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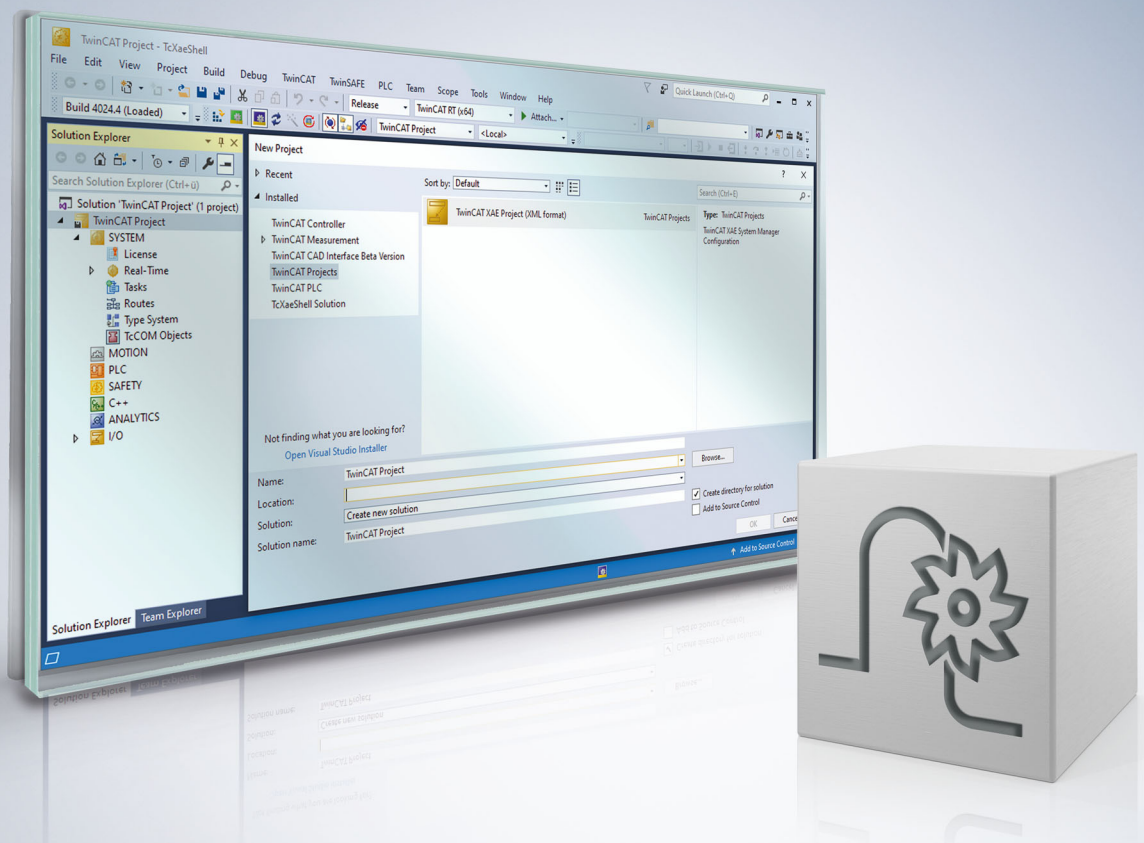
Functional description | EN

TF5200 | TwinCAT 3 CNC

Velocity smoothing



1/18/2024 | Version: 1.03

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This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning the components.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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This documentation uses the following icons next to the safety instruction and the associated text. Please read the (safety) instructions carefully and comply with them at all times.

Icons in explanatory text

1. Indicates an action.

⇨ Indicates an action statement.

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Acute danger to life!

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If you fail to comply with the safety instruction next to this icon, it may result in personal injury or damage to machines.

NOTICE

Restriction or error

This icon describes restrictions or warns of errors.

Tips and other notes

This icon indicates information to assist in general understanding or to provide additional information.

General example

Example that clarifies the text.

NC programming example

Programming example (complete NC program or program sequence) of the described function or NC command.

Specific version information

Optional or restricted function. The availability of this function depends on the configuration and the scope of the version.

Contents

List of figures

1 Overview

Task

The aim of this functionality is to reduce machine oscillations caused by frequent program-related acceleration and deceleration processes. The functionality smooths the planned path velocity curve while taking a predefined criterion into consideration.

Effectiveness

Smoothing the path velocity curve or reducing acceleration and deceleration processes is achieved by cross-block adjustment of the planned maximum path velocities. The maximum path velocities are adjusted by reducing them, which can result in a longer machining time.

Specifying the smoothing criterion (productivity factor) defines

- the degree of smoothing as well as
- the maximum machining time that is tolerable.

This functionality is available as of CNC Build V3.01.3079.21.

Parameterisation

In order to use this functionality, it must be enabled by the parameter P-CHAN-00600 [▶ 14].

Programming

The functionality is parameterised by the NC command #LAH[...] [▶ 12].

Mandatory note on references to other documents

For the sake of clarity, links to other documents and parameters are abbreviated, e.g. [PROG] for the Programming Manual or P-AXIS-00001 for an axis parameter.

For technical reasons, these links only function in the Online Help (HTML5, CHM) but not in pdf files since pdfs do not support cross-linking.

2 Description

Depending on the NC program used, many successive acceleration and deceleration processes are possible during machining. This leads to an unsettled velocity curve, to oscillations and therefore to greater stress on the machine.

The aim of the velocity smoothing functionality is to counteract this.

The aims in detail:

- avoids unnecessary acceleration and deceleration processes
- achieves smoother running of the machining
- reduces machine oscillations
- reduces stress on the machine

Requirement

The functionality must be enabled by the channel parameter P-CHAN-00600.

```
configuration.path_preparation.function FCT_DEFAULT | FCT_VSM
```

Operation mode of velocity smoothing

The velocity smoothing function considers cross-block motion blocks and reduces the maximum path velocities to a local minimum, if necessary, by adjusting them. The function acts exclusively on the maximum permissible path velocity of each block and therefore on the transition velocity of the motion blocks.

Velocity smoothing gives preference to blocks where a reduced increase in machining time is achieved by decreasing path velocity instead of reducing blocks with a longer machining time.

The smoothing effect of the function is negligible with NC programs that have many block transition velocities close to or equal to 0.

Smoothing the path velocity curve also means a longer machining time.

Properties of velocity smoothing

- Velocity smoothing is a cross-block function.
- The maximum reduction in path velocity is dependent on the productivity factor and the minimum actual maximum velocity of a block in the range under review.
- The symmetrical operation mode of the smoothed path velocity curve with forward and backward motion is largely identical.
- Velocity smoothing has a slowing effect on block supply due to the buffering of block supply. A possible solution to this is to give a higher priority to the SDA task.

2.1 Productivity factor

The user can use the productivity factor to control the effect of velocity smoothing. The productivity factor controls two variables:

- the degree of smoothing
- limiting productivity losses

Determining the productivity factor:

$$\text{Productivity factor}[\%] = \frac{\text{Processing time without velocity smoothing}}{\text{Processing time with velocity smoothing}} * 100$$

Reducing the maximum path velocity by smoothing results in a longer machining time. This is due to the following factors:

$$\text{Processing time extension } [\%] = \frac{\text{Processing time with velocity smoothing}}{\text{Processing time without velocity smoothing}} * 100$$

The maximum expected increase in machining time (as a percentage) for the given productivity factor can also be determined as follows:

$$\text{Processing time extension } [\%] = {}^{1}/_{\text{Productivity}[\%]} * 100$$

The real productivity factor achieved is always >= the specified productivity factor.

Example of calculating the productivity factor

Productivity factor = 90(%) means that the smoothed curve has a minimum of 90% of the original productivity. This means that the maximum increase in machining time in % is 1/0.9x100 = 111.11%. The NC program then requires a maximum of 11.11% more machining time than originally programmed.

The figures below show the effect on the velocity curve with and without various productivity factors using the example of an HSC program.

Blue = Permissible maximum path velocity using the CNC object “Maximum velocity on path [▶ 16]”.

Red = Path velocity using the CNC object “Current velocity on path [▶ 16]”.

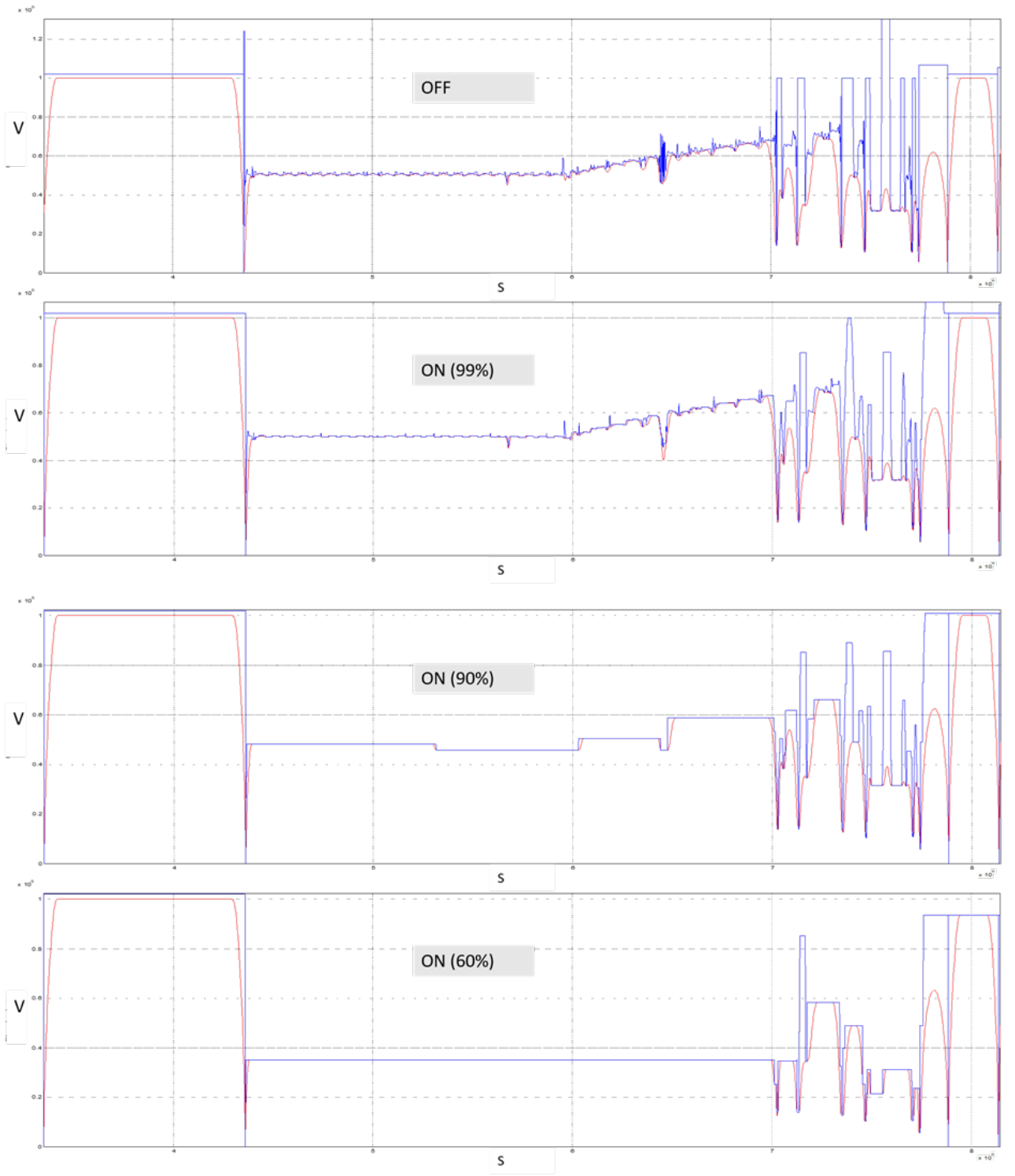

Fig. 1: Effect of different productivity factors in velocity-path representation

If a productivity factor of 100 (%) is specified, the curve of the maximum blockwise path velocities will also be always adjusted or changed as well. However, this should have no influence on productivity as defined by the default of 100%.

3 Programming

Velocity smoothing in the NC program is programmed using the #LAH command. This NC command can be used to enable/disable velocity smoothing and to change the parameters when the NC program is active.

```
Syntax:
```

#LAH [SMOOTH_PATH_VEL =.. PROD_FACT =..] non-modal

SMOOTH_PATH_VEL =..	Enable/disable velocity smoothing 0: Velocity smoothing not enabled 1: Velocity smoothing enabled
PROD_FACT=..	Productivity factor in % Value range: 0 < productivity factor <= 100%

NOTICE

When you enable velocity smoothing and change the productivity factor, both keywords must always be programmed.

If one parameter is missing, the error ID 21104 is output.

Programming example for velocity smoothing

This programming example shows a simple NC program where a linear block sequence is passed through 3 times.

- Pass 1 (S1): without velocity smoothing
- Pass 2 (S2): with velocity smoothing of 90% enabled
- Pass 3 (S3): Velocity smoothing parameters are changed to 50% and then velocity smoothing is disabled.

```
%main
( Pass 1)
N020 G00 G90 X0 Y0 Z0
N030 G01 X1 Y1 F30000
N040 G01 X2 Y0
N050 G01 X0
( Pass 2)
N060 #LAH [SMOOTH_PATH_VEL = 1 PROD_FACT = 90]
N070 G01 X1 Y1
N080 G01 X2 Y0
N090 G01 X0
( Pass 3)
N100 #LAH [SMOOTH_PATH_VEL = 1 PROD_FACT = 50]
N110 G01 X1 Y1
N120 G01 X2 Y0
N130 G01 X0
N140 #LAH [SMOOTH_PATH_VEL = 0] (Deactivation)
N150 G260
N160 M30
```

Blue: maximum permissible path velocity

Red: current path velocity

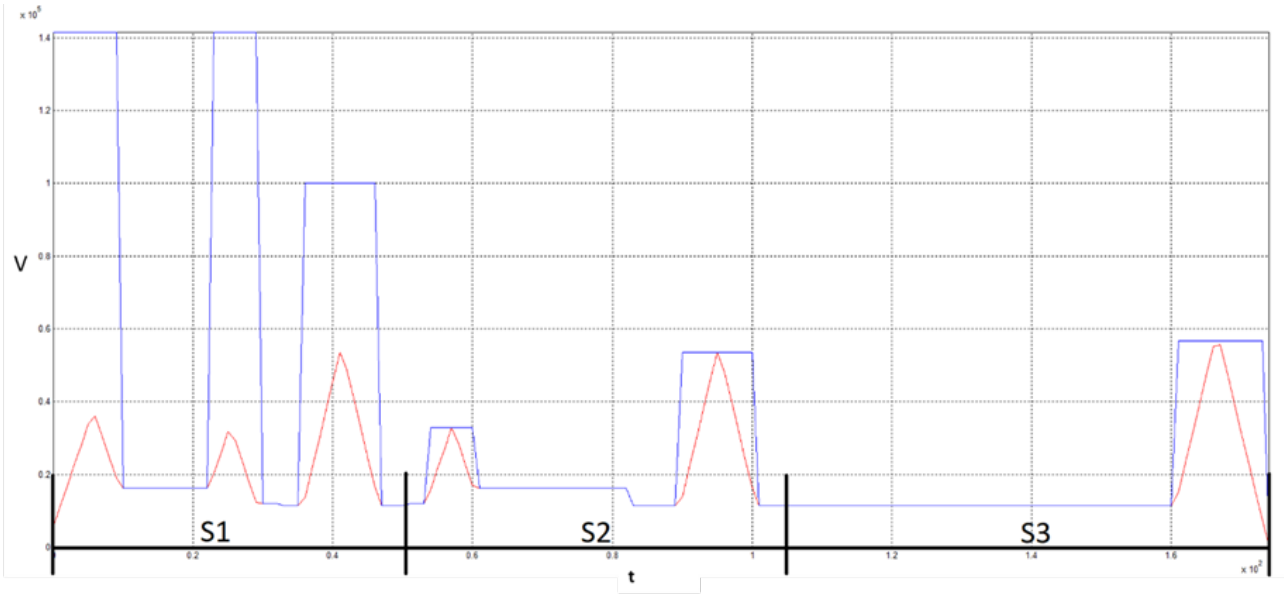

Fig. 2: Resulting velocity curve of the above programming example

4 Parameter

4.1 Overview

ID	Parameter	Description
P-CHAN-00600	configuration.path_preparation.function	Enable functionalities for path preparation
Alternatively:		
P-STUP-00060	..path_preparation.function	Enable functions in path preparation (Alternative but not recommended).

4.2 Description of parameters

Channel parameters

P-CHAN-00600	**Defining functionalities for path preparation.**
Description	This parameter defines the individual functionalities for path preparation. The individual functions can be enabled or disabled for testing or for performance reasons.
Parameter	configuration.path_preparation.function
Data type	STRING
Data range	See Description of parameters [▶ 15]
Dimension	----
Default value	FCT_DEFAULT
Remarks	Parameter is available as of the following Builds: V2.11.2040.04 ; V2.11.2810.02 ; V3.1.3079.17 ; V3.1.3107.10 Functions can be defined in P-CHAN-00605 and P-CHAN-00606 depending on the machining mode.

Start-up parameters

P-STUP-00060	**Defining functionalities for path preparation.**
Description	This parameter defines the individual functionalities for path preparation. The individual functions can be enabled or disabled for testing or for performance reasons.
Parameter	configuration.channel[i].path_preparation.function
Data type	STRING
Data range	See Description of parameters [▶ 15]
Dimension	----
Default value	FCT_DEFAULT
Remarks	

Path preparation function table

Flag	Description
FCT_DEFAULT	The functions FCT_FFM | FCT_PRESEGMENTATION | FCT_SPLINE | FCT_POLY | FCT_CAX | FCT_CAX_TRACK | FCT_SEGMENTATION are available.
FCT_FFM	Free-form surface mode, #HSC [OPMODE 1 CONTERR 0.01], #HSC [OPMODE 2]
FCT_PRESEGMENTATION	Linear pre-segmentation in HSC mode
FCT_SPLINE	#HSC[], AKIMA, B-Spline, G150/G151
FCT_POLY	#CONTOUR MODE[], G61, G261/G260
FCT_CAX	C axis processing, i.e. the spindle is embedded in the NC channel.
FCT_CAX_TRACK	#CAX TRACK, tracking an axis according to the contour angle
FCT_SEGMENTATION	For dynamic segmentation of the path contour, e.g. if the curvature of a polynomial segment varies significantly.

The following functions must also be enabled:	
FCT_LIFT_UP	Automatic lifting/lowering of an axis (path-based coupling). Example: FCT_DEFAULT | FCT_LIFT_UP
FCT_EMF	Edge machining (sharp angle contours). Example: FCT_DEFAULT | FCT_EMF
FCT_EMF_POLY_OFF	Edge machining inactive with polynomials. Contrary to the setting with FCT_EMF, edge signal generation is masked when path polynomial generation is active in the channel. Polynomials are generated for smoothing G261 or when B Spline is active. The resulting geometry is then tangential. Example: FCT_DEFAULT | FCT_EMF_POLY_OFF
FCT_SYNC	Synchronisation of an axis on a path group. Example: FCT_DEFAULT | FCT_SYNC
FCT_PRECON	Optimised planning using #HSC[BSPLINE]. Example: FCT_DEFAULT | FCT_PRECON
FCT_LIFT_UP_TIME	Automatic lifting/lowering of an axis (time-based coupling). Example: FCT_DEFAULT | FCT_LIFT_UP_TIME
FCT_PTP	Dynamically optimised contouring of the complete contour. Example: FCT_DEFAULT | FCT_PTP
FCT_M_PRE_OUTPUT	Pre-output of M/H functions (microjoints). Example: FCT_DEFAULT | FCT_M_PRE_OUTPUT
FCT_SURFACE	HSC machining with Surface Optimiser Example: FCT_DEFAULT | FCT_SURFACE
FCT_SEG_CHECK	Block segmentation in combination with path-controlled offset of M functions (dwell time), see P-CHAN-00650 and Description of parameters [▶ 15] Example: FCT_DEFAULT | FCT_SEG_CHECK
FCT_NIBBLING	Activate the nibbling function Example: FCT_DEFAULT | FCT_NIBBLING
FCT_PUNCHING	Activate the punching function Example: FCT_DEFAULT | FCT_PUNCHING
FCT_VSM	Activate the velocity smoothing function Example: FCT_DEFAULT | FCT_VSM as of V3.1.3079.21

4.3 CNC objects

Name	Maximum velocity on path		
Description	This object reads the maximum velocity on the path.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0xF
Data type	UNS32	**Length**	4
Attributes	read	**Unit**	[µm/s]
Remarks			

Name	Current velocity on path		
Description	This object reads the current velocity on the path.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x15
Data type	REAL64	**Length**	8
Attributes	read	**Unit**	[µm/s]
Remarks			

Name	Maximum velocity on path at block end		
Description	This object reads the maximum velocity on the path at block end.		
Task	GEO (Port 551)		
Index group	0x12130<C_{ID}>	**Index offset**	0x10
Data type	UNS32	**Length**	4
Attributes	read	**Unit**	[µm/s]
Remarks			

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