8. Further options and expansions
8.1 Programming variables

Allocation of variables
Variable programming provides the possibility of adapting a generally applicable program for a particular application, simply by altering the values of variables.
This can be advantageous, for example, when similar turned parts are to be produced, making variations every hour or every day. The required program alterations are then reduced to a minimum.
It is also possible to define cycles for certain movement sequences, for example by writing a subprogram with variables.
The variables are included in place of numeric values. Variable names start with the letter V followed by a number from 1 to 299.

Example: V11 = 30

Variable 11 has the value 30, or in other words, the value 30 has been allocated to variable 11.

Another example:
V20 = SIN(V21)

The sine of variable V21 has been allocated to variable 20.
A variable may not be included in a mathematical expression if it has not been allocated a value.

Programming
If a variable expression is included in an NC program, it may have the following the structure:

N 1 G1 X{V11 + 10} Z{V12}

In block N1 the tool is to traverse to the X coordinate resulting from the addition of V11 + 10, and to the Z coordinate determined by the value allocated to V12.

Supposing V11 has the value 30, V12 the value 50, then block N1 effects the command to traverse to X = 40 and Z = 50.

Attention:
The angle values of trigonometric functions must be entered as circul. measures.

Conversion:

$$\text{circul. meas.} = \frac{\text{angular value} \cdot \pi}{180^\circ}$$

$$\text{angular value} = \frac{\text{circul. meas.} \cdot 180^\circ}{\pi}$$

Variables in NC programs must be enclosed by braces. The braces may include any mathematical expressions and functions.
Programming them is similar to, and just as easy as, using a pocket calculator.

Input of a variable allocation
Input is done in the **EDITOR** mode (see section 4)

Press the VARIABLE ALLOCAT. softkey.

The monitor displays:
INPUT VARIABLE ALLOCATION V:{

(	)	+
V	=	* >
/		^

Press the V softkey.

Press the "continue" key.

Several subsequent menus of the same level are displayed in order to be able to enter a variable allocation.

Enter variable allocation,
e.g. V11 = V12 * 30 + sin(3.14)

Confirm

The NC block now has:
N... V{V11 = V12 * 30 + sin(3.14)}

The variable allocations are automatically put in braces by the control system.

Variables, input during program execution
The allocation may also be carried out when the program is executed, for example, because certain feed values or slide positions can be determined much easier when this is done directly on the machine.

Press the VARIABLE ALLOCAT. softkey.

Browse through the subsequent menues.

The third subsequent menu is displayed:

SQUARE ROOT "SQRT"	EXPONENT FUNCTION "EXP"	NATURAL LOGARITH "LN"
INTEGER TRANSIT "INT"	ROUNDOFF "ROUND"	ABSOLUTE VALUE "ABS"
INPUT	SIGNUM FUNCTION "SGN"	OUTPUT

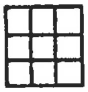
Press the INPUT softkey.

The following menu is displayed:

TEXT		VARIABLE

Press the VARIABLE softkey.

The display in the dialog line is:
INPUT VARIABLE ALLOCATION
V:{? = V



Enter digits, e.g. 11.

Confirm

The NC block has now:

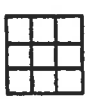
V{? = V11}

Example
In the following program, no defined value must be allocated to variable V11 as this is done during the program procedure.

```
N 0  G90  G95...
N 1  G0  X0  Z0
N 2  V{? = V11}
N 3  G1  X{V11}  Z-30
...
...
```

Values for V11 can be entered during a program test run in the **EDITOR** operating mode (see sect. 4) or when working in the **AUTOMATIC** operating mode (see sect. 5).

The display in the dialog line is:
INPUT VARIABLE:



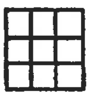
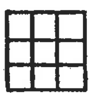
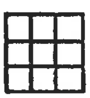
Enter digits, e.g. 20.

Confirm

Value 20 is allocated to address X.

Output of variables
It is possible to enter an explanatory text (**max. 48 characters**) and/or a variable at any point in the program. Depending on the programming of parameter N18, either the specified text or the allocated value of the variable is displayed on the dialogue line as additional information for the operator when executing the program or, in addition to being displayed, is also output to a printer via the reader/puncher interface.
Optionally, the informational text or the variable values allocated before or during the program run can therefore be output via a connected printer (e.g. to obtain hard copies of the in-process measurement results; see the example in Chapter 8.2 as well).

In order to do so, proceed as described under "Input of variables".

	Press the OUTPUT softkey.	The following message appears: ENTER VARIABLE ALLOCATION V:{! =
	For text input, press the TEXT softkey.	The texts can be entered via the follower menus.
	For entering a variable, press the VARIABLE softkey.	Variables can be entered using the subsequent menues.
	Confirm.	The input is terminated, and the control system closes the input via }.

Here, all characers of the ASCII-code can be used except for {()}. They are generated independently by the control system, the individual inputs may be separated using a comma. Texts and variables may be arranged at will one after the other.

Example:

V{! = (VARIABLE VALUE:), V15, FOR ANGLES)

When the program is executed, the entered texts and the current value of the variable are displayed in the dialog line.
(in this example, variable V15 has been allocated the value 50)

The display in the dialog line is:
VARIABLE VALUE: 50 FOR ANGLES
or additional output via reader/puncher interface

Note: In the diagnosis operating mode variable allocations can be displayed via VARIABL. EXPRESS. CYCLIC (see section 7).

Programmable mathematical operators and functions

The following operators are allowed:

Addition	+
Subtraction	-
Multiplication	*
Division	/
Power	^

The following applies for inputs:
"Dot before dash" and **"Power before point"**

The following functions are allowed, whereby the argument must always be in brackets (...) :

+ (...) and - (...) sign
SQRT (...) square root
ABS (...) amount
TAN (...) tangent [circular measure]
ARCTAN (...) arc tangent
SIN (...) sine [circular measure]
ARCSIN (...) arc sine
COS (...) cosine [circular measure]
ARCOS (...) arc cosine
EXP (...) exponential function
LN (...) natural logarithm
INT (...) whole number [integer function]
ROUND (...) round up of off
SGN (...) sign (-1, 0, 1) [signum function]

Moreover, brackets may be nested to the 6th depth.

Example:

For $\sqrt{3(\sin(\pi/2))^3}$ enter

SQRT (3 * (SIN (3.1416/2)) ^ 3)

Note: Softkeys LOGICAL AND "AND", LOGICAL OR "OR" or LOGICAL NOT "NOT" are contained in the menu, but have no function for the moment.

Conditional jump
In addition to the jump function with G61 described in section 3, conditional jump instructions are possible with the following operators for comparison:

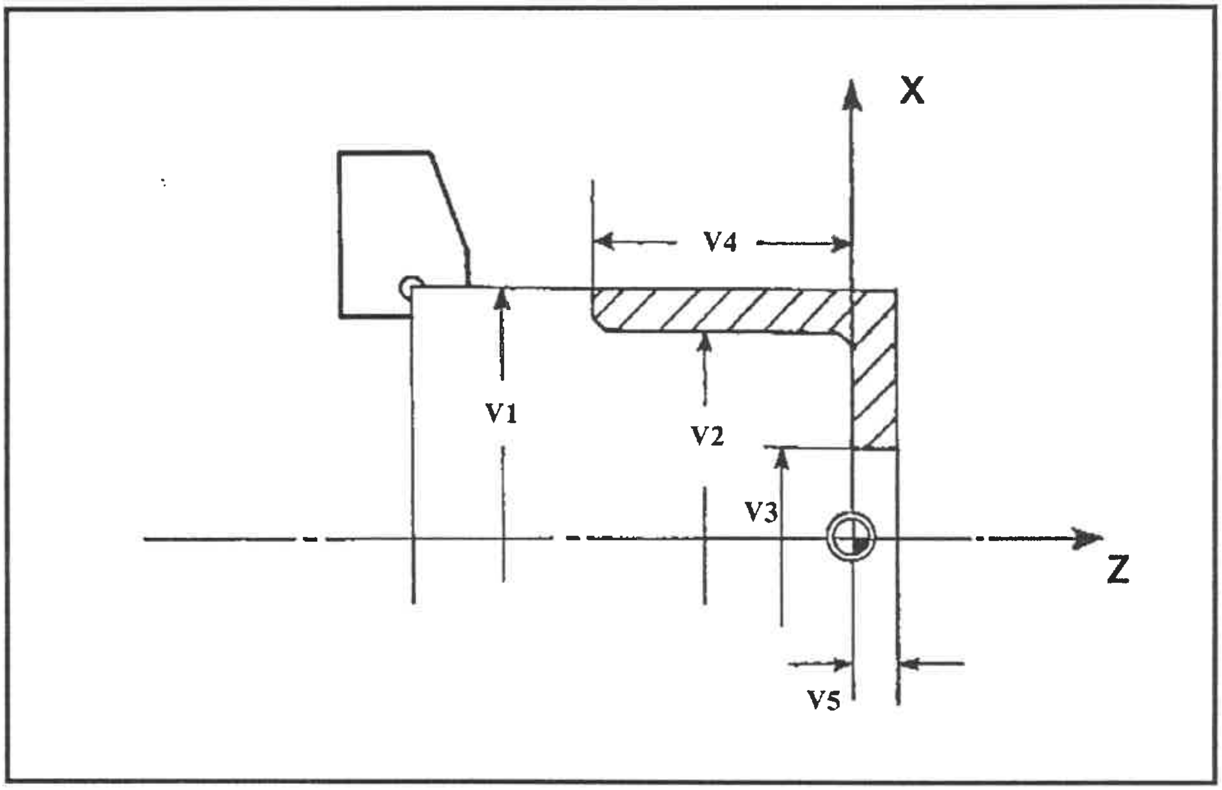
>	greater than
<	less than
==	equal to
<>	not equal to
>=	greater than or equal to
<=	less than or equal to

Example:

```
...
N  9 ...
N 10  G61  H{V11 + 2 > V13 - 2}  N15
N 11 ...
...
...
...
N15 ...
N16 ...
```

The program is continued with block N15 when V11 + 2 is larger than V13 - 2.
If this is not the case, then the program will be continued with block N11.
The characters H{ are generated automatically by the control system

The following example shows a program with variables for calculating a frequently used contour structure. Since the contour is to be machined with different dimensions, the dimension values for blank diameter, diameter of the finished part, cross diameter, length for turning the outside diameter and blank allowance are provided as variable allocations V1 - V5. During the program procedure only the corresponding dimensions need be entered as program parameters.




```
% 8002
N1  V{V100 = 0}
N2  V{? = (ARE THE VALUES TO BE INQUIRED?  0 = NO; 1 = YES), V100}
N3  G61  H{V100 <> 1} N9
N4  V{? = (BLANK DIAMETER), V1}
N5  V{? = (DIAMETER FINISHED PART), V2}
N6  V{? = (CROSS DIAMETER), V3}
N7  V{? = (LENGTH TURNING OUTSIDE), V4}
N8  V{? = (BLANK ALLOWANCE), V5}
N9  G95  G96  F0.3  S180  M42  M4  T2
N10  G0  X{V1+2}  Z{V5+3}
N11  G818  X{V2-6}  I3.5
N12  G1  Z0
N13  G88  X{V2}  I2
N14  G1  Z{-V4}
N15  G88 X{V1+2} I2
N16  G80
N17  G0  X{V2+2}  Z{V5}
N18  G82  X{V3}  Z0  K2.5
N19  G14  Q2
N20  M30
```

Explanation:

N1: Value 0 is allocated to variable V100

N2: During the program procedure variable V100 must be allocated a value or the current value must be confirmed. This variable allocation determines whether in the next block with G61 a jump is made to N9 or whether the program procedure is to be continued with block N4.
A full written text is displayed in round brackets in the edit line:
ARE THE VALUES TO BE INQUIRED? 0 = NO; 1 = YES

N3: Jump instruction: the program jumps to block N9 if the current value of the Variable V100 is **not equal** 1; if the value is 1, the program is continued with block N4.

N4: Here the diameter of the blank must be entered during the program procedure, the text displayed on the monitor in the edit line is: BLANK DIAMETER

N5: Entering the diameter of the machined contour. The edit line display is:
DIAMETER FINISHED PART

N6: Enter diameter of target point of cross machining. The edit line display is:
CROSS DIAMETER

N7: Length of the contour to be machined. The edit line display is:
LENGTH OF TURNING OUTSIDE DIAMETER

N8: Length of contour section for cross machining. The edit line display is:
BLANK ALLOWANCE

Note: If the blocks N4 - N8 are skipped by programming N3 accordingly, then the control system uses the variable allocations that are stored under V1 - V5 at that time.

N9: Start conditions: feedrate, speed, gear range, turning direction of the spindle, tool selection

N10: Positioning 1mm before or above the turning part in rapid traverse

N11: Call cycle "Longitudinal roughing G818"

N12: Straight line

N13: Cycle chamfer

N14: Straight line

N15: Cycle chamfer

N16: End of cycle

N17: Positioning for transversal machining cycle (1mm above the part)

N18: Cycle transversal machining

N19: Reaching the tool change point

N20: End of program

Functions designed for storing correction values in parameters

In case of the control system being provided with the options in-process measuring and post-process measuring, then the programming of variables is extended by a number of functions belonging to the extended NC range and being written in brackets **T[...], D[...]**.

T *number*	[*designation axis*] =	tool measuring offset MX, MZ (parameter **N1501** bis **N1564**)
D *number*	[*designation axis*] =	D-correction **DX, DZ**

Examples

N... **V{ D45[X] = V{ D45[X] + V150/2 + 0.5 }**

(Half of the contents of the variable V150 + empirical value (0.5 mm) is added to the D-correction D45(X)

N... **V{ D5[Z] = 0**

(The D-correction D5(Z) is set to zero)

N... **V{ T10[MX] = V970 }**

(The difference in measurements from V970 is transferred to the measuring offset X for T10)

Functions for inactivating tools

If, during the calculation of the difference in measurements, a workpiece is recognized to have left the tolerance range, then the corresponding tool can be inactivated, since it is obviously worn out, and replaced by an exchange tool (provided that the service life surveillance was switched on and that exchange tools were defined).
For this purpose, the tool diagnosis variables were designed (for their description, see the diagnosis operating mode).

T [*event*] = 1

Example:

N... **V{ T5[4] = 1 }**

(Tool T5 is inactivated by the event "inactive due to part measuring")

During service life monitoring with defined exchange tools, as well as for tool change, it is always the original tool that is programmed. It is always the tool that is momentarily active which is set inactive by the tool organization.

Freely available variables
The variables **V1** to **V299** are freely available to the operator (the control system must be equipped with the optional variables programming)

Note: These variables are set "undefined" by switching on the main switch.

Diagnostic variables
Variables **V601** to **V605** each contain the last M- and T-command of slides 1 - 5 transferred to the SPS; these variables are automatically updated by the control system.

Example:	V601	0003 0001
	Slide 1	**M3 T1**

Variables with determined significance (reserved variables)
The ranges of variables **V700** to **V999** are reserved by the control system for fixed programmed functions such as measuring, inspection cycle and so on, that is, these variables may be used **exclusively** for their designed purpose.

The following list contains a survey of the variables with fixed purpose of application.

V601 - V605	Diagnostic variables (last M- and T-command transferred to the SPS)
V700	Slide-dependent indicator which selects a data block for transfer purposes. Its value must be between 1 and 4 (for a maximum of four data blocks).
V701 - V710	Transfer variables
V711 - V719	Transfer variables, type integer (only integral numbers can be entered)
V750	Selection of the group of events for the periodical countdown function (G990)
V760	Piece counter - count displayed on the monitor when piece counting is activated.
V800 - V829	General program cycles (customer-specific part programs provided by the machine manufacturer)
V830 - V837	Reserve (to be allocated at will at the moment)
V838 - V933	Tool inspection (restart program)
V934	Storage of spindle values (in preparation)
V935	Storage of C-axis values (in preparation)

V936	Storage of Y-axis values (in preparation)
V937, V938	Storage of values (G901) and (G902)
V939	Global measuring result
V940	Variable indicates that new correction values and thus a new global result are available (V940 = 1)
V941 - V956	Correction values of the points of measurement M1 to M16
V957 - V969	Reserve (to be allocated at will at the moment)
V970	Offset measured value (0 to 9)
V971 - V979	Measured values from the electronic measuring system (EMS)
V980	Measuring position X-axis (is available after the control flank of the probe is recognized)
V981	Measuring position Z-axis (is available after the control flank of the probe is recognized)
V982	Error number of measuring, for error reaction
V983 - V999	Reserved for measuring cycles

Survey of bracket types
In the NC-syntax of the ELTROPILOT L - control system three different bracket types are used:

Round brackets ( )

1) The round brackets have to be used basically in each mathematical expression (term); e.g:

```
SIN(V21)
COS (3.14)
SQRT(3*(SIN(3.14/2))^3
```

(hereby the operator is allowed to use brackets up to the 6^{th} level)

2) If a program is entered via an external programming system, the program may contain information texts. The texts have to be written in round brackets. Processing the very program in AUTOMATIC mode, these texts appear in the block monitor. If the very program is called up in the EDITOR mode of operation, the text also appears. To be sure that the program routine is continued after blocks with information texts in the AUTOMATIC mode, such a block has to include the function G90; e.g.:

```
N1 (SHAFT PART)  G90
N2...
...
```

Parenthesis brackets { }

Paranthesis brackets are used for variable allocation, variable imput, variable output , and for the jump function G61. Programming these functions, these brackets are generated by the control system.

Square brackets [ ]

This type of brackets is used for extended NC-functions, like e.g.:

V{ D5[Z] = 0 }
D-correction is set to zero

V{ T10[MX] = V970 }
Store measuring difference from V970 into measuring offset for T10

V{ T5[4] = 1 }
Tool T5 is inactivated by event 4

8.2 In-process measuring

General

The actual dimensions must be detected in order to recognize deviations in dimension at the workpiece or at the tool, and to correct them in further steps of machining. This is done by means of a probe which emits a switching signal when it is deviated from its position of rest by contacts, for example with the workpiece, the tool or the pallet. Such a probe is also called a **switching probe.**
When the probe connected **directly** to the measuring circuit is deviated, the switching flank is used by the measuring hardware to store the slide position. The delay in the detection of the actual value lies within the range of microseconds. Thus it has no influence on the accuracy of measurement that can be achieved when commercial probes are used, even when the speed of measurement is increased.
After a maximum delay of **20 ms** the axis drive is stopped. A trailing distance that may still exist is being traversed.
The final point programmed in that block, which **must** be positioned behind the expected point of measurement, is cancelled (cancellation of the remaining distance). Thus the maximum speed of measurement depends only on the admissible deflection of the present probe, on the delay of a **maximum of 20 ms** and on the trailing distance of the axis.
The actual values for X and Z are available for further calculation in the variables memories determined by the manufacturer (V980 = position of measurement for the X-axis, V981 = position of measurement for the Z-axis).
The calculated values can then be stored in the corresponding parameter **(e.g. D-corrections, tool dimensions).**
The measuring process itself as well as the calculation of the measured value is realized via measuring cycles which exist as NC-program or which can be generated by the user according to the individual needs and then be called up via **L...** by the main program The fixed variables must be described with actual values (e.g. nominal dimension, tolerance range etc.) before the measuring cycle is called up.

Measuring the workpiece

In order to detect the actual dimensions, the machining program is traversed using a probe instead of a tool. The actual values detected in that way refer to the tip of the probe.
After the measured values have been calculated and evaluated, they are stored in the corresponding tool correction memory.

For programming examples and their explanation, see section 7.1 diagnosis/tool diagnosis operating mode.

Measuring the tool

During the measurement of the tool, the tool that has been taken as exchange tool is moved towards the probe. This probe is either fixed in its position or it is taken into the working space by means of a mechanical device.
As far as the internal process in the CNC is concerned, the measurement of the tool is comparable to the measurement of the workpiece. However, it is necessary to calculate the results of the measurements in the memory for the tool measurement offset **MX, MZ** (addition to the tool lengths **X, Z**) or in the D-correction **DX, DZ**, depending on the strategy that is employed.

Measurement of the tool with pre-set tools
Here, the cycle of measurement can be started from any point.

Tools measurements with tools that are not pre-set
In this case, the tool must be positioned in the setup mode in line with and in front of the probe before calling up the measuring cycle. This positioning must be done in a way that the probe can be reached by the other axis directly and without danger of collision.
In the measuring cycle this axis approaches the probe parallel to the axis and calculates the difference in measurements into the memory for the measurement offset of the measured axis.
Thus it is possible for the measuring cycle to measure the tool on the second axis so that the tool is then completely measured.

Example: Measurement of a tool that is roughly pre-set

```
%100
N 1  G0  X310  Z600
N 2  T6
N 3  G94  F300
N 4  M...
N 5  L111
N 6  V { D6[X] = D6[X] - V990 }
N 7  L112
N 8  V { D6[Z] = D6[Z] - V990 }
N 9  M...
N10  G95  F0.2
N11  G0  X310  Z600
N12  M30
```

Measuring cycle X %111

```
N 1  G920
N 2  G911
N 3  G0  Z { (M1[+Z] + M1[-Z]) / 2 }
N 4  G0  X { M1[+X] * 2 + 10 }
N 5 G912
N 6 G1 X { M1[+X] * 2 - 10 }
N 7 G1 X { M1[+X] * 2 + 10 }
N 8 G913
N 9 V { V990 = M1[X] - V980 }
N10 V { ! = ( DEVIATION IN MEASUREMENT X = ), V990 }
N11 G980
N12 M30
```

Measurement cycle Z %112

```
N 1  G920
N 2  G911
N 3  G0  Z {M1 [+Z] + 10}
N 4  G0  X { (M1[+X] + M1[-X]))
N 5 G912
N 6 G1 Z { M1[+Z] - 10 }
N 7 G0 Z { M1[+Z] + 10 }
N 8 G913
N 9 V { V990 = M1[+Z] - V981 }
N10 V { ! = ( DEVIATION IN MEASUREMENT Z = ), V990 }
N11 G980
N12 M30
```

Explanation (part programme)

N 1	Starting conditions
N 2	Changing in tool T6
N 3	Feed 300 mm/min
N 4	Swivelling in the probe
N 5	Call-up of subprogram L111, activating the cycle of measurement for X
N 6	Loading the contents of variable V990 (difference in measurements) into the D-correction for tool T6 (parameter N1106)
N 7	Call-up of subprogram L112, activating the cycle of measurement for Z
N 8	Loading the contents of the variable V990 (difference in measurements) into the D-correction for tool T6 (parameter N1106)
N 9	Retract the probe
N10	Feed 0.2 mm/rev.
N11	Rapid traverse back to start point
N12	End of program

%111 (cycle of measurement in X-direction, as subprogram)

N 1	Inactivate active zero pont shift
N 2	Activate probe monitoring
N 3	Centering in Z-direction between the dimensions determined in parameter N751 for +Z and -Z.
N 4	Positioning in X-direction at 10 mm in front of the probe
N 5	Switching over of the probe input activated by G911 to detection of actual values
N 6	Measuring process in X-direction; measured value is loaded to V980
N 7	Retract measuring probe
N 8	Finishing the measurement
N 9	The measuring deviation, the difference between nominal position (M1[+X]) and measured value (V980), is loaded into the variable V990 (radius dimensions)
N10	The measurement deviation in X is displayed on the sreen as operating information (variables output)
N11	Activating the zero point shift that was inactivated by G920
N12	End of program of the measuring cycle

%112 (Measuring cycle in Z-direction, as subprogram)

N 1	Inactivate active zero point shift
N 2	Activate probe monitoring
N 3	Positioning in Z-direction at 10 mm in front of the probe
N4	Centering in Z-direction between the dimensions determined in parameter N751 for +Z and -Z.
N 5	Switch-over of the probe input activated by G911 to detection of actual values
N 6	Measuring process in Z-direction, measured value is loaded to V981
N 7	Retracting the probe
N 8	Finishing the measuring process
N 9	The deviation in measurements, the difference between nominal position (M1[+Z]) and measured value (V981), is loaded into variable V990.
N10	The deviation in measurement in Z is displayed on the screen as operating information (variables output).
N11	Activating the zero point shifts inactivated by G920
N12	End of program of the measuring cycle

Print-out and transfer of measured values
The output of variables can be utilized to provide an available printer with data (informational texts or contents of variables) via the reader/puncher interface.
For this purpose, set the parameter N18 to 1 and use parameter N19 to enter the control character required for the relevant printer for paper feed at the end of each line.

The following example illustrates the principle of print-out and transfer of measured values.

```
% 5000
N 10      V {? =   ( WORKPIECE NO.: ), V10}
N 20      V {? =   ( DATE: ), V11}
N 30      V {! =   ( EPL-MEASUREMENT PROTOCOL )}
N 40      V {! =   ( )}
N 50      V {! =   ( WORKPIECE NO.: ), V10}
N 60      V {! =   ( DATE: ), V11}
N 70      V {! =   ( )}
N 80      V {! =   ( PART    MEAS. PT      NOM.      ACT.      DIFF )}
N 90      V {! =   ( )}
N100      V {V1 = 1}
N200...   Machining program
...
...
...
N500      Execution of the first in-process measurement

               Measuring point number to V02
               Nominal value to V03
               Actual value to V04
               Difference to V05
...
...
N590      L 1000
N600      Execution of the second in-process measurement

               Measuring point number to V02
               Nominal value to V03
               Actual value to V04
               Difference to V05
..
...
N690      L 1000
N700      V{ V01 = V01 + 1 }
N710      G61  N200


%1000
N 10      V{! = V01, V02, V03, V04, V05}
N 20      G909
```

The measurement protocol according to exemplary program %5000 would look like this:

EPL-MEASUREMENT PROTOCOL

WORKPIECE - NO.: 260763
DATE: 120589

PART	MEAS.PT.	NOM.	ACT.	DIFF.
0.001,	0.001,	100.000,	100.025,	0.025
0.001,	0.002,	150.000,	149.089,	-0.011
0.002,	0.001,	100.000,	100.013,	0.013
0.002,	0.002,	150.000,	150.005,	0.005
0.003,	0.001,	100.000,	100.007,	0.007
0.003,	0.002,	150.000,	150.003,	0.003
0.004,	0.001,	100.000,	99.082,	-0.018
0.004,	0.002,	150.000,	149.094,	-0.006
0.005,	0.001,	100.000,	100.003,	-0.003
0.005,	0.002,	150.000,	149.099,	-0.001
...				
...				
...				

Note
Each variable value is considered by the control system as decimal fraction with four digits before and three digits after the decimal point, non-existing digits are automatically filled up with SPACE characters. The control system automatically inserts two SPACE characters between two variable values or between two texts so that the printed list looks like a table.

8.3 Post-process measuring

The ELTROPILOT L2 - control system must be provided with the option "post-process measuring" when an externally produced post-process measuring device is to be used. The control software is designed for a maximum number of 16 different points of measurement.
In order to execute measurements, the parameters N697 to N716 must first be programmed accordingly:

N 697	Switching on the post-process measuring
N 698	Determining the type of measuring device (serial/parallel)
N 699	If necessary, adapt the logical sign of the measured value output by the measuring device to the control software
N 700	Conditions for the tool change after the tolerance limit B was exceeded
N 701 to N 716	Determining the tolerance limits and the criteria for measuring

The programming of these parameters is explained in detail in the description of the parameters in section 6.

Programming example
The following example shows one of the possibilities of programming which can be realized according to the individual criteria by the operator.
This example is referred to the point of measurement 1.

```
%1

N 1  ...
N 2  G61  H{ V941 > 1.0 }  N6
N 3  V{ V941 = ( V941 * 0.9 ) }
N 4  V{ D1[X] = D1[X] + V941 }
N 5  G61  N8
N 6  V{ V941 = 0 }
N 7  V{ T1[1] = 1 }
N 8  V{ V940 = 0 }
N 9  M30
```

Explanation

N 1 ...

N 2 The program jumps to block N6 if the measured value is larger than 1 mm, otherwise the program is continued with block N3

N 3 Multiplying the correction factor (values between 0 ... 1.0 can be determined for the evaluation of the measured value) by the measured value.

N 4 Transferring the measured value into the tool correction number D1.

N 5 Program jump to N8

N 6 Deleting the measured value

N 7 Inactivating the tool, since the measured value is larger than 1 mm

N 8 Resetting variable V940. This is necessary only for the first of the active points of measurement of the measuring series.

N 9 End of program; jump to block N1

General notes:

Global result of the measurement
A global result is calculated from each cycle of measurement and it is written into the variable V939 by the control system. There are four different global results:

0 = Part is good
1 = Part can be refinished
2 = Part is rejected
3 = Part was not measured

Correction values
The correction values of all active points of measurements are always written together in the variables **V941** to **V956**.
If a tool change is to take place, then a **1** is added to the corresponding correction value.

Making a new global result available
The variable **V940** is set from **0** to **1** when new correction values and thus a new global result is available.

8.4 Electronic measuring system (EMS)

Notes for handling the electronic measuring system EMS
By means of the electronic measuring system measured values from the points of measurement can be transferred directly to the variables memory of the control system. A maximum of nine measurements is possible per series of measurements. The measured values are stored in the variables **V971** to **V979**. (To do this, the control system must be provided with the additional option "programming of variables").
The electronic measuring system consists of an interface with three junctions for the connection of an electronic caliper gauge or a micrometer screw.

Connecting the electronic measuring system
The interface (MUX 3) is connected to the serial interface of the control system where there is also the **READER/PUNCHER** connection.
Then up to three measuring devices can be connected to the three junctions of the interface at the same time.

Transferring the measured values into the variables memory
At present, nine different points of measurement can transfer measured values into the variables memory.
The measured values are stored in the variables **V971** to **V979**.
In order to transfer each measured value, actuate the data transmission button on the measuring device or the "load key" at the interface.
The measured values are displayed on the screen in the dialog line under the corresponding number, e.g.:

EMS MEASURING POINT 1 MEASURED VALUE: ± nnnn.nnn

EMS - counter
The EMS - counter (0 .. 9) contains information concerning the point of measurement that was measured last. It is stored in the variable **V970**.
The counter is altered before the measured result is transferred into the variable, that is, the counter in variable **V970** is increased by 1 before a measured value is transferred.
The counter is automatically reset at the measurement following the measured value 9, that is, the contents of the variable **V970** becomes zero.
If two successive zeroes are indicated as measured values (by pushing together the caliper gauge or actuating the RESET key on the interface (MUX 3) twice), then the counter is also reset to the measured value 1 (V970 = 0).
The counter can be altered both via the **EMS** and the part program; V{ V970 = ... }

Note
When requesting variable **V970** as conditional event via function G61 only the relations <, <> and > may be used
(e.g. N... G61 H{V970 <> 4} N... N... G61 H{V970 > 5} N...)
An error message will be displayed if == is used.

The following list gives a survey of the change in the counter status by the EMS:

a) **Counter = 1 and the following measured value <> 0**

Counter is increased to 2.

b) **Counter = 9 and the following measured value <> 0**

This leads to the error message 7350 EMS: Too many measurements and to the initialization of the counter to 0.

c) **Counter <> 0 and the following measured value = 0 (zero measurement)**

The counter is diminished by 1.
Thus the last measurement can be repeated.

d) **Counter <> 0 , following measured value = 0 and last measured value = 0 (two successive zero measurements)**

The counter is initialized to 0. The whole series of measurements can be repeated.

e) **Counter = 0 and several following zero measurements**

The status of the counter is increased by 1 by the following zero measurements the measured values will not be altered, however.
When the counter status is = 0, it is increased to 5 by 5 following zero measurements. Another measurement <> 0 is transferred into the variable **V976** when the counter status is 6.

The following programming example shows one possibility to program the calculation of the measured value of the point of measurement 1. The measured value is stored in variable **V971**. Programs for the other points of measurement are to be structured similarly.

Programming example

%1

```
N1   V{! = ( NOMINAL DIMENSION MEASURING POINT 1 ), V10}
N2   V{! = ( TOLERANCE MEASURING POINT 1 ), V15}
N3   G61 H{ V971 == 0}  N11
N4   V{ V11 = V10 - V971 }
N5   V{ V12 = V15 - ABS(V11)}
N6   G61 H{ V12 >= 0 } N9
N7   V{! = ( TOLERANCE OF MEASURING POINT 1 EXCEEDED ), V11 }
N8   M0
N9   V{ D1[X] = D1[X] + V11 }
N10  V{ V971 = 0 }
N11  M30
```

Explanation

N 1 Operating information; output of the variable V10, to which the value of the nominal dimension at the point of measurement must have been allocated previously.

N 2 Operating information; output of the variable V15, to which the tolerance value at the point of measurement must have been allocated previously.

N 3 Jump command: if the value of the variable V971 (measured value) is unequal to zero, then the program is continued with block N4. If the value is equal to zero (zero measurement), then there is a jump to the end of the program (N11).

N 4 The value of the difference between the nominal dimension (V10) and the measured value (V971) is allocated to the variable V11.

N 5 The difference between the tolerance value at the point of measurement 1 (V15) and the absolute amount of the contents of the variable V11 is allocated to the variable V12.

N 6 Jump command: if the value of the variable V12 is larger or equal to zero, then there is a jump to block N9. If the tolerance is exceeded, then the program is continued with block N7.

N 7 Operating information (the text and the contents of the variable V11 are displayed.)

N 8 Programmed stop. The program can be continued using **cycle start.**

N 9 The value of variable V11 (difference between nominal and measured value) is added to the correction D1[X].

N10 The value zero is allocated to the variable V971.

N11 End of the program (with return to the beginning of the program)

In the following some ranges of application of the measuring program are represented, where the program is called up as sub-program L1.

% 2

```
...
N 11  G4  1.0
N 12  G61 H{V970 <> 4 }  N11
N 13  L1
N 14  M30
```

Explanation
The measuring result of the point of measurement 4 is expected in the part program.

```
%3
...
N11  L1
N12  G61 H{ V970 < 5 } N14
N13  V{ V970 == 0 }
N14  M30
```

Explanation
The series of measurements consists of 5 points of measurement. The counter is reset to zero after each fifth measurement.

```
% 4
...
N16  L1
N17  G61 H{ V970 <> 4 } N20
N18  G61 H{ V20 == 1  } N21
N18  V{ V20  + 1 }
N19  V{ V970 - 1 }
N20  M30
N21  V{ V20 = 0 }
N22  M30
```

Explanation
The point of measurement 4 is measured twice. For this, the counter is diminished by 1.

8.5 DNC operating mode

General
The DNC-module of the **ELTROPILOT L2**-control system allows the direct connection between the control of the machine tool and a production supervisory computer (German abbrev. **FLR**). At present the interface allows the transmission of

- **NC-part programs,**
- **machine data (parameter),**
- **texts of the supervisory computer**

The transmission of part programs and parameters is possible in both directions, from the supervisory computer to the control system and vice versa. The transmission of texts from the supervisory computer is possible only in one direction, from the supervisory computer to the control system.
The DNC module in the **ELTROPILOT L2**-control is realized by means of a **SET16** board. The SET is provided with a Dual-Port-RAM - range producing the connection of the basic software to the NC and with two serial interfaces. One of the serial interfaces serves as a connection with the supervisory computer, whereas the other interface can be used for diagnosis purposes. The interfaces can be operated at choice in the **20 mA** or in the **V.24** mode.

Conditions
DNC-operation can generally be performed in all **ELTROPILOT L2** - control systems, provided that the option DNC is present.
In addition, DNC-operation must be switched on in the parameter memory **(N0015)**.
When the DNC-option is switched on or off using the parameter, then the supervisory computer is informed about this with the following message:

EPL: R ZD I a b c

This message contains the following three pieces of information:

(a) Status of the DNC-parameter

DNC-ON - DNC switched on
DNC-OFF - DNC switched off

(b) Version of the DNC - SET

DNC2 - For this description the DNC-SET with the version 2 is to be applied.

(c) Expansion stage of the DNC - SET

T - Part programs
M - Machine states
B - Operator inputs
P - Parameter
N - Messages
O - DNC - ON/OFF

The identifications of the type of message are always written in this order. If one message is not present, depending on the expansion stage, then it is replaced by a zero.

When the DNC option is switched off by means of the parameter, then the **DNC-SET** is re-initialized. No data will be transmitted via the junction to the supervisory computer.

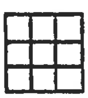
Data transmission by the supervisory computer
When the DNC operating mode is switched on, the supervisory computer can cause a data transmission of NC part programs or NC parameters to take place at any time (and in any operating mode) without the operator having to interfere. A transmission in progress is indicated on the screen with the message

EXTERNAL INPUT : % xxxxxxxx or
EXTERNAL OUTPUT : % xxxxxxxx

where xxxxxxxx stands for the eight-digit program number.
Any errors will be displayed in the error line.

Operation
When working in the DNC operating mode, proceed as follows:

Press the operating modes key. The operating modes menu is displayed on the screen.

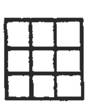


Press the DNC softkey The DNC menu is displayed on the screen.

NC-PARTS PROGRAM	PARAMET.	TERMINAL
PROGRAM LIST *)		USER *) ENTRY >
DATA ON	DATA OFF	DATA INTER-RUPT

*) Without meaning at present

Input of part programs
If part programs are to be entered from the supervisory computer to the control system, proceed as follows:



Press the NC-PART PROGRAM softkey INPUT PROGRAM NUMBER OR CONFIRM

Confirm The displayed program is selected

Enter digits e.g. 45	
Confirm	%45
Press the DATA ON softkey	EXTERNAL INPUT: % 45 Program 45 is transferred to the program memory of the control system.

A running transmission can be interrupted at any point.

Press the DATA INTER-RUPT softkey	Error 2404 is displayed on the screen: Interruption via stop key

Output of part programs

If part programs are to be transferred from the control sytem to the supervisory computer, then proceed as follows:

Press the NC-PART PROGRAM softkey	INPUT PROGRAM NUMBER OR CONFIRM:
Confirm	The program on display is selected.
Enter digits e.g. 25	
Confirm	%25
Press the DATA OFF softkey	EXTERNAL OUTPUT: % 25 Program 25 is transferred from the control system to the supervisory computer.

A running transmission can be interrupted at any point.

Press the DATA INTER-RUPT softkey	Error 2404 is displayed on the screen: Interruption via stop key

Format of transmission and syntax of the NC

Data transmission from the control system to the supervisory computer is realized in the **ISO-code** (8-bit code: ASCII, even parity). The parity is checked twice (vertical and longitudinal parity). When the transmission is faulty, data blocks may be repeated up to three times.
A determined syntax must be observed during the transmission of NC part programs. This is automatically observed during the output to the supervisory computer.
An NC-program begins with the per cent character and a number of eight digits or letters at maximum. The head of the program must end with the invisible control characters "carriage return" **(CR)** and "line feed" **(LF)**. It is followed by the NC blocks or commentary texts in brackets.
An NC-block consists of a maximum of **254** characters and is terminated with **CR** and **LF**. The NC-program must end with 16 control characters (other than CR, LF or tabulator HT), e.g. (CTRL key +D).

e.g.: NC - part program

%11028801<CR><LF>

N1 **(EXAMPLE FOR GEOMETRY PROGRAMMING) <CR><LF>**
N2 G96 G95 S100 F1 M4 T1 **<CR><LF>**
N3 G1 X200 Z215 **<CR><LF>**
N4 G1 A-12 B50 **<CR><LF>**
N5 G2 X? Z70 R65 **<CR><LF>**
N6 G1 X0 Z0 A-18 **<CR><LF>**
N7 G0 X200 M30 **<CR><LF>**
^D^D^D^D^D^D^D^D^D^D^D^D^D^D^D^D

Transmission of parameters

When transmitting from the supervisory computer to the control system or vice versa, then all or several connected parameters (a minimum of two) can be transmitted.
To do this, the number of the first and the last parameter (exclusively) to be transmitted must be indicated, and the last parameter must be existent.
If the numerical difference between the first and the last parameter is larger than 999, then all parameters starting from the first will be transmitted.

Parameter input

If parameters are to be transmitted from the supervisory computer to the control system, then proceed as follows:

Press the PARAMETER softkey	INPUT NUMBER OF PARAMETER BLOCK: N
Enter digits e.g.: 3	

Confirm — INPUT NUMBER OF PARAMETER BLOCK: N

Enter digits
e.g. 40

Confirm — P1 3 37
A number of 37 parameters (numerical difference between the first and the last of the parameters to be transmitted) is to be transmitted. The first of these parameters to be transmitted is parameter N3.
These statements refer to slide 1 **(P1)**

Press the DATA ON softkey — EXTERNAL INPUT: %0000001
Parameters N3 to N39 are transmitted, provided that they exist.

Parameter output
If parameters are to be transmitted from the control system to the supervisory computer, then proceed as follows:

Press the PARAMETER softkey — INPUT NUMBER OF PARAMETER BLOCK: N

Enter digits
e.g.: 1

Confirm — INPUT NUMBER OF PARAMETER BLOCK: N

Enter digits
e.g. 1064

Confirm

P1 1 0
More than 999 parameter numbers (**numerical** difference between the first and the last parameter to be transmitted) are to be transmitted and in this case a zero is displayed.
The first parameter to be transmitted is parameter N1.
These statements are referred to slide 1 **(P1)**

Press the DATA OFF softkey

EXTERNAL OUTPUT: %00000001
All parameters (N3 to N1564) are transmitted, provided that they exist.

A running transmission can be interrupted at any point.

Press the DATA INTERRUPT softkey

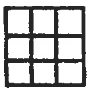
Error 2404 is displayed on the screen:
Interruption via stop key

Format of transmission
The syntax for the transmission of parameters is similar to the one used for NC part programs. The per cent character is followed by the identification of the parameter **00000001** and the **CR** and **LF** characters. The following parameter blocks consist of the identification of the number of the parameter block N, a number of the parameter block of a maximum of four digits, **5** blanks, the parameter value and then **CR** and **LF**. The parameter data block is terminated by **16** control characters (not CR, LF or HT).

e.g.: NC - parameter for the maximum number of r.p.m in the four gear stages

%00000001<CR><LF>
N31 4000<CR><LF>
N32 2850<CR><LF>
N33 2000<CR><LF>
N34 1500<CR><LF>
^D^D^D^D^D^D^D^D^D^D^D^D^D^D^D^D

Terminal
This is a special function used for communication between the supervisory computer and the control system with which it is possible to transmit texts and pictures used as operator information from the supervisory computer to the screen of the control system.



Press the TERMINAL softkey

The screen is cleared for operator information from the supervisory computer

Press the operating modes key

Return to the DNC-menu

Texts from the supervisory computer
The supervisory computer is provided with the possibility to display a text on the monitor of the control system. A maximum of 32 characters can be displayed in the error line, as shown in the following example:

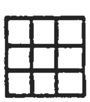
3509 MESSAGE FROM THE SUPERVISORY COMPUTER : FLR IS READY !

If the error line is occupied by an error message, then the message coming from the supervisory computer is stored in the error memory of the control system.

Diagnosis in side-line operation
If diagnosis is to be selected from the DNC-mode in side-line operation, proceed as follows:

Press the "Continue" key when in the DNC main menu.

The follow-up menu will be displayed.



Press DIAGNOSIS softkey.

The DIAGNOSIS main menu will be displayed (see also Chapter 7.1, DIAGNOSIS in side-line operation).