DOCUMENTATION ISG-kernel

Functional description
Spindle operation mode

Short Description:
FCT-S2

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Preface

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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

Links below (DE)

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or (EN)

https://www.isg-stuttgart.de/en/products/softwareproducts/isg-kernel/documents-and-downloads

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

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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

When a spindle drive is operated at current limit, it may result in an excessive position lag at high speeds, causing error messages in the drive and/or the CNC. To avoid this, it is necessary at high speeds to change to controlled operation (no position control) and to only operate the spindles position-controlled for positioning movements.

Properties

Automatic changeover by the CNC with position control in the drive is only available for SERCOS and CANopen drives.

A change between the two operation modes can take place automatically during the movement.

Release Note

This function is available for CANopen drives as of CNC Build v3.1.3079.13.

Parameter definition

Automatic changeover and switch-back can be specified by using the appropriate parameters. They are:

- **P-AXIS-00264:** antr.sercos.op_mode_for_velocity_control
- **P-AXIS-00267:** antr.sai_op_mode_change.v_velocity_control_on
- **P-AXIS-00268:** antr.sai_op_mode_change.v_position_control_on

The section Parameters [▶ 16] contains a detailed description of the commands.

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

Boundary condition

Basically a spindle can be operated position-controlled or speed-controlled. The operation mode is defined statically in most cases, whereby all the parameters required for each operation mode must be configured in the drive telegram for SERCOS and CANopen drives.

If a modulo transition takes place in the drive positions in position-controlled mode (position control in the drive), the maximum speed is limited to 180° per tracing cycle for spindles. Otherwise, the drive controller cannot determine the rotation direction from the specified path change. For example, for a tracing cycle of 2 ms, this results in a maximum speed of 15,000 rpm.

When a spindle drive is operated at current limit, it may result in an excessive position lag at high speeds, causing error messages in the drive and/or the CNC. This may make it necessary to change to controlled operation (no position control) at high speeds and to only operate the spindle position-controlled for positioning movements.

Functionality

To permit higher speeds, the spindle is operated

- speed-controlled with speed-only programming and
- position-controlled when a position is specified.

A change between the two operation modes can take place automatically during the movement.

- With CNC position-controlled drive, an operation mode changeover takes place internally in the controller.
- With speed-only programming, the position control loop is opened automatically and a speed command value is sent to the drive.

Notice

If position control takes place in the drive, the changeover between position and speed control is always supported by the drive.

Automatic changeover by the CNC with position control in the drive is only available for SERCOS and CANopen drives.

The drive needs no special requirements for automatic changeover for drives with position control in the CNC:

Programing Example

Changeover of operation mode

```
%spindle-position
N30 S200 M4
N40 M19 S.POS=180 S1000 M4
N50 S200 M3
N60 M19 S.POS=180 S1000 M4
N70 S200 M4
N80 M19 S.POS=180 S1000 M3
M30
```

2.1 Drives with position control in the drive

Parameterising the drive

Control with digital drives takes place in the drive itself. The CNC specifies a position/speed command value for the drive per tracing interval. The current actual value (position and speed) can be used in the CNC for display functions and monitoring.

In addition, the CNC sends the required operation mode cyclically to the drive.

SERCOS parameters

The following parameters are essential for a SERCOS drive for the position/speed control operation modes:

Main operation mode S-0-0032 = 3 (position actual value with encoder 1)

- S-0-0051 position actual value (encoder 1) / S-0-0053 position actual value (encoder 2)
- S-0-0047 position command value

Auxiliary operation mode 1 S-0-0033 = 2 (speed control)

- S-0-0040 speed value
- S-0-0036 speed command value

In addition to the auxiliary operation mode 1, other auxiliary operation modes 2 and 3 are provided.

What are also important are the scaling type settings.. Weighting should always be set to rotary weighting for spindles.

- S-0-0076 position scaling type (bit 2-0)
- S-0-0044 speed scaling type (bit 2-0)
- S-0-00160 acceleration scaling type (bit 2-0)

Parameter:

(000) unscaled
(001) translatory scaling
(010) rotary scaling

CANopen parameters

The objects below are essential for the position control operation mode with a CANopen drive:

Object 6060_h (Modes of operation) = P-AXIS-00463 [▶ 17]

- Object $607A_h$ Target Position
- Object 6064_h Position actual value

After DS402 the following applies to Object 6060_h in the position control operation mode by default:

Object 6060_h = Cyclic_synchronous_position_mode_CSP(8)

After the changeover speed is exceeded, the CNC changes automatically to speed control.

Object 6060_h (Modes of operation) = P-AXIS-00464 [▶ 17]

The following object is required for this operation mode:

- Object $60FF_h$ Target velocity
- Object $606C_h$ Velocity actual value

After DS402 the following applies to Object 6060_h in the speed control operation mode by default:

Object 6060_h = Cyclic_synchronous_position_mode_CSP(9)

In addition, the CNC requires feedback from the drive regarding which operation mode is currently active.,

Object 6061_h (Modes of operation display)

2.2 Drives with position control in the CNC

Notice

To change between position and speed control in CNC-controlled drives, the scaling of the manipulated variable (P-AXIS-00129, P-AXIS-00128) must be set correctly.

Parameterising the drive

For drives where position control is executed in the CNC, the drive must be in the ‘speed control’ operation mode. Otherwise, no special settings are required in the drive since a command speed is sent to the drive both in position-controlled and speed-controlled mode.

Settings in the CNC

For drives where position control can be executed both in the drive and in the CNC, e.g. with SERCOS, the operation mode “antr.operation_mode“ CNC-position control “CNC_POSITION_CONTROL” must be selected for the spindle (P-AXIS-00320).

To switch over to controlled mode, the scaling of the speed manipulated variable getriebe[i].multi_gain_z / getriebe[i].multi_gain_n (P-AXIS-00129, P-AXIS-00128, CMS-A1] must be set correctly. This can be checked by checking the displayed position lag at a constant endless motion M3 or M4 of the spindle and when feedforward control is inactive. When scaling is correct, the position lag value of the spindle speed caused by the proportional gain of the position control loop (see P-AXIS-00099) equals:

Position lag[°] = speed[°/s] / P-AXIS-00099 * 0.01[1/s]

The parameter antr.sercos.op_mode_for_velocity_control (P-AXIS-00264) for the 'speed control’ operation mode, antr.canopen.cyclic_position_op_mode (P-AXIS-00463 [▶ 17]), antr.canopen.cyclic_velocity_op_mode(P-AXIS-00464 [▶ 17]) and antr.sai_op_mode_change.feed_forward_v_weighting(P-AXIS-00766) have no meaning for CNC-controlled drives.

2.3 Properties

Changeover to speed control

If a speed (S word) is programmed with M3 or M4 and it is higher than the specified changeover parameter, the system changes over automatically to speed control.

Switch back to position control

A switch-back to position control takes place under the following conditions:

- Positioning was programmed with M19.
- A CNC reset was triggered.
- A spindle axis was issued from the spindle interpolator (NC command S[PUTAX]).
- Homing was started (G74).

Notice

If a previous speed programming was changed over to speed control, no switch-back to position control takes place if an additional speed below the switch-back speed is programmed.

Effect of switch-back speed

The command position is not considered during speed control. When a changeover occur to position control, the CNC determines the theoretical command position of the next cycle using:

- the current speed
- the Kv factor (of the drive or the controller position control) and
- the bus run time

The axis can then be switched back to position control without standstill.

The switch-back speed indicates the speed at which switch-back to position control may take place.

Notice

Since the actual speed may fluctuate slightly, especially at high speeds, a slight jerk may occur in the drive at high speeds on switch-back to position control.

For this reason, do not select a switch-back speed that is too high.

Programing Example

Effect of switch-back speed

```
%spindle-position
N10 M3 S1000
N20 M19 S.POS=180 M4 S50
M30
```

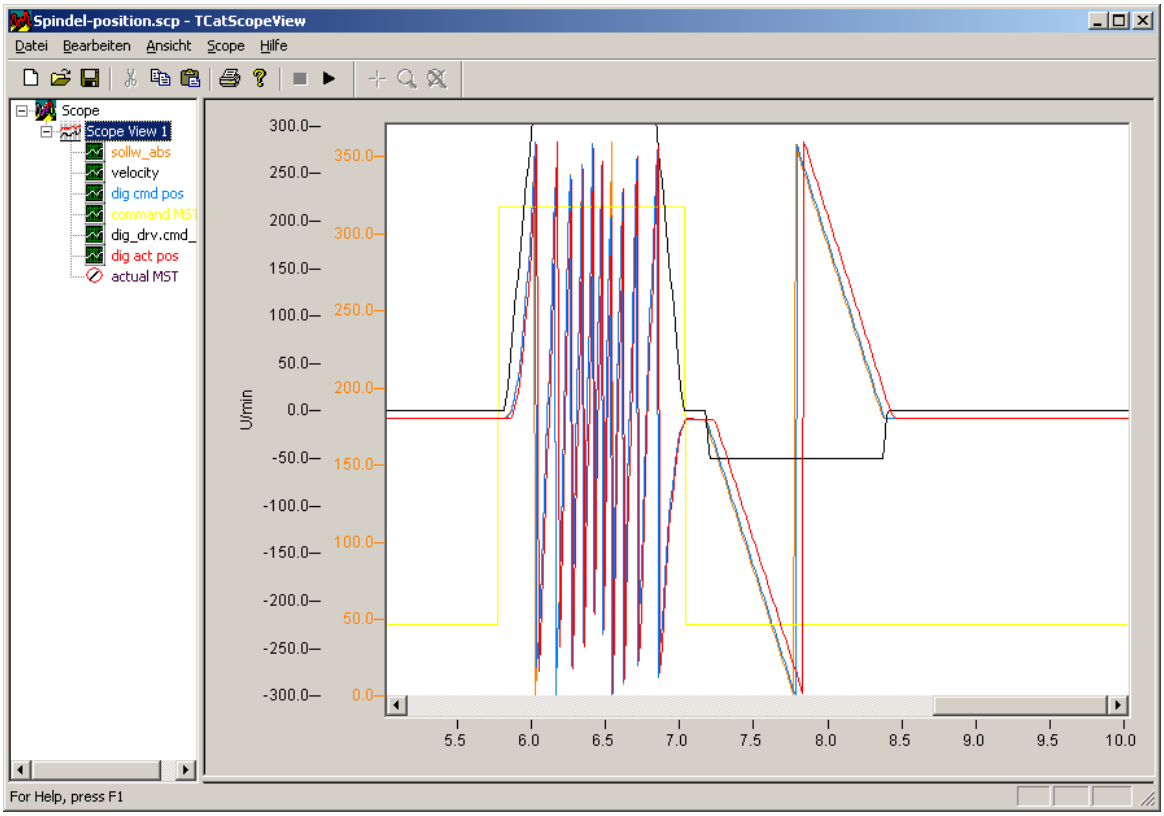

Fig. 1: Positioning at specified speed and reversal

Programing Example

Special case

If the positioning speed is above the changeover speed with M19, positioning still takes place in position-controlled mode.

Depending on the distance traversed, it is therefore possible to traverse above the changeover speed for a short time in position-controlled mode.

```
%spindle-position
(antr.sai_op_mode_change.v_velocity_control_on 1200000
( -> 200 rpm
(antr.sai_op_mode_change.v_position_control_on 600000
( -> 100 rpm

N10 M4  S1000
N20 M19 S.POS=180 M4 S500
M30
```

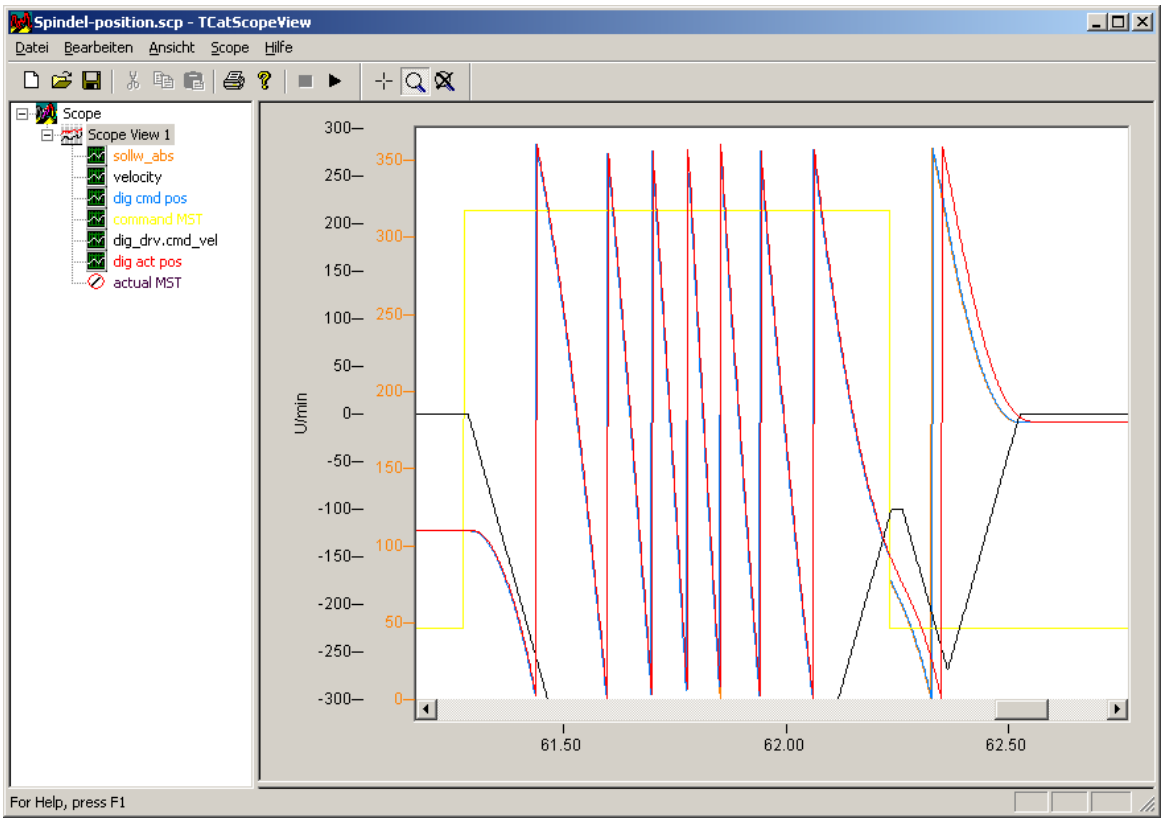

Fig. 2: Positioning at 500 rpm despite changeover speed of 200 rpm

3 Example

Programing Example

SERCOS drive with position control in the drive

As of a speed of 200 rpm, the system should change over to speed control. Switch-back may occur as of 50 rpm. In position control, the drive should run at a speed feedforward control of 50%.

The drive has a Kv factor of 20/s and the path resolution is 220 incr./rev. In addition, the drive expects 10E-4 rpm at the speed interface.

The following settings are required in the axis list in addition to the drive telegram

```
# [10-3degrees/s] -> 1200000 10-3degrees/s = 200 rpm
antr.sai_op_mode_change.v_velocity_control_on     1200000
# [10-3degrees/s] ->  300000 10-3degrees/s =  50 rpm
antr.sai_op_mode_change.v_position_control_on     300000
# Consideration of speed feedforward control
antr.sai_op_mode_change.feed_forward_v_weighting  500
antr.nbr_delay_cycles                 4
# CANopen Kv : 0x30C0:01 [1/s]
# CNC Kv : [0.01/s]
getriebe[0].kv                        2000
#Path resolution of drive [incr./rev.]
#Path resolution CNC [incr./0.0001°]
getriebe[0].wegaufz                   1048576
getriebe[0].wegaufn                   3600000
#Normalisation of speed CNC [incr./0.001°]
antr.v_time_base                      0   (0=min,1=sec,2=ta)
antr.v_reso_num                       1
antr.v_reso_denom                     36
```

Programing Example

SERCOS drive with position control in the drive

As of a speed of 200 rpm, the system should change over to speed control. Switch-back may occur as of 50 rpm. The drive has a Kv factor of 4000/min. The following settings are required in the axis list in addition to the drive telegram:

```
# 0-main mode, 1-1st auxiliary, 2-2nd auxiliary, 3-3rd auxiliary
antr.sai_op_mode_change.v_velocity_control_on    1
# [10-3degrees/s] -> 1200000 10-3degrees/s = 200 rpm
antr.sai_op_mode_change.v_position_control_on    1200000
# [10-3degrees/s] ->  300000 10-3degrees/s =  50 rpm
antr.velocity_position_control_off               300000
# default is 1
antr.nbr_delay_cycles                            4
# CNC Kv : [0.01/s]
getriebe[0].kv                                   6666
```

Programing Example

SERCOS drive with position control in the CNC

As of a speed of 200 rpm, the system should change over to speed control. Switch-back may occur as of 50 rpm. A Kc factor of 100/s is set in the CNC:

Scaling of the speed command value in the drive is 10^{-4} rpm. The following settings are required in the axis list in addition to the drive telegram:

```
# Position control mode in the CNC
antr.operation_mode                          CNC_POSITION_CONTROL
# [10-3degrees/s] -> 1200000 10-3degrees/s = 200 rpm
antr.sai_op_mode_change.v_velocity_control_on      1200000
# [10-3degrees/s] ->  300000 10-3degrees/s =  50 rpm
antr.sai_op_mode_change.v_position_control_on      300000
# CNC Kv : [0.01/s]
getriebe[0].kv                                     10000
# Manipulated variable scaling [°/min]:
# 1000°/min = 10000000°/360° * 10^-4 rpm
getriebe[0].multi_gain_z                           10000000
getriebe[0].multi_gain_n                           360
```

4 Parameter

4.1 Overview

ID	Parameter	Description
P-AXIS-00264	antr.sercos.op_mode_for_velocity_control	Operation mode for velocity control
P-AXIS-00463	antr.canopen.cyclic_position_op_mode	Operation mode for drive position control (CANopen)
P-AXIS-00464	antr.canopen.cyclic_velocity_op_mode	Operation mode for drive velocity control (CANopen)
P-AXIS-00766	antr.sai_op_mode_change.feed_forward_v_weighting	Weighting of speed feedforward control set in the drive
P-AXIS-00767	antr.sai_op_mode_change.v_velocity_control_on	Changeover speed in speed-controlled mode
P-AXIS-00768	antr.sai_op_mode_change.v_position_control_on	Change-back speed in position-controlled mode

4.2 Description

P-AXIS-00264	**Operation mode for velocity control (SERCOS)**	
Description	This parameter defines the required operation mode during switching to velocity control.	
Parameter	antr.sercos.op_mode_for_velocity_control	
Data type	UNS16	
Data range	0 ≤ op_mode_for_velocity_control ≤ 3 where: 0: Main operation mode S-0-0032 1: Auxiliary operation mode 1, S-0-0033 2: Auxiliary operation mode 2, S-0-0034 3: Auxiliary operation mode 3, S-0-0035	
Axis types	S	
Dimension		S: ----
Default value	0	
drive types.	SERCOS	
Remarks	The main mode can also be used for speed control.	

P-AXIS-00463	Operation mode for drive position control (CANopen)	
Description	Parameter is used if the transmission of the drive operation mode (CANopen object 0x6060) is configured in the cyclic process data. Enter the value to be transferred after controller and fieldbus start-up for the operation mode ‘cyclic synchronous position mode’.	
Parameter	antr.canopen.cyclic_position_op_mode	
Data type	SGN16	
Data range	MIN(SGN16) … MAX(SGN16)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	8	
drive types.	CANopen	
Remarks		

P-AXIS-00464	Operation mode for drive velocity control (CANopen)	
Description	Parameter is used if the transmission of the drive operation mode (CANopen object 0x6060) is configured in the cyclic process data. Enter the value to be transferred after controller and fieldbus start-up for the operation mode ‘cyclic synchronous position mode’.	
Parameter	antr.canopen.cyclic_velocity_op_mode	
Data type	SGN16	
Data range	MIN(SGN16) … MAX(SGN16)	
Axis types	T, R, S	
Dimension	T: ----	R,S: ----
Default value	9	
drive types.	CANopen	
Remarks		

P-AXIS-00766	Weighting of velocity feedforward control	
Description	To allow smooth switching between position- and speed-controlled mode, the weighting of the velocity feedforward control set in the drive must be considered. This weighting can be set with this parameter.	
Parameter	antr.sai_op_mode_change.feed_forward_v_weighting	
Data type	UNS16	
Data range	0 <= P-AXIS-00766 <= 1200	
Axis types	S	
Dimension		S:0.1%
Default value	0	
drive types.	SERCOS, CANopen	
Remarks	The weighting of velocity feedforward control is configured for CANopen drives by the object 3062h. With SERCOS drives, velocity feedforward control is weighted by the parameter S-0-0296.	

P-AXIS-00767	Velocity limit for switching to velocity controlled mode	
Description	This parameter specifies a limit speed. The limit speed only acts if a speed greater than the changeover speed is specified. It is then switched over to speed-controlled mode.	
Parameter	antr.sai_op_mode_change.v_velocity_control_on	
Data type	SGN32	
Data range	0 ≤ P-AXIS-00767 ≤ MAX(SGN32)	
Axis types	S	
Dimension		S: 0.001°/s
Default value	2000000000	
drive types.	SERCOS, CANopen	
Remarks	Only a speed of 0 is practical for a sensorless spindle. Therefore the command velocity of the interpolator is always output and not the setpoint velocity of the position controller. P-AXIS-00767 replaces the parameter P-AXIS-00265 as of v3.1.3079.13. However, the latter retains its functionality.	

P-AXIS-00768	Velocity limit for switching back to position control	
Description	This parameter specifies the limit speed for switching back to position control. The limit speed P-AXIS-00768 only acts if the current speed is greater than P-AXIS-00768 for positioning with M19. It is first decelerated to P-AXIS-00768 before position control is switched on.	
Parameter	antr.sai_op_mode_change.v_position_control_on	
Data type	SGN32	
Data range	0 ≤ P-AXIS-00768 ≤ MAX(SGN32)	
Axis types	S	
Dimension		S: 0.001°/s
Default value	0	
drive types.	SERCOS, CANopen	
Remarks	Only a speed of 0 is practical for a sensorless spindle. Therefore the command velocity of the interpolator is always output and not the setpoint velocity of the position controller. P-AXIS-00768 replaces the parameter P-AXIS-00265 as of v3.1.3079.13. However, the latter retains its functionality.	

5 Appendix

5.1 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:

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Keyword index

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