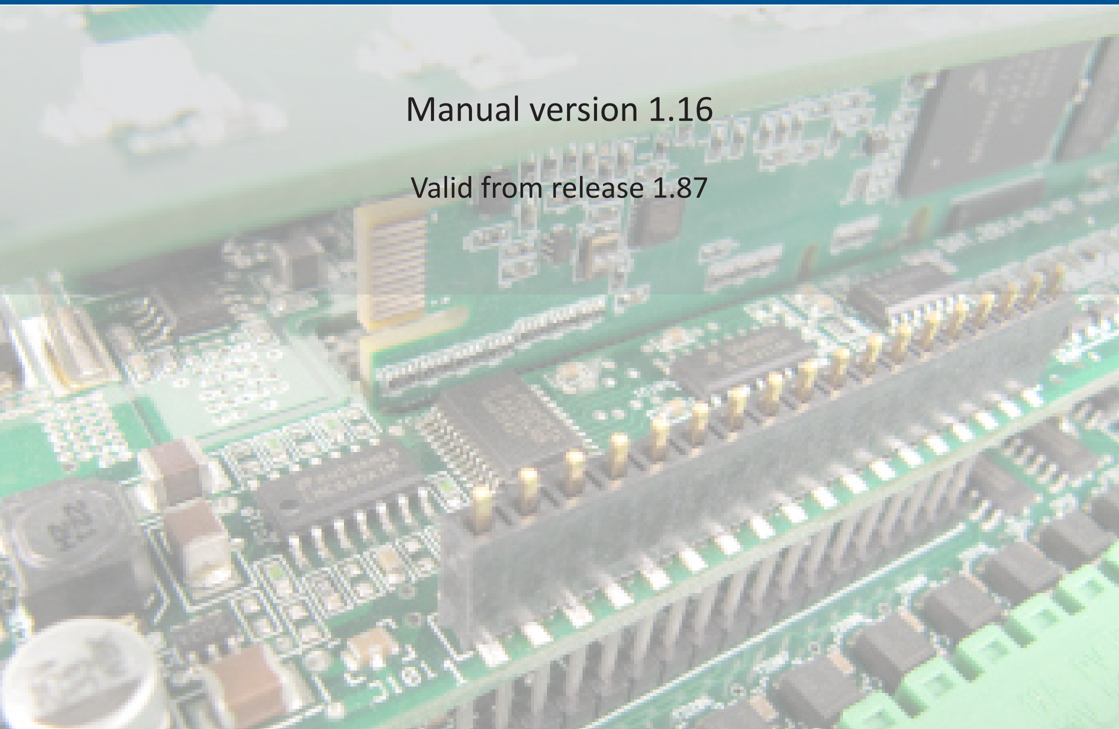
# IMSE
# Ultra

## Script Language
## Reference manual



Manual version 1.16

Valid from release 1.87

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All information in this document can be changed without notice. It is likely that certain sections will be changed at the release of new product versions. Be sure to have the latest version of this document and the corresponding version of Ultra.

# 1 Introduction

Welcome to IMSE Ultra. This series of products consists of control units IMSE UltraBase20, IMSE UltraBase30, IMSE UltraBase40, display IMSE UltraTouch and expansion modules that can be connected to expand the number of inputs and outputs.

This manual aims to describe the script language. The first part describes application scripts. These are scripts that form applications which can be mixed with graphical programming. The second part describes communication scripts. These are used to write type definitions for external units.

The manual is a reference manual, and the reader should be familiar with the general concepts of programming.

## 1.1 Manual Version

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Version 1.12, 2022-01-10. Valid from Release 1.65.

Version 1.13, 2022-06-20. Valid from Release 1.65.

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Version 1.15, 2022-11-14. Valid from Release 1.87

Version 1.16, 2024-05-20. Valid from Release 1.87

## 1.2 Other Manuals

**User manual**: a guide for how to use the configured system.

**Configuration manual**: information on how to configure the system.

**Quick start guide**: information on how to quickly get the system up and running.

All manuals are available for download at **www.abelko.se**.

# 2 UltraScript

**UltraScript**, or Ultra Platform Script (UPG), is the programming language that is the base of the Ultra platform. Everything an Ultra does, above the basic functionality of the resources like channels and alarms are dictated by a script. All graphical programs are translated to scripts to be executed.

You can do a lot with the graphical programming tool, but there are a few things that cannot be expressed with it. There may also be tasks that is possible to do graphically but are more easily implemented in script. There is also the matter of personal preferences. Some people are more comfortable using written programming language, others prefer graphical programming.

## 2.1 Language Basics

The UltraScript language is a programming language specifically for the Ultra platform. It has a syntax based on other languages like Pascal, Modula2 and Structured text. It is an imperative language which means that it works in the same basic way most languages do. An experienced programmer should not find it difficult to begin programming UltraScript using examples.

Some common language constructs are not part of the UltraScript language. It does not for example have *for* or *while loops*, or indexed arrays. The reason for this is that these are "dangerous" language constructs. Loops may, through programmer mistakes, end up being eternal and an array index may be out of bonds. That would be really dangerous in a control loop causing the system to lock up, or go into some advanced error handling. The UltraScript language has eliminated the need for these constructs, and thus potential errors. It is a little bit simpler than full programming languages, but still powerful enough, safer and easy to learn.

The Ultra platform runs on a one second tick. All applications and routines are run once every second, calculating new output values and internal states. There is therefore no main loop in a script application or an end.

## 2.2 UltraScript vs WMPro Scripts

The Ultra platform is the successor of the IMSE WebMaster pro, and the script language is based on the Goliath Platform Script (GPS) used in WMPro. The basic syntax of a routine is still the same, but the new application concept of the Ultra makes it impossible to maintain full backward compatibility. WMPro scripts have to be transformed into application scripts. This involves changing some declarations but not the algorithm part of the script. There are however new powerful language constructs in UltraScript, so don't stop reading now even if you are an experienced WMPro programmer.

GFBI type definitions written for WMPro can be used without change in an Ultra device. The Ultra does allow new more powerful and easily read syntax to be used, so the opposite is not automatically true.

# 3 Application Scripts

An application in an Ultra controller consists of an application script and all its associated resources, like channels, alarms, parameters, overviews etc. The application resource is a container for all the parts of an application.

Applications can be hierarchically organized. A **top level application** can contain sub applications, which also can in their turn contain sub applications. **Sub applications** will always have a parent application which runs them. Only top level applications can be started and stopped independently.

An application cannot run unless it has a syntactically correct application script associated with it. The application script has the same syntax regardless if it is a top level application or a sub application. It is the configuration of the application resource that decides whether it is at top level or not.

Applications do not communicate with physical IO directly. It defines a set of input and output channels through which it communicates with other parts of the system.  At top level the graphical programming tool is used to connect the application inputs and outputs to IO-units that in the end correspond to physical IO. Application IO's can also be connected to other applications.

Groups and objects are other ways for an application to interact with the rest of the world. This is described in a separate chapter. *Groups and objects will be implemented in later releases.*

When running an application it will be executed once every second. The basic sequence is: inputs are updated, alarms are updated, the application scripts are executed and lastly outputs are updated.

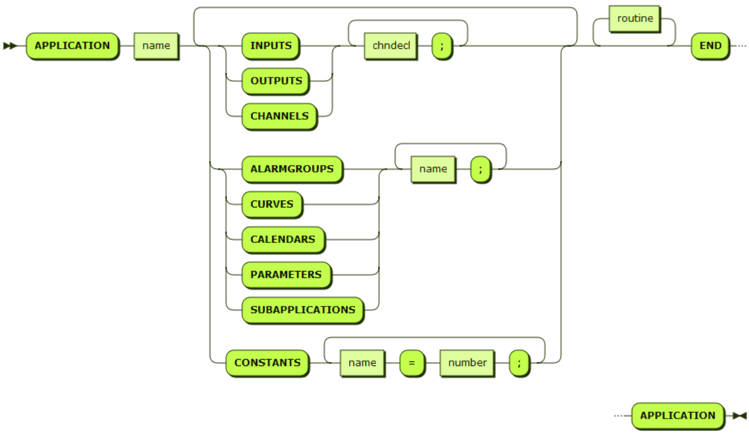
## 3.1 Declaration

The application script consists of a resource declaration part (where the resources it will access are declared), a sub application declaration part and a routine declaration part.

### 3.1.1 Example

```
APPLICATION MyApplication
  INPUTS
    OutdoorTemp;
    SystemFwrdTemp ALARMS LowTemp, HighTemp;
  OUTPUTS
    Heater;
  PARAMETERS
    Boost;
  CURVES
    SetPointCurve;
  CALENDARS
    Summer;
  SUBAPPLICATIONS
    AnotherApp;

  ROUTINE HeatCtrl
  VAR
    SetPoint;
  BEGIN
    SetPoint := SetPointCurve(OutdoorTemp) + Boost;
    AnotherApp.SetPoint <- SetPoint;
    AnotherApp.CurrentVal <- SystemFwrdTemp;
    CALL(AnotherApp);
    Heater <- AnotherApp.Out;

    IF SystemFwrdTemp.LowTemp THEN
      Heater <- 100;
    ENDIF;

    IF SystemFwrdTemp.HighTemp THEN
      Heater <- 0;
    ENDIF;

    IF Summer THEN
      Heater <- 0;
    ENDIF;
  END;
END APPLICATION;
```

### 3.1.2 Syntax Graph




*Syntaxgraph 1: application*

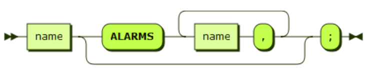
### 3.1.3 Names

Applications and all other resources have a name. This is the identity of the resource. It is stored as an identity string in the resource. The names must be unique within the application, and the named resources must exist. There is an option to automatically create missing resources when parsing a script. This makes it easier to write scripts, but the programmer must remember to configure the empty resources afterward. They are created only with the identity string *defined*.

Sub applications cannot be auto created. They must be created manually in advance, as a sub application to the application you are coding. Missing resources generates syntax error.

### 3.1.4 Inputs, Outputs and Channels - ChnDecl

Inputs, outputs and channels are all channels. They are defined according to the following syntax graph:




*Syntaxgraph 2: chndecl*

When defining a channel you also define its alarms by naming them. This is required to access them from script.

**Input channels** are channels that can be assigned values from parent applications. In the graphical programming they will appear as inputs on the application block. You are not allowed to assign values to input channels in the application script, they are read only.

**Output channels** are channels that can be read by parent applications and appear as application outputs in graphical programming.

Channels declared with the `CHANNEL` keyword are internal to the application.

### 3.1.5 Routine Declaration Part

The final part of the application is the routine declaration part. This may contain one or many routines. These define what the application actually does.

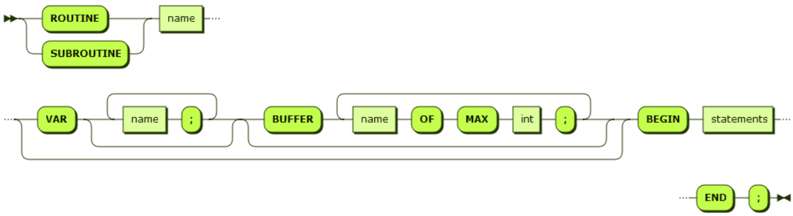
All declared routines in an application will be executed in the declared order when the application is executed. Routines can also be declared as `SUBROUTINES`. These routines will not be automatically executed. They are executed when explicitly called using a `CALL` statement.

# 4 Routines

Routines correspond to *procedures* or *void functions* in other programming languages. They may define local variables and they define statements that do things to the local variables or the resources declared in the application declaration.

The example code in 3.1.1 contains a routine declaration.

A routine may also be declared as `SUBROUTINE`. All routines will be executed when the application is executed, but a sub routine will only be executed when explicitly called from another routine or a parent application.




*Syntaxgraph 3: routine*

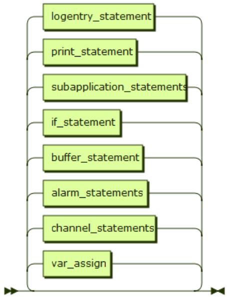
## 4.1 Syntax Graph

Variables are declared simply by naming them. Buffers will be explained in a separate chapter.

Between `BEGIN` and `END` you place the statements that make up the program.

# 5 Statements

Statements are program code that makes something happen or controls the flow of a program. The most important are **assignments**, **if statements** and **calls**. There are other statements, which will be explained in this chapter or in subsequent chapters describing special features.




*Syntaxgraph 4: statements*

Expressions are common parts of statement syntax. Expressions will be explained in chapter 6.

## 5.1 Assignments

In general you can assign values to channels, output channels and variables. The script language makes a distinction between variable assignment and channel assignment with different syntax.

### 5.1.1 IF-statements

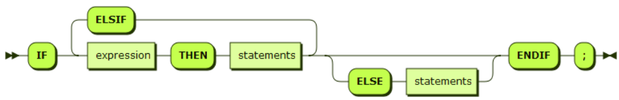



*Illustration 1: if-statement*

If-statements are the main program control flow mechanism in UltraScript.

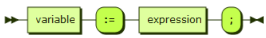
If the expression after `IF` keyword is evaluated to a nonzero value it is considered true and the statements after `THEN` will be executed. If it is zero the next `ELSIF` will be tried. If no `IF` or `ELSIF` expression is nonzero the `ELSE` statements will be executed, if it exists.

```
ROUTINE IfExamples
  BEGIN
    IF Temp > 95 THEN
```

```
      Warning <- 1;
    ELSE
      Warning <- 0;
    ENDIF;

    IF Temp > 80 THEN
      Valve <- 100;
    ELSIF Temp > 60 THEN
      Valve <- 60;
    ELSIF Temp > 40 THEN
      Valve <- 20;
    ELSE
      Valve <- 0;
    ENDIF;

    IF Force THEN
      Valve <- FValue;
    ENDIF;
  END;
```

### 5.1.2 Variable Assignment

Variable assignment is done using a Pascal like hard assignment with ':='. The variable is local to the routine, so you can be sure that it will have the assigned value until it is assigned another value in the same routine.




*Syntaxgraph 5: assign_var*

When the application is started or restarted, all variables begin with the value zero.

### 5.1.3 Channel Value Assignment

Channels are assigned new values using the '<-' syntax, as shown in the `IF`-statement example. This arrow-like operator mean you are putting a value into the channel. The channel is global to the application, and can be affected by other routines and other functionality the channel has. You can therefore not be sure that it will continue to have the value that has been assigned to it.

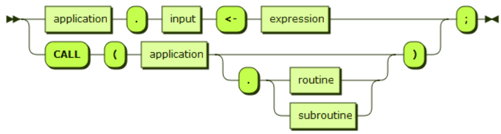
Channels can also be connected to the outside world so when assigning a channel it can affect physical outputs, which indeed in the end often is the purpose of the application.

The purpose of having two assignment operators ':= ' and '<-' is to make this potential different effect visible.

More details about channels are described in chapter 7. Assigning values to sub application channels is described in the chapter 10.

## 5.2 Call Statements

The call statement is invoked to execute a subroutine, a subapplication, a sub routine of a subapplication or a group iterator. The syntax graph below also describes assignment to subapplication input channels.




*Syntaxgraph 6: subapplication_statement*

Making a call to a subapplication, as in the example in 3.1.1, causes all the routines in that application to be executed. Calling a specific subroutine in the same application or in a subapplication executes only that specific subroutine.

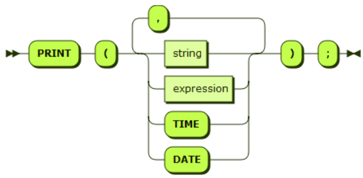
```
APPLICATION ScriptExample
INPUTS
  Run;
  Reset;
  Angle;
  Position;
OUTPUTS
  Signal;
SUBAPPLICATIONS
  InvertedPendulum;

SUBROUTINE RestPosition
BEGIN
  IF ABS(Position) > 0.5 THEN
    Signal <- -25 * SIGN(Position);
  ELSE
    Signal <- 0;
  ENDIF;
END;

ROUTINE Main
BEGIN
  IF Run THEN
    InvertedPendulum.Angle <- Angle;
    InvertedPendulum.Position <- Position;
    CALL (InvertedPendulum.Update);
    Signal <- InvertedPendulum.Signal;
  ELSIF Reset THEN
    CALL (RestPosition);
  ELSE
    Signal <- 0;
```

```
  ENDIF;
END;

END APPLICATION;
```

Group scripts and iterators are explained in chapter 13.

## 5.3 Print Statements

Print statements can be used for debugging purposes. A line of text can be printed to the application print. The application log is a circular buffer so excessive printing may hide older interesting information.




*Syntaxgraph 7: print_statement*

*DATE* and *TIME* adds current date and time to the string. Note that no extra spaces are added before an expression value. Add a space as the last character in a string to separate it from a following value.

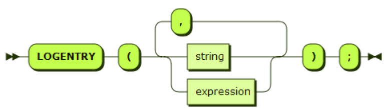
```
PRINT(DATE, TIME, "Temp ", Temp);
```

This example will print a string like:

*2013-11-04 10:32:45 Temp 95.3*

## 5.4 Logentry Statements

A logentry statement puts a message into the alarm log. This can be used to correlate important events with alarms in a system, like start and stops of machinery, or entry into special operating modes. Beware however that logentry messages may quickly fill the alarm log if overused. The alarm log has a limited number of entries and the oldest will be lost when a new is entered.




*Syntaxgraph 8: logentry_statement*

The logentry statement has a similar syntax as the print statement, except that the time and date keywords cannot be used. The log entry message will receive a time stamp in the log anyway.

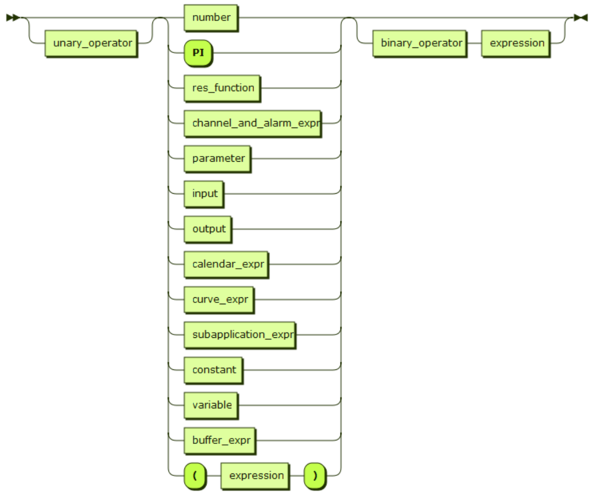
Example:

```
LOGENTRY( “Summer blocking activated. ( “, Temp, “ °C)“);
```

This logentry could be used when a heating system passes a limit that makes it entry a summer mode, when heating is blocked.

# 6 Expressions

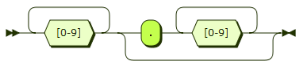
Expressions are syntactic constructs that evaluates to a single value. This includes among others constant numbers, names of variables and channels, mathematical operators and functions.




*Syntaxgraph 9: expression*

## 6.1 Numbers

The syntax for numbers is intuitive. A dot is used as decimal separator.




*Syntaxgraph 10: number*

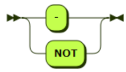
## 6.2 Resource Names

All names defined in the application declaration, except curves and sub applications, can be used in expressions. They will represent the present value of the resource it represents.

Variables declared in a routine declaration can be used in expressions within that routine. Buffer names and routine names have no value associated with them and cannot be used in expressions.

## 6.3 Operators

### 6.3.1 Unary Operators



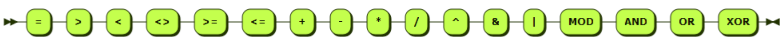

*Syntaxgraph 11: unary_operator*

An unary operator is an operator that operates on a single operand. The operand is to the right of the operator. The minus sign will negate the value standing on the right side of it. This means that writing –1.23 becomes syntactically correct.

The `NOT` operator is a Boolean operator. All Boolean operators treat a nonzero value as true and zero as false. The not operator will make nonzero values zero, and change zero values to the nonzero value of one. All Boolean operations in the script language resulting in the value true will be represented by the value one.

### 6.3.2 Infix Operators

Infix operators work on two operands, and is placed between the two operands. In an expression with infix operators precedence is important. 4 / 2 + 2 is 4 and not 1, because the / operator has higher precedence than +. UltraScript uses standard mathematical precedence*. (Note; this may differ from precedence order of gps-scripts int the WMPro.)*




*Syntaxgraph 12: infix_operator*

The table below lists all infix operators.

| Operator | Boolean result | Comment |
|---|---|---|
| XOR | X | Logic exclusive or |
| OR | X | Logic or |
| AND | X | Logic and |
| ^ | | Power, x^y is the same as $x^y$. |
| * | | Multiplication |
| / | | Division |
| MOD | | Modulus, 11 MOD 5 is 1. |
| - | | Subtraction |
| + | | Addition |
| <> | X | Not equal |
| <= | X | Smaller than or equal |
| >= | X | Bigger than or equal |
| < | X | Smaller than |
| > | X | Bigger than |
| = | X | Equal |
| & | | Bitwise and |
| \| | | Bitwise or |

Operators with a Boolean result will return either one or zero.

### 6.3.3 Parenthesis

Parenthesis can be used to enforce or clarify precedence behavior. An expression between parentheses is treated as a separate expression.

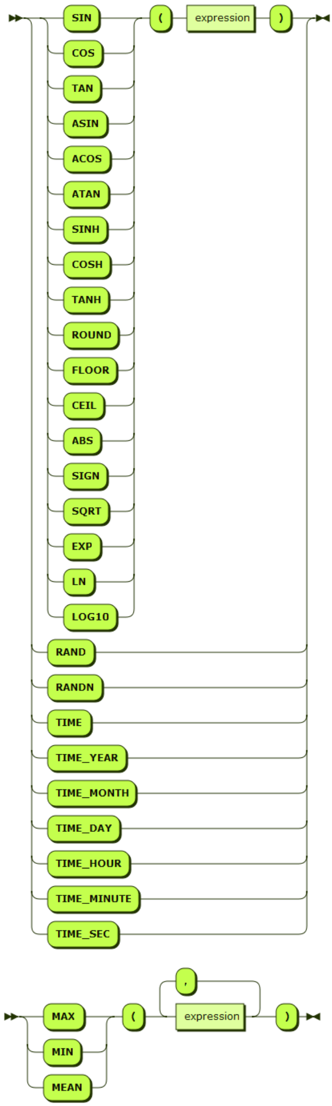
## 6.4 Reserved Functions

Reserved functions are mathematical functions that take an argument and return a calculated value. There are also reserved functions that need no argument. The constant PI works the same way, but is a reserved constant.

Most functions are standard library functions and should not require any comments. Angels are presented in radians. The `SIGN` function returns −1 for negative arguments, 1 for positive and 0 if the argument is zero.

`RAND` and `RANDN` return random numbers. `RAND` returns a uniformly distributed random number between 0 and 1. `RANDN` returns numbers with the approximate N(0,1) normal distribution.

`TIME` returns current time in seconds. The other time functions returns different parts of current time and date. `TIME_SEC` for example returns a value between 0 and 59, based on the real time clock. Note that the real time clock can be changed by a user or SNTP update. If you need a time counter that is constantly increasing you can achieve this by adding one to a variable for every call to a routine. When an application is running its routines will be called once every second.




*Syntaxgraph 14: reserved_function*

## 6.5 Other Expressions

There are other syntactically correct expressions closely related to specific resources. These are explained in separate chapters.

## 6.6 Examples and Error Handling

There are expressions that in some cases cannot be evaluated. In many program languages this results in an exception or in a crash. In a controller application this may be dangerous. A poorly written program may run perfectly for years before it encounters a situation that cannot be evaluated. Rather than crash, the UltraScript interpreter handles such errors by the best it can. The result of a division by zero is infinite. The script parser cannot calculate with infinity, therefore it evaluates division by zero to a very large number, that in every practical sense is close to infinity.

Below is a table with example expressions and what they evaluate to. X, y and z are variables assigned the values 4, 2, and 100.

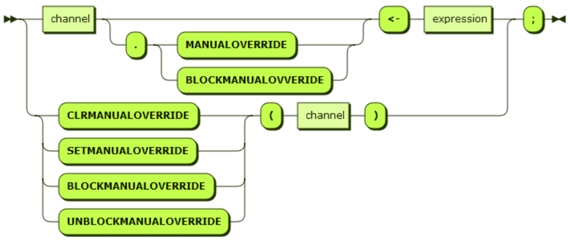
```
x := 4.000000
y := 2.000000
z := 100.000000

x^y+0.5*z  66.000000
SIN(PI/2.0)       1.000000
FLOOR(11/5)       2.000000
11 MOD 5   1.000000
x=2        0.000000
x=2*y             1.000000
x AND y > z       0.000000
SIGN(x * -PI)     -1.000000
SQRT(x)           2.000000
SQRT(-1)   0.000000
2/0        99999999394896024185l8643389688.804746
LN(-1)            -99999999394896024185l8643389688.804746
LOG10(0)   -99999999394896024185l8643389688.804746
```

The last four examples are examples of illegal mathematical operations. They do however give results anyway. The results are the most reasonable results possible, and will prevent the system from crash. The last three are large numbers that represents positive and negative infinites.

# 7 Channels

Channel declarations are explained in 3.1.4. All channels can be used in expressions but input channels cannot be assigned new values.

Apart from the channel value itself there are expressions and statements regarding manual override of channels. A syntax graph for channel statements is shown below. A combined syntax graph for channel and alarm expressions is shown in chapter 8.




*Syntaxgraph 15: channel_statements*

## 7.1 Manual Override

It is possible to manually override a channels value. When overridden by a user the value assigned to it by script is hidden. All references to its current value will return the override value, both in expressions and when displayed. When the override is disabled (or timed out) the last assigned value will be used as current value again.

Whether a channel can be overridden or not is part of its settings (check **Allow Manual Override** under **Optional settings** in a channel or IO-channel edit dialogue).

In some cases it may be dangerous to override a channel value. It is therefore possible to temporarily disable the possibility to override a channel from script. When blocked by script the user cannot override the channel. This is done by assigning one to `channel.BLOCKMANUALOVERRIDE`. Assigning zero unblocks it again. This does not affect the user setting for enabling manual override for a channel. If it is not enabled, unblocking it will not enable manual override. As a statement `channel.BLOCKMANUALOVERRIDE` return zero if manual override is enabled and not blocked, else one.

`MANUALOVERRIDE` in expression returns one if the channel is in manual override, else zero. Assigning 1 or 0 to `MANUALOVERRIDE` sets manual override on and off as if the user had done it. This means that it will not be enabled if manual override is not enabled or blocked. Note that enabling or disabling manual override from script only lasts for one cycle, until the script is executed again. This may or may not, depending on the script in question, execute the override again.

There are also functions like statements that do the same thing for backward compatibility with WMPro. `CLRMANUALOVVERIDE(channel)` and `SETMANUALOVERRIDE(channel)` clears and sets manual override , equivalent to assigning `channel.MANUALOVERRIDE <- 0` and `channel.MANUALOVERRIDE <- 1.`

`BLOCKMANUALOVERRIDE(channel)` and `UNBLOCKMANUALOVERRIDE(channel)` does the same thing or `channel.BLOCKMANUALOVERRIDE`.

`ISMANUALOVERRIDE(channel)` is an expression that returns one if the channel currently is overridden, like `channel.MANUALOVERRIDE.`

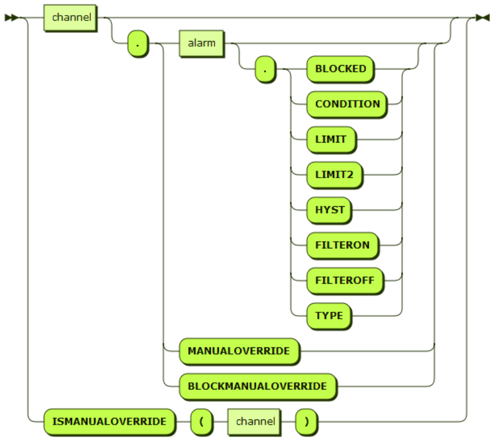
## 7.2 Count Total Active Manual Overrides

The special keyword `MO_CountActiveTotal` returns the number of manual overrides that are active for any Channel or IOChannel in the device. (It is available from release 1.48.)

The intended use is to make it possible to trigger an alarm if there are any manual overrides active.

# 8 Alarms

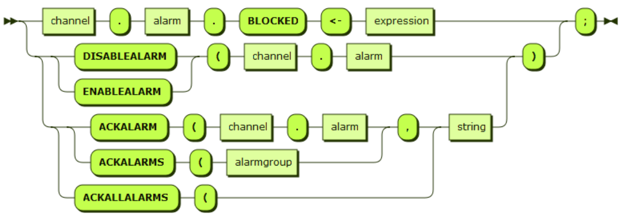
All alarms belong to a channel. They monitors the channel and are either active = 1, or inactive = 0. Alarm declarations are explained in 3.1.4.




*Syntaxgraph 16: channel_and_alarm_expressions*

To use the alarm status in an expression write the channel name dot alarm name (channelname.alarmname). It is also possible to access several alarm property values in expressions.

It is not possible to assign values to alarms but it is possible to disable and enable alarms.




*Syntaxgraph 17: alarm_statements*

You can acknowledge a single alarm or all alarms belonging to the application and its sub applications. The string argument is the string used as signature. The intended use of these functions is to connect a pushbutton to an input and use it as an alarm acknowledgement button.

## 8.1 Blocking Alarms

It can be very useful to disable alarms when a plant is in a state where it is not valid, or when a function in an application is not used.

It is possible to write to the `BLOCKED` property of an alarm, which is a boolean. For backward compatibility there are also `DISABLEALARM` and `ENABLEALARM` statements.

In blocked state an alarm cannot become active. Active alarms becomes inactive when blocked. If there is an active alarm that needs to be acknowledged, it remains active until it is acknowledged.

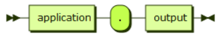
# 9 Curves

A curve is an interpolating lookup table, presented as a configurable curve. It can be called in expressions like a function with an argument.

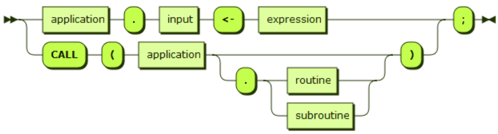

*Syntaxgraph 18: curve_expression*

The value of the argument expression is used as a point on the x-axis, and the corresponding value on the y-axis is returned.

# 10 Subapplications




*Syntaxgraph 19: subapplication_expression*

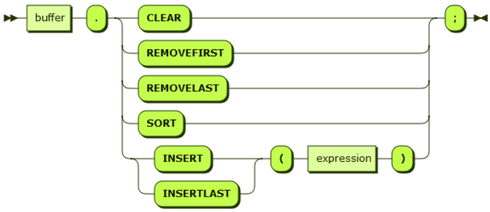



*Syntaxgraph 20: subapplication_statement*

# 11 Buffers

A buffer is a local variable in a routine that can hold many values. When defined it is decided how many values it can hold as a maximum. This number must be between 2 and 4000. The syntax for defining a buffer is described in chapter 4.

## 11.1 Buffer Statements




*Syntaxgraph 21: buffer_statement*

A buffer starts empty. The `INSERT` statement inserts a value as first element in the buffer. If there are elements in the buffer they will be shifted left (if you presume the rightmost value is the first). If the buffer is full the last value will be lost.

Then `INSERTLAST` statement is equivalent to `INSERT`, but it inserts the value last, and the first element is lost if the buffer is full.

The `REMOVEFIRST` and `REMOVELAST` statements remove one value from either end of the buffer, if it is not empty. `CLEAR` removes all values from the buffer so that it becomes empty.

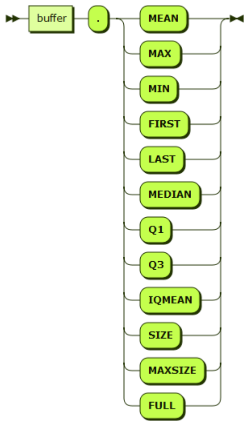
The `SORT` statement sorts the values in the buffer so that the smallest value becomes the first and the largest the last.

## 11.2 Buffer Expressions

A buffer itself does not evaluate to a value. Using dot notation there are however several statistical values that can be used, as well as some status information. `FIRST` and `LAST` returns the first or last value in the buffer, or zero if it is empty. `MAX` and `MIN` return the highest or lowest value, or zero if the buffer is empty.

`MEAN`, `MEDIAN`, `Q1`, `Q3` and `IQMEAN` returns statistical results. `Q1` and `Q3` returns the first or last quartile. `IQMEAN` returns the mean value of the values between `Q1` and `Q3`. All these returns zero if the buffer is empty.

`MAXSIZE` returns the defined max size of the buffer and `SIZE` returns the current number of values in the buffer. `FULL` returns 1 if the buffer is full, else zero.




*Syntaxgraph 22: buffer_expression*

# 12 Communication monitoring (portal)

It is possible to access the status of the portal update and thus implement a restart function of a modem or similar.

`StatusPortalAbelko <- SYSSTAT.PortalStatus(1);`
The above line returns the status of the portal update for the first defined portal and sends that value to the variable `StatusPortalAbelko`.

The status codes available are as follows, starting at 0:

`PORTAL_STATUS_NOTUPDATED`, // until it is updated once

`PORTAL_STATUS_DISABLED`, // after it has run once and is disabled it will get this status

`PORTAL_STATUS_UPDATED`, // updated ok

`PORTAL_STATUS_UPDATEERROR`, // some error in com with portalserver

`PORTAL_STATUS_DENIED`, // portalserver said 403

`PORTAL_STATUS_INTERNALERROR` // curl error

If everything is ok and the portal is updated, you get a status `PORTAL_STATUS_UPDATED`, i.e. a 2nd in the variable `StatusPortalAbelko`.

`ErrorPortalAbelko <- SYSSTAT.PortalErrorCounter(1);`
The above line indicates how many failed attempts were made to update the portal. Resets on a successful attempt.

# 13 Groups

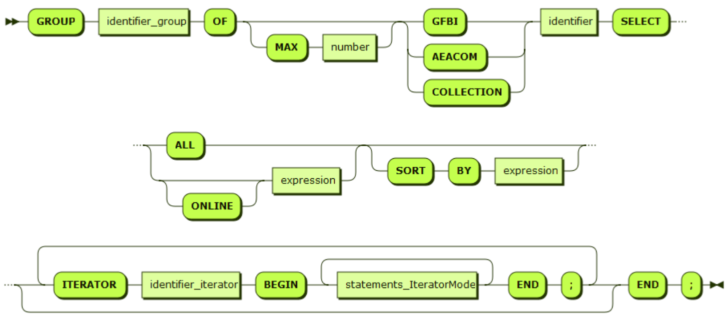
Groups can be created to handle groups of things, like external units of the same type, or instances of collections of channels. Groups lets you write iterators that executes the same code for every thing in the group, and lets you get statistical values from the group. Conditions can be defined for what things are included in the group, and it may be sorted.

There are three common scenarios where group scripts are very useful.

1. Prioritization tasks, like run time equalization, where you choose which thing to start or stop with varying demand depending on a prioritization criteria, like run time.
2. Statistical readouts; When you have many sensors connected on a communication bus, and want the mean, max or min value, a group will produce that easily. A group can handle a varying number of sensors being connected and going offline.
3. Plug and play functionality; A group can be set up to include all external devices of a defined type connected to a communication port. With a group iterator it can be given instant functionality when it is connected. An IO unit type may be programmed to start working as a shunt group controller, so that the installer can add any number of shunt groups without using the graphical programming tool.

You will need to understand `GFBI`, `AEACOM` or `COLLECTION` described later to fully understand and utilize `GROUP` scripts.

## 13.1 Group Syntax




*Syntaxgraph 39: group*

A group is defined in an application, at the same level as a ROUTINE. Chapter 13.4 contains a complete example.

A Group may reference GFBI or AEACOM units, or a COLLECTION. The identifier after the GFBI or AEACOM keyword must match the TYPEID identifier of a communication definition script. If the optional TYPEID keyword  is missing in a definition script, it must match the NAMED identifier. If the identifier does not match any installed script, you will get a syntax error. Note that communication definition scripts are not included in a template.

The COLLECTION keyword must be followed by a collection identifier already defined in the same application.

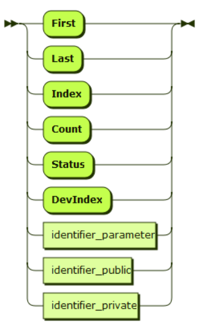
The SELECT keyword must be followed by an expression that evaluates to true or false, or the keyword ALL. The select expression can reference values in the things the group references. These are declared as PARAMETER, PUBLIC and PRIVATE in communication definitions, and INPUTS, OUTPUTS and PRIVATE in collections. Only items for which the expression is true will be included.

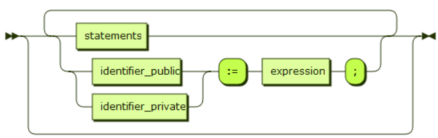
ONLINE is a special selection keyword that prescribes that only external units with status OK will be included.

SORT BY is an optional sorting order expression. The items will be sorted in ascending order for iterator execution.

### 13.1.1 Iterator

A group can contain zero or more ITERATOR declarations. The statements between BEGIN and END will be performed once for each item in the group. In iterator mode expressions and statements may contain values declared for the type of item the group contains, and some special expressions are available.




*Syntaxgraph 40: IteratorMode statements and expression (left)*

Explanations of the automatic variables that can be used in expressions in an iterator:

| **Name** | **Value** |
|---|---|
| Index | Index in the group members list. Starts at zero and ends at Count. |
| Count | The number of members in the group. |
| Status | Device status: 0 = OK, 1 = FAILED, 2 = TRYING |
| First | One during the first execution of an iterator, when Index is one. Else zero. |
| Last | One during the last execution of an iterator, when Index = Count. Else zero. |
| DevIn-dex | The index in the external devices list for the device the iterator is currently operating on. |

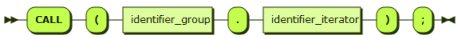
It is important to know that if status is used in a communication script for a variable it is not possible to reach that value because it is overridden by the automatic variable status that hold the device status. Status is however not a reserved word but due to the reasons given it is not recommended to use as a variable name anywhere in scripts.

## 13.2 Group statements and expressions

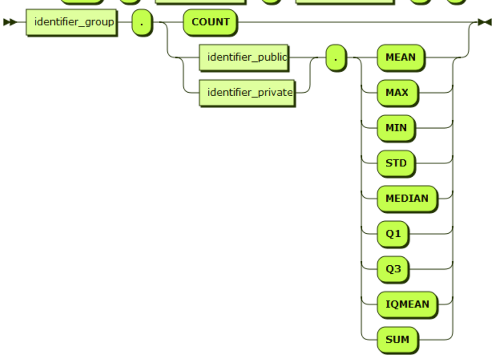
A previously defined `GROUP` can be referenced in routines and subroutines.

Iterators can be invoked using a `CALL` statement.

*Syntaxgraph 41: Group statement*




Properties of the group can be used in expressions.

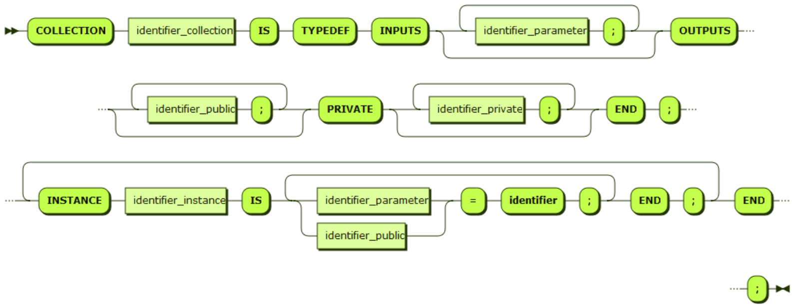



*Syntaxgraph 42: Group expression*

Note that private variables cannot be accessed outside iterators. `COUNT` returns the number of items in the group. Keywords after an item value identifier denotes different statistical properties. Most are quite self-explanatory. `STD` is standard deviation, `MEDIAN` is the middle value, `Q1` and `Q3` is the first and third quartile values.

## 13.3 Collection

Collections is a way to define 'things' to make groups of in an application script. A type definition defines what the things in the collection all consists of, and instances connects the things to channels and parameters.




*Syntaxgraph 43: Collection*

Each INSTANCE creates an instantiated collection where the INPUTS and OUTPUTS defined in the TYPEDEF section are set to alias channels or parameters defined by the APPLICATION.

INPUTS corresponds to PARAMETER in a communication script. An iterator can not change the value of an input, and inputs may be connected any channel or parameter.

OUTPUTS can be changed by iterators, and can therefore only be connected to channels declared as CHANNELS or OUTPUTS in the APPLICATION. PRIVATE declares local variables that can not be connected to anything else.

The naming aliasing created the collection definition can be used in regular scripts to, using dot notation like the example:

```
CollectionX.InstanceY.OutputZ <- CollectionX.InstanceY.InputQ;
```

## 13.4 Example

Below is a small example of how group scripts and collections may be used.

```
APPLICATION CollectionDemo
  INPUTS
    Rel1_MO;
    Rel2_MO;
    Rel3_MO;
```

```
    Demand;
  OUTPUTS
    Rel1_Out;
    Rel2_Out;
    Rel3_Out;

  CHANNELS
    Rel1_OnTime;
    Rel2_OnTime;
    Rel3_OnTime;

    Count_Total;
    Count_On;
    Count_Off;

    Count_Demanded;

  COLLECTION Something IS
    TYPEDEF
      INPUTS
        Blocked;
      OUTPUTS
        Run;
        RTime;
    END;
    INSTANCE Thing1 IS
      Blocked = Rel1_MO;
      RTime = Rel1_OnTime;
      Run = Rel1_Out;
    END;
    INSTANCE Thing2 IS
      Blocked = Rel2_MO;
      RTime = Rel2_OnTime;
      Run = Rel2_Out;
    END;
    INSTANCE Thing3 IS
      Blocked = Rel3_MO;
      RTime = Rel3_OnTime;
      Run = Rel3_Out;
    END;
  END;


  GROUP AllThings OF COLLECTION Something SELECT ALL
    ITERATOR Update
    BEGIN
      RTime := RTime + Run;
      IF Blocked THEN
        Run := 0;
      ENDIF;
    END;
  END;
```

```
    GROUP OnThings OF COLLECTION Something
      SELECT (Run = 1 AND Blocked = 0)
      SORT BY RTime
      ITERATOR StopOne
      BEGIN
        IF Last THEN
          Run := 0;
        ENDIF;
      END;
    END;

    GROUP OffThings OF COLLECTION Something
      SELECT (Run = 0 AND Blocked = 0)
      SORT BY RTime
      ITERATOR StartOne
      BEGIN
        IF First THEN
          Run := 1;
        ENDIF;
      END;
    END;

    ROUTINE Main
    BEGIN
      Count_Total <- AllThings.COUNT;
      Count_On <- OnThings.COUNT;
      Count_Off <- OffThings.COUNT;

      CALL(AllThings.Update);

      Count_Demanded <- ROUND((Demand / 100) * Count_Total);

      IF Count_On < Count_Demanded THEN
        CALL(OffThings.StartOne);
      ELSIF Count_On > Count_Demanded THEN
        CALL(OnThings.StopOne);
      ENDIF;
    END;
  END APPLICATION;
```

This could be an application to start and stop cooling fans depending on the Demand input channel, ranged from 0 to 100 %.

Each fan represented by the collection of

- A Run channel output, connected to a relay
- A Blocked channel, connected to a Manual override signal
- A RTime channel to store running time, connected to a persistent channel

Three Instances are defined, so the example fits in an UltraBase20.

The AllThings group includes all defined instances. It is used to count how many instances there are. It also has an iterator Update that counts up the running time if it is running, and ensures that the output is turned off if the Block signal is high.

The OnThings group includes only things that are on and not blocked. It is sorted by running time. The iterator StopOne uses the Last keyword to set the Run channel of the thing with the highest running time off.

The OffThings gropup is the opposite. It includes things that are off, and has the iterator StartOne that set Run on for the thing with the shortest running time.

The Main routine updates a few channels to display how many things (fans) are running and not running, and calls the Update iterator for the AllThings group.

Count_Demanded is how many things (fans) that should be on, and is calculated from the Demand input and how many are available.

If the number of things that are on is different from the demand, one is started or stopped using iterator calls. The iterators ensures that running time is distributed equally among the things. If one thing becomes blocked, the Update iterator will turn it off. The number of OnThings decreases, so another thing will automatically be started, if available.

Some additional notes. A group may be empty, containing zero things. Statistical values for empty groups will return zero, or infinity. When calling an Iterator for an empty group it will be performed zero times.

Maximum things in a group is 1024, if not explicitly defined to a lower number.

# 14 Objects

Will be implemented in later releases.

# 15 GFBI

The `DEVICETYPE` definition defines a class of external devices on RS485 using the General Field Bus Interface (GFBI). GFBI can handle protocols on the RS485 that follows these criteria:

- The WMultra is master; slaves are quiet unless they answer a question from the master.
- The size of a correct answer to a specific question is constant and known.
- Data is in binary form, no strings.
- The checksum or CRC method can be handled by GFBI (should be `True` for most protocols.)

Different device types using different protocols can be connected at the same time, given that they do not interfere with each other.

The GFBI handles telegrams. The device type definitions define how a question telegram should be compiled. The GFBI motor sends this telegram on the RS485 line and starts to listen for an answer of the correct size. If one is received within the timeout period it is parsed using the reply definition.

## 15.1 The Device Type Definition

### 15.1.1 Overview

Each device type has a name visible in the user interface and an identifier, used in scripts and as identifier in the parameter bank. For backward compatibility it is possible to use a type number. If used, the type number will be used as identifier. The identifier must be unique in a WMultra.

The definition contains a number of variables. Some used as parameters with public names, other used as values with public names and some are for internal script use only.

The communication speed and checksum type is defined for all telegrams and then the telegrams themselves are defined. Telegram definitions consist of a question compiler and an answer interpreter. They also have public descriptive names.

A scheduler is an optional part of a device type definition. If used, it contains script code run every second to decide which telegrams to send.

### 15.1.2 WMPro / WMultra Compatibility and Differences

The WMultra GFBI motor is backward compatible and accepts all device type scripts written for WMPro. WMultra syntax has however been extended to enable simpler and more versatile scripts.

The first difference is that `TYPEID` can be omitted. The ID is a string in WMultra, and the name string will be used as ID if `TYPEID` is not present. For WMultra the recommendation is to not declare a TYPEID number.

The second difference is the possibility to support multiple languages for public names in the script. This is optional but recommended for scripts that will be used in many countries.

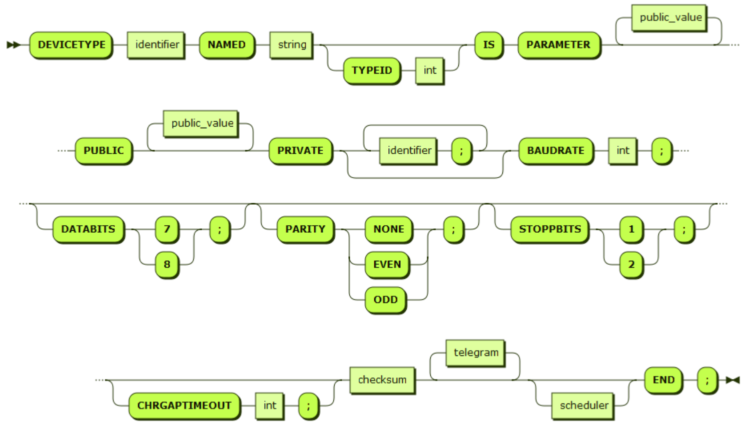
The syntax for telegram parsers and interpreters has been more relaxed. It is now possible to write this code as any other script code, with special extensions. This makes the code easier to read and more powerful. It can also handle more data types.

The last major difference is the introduction of the `SCHEDULER` script. This code is run every second and defines when a telegram should be sent. This enables a more precise control of the telegrams and can be used to implement state machines that ensures that telegrams are sent in a specific order, or only when necessary.

Another difference not visible in script code is in the enqueuing of telegrams. In WMPro each device could just have one telegram enqueued at a time. In WMultra the telegrams can be enqueued independently of each other. This means that several telegrams can be exchanged with a single device every second.

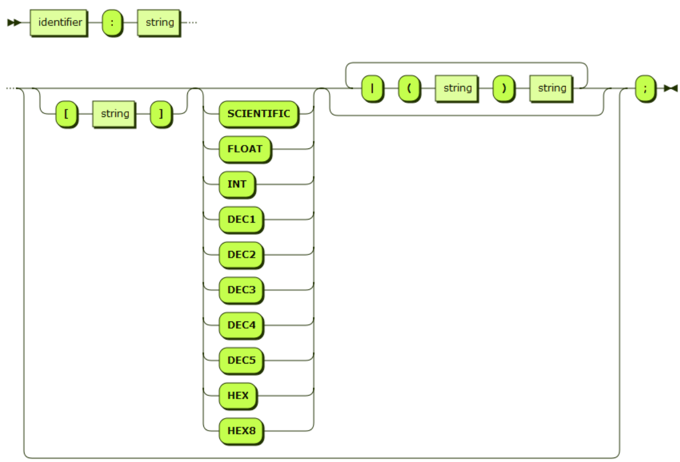
### 15.1.3 Syntax

Below is the syntax graph for a device type definition. There is no need to be overwhelmed, there will be examples later.



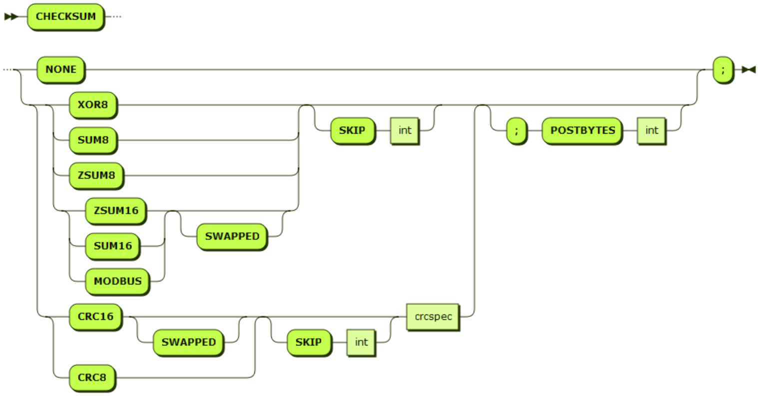

*Syntaxgraph 23: devicetype*

Parameters are outputs or settings. Public values are input values. Both can have formatting specifications in the script.




*Syntaxgraph 24: public_value*

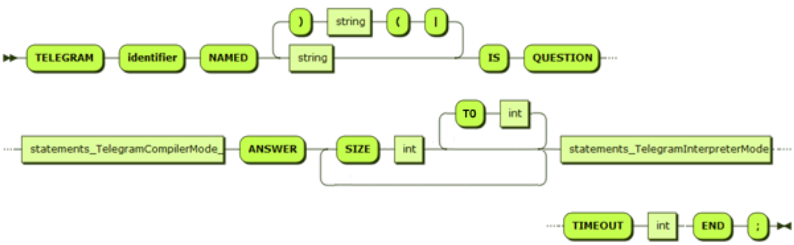
The `checksum` part of the script defines if any checksum or crc is used. The crc used in modbus is predefined, but generic crcs can be defined and some simple checksums as well. `Skip` and `postbytes` defines bytes not included in the checksum.




*Syntaxgraph 25: checksum*

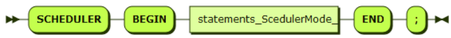

*Syntaxgraph 26: crcspec*

A `telegram` is the combination of a message sent from the master and the returned answer.



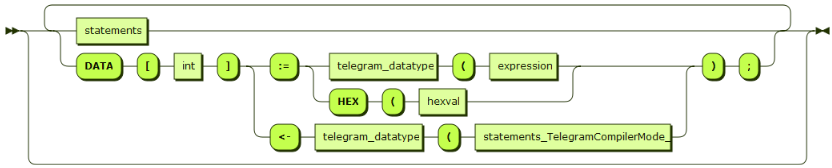

*Syntaxgraph 27: telegram*

A `scheduler` defines when telegrams are sent. If not defined in script a default scheduler is used.

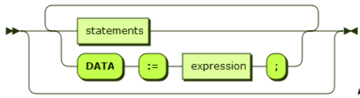



*Syntaxgraph 28: scheduler*

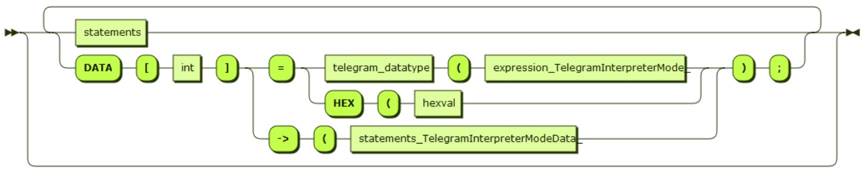
The `statements` in a telegram and scheduler are extended with special syntax depending on the mode. This mode also extends to expressions. Below are syntax graphs for these extensions.



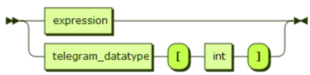

*Syntaxgraph 29: statement_TelegramCompilerMode_*



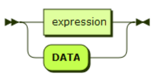

*Syntaxgraph 30: statement_TelegramCompilerModeData_*



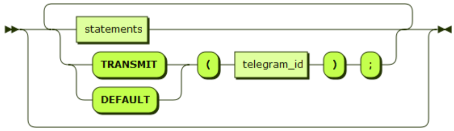

*Syntaxgraph 31: telegram_InterpreterMode_*



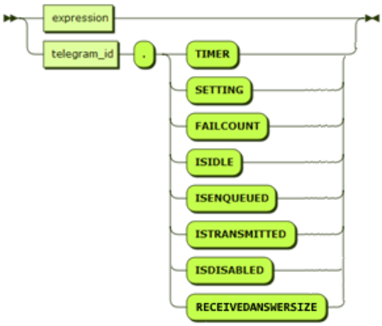

*Syntaxgraph 32: expression_InterpreterMode_*




*Syntaxgraph 33: expression_InterpreterModeData_*




*Syntaxgraph 34: statements_SchedulerMode_*




*Syntaxgraph 35: expression_SchedulerMode_*

The syntax graph below defines the keywords for data access in telegrams:


*Syntaxgraph 36: telegram_datatype*

### 15.1.4 Example

The example below illustrates many of the possibilities in a WMultra devicetype definition.

```
DEVICETYPE WMultraDemo NAMED "WMultraDemo" IS
 PARAMETER
  Address : "Address" INT
   | (sv) "Adress"
   | (en) "Address";
  DO1 :     "DO1" INT
   | (sv) "Reläutgång"
   | (en) "Relay output";
 PUBLIC
  AIN1 :    "AIN1" ["%"] DEC1
   | (sv) "Analogingång 1"
```

```
   | (en) "Analogue input 1";
  AIN2 :    "AIN2" ["%"] DEC1
   | (sv) "Analogingång 2"
   | (en) "Analogue input 2";
 PRIVATE
  DO1readback;
  LastDO;
  State;
 BAUDRATE 115200;
 DATABITS 8;
 PARITY NONE;
 STOPPBITS 1;
 CHRGAPTIMEOUT 4;
 CHECKSUM MODBUS SWAPPED;

 TELEGRAM ReadInputs NAMED "ReadInputs"
   | (sv) "Läs ingångar"
   | (en) "Read Inputs"
 IS
  QUESTION
   IF State = 0 THEN
    DATA[0] := BYTE(Address);
    DATA[1] := HEX(03);
    DATA[2] := HEX(00);
    DATA[3] := HEX(14);
    DATA[4] := HEX(00);
    DATA[5] := HEX(04);
   ELSE
    DATA[0] := BYTE(Address);
    DATA[1] := HEX(03);
    DATA[2] := HEX(00);
    DATA[3] := HEX(58);
    DATA[4] := HEX(00);
    DATA[5] := HEX(01);
   ENDIF;
  ANSWER SIZE 7 TO 13
   IF State = 0 THEN
    DATA[0] = BYTE(Address);
    DATA[1] = HEX(03);
```

```
    DATA[2] = HEX(08);
    AIN1 := RWORD[3] / 655.36;
    AIN2 := RWORD[7] / 655.36;
    State := 1;
  ELSE
    DATA[0] = BYTE(Address);
    DATA[1] = HEX(03);
    DATA[2] = HEX(02);
    IF RECEIVEDANSWERSIZE = 7 THEN
    DO1readback := BYTE[04];
    ENDIF;
    State := 0;
  ENDIF;
  TIMEOUT 300
END;

TELEGRAM WriteDO NAMED "WriteDO"
  | (sv) "Ställ relä"
  | (en) "Set relay"
IS
  QUESTION
    DATA[0] := BYTE(Address);
    DATA[1] := HEX(10);
    DATA[2] := HEX(00);
    DATA[3] := HEX(03);
    DATA[4] := HEX(00);
    DATA[5] := HEX(04);
    DATA[6] := HEX(08);
    DATA[7] := RWORD(DO1);
  ANSWER SIZE 8
    DATA[0] = BYTE(Address);
    DATA[1] = HEX(10);
  TIMEOUT 300
END;

SCHEDULER BEGIN
DEFAULT(ReadInputs);  %Transmit telegram
                     %according to normal settings

IF DO1 <> DO1readback OR DO1 <> LastDO THEN
```

```
    TRANSMIT(WriteDO);  %Transmit telegram if DO has
                 %changed or mismatches
    IF ReadInputs.ISIDLE THEN
     State := 1;        %If telegram is idle set it
                 %to readback DO1
    ENDIF;
    TRANSMIT(ReadInputs); %Transmit read telegram to
                  %readback DO1
    LastDO := DO1;
  ENDIF;
 END;
END;
```

## 15.2 Semantics Explanation

### 15.2.1 First Row

The first row, from DEVICETYPE to IS, is not very complicated. The identifier directly after the DEVICETYPE keyword is the id of the devicetype and must be unique in the WMultra. To avoid potential errors and confusion they should be truly unique. If this line contains the optional TYPID number, this number will be used as id string instead.

The NAMED string is the name for the device type as it will be presented to users.

### 15.2.2 PARAMETER, PUBLIC and PRIVATE

After the PARAMETER keyword all parameter variables are defined. The definition consists of an identifier and a name string. After the name string comes, optionally, a unit string and a format specifier. The name string is used as the default string, but it is possible to add language specific alternatives for the name string. These consist of a language code and a string. The example contains English and Swedish translations.

In the script PARAMETER variables are not assignable.

The variables after the keyword PUBLIC are pretty much the same, but these are true variables and their string names and values are presented on the external devices page in the user interface.

Variables defined after PRIVATE does not have an associated string as they are not presented to the user. They are used only as script variables.

### 15.2.3 BAUDRATE to CHECKSUM

The `BAUDRATE` definition sets the baudrate for all telegrams. The number must be between a valid number. On the WMultra platform the following numbers are valid:

50,75,110,134,150,200,300,600,1200,1800,2400,4800,9600,19200,38400,57600,115200,230400,460800,500000,576000,921600,1000000,1152000,1500000,2000000,2500000,3000000,3500000,4000000.

`DATABITS` is the number of bits in each transmitted byte. 7 or 8 are valid numbers. If omitted 8 is default.

`PARITY` may be `ODD`, `EVEN` or `NONE`, where none is default if omitted.

`STOPPBITS` may be 1 or 2, where 1 is default.

`CHRGAPTIMEOUT` defines how long silence, expressed as number of bytes, that triggers an end of telegram event. Default is 4, which is consistent with the modbus specification.

The `CHECKSUM` definition defines what kind of checksum is being used on the telegrams. It is used both on questions and replies.

`SUM8` is simply the sum of all bytes, stored in a single byte. `ZSUM8` is the same thing, but the checksum value is such that the sum of all bytes including the checksum is zero.

The optional `SKIP` number defines that a number of bytes in the beginning should not be part of the checksum.

`SUM16` and `ZSUM16` is basically the same thing, but with word (16 bit) size sums. For these there is also the option `SWAPPED`. In the WMultra a multibyte checksum (unlike other multibyte datatypes) is default in big endian format, with the high byte first. If the protocoluses little endian checksum, use `SWAPPED`.The `MODBUS` keyword sets the checksum to be a modbus style CRC. The `SWAPPED` and `SKIP` keywords can be used here to. The `CRC8` and `CRC16` keywords starts a general CRC definition.

If the checksum is not placed last in the telegram, use the `POSTBYTES` keyword to define how many bytes that comes after the checksum.

For Modbus write `MODBUS SWAPPED` as in the example.

## 15.3 Semantics Explanation: Telegram Definitions

A device type definition can contain several telegram definitions. Each telegram defines a name string that is presented to the user. This string can be defined for different languages.

### 15.3.1 Question Compiler Definition

The question part of a telegram definition states how the frame sent to the external device should look like. Each byte of the frame must be defined. This is done by assigning values to a data array. `DATA[n]` represents the n'th byte in the frame. It can be assigned to a value using colon equals ":=" assignment.

The simplest form of assignment is using `HEX`, where the byte is assigned a constant hex value. The `HEX` function only accepts a single byte value, described by two letters. A to F must be capital when used.

The `BYTE`, `WORD` and `WORD32` and the other `telegram_datatype` keywords takes an expression as argument. The only identifiers in scope are the variables and parameters defined in the `DEVICETYPE`, but calculations can be made on them.

With the `BYTE` keyword the value is typecasted to a char and assigned to the byte. `WORD` and `RWORD` typecasts the value to an unsigned integer, and assigns it to byte n and n+1. `WORD` uses little endian and `RWORD` big endian. Larger data types affect more bytes. See the separate telegram datatype definitions in section, 15.5.

When using the left arrow assignment "<-" one or several statements are expected between the left and right parentheses after the keyword. Allowed keywords are `BYTE`, `WORD`, `RWORD`, and `FLOAT`. The execution of the statements must result in that the special variable `DATA` (used without square brackets within the left and right parentheses) is assigned a value.

`DATA` is an automatic variable that is in scope for these statements. The main intended use for this construct is to allow `IF`-statements. This is an assignment style used in WMPro and it is still valid in WMultra. In WMultra statements are allowed freely in the question compiler. The <- assignment construct is therefore not needed, nor recommended, unless WMPro compatibility is required.

The GFBI automatically appends the checksum as defined after the highest frame index used. If not all bytes in the frame are assigned a value the result is unpredictable.

### 15.3.2 Answer Parser Definition

For an answer the expected size, in bytes, must be defined either as an exact value or a range between a minimum and a maximum value. If the keyword `SIZE` is omitted the maximum allowed range of 1 to 4096 will be used. Any reply with the wrong size is considered faulty. The checksum must also be correct. Counters keep track of sent and received telegrams, as well as checksum errors.

Next step in validating the answer is by the answer parser. Individual bytes and words in the received frame are accessible with the `DATA[n]` keyword, as for the question compiler. Here data is not assigned, but with equal operator a check is made that the data in the frame equals the expression on the right side of the equal sign. The telegram_datatype keywords are used exactly as they are in colon equals assignment in questions.
The automatic variables `TIMESTAMP` that gives a relative timestamp in seconds for the received answer, and `RECEIVEDANSWERSIZE` that gives the size in bytes of the received answer, are also available.

If one or more equalities do not hold, the frame is considered faulty. A format error counter will be increased. The parsing will stop when the first mismatch is found.

Public and private variables can be assigned values containing data from the buffer. The telegram datatype keywords can be used in the expressions, followed by a buffer index within square brackets.For backward compatibility with WMPro right arrow assignment "->" is also possible. This is similar to the left arrow assignment in the question compiler definition but goes in the other direction. The telegram_datatype keywords are allowed, and statements are expected between the left and right parentheses. The difference is that the automatic variable `DATA` (used without square brackets within the left and right parentheses) will have been assigned with the value from the frame. Use this construct only if WMPro compatibility is necessary.

### 15.3.3 TIMEOUT

The last part of a telegram definition is the timeout. This is the number of milliseconds the GFBI will wait for a reply before giving up.

## 15.4 Semantics Explanation: SCHEDULER

The main purpose of the scheduler is to define when to send certain telegrams. If not present a default scheduler is used. The default scheduler uses the telegram setting where the user defines how often a telegram should be enqueued.

In the scheduler code use the `TRANSMIT` statement to enqueue a telegram for sending. You can also use the `DEFAULT` statement to let the telegram be scheduled according to the default update time setting. See the code example (15.1.4) where the ReadInputs telegram is scheduled with `DEFAULT`.

In the example the scheduler is used to transmit the WriteDO telegram only when the DO1 parameter is changed, or its actual state as read by ReadInputs differs from the parameter. The example also uses the possibility to read the status of a telegram. In this case to read back the DO1 status as soon as it has been written.

The order in which `TRANSMIT` is called for different telegram during a single run of the scheduler script does not decide the order in which they are transmitted. The `TRANSMIT` statements only changes the status of the telegram to scheduled, which means that it will be compiled and enqueued in the next step. If two telegrams are scheduled the same second they will be enqueued in the order they are defined.

Calling `TRANSMIT` on a telegram that is already enqueued and has not received an answer has no effect.

## 15.5 Telegram datatype definitions

The available datatypes are shown in *Syntaxgraph 36*. They are used to describe how data is represented. What they mean is explained in the table below.

| **Keyword** | **Bytes** | **Description** |
|---|---|---|
| BYTE | 1 | Unsigned 8 bit byte |
| SBYTE | 1 | Signed 8 bit byte |
| WORD | 2 | Unsigned 16 bit word, little endian [BA] |
| RWORD | 2 | Unsigned 16 bit word, big endian [AB] |
| INT | 2 | Signed 16 bit word, little endian [BA] |
| RINT | 2 | Signed 16 bit word, big endian [AB] |
| WORD32 | 4 | Unsigned 32 bit word, little endian [DCBA] |
| RWORD32 | 4 | Unsigned 32 bit word, big endian [ABCD] |
| WSWORD32 | 4 | Unsigned 32 bit word, little endian [CDAB], WS, Word Swapped *NOTE: Incorrectly named! (Should have been BSWORD32)* |
| BSWORD32 | 4 | Unsigned 32 bit word, little endian [BADC], BS, Byte Swapped *NOTE: Incorrectly named! (Should have been WSWORD32)* |
| INT32 | 4 | Signed 32 bit word, little endian [DCBA] |
| RINT32 | 4 | Signed 32 bit word, big endian [ABCD] |
| FLOAT | 4 | IEEE 745, little endian [DCBA] |
| BSFLOAT | 4 | IEEE 745, little endian [CDAB] |
| WSFLOAT | 4 | IEEE 745, little endian [BADC] |
| RFLOAT | 4 | IEEE 745, big endian [ABCD] |
| DOUBLE | 8 | 64 bit floating point, little endian [HGFEDCBA] |
| RDOUBLE | 8 | 64 bit floating point, big endian [ABCDEFGH] |

For multibyte values the byte order is important. Byte order is described with the order of letters A-H (or a subrange thereof), where A represents the most significant byte.

## 15.6 Telegram Expression Values Definition

When writing a scheduler the expressions described in *Syntaxgraph 35* is available. This includes special telegram values.

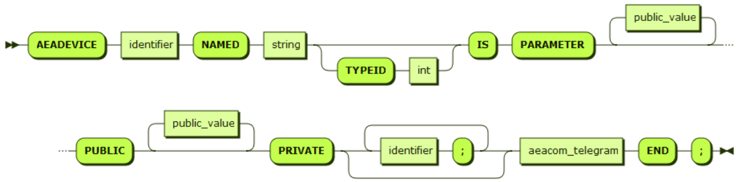
| **Keyword** | **Semantics** |
|---|---|
| TIMER | The idle timer counts seconds in idle mode, i.e. how long since it last left the queue. The timer is only updated by the DEFAULT scheduler. |
| SETTING | The user telegram setting value. For the default scheduler this is how often the telegram should be sent. |
| FAILCOUNT | Counts failures. Is reset by a successful reply. |
| ISIDLE | One if telegram is in idle state. |
| ISENQUEUED | One if the telegram is enqueues. |
| ISTRANSMITTED | One if the telegram has been sent out on the bus and is awaiting a reply. |
| ISDISABLED | One if telegram is disabled. |
| RECEIVEDANSWERSIZE | The size in bytes of the received answer. |

Below is a simple status diagram that describes how a telegram changes between states.

# 16 AeACom

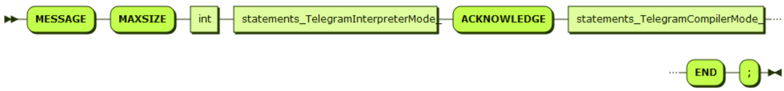
AeACom type definitions is used for expansion modules and other devices on the AeACom bus. It is similar to the GFBI type definitions, but with some differences.

In AeACom the master sends out a sync frame that defines time slots. The slaves selects one time slot and sends a telegram to the master. The master then sends an acknowledge message to the slave. Thus, there is only one telegram definition in a AeACom type definition.




*Syntaxgraph 37: aeadevice*

The NAMED, PARAMETER, PUBLIC and PRIVATE sections are the same as for a GFBI telegram definition. There are no communication settings in the definitions, as the protocol is known. The only telegram has its own syntax graph.




*Syntaxgraph 38: aeacom_telegram*

The message part is the message sent by the slave device. The interpreter is written in the same way a GFBI telegram interpreter (ANSWER) is written. The acknowledge is the reply the Ultra sends to the slave. It is written in the same way as a GFBI compiler (QUESTION).

# 17 GUI Formatting Codes

GFBI and AeACom type definitions may contain some special codes that tells the Ultra user interface how to treat different inputs and outputs. This helps to create a better user experience, especially for devices with much IO or settings.

Nodes is one concept that is used to group inputs and outputs under sub nodes in the graphical programming interface, and in external units interface. It is normal to create one node for each physical IO, if it has many channels associated with it.

Information can also be moved to a special settings menu. The user interface will then create a settings menu for the associated node, or a device settings menu if there is no associated node. These public or parameter channels will not be available to connect in graphical programming.

Example code excerpt:

```
PARAMETER
    ComTimeout: "Com timeout" [""]   INT
      | (sv)   "Kommunikationstimeout"
      | (en)   "Communication timeout"
      | (MENU) "YES";

    DI1_CounterReset :"DI1 Reset counter" [""] INT
      | (sv)   "DI1 Nollställ räknare"
      | (en)   "DI1 Reset counter"
      | (NODE) "DI1";
PUBLIC
    DI1  :"DI1" [""] INT
      | (sv)   "DI1"
      | (en)   "DI1"
      | (NODE) "DI1";

    DI1_Counter  :"DI1 Counter" [""]   INT
      | (sv)   "DI1 Räknare"
      | (en)   "DI1 Counter"
      | (NODE) "DI1";
```

The formatting codes uses special language keys. NODE defines the name of a node. (MENU) “YES” defines that it is a menu element. If both NODE and MENU are present it becomes a node menu item.

# 18 Script Editor Features

The script editor is a simple text editor with syntax highlighting, and some features. Standard shortcut functions like Ctrl+C, Ctrl+V,  Ctrl+X works for copy and paste. Ctrl+Z is undo, Ctrl+Y redo.

## 18.1 Search and Replace

Use Ctrl+F to bring a search dialogue, and Ctrl+D for a search and replace. Ctrl+G brings up a Goto line number dialogue.

## 18.2 Autocomplete and Shorthands

If you start to write a keyword and press Ctrl+Space, a list of suggested keywords appear. If only one keyword maches it will be autocompleted.

Shorthands are used to get a script stub. Write the shorthand keyword and press Ctrl+Shift+Space. For example, writing ife and then pressing Ctrl+Shift+Space yields

```
IF () THEN

ELSE

ENDIF;
```

Other stub keywords are

| Stub keyword | Result |
|---|---|
| app | APPLICATION outline |
| buff | BUFFER definition outline |
| ife | IF THEN ELSE outline |
| rout | ROUTINE outline |
| srout | SUBROUTINE outline |