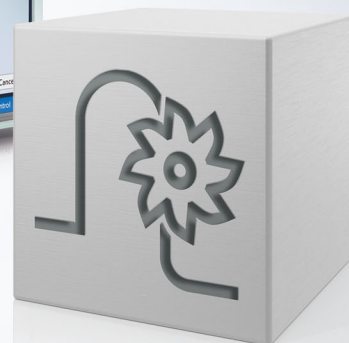
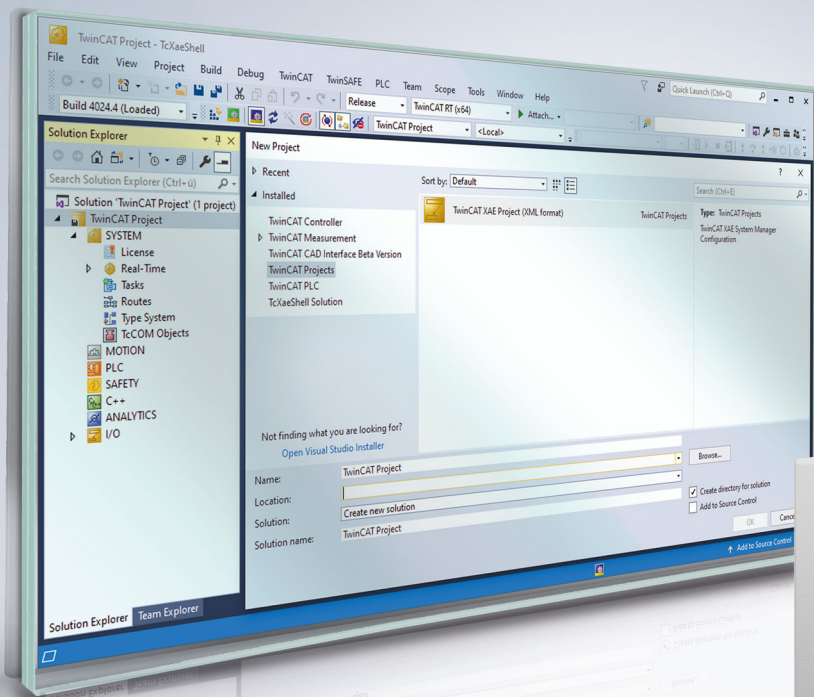


BECKHOFF New Automation Technology

Functional description | EN

TF5200 | TwinCAT 3 CNC

Advanced calculation



Notes on the documentation

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.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Trademarks

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH.

Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

Patent Pending

The EtherCAT technology is patent protected, in particular by the following applications and patents:

EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702

with corresponding applications or registrations in various other countries.



EtherCAT® is registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany

Copyright

© Beckhoff Automation GmbH & Co. KG, Germany.

The reproduction, distribution and utilisation of this document as well as the communication of its contents to others without express authorisation are prohibited.

Offenders will be held liable for the payment of damages. All rights reserved in the event of the grant of a patent, utility model or design.

General and safety instructions

Icons used and their meanings

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.

DANGER

Acute danger to life!

If you fail to comply with the safety instruction next to this icon, there is immediate danger to human life and health.

CAUTION

Personal injury and damage to machines!


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.

Table of contents

Notes on the documentation.....	3
General and safety instructions	4
1 Overview	8
2 Description	9
3 Programming.....	11
4 Parameter.....	12
4.1 Overview	12
4.1.1 Start-up parameters	12
4.1.2 Channel parameter	12
4.2 Description	12
4.2.1 Start-up parameters	12
4.2.2 Channel parameter	13
4.3 CNC objects	14
4.3.1 Channel-specific CNC objects	14
4.3.2 Axis-specific CNC objects	15
4.4 HLI parameters	16
5 Support and Service	18
Index.....	19

List of figures

Fig. 1 Chronological sequence..... 9

1 Overview

Task

When it is used in particular in additive manufacturing, a predictive control of the applying unit may help to compensate for dead times within the system and so improve the machining result.

i This function is available as of CNC Build V3.1.3074.0.

Properties

Starting from the momentary point in time, the state at a specified future time is determined by a pre-calculation and then provided for use.

i This function is an additional option requiring a license.

Parameterisation

The function must be activated by P-STUP-00070.
P-CHAN-00324 defines the point in time for the future state.

Programming

The points in time can also be defined by the NC command
`#CHANNEL SET[ESA TIME<i>=<...>] [▶ 11]`.

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

The precalculation of future data elements function provides users with a prediction of future data elements at a configurable future point in time starting from the present point in time.

This function is activated by P-STUP-00070:

configuration.channel[0].interpolator.function FCT_DEFAULT | **FCT_CALC_STATE_AT_T**

Depending on the mode setting (P-CHAN-00325), the function permits the precalculation.

Mode 1: Precalculation of path velocities at up to 10 future points in time

Mode 2: In addition to the path velocities of Mode 1, the axis positions, velocities and accelerations of all axes located in the channel are precalculated in the first time entry.

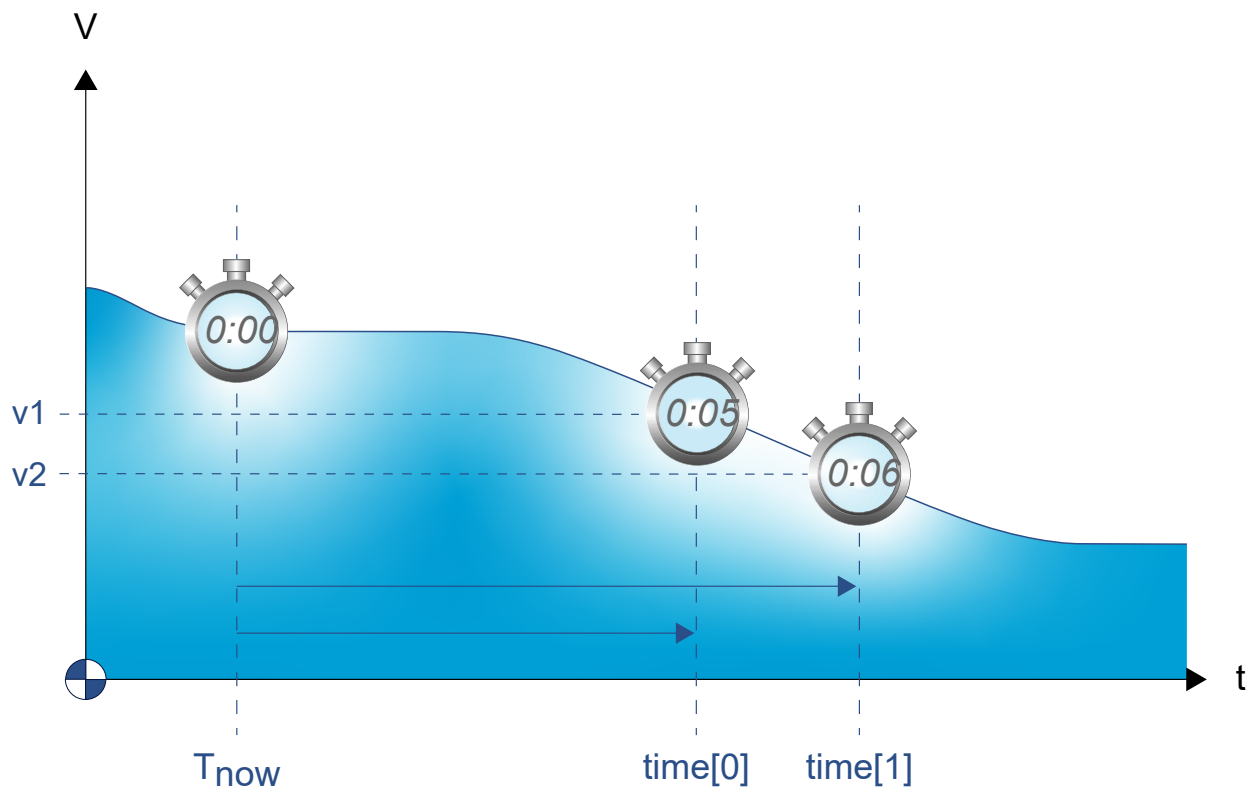


Fig. 1: Chronological sequence

Precalculation of path velocity

The results for future path velocities can be read by [CNC objects \[► 14\]](#) (ESA pathfeed).

Precalculation is limited to the look-ahead function. If no prediction is possible for path velocity planning (time offset too great), the value -1.0 is output.

i If the result -1 is output for future path velocity, no value could be calculated.

Adapt the look-ahead buffer by P-STUP-00071

As of CNC Build V3.3104.08 future [path velocities \[► 17\]](#) can also be read over the [HLI interface \[► 16\]](#). The data element [esa_data_valid \[► 17\]](#) indicates whether the future data element is valid.

Precalculation of an axis state

The results of these calculations are also contained in corresponding CHC objects to precalculate the axis position [▶ 15], velocity [▶ 15] or acceleration [▶ 15] of axes. Only the value of the first time entry is used to precalculate at axis level.

The first time entry is defined by P-CHAN-00324 [▶ 13] (esa.time[0]) or by #CHANNEL SET [ESA_TIME0=...] [▶ 11].

As of CNC Build V3.3104.08 future axis states can also be read over the HLL interface [▶ 16]. The data element esa_data_valid [▶ 16] indicates whether the future data element is valid.

Recommendation for look-ahead buffer

Setting for the available look-ahead buffer (P-STUP-00071):

```
configuration.channel[0].interpolator.number_blocks_lah 500
```

3 Programming

The offset time can also be defined in the NC program by the following command as an alternative to configuration in the channel parameter list with [P-CHAN-00324](#) [► 13]:

Syntax:

```
#CHANNEL SET [ ESA_TIME<i>=.. ]
```

ESA_TIME<i>=<expr> Offset time i in [s] where i = 0 ... 9. 10 ESA times (Estimated State of Arrival) can be defined. Only time values greater than 0 are considered.

Setting 3 ESA times

```
#CHANNEL SET [ESA_TIME0=0.3 ESA_TIME1=0.5 ESA_TIME2= 0.8]
```

4 Parameter

4.1 Overview

4.1.1 Start-up parameters

ID	Parameter	Description
P-STUP-00070	configuration.channel[i].interpolator.function	Define interpolator functionality
P-STUP-00071	configuration.channel[i].interpolator.number_blocks_lah	User-specific size of look-ahead buffer

4.1.2 Channel parameter

ID	Parameter	Description
P-CHAN-00324	esa.time[i]	Precalculation - time offset
P-CHAN-00325	esa.mode	Precalculation - mode

4.2 Description

4.2.1 Start-up parameters

P-STUP-00070	Definition of interpolator functionalities
Description	This parameter defines individual functionalities and the size of the look-ahead buffer in the interpolator, i.e. it defines the number of blocks to calculate deceleration distance and dynamic planning.
Parameter	configuration.channel[i].interpolator.function
Data type	STRING
Data range	See Interpolation function table.
Dimension	----
Default value	FCT_IPO_DEFAULT
Remarks	

P-STUP-00071	User-specific size of look-ahead buffer
Description	This parameter permits the user-defined definition of the number of NC blocks in the look-ahead buffer. The parameter is only evaluated if P-STUP-00070 is set with FCT_LOOK_AHEAD_CUSTOM.
Parameter	configuration.channel[i].interpolator.number_blocks_lah *
Data type	UNS32
Data range	0 ... 10000
Dimension	----
Default value	120
Remarks	As of Build V2.11.20 and higher, the default size of the look-ahead buffer is 70 blocks. As of Build V2.11.28 and higher, the default size is 120 blocks. As the size increases, the additional calculations make greater demands on the controller hardware.

	<p>As of Build V3.1.3067.07 the upper limit of the data range is 500 blocks. If #SLOPE[TYPE=STEP] is used, the upper limit is 10000 blocks as of Build V3.1.3060.0.</p> <p>* P-STUP-00071 in V2.11.20 and higher : configuration.channel[i].interpolator.parameter</p>
--	---

4.2.2 Channel parameter

P-CHAN-00324	Default offset time to calculate future states
Description	At a set time greater than 0, the <ul style="list-style-type: none"> • path velocity • attempts to calculate axis position, velocity and acceleration at the parameterised point in the future.
Parameter	esa.time[i] where i = 0 ... 9
Data type	REAL64
Data range	$0 \leq \text{time}[i] \leq \text{MAX_REAL64}$
Dimension	s
Default value	0.0
Remarks	The maximum possible number of entries is limited to 10. Axis position, velocity and acceleration only estimated with the entry esa.time[0].

P-CHAN-00325	Precalculation mode
Description	This parameter sets the precalculation mode. <ul style="list-style-type: none"> • Mode 1: Precalculation of path velocity at up to 10 future points in time • Mode 2: in addition to Mode 1, the precalculation of axis positions, velocities and accelerations of all the axes in the channel is conducted for the first time entry
Parameter	esa.mode
Data type	UNS32
Data range	1 / 2
Dimension	----
Default value	1
Remarks	

4.3 CNC objects

4.3.1 Channel-specific CNC objects

Name	ESA: Active time [0]		
Description	First configured time at which feedrate is detected.		
Task	GEO (Port 551)		
Index group	0x12130<C _{ID} >	Index offset	0x112
Data type	REAL64	Length	8
Attributes	read	Unit	[s]
Remarks			

Name	ESA: Pathfeed [0]		
Description	Calculated pathfeed at first configured point in time. Determining the point of time: P-CHAN-00324 [▶_13] (esa.time[0]) or #CHANNEL SET[ESA TIME0 = <value>] [▶_11]		
Task	GEO (Port 551)		
Index group	0x12130<C _{ID} >	Index offset	0x113
Data type	REAL64	Length	8
Attributes	read	Unit	[µm/s]
Remarks			

Additional points in time can be read similarly to the first point in time (Active time [0]/ ESA: Pathfeed [0]).

Point in time i	Offset ESA: Active time [i]	Offset ESA: Pathfeed [i]
0	0x112	0x113
1	0x114	0x115
2	0x116	0x117
3	0x12b	0x12c
4	0x12d	0x12e
5	0x12f	0x130
6	0x131	0x132
7	0x133	0x134
8	0x135	0x136
9	0x137	0x138

Points in time can also be specified in analogy, either using P-CHAN-00324 [▶_13] (esa.time[i]) or #CHANNEL SET[ESA_TIME<i> = <value>]]

4.3.2 Axis-specific CNC objects

Name	ESA: position in future		
Description	Predicted axis position at defined point in time. The point in time is defined by P-CHAN-00324 [▶ 13] (esa.time[0]) or by #CHANNEL SET [ESA TIME0= <value>] [▶ 11]		
Task	GEO (Port 551)		
Index group	0x12130<C _{ID} >	Index offset	0x<A _{ID} >0087
Data type	REAL64	Length	8
Attributes	read	Unit	[0.1 μm or 0.0001°]
Remarks			

Name	ESA: velocity in future		
Description	Predicted axis velocity at defined point in time. The point in time is defined by P-CHAN-00324 [▶ 13] (esa.time[0]) or by #CHANNEL SET [ESA TIME0= <value>] [▶ 11]		
Task	GEO (Port 551)		
Index group	0x12130<C _{ID} >	Index offset	0x<A _{ID} >0088
Data type	REAL64	Length	8
Attributes	read	Unit	[1 μm/s or 0.001°/s]
Remarks			

Name	ESA: acceleration in future		
Description	Predicted axis acceleration at defined point in time. The point in time is defined by P-CHAN-00324 [▶ 13] (esa.time[0]) or by #CHANNEL SET [ESA TIME0= <value>] [▶ 11]		
Task	GEO (Port 551)		
Index group	0x12130<C _{ID} >	Index offset	0x<A _{ID} >0089
Data type	REAL64	Length	8
Attributes	read	Unit	[mm/s ² bzw. °/s ²]
Remarks			

4.4 HLI parameters



Connection to the HLI interface is available as of CNC Build V3.3104.08.

Precalculated axis-specific states

Precalculated data is valid, axis	
Description	This data element indicates whether precalculated axis data is valid. If the data element is TRUE, the values are valid for the precalculation of position [► 16], velocity [► 16] and acceleration [► 16] at a future point in time. FALSE indicates that no data could be calculated for the future point in time. The point in time is defined by the Index 0 in P-CHAN-00324 [► 13] or by #CHANNEL SET[ESA_TIME0=...] [► 11] .
Signal flow	CNC →PLC
ST Path	gpAx[axis_idx]^.ipo_state.esa_data_valid
Data type	BOOL
Value range	TRUE/FALSE
Access	PLC is reading
Special feature	Available as of Build V3.1.3104.08

Precalculated position, axis	
Description	Axis position at a future point in time. The point in time is defined by the Index 0 in P-CHAN-00324 [► 13] or by #CHANNEL SET[ESA_TIME0=...] [► 11] .
Signal flow	CNC →PLC
ST Path	gpAx[axis_idx]^.ipo_state.esa_pos
Data type	LREAL
Access	PLC is reading
Special feature	Available as of Build V3.1.3104.08

Precalculated velocity, axis	
Description	Axis velocity at a future point in time. The point in time is defined by the Index 0 in P-CHAN-00324 [► 13] or by #CHANNEL SET[ESA_TIME0=...] [► 11] .
Signal flow	CNC →PLC
ST Path	gpAx[axis_idx]^.ipo_state.esa_vel
Data type	LREAL
Access	PLC is reading
Special feature	Available as of Build V3.1.3104.08

Precalculated acceleration, axis	
Description	Axis acceleration at a future point in time. The point in time is defined by the Index 0 in P-CHAN-00324 [► 13] or by #CHANNEL SET[ESA_TIME0=...] [► 11] .
Signal flow	CNC →PLC
ST Path	gpAx[axis_idx]^ . ipo_state.esa_acc
Data type	LREAL
Access	PLC is reading

Special feature	Available as of Build V3.1.3104.08
-----------------	---

Precalculated axis-specific states

Up to 3 precalculated velocities can be read by the HLI interface.

Precalculated data is valid, path	
Description	If a data element in the field is TRUE, path velocity was precalculated for a future point in time and is therefore valid. This is indicated by the same index as precalculated velocity [► 17] . FALSE indicates that no value could be calculated for the future point in time. Several points in time were defined by P-CHAN-00324 [► 13] . Times can also be defined by #CHANNEL SET[ESA TIME<i>=...] [► 11].
Signal flow	CNC →PLC
ST Path	gpCh[channel_idx]^bahn_state.esa_data_valid[]
Data type	ARRAY[0..2] OF BOOL
Value range	TRUE/FALSE
Access	PLC is reading
Special feature	Available as of Build V3.1.3104.08

Precalculated velocity, path	
Description	Path velocity at a future point in time. Several points in time were defined by P-CHAN-00324 [► 13] . The index of a configured point in time corresponds with the index of the precalculated path velocity. Times can also be defined by #CHANNEL SET[ESA TIME<i>=...] [► 11].
Signal flow	CNC →PLC
ST Path	gpCh[channel_idx]^bahn_state.esa_vb[]
Data type	ARRAY[0..2] OF LREAL
Access	PLC is reading
Special feature	Available as of Build V3.1.3104.08

5 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Download finder

Our [download finder](#) contains all the files that we offer you for downloading. You will find application reports, technical documentation, technical drawings, configuration files and much more.

The downloads are available in various formats.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for [local support and service](#) on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on our internet page: www.beckhoff.com

You will also find further documentation for Beckhoff components there.

Beckhoff Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

Hotline: +49 5246 963-157
e-mail: support@beckhoff.com

Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

Hotline: +49 5246 963-460
e-mail: service@beckhoff.com

Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG

Huelshorstweg 20
33415 Verl
Germany

Phone: +49 5246 963-0
e-mail: info@beckhoff.com
web: www.beckhoff.com

Index

A

Achse	
Vorabberechnung:Beschleunigung	16
Vorabberechnung:Geschwindigkeit	16
Vorabberechnung:Position	16
axis	
precalculated:valid	16
validity:precalculated	16
axis:validity code	
precalculated	16

B

Beschleunigung	
Vorabberechnung	16

G

Geschwindigkeit	
Vorabberechnung	16

P

Path	
precalculated:valid	17
precalculated:velocity	17
validity:precalculated	17
path:validity code	
precalculated	17
P-CHAN-00324	13
P-CHAN-00325	13
Position	
Vorabberechnung	16
precalculated	
path:velocity	17
P-STUP-00070	12
P-STUP-00071	12

V

Velocity	
precalculated	17
Vorabberechnung	
Achse:Beschleunigung	16
Achse:Geschwindigkeit	16
Achse:Position	16

More Information:
www.beckhoff.com/TF5200

Beckhoff Automation GmbH & Co. KG
Hülshorstweg 20
33415 Verl
Germany
Phone: +49 5246 9630
info@beckhoff.com
www.beckhoff.com

