OSCAT

BASIC:LIBRARY

Documentation In English

Version 3.33

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1. Legal

1.1. 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.

1.2. 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.

1.3. 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.

1.4. 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.

1.5. 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.

2. Introduction

2.1. Objectives

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:

1. The libraries of almost all manufacturers are being protected and the Source Code is not freely accessible, which is in case of a error and correction of the error extremely difficult, often impossible.
2. The graphic development of programs with vendor-specific libraries can quickly become confusing, inefficient and error-prone, because existing functions can not be adjusted and expanded to the actual needs. The Source codes are not available.
3. A change of hardware, especially the move to another manufacturer, is prevented by the proprietary libraries and the benefits that a standard such as IEC61131 offer would be so restricted. A replacement of a proprietary library of a competitor is excluded, because the libraries of the manufacturers differ greatly in scope and content.
4. The understanding of complex modules without an insight into the source code is often very difficult. Therefore the programs are inefficient and error prone.

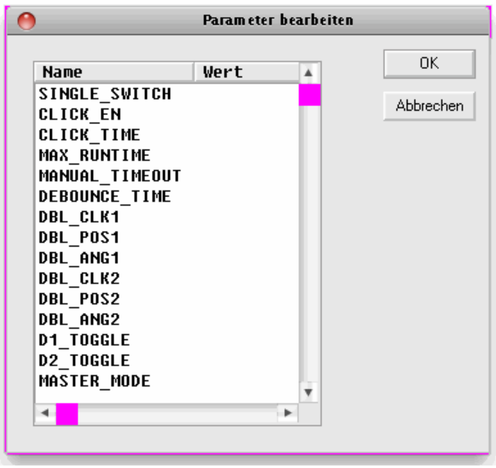
OSCAT will create with the open OSCAT Library a powerful and comprehensive standard for the programming of PLC, which is available in the Source Code and verified and tested by a variety of applications in detail. Extensive knowledge and suggestions will continue to flow through a variety of applications to the library. Thus, the library can be described as very practical. OSCAT understands his library as a development template and not as a mature product. The user is solely responsible for the tests in its application modules with the appropriate procedures and to verify the necessary accuracy, quality and functionality. At this point we reference to the license and the disclaimer mentioned in this documentation.

2.2. Conventions

1. Direct modification in memory:
   Functions, which modify input values with pointer like _Array_Sort, starts with an underscore "_". _Array_Sort sorts an array directly in memory, which has the significant advantage that a very large array may not be passed to the function and therefore memory of the size of the array and the time is saved for copying. However, it is only recommended for experienced users to use these functions, as a misuse may lead to serious errors and crashes! In the application of functions that begin with "_", special care is appropriate and in particular to ensure that the call parameters never accept undefined values.

2. Naming of functions:
   Function modules with timing manner, such as the function PT1 are described by naming FT_<modulname> (ie. FT_PT1). Functions without a time reference are indicated with F_<modulename>.

3. Logical equations:
   Within this guide, the logical links are used & for AND , + for OR, /A for negated A and # for a XOR (exclusive OR).

4. Setup values for modules:
   

   To achieve that the application and programming remains clear and that complex functions can be represented simply, many of the modules of the library OSCAT have adjustable parameters that can be edited in application by double-clicking on the graphic symbol of the module. Double-clicking on the icon opens a dialog box that allows you to edit the Setup values. If a function is used multiple times, so the setup values are set individually for each module. The processing by double-clicking works on CoDeSys exclusively in CFC. In ST, all parameters, including the setup parameters may passed in the function call. The setup parameters are simply added to the normal inputs. The parameters are in the graphical interface entered by double click and then processed as constants under IEC61131. It should be noted that time values has to be written with syntax "T#200ms" and TRUE and FALSE in capital letters.

5. Error and status Reporting (ESR):

   More complex components are largely contributed a Error or status output. A Error Output is 0 if no error occurs during the execution. If, however, in a module a error occurs, this output takes a value in the range 1 ..99 and reports a error with a error number. A status or Error Collection module may collect these messages and time-stamped, store them in a database or array, or by TCP/IP forward it to higher level systems. An output of the type Status is compatible with a Error starting with identical function. However, a status output reports not only errors but also leads on activities of the module log. Values between 1..99 are still error messages. Between 100..199 are located the reports of state changes. The range from 200..255 is reserved for Debug Messages. With this, within the library OSCAT standard functionality, a simple and comprehensive option is offered to integrate operational messages and error messages in a simple manner, without affecting the function of a system. Modules that support this procedure, as of revision 1.4 are marked "ESR-ready." For more information on ESR modules, see the section "Other functions".

2.3. Test environment

The OSCAT library is designed with CoDeSys and tested on different systems.

The test environment consists of the following systems:

1. Beckhoff BX 9000
   with TwinCAT PLC Control Version 2.10.0
2. Beckhoff CX 9001-1001
   with TwinCAT PLC Control Version 2.10.0
3. Wago 750-841
   with CoDeSys Version 2.3.9.31
4. Möller EC4P222
   with CoDeSys Version 2.3.9.31
5. CoDeSys Simulation on I386 CoDeSys 2.3.9.31
6. CoDeSys Simulation on I386 CoDeSys 3.4
7. S7 and STEP 7: The OSCAT library is compiled and verified on STEP7 since version 1.5.
8. PCWORX / MULTIPROG: The OSCAT library since version 2.6 compiled on MULTIPROG and verified.
9. Bosch Rexroth IndraLogic XLC L25/L45/L65 with Indraworks 12VRS
10. Bosch Rexroth IndraMotion MLC L25/L45/L65 with Indraworks 12VRS
11. Bosch Rexroth IndraMotion MTX L45/L65/L85 with Indraworks 12VRS

We are constantly striving OSCAT the library to also test in other test environments.

2.4. Global constants

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.

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.

2.5. 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.

2.6. 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.

3. Data types of the OSCAT Library

Die OSCAT Bibliothek definiert neben den Standard Datentypen weitere Datentypen. Diese werden innerhalb der Bibliothek verwendet, können aber jederzeit von Anwender für eigene Deklarationen verwendet werden. Ein Löschen oder verändern von Datentypen kann dazu führen das Teile der Bibliothek sich nicht mehr kompilieren lassen.

3.1. CALENDAR

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.

*.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

3.2. COMPLEX

The COMPLEX structure can present complex numbers.

*.RE (Real part of a complex number)

*.IM Imaginary part of a complex number)

3.3. CONSTANTS_LANGUAGE

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

(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.

*.LMAX: INT:= 3 specifies how many languages are available

*.WEEKDAYS: ARRAY[1..3, 1..7] OF STRING(10):= ' Monday','Tuesday'

'Wednesday','Thursday','Friday','Saturday','Sunday','Monday',

'Tuesday','Wednesday','Thursday','Friday','Saturday','Sunday';

*.WEEKDAYS2: ARRAY[1..3, 1..7] OF STRING(2):=

'Mo','Tu','We','Th','Fr','Sa','Su',

'Mo','Di','Mi','Do','Fr','Sa','So';

*.MONTHS: ARRAY[1..3, 1..12] OF STRING(10):= 'January','February',

'March','April','May','June','July','August','September','October', 'November','December',

'January','February','March','April','May','June','July','August',

'September','October','November','December';

*.MONTHS3:ARRAY[1..3, 1..12] OF STRING(3):=

'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec',

'Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','October','Nov','Dec';

*.DIRS:ARRAY[1..3,0..15] OF STRING(3):= 'N','NNE','NE','ENE','E',

'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';

3.4. CONSTANTS_LOCATION

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

*.DEFAULT: INT:= 1

(1 = Germany, 2 = Austria, France 3 =, 4 = Belgium-German,

5 = Italy, South Tyrol).

*.LMAX: INT:= 3 indicates how many places are defined.

*.LANGUAGE : ARRAY[1..5] of INT := 2,2,3,2,2;

for each location, the language is defined.

3.5. CONSTANTS_MATH

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

*.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:= 2.71828182845904523 5	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

3.6. CONSTANTS_PHYS

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

3.7. CONSTANTS_SETUP

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;

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

*.DECADES: ARRAY[0..8] OF REAL:= 1,10,100,1000,10000,100000,

1000000,10000000,100000000;

3.8. ESR_DATA

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

3.9. FRACTION

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

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

3.10. HOLIDAY_DATA

The structure HOLIDAY_DATA is used to define and describe holidays.

*.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 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.

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); *)*

3.11. REAL2

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

3.12. SDT

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

*.YEAR: INT	Year
*.MONTH: INT	Month
*. DAY: IN T	Day
WEE *. KDAY: INT	Week (1 = Monday, 7 = Sunday)
*. HOUR: INT	Hours
*. MINUTE: INT	Minutes
*. SECOND: INT	Seconds

*. MS: INT	Milliseconds

3.13. TIMER_EVENT

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

*.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

3.14. VECTOR_3

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. Other Functions

4.1. ESR_COLLECT

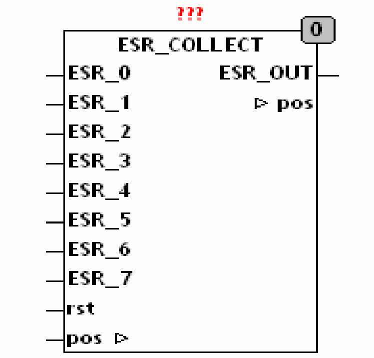
Type Function module

Input ESR_0.. 7: ESR_DATA (ESR inputs)

RST: BOOL (asynchronous reset input)

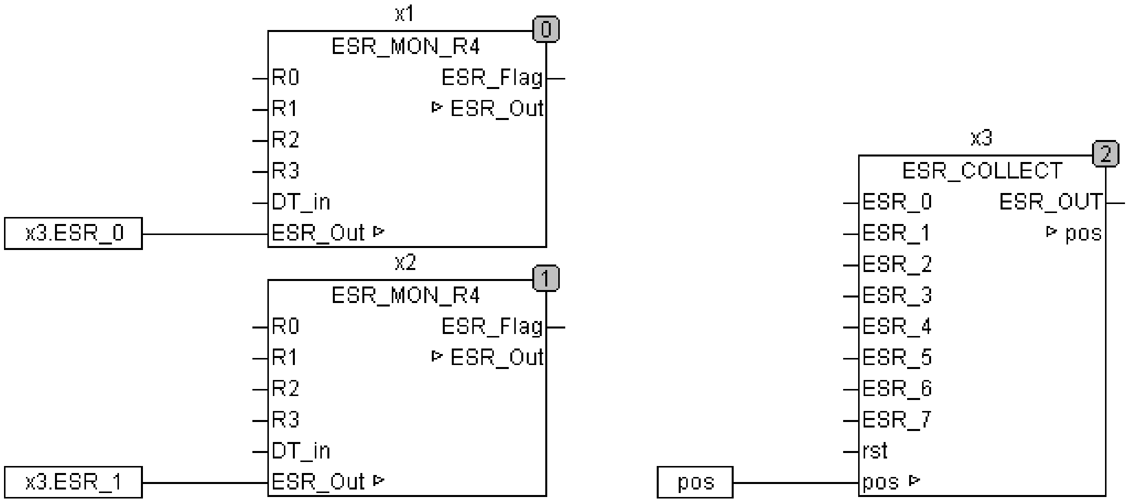
Output ESR_OUT : ESR_DATA (Array with the ESR protocol)

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:

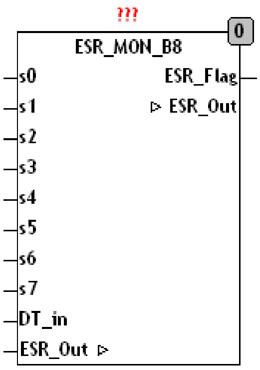
. TYPE	.ADRESS	.DS	.TS	.DATA [0..7]	
1	Label	Date	TIME	Status, 1 Byte	ESR Error
2	Label	Date	TIME	Status, 1 Byte	ESR Status
3	Label	Date	TIME	Status, 1 Byte	ESR Debug
10	Label	Date	TIME	not used	Boolean input low transition
11	Label	Date	TIME	not used	Boolean input high transition
20	Label	Date	TIME	Byte 0 - 3 Real Value	Real Value change

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

4.2. 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:

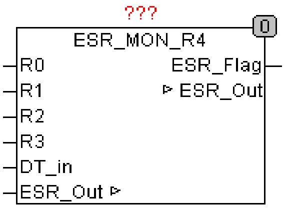
.TYPE	11 rising edge , 10 falling edge
.ADRESS	Byte address of ISR data recording
.LINE	Line number (input) of the ESR data recording
.DS	Date stamp of type DATE_TIME
.DT	Timestamp of type TIME (PLC- Timer)
.Data	Data block blank of 8 bytes

An application example for the module is in the description of ESR_COL-LECT.

4.3. 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)



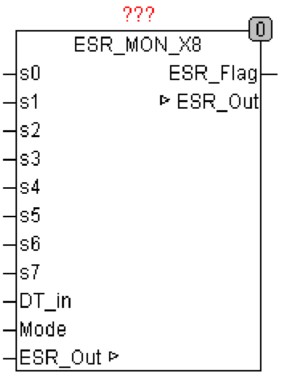
ESR_MON_R4 monitors up to 4 analog signals for changes and provides them with a time s stamp and the address of the input signal. The collected messages are buffered and passed to a protocol module on ESR_OUT. The output ESR_FLAG is set to TRUE when messages are present. A change of an input is recorded 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.

4.4. 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.

- Mode = 1, only error messages are processed.
- Mode = 2, status and error messages are processed.
- Mode = 3, error, status and debug messages are processed.

When the MODE input is not wired, automatically all messages are processed.

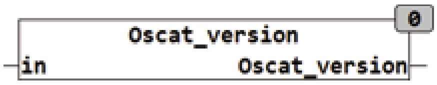
The ESR data at the output consist of the following items:

.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.

4.5. OSCAT_VERSION

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

4.6. STATUS_TO_ESR

Type Function: ESR_DATA

Input STATUS : BYTE (status byte)

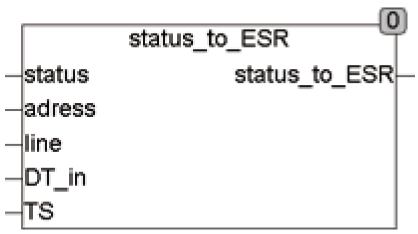
ADRESS: Byte (address, bytes)

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

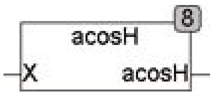
.DT Timestamp of type TIME (PLC-timer)

.Data Data block of 8 bytes

5. Mathematics

5.1. ACOSH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)

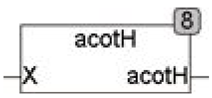


ACOSH calculates the arcus hyperbolic cosine of the following formula:

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

5.2. ACOTH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)



Acoth calculates the arc cotangent hyperbolic with following formula:

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

5.3. AGDF

Type	Function: REAL

Input	X: REAL (input)
Output	REAL (Gundermann inverse function)

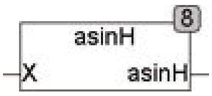
AGDF calculates the inverse Gundermann function.

The calculation is done using the formula:

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

5.4. ASINH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)

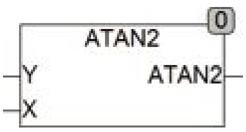


ASINH calculate the arc hyperbolic sine by the formula:

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

5.5. ATAN2

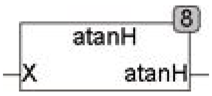
Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)



ATAN2 calculates the angle of coordinates (Y, X) in RAD. The result is between -⊗ and +⊗

5.6. ATANH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)



ATANH calculates the Arcus Hyperbolic tangent as follows:

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

5.7. BETA

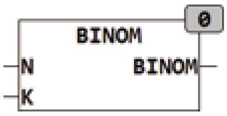
Type	Function: REAL
Input	X: REAL (input)
	Y: REAL (input value)
Output	REAL (output value)

BETA computes the Euler Beta function.

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

5.8. BINOM

Type	Function: DINT
Input	N: INT (input value)
	K: INT (input value)
Output	DINT (output value)

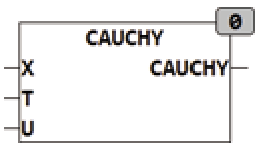


BINOM calculates the binominal coefficient N over K for integer N and K.

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

5.9. CAUCHY

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

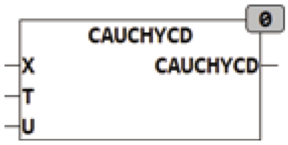


CAUCHY calculates the density function for Cauchy.

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

5.10. CAUCHYCD

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

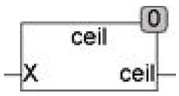


CAUCHYCD calculated the distribution function after Cauchy.

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

5.11. CEIL

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

5.12. CEIL2

Type	Function: DINT
Input	X: REAL (input)
Output	DINT (output value)

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

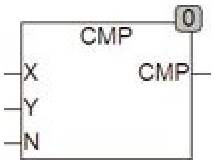
Example: CEIL2(3.14) = 4

CEIL2(-3.14) = -3

CEIL2(2) = 2

5.13. CMP

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.

Examples:

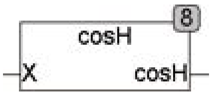
CMP(3.140,3.149,3) = TRUE   CMP(3.140,3.149,4) = FALSE

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.

5.14. COSH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)

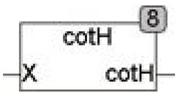


COSH calculates the hyperbolic cosine using the formula:

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

5.15. COTH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)



COTH calculates the hyperbolic cotangent by the following formula:

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

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.

5.16. D_TRUNC

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

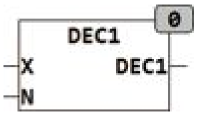
5.17. DEC1

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.

5.18. 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.⊛. If RAD is greater than 2⊛, the equivalent to 2⊛ is deducted until the input RAD is between 0 and 2⊛.

DEG(π) = 180 Grad, DEG(3π) = 180 Grad

DEG(0) = 0 Grad, DEG(2π) = 0 Grad

5.19. DIFFER

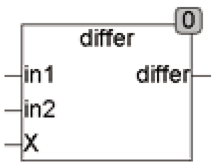
Type Function: BOOL

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

5.20. ERF

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} .

5.21. ERFC

Type Function: REAL

Input X: REAL (input)

Output REAL (result)

The function ERFC calculates the inverse error function of X.

5.22. EVEN

Type Function: BOOL

Input in: DINT (input)

Output BOOL (TRUE, if in straight)

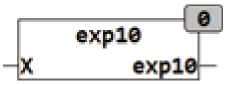
The function EVEN = TRUE if the input IN is even and FALSE for odd IN.

Example: EVEN(2) is TRUE

EVEN(3) returns FALSE

5.23. EXP10

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (exponential base 10)



The function Exp10 returns the exponential base 10

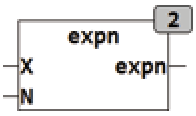
Exp10 (2) = 100

EXP10(0) = 1

EXP10(3.14) = 1380.384265

5.24. EXPN

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 specifically 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.

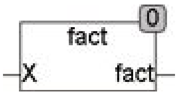
EXPN(10,-2) = 0.01 EXPN(1.5,2) = 2.25

EXPN(0,0) = 1

5.25. FACT

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! = 1*2*3...*(X-1)*X, 0! = 1

Faculties of negative or non-whole numbers are not defined.

Example: 1! = 1

2! = 1*2 = 2

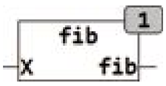
5! = 1*2*3*4*5 = 120

5.26. FIB

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.

5.27. FLOOR

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

5.28. Floor2

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

5.29. FRACT

Type Function: REAL

Input X : REAL (input)

Output REAL (fractional part of X)

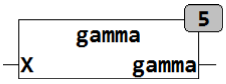
The function Fract returns the fractional part of X .

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.

5.30. GAMMA

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (Gamma function)



The function GAMMA calculates the gamma function after approximation of NEMES.

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

The gamma function can be used for Integer X as replacement for the Faculty.

5.31. GAUSS

Type	Function: REAL
Input	X: REAL (input)
	U: REAL (locality of the function)
	SI: REAL (Sigma, spreading the function)
Output	REAL (Gaussian function)

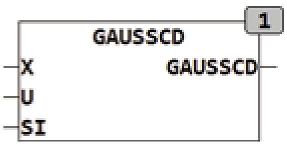
The function calculates the Gaussian normal distribution using the following formula:

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

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.

5.32. 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:

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

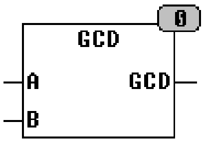
The normal distribution is the density function normally distributed random variables. With the parameters U = 0 and SI = 1, it follows the standard normal distribution. The distribution function (Cumulative Distribution Function).

5.33. 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.

5.34. GDF

Type Function: REAL

Input X: REAL (input)

Output REAL (Gundermann function)

GDF calculate the Gundermann function.

The calculation is done using the formula: $gdf = 2\,atan(e^{X}) - \frac{\pi}{2}$

The result of GDF is between -π/2 and + π/2

GDF(0) = 0

5.35. 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:

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

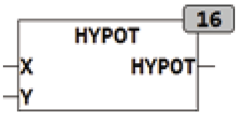
5.36. HYPOT

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.

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

5.37. INC

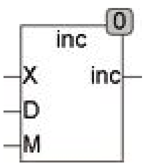
Type Function: INT

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

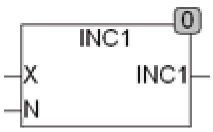
Example: INC(3, 2, 5) ergibt 5

INC(4, 2, 5) ergibt 0

INC(0,-1,7) ergibt 7

5.38. INC1

Type	Function: INT
Input	X: INT(number of values X can be)
	N INT(the variable that is incremented)
Output	INT (Return Value)

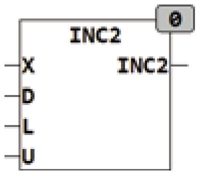


INC1 count the variable X from 0.. N-1 and then starts again from 0, so that exactly N different values are produced starting from 0.

5.39. INC2

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

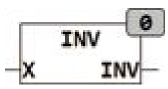
INC2(0, -2, -1, 3) result 3

5.40. INV

Type Function: REAL

Input X: REAL (input)

Output REAL (1 / X)

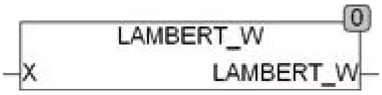


INV calculates the inverse of X:

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

5.41. LAMBERT_W

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)



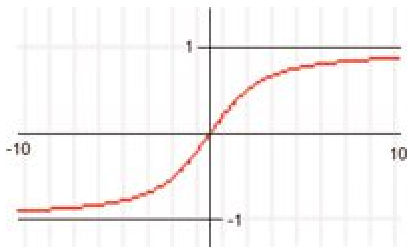
The LAMBERT_W function is defined for x > = -1/e. When the value is below the range the is result -1000. The range of LAMBERT_W function is >= -1.

5.42. LANGEVIN

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)

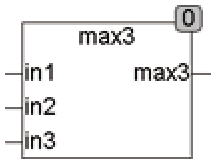
The The Langevin Function is very similarto sigmoid function, but more slowly approaching the limits. In contrast to the sigmoid are the values at -1 and +1. The Langevin function is mainly at CPUs without floating point unit much faster than the Sigmoid function.

The following chart shows the progress of the Langevin function:



5.43. MAX3

Type	Function: REAL
Input	IN1: REAL (input 1)
	IN2: REAL (input 2)
	IN3: REAL (input 3)
Output	REAL (maximum of 3 inputs)

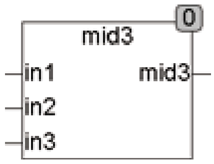


The function MAX3 delivers the maximum value of 3 inputs. Basically, the in standard IEC61131-3 contained function MAX should be equipped with a variable number of inputs. However, since in some systems the MAX function is supported only two inputs, the function MAX3 is offered.

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

5.44. 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)

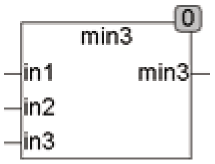


The function MID3 returns the average value of 3 inputs, but not the mathematical average.

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

5.45. MIN3

Type	Function: REAL
Input	IN1: REAL (input 1)
	IN2: REAL (input 2)
	IN3: REAL (input 3)
Output	REAL (Minimum 3 inputs)

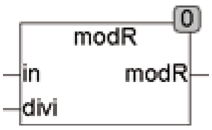


The function MIN3 returns the minimum value of 3 inputs. Basically, the function MIN in standard functionality IEC61131-3 should have a variable number of inputs. However, since in some systems the function MIN supportes only two inputs, the function MIN3 is available.

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

5.46. 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.

5.47. 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

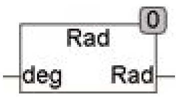
5.48. NEGX

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (-X)

NEGX returns the negated input value (-x).

5.49. RAD

Type	Function: REAL
Input	DEG: REAL (angle in degrees)
Output	REAL (angle in radians)

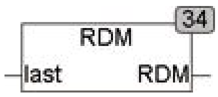


The RAD function converts an angle value from degrees to radians. Taking into account that the DEG will not be greater than 360. If DEG is greater than 360, 360 is to be subtracted as long as DEG is again between 0-360 °.

RAD(0) = 0 RAD(180) = π
RAD(360) = 0 RAD(540) = π

5.50. RDM

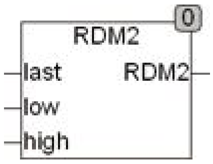
Type	Function: REAL
Input	LAST: REAL (last calculated value)
Output	REAL (random number between 0 and 1)



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)

5.51. 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.

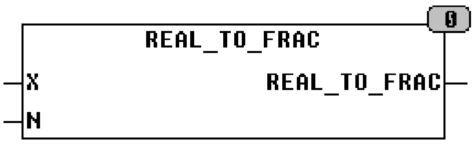
5.52. RDMDW

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.

5.53. 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)

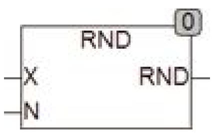
Example:

REAL_TO_FRAC(3.1415926, 1000) results 355 / 113.

355/133 gives the best approximation for the denominator < 1000

5.54. 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

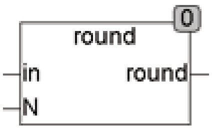
5.55. ROUND

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.

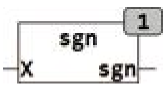
Example: ROUND(3.555, 2) = 3.56

5.56. SGN

Type Function: INT

Input X: REAL (input)

Output INT (Signum the input X)



The function SGN calculates the Signum of X.

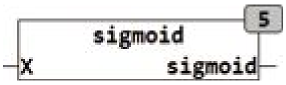
SGN = +1 if X > 0

SGN = 0 if X = 0

SGN = -1 if X < 0

5.57. SIGMOID

Type	Function: INT
Input	X: REAL (input)
Output	REAL (result of Sigmoid)

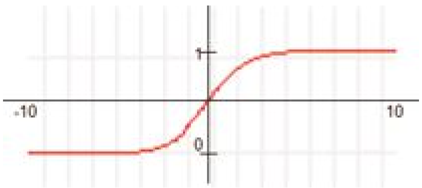


The Sigmoid is also named Gooseneck - function and described by the following equation:

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 :



5.58. SIGN_I

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.

5.59. SIGN_R

Type Function: BOOL

Input IN: REAL (input)

Output BOOL (TRUE if the input is negative)

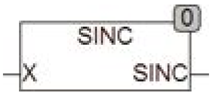
The SIGN_R function returns TRUE if the input value is negative. The input values are of type REAL.

5.60. 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.

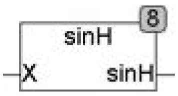
$$\sinh = \frac{\left(e^{X} - e^{-X}\right)}{2}$$

5.61. SINH

Type Function: REAL

Input X: REAL (input)

Output REAL (output value)

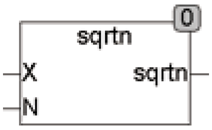


SINH calculates the sinus Hyperbolic according the following formula:

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

5.62. 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:

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

5.63. TANC

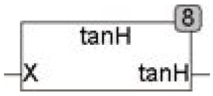
Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)

TANC TANC function calculates the following formula:
with TANC(0) = 1.

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

5.64. TANH

Type	Function: REAL
Input	X: REAL (input)
Output	REAL (output value)

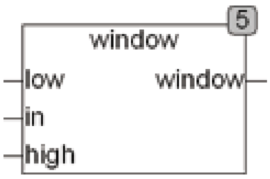


TANH calculates the Tangent Hyperbolic according to the following formula:

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

5.65. 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)



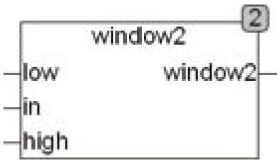
The WINDOW function tests whether the input value is within the limits defined by the LOW and HIGH.

WINDOW is exactly TRUE if IN < HIGH and IN > LOW.

5.66. WINDOW2

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 .

6. Arrays

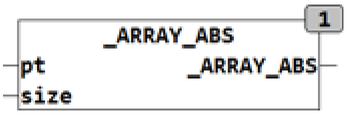
6.1. _ARRAY_ABS

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]

6.2. _ARRAY_ADD

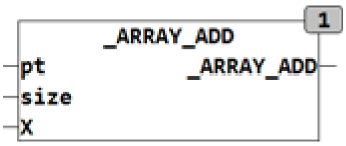
Type Function: BOOL

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]

6.3. _ARRAY_INIT

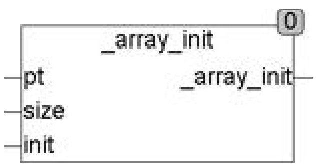
Type Function: BOOL

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.

6.4. _ARRAY_MEDIAN

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.

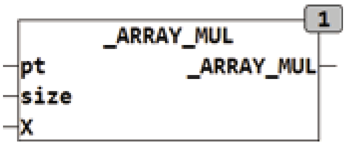
6.5. _ARRAY_MUL

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]

6.6. _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.

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).

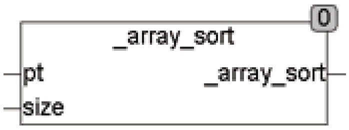
Output array: (0,1,2,3,4,5,6,7,8,9)

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.

6.7. _ARRAY_SORT

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.

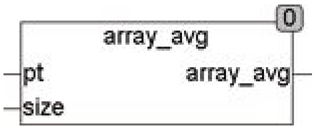
The function only returns TRUE. The array specified by the pointer is manipulated directly in memory.

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))

6.8. ARRAY_AVG

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



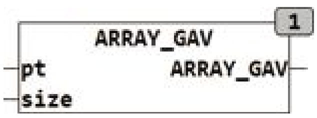
The function _ARRAY_AVG calculates the median value of an arbitrary array ofREAL. When called, a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads: ARRAY_AVG(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a 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))

6.9. ARRAY_GAV

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

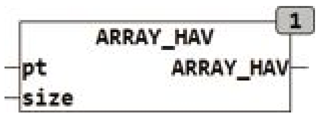
array to be manipulated. ADR() is a standard function which identifies the pointer to the array and SIZEOF() is a standard function, which determines the size of the array. In order to determine the maximum, the array referenced by the pointer is scanned directly in memory. The function ARRAY_GAV does 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))

6.10. ARRAY_HAV

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.

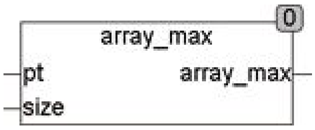
Example: ARRAY_HAV(ADR(bigarray), SIZEOF (bigarray))

6.11. ARRAY_MAX

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 ofREAL. 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))

6.12. 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))

6.13. ARRAY_SDV

Type	Function: REAL
Input	PT: Pointer (Pointer to the array)
	SIZE: UINT (size of the array)
Output	REAL (standard deviation of the array)

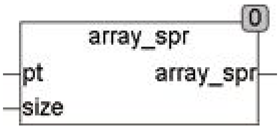
The function _ARRAY_SDV calculates the standard deviation (Standard Deviation) value of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads: ARRAY_SDV(ADR(Array), SIZEOF(Array)), where array is the name of the array 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))

6.14. 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.

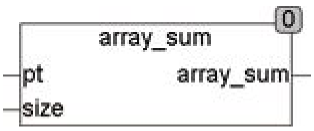
This type of processing arrays is very efficient because no additional memory is required and no surrender values must be copied.

Example: ARRAY_SPR(ADR(bigarray), SIZEOF(bigarray)) =

maximumvalue(bigarray) - minimalvalue(bigarray)

6.15. ARRAY_SUM

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))

6.16. ARRAY_TREND

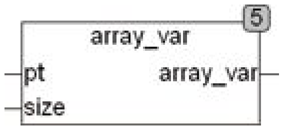
Type	Function: REAL
Input	PT: Pointer (Pointer to the array)
	SIZE: UINT (size of the array)
Output	REAL (development trend of the array)

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))

6.17. ARRAY_VAR

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



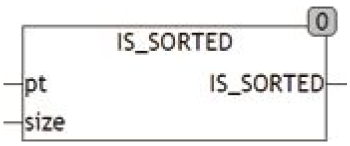
The function _ARRAY_VAR calculates the variance of an arbitrary array of REAL. When called a pointer to the array and its size in bytes is passed to the function. Under CoDeSys the call reads: ARRAY_VAR(ADR(Array), SIZEOF(Array)), where array is the name of the array to be manipulated. ADR() is a standard 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))

6.18. IS_SORTED

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))

7. Complex Mathematics

7.1. INTRODUCTION

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.

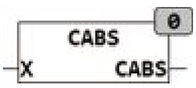
*.IM Imaginary part of the type REAL.

7.2. CABS

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.

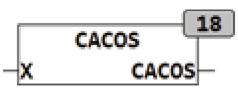
CABS = SQRT(X.RE² + X.IM²)

7.3. CaCO

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



Cacos calculates the arc cosine of a complex number

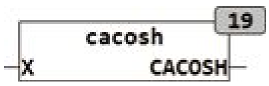
The range of values of the result is between [0, π] for the real part and [-∞, +∞] for the imaginary part.

7.4. 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 [- ⊗ ,+ ⊗] For the imaginary part.

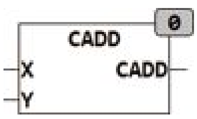
7.5. CADD

Type Function: COMPLEX

Input X: COMPLEX (Input)

Y:COMPLEX(Input value)

Output COMPLEX (result)



CADD adds two complex numbers X and Y.

7.6. CARG

Type Function: REAL

Input X: COMPLEX (Input value)

Output REAL (result)

CARG calculates the angle of a complex number in the coordinate system.

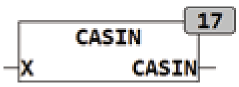
The range of values of the result is between [-π , +π].

7.7. CASIN

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



CASIN calculates the arc sine of a complex number

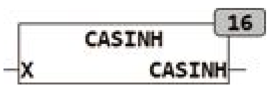
The range of values of the result is between [-⊛/2,+⊛/2] For the imaginary part.

7.8. CASINH

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



CASINH calculates the arc hyperbolic sine of a complex number

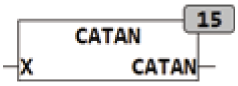
[fzy] The range of values of the result is between [- ⊛ ,+ ⊛] For the imaginary part.

7.9. 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.

7.10. CATANH

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)

CATANH calculates the arc hyperbolic tangent of a complex number

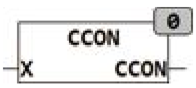
The range of values of the result is between [- π/2,+π/2] for the imaginary part.

7.11. CCON

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



CCON calculated the conjugation of a complex number

CCON.RE = X.RE

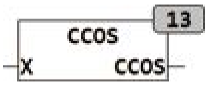
CCON.IM = -X.IM

7.12. CCOS

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



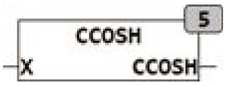
CCOs calculates the cosine of a complex number

7.13. CCOSH

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



CCOSH calculates the hyperbolic cosine of a complex number

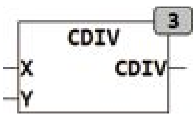
7.14. CDIV

Type Function: COMPLEX

Input X: COMPLEX (Input)

Y:COMPLEX(Input value)

Output COMPLEX (result)



CDIV dividing two complex numbers X / Y.

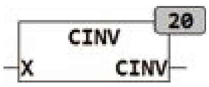
7.15. CEXP

Type Function: COMPLEX
Input X: COMPLEX (Input)
Output COMPLEX (result)

CEXP calculates the complex exponent to base E, CEXP = E^X.

7.16. CINV

Type Function: COMPLEX
Input X: COMPLEX (Input)
Output COMPLEX (result)



CINV calculated the reciprocal of a complex number, CINV = 1/X

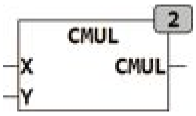
7.17. CLOG

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).

7.18. CMUL

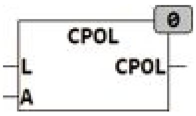
Type	Function: COMPLEX
Input	X: COMPLEX (Input)
	Y:COMPLEX(Input value)
Output	COMPLEX (result)



CMUL Multiplies two complex numbers X and Y.

7.19. CPOL

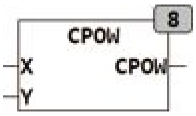
Type	Function: COMPLEX
Input	L: REAL (Length or Radius)
	A: REAL (Angle value)
Output	COMPLEX (result)



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

7.20. CPOW

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.

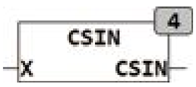
7.21. CSET

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.

7.22. Csin

Type	Function: COMPLEX
Input	X: COMPLEX (Input)
Output	COMPLEX (result)

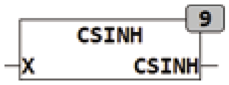


Csin calculates the sine of a complex number

7.23. CSINH

Type	Function: COMPLEX
Input	X: COMPLEX (Input)

Output COMPLEX (result)



CSINH calculates the hyperbolic sine of a complex number

7.24. CSQRT

Type Function: REAL

Input X: COMPLEX (Input)

Output REAL (result)

CSQRT calculates the square root of a complex number

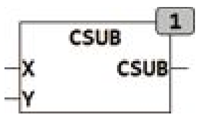
7.25. CSUB

Type Function: COMPLEX

Input X: COMPLEX (Input)

Y:COMPLEX(Input value)

Output COMPLEX (result)



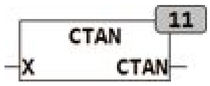
CSUB Subtracts two complex numbers, Csub = X - Y.

7.26. CTAN

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



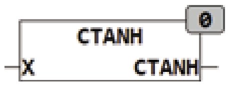
CTAN calculates the tangent of a complex number

7.27. CTANH

Type Function: COMPLEX

Input X: COMPLEX (Input)

Output COMPLEX (result)



CTANH calculates the hyperbolic tangent of a complex number

8. Arithmetics with Double Precision

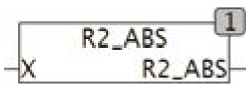
8.1. Introduction

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.

8.2. R2_ABS

Type	Function: REAL2
Input	X: REAL2 (Input)
Output	REAL2 (result double-precision)

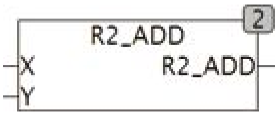


R2_ABS returns the absolute value of x in double precision.

8.3. R2_ADD

Type	Function: REAL2
Input	X: REAL2 (Input)
	Y: REAL (value to be added)

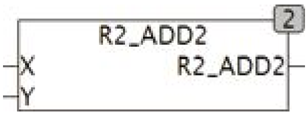
Output REAL2 (result double-precision)



R2_ADD adds to a double-precision value X is a single-precision value Y. The result has again double precision.

8.4. R2_ADD2

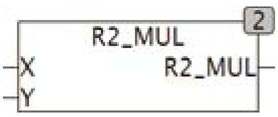
Type	Function: REAL2
Input	X: REAL2 (Input)
	Y: REAL2 (value to be added)
Output	REAL2 (result double-precision)



R2_ADD2 adds to a double precision value X to another double-precision value Y. The result has again double precision.

8.5. 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.

8.6. R2_SET

Type Function: REAL2

Input X: REAL (Input)

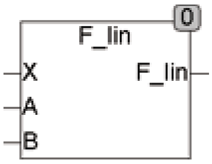
Output REAL2 (result double-precision)

R2_SET sets a double precision value to the input value x with single precision.

9. Arithmetic Functions

9.1. F_LIN

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

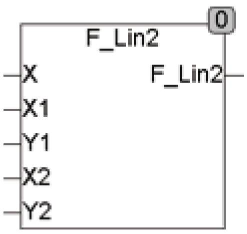


The function F_LIN returns the Y value of a linear equation.

F_LIN = A*X + B

9.2. F_LIN2

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).

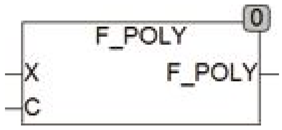
9.3. F_POLY

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

9.4. F_POWER

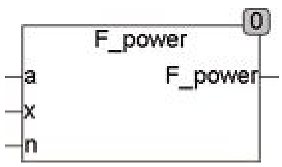
Type Function: REAL

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 .

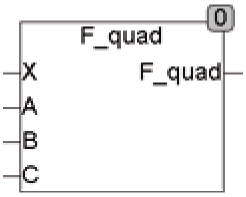
9.5. F_QUAD

Type Function: REAL

Input X : REAL

A, B, C: REAL

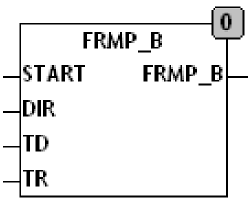
Output REAL (F_QUAD = A * X^2 + B * X + C)



F_QUAD calculates the result of a quadratic equation using the formula $f\_QUAD = A * X^{2} + B * X + C$.

9.6. 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.

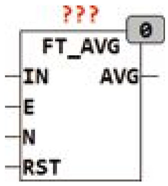
9.7. FT_AVG

Type	Function module
Input	IN: REAL (input signal)
	E: BOOL (enable input)

N: INT (number of values over which the average is calculated)

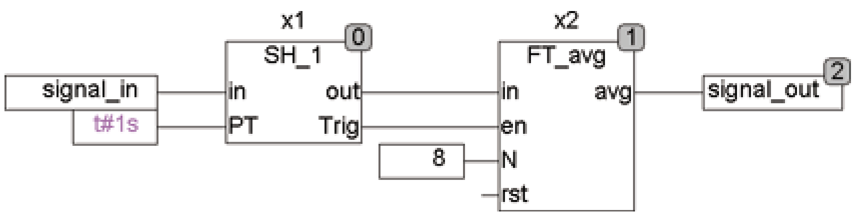
RST: BOOL (Reset input)

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.



9.8. FT_MIN_MAX

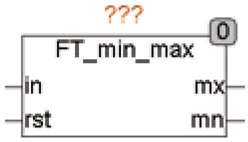
Type Function module

Input IN: REAL (input signal)

RST: BOOL (Reset input)

Output MX: REAL (maximum value of the input signal)

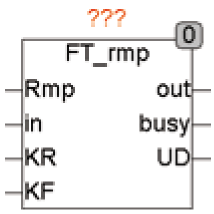
MN: REAL (minimum value of the input signal)



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.

9.9. FT_RMP

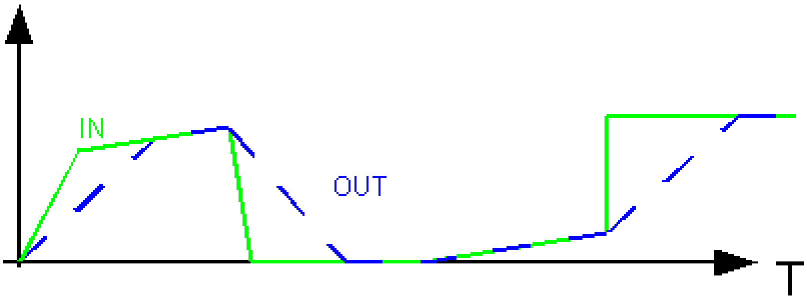
Type	Function module
Input	RMP: BOOL (Enable Signal)
	IN: REAL (input signal)
	KR: REAL (rate of increase in 1 / seconds)
	TV: REAL (speed of the drop in 1 / seconds)
Output	OUT_MAX: REAL (upper output limit)
	BUSY: BOOL (Indicates if the output rises or falls)
	UD: BOOL (TRUE, when output is rising 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.

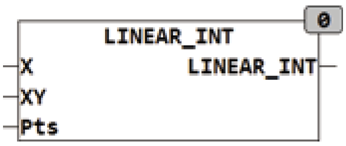
The output follows the input signal as long as the rise and fall speed of the input signal is smaller than that by KR and KF defined maximum increase or decrease speed. Changing the input signal faster, the output runs at the speed of KR or KF after the input signal. The ramp generation is real-time, 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:



9.10. 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

BEISPIEL : 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;

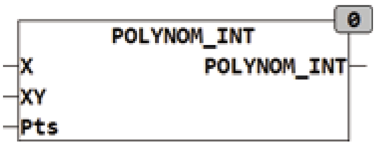
LINEAR_INT (30.0, example, 4) = 20.0344;

LINEAR_INT (66.41, example, 4) = 55.54229;

LINEAR_INT (66.41, example, 4) = 55.54229;

9.11. 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 : 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;

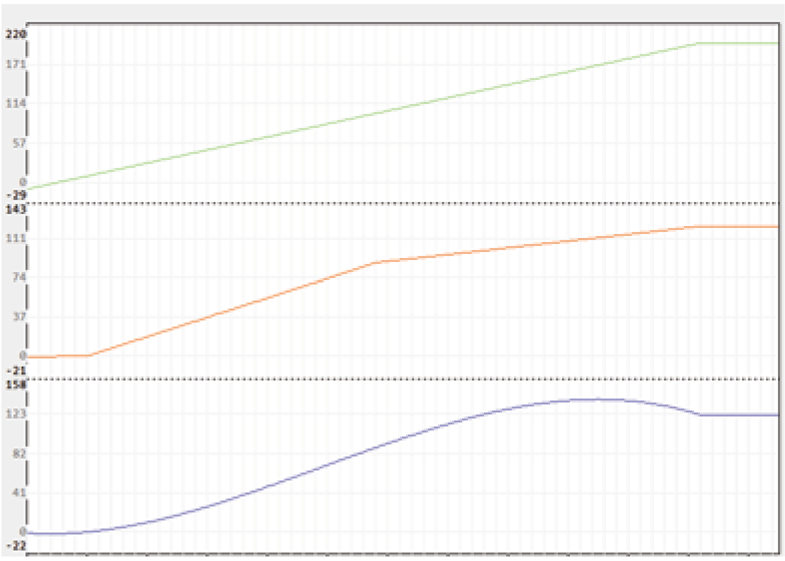
POLYNOM_INT(30.0, example, 4) = 11.4257;

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.

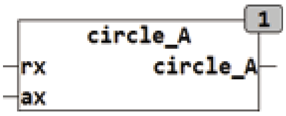
The following trace recording shows the variation of output to input. Here, clearly, the overshoot of the polygon with respect to a linear interpolation can be seen. Green = input X, Red = linear interpolation, Blue = polynomial interpolation.

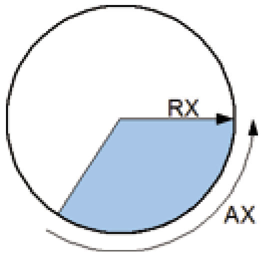


10. Geometric Functions

10.1. CIRCLE_A

Type	Function
Input	RX: REAL (circle radius)
	RX: REAL (circle radius)
Output	REAL (area of circle segment)

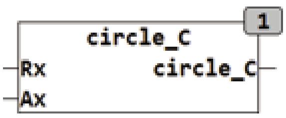


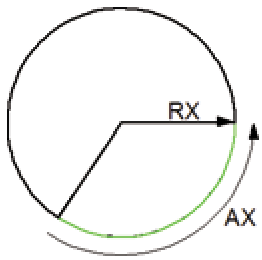


CIRCLE_A calculates the area of a circle segment with the angle AX and radius RX. If the angle is set AX = 360 so the circle area is calculated.

10.2. CIRCLE_C

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.

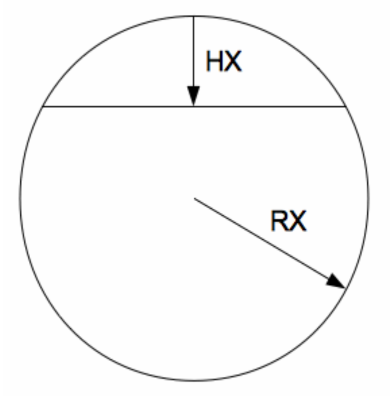
10.3. CIRCLE_SEG

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.

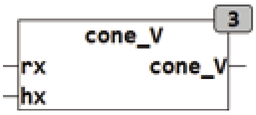
10.4. CONE_V

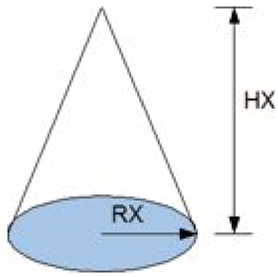
Type Function

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.

10.5. ELLIPSE_A

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.

10.6. ELLIPSE_C

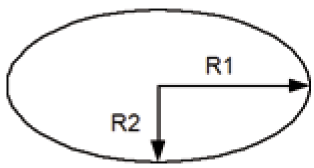
Type Function

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.



10.7. SPHERE_V

Type Function

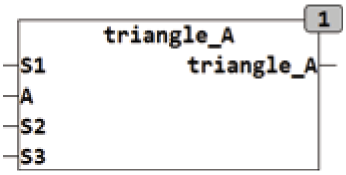
Input RX: REAL (radius)

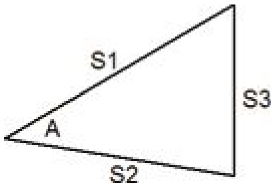
Output REAL (volume of ball)

SPHERE_V calculates the volume of a sphere with a radius of RX.

10.8. TRIANGLE_A

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).

11. Vector Mathematics

11.1. Introduction

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.

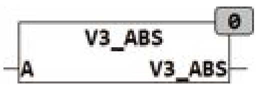
V.Z Z component of the type REAL.

11.2. V3_ABS

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...

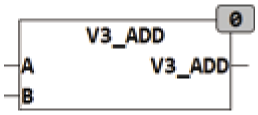
11.3. V3_ADD

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)

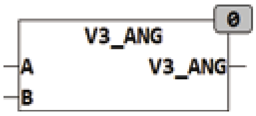


V3_ADD adds two three dimensional vectors.

V3_ADD([3,4,5],[1,2,3]) = (4,6,8)

11.4. 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)

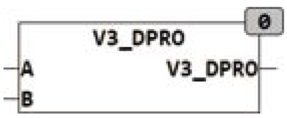


V3_ANG calculates the angle between two three dimensional vectors

V3_ANG([1,0,0],[0,1,0]) = 1,57.. (π / 2)

11.5. V3_DPRO

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)



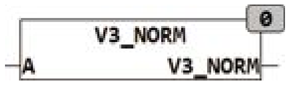
V3_DPRO calculates the scalar product of two-dimensional vectors.

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

11.6. V3_NORM

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

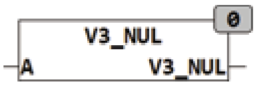


V3_NORM generates from any one-dimensional vector a vector Normalized to length 1 with the same direction. A vector of length 1 is called unit vector

V3_NORM(3,0,0) = (1,0,0)

11.7. V3_NUL

Type	Function
Input	A: VECTOR_3 (vector with the coordinates X, Y, Z)
Output	BOOL (TRUE if vector is a zero vector)

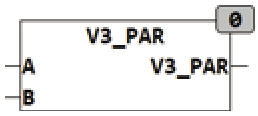


V3_NUL checks if the vector A is a zero vector. A vector is then a zero vector if all the components (X, Y, Z) are zero.

V3_NUL(0,0,0) = TRUE

11.8. V3_PAR

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

11.9. V3_REV

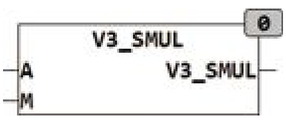
Type	Function
Input	A: VECTOR_3 (vector with the coordinates X, Y, Z)
Output	VECTOR_3 (vector with the coordinates X, Y, Z)

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)

11.10. V3_SMUL

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)

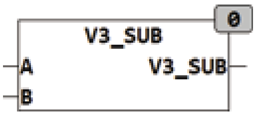
11.11. V3_SUB

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)

11.12. V3_XANG

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..

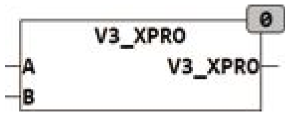
11.13. V3_XPRO

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)

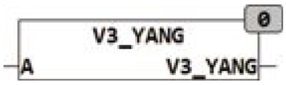


V3_XPRO calculates the cross product of two-dimensional vectors A and B

V3_XPRO([1,2,3],[2,1,2]) = (1,4,-3)

11.14. V3_YANG

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..

11.15. V3_ZANG

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..

12. Time & Date

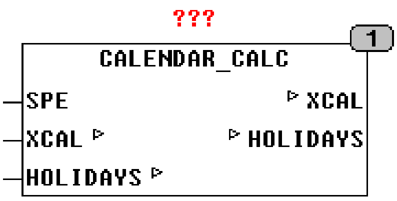
12.1. Introduction

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.

12.2. CALENDAR_CALC

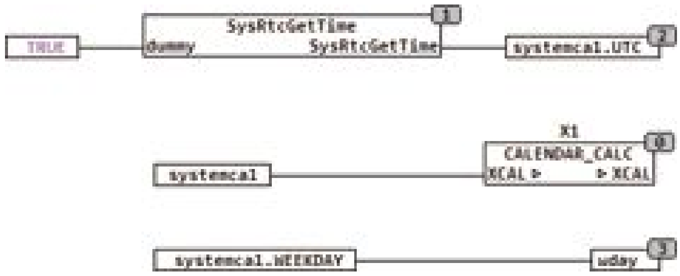
Type	Function module
Input	SPE: BOOL (TRUE calculates the current sun position)
I / O	XCAL: CALENDAR (external variables)
HOLIDAYS	HOLIDAY_DATA (holiday list)



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).

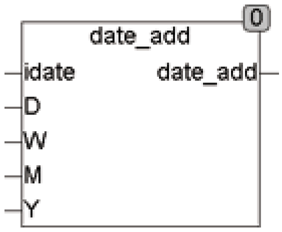


In the external array HOLIDAYS up to 30 holidays can be defined. For examples, see the description of the data type HOLIDAY_DATA. This array of HOLIDAY_DATA must be defined outside of the module and be pre-assigned as a variable with the holiday dates.

12.3. DATE_ADD

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

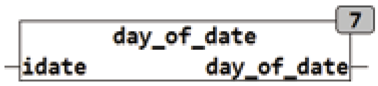
adds additional 3 days and 1 week and then draws 1 month and 2 years from.

12.4. DAY_OF_DATE

Type Function: DINT

Input IDATE: DATE (date)

Output DINT (day in month of inout date)

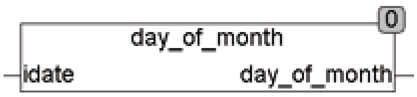


The function calculates the DAY_OF_DATE day since 1.1.1970. The result of the function is of type DINT because the entire DATE Range Includes 49,710 days.

12.5. DAY_OF_MONTH

Type Function: INT

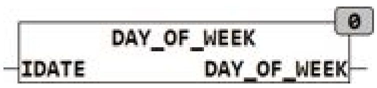
Input	IDATE: DATE (date)
Output	INT (day in month of input date)



The DAY_OF_MONTH function calculates the day of the month from the input date IDATE.

12.6. DAY_OF_WEEK

Type	Function: INT
Input	IDATE: DATE (date)
Output	INT (month in the year of the input date)



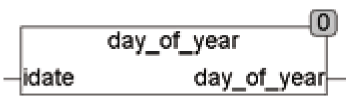
The function calculates the DAY_OF_WEEK week from the date of receipt IDATE.

Monday = 1 .. Sunday = 7 The calculation is done in accordance with ISO8601.

Example: DAY_OF_WEEK(D#2007-1-8) = 1

12.7. DAY_OF_YEAR

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

12.8. DAY_TO_TIME

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

12.9. DAYS_DELTA

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.

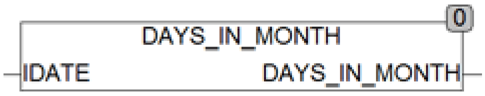
Example: DAYS_DELTA(10.1.2007, 1.1.2007) = -9

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.

12.10. DAYS_IN_MONTH

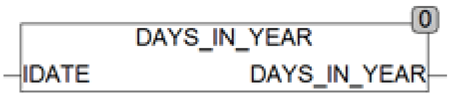
Type	Function: INT
Input	IDATE: DATE (current date)
Output	INT (number of days of current month)



The days_in_month function calculates the number of days in the current month.

12.11. DAYS_IN_YEAR

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.

12.12. DCF77

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)

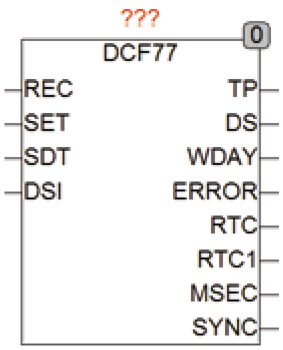
MSEC: INT (milliseconds from RTC and RTC1)

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)

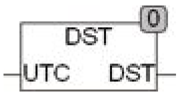


The function DCF77 decodes the serial signal of DCF77 receiver and controls 2 internal clock RTC and RTC1, or via output TP external (downstream) watches. An output DS is TRUE if daylight saving time is. The output WDAY is the weekday (1 = Monday). The output ERROR is TRUE if no valid signal is received. 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.

12.13. DT2_TO_SDT

Type	Function: BOOL
Input	UTC: DATE_TIME (Universal Time)
Output	BOOL (TRUE if daylight saving time)



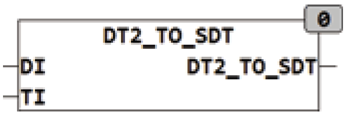
The DST function checks whether daylight saving time is right now or not. It can be used to an existing non-DST enabled clock to switch to summer and winter in exact seconds.

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.

12.14. DT2_TO_SDT

Type	Function: SDT
Input	DI: DATE (date)
	TI: TOD (time of day)
Output	SDT (Structured date time value of type SDT)



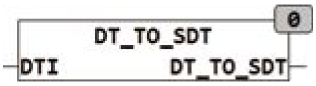
DT2_TO_SDT converts a date and time of day to day in a structured date type SDT.

12.15. DT_TO_SDT

Type Function: SDT

Input DTI: DT (date time value)

Output SDT (Structured date time value of type SDT)



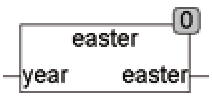
DT_TO_SDT converts a date value into a structured date day of type SDT.

12.16. EASTER

Type Function: DATE

Input YEAR : INT (year)

Output DATE (date of Easter Sunday for the specified year)

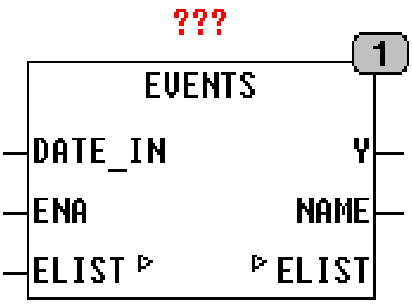


The function EASTER calculates for a given year, the date of Easter Sunday. Most religious holidays have a fixed distance from Easter, so that in the case that Easter is known for a year, these holidays can also be determined easily. EASTER is also used in the module HOLIDAY to calculate holidays.

12.17. 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

Examples:

(NAME: = 'Foundation Day', DAY = 13 MONTH = 7, USE: = 1) solid event "Foundation Day" on 13 July for one day.

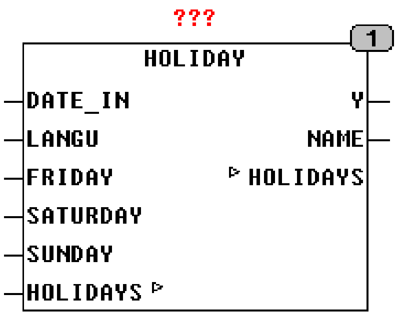
(NAME: = 'Foundation Day', DAY = 13 MONTH = 7, USE: = 0) event at a fixed date USE = 0 means it is not active.

(NAME: = 'Operation Holiday' DAY: = 1, MONTH = 8, USE: = 31) defines an event with a duration of 31 days.

12.18. 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)

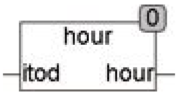


The HOLIDAY function shows the output Y with TRUE holidays and also provides the name of the current holiday at the output NAME. HOLIDAY can, in addition to celebration days during the weekdays Friday, Saturday or Sunday be active and deliver at the output Y TRUE, depending on whether the inputs are 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.

12.19. HOUR

Type	Function: INT
Input	ITOD: TIMEOFDAY (day time)
Output	INT (current hour)



The HOUR function extracts the current hour of the day.

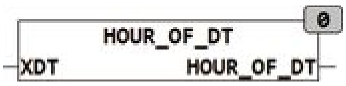
Example: HOUR(22:55:13) = 22

12.20. HOUR_OF_DT

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

12.21. HOUR_TO_TIME

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

12.22. HOUR_TO_TOD

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.

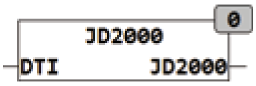
Example: HOUR_TO_TOD(12.1) = 12:06:00

12.23. 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).

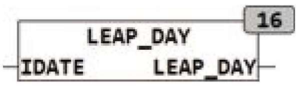
The Julian date is the time in days since January 1st. 4713 BC, as a float at 12:00. The January 1st. 2000 00:00 corresponds to the Julian date 2451544.5. Since a date as the January 1st 2000 can would already exceed the resolution limit of a REAL with about 7 character, the Julian date can not be represented 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.

12.24. 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

12.25. 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.

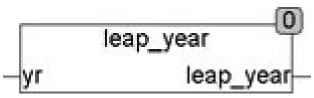
Example: LEAP_OF_YEAR(D#2004-01-12) = TRUE

12.26. LEAP_YEAR

Type Function: BOOL

Input YR: INT (year)

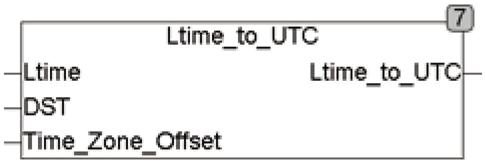
Output BOOL (TRUE if the specified year is a leap year)



The function LEAP_YEAR tests if the input year is a leap year and passs TRUE if true. 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.

12.27. 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.

12.28. MINUTE

Type	Function: INT
Input	ITOD: TIMEOFDAY (day time)
Output	INT (current minute)

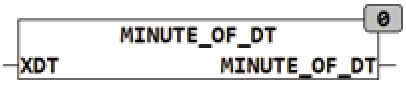
The MINUTE function extracts the current minute of the day.

Example: MINUTE(22:55:13) = 55

12.29. MINUTE_OF_DT

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

12.30. MINUTE_TO_TIME

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.

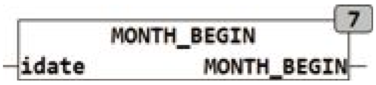
Example: MINUTE_TO_TIME(122.5) = T#2h2m30s

12.31. 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

12.32. MONTH_END

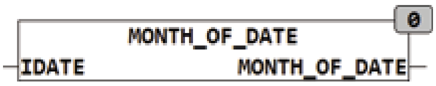
Type	Function: DATE
Input	IDATE: DATE (current date)
Output	DATE (date of the last day of the current month)

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

12.33. 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

12.34. MULTIME

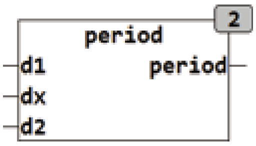
Type	Function: TIME
Input	T: TIME (input time)
	M: REAL (multiplier)
Output	TIME (result input time multiplied by M)

The MULTIME function multiplies a time value with a multiplier.

Example: MULTIME(T#1h10m, 2.5) = T#2h55m

12.35. 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)

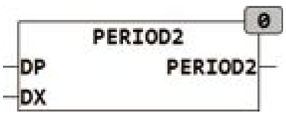


The function checks whether an input date DX is greater or equal than D1 and is less equal D2. If the date DX in the period between D1 and D2 (D1 and D2 included) is the output of the function TRUE. PERIOD ignores the years in the dates D1, D2 and DX. The test is performed only for months and days, so 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.

12.36. 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)



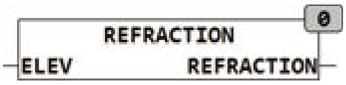
PERIOD2 check if the DX date within a specified period of 4 periods. The periods are in an array [0..3,0..1] of DATE specified. In contrast to the function PERIOD of PERIOD2 reviewes also the year. The periods are specified in ARRAY DP, where DP[N,0] is the beginning date of the period N, DP[N,1] N is 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.

12.37. REFRACTION

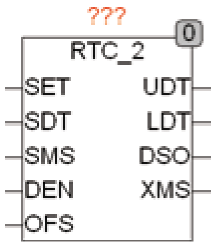
Type	Function: REAL
Input	ELEV: REAL (elevation in degrees above the horizon)
Output	REAL (refraction in degrees)



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.

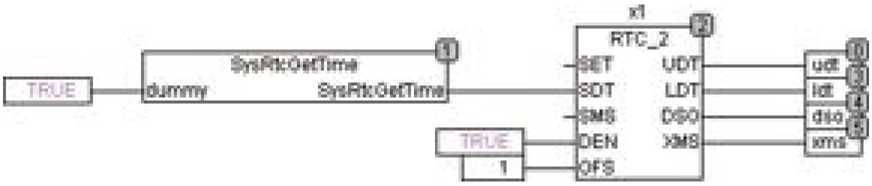
12.38. RTC_2

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 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 01:00 UTC (02:00 CET) to summer time (03:00 GMT) and on the last Sunday of October at 01:00 UTC (03:00 BST) 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.



12.39. RTC_MS

Type Function module

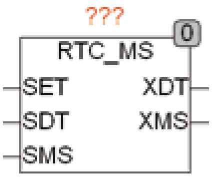
Input SET: BOOL (set input)

SDT: DT (set date and time)

SMS: INT (set Milliseconds)

Output XDT: DT (Date and Time Out)

XMS: INT (milliseconds output)



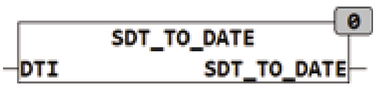
RTC_MS is a clock component with a resolution of milliseconds and date. The time is automatically every time you SET = TRUE to the value of SDT and SMS. If SET = FALSE the time is running on their own and provides the output XDT the current date and time, and at the output XMS milliseconds. The output 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.

12.40. SDT_TO_DATE

Type Function: DATE

Input DTI: SDT (structured input value as date / time value)

Output DATE (Date value)



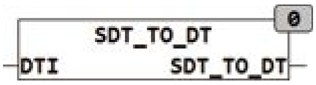
SDT_TO_DATE produces a date value of a structured date-time value

12.41. SDT_TO_DT

Type Position: DT

Input DTI: SDT (structured input value as date / time value)

Output DT (date-time value)



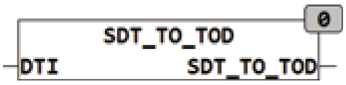
SDT_TO_DT generates a date-time value of a structured date-time value

12.42. SDT_TO_TOD

Type Function: TOD

Input DTI: SDT (structured input value as date / time value)

Output TOD (time of day)



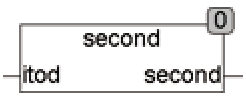
SDT_TO_TOD produces a time of day of a structured date-time value.

12.43. SECOND

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

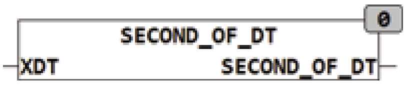
Example: SECOND(22:10:12.331) = 12.331

12.44. 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

12.45. SECOND_TO_TIME

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

12.46. SET_DATE

Type Function: DATE

Input YEAR: INT (year)

MONTH: INT (month)

DAY: INT (day)

Output DATE (Composite date)

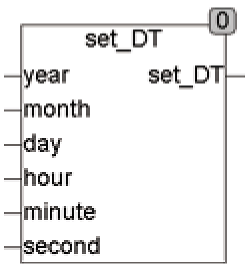
The function SET_DATE calculates a Date (DATE) from the input values, day, month and year. SET_DATE does not test the validity of a date. For example, also be February, 30th will be set, which, of course results the 1st March or in a leap year, the March, 2nd. SET_DATE can therefore also be used to generate 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

12.47. SET_DT

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

12.48. SET_TOD

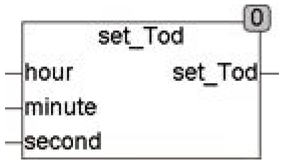
Type Function: TOD

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

12.49. 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).

12.50. SUN_POS

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.

12.51. SUN_TIME

Type Function module

Input LATITUDE: REAL (latitude of the reference location)

LONGITUDE : REAL (longitude of the reference location)

UTC: DATE (Universal Time)

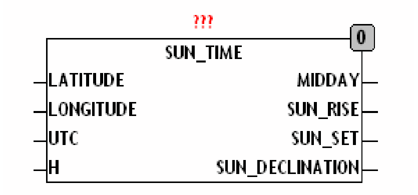
H: Real (angle above the horizon in degrees)

Output MIDDAY : TOD (sun exactly south)

SUN_RISE : TOD (time of sunrise)

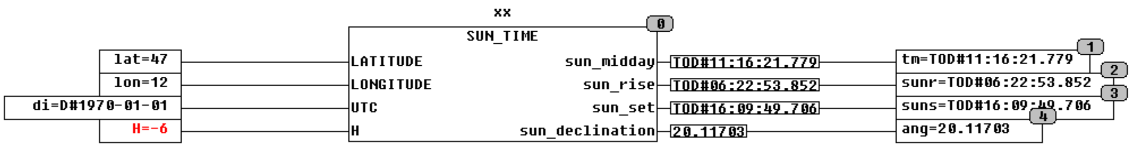
SUN_SET: TOD (time of sunset)

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 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.

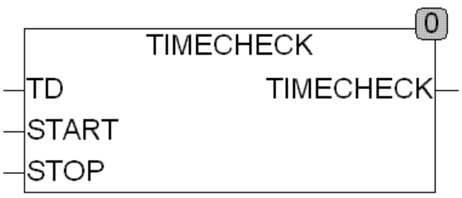
Additional information on sunrise and sunset times are available on the following websites:

http://www.calsky.com/cs.cgi

http://lexikon.astronomie.info/java/sunmoon/

12.52. TIME CHECK

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

12.53. UTC_TO_LTIME

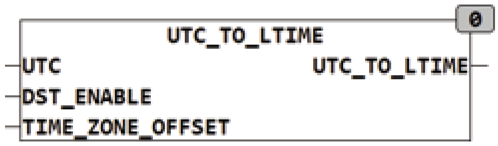
Type Function module

Input UTC: DATE_TIME (Universal Time)

DST_ENABLE: BOOL(TRUE allows DST)

TIME_ZONE_OFFSET: INT(time difference to UTC in minutes)

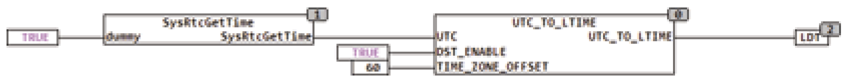
Output DT: DATE_TIME (local time)



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 SYSRTCGET-TIME routine. The PLC clock must be in this case set to UTC.

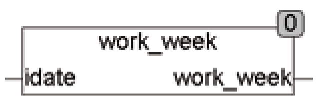


12.54. WORK_WEEK

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.

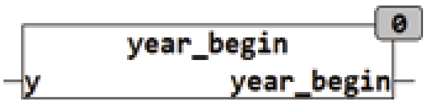
As the work week (Work Week) International is not always used consistent, before the application of the function is to clarify, whether the work week according to ISO8601 is desired in the desired application function.

12.55. YEAR_BEGIN

Type Function: DATE

Input Y: INT (year)

Output DATE (date of 1 January of the year)



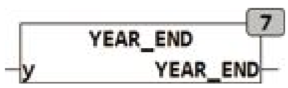
YEAR_BEGIN calculate the date of the first January for the year Y.

12.56. YEAR_END

Type Function: DATE

Input Y: INT (year)

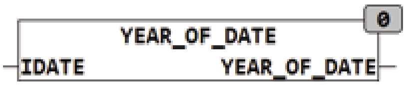
Output DATE (date of December 31 for the year)



YEAR_END calculates '31 December in the year Y.

12.57. YEAR_OF_DATE

Type	Function: INT
Input	IDATE: DATE (date)
Output	INT (year of the date)



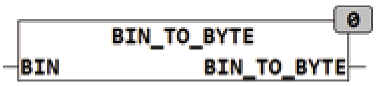
The function YEAR_OF_DATE calculates the corresponding year from the date of input IDATE.

Example: YEAR_OF_DATE(31.12.2007) = 2007

13. String Functions

13.1. BIN_TO_BYTE

Type	Function: BYTE
Input	BIN: STRING (12) (Octal string)
Output	BYTE (output value)

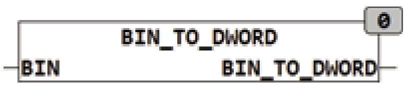


The function BIN_TO_BYTE converts a binary encoded string in a BYTE value. There, this method only binary characters are '0 'and '1' is interpreted, others in BIN occurring characters are ignored.

Example: BIN_TO_BYTE ('11 ') result 3.

13.2. BIN_TO_DWORD

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.

13.3. BYTE_TO_STRB

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 '

13.4. 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.

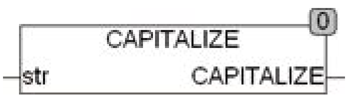
Example : BYTE_TO_STRH(15) = '0F'

13.5. 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.

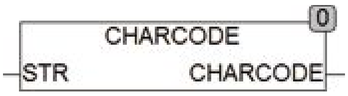
Capitalize('peter pan') = 'Peter Pan'

13.6. CHARCODE

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 €

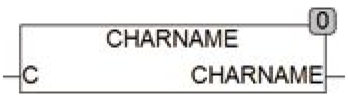
CHARCODE(',') = 44

13.7. 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'

char	***code***	***name***	***char***	***code***	***name***	***char***	***code***	***name***
"	34	quot	½	189	frac12	ß	223	szlig
&	38	amp	¾	190	frac34	à	224	agrave
<	60	lt	¿	191	iquest	á	225	aacute
>	62	gt	À	192	Agrave	â	226	acirc
€	128	euro	Á	193	Aacute	ã	227	atilde
	160	nbsp	Â	194	Acirc	ä	228	auml
¡	161	iexcl	Ã	195	Atilde	å	229	aring
¢	162	cent	Ä	196	Auml	æ	230	aelig
£	163	pound	Å	197	Aring	ç	231	ccedil
¤	164	curren	Æ	198	AElig	è	232	egrave
¥	165	yen	Ç	199	Ccedil	é	233	eacute
¦	166	brvbar	È	200	Egrave	ê	234	ecirc
§	167	sect	É	201	Eacute	ë	235	euml
¨	168	uml	Ê	202	Ecirc	ì	236	igrave
©	169	copy	Ë	203	Euml	í	237	iacute
ª	170	ordf	Ì	204	Igrave	î	238	icirc
«	171	laquo	Í	205	Iacute	ï	239	iuml
¬	172	not	Î	206	Icirc	ð	240	eth
-	173	shy	Ï	207	Iuml	ñ	241	ntilde
®	174	reg	Ð	208	ETH	ò	242	ograve
¯	175	macr	Ñ	209	Ntilde	ó	243	oacute
°	176	deg	Ò	210	Ograve	ô	244	ocirc
±	177	plusmn	Ó	211	Oacute	õ	245	otilde
²	178	sup2	Ô	212	Ocirc	ö	246	ouml
³	179	sup3	Õ	213	Otilde	÷	247	divide
´	180	acute	Ö	214	Ouml	ø	248	oslash
µ	181	micro	×	215	times	ù	249	ugrave
¶	182	para	Ø	216	Oslash	ú	250	uacute
·	183	middot	Ù	217	Ugrave	û	251	ucirc
¸	184	cedil	Ú	218	Uacute	ü	252	uuml
¹	185	sup1	Û	219	Ucirc	ý	253	yacute
º	186	ordm	Ü	220	Uuml	þ	254	thorn
»	187	raquo	Ý	221	Yacute	ÿ	255	yuml

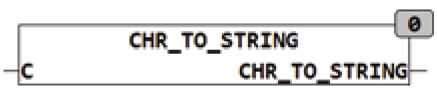
If no name is known for a code, the code is returned as a single character. For the Code 0 an empty string is returned. CHARNAME uses the global variables SETUP.CHARNAMES which includes the list of names with codes.

13.8. CHR_TO_STRING

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.

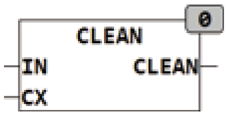
13.9. CLEAN

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'

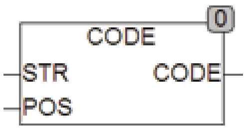
13.10. CODE

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).

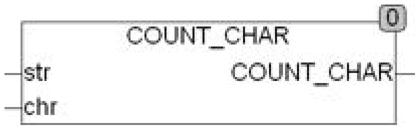
13.11. COUNT_CHAR

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.

13.12. DEC_TO_BYTE

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 .

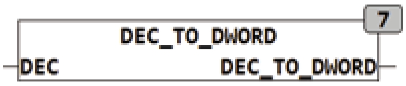
Example: DEC_TO_BYTE('34 ') is 34.

13.13. 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 .

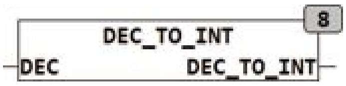
Example: DEC_TO_DWORD('34 ') is 34.

13.14. DEC_TO_INT

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.

13.15. DEL_CHARS

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'

13.16. 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:

#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 ')

Examples:

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'

13.17. DWORD_TO_STRB

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 :

DWORD_TO_STRB(127) = '00000000000000000000000001111111'

13.18. DWORD_TO_STRF

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'

13.19. DWORD_TO_STRH

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.

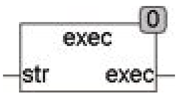
Example: DWORD_TO_STRH(127) = '0000007F'

13.20. EXEC

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'

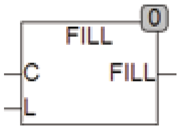
EXEC('4-2') = '2'

13.21. FILL

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.

13.22. FIND_CHAR

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.

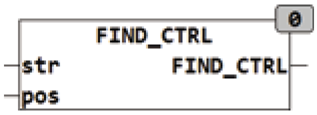
13.23. FIND_CTRL

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.

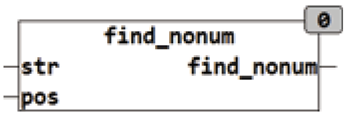
13.24. FIND_NONUM

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.

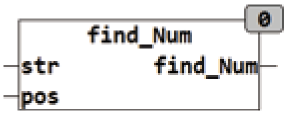
Numbers are the letters "0..9" and "."

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

13.25. FIND_NUM

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

13.26. FINDB

Type	Function: INT
Input	STR1: STRING (String input)
	STR1: STRING (String input)
Output	INT (position of last occurrence of STR2 in STR1)

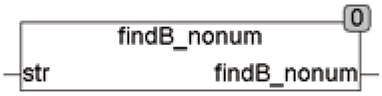
The function FINDB searched for the presence of STR2 in STR1 and returns the last position of STR2 in STR1.

If STR2 is not found, a 0 is returned.

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

13.27. FINDB_NONUM

Type	Function: INT
Input	STR: STRING (String input)
Output	INT (position of the last letter that is not a number)



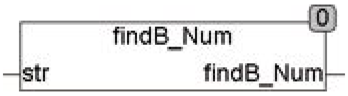
The function FINDB_NONUM STR searches from right to left and returns the last position which is not a number.

Numbers are the letters "0..9" and "."

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

13.28. FINDB_NUM

Type	Function: INT
Input	STR: STRING (String input)
Output	INT (of the last character, which is a number or point)



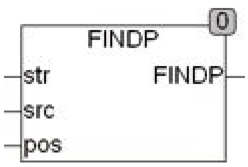
The function FINDB_NUM searches STR from right to left and returns the last position that is a number.

Numbers are the letters "0..9" and "."

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

13.29. FINDP

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.

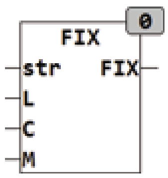
Example: FINDP('ein Fuchs ist ein Tier','ein',1) = 1;

FINDP('ein Fuchs ist ein Tier','ein',2) = 15;

FINDP('ein Fuchs ist ein Tier','ein',16) = 0;

13.30. FIX

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.

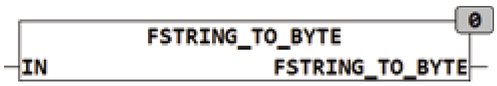
13.31. FLOAT_TO_REAL

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.

13.32. FSTRING_TO_BYTE

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).

13.33. FSTRING_TO_DT

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.

#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

Examples:

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

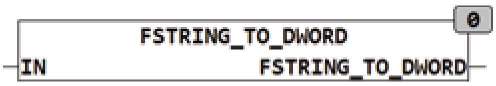
FSTRING_TO_DT('13:14', '#h:#m')

13.34. FSTRING_TO_DWORD

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).

13.35. FSTRING_TO_MONTH

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.

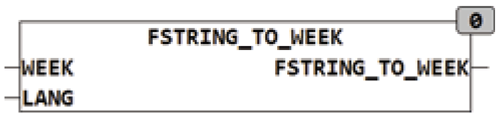
13.36. FSTRING_TO_WEEK

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.

13.37. FSTRING_TO_WEEKDAY

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 lower-case. Since the function evaluates only the first two characters, the week-days 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

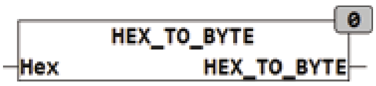
As an alternative form, the weekday can be specified as number 1..7. LANG specifies the used language, 1 = English, 2 = German, 0 = defined default language in the Setup.

13.38. HEX_TO_BYTE

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.

13.39. HEX_TO_DWORD

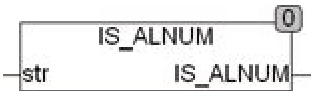
Type	Function: DWORD
Input	HEX: STRING(20) (hex string)
Output	DWORD (output value)

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.

13.40. IS_ALNUM

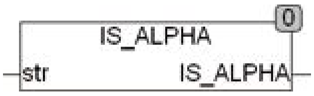
Type	Function: BOOL
Input	STR: STRING (String input)
Output	BOOL (TRUE if STR contains only letters or numbers)



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.

13.41. IS_ALPHA

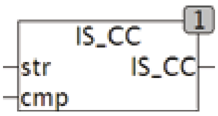
Type	Function: BOOL
Input	STR: STRING (String input)
Output	BOOL (TRUE if STR contains only letters)



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.

13.42. 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.

Examples:

IS_CC('3.14', '0123456789.') = TRUE

IS_CC('-3.14', '0123456789.') = FALSE

13.43. IS_CTRL

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

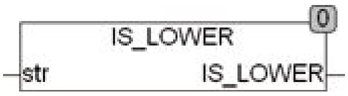
13.44. IS_HEX

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.

13.45. 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.

13.46. IS_NCC

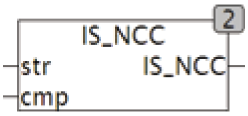
Type Function: BOOL

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.

Examples:

IS_NCC('3.14', ',-+()') = TRUE

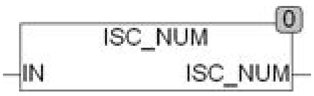
IS_NCC('-3.14', ',-+()') = FALSE

13.47. 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.

13.48. IS_UPPER

Type Function: BOOL

Input STR: STRING (String input)

Output BOOL (TRUE if STR contains only capital letters)

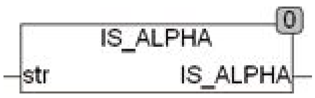
IS_UPPER checks if in the string STR all capital letters are included. If an incorrect, non capital character is found the function returns FALSE. If in STR are only capital letters included, the function returns TRUE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = 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.

13.49. ISC_ALPHA

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 = FAS-
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

13.50. 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.

13.51. 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)

13.52. ISC_LOWER

Type	Function: BOOL
Input	IN: BYTE (characters)
Output	Type

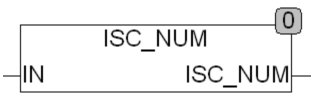
ISC_LOWER tests whether a sign IN is a lowercase letter, If IN is a lower case the function returns TRUE, else the function returns FALSE. In examining the Global Setup EXTENDED_ASCII constant is considered. If EXTENDED_ASCII = TRUE the extended ASCII character-set to be considered in accordance with 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

13.53. ISC_NUM

Type	Function: BOOL
Input	IN: BYTE (characters)
Output	Type



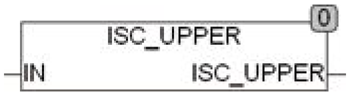
ISC_NUM tests whether a sign IN is a number, if IN is a character 0..9, the function returns TRUE, if not the function returns FALSE. The character 0..9 are codes (48..57)

13.54. 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:

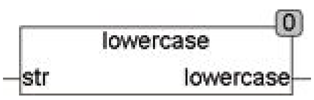
Code	EXTENDED_ASCII=TRUE	EXTENDED_ASCII = FASLE
0..64,91..191,215, 223..255	FALSE	FALSE
65..90	TRUE	TRUE
192..214	TRUE	FALSE
216..222	TRUE	FALSE

13.55. LOWERCASE

Type Function: STRING

Input STR: STRING (String input)

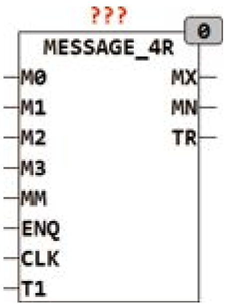
Output STRING (STRING in lowercase)



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.

13.56. MESSAGE_4R

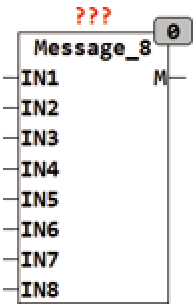
Type	Function module
Input	M0 :. M3 STRING(string_length) (Information)
	MM: INT (message appears maximum)
	ENQ: BOOL (enable input)
	CLK: BOOL (input to the next turn)
	T1: TIME (time for automatic advance)
Output	MX: STRING(string_length) (output string)
	MN: INT (currently active message)
	TR: BOOL (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.

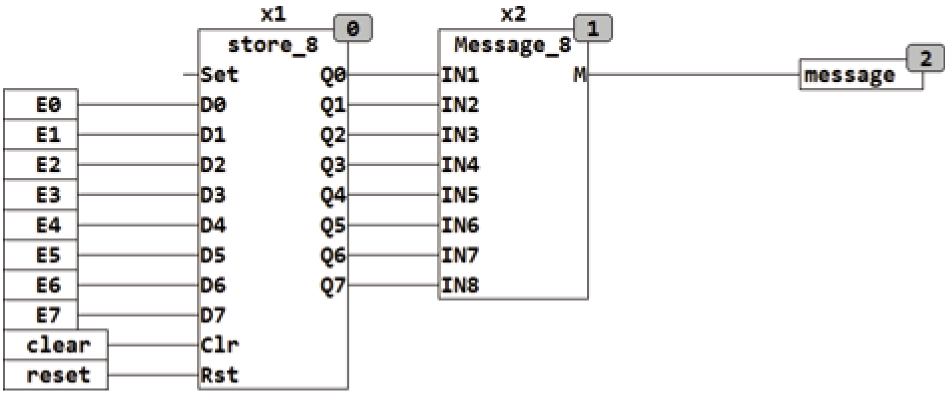
13.57. MESSAGE_8

Type	Function module
Input	IN1..IN8: BOOL (select inputs)
Setup	S1..S8: STRING(default message)
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.

13.58. MIRROR

Type Function: STRING

Input STR: STRING (String input)

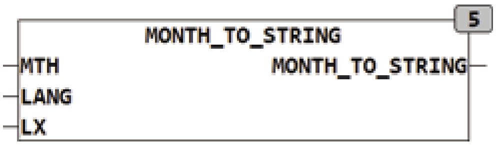
Output STRING (input string read backwards)

MIRROR reads the string STR reverse and passes the characters in reverse order.

Example: MIRROR ('This is a test') = 'tset a si siht'

13.59. 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'

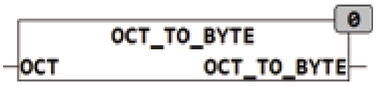
dependent on the global constant LANGUAGE_DEFAULT

MONTH_TO_STRING(1,2,0) = 'Januar'

MONTH_TO_STRING(1,2,3) = 'Jan'

13.60. 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.

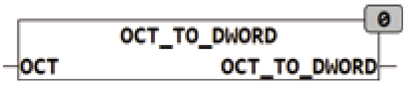
Example: OCT_TO_BYTE('11') results 9.

13.61. OCT_TO_DWORD

Type Function: DWORD

Input OCT : STRING(20) (Oktale Zeichenkette)

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.

13.62. REAL_TO_STRF

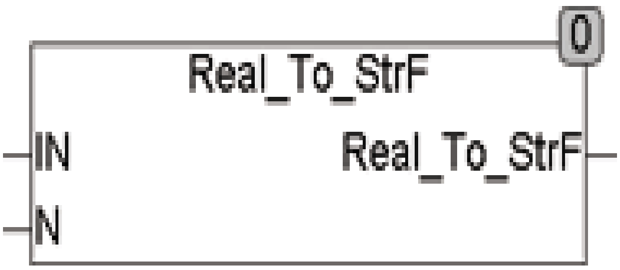
Type Function: STRING(20)

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.

Examples:

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'

13.63. 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.

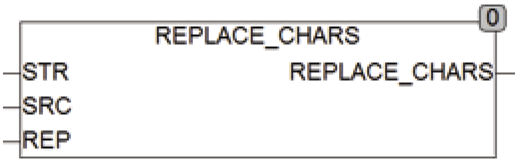
Example: REPLACE_ALL('123BB456BB789BB','BB','/') = '123/456/789/'

REPLACE_ALL('123BB456BB789BB','BB','') = '123456789'

13.64. 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') = 'ab-cABC'

13.65. REPLACE_UML

Type	Function: STRING
Input	STR: STRING (String input)
Output	STRING (String output)

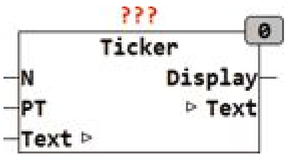
REPLACE_UML replaces umlauts with a combination of two characters so that the result contains no more umlauts. The large and small letters are considered here. If a word is all upper case and is an umlaut is mentioned, this is replaced by a capital letter followed by a lowercase letter, in the case of 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.

13.66. TICKER

Type	Function module
Input	N: INT (length of the display Strings)
	PT: TIME (slide delay, Default = T#1s)

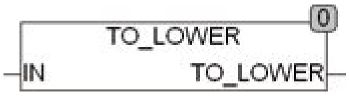
I / O	TEXT: STRING (String input)
Output	DISPLAY: STRING (String output)



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.

13.67. TO_LOWER

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:

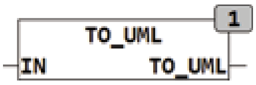
Code	EXTENDED_ASCII = TRUE	EXTENDED_ASCII = FALSE
0..64	0..64	0..64
65..90	97..122	97..122
91..191	91..191	91..191
192..214	224..246	192..214
215	215	215
216..222	248..254	216..254
223..255	223..255	223..255

13.68. TO_UML

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.

13.69. TO_UPPER

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

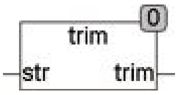
216..222	248..254	216..254
223..255	223..255	223..255

13.70. TRIM

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'

13.71. TRIM1

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'

13.72. TRIME

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.

13.73. UPPER CASE

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

13.74. WEEKDAY_TO_STRING

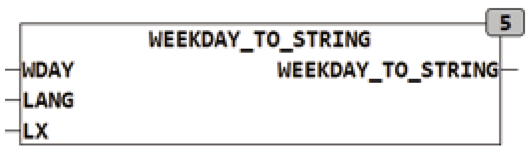
Type Function: STRING (10)

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

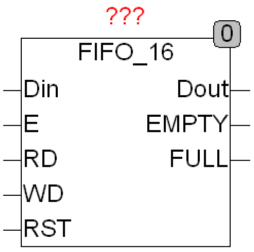
WEEKDAY_TO_STRING(1,2,0) = ' Monday '

WEEKDAY_TO_STRING(1,0,2) = ' Mon '

14. Memory Modules

14.1. FIFO_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)

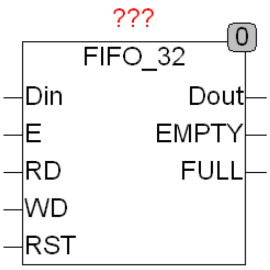


FIFO_16 is a First-In First-Out Memory with 16 memory locations for DWORD data. The two outputs EMPTY and FULL indicate when the memory is full or empty. The RST input clears the entire contents of the memory. The FIFO is described by DIN, by put a TRUE to the input WD, and a true-pulse on the input 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.

14.2. FIFO_32

Type	Function module
Input	DIN: DWORD (data input)
	E: BOOL (enable input)

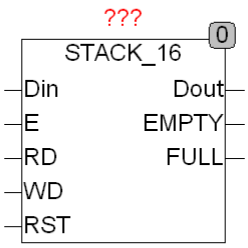
	RD: BOOL (read command)
	WD: BOOL (write command)
	RST: BOOL (Reset input)
Output	DOUT: DWORD (data output)
	EMPTY: BOOL (EMPTY = TRUE means that memory is empty)
	FULL: BOOL (FULL = TRUE means: memory is full)



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.

14.3. STACK_16

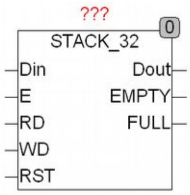
Type	Function module
Input	DIN: DWORD (data input)
	E: BOOL (enable input)
	RD: BOOL (read command)
	WD: BOOL (write command)
	RST: BOOL (Reset input)
Output	DOUT: DWORD (data output)
	EMPTY: BOOL (EMPTY = TRUE means that memory is empty)
	FULL: BOOL (FULL = TRUE means: memory is full)



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.

14.4. STACK_32

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.

15. Pulse Generators

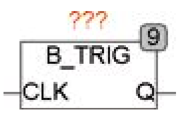
15.1. A_TRIG

Type	Function module
Input	IN: REAL (input signal)
	RES: REAL (input change)
Output	Q: BOOL (output)
	D: REAL (last change of the input signal)

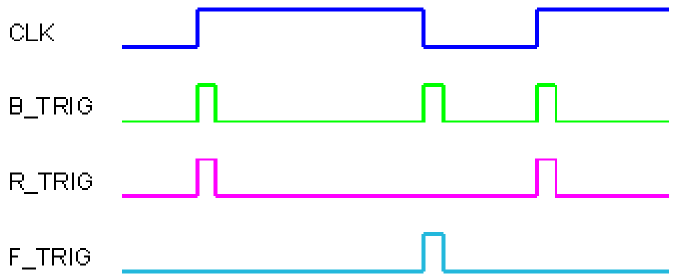
A_TRIG monitors an input value on change and every time when the input value changes by more than RES, the module generates an output pulse for a cycle so that the new value can be processed. At the same time, the device remembers the current input value with which it compares with the input IN at the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

15.2. B_TRIG

Type	Function module
Input	CLK: BOOL (Input signal)
Output	Q: BOOL (output)

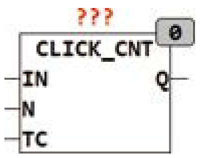


The function module B_TRIG generates after a change of edge on the CLK input an output pulse for exactly one PLC cycle. In contrast to the two standard modules R_TRIG and F_TRIG that produce only at falling or rising edge of a pulse, B_TRIG generates at falling and rising edge of an output pulse.

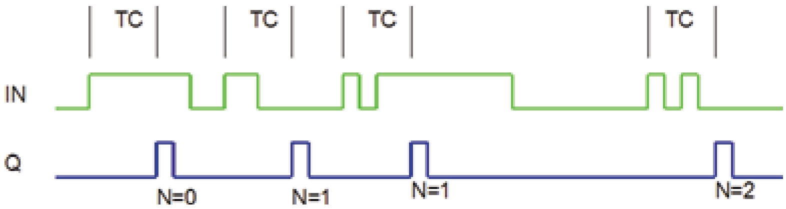


15.3. CLICK_CNT

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)

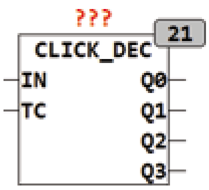


CLICK_CNT determines the number of pulses within the unit time TC. at input IN. A rising edge at IN will start an internal timer with time TC. During the course of Timers the module counts the falling edges of IN and reviewes after the expiry of the time TC whether N pulses are within the time TC. Just 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.

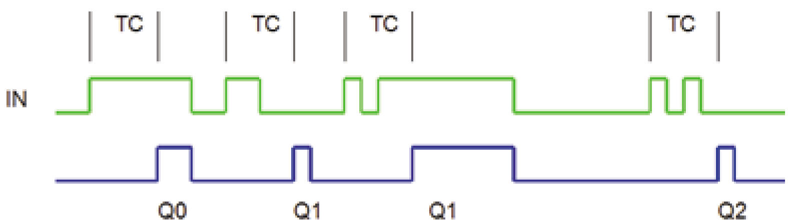


15.4. CLICK_DEC

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.



15.5. CLK_DIV

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)

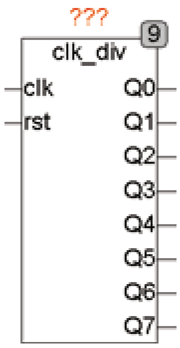
Q3: BOOL (divider output CLK / 16)

Q4: BOOL (divider output CLK / 32)

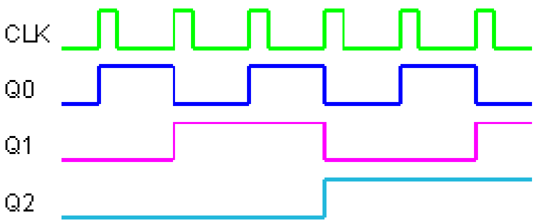
Q5: BOOL (divider output CLK / 64)

Q6: BOOL (divider output CLK / 128)

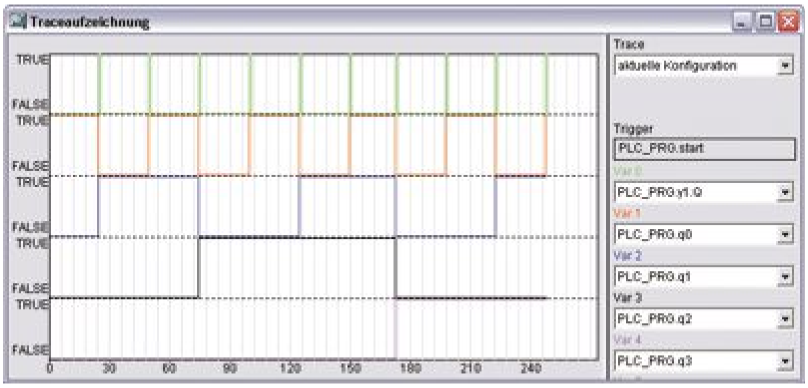
Q7: BOOL (divider output CLK / 256)



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:



15.6. CLK_N

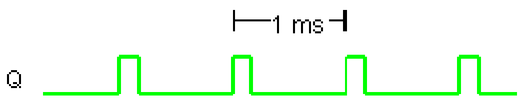
Type	Function module
Input	N: INT (Clock Divider)
Output	Q: BOOL (clock output)

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:

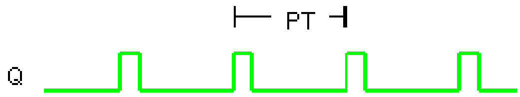


15.7. CLK_PRG

Type	Function module
Input	PT: TIME (cycle time)

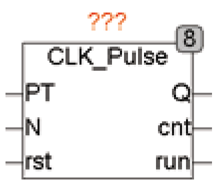
Output Q: BOOL (clock output)

CLK_PRG generates clock pulses with a programmable period PT. The output pulses are only one PLC cycle.



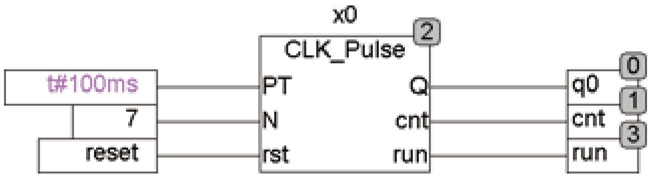
15.8. CLK_PULSE

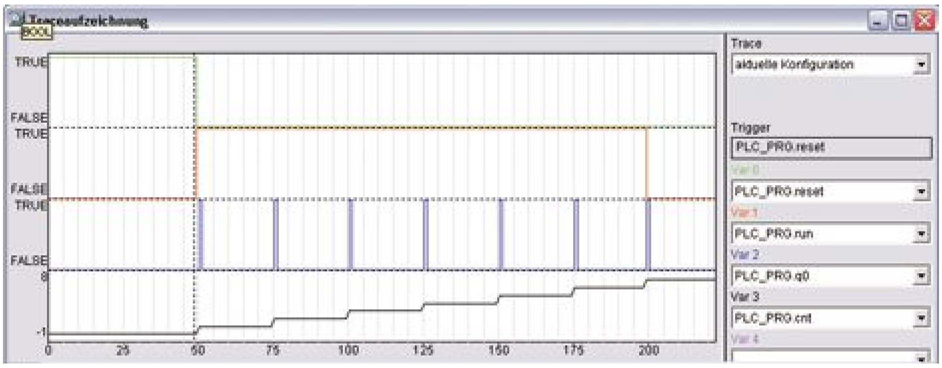
Type	Function module
Input	PT: TIME (cycle time)
	N: INT (number of pulses to be generated)
	RST: BOOL (Reset)
Output	Q: BOOL (clock output)
	CNT: INT (counter of output pulses)
	RUN: BOOL (TRUE, if pulse generator is running)



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.

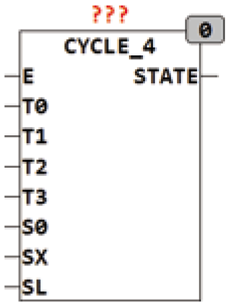




The trace recording, shows how the RESET (green) is inactive and thus RUN (red) is active. The generator generates then 7 pulses (blue), as specified at the input N. The output CNT counts from 1 on the first pulse to 7 by the last pulse. After the end of the sequence RUN is inactive again and the cycle is complete until it is started by a new reset.

15.9. CYCLE_4

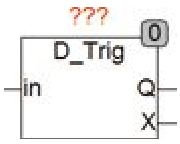
Type	Function module
Input	E: BOOL (Enable Input)
	T0 _ T3: TIME (run time of each States)
	S0: BOOL (continuous cycle Enable)
	SX: INT (State if SL = TRUE)
	SL: BOOL (asynchronous Load input)
Output	STATE: INT (status output)



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.

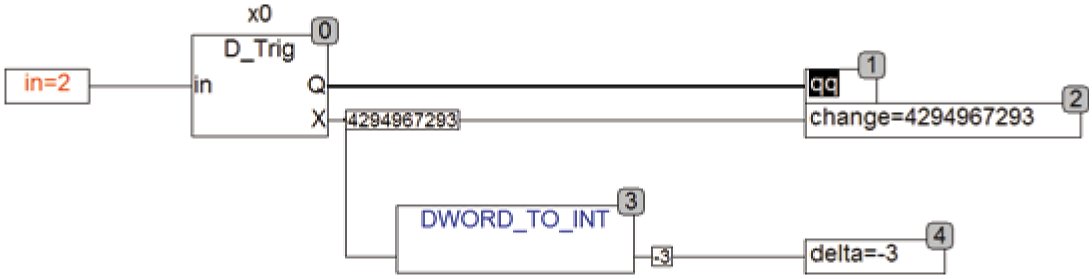
15.10. D_TRIG

Type	Function module
Input	IN: DWORD (input signal)
Output	Q: BOOL (output)
	X: DWORD (change of the input signal)



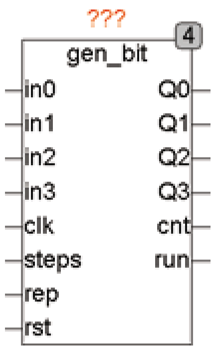
The function module D_ TRIG generates after a change at the input IN an output pulse for exactly one PLC cycle. The module works similar to the standard function blocks R_TRIG and F_TRIG and the library module B_TRIG. While B_TRIG, R_TRIG and F_TRIG monitor a Boolean input, the module D_TRIG triggers 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:



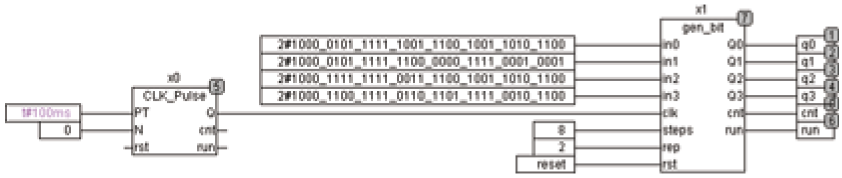
15.11. GEN_BIT

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)

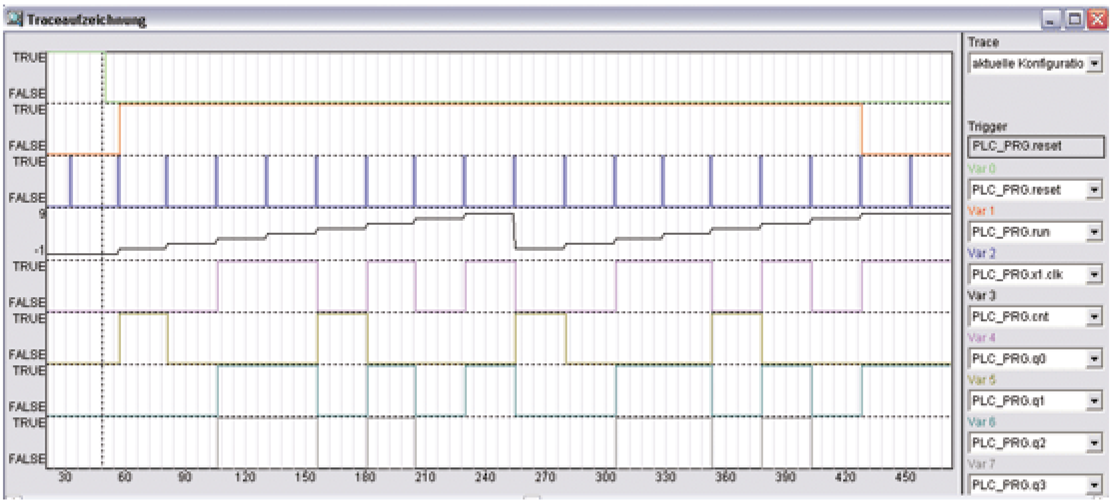


GEN_BIT is a fully programmable pattern generator. At the inputs in0 .. IN7 are the bit patterns at the input CLK in each case as a DWORD and passed by each clock pulse to the outputs Q0 .. Q3 starting from bit 0 of ascending. After the first clock pulse at the input CLK the output Q0 has bit 0 of IN0 , 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:



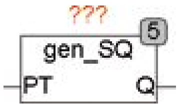
In this example, the lowest 8 bits (bits 0 .. 7) at the inputs IN are pushed to the outputs Q. The sequence begins with bit 0 and ends at bit 7 (8 Steps are defined by the input 8). This sequence is repeated 2 times (2 repetitions at the input REP) and then stopped.



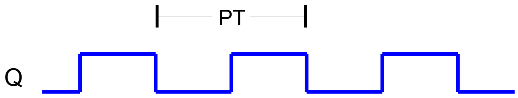
The Trace Recording shows the reset signal becoming inactive (green), which starts the generator and after the first clock pulse passes bit 0 to the outputs.

15.12. GEN_SQ

Type	Function module
Input	PT: TIME (period time)
Output	Q: BOOL (output)

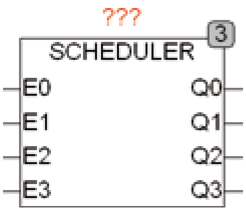


Gen_SQ is a generator with programmable period time and a fixed duty cycle of 50%. The input PT defines the period time and the output Q passes the output signal.



15.13. SCHEDULER

Type	Function module
Input	E0..3: BOOL (release signal for Q0..3)
Setup	T0..3: TIME (cycle time)
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? .

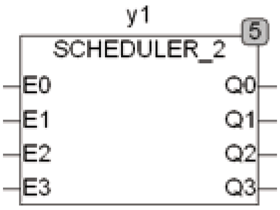
15.14. SCHEDULER_2

Type	Function module
Input	E0..3: BOOL (release signal for Q0..3)

Setup C0 .. 3: UINT (The output Q? is activated the C? cycles)

O0 .. 3: UINT (delay for the outputs)

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.

15.15. SEQUENCE_4

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)

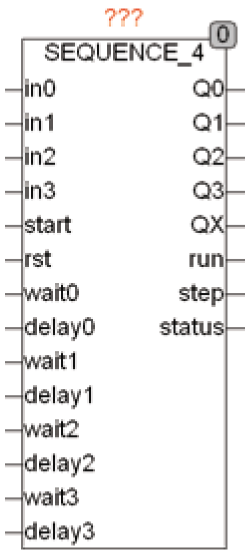
Output Q 0..3: BOOL (control outputs)

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.

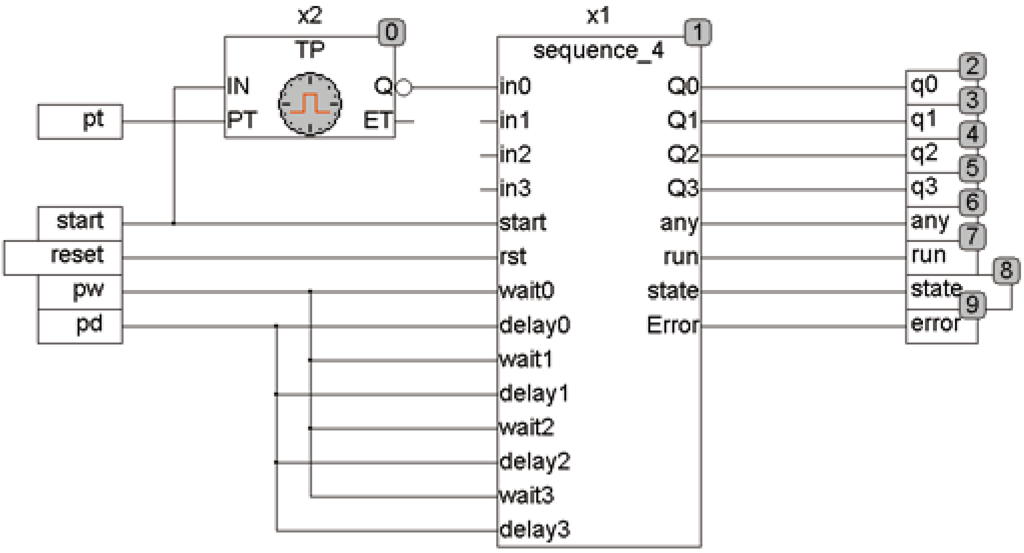
The initial state is compatible and ESR shows a value of 1-4 indicates that an error has occurred. An error occurs if the corresponding input signal to IN does not occur during the waiting period.

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.

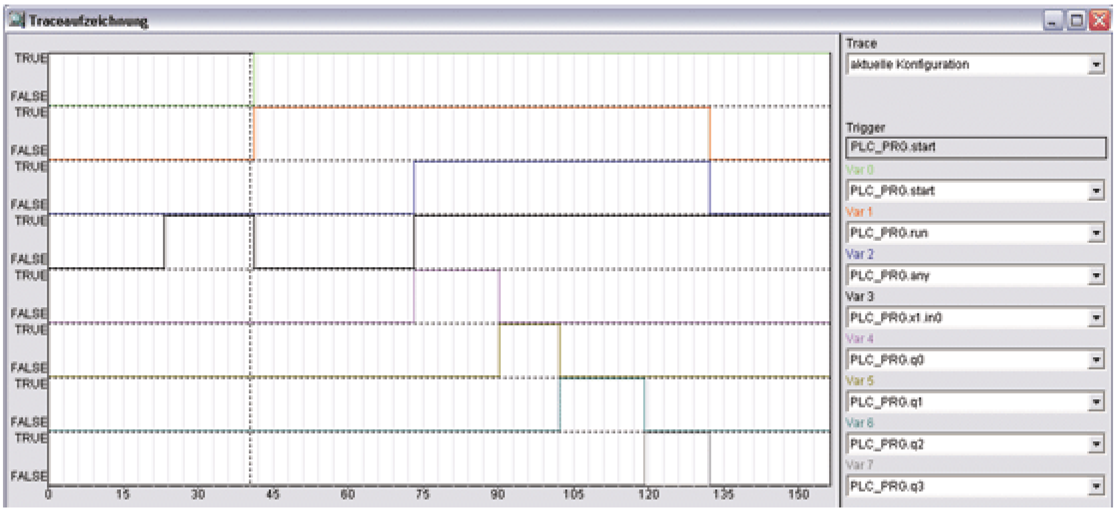
Example:

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.



15.16. SEQUENCE_64

Type Function module

Input START: BOOL (rising edge starts the sequence)

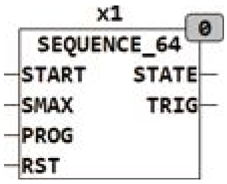
SMAX INT (last State the sequence)

PROG: ARRAY [0..63] OF TIME (duration of the individual states)

RST: BOOL (asynchronous reset input)

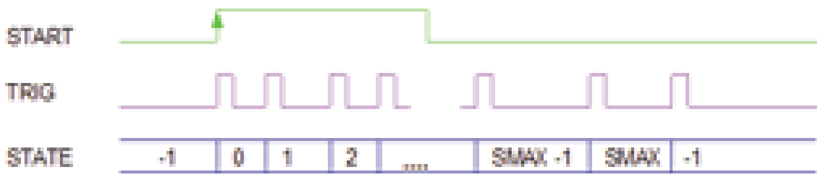
Output STATE: INT (State Output)

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:



15.17. SEQUENCE_8

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)

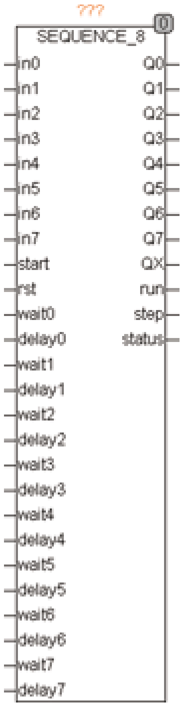
Output Q 0..7: BOOL (control outputs)

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)

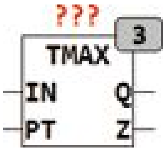
STATUS: BYTE (0 if no error, else > 0)



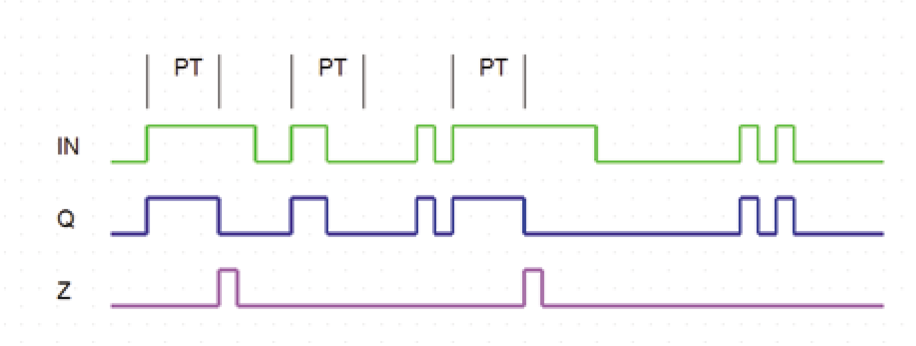
A functional description of SEQUENCE_8 can be found at SEQUENCE_4. SEQUENCE_8 function is identical with SEQUENCE_4. He has 8 instead of 4 channels. SEQUENCE_8 is used in the OSCAT library module Legionella.

15.18. TMAX

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.



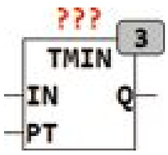
15.19. TMIN

Type Function module

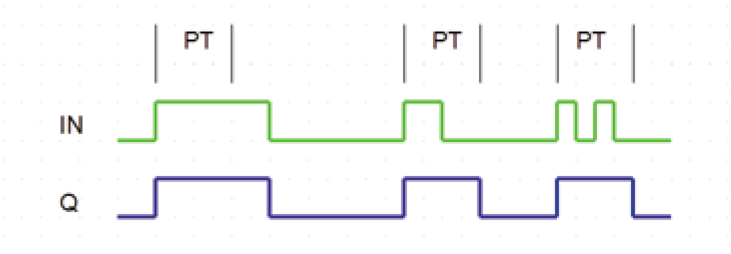
Input IN: BOOL (Input)

PT: TIME (switch off delay)

Output Q: BOOL (output)



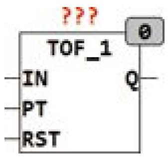
TMIN ensures that the output pulse Q is at least PT is set to TRUE, even if the input pulse at IN is shorter than PT. otherwise the output Q follows the input IN.



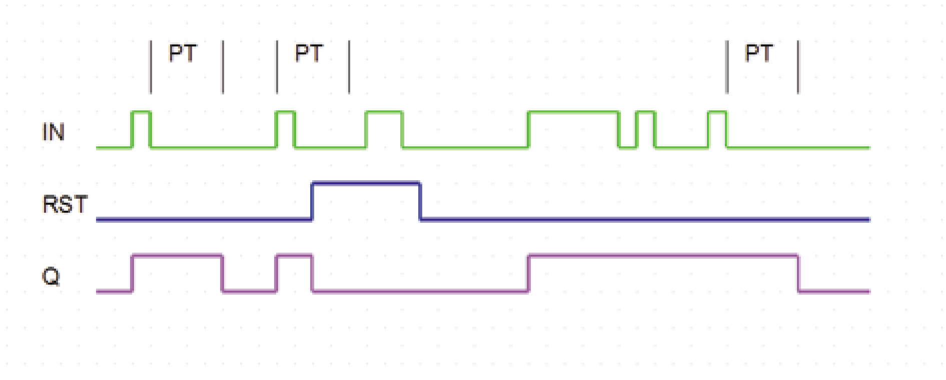
15.20. TOF_1

Type Function module

Input	IN: BOOL (Input)
	PT: TIME (switch off delay)
	RST: BOOL (asynchronous reset)
Output	Q: BOOL (output)

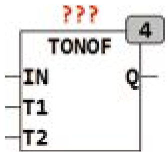


TOF_1 extended an input pulse at IN by the time PT. TOF_1 has the same functionality as TOF from the standard LIB, but with an additional asynchronous reset input.



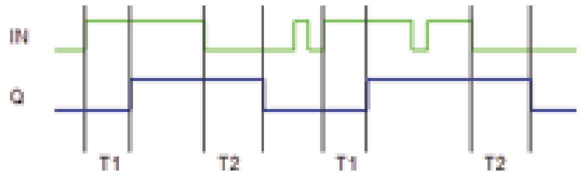
15.21. TONOF

Type	Function module
Input	IN: BOOL (Input)
	T1: TIME (ON Delay)
	T2: TIME (OFF Delay)
Output	Q: BOOL (output pulse)



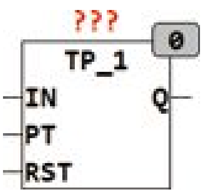
TONOF creates a ON delay T1 and an OFF delay T2

The rising edge of the input signal IN is delayed by T1 and the falling edge of IN is delayed by T2.



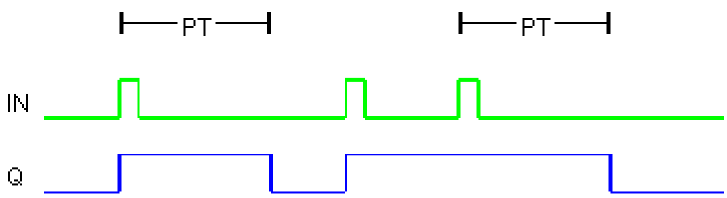
15.22. TP_1

Type	Function module
Input	IN: BOOL (Input)
	PT: TIME (pulse duration)
	RST: BOOL (asynchronous reset)
Output	Q: BOOL (output pulse)



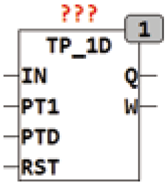
TP_1 is an edge-triggered pulse generator which generates a rising edge at IN an output pulse at Q with the duration of PT. During the output pulse an another rising edge to IN is created, the output pulse will be extended so that after the last rising edge of output for the duration of PT remains TRUE.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

Timing of TP_1:



15.23. TP_1D

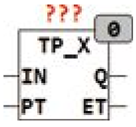
Type	Function module
Input	IN: BOOL (Input)
	PT1: TIME (pulse duration)
	PTD: TIME (Delay can be generated by new pulse)
	RST: BOOL (asynchronous reset)
Output	Q: BOOL (output pulse)



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.

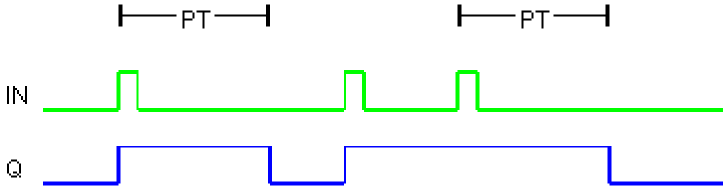
15.24. TP_X

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.

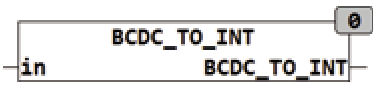
Timing of TP_X:



16. Logic Modules

16.1. BCDC_TO_INT

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.

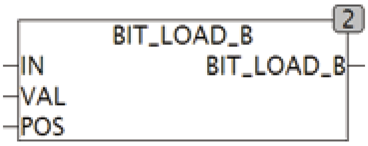
16.2. BIT_COUNT

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.

16.3. BIT_LOAD_B

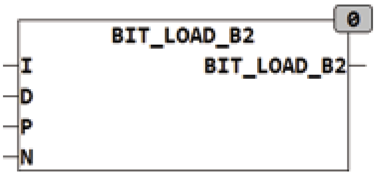
Type	Function: BYTE
Input	IN: BYTE (input)
	VAL: BOOL (value of bits to be loaded)
	POS: INT (position of the bits to be loaded)
Output	BYTE (output)



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.

16.4. BIT_LOAD_B2

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

16.5. BIT_LOAD_DW

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.

16.6. BIT_LOAD_DW2

Type Function: DWORD

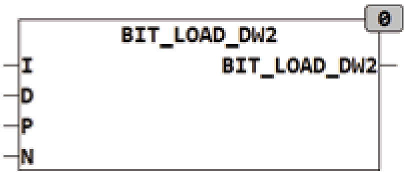
Input I: DWORD (input value)

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.

Examples, see BIT_LOAD_B2

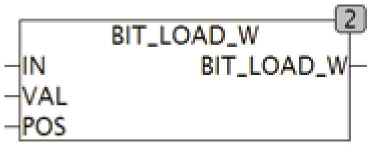
16.7. BIT_LOAD_W

Type Function: WORD

Input IN: WORD (input)

VAL: BOOL (value of bits to be loaded)

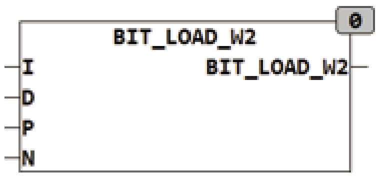
	POS: INT (position of the bits to be loaded)
Output	WORD (output)



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.

16.8. BIT_LOAD_W2

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.

Examples, see BIT_LOAD_B2

16.9. BIT_OF_DWORD

Type	Function: BOOL
Input	IN: DWORD (input)

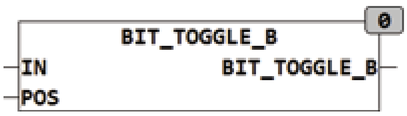
	N: INT (number of bits 0..31)
Output	BOOL (output bit)

BIT_OF_DWORD extracts a bit of the DWORD at the input IN.

Bit0 für N=0, Bit1 für N=1 and so on.

16.10. BIT_TOGGLE_B

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

16.11. BIT_TOGGLE_DW

Type	Function: DWORD
Input	IN: DWORD (input data)
	POS: INT (Position)
Output	DWORD (output byte)

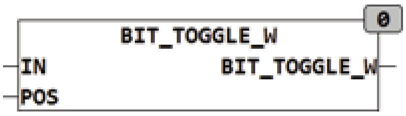
BIT_TOGGLE_DW inverts a specified bit at IN.

BIT_TOGGLE_DW(2#0000_1111, 2) = 2#0000_1011

BIT_TOGGLE_DW(2#0000_1111, 7) = 2#1000_1111

16.12. BIT_TOGGLE_W

Type	Function: WORD
Input	IN: WORD (input data)
	POS: INT (Position)
Output	WORD (output byte)



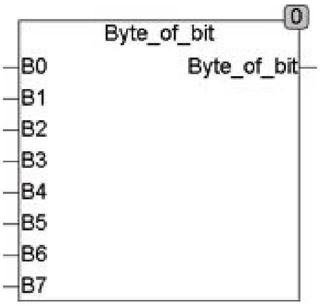
BIT_TOGGLE_W inverts a specified bit POS at IN.

BIT_TOGGLE_W(2#0000_1111, 2) = 2#0000_1011

BIT_TOGGLE_W(2#0000_1111, 7) = 2#1000_1111

16.13. BYTE_OF_BIT

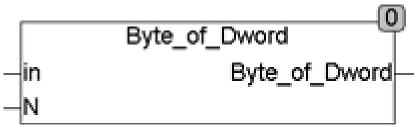
Type	Function: BYTE
Input	B0 .. B7: BOOL (input bits)
Output	BYTE (output byte)



BYTE_OF_BIT uses one byte of 8 individual bits (B0 .. B7) together.

16.14. BYTE_OF_DWORD

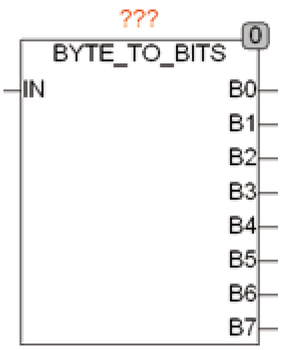
Type	Function: BYTE
Input	IN: DWORD (DWORD input)
Output	BYTE (output byte)



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

16.15. BYTE_TO_BITS

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.

16.16. BYTE_TO_GRAY

Type Function: BYTE

Input IN: BYTE (input byte)

Output Byte (value in Gray code)

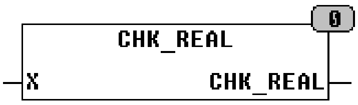
BYTE_TO_GRAY converts a byte value (IN) in the Gray code.

16.17. 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 + Infinity

#40 - Infinity

#80 NAN

For more information see the IEEE754 floating point specification.

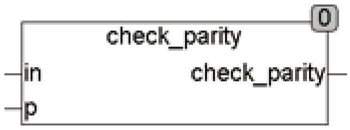
16.18. CHECK_PARITY

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 for output = TRUE:

Example output = FALSE:

16.19. 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.

16.20. CRC_GEN

Type Function : DWORD

Input PT: POINTER TO ARRAY OF BYTE (data package)

SIZE: UINT (size of the Arrays)

Setup PL: UINT (length of the polynomial)

PN: DWORD (polynomial)

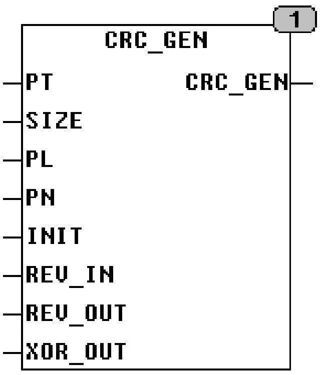
INIT: DWORD (INIT data)

REV_IN: BOOL (input data bytes invert)

REV_OUT: BOOL (invert output data)

XOR_OUT: DWORD (Last XOR of the output)

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 ($1*X^3 + 1*X^2 + 0+X^1 + 1*X^0$). 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:

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

16.21. DEC_2

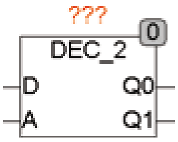
Type Function module

Input D: BOOL (input bit)

A: BOOL (address)

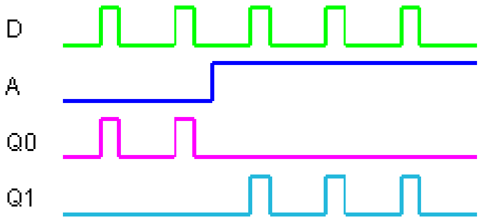
Output Q0: BOOL (TRUE if A=0)

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

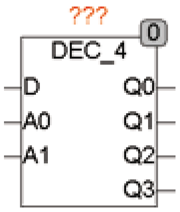
Logical connection: Q0 = D & /A; Q1 = D & A



16.22. DEC_4

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)



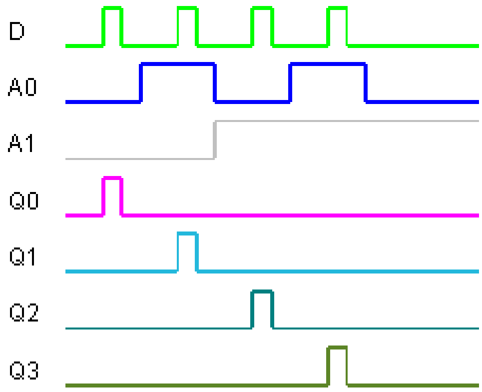
DEC_4 is a 4-bit decoder module. If A0=0 and A1=0, the input D is passed to output Q0. If A0=1 and A1=1, the input D is passed to output Q3. In other words, Q0=1, if D=1 and A0=0 and A1=0.

Logical connection: Q0 = D & / A0 & / A1

Q1 = D & A0 & /A1

Q2 = D & /A0 & A1

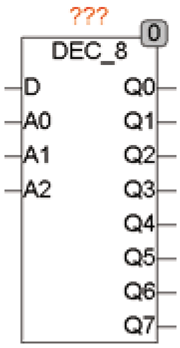
Q3 = D & A0 & A1



16.23. DEC_8

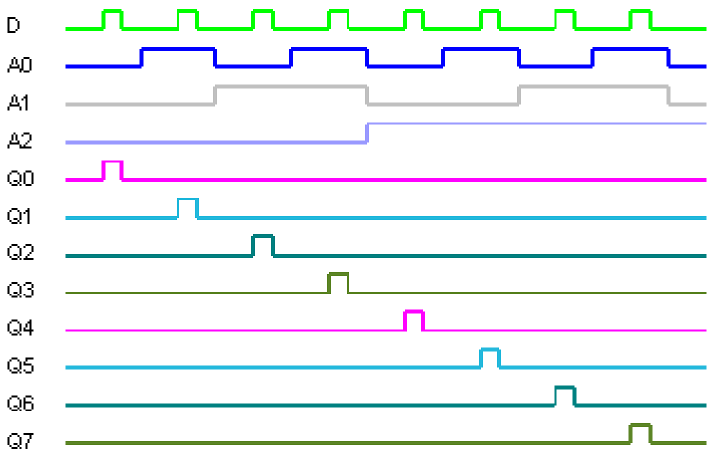
Type Function module

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

16.24. DW_TO_REAL

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.

16.25. DWORD_OF_BYTE

Type Function: DWORD

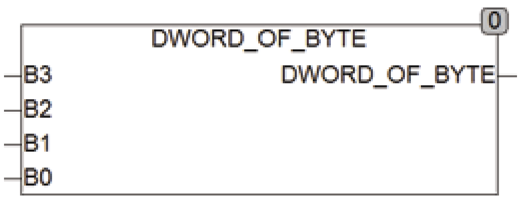
Input B3: Byte (input byte 3)

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.

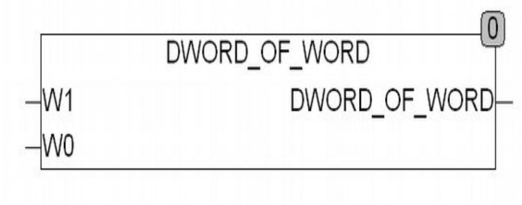
16.26. DWORD_OF_WORD

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.

16.27. GRAY_TO_BYTE

Type Function

Input IN: BYTE (Gray coded value)

Output Byte (Binary Value)

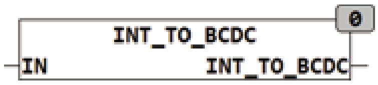
GRAY_TO_BYTE converts a Gray-coded value (IN) in a byte.

16.28. INT_TO_BCDC

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.

16.29. MATRIX

Type Function module

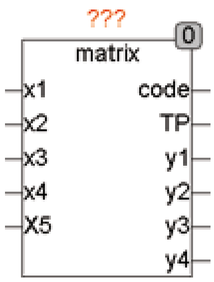
Input X1 .. X5: BOOL (line inputs)

Setup RELEASE: BOOL (a key code when you press and release of a key generated)

Output CODE: Byte (output for key code)

TP: BOOL (TP is TRUE for one cycle when a new Key code is present)

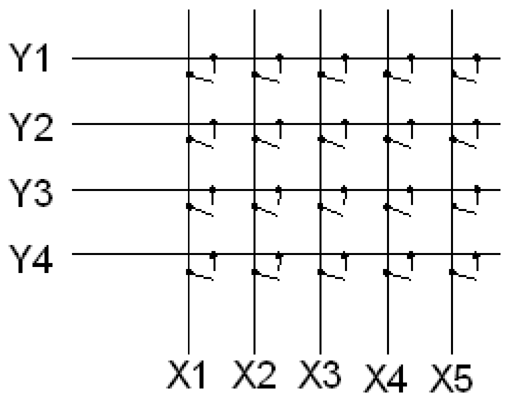
Y1 .. Y4: BOOL (line outputs)



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:

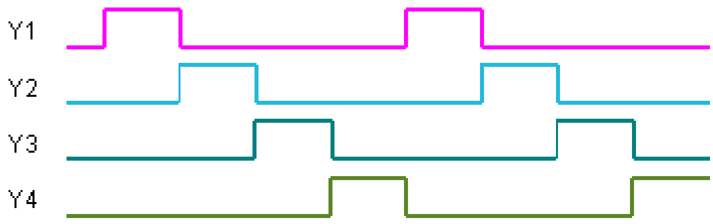
Bit	CODE Output
7	1 when key is pressed, 0 when key is released
6	Line number Bit 2
5	Line number Bit 1
4	Line number Bit 0
3	Always 0
2	Row number Bit 2
1	Row Number Bit 1
0	Row Number Bit 0

The matrix controller is wired as follows:



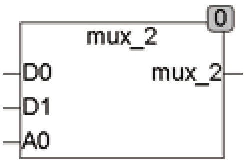
This simple circuit can analyze up to 20 (4 * 5) keys. However, it should be noted here that only in cases a number of keys can be pressed simultaneously. The controller can handle with this circuit, several buttons in a column in any doubt, but not when keys are pressed simultaneously on different columns. 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:



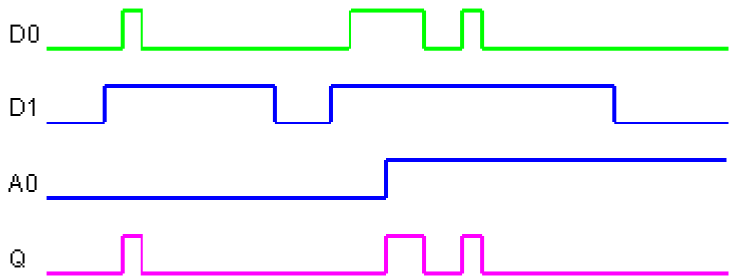
16.30. MUX_2

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

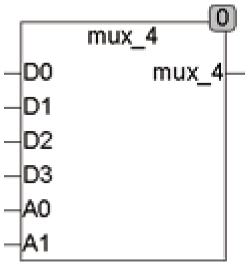
Logical connection: MUX_2 = D0 & /A0 + D1 & A0



16.31. MUX_4

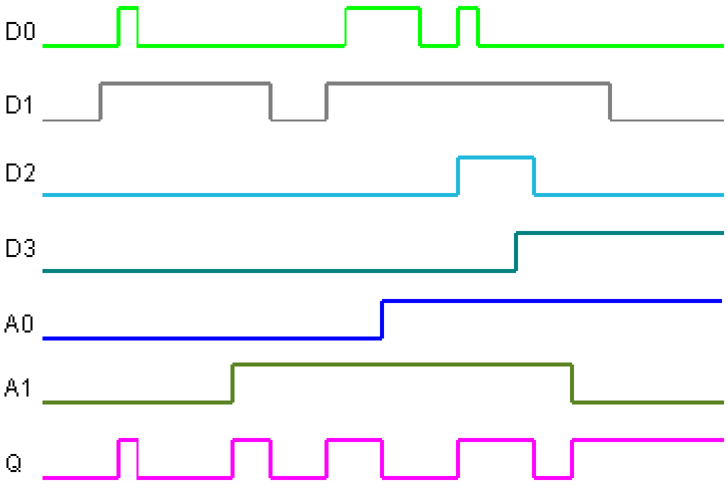
Type	Function: BOOL
Input	D0: BOOL (input 0)

	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 + D2 & /A0 & A1 + D3 & A0 & A1



16.32. PARITY

Type	Function: BOOL
Input	IN: BYTE (BYTE input)
Output	BOOL (output is TRUE if parity is even)

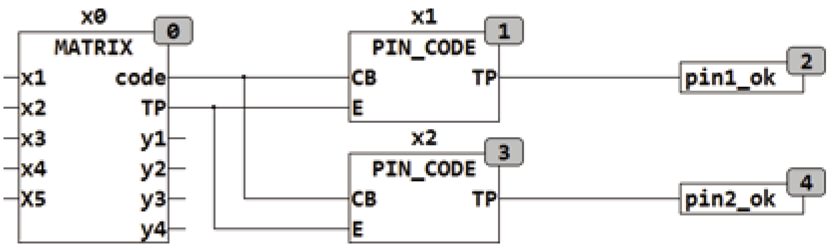
PARITY calculates even parity over the input byte IN. The output is TRUE if the number of true bits in the byte (IN) is odd.

16.33. PIN_CODE

Type	Function module
Input	CB: BYTE (input)
	E: BOOL (Enable Input)
SETUP	PIN: STRING(8) (String to be tested)
Output	TP (Trigger Output)

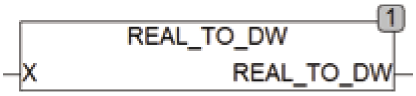
PIN_CODE checks a stream of bytes for the presence of a specific sequence. If the sequence is found, this is indicated by a TRUE at output TP.

In the following example, two modules PIN_CODE be used to decode two CODE_SEQUENCES of a matrix keyboard.



16.34. REAL_TO_DW

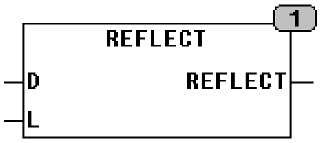
Type	Function: DWORD
Input	IN: REAL (input)
Output	DWORD (output value)



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.

16.35. 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
```

16.36. 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

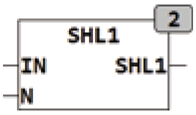
16.37. SHL1

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

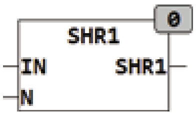
16.38. SHR1

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

16.39. SWAP_BYTE

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.

16.40. SWAP_BYTE2

Type	Function: DWORD
Input	IN: DWORD (input data)
Output	DWORD (Result)

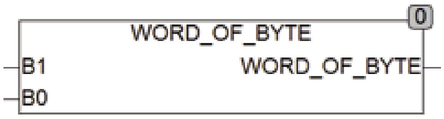
SWAP_BYTE2 reverses the order of bytes in a DWORD.

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

16.41. WORD_OF_BYTE

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.

16.42. WORD_OF_DWORD

Type Function: WORD

Input IN: DWORD (DWORD input)

Output WORD (output WORD)

WORD_OF_DWORD extracts a word (W0 .. W1) from a DWORD.

17. Latches, Flip-Flop and Shift Register

17.1. COUNT_BR

Type Function module

Input SET: BOOL (Asynchronous Set)

IN: BYTE (default value for set)

UP: BOOL (forward switch edge-triggered)

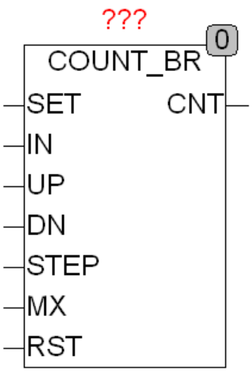
DN: BOOL (reverse switch edge-triggered)

STEP: BYTE (increment of Counters)

MX: BYTE (maximum value of the Counters)

RST: BOOL (asynchronous reset)

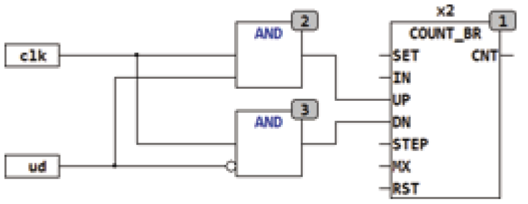
Output CNT: BYTE (output)



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.

	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

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:

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.

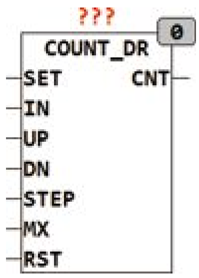
The implementation of a counter 0 .. 50 in increments of ten is as follows:

MX = 59, STEP = 10 results in 0,10 ...50,0,10

the transition from 50 to 0 is then exactly 10 steps.

17.2. COUNT_DR

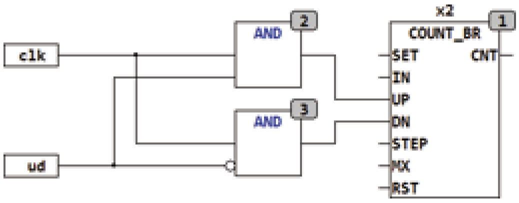
Type	Function module
Input	SET: BOOL (Asynchronous Set)
	IN: DWORD (default value for set)
	UP: BOOL (forward switch edge-triggered)
	DN: BOOL (reverse switch edge-triggered)
	STEP: DWORD (increment of Counters)
	MX: DWORD (maximum value of the Counters)
	RST: BOOL (asynchronous reset)
Output	CNT: DWORD (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.

	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

If the independent inputs UP and DN with CLK and a control input UP/DN

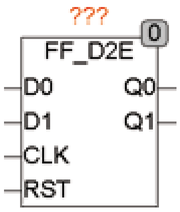


should be replaced, id can be done using two AND gates at the inputs:

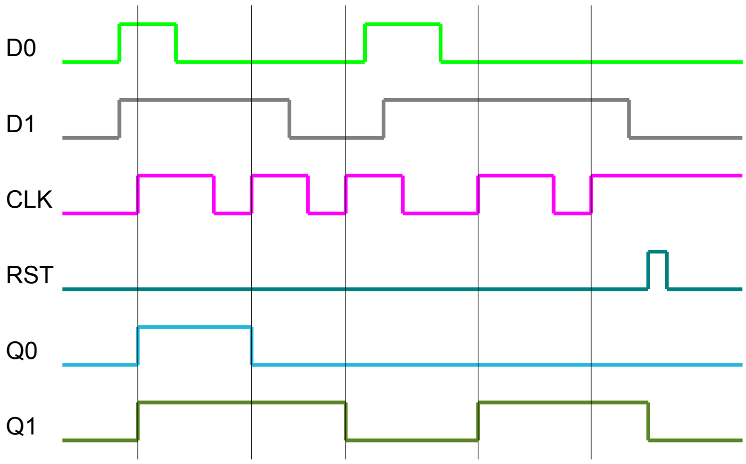
17.3. FF_D2E

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)

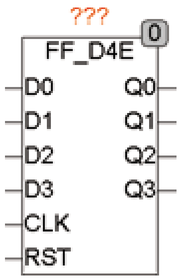


FF_D2E is a 2-bit edge-triggered D-Flip-Flop with asynchronous reset input. The D-Flip-Flop stores the values at the input D at a rising edge at the CLK input.



17.4. FF_D4E

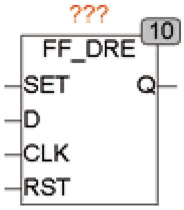
Type	Function module
Input	D0: BOOL (Data 0 in)
	D1: BOOL (Data 1 in)
	D2: BOOL (Data 2 in)
	D3: BOOL (Data 3 in)
	CLK: BOOL (clock input)
	RST: BOOL (asynchronous reset)
Output	Q0 : BOOL (Data 0 Out)
	Q1 : BOOL (Data 1 Out)
	Q2 : BOOL (Data 2 Out)
	Q3 : BOOL (Data 3 Out)



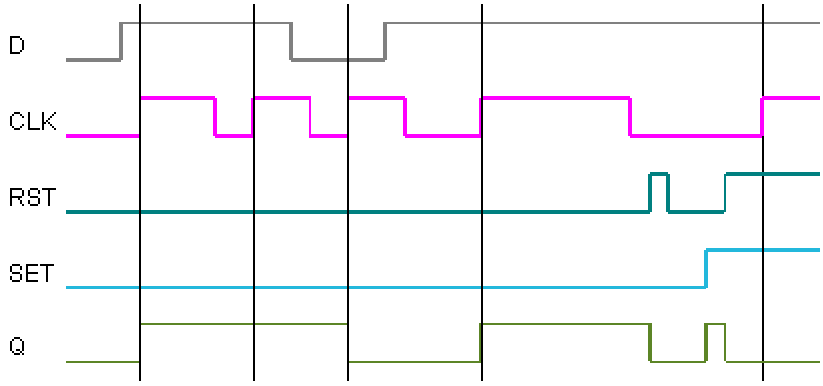
FF_D2E is a 4-bit edge-triggered D-Flip-Flop with asynchronous reset input. The D-Flip-Flop stores the values at the input D at a rising edge on CLK. Detailed information can be found in the block FF_D2E.

17.5. FF_DRE

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)

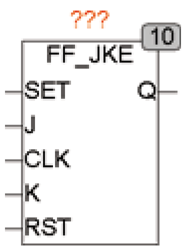


FF_DRE is a edge-triggered D-Flip-Flop with Asynchronous Set and Reset input. A rising edge at CLK stores the input D to output Q. A TRUE on the SET or RST input resets or clears the output Q at any time regardless of CLK. The reset input has priority over the input set. If both are active (TRUE) are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

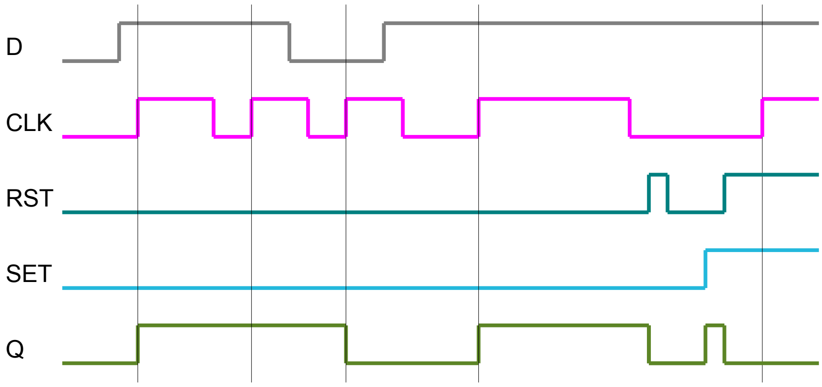


17.6. FF_JKE

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)

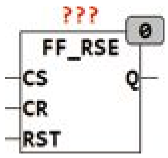


FF_JKE is an edge-triggered JK-flop-flop with asynchronous Set and Reset inputs. The JK-Flip-Flop sets the output Q when with a rising edge of the CLK the Input J is TRUE. Q is FALSE when on a rising clock edge the input K is TRUE. If the two inputs J and K on a rising clock edge are TRUE, the output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



17.7. FF_RSE

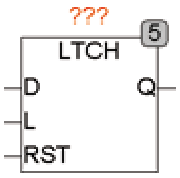
Type	Function module
Input	CS: BOOL (edge-sensitive Set)
	CR: BOOL (edge-sensitive reset)
	RST: BOOL (asynchronous reset)
Output	Q: BOOL (output)



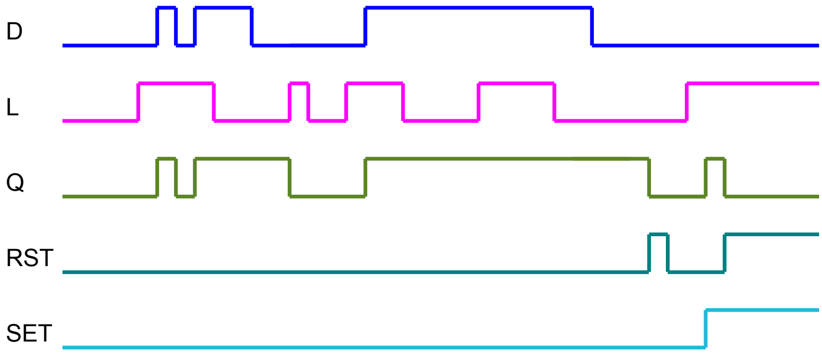
FF_RSE an edge-triggered RS flip-flop. The output Q is set by a rising edge of CS and cleared by a rising edge on CR. If both edges (CS and CR) rise at the same time, the output is set to FALSE. An asynchronous reset input RST sets the output at any time to FALSE.

17.8. LTCH

Type	Function module
Input	D: BOOL (Data in)
	L : BOOL (Latch enable Signal)
	RST: BOOL (asynchronous reset)
Output	Q : BOOL (Data Out)

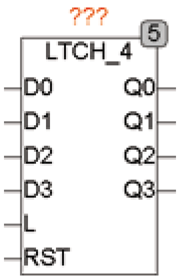


LTCH is a transparent storage element (Latch). As long as L is true, Q follows the input D and the falling edge of L stores the output Q the current input signal to D. With the asynchronous reset input of the Latch will be deleted at any time regardless of L.



17.9. LATCH4

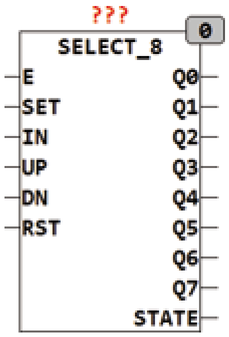
Type	Function module
Input	D0.. D3: BOOL (Data in)
	L : BOOL (Latch enable Signal)
	RST: BOOL (asynchronous reset)
Output	Q0 .. Q3: BOOL (Data Out)



LTCH4 is a transparent storage element (Latch). As long as L is TRUE, Q0 - Q3 follows inputs D0 - D3 and with the falling edge of L the outputs Q0 - Q3 stores the current input signal D0 - D3. With the asynchronous reset input of the Latch can be deleted at any time regardless of L. Further explanations and details can be found in the module LTCH.

17.10. SELECT_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)

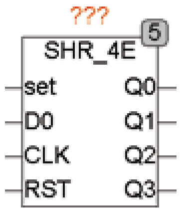


SELECT_8 set only one output to TRUE as long as E = TRUE. The active output Q0..Q7 can be selected by the SET input and the value at the input IN. A TRUE at SET and a value of 5 at the input IN set the output Q5 to TRUE while all other outputs are set to FALSE. A TRUE at the input RST set output Q0 to 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.

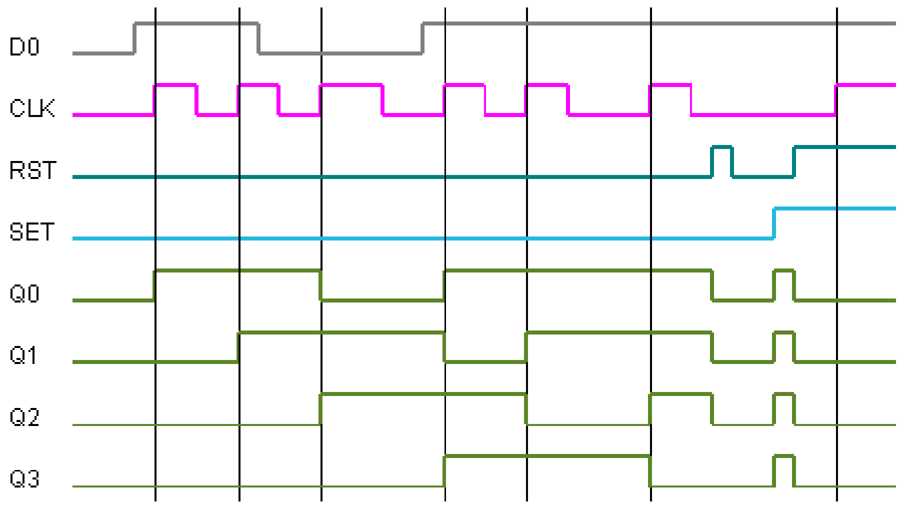
	E	SET	IN	UP	DN	RST	Q	STATE
Reset	X	-	-	-	-	1	Q0 if EN=1	0
Set	X	1	N	-	-	0	QN if EN=1	N
up	X	0	-	↑	0	0	QN+1 if EN=1	N + 1
down	X	0	-	0	↑	0	QN-1 if EN=1	N - 1

17.11. SHR_4E

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.

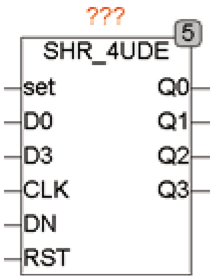


17.12. SHR_4UDE

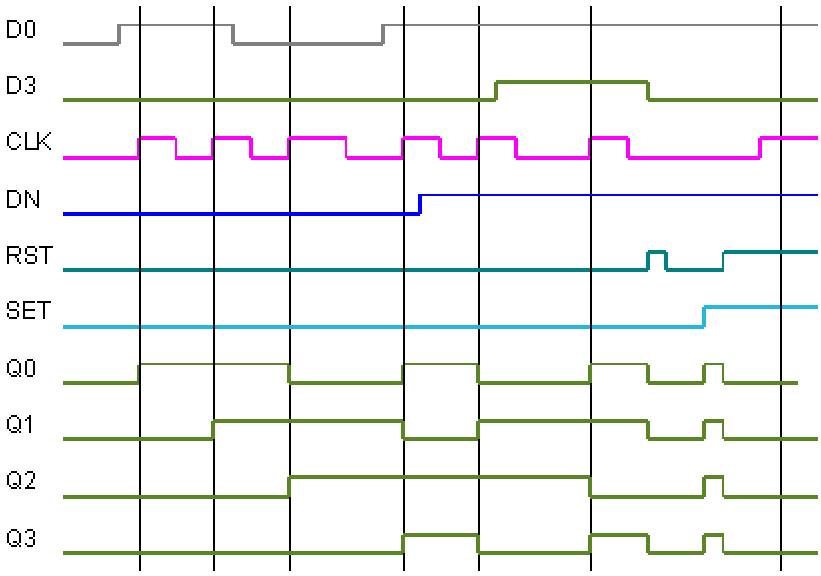
Type	Function module
Input	SET: BOOL (Asynchronous Set)
	D0: BOOL (Data Input Bit 0)
	D3: BOOL (Data Input Bit 3)
	CLK: BOOL (clock input)
	DN: BOOL (control input Up / Down TRUE = D own)
	RST: BOOL (asynchronous reset)
Output	Q0: BOOL (Data Out 0)
	Q1: BOOL (Data Out 1)

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.



17.13. SHR_8PLE

Type Function module

Input DIN: BOOL (Shift Data Input)

Dload: Byte (data word for parallel Load)

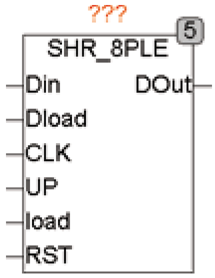
CLK: BOOL (clock input)

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.

17.14. SHR_8UDE

Type Function module

Input SET: BOOL (Asynchronous Set)

D0: BOOL (Data Input Bit 0)

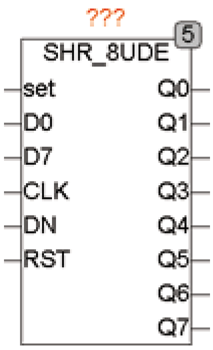
D3: BOOL (Data Input Bit 3)

CLK: BOOL (clock input)

DN: BOOL (control input Up / Down, TRUE = Down)

RST: BOOL (asynchronous reset)

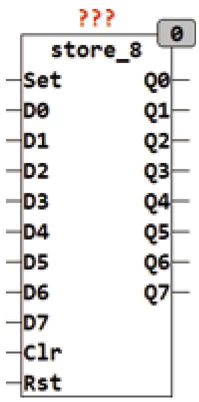
Output Q0 .. Q7: BOOL (Data Out)



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.

17.15. STORE_8

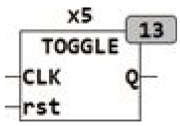
Type	Function module
Input	SET: BOOL (Asynchronous Set)
	D0..D7: BOOL (Data Input Bit 0..7)
	CLR: BOOL (gradual reset input)
	RST: BOOL (Asynchronous set input)
Output	Q0..Q7: BOOL (event outputs)



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 re-set 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.

17.16. TOGGLE

Type	Function module
Input	CLK: BOOL (clock input)
	RST: BOOL (asynchronous reset)
Output	Q: BOOL (output)

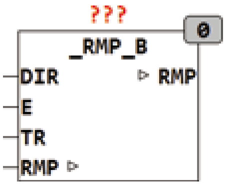


TOGGLE is a edge-triggered Toggle Flip -Flop with asynchronous reset input. The TOGGLE Flip Flop invertes output Q on a rising edge of CLK. The output changes on each rising edge of CLK his condition.

18. Signal Generators

18.1. _RMP_B

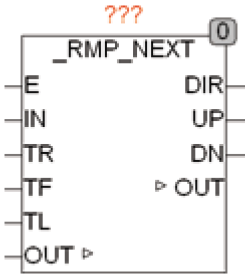
Type	Function module
Input	DIR: BOOL (Direction, TRUE means Up)
	E: BOOL (Enable Input)
	TR: TIME (time to run a full ramp)
I / O	RMP: BYTE (output signal)



_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.

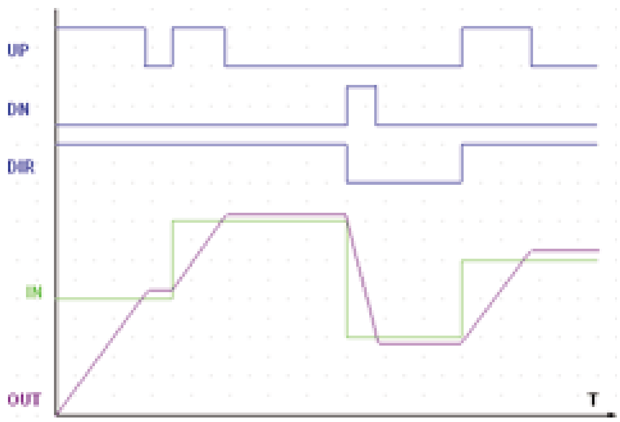
18.2. _RMP_NEXT

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:



18.3. _RMP_W

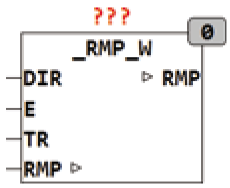
Type Function module

Input DIR: BOOL (Direction, TRUE means Up)

E: BOOL (Enable Input)

TR: TIME (time to run a full ramp)

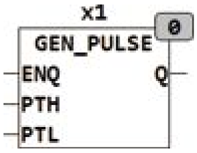
I / O RMP: WORD (output signal)



_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.

18.4. GEN_PULSE

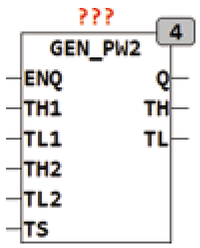
Type	Function module
Input	ENQ: BOOL (Enable Input)
	PTH: TIME (pulse duration HIGH)
	PTL: TIME (pulse duration LOW)
Output	Q: BOOL (output)



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.

18.5. GEN_PW2

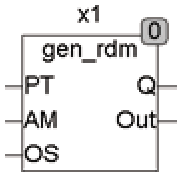
Type	Function module
Input	ENQ: BOOL (Enable Input)
	TH1: TIME (set time HIGH when TS = LOW)
	TL1: TIME (set time LOW when TS = LOW)
	TH2: TIME (set time HIGH when TS = HIGH)
	TL2: TIME (set time LOW when TS = HIGH)
	TS: BOOL (selection for the end times)
Output	Q: BOOL (binary output)
	TL: TIME (elapsed 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.

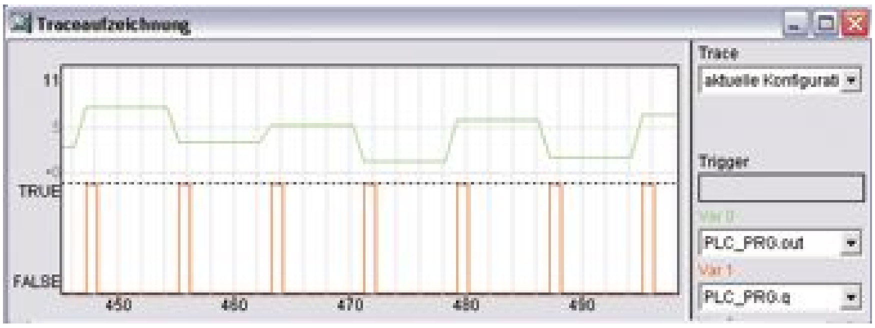
18.6. GEN_RDM

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)



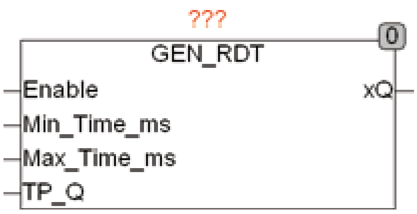
GEN_RDM is a random signal generator. It generates the output OUT a new value in PT intervals. The output Q is TRUE for one cycle when the output OUT has changed. The input AM and OS set the amplitude and the offset for the output OUT. If the inputs OS and AM are not connected, then the default values 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.



18.7. GEN_RDT

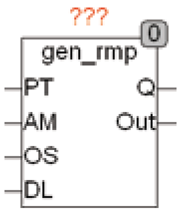
Type	Function module
Input	ENABLE: BOOL (enable input)
	MIN_TIME_MS: TIME (Minimum cycle time)
	MAX_TIME_MS: TIME (maximum cycle time)
	TP_Q: TIME (pulse width of the output pulse to XQ)
Output	XQ: BOOL (binary output)



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.

18.8. GEN_RMP

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)

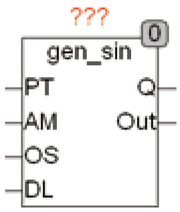


GEN_RMP is a sawtooth generator. It generates a ramp at the output OUT with the duration of PT and repeats this continuously. The output Q is for exactly one cycle TRUE when the ramp starts at the output OUT. The input AM and OS set the amplitude and the offset for the output OUT. If the inputs OS and 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

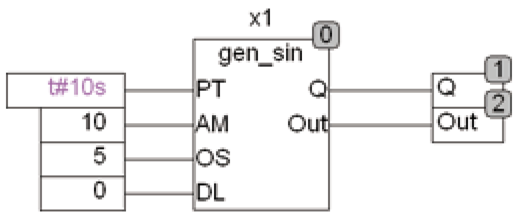
18.9. GEN_SIN

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)

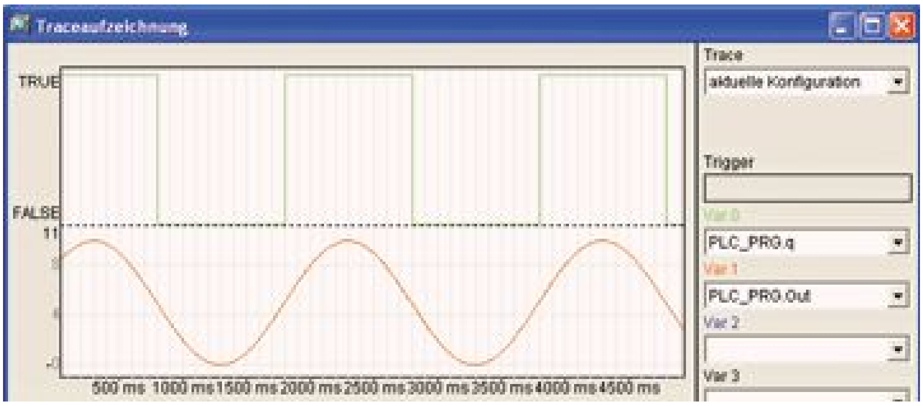


GEN_SIN is a sine wave generator with programmable period, adjustable amplitude and signal offset. A special feature is a adjustable delay so that with multiple generators overlapping signals can be generated. A Binary Output Q passes a logical signal, which is generated phase equal to the sine signal. 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.

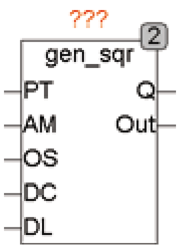


The above example generates a sine wave with 0.1 Hz (PT = 10 s) and a lower peak value of 0 and upper peak value of 10.



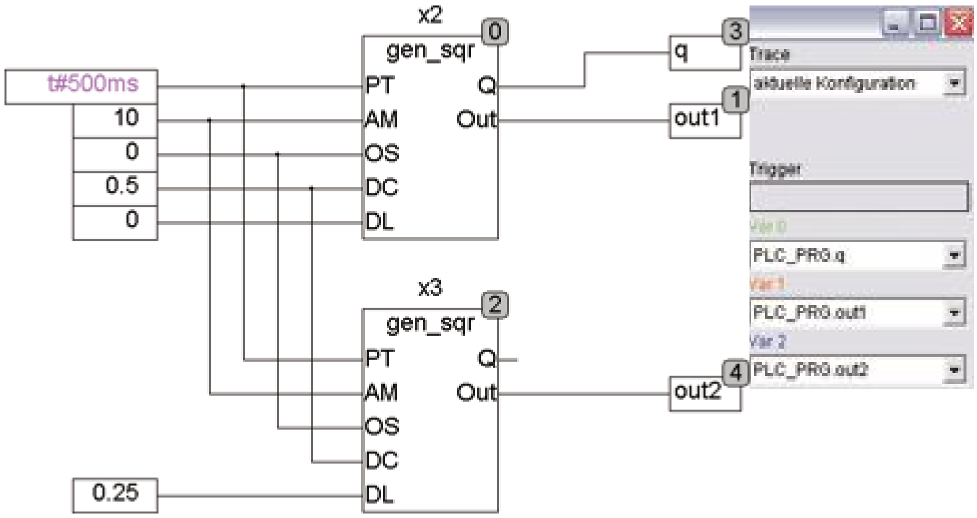
18.10. GEN_SQR

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.



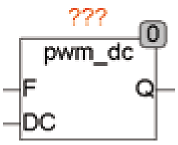
18.11. PWM_DC

Type Function module

Input F: REAL (output frequency)

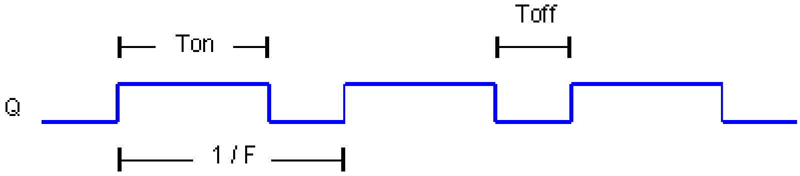
DC: REAL (duty cycle 0..1)

Output Q: BOOL (output)



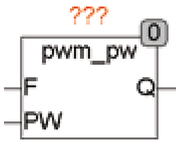
PWM_DC is a Duty - cycle modulated frequency generator. The generator generates a fixed frequency F with a duty cycle (TON / TOFF) which can be modulated (adjusted) by the input DC. A value of 0.5 at the input DC generates a duty cycle of 50%.

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

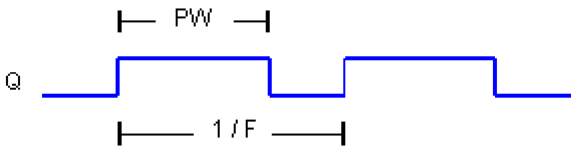


18.12. PWM_PW

Type	Function module
Input	F: REAL (output frequency)
	PW:TIME (pulse duration high)
Output	Q: BOOL (output)

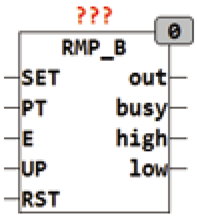


PWM_PW is a pulse width modulated frequency generator. The generator generates a fixed frequency F with a duty cycle (TON / TOFF) which can bemodulated (set) by the input PW. The input passes the time before the signal remains TRUE.



18.13. RMP_B

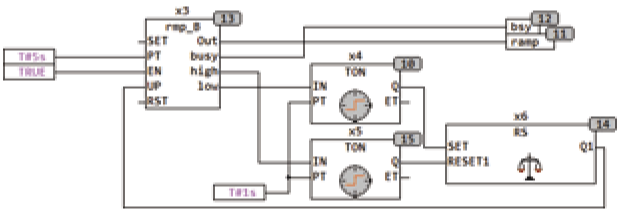
Type	Function module
Input	SET: BOOL (set input)
	PT: TIME (duration of a ramp 0..255)
	E: BOOL (enable input)
	UP: BOOL (direction UP = TRUE means Up)
	RST: BOOL (Reset input)
Output	I/O
	BUSY: BOOL (TRUE, when ramp is running)
	HIGH: BOOL (maximum output value is reached)
	LOW: BOOL (Minimum output value is reached)



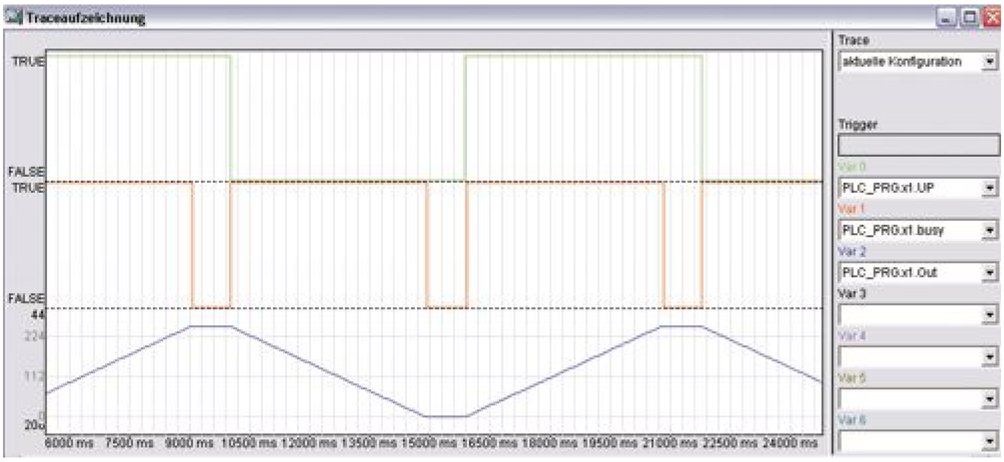
RMP_B is a ramp generator with 8 bits (1 byte) resolution. The ramp of 0..255 is divided into a maximum of 255 steps and go through, in a time of PT once complete. An enable signal E switches the ramp generator on or off. An asynchronous reset sets each time the output to 0, and a pulse at the SET input 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.

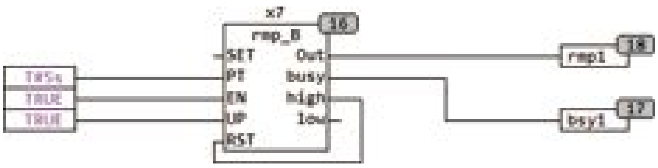
The following example shows an application of RMP_B. The outputs HIGH and LOW triggers both NTSC (X4, X5) 1 second delayed, and switch with the RS Flip Flop (X6) the UP input of the Ramps generators in order. The result is a ramp of 5 seconds, followed by an break of 1 second and then the reverse gradient of 5 seconds and then a break of 1 second. In the Trace the history of the signals can be seen.



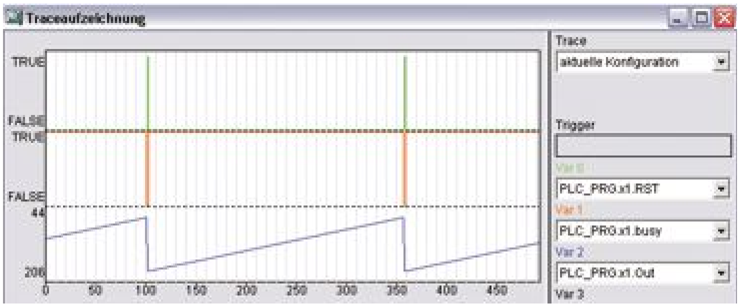
Timing diagram for Up / Down Ramp:



Another example shows the use of a sawtooth RMP_B.

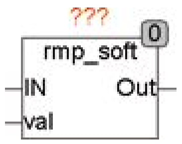


Timing diagram for sawtooth:



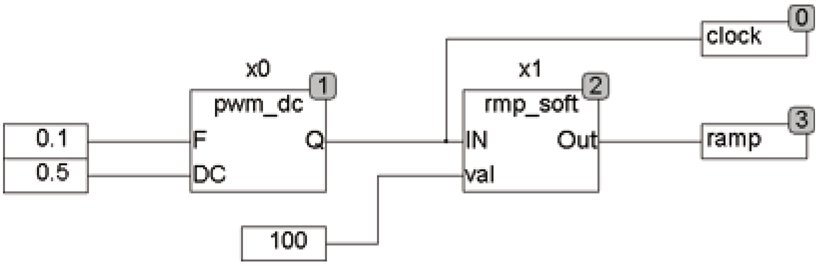
18.14. RMP_SOFT

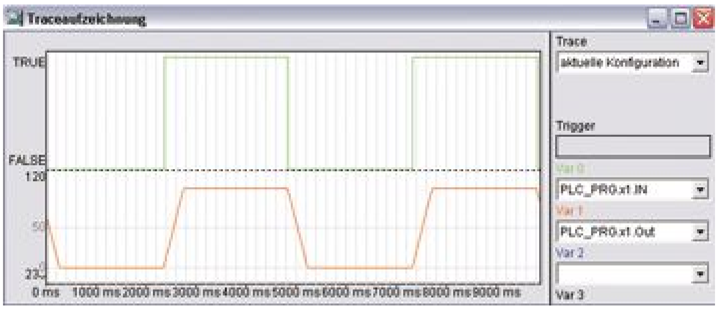
Type	Function module
Input	IN: BOOL (enable input)
	VAL: Byte (maximum output value)
Setup	PT_ON: TIME (rise time, Default is 100 ms)
	PT_OFF: TIME (fall time; Default is 100 ms)
Output	I/O



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.

Example:





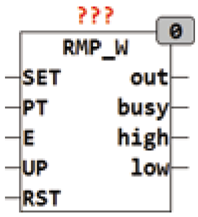
18.15. RMP_W

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.

19. Signal processing

19.1. AIN

Type Function

Input IN: DWORD (input from the A / D converter)

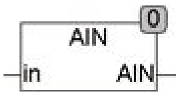
Output REAL (output value)

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:

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.

19.2. AIN1

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)

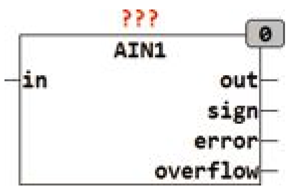
OUT_MAX: REAL (output value at CODE_MAX)

CODE_MIN: DWORD (Minimum input value)

CODE_MAX: DWORD (maximum input)

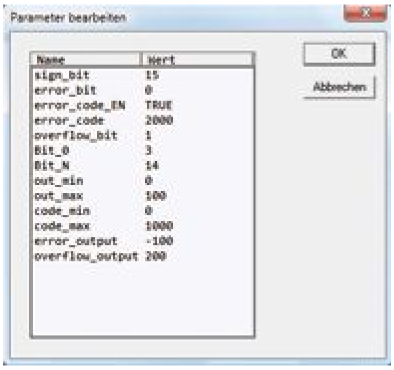
ERROR_OUTPUT: REAL (output value ERROR)

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.

19.3. AOUT

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.

Examples :

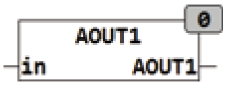
A 12-bit D/A converter without a sign and output range from 0-10 is defined as follows: Bits = 12, Sign = 255, LOW = 0, HIGH = 10

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.

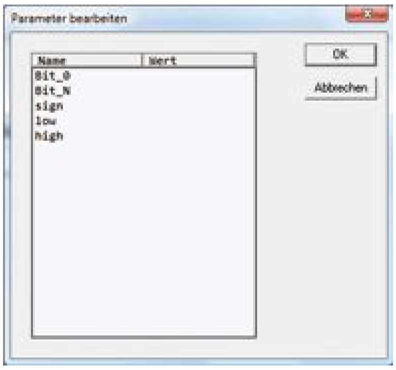
A 24-bit D/A converter without a sign and output range from -10 - +10 is defined as follows: Bits = 24, Sign = 255, LOW = -10, HIGH = +10

19.4. AOUT1

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)

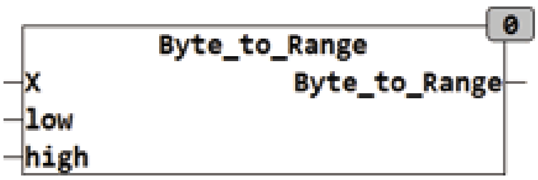


AOUT1 generates from the REAL input value IN a digital output value for D/A converter or other modules of digital data. Using Setup variables, the digital output value can be adapted to different needs. The IN input value is converted using the information in LOW and HIGH and with the length specified 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.



19.5. BYTE_TO_RANGE

Type	Function
Input	IN: BYTE (input)
	LOW: REAL (initial value at X = 0)
	HIGH: REAL (initial value at X = 255)
Output	REAL (output value)



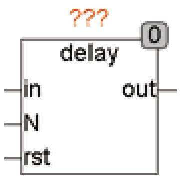
BYTE_TO_RANGE convert a BYTE value to a REAL. An input value of 0 corresponds to the REAL value of LOW and an input value of 255 corresponds to the input value of HIGH.

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)

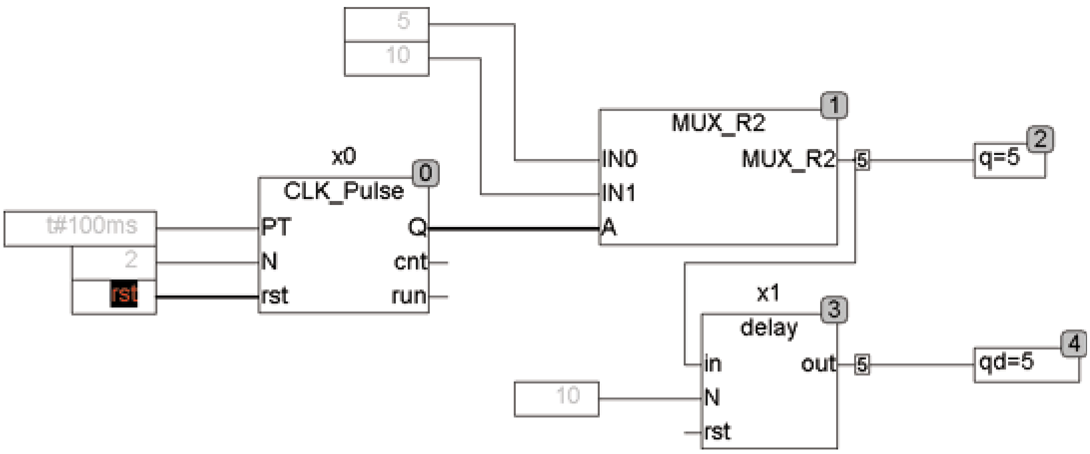
19.6. DELAY

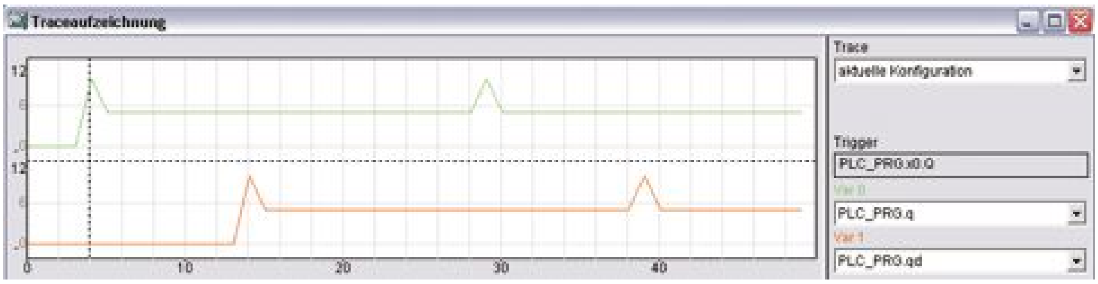
Type	Function module
Input	IN: REAL (input value)
	N: INT (number of delay cycles)
	RST: BOOL (asynchronous reset)
Output	OUT: REAL (delayed output value)



DELAY delays an input signal (IN) for N cycles. The input RESET is asynchronous, and may delete the Delay buffer.

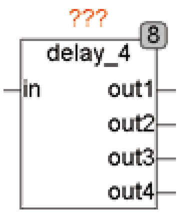
The Example shows a generator that produces pulses of 5 to 10 and a Delay, that generates a 10 cycles delay.





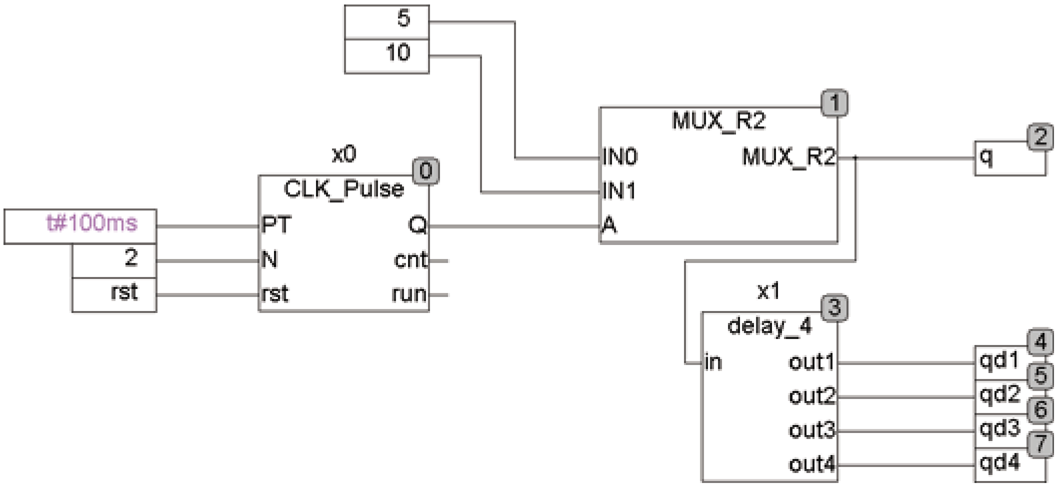
19.7. DELAY_4

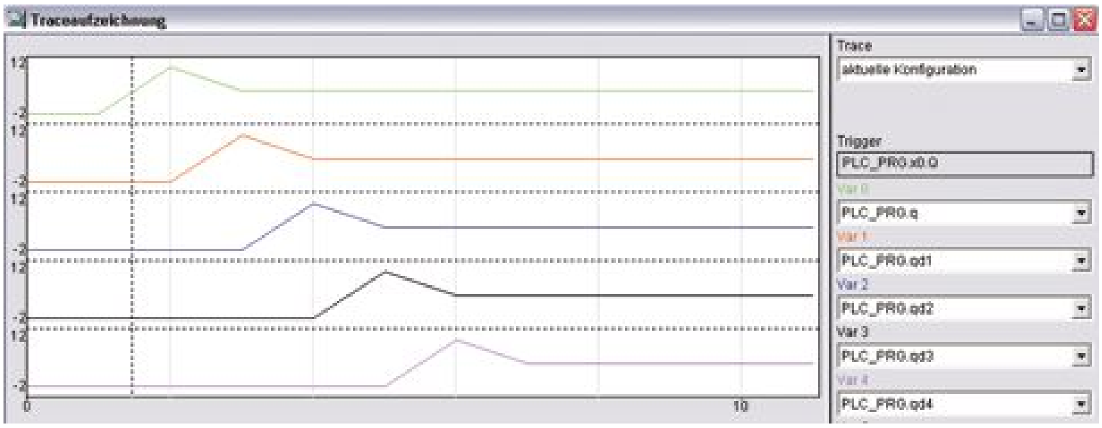
Type	Function module
Input	IN: REAL (input value)
Output	OUT1: REAL (by 1 cycle delayed output value)
	OUT2: REAL (by 2 cycles delayed output value)
	OUT3: REAL (by 3 cycles delayed output value)
	OUT4: REAL (by 4 cycles delayed output value)



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.

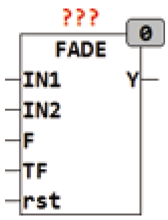
Example :





19.8. FADE

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.

19.9. FILTER_DW

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.

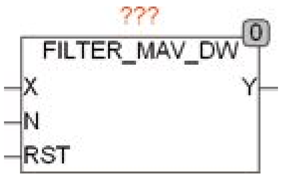
19.10. FILTER_I

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.

19.11. 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)



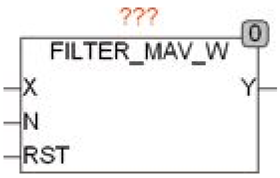
FILTER_MAV_DW is a filter with moving average. The filter with moving average (also Moving Average Filter called) the average of N successive readings is output as an average.

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

19.12. FILTER_MAV_W

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

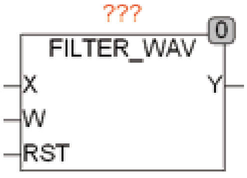
19.13. FILTER_W

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.

19.14. FILTER_WAV

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)



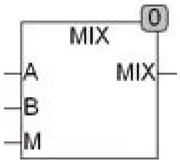
FILTER_WAV is a filter with a weighted average. (Also called FIR filter) the filter with a weighted average of individual values in the buffer are evaluated with different weights.

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.

19.15. MIX

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)

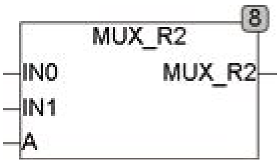


MIX provides at the output a mixed ratio M value, mixed from values A and B. The input M passes the proportion of B in the range 0..1.

MIX = (M-1)*A + M*B

19.16. 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

19.17. MUX_R4

Type Function

Input IN0: REAL (input 0)

IN1: REAL (input value of 1)

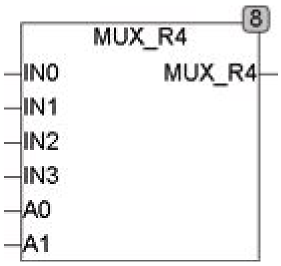
IN2: REAL (input 0)

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;

19.18. OFFSET

Type Function

Input X: REAL (input)

O1: BOOL (Enable Offset 1)

O2 : BOOL (Enable Offset 2)

O3 : BOOL (Enable Offset 3)

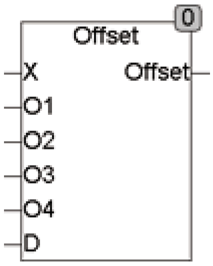
D : BOOL (Enable Default)

Output REAL (output value with offset)

Setup Offset_1: REAL (offset that is added when O1 = TRUE)

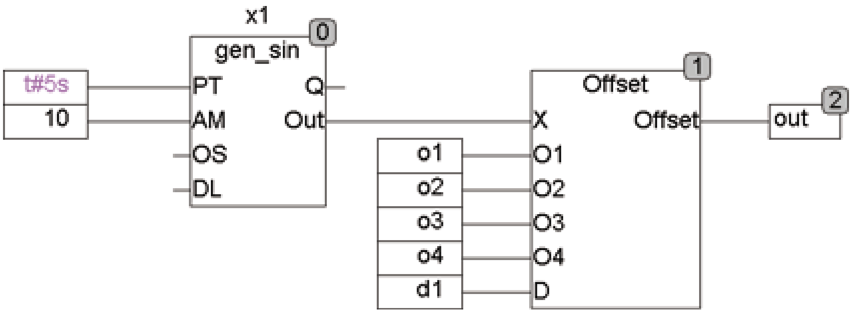
Offset_2: REAL (offset that is added when O2 = TRUE)

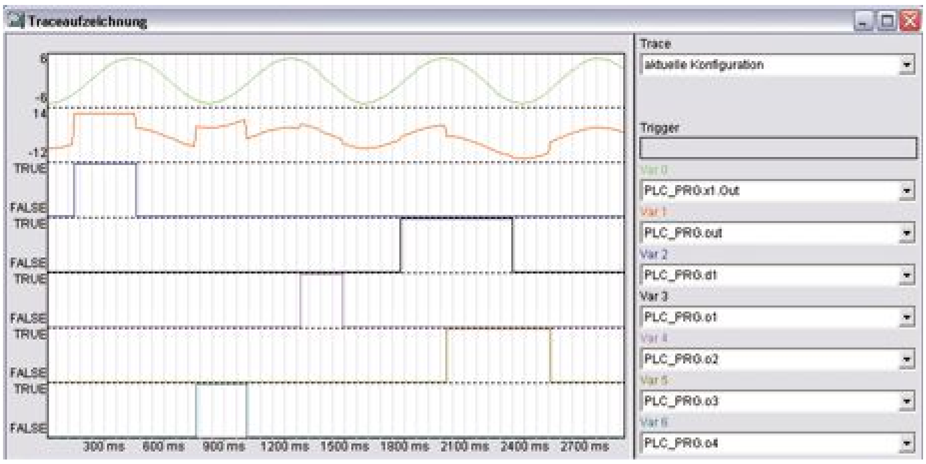
Offset_3: REAL (offset that is added when O3 = TRUE)
Offset_4: REAL (offset is added if O4 = TRUE)
Default : REAL (This is used instead of X, if D = TRUE)



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.

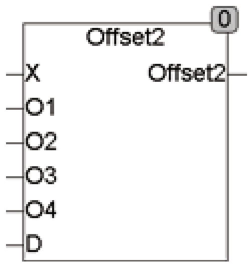
The following example illustrates the operation of offset:





19.19. OFFSET2

Type	Function
Input	X: REAL (input)
	O1 : REAL (Enable Offset 1)
	O2 : REAL (Enable Offset 2)
	O3 : REAL (Enable Offset 3)
	D : BOOL (Enable Default)
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)

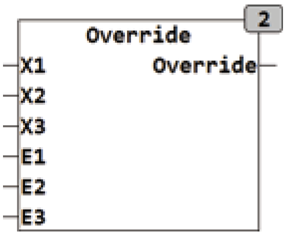


The function Offset2 adds an offset to an input signal depending on the binary value of O1.. O4. If more offsets are selected simultaneously, then the offset with the highest numbers added up and the others ignored. If O1 and O3 are simultaneously TRUE, then Offset_3 is added and not Offset_1. With the 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.

19.20. 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:

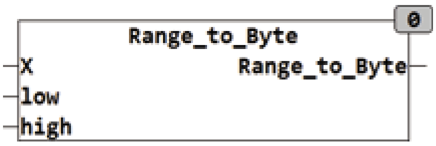
OVERRIDE(10,-12,11, TRUE, TRUE, TRUE) = -12

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

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

19.21. RANGE_TO_BYTE

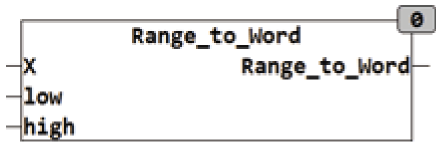
Type	Function
Input	X: REAL (input)
	LOW : REAL (Lower Range limit)
	HIGH: REAL (upper limit)
Output	BYTE (output value)



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.

19.22. RANGE_TO_BYTE

Type	Function
Input	X: REAL (input)
	LOW : REAL (lower range limit)
	HIGH: REAL (upper limit)
Output	WORD (output value)



RANGE_TO_WORD converts a REAL value to a WORD 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 that corresponds to HIGH is converted to an output value of 65535. The X input is limited to the range from LOW to HIGH, an overflow of the output WORD therefore can not happen.

19.23. SCALE

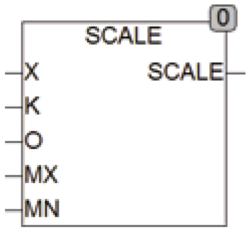
Type	Function: REAL
Input	X: Byte (input)
	K: Byte (multiplier)

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)

19.24. SCALE_B

Type Function: REAL

Input X: DWORD (input)

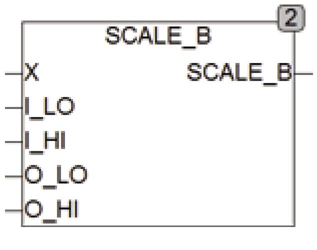
I_LO: DWORD (min input value)

I_HI: DWORD (max input value)

O_LO: REAL (min output value)

O_HI: REAL (output value max)

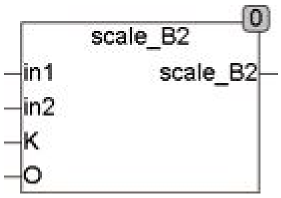
Output REAL (output value)



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.

19.25. 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)

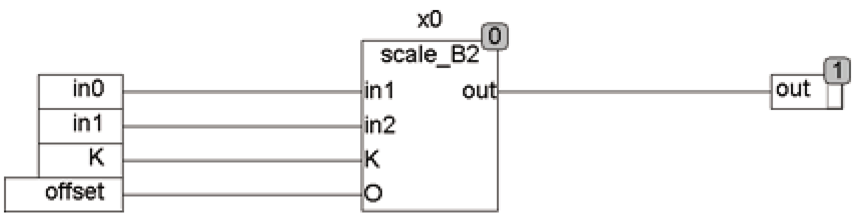


SCALE_B2 calculates from the input value IN and the setup values IN_MIN and IN_MAX an internal value, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN1 = 0 means IN1_MIN is taken into account, IN1 = 255 means IN1_MAX is considered. K is not connected then 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:



IN0 is an air valve, which controls the air volume between 100m³/h and 600m³/h for the setting values IN0 - Controls (0-255).

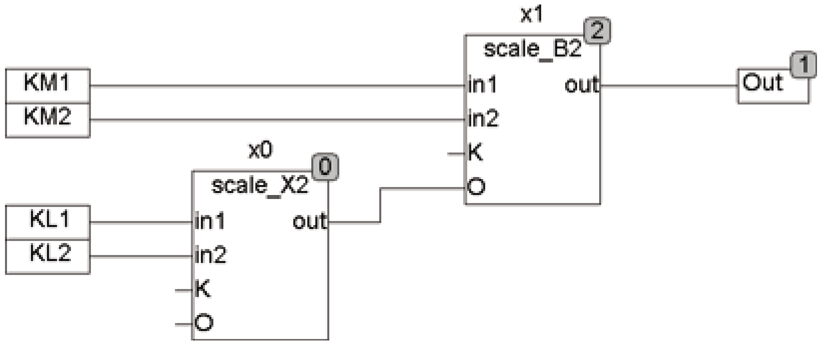
IN1 is an exhaust device that the exhaust air from 0m³/h to 400 m³/h for the control values IN1 controls 0- 255.

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.



19.26. 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)

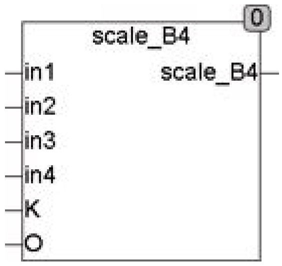
IN2_MAX: REAL (highest value for IN2)

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)



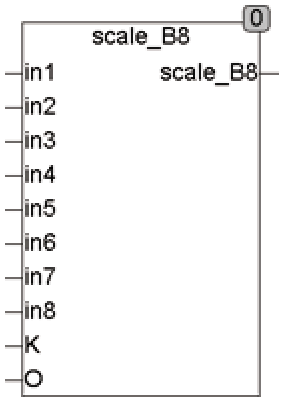
SCALE_B4 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = 0 means IN_MIN is included, IN = 255 means IN_MAX is not considered. If K is not connected, then the multiplier is 1

OUT = (in1 * (IN1_MAX – IN1_MIN) / 255 + IN1_MIN
+ in2 * (IN2_MAX – IN2_MIN) / 255 + IN2_MIN
+ in3 * (IN3_MAX – IN3_MIN) / 255 + IN3_MIN
+ 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.

19.27. 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
+ in2 * (IN2_MAX – IN2_MIN) / 255 + IN2_MIN
+ in3 * (IN3_MAX – IN3_MIN) / 255 + IN3_MIN
+ in4 * (IN4_MAX – IN4_MIN) / 255 + IN4_MIN
+ in5 * (IN5_MAX – IN5_MIN) / 255 + IN5_MIN
+ in6 * (IN6_MAX – IN6_MIN) / 255 + IN6_MIN
+ in7 * (IN7_MAX – IN7_MIN) / 255 + IN7_MIN
+ 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.

19.28. SCALE_D

Type Function: REAL

Input X: DWORD (input)

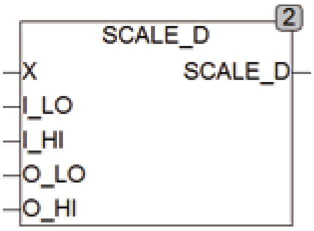
I_LO: DWORD (min input value)

I_HI: DWORD (max input value)

O_LO: REAL (min output value)

O_HI: REAL (output value max)

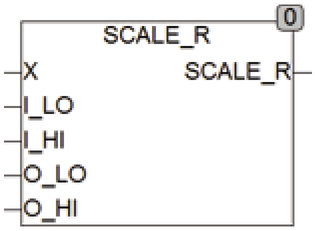
Output REAL (output value)



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.

19.29. SCALE_R

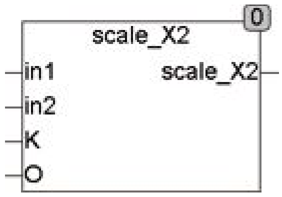
Type	Function: REAL
Input	X: REAL (input)
	I_LO: REAL (min input value)
	I_HI: REAL (input value max)
	O_LO: REAL (min output value)
	O_HI: REAL (output value max)
Output	REAL (output value)



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.

19.30. SCALE_X2

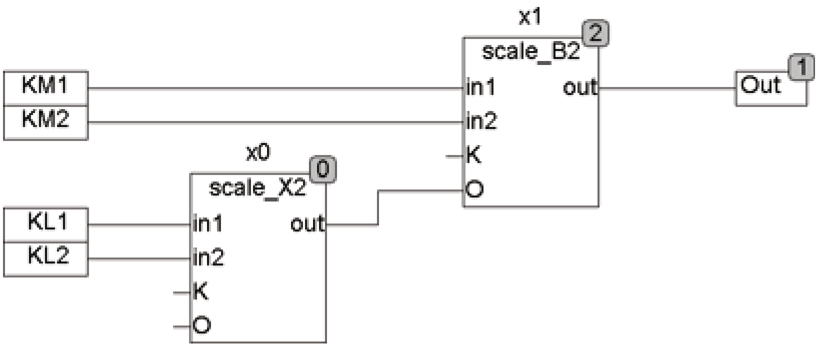
Type	Function
Input	IN1 .. 2: BOOL (input values)
	K: REAL (multiplier)
	O: REAL (offset)
Output	REAL (output value)
Setup	IN_MIN: REAL (lowest value for IN)
	IN_MAX: REAL (highest value for IN)



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

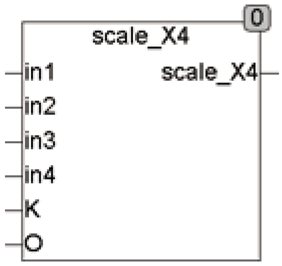
SCALE_X2 can be used, for example, to calculate total air quantities in ventilation systems, or wherever controlled flaps are used and the resulting total needs to be calculated. By the input offset, SCALE_X2 can easily be cascaded with other SCALE modules.

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.



19.31. 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)

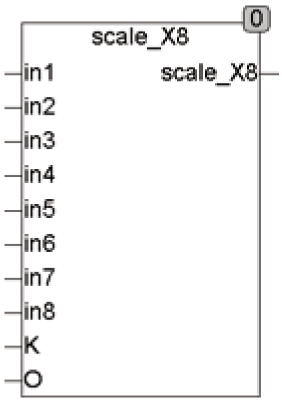


SCALE_X4 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = FALSE means IN_MIN is included, IN = TRUE means IN_MAX is considered. The sum is multiplied by K and 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.

19.32. SCALE_X8

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)

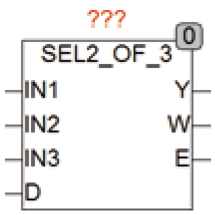


SCALE_X8 calculates from the input values IN and the setup values IN_MIN and IN_MAX internal values, then add all the internal values, multiplies the sum by K and add the offset O. An input value IN = FALSE means IN_MIN is included, IN = TRUE means IN_MAX is considered. The sum is multiplied by K and 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.

19.33. SEL2_OF_3

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)

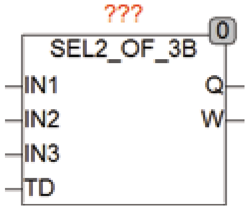


SEL2_OF_3 evaluates 3 inputs (IN1 .. IN3) and checks whether the deviation of the input value is less than or equal to D. The average of the three inputs is output at output Y. The individual inputs are only considered if they are not further away from another input than D. If the mean value of only 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.

19.34. SEL2_OF_3B

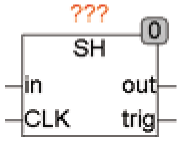
Type	Function: BOOL
Input	IN1: BOOL (input 1)
	IN2: BOOL (input 2)
	IN2: BOOL (input 2)
	TD: TIME (Delay for output for W)
Output	Q: BOOL (output)
	W: BOOL (warning)



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.

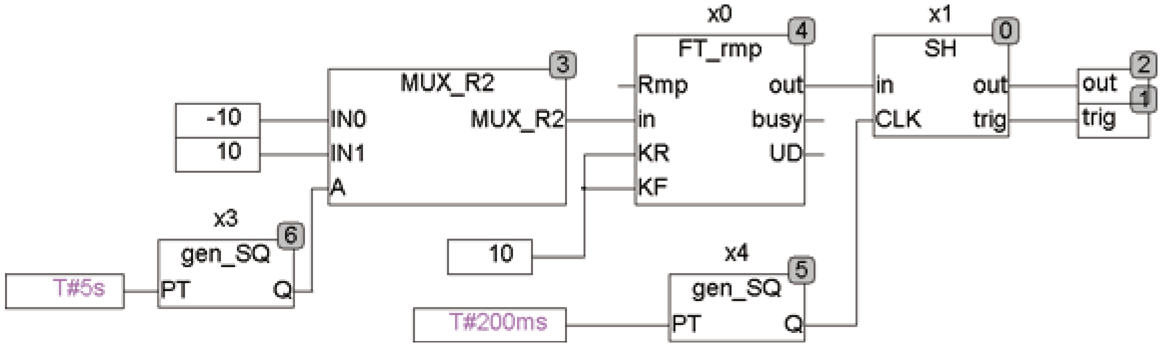
19.35. SH

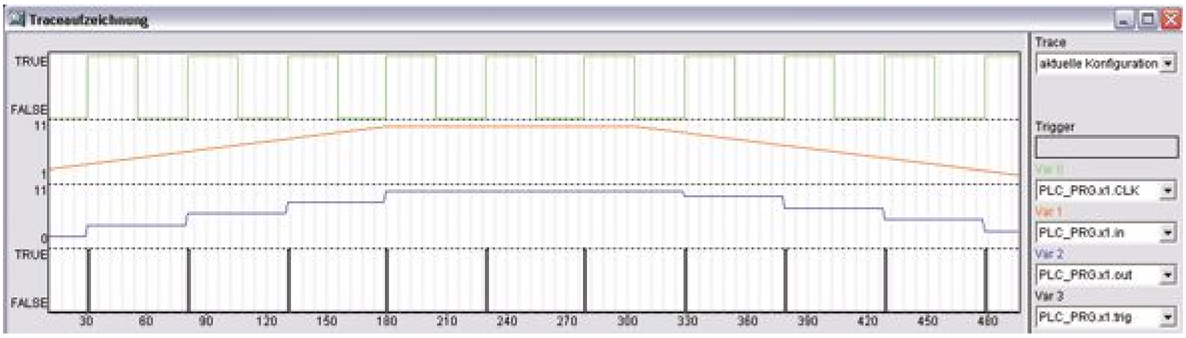
Type	Function module
Input	IN: REAL (input signal)
	CLK: BOOL (clock input)
Output	OUT_MAX: REAL (upper output limit)
	TRIG: BOOL (Trigger Output)



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.

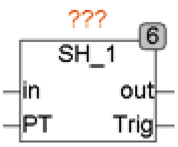
The following Example explains the function of SH:





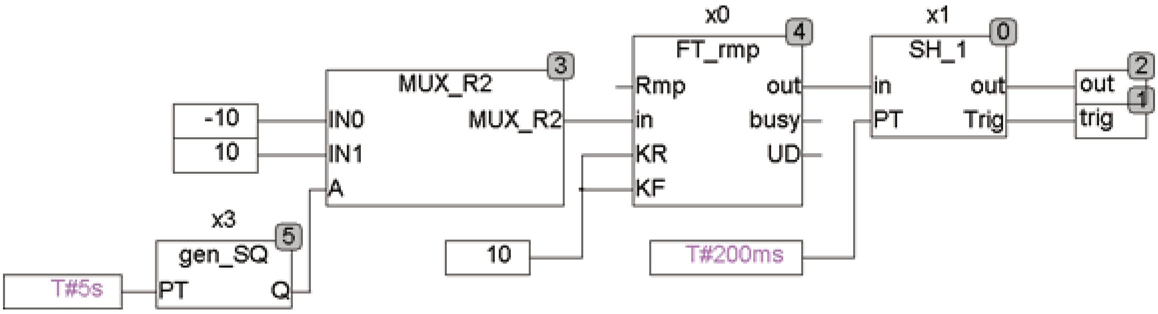
19.36. SH_1

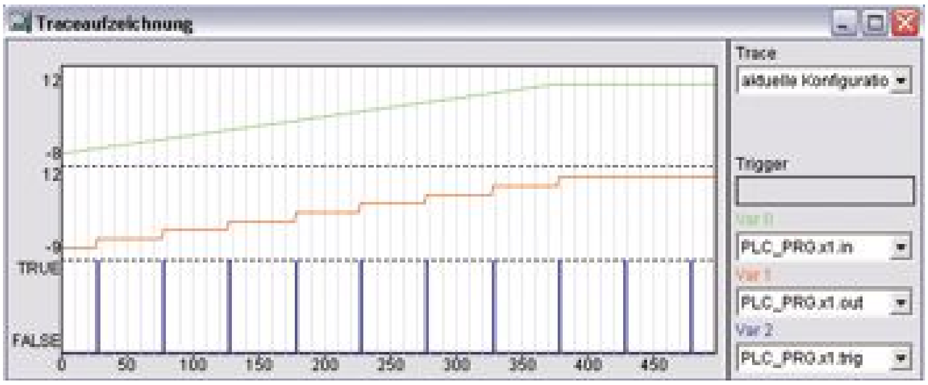
Type	Function module
Input	IN: REAL (input signal)
	PT: TIME (sampling time)
Output	OUT_MAX: REAL (upper output limit)
	TRIG: BOOL (Trigger Output)



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.

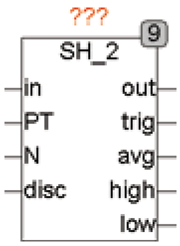
The following Example illustrates how SH_1 works:





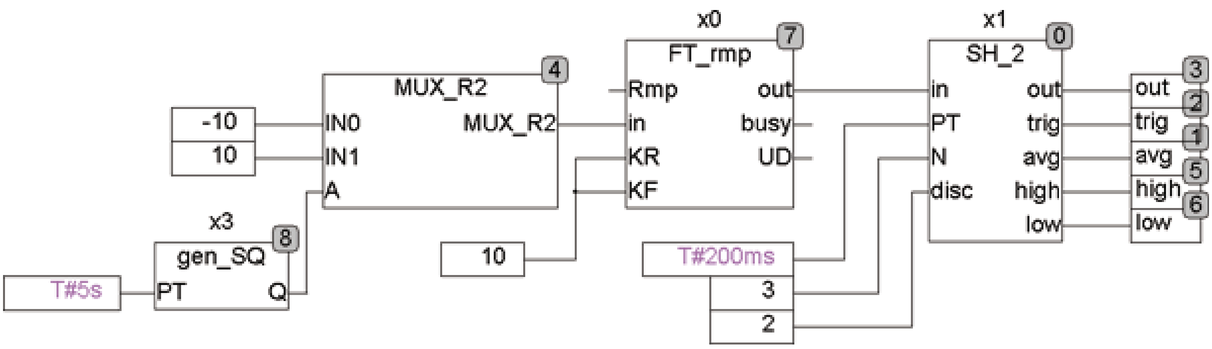
19.37. SH_2

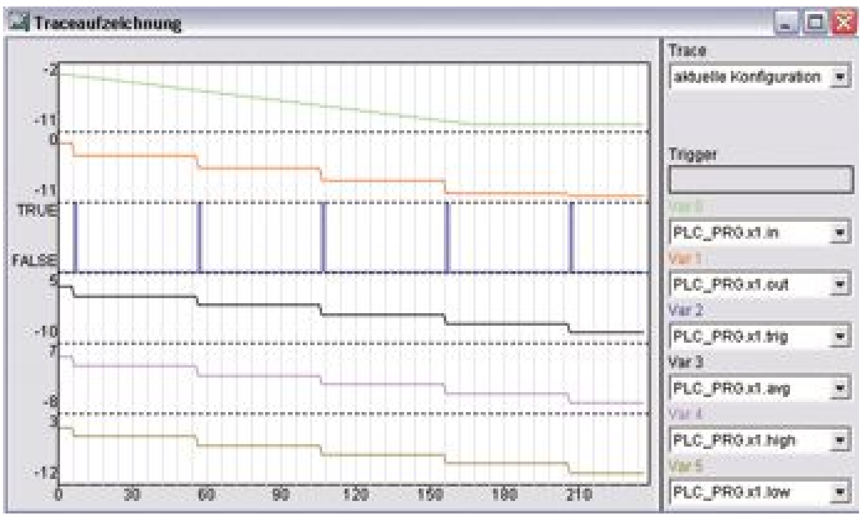
Type	Function module
Input	IN: REAL (input signal)
	PT: TIME (sampling time)
	N: INT (number of Samples of Statistics)
	DISC: INT (discard DISC values)
Output	OUT_MAX: REAL (upper output limit)
	TRIG: BOOL (Trigger Output)
	AVG: REAL (average)
	HIGH: REAL (maximum)
	LOW: REAL (minimum)



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.

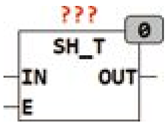
The following example illustrates how SH_2 works:





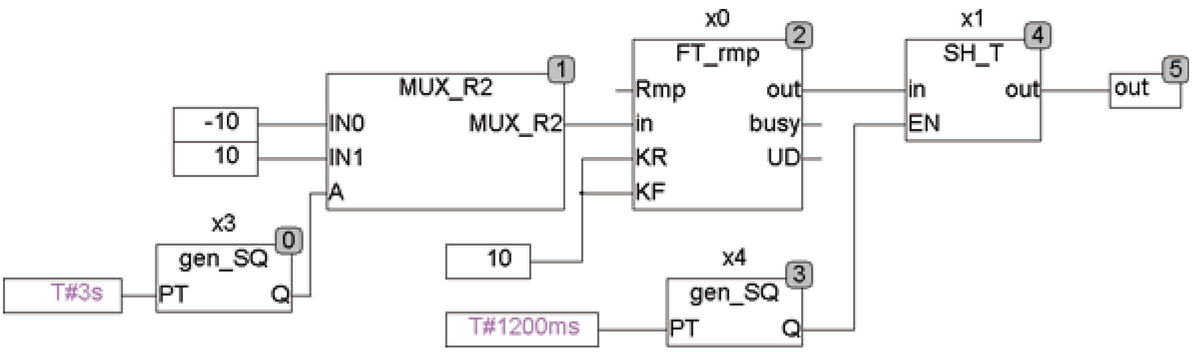
19.38. SH_T

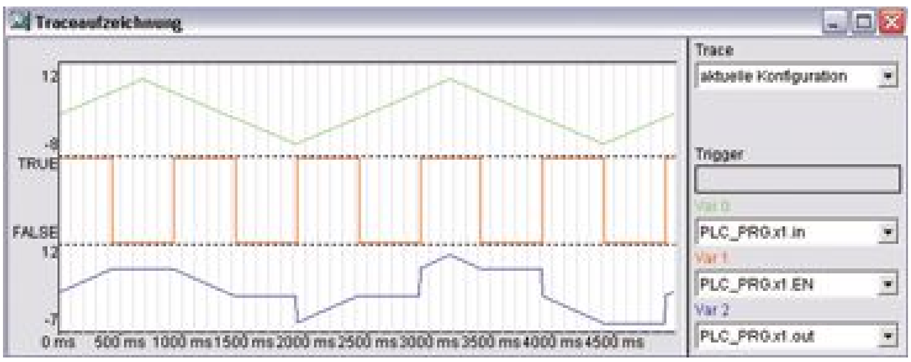
Type	Function module
Input	IN: REAL (input signal)
	E: BOOL (enable Signal)
Output	OUT_MAX: REAL (upper output limit)



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.

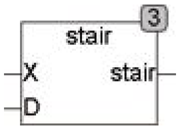
The following example illustrates the operation of SH_T





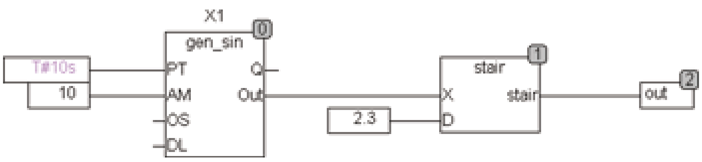
19.39. STAIR

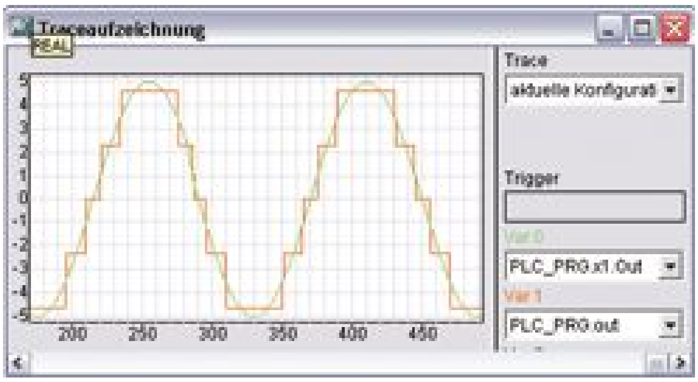
Type	Function
Input	X: REAL (input)
	D: REAL (step size of the output signal)
Output	REAL (output)



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:

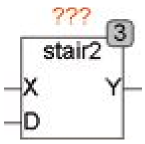




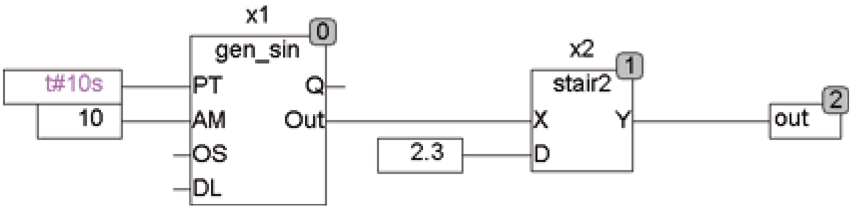
19.40. STAIR2

Type	Function module
Input	X: REAL (input)
	D: REAL (step size of the output signal)

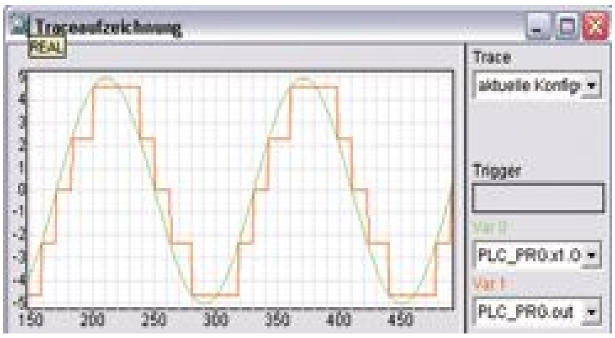
Output Y: REAL (output signal)



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:



19.41. TREND

Type Function module

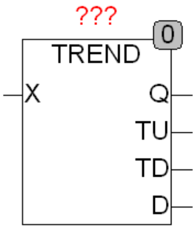
Input X: REAL (input)

Output Q: BOOL (X ascending = TRUE)

TU: BOOL (TRUE if the input X increases)

TD: BOOL (TRUE if input X reduces)

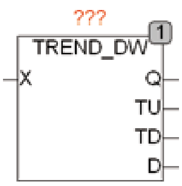
D: REAL (deltas of the input change)



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.

19.42. TREND_DW

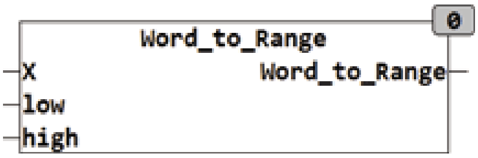
Type	Function module
Input	X: DWORD (input signal)
Output	Q: BOOL (X ascending = TRUE)
	TU: BOOL (TRUE if the input X increases)
	TD: BOOL (TRUE if input X reduces)
	D: DWORD (Delta of the input change)



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.

19.43. WORD_TO_RANGE

Type	Function
Input	X: WORD (input)
	LOW: REAL (initial value at X = 0)
	HIGH: REAL (initial value at X = 65535)
Output	REAL (output value)



WORD_TO_RANGE converts a WORD value to a REAL value. An input value of 0 corresponds to the real value of LOW and an input value of 65535 corresponds to the input value of HIGH.

To convert a WORD value of 0..65535 in a percentage of 0..100, the module is called as follows:

WORD_TO_RANGE(X,100,0)

20. Sensors

20.1. MULTI_IN

Type Function: REAL

Input IN_1: REAL (input 1)

IN_2: REAL (input 2)

IN_3: REAL (input 3)

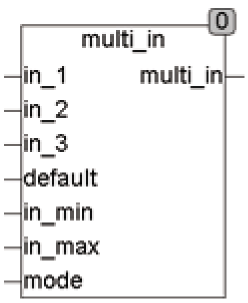
DEFAULT: REAL (default value)

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.

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

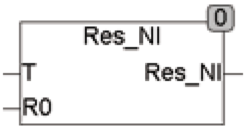
Regardless of the mode input values that are greater than IN_MAX or less than IN_MIN be ignored. If no calculation is possible as defined by mode, the input Default is used as a output value. Multi_in is used when different sensors measures the same value and high security and reliability is required. A possible application is to measure the outside temperature at various points and the surveillance on cable or sensor failure.

20.2. 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:

$$RES\_NI = R0 + A*T + B*T^2+C*T4$$

$$A = 0.5485$$

$$B = 0.665E-3$$

$$C = 2.805E-9$$

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		

20.3. 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.

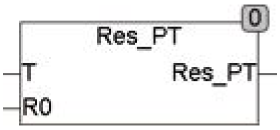
The calculation is done using the formula:

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

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.

20.4. RES_PT

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 + A*T + B*T²)

and for temperatures below 0 ° C

RES_PT = R0 * (1 + A*T + B*T² + C*(T-100)*T³

A = 3.90802E-3

B = -5.80195E-7

C = -427350E-12

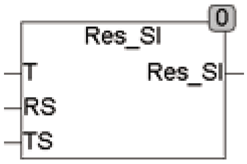
The calculation is suitable for temperatures from -200.. +850°C.

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	238,38
-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

20.5. RES_SI

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.

20.6. SENSOR_INT

Type Function: REAL

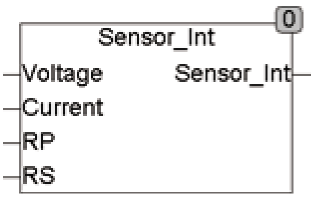
Input VOLTAGE : REAL (measured in volts)

CURRENT : REAL (Current measured in amperes)

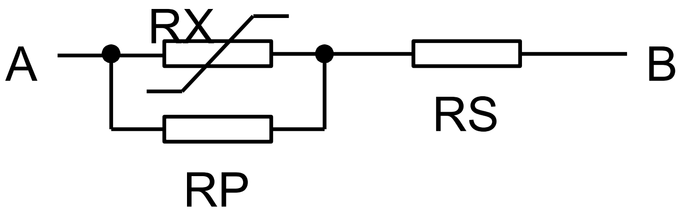
RP: REAL (parallel parasitic resistance in ohms)

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.



Between 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.

20.7. TEMP_NI

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 + A*T + B*T²+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		

20.8. TEMP_NTC

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 formu-

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

la:

20.9. TEMP_PT

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

$$RES\_PT = R0 * (1 + A*T + B*T^2)$$

and for temperatures below 0 ° C

$$RES\_PT = R0 * (1 + A*T + B*T^2 + C*(T-100)*T^3$$

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

20.10. TEMP_SI

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:

$$RES\_SI = RS + A*(T-TS) + B*(T-TS)^2$$

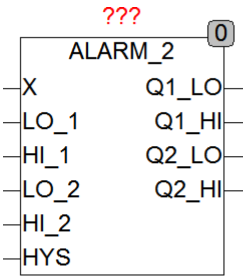
$$A = 7.64E-3; B = 1.66E-5$$

The calculation is suitable for temperatures from -50.. +150 °C.

21. Measuring Modules

21.1. ALARM_2

Type	Function module
Input	X: REAL (input)
	RST: BOOL (reset input for alarm output)
Output	LOW: BOOL (TRUE, if X < TRIGGER_LOW)



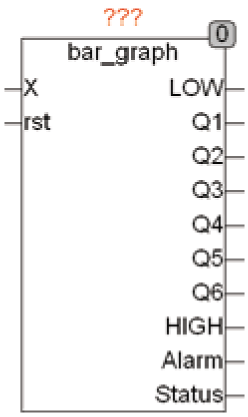
ALARM_2 examine whether X exceeds up the limits HI_1 or HI_2 and relies on the outputs Q1_HI or Q2_HI TRUE. If the limits LO_2 or LO_1 are below, it set Q1_LO or Q2_LO to TRUE. The outputs will remain TRUE as the corresponding limit over-or under-rature. To prevent a flutter of the outputs alternatively 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.

21.2. BAR_GRAPH

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)

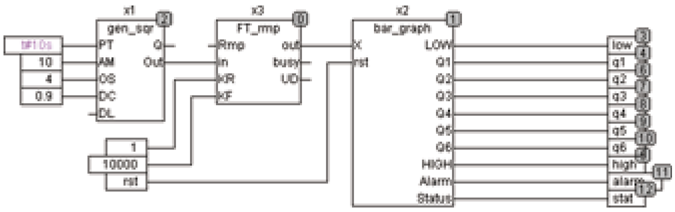


BAR_GRAPH is a level Detector, which activates depending on the input value an output. The threshold for the LOW and HIGH Outputs can be set by the setup variables TRIGGER_LOW and TRIGGER_HIGH. LOW is TRUE if X is less than TRIGGER_LOW and HIGH is true if X is greater or equal than TRIGGER_HIGH. If the 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.

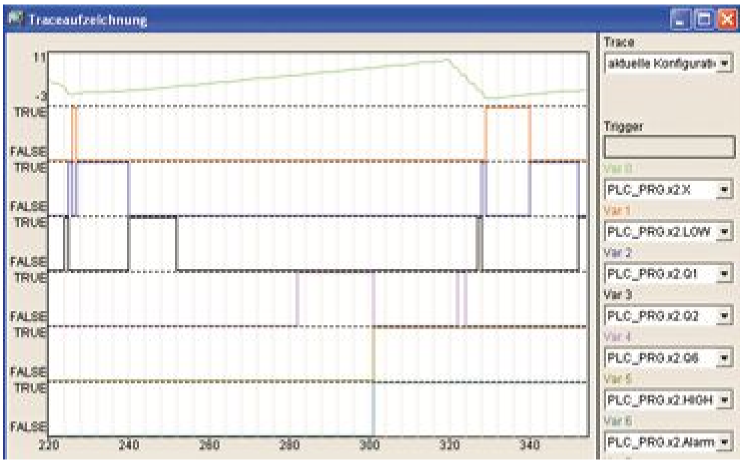
The output Status is an ESR compliant output and forwards states and alarms to ESR components.

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

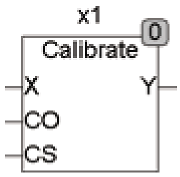
The following example shows a signal characteristic of n Bar_Graph:



21.3. CALIBRATE



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.

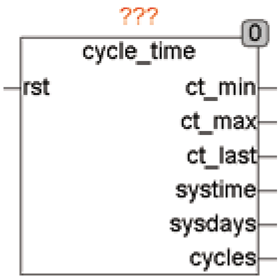
Example :

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.

21.4. CYCLE_TIME

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)

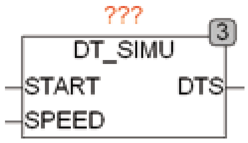


CYCLE_TIME monitors the cycle time of a PLC and provides the user with a range of information about cycle times and run times. The total number of cycles is also measured. Hereby, the user can, for example ensure that a function is called every 100 cycles. Control modules can report errors if the cycle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

21.5. DT_SIMU

Type	Function module

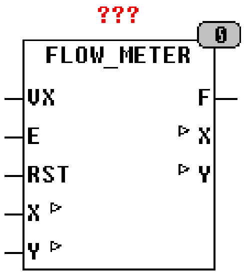
Input	START DT (start DATETIME)
	SPEED: REAL (speed for the output DTS)
Output	DTS: DT (Simulated DATE TIME)



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.

21.6. 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)
SETUP	PULSE_MODE: BOOL (pulse counter when TRUE)
	UPDATE_TIME: TIME (measuring time for F)
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.

Example 1:

VX := 4 m³/h;

PULSE_MODE := FALSE;

UPDATE_TIME := T#100ms;

The device measures the flow in m³/h and counts the flow as long as the input E is TRUE. The output F shows (4.0m³/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;

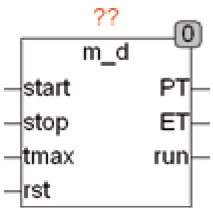
PULS_MODE := TRUE;

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.

21.7. M_D

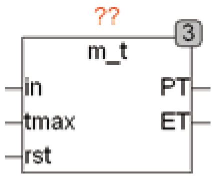
Type	Function module
Input	START: BOOL (input)
	STOP: BOOL (input)
	TMAX : TIME (Timeout für ET)
	RST: BOOL (Reset input)
Output	PT: TIME (elapsed time)
	ET: TIME (Elapsed time since last rising edge)
	RUN: BOOL (TRUE if measure processes)



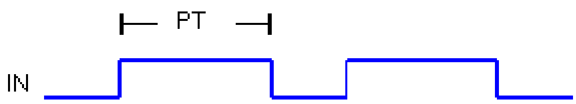
M_D measures the time between a rising edge of START and a rising edge on STOP. PT is the result of the last measurement. Output ET is the elapsed time since the last rising edge of START. M_d requires a rising edge to start the measurement. If at the first call already START is TRUE, it is not seen 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.

21.8. M_T

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.



21.9. 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)

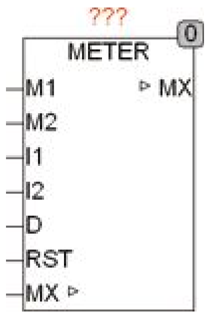
ET: TIME (Elapsed time during the measurement)

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.

21.10. METER

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.

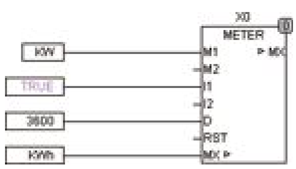
Example :

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

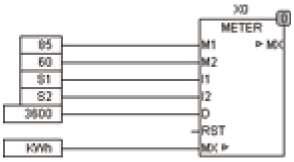
In this example, at each cycle a value of 0.09[W] * 0.01[S]/3600 = 2.5E-7[Wh] on the output MX is added. This represents a change in the 14 decimal place of the output.

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.

21.11. METER_STAT

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)

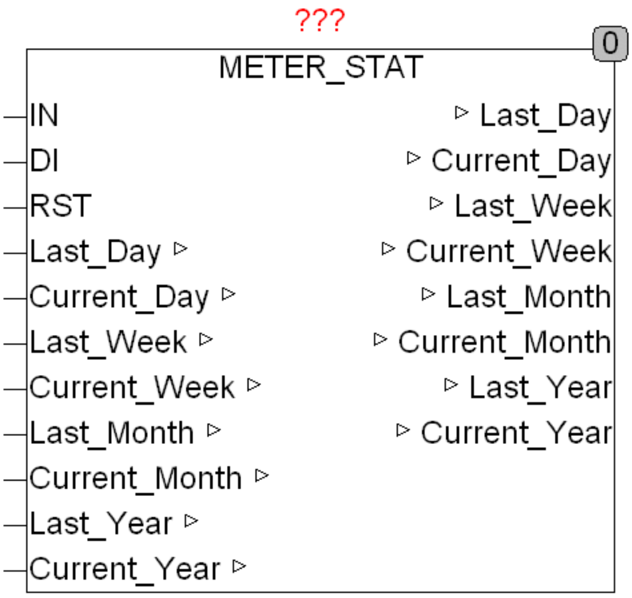
LAST_MONTH: REAL (consumption value of the last month)

CURRENT_MONTH: REAL (consumption of the current month)

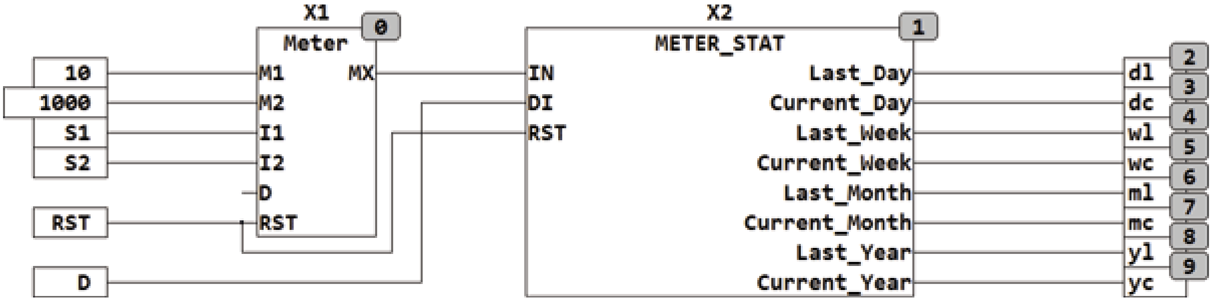
LAST_YEAR: REAL (consumption value of last year)

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.

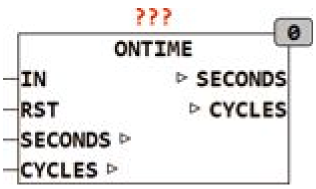


The following example shows the application of METER_STAT with the module METER:



21.12. ONTIME

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.

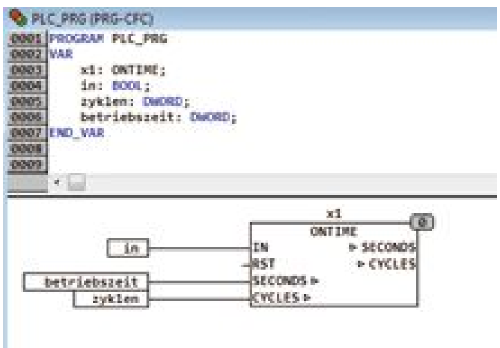
The declaration of the variables for the operating time and cycles must be UDINT type and can be alternatively RETAIN or PERSISTENT.

```
VAR RETAIN PERSISTENT
        Betriebszeit_in_Sekunden: UDINT;
        Cycles: UDINT;
END_VAR
```

The following table explains, RETAIN and PERSISTENT:

x = Wert bleibt erhalten - = Wert wird neu initialisiert

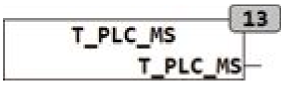
nach Online-Befehl	VAR	VAR RETAIN	VAR PERSISTENT	VAR RETAIN PERSISTENT VAR PERSISTENT RETAIN
Reset	-	x	-	x
Reset Kalt	-	-	-	-
Reset Ursprung	-	-	-	-
Laden (=Download)	-	-	x	x
Online Change	x	x	x	x



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.

21.13. T_PLC_MS

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 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 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.

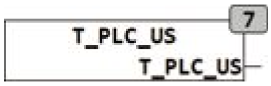
T_PLC_US thus offers all possibilities to test time-dependent software, both for the problem of overflow, and for very slow time-dependent functions.

The constant DEBUG, N and OFFSET were intentionally not implemented as inputs of the function to avoid accidental misuse.

21.14. T_PLC_US

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.

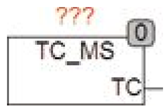
T_PLC_US offers several ways to test the overflow and time-dependent software. With the constant DEBUG, the test mode is switched on and then, using the constants N and offset , starts the timer at a certain level, thus specifically the overflow can be tested without waiting the 49. Offset definces a 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.

21.15. TC_MS

Type Function module

Output TC: DWORD (last cycle time in milliseconds)

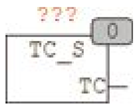


TC_MS determines the last cycle time, that is the time since the last call of the module has passed. The time comes in milliseconds.

21.16. TC_S

Type Function module

Output TC: REAL (last cycle time in seconds)

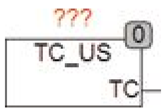


TC_S determines the last cycle time, that is the time since the last call of the module has passed. The time will be delivered in seconds, but has an accuracy in microseconds. The module calls the function T_PLC_US(). T_PLC_US () returns the internal PLC Timer in microseconds with a step width of 1000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

21.17. TC_US

Type Function module

Output TC: DWORD (last cycle time in milliseconds)

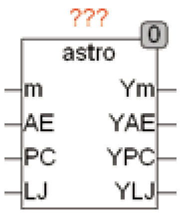


TC_US determines the last cycle time, that is the time since the last call of the module has passed. The time comes in milliseconds. The module calls the function T_PLC_US(). T_PLC_US () returns the internal PLC Timer in microseconds with a step width of 1000 microseconds. If a higher resolution is required the function T_PLC_US() has to be adjusted to the appropriate system.

22. Calculations

22.1. ASTRO

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

22.2. BFT_TO_MS

Type	Function
Input	BFT: INT (wind force on the Beaufort scale)
Output	MS: REAL (Wind speed in meters / second)

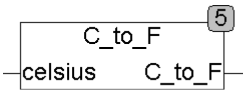
BFT_TO_MS calculete wind speeds on the Beaufort scale in meters per second.

The calculation is done using the formula:

BFT_TO_MS = 0.836m/s * B^3/2

22.3. C_TO_F

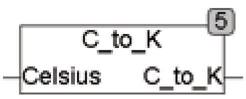
Type	Function: REAL
Input	CELSIUS: REAL (temperature in ° C)
Output	REAL (temperature in Fahrenheit)



C_TO_F converts a temperature reading from Celsius to Fahrenheit.

22.4. C_TO_K

Type	Function: REAL
Input	CELSIUS: REAL (temperature in ° C)
Output	REAL (temperature in Kelvin)

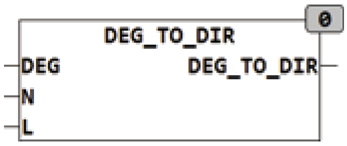


C_TO_K converts a temperature reading from Celsius to Kelvin.

22.5. DEG_TO_DIR

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.

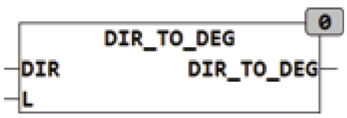
22.6. DIR_TO_DEG

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°

22.7. ENERGY

Type Function module

Input J: REAL (Joule)

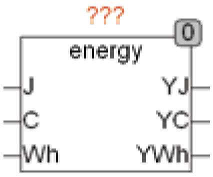
C: REAL (calorie)

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)

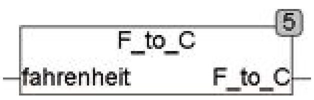
1 Wh = 3,6 * 103 J = 860 C

22.8. 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.

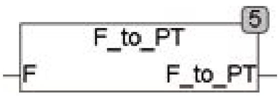
22.9. F_TO_OM

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

22.10. F_TO_PT

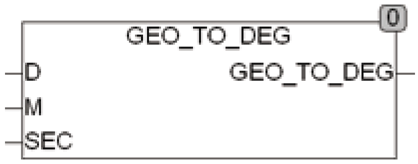
Type	Function: REAL
Input	F : REAL (frequency)
Output	TIME (period)



F_TO_PT converts a frequency value of Hz in the corresponding period.

22.11. GEO_TO_DEG

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.

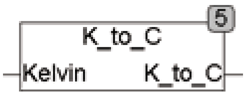
GEO_TO_DEG (2,59,60.0) is 3.0 degrees

22.12. 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.

22.13. KMH_TO_MS

Type Function : REAL

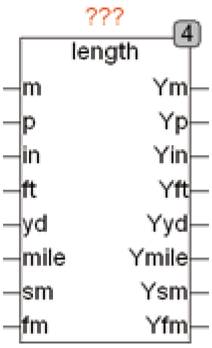
Input KMH: REAL (speed in m/s)

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

22.14. 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

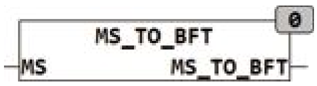
1 MILE = 1609,344 m

1 SM = 1852 m

1 FM = 1,829 m

22.15. 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

22.16. MS_TO_KMH

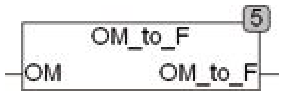
Type	Function: REAL
Input	MS: REAL (speed in km/h)
Output	REAL (speed in m/s)

MS_TO_KMH calculates a speed value of meters/second to kilometers/hour to.

MS_TO_KMH := MS * 3.6

22.17. OM_TO_F

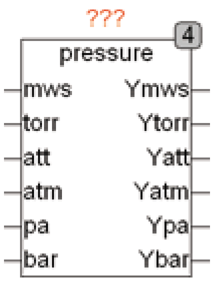
Type	Function: REAL
Input	OM: REAL (angular frequency omega)
Output	REAL (frequency in Hz)



OM_TO_F calculates the frequency in Hz of the angular frequency Omega.

22.18. 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 / m^2

1 BAR = 105 Pa

22.19. 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.

22.20. SPEED

Type Function module

Input MS: REAL (meters / second)

KMH: REAL (kilometers / hour)

CN: REAL (knots = miles / hour)

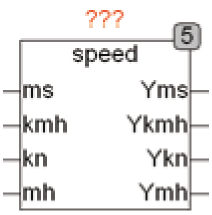
MH: REAL (miles / hour)

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

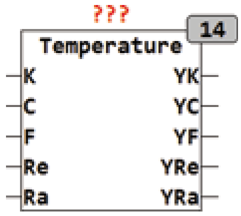
1 kmh = kilometers / hour = 1 / 3, 6 m / s

1 knot = knot = 1 nautical mile / hour = 0.5144 m / s

Mh = 1 mile per hour = 0.44704 m / s

22.21. TEMPERATURE

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

23. Control Modules

23.1. Introduction

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:

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))	

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.

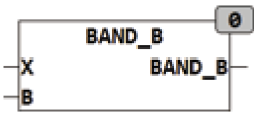
23.2. BAND_B

Type Function: BYTE

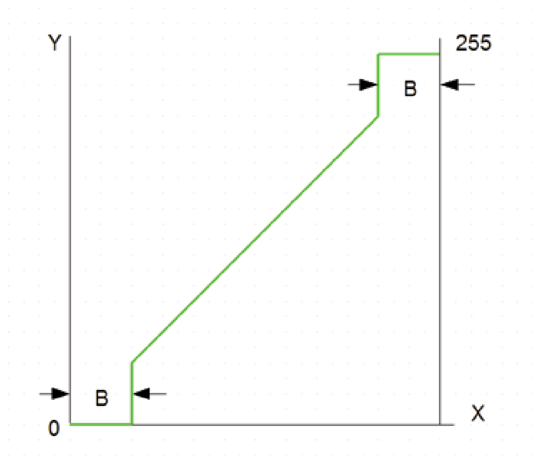
Input X: BYTE (input value)

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.



23.3. CONTROL_SET2

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)

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)

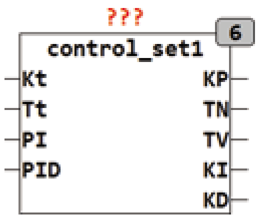
Output KP: REAL (variable gain KP)

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.

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

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

Controller	PI	PID	KP	TN	TV

Type					
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

23.4. CONTROL_SET2

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)

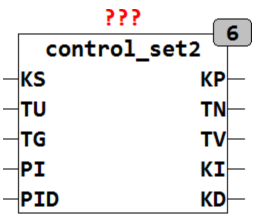
Output KP: REAL (variable gain KP)

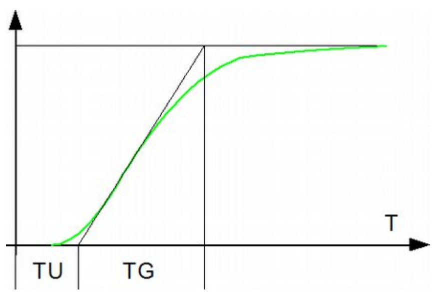
TN: REAL (past set time of the integrator)

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:

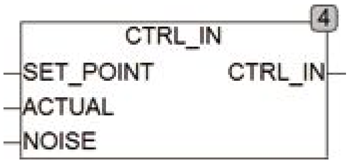
Controller Type	PI	PID	KP	TN	TV
P Controller	0	0	P_K * TG / TU / KS		
PI Control	1	0	PI_K * TG / TU / KS	PI_TN * TU	
PID Controller	0	1	PID_K * TG / TU / KS	PID_TN * TU	PID_TV * TU

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 = 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

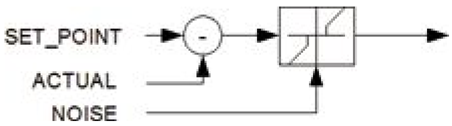
23.5. CTRL_IN

Type	Function: REAL
Input	SET_POINT: REAL (default)
	ACTUAL: REAL (process value)
	NOISE: REAL (threshold)
Output	REAL (Process deviation)



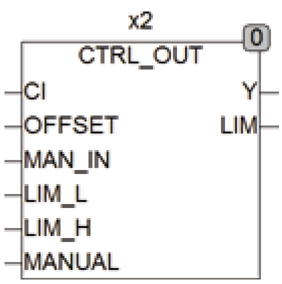
CTRL_IN calculates the process deviation (SET_POINT _ ACTUAL) and passes them at the output. If the difference is less than the value at the input NOISE of the output remains at 0. CTRL_IN can be used to build own rule modules.

Block diagram of CTRL_IN:



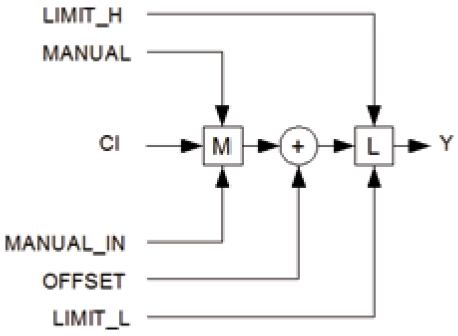
23.6. CTRL_OUT

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)



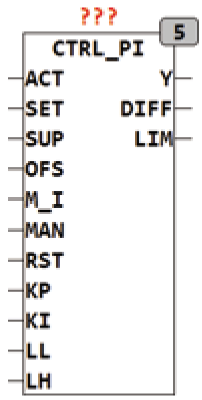
CTRL_OUT adds to the CI input the value of OFFSET and returns the result to Y if MANUAL = FALSE. If MANUAL is TRUE at output Y the input value of MAN_IN + OFFSET is issued. Y is always limited to the boundaries defined by LIM_L and LIM_H. If Y reaches one of the limits, then the output LIM is TRUE. CTRL_OUT can be used to build own rule modules.

Block diagram of CTRL_OUT:



23.7. CTRL_PI

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

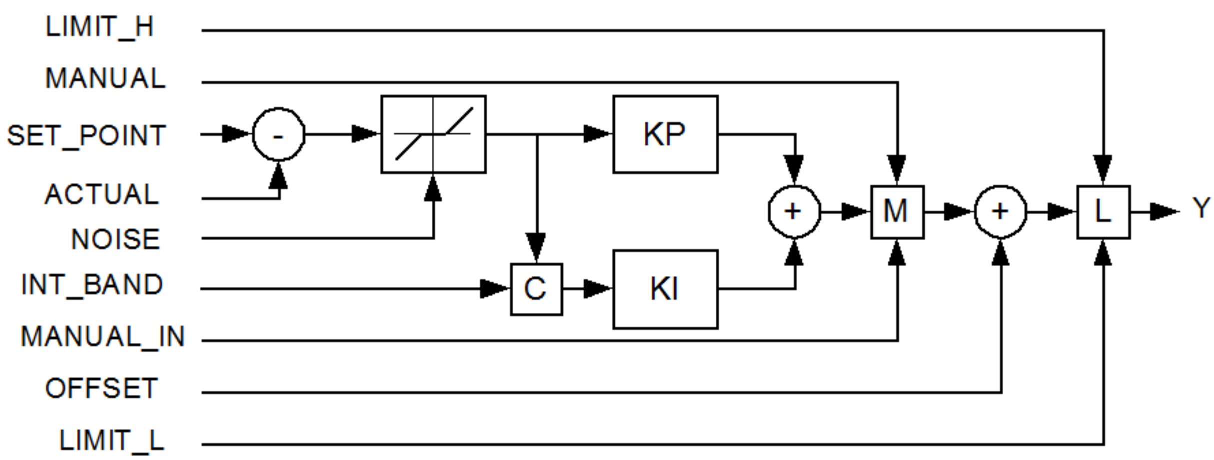
where DIFF = SET_POINT - ACTUAL

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.

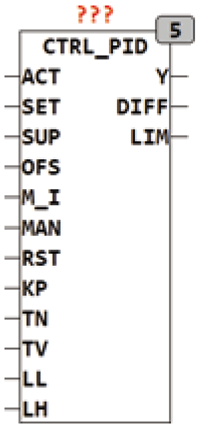
The controller works with a dynamic air- Up that prevents that the integrator, when reaching a output limit and further deviation, continues to run unlimited and affects the properties usually negative. In the introduction chapter of the control technology, more details can be found on anti-wind-up.

The following graph illustrates the internal structure of the controller:



23.8. CTRL_PID

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

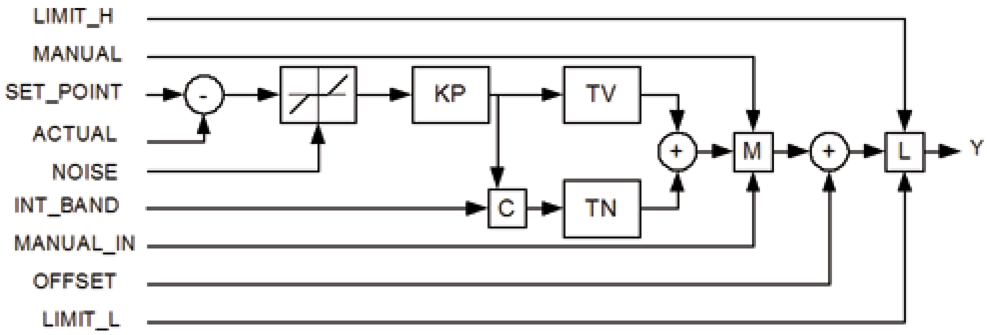
ACT is the measured value for the controlled system and SET is the setpoint for the controller. The input values of LH and LL limit the output value Y. With RST, the internal integrator will always set to 0. The output LIM signals that the controller has reached the limit of LL or LH. The PID controller 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: 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 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-windup.

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

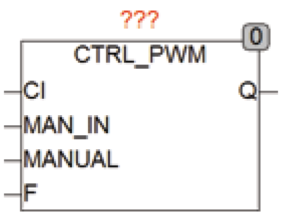
The following graph illustrates the internal structure of the controller:



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.

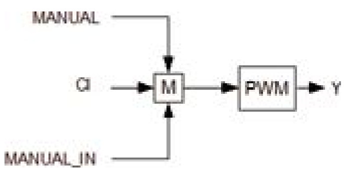
23.9. CTRL_PWM

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)

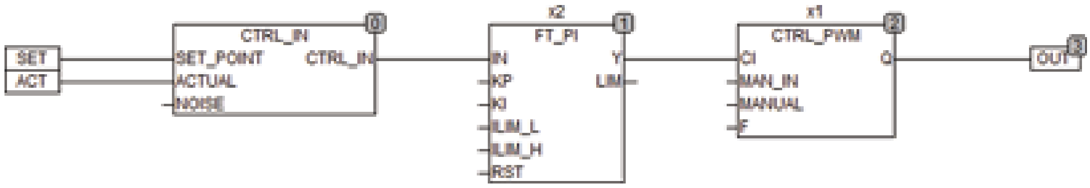


CTRL_PWM converts the input value of CI (0 .1) in a pulse width modulated output signal Q. When MANUAL is TRUE at the output Q the input value of MAN_IN is passed. CTRL_OUT can be used to build own rule modules.

Block diagram of CTRL_PWM:

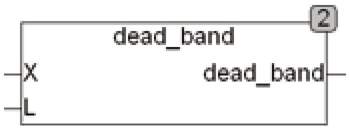


The following example shows a PI controller with PWM output:



23.10. DEAD_BAND

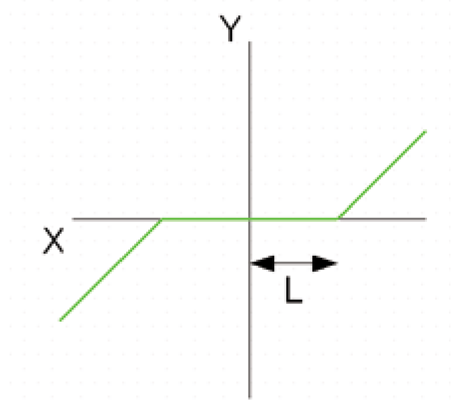
Type	Function
Input	X: REAL (input)
	L: REAL (Lockout Value)
Output	REAL (output value)



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.

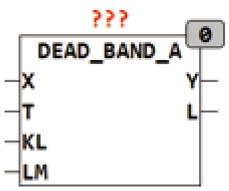
DEAD_BAND = X - SGN(X)*L if ABS(X)> L if ABS(X) > L

DEAD_BAND = 0 if ABS(X) <= L



23.11. DEAD_BAND_A

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.

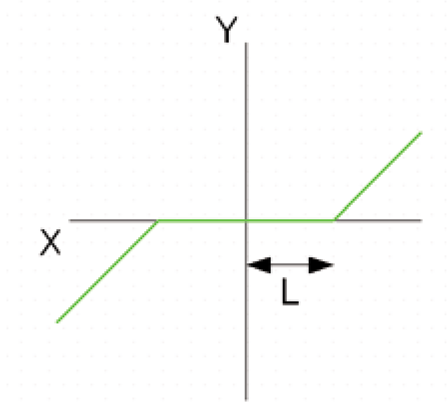
The size L is calculated by filtering the HF cpmponents of the input signal X using a low pass with time constant T and the dead zone L calculated from the amplitude of the HF portion. The sensitivity of the device can be changed via the parameter KL. KL is predefined to 1 and can be unconnected. Reasonable 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.

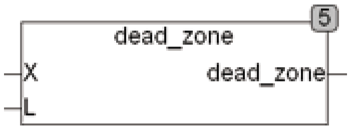
DEAD_BAND = X - SGN(X)*L if ABS(X)> L if ABS(X) > L

DEAD_BAND = 0 if ABS(X) <= L



23.12. DEAD_ZONE

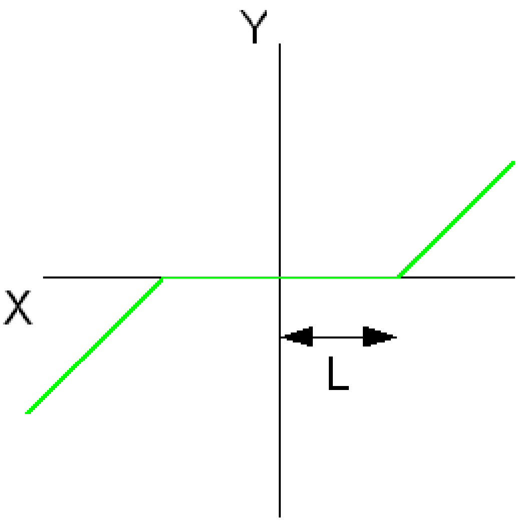
Type	Function: REAL
Input	X: REAL (input)
	L: REAL (Lockout Value)
Output	REAL (output value)



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.

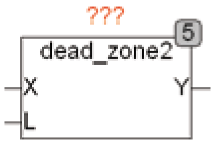
DEAD_ZONE = X if ABS(X) > L

DEAD_ZONE = 0 if ABS(X) <= L



23.13. DEAD_ZONE2

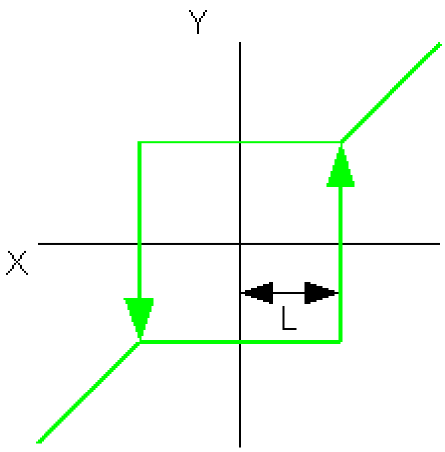
Type	Function module
Input	X: REAL (input)
	L: REAL (Lockout Value)
Output	Y: REAL (output value)



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.

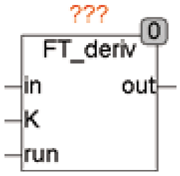
DEAD_ZONE2 = X if ABS (X) > L

DEAD_ZONE2 = + / - L if ABS (X) <= L



23.14. FT_DERIV

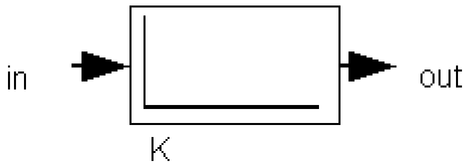
Type	Function module
Input	IN: REAL (input signal)
	K: REAL (multiplier)
	RUN: BOOL (enable input)
Output	OUT: REAL (derivation of the input signal K * X/ , T)



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

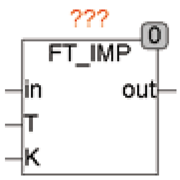
In other words, the derivative of the input signal, the instantaneous slope of the input signal. With the input RUN the FT_DERIV can be enabled or disabled. FT_DERIV works internally in microseconds and fulfill also the requirements of very fast PLC controller with cycle times under a millisecond.

Structure diagram:



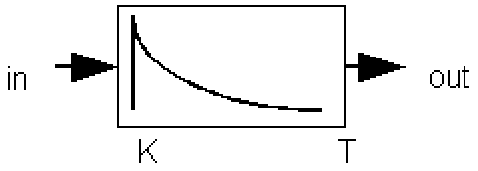
23.15. FT_IMP

Type	Function module
Input	IN: REAL (input signal)
	T: TIME (time constant)
	K: REAL (multiplier)
Output	OUT: REAL (High pass with time constant T)



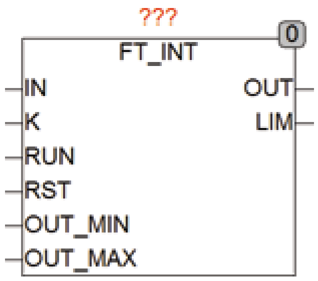
FT_IMP is a high-pass filter with time constant T and multiplier K. An abrupt change at the input is visible at the output, but after the time T the value is already smoother by 63% and after 3 * T by 95%. Thus, after an abrupt change of the input signal from 0 to 10, the output passes 10 at the beginning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

Structure diagram:



23.16. FT_INT

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)

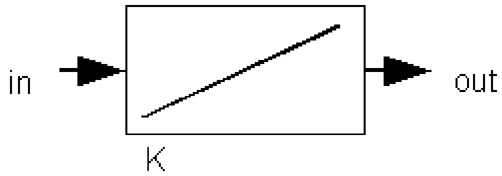


FT_INT is an integrator module which provides the integral of the input signal at the output. The input K is a multiplier for the output signal. Run switches the integrator on if TRUE and off when FALSE. RST (reset) sets the output to 0. The inputs OUT_MIN and OUT_MAX serve upper and lower limits for 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.

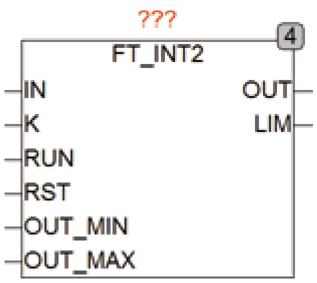
For example, an input signal of 0.0001 would be at a sampling time of 1 millisecond and a baseline of 100000 to add a value of 0.0001 * 0.001 seconds = 0.000001 to the baseline of 100000, which inevitably results in the value of 100000 again, because the resolution of the data type Real can only collect up to 8. This should be considered especially if FT_INT should serve as a utility meter or similar applications.

Structure diagram:



23.17. FT_INT2

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)

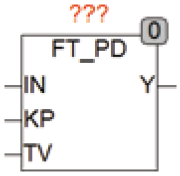


FT_INT2 is an integrator module which calculates internal with double-precision and ensures a resolution of 14 decimal places. This makes it suitable to use FT_INT2 unlike FT_INT, for power meters and similar applications.

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.

23.18. FT_PD

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)

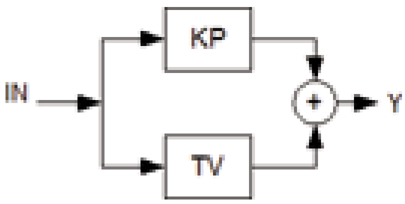


FT_PD is a PD controller, the following formula works:

Y = KP * (IN + DERIV(IN))

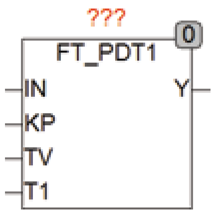
FT_PD can be used in conjunction with the modules CTRL_IN and CTRL_OUT to establish a PD controller.

The following graph illustrates the internal structure of the controller:



23.19. FT_PDT1

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)

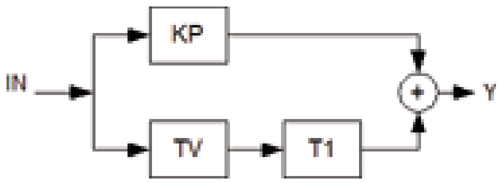


FT_PDT1 is a PD controller with a T1 link in the D-term. The device operates as follows:

Y = KP * (IN + PT1(DERIV(IN))

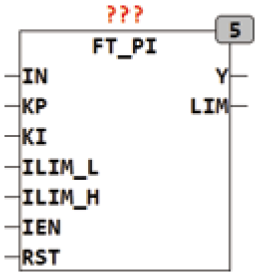
FT_PDT1 can be used in conjunction with the modules CTRL_IN and CTRL_OUT and other regulatory technical modules to build complex control circuits.

Internal structure of the block:



23.20. FT_PI

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)



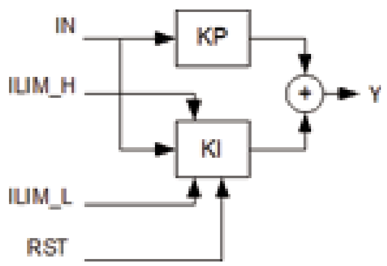
FT_PI is a PI controller which works following the formula:

Y = KP * IN + KI * INTEG(IN)

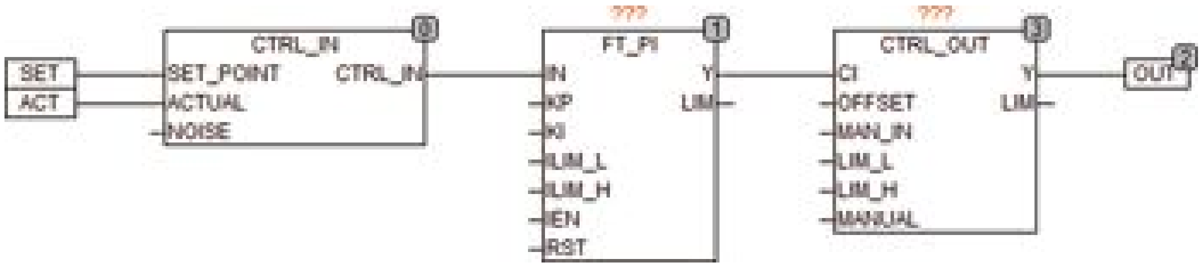
The input values ILIM_H and ILIM_L limits the working area of the internal integrator. With RST, the internal Integrator can always be set to 0. The output LIM indicates that the Integrator has reached one of the limits ILIM_L oe ILIM_H. The PI controller is free running and uses the trapezoidal rule 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:

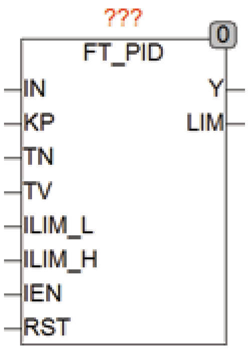


FT_PI can be used in conjunction with the modules CTRL_IN and CTRL_OUT to build a PI controller.



23.21. FT_PID

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))

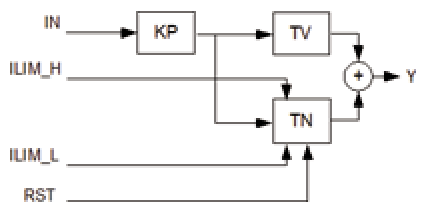
The control parameters are given in the form of KP, TN and TV, and if there are parameters KP, KI and KD they can be converted using the following formula:

TN = KP/KI und TV = KD/KP

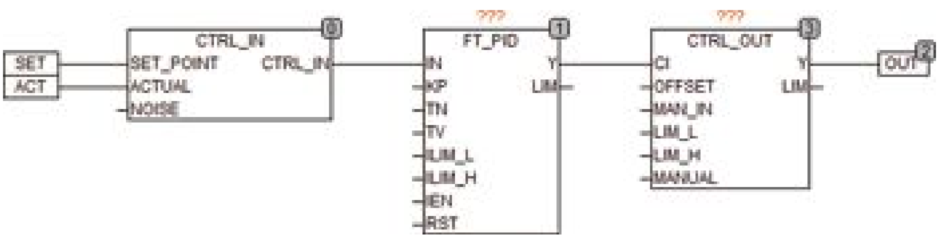
The input values ILIM_H and ILIM_L limit the working area of the internal integrator. With RST, the internal integrator will always set to 0. The output LIM signals that the integrator runs one of the limits or ILIM_L ILIM_H. The PI controller is free running and uses the trapezoidal rule to calculate 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.



23.22. FT_PIDW

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)

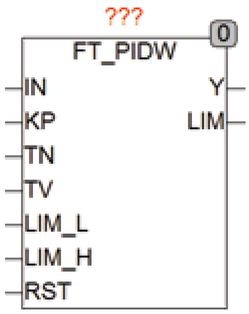
LIM_L: REAL (lower limit of the integrator output)

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:

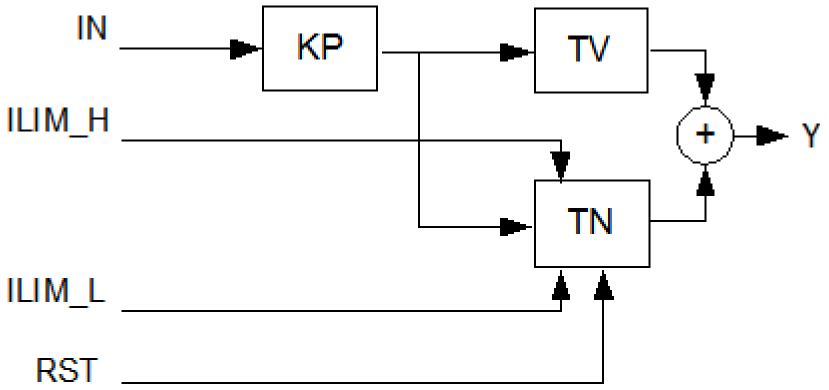
TN = KP/KI und TV = KD/KP

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.

23.23. 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)

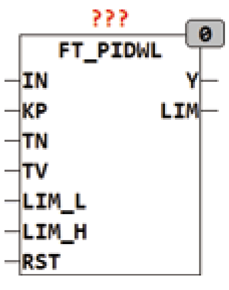
LIM_L: REAL (lower limit of the integrator output)

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:

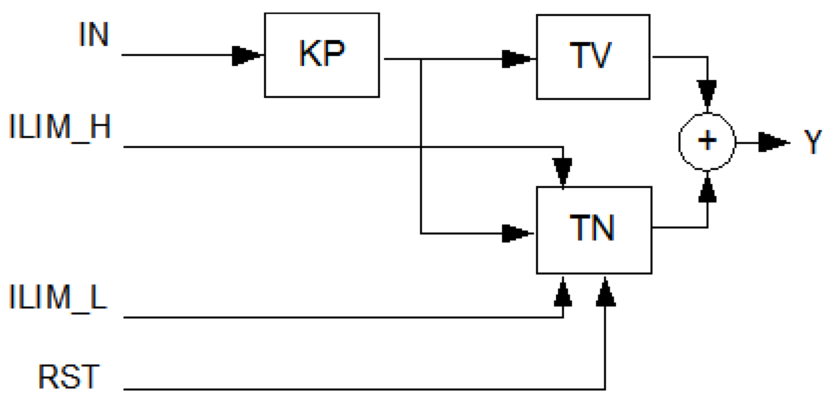
TN = KP/KI und TV = KD/KP

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 .

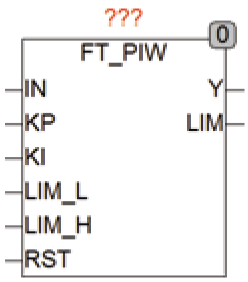
The following graph illustrates the internal structure of the controller:



FT_PD can be used in conjunction with the modules CTRL_IN and CTRL_OUT to establish a PD controller.

23.24. FT_PIW

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:

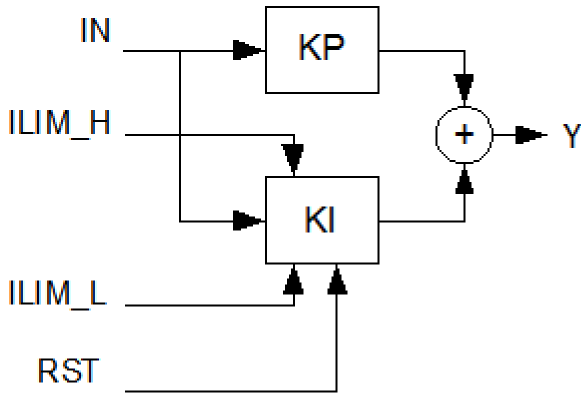
Y = KP * IN + KI * INTEG(IN)

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.

23.25. FT_PIWL

Type Function module

Input IN: REAL (input signal)

KP: REAL (proportional part of the controller)

KI: REAL (integral part of the controller)

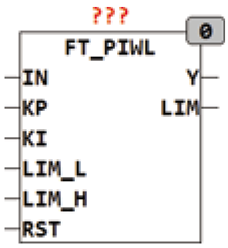
LIM_L: REAL (lower limit of the integrator output)

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:

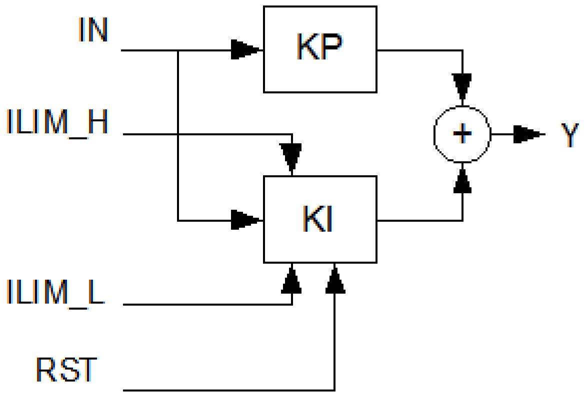
Y = KP * IN + KI * INTEG(IN)

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 .

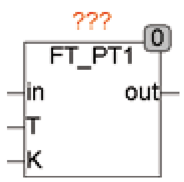
The following graph illustrates the internal structure of the controller:



FT_PIWL can used together with the modules CTRL_IN and CTRL_OUT to build complex controllers.

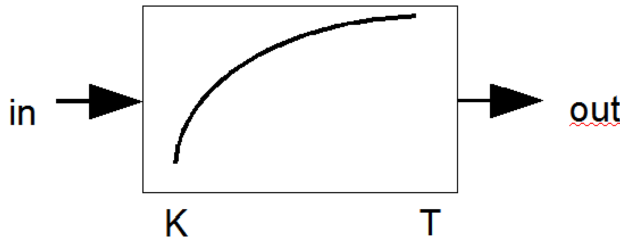
23.26. FT_PT1

Type	Function module
Input	IN: REAL (input signal)
	T: TIME (time constant)
	K: REAL (multiplier)
Output	OUT_MAX: REAL (upper output limit)

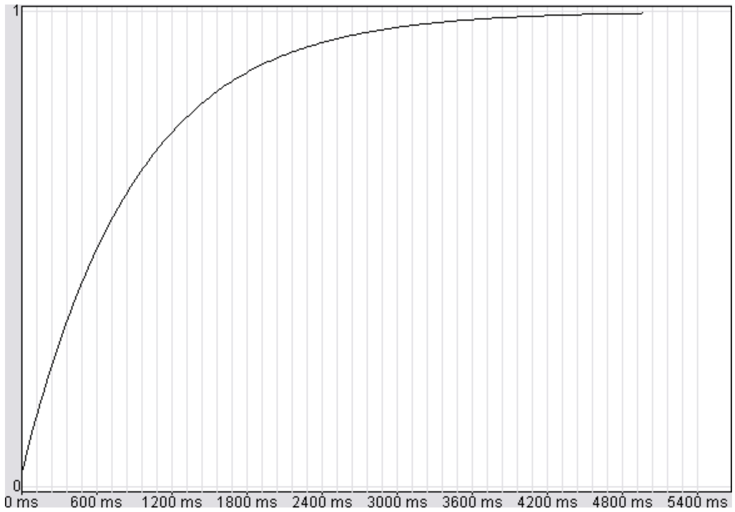


FT_PT1 is an LZI- Transmission link with a proportional transfer behavior 1 Order, even as a low pass filter 1 order referred to. The multiplier K sets the gain (multiplier) is fixed and T is the time constant.
A change at the input is attenuated at the output visible. The output signal increases within 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:

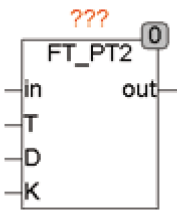


Step response for T = 1, K = 1



23.27. FT_PT2

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

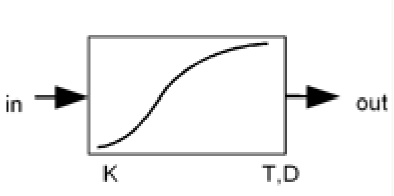
K sets the gain (multiplier), T and D the time constant and the damping. If the input T of T#0s is equal to the output OUT = K * IN.

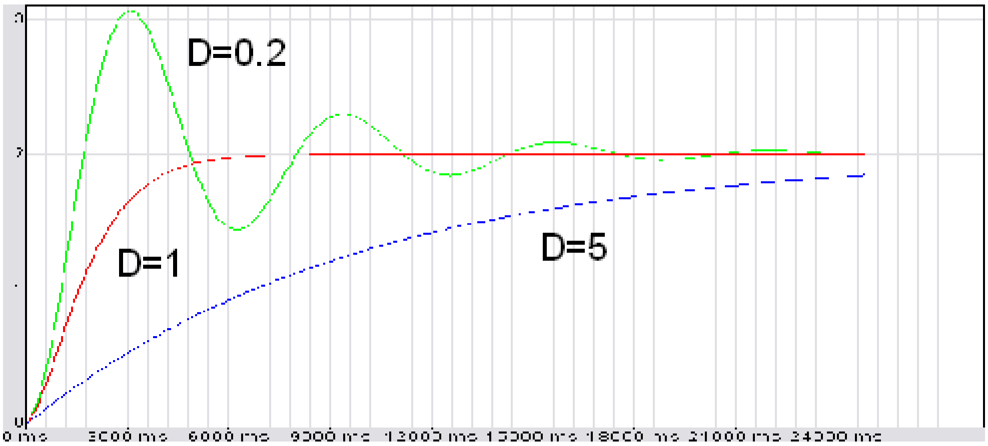
The corresponding functional relationship in the time windows is given by the following differential equation:

$T^2 * OUT''(T) + 2 * D * T * OUT'(T) + OUT(T) = K * in(T)$.

Structure diagram:

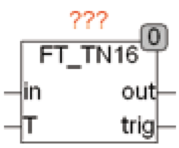
Step response for T = 1, K = 2, D = 0,2 / 1 / 5



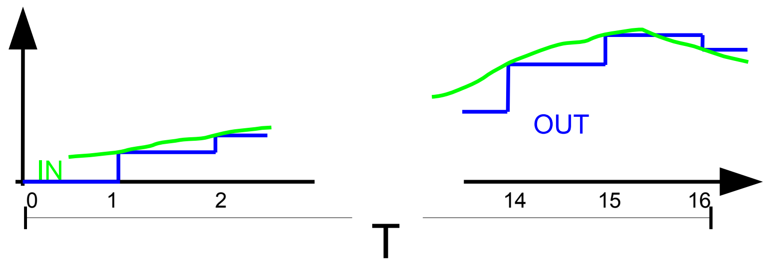


23.28. FT_TN16

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.



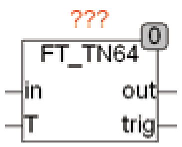
23.29. FT_TN64

Type Function module

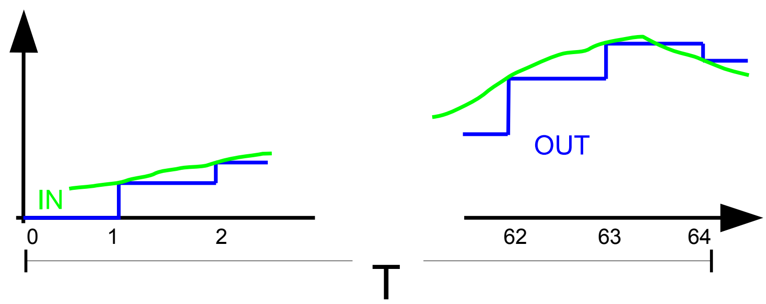
Input IN: REAL (input signal)

T: REAL (delay time)

Output OUT_MAX: REAL (upper output limit)

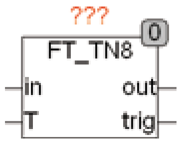


FT_TN64 delays an input signal by an adjustable time T and scans it in time T 64 times. After each update of the output signal OUT, TRIG is TRUE for one cycle.

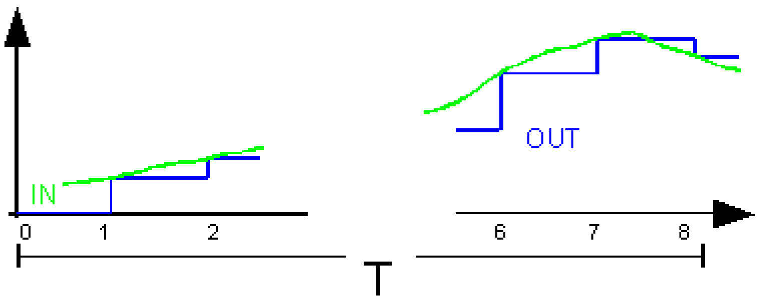


23.30. Ft_ TN8

Type	Function module
Input	IN: REAL (input signal)
	T: REAL (delay time)
Output	OUT_MAX: REAL (upper output limit)

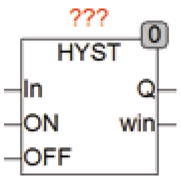


FT_TN8 delays an input signal by an adjustable time T and scanned it in time T by 8 times. After each update of the output signal OUT, TRIG is TRUE for one cycle.



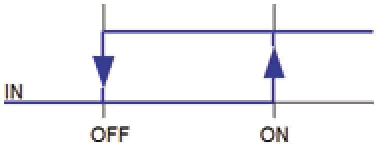
23.31. HYST

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)

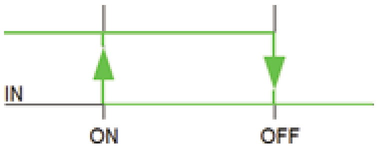


HYST is a standard Hysteresis module, its function depends on the input values ON and OFF.

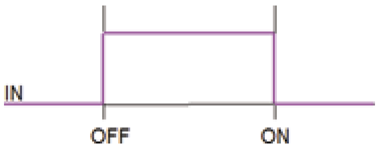
Is ON > OFF then the output TRUE if IN > ON and is FALSE when IN < OFF.



Is ON < OFF then the output TRUE if IN < ON and is FALSE when IN > OFF.

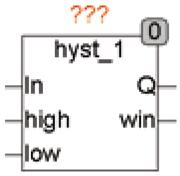


The output WIN is TRUE if IN is between ON and OFF, is IN is out of range ON - OFF WIN gets FALSE.



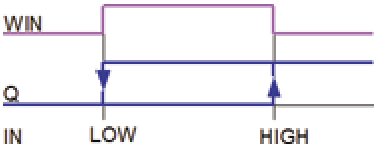
23.32. HYST_1

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)

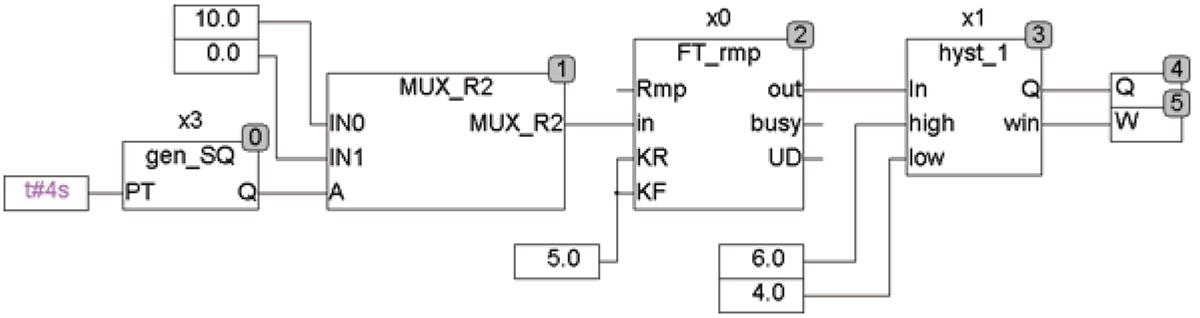


HYST_1 is a hysteresis module that works with upper and lower limit. The output Q is only true if the input signal at IN has exceeded the value HIGH. It is then held true until the input signal falls below LOW and Q gets FALSE. A further output WIN indicates whether the input signal is between LOW and HIGH.

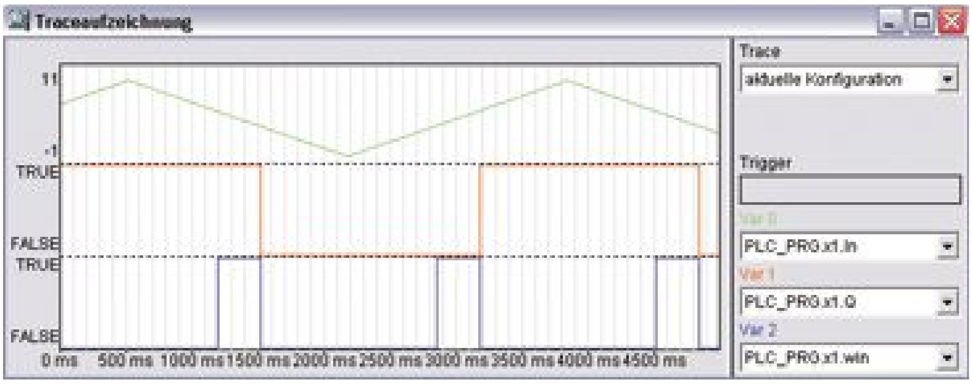
The following example shows a triangular wave generator with down-



stream hysteresis hysteresis module HYST_1.



The green line shows the input signal, red is the output hysteresis and



blue the WIN.

23.33. HYST_2

Type Function module

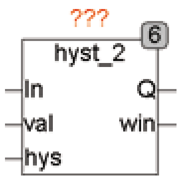
Input IN: REAL (input value)

VAL: REAL (mean of the hysteresis)

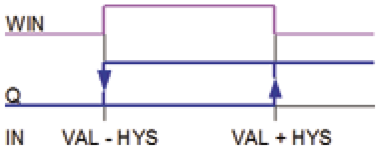
HYS: REAL (width of hysteresis)

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.

23.34. HYST_3

Type Function module

Input IN: REAL (input value)

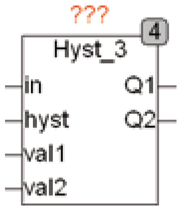
HYST: REAL (width of hysteresis)

VAL1: REAL (mean of the hysteresis 1)

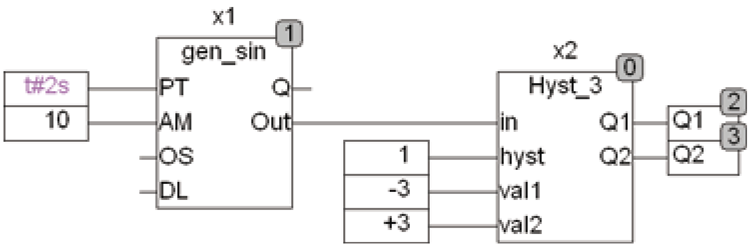
VAL2: REAL (mean of the hysteresis 2)

Output Q1: BOOL (Output 1)

Q2: BOOL (Output 2)

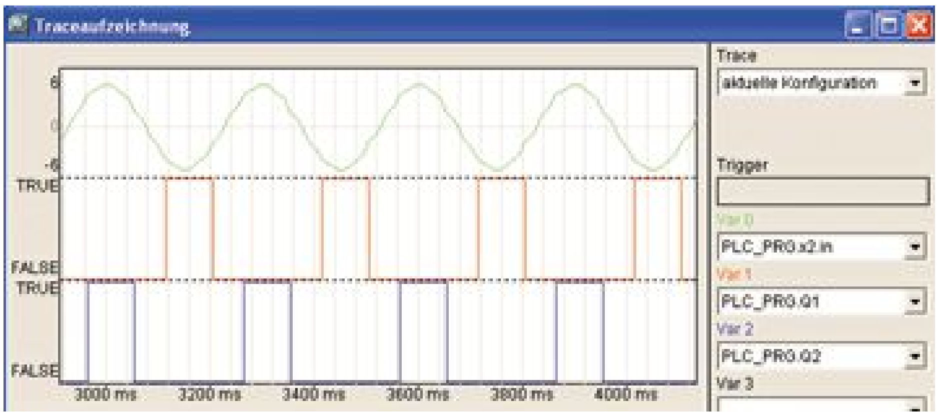


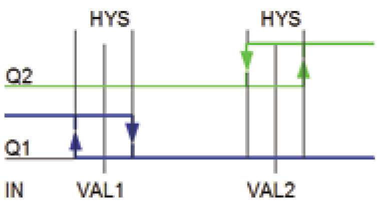
HYST_3 is a three-point controller. The three-point controller consists of two hysteresis. Q1 is a hysteresis with val1 as the threshold and HYST as hysteresis. Q1 is TRUE when IN is less than VAL1 - HYST / 2 and FALSE when IN is greater than VAL1 + HYST / 2 . Q2 is analogous to val2. The three-point 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:

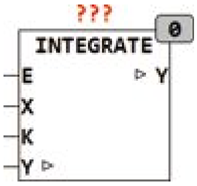




23.35. INTEGRATE

Type Function module

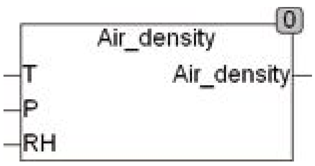
Input	E: BOOL (Enable Input, Default = TRUE)
	X: REAL (input)
	K: REAL (Integration value in 1/s)
I / O	Y: REAL (IntegratorOutput)



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.

23.36. AIR_DENSITY

Type	Function : REAL
Input	T: REAL (air temperature in ° C)
	P: REAL (air pressure in Pascal)
	RH: REAL (humidity in %)
Output	(Density of air in kg / m³)

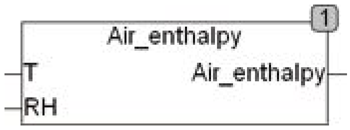


AIR_DENSITY calculates the density of air in kg / m³ depending on pressure, humidity and temperature. The temperature is given in ° C, pressure in Pascal and the humidity in % (50 = 50%).

23.37. AIR_ENTHALPY

Type	Function : REAL
Input	T: REAL (air temperature)
	RH: REAL (Relative humidity of the air)

Output (Enthalpy of air in J/g)



AIR_ENTHALPY calculates the enthalpy of moist air from the statements T for temperature in degrees Celsius and relative humidity RH in % (50 = 50%). The enthalpy is calculated in joules/gram.

23.38. BOILER

Type Function module

Input T_UPPER: REAL (input upper temperature sensor)

T_LOWER: REAL (lower input temperature sensor)

PRESSURE: REAL (input pressure sensor)

ENABLE: BOOL (hot water requirement)

REQ_1: BOOL (input requirements for predefined Temperature 1)

REQ_2: BOOL (input requirements for predefined Temperature 2)

BOOST: BOOL (input requirement for immediate Deployment)

Output HEAT: BOOL (output loading circuit)

ERROR: BOOL (error signal)

STATUS: Byte (ESR compliant status output)

Setup T_UPPER_MIN: REAL (minimum temperature at top)

Default = 50

T_UPPER_MAX: REAL (maximum temperature at top)

Default = 60

T_LOWER_ENABLE : BOOL (FALSE, if lower Temperature Sensor does not exist)

T_LOWER_MAX: REAL (maximum temperature of bottom)

Default = 60

T_REQUEST_1: REAL (temperature requirement 1)

Default = 70

T_REQUEST_2: REAL (temperature requirement 2)

Default = 50

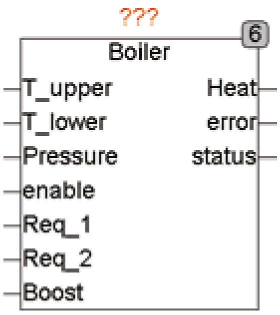
T_REQUEST_HYS: REAL (hysteresis control) Default = 5

T_PROTECT_HIGH: REAL (upper limit temperature,

Default = 80)

T_PROTECT_LOW: REAL (lower limit temperature,

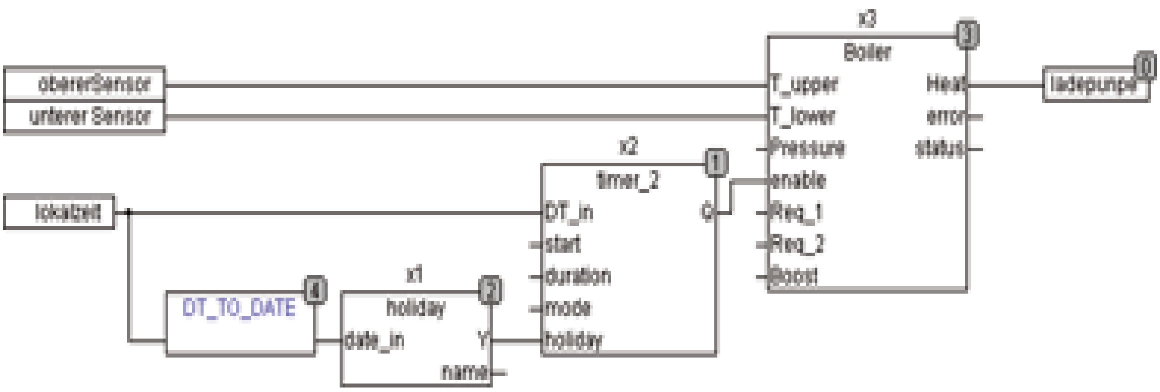
Default = 10)



BOILER is a Controllerfor buffers such as warm water buffer. With two separate temperature sensor inputs also storage layers can be controlled. With the setup variable T_LOWER_ENABLE the lower temperature sensor can be switched on and off. When the input ENABLE = TRUE, the boiler is heated (HEAT = TRUE) until the preset temperature T_LOWER_MAX reaches the lower area of the buffer and then turn off the heater, until the lower limit temperature of the upper region (T_UPPER_MIN) is reached. If T_LOWER_ENABLE is set to FALSE, the lower sensor is not evaluated and it control the temperature between T_UPPER_MIN and T_UPPER_MAX at the top. A PRESSURE-input protects the boiler and prevents the heating, if not enough water pressure in the boiler is present. If a pressure sensor is not present, the input is unconnected. As further protection are the default values T_PROTECT_LOW (antifreeze) and T_PROTECT_HIGH are available and prevent the temperature in the buffer to not exceed an upper limit and also a lower limit. If an error occurs, the output ERROR is set to TRUE, while a status byte is reported at output STATUS, which can be further evaluated by modules such as ESR_COLLECT. By a rising edge at input BOOST the buffer temperature is directly heated to T_UPPER_MAX (T_LOWER_ENABLE = FALSE) or T_LOWER_MAX (T_LOWER_ENABLE = TRUE). BOOST can be used to impairment heating up the boiler when ENABLE is set to FALSE. The heating by BOOST is edge-triggered and leads during each rising edge at BOOST to exactly one heating process. Due to a rising edge on BOOST while ENABLE = TRUE the heating is started immediately until the maximum temperature is reached. The boiler will be loaded to provide maximum heat capacity. The inputs REQ_1 and REQ_2 serve any time to provide a preset temperature (or T_REQUEST_1 T_REQUEST_2). REQ can be used for example to provide a higher temperature for legionella disinfection or for other purposes. The provision of the request temperatures is made by measuring at the upper temperature sensor and with a 2-point control whose hysteresis is set by T_REQUEST_HYS.

Status	
1	upper temperature sensor has exceeded the upper limit temperature
2	upper temperature sensor has fallen below the lower limit temperature
3	lower temperature sensor has exceeded the upper limit temperature
4	lower temperature sensor has fallen below the lower limit temperature
5	Water pressure in the buffer is too small
100	Standby
101	BOOST recharge
102	Standard recharge
103	Recharge on Request Temperature 1
104	Recharge on Request Temperature 2

The following Example shows the application of a BOILER with a TIMER and a public holiday mode:

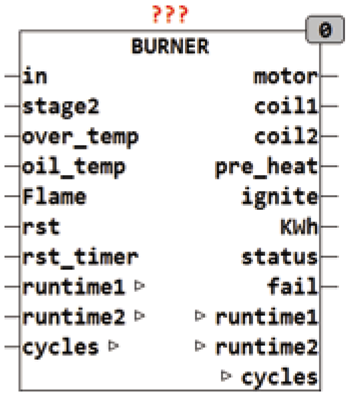


23.39. BURNER

Type Function module

Input IN: BOOL (control input)

	Stage2: BOOL (control input level 2)
	OVER_TEMP: BOOL (temperature limit of the boiler)
	OIL_TEMP: BOOL (thermostat of fuel oil warming)
	FLAME: BOOL (flame sensor)
	RST: BOOL (reset input for failure reset)
	RST_TIMER: BOOL (reset for the service counter)
Output	MOTOR: BOOL (control signal for the motor)
	COIL1: BOOL (control signal for valve oil Level 1)
	COIL2: BOOL (control input for oil valve stage 2)
	PRE_HEAT: BOOL (fuel oil warming)
	IGNITE: BOOL (ignition)
	KWH: REAL (kilo watt hour meter)
	STATUS: BYTE (ESR compliant status output)
	FAIL: BOOL (fault: TRUE if error appearance)
I / O	RUNTIME1: UDINT (operating time level 1)
	Runtime2: UDINT (operating time level 2)
	CYCLES: UDINT (number of burner starts)
Setup	PRE_HEAT_TIME: TIME (maximum time for fuel oil warming)
	PRE_VENT_TIME: TIME (prepurge)
	PRE_IGNITE_TIME: TIME (pre ignition time)
	POST_IGNITE_TIME: TIME (post ignition time)
	STAGE2_DELAY: TIME (delay level 2)
	SAFETY_TIME: TIME ()
	LOCKOUT_TIME: TIME (time must elapse before with a RST a interference can be deleted)
	MULTIPLE_IGNITION: BOOL ()
	KW1: REAL (burner output at level 1 in KW)
	KW2: REAL (burner output at level 2 in KW)

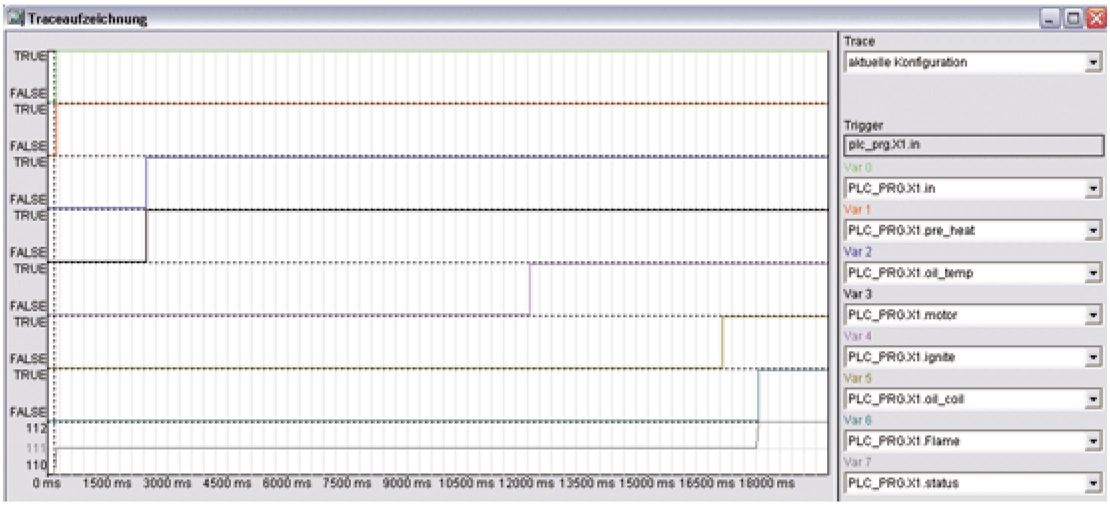


BURNER is a control interface for oil or gas burner operating at kilowatt hour meter and counter. The module controls a two-stage burner with optional fuel oil warming. The input IN is the control input that starts the burner only when the input OVER_TEMP is FALSE. OVER_TEMP is the boiler thermostat protection, which gets TRUE, if the boiler temperature has reached the maximum temperature. A burner start begins with the fuel oil warming, by PRE_HEAT gets TRUE. Then it waits for a signal at the input OIL_TEMP. If the signal OIL_TEMP is within the PRE_HEAT_TIME not TRUE and the oil temperature is not reached, the start sequence is interrupted and the output FAIL is set to TRUE. At the same time the error is spent at the Output STATUS. After fuel oil warming the motor gets on and sets the fan in operation. Then after a defined time the ignition is switched and the oil valve is opened. If no response of the flame sensor after specified time (SAFETY_TIME), the module shows a failure. A fault is signaled even if the flame sensor responds before the ignition. If after a successful ignition, the flame breaks off and the set-variable MULTIPLE_IGNITION = TRUE, immediately a ignition is started. A second stage is activated automatically after the time STAGE2_DELAY when the input STAGE2 is TRUE.

If a fault occurs, then the module is locked for a fixed time LOCKOUT_TIME and only after this time a RST can start the operation again. During the LOCKOUT_TIME, the RST Input must be FALSE. A TRUE at input OVER_TEMP stops immediately every action and reports the error 9.

The status output indicates the current state of the module:

110 = Wait for Start signal (Standby)
111 = startup sequence is executed
112 = burner runs on stage 1
113 = burner runs at stage 2



A number of error conditions are provided at the output STATUS, if an error is present:

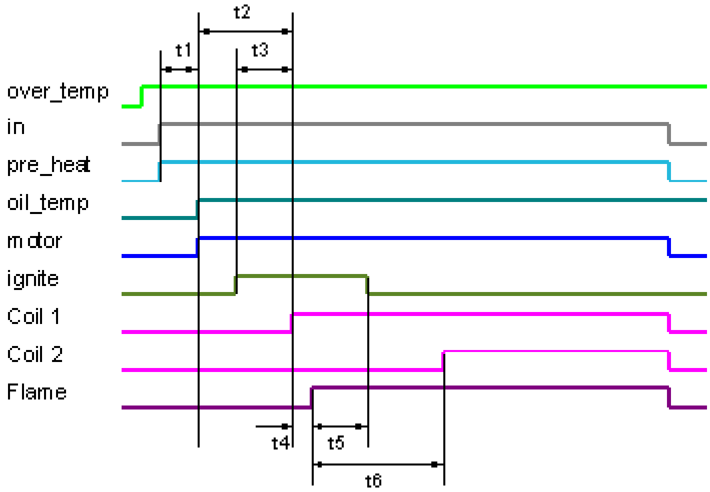
1 = fuel oil warming has not responded within the PRE_HEAT_TIME
2 = flame sensor is active during fuel oil warming (PRE_HEAT_TIME)
3 = flame sensor is active during the aeration period (PRE_VENTILATION_TIME)
4 = safety time (Safety_Time) was passed without a flame
5 = flame stops in operation
9 = boiler overheating contact has tripped

Trace recording of a normal boot sequence:

The signal IN starts the sequence with the output PRE_HEAT. After reaching the oil temperature (OIL_TEMP = TRUE), the engine started and the PRE_VENTILATION_TIME (time from engine start until oil valve is open) awaited. After an adjustable time (PPR_IGNITION_TIME) before opening the oil valve, the ignition is turned on. The ignition is then on until the POST_IGNITION_TIME has expired. The operating time per stage is measured independently in seconds.

IN	over tem	Oil tem	Flame	Rst	motor	Oil coil	Pre hea	ignite	Status	fail	
0	0	-	-	0	0	0	0	0	110	0	Wait mode
1	0	0	0	0	0	0	1	0	111	0	fuel oil warming period
1	0	1	0	0	1	0	1	0	111	0	aeration period
1	0	1	0	0	1	0	1	1	111	0	pre ignition period
1	0	1	0	0	1	1	1	1	111	0	Open valve stage 1
1	0	1	1	0	1	1	1	1	112	0	Flame burns post ignition period
1	0	1	1	0	1	1	1	0	112	0	Burner is running
1	0	1	0	0	1	1	1	1	111	0	Post-ignition after flame stops
-	1	-	-	-	-	-	-	-	9	1	Boiler overheating
1	0	1	1	0	1	0	1	0	3	1	foreign light failure

The following time diagram explains the various setup times and the sequence:



The timing diagram reflects the exact time line:

t1 = pre-heating (PRE_HEAT_TIME)

t2 = prepurge (PRE_VENT_Time)

t3 = pre ignition time (PRE_IGNITE_TIME)

t4 = safety time (SAFETY_TIME)

t5 = post ignition time (POST_IGNITE_TIME)

t6 = delay for stage 2 (STAGE2_DELAY)

23.40. DEW_CON

Type	Function : REAL
Input	RH: REAL (Relative Humidity)
	T: REAL (temperature in °C)
Output	REAL (water vapor concentration in g/m³)

The module DEW_CON calculates from the relative humidity (RH) and temperature (T in °C) water vapor concentration in the air. The result is calculated in grams/m³. RH is shown in % (50 = 50%) and indicates the temperature in °C.

The module is suitable for temperatures from -40°C to +90°C.

23.41. DEW_RH

Type Function : REAL

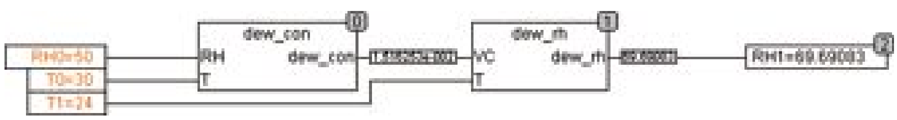
Input VC: REAL (water vapor concentration in air, in grams / m³)

T: REAL (temperature in °C)

Output REAL (Relative humidity in %)

The module DEW_RH calculates the relative humidity in % (50 = 50%) from the water vapor concentration (VC) and temperature (T in ° C) . The water vapor concentration is measured in grams / m³. DEW_CON can be used for calculations in both directions (heat up and cool down). If cooled too much, then the maximum relative humidity limited to 100%. For calculation of the dew point of the module DEW_TEMP is recommended.

In the following example, the case will be calculated when air is cooled from 30°C and relative humidity of 50% by 6 degrees. The module DEW_CON provides the moisture concentration in the outlet air of 30° and DEW_RH calculates the resulting relative humidity RH of 69.7%. These calculations are important when air is cooled or heated. In air conditioning systems a resulting relative humidity of 100% hast to be avoided due to condensation and the resulting problems.



See also the modules DEW_CON and DEW_TEMP.

23.42. DEW_TEMP

Type Function : REAL
Input RH: REAL (Relative Humidity)
T: REAL (temperature in °C)
Output REAL (dew point)

The module DEW_TEMP calculate the dew point temperature from the relative humidity (RH) and temperature (T in ° C). The relative humidity is given in % (50 = 50%).

23.43. HEAT_INDEX

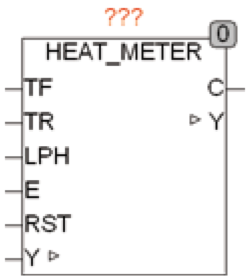
Type Function : REAL
Input T: REAL (temperature in °C)
RH: REAL (Relative Humidity)
Output REAL (Heat Temperature Index)

HEAT_INDEX calculates at high temperatures and high humidity wind chill. The function is defined for temperatures above 20 ° C and relative humidity > 10%. For values outside the defined range, the input temperature is passed out.

23.44. HEAT_METER

Type Function : REAL
Input TF: REAL (flow temperature in °C)
TR: REAL (back flow temperature in °C)

	LPH: REAL (Flow in L/h or L/pulse)
	E: BOOL (Enable Signal)
	RST: BOOL (asynchronous reset input)
Setup	CP: REAL (Specific heat capacity 2nd component)
	DENSITY: REAL (density of the 2nd component)
	CONTENT: REAL (share, 1 = 100%)
	PULSE_MODE: BOOL (pulse counter if TRUE)
	RETURN_METER: BOOL (flow meter in the return if TRUE)
	AVG_TIME: TIME (time interval for current consumption)
Output	C: REAL (current consumption in joules/hour)
I / O	Y: REAL (amount of heat in joules)



HEAT_METER is a calorimeter. The amount of heat Y is measured in joules. The inputs of TF and TR are the forward and return temperature of the medium. At the input LPH the flow rate in liters/hour, resp. the flow rate per pulse of E is specified. The property of E is determined by the Setup Variable PULSE_MODE. PULSE_MODE = FALSE means the amount of heat is added continuously as long as E is set to TRUE. PULSE_MODE = TRUE means the amount of heat with each rising edge of E is added up. The PULSE_MODE is turned on the use of heat meters, while indicating the flow rate in liters per pulse at the input LPH and the heat meter is connected at the input E. If no flow meter is present, the the pump signal is connected at input E and at the input LPH given the pump capacity in liters per hour. When using a flow meter with analog output is the output to be converted to liters per hour and sent to the input LPH, the input E will be set to TRUE. With the setup variables CP, DENSITY and CONTENT the 2nd component of the medium is specified. For operation with pure water no details of CP, DENSITY and CONTENT are necessary. [fzy] If a mixture of water and a 2nd media is present, with CP the specific heat capacity in J/KgK, with DENSITY the density in KG/l and with CONTENT the portion of the 2nd component is specified. A proportion of 0.5 means 50% and 1 would be equivalent to 100%. The setup variables RETURN_METER is specified whether the flow meter sits in forward or reverse. RETRUN_METER =

TRUE for return measurement and FALSE for flow measurement. The output C of the module represents the current consumption. The current consumption is measured in joules/hour, and is determined at the intervals of AVG_TIME.

The module has the following default values that are active when the corresponding values are not set by the user:

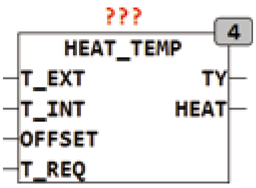
PULSE_MODE = FALSE

RETURN_METER = FALSE

AVG_TIME = T#5s

23.45. HEAT _TEMP

Type	Function module
Input	T_EXT: REAL (TAT)
	T_INT: REAL (nominal room temperature)
	OFFSET: REAL (lowering or raising the
	Room temperature)
	T_REQ: REAL (temperature requirement)
Output	TY: REAL (heating circuit flow temperature)
	HEAT: BOOL (heating requirement)
Setup	TY_MAX: REAL (maximum heating circuit temperature, 70°C)
	TY_MIN: REAL (minimum heating circuit temperature, 25°C)
	TY_C: REAL (design temperature, 70°C)
	T_INT_C: REAL (room design temperature, 20°C)
	T_EXT_C: REAL (T_EXT at design temperature -15°C)
	T_DIFF_C: REAL (forward / reverse differential 10°C)
	C: REAL (constant of the heating system, DEFAULT = 1.33)
	H: REAL (threshold requirement for heating 3°C)



HEAT_TEMP calculates the flow temperature of the outside temperature by the following formula:

TY = TR + T_DIFF / 2 * TX + (TY_Setup - T_DIFF / 2 - TR) * TX ^ (1 / C)

with: TR = T_INT + OFFSET

TX := (TR - T_EXT) / (T_INT_Setup - T_EXT_Setup);

The parameters of the heating curve are given by the setup variables TY_C (design flow temperature), T_INT_C (room temperature at the design point), T_EXT_C (outside temperature at the design point) and T_DIFF_C (difference between forward / reverse at the design point). With the input offset, the heating curve of room reduction (negative offset) or room boost (positive offset) can be adjusted. With the setup variables TY_MIN and TY_MAX the flow temperature can be kept to a minimum and maximum value. The input T_REQ is used to support requirements such as external temperature from the boiler. If T_REQ is larger than the calculated value of the heating curve for TY so TY is set to T_REQ. The limit of TY_MAX does not apply to the request by T_REQ. The setup variable H define at what outside temperature the heating curve is calculated, as long as T_EXT + H >= T_INT +OFFSET the TY stays at 0 and HEAT is FALSE. If T_EXT + H < T_INT + OFFSET the HEAT is TRUE and TY outputs the calculated flow temperature. The setup variable C determines the curvature of the heating curve. The curvature is dependent on the heating system.

Convectors: C = 1.25 – 1.45

Panel radiators: C = 1.20 – 1.30

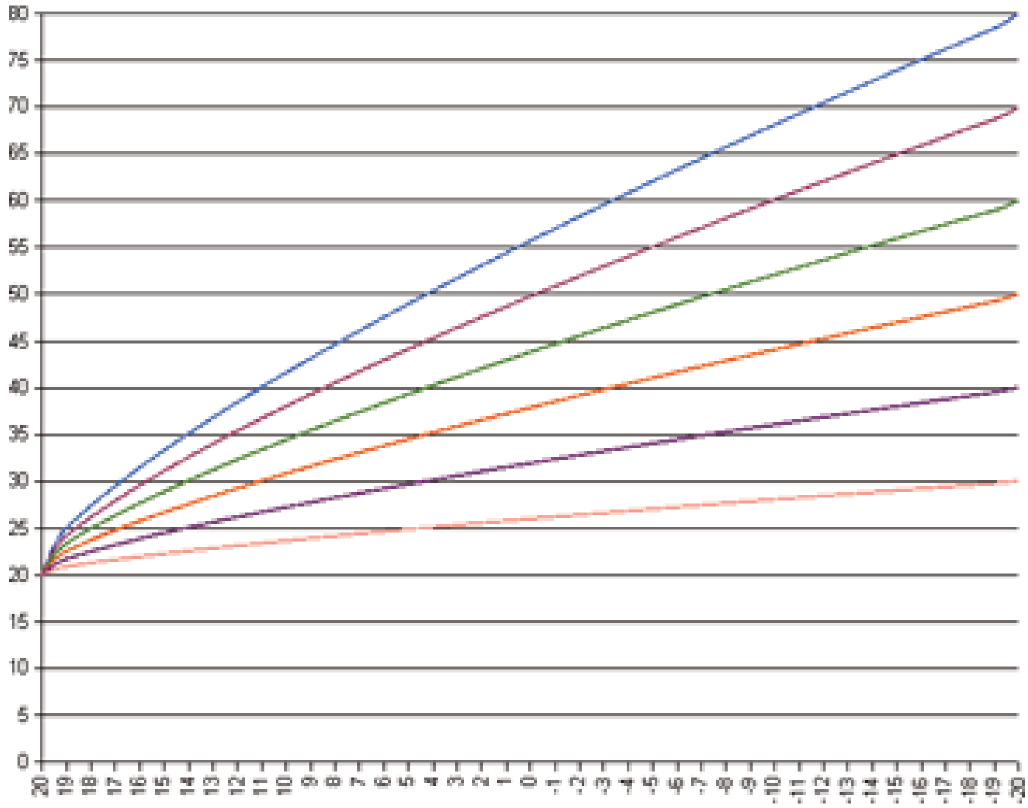
Radiators: C = 1.30

Pipes: C = 1.25

Floor heating: C = 1.1

The larger the value of C, the stronger the heating curve is curved. A value of 1.0 gives a straight line as the heating curve. Typical heating systems are between 1.0 and 1.5.

The graph shows Heating curves for the design temperatures of 30 - 80°C flow temperature at -20 ° C outside temperature and at a C of 1.33:



23.46. LEGIONELLA

Type	Function module
Input	MANUAL: BOOL (Manual Start Input)
	TEMP_BOILER: REAL (boiler temperature)
	TEMP_RETURN: REAL (temperature of the circulation pipe)
	DT_IN: DATE_TIME (Current time of day and date)
	RST: BOOL (Asynchronous Reset)
Output	HEAT: BOOL (control signal for hot water heating)
	PUMP: BOOL (control signal for circulation pump)
	STATUS: Byte (ESR compliant status output)
	Valve0..7: BOOL (control outputs for valves of circulation)
	RUN: bool (true if sequence is running)
Setup	T_START: TOD (time of day at which the disinfection starts)
	DAY: INT (weekday on which the disinfection starts)

TEMP_SET : REAL (temperature of the boiler)

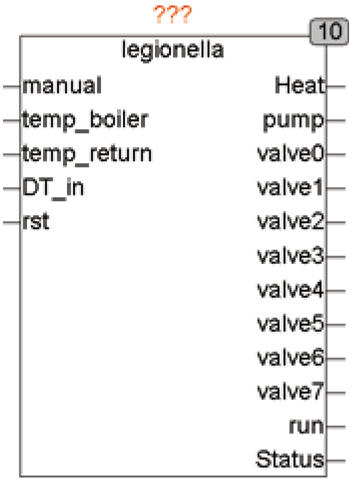
TEMP_OFFSET: REAL ()

TEMP_HYS: REAL ()

T_MAX_HEAT: TIME (maximum time to heat up the boiler)

T_MAX_RETURN: TIME (maximum time until the input TEMP_RETURN to be active after VALVE)

TP_0 .. 7: TIME (disinfection time for circles 0..7).



LEGIONELLA has an integrated timer, which starts on a certain day (DAY) to a specific time of day (T_START) the desinfection. For this purpose, the external interface of the local time is needed (DT_IN). Each time can be started the desinfection by hand with a rising edge at MANUAL.

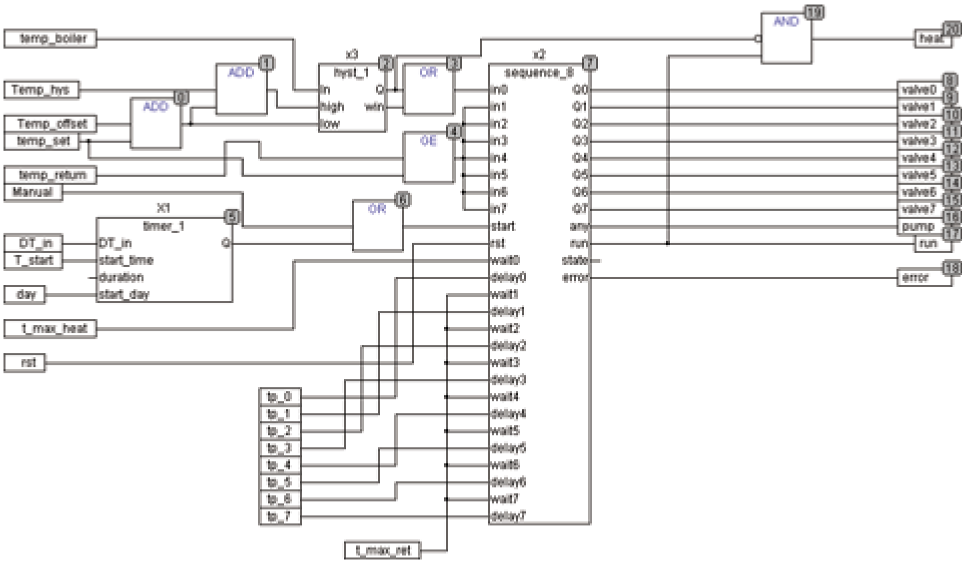
The process of a disinfection cycle is started with an internal start due to DT_IN, DAY and T_START, or by a rising edge at MANUAL. The output HEAT is TRUE and controls the heating of the boiler. Within the heating time T_MAX_HEAT the input signal TEMP_BOILER must go then to TRUE. If the temperature is not reported within T_MAX_HEAT, the output STATUS passes fault. The disinfection then continues anyway. After the heating, the heater temperature is measured and reheated if necessary by TRUE at the output HEAT. When the boiler temperature is reached, PUMP gets TRUE and the circulation pump is turned on. Then the individual valves are opened one after the other and measured, whether within the time T_MAX_RETURN the temperature war reached at the return of the circulation line. If a return flow thermometer is not present, the input T_MAX_RETURN remains open.

The output STATE is compatible with ESR, and may give the following messages:

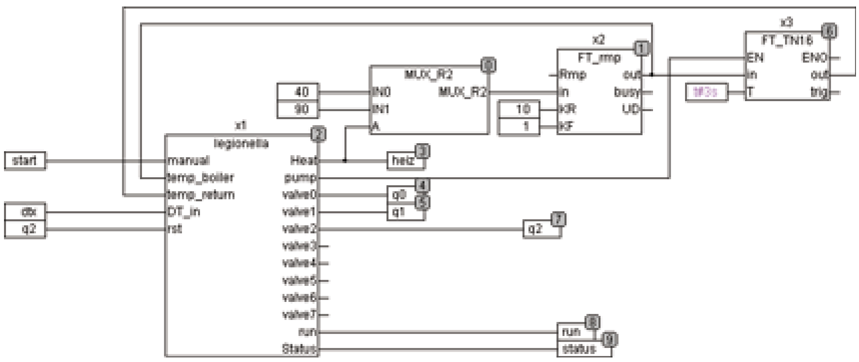
110	On	hold
111	Sequence run	

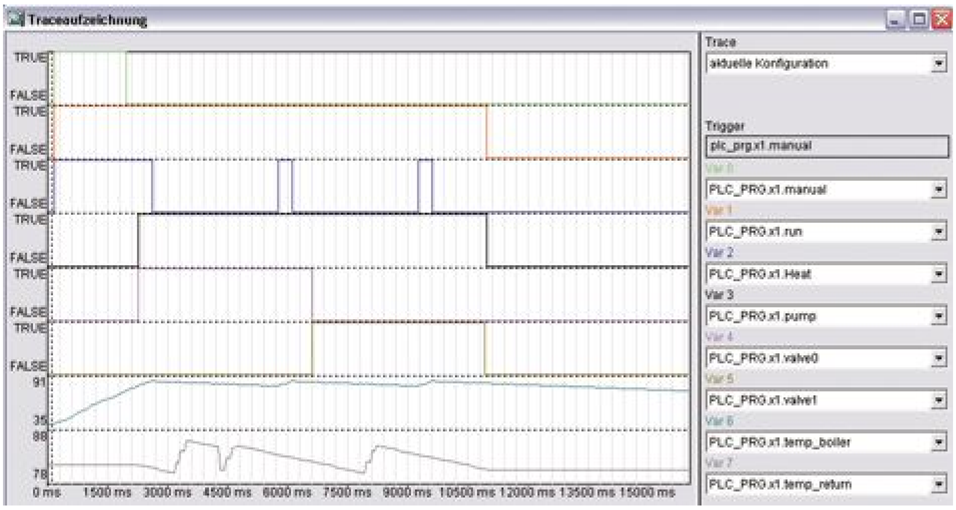
1	Boiler temperature was not reached
2	Return temperature at Ventil0 was not reached
3..8	Return temperature at valve1..7 was not reached

Schematic internal structure of Legionella:



The following example shows a simulation for 2 disinfection circuits with trace recording. In this structure, VALVE2 connected to the input RST and thus disrupts the sequence after of two circles:





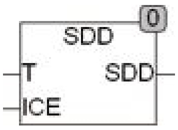
23.47. SDD

Type Function : REAL

Input T: REAL (air temperature in ° C)

ICE: BOOL (TRUE for air over ice and FALSE for air over water)

Output REAL (saturation vapor pressure in Pa)



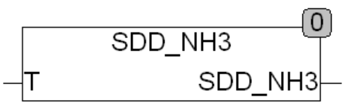
SDD calculates the saturation vapor pressure for water vapor in air. The temperature T is given in Celsius. The result can be calculated for air over ice (ICE = TRUE) and for air to water (ICE = FALSE). The scope of the function is -30°C to 70°C over water and at -60°C to 0°C on ice. The calculation is performed according to the Magnus formula.

23.48. SDD_NH3

Type Function : REAL

Input T: REAL (temperature in °C)

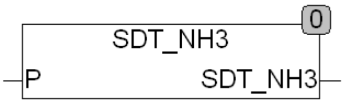
Output REAL (saturation vapor pressure in Pa)



SDD_NH3 calculates the saturation vapor pressure for ammonia (NH3). The temperature T is given in Celsius. The scope of the function is located at -109°C to 98°C.

23.49. SDT_NH3

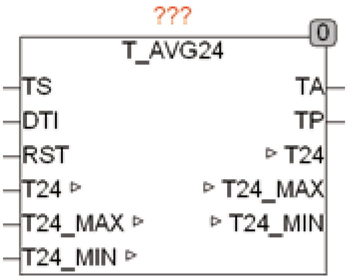
Type	Function : REAL
Input	T: REAL (temperature in °C)
Output	REAL (saturation vapor pressure in Pa)



SDT_NH3 calculates the saturation temperature for ammonia (NH3). The pressure P is given in Celsius. The scope of the function is 0.001 bar to 60 bar.

23.50. T_AVG24

Type	Function module
Input	TS: INT (external temperature sensor)
	DTI: DT (Date and time of day)
	RST: BOOL (Reset)
Setup	T_FILTER: TIME (T of the input filter)
	SCALE: REAL:= 1.0 (scaling factor)
	SFO: REAL (zero balance)
Output	TA: REAL (Current outside temperature)
	TP: BOOL (TRUE if T24 is renewed)
I / O	T24: REAL (daily average temperature)
	T24_MAX: REAL (Maximaltemp. in the last 24 hours)
	T24_MIN: REAL (minimum temperature in the last 24 hours)

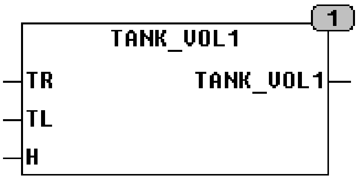


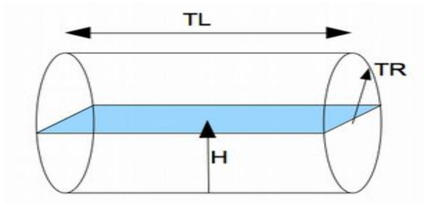
T_AVG24 determines the daily average temperature T24. The sensor input TS is of type INT and is the temperature * 10 (a value of 234 means 23.4 °C). The data of filter run for noise suppression on a low-pass filter with time T_FILTER. By scale and SFO a zero error, and the scale of the sensor can be adjusted. At output TA shows the current outside temperature, which is measured every hour and half hour. The module writes every 30 minutes the last, over the 48 values calculated daily average in the I / O variable T24. This needs to be defined externally and thereby can be de-finded remanent or persistent. If the first start a value of -1000 found in T24, then the module initializes at the first call with the current sensor va-lue, so that every 30 minutes a valid average may be passed. If T24 has any value other than -1000, then the module is initialized with this value and calculates the average based on this value. This allows a power failure and remanent storage of T24 an immediate working after restart. A reset input can always force a restart of the module, which depending on the value in T24, the module is initializes with either TS or the old value of T24. If the module should be set on a particular average, the desired value is written into T24 and then a reset generated.

T24_MAX and T24_MIN passes the maximum and minimum values of the last 24 hours. To determine the maximum and minimum value, the tempe-ratures of each half hour are considered. A temperature value that occurs between 2 measurements is not considered.

23.51. TANK_VOL1

Type	Function: REAL	
Input	TR : REAL	(Radius of the tank)
	TL: REAL	(Length of the tank)
	H: REAL	(Filling height of the tank)
Output	Real	(Contents of the tank to the fill level)

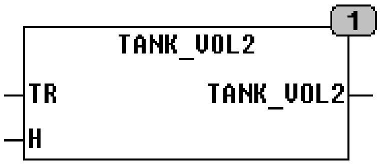


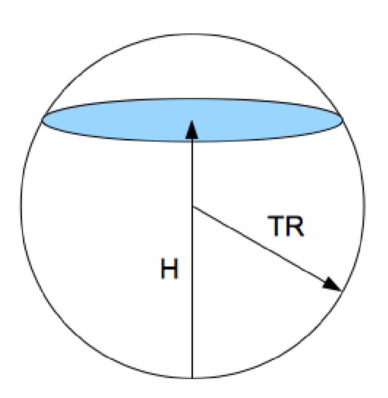


TANK_VOL1 calculates the contents of a tube-shaped tanks filled to the height H.

23.52. TANK_VOL2

Type	Function: REAL	
Input	TR : REAL	(Radius of the tank)
	H: REAL	(Filling height of the tank)
Output	Real	(Contents of the tank to the fill level)





TANK_VOL2 calculates the contents of a spherical tanks filled to the height H.

23.53. TEMP_EXT

Type	Function module
Input	T_EXT1: REAL (external temperature sensor 1)
	T_EXT2: REAL (external temperature sensor 2)
	T_EXT3: REAL (external temperature sensor 3)
	T_EXT_Setup: BYTE (query mode)
	DT_IN: DATE_TIME (daytime)
Output	T_EXT: REAL (output outside temperature)

HEAT: BOOL (heating signal)

COOL: BOOL (cooling signal)

Setup T_EXT_MIN: REAL (minimum outdoor temperature)

T_EXT_MAX: REAL (maximum outside temperature)

T_EXT_DEFAULT: REAL (default external temperature)

HEAT_PERIOD_START: DATE (start of heating season)

HEAT_PERIOD_STOP: DATE (end of heating season)

COOL_PERIOD_START: DATE (start of cooling period)

COOL_PERIOD_STOP: DATE (end of cooling period)

HEAT_START_TEAMP_DAY (heating trigger temperature day)

HEAT_START_TEAMP_NIGHT (heating trigger temperature night)

HEAT_STOP_TEMP: REAL (heating stop temperature)

COOL_START_TEAMP_DAY (cooling start temperature day)

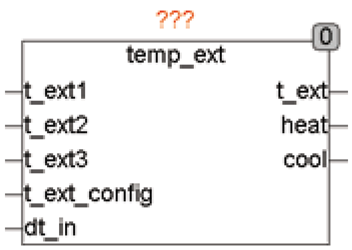
COOL_START_TEMP_NIGHT (cooling start temperature night)

COOL_STOP_TEMP: REAL (cooling stop temperature)

START_DAY: TOD (start of the day)

START_NIGHT: TOD (early night)

CYCLE_TIME: TIME (query time for outside temperature)



TEMP_EXT processes up to 3 remote temperature sensor and provides by mode a selected external temperature to the heating control. It calculates signals for heating and cooling depending on outdoor temperature, date and time. With the input T_EXT_Setup is defined how the output value T_EXT is determined. If T_EXT_Setup is not connected, then the default value 0. The setup values T_EXT_MIN and T_EXT_Max set the minimum and maximum value of the external temperature inputs. If these limits are exceeded or not reached, a fault in the sensor or broken wire is assumed and instead of measured valued the default value T_EXT_DEFAULT is used.

T_EXT_Setup	T_EXT
0	Average of T_EXT1, T_ext2 and T_ext3
1	T_EXT1

2	T_EXT2
3	T_EXT3
4	T_EXT_DEFAULT
5	Lowest value of the 3 inputs
6	Highest value of 3 inputs
7	Average value of 3 inputs

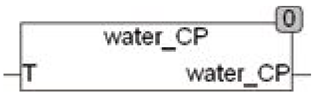
With the setup variables HEAT_PERIOD and COOL_PERIOD is defines when heating and when cooling is allowed. The decision, whether the output HEAT or COOL gets TRUE, still depends on the setup values HEAT_START - HEAT_STOP and COOL_START and COOL_STOP. These values can be defined separately for day and night. The start of a day and night period can be determined by the setup variables START_DAY and START_NIGHT. A variable CYCLE_TIME specifies how often the outside temperature to be queried.

23.54. WATER_CP

Type Function : REAL

Input T: REAL (water temperature in °C)

Output REAL (Specific heat capacity at temperature T)



WATER_CP calculates the specific heat capacity of liquid water as a function of temperature at atmospheric pressure. The calculation is valid in the temperature range from 0 to 100 degrees Celsius and is calculated in joules / (gram * kelvin). The temperature T is given in Celsius.

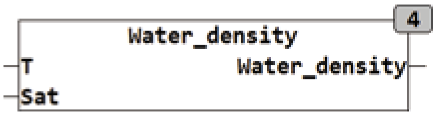
23.55. WATER_DENSITY

Type Function : REAL

Input T: REAL (temperature of the water)

SAT: BOOL (TRUE, if the water is saturated with air)

Output REAL (water density in grams / liter)



WATER_DENSITIY calculates the density of liquid water as a function of temperature at atmospheric pressure. The temperature T is given in Celsius. The highest density reached water at 3.983 °C with 999.974950 grams per liter. WATER_DENSITY calculates the density of liquid water, not frozen or evaporated water. WATER_DENSITY calculates the density of air-free water when SAT = FALSE, and air-saturated water when SAT = TRUE. The calculated values are calculated using an approximate formula and results values with an accuracy greater than 0.01% in the temperature range of 0 - 100°C at a constant pressure of 1013 mBar.

The deviation of the density of air saturated with water is corrected according to the formula of Bignell.

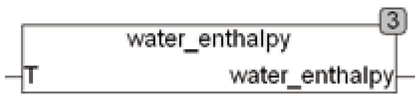
The dependence of the density of water pressure is relatively low at about 0.046 kg/m³ per 1 bar pressure increase, in the range up to 50 bar. The low pressure dependence has practical applications, no significant influence.

23.56. WATER_ENTHALPY

Type Function : REAL

Input T: REAL (temperature of the water)

Output REAL (enthalpy of water in J/g at temperature T)



WATER_ENTHALPY calculates the Enthalpy (Heat content) of liquid water as a function of temperature at atmospheric pressure. The temperature T is given in Celsius. The calculation is valid for a temperature of 0 to 100 ° C and the result is the amount of heat needed to head the water from 0 ° C to a temperature of T. The result is expressed in joules / gram J / g and passed as KJ/Kg. It is calculated by linear interpolation in steps of 10 ° and thus reach a sufficient accuracy for non-scientific applications. A possible Application of WATER_ENTHALPY is to calculate the amount of energy needed, for example, to head a buffer tank at X (T2 - T1) degree. From the energy required then the runtime of a boiler can be calculated exactly and the required energy can be provided. Since there temperature readings are significantly delays, with this method a better heating is possible in practice.

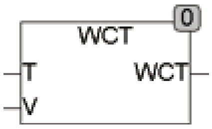
23.57. WCT

Type Function : REAL

Input T: REAL (outdoor temperature in ° C)

V: REAL (Wind speed in km/h)

Output REAL (wind chill temperature)

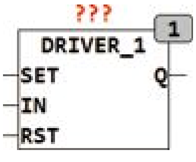


WCT calculates the wind chill temperature depending on the wind speed in km/h and the outside temperature °C. The wind chill temperature is defined only for wind speeds greater than 5 km/h and temperatures below 10 °C. For values outside the defined range, the input temperature is output.

24. Device Driver

24.1. DRIVER_1

Type	Function module
Input	SET: BOOL (asynchronous set input)
	IN: BOOL (switch input)
	RST: BOOL (asynchronous reset input)
Setup	TOGGLE_MODE: BOOL (mode of the input IN)
	TIMEOUT: TIME (maximum duty cycle of the outputs)
Output	Q0: BOOL (output)

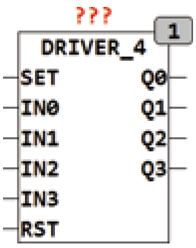


DRIVER_1 a driver module whose output Q can be set by the input IN is when TOGGLE_MODE = FALSE. The output is then held to TRUE until it is either set to FALSE by an asynchronous reset (RST) or until expiry of the maximum switching time (TIMEOUT). Further impulses at the input IN thereby extend the TRUE 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.

24.2. DRIVER_4

Type	Function module
Input	SET: BOOL (asynchronous set input)
	IN0...IN3: BOOL (switching inputs)
	RST: BOOL (asynchronous reset input)
Setup	TOGGLE_MODE: BOOL (mode of the input IN)

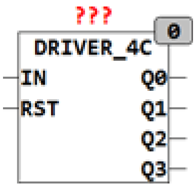
	TIMEOUT: TIME (Maximum Ontime of outputs)
Output	Q0 .. Q3: BOOL (outputs)



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.

24.3. DRIVER_4C

Type	Function module
Input	IN: BOOL (switch input)
	RST: BOOL (asynchronous reset input)
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)
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.

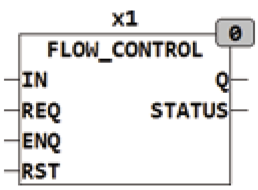
Example:

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,......

24.4. FLOW_CONTROL

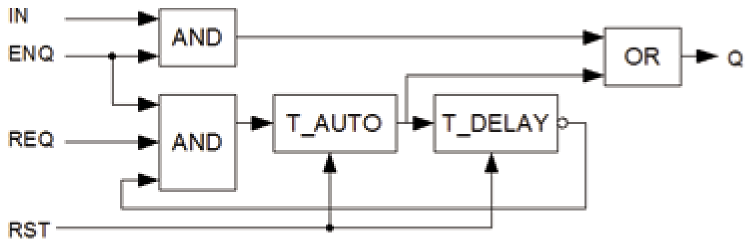
Type	Function module
Input	IN: BOOL (control input)
	REQ: BOOL (Request for automatic mode)
	ENQ: BOOL (Enable for output Q)
	RST: BOOL (asynchronous reset input)
Setup	T_AUTO: TIME (valve switch time in automatic mode)
	T_DELAY: TIME(valve disable Time in automatic mode)
Output	Q: BOOL (switching output 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

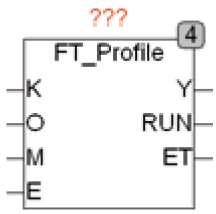
The diagram illustrates the structure of inferential FLOW_CONTROL:



24.5. FT_PROFILE

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

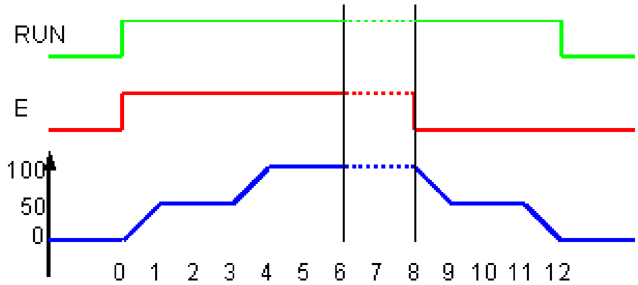
TIME_10, VALUE_10 = 6s, 100

TIME_11, VALUE_11 = 7s, 50

TIME_12, VALUE_12 = 9s, 50

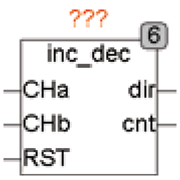
TIME_13, VALUE_13 = 10s, 0

The graphs represent the output of both phase 3 is stretched by E, and without stretching.



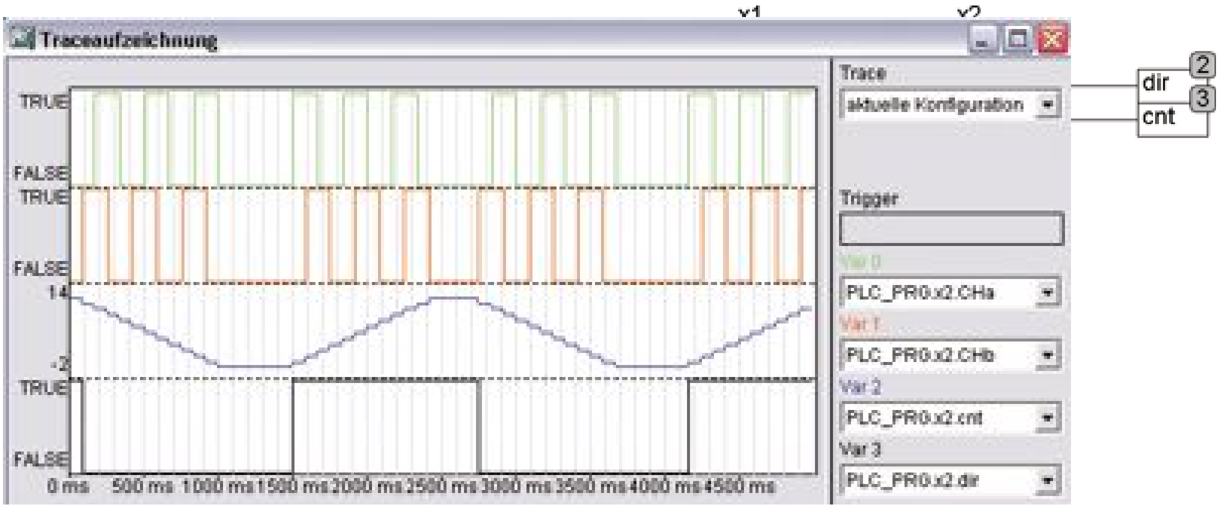
24.6. INC_DEC

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)



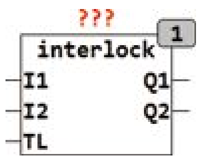
INC_DEC is a decoder for incremental encoder. Encoder (rotation encoder) deliver two overlapping pulses, channel A and channel B. By the two channels, the direction and angle of rotation is decoded. INC_DEC detect each edge of the encoder, so 4 times the resolution is achieved. The output DIR shows the 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.



24.7. INTERLOCK

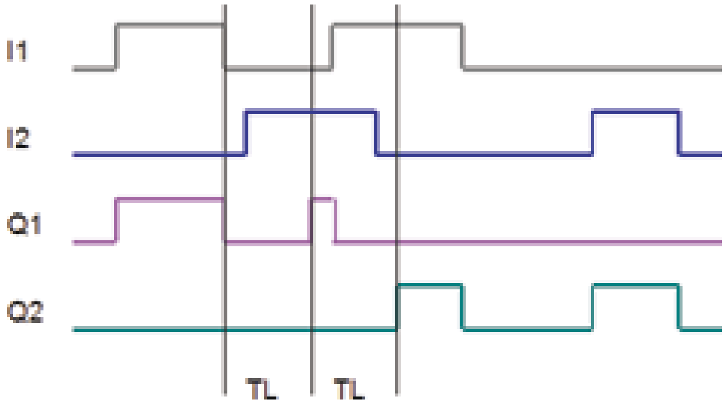
Type	Function module
Input	I1: BOOL (input 1)
	I2: BOOL (input 2)
	TL: TIME (lock time)
Output	Q1: BOOL (output 1)
	Q2: BOOL (output 2)



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.

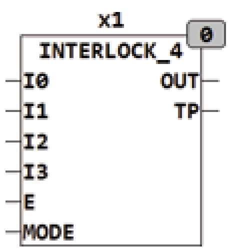
I1	I2	Q1	Q2
0	0	0	0
0	1	0	1
1	0	1	0

1	1	0	0



24.8. INTERLOCK_4

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.

24.9. MANUAL

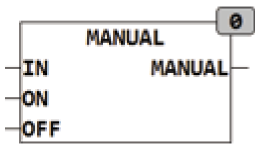
Type Function: BOOL

Input IN: BOOL (Input)

ON: BOOL (manual mode on)

OFF: BOOL (manual mode off)

Output BOOL (output)

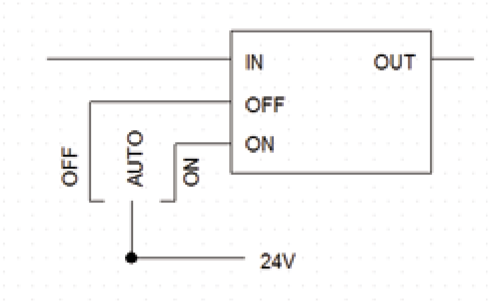


MANUAL can override an input signal IN with TRUE or FALSE.

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

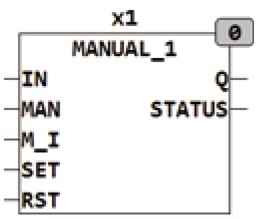
The typical use of MANUAL by means of a switch with 3 positions (OFF, AUTO, ON) where the connections are OFF at OFF and On at On and AUTO of the switch remains open.

The following diagram shows the possible connection of a switch with 3 positions:



24.10. 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.

24.11. MANUAL_2

Type Function module

Input IN: BOOL (Input)

ENA: BOOL (block Enable Input)

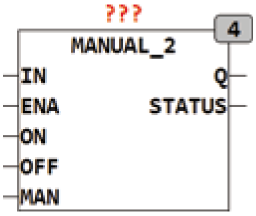
ON: BOOL (Forces the output to TRUE)

OFF: BOOL (Forces the output to FALSE)

MAN: BOOL (starting mode in manual mode)

Output Q: BOOL (output)

STATUS: BYTE (ESR compliant status output)



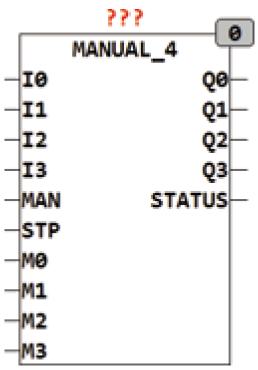
MANUAL_2 , a digital signal and override switches between manual and automatic operation. The module is designed so that a 3-position switch switches between off and auto. In the automatic the signal mode is set to IN, in the case of enforced off, the OFF is set to TRUE and in the case of enforced on, 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	force High
-	H	L	H	-	L	102	force Low
-	H	H	H	X	X	103	Manual Input
-	H	H	H	L	L	103	Force with Priority for OFF

-	H	H	H	H	H	103	Force with Priority for ON

24.12. 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)



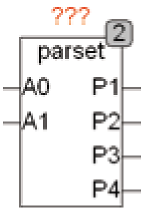
MANUAL_4 can override 4 digital signal in manual mode. As long as MAN = FALSE the outputs Q follows direct the input I. As soon as the inputs MAN = TRUE, the outputs follow the states of the inputs M. The STP input follow is in manual mode, a rotating set of outputs are generated. STP is active only 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

24.13. Parset

Type	Function module
Input	A0: BOOL (selection input 0)
	A1: BOOL (selection input 1)
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)
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.

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

24.14. PARSET2

Type Function module

Input X: REAL (input)

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

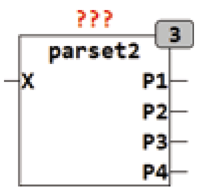
TC: TIME (ramp time at the outputs P)

Output P1: REAL (parameter 1 out)

P2: REAL (Parameter 2 Output)

P3: REAL (Parameter 3 Output)

P4: REAL (Parameter 4 Output)

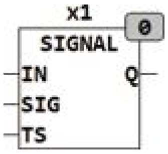


Parset selects from up to 4 sets of parameters one and returns the values at the outputs P1 to P4. The values for the parameter sets are defined with the setup variables. If the TC setup variable to a value > 0 is set, the outputs do not change abruptly to a new value, but run in a ramp to the new value 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.

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

24.15. SIGNAL

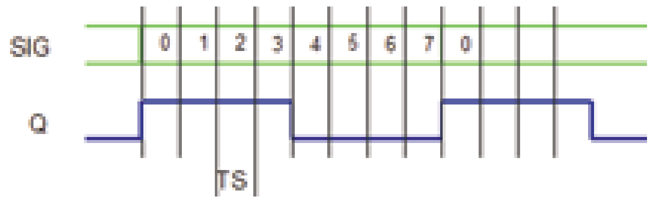
Type	Function module
Input	IN: BOOL (enable input)
	SIG: BYTE (Bitpattern)
	TS: TIME (switching time)
Output	Q: BOOL (output)



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.

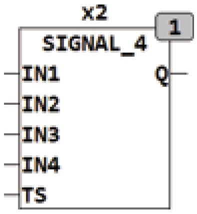
The following graph illustrates the functioning of signal for

SIG = 2#1111_0000:



24.16. SIGNAL_4

Type	Function module
Input	IN1..IN4: BOOL (input for Bitpattern S1..S4)
	TS: TIME (switching time)
Setup	S1.. S4: BYTE (Bitpattern S1 .. S4)
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.

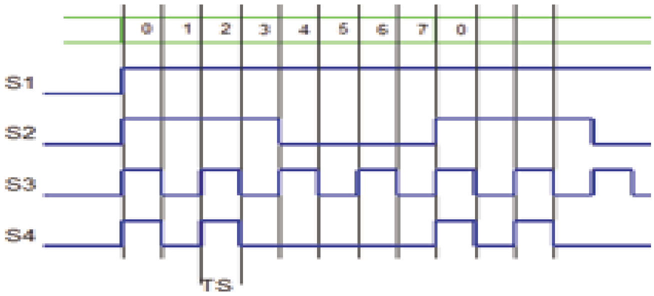
The module has the following default by Bitpattern, but can be changed by the user if required:

S1 = 2#1111_1111

S2 = 2#1111_0000

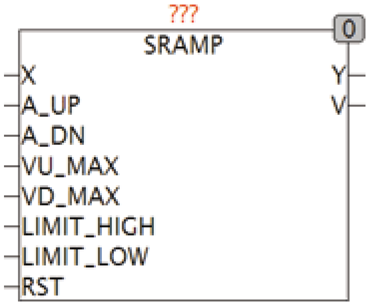
S3 = 2#1010_1010

S4 = 2#1010_0000



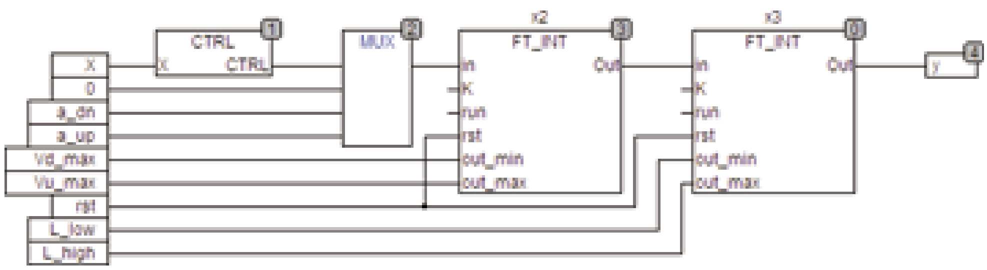
24.17. SRAMP

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)



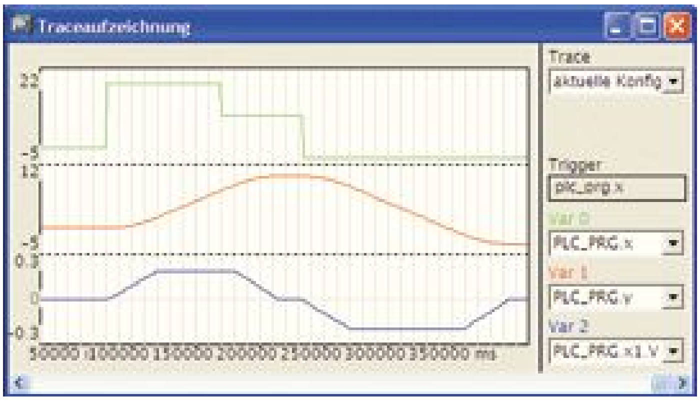
SRAMP generates an output signal which is is limited by the adjustable parameters. The output follows the input signal and is limited by maximum speed (VU_MAX and VD_MAX), upper and lower limit (LIMIT_LOW and LIMIT_HIGH), and maximum acceleration (A_UP and A_DN). SRAMP is used to drive motors, for example. 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.



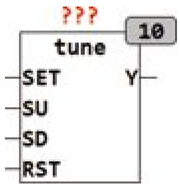
The Trace Recording shows an example of SRAMP. The input (green) increases from 0 to 20 and then immediately to 10 while the output increases with the maximum acceleration to maximum speed. Then is shown that the Input during the course may change. In this example, it slowed down in time, so that the 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.



24.18. TUNE

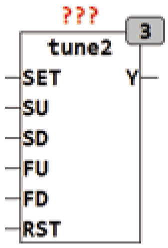
Type	Function module
Input	SET: BOOL (Asynchronous set input)
	SU, SD: BOOL (inputs for up and down)
	RST: BOOL (asynchronous reset input)
Setup	SS: REAL (step size for small step)
	SS: REAL (step size for small step)
	Limit_H: REAL (upper limit)
	RST_VAL: REAL (initial value after reset)
	RST_VAL: REAL (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)
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.

24.19. TUNE2

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)
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)
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.

25. BUFFER Management

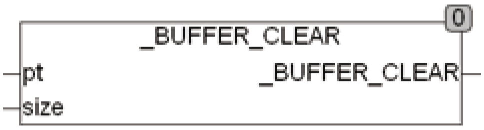
25.1. _BUFFER_CLEAR

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.

25.2. _BUFFER_INIT

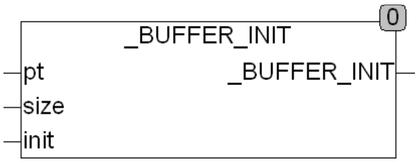
Type Function : BOOL

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.

25.3. _BUFFER_INSERT

Type Function : INT

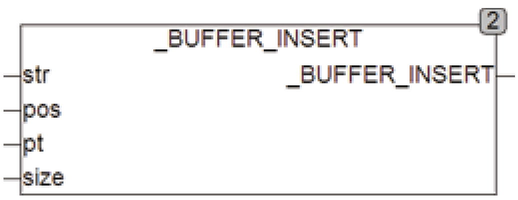
Input STR: STRING (string to be copied)

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



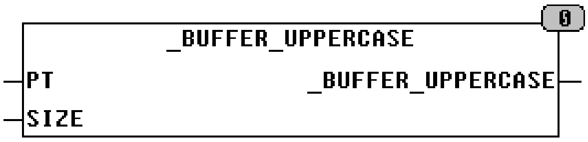
The function _BUFFER_INSERT copies a string in any array of Byte and moves the rest of the array to the length of the string. The string is stored from any position POS in the buffer. The first element in the array has the position number 0. When called, a pointer to the array and its size in bytes is 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))

25.4. _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))

25.5. _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))

25.6. BUFFER_COMP

Type Function : INT

Input PT1: POINTER (address of the first Buffer)

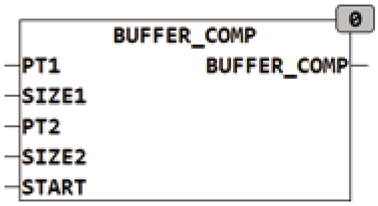
Size1: INT (size of the first buffer)

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.

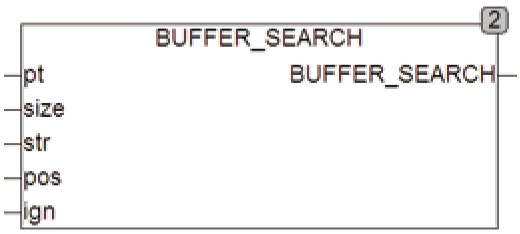
When called, a Pointer to the array and its size in bytes is passed to the function. In CoDeSys the call reads: BUFFER_COMP(ADR(BUF1), SIZEOF(BUF1), ADR(BUF2), SIZEOF(BUF2)), where BUF1 and BUF2 are the names of the arrays to be manipulated. ADR() is a standard function which indentifies the Pointer 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))

25.7. 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 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: BUFFER_SEARCH (ADR (Array), SIZEOF (ARRAY), STR, POS, IGN), where 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. 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.

25.8. BUFFER_TO_STRING

Type Function : STRING

Input PT: POINTER TO BYTE (address of the Buffer)

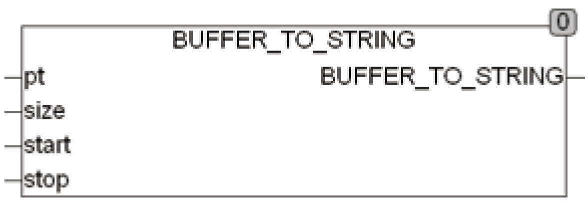
SIZE: UINT (size of the buffer)

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)

26. List Processing

26.1. 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'

26.2. 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)

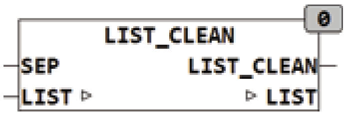
LIST_ADD adds another element to the end of a list. The list consists of Strings (elements) that begin with the separation character SEP.

Example:

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

26.3. 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.

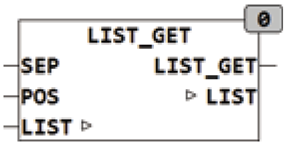
LIST_CLEAN('&ABC$23&&NEXT', 38) = '&ABC&23&NEXT'

LIST_CLEAN('&&23&&NEXT&', 38) = '&23&NEXT'

LIST_CLEAN('&&&&', 38) = ''

26.4. 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) = ''

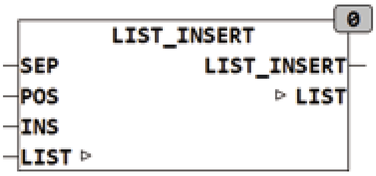
LIST_GET('&ABC&23&&NEXT', 38, 4) = 'NEXT'

LIST_GET('&ABC&23&&NEXT', 38, 5) = ''

LIST_GET('&ABC&23&&NEXT', 38, 0) = ''

26.5. 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'

26.6. 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

26.7. 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 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;
```

26.8. 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 :

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'

26.9. 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.

Index of Modules