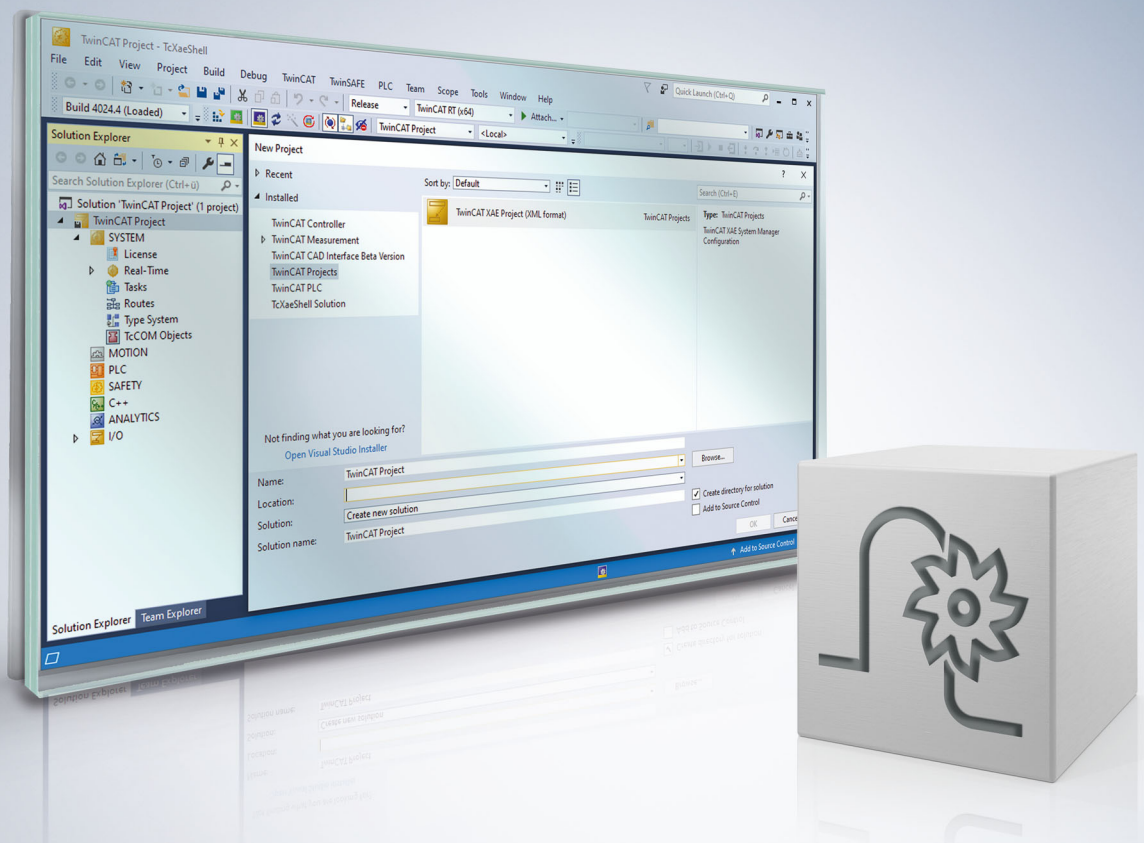
BECKHOFF New Automation Technology

Functional description | EN

TF5240 | TwinCAT 3 CNC

TCP Velocity limitation



5/21/2026 | Version: 1.1

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NC programming example

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

Specific version information

Names a specific version number as of which a new or revised functionality is available. Availability is dependent on the exact version and, where applicable, the license.

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1 Overview

Task

This function limits the TCP (tool centre point) velocity of any kinematic to a maximum value. The function is used, for example, with industrial robots that are equipped with the T1 operation mode according to EN ISO 10218-1. This allows operators to enter the robot workspace in order to carry out set-up work.

If set-up work is carried out with a CNC that controls the robot, the operator can limit the TCP velocity to a non-hazardous value.

Properties

The function is independent of the kinematic used in the NC program. The TCP velocity limit of a kinematic is enabled and disabled via the HLI of the CNC before program start or even during operation.

This function is available as of CNC Build V3.1.3079.26.

Parameterisation

See Parameterisation example for operation mode in T1 mode [▶ 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

NOTICE

On its own, the kinematic velocity limit is not a safety function.

To ensure T1 operation safety, the TCP velocity of the robot must additionally be monitored in a safety PLC.

The aim is to provide error-free control of a robot in T1 mode. It prevents the velocity monitor from reporting a velocity that is too high. This would result in the machine changing to an error state. This also applies to operation without active transformation (cf. Reduced velocity).

The velocity limit has the following properties:

- The limit acts in NC automatic and manual modes.
- When the limit is enabled via the HLI, the lowest velocity is used for all the set kinematics.
- The velocity override continues to act on the programmed velocity.
- One kinematic and one velocity can be specified for each limit.

Operating principle

The velocity limit calculates a Cartesian position using the forward transformation of the specified kinematic. This is then used in motion blocks to calculate the path velocity, provided it does not exceed the specified maximum velocity of the Cartesian motion.

When the tcp_velocity_limit control unit [▶ 16] is set to TRUE, the new path velocity is applied to the maximum path velocity as an additional limit during interpolation.

The velocity limit function can be enabled either at program start or by the NC command #LIMIT ON[TCP_VEL …].

With the program start variant, the channel parameter **limit.kin[i].active** must be set to 1 (P-CHAN-00464 [▶ 15]).

In both cases, no errors should be made when programming the kinematic to be limited.

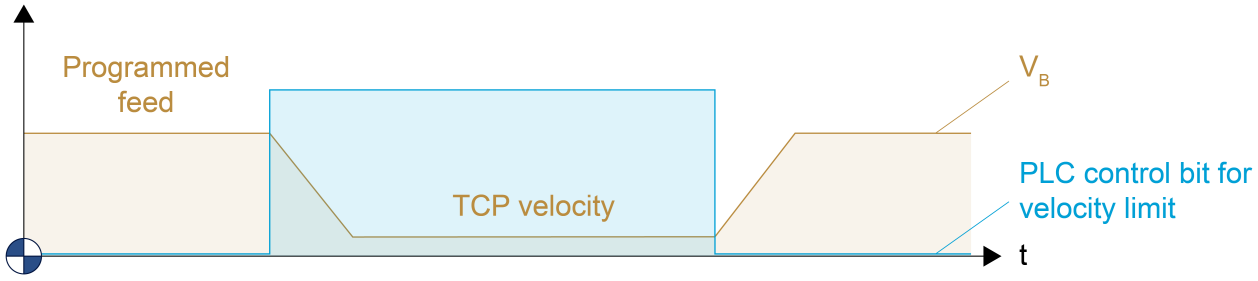


Fig. 1: Limiting the TCP velocity

It is not permitted to perform an axis exchange when the TCP velocity limit function is active.

The TCP velocity limit is calculated by setting P-CHAN-00464 [▶ 15] at program start..

The calculated limit value is used by setting the tcp_velocity_limit control unit [▶ 16].

2.1 Tool parameter modes

The kinematic of the velocity limit is independent of the kinematic processed. The behaviour at tool change can be adapted by the parameter P-CHAN-00469 [▶ 15].

P-CHAN-00469 = 0 (default)

If the T/D word follows a tool change, the tool length and the tool head offsets of the kinematic are updated.

If the tool is changed without a following T/D word (e.g. using V.G.WZ_AKT), the kinematic parameters must be explicitly updated using the #LIMIT REFRESH [KIN] [▶ 13] command.

The #TRAFO ON / OFF function does not automatically update the kinematic of the TCP velocity monitor.

The same applies if the kinematic parameters themselves are changed, e.g. using V.G.KINEMATIK[i].PARAM[j].

The parameters of kinematics are always updated:

- at program start,
- when the D word is set,
- by the #LIMIT REFRESH [KIN] command.

P-CHAN-00469 = 1

In this mode, the kinematic parameters are not updated by a T/D word. In addition, the length or tool head offsets of the active tool are not added to the kinematic data of the kinematic at any time.

However, if tool parameters of the TCP kinematic have to be changed, they can be adapted using the V.G. variables V.G.LIMIT.KIN[i].TOOL.KIN_PARAM[j] [▶ 13] and V.G.LIMIT.KIN[i].TOOL.LENGTH [▶ 13].

Once the LIMIT parameters are written, they remain effective until they are overwritten or the controller is restarted. These parameters are then used as in Mode=0 of the tool parameters (additional to the kinematic parameters).

When the V.G. parameters are written, they are added to the kinematic parameters at the next program start or added immediately by using the NC command #LIMIT REFRESH [KIN].

The #LIMIT REFRESH [KIN] [▶ 13] command updates all active limit kinematics. The mode then decides whether the parameters of the V.G.LIMIT… or of the active tool are added.

Mode = 1 should be used if…

- the tool parameters have no relevance for the limit function,
- they are not compatible with other kinematics, or
- the tool has different parameters for the limit.

In combination with the couple kinematic KIN_ID 210, no kinematic parameter changes are adopted by means of the tool or the V.G.LIMIT.

2.2 Application examples

P-CHAN-00469 = 0

- **KIN_TYP_45**

Without a velocity limit, there is no possibility to limit the TCP velocity when the transformation is inactive, for example.

If the velocity limit is active, the TCP will not move too rapidly when the limit is activated. This even applies to axis-specific programming.

P-CHAN-00469 = 1

- **KIN_TYP_45, Monitor the elbow (with Universal Kinematics)**

When an elbow movement is monitored, it is not recommended to use tool offsets or change them when a tool is changed.

- **KIN_TYP_45, Moved workpiece**

When the workpiece is moved, the tool is placed at a fixed position in space. The tool offset can be parameterised using #CS coordinate systems. The offset of the workpiece at the flange is of interest to the TCP velocity limit in order to move the workpiece in certain limits (e.g. with a long rod).

When the workpiece is manoeuvred, the offset to the workpiece tip can be parameterised at TCP or with a tool offset using V.G.LIMIT.KIN[i].TOOL.KIN_PARAM[j] [▶ 13] without changed in the parameters of kinematic 45.

2.3 Parameterisation example for operation mode in T1 mode

Extract of parameters entered in the channel parameter list:

```
limit.kin[i].active                 1         #P-CHAN-00464
limit.kin[i].id                     1         #P-CHAN-00830
limit.kin[i].mode                   0         #P-CHAN-00469
limit.kin[i].velocity.max           250000.0 #P-CHAN-00466
limit.kin[i].velocity.ipo_weight_fact  70   #P-CHAN-00478
```

Explanations:

i: Index of the function, 2 > i ≥ 0

active: Activate this limit

id: ID the kinematic to limit motion velocity (only kin_step[0])

mode: Set the mode for the tool parameters.

velocity.max: The maximum velocity in µm/s

velocity.ipo_weight_fact: Weighting factor of the velocity portion of the interpolation when G201 is active.

2.4 Universal Kinematics ID 91 and V.G.LIMIT.KIN[i].TOOL

Do not use any parameters via V.G. or tool head offsets with Universal Kinematics ID 91 since the Universal Kinematics have a different internal structure.

Always use V.G. variables in the NC program to adapt the tool in Universal Kinematics, e.g. V.G.KIN[91].PARAM[i] or V.G.KIN[91].ZERO.

With Universal Kinematics, set the mode (P-CHAN-00469 [▶ 15]) to 1 for the velocity limit.

3 Programming

NC command for updating all kinematic parameters in the TCP kinematic according to P-CHAN-00469 [▶ 15]:

```
Syntax:
```

#LIMIT REFRESH [KIN] modal

Global variables (V.G.) to access the tool parameters of the TCP kinematic in the NC program:

LIMIT.KIN[i].TOOL. LENGTH	Tool length where <i>:= 0, 1 index of the configured kinematic	Real	[mm]	R/W
LIMIT.KIN[i].TOOL. KIN_PARAM[j]	Kinematic parameter of the tool where <j>:= 0..69 Index of the kinematic parameter	Real	[0.1 µm, 10-4°]	R/W

3.1 Programming example – Update the kinematic

Update the kinematic using P-CHAN-00469 [▶ 15] **= 0**

```
%100
N010 G1 G90 F5000
N015 V.G.WZ_AKT.KIN_PARAM[0] = 1000

N020 #LIMIT REFRESH [KIN]
N050 …

%101
N010 G1 G90 F5000
N015 V.G.WZ_AKT.KIN_PARAM[0] = 1000
N020 T1 D1
N050 … Follow
```

Update the kinematic using P-CHAN-00469 [▶ 15] **= 1**

```
%102
N010 G1 G90 F5000
N015 V.G.LIMIT.KIN[0].TOOL.KIN_PARAM[0] = 1000
N016 V.G.LIMIT.KIN[0].TOOL.LENGTH = 1000

N020 #LIMIT REFRESH [KIN]
N050 …
```

Update the kinematic parameters The kinematic parameters of KIN_TYP_45 are directly adapted.

```
%103
N010 G1 G90 F5000
N015 V.G.KIN[45].PARAM[0] = 1000

N020 #LIMIT REFRESH [KIN]
N050 …
```

4 Parameter

4.1 Overview

HLI	Description
tcp_velocity_limit	BAHN_MC_CONTROL_BOOL_UNIT to activate the limit.

ID	Parameter	Description
P-CHAN-00464	limit.kin[i].active	Activate additional functionality for kinematics
P-CHAN-00466	limit. kin [i].velocity.max	Limit velocity in µm/s
P-CHAN-00469	limit.kin[i].mode	Mode for use of parameters with a tool change.
P-CHAN-00478	limit.kin[i].velocity.ipo_ weight_factor	Velocity percentage of the interpolation with G201.
P-CHAN-00830	limit.kin[i].id	Transformation ID of the kinematic used.

V.G.<var_name>	Meaning	Data type	Unit of In/Output	Permitted access: **R**ead/ **W**rite
LIMIT.KIN[i].TOOL. LENGTH	Tool length where <i>:= 0, 1 index of the configured kinematic	Real	[mm]	R/W
LIMIT.KIN[i].TOOL. KIN_PARAM[j]	Kinematic parameter of the tool where <j>:= 0..69 Index of the kinematic parameter	Real	[0.1 µm, 10-4°]	R/W

4.2 Channel parameters

P-CHAN-00464	**Activate additional functionality for kinematics**
Description	Activates additional functionalities of the specified kinematic. For example, with load model or TCP velocity monitoring [▶ 8]. When this parameter is set, the specified kinematic is used to calculate the TCP during TCP velocity monitoring. When the limit is switched on via tcp_velocity_limit control unit [▶ 16] , the limit is applied.
Parameter	limit.kin[i].active
Data type	BOOLEAN
Data range	0: No calculation 1: The corresponding velocity of the limit is calculated.
Dimension	----
Default value	0
Remarks	Parameter available as of V3.1.3079.26

P-CHAN-00466	**Velocity limit**
Description	The maximum velocity that may be moved for this kinematic system when the function is active.
Parameter	limit.kin[i].velocity.max
Data type	REAL64
Data range	> 0.001 µm/s
Dimension	µm/s
Default value	0
Remarks	Parameter available as of V3.1.3079.26

P-CHAN-00469	**Mode for the use of tool head offsets**
Description	This parameter defines the strategy with which tool parameters are used for the calculating kinematics.
Parameter	limit.kin[i].mode
Data type	UNS32
Data range	0: If the T/D command is output after a tool change, the tool length and the tool head offsets of the kinematics are updated. 1: In this mode, the kinematic parameters are **not** updated with a T/D word. In addition, the length or tool head offsets of the active tool are not added to the kinematic data of the kinematic at any time.
Dimension	---
Default value	0
Remarks	Mode = 1 should be used if tool parameters have no relevance for the limit function, they are not compatible between the kinematics or the tool is parameterised differently for the limit. Parameter available as of V3.1.3079.26

P-CHAN-00478	**Velocity percentage of the interpolation with G201**
Description	The parameter defines the velocity percentage [in %] of the interpolation in the velocity P-CHAN-00466 when G201 is active.
Parameter	limit.kin[i].velocity.ipo_weight_factor
Data type	UNS16
Data range	
Dimension	25 <= ipo_weight_factor <= 75
Default value	70

Remarks	Manual mode contains the usual part of 100%; the default value is 70, i.e. 30. Parameter available as of V3.1.3079.26

P-CHAN-00830	**Kinematic ID of velocity monitoring**
Description	This parameter defines the ID of the kinematic used to calculate velocity. The kinematic must be defined by the same ID in kin_step[0].
Parameter	limit.kin[i].id
Data type	UNS16
Data range	0...MAX(UNS16)
Dimension	---
Default value	0
Remarks	If the parameter is activated (value unequal to 0), a kinematic type must be specified; otherwise the error message ID 22108 is output. Available as of V3.1.3080.09

4.3 HLI parameters

Switch on velocity limit	
Description	By setting this command, the maximum path velocity is limited according to the kinematic and velocity settings.
Data type	MC_CONTROL_BOOL_UNIT, see description of Control unit
Access	PLC reads request_r + state_r and writes command_w + enable_w
ST path	gpCh[channel_idx]^.bahn_mc_control.**tcp_velocity_limit**
Commanded, requested and return values	
ST element	**.command_w** **.request_r** **.state_r**
Data type	BOOL
Unit	
Value range	[TRUE = limits active, FALSE = limits not active]
Redirection	
ST element	.enable_w
Special feature	**Available as of CNC Build V3.1.3079.26**

5 Error messages

Error ID	Description
22106	Double programming in #LIMIT command.
22107	Kinematic name of the kinematic velocity limit is unknown.
22108	Kinematic name of the kinematic velocity limit is invalid.
22109	The specified velocity for the kinematic velocity limits is too low.
22110	The weighting factor for the velocity in the kinematic velocity limit is too low.
22111	The weighting factor for the velocity in the kinematic velocity limit is too high.
51025	Initialisation of the kinematic of the TCP velocity limit failed.
120801	Initialisation of the kinematic of the TCP velocity limit failed.

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