SOFTWARE

KR C1 / KR C2 / KR C3

Reference Guide

Release 4.1

PD Interleaf

Contents

1 General

1.1 Typographical conventions

The following type style is used in this handbook for displaying the syntax:

Example	Explanation
IF, THEN, TRIGGER, ...	Necessary keywords and characters are printed as upper–case characters in bold type.
Signal, Interface_Name, Data Type, ...	The names of the command options are printed in bold italic characters, in upper and lower–case.
Name, Distance, Time, Priority, ...	Terms printed in upper/lower–case characters must be replaced by program–specific information.
DELAY = Time **,** 〈**ELSE** , ...	Elements in square brackets are optional.
+|-	Mutually exclusive options are separated by the OR sign "|".

1.2 Graphic conventions

The following symbols are used throughout this handbook:

The **“EXAMPLE”** symbol is found by descriptions and illustrations of practical examples.

Cross–reference to other sections or chapters in the handbook containing further information and explanations.

Information which is of particular significance or is useful for greater understanding.

The **“TIP”** symbol is used to identify text passages containing recommendations and advice to make your work easier.

The **“NOTE”** icon is used to emphasize general or additional information on a particular subject or highlights special features.

The **“CAUTION!”** symbol is used where failure to fully and accurately observe operating instructions, work instructions, prescribed sequences and the like could result in damage to the robot system.

This symbol is used where failure to fully and accurately observe operating instructions, work instructions, prescribed sequences and the like could result in injury or a fatal accident.

2 Reference section

2.1 Fundamentals

2.1.1 Programs, data lists and modules

The KRC saves the program code in files with the file extension SRC. Permanent data are saved in so–called data lists, files with the file extension DAT. A module consists of an SRC file and a DAT file with the same name.

2.1.2 Names and literals

A literal represents an actual value, e.g. the symbol “1” represents the number “one”, while a name or designation represents a data object containing a value (e.g. a variable) or a fixed value (e.g. a constant).

The following restrictions apply to a variable or constant name:

- It can have a maximum length of 24 characters.
- It can consist of letters (A–Z), numbers (0–9) and the signs “_” and “$”.
- It must not begin with a number.
- It must not be a keyword.

2.1.3 Data types

There are two different groups of data types: data types, such as **INT**, which are predefined in the system, and user–defined data types, which in turn are based on the data types **ENUM** and **STRUC**.

These two groups differ in practice in two respects:

- Data types predefined in the system are valid globally, while user–defined data types are only visible locally unless the keyword **GLOBAL** has been used in their declaration or they have been declared in the $CONFIG.DAT file.
- The keyword **DECL** can be omitted when declaring data types that are predefined in the system.

2.1.3.1 Simple data types

Data type	Keyword	Meaning	Range of values
Integer	**INT**	Integer	$-2^{31}-1 \ldots 2^{31}-1$
Real	**REAL**	Floating–point number	±1.1E–38...±3.4E+38
Boolean	**BOOL**	Logic state	TRUE, FALSE
Character	**CHAR**	Character	ASCII character

2.1.3.2 Implicit type conversion

The result of an arithmetic operation is only INT if both operands are of the data type INT. If the result of an integer division is not an integer, it is cut off at the decimal point.

If one of the operands is of the data type REAL, the result too will be of the data type REAL.

Operands	**INT**	**REAL**
INT	INT	REAL
REAL	REAL	REAL

2.1.3.3 Predefined data types

The following data types for motion programming are predefined in the controller software.

STRUC AXIS REAL A1, A2, A3, A4, A5, A6

The components A1 to A6 of the structure AXIS are angle values (rotational axes) or translation values (translational axes) for the axis–specific movement of robot axes 1 to 6.

STRUC E6AXIS REAL A1, A2, A3, A4, A5, A6, E1, E2, E3, E4, E5, E6

The angle values or translation values for the external axes are stored in the additional components E1 to E6.

STRUC FRAME REAL X, Y, Z, A, B, C

The space coordinates are stored in X, Y, Z and the orientation of the coordinate system is stored in A, B, C.

STRUC POS REAL X, Y, Z, A, B, C, INT S, T

The additional components S (Status) and T (Turn) can be used for the unambiguous definition of axis positions.

STRUC E6POS REAL X, Y, Z, A, B, C, E1, E2, E3, E4, E5, E6, INT S, T

2.1.3.4 Implicit data type assignment

If a variable name is used, without it first being declared in a KRL program, it is automatically assigned the data type POS.

Implicit data type assignment should not be used deliberately as it makes programs less easy to follow.

2.1.4 Constants

A constant has a name, a data type and a fixed value which cannot be altered following initialization.

Constants must be defined and initialized in a data list.

In order to be able to use constants, the constant option CONST_KEY in the file Progress.ini, in the INIT directory, must be set to TRUE:

CONST_KEY=TRUE

2.1.5 Variables

A variable has a name, a data type and a memory area in which its changeable value is stored.

2.1.5.1 System variables

The names of the KRL system variables all begin with the character “$”; this character must not, therefore, be used at the start of user variable names.

2.1.6 Operators

The following operators are available for the manipulation of data objects:

2.1.6.1 Arithmetic operators

Symbol	Function
+	Addition
−	Subtraction
/	Division
*	Multiplication

2.1.6.2 Logic operators

Symbol	Function
NOT	Inversion
AND	Logic AND
OR	Logic OR
EXOR	Exclusive OR

2.1.6.3 Relational operators

Symbol	Function
==	Equal to
<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to
<>	Not equal to

2.1.6.4 Bit operators

Symbol	Function
B_NOT	Bit–by–bit inversion
B_AND	Bit–by–bit AND operation
B_OR	Bit–by–bit OR operation
B_EXOR	Bit–by–bit exclusive OR operation

2.1.6.5 Geometric operator

Symbol	Function
:	Performs the vector addition of frames (geometric addition) between the data types FRAME and POS.

2.1.6.6 Priority of operators

In complex expressions with more than one operator, the individual expressions are executed in the order of priority of the operands.

Priority	Operator
1 (highest)	NOT, B_NOT
2	*, /
3	+, −
4	AND, B_AND
5	EXOR, B_EXOR
6	OR, B_OR
7 (lowest)	==, <, >, <=, >=, <>

The following rules also apply:

- Bracketed expressions are processed first.
- Non−bracketed expressions are executed in the order of priority of their operators.
- Logic operations with operators of the same priority are executed from left to right.

2.1.7 Declaration

A declaration assigns a data type to a name.

2.1.8 Initialization

Initialization assigns a value to a declaration.

2.1.9 Expression

An expression is a construction of data objects and operators with its own data type and value.

- An expression is **arithmetic** if its result has the data type INT or REAL.
- An expression is **logical** if its result has the data type BOOL.
- An expression is **geometric** if its result has the data types FRAME, POS, E6POS, AXIS or E6AXIS.

2.1.10 Statement

Statements are commands which do not, in themselves, represent a fixed value and data type. Simple statements consist of a single command line, while compound statements contain an entire control structure.

2.1.11 Comment

A comment is text that is ignored by the compiler. It is separated from the program code in a program line by means of the ";" character.

2.1.12 Motion programming

One special feature of a robot programming language is the possibility of programming points between which the robot TCP (Tool Center Point) moves. There are two basic traversing modes:

2.1.12.1 PTP motions (PTP = Point–To–Point)

The robot moves to the destination point with the maximum axis–specific acceleration and velocity of the leading axis. It does not keep to a specific path.

2.1.12.2 CP motions (CP = Continuous Path)

The robot TCP moves along a linear (LIN) or circular (CIRC) path between the start point and the destination point. The type of motion is dependent on the programmed path velocity and acceleration, the orientation control, and, if exact positioning is not required, the nature of the approximate positioning, as well as on the start point and destination point.

2.1.13 Control structures

Control structures are available for influencing program execution. These can be used to make the order in which program lines are executed dependent on conditions. One example of this is the IF ELSE statement.

2.1.14 Subprograms

Subprograms are program code which is reached by means of branches from the main program. Once the subprogram has been executed, program execution is resumed in the command line directly below the subprogram call.

In addition to the main program, further subprograms can also be defined in SRC files. The main program is recognized globally if its name is the same as that of the SRC file in which its program code is contained. If further subprograms of an SRC file are to be recognized globally, the keyword **GLOBAL** must be used.

2.1.15 Functions

Functions, like subprograms, are program units that can be called; however, they also possess a data type.

2.1.16 Block structure

The KRL programming language is structured in blocks. A block consists of statements, declarations, parameters and/or comments. These statements and declarations are executed block by block by the system.

KRL blocks must be created in accordance with certain rules. The prescribed structure of the blocks can be noted from the syntax descriptions of the declarations and statements in the instruction index.

A block contains either:

- a declaration
- a statement
- a comment

Empty blocks can also be used. They consist only of an end of block character.

A block begins at the start of a line without any special identifier. Blocks may also start with one or more blanks. Each block is ended by pressing the RETURN key. If blocks are too long to fit on the display, the system will automatically move onto the next line. The maximum line length is 474 characters.

2.1.17 Areas of validity

If variables, constants, subprograms, functions or interrupts are to be globally valid, i.e. recognized in all KRL programs that are loaded, the keyword **GLOBAL** must be used. The data objects are otherwise only recognized locally, with one exception: variables declared in the $CONFIG.DAT file are also recognized globally.

Areas of validity of local data objects:

- A local variable is valid in the program code containing the declaration of the variable and situated between the keywords **DEF** and **ENDDEF**.
- A local constant is recognized in the module to which the data list, in which the constant was declared, belongs.
- Local subprograms and local functions are recognized in the main program of the shared SRC file.
- A local interrupt is only recognized at, or below, the programming level in which it was declared.

If there are local and global variables with the same name, the compiler uses the local variable within its area of validity.

Global variables and constants can only be declared in data lists.

In order to be able to use the keyword GLOBAL, the global option in the file "Progress.ini", in the INIT directory, must be set to TRUE:

GLOBAL_KEY=TRUE

2.1.18 Keywords

Keywords are sequences of letters having a fixed function. They appear in bold upper–case letters in the description of the syntax.

There are reserved and non–reserved keywords:

- **Reserved keywords** may not be used in any other way than with the meaning defined for them. Most importantly, they must never be used as names for data objects. Some of the keywords listed in the table below are actually recognized by the compiler but are not yet used in the system. They are thus not implemented, but reserved nevertheless.
- In the case of **non–reserved keywords**, the meaning is restricted to a particular context. This context can be identified from the description of the syntax, in which the keyword again appears in bold upper–case letters. Outside of this context, a non–reserved keyword is interpreted as a name. To avoid any confusion, however, the non–reserved keywords should not be used as names.

The following table gives a list of all of the keywords used in the declarations, statements and definitions of the KRL robot programming language:

Keyword	Function	Brief information
ANIN	Statement	Cyclic reading of the analog inputs.
ANOUT	Statement	Operator control of the analog output.
BRAKE	Statement	Braking of the robot motion in interrupt routines.
CASE	Statement	Initiates a branch in the SWITCH statement
CCLOSE	Statement	Closing of channels.
CHANNEL	Declaration	Declaration of signal names for input and output channels.
CIRC	Statement	Circular motion.
CIRC_REL	Statement	Circular motion with relative target coordinates.
CONFIRM	Statement	Acknowledging of acknowledgement messages.
CONTINUE	Statement	Prevention of advance run stops.
COPEN	Statement	Opening an input/output channel.
CREAD	Statement	Reading of data from channels.
CWRITE	Statement	Writing of data to channels.
DECL	Declaration	Declaration of variables and arrays.
DEF	Definition	Declaration of programs and subprograms.
DEFAULT	Statement	Initiates the default branch in the SWITCH statement.
DEFDAT	Definition	Declaration of data lists.
DEFFCT	Definition	Declaration of functions.
DELAY	Parameter	Initiates the specification of the delay in the TRIGGER and ANOUT statements.
DIGIN	Statement	Cyclic reading in of digital inputs.
DISTANCE	Parameter	Initiates the specification of the switching point in the TRIGGER statement
DO	Statement	Initiates both the call of the interrupt routine in the INTERRUPT declaration and the call of a subprogram or an assignment of a value in the TRIGGER statement.
ELSE	Statement	Initiates the second statement branch in the IF statement.
END	Statement	End of a subprogram (see DEF).
ENDDAT	Statement	End of a data list (see DEFDAT).
ENDFCT	Statement	End of a function (see DEFFCT).
ENDFOR	Statement	Ends the FOR loop statement.

ENDIF	Statement	Ends the IF branching.
ENDLOOP	Statement	Ends the LOOP.
ENDSWITCH	Statement	Ends the SWITCH branches.
ENDWHILE	Statement	Ends the WHILE loop statement.
ENUM	Declaration	Declaration of enumeration types.
EXIT	Statement	Unconditional exit from loops.
EXT	Declaration	Declaration of external subprograms.
EXTFCT	Declaration	Declaration of external functions.
FOR	Statement	Counting loop or initiation of the WAIT statement condition.
GLOBAL	Declaration	Declaration of a global area of validity.
GOTO	Statement	Unconditional jump statement.
HALT	Statement	Neatly interrupt program execution and halt processing.
IF	Statement	Execution of statements depending on the result of a logical expression.
IMPORT	Declaration	Imports variables from data lists.
INTERRUPT	Statement	Definition of an interrupt function and its activation and deactivation.
IS	Statement	Initiates the source specifications in the IMPORT declaration.
LIN	Statement	Linear motion.
LIN_REL	Statement	Linear motion with relative coordinates.
LOOP	Statement	Endless loop.
MAXIMUM	Parameter	Keyword for the maximum value of analog outputs.
MINIMUM	Parameter	Keyword for the minimum value of analog outputs.
PRIO	Parameter	Initiates the specification of the priority when calling a subprogram in the TRIGGER statement.
PTP	Statement	Point−to−point motion.
PTP_REL	Statement	Point−to−point motion with relative coordinates.
PULSE	Statement	Activation of a pulse output.
REPEAT	Statement	Program loop that is always executed at least once (non−rejecting loop). The termination condition is checked at the end of the loop.
RESUME	Statement	Aborting of subprograms and interrupt routines.

RETURN	Statement	Return from functions and subprograms.
SEC	Statement	Initiates the specification of the wait time in the WAIT statement.
SIGNAL	Declaration	Declaration of signal names for input and output.
SREAD	Statement	Breaks a data set down into its constituent parts.
STRUC	Declaration	Declaration of structure types.
SWITCH	Statement	Choice between several statement branches.
SWRITE	Statement	Combination of data to form a data set.
THEN	Statement	Initiates the first statement branch in the IF statement.
TO	Statement	Separates initial and final values in the FOR statement and initiates the specification of the digital inputs/outputs in the SIGNAL declaration.
TRIGGER	Statement	Path–related triggering of a switching action synchronous to the robot motion.
UNTIL	Statement	Initiates the “end” inquiry in the REPEAT loop
WAIT	Statement	Wait for a continue condition or for a specified period of time.
WHEN	Statement	Initiates the logic expression in the INTERRUPT declaration and the specification of the path–related distance criterion in the TRIGGER statement.
WHILE	Statement	Program loop; termination condition is checked at the beginning of the loop (rejecting loop).

2.2 Command index

2.2.1 ANIN

2.2.1.1 Brief information

Cyclic reading of the analog inputs.

2.2.1.2 Syntax

Reading of an analog input:

```
ANIN ON Signal_Value = Factor * Signal_Name 〈± Offset
```

Termination of the read operation:

```
ANIN OFF Signal_Name
```

Argument	Type	Explanation
`Signal_Value`	REAL	The result of the cyclical reading is stored in *Signal_Value*. Signal_Value can be a variable, an analog signal or a signal declaration.
`Factor`	REAL	*Factor* can be a constant, variable or signal declaration.
`Signal_Name`	REAL	*Signal_Name* designates a signal declaration with an analog input.
`Offset`	REAL	*Offset* can be a constant, variable, signal declaration or analog signal.

All of the variables used in the ANIN statement must be declared in data lists.

A maximum of 3 ANIN ON statements may be active at any given time.

2.2.1.3 Description

The analog module makes analog interfaces available which can be read by means of the pre–defined signal variables $ANIN[1] to $ANIN[8]. The analog inputs can be read over a period of time using ANIN or can be assigned to a variable of data type REAL once by means of the operator "=". In the case of cyclic reading with the ANIN statement, the analog interfaces are read in the low–priority cycle (12 ms). Three ANIN ON statements can be used at the same time. Two ANIN ON statements can write to the same signal value or access the same analog interface. It is possible to combine analog inputs logically with other operators and to assign them to a signal value by using the optional arithmetic of the ANIN statement.

The analog module makes available 8 analog interfaces with a resolution of 12 bits (4.88 mV, not electrically isolated). The input voltage can vary from –10 V to +10 V but may not exceed 35 V. The hardware inputs can be assigned to interface numbers by means of system parameters. Accessing an analog input triggers an advance run stop.

If the input voltage exceeds 35 V, the analog module or parts of it can be destroyed.

2.2.1.4 Example

The path correction (system variable $TECHIN[1]) is to be corrected in accordance with the sensor input $ANIN[2]. The sensor input $ANIN[2] is logically combined with the symbolic variable SIGNAL_1. The result of multiplying the variable FACTOR and the current value of SIGNAL_1 is added to the variable OFFSET and written cyclically to the system variable for the path correction $TECHIN[1].

```
SIGNAL SIGNAL_1 $ANIN[2]
ANIN ON $TECHIN[1] = FACTOR * SIGNAL_1 + OFFSET
```

The cyclic scanning of SIGNAL_1 is ended using the ANIN OFF instruction.

```
ANIN OFF SIGNAL_1
```

SIGNAL, ANOUT, DIGIN

2.2.2 ANOUT

2.2.2.1 Brief information

Control of the analog output.

2.2.2.2 Syntax

Starting the analog output:

```
ANOUT ON Signal_Name = Factor * Control_Element ⟨± Offset
         ⟨DELAY = ±Time
         ⟨MINIMUM = Minimum_Value ⟨MAXIMUM = Maximum_Value
```

Ending the analog output:

```
ANOUT OFF Signal_Name
```

Argument	Type	Explanation
`Signal_Name`	REAL	The *Signal_Name* represents a signal declaration defined using the statement SIGNAL and referring to an analog output. The analog output, e.g. $ANOUT[1], must not be entered directly.
`Factor`	REAL	*Factor* can be a variable, signal declaration, analog signal or constant.
`Control_ Element`	REAL	*Control_Element* can be a variable, signal declaration or analog signal.
`Offset`	REAL	*Offset* can be a variable, signal declaration, analog signal or constant.
`Time`	REAL	The *Time* is specified in seconds as a real number.
`Minimum_Value, Maximum_Value`	REAL	Minimum_Value and Maximum_Value must be between –1.0 and +1.0 and limit the output. The actual value does not fall below/exceed the specified minimum/maximum values, even if the calculated values fall outside this range. The minimum value must, of course, always be less than the maximum value and the keyword sequence MINIMUM MAXIMUM must be maintained.

All of the variables used in the ANOUT statement must be declared in data lists.

2.2.2.3 Description

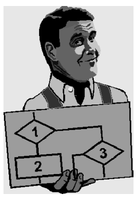
Unlike the binary or digital output, the analog output is not controlled simply by means of a simple value assignment but by means of the ANOUT statement. The signal name is defined using the SIGNAL command.

The expression that can be specified for calculating the value of the analog output is calculated cyclically. It must not, however, be too extensive, so that it can be calculated within the cycle time. The result of the expression must be in the range –1 to +1 or 0 to +1, corresponding to the configuration of the hardware. If the result of the expression exceeds these limits, the output takes the relevant final value and the hint message "Limit signal name" is displayed until the result falls below these limits again. The keywords **MINIMUM** and **MAXIMUM** can be used, however, to define lower output limit values.

The optional keyword **DELAY** can be used to program positive or negative delays. The value of the delay is specified in seconds as a real number.

The robot controller provides 16 analog outputs ($ANOUT[1] ... $ANOUT[16]) as standard. The analog outputs can be read and set.

2.2.2.4 Example



The analog output $ANOUT[5] is assigned to the symbolic name ANALOG_1. When the analog value output is activated, the product of the variable FACTOR and the system variable $TECHVAL[1], increased by the value of the variable OFFSET_1, is cyclically calculated and written to the analog output $ANOUT[5]. The analog output is ended using ANOUT OFF ANALOG_1.

Please note: in order for $TECHVAL[i] to provide an unfiltered signal corresponding to the technology–specific function, $TECH_ANA_FLT_OFF[i] must be set to TRUE.

```
SIGNAL ANALOG_1 $ANOUT[5]
ANOUT ON ANALOG_1 = FACTOR * $TECHVAL[1] + OFFSET_1
...
ANOUT OFF ANALOG_1
```

The analog output $ANOUT[1] is assigned to the symbolic name ADHESIVE for controlling the dispensing of adhesive in proportion to the velocity. The control value is calculated from half of the path velocity (system variable $VEL_ACT; in order to obtain an uncorrupted signal proportional to the path velocity, $VEL_FLT_OFF must have the value TRUE) and a constant addition of 0.2. Output of the cyclically calculated output signal is delayed for 0.05 seconds using the optional parameter DELAY. The analog output is ended by using ANOUT OFF ADHESIVE.

```
SIGNAL ADHESIVE $ANOUT[1]
ANOUT ON ADHESIVE = 0.5*$VEL_ACT + 0.2 DELAY = 0.05
...
ANOUT OFF ADHESIVE
```

ANIN, SIGNAL

2.2.3 BRAKE

2.2.3.1 Brief information

Braking of the robot motion in interrupt routines.

2.2.3.2 Syntax

```
BRAKE 〈F
```

Argument	Type	Explanation
F		Specifying the parameter F (brake fast) causes the robot to be braked with increased deceleration, just like in an Emergency Stop. If the path–maintaining stop is configured for the selected operating mode using the machine data $EMSTOP_PATH, the robot is braked on the path in a time–optimal manner. Otherwise, the axes are only braked in a synchronized manner, leaving the path.

2.2.3.3 Description

The BRAKE statement is used in an interrupt routine to brake the robot motion that it still active. BRAKE brakes the motion with the same deceleration as with an operator stop. Braking using the BRAKE statement occurs on the programmed path if the argument F is not specified.

The interrupt routine is not continued until the robot has come to a stop.

The BRAKE statement must not be used outside interrupt routines. Failure to observe this will cause execution of the program to be aborted.

2.2.3.4 Example

A non–path–maintaining Emergency Stop is executed via the hardware during application of adhesive. You would now like to use the program to stop application of the adhesive and reposition the adhesive gun onto the path after enabling (by input 10).

```
DEF STOPSP()
; Interrupt routine
BRAKE F
ADHESIVE = FALSE
WAIT FOR $IN[10]
LIN $POS_RET
; Move gun to position at which the path was left
ADHESIVE = TRUE
END
```

INTERRUPT DECL, INTERRUPT

2.2.4 CCLOSE

2.2.4.1 Brief information

Input/output channels that have previously been declared with the “CHANNEL” statement can be closed using the “CCLOSE” statement. “CCLOSE” deletes all of the data that are waiting to be read. When deselecting and resetting a program, all of the channels that are open there are closed.

2.2.4.2 Syntax

```
CCLOSE (Handle, State)
```

Argument	Type	Explanation
`Handle`	INT	The “handle” variable transferred by “COPEN”.
`State`	STATE_T	“CMD_STAT” is an enumeration type which is the first component of the State variable of the structure type “STATE_T”. Values of the component “CMD_STAT” that are relevant for “CCLOSE” are: **`CMD_OK`** Command successfully executed **`CMD_ABORT`** Command not successfully executed

2.2.4.3 Description

Input/output channels that have previously been declared with the “CHANNEL” statement can be closed using the “CCLOSE” statement.

Possible causes of “CMD_ABORT” are:

The channel

- is already closed;
- HANDLE not valid;
- has been opened by another process.

The “HANDLE” can no longer be used for channel statements once this function has been called successfully. The value of the variable is not changed, however.

“CCLOSE” deletes all of the data that are waiting to be read. When deselecting and resetting a program, all of the channels that are open there are implicitly closed.

The complete definition of the status and mode information for channel statements can be found in the chapter “CHANNEL”.

2.2.4.4 Example

Closing of a channel with the handle “HANDLE”. The status variable “`SC_T`” returns information about the status.

```
CCLOSE(HANDLE,SC_T)
```

A complete example of a program can be found in the chapter “CHANNEL”.

2.2.5 CHANNEL

2.2.5.1 Brief information

The “CHANNEL” statement is used for declaring signal names for input and output channels.

2.2.5.2 Syntax

```
CHANNEL :Channel_Name:  Interface_Name  Structure_Variable
```

Argument	Type	Explanation
`Channel_Name`		Any symbolic name
`Interface_Name`		Predefined signal variable **`SER_1`** serial interface 1 **`SER_2`** serial interface 2
`Structure_Variable`		System–dependent structure variable specifying the protocol. Evaluation is not carried out.

2.2.5.3 Description

The robot controller contains two classes of interface:

- simple process interfaces – **signals** – and
- logic interfaces – **channels**.

All of the interfaces are addressed using symbolic names. The specific interface names (symbolic names) are logically combined with the predefined signal variables for channels by means of the CHANNEL declaration.

The predefined signal variables for channels are

- **SER_1** and
- **SER_2**

for the serial interfaces, and

- **$CMD (e.g. “RUN....”)**

for the command interpreter.

The procedure for accessing channels is the same. In order to be able to access a channel, it must be declared in the “CHANNEL” declaration.

The variables are predefined in the file “$CUSTOM.DAT” (directory “....\PROGRAM FILES\KRC\MADA\STEU”) “:SER_1” and “:SER_2”.

The channel can then be opened with the “COPEN” statement. The “CREAD” statement can be used to read the channel, while the “CWRITE” statement is used to write to the channel. The channel is closed with the “CCLOSE” statement.

The state and mode information for channel statements are the same.

The state information is returned in a variable of the predefined structure type “STATE_T”. “STATE_T” has the following definition:

```
STRUC STATE_T CMD_STAT RET1, INT HITS, INT LENGTH
```

"CMD_STAT" is a predefined enumeration type of the following form:

```
ENUM CMD_STAT CMD_OK, CMD_TIMEOUT, DATA_OK, DATA_BLK, DATA_END,
CMD_ABORT, CMD_REJ, CMD_PART, CMD_SYN, FMT_ERR
```

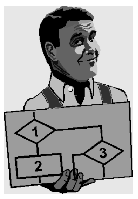
The modes that can be used with the statements "CREAD" and "CWRITE" are made available as a predefined enumeration type:

```
ENUM MODUS_T SYNC, ASYNC, ABS, COND, SEQ
```

The meaning of the state and mode are explained in the sections on the individual commands. Only the parameters listed there are used.

2.2.5.4 Example

Assignment of a channel name to a physical channel



With the "CHANNEL" statement:
Channel name :SER_2
is assigned to
physical channel :SER_2
predefined in the file "$CUSTOM.DAT"
(directory ....\PROGRAM FILES\KRC\MADA\STEU)

```
CHANNEL :SER_2 :SER_2 $PSER_2
```

SIGNAL, COPEN, CCLOSE, CREAD, CWRITE

2.2.6 CIRC

2.2.6.1 Brief information

Programming a circular motion.

2.2.6.2 Syntax

```
CIRC  Auxiliary_Point, Target_Position 〈,CA Circular_Angle
⮑     〈Path_Approximation
```

Argument	Type	Explanation
`Auxiliary_ Point`	POS, E6POS, FRAME	Geometric expression producing an auxiliary point on the circular path. Only Cartesian coordinates can be used here. The reference system for the Cartesian auxiliary position is defined by the system variable $BASE. The orientation angles and the angle status specifications S and T for an auxiliary point are always disregarded. If structure components are missing in the auxiliary point, these values are taken unchanged from the current position.
`Target_ Position`	POS, E6POS, FRAME	Geometric expression specifying the target position of the circular motion. Only Cartesian coordinates can be used here. The reference system for the Cartesian target position is defined by the system variable $BASE. The angle status specifications S and T for a target position of type POS or E6POS are always disregarded. If structure components are missing in the target position, these values are taken unchanged from the current position.
!		The auxiliary point and the target point can also be taught. If this is to be done later, a “**!**” is programmed in the place of the auxiliary point and target position.

`Circular_ Angle`	REAL	Arithmetic expression allowing the arc to be lengthened or shortened in conjunction with the keyword CA (circular angle). The unit of measurement is degrees. There is no limit for the circular angle. In particular, a circular angle greater than 360° can be programmed. If the circular angle is positive, the robot moves along the circular path in the direction defined by the start position, the auxiliary point and the target position. If it is negative, the robot moves along the circular path in the opposite direction. When specifying a circular angle, the programmed target position is not generally the real target position. This is defined by the angle specification.
Approximate_ Positioning	Keyword	This option allows you to use approximate positioning. The possible entries are: • **C_DIS** (default value) • **C_ORI** • **C_VEL**

Programming the path velocity and acceleration of the TCP:

	Variable	Data type	Unit	Function
Velocities	$VEL.CP	REAL	m/s	Travel speed (path velocity)
	$VEL.ORI1	REAL	°/s	Swivel velocity
	$VEL.ORI2	REAL	°/s	Rotational velocity
Accelerations	$ACC.CP	REAL	m/s^2	Path acceleration
	$ACC.ORI1	REAL	$°/s^2$	Swivel acceleration
	$ACC.ORI2	REAL	$°/s^2$	Rotational acceleration

Orientation control of the tool with CIRC motions:

Variable	Effect
$ORI_TYPE = #CONSTANT	During the path motion the orientation remains constant; the programmed orientation is ignored for the destination point and that for the start point used.
$ORI_TYPE = #VAR	During the path motion the orientation changes continuously from the initial orientation to the destination orientation.
$CIRC_TYPE = #BASE	Orientation control relative to the base system ($BASE).
$CIRC_TYPE = #PATH	Orientation control relative to the tool–based moving frame on the circular path.

System variables for defining the start of approximate positioning:

Variable	Data type	Unit	Meaning	Keyword in the command
$APO.CDIS	REAL	mm	Translational distance criterion	**C_DIS**
$APO.CORI	REAL	°	Orientation distance	**C_ORI**
$APO.CVEL	INT	%	Velocity criterion	**C_VEL**

2.2.6.3 Description

In the case of CIRC motions, the controller calculates a circular motion from the current position via an auxiliary point to an end point, which is thus unambiguously determined by the target position or the circular angle. The robot is moved to the end point via intermediate points, which are calculated and executed at intervals of one interpolation cycle.

Just as for LIN motions, both the velocities and accelerations and the system variables $TOOL and $BASE must also be programmed for circular motions. However, the velocities and accelerations no longer refer to the motor speed of each axis but to the TCP. The system variables

- $VEL for the path velocity and
- $ACC for the path acceleration

are available for defining them.

Orientation control

- Space–related or path–related orientation
  You can basically choose between space–related and path–related orientation control. In the case of space–related orientation control, the orientation is interpolated relative to the current base system ($BASE); with path–related orientation, on the other hand, it is interpolated relative to the tool coordinate system (tool–based moving frame). The type of orientation control is defined with the aid of the system variable $CIRC_TYPE:
  - $CIRC_TYPE=#BASE for space–related orientation control and
  - $CIRC_TYPE=#PATH for path–related orientation control.
- Variable and constant orientation
  You can also choose between variable and constant orientation. If you select variable orientation, this means that the change in orientation which occurs between the start position and the programmed target position is taken into account. It is executed either in relation to space or in relation to the path. In the case of constant space–related orientation, the orientation at each control point is absolutely identical to the orientation at the start point. With constant path–related orientation, the relative orientation is constant in relation to the tool–based moving frame. If an orientation has been specified for the target position, this is disregarded with constant orientation. The system variable $ORI_TYPE is used for defining the orientation:
  - $ORI_TYPE=#VAR for variable orientation and
  - $ORI_TYPE=#CONSTANT for constant orientation control.

Angle status

In the case of CIRC motions, the angle status of the end point is always the same as that of the start point. For this reason, the specifications Status S and Turn T for a target position of data type POS or E6POS are always disregarded.

In order to always ensure an identical motion sequence, the constellation of the axes must first be unambiguously defined. The first motion instruction of a program must therefore always be a PTP instruction specifying S and T.

Approximate positioning

It is unnecessary and time–consuming to position the robot exactly to auxiliary points. You can therefore start a transition to the following motion block (PTP, LIN or CIRC) at a defined distance from the target position (so–called approximate positioning).
Approximate positioning is programmed in two steps:

- Definition of the approximate positioning range with the aid of the system variable $APO:
  - $APO.CDIS:
    translational distance criterion (activated by C_DIS):
    the approximate positioning contour is started at a specified distance (unit [mm]) from the target point.
  - $APO.CORI:
    orientation distance (activated by C_ORI): the TCP leaves the individual block contour when the dominant orientation angle (swiveling or rotation of the longitudinal axis of the tool) falls below the specified angle distance to the target point.
  - $APO.CVEL
    velocity criterion (activated by C_VEL): when the $APO.CVEL percentage of the velocity defined in $VEL.CP is achieved, the approximate positioning contour is initiated. A maximum of half the programmed distance may be approximated.
- Programming of the motion instruction with a target position and an approximate positioning mode:
  - **CIRC–CIRC or CIRC–LIN approximate positioning**
    In the case of CIRC–CIRC and CIRC–LIN approximate positioning, a symmetrical approximate positioning contour cannot be calculated. The approximate positioning path consists of two parabolic segments, which also have a tangential transition between each other and also to the individual blocks. To define where approximate positioning is to begin and end, one of the keywords C_DIS, C_ORI or C_VEL has to be programmed.
  - **CIRC–PTP approximate positioning**
    A precondition for approximate positioning is that none of the robot axes rotates more than 180° in the CIRC block and that the position S does not change. The start of approximate positioning is defined by one of the variables $APO.CDIS, $APO.CORI and $APO.CVEL and the end by the variable $APO.CPTP. One of the keywords C_DIS, C_ORI and C_VEL has to be programmed in the CIRC instruction.

For approximate positioning, the computer advance run must be enabled. If it is not, the message “Approximation not possible” will be displayed. In the case of CIRC–PTP approximate positioning, the advance run is limited to 1, however!

- Program statements that stop the advance run may not appear between approximate positioning blocks (remedy with CONTINUE).
- The greater the velocity and acceleration are, the greater the dynamic deviations from the path will be (following error).
- Changing the acceleration has a considerably lesser effect on the path contour than changing the velocity.
- Interpolation is always carried out on a space–related basis in the approximate positioning range.
- The initial orientation for approximate positioning is always the orientation that would be achieved at the approximate positioning point relative to the base.
- If two CIRC blocks are executed with path–related orientation, the reorientation in the approximate positioning range is nevertheless space–related.

2.2.6.4 Example

Circular motion with taught auxiliary and target coordinates.

```
CIRC !
```

Circular motion with taught auxiliary and target coordinates; the target point of the motion is determined by the circular angle of –35°.

```
CIRC ! ,CA -35
```

Circular motion with programmed auxiliary and target coordinates.

```
CIRC {X 5,Y 0, Z 9.2},{X 12.3,Y 0,Z -5.3,A 9.2,B -5,C 20}
```

Circular motion with programmed auxiliary and target coordinates; approximate positioning is activated.

```
CIRC {Z 500,X 123.6},POINT1,CA +260 C_ORI
```

Constant path–related orientation control.

```
$ORI_TYPE=#CONSTANT
$CIRC_TYPE=#PATH
CIRC AUX_POINT,{X 34, Y 11, Z 0}
```

CIRC–PTP approximate positioning from point 2 to point 3. Approximate positioning is started 30 mm before point 2.

```
$APO.CDIS=30
$APO.CPTP=20
PTP POINT1
CIRC AUX_POINT,POINT2,CA ANGLE C_DIS
PTP POINT3
```

CIRC_REL, PTP, LIN, CONTINUE

2.2.7 CIRC_REL

2.2.7.1 Brief information

Circular motion with relative coordinates.

2.2.7.2 Syntax

```
CIRC_REL   Auxiliary_Point,Target_Position
           ⟨,CA Circular_Angle
           ⟨Approximate_Positioning
```

Argument	Type	Explanation
Target_ Position	POS, E6POS, FRAME	Geometric expression specifying the target position of the circular motion. Only Cartesian coordinates can be used here. These are to be interpreted *relative* to the current position before the CIRC motion. Translational distances are executed in the direction of the axes of the base coordinate system $BASE. If the target position contains undefined structure components, these values are set to 0, i.e. the absolute values remain unchanged. The predefined variable $ROTSYS defines the effect of the programmed orientation components. The angle status specifications S and T for a target position of type POS or E6POS are always disregarded.

`Auxiliary_ Point`	POS, E6POS, FRAME	Geometric expression producing an auxiliary point on the circular path. The auxiliary point is to be specified in *relative* and Cartesian coordinates! Translational distances are executed in the direction of the axes of the base coordinate system $BASE. If the auxiliary point contains undefined structure components, these values are set to 0, i.e. the absolute values remain unchanged. The predefined variable $ROTSYS defines the effect of the programmed orientation components. The orientation angles and the angle status specifications S and T for an auxiliary point are always disregarded.
`Circular_ Angle`	REAL	Arithmetic expression allowing the arc to be lengthened or shortened in conjunction with the keyword CA (circular angle). The unit of measurement is degrees. There is no limit for the circular angle. In particular, a circular angle greater than 360° can be programmed. If the circular angle is positive, the robot moves along the circular path in the direction defined by the start position, the auxiliary point and the target position. If it is negative, the robot moves along the circular path in the opposite direction. When specifying a circular angle, the programmed target position is not generally the real target position. This is defined by the angle specification.
`Approximate_ Positioning`	Keyword	This option allows you to use approximate positioning. The possible entries are: • **`C_DIS`** (default value) • **`C_ORI`** • **`C_VEL`**

Programming the path velocity and acceleration of the TCP:

	Variable	Data type	Unit	Function
Velocities	$VEL.CP	REAL	m/s	Travel speed (path velocity)
	$VEL.ORI1	REAL	°/s	Swivel velocity
	$VEL.ORI2	REAL	°/s	Rotational velocity
Accelerations	$ACC.CP	REAL	m/s^2	Path acceleration
	$ACC.ORI1	REAL	°/s^2	Swivel acceleration
	$ACC.ORI2	REAL	°/s^2	Rotational acceleration

Orientation control of the tool with CIRC motions:

Variable	Effect
$ORI_TYPE = #CONSTANT	During the path motion the orientation remains constant; the programmed orientation is ignored for the destination point and that for the start point used.
$ORI_TYPE = #VAR	During the path motion the orientation changes continuously from the initial orientation to the destination orientation.
$CIRC_TYPE = #BASE	Orientation control relative to the base system ($BASE).
$CIRC_TYPE = #PATH	Orientation control relative to the tool–based moving frame on the circular path.

System variables for defining the start of approximate positioning:

Variable	Data type	Unit	Meaning	Keyword in the command
$APO.CDIS	REAL	mm	Translational distance criterion	**C_DIS**
$APO.CORI	REAL	°	Orientation distance	**C_ORI**
$APO.CVEL	INT	%	Velocity criterion	**C_VEL**

2.2.7.3 Description

The relative CIRC instruction basically works in exactly the same way as the absolute CIRC instruction. The target coordinates are merely defined relative to the current position instead of with the aid of absolute space or axis coordinates.
Apart from this, all the information contained in the description of the absolute CIRC instruction applies here.

2.2.7.4 Example

Circular motion with programmed auxiliary and target coordinates; the target point of the motion is defined by a circle angle of 500°; approximate positioning is activated.

```
CIRC_REL {X 100,Y, 3.2,Z -20},{Y 50},CA 500 C_VEL
```

LIN–CIRC approximate positioning from point 1 to point 2 and CIRC–CIRC approximate positioning from point 2 to point 3. Approximate positioning to point 1 is started when the velocity has been reduced to 0.6 m/s (50% of 1.2 m/s). Approximate positioning to point 2 begins 20 mm before point 2.

```
$VEL.CP=1.2
$APO.CVEL=50
$APO.CDIS=20
LIN POINT1 C_VEL
CIRC_REL AUX_POINT,POINT2_REL C_DIS
CIRC AUX_POINT,POINT3
```

CIRC, PTP_REL, LIN_REL, CONTINUE

2.2.8 CONFIRM

2.2.8.1 Brief information

Acknowledging of acknowledgement messages.

2.2.8.2 Syntax

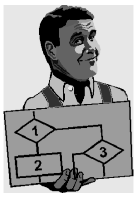
```
CONFIRM Management_Number
```

Argument	Type	Explanation
`Management_ Number`	INT	Arithmetic expression specifying the management number of the message that is to be acknowledged. Specifying the management number 0 means that all of the messages that can be acknowledged are acknowledged.

2.2.8.3 Description

Acknowledgement messages can be acknowledged under program control using the statement CONFIRM. After a message has been successfully acknowledged, it is no longer present.

2.2.8.4 Example



Acknowledgement of the acknowledgement message with the number 27.

```
CONFIRM 27
```

Acknowledgement of the acknowledgement message with the number M_NUMBER.

```
CONFIRM M_NUMBER
```

Acknowledgement of the acknowledgement message with the number M_NUMBER+5.

```
CONFIRM M_NUMBER+5
```

Acknowledgement of all existing acknowledgement messages.

```
CONFIRM 0
```

After a stop signal (e.g. Emergency Stop) has been canceled, an acknowledgement message is always displayed. This must be acknowledged first before you can work any further. The following subprogram detects and acknowledges this message automatically, provided that the correct operating mode (not manual operation) is selected and that the stop state has really been canceled. As a robot program cannot be started if an acknowledgement message is active, the subprogram must be located in a Submit file.

```
DEF AUTO_QUIT()
INT M
DECL STOPMESS MESSAGE           ; Predefined structure type for stop messages
IF $STOPMESS AND $EXT THEN      ; Check stop message and operating mode
      M=MBX_REC($STOPMB_ID,MLD); Read current state into MESSAGE
      IF M==0 THEN              ; Check that message may be acknowledged
            IF ((MESSAGE.GRO==2) AND (MESSAGE.STATE==1)) THEN
                  CONFIRM MLD.CONFNO; Acknowledgement of this message
            ENDIF
      ENDIF
ENDIF
END
```

2.2.9 CONTINUE

2.2.9.1 Brief information

Prevention of advance run stops.

2.2.9.2 Syntax

```
CONTINUE
```

2.2.9.3 Description

You can use the system variable $ADVANCE to define how many motion blocks the controller executes in advance. In the case of instructions concerning the periphery (e.g. input/output instructions), the computer advance run is always stopped, however. If you do not want this to happen, the CONTINUE statement must be programmed before the relevant instruction.

The CONTINUE statement always only applies to the following instruction line, even if this is a blank line!

2.2.9.4 Example

Prevention of an advance run stop with $OUT:

```
CONTINUE
$OUT[1]=TRUE
CONTINUE
$OUT[2]=FALSE
```

ANOUT, HALT, WAIT, PULSE

2.2.10 COPEN

2.2.10.1 Brief information

Input/output channels that have previously been declared with the “CHANNEL” statement can be opened using the “COPEN” statement.

2.2.10.2 Syntax

```
COPEN (Channel_Name, Handle)
```

Argument	Type	Explanation
`Channel_Name`		Channel name declared in the “CHANNEL” statement.
`Handle`	INT	User–defined variable

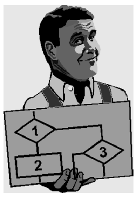
2.2.10.3 Description

Input/output channels that have previously been declared with the CHANNEL statement can be opened using the “COPEN” statement – which may be included in programs at control or robot levels.

The “Handle” variable identifies the relevant channel for all of the following accesses. If the system refuses to open a channel, a 0 is returned.

The predefined variable “$CMD” is available for command execution, which is generally open.

2.2.10.4 Example



Opening of a channel with the declared channel name “:SER_2” and the handle “HANDLE”.

```
        COPEN(:SER_2,HANDLE)
```

A complete example of a program can be found in the chapter “CHANNEL”.

2.2.11 CREAD

2.2.11.1 Brief information

Reading of data from channels.

Application example:	Data exchange (read statement) between KR C1 and a partner device (PC, intelligent sensor ...).

The “CREAD” statement is used for reading data from open channels. Two cases are distinguished here:

- **Active reading**
  The program requests an input via a channel. The channel drivers set an input request and return the data that are received to the CREAD statement as a result.
- **Passive reading**
  A predefined variable (INT $DATA_SER1 or INT $DATA_SER2), which is incremented by the channel driver after the arrival of unrequested data, is made available for each of the channels “:SER_1” and “:SER_2”. The variables are initialized with 0 when a warm restart is carried out or when a channel is opened or closed.
  There are also differences in the way that the system waits for the feedback signal of a read request: absolutely or conditionally. Absolutely means that the system waits until the channel provides the data requested. In the case of conditional waiting, the system checks whether data are available.

2.2.11.2 Syntax

```
CREAD (Handle, State, Mode, Timeout, Offset, Format,
      Var1,..., VarN)
```

Argument	Type	Explanation
Handle	INT	The handle variable transferred by “COPEN”. **Note:** the variable “$CMD” will be rejected!

State	STATE_T	“CMD_STAT” is an enumeration type which is the first component of the “State” variable of the structure type “STATE_T”. “CMD_STAT” can have the following values which are relevant for “CREAD”: **CMD_OK** Command successfully executed; No data available in #COND mode **CMD_TIMEOUT** Reading aborted in “ABS” mode due to the defined time limit being exceeded; **DATA_OK** A data block has been received from the channel. All of the data have been assigned to the variables in accordance with the format description. However, it is not necessary for all the variables to have been described (see also the status variable “HITS” below); **DATA_BLK** Data have been read but further data which can be read using the mode “SEQ” are ready. **DATA_END** Data have been read. The data block has been completely read; **CMD_ABORT** Reading has been aborted, e.g. due to an error message from the channel or to a fatal error during read–out of the data. If the format specification and the variable type do not agree, reading is aborted not with CMD_ABORT but with DATA_BLK; **FMT_ERR** Incorrect format specification or non–corresponding variable. Other components of the State variable that are important for CREAD: **HITS** Number of correctly read formats. **LENGTH** Length of the “%s” or “%r” format that occurs first in the format. The lengths of all following “%s” or “%r” formats are not determined. If necessary, use several “CREAD” statements.
Mode	MODUS_T	“MODUS_T” is an enumeration type that can have the following values that are relevant for “CREAD”: **ABS** Active reading of the channel. The function waits until the channel makes a data block available or until waiting is aborted by Timeout. **COND** Unrequested reading of a channel. **SEQ** Completion of the reading of a data block from Bytes Offset onwards that has previously been requested using “ABS” or “COND” or returned to “CWRITE” as a reply and which has not yet been completely read out.

`Timeout`	REAL	The parameter "Timeout" can be used to specify a time in seconds, after which the wait for a data block is aborted. A Timeout with the value 0.0 corresponds to an endless wait. A value over 60 or negative values are rejected. A system–related inaccuracy is inherent in the wait time.
`Offset`	INT	The variable "Offset" is used to specify the number of bytes in the data that have been received after which the system is to start reading. If reading is to start from the beginning, Offset must be set to 0 (zero). After a "CREAD" statement that does not assign all of the data received to program variables, Offset specifies the number of characters that have been assigned so far.
`Format`	CHAR[ ]	The variable "Format" of the type "CHAR[ ]" (Textstring) contains the format of the text that is to be generated. The structure of the variable largely corresponds to the format string of the function "FPRINTF" of the "C" programming language.
`Var`		The variables corresponding to "Format".

2.2.11.3 Description

The "CREAD" statement is used for reading data from open channels. Two cases are distinguished here:

- **Active reading**
  The program requests an input via a channel. The channel drivers set an input request and return the data that are received to the CREAD statement as a result.
- **Passive reading**
  Another partner has written data to a channel without being requested to and expects the data to be collected. A predefined variable is made available for each of the channels "SER_1" and "SER_2".
  `INT $DATA_SER1` or
  `INT $DATA_SER2`,
  and these are incremented by the channel driver after the arrival of unrequested data. The variables are initialized with 0 (zero) when the system is started or when a channel is opened or closed.

There are also differences in the way that the system waits for the feedback signal of a read request. The "CREAD" statement can wait absolutely or conditionally.

- *Absolutely* means that the system waits until the channel provides the data of the type requested.
- In the case of *conditional* waiting, the system checks whether data are available.

By using the feedback signal, it can be determined whether the read statement was successful or not. The relevant procedure is defined by the parameter "Mode".

If a Handle that does not come from a "COPEN" statement of the process is transferred in the "CREAD" statement or if the channel has already been closed again, the acknowledgment message "INVALID HANDLE" is displayed.

The specification of other modes or of non–initialized variables causes an error to be detected in the variable “Status”. If reading with “ABS” oder “COND” is successful, the data of the data block that was previously received are overwritten, even if they have not yet been completely read out.

The text that is returned is segmented in accordance with the format specification. The values that are determined are assigned to the appropriate variables, with the system checking whether the value is valid for each variable. A conversion specification for the variable “Format” supports the formats described in Kernighan/Ritchie (The C Programming Language, Prentice Hall, 1978), with the exception of o, p, n, u and [list].

The length specifications “H” and “L” may not be used.

Only 9 format parameters may be specified in a CREAD statement.
If several variables are available for formatting, the read–in must be continued in #SEQ mode.

The system cannot distinguish between upper and lower–case letters. Read–in is aborted after the occurrence of the first error (unsuitable format or invalid value).

The conversion character “R”, which reads in either a byte sequence of the specified length (similar to with writing, e.g. “%2.5r”) or all bytes up to the end of the message, is also introduced.

Unlike the other formats, the reading of an individual byte must be explicitly stated using “%1r”.

There is no point specifying a width with the format “%c”; such a specification is therefore rejected. The byte sequence can be assigned to a sufficiently large variable of type INT, REAL, CHAR, BOOL, ENUM or to one–dimensional arrays of these types.

It is assumed that integer data appear in “little endian” format and are signed.

Data of type Real must be in 32–bit representation in IEEE 754 standard format
bit 31 sign,
bit 30–23 exponent,
bit 22– 0 mantissa.

The types and values are checked in accordance with the following table at run time:

Format Variable	%d %i %x	%f %e %g	%c	%s	%1r	(3) %1. ⟨WDH⟩ r	%2r	(3) %2. ⟨WDH⟩ r	%4r	(3) %4. ⟨WDH⟩ r	(4) %r	(3) %. ⟨WDH⟩ r
(Signal) INT	X	–	X	–	X	–	X	–	X	–	X	–
INT array	–	–	–	–	–	X	–	X	–	X	X	X
REAL	X	X	–	–	–	–	–	–	X	–	X	–
REAL array	–	–	–	–	–	–	–	–	–	X	X	X
(Signal) BOOL (1)	X	–	X	–	X	–	X	–	X	–	X	–
BOOL array	–	–	–	–	–	X	–	X	–	X	X	X
ENUM (2)	X	–	X	–	X	–	X	–	X	–	X	–
ENUM array	–	–	–	–	–	X	–	X	–	X	X	X
CHAR	X	–	X	–	X	–	–	–	–	–	X	–
CHAR array	–	–	–	X	–	X	–	–	–	–	X	X

Remarks

- Every value that is not equal to 0 (zero) is converted to TRUE
- The system checks whether the value is a permissible ENUM value. If it is not, reading is aborted. ENUM begins at 1.
- If there are not enough data available to satisfy the requirements of the format (e.g. %2.5r, but only 7 bytes are present), nothing is read for this format and the CREAD statement is aborted. The ignored data are, however, still ready for reading.
- Only as many bytes as can fit into the variable are read. The rest are still ready for reading. If the array is actually big enough but the number of available bytes is not a multiple of the size of an array element, the redundant bytes for the following format or for the next CREAD statement are left for reading.

A message that is not completely read can be read further by the following “CREAD” calls. The number of bytes of the “%s” or “%r” format specified first in the format string that have actually been read is returned in the status variable.

All of the other lengths are not determined. It is therefore advisable to use “%s” and “%r” formats only once in a format string and to repeat the “CREAD” call.

If the “%s” or “%r” format is not among the formats that have been successfully read (see “HITS” of the variable State), the value of “LENGTH” is not changed by the statement.

Particularly time–intensive input and output operations can have a considerable effect on program execution.

The following applies to all statements:

– A statement always waits until it is completely finished and then returns to the program. This is particularly important for the absolute CREAD statement for reading to text channels.

– Regardless of this, these statements can be interrupted by interrupt programs. Any attempts to access channels there can only be interrupted by other interrupt subprograms.

The complete definitions of the status and mode information for channel instructions can be found in the “CHANNEL” declaration. See Section 2.2.5.

A complete example of a program can be found in the chapter “CHANNEL”.

2.2.12 CWRITE

2.2.12.1 Brief information

The “CWRITE” statement enables texts to be written to an open channel, or commands to be written to a command channel.

Application example: Data exchange (write statement) between KR C1 and a partner device (PC, intelligent sensor ...).

2.2.12.2 Syntax

```
CWRITE (Handle, State, Mode, Format, Var1, ..., VarN)
```

Argument	Type	Explanation	
Handle	INT	The “Handle” variable transferred by “COPEN” or the predefined variable “$CMD”.	
State	STATE_T	“CMD_STAT” is an enumeration type which is the first component of the State variable of the structure type “STATE_T”.	
		“CMD_STAT” can have the following values which are relevant for CWRITE:	
		CMD_OK	Command successfully executed;
		DATA_OK	The command has been successfully executed. Data are ready to be read as a reply;
		CMD_ABORT	Command not successfully executed because “HANDLE” is not valid;
		CMD_REJ	Only with Weltronic protocol: BCC error
		CMD_SYN	Syntax error in the command. The syntax of the command is wrong and the command cannot therefore be executed. This also applies when an invalid Mode is specified.
		FMT_ERR	Incorrect format specification or non–corresponding variable.
		Another component of the status variable that is important for “CWRITE”:	
		HITS	Number of correctly written formats.
Mode	MODUS_T	Variable of type “MODUS_T” (structure type) defining how the channels are written to. It can have the following values:	
		SYNC	The statement is not executed until the data have been sent to the partner station.
		ASYNC	The statement is not executed until the channel driver has confirmed that the data have been received.

Format	CHAR[]	The variable “Format” contains the format of the text that is to be generated. The structure of the variable largely corresponds to the format string of the function “FPRINTF” of the “C” programming language.
Var		The variables corresponding to “Format”.

2.2.12.3 Description

The statement “CWRITE” enables texts to be written to an open channel, or commands to be written to a command channel.

The value of “Mode” is not relevant for writing to the command channel. If “Mode” is a non−initialized variable in the other cases, the statement is aborted and an error flag is set in the variable “Status”.

If “Mode” has a value other than SYNC or ASYNC, data are written to the channel in the SYNC mode.

The conversion specification for the variable Format has the following structure:
%FWGU

The following definitions apply here:

- **F** Formatting character +, −, #, etc. (optional).
- **W** Width, specifies the minimum number of bytes that are to be output (optional).
- **G** Precision, its significance is dependent on the conversion character. ’.’ or ’.*’ or ’.integer’ can be used (optional).
- **U** Permissible conversion characters: c, d, e, f, g, i, s, x and %. The system cannot distinguish between upper and lower−case letters. In addition to the conversion characters given above (corresponding to “FPRINTF” in “C”), the character “r” is also available.

The format variable “%r” converts the value of its variable not into ASCII but into binary notation. With the format “%r” , the system does not check whether the variable or the array element is initialized.

By entering a width (“%2r”), you can specify to how many bytes the value is to be extended or compressed. REAL values are an exception here.

When compressing the value, the high−order bytes are disregarded; the value is extended by adding zero bytes at the end (little endian format).

If the width is not specified, the internal representation is output: 4 bytes for INTEGER, REAL and ENUM, one byte for BOOL and CHAR.

The precision can only be specified for arrays and is interpreted as a repeat number. A corresponding number of an array’s elements can be output, starting with the first. If the repeat number is greater than the array, no array element is written and the output is aborted.

“*” cannot be specified for the precision. If a value for precision is omitted, the array is written in its entirety.

The variables “Var1”, ..., “VarN” may not be of a structure type or an array of a structure type (including structures such as “POS”). Types are checked in accordance with the following table at run time.

Conversion is aborted if types are incompatible or when the system encounters the first value that has not been initialized, except in the case of “%r”. An error message is not output.

The incorrect format can be inferred from the value of HITS (see below).

Boolean values are output as 0 or 1, ENUM values as numbers.

Format Variable	%d %i %x	%f %e %g	%c	%s	%1r	%1. ⟨WDH⟩ r	%2r	%2. ⟨WDH⟩ r	%4r	%4. ⟨WDH⟩ r	%r	%. ⟨WDH⟩ r
(Signal) INT	X	X	–	–	X	–	X	–	X	–	X	–
INT array	–	–	–	–	–	X	–	X	–	X	X	X
REAL	–	X	–	–	–	–	–	–	X	–	X	–
REAL array	–	–	–	–	–	–	–	–	–	X	X	X
(Signal) BOOL	X	–	–	–	X	–	X	–	X	–	X	–
BOOL array	–	–	–	–	–	X	–	X	–	X	X	X
ENUM	X	–	–	–	X	–	X	–	X	–	X	–
ENUM array	–	–	–	–	–	X	–	X	–	X	X	X
CHAR	X	–	X	–	X	–	–	–	–	–	X	–
CHAR array	–	–	–	X	–	X	–	–	–	–	X	X

The “CWRITE” statement, which can be used in programs at the control or robot levels, triggers an advance run stop.

Particularly time–intensive input and output operations can have a considerable effect on program execution.

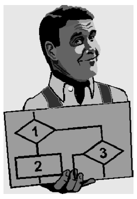
The following applies to all statements: A statement always waits until it is completely finished and then returns to the program. This is particularly important for the absolute CWRITE statements for command channels.

Regardless of this, these statements can be interrupted by interrupt routines. Any attempts to access channels there can themselves be interrupted again only by other interrupt subprograms.

Commands which can return segmented or several feedback signals are rejected by the command channel.

The complete definition of the status and mode information for channel instructions can be found in the “CHANNEL” declaration.

2.2.12.4 Example



Several examples of the “CWRITE” statement are given below.

Conversion of the value into decimal and hexadecimal format

Conversion of the value of “`I`” into decimal and hexadecimal ASCII format:

```
INT I
I=123

%D,I ;transmission data 3 bytes: 123

%X,I ;transmission data 2 bytes: 7B
```

Conversion of the value of “`I`” into binary notation

```
INT I
I=123
%R,I ;transmission data 1 byte:{      (Hex. 7B)

I=123456
%R,I ;transmission data 3 bytes:@â□(Hex.40E201)
```

Writing of the first 5 array names of R[ ]

Writing of the values of the first 5 array names of “R[ ]”. Random values are generated for array elements that have not been initialized.

```
REAL R[10]

%.5R,R[] ; transmission data 20 bytes in binary notation
```

Output of values of all array elements

The following statement is used to output the values of all array elements:

```
REAL R[10]

%R,R[]
```

Output of certain array elements

Output of the array elements of “S”, ending with the first non–initialized element:

```
CHAR S[100]

%S,S[]
```

Writing of the first 50 array elements of S

Writing of the first 50 array elements of “S”, disregarding the initialization information:

```
CHAR S[100]

%.50R,S[]
```

Conversion of the internal value of the ENUM variable into ASCII

Conversion of the internal value of the “ENUM” variable into ASCII. The corresponding number is output.

```
DECL ENUM_TYP E

%D,E
```

Writing of two real values (defined length) with name

```
REAL W1,W2

W1=3.97

W2=-27.3

CWRITE(..,..,..,"Value1=%+#07.3F Value2=+#06.2F",W1.W2)
              ;transmission data: Value1=+03.970 Value2=-27.30
```

A complete example of a program can be found in the chapter “CHANNEL”.

2.2.13 DECL

2.2.13.1 Brief information

Declaration of variables and constants in programs and data lists.

2.2.13.2 Syntax

Declaration of **variables in programs:**

```
⟨DECL  Data_Type Variable_Name1 ⟨, ...,
↳     Variable_NameN
```

Declaration of **arrays in programs:**

```
⟨DECL  Data_Type Array_Name1 [Size1 ⟨, ...,
↳     Size3  ] ⟨, ..., Array_NameN [SizeN1 ⟨,...,
↳     SizeN3 ]
```

Declaration of **variables in data lists:**

```
⟨DECL ⟨GLOBAL  Data_Type Variable_Name1 ⟨, ...,
↳     Variable_NameN
```

or with simultaneous value assignment:

```
⟨DECL ⟨GLOBAL  Data_Type Variable_Name = Value
```

Declaration of **arrays in data lists:**

```
⟨DECL ⟨GLOBAL  Data_Type Array_Name [Size1 ⟨,...,
↳     Size3  ] ⟨, ..., Array_NameN [SizeN1 ⟨,...,
↳     SizeN3 ]
```

Declaration and initialization of **constants in data lists:**

```
DECL ⟨GLOBAL  CONST Data_Type Constant_Name = Value
```

Declaration and initialization of **constant arrays in data lists:**

```
DECL ⟨GLOBAL  CONST Data_Type Array_Name [Size1 ⟨,...,
↳     Size3  ]

Array_Name[1 ⟨, 1, 1  ] = Value1
...
Array_Name[Size1 ⟨, Size2, Size3  ] = ValueN
```

Argument	Type	Explanation
`Data_Type`		Simple data types are: • INT, REAL, CHAR, BOOL These can be any of the structure and enumeration types predefined in the system files, e.g.: • FRAME, POS, E6POS, AXIS, E6AXIS These can be self–defined data types: • structure types (STRUC) or • enumeration types (ENUM)

`Variable_Name,`
`Array_Name,`
`Constant_Name,`
`Object_Name`
		Name of the object that is to be declared.

`Size`	INT	Unsigned, positive, integral constant defining the size of the array. The number of constants produces the dimension of the array. The array dimension can be a maximum of three.
`Value`		Constant of the declared data type.
`Array_Index`	INT	Constant that can range from 1 to Size. It identifies the array element that is being assigned a value.

Global variables and constants can only be declared in data lists.

In order to be able to use the keyword GLOBAL, the global option in the file “Progress.ini”, in the INIT directory, must be set to TRUE:
GLOBAL_KEY=TRUE

In order to be able to use constants, the constant option CONST_KEY in the file Progress.ini, in the INIT directory, must be set to TRUE:
CONST_KEY=TRUE

2.2.13.3 Description

All of the variables used in the program must be declared in the declaration with a name and a data type. Simple, complex and freely definable data types are available for doing so.

The declaration begins with the keyword DECL, followed by a data type and the list of variables and arrays that are to have this data type. When declaring variables and arrays of a predefined type, the keyword DECL can be omitted. In addition to the simple data types INT, REAL, CHAR and BOOL, the data types POS, E6POS, FRAME, AXIS, E6AXIS etc., amongst others, are predefined. The declaration can be completely omitted for variables with the data type POS, since this data type is the standard data type and is assigned by default. The keyword DECL may not be omitted from the declaration of user–defined structure or enumeration types.

Declaration of arrays
Just as with variables, each data type can be used for arrays. In addition to the data type and the array name, the array sizes and the dimension must also be declared for an array. The dimension is determined by the number of array sizes that are specified. It can be a maximum of three. The array sizes appear after the name of the array in square brackets and are

separated by commas. Each array size is an unsigned, integral constant. It must be equal to or greater than 1.

If an array is transferred as a formal parameter in a subprogram or function call, it must be declared in the definition of this subprogram or function, just like a variable. The array sizes must be omitted in this declaration but not the square brackets and the commas which determine the array dimension. When calling the subprogram or function, the array sizes are determined by the associated current parameters that are transferred.

Declaration of variables with a default setting
Variables can be declared in data lists and assigned an initial value as a default at the same time. A declaration statement containing a default setting cannot be used in the declaration section of programs and functions.

In the case of variables with simple data types, the initial value is to be specified as a simple constant. With structure variables, the initial value is an aggregate.

The declaration statement for assigning a default setting to variables begins, just like with the simple declaration, with the keyword DECL, a data type and the name of the variable that is to be assigned a default setting.

An "=" sign and the initial value given in the form of a constant follow the variable name. When declaring a default setting, you cannot list several variables in a declaration statement. A separate declaration statement is required for each variable that is to be assigned a default setting. The keyword DECL may also be omitted when assigning a default setting.

The data type of the constant to the right of the "=" sign must be compatible with the explicitly specified data type on the left–hand side but does not have to be identical to it. If the data types are compatible, the system automatically matches them, as in the case of a value assignment.

Declaration of arrays with a default setting
A declaration statement containing a default setting cannot be used in the declaration section of programs and functions. Nor can a single line in a data list contain both declarations and initializations.

In the case of an array with a simple data type, the initial values are to be specified as simple constants. In the case of arrays with a structure type, the initial value for each array element is an aggregate.

When declaring default settings for arrays, a separate statement must be written for each array element.

The declaration for assigning a default setting to an array consists of at least two blocks.

- The first block contains a normal array declaration with the declaration DECL.
- The second block contains the specification of an array element, followed by an "=" sign and the initial value for this element.
- Further blocks of this type in which default settings are assigned to other array elements may follow.

When assigning a default setting to more than one element of an array, the elements must be specified in ascending sequence of the array index. The right–hand array index varies fastest.

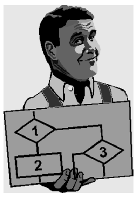
The data type of the constant to the right of the "=" sign must be compatible with the explicitly declared data type of the array but does not have to be identical to it. If the data types are compatible, the system automatically matches them, as in the case of a value assignment.

Assigning character strings as defaults
If you want to assign the same character string to all of the elements of an array of type Character as a default setting, you do not have to assign it to each array element individually. The right–hand array index is omitted (i.e. no index is written for a one–dimensional array) and a character string constant is thus assigned as a default setting to an entire line.

Declarations of variables of the data type “freely definable structure type” or “freely definable enumeration type”

The keyword DECL must be programmed here if the following data type name is not a predefined system data type. The data type definitions STRUC and ENUM must always appear before the DECL declaration for all variables of this type.

2.2.13.4 Example:



Declaration without initialization.

```
DECL POS P1
; The keyword DECL can also be omitted
INT A1,A2
REAL VEL[7],ACC[7],B
DECL S_PAR_TYPE S_PAR[3]
```

Declaration of arrays with initialization (only in data lists).

```
INT A[7]                ; Array for 7 integer values
A[1]=27                 ; The first array element is assigned the value 27
A[2]=313
A[6]=11
CHAR TEXT1[80]
TEXT1[]=”Message Text”
CHAR TEXT2[2,80]
TEXT2[1,]=”First Message Text”
TEXT2[2,]=”Second Message Text”
```

Declaration of variables with initialization (only in data lists).

```
FRAME F1={X 123.4, Y -56.7, Z 89.56}
```

STRUC, ENUM, DEFDAT

2.2.14 DEF ... END

2.2.14.1 Brief information

Declaration of programs and subprograms.

2.2.14.2 Syntax

```
⟨GLOBAL  DEF Program_Name(⟨Parameter_List )
⟨DECL Data_Type Parameter_Name1
...
DECL Data_Type Parameter_NameZ
⟨further declarations
⟨Statements
END
```

```
Parameter_List = Parameter_Name1
↳    ⟨ , ..., Parameter_NameI  : IN | ⟨OUT ⟨ , ...,
↳    ⟨ Parameter_NameN
↳    ⟨ , ..., Parameter_NameZ  : IN | ⟨OUT
```

Argument	Type	Explanation
`Program_Name`		The name of the program that is to be defined is entered here. It is an object name and may not be more than 24 characters long in the case of global functions. The length is restricted by the controller's directory system.
`Parameter_ List`		The parameter list contains the following specifications: • Parameter names. • In the case of output parameters of type Array (input parameters cannot be arrays), the array dimension is added to the name of the array using the following notation: `[]` One–dimensional array `[,]` Two–dimensional array `[,,]` Three–dimensional array • The transfer mode of the respective parameter: **`:IN`** Input parameter (call by value) **`:OUT`** Output parameter (call by reference) (default value)

`Declaration`		Only declarations may appear in the declaration section. Program statements cannot be used here. The border between the declaration section and the statement section is defined by the first statement.
`Statements`		Only statements may appear in the statement section. Declarations cannot be used here. You can exit a local subprogram using a RETURN statement. Without a RETURN statement, the END statement is the last statement to be executed.

2.2.14.3 Description

By default, the first program in an SRC file has the same name as the SRC file and is recognized globally, even without using the keyword GLOBAL.

When a program is called, there are two kinds of parameter transfer: transfer with an input parameter and transfer with an output parameter.

Input parameter (keyword IN)
Only the value of the variable is transferred here. This direct parameter transfer works like the assignment of a default setting to the variable in the subprogram. The value that is currently transferred can be a constant, a variable, a function call or a simple or complex expression.

A value cannot be returned to the calling module in the case of an IN parameter (call by value). It is only used for transferring a value to the subprogram.

If the data types of the current and formal IN parameters are not identical but are compatible, the system automatically converts the type of the value that has been transferred. Arrays cannot be transferred as an input parameter (IN).

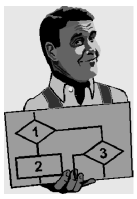
Output parameter (keyword OUT)
A variable name is transferred here (call by reference). The variable must have a value at the time of the subprogram call. This value can be used in the subprogram that is called.

A parameter of type OUT can be assigned a (new) value in the subprogram that is called. For this reason, the data types of the current and formal parameters must be identical in the case of the transfer mode OUT.

Transfer as an output parameter is the default setting, i.e. OUT does not have to be specified.

END statement
The END statement is always the last block of a global or local subprogram. The last block of a subprogram that can be executed is either the RETURN statement or, if this is missing, the END statement.

2.2.14.4 Example:



Declaration of a program without formal parameters.

```
DEF PROG()
...
END
```

Declaration of a subprogram with the formal parameters Current and Voltage. Due to the default setting, they are output parameters.

```
DEF WELD(CURRENT,VOLTAGE)
...
END
```

Declaration of a subprogram with the formal parameters Current and Voltage as input parameters and RESULT as an output parameter.

```
DEF WELD(CURRENT:IN,VOLTAGE:IN,RESULT:OUT)
...
END
```

In the subprogram CALCULATE, some variables undergo arithmetic operations. After the subprogram has been called, the variables A and B in the main program have the following values: A=11, B=2.

```
DEF PROG()
INT A,B
A=1
B=2
CALCULATE(A,B)
...
END
DEF CALCULATE(X1:OUT,X2:IN)
INT X1,X2
X1=X1+10
X2=X2+10
END
```

END, DEFFCT, RETURN

2.2.15 DEFDAT ... ENDDAT

2.2.15.1 Brief information

Declaration of data lists.

2.2.15.2 Syntax

```
DEFDAT Data_List_Name 〈PUBLIC
〈Declarations
ENDDAT
```

Argument	Type	Explanation
`Data_List_ Name`		The name of the data list that is to be defined is entered here. It is an object name and can have a maximum length of 24 characters. The length is restricted by the controller's directory system. If the name of the data list is identical to that of a module, the data list is then assigned to this module, as a result of which the declarations of the data list also apply in the module of the same name. A module and the data list assigned to it form a module package.
`PUBLIC`		By adding this keyword, other modules and data lists can also access this data list, and the variables, etc., that are defined here can be used in other module packages. They must be declared using the keyword GLOBAL.
`Declaration`		• External declarations for subprograms and function modules that are used in the module. • Import declarations for imported variables. • Declarations for variables. • Declarations for signal and channel names. • Declarations for structure and enumeration types. • The variable declarations in the declaration section of the data list may contain default settings.

2.2.15.3 Description

In addition to the predefined data lists, you can define further data lists yourself. Data lists are used for preparing program–specific and higher–level declarations. Variable values that can be saved (=default settings) can be declared in data lists. In particular, the data lists can contain taught positions. A data list can also exist as an independent object. In this case, there is no module of the same name.

The ENDDAT statement is always the last block of every data list.

No statements may appear in data lists, except the initialization of variables and constants.

2.2.15.4 Example:

Declaration of a data list.

```
DEFDAT WELD
...
ENDDAT
```

Declaration of a data list with global accessibility.

```
DEFDAT CENDAT PUBLIC
...
ENDDAT
```

The module package PROG_1 consists of the module and the assigned data list PROG_1.

This is omitted in the main program as it is declared and initialized in the data list. If the variable OTTO in the main program is assigned a new value, this is also entered in the data list and remains permanently stored there.

The "new" value is thus used after the controller has been switched off and back on again. This is essential for online correction and other program modifications. If you want to always start a main program with the same value, the desired value must be assigned as a default to the appropriate variable in the main program.

```
DEFDAT PROG_1
INT OTTO = 0
ENDDAT

DEF PROG_1()
HALT                 ; OTTO is now 0
OTTO=25
HALT                 ; The data list now contains: INT OTTO=25
END
```

Global data lists: The variable OTTO is to be recognized in PROG_1 and PROG_2. It is possible to allow an outside main program to access the variables defined in a data list. To do so, the data list must be defined as PUBLIC and the variables must be declared as GLOBAL.

```
DEFDAT PROG_1 PUBLIC
GLOBAL INT OTTO = 0
ENDDAT

DEF PROG_1()
HALT
OTTO = 25
END

DEF PROG_2()
OTTO=27
END
```

IMPORT

2.2.16 DEFFCT ... ENDFCT

2.2.16.1 Brief information

Declaration of functions.

2.2.16.2 Syntax

```
⟨GLOBAL  DEFFCT Data_Type Function_Name (⟨Parameter_List )
⟨DECL Data_Type Parameter_Name1
...
DECL Data_Type Parameter_NameZ
⟨further declarations
⟨Statements
ENDFCT
```

```
Parameter_List = Parameter_Name1
↳    ⟨ , ..., Parameter_NameI  : IN | ⟨OUT ⟨ , ...,
↳    ⟨ Parameter_NameN
↳    ⟨ , ..., Parameter_NameZ  : IN | ⟨OUT
```

Argument	Type	Explanation
GLOBAL		The keyword GLOBAL makes the function available for all loaded KRL programs.
Data_Type		Data type of the function.
Function_ Name		Name of the function that is to be defined. It is an object name and may not be more than 24 characters long. The length is restricted by the controller's directory system.
Parameter_ List		The parameter list contains the following specifications: • The parameter names. • In the case of output parameters of type Array (input parameters cannot be arrays), the array dimension is added to the name of the array using the following notation: `[]` One–dimensional array `[,]` Two–dimensional array `[,,]` Three–dimensional array • The transfer mode of the respective parameter: **:IN** Input parameter (call by value) **:OUT** Output parameter (call by reference) (default value)

Declarations		Only declarations may appear in the declaration section. The border between the declaration section and the statement section is defined by the first statement.
Statements		Only statements may appear in the statement section. The return value of the function is transferred using the RETURN statement.

2.2.16.3 Description

A function sends a return value to the calling module. A function call is an expression and the function can thus be assigned to a variable or used by other arithmetic statements. When calling a function, there are two kinds of parameter transfer: transfer with an input parameter and transfer with an output parameter.

Input parameter

A value is transferred. The direct parameter transfer works like the assignment of a default setting to the variable in the function.

The value that is currently transferred can be a constant, a variable, a function call or a simple or complex expression. A value cannot be returned to the calling module in the case of an IN parameter (call by value). It is only used for transferring a value to the subprogram or function.

If the data types of the current and formal IN parameters are not identical but are compatible, the system automatically converts the type of the value that has been transferred. Arrays cannot be transferred as an input parameter (IN).

Output parameter

A variable name is transferred here (call by reference). The variable can have a value at the time of the subprogram call. This value can be used in the subprogram that is called.

A parameter of type OUT can be assigned a (new) value in the function that is called. This value is then returned to the calling module, which can make further use of it. For this reason, the data types of the current and formal parameters must be identical in the case of the transfer mode OUT.

Transfer as an output parameter is the default setting, i.e. OUT does not have to be specified.

ENDFCT statement

The ENDFCT statement is always the last block of a global or local function. The last block of a function that can be executed is always the RETURN statement. If the interpreter encounters an ENDFCT statement whilst executing a function, a runtime error occurs.

2.2.16.4 Example

Declaration of a function of data type INT with the name FCT1 and the transferred parameters P1 and P2.

```
DEFFCT INT FCT1(P1,P2)
...
ENDFCT
```

Declaration of a function of data type BOOL with the name WELD and the input parameters CURRENT and VOLTAGE.

```
DEFFCT BOOL WELD(CURRENT:IN,VOLTAGE:IN)
...
ENDFCT
```

In a function, the difference between two variables is to be calculated and transferred to the main program.

```
DEF PROG_1()
EXTFCT INT DELTA(INT:OUT,INT:OUT)
INT A,B,C
A=1
B=25
C=DELTA(A,B)
END

DEFFCT INT DELTA(X1:OUT,X2:OUT)
INT X1,X2,X3
X3=X2-X1
RETURN(X3)
ENDFCT
```

DEF, RETURN

2.2.17 DIGIN

2.2.17.1 Brief information

Cyclic reading in of digital inputs.

2.2.17.2 Syntax

Reading a digital input:

```
DIGIN ON Signal_Value = Factor * $DIGINX 〈± Offset
```

Termination of the read operation:

```
DIGIN OFF $DIGINX
```

Argument	Type	Explanation
`Signal_Value`	Real	The result of the operation is stored in Signal_Value. It can be a variable or a signal name.
`Factor`	Real	The factor can be a constant, variable or signal name.
$DIGINX		***$DIGINX*** designates a predefined digital signal name: $DIGIN1 to $DIGIN6.
`Offset`	Real	Offset can be a constant, variable or signal name.

All of the variables used in the DIGIN statement must be declared in data lists.

Accessing the digital inputs triggers an advance run stop. Array indices are only evaluated once in the DIGIN ON statement. The expression that is produced after the array indices have been replaced by numeric values is cyclically evaluated. Digital inputs cannot be used in the INTERRUPT statement.

2.2.17.3 Description

The controller provides six digital interfaces which can be read via the predefined signal variables $DIGIN1 to $DIGIN6. Each of the digital inputs can have a length of 32 bits and an associated strobe output. The controller can interpret these inputs with or without a sign. The digital inputs are configured in the file “$MACHINE.DAT”.

The digital inputs can be read over a period of time using DIGIN or can be assigned to a variable of data type REAL once by means of the operator “=”. Two DIGIN ON statements can be used at the same time. Two DIGIN ON statements can read the same digital input. It is possible to logically combine digital inputs with other operators and to assign them to a signal value by using the optional arithmetic of the DIGIN statement. A DIGIN ON statement can also access analog input signals (see example).

The cyclic read–in of the digital inputs is deactivated using the DIGIN OFF statement followed by the signal name.

2.2.17.4 Examples

The digital input $DIGIN1 is assigned to the binary input signals $IN[1020] to $IN[1026]. The analog input $ANIN[1] is assigned the symbolic name FACTOR. The system variable $TECHIN[1] is assigned the result of the product of the analog input value and the digital input, increased by the value of the variable OFFSET. The DIGIN OFF instruction deactivates the cyclic read–in of the digital inputs.

```
SIGNAL $DIGIN1 $IN[1020] TO $IN[1026]
SIGNAL FACTOR $ANIN[1]
DIGIN ON $TECHIN[1] = FACTOR * $DIGIN1 + OFFSET
...
DIGIN OFF $DIGIN1
```

SIGNAL, ANIN, ANOUT

2.2.18 ENUM

2.2.18.1 Brief information

Declaration of enumeration data types.

2.2.18.2 Syntax

```
⟨GLOBAL ENUM Enumeration_Type_Name Enumeration_Constant1
    ⟨,..., Enumeration_ConstantN
```

Argument	Type	Explanation
`Enumeration_ Type_Name`		Name of the new enumeration data type.
`Enumeration_ Constant`		The enumeration constants are the values that a variable of the enumeration data type can take. The name of each constant must be unambiguous within the data type.

The keyword GLOBAL, in the context of declaring Enum data types, may only be used in data lists.

2.2.18.3 Description

The enumeration type is a data type made up of a finite number of integer constants. The enumeration constants represent the discrete values that an enumeration variable can take. Variables with an enumeration type do not follow a continuous scale of values, but can only take the constants that are listed in the definition as values. The constants are freely definable names and can be defined by the user.

The enumeration type definition may appear in the declaration section of modules or in data lists. Global ENUM declarations are only allowed in data lists.

Symbolic designation of enumeration constants

You are able to use short or full symbolic names.

If using short symbolic names, a "#" character is inserted before the name of the enumeration constant, e.g. #monday.

If using a full symbolic name, an enumeration constant is identified by the name of the enumeration type followed by a "#" character and the name of the enumeration constant, e.g. WEEK_TYPE#MONDAY. There are two instances where the full symbolic name of enumeration constants must be given:

1. If the enumeration constant is used as a current parameter in a subprogram or function call in an individual command outside the module.
2. If the enumeration constant appears on the left–hand side of a comparison.

The names of enumeration types should end in `_TYPE` so as to distinguish variable names from enumeration types.

2.2.18.4 Example

Declaration of an enumeration data type with the name STATE_TYPE and the constants S_START, S_STOP and S_WAIT.

```
ENUM STATE_TYPE S_STOP, S_START, S_WAIT
```

An enumeration data type with the name SWITCH_TYPE and the constants ON and OFF is declared in the following program. These are addressed in the program using their short symbolic names.

```
DEF PROG()
ENUM SWITCH_TYPE ON, OFF
DECL SWITCH_TYPE ADHESIVE
IF A>10 THEN
      ADHESIVE=#ON
ELSE
      ADHESIVE=#OFF
ENDIF
END
```

DECL, STRUC

2.2.19 EXIT

2.2.19.1 Brief information

Unconditional exit from loops.

2.2.19.2 Syntax

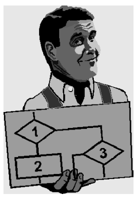
```
EXIT
```

2.2.19.3 Description

The EXIT statement appears in the statement block of a loop. It may be used in any loop.

The EXIT statement can be used to exit the current loop. The program is then continued after the ENDLOOP statement.

2.2.19.4 Example



Exit from an endless loop.

```
LOOP
      A=(A+1)*0.5/B
      IF A>=13.5 THEN
            EXIT
      ENDIF
ENDLOOP
```

FOR, WHILE, REPEAT, LOOP

2.2.20 EXT

2.2.20.1 Brief information

Declaration of external subprograms.

2.2.20.2 Syntax

```
EXT Program_Source(⟨Parameter_List )
```

```
Parameter_List = Data_Type1
↳    ⟨ , ..., Data_TypeI  : IN | ⟨OUT ⟨ , ...,
↳    ⟨ Data_TypeN
↳    ⟨ , ...,Data_TypeZ  : IN | ⟨OUT
```

Argument	Type	Explanation
Program_ Source		Identifies the path and the name of the subprogram used.
Parameter_ List		The parameter list contains the following specifications: • The data types of all of the parameters of the external subprogram in the defined sequence. • In the case of array parameters, the array dimension using the following notation: `[]` One–dimensional array `[,]` Two–dimensional array `[,,]` Three–dimensional array • The transfer mode of the respective parameter: **:IN** Input parameter (call by value) **:OUT** Output parameter (call by reference) (default value) The sequence of the parameter list must be observed. The individual parameters are separated from one another by commas.

EXT declarations cannot be used in subprograms.

2.2.20.3 Description

The EXT declaration is used to identify external subprograms to the program in which they are called. Only the main program can be used (program name is the same as the name of the SRC file), not other subprograms in the same file. Other subprograms in an SRC file can be identified generally using the keyword GLOBAL.

The EXT declaration must be used to make both the name and path of the subprogram that is to be called and the parameters that are used known to the compiler. By specifying a parameter list, the required storage space is also clearly defined.

2.2.20.4 Example

Declaration of an external subprogram with the name SP1 in the directory R1.

```
EXT /R1/SP1()
```

Declaration of an external subprogram with the name SP1 and declaration of the required parameters.

```
EXT /SP1(INT,REAL:IN,CHAR[],INT[,,]:IN)
```

Declaration of an external subprogram with the name SP1 and declaration of the required parameters.

```
DEF PROG()          ; Main program
EXT SP1(INT:OUT,REAL:OUT,BOOL:IN)
INT A
REAL B
BOOL C
...
SP1(A,B,C)
...
END
DEF SP1 (X1:OUT,X2:OUT,X3:IN); External subprogram
INT X1
REAL X2
BOOL X3
...
END
```

DEF, EXTFCT

2.2.21 EXTFCT

2.2.21.1 Brief information

Declaration of external local functions.

2.2.21.2 Syntax

```
EXTFCT Data_Type Program_Source(〈Parameter_List )
```

```
Parameter_List = Data_Type1
↳    〈 , ..., Data_TypeI  : IN | 〈OUT 〈 , ...,
↳    〈 Data_TypeN
↳    〈 , ...,Data_TypeZ  : IN | 〈OUT
```

Argument	Type	Explanation
`Data_Type`		The data type must correspond to the function declaration.
`Program_ Source`		Identifies the path and the name of the function used.
`Parameter_ List`		The parameter list contains the following specifications: • The data types of all of the parameters of the external function in the defined sequence. • In the case of array parameters, the array dimension using the following notation: `[]` One–dimensional array `[,]` Two–dimensional array `[,,]` Three–dimensional array • The transfer mode of the respective parameter: `:IN` Input parameter (call by value) `:OUT` Output parameter (call by reference) (default value) The sequence of the parameter list must be observed. The individual parameters are separated from one another by commas.

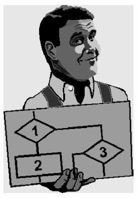
EXTFCT declarations cannot be used in subprograms.

2.2.21.3 Description

The EXTFCT declaration is used to identify external functions to the program in which they are called. Only the main program can be used (function name is the same as the name of the SRC file), not other functions in the same file. Other functions in an SRC file can be identified generally using the keyword GLOBAL.

The EXTFCT declaration must be used to make both the name and path of the external function that is to be called and the parameters used known to the compiler. By specifying a parameter list, the required storage space is also clearly defined.

2.2.21.4 Example



Declaration of an external function with the name FCT1 in the directory R1.

```
EXTFCT /R1/FCT1()


DEF PROG()
```

; Main program

```
EXTFCT INT DELTA(INT:OUT,INT:IN)
INT A,B,C
...
A=5
B=20
C=DELTA(A,B)
```

; Function call

```
...
END
```

Declaration of an external function with the name FCT1 and the transfer parameters.

```
EXTFCT /FCT1(INT,REAL:IN,CHAR[],INT[,,]:IN)
```

Declaration of an external function with the name FCT1 and the transfer parameters.

```
EXTFCT FCT1(INT:OUT,REAL:OUT,BOOL:IN)
```

In a function, the difference between 2 variables is to be calculated and transferred to the main program. The values of the variables after the function has been called are: A=15, B=20, C=15.

```
DEF PROG()
```

; Main program

```
EXTFCT INT DELTA(INT:OUT,INT:IN)
INT A,B,C
...
A=5
B=20
C=DELTA(A,B)
```

; Function call

```
...
END
```

```
DEFFCT INT DELTA(X1:OUT,X2:IN)
```

; External function

```
INT X1,X2,X3
X1=X2-X1
X3=X1
RETURN(X3)
ENDFCT
```

DEFFCT, EXT

2.2.22 FOR ... TO ... ENDFOR

2.2.22.1 Brief information

Counting loop.

2.2.22.2 Syntax

```
FOR Counter = Start TO End 〈STEP Increment
〈Statements
ENDFOR
```

Argument	Type	Explanation
`Counter`	INT	An integer variable used as a loop counter.
`Start`	INT	Arithmetic expression specifying the initial value for the counter.
`End`	INT	Arithmetic expression specifying the final value for the counter.
`Increment`	INT	Arithmetic expression of the amount by which the counter is incremented with each execution of the loop: • Increment may be negative • Increment may not be zero • Increment may not be a variable If no increment is specified, the default value 1 is used.

2.2.22.3 Description

A specified number of runs can be very clearly programmed using the FOR loop. The loop runs are counted with the aid of the counter.

The execution condition for FOR is as follows:

- with a **positive** increment: if the counter is **greater** than the final value, then the loop is ended.
- with a **negative** increment: if the counter is **less** than the final value, then the loop is ended.

The execution condition is checked **before** each loop run. In extreme cases, the FOR loop is not executed at all.

An expression of type Integer must be given for both the initial and final values of the counter. The expressions are evaluated once at the start of the loop. The timer is preset to the initial value and is incremented or decremented after each loop run.

The increment may not be zero. If no increment is specified, it has the default value 1. Negative values can also be used for the increment.

The value of the counter can be used in the statements inside and outside of the loop. Within the loop, it serves, for example, as an up-to-date index for the processing of arrays. After exiting the loop, the counter retains its most recent value.

There must be an ENDFOR statement for every FOR statement. After completion of the last loop execution, the program is resumed with the first instruction after ENDFOR. The loop execution can be exited prematurely using the EXIT statement.

2.2.22.4 Example

FOR loop that increases variable B by 1 in 10 executions.

```
FOR A=1 TO 10
      B=B+1
ENDFOR
```

FOR loop that, in steps of two, increments counter A after each run and increases variable B by the value of the counter. Should variable B reach the value 10, the loop is prematurely ended.

```
FOR A=1 TO 15 STEP 2
      B=B+A
      IF B==10 THEN
            EXIT
      ENDIF
ENDFOR
```

EXIT, SWITCH, REPEAT, WHILE, LOOP

2.2.23 GOTO

2.2.23.1 Brief information

Unconditional jump statement.

2.2.23.2 Syntax

```
GOTO Marker
```

Argument	Type	Explanation
Marker		Marker describes the destination of the jump statement.

2.2.23.3 Description

The unconditional jump statement GOTO is a program execution instruction. After the GOTO statement has been processed, the program will resume execution at the point specified by this statement.

The destination must be in the same subprogram or function as the GOTO statement. It is defined by the *marker* followed by a colon.

Jumping to a destination in an IF statement or in a loop from outside, or from one CASE statement to another CASE statement is not possible.

The program very quickly becomes confusing and unstructured when using GOTO. It is better to use the branching statement IF or the selection statement SWITCH instead.

2.2.23.4 Example

Unconditional jump to the program position MARKER_1.

```
GOTO MARKER_1
```

Unconditional jump from an IF statement to the program position END.

```
IF X>100 THEN
      GOTO END
ELSE
      X=X+1
ENDIF
A=A*X
...
END:
END
```

IF, SWITCH, REPEAT, WHILE, LOOP

2.2.24 HALT

2.2.24.1 Brief information

Interrupts program execution and halts processing.

2.2.24.2 Syntax

```
HALT
```

2.2.24.3 Description

The HALT statement stops execution of the program. The last motion instruction to be executed will, however, be completed.

Execution of the program can only be resumed using the Start key. The next instruction after HALT is then executed.

In an interrupt routine, program execution is only stopped after the advance run has been completely executed. In the event of a BRAKE statement, on the other hand, program execution is stopped immediately.

WAIT FOR, WAIT SEC, BRAKE

2.2.25 IF ... THEN ... ENDIF

2.2.25.1 Brief information

Execution of statements depending on the result of a logical expression.

2.2.25.2 Syntax

```
IF Condition THEN
      Statements
⟨ELSE
      Statements
ENDIF
```

Argument	Type	Explanation
`Condition`	BOOL	Logical expression which can contain a Boolean variable, a Boolean function call or a logical operation with a Boolean result, e.g. a comparison.

2.2.25.3 Description

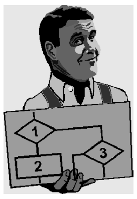
The branching statement IF is a program execution instruction. Depending on a condition, either the first statement block (THEN block) or the second statement block (ELSE block) is executed. The program is subsequently continued with the statements following ENDIF.

There is no limit on the number of statements contained in the statement blocks. Several IF statements can be nested in each other.

The keyword ELSE and the second statement block may be omitted. If the condition is not satisfied, the program is then continued at the position immediately after ENDIF.

There must be an ENDIF for each IF.

2.2.25.4 Example



IF loop without a second statement block.

```
IF A==17 THEN
      B=1
ENDIF
```

IF loop with a second statement block.

```
IF $IN[1] THEN
      $OUT[17]=TRUE
ELSE
      $OUT[17]=FALSE
ENDIF
```

2.2.26 IMPORT ... IS ... .

2.2.26.1 Brief information

Import of data from data lists.

2.2.26.2 Syntax

```
IMPORT Data_Type Import_Name IS Data_Source..Data_Name
```

Argument	Type	Explanation
Data_Type		The data must be imported with the data type with which they are declared in the external data list.
Import_Name		The imported data can be assigned a name different to the one that they have in the external data list.
Data_Source		The data source identifies the path and the name of the data list from which the data are to be imported.
Data_Name		The data name corresponds to the variable name assigned to the data in the external data list.

2.2.26.3 Description

The IMPORT statement allows external data lists bearing the attribute “PUBLIC” to be accessed. The IMPORT statement allows variables, entire arrays or array elements to be imported into your own programs or data lists from an external data list. Each variable that is to be imported requires its own IMPORT statement. Variables that have already been imported cannot be accessed using another IMPORT statement. The variables must be imported from the data lists in which they were originally created.

The data must be imported with the same data type with which they are declared in the external data list. The system does not check that the correct data types have been selected until the linking operation is carried out.

The data can be given a different name in your own data list or program to the one that they have in the external data list.

The directory and the name of the data list are specified by the path. The data name corresponds to the name used by the variable in the external data list.

The data source and data name are connected to one another by two periods. No blanks may appear between the two periods.

2.2.26.4 Example

Import of the value of the integer variable VALUE from the data list DATA. The variable name VALUE is retained.

```
IMPORT INT VALUE IS /DATA..VALUE
```

Abbreviated form

```
IMPORT INT VALUE
```

Import of the POS array POS_EX from the data list R1/POSITION. The variable name is to be POS 1 in your program.

```
IMPORT POS POS1[] IS /R1/POSITION..POS_EX
```

DEFDAT

2.2.27 INTERRUPT DECL ... WHEN ... DO

2.2.27.1 Brief information

Declaration of an interrupt.

2.2.27.2 Syntax

```
GLOBAL  INTERRUPT DECL Prio WHEN Event DO Subprogram
```

Argument	Type	Explanation
GLOBAL		The keyword GLOBAL is used for the identification of interrupts, including at levels above the subprogram in which they are declared. If an interrupt has been declared in a subprogram, it is also recognized in the main program in which it is called.
`Prio`	INT	Arithmetic expression specifying the priority of the interrupt. Priority levels 1 to 128 are available, but the range 40–80 is reserved for automatic priority allocation by the system. An interrupt with priority 1 is processed first.
`Event`	BOOL	Logical expression defining the interrupt event. The following are permissible: • A Boolean constant • A Boolean variable • A signal name • A comparison • A simple logical operation: NOT, OR, AND or EXOR The following cannot be used: • Structure components
`Subprogram`		Name and parameters of the subprogram (interrupt routine) that is to be executed when an interrupt occurs.

If the program has reached a HALT statement, interrupts are still detected and executed (including motion instructions!). After the instruction has been executed, the program is once again paused at the HALT statement.

The interrupt declaration is an instruction. It must not, therefore, be located in the declaration section!

When first declared, an interrupt is deactivated and disabled.

Runtime variables may not be transferred as interrupt routine parameters, apart from variables declared in a data list.

Up to 32 interrupts may be declared at any one time.

2.2.27.3 Description

The interrupt function allows the user to react to an event that does not occur synchronously with program execution, using a program statement. Such events can be an Emergency Stop, error messages, input signals, etc. The possible causes of an interrupt and the system's reaction to each of them are defined using the interrupt declaration. Each interrupt is assigned a priority, an event and the interrupt routine that is to be called. 32 interrupts may be declared at the same time. A declaration may be overwritten by another at any time.

A defined interrupt triggers a reaction if all four of the following conditions are satisfied:

1. The interrupt must be activated (INTERRUPT ON).
2. The interrupt must be enabled (INTERRUPT ENABLE).
3. The interrupt must have the highest priority.
4. The associated event must have occurred. This event is detected by means of an edge when it occurs (edge–triggered).

If several interrupts occur at the same time, the interrupt with the highest priority is processed first, then those of lower priority. The interrupt is not detected until the level at which it is declared. At higher programming levels, despite being activated, the interrupt is not recognized. In other words, an interrupt declared in a subprogram is not recognized in the main program. In order to be recognized in the main program and at all other levels, it must be declared as global.

After the event has been detected, the current actual position of the robot is stored and the interrupt routine is called. This can be a local subprogram or an external subprogram module. As usual, it is ended using the RETURN or END statement. The interrupted program is subsequently resumed at the point where the interrupt occurred (except in the case of RESUME).

Statements that trigger an advance run stop in the normal program (e.g. $OUT[]) do not do so in the interrupt subprogram. The interrupt routine runs on the command level, i.e. it is executed block by block in sequence.

Interrupts to the system variables $EM_STOP and $STOPMESS are also executed in the event of an error, i.e. the INTERRUPT statements are executed despite the robot being stopped (but motion instructions are disregarded).

Each declared and activated interrupt can be detected once during an operator stop. After restarting the system, the interrupts that have occurred are executed in order of their priority (if they are enabled). The program is subsequently continued.

When calling the interrupt routine, the parameters are transferred in exactly the same way as for normal subprogram calls.

2.2.27.4 Example

Definition of an interrupt with priority 5 that calls the subprogram STOPSP if the variable $STOPMESS is true.

```
INTERRUPT DECL 5 WHEN $STOPMESS DO STOPSP()
```

Definition of an interrupt with priority 23 that calls the subprogram SP1 with the parameters 20 and VALUE if $IN[12] is true.

```
INTERRUPT DECL 23 WHEN $IN[12]==TRUE DO SP1(20,VALUE)
```

2 objects, which can be detected by 2 sensors connected to inputs 6 and 7, are located on a pre–programmed path. The robot is to be moved subsequently to these two positions.

```
DEF PROG()

      ; Main program
...
INTERRUPT DECL 10 WHEN $IN[6]==TRUE DO SP1()
INTERRUPT DECL 20 WHEN $IN[7]==TRUE DO SP2()
...
LIN START_POINT
INTERRUPT ON
INTERRUPT ENABLE
LIN END_POINT
INTERRUPT OFF


            ; Move to reference point
LIN POINT1
LIN POINT2
...
END
DEF SP1()

      ; Local interrupt routine 1
POINT1=$POS_INT
END
DEF SP2()

      ; Local interrupt routine 2
POINT2=$POS_INT
END
```

INTERRUPT, BRAKE, RESUME, TRIGGER

2.2.28 INTERRUPT

2.2.28.1 Brief information

Activation and deactivation of interrupts.

2.2.28.2 Syntax

```
INTERRUPT Action 〈Priority
```

Argument	Type	Explanation
Action	Keyword	The relevant keyword is entered here: • **ON** to activate • **OFF** to deactivate • **ENABLE** to enable • **DISABLE** to disable a declared interrupt.
Priority	INT	Arithmetic expression specifying the priority of the interrupt that you want to activate or deactivate. If this parameter is omitted, the statements for activating and deactivating interrupts refer to **all declared** interrupts and the statements for enabling and disabling interrupts refer to **all activated** interrupts.

2.2.28.3 Description

This statement is used to activate, deactivate, enable and disable the execution of an interrupt.

If a declared interrupt is activated, it is monitored cyclically. When an event is detected, the occurrence of the event and the current actual position are stored. A deactivated interrupt is not executed.

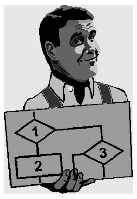
An activated interrupt can be enabled or disabled. The disabling statement allows parts of a program to be safeguarded against interruption. A disabled interrupt will be recognized and saved but not executed. As soon as they are enabled, the interrupts that have occurred are executed in order of their priority. There is no further reaction to an event that has been saved if the interrupt is switched off before triggering. If an interrupt occurs several times while it is disabled, it is only executed once on being enabled.

When an interrupt occurs, this, together with all of the interrupts of lower priority, are disabled for the entire duration of execution. When returning from the interrupt routine, they are enabled again. This also applies to the current interrupt, which is immediately called again if, for example, the signal is still on after the interrupt routine has been executed. If you want to stop the interrupt being called again, it must be disabled or deactivated in the interrupt routine. The interrupt routine is always completely executed, irrespective of whether the interrupt has been disabled or deactivated.

An interrupt can itself be interrupted again after the first statement in the interrupt routine by interrupts of higher priority. The programmer is thus able to prevent this by disabling or deactivating one or all of the interrupts in the first instruction. After one of the interrupts of higher priority has been ended, the interrupted interrupt routine resumes at the point at which it was interrupted.

Up to 16 interrupts may be activated at any one time. Bear this particularly in mind in the case of global activation of interrupts.

2.2.28.4 Example



The declared interrupt of priority level 2 is activated.

```
INTERRUPT ON 2
```

The declared interrupt of priority level 5 is deactivated.

```
INTERRUPT OFF 5
```

All declared interrupts are activated.

```
INTERRUPT ON
```

All declared interrupts are deactivated.

```
INTERRUPT OFF
```

The activated interrupt of priority level 3 is enabled.

```
INTERRUPT ENABLE 3
```

The activated interrupt of priority level 2 is disabled.

```
INTERRUPT DISABLE 2
```

All activated interrupts are enabled.

```
INTERRUPT ENABLE
```

All activated interrupts are disabled.

```
INTERRUPT DISABLE
```

A non–path–maintaining Emergency Stop is executed via the hardware during application of adhesive. You would now like to use the program to stop application of the adhesive and reposition the adhesive gun onto the path after enabling (by input 10).

```
DEF PROG()
                  ; Main program
...
INTERRUPT DECL 1 WHEN $STOPMESS DO STOPSP()
...
LIN POINT1
INTERRUPT ON
INTERRUPT ENABLE
LIN POINT2
INTERRUPT OFF
...
END
DEF STOPSP()
                  ; Interrupt routine
BRAKE F
                  ; Quick braking of the motion
ADHESIVE=FALSE
WAIT FOR $IN[10]
LIN $POS_RET
                  ; Position at which the path was left
ADHESIVE=TRUE
END
```

INTERRUPT DECL, BRAKE, RESUME, TRIGGER

2.2.29 LIN

2.2.29.1 Brief information

Linear motion.

2.2.29.2 Syntax

```
LIN Target_Position 〈Approximate_Positioning
```

Argument	Type	Explanation
`Target_ Position`	POS, E6POS, FRAME	Geometric expression specifying the target point of the linear motion. Only Cartesian coordinates can be used here. The reference system for the Cartesian target position is defined by the system variable $BASE. The angle status specifications S and T for a target position of type POS or E6POS are always disregarded. If the target position contains undefined structure components, these values are taken unchanged from the current position. The target position can also be taught. If this is to be done later, a "!" is programmed as the target position.
Approximate_ Positioning	Keyword	This option allows you to use approximate positioning. The possible entries are: • **C_DIS** (default value) • **C_ORI** • **C_VEL**

Programming the path velocity and acceleration of the TCP:

	Variable	Data type	Unit	Function
Velocities	$VEL.CP	REAL	m/s	Travel speed (path velocity)
	$VEL.ORI1	REAL	°/s	Swivel velocity
	$VEL.ORI2	REAL	°/s	Rotational velocity
Accelerations	$ACC.CP	REAL	m/s^2	Path acceleration
	$ACC.ORI1	REAL	$°/s^2$	Swivel acceleration
	$ACC.ORI2	REAL	$°/s^2$	Rotational acceleration

Orientation control of the tool with LIN motions:

Variable	Effect
$ORI_TYPE = #CONSTANT	During the path motion the orientation remains constant; the programmed orientation is ignored for the destination point and that for the start point used.
$ORI_TYPE = #VAR	During the path motion the orientation changes continuously from the initial orientation to the destination orientation.

System variables for defining the start of approximate positioning:

Variable	Data type	Unit	Meaning	Keyword in the command
$APO.CDIS	REAL	mm	Translational distance criterion	**C_DIS**
$APO.CORI	REAL	°	Orientation distance	**C_ORI**
$APO.CVEL	INT	%	Velocity criterion	**C_VEL**

2.2.29.3 Description

In the case of LIN motions, the controller calculates a straight line equation from the current position to the target position specified in the LIN instruction. The robot is moved to the end point via auxiliary points, which are calculated and executed at intervals of one interpolation cycle.

Just as for PTP motions, both the velocities and accelerations and the system variables $TOOL and $BASE must also be programmed for linear motions. However, the velocities and accelerations no longer refer to the motor speed of each axis but to the TCP. The system variables

• $VEL	for the path velocity and
• $ACC	for the path acceleration

are available for defining them.

Angle status

In the case of LIN motions, the angle status of the end point is always the same as that of the start point. For this reason, the specifications S and T for a target position of data type POS or E6POS are always disregarded.

In order to always ensure an identical motion sequence, the constellation of the axes must first be unambiguously defined. The first motion instruction of a program must therefore always be a PTP instruction specifying S and T.

Orientation

You can choose between constant and variable orientation with the aid of the system variable $ORI_TYPE:

- **$ORI_TYPE=#VAR**
  During the linear motion, the orientation changes uniformly from the start orientation to the target orientation (default setting).
- **$ORI_TYPE=#CONSTANT**
  The orientation remains constant during the linear motion. The programmed orientation is disregarded for the end point and that of the start point is used.

If axis angle 3 or 5 changes sign during a LIN or CIRC motion, the orientation can only be maintained if some of the axes accelerate and move at an infinitely fast rate. As this is not possible, the controller will abort the motion with an error message when the motor limit values are exceeded or continue the motion at a reduced velocity. The reaction can be determined by the user.

The system variable $CP_VEL_TYPE is used to define the operating modes in which the velocity is reduced in the event of the axis limit values being exceeded. The variable can take 3 values:

#VAR_T1	**Velocity reduction in T1 mode only.**
#VAR_ALL	**Velocity reduction in all modes.**
#CONSTANT	**This function is not activated.**

The user can also define the operating mode in which the velocity reduction is indicated by means of a message in the message window:

$CpVelRedMeld = 1 The velocity reduction is only indicated in modes T1 and T2.

$CpVelRedMeld = 100 The velocity reduction is indicated in all operating modes.

Approximate positioning

It is unnecessary and time–consuming to position the robot exactly to auxiliary points. You can therefore start a transition to the following motion block (PTP, LIN or CIRC) at a defined distance from the target position (so–called approximate positioning). A maximum of half the programmed distance may be approximated.

Approximate positioning is programmed in two steps:

- Definition of the approximate positioning range with the aid of the system variable $APO:
  - $APO.CDI
    translational distance criterion (activated by C_DIS): the approximate positioning contour is started at a specified distance (unit [mm]) from the target point.
  - $APO.CORI
    orientation distance (activated by C_ORI): the TCP leaves the individual block contour when the dominant angle is less than the specified distance from the target point.
  - $APO.CVEL
    velocity criterion (activated by C_VEL): when the $APO.CVEL percentage of the velocity defined in $VEL.CP is achieved, the approximate positioning contour is initiated.
- Programming of the motion instruction with a target position and an approximate positioning mode:
  - **LIN–LIN or LIN–CIRC approximate positioning**
    For LIN–LIN approximate positioning, the controller calculates a parabolic path. In the case of LIN–CIRC approximate positioning, a symmetric approximate positioning contour cannot be calculated. The approximate positioning path consists of two parabolic segments, which also have a tangential transition between each other and also to the individual blocks. To define where approximate positioning is to begin, one of the keywords C_DIS, C_ORI or C_VEL has to be programmed.
  - **LIN–PTP approximate positioning**
    A precondition for approximate positioning is that none of the robot axes rotates more than 180° in the LIN block and that the position S does not change. The start

of approximate positioning is defined by one of the variables $APO.CDIS, $APO.CORI and $APO.CVEL and the end by the variable $APO.CPTP. One of the keywords C_DIS, C_ORI and C_VEL has to be programmed in the LIN instruction.

For approximate positioning, the computer advance run must be enabled. If it is not, the message “Approximation not possible” will be displayed. In the case of LIN–PTP approximate positioning, the advance run is limited to 1, however!

Notes:

- Program statements that stop the advance run may not appear between approximate positioning blocks (remedy with CONTINUE).
- The greater the velocity and acceleration are, the greater the dynamic deviations from the path will be (following error).
- Changing the acceleration has a considerably lesser effect on the path contour than changing the velocity.

2.2.29.4 Example

Linear motion with taught target coordinates.

```
LIN !
```

Linear motion with programmed target coordinates; approximate positioning is activated.

```
LIN POINT1 C_DIS
```

Specification of the target position in (Cartesian) BASE coordinates.

```
LIN {X 12.3,Y 100.0,Z -505.3,A 9.2,B -50.5,C 20}
```

Specification of only two values for the target position. The old assignment is retained for the remaining values.

```
LIN {Z 500,X 123.6}
```

Specification of the target position with the aid of the geometric operator: it is produced by subtracting 30.5 millimeters in the X direction and adding 20 millimeters in the Z direction of the TOOL coordinate system to point 1, which is defined in the BASE coordinate system.

```
LIN POINT1:{X -30.5,Z 20}
```

LIN–PTP approximate positioning from point 2 to point 3. Approximate positioning is started 30 mm before point 2.

```
$APO.CDIS=30
$APO.CPTP=20
PTP POINT1
LIN POINT2 C_DIS
PTP POINT3
```

LIN_REL, PTP, CIRC, CONTINUE

2.2.30 LIN_REL

2.2.30.1 Brief information

Linear motion with relative coordinates.

2.2.30.2 Syntax

```
LIN_REL Target_Position 〈Approximate_Positioning
```

Argument	Type	Explanation
Target_ Position	POS, E6POS, FRAME	Geometric expression specifying the target point of the linear motion. Only Cartesian coordinates can be used here. These are to be interpreted *relative* to the current position. The target position cannot be taught. Translational distances are executed in the direction of the axes of the base coordinate system $BASE. If the target position contains undefined structure components, these values are set to 0, i.e. the absolute values remain unchanged. The predefined variable $ROTSYS defines the effect of the programmed orientation components. The angle status specifications S and T for a target position of type POS or E6POS are always disregarded.
Approximate_ Positioning	Keyword	This option allows you to use approximate positioning. The possible entries are: • **C_DIS** (default value) • **C_ORI** • **C_VEL**

Programming the path velocity and acceleration of the TCP:

	Variable	Data type	Unit	Function
Velocities	$VEL.CP	REAL	m/s	Travel speed (path velocity)
	$VEL.ORI1	REAL	°/s	Swivel velocity
	$VEL.ORI2	REAL	°/s	Rotational velocity
Accelerations	$ACC.CP	REAL	m/s^2	Path acceleration
	$ACC.ORI1	REAL	°/s^2	Swivel acceleration
	$ACC.ORI2	REAL	°/s^2	Rotational acceleration

Orientation control of the tool with LIN motions:

Variable	Effect
$ORI_TYPE = #CONSTANT	During the path motion the orientation remains constant; the programmed orientation is ignored for the destination point and that for the start point used.
$ORI_TYPE = #VAR	During the path motion the orientation changes continuously from the initial orientation to the destination orientation.

System variables for defining the start of approximate positioning:

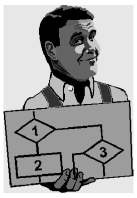
Variable	Data type	Unit	Meaning	Keyword in the command
$APO.CDIS	REAL	mm	Translational distance criterion	**C_DIS**
$APO.CORI	REAL	°	Orientation distance	**C_ORI**
$APO.CVEL	INT	%	Velocity criterion	**C_VEL**

2.2.30.3 Description

The relative LIN instruction basically works in exactly the same way as the absolute LIN instruction. The target coordinates are merely defined relative to the current position instead of with the aid of absolute space or axis coordinates.

Apart from this, all of the information contained in the description of the absolute LIN instruction applies here.

2.2.30.4 Example



The robot moves 100 mm in the X direction and 200 mm in the negative Z direction from the current position. Y,A,B,C,S remain constant and T is determined by the motion.

```
LIN_REL {X 100,Z -200}
```

LIN–LIN approximate positioning from point 1 to point 2 and LIN–CIRC approximate positioning from point 2 to point 3. Approximate positioning to point 1 is started when the velocity has been reduced to 0.3 m/s (30% of 0.9 m/s). The approximate positioning contour before point 2 begins 20 mm before the point.

```
$VEL.CP=0.9
$APO.CVEL=30
$APO.CDIS=20
LIN POINT1 C_VEL
LIN_REL POINT2_REL C_DIS
CIRC AUX_POINT,POINT3
```

LIN, PTP_REL, CIRC_REL, CONTINUE

2.2.31 LOOP ... ENDLOOP

2.2.31.1 Brief information

Programming an endless loop.

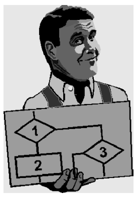
2.2.31.2 Syntax

```
LOOP
Statements
ENDLOOP
```

2.2.31.3 Description

Cyclic executions can be programmed using LOOP. The statement block in the LOOP is continually repeated. If you want to end the repeated execution of the statement block, you must call the EXIT statement.

2.2.31.4 Example



Endless loop.

```
LOOP
      A=A+1
      IF A==65 THEN
            EXIT
      ENDIF
ENDLOOP
```

EXIT, SWITCH, FOR, REPEAT, WHILE

2.2.32 PTP

2.2.32.1 Brief information

Point–to–point motion.

2.2.32.2 Syntax

```
PTP Target_Position 〈C_PTP 〈Approximate_Positioning
```

Argument	Type	Explanation
`Target_ Position`	POS, E6POS AXIS, E6AXIS, FRAME	Geometric expression specifying the target point of the motion. Cartesian and axis–specific coordinates can be used here. The reference system for a Cartesian target position is defined by the system variable $BASE. If the target position contains undefined structure components, these values are taken unchanged from the current position. The target position can also be taught. If this is to be done later, a "**!**" is programmed as the target position.
`C_PTP`	Keyword	This option causes the robot to be approximately positioned to the specified target point of a PTP motion. This specification is sufficient for PTP–PTP approximate positioning. The option ***Approximate_Positioning*** must also be specified for approximate positioning in a subsequent CP block.
`Approximate_ Positioning`	Keyword	This option is used to specify an approximate positioning criterion for entering a subsequent CP motion block. It can only be used in conjunction with the C_PTP option. The possible entries are: • **`C_DIS`** Distance criterion (default value) • **`C_ORI`** Orientation criterion • **`C_VEL`** Velocity criterion

2.2.32.3 Description

The point–to–point motion offers the quickest way of moving the robot arm from the current position to a programmed target position. The axes are moved in a synchronized manner, i.e. all of the axes start and end the motion at the same time. The controller calculates the velocity of each axis so that at least one axis moves at the predefined limit for velocity and acceleration. The maximum velocity and maximum acceleration must be programmed separately for each axis. The system variables

• $VEL_AXIS[*No*]	for the axis–specific velocity, and
• $ACC_AXIS[*No*]	for the axis–specific acceleration

are available. All of the values are specified as a percentage of a maximum that is defined in the machine data.

If these two system variables have not been programmed before the first motion instruction, an error message will occur when the program is executed! This also applies to the system variables $TOOL and $BASE if the target position is specified in Cartesian coordinates.

Angle status

Because of kinematic singularities, a robot can reach the same position in space with the axes in different angular positions. The angular position of the axes can be unambiguously defined with the aid of the specifications **S** (Status) and **T** (Turn) in the geometric expression. Both require integer inputs, which should preferably be entered in binary notation. The bits have the following significance:

Status:

- Bit 1: Position of the wrist root (0 basic area, 1 overhead area)
- Bit 2: Angular position for axis 3 (0 negative, 1 positive)
- Bit 3: Angular position for axis 5 (0 positive, 1 negative). The angular position in each case is regarded in relation to a fixed zero position for each axis.

Turn:

- Bit x: Angular position for axis x (0 positive, 1 negative)

The angular position in each case is regarded in relation to a fixed zero position for each axis.

If the specification for Turn T is omitted from a PTP motion, the robot will always move along the shortest path. If the specification for Status S is omitted, the status from the previous point is retained. In order to ensure that the motion sequence is always identical, the first motion instruction of a program must therefore always be a PTP instruction specifying S and T.

Approximate positioning

It is unnecessary and time–consuming to position the robot exactly to auxiliary points. You can therefore start a transition to the following motion block (PTP, LIN or CIRC) at a defined distance from the target position (so–called approximate positioning). A maximum of half the programmed distance may be approximated.

Approximate positioning is programmed in two steps:

▪ Definition of the approximate positioning range with the aid of the system variable $APO:

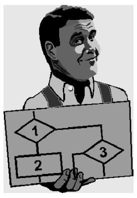
  - $APO.CPTP axial approximate positioning criterion (activated by C_PTP): approximate positioning is started when the leading axis is the $APO.CPTP percentage of a maximum angle defined in $APO_DIS_PTP[*No*] away from the approximate positioning point.
  - $APO.CDIS translational distance criterion (activated by C_DIS): the approximate positioning contour is started at a specified distance (unit [mm]) from the approximate positioning point.
  - $APO.CORI orientation distance (activated by C_ORI): the TCP leaves the individual block contour when the dominant angle is less than the specified distance from the approximate positioning point.
  - $APO.CVEL velocity criterion (activated by C_VEL): when the $APO.CVEL percentage of the velocity defined in $VEL.CP is achieved, the approximate positioning contour is initiated.

- Programming of the motion instruction with a target position and an approximate positioning mode:
  - **PTP–PTP approximate positioning**
    Program the keyword C_PTP in the PTP instruction containing the target position to which the robot is to be approximately positioned. The approximate positioning range is defined by assigning a value to the variable $APO.CPTP. Approximate positioning begins when the last axis falls below a specified angle to the target position. The approximate positioning contour describes a parabola in space. This is calculated by the controller, the programmer having no influence on its form. Only the start (and thus also the end) of approximate positioning can be programmed.
  - **PTP–LIN or PTP–CIRC approximate positioning**
    A precondition for approximate positioning is that none of the robot axes rotates more than 180° in the LIN or CIRC block and that the position S does not change. The start of approximate positioning is defined by the variable $APO.CPTP. The end of approximate positioning is defined by one of the variables $APO.CDIS, $APO.CORI and $APO.CVEL. Now program the keyword C_PTP in the PTP statement and one of the keywords C_DIS (default value), C_ORI or C_VEL to define the approximate positioning.

For approximate positioning, the computer advance run must be enabled. If it is not, the message “Approximation not possible” will be displayed.

- The smaller $APO.CPTP is, the smaller the approximate positioning range will be.
- A $TOOL statement may not appear between two approximate positioning points.
- The greater the velocity and acceleration are, the greater the dynamic deviations from the path will be (following error).
- Changing the acceleration has a considerably lesser effect on the path contour than changing the velocity.
- If the robot is approximately positioned to points using $APO.CPTP=0, the robot will actually be positioned to them exactly but the run time will nevertheless be reduced (the following error does not have to be eliminated).

2.2.32.4 Example



PTP motion with target coordinates still to be taught.

```
PTP !
```

PTP motion with programmed target coordinates; approximate positioning is activated.

```
PTP POINT1 C_PTP
```

Specification of the target position in (Cartesian) BASE coordinates.

```
PTP {X 12.3,Y 100.0,Z 50,A 9.2,B 50,C 0,S 'B010',T 'B1010'}
```

Specification of the target position in axis–specific coordinates.

```
PTP {A1 10,A2 -80.6,A3 -50,A4 0,A5 14.2, A6 0}
```

Specification of only two values for the target position. The old assignment is retained for the remaining values.

```
PTP {Z 500,X 123.6}
```

Specification of the target position with the aid of the geometric operator: it is produced by adding 100 millimeters in the X direction of the TOOL coordinate system to point 1, which is described in the BASE coordinate system.

```
PTP POINT1:{X 100}
```

PTP–LIN approximation from point 2 to point 3. The approximate positioning contour is started when the leading axis has to complete a residual angle of less than 20% of its maximum defined in $APO_DIS_PTP[*No*] on its way to point 2.

```
$APO.CORI=10
$APO.CPTP=20
PTP POINT1
PTP POINT2 C_PTP C_ORI
LIN POINT3
```

PTP_REL, LIN, CIRC, CONTINUE

2.2.33 PTP_REL

2.2.33.1 Brief information

Point–to–point motion with relative coordinates.

2.2.33.2 Syntax

```
PTP_REL Target_Position 〈C_PTP 〈Approximate_Positioning
```

Argument	Type	Explanation
`Target_ Position`	POS, E6POS AXIS, E6AXIS	Geometric expression specifying the target point of the motion. Cartesian and axis–specific coordinates can be used here. These are to be interpreted *relative* to the current position. The target position cannot be taught. Translational distances are executed in the direction of the axes of the base coordinate system $BASE. If the target position contains undefined structure components, these values are set to 0, i.e. the absolute values remain unchanged. The predefined variable $ROTSYS defines the effect of the programmed orientation components.
`C_PTP`	Keyword	This option causes the robot to be approximately positioned to the specified target point of a PTP motion. This specification is sufficient for PTP–PTP approximate positioning. The option ***Approximate_Positioning*** must also be specified for approximate positioning in a subsequent CP block.
`Approximate_ Positioning`	Keyword	If the PTP motion is followed by a CP motion, this option can be used to specify a criterion for the transition to the CP motion. It can only be used in conjunction with the C_PTP option. The possible entries are: • **`C_DIS`** Distance criterion (default value) • **`C_ORI`** Orientation criterion • **`C_VEL`** Velocity criterion

2.2.33.3 Description

The relative PTP instruction basically works in exactly the same way as the absolute PTP instruction. The target coordinates are merely defined relative to the current position instead of with the aid of absolute space or axis coordinates. You can thus move each axis individually by a specified number of degrees or move the robot along specified space coordinates.

Apart from this, all the information contained in the description of the absolute PTP instruction applies here.

2.2.33.4 Example

Axis 2 is moved 30 degrees in a negative direction. None of the other axes moves.

```
PTP_REL {A2 -30}
```

The robot moves 100 mm in the X direction and 200 mm in the negative Z direction from the current position. Y,A,B,C,S remain constant and T is calculated in relation to the shortest path.

```
PTP_REL {X 100,Z -200}
```

PTP–PTP approximation from point 1 to point 2 and PTP–CIRC approximation from point 2 to point 3. The approximate positioning contour is started when the leading axis has to cover a residual angle of less than 40% of its maximum defined in $APO_DIS_PTP[*No*] on its way to point 1 and point 2 respectively.

```
$APO.CDIS=30
$APO.CPTP=40
PTP POINT1 C_PTP
PTP_REL POINT2_REL C_PTP; C_DIS is set by default
CIRC AUX_POINT,POINT3
```

PTP, LIN_REL, CIRC_REL, CONTINUE

2.2.34 PULSE

2.2.34.1 Brief information

Activation of a pulse output.

2.2.34.2 Syntax

```
PULSE (Signal, Level, Pulse_Duration)
```

Argument	Type	Explanation
`Signal`	BOOL	Output to which the pulse is to be fed. The following are permitted: • **OUT[*No*]** • Signal variable
Level	BOOL	Logical expression: • **TRUE** represents a positive pulse output (high) • **FALSE** represents a negative pulse (low)
`Pulse_ Duration`	REAL	Arithmetic expression specifying the pulse duration. Values range from 0.1 to 3.0 seconds. The pulse interval is 0.1 seconds, i.e. the pulse duration is rounded up or down accordingly.

2.2.34.3 Description

The PULSE statement is used for activating a pulse output. When the program statement is executed, the binary output is set to a defined level for a specified period of time. After the pulse duration has elapsed, the output signal is automatically reset by the system. The output signal is set and reset irrespective of the previous length of the output.

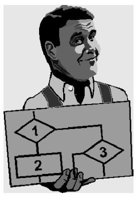
If an output with an opposite level is activated during a pulse, the pulse is shortened. If a pulse output is activated again before the falling edge, the pulse duration restarts. In the case of pulse outputs with a positive level, the binary output is set to TRUE; in the case of pulse outputs with a falling level, the binary output is set to FALSE.

Because the PULSE statement is executed internally by the controller at the low–priority clock rate, a tolerance in the order of the pulse interval is produced (0.1 seconds). The time deviation is about 1% – 2% on average. The deviation is about 13% for very short pulses.

- Pulse times outside the permitted interval are only detected when the program is running; they trigger a program stop.
- A maximum of 16 pulse outputs may be programmed simultaneously.
- The programmed pulse time continues to elapse in the event of a process stop.
- In the case of RESET and CANCEL, on the other hand, the pulse is terminated.
- The active pulse can be influenced by interrupts.
- The PULSE statement triggers an advance run stop. Only in the TRIGGER statement is it executed concurrently with robot motion.
- If the program reaches the END statement during an active pulse, the pulse is not terminated.
- If a pulse output is programmed before the first motion block, the pulse duration also elapses if the Start key is released again and the robot has not yet reached the path (BCO).

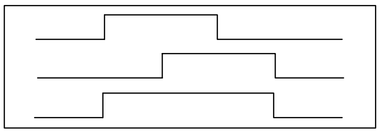
The pulse is not terminated in the event of an Emergency Stop, an operator stop or an error stop!

2.2.34.4 Example



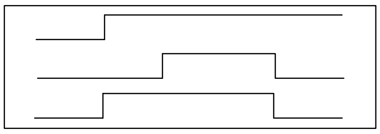
If a pulse output is activated again before the falling edge, the pulse duration restarts.

```
PULSE($OUT[50],TRUE,0.5)
PULSE($OUT[50],TRUE,0.5)
Output 50
```



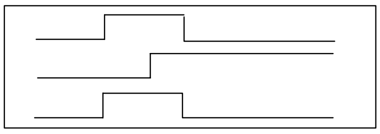
If an output is already set before the pulse, it will be reset by the falling edge of the pulse.

```
$OUT[50]=TRUE
PULSE($OUT[50],TRUE,0.5)
Output 50
```



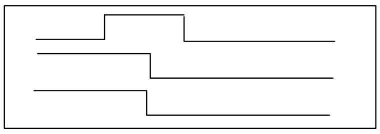
If the same output is set during the pulse duration, it will be reset by the falling edge of the pulse output.

```
PULSE($OUT[50],TRUE,0.5)
$OUT[50]=TRUE
Output 50
```



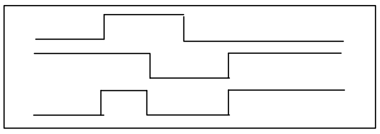
If output 50 is reset during the pulse duration, the pulse duration is reduced accordingly.

```
PULSE($OUT[50],TRUE,0.5)
$OUT[50] = FALSE
Output 50
```



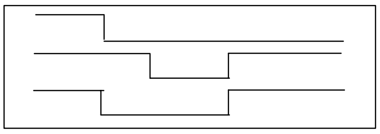
If a negative pulse is applied to the same output during the pulse duration of a positive pulse, the positive level is immediately set to Low and then reset to High after the pulse duration has elapsed.

```
PULSE($OUT[50],TRUE,0.5)
PULSE($OUT[50],FALSE,0.5)
Output 50
```



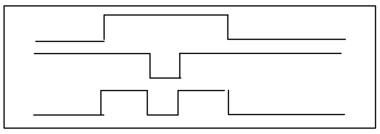
If a negative pulse is applied to an output that is set to Low, the output remains Low until the end of the pulse and is then set to High.

```
$OUT[50] = FALSE
PULSE($OUT[50],FALSE,0.5)
Output 50
```



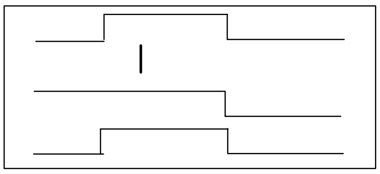
If an output is reset and then set again during a pulse, the output is reset again at the end of the pulse.

```
PULSE($OUT[50],TRUE,0.8)
Output manipulation
Output 50
```



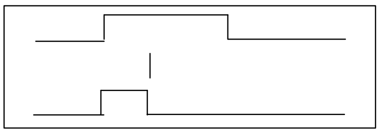
If a pulse is programmed before the END statement, the duration of program execution is increased accordingly.

```
PULSE($OUT[50],TRUE,0.8)
END statement
Program active
Output 50
```



If program execution is reset or aborted (RESET/CANCEL) while a pulse output is active, the pulse is immediately reset.

```
PULSE($OUT[50],TRUE,0.8)
RESET or CANCEL
Output 50
```



2.2.35 REPEAT ... UNTIL

2.2.35.1 Brief information

Program loop that is always executed at least once (non–rejecting loop). The termination condition is checked at the end of the loop.

2.2.35.2 Syntax

```
REPEAT
Statements
UNTIL Termination_Condition
```

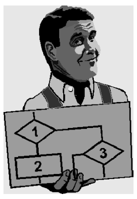
Argument	Type	Explanation
Termination _Condition	BOOL	Logical expression which can contain a Boolean variable, a Boolean function call or a logical operation with a Boolean result, e.g. a comparison.

2.2.35.3 Description

The REPEAT loop is repeated depending on a condition specified by the user.

This termination condition is checked **after** each loop execution. The statement block is always executed at least once.
If the logic condition has the value FALSE, the statement block is repeated. If the logic condition has the value TRUE, the program is resumed at the next statement after the condition.

2.2.35.4 Example



The loop is executed 100 times. R has the value 101 after the last loop execution.

```
R=1
REPEAT
      R=R+1
UNTIL R>100
```

The loop is to be executed until $IN[1] is true.

```
REPEAT
      Statements
UNTIL $IN[1]==TRUE
```

The loop is executed once, even though the termination condition is already fulfilled before the loop execution. The termination condition is not checked until the end of the loop. After exiting the loop, R has the value 102.

```
R=101
REPEAT
      R=R+1
UNTIL R>100
```

EXIT, SWITCH, FOR, WHILE, LOOP

2.2.36 RESUME

2.2.36.1 Brief information

Aborting of subprograms and interrupt routines.

2.2.36.2 Syntax

```
RESUME
```

2.2.36.3 Description

The RESUME statement is only executed during the processing of interrupts. It can therefore only be used in a module that is initiated by an interrupt. All active interrupt routines and subprograms up to the level at which the current interrupt was declared are aborted by RESUME.

At the time that the RESUME statement is reached
- **the variable $ADVANCE must be equal to 0 (no advance run).**
- **the advance run pointer must not be at the level at which the interrupt was declared; it must be at least one level below this (otherwise the program is stopped and has to be reset!).**

- The motion after RESUME should not be a circular motion (CIRC) because the start point is different each time (different circles).
- Changing the variable $BASE in the interrupt routine only has an effect there.
- An $ADVANCE assignment cannot be used in the interrupt routine.

2.2.36.4 Example

The robot is to search for a part on a pre–programmed path. The part can be detected by a sensor connected to input 15. After locating the part, the robot is not to continue to the end point of the path, but is to return to the interrupt position, pick up the part and take it to the setdown point.

```
DEF PROG()                ; Main program
...
INTERRUPT DECL 1 WHEN $IN[15] DO FOUND()
...
PTP HOMEPOS
...
SEARCH()                  ; Search path must be programmed in a subprogram!
LIN SETDOWN POINT
...
END
DEF SEARCH()              ; Subprogram for searching for the part
LIN START_POINT C_DIS
LIN TARGET_POINT
$ADVANCE=0                ; No advance run permitted
END
DEF FOUND()               ; Interrupt routine
INTERRUPT OFF             ; So that the interrupt routine is not executed twice
BRAKE
LIN $POS_INT              ; Return to point where interrupt occurred
...                       ; Pick up part
RESUME                    ; Abort search path
END
```

INTERRUPT DECL, INTERRUPT, BRAKE, RETURN

2.2.37 RETURN

2.2.37.1 Brief information

Return from functions and subprograms.

2.2.37.2 Syntax

For functions:

```
RETURN Function_Value
```

For subprograms:

```
RETURN
```

Argument	Type	Explanation
`Function_ Value`	The data type must correspond to the function type	The function value is the value that is transferred when exiting a function.

2.2.37.3 Description

The RETURN statement is used in functions or subprograms. It ends the execution of the function or subprogram and causes the system to return to the calling module.

RETURN statement in functions

The execution of functions must be ended by a RETURN statement containing the function value that has been determined. The function value can be specified as a constant, a variable or an expression. The data type must agree with the defined data type of the function in the DEFFCT declaration.

RETURN statement in subprograms

The RETURN statement may only consist of the keyword RETURN in the statement section of subprograms. It may not contain an expression. Function values cannot be transferred.

2.2.37.4 Example

Return from functions to the calling module and transfer of the function value 0.

```
RETURN 0
```

Return from functions to the calling module and transfer of the function value (X*3.1415)/360.

```
RETURN (X*3.1415)/360
```

Return from functions to the calling module and transfer of the function value X.

```
DEFFCT INT X()
      INT XRET
      XRET=10
      RETURN XRET
ENDFCT
```

Return from the subprogram to the calling module.

```
DEF PROG_2()
      Declarations
      Statements
RETURN
END
```

DEFFCT, DEF

2.2.38 SIGNAL

2.2.38.1 Brief information

Declaration of signal names for input and output signals.

Interrupting the transfer of system states to the periphery.

2.2.38.2 Syntax

Declaration of signal names for input and output signals:

```
SIGNAL Signal_Name Interface_Name 〈TO Interface_Name
```

Interrupting the transfer of system states to the periphery:

```
SIGNAL System_Signal_Name FALSE
```

Argument	Type	Explanation
Signal_Name		Any symbolic name.
Interface_ Name		Type of the predefined signal variable. The following types can be selected: • **$IN[***No***]** binary inputs • **$OUT[***No***]** binary outputs • **$DIGIN[***No***]** digital inputs • **$ANIN[***No***]** analog inputs • **$ANOUT[***No***]** analog outputs *No* refers to the corresponding inputs or outputs of the controller.
System_ Signal_Name		Name of a predefined binary system output, e.g. $T1.
FALSE		System state is not transferred to the periphery. The option TRUE is not available.

2.2.38.3 Description

The robot controller has two classes of interface:

1. simple process interfaces (signals)
2. logic interfaces (channels)

All of the interfaces are addressed using symbolic names. Your own *Interface_Names* (symbolic names) are logically combined with the predefined signal variables by means of the SIGNAL instruction. SIGNAL declarations must appear in the declaration section. An output may appear in several SIGNAL statements. The number of signal numbers corresponds to the number of inputs or outputs that the controller has. As can be seen from the predefined signal variable names, there is a further distinction between binary and digital inputs or outputs. In the case of binary inputs or outputs, inputs or outputs are addressed individually. In the case of digital signals, several inputs or outputs are combined.

Several successive binary inputs or outputs can also be combined to form one digital input or output using the instruction SIGNAL and the TO option. The signals combined in this way can be optionally addressed with a decimal name, a hexadecimal name (prefix H) or with a bit pattern name (prefix B). They can also be processed with Boolean operators. A maximum of 32 binary signals can be combined to form one digital signal. To combine signals, both predefined signal names must be binary inputs or outputs and describe a continuously ascending sequence with their index. A maximum of 32 inputs or outputs can be combined.

The robot controller can be fitted with an input/output module providing 32 inputs and 32 outputs. Outputs 1 to 28 have a load rating of 100 mA and outputs 29 to 32 have a 2 A capacity. Unused outputs can be used as flags. The signal name is declared internally as being of type BOOL in the case of binary inputs or outputs and of type Integer in the case of digital inputs or outputs.

2.2.38.4 Example

The binary output $OUT[7] is assigned to the symbolic name Switch. The switch ($OUT[7]) is set.

```
SIGNAL SWITCH $OUT[7]
Switch = TRUE
```

The binary inputs $IN[1] to $IN[8] are combined to form one digital input under the symbolic name INWORD.

```
SIGNAL INWORD $IN[1] TO $IN[8]
```

The binary outputs $OUT[1] to $OUT[8] are combined to form one digital output under the symbolic name OUTWORD. The outputs $OUT[3], $OUT[4], $OUT[5] and $OUT[7] are set by the digital output $OUTWORD.

```
SIGNAL OUTWORD $ OUT[1] TO $ OUT[8]
OUTWORD = ‘B01011100’
```

ANIN, ANOUT, DIGIN, CHANNEL

2.2.39 SREAD

2.2.39.1 Brief information

The “SREAD” statement breaks a data set (text string) down into its constituent parts.

2.2.39.2 Syntax

```
SREAD (String1, State, Offset, Format, String2, Value, Var)
```

Argument	Type	Explanation
`String1`	CHAR[]	The manipulated, transferred String2 is read from this character array.
`State`	STATE_T	This structure returns information about the state from the kernel system, which the user can evaluate. **`STATE.MSG_NO`** If an error occurs during execution of a command, this variable contains the error number. **`CMD_OK`** Command successfully executed **`CMD_ABORT`** Command not successfully executed **`FMT_ERR`** Incorrect format specification or non–corresponding variable. State variable: **`HITS`** Number of correctly written formats **`LENGTH`** Length of the “%s” format that occurs first in the format.
`Offset`	INT	Specifies the position from which String1 is copied into String2.
`Format`	CHAR[ ]	The variable “Format” contains the format of the text that is to be generated.
`String2`	CHAR[ ]	String1 is copied into the character array.
`VALUE`	INT REAL BOOL	Data are pasted into this variable, from String1, with the format specified. Boolean values are output as 0 or 1, ENUM values as numbers.
`Var`		The variables corresponding to “Format”.

2.2.39.3 Description

The “SREAD” command is used for processing character strings. Unlike with “CREAD”, data is not read from an open channel but from a variable.

The conversion specification for the variable Format has the following structure:

%FWGU

The following definitions apply here:

- **F** Formatting character +, –, #, etc. (optional).
- **W** Width, specifies the minimum number of bytes that are to be output (optional).
- **G** Precision, its significance is dependent on the conversion character.
  '.' or '.*' or '.integer' can be used (optional).
- **U** Permissible conversion characters: d, e, f, g, i, s, x and %.
  The system cannot distinguish between upper and lower–case letters.

By entering a width, you can specify to how many bytes the value is to be extended or compressed. REAL values are an exception here.

When compressing the value, the high–order bytes are disregarded; the value is extended by adding zero bytes at the end (little endian format).

If the width is not specified, the internal representation is output: 4 bytes for INTEGER, REAL and ENUM, one byte for BOOL and CHAR.

The incorrect format can be inferred from the value of HITS (see below).

The types and values are checked in accordance with the following table at run time:

Format Variable	**%d** **%i** **%x**	**%f** **%e** **%g**	**%s**	**%c**	(3) **%1.** ⟨WDH⟩ r	(3) **%2.** ⟨WDH⟩ r	(3) **%4.** ⟨WDH⟩ r	(3) **%.** ⟨WDH⟩ r
(Signal) INT	X	–	–	X	–	–	–	–
INT array	–	–	–	–	X	X	X	X
REAL	X	X	–	–	–	–	–	–
REAL array	–	–	–	–	–	–	X	X
(Signal) BOOL (1)	X	–	–	X	–	–	–	–
BOOL array	–	–	–	–	X	X	X	X
ENUM (2)	X	–	–	X	–	–	–	–
ENUM array	–	–	–	–	X	X	X	X
CHAR	X	–	–	X	–	–	–	–
CHAR array	–	–	X	–	X	–	–	X

Remarks

- Every value that is not equal to 0 (zero) is converted to TRUE
- The system checks whether the value is a permissible ENUM value. If it is not, reading is aborted. ENUM begins at 1.
- If there are not enough data available to satisfy the requirements of the format, nothing is read for this format and the SREAD statement is aborted. The ignored data are, however, still ready for reading.
- Only as many bytes as can fit into the variable are read. The rest are still ready for reading. If the array is actually big enough but the number of available bytes is not a multiple of the size of an array element, the redundant bytes for the following format or for the next SREAD statement are left for reading.

2.2.39.4 Example

Reading the content of the variable HUGO using formatting characters

```
INT OFFSET
      DECL STATE_T STATE
      DECL CHAR HUGO[20]
OFFSET=0
      HUGO[]="1234567890"
      SREAD(HUGO[],STATE,OFFSET,%01d%02d,VAR1,VAR2)
;Result: VAR1=1; VAR2=23
```

When reading with “SREAD”, it is necessary to define a “Format”.

In our example this corresponds to:	%01d	Number of characters to be read, here one, therefore in VAR1 the first number in HUGO, i.e. 1.
	%02d	Number of characters to be read, here two, therefore in VAR2 the second and third numbers in HUGO, i.e. 2 and 3.

2.2.40 STRUC

2.2.40.1 Brief information

Declaration of structure data types.

2.2.40.2 Syntax

```
⟨GLOBAL  STRUC Structure_Type_Name
⮱    Data_Type1 Component_Name1 ⟨⟨,..., Component_NameM
⮱    ,...,
⮱    Data_TypeN Component_NameN ⟨,..., Component_NameZ
```

Argument	Type	Explanation
GLOBAL		The keyword GLOBAL is used to identify the structure, including in external programs, and may only be used in data lists.
`Structure_ Type_Name`		Name of the structure data type.
`Data_Type`	Any data types	The components of a structure type may be of any data type. Structure types can also be used as components; this is called a nested structure type. Arrays can be used as components of a structure type if they have the type CHAR and are one–dimensional. In this case, the array limit follows the name of the array in square brackets in the definition of the structure type.
`Component_ Name`		The individual elements of a structure type are called structure components. A data type and a name are defined for each component of a structure. The component name must be unambiguous within the structure type.

The keyword GLOBAL, in the context of declaring structure data types, may only be used in data lists.

2.2.40.3 Description

A structure type is a complex data type consisting of several identical or different data types. AXIS, FRAME, POS, E6POS and E6AXIS are important predefined structure types. No structure types having these names may be defined by the user.

As a user, you can freely define further structure types using the structure type declaration STRUC. The STRUC definition for a freely defined structure type must occur before the declaration of variables of this type, both in terms of its actual position in the program and in terms of when it will be reached by the system. The following sequence must be observed: first the STRUC declaration, then the declaration of variables.

The following applies here:

- The predefined data list $CONFIG is located before the data lists that are local to the module.
- A data list that is local to a module is located before its module.

Accessing components of structure variables

The components of a structure variable can be processed individually. To identify them, a period, followed by the name of the structure components, is added to the variable name. In order to be able to access a component of the internal structure in the case of a structure nest, string the variable name, the name of the external structure components **and** the name of the internal structure components together, separating them by means of a period.

Assigning values to structure variables

A value can be assigned individually to each component of structure variables by using a value assignment. To assign values to several or all of the components of a structure variable at the same time, use an aggregate. When declaring the structure variable in the data list, you can assign an aggregate to it as its default initial value.

The names of structure types should end in `_TYPE` so as to distinguish them from variable names.

2.2.40.4 Example

Declaration of a structure type W1_TYPE with the components CURRENT, VOLTAGE and FEED of data type REAL.

```
STRUC W1_TYPE REAL CURRENT, VOLTAGE, FEED
```

Declaration of a structure type W2_TYPE with the component CURRENT of data type REAL and of the array component TEXT[80] of data type CHAR.

```
STRUC W2_TYPE REAL CURRENT, CHAR TEXT[80]
```

The following information is to be transferred in a variable to a subprogram for arc welding:

- Wire speed
- Characteristic
- With/without arc in simulation

```
DEF PROG()
STRUC W_TYPE REAL WIRE,INT CHARAC,BOOL ARC
DECL W_TYPE W_PARAMETER
W_PARAMETER.WIRE=10.2; Individual initialization of the components
W_PARAMETER.CHARAC=60
W_PARAMETER.ARC=TRUE
W_UP(W_PARAMETER); Call of the welding subprogram...
                  ; Initialization with the aid of an aggregate
W_PARAMETER={WIRE 7.3, CHARAC 50, ARC TRUE}
W_UP(W_PARAMETER); Another call of the welding subprogram...
END
```

ENUM, DECL

2.2.41 SWITCH ... CASE ... ENDSWITCH

2.2.41.1 Brief information

Choice between several statement branches.

2.2.41.2 Syntax

```
SWITCH Selection_Criterion
CASE Block_Identifier1 ⟨,Block_Identifier2,...
Statements
...
⟨CASE Block_IdentifierN ⟨,Block_IdentifierM,...
Statements
⟨DEFAULT
Default_Statements
ENDSWITCH
```

Argument	Type	Explanation
Selection_ Criterion	INT, CHAR, enumeration type	The selection criterion can be a variable, a function call or an expression of the specified data type.
Block_ Identifier	INT, CHAR, enumeration type	The identifiers for the relevant CASE blocks may only be integer character or enumeration constants. The type of the constants must agree with the type of the selection criterion. There must be at least one block identifier. You can specify as many block identifiers as you want to one program branch. If the same block identifier is used repeatedly, only the first branch having this identifier is executed. The remaining program branches are disregarded. Several block identifiers are separated from each other by a comma.

2.2.41.3 Description

The SWITCH statement is a selection instruction for various program branches. A selection criterion is assigned a certain value ahead of the SWITCH statement. If this value agrees with a block identifier, the corresponding branch is executed and the program jumps straight to the ENDSWITCH statement without taking subsequent block identifiers into consideration. If no block identifier agrees with the selection criterion, the DEFAULT statement block is executed, if there is one; otherwise, the program resumes at the statement after ENDSWITCH.

Several block identifiers can be assigned to one program branch. On the other hand, it is not sensible to use one block identifier several times, as only the first branch with the corresponding identifier will ever be taken into consideration.

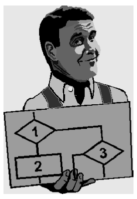
The data types for the selection criterion and the block identifier must correspond.

A SWITCH statement must contain at least one CASE statement; it must be ensured that no blank lines or comments appear between the SWITCH instruction and the first CASE statement.

The DEFAULT statement can be omitted. The default statement may only occur once in a SWITCH statement.

The SWITCH statement cannot be prematurely exited using the EXIT statement.

2.2.41.4 Example



Selection criterion and block identifier are of type Integer. The DEFAULT statement is used here to output an error message.

```
SWITCH VERSION
      CASE 1
            SP_1(); Call of the subprogram SP_1
      CASE 2,3
            SP_2(); Call of the subprogram SP_2
            SP_3(); Call of the subprogram SP_3
            SP_3A(); Call of the subprogram SP_3a
      DEFAULT
            ERROR_SP(); Call of the subprogram ERROR_SP
ENDSWITCH
```

Selection criterion and block identifier are of type Character. The statement SP_5() is never executed here because the block identifier “JOHN” appears twice.

```
SWITCH NAME
      CASE ”ALFRED”
            SP_1(); Call of the subprogram SP_1
      CASE ”BERT”,”JOHN”
            SP_2(); Call of the subprogram SP_2
            SP_3(); Call of the subprogram SP_3
      CASE ”JOHN”
            SP_5(); Call of the subprogram SP_5
ENDSWITCH
```

EXIT, FOR, REPEAT, WHILE, LOOP

2.2.42 SWRITE

2.2.42.1 Brief information

The “SWRITE” statement makes it possible to combine several data to form a data set.

2.2.42.2 Syntax

```
SWRITE (String1, State, OFFSET, Format, String2, VALUE)
```

Argument	Type	Explanation
`String1`	CHAR[ ]	The manipulated String2 is written in this character array.
`State`	STATE_T	This structure returns information about the state from the kernel system, which the user can evaluate. **`STATE.MSG_NO`** If an error occurs during execution of a command, this variable contains the error number. **`CMD_OK`** Command successfully executed **`CMD_ABORT`** Command not successfully executed State variable: **`HITS`** Number of correctly written formats.
`OFFSET`	INT	Specifies the position from which String2 is copied into String1.
`Format`	CHAR[ ]	The variable “Format” contains the format of the text that is to be generated.
`String2`	CHAR[ ]	This character array is copied into the character array String1. String2 may also contain formatting characters, which paste the content of the variable “VALUE” in this position with the format specified.
`VALUE`	INT REAL BOOL	The content of this variable is pasted into String2 with the format specified. Boolean values are output as 0 or 1, ENUM values as numbers.

2.2.42.3 Description

The “SWRITE” command is used for processing character strings. Unlike with “CWRITE”, data is not written to an open channel, but to a variable.

The conversion specification for the variable Format has the following structure:

`%FWGU`

The following definitions apply here:

- **`F`** Formatting character +, –, #, etc. (optional).
- **`W`** Width, specifies the minimum number of bytes that are to be output (optional).

- **G** Precision, its significance is dependent on the conversion character. ’.’ or ’.*’ or ’.integer’ can be used (optional).
- **U** Permissible conversion characters: c, d, e, f, g, i, s, x and %. The system cannot distinguish between upper and lower–case letters.

By entering a width, you can specify to how many bytes the value is to be extended or compressed. REAL values are an exception here.

When compressing the value, the high–order bytes are disregarded; the value is extended by adding zero bytes at the end (little endian format).

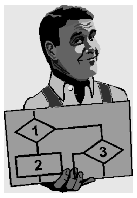
If the width is not specified, the internal representation is output: 4 bytes for INTEGER, REAL and ENUM, one byte for BOOL and CHAR.

The incorrect format can be inferred from the value of HITS (see below).

Format Variable	%d %i %x	%f %e %g	%s	%c	%1. ⟨WDH⟩ r	%2. ⟨WDH⟩ r	%4. ⟨WDH⟩ r	%. ⟨WDH⟩ r
(Signal) INT	X	X	–	–	–	–	–	–
INT array	–	–	–	–	X	X	X	X
REAL	–	X	–	–	–	–	–	–
REAL array	–	–	–	–	–	–	X	X
(Signal) BOOL	X	–	–	–	–	–	–	–
BOOL array	–	–	–	–	X	X	X	X
ENUM	X	–	–	–	–	–	–	–
ENUM array	–	–	–	–	X	X	X	X
CHAR	X	–	–	X	–	–	–	–
CHAR array	–	–	X	–	X	–	–	X

The “SWRITE” statement, which can be used in programs at the control or robot levels, triggers an advance run stop.

2.2.42.4 Example



Copy the content of the variable HUGO into the variable BERTA

```
INT OFFSET
DECL STATE_T STATE
DECL CHAR HUGO[20]
DECL CHAR BERTA[20]

OFFSET=0
HUGO[]= “TEST”
BERTA[]=”   “
SWRITE(BERTA[],STATE,OFFSET,HUGO[])
            ;Result: BERTA[]=“TEST”
            ;as “OFFSET” called by reference,
            this variable now has the value 4
            ;repeat the same command
SWRITE(BERTA[],STATE,OFFSET,HUGO[])
            ;Result: BERTA[]=“TESTTEST”
OFFSET=OFFSET+1
SWRITE(BERTA[],STATE,OFFSET,HUGO[])
            ;Result: BERTA[]=“TESTTEST TEST”
```

Use of formatting characters

```
INT OFFSET
INT NO
DECL STATE_T STAT
DECL CHAR HUGO[20]
DECL CHAR BERTA[20]


NO=1
OFFSET=0
HUGO[]=”TEST%d”
BERTA[]=”   “
SWRITE(BERTA[],STATE,OFFSET,HUGO[],NO)
            ;Result: BERTA[]=“TEST1“

OFFSET=OFFSET+1
NO=22
SWRITE(BERTA[];STATE,OFFSET,HUGO[],NO)
            ;Result: BERTA[]=“TEST1TEST22”
```

2.2.43 TRIGGER WHEN DISTANCE ... DO

2.2.43.1 Brief information

Path−related triggering of a switching action parallel to the robot motion.

2.2.43.2 Syntax

```
TRIGGER    WHEN DISTANCE=Distance DELAY=Time DO Statement
           〈PRIO=Priority
```

Argument	Type	Explanation
Distance	INT	Variable or constant specifying where the switching operation is to occur: • **DISTANCE=0** at the start • **DISTANCE=1** at the end of the motion block. Only these two values may be assigned!
Time	INT	Variable or constant that can be used for delaying and advancing the switching operation. If the value is • positive, execution of the statement is delayed • negative, execution of the statement is advanced by a specified time. The unit is milliseconds.
Statement		The instruction can be • an assignment of a value to a variable or • a PULSE statement or • a subprogram call Subprograms are executed like interrupt routines. The desired priority must therefore be specified by means of the operation PRIO.
Priority	INT	Variable or constant specifying the priority of the interrupt. Every Trigger statement with a subprogram call must be assigned a priority. Priority levels 1...39 and 81...128 are available. Priority levels 40 to 80 are reserved for the system and are allocated automatically if the value –1 is entered for the priority. A level 1 interrupt has the highest priority.

2.2.43.3 Description

The TRIGGER statement can be used to execute a subprogram or to assign a value to a variable parallel to the next robot motion depending on a distance criterion.

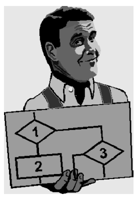
The path relation is defined by specifying whether the switching operation is to occur at the beginning of the motion block or at the end by means of the parameter *Distance*:

- For single blocks, DISTANCE=0 indicates the start point and
- DISTANCE=1 the target point

of the following motion. In the case of approximate positioning blocks, DISTANCE=1 signifies the middle of the following approximate positioning arc. If the previous block is already an approximate positioning block, DISTANCE=0 signifies the target point of the preceding approximate positioning arc.

It is possible to delay or advance the statement by a specified period of time using the DELAY option. The switching point can, however, only be delayed or advanced in so far as it still remains in the block concerned. An automatic limitation takes place at the block limits. So in the case of a single block and DISTANCE=1, the switching point cannot be moved past the target point and further along the path by specifying a positive DELAY value. Specifying a negative DELAY value ensures that the switching operation has already occurred before the target point is reached. But even here, the switching point can be advanced no further than the start point of the motion.

2.2.43.4 Example



Switching operation 130 milliseconds after the start of the next motion; setting of a signal.

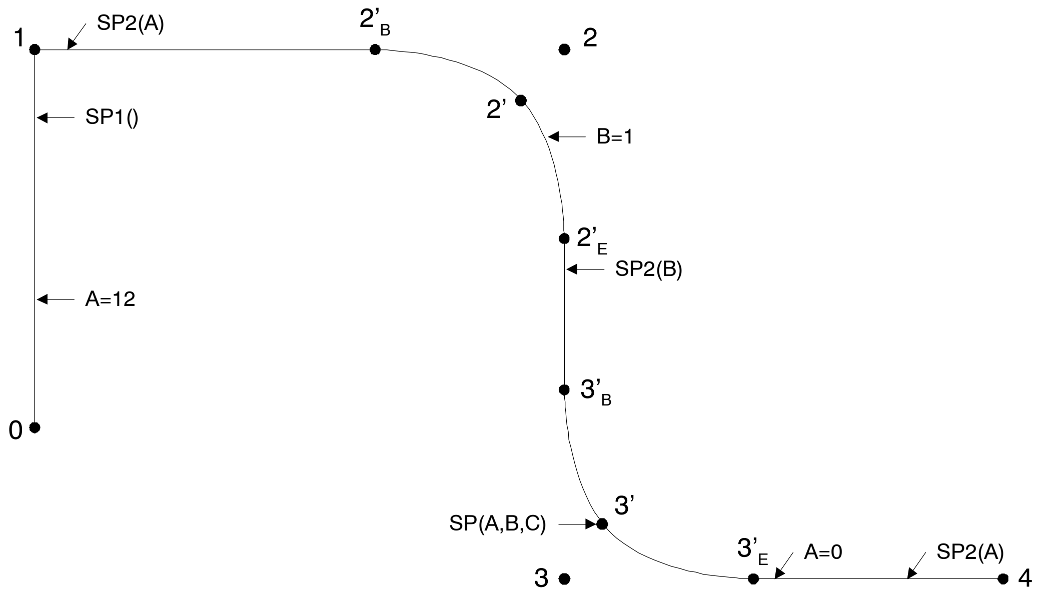
```
TRIGGER WHEN DISTANCE=0 DELAY=130 DO $OUT[8]=TRUE
```

Switching operation at the end of the next motion; call of a subprogram with priority 5.

```
TRIGGER WHEN DISTANCE=1 DO QUOTIENT(DIVIDEND,DIVISOR)PRIO=5
```

Switching ranges with different motion sequences and DELAY options.

```
DEF PROG()
...
PTP POINT0
TRIGGER WHEN DISTANCE=0 DELAY=40 DO A=12
                     ; Switching range: 0 – 1
TRIGGER WHEN DISTANCE=1 DELAY=-20 DO SP1() PRIO=10
                     ; Switching range: 0 – 1
LIN POINT1
TRIGGER WHEN DISTANCE=0 DELAY=10 DO SP2(A) PRIO=5
                     ; Switching range: 1 – 2’B
TRIGGER WHEN DISTANCE=1 DELAY=15 DO B=1
                     ; Switching range: 2’B – 2’E
LIN POINT2 C_DIS
TRIGGER WHEN DISTANCE=0 DELAY=10 DO SP2(B) PRIO=12
                     ; Switching range: 2’E – 3’B
TRIGGER WHEN DISTANCE=1 DO SP(A,B,C) PRIO=6
                     ; Switching range: 3’B –3’E
LIN POINT3 C_DIS
TRIGGER WHEN DISTANCE=0 DELAY=50 DO SP2(A) PRIO=4
                     ; Switching range: 3’E – 4
TRIGGER WHEN DISTANCE=1 DELAY=-80 DO A=0
                     ; Switching range: 3’E – 4
LIN POINT4
...
END
```



INTERRUPT DECL, INTERRUPT, PULSE

2.2.44 TRIGGER WHEN PATH ... DO

2.2.44.1 Brief information

Path−related and delayed triggering of a switching action parallel to the robot motion.

2.2.44.2 Syntax

```
TRIGGER    WHEN PATH=Distance DELAY=Time DO Statement
⇨          〈PRIO=Priority
```

Argument	Type	Explanation
`Distance`	INT	Specifies, in mm, the distance at which the switching operation is triggered relative to the target point of the next motion. If the switching operation is to be triggered before the target point, the value for Distance must be negative. If Distance is positive, the switching operation is triggered after the target point. If the target point is approximated, the start point for *`Distance`* is the center point of the approximate positioning motion. With a positive value for *`Distance`*, it is possible to shift the switching point as far as the next exact positioning point programmed after the trigger. With a negative value for *`Distance`*, the switching point can be shifted back as far as the start point. If the start point is approximated, the switching point can be shifted as far as the start of the approximate positioning range.
`Time`	INT	The specification "`Time`" is used to delay or advance the switching point relative to the Path specification by a defined amount of time. The switching point can only be shifted within the switching range specified above. The unit is milliseconds.

`Statement`		The instruction can be • an assignment of a value to a variable or • a `PULSE` statement or • a subprogram call. Subprograms are executed like interrupt routines. The desired priority must therefore be specified by means of the operation `PRIO`.
`Priority`	INT	Variable or constant specifying the priority of the interrupt. Every Trigger statement with a subprogram call must be assigned a priority. Priority levels 1...39 and 81...128 are available. Priority levels 40 to 80 are reserved for the system and are allocated automatically if the value –1 is entered for the priority. A level 1 interrupt has the highest priority.

2.2.44.3 Description

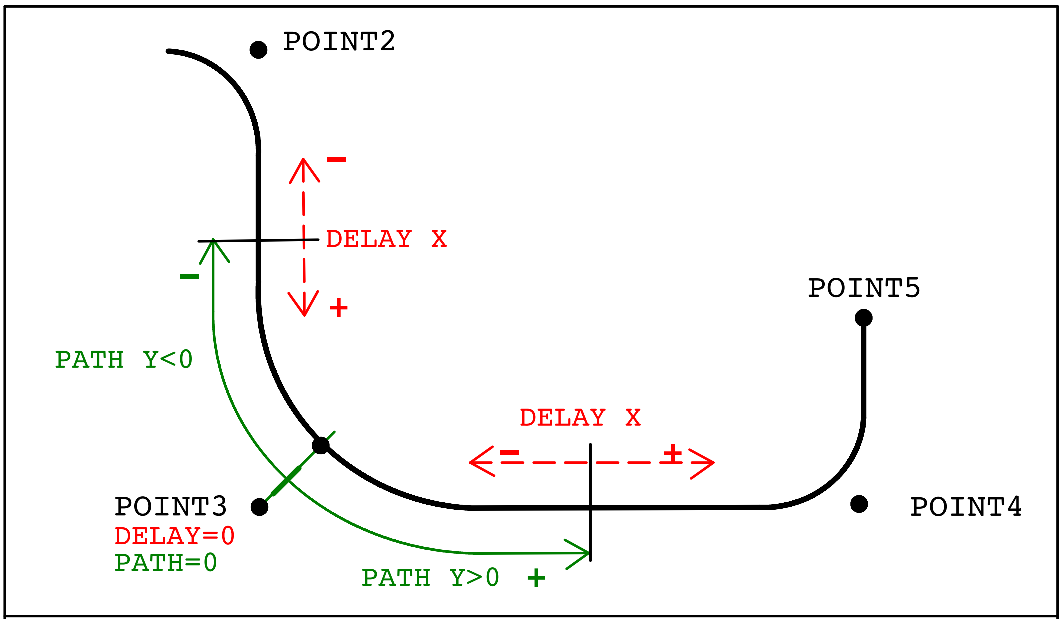
If you are using the path–related TRIGGER statement, you can trigger the switching action at any position along the path by specifying a distance. As with "Trigger when Distance", this again can additionally be delayed or brought forward.

The conditions governing the position on the path at which the distance criterion is evaluated, dependent on an approximate positioning motion, are shown in the table above. The time criterion is always calculated from the Path specification. The switching range is again dependent on the approximate positioning and is shown in the table above.

Instruction sequence:

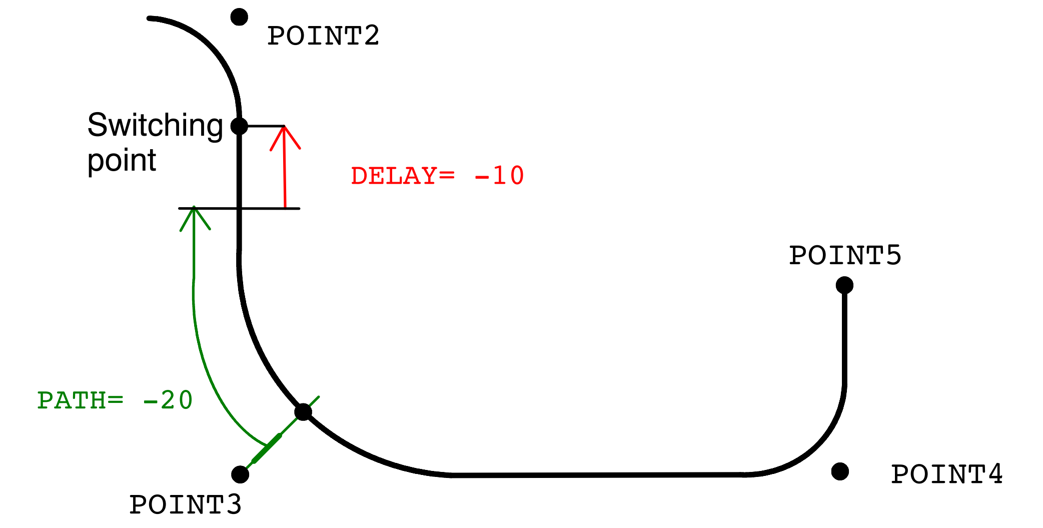
```
⋮
LIN POINT2 C_DIS
TRIGGER WHEN PATH = Y DELAY= X DO $OUT[2]=TRUE
LIN POINT3 C_DIS
LIN POINT4 C_DIS
LIN POINT5
⋮
```

Since the switching point can be shifted from the motion point before which it was programmed, past all subsequent approximate positioning points, as far as the next exact positioning point, it is possible to shift the switching point from the approximate positioning start point `POINT2` to `POINT5`. If `POINT2` was not approximated in this sequence of instructions, the switching point could only be shifted as far as the exact positioning point `POINT2`.



Numeric example:

X= –10, Y= –20



INTERRUPT DECL, INTERRUPT, PULSE

2.2.45 WAIT FOR

2.2.45.1 Brief information

Wait for a continue condition.

2.2.45.2 Syntax

```
WAIT FOR Continue_Condition
```

Argument	Type	Explanation
`Continue_ Condition`	BOOL	Logical expression used for specifying the condition when program execution is to be continued: • if the logical expression is already TRUE when WAIT is called, program execution is not halted. • if the logical expression is FALSE, program execution is halted until the expression has the value TRUE.

2.2.45.3 Description

The WAIT statement halts execution of the program and continues it after a specified wait time. The length of the wait time is determined by the occurrence of the programmed event.

If, due to incorrect formulation, the expression can never take the value TRUE, the compiler does not recognize this. In this case, execution of the program will be permanently halted because the program is waiting for a condition that cannot be fulfilled.

2.2.45.4 Example

Interruption of program execution until $IN[17] is TRUE.

```
WAIT FOR $IN[17]
```

Interruption of program execution until BIT1 is FALSE.

```
WAIT FOR BIT1 == FALSE
```

WAIT SEC

2.2.46 WAIT SEC

2.2.46.1 Brief information

Wait times.

2.2.46.2 Syntax

```
WAIT SEC Wait_Time
```

Argument	Type	Explanation
`Wait_Time`	INT, REAL	Arithmetic expression used for specifying the number of seconds that program execution is to be interrupted for. If the value is negative, the program does not wait. With small wait times, the accuracy is determined by a multiple of the interpolation cycle.

2.2.46.3 Description

The WAIT statement halts execution of the program and continues it after a specified wait time. The length of the wait time is specified in seconds.

2.2.46.4 Example

Interruption of program execution for 17.156 seconds.

```
WAIT SEC 17.156
```

Interruption of program execution in accordance with the variable value of V_WAIT in seconds.

```
WAIT SEC V_WAIT
```

WAIT FOR

2.2.47 WHILE ... ENDWHILE

2.2.47.1 Brief information

Program loop; termination condition is checked at the beginning of the loop (rejecting loop).

2.2.47.2 Syntax

```
WHILE Repetition_Condition
Statements
ENDWHILE
```

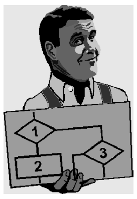
Argument	Type	Explanation
`Repetition_ Condition`	BOOL	Logical expression which can contain a Boolean variable, a Boolean function call or a logical operation with a Boolean result, e.g. a comparison.

2.2.47.3 Description

The WHILE loop is repeated depending on a condition specified by the user. This repetition condition is checked **before** each loop execution. The statement block is never executed if the repetition condition is not already fulfilled beforehand.

The statement block is executed if the logic condition has the value TRUE, i.e. the repetition condition is fulfilled. If the logic condition has the value FALSE, the program is resumed with the next instruction after ENDWHILE. Each WHILE statement must be ended by an ENDWHILE statement.

2.2.47.4 Example



The loop is executed 99 times. W has the value 100 after exiting the loop.

```
W=1
WHILE W<100
      W=W+1
ENDWHILE
```

The loop is executed until $IN[1] is true.

```
WHILE $IN[1]==TRUE
      Statements
ENDWHILE
```

The loop is never executed because the repetition condition is not already satisfied before the loop is executed. After exiting, W has the value 100.

```
W=100
WHILE W<100
      W=W+1
ENDWHILE
```

EXIT, SWITCH, FOR, REPEAT, LOOP

2.3 System functions

2.3.1 VARSTATE()

2.3.1.1 Brief information

Polls the state of a variable. VARSTATE() is a function with a return value of type “VAR_STATE”:

ENUM VAR_STATE DECLARED, INITIALIZED, UNKNOWN

The declaration of VARSTATE:

VAR_STATE VARSTATE(CHAR VAR_STR[80]:IN)

2.3.1.2 Syntax

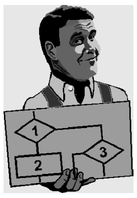
```
DECL VAR_STATE Variable_Name
Variable_Name = VARSTATE(”Variable”)
```

Argument	Type	Explanation
`Variable_Name`	**VAR_STATE**	Any variable name.
`Variable`	any	Name of a variable for which the state is to be determined.

2.3.1.3 Description

The function VARSTATE can be used to determine the state of a variable. The return value of the function can take the Enum constants DECLARED, INITIALIZED or UNKNOWN.

2.3.1.4 Example



```
DEF PROG1()
INT A,B
CHAR STR[5]
A=99
STR[]="A"

IF VARSTATE("A")==#DECLARED THEN
; This IF condition is incorrect as A has not only been declared, but has also already
been initialized.
$OUT[1]=TRUE
ENDIF

IF VARSTATE("A")==#INITIALIZED THEN
; This IF condition is correct.
$OUT[2]=TRUE
ENDIF

IF VARSTATE("A")==#UNKNOWN THEN
; This IF condition is incorrect.
$OUT[3]=TRUE
ENDIF

IF VARSTATE("B")==#DECLARED THEN
; This IF condition is correct.
$OUT[4]=TRUE
ENDIF

IF VARSTATE("NOTHING")==#UNKNOWN THEN
; This IF condition is correct, assuming that there is no variable with the name
"NOTHING" in $CONFIG.DAT.
$OUT[5]=TRUE
ENDIF

IF VARSTATE(STR[])==#INITIALIZED THEN
; This IF condition is correct as A has already been initialized.
$OUT[6]=TRUE
ENDIF

END
```