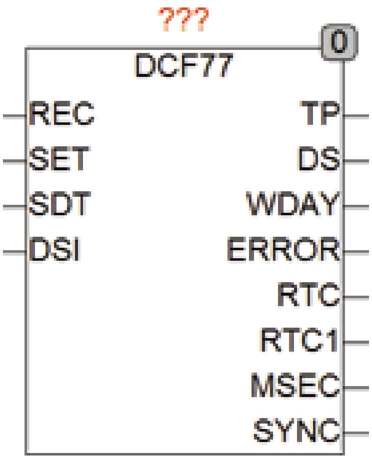
Input IDATE	DATE (current date)
Output	INT (number of days in the current year)
	The DAYS_IN_YEAR function calculates the number of days in the current year.



12.0.11 Type Function module

Input REC	BOOL (input for the DCF77 receiver)

SET	BOOL (Asynchronous SET input)
SDT	DT (initial value for RTC)
DSI	BOOL (DST in)
Output TP	BOOL (pulse for setting downstream clock)
DS	BOOL (TRUE if daylight saving time is)
WDAY	INT (weekday)
ERROR	BOOL (TRUE, if REC supplies no signal)
RTC	DT (Synchronized Universal Time UTC)
RTC1	DT (Synchronized local time)
MSEC	INT (milliseconds from RTC and RTC1)
SYNC	BOOL (TRUE, when RTC is in sync with DCF)
Setup SYNC_TIMEOUT	TIME (Default = T#2m)
Time_offset	INT (time offset for RTC1, Default = 1 hour)
DST_EN	BOOL (daylight saving time for RTC1, Default = TRUE)
	The function DCF77 decodes the serial signal of DCF77 receiver and controls 2 internal clock RTC and RTC1, or via output TP external (downstream) watches. An output DS is TRUE if daylight saving time is. The output WDAY is the weekday (1 = Monday). The output ERROR is TRUE if no valid signal is received. The internal clocks continue to run anyway, also if they already synchronized. A Another output SYNC indicates that in internal clocks are synchronized with DCF77 and gets FALSE if they were synchronized by not less than the setup variable SYNC_TIMEOUT specified time. The internal clocks runs always with the accuracy of the SPS Timers further. By double-clicking the icon in the CFC editor other setup variables are defined. Here SYNC_TIMEOUT sets, after which time the output signal SYNC gets FALSE, if the internal clock RTC and RTC1 were not synchronized by DCF77. The variable time_offset determines the time difference between local time (RTC1) from the UTC. Default is 1 hour for CET (Central European Time). The variable TIME_OFFSET is of type INTEGER thus also time zones with negative offset (west of Greenwich) are possible.
	By DST_EN is determined whether RTC1 should automatically switch to summer time or not. The output MSEC extends the by RTC to RTC1 provided time to milliseconds. The SDT is used to put the internal clock RTC and RTC1 to a defined initial value, so that immediately after the start a valid time is available. During the first cycle date and time is copied from SDT to RTC and runs from the first cycle. If necessary, the internal CLOCK can be set always new with the asynchronous set input SET. However, it is overwritten again by a valid DCF77 signal after a cycle, unless the SET input remains TRUE. If a valid DCF77 signal was decoded, RTC and RTC1 is synchronized to the corresponding precise DCF77 time. At the input of SDT for example, the time from the information contained in the PLC Hardware Clock can be used. It must be ensured, that the DCF77 is called only if a valid time is already present in SDT, the DCF77 reads this value only once in the first cycle, or at any time when the SET input is set to TRUE.

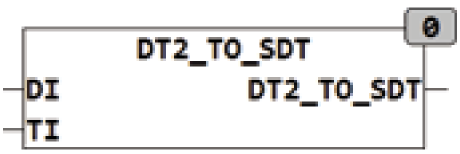


12.0.12 Type Function: BOOL

Input UTC	DATE_TIME (Universal Time)
Output	BOOL (TRUE if daylight saving time)
	The DST function checks whether daylight saving time is right now or not. It can be used to an existing non-DST enabled clock to switch to summer and winter in exact seconds.
The function of DST switches on the last Sunday of March at 01	00 UTC (02:00 CET) to summer time (03:00 GMT) and on the last Sunday of October at 01:00 UTC (03:00 BST) to 02:00 CET back. The output of DST is TRUE if daylight saving time is.
The summer time is calculated based on UTC (Universal Time). A calculation of location-time for daylight saving time is generally not possible because in the last Sunday of October, the hour of 2	00 a.m. to 3:00 a.m. PST or PDT there exists twice. The summer time will be changed in all countries of the EU since 1992, at the same second to world time. In Central Europe at 02:00, at 01:00 in England and Greece at 04:00. By using the world time calculation of daylight saving time for all European time zones is calculated correctly.

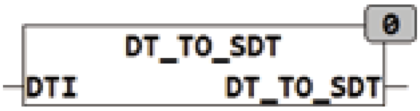
12.0.13 Type Function: SDT

Input DI	DATE (date)
TI	TOD (time of day)
Output	SDT (Structured date time value of type SDT)
	DT2_TO_SDT converts a date and time of day to day in a structured date type SDT.



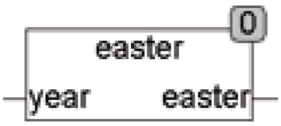
12.0.14 Type Function: SDT

Input DTI	DT (date time value)
Output	SDT (Structured date time value of type SDT)
	DT_TO_SDT converts a date value into a structured date day of type SDT.



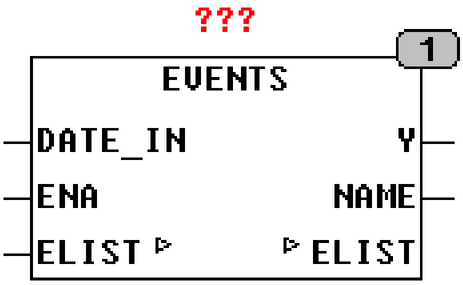
12.0.15 Type Function: DATE

Input YEAR	INT (year)
Output	DATE (date of Easter Sunday for the specified year)
	The function EASTER calculates for a given year, the date of Easter Sunday. Most religious holidays have a fixed distance from Easter, so that in the case that Easter is known for a year, these holidays can also be determined easily. EASTER is also used in the module HOLIDAY to calculate holidays.



12.0.16 EVENTS

Type	Function module
Input Date_in	DATE (input date)
ENA	BOOL (Enable Input)
I / O ELIST	ARRAY [0.49] of HOLIDAY_DATA
Output Y	BOOL (TRUE if date_in is an event)
Name	STRING(30) (name of today's event)
	The module EVENTS shows the output Y with TRUE special days and also provides the names of the events at the output NAME. EVENTS can also take into account events over several days. The array ELIST name, date and duration of events are set.
	In the external array ELIST can define up to 50 such events in the following format.
***.NAME**	STRING(30) specifies the name of the event
***.DAY**	SINT Events of the month
***.MONTH**	SINT Month of Events
***.USE**	SINT Duration of the event in days

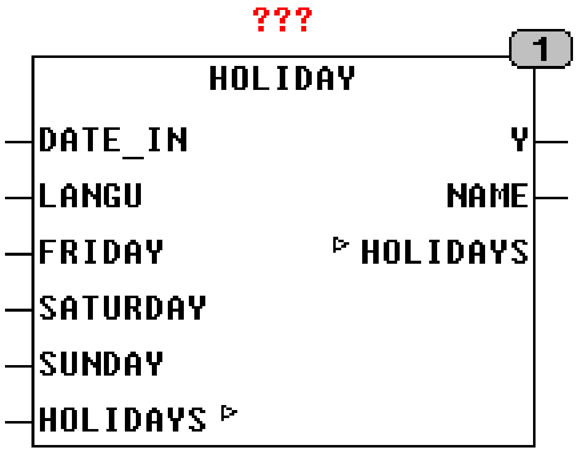


Example:

`(NAME: = 'Foundation Day', DAY = 13 MONTH = 7, USE: = 1) solid event "Foundation Day" on 13 July for one day. (NAME: = 'Foundation Day', DAY = 13 MONTH = 7, USE: = 0) event at a fixed date USE = 0 means it is not active. (NAME: = 'Operation Holiday' DAY: = 1, MONTH = 8, USE: = 31) defines an event with a duration of 31 days.`

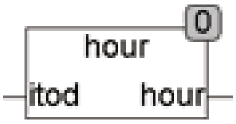
12.0.17 HOLIDAY

Type	Function module
Input Date_in	DATE (input date)
Langue	INT (desired language)
FRIDAY	BOOL (Y is true on Friday when TRUE)
SATURDAY	BOOL (Y is true on Saturdays if TRUE)
SUNDAY	BOOL (Y is TRUE if TRUE on Sundays)
I / O HOLIDAYS	ARRAY [0..29] of HOLIDAY_DATA
Output Y	BOOL (TRUE if DATE_IN is a holiday)
Name	STRING(30) (name of present-day holiday)
	The HOLIDAY function shows the output Y with TRUE holidays and also provides the name of the current holiday at the output NAME. HOLIDAY can, in addition to celebration days during the weekdays Friday, Saturday or Sunday be active and deliver at the output Y TRUE, depending on whether the inputs are FRIDAY, SATURDAY or SUNDAY set to TRUE. In the array HOLIDAYS are name and date of holidays defined and also universally adaptable to other countries. Holidays can be defined as a fixed date, with a distance of Easter or the week before a fixed date. The input LANGU selects the appropriate language from the setup data so that expenditure for Friday, Saturday and Sunday can be customized language-specific. [fzy] The languages are global constants in the “LOCATION SETUP” defined and can be expanded or adapted.
	In the external array HOLIDAYS up to 30 holidays can be defined. Examples are located in the description of the data type HOLYDAY_DATA.



12.0.18 Type Function: INT

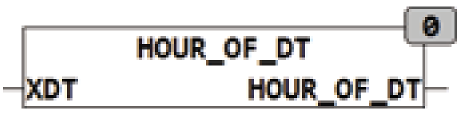
Input ITOD	TIMEOFDAY (day time)
Output	INT (current hour)
	The HOUR function extracts the current hour of the day.



Example:
`HOUR(22:55:13) = 22`

12.0.19 Type Function: INT

Input XDT	DATETIME (input)
Output	INT (current hour)
	HOUR_OF_DT extracts the hour from a current DT value.
HOUR_OF_DT(DT#2008-6-6-10	22:20) = 10



12.0.20 Type Function: TIME

Input IN	REAL (number of hours with decimals)
Output	TIME (TIME)
	The function HOUR_TO_TIME calculates a time value (TIME) from the input value in hours as REAL.

Example:
`HOUR_TO_TIME(1.1) = T#1h6m`

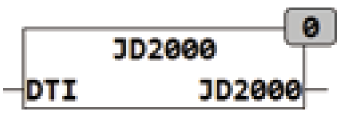
12.0.21 Type Function: TIME

Input IN	REAL (number of hours with decimals)
Output	TIME (days)
	The function HOUR_TO_TOD calculate a time of day (TIMEOFDAY) from the input value in hours as REAL.

Example:
`HOUR_TO_TOD(12.1) = 12:06:00`

12.0.22 JD2000

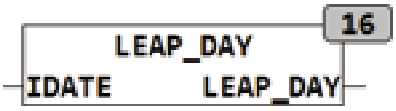
Type Function	REAL
Input DTI	DT (Gregorian date)
Output REAL (astronomical, Julian Day as of 1/1/2000 12	00)
JD2000 calculates the astronomical Julian day since January, 1st., 2000 12	00 (the Standardäquinoktium).
The Julian date is the time in days since January 1st. 4713 BC, as a float at 12	0. The January 1st. 2000 00:00 corresponds to the Julian date 2451544.5. Since a date as the January 1st 2000 can would already exceed the resolution limit of a REAL with about 7 character, the Julian date can not be represented correctly with the data type REAL. The function counts the JD2000 Julian days since 1/1/2000 12:00 pm and can present a current date in the data type REAL.



12.0.23 LEAP_DAY

Type Function	BOOL
Input IDATE	DATE (date)
Output	BOOL (TRUE if the current day is 29 February)

	The LEAP_DAY function checks if the input date is a leap or a 29th February. The test is valid for the time window from 1970 to 2099. In the year 2100 a leap year indicated although this is not one. However, since the range of dates according to IEC61131-3 extends only to the year 2106 this correction will be omitted.



Example:
`LEAP_DAY(D#2004-02-29) = TRUE`

12.0.24 LEAP_OF_DATE

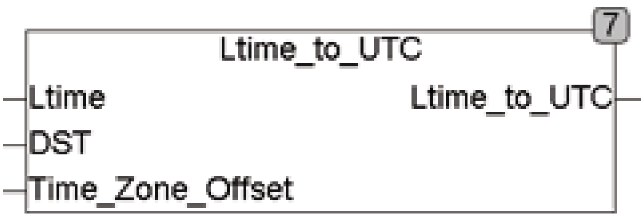
Type Function	BOOL
Input IDATE	DATE (date)
Output	BOOL (TRUE if IDATE is a leap year)
	The function LEAP_OF_DATE tests whether the input date is in a leap year. The function calculates whether a date falls within a leap year and returns TRUE if necessary. The test is valid for the time window from 1970 to 2099. In the year 2100 a leap year is indicated although this is not one. However, since the range of dates according to IEC61131-3 extends only to the year 2106 this correction will be omitted.

Example:
`LEAP_OF_YEAR(D#2004-01-12) = TRUE`

12.0.25 LTIME_TO_UTC

Type Function	DATE_TIME
Input LTIME	DATE_TIME (local time)
DST	BOOL (TRUE if daylight saving time is true)
TIME_ZONE_OFFSET	INT (time difference to UTC in minutes)
Output	DATE_TIME (UTC, Universal Time)
	LTIME_TO_UTC calculates UTC (Universal Time) from a given local time. The world time is calculated by subtracting from the TIME_ZONE_OFFSET LTIME local time. If the DST is active (DST = TRUE), an additional hour of LTIME is deducted.

| **Note** | The summer time is not regulated the same in all countries. The function assumes that in addition to summer time a further hour is added to offset. |



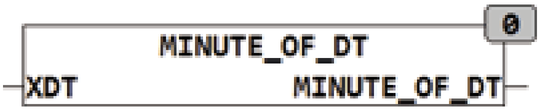
12.0.26 MINUTE

Type Function	INT
Input ITOD	TIMEOFDAY (day time)
Output	INT (current minute)
	The MINUTE function extracts the current minute of the day.

Example:
`MINUTE(22:55:13) = 55`

12.0.27 Type Function: INT

Input XDT	DATETIME (input)
Output	INT (current minute)
	MINUTE_OF_DT extracts the current minute from a DT value.
MINUTE_OF_DT(DT#2008-6-6-10	22:20) = 22



12.0.28 Type Function: TIME

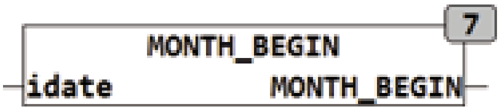
Input IN	REAL (number of minutes with decimals)
Output	TIME (TIME)
	The function MINUTE_TO_TIME calculates a time value (TIME) from the input in minutes as REAL.

Example:
`MINUTE_TO_TIME(122.5) = T#2h2m30s`

12.0.29 MONTH_BEGIN

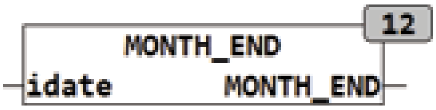
Type Function	DATE
Input IDATE	DATE (current date)
Output	DATE (date of the 1st day of current month)
	MONTH_BEGIN calculates the date of first Day of the current month and current year.

	MONTH_BEGIN(D#2008-2-13) = D#2008-2-1



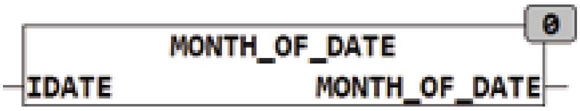
12.0.30 MONTH_END

Type Function	DATE
Input IDATE	DATE (current date)
Output	DATE (date of the last day of the current month)
	MONTH_END calculates the date of the last day of the current month and current year.
	MONTH_END(D#2008-2-13) = D#2008-2-29



12.0.31 MONTH_OF_DATE

Type Function	INT
Input IDATE	DATE (date)
Output	INT (month in the year of the input date)
	The MONTH function calculates the month of the year from the date of input date IDATE.



Example:
`MONTH_OF_DATE(D#2007-12-31) = 12 MONTH_OF_DATE(D#2006-1-1) = 1`

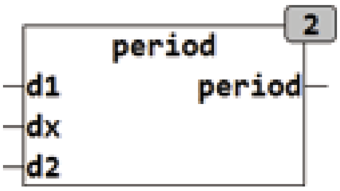
12.0.32 Type Function: TIME

Input T	TIME (input time)
M	REAL (multiplier)
Output	TIME (result input time multiplied by M)
	The MULTIME function multiplies a time value with a multiplier.

Example:
`MULTIME(T#1h10m, 2.5) = T#2h55m`

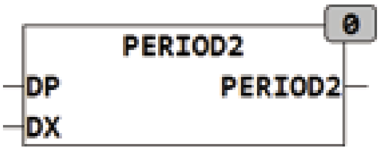
12.0.33 PERIOD

Type Function	BOOL
Input D1	DATE (period begin)
DX	DATE (date to be tested)
D2	DATE (period end)
Output	BOOL (TRUE if DX within the period D1 .. D2)
	The function checks whether an input date DX is greater or equal than D1 and is less equal D2. If the date DX in the period between D1 and D2 (D1 and D2 included) is the output of the function TRUE. PERIOD ignores the years in the dates D1, D2 and DX. The test is performed only for months and days, so this function works for each year. The test period can also after 31 Extend beyond December, so for example from 9/1 - 3/15, a typical application is to determine whether there is a heating period. That PERIOD work properly the two dates D1 and D2 may not be in a leap year. It can, for example, always be 2001, or even any other year that is not a leap year.
	PERIOD (10/1/2001, 11/11/2007, 31/03/2001) returns TRUE, because the test date within the period from 10/1 - 3/31 content.



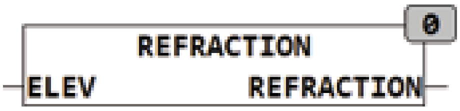
12.0.34 PERIOD2

Type Function	BOOL
Input DP	ARRAY [0..3,0..1] of DATE (periods)
DX	DATE (date to be tested)
Output	BOOL (TRUE if DX is within one of the periods)
	PERIOD2 check if the DX date within a specified period of 4 periods. The periods are in an array [0..3,0..1] of DATE specified. In contrast to the function PERIOD of PERIOD2 reviewes also the year. The periods are specified in ARRAY DP, where DP[N,0] is the beginning date of the period N, DP[N,1] N is the end date of period.
The function test using the formula	DX >= DP [N,0] AND DX <= DP [N,1]. In each case it is considered N = 0 to 3. If DX is one of the 4 periods, the output is set to TRUE.
	The individual periods need not be present sorted. PERIOD2 can be used to define holiday or vacation time. PERIOD2 reviews not repeated periods, but tests yearly repeated periods.



12.0.35 REFRACTION

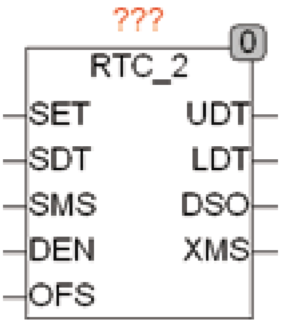
Type Function	REAL
Input ELEV	REAL (elevation in degrees above the horizon)
Output	REAL (refraction in degrees)
REFRACTION calculates the atmospheric refraction outside the atmosphere and celestial bodies. A celestial body appears by the refraction of light in the atmosphere by the refraction higher above the horizon than he actually is. The refraction is 0 at the zenith (at 12	00 noon) and increases much close to the horizon. At 0° (the horizon), the refraction is −0.59° and 10° above the horizon, it is 0.09°. The refraction is needed to calculated orbits of celestial bodies and to correct satellite so that they match with observation. The module calculates an average value for the pressure of 1010mBar and 10° C. When the sun is actually at 0°, so exactly in the horizon, it appears above the horizon because of refraction at 0.59 degrees . The visible sun position is the actual (astronomical) sun position H + the refraction of the sun. The refraction angle is also calculated below the horizon ELEV < - 2°, so that below the horizon always the refraction is added to the astronomical refraction angle, so as the distance to the sun can be calculated correctly at any time. For astronomical angle < −1.9 ° is the refraction remains constant at 0.744 degrees.

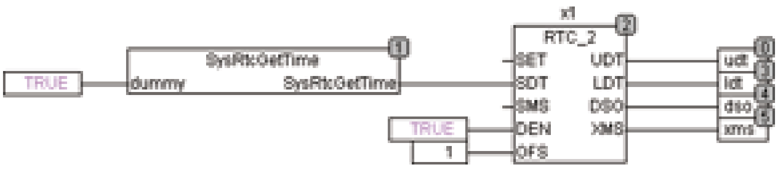


12.0.36 RTC_2

Type	Function module
Input SET	BOOL (set input)
SDT	DT (set date and time)
SMS	INT (set Milliseconds)
DEN	BOOL (automatic daylight saving time ON)
SFO	INT (local time offset from UTC in minutes)
Output UDT	DT (Date and time output for Universal Time)
LDT	DT (local time)
DSO	BOOL (summer active)
XMS	INT (milliseconds)
RTC_2 is a clock component of the UTC and local time at the outputs of LDT and UDT	00 UTC (02:00 CET) to summer time (03:00 GMT) and on the last Sunday of October at 01:00 UTC

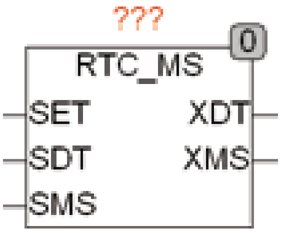
provides. The time is automatically every time you SET = TRUE to the value of SDT and SMS. If SET = FALSE the time runs on and on and provides at the output UDT the current date and time for Universal Time (UTC), and at the output LDT the current local time. The output LDT corresponds UDT + OFS + summer time when it is current. Summer time is, if DEN = TRUE, automatically switched back on the last Sunday of March at 01	(03:00 BST) on 02:00 CET. The output of DSO is TRUE if daylight saving time is. If DEN is FALSE, no summer time change is made. The accuracy of the clock depends on the millisecond Timer of the PLC. The input SFO specifies the time offset of LDT to UDT, for MEZ this value is 1 hour. SFO is specified as INT in minutes so that a negative offset is available. For CET (Central European Time, an offset is set to 60 minutes.) RTC_2 takes over the Power Up automatically applied to the SDT start time and date. The output of XMS passes the milliseconds and every second counts from 0 - 999
	The following example when starting the system time is taken.





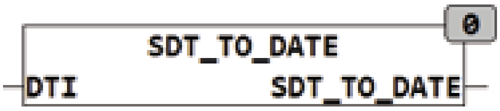
12.0.37 RTC_MS

Type	Function module
Input SET	BOOL (set input)
SDT	DT (set date and time)
SMS	INT (set Milliseconds)
Output XDT	DT (Date and Time Out)
XMS	INT (milliseconds output)
	RTC_MS is a clock component with a resolution of milliseconds and date. The time is automatically every time you SET = TRUE to the value of SDT and SMS. If SET = FALSE the time is running on their own and provides the output XDT the current date and time, and at the output XMS milliseconds. The output XMS counts every second 0-999 and begins with the next second again at 0. The accuracy of the clock depends on the millisecond Timer of the PLC.



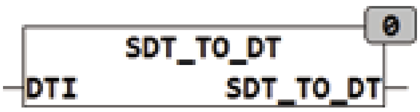
12.0.38 Type Function: DATE

Input DTI	SDT (structured input value as date / time value)
Output	DATE (Date value)
	SDT_TO_DATE produces a date value of a structured date-time value



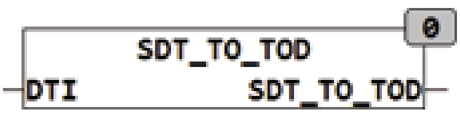
12.0.39 Type Position: DT

Input DTI	SDT (structured input value as date / time value)
Output	DT (date-time value)
	SDT_TO_DT generates a date-time value of a structured date-time value



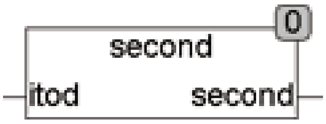
12.0.40 SDT_TO_TOD

Type Function	TOD
Input DTI	SDT (structured input value as date / time value)
Output	TOD (time of day)
	SDT_TO_TOD produces a time of day of a structured date-time value.



12.0.41 Type Function: REAL

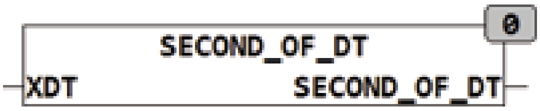
Input ITOD	TOD (time of day)
Output	REAL (seconds and milliseconds of time of day)
	The function SECOND extracts the seconds portion of the day



Example:
`SECOND(22:10:12.331) = 12.331`

12.0.42 SECOND_OF_DT

Type Function	INT
Input XDT	DATETIME (input)
Output	INT (current second)
	SECOND_OF_DT extracts the second from a current DT value.
SECOND_OF_DT(DT#2008-6-6-10	22:20) = 20



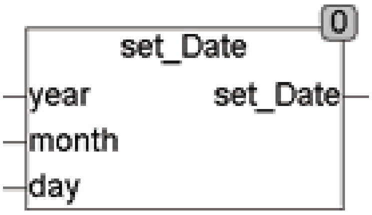
12.0.43 Type Function: TIME

Input IN	REAL (number of seconds with decimals)
Output	TIME (TIME)
	The function SECOND_TO_TIME calculates a value (TIME) from the input value in seconds as a REAL.

Example:
`SECOND_TO_TIME(63.123) = T#1m3s123ms`

12.0.44 Type Function: DATE

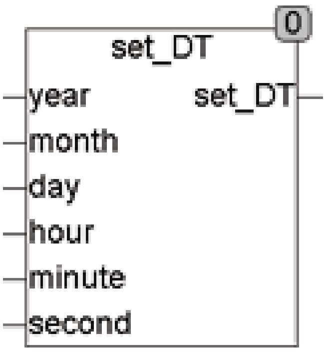
Input YEAR	INT (year)
MONTH	INT (month)
DAY	INT (day)
Output	DATE (Composite date)
	The function SET_DATE calculates a Date (DATE) from the input values, day, month and year. SET_DATE does not test the validity of a date. For example, also be February, 30th will be set, which, of course results the 1st March or in a leap year, the March, 2nd. SET_DATE can therefore also be used to generate any day of the year. This can be a quite practicable application. In this case, the monthly amount may also be 0. An invalid month always gives a date in relation to January. An invalid month (month < 1 or month > 12) is always interpreted as January.



Example:
`SET_DATE(2007,1,365) = 31.12.2007`
Example: SET_DATE(2007, 1, 22) = 22.1.2007

12.0.45 Type Function: DATE_TIME

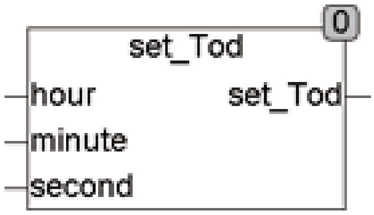
Input YEAR	INT (year)
MONTH	INT (month)
DAY	INT (day)
HOUR	INT (hour)
MINUTE	INT (min)
SECOND	INT (seconds)
Output	DATE_TIME (Composite time date)
	The function SET_DT calculates a time-date value (DATE_TIME) from the input values, day, month, year, hour, minute and seconds.



Example:
`Set_DT(2007, 1, 22, 13, 10, 22) = DT#2007-1-22-13:10:22`

12.0.46 Type Function: TOD

Input HOUR	INT (hour)
MINUTE	INT (min)
SECOND	REAL (seconds and milliseconds)
Output	TOD (output value day)
	The function SET_TOD calculates a time of day (TOD) from the input values, hours, minutes and seconds.



Example:
`Set_TOD(13, 10, 22.33) = 13:10:22.330`

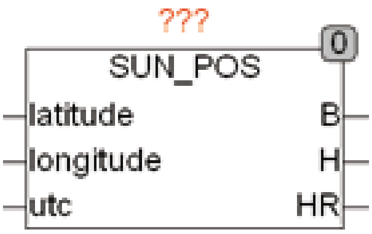
12.0.47 SUN_MIDDAY

Type	Function
Input LON	REAL (longitude of the reference location)
UTC	DATE (Universal Time)
Output	TOD (time of day when Sun is exactly in the south)
	The function SUN_MIDDAY calculates at what time the sun is exactly in the south, depending on the date . The calculation is done in UTC (Universal Time).

12.0.48 Type Function module

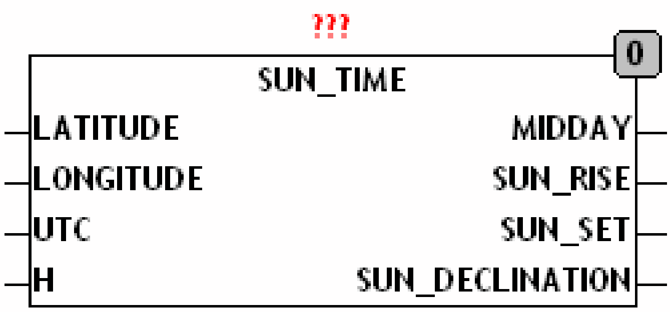
Input LATITUDE	REAL (latitude of the reference location)
LONGITUDE	REAL (longitude of the reference location)
UTC	DATE_TIME (Universal Time)
Output B	REAL (azimuth in degrees from North)
H	REAL (Astronomical sun height)
HR	REAL (solar altitude in degrees above the horizon with refraction)
	SUN_POS calculated the position of the sun (B, H) at the current time. The time is expressed as Universal Time (UTC). Any possible local time must first be converted to UTC. At the sun position HR, the atmospheric refraction for 1010mbar and 10°C is already taken into account. The accuracy is better than 0.1 degrees for the period from 2000 to 2050. Possible applications of SUN_POS are the tracking of solar panels or a sun dependent tracking of the slats of blinds. SUN_POS is a complicated algorithm, but delivers the exact values. To keep the load of a PLC as low as possible, the calculation can be performed, for example, only every 10 seconds, which corresponds to an uncertainty of 0.04 degrees. The output B passes the solar angle in degrees from north (south = 180 °). H is the Astronomical angle above the horizon (the horizon = 0 °). HR is the sun above the horizon to the atmospheric corrected by the refraction (refraction). An observer on the Earth sees the sun in a, by the refraction raised position, of

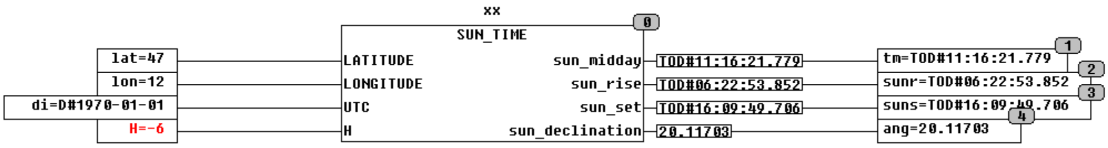
	the horizon, which will cause the sun is shining already, but it is still slightly below the horizon.



12.0.49 SUN_TIME

Type	Function module
Input LATITUDE	REAL (latitude of the reference location)
LONGITUDE	REAL (longitude of the reference location)
UTC	DATE (Universal Time)
H	Real (angle above the horizon in degrees)
Output MIDDAY	TOD (sun exactly south)
SUN_RISE	TOD (time of sunrise)
SUN_SET	TOD (time of sunset)
SUN_Declension	REAL (height in the sun South)
	The function block SUN_TIME is a astro timer. It calculates sunrise and sunset for any day, defined by the input UTC. In addition to sunrise and sunset, the time of the solar azimuth (daily peak in the south) and the solar angle above the horizon in the azimuth is calculated. This SUN_TIME will work regardless of the site all the time is calculated in UTC (Universal Time) and can again be converted to local time as needed. In addition, to the times of sunrise and sunset, the module also calculates the angle of the sun above the horizon SUN_DECLINATION. SUN_TIME uses a complex algorithm to minimize the loading of a PLC as low as possible, the values should be calculated with SUN_TIME only once per day. SUN_TIME is used for the control of blinds, in order to pull up just before sunrise and enjoy in the bedroom the twilight. Other applications are include controlling irrigation in horticulture to using the sunrise and sunset or even for tracking solar panels. Further calculations of Sun's position is provided by the module SUN_POS. SUN_TIME is only in latitudes between 65°S and 65°North is available. The output MIDDAY passes, at what time the sun is the south and SUN_DECLINATION stating the angle above the horizon in degrees.



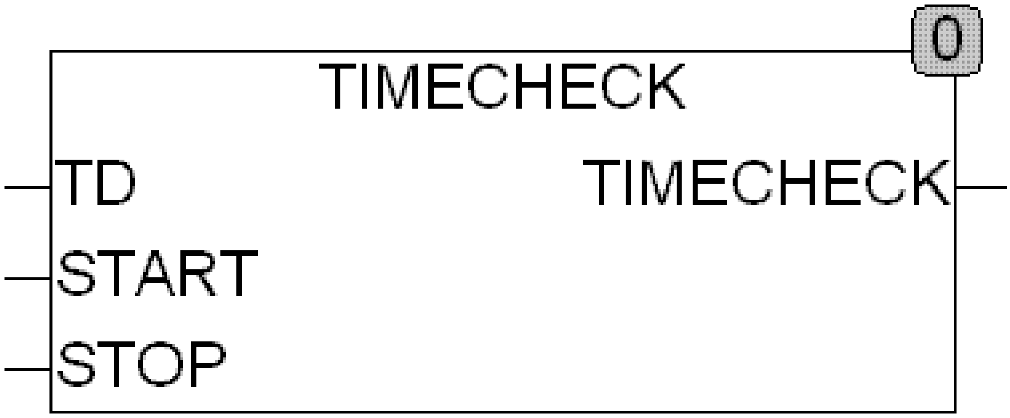


Example:

Example of 1.1.1970, 12° East and 47° North: The times of sunrise and - Sunset in UTC (Universal Time), the highest position of the sun will be at 11:16 UTC at 20 degrees above the horizon. As at the input -6 ° is given, the module calculates the Civil twilight. SUN_RISE is the time, when the upper edge of the sun is visible on the horizon. SUN_SET is the time when the upper edge of the sun disappears behind the horizon. The horizon is just above the open sea constantly at 0° depending on the terrain and location of hills and mountains, this time may differ materially for various locations. A corresponding correction can only be place dependent, where is the basis for revisions is, thatthe sun travels in one minute 4 degrees. For practical applications, except on the open sea must both rise as well as set times be adjusted accordingly. With the input of H can be defined, how many degrees before or after the horizon SUN_RISE and SUN_SET is determined. If not specified on input H, the module works internally with the default of -0.83333 degrees which will compensate the refraction at the horizon. For civil, nautical and astronomical twilight at the entrance of H, the corresponding values (-6 °, -12 °, -18 °) are given. For sunrise and sunset, there are different definitions and requirements: The Civil twilight describes that time when the sun is 6 degrees below the horizon, it is the time where daylight is already achieved. As nautical twilight is the period when the sun is 12 ° below the horizon, it is the time when the first lightening on the horizon is determined. The Astronomical twilight is the time when the sun is 18 degrees below the horizon, it is the time at which no illumination of the sun longer measurable. Additional information on sunrise and sunset times are available on the following websites: http://www.calsky.com/cs.cgi http://lexikon.astronomie.info/java/sunmoon/

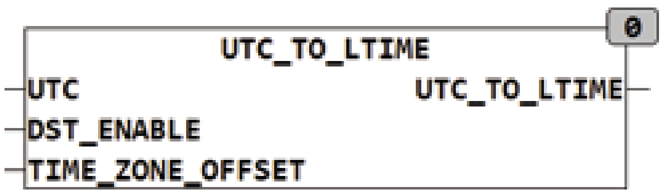
12.0.50 Type Function: BOOL

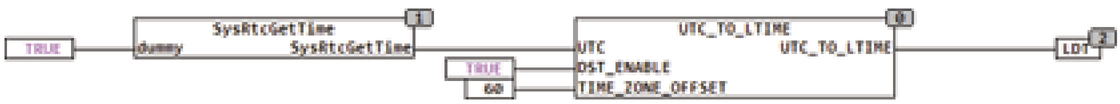
Input TD	TOD(time of day)
TD	TOD(time of day)
STOP	TOD(stop time)
Output	BOOL (Return Value)
	TIME CHECK checks whether the daily time TD is between the START and STOP time. TIME CHECK returns TRUE if TD > = START and TD < STOP. IF START and STOP are defined in a way that START > STOP, the output with the start set to TRUE and remains by midnight TRUE until at the next day STOP is reached.
The function has the following definition	
START < STOP	TD >= START AND TD < STOP
START > STOP	TD >= START OR TD < STOP



12.0.51 Type Function module

Input UTC	DATE_TIME (Universal Time)
DST_ENABLE	BOOL(TRUE allows DST)
TIME_ZONE_OFFSET	INT(time difference to UTC in minutes)
Output DT	DATE_TIME (local time)
	The function module UTC_TO_LTIME calculates from the universal time at input UTC the local time (LOCAL_DT), with automatic daylight saving time if DST_ENABLE is set to True. If DST_ENABLE is FALSE, the local time is calculated without daylight saving.
	This function module requires UTC at the input, which is normally provided by the PLC and can be read by a routine of the manufacturer.
	The following example an application for a WAGO 750-841 CPU is shown. The reading of the internal clock is done by the manufacturer SYSRTCGETTIME routine. The PLC clock must be in this case set to UTC.

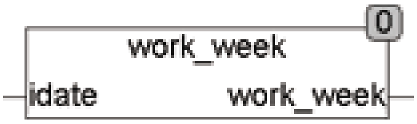




12.0.52 Type Function: INT

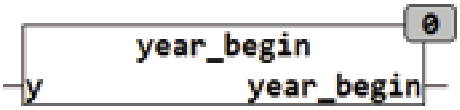
Input IDATE	DATE (date)
Output	INT (working week of the input date)
	The function WORK_WEEK calculates the week from the date of input IDATE. The week starts with 1 for the first week of the year. The first Thursday of the year is always in the first week. If a year starts with a Thursday or end on a Thursday this year has 53 calendar weeks. If the first day of the year a Tuesday, Wednesday or

	Thursday so the week begins one early as December of last year. If the first day of the year is Friday, Saturday or Sunday, the last week of the year extends into January. The calculation is done in accordance with ISO8601.
	As the work week (Work Week) International is not always used consistent, before the application of the function is to clarify, whether the work week according to ISO8601 is desired in the desired application function.



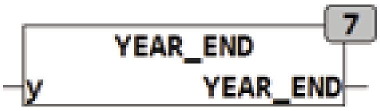
12.0.53 Type Function: DATE

Input Y	INT (year)
Output	DATE (date of 1 January of the year)
	YEAR_BEGIN calculate the date of the first January for the year Y.



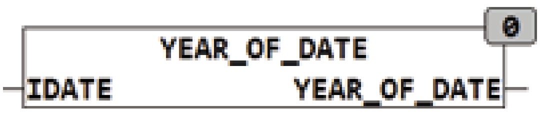
12.0.54 Type Function: DATE

Input Y	INT (year)
Output	DATE (date of December 31 for the year)
	YEAR_END calculates '31 December in the year Y.



12.0.55 Type Function: INT

Input IDATE	DATE (date)
Output	INT (year of the date)
	The function YEAR_OF_DATE calculates the corresponding year from the date of input IDATE.



Example:

```
YEAR_OF_DATE(31.12.2007) = 2007
```