NUM 1020/1040/1060

POLYGON CUTTING MANUAL

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The physical, technical and functional characteristics of the hardware and software products and the services described in this document are subject to modification and cannot under any circumstances be regarded as contractual.

The programming examples described in this manual are intended for guidance only. They must be specially adapted before they can be used in programs with an industrial application, according to the automated system used and the safety levels required.

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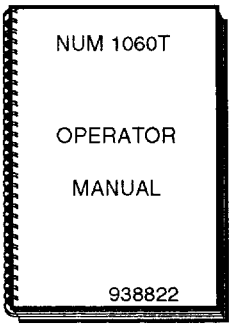
Record of Revisions

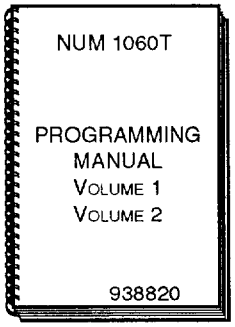
DOCUMENT REVISION		
Date	**Revision**	**Reasons for Revision**
04-96	0	Document creation

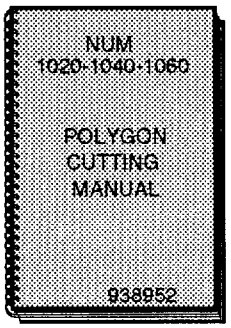
Structure of the NUM 1020-1040-1060 Production Documentation

User Documents

These documents are addressed to the CNC operators.

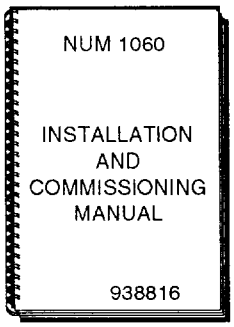


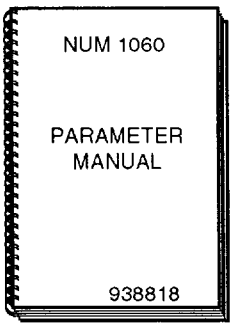


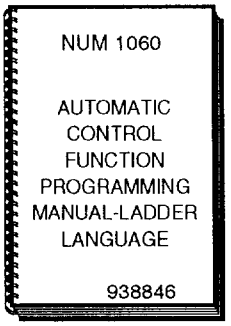


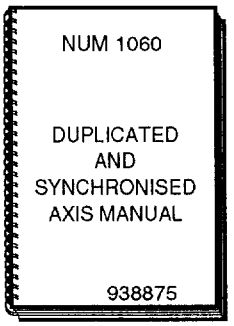
OEM Documents

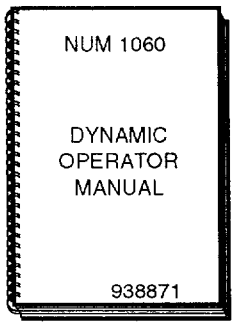
These documents are addressed to OEMs integrating the CNC on a machine.

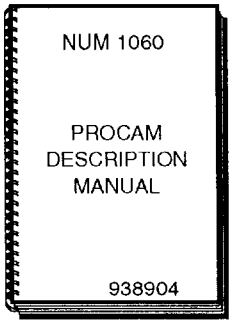






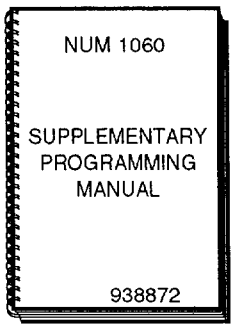


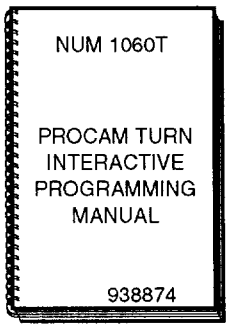


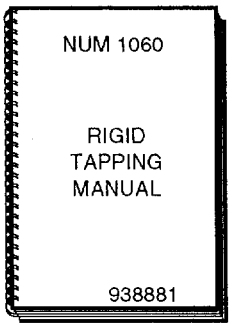


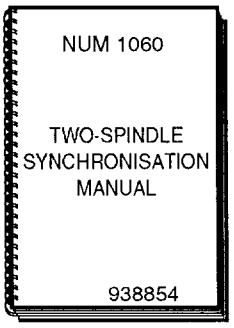
Special Programming Documents

These documents concern special CNC programming applications.

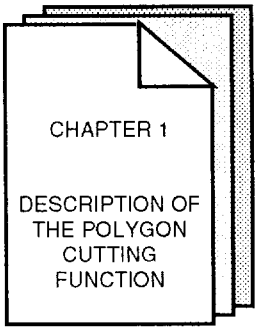




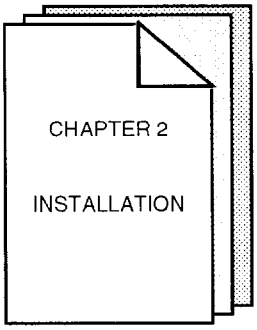




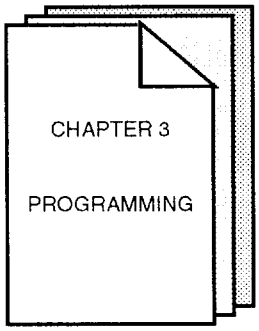
Polygon Cutting Manual



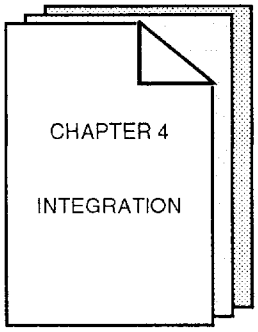
Description of the conditions of use of the polygon cutting function.



Description of installation of the polygon cutting function on the CNC.



Description of programming of:
- the polygon cutting function,
- modulo axis as spindle.



Description of integration of:
- the polygon cutting function,
- a modulo axis as spindle.

Agencies

The list of NUM agencies is given at the end of the manual.

Questionnaire

To help us improve the quality of our documentation, we kindly request you to return the questionnaire at the end of the manual.

1 Description of the Polygon Cutting Function

1.1 Principle of Polygon Cutting

Polygon cutting is used to cut flats or polygonal shapes on a part of revolution.

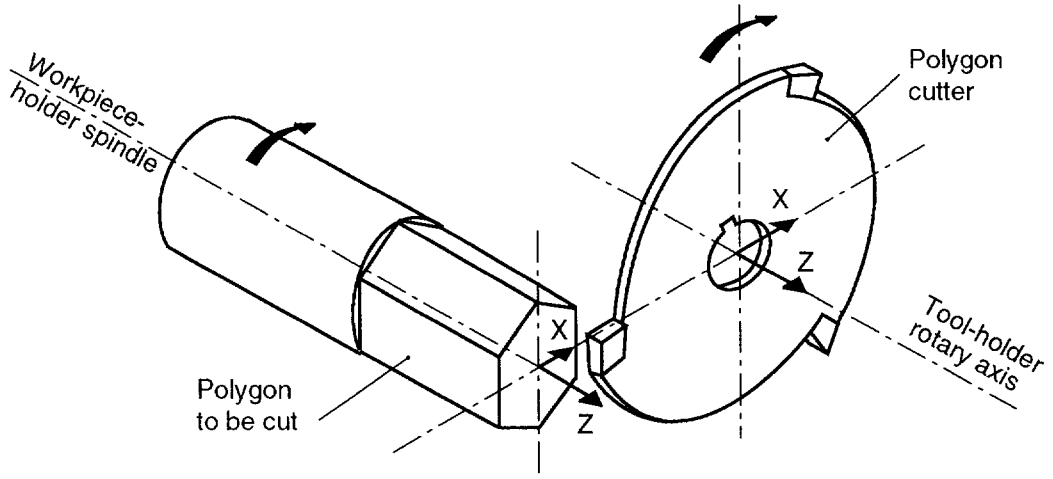
The cutting technique is based on synchronisation of a rotary axis and a spindle rotating in the same direction in a programmed speed ratio.

The number of teeth on the tool mounted on the tool-holder rotary axis depends on the number of flats to be machined. An angular offset can be programmed.

1.2 Tools

Flats are machined in the plane using a special cutter (with brazed or added inserts) whose diameter is generally around three times that of the part to be cut. The cutter can have 1, 2, 3, 4 or 5 teeth.

1.3 Workpiece/Tool Position



1.4 Requirements for Use

The polygon cutting function gives the same results as with mechanical polygon cutting and requires compliance with the same operational requirements.

The requirements for use are determined by:
- the type of material to be cut,
- the diameter of the part to be cut,
- the diameter and thickness of the cutter (maximum 12 mm).

These requirements directly affect the flatness and surface condition of the flats as do the rotation speeds and feed rates used.

1.5 Conditions of Use

The following are used for polygon cutting:
- a rotary polygon cutter axis with a 4500- or 5000-point encoder,
- a workpiece-holder spindle with 1024-point encoder.

The programmed rotation speeds must be compatible with the speed accepted on the polygon cutter rotary axis.

The rotary axis must be initialised by homing.

1.6 Necessary Options

Use of the polygon cutting function requires availability of the following options:
- structured programming,
- dynamic operators.

2 Installation

2.1 General

2.1.1 Configuration

The polygon cutting function includes:
- a diskette titled "Polygon cutting" (3 1/2" DD),
- the Polygon Cutting Operator Manual.

2.1.2 Equipment Required for Loading the Programme

A PC including:
- the MS-DOS operating system,
- a 3 1/2" HD diskette drive,
- a serial port,
- an RS 232 serial interface cable.

2.1.3 Contents of the "Polygo" Diskette

The diskette contains:
- a load file called "minicom.exe",
- two binary files, each in language versions "f" and "e":
  - polygon file titled "polygo_f.bin" for French and "polygo_e.bin" for English,
  - modulo rotary axis as spindle file titled "axebro_f.bin" for French and "axebro_e.bin" for English.

Additional Information

The "minicom.exe" load file is used only to load the two other files into the CNC.

REMARK *The "minicom.exe" file is available only in French and English.*

In the section below describing load of the polygon cutting and modulo rotary axis spindle files , each instruction including the expression "[language code]" is replaced by the letter corresponding to the selected language:
- "f" for French,
- "e" for English.

2.2 Loading the Files

2.2.1 Loading the Polygon Cutting File

Requirements

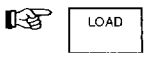
The PC and CNC must be interconnected by an interface cable, plugged into the PC COM1 or COM2 serial port and a serial connector of the CNC configured for loading (see Operator Manual).

The CNC must be on, with the Current Position page displayed and the basic soft keys displayed at the bottom of the screen.

Actions

Select the file load mode.

Select the FILE LOADING MENU.



The FILE LOADING MENU is displayed with item 0, PROGRAMS selected.

Prepare the CNC for program load.

The CNC goes on wait with the INCYC light lit.

On the PC

Turn on the PC.

Prompt C:\> is displayed showing that drive c is selected.

Insert the polygon cutting diskette in the PC drive.

Enter DOS command A: (or B:) and press Enter.

The system switches to the selected drive and displays the prompt A:\> (or B:\>).

Enter the command minicom.exe and press Enter.

The MINICOM menu is displayed:

1 —> PARAMETERS SETTING UP
2 —> SENDING AN ASCII OR OBJECT FILE
3 —> SENDING A BINARY FILE

The cursor is on 1 —> PARAMETERS SETTING UP.

Press Enter to select PARAMETERS SETTING UP.

The PARAMETERS SETTING UP page is displayed.

Set the parameters and press Enter to confirm each setting.

The default settings are listed below. They can be changed using the arrow or +/- keys:

Serial port:	COM1
Sending baudrate:	9600 bauds
Directory:	A:\
Language:	Français (French).

Press enter to return to the MINICOM menu.

The MINICOM menu is displayed.

Move the cursor to 3 —> SENDING A BINARY FILE using the arrow keys.

The SENDING A BINARY FILE page is displayed.

Select file polygo-[language code].bin with the arrow keys.

File polygo_[language code].bin is highlighted.

Press Enter to start loading file polygo_[language code].bin.

On the CNC

The file is loaded into the CNC and the INCYC light goes out at the end of loading.

REMARK *Check for presence of the following files in CNC area 0 (see Operator Manual):*
- %10200
- %10200.9
- %20500

At the end of debugging (see Chapter 4 of this manual), it is recommended to transfer these files into CNC area 3.

2.2.2 Loading the Modulo Rotary Axis as Spindle File

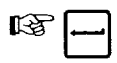
Requirements

On the CNC

The FILE LOADING MENU is displayed with item 0, PROGRAMS selected.

Actions

On the CNC

Prepare the CNC for program load (see the beginning of Sec. 2.2.1). 

The CNC goes on wait with the INCYC light lit.

On the PC

The SENDING A BINARY FILE page is displayed.

Select file "axebro_[language code].bin" with the arrow keys.

File "axebro_[language code].bin" is highlighted.

Start loading file "axebro_[language code].bin" by pressing the Enter key.

On the CNC

The file is loaded and the INCYC light goes out at the end of loading.

On the PC

The SENDING A BINARY FILE page is displayed.

Exit from the SENDING A BINARY FILE page by pressing the ESC key.

The MINICOM menu is displayed.

Exit from the MINICOM menu by pressing Alt + X.

The drive prompt A:\ (or B:\) is displayed.

REMARK *Check for presence of the following files in CNC area 0 (see Operator Manual):*
- *%10201*
- *%10201.9*
- *%20500*

At the end of debugging (see Chapter 4 of this manual), it is recommended to transfer these files into CNC area 3.

3.1 Programming the Polygon Cutting Function

G200	Polygon cutting function call

Programming this function calls the polygon cutting subroutine.

Syntax

N.. G200 ER.. [ED..]

G200	Polygon cutting function call.
ER..	Cutter/workpiece rotation speed ratio (see table below).
ED..	Possible angular offset on the rotary axis (expressed in thousandths of a degree).

Cancellation

The polygon cutting function is cancelled by programming G200 ER0.

Notes

Argument ER is compulsory. If it is not programmed, error message 503 is returned.

When argument ED is not programmed, the value contained in variable L188 is used as default.

The polygon function call and cancellation blocks must not include any other function.

3.1.1 Polygon Cutting Possibilities

The speed ratio programmed determines the number of flats (based on the number of teeth on the cutter) and the value of the curve on the flat cut.

Cutter/workpiece speed ratio	Number of teeth on the cutter (evenly spaced)				
	1	2	3	4	5
ER = 1	1 flat	2 flats	3 flats	4 flats	5 flats
ER = 2	2 flats	4 flats	6 flats	8 flats	10 flats
ER = 3	3 flats	6 flats	9 flats	12 flats	

REMARK *Ratio 2 gives the smallest curve. With the other ratios, the curves are larger, depending on the workpiece diameter.*
Ratio 1 = convex
Ratio 3 = concave

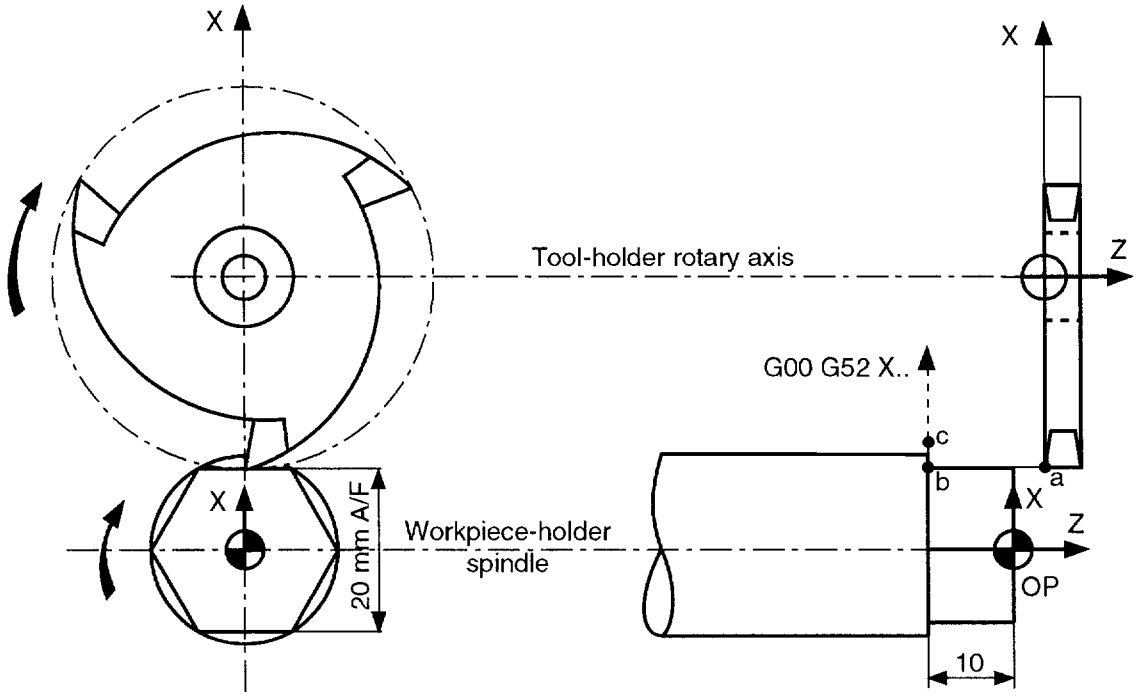
3.1.2 Programming Logic

The logical programming order below is given as an example:
- call of the polygon cutting tool and its offset (T.. D..),
- start of rotation of the workpiece-holder spindle (M03/M04 S..),
- call to the polygon cutting subroutine with specification of a ratio between 1 and 3 (G200 ER..), possibly with an offset (ED..),
- optional timeout to allow the tool-holder axis to reach the speed of the programmed ratio (G04 F..),
- positioning of the cutter (X../Z..),
- machining of the flat(s) by plunging and/or turning (X../Z..),
- tool retraction (X../Z..),
- cancellation of the polygon cutting subroutine (G200 ER0).

3.1.3 Example

Diagram

Polygon cutting of a hexagon with a three-tooth cutter (ratio ER = 2).



Programme

```
N.. ...
N.. T.. D.. M06 (3-TOOTH CUTTER)
N.. S2400 M40 M03 (or M04)
N.. G200 ER2
N.. G04 F3
N.. G00 X200 Z2
N.. G95 F0.04 G01 Z-10
N.. X25
N.. G00 G52 X..
N.. G200 ER0
N..
```

Call to cutter and offset
Start of rotation of the workpiece-holder spindle
Polygon cutting function (speed ratio = 2)
Timeout
Positioning in a
Cutting of the polygon to point b
Facing to c
Cutter retraction
Cancellation of the polygon cutting function

3.2 Programming of the Modulo Axis as Spindle Function

G201	Call to the module axis as spindle function.

Programming this function calls a subroutine to programme a modulo axis as spindle with continuous rotation but without indexing or constant surface speed, etc.

With the polygon cutting function disabled, G201 allows the polygon cutting tool rotary axis to be used as spindle to control a rotary tool.

Syntax

N.. G201 EM.. S..

G201	Modulo axis as spindle subroutine call.
EM..	Axis rotation - EM3: clockwise rotation (M03), - EM4: counterclockwise rotation (M04), - EM5: rotation stop (M05).
S..	Tool rotation speed in rpm.

Cancellation

The modulo axis as spindle subroutine is cancelled by programming G201 EM5.

Notes

Arguments EM and S are mandatory. If they are not programmed, error messages 502 and 505 are returned respectively.

The function call and cancellation blocks should not include any other function.

3.3 Error Messages

The following error messages are specific to polygon cutting:

- N500 Speed too high
- N501 Mechanical ratio equal to zero
- N502 Mandatory programming of EM
- N503 Mandatory programming of ER
- N504 Incorrect value of EM
- N505 Mandatory programming of S

4.1 Integration of the Polygon Cutting Function

Integration must be carried out in compliance with the machine parameter manual.

4.1.1 Machine Parameters Concerned

The following machine parameters concern the tool-holder rotary axis:
- P0: axis displayed
- P1: modulo rotary axis
  i.e. modulo 3600000
- P2: measured axis
- P3: servo-controlled and interpolated axis
- P9: axis assignment to a group
- P11: axis measurement conversion coefficient
- P21: servo-control coefficient
- P22: in-position window
- P30: limit speed on the axis

4.1.2 Setting the Maximum Speed on the Rotary Tool-Holder Axis

To set the maximum speed on the rotary tool-holder axis, it is necessary to set parameters P11, P21, P22 and possibly P30.

Maximum Speeds Based on the RTC

The maximum speed that can be obtained with RTCs of 7 ms and 5 ms are as follows:
- 12800 rpm with a 7 ms RTC,
- 18000 rpm with a 5 ms RTC.

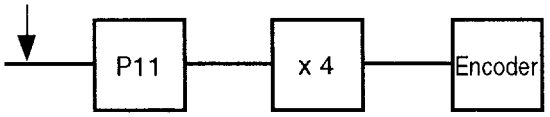
Setting the Axis Measurement Conversion Coefficient (P11)

Set P11 so that the CNC senses a maximum of 30000 points per sample at the maximum speed.

Example:

It is desired to have a rotation speed of 300 rpm with a 5 ms RTC

30000 points per sample



$$\frac{3000 \text{ rpm} \times 5}{60 \times 1000} = \text{Quarter rev per sample}$$

The encoder has a resolution of 5000 points, i.e. x 4 = 20000 points per revolution. For a quarter rev per sample, the CNC receives 5000 points per sample. A multi/divi ratio between 1/1 and 6/1 is therefore possible.

Setting Servo-Control Coefficient (P21)

Set P21 to obtain 9 V at the maximum speed, i.e. 3000 rpm.

Setting the In-Position Window (P22)

Set P22 so that it is larger than εp max or cycle start is inhibited.

Setting the Limit Speed on the Axis (P30)

The setting of P30 is not meaningful unless the axis is programmed and processed by interpolations. P30 is ignored when the axis is controlled by dynamic operators.

4.1.3 Variables Used for Polygon Cutting

The values assigned to the variables used in the subroutines are given as an illustration.

The following variables are used in subroutine %10200 for calling and customising polygon cutting and subroutine %10200.9 executing the function.

- B = 1 — Selection of workpiece-holder spindle: 1, 2, 3 or 4
- A = 5 — Selection of the tool-holder axis physical address
- L180 = 81050 — First number of E81xxx parameters used. The next 20 parameters are reserved
- L181 = 82050 — First number of E82xxx parameters used. The next 20 parameters are reserved
- L182 = 20 — Number of increments/RTC for speed build-up
- L183 = 40 — Position correction coefficient in 1/1024
- L184 = 100 — Torque compensation coefficient in 1/1024
- L185 = 60 — First number of the dynamic operators used. The next 27 operators are reserved for polygon cutting
- L186 = 42006 — PLC parameter E42xxx used: polygon cutting inhibited = 0, enabled = 1
- L187 = 1 — Number of encoder points: 1 = 5000, 2 = 4500
- L188 = 0 — Value of the angular offset. By default in thousandths of a degree
- L189 = 500 — First number of the error messages.

4.1.4 Timeouts Included in the Subroutine

Two timeouts, G04 F.., are set in subroutine %10200.9:
- rotary tool-holder axis speed build-up timeout (default 0.3 s),
- rotary tool-holder axis synchronisation timeout (default 0.6 s).

4.1.5 Setting Variables in the Subroutine

Set the parameters of subroutine %10200 in the order given below for servo-control of the rotary tool-holder axis.

Setting the Axis Speed-Build Up Parameter (L182)

This parameter sets the axis speed build-up time (default 20).

$\tau = 2^{10} \times HTRs / L182$

Setting the Axis Position Servo-Control Parameter (L183)

This parameter sets the axis integration time constant (default 40).

If an instability appears after setting this parameter, decrease the value of L183 until the system stabilises.

$\tau = 2^{10} \times HTRs / L183$

Setting the Parameter Related to Torque Compensation Servo-Control (L184)

This parameter sets the derived gain (default value 1020). It also corrects position errors due to torque variations during machining.

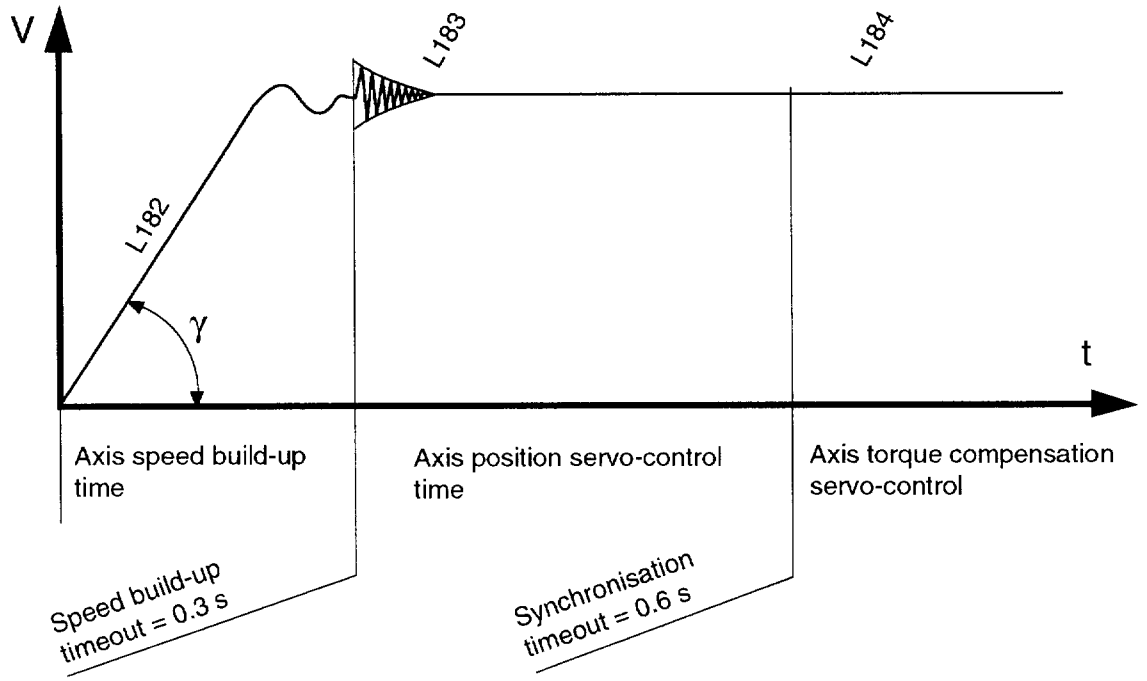
Derived gain = 2^{10} / L184

Display of the Influence of the Settings

The 11th parameter, E81xxx, displays the position error between the spindle and rotary axis and therefore shows the influence of the settings (value expressed in 1:20000 or 1:18000 revolution depending on the encoder used).

4.1.6 Servo-Control of the Rotary Axis

Schematic Representation of the Rotary Axis Servo-Control Curve



4.2 Integrating the Modulo Rotary Axis as Spindle Function

The same machine parameters (P..) are used for this function as for the polygon cutting function.

4.2.1 Variables Used for Modulo Rotary Axis Used as Spindle

The following variables are used in subroutine %10201 for calling and customising the function and subroutine %10201.9 for executing the function.

- L165 = 81100 — First number of parameters E81xxx used
- L166 = 82100 — First number of parameters E82xxx used
- L167 = 2 — Value of the mechanical ratio
- L168 = 5000 — Axis encoder resolution
- L169 = 111 — Coefficient to obtain a 10 V output at maximum speed
- L170 = 5 — Rotary axis address
- L171 = 50000 — Max speed
- L172 = 500 — First number of the error messages
- L173 = 2 — Number of increments/RTC for speed build-up
- L174 = 61 — First number of the dynamic operators used (the next 15 operators are reserved).

4.2.2 Setting the Subroutine Variables

For the modulo rotary axis used as spindle, the settings must be made in the order given below.

Mechanical Ratio (L167)

L167 = motor/axis

Maximum Spindle Rotation Speed (L171)

$$L171 = \frac{\text{max motor speed}_{(rpm)} \times RTC_{(ms)} \times L168 \times 4}{6000}$$

Setting Machine Parameters P11, P21, P22 and P30

The machine parameters are set in the same way as for the polygon cutting function (see Sec. 4.1.2).

Coefficient Giving a 10 V Output at Maximum Speed (L169)

L169 specifies the setting of the coefficient used to obtain a 10 V output for the maximum speed.