DOCUMENTATION ISG-kernel

Functional description
TCP velocity limit

Short Description:
FCT-C47

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Preface

Legal information

This documentation was produced with utmost care. The products and scope of functions described are under continuous development. We reserve the right to revise and amend the documentation at any time and without prior notice.

No claims may be made for products which have already been delivered if such claims are based on the specifications, figures and descriptions contained in this documentation.

Personnel qualifications

This description is solely intended for skilled technicians who were trained in control, automation and drive systems and who are familiar with the applicable standards, the relevant documentation and the machining application.

It is absolutely vital to refer to this documentation, the instructions below and the explanations to carry out installation and commissioning work. Skilled technicians are under the obligation to use the documentation duly published for every installation and commissioning operation.

Skilled technicians must ensure that the application or use of the products described fulfil all safety requirements including all applicable laws, regulations, provisions and standards.

Further information

This link

https://www.isg-stuttgart.de/de/isg-kernel/kernel-downloads.html

contains further information on messages generated in the NC kernel, online help, PLC libraries, tools, etc. in addition to the current documentation.

Disclaimer

It is forbidden to make any changes to the software configuration which are not contained in the options described in this documentation.

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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

➢ 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.

Attention

Restriction or error

This icon describes restrictions or warns of errors.

Notice

Tips and other notes

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

Example

General example

Example that clarifies the text.

Programing Example

NC programming example

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

Release Note

Specific version information

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

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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.

Release Note

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

Parameterisation

See Parameterisation example for operation mode in T1 mode [▶ 10]

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

Attention

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 limited path velocity is already calculated at program start if the channel parameter **limit.kin[i].active** is set to 1. Therefore, no errors should be made when programming the kinematic.

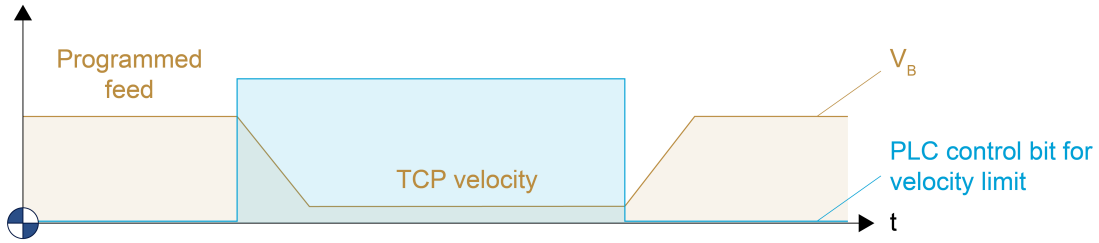

Fig. 1: Limiting the TCP velocity

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] [▶ 11] 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] [▶ 11] and V.G.LIMIT.KIN[i].TOOL.LENGTH [▶ 11].

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] [▶ 11] 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.

Notice

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] [▶ 11] 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

Programing Example

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
```

Programing Example

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 …
```

Programing Example

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].velo-city.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].velo-city.ipo_weight_fa ctor	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	Permit-ted 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 [▶ 6]. 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 limiting	
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 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.

6 Appendix

6.1 Suggestions, corrections and the latest documentation

Did you find any errors? Do you have any suggestions or constructive criticism? Then please contact us at documentation@isg-stuttgart.de. The latest documentation is posted in our Online Help (DE/EN):

QR code link: https://www.isg-stuttgart.de/documentation-kernel/

The link above forwards you to:

https://www.isg-stuttgart.de/fileadmin/kernel/kernel-html/index.html

Notice

Change options for favourite links in your browser;

Technical changes to the website layout concerning folder paths or a change in the HTML framework and therefore the link structure cannot be excluded.

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Keyword index

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