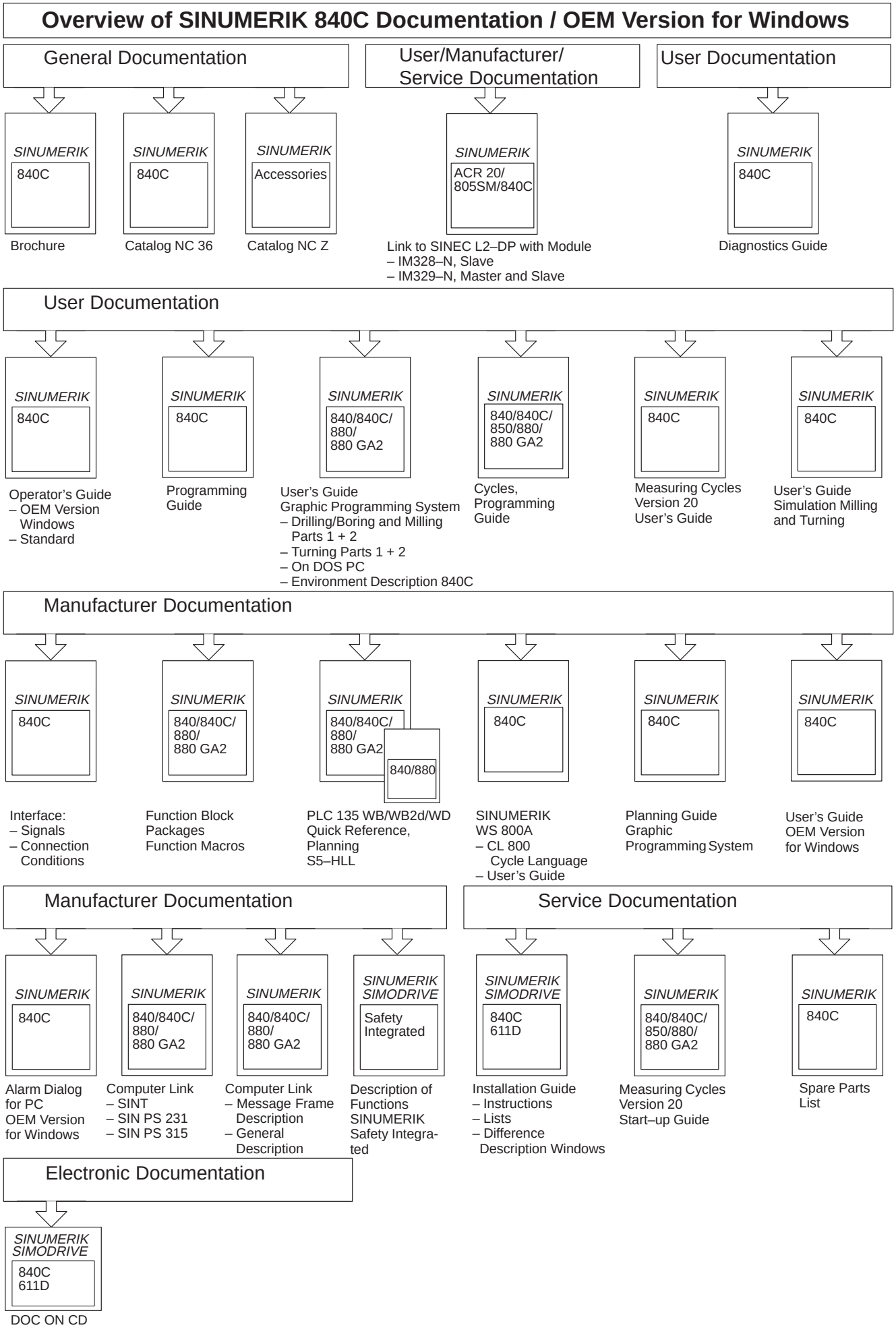
SIEMENS

SINUMERIK 840C/SIMODRIVE 611D
Safety Integrated

Description of functions 05/99 Edition

Manufacturer-Documentation

Overview of SINUMERIK 840C Documentation / OEM Version for Windows



SIEMENS

SINUMERIK 840 C/ SIMODRIVE 611D

Safety Integrated

Description of Functions

Manufacturer Documentation

Valid for

Control	*Software version*
SINUMERIK 840 C with 611D and Safety Integrated	up to 4.2
SINUMERIK 840C with 611D and Safety Integrated	from 6.3

05/99 Edition

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SINUMERIK® documentation

Printing history

Brief details of this edition and previous editions are listed below.

The status of each edition is shown by the code in the "Remarks" column.

Status code in the "Remarks" column:

A .... New documentation.
B .... Unrevised reprint with new Order No.
C .... Revised edition with new status.

Edition	Order No.	Remarks
04/96	6FC5 297-0AB80 - 0BP0	**A**
08/97	6FC5 297-0AB80 - 0BP1	**C**
05/99	6FC5 197-0AC50 - 0BP0	

This manual is included in the documentation available on CD-ROM (DOCONCD)

Edition	Order No.	Remarks
07.99	6FC5 298-4CA00-0BG1	**C**

Further information is available at the following Internet website:
http://www.ad.siemens.de/sinumerik

This publication was produced with WinWord V 7.0, Designer V 4.0 and the DokuTool Aut2WinDoc.

Other functions not described in this documentation might be executable in the control. This does not, however, represent an obligation to supply such functions with a new control or when servicing.

We have checked that the contents of this publication agree with the hardware and software described herein. The information given in this publication is reviewed at regular intervals and any corrections that might be necessary are made in the subsequent printings. Suggestions for improvement are welcome at all times.

Subject to change without prior notice.

Order No.: 6FC5 197-0AC50-0BP0
Printed in the Federal Republic of Germany

Siemens-Aktiengesellschaft.

Preface

Notes for the reader

Structure of the documentation

The SINUMERIK documentation is organized in 3 parts:

- General documentation
- User documentation
- Manufacturer/service documentation

Target group

This documentation is intended for machine tool manufacturers who use SINUMERIK 840D, SINUMERIK 840C with SIMODRIVE 611D and integrated safety functions (SINUMERIK Safety Integrated (SI)).

Objective

This Description of Functions gives all the information about SI functions integrated in the SINUMERIK 840D and SINUMERIK 840C with SIMODRIVE 611D that may be relevant for start-up and configuration.

Standard scope

The main areas covered by this Description of Functions are as follows:

- General information about integrated safety systems
- Description of safety functions
- Lists and description of all signals and data
- Installation and Start-up
- Description of alarms
- One example configuration

User-oriented activities such as the creation of part programs and control operating procedures are described in detail in separate documents.

Separate descriptions are likewise provided of the tasks to be performed by the machine tool manufacturer such as configuring, design and PLC programming.

For more detailed information on SINUMERIK 840D, SINUMERIK 840C and SIMODRIVE 611D and other publications covering all SINUMERIK controls (e.g. Universal Interface, Measuring Cycles...), please contact your local Siemens office.

Notes on how to use this Manual

The following reference guides are provided in this Description of Functions:

- Full table of contents
- Table of contents for each section
- Appendix with list of abbreviations and references
- General index

If you need information about a certain term, please go to the section headed Index in the Appendix and look for the term concerned. Both the section number and the page number on which you will find the information you need are listed in this section.

Products with integrated safety functions

This Descriptions of Functions applies to the following systems:

SINUMERIK 840D with SIMODRIVE 611D and Safety Integrated
SINUMERIK 840C with SIMODRIVE 611D and Safety Integrated

04/96 edition

Note

Documentation with edition date 04/96 describes the scope of functions available with the following SW versions:

SINUMERIK 840D/611D with software version 3.4
SINUMERIK 840D/611D with software version 5.4

08/97 edition

Note

Documentation with edition date 08/97 describes the scope of functions available with the following SW versions:

SINUMERIK 840D/611D with software version 4.2
SINUMERIK 840C/611D with software version 6.1

The following table lists the main functions added since Edition 04.96 and described in Edition 08.97:

Table 0-1 New functions described in Edition 08.97

Ser. No.	Function	SINUMERIK 840D/611D SW 4.2	SINUMERIK 840C/611D SW 6.1
1	Override for safe speed	x[1)]	
2	Safe braking ramp	x	x[2)]
3	Safe speed oriented stop reactions	x	
4	Safe cams for endlessly turning rotary axes	x	
5	Modulo display of safe actual value for rotary axes	x	
6	Synchronization of cam SGAs	x	x
7	SGA “$n < n_x$“	x	x
	SGA “SBH active”	x	x
	SGA “SG active”	x	x
10	Deletion of zero speed position for SBH/SG axes	x[3)]	x[4)]
11	Encoder limit frequency 300 kHz	x[3)]	x[4)]
12	Acceptance report (not a function)	x	x

Notes:
1) → x: Function has been added
2) → Function is implemented in drive monitoring channel
3) → Available from SW version 3.6
4) → Available from SW version 5.7

840C 05/99 edition

Note

Documentation with edition date 05/99 describes the scope of functions available with the following SW versions:

SINUMERIK 840D/611D up to software version 4.2
SINUMERIK 840C/611D with software version 6.3

In the 5/99 edition of SINUMERIK 840C, essentially the following function has been added for SINUMERIK 840C/611D since the 08/97 edition:

- Actual value synchronisation (Section 3.7)

840D 04/99 edition

The function extensions of the 840D are described for SW 4.4.18 in a separate 840D document, 04/99 edition (order no. 6FC5 297-5AB 80 - BP0

Explanation of symbols

The following symbols with special significance are used in the documentation:

Note

The "Note" symbol is displayed in this document to draw your attention to information relevant to the subject in hand.

!

Important

The "Important" symbol is displayed in this document to draw your attention to an important item of information.

Ordering data option

In this document, you will encounter the symbol shown on the left with a reference to an ordering data option. Please note that the function described can operate only if the specified option is installed in the control system.

Danger

This symbol indicates that death, grievous injury or substantial property damage **will** occur if the appropriate precautions are not taken.

Warning

This symbol indicates that death, grievous injury or substantial property damage **may** occur if the appropriate precautions are not taken.

Caution

This symbol indicates that minor injuries or property damage **may** occur if the appropriate precautions are not taken.

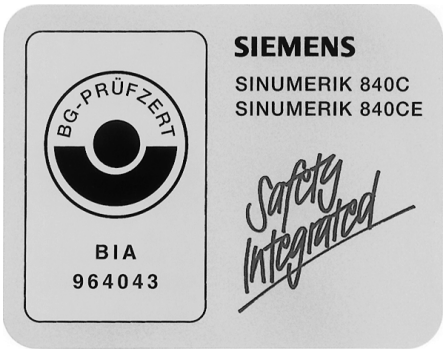
Logo

This symbol indicates the SINUMERIK Safety Integrated function.

Type-examination certificate sign (BG-PRÜFZERT)

A type-examination certificate from the German Institute for Occupational Safety (BIA) has been granted to the SINUMERIK 840D/DE and SINUMERIK 840C/CE systems with Safety Integrated.

BG-PRÜFZERT mask for SINUMERIK 840D/DE with SIMODRIVE 611D and Safety Integrated

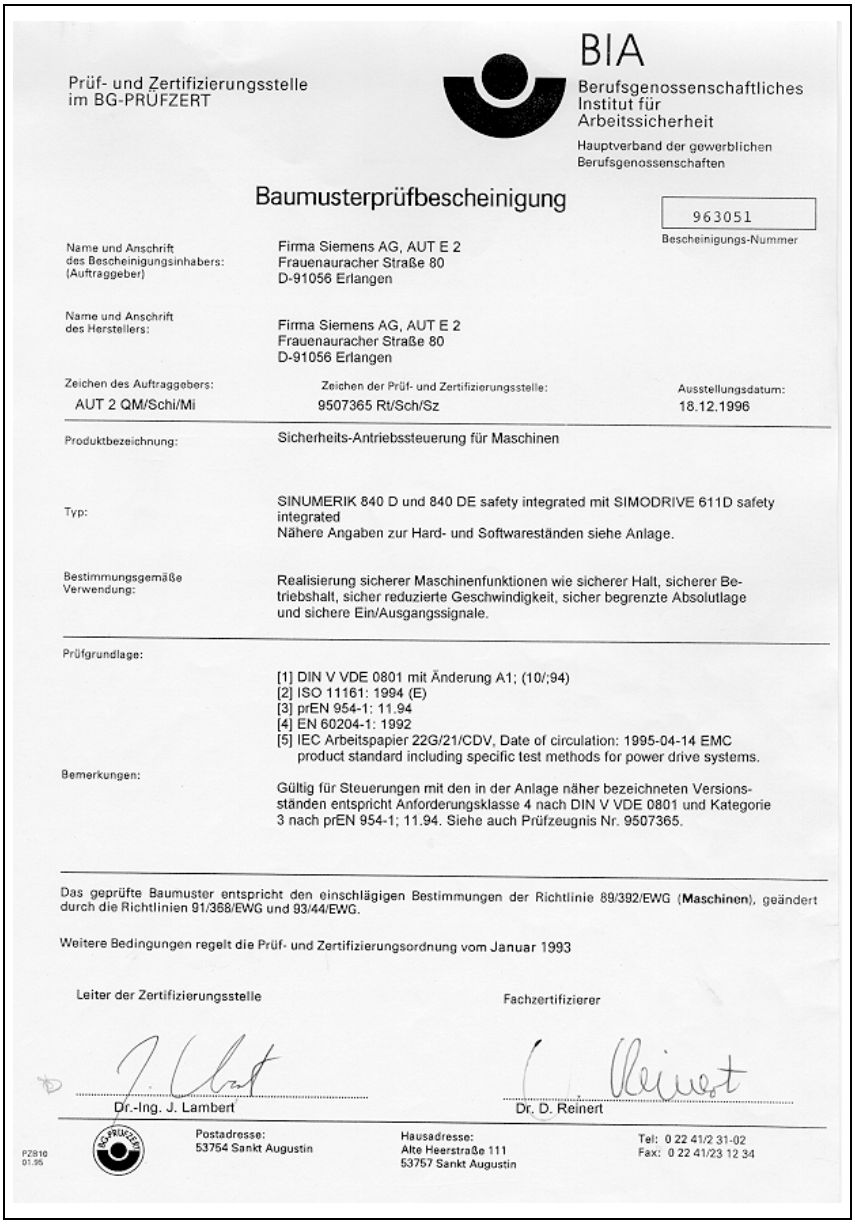


BG-PRÜFZERT mask for SINUMERIK 840C/CE with SIMODRIVE 611D and Safety Integrated

PRUEF_01.DS4

Fig. 0-1 Type-examination certificate sign for SINUMERIK 840D/611D and 840C/611D

Type-examination certificate for SINUMERIK 840D/611D



Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

BIA
Berufsgenossenschaftliches Institut für Arbeitssicherheit
Hauptverband der gewerblichen Berufsgenossenschaften

Baumusterprüfbescheinigung

963051
Bescheinigungs-Nummer

Name und Anschrift des Bescheinigungsinhabers: (Auftraggeber)	Firma Siemens AG, AUT E 2 Frauenauracher Straße 80 D-91056 Erlangen
Name und Anschrift des Herstellers:	Firma Siemens AG, AUT E 2 Frauenauracher Straße 80 D-91056 Erlangen

Zeichen des Auftraggebers:	Zeichen der Prüf- und Zertifizierungsstelle:	Ausstellungsdatum:
AUT 2 QM/Schi/Mi	9507365 Rt/Sch/Sz	18.12.1996

Produktbezeichnung:	Sicherheits-Antriebssteuerung für Maschinen
Typ:	SINUMERIK 840 D und 840 DE safety integrated mit SIMODRIVE 611D safety integrated Nähere Angaben zur Hard- und Softwareständen siehe Anlage.
Bestimmungsgemäße Verwendung:	Realisierung sicherer Maschinenfunktionen wie sicherer Halt, sicherer Betriebshalt, sicher reduzierte Geschwindigkeit, sicher begrenzte Absolutlage und sichere Ein/Ausgangssignale.
Prüfgrundlage:	[1] DIN V VDE 0801 mit Änderung A1; (10/;94) [2] ISO 11161: 1994 (E) [3] prEN 954-1: 11.94 [4] EN 60204-1: 1992 [5] IEC Arbeitspapier 22G/21/CDV, Date of circulation: 1995-04-14 EMC product standard including specific test methods for power drive systems.
Bemerkungen:	Gültig für Steuerungen mit den in der Anlage näher bezeichneten Versionsständen entspricht Anforderungsklasse 4 nach DIN V VDE 0801 und Kategorie 3 nach prEN 954-1; 11.94. Siehe auch Prüfzeugnis Nr. 9507365.

Das geprüfte Baumuster entspricht den einschlägigen Bestimmungen der Richtlinie 89/392/EWG (**Maschinen**), geändert durch die Richtlinien 91/368/EWG und 93/44/EWG.

Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Januar 1993

Leiter der Zertifizierungsstelle
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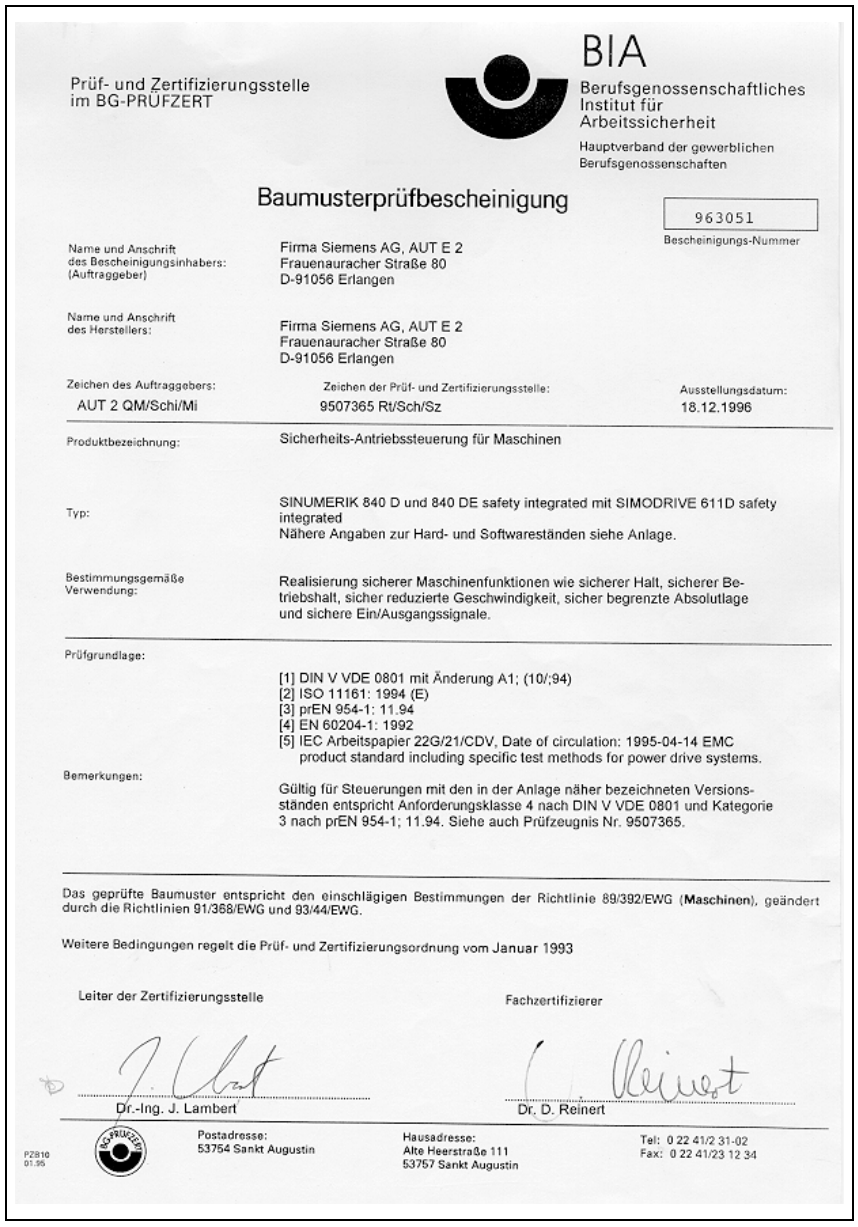
Fig. 0-2 Type-examination certificate for SINUMERIK 840D and 840DE with SIMODRIVE 611D Safety Integrated

Note

The Appendix mentioned above is not included in this document. If you require any data from this Appendix, please contact the department named on the Corrections/Suggestions sheet (last page).

Type-examination certificate for SINUMERIK 840C/611D



Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

BIA
Berufsgenossenschaftliches Institut für Arbeitssicherheit
Hauptverband der gewerblichen Berufsgenossenschaften

Baumusterprüfbescheinigung

963051
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Zeichen des Auftraggebers: AUT 2 QM/Schi/Mi
Zeichen der Prüf- und Zertifizierungsstelle: 9507365 Rt/Sch/Sz
Ausstellungsdatum: 18.12.1996

Produktbezeichnung: Sicherheits-Antriebssteuerung für Maschinen

Typ: SINUMERIK 840 D und 840 DE safety integrated mit SIMODRIVE 611D safety integrated
Nähere Angaben zur Hard- und Softwareständen siehe Anlage.

Bestimmungsgemäße Verwendung: Realisierung sicherer Maschinenfunktionen wie sicherer Halt, sicherer Betriebshalt, sicher reduzierte Geschwindigkeit, sicher begrenzte Absolutlage und sichere Ein/Ausgangssignale.

Prüfgrundlage:
[1] DIN V VDE 0801 mit Änderung A1; (10/;94)
[2] ISO 11161: 1994 (E)
[3] prEN 954-1: 11.94
[4] EN 60204-1: 1992
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Das geprüfte Baumuster entspricht den einschlägigen Bestimmungen der Richtlinie 89/392/EWG (**Maschinen**), geändert durch die Richtlinien 91/368/EWG und 93/44/EWG.

Weitere Bedingungen regelt die Prüf- und Zertifizierungsordnung vom Januar 1993

Leiter der Zertifizierungsstelle
Dr.-Ing. J. Lambert

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Fig. 0-3 Type-examination certificate for SINUMERIK 840C with SIMODRIVE 611D Safety Integrated

Note

The Appendix mentioned above is not included in this document. If you require any data from this Appendix, please contact the department named on the Corrections/Suggestions sheet (last page).

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Brief Description

1

SINUMERIK Safety Integrated can be used to implement practical protective measures for operating personnel and machinery based on innovative control and drive technology.

What is the purpose of safety systems?

Even highly automated production processes require monitoring and direct intervention by human operators. These operators are exposed to various risks even when machinery is used exactly as prescribed by the manufacturer. The general objective is to create a safety system that protects the operator, machine, tool and workpiece. All possible operating states and operating modes of the machine (e.g. installation and start-up, maintenance, setting-up, testing or automatic operation) must be taken into account when devising safety measures.

In order to minimize the risks, only the most reliable and effective of protective measures should be used.

The effectiveness of safety systems is based on 3 basic principles:

- Reliable operation
- Fast, selective reaction
- User friendliness (to make system widely acceptable to operators)

The safety measure becomes ineffective if it fails to fulfil even just one of these conditions.

What is the difference between conventional and modern approaches to safety?

A distinction is made between **passive** and **active protective measures**. The passive protective measures include, for example, fully encapsulated machines that are prevented from executing any hazardous motions with the protective door opened. Such systems generally make it difficult to implement practical machine operating procedures and are thus rejected by many users.

Conventional monitoring devices that belong to the category of active protective measures are used as additional, external systems that operate independently of the control and drive electronics. They are limited to monitoring speed and zero speed (standstill). The reaction time of such devices is relatively long in relation to the acceleration capability of highly dynamic drives.

The basic difference between conventional monitoring equipment and modern safety technology is that modern safety functions are completely integrated into the control and drive systems. Thanks to fully digital technology that allows master data to be applied throughout the whole system, it is now possible, for the first time in NC technology, to implement safety systems in which electronics and software are essentially responsible for safety functions. Modern safety measures have therefore become an integral component of the basic system.

And how do these systems guarantee safety?

Safety is based on the existing multi-processor structure in fully digital systems. A two-channel system structure is formed by the drive CPU and the NC CPU. The safety functions are incorporated redundantly into the control and drive. The process quantities and safety-relevant system data are cross-checked (cross-monitored). The existing parallel drive bus ensures that the monitoring channels can communicate with one another. Safety-relevant software and hardware functions are tested at defined time intervals on the basis of forced dormant error detection.

One special feature is that this safety strategy can be implemented with only **one** measuring system (i.e. motor measuring system). A second measuring encoder is not required, but can be installed as a direct measuring system (e.g. as linear scale). This remarkable feature has been achieved through the use of high-quality measuring circuit electronics. Safety-relevant errors in the system always result in the hazardous motion being stopped safely. This also applies to encoder errors.

Special types of error require the power between the power section and motor to be disconnected. In SINUMERIK Safety Integrated, this is done without contacts and can thus be initiated with virtually no delay for specific axes. The DC link does not, therefore, need to be discharged.

Note

The safety strategy fulfils the requirements of safety category 3 according to EN 954-1.
SINUMERIK Safety Integrated is the product of close cooperation between the "Iron and Metal II" Technical Committee (Fachausschuß "Eisen und Metall II") of the German Professional Association and the German Institute for Occupational Safety (Berufsgenossenschaftliches Institut für Arbeitssicherheit BIA).

Integrated safety functions

The SINUMERIK Safety Integrated package includes the following integrated safety functions:

Table 1-1 Safety functions in overall system

Safety functions	Remarks
Safety-relevant I/O signals	Digital signals, on two channels via separate I/O devices
Safe standstill	Drive pulses are cancelled
Safe operational stop	Drives remain closed-loop position controlled
Safely reduced speed	Linear and rotary
Safe stopping process	Transition from motion to standstill
Safely limited absolute position	Limit switch
Safe cams	Range identification

The safety functions are available in all modes and are therefore also available for machine protection.
They must be coupled with the process via safety-relevant I/O signals.

A further, decisive feature is the extremely short error identification time (time that elapses before the limit-value violation is detected depending on monitoring clock cycle). The response behaviour and response times can be configured. Various stop variations ranging from instantaneous power disconnection to emergency retraction along axis path can be selected.

In the "Setting-up" operating mode, with the protective door open and without the enabling switch, the operator can traverse the feed axes in the danger zone in accordance with the valid standards. Thus, the often demanded "single-handed control" using jog keys is possible. The drives can remain closed-loop position-controlled at any time. If a fault occurs, the system goes into a safe condition. The operator is not aware of or impeded by the safety functions. Thus, he can work freely without any restriction but can still enjoy full protection. Thus, a high level of acceptance is achieved.

There is no longer any need to worry about protective functions being manipulated or tampered with as there is absolutely no reason to do this. Thus, protective functions are fully effective.

The machine OEM can now easily and economically implement the safety-related requirements of EU Machinery Directive 89/392/EU, not only for machines covered by Appendix IV but also for other machines.

Which components can be omitted?

The integration of operator and machine safety into one strategy creates new cost-cutting potential for machine manufacturers and end users.

The infrastructure of the machine is simplified

- Electromechanical components such as limit switches, reference cams, range cams, etc. are no longer required
- Axis-specific cabling is reduced to a minimum

The quantity of equipment installed in the control cubicle is also reduced.

- External monitoring devices are replaced
- Power contactors between the converter and motor can be omitted
- External safety-relevant signals can be connected directly via inputs/outputs
- Some sophisticated contactor combinations are replaced by electronic circuitry

The machine functionality is extended

- The drives can remain under closed-loop position control in set-up and test modes
- The system responses can be configured

The availability of the machine is increased

- Fewer wearing parts (e.g. cams, contactors)
- Shorter installation and start-up procedure
- Simpler servicing and maintenance

Conclusion

This new approach to safety offers enormous potential. From innovative technology to mechatronics (intelligent machines), modern safety systems are making a vital contribution.

Notes

General Information on Safety Systems

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2.1 Directives, standards and legislation

2.1.1 EU directives

EU directives, that set minimum legal standards

The following EU directives are binding as the minimum legal standards for the development and production of a machine tool and its components:

Table 2-1 EU directives that set minimum legal standards

Directive	Binding from
Machinery Directive 89/392/EEC	1st January 1995
EMC Directive 89/336/EEC	1st January 1996
Low-Voltage Directive 73/23/EEC	1st January 1997

The SINUMERIK 840D and SINUMERIK 840C with 611D systems and their functions with SINUMERIK Safety Integrated fully comply with all applicable standards in directives specified above.

Conformity with Directives

Thanks to the SINUMERIK Safety Integrated system, therefore, the machine manufacturer can bring his machine into conformity to the applicable directives with little extra cost or planning.

2.1.2 Relevant safety standards

Important safety standards

In order to implement the above directives, particularly the Machinery Directive, it was necessary to apply international, European and national standards consistently in the design of SINUMERIK Safety Integrated. The most important safety standards are listed in the table below

Table 2-2 Important safety standards

Standard	Description
DIN EN 292-1/2	Basic Concepts, General Principles for Design
EN 775 (ISO 10218)	Manipulating Industrial Robots; Safety
EN 954	Safety Related Parts of Control Systems
DIN EN 1050	Risk Assessment
DIN EN 60204-1	Electrical Equipment of Machines
ISO 11161	Safety of Integrated Production
DIN V VDE 0801	Principles for Computers in Safety-Related Systems

Note

With regard to the EMC and low-voltage directives, the relevant standards are listed in the Declarations of Conformity to be made for the equipment.

2.1.3 Risk analysis and assessment

General

According to Machinery Directive 89/392/EEC, the manufacturer of a machine or a safety component or the person or persons responsible for placing such equipment on the market is legally obliged to carry out a risk analysis in order to determine all risks that may arise in connection with the machine or safety component concerned. He must design and construct the machine or safety component on the basis of this analysis.

A risk assessment must indicate all residual risks that need to be documented.

Error analysis on SINUMERIK Safety Integrated

SINUMERIK Safety Integrated and its error analysis (see Section 2.8 Error analysis) provides the machine manufacturer with information about the measures integrated in the control and drive for dealing with errors arising as the result of internal or external disturbances. He can incorporate this information directly into his risk analysis that is based on the EU Machinery Directive, Appendix 1.

2.1.4 Type examination according to Machinery Directive

Certification of SINUMERIK Safety Integrated

SINUMERIK Safety Integrated is certified by an accredited test laboratory according to the EU Machinery Directive. SINUMERIK Safety Integrated complies with safety category 3 according to EN 954-1.

SINUMERIK Safety Integrated can therefore be used on all machine tools. The machine tool manufacturer can verify his machines himself with SINUMERIK Safety Integrated regardless of whether harmonized standards exist or not. A machine must, however, pass an acceptance test successfully (see Section 5.1.1 Acceptance test and report). Verification is greatly simplified even for machines that are covered by Appendix IV of the EU Machinery Directive for which no harmonized standards yet exist.

The machine manufacturer should indicate that his machine has a type examination certificate for SINUMERIK Safety Integrated in his documentation or declaration of conformity.

2.1.5 Product liability directive or law

Product liability

Damage resulting from defective products and absolute proof of the fault cause are the prerequisites for product liability. The only effective protection against such liability are measures that can prevent the occurrence or the effects of faults or errors that impair or endanger the proper operation of machinery.

With SINUMERIK Safety Integrated, Siemens has implemented a safety system for operating personnel and machines that is state of the art in terms of both science and technology.

2.2 Definition of terms

Safety considerations

(extract from DKE-AK 226.03 dated January 17, 1996)

The operational safety of a machine is mainly dependent on the extent to which the machine executes or initiates hazardous movements. Isolating or proximity-type protective equipment automatically prevent the operator from gaining access to such danger zones, but occasionally it is necessary for machines to be operated with the protection equipment deactivated. Alternative safety measures are then needed that afford sufficient operator protection even in this type of situation.

In many cases, the purpose of these safety schemes is to influence the movements of the electrical drive system is such a way that operators are not exposed to any risk. In such cases, the response of the drive system in the event of disturbances or faults must fulfil certain criteria. In some cases, these requirements are defined in machine-specific standards by a safety category according to EN 954-1. The requirements specified in category 1 should generally be applied to non-solid-state circuits, making allowance for the state of the art.

In most cases, the control electronics of the electrical drive system are also responsible for implementing safety functions. The circuit structures required for this purpose are too complex to be covered by category 1. Unless otherwise defined in machine-specific standards, these safety-related functions must comply with the requirements stipulated in at least category 3 according to EN 954-1.

2.2.1 General definitions of terms

Reliability and safety

The terms "Reliability" and "Safety" are defined in EN 292-1 as follows:

Table 2-3 Reliability and safety

Term	Definition
Reliability	The ability of a product, a part or an apparatus to perform a required function under specific conditions and for a specified period of time without malfunction.
Safety	The ability of a product to perform its function(s) and to be transported, erected, installed, maintained, disassembled and removed in compliance with the conditions of its intended use as defined by the manufacturer in the Operating Manual (and to which reference is made in some cases for certain periods in the Operating Instructions) without causing injury or ill-health.

Electrical drive system

(extract from DKE-AK 226.03 dated January 17, 1996)

A units consisting of the drive control unit, power output module and drive motor including power and data leads and parts, pulse encoder, position encoder, etc. Parts of the drive control can also be integral components of the electronic control system.

Safe

(extract from DKE-AK 226.03 dated January 17, 1996)

"Safe" in connection with drive functions (e.g. safe stopping, safe operational stop, etc.) means that one of the categories according to EN 954-1 associated with the risk analysis must be applied to the behaviour of the control components. The categories to be applied are defined in machine-specific standards in some cases.

Safe operation or Safety Integrated (SI)

Safe operation (Safety Integrated, abbreviated to SI) is selected after activation of the configured safety function(s) for this machine.

Dormant error

A dormant error in the software and/or hardware is not noticeable in normal operation (because, for example, the faulty component/program is not used/processed in the currently selected operating mode. The error can be detected only if the defective component is used in the software and hardware (e.g. during testing).

2.2.2 Definition of terms for safety functions

There are different versions of the terms for safety functions used in the papers drawn up by working committees of German standards institutes (DKE-AK 226.03) and the terms used in this documentation. This is illustrated by the lists of translation terms in the following table.

Table 2-4 Translation of terms used

Terms from working papers (German)	English	Term used in this documentation (abbreviation)	See Section
Sichere Ein-/Ausgangssignale	Safe input/output signals	Safety-relevant I/O signals (SGEs/SGAs) [1)]	3.1
Sicherer Halt	Safe standstill	Safe standstill (SH)	3.2
Sicherer Betriebshalt	Safe operational stop	Safe operational stop (SBH)	3.3
Sicher reduzierte Geschwindigkeit	Safely reduced speed	Safe speed (SG)	3.4
Sicheres Stillsetzen [2)]	Safe stopping process	-	2.5
Sicher begrenzte Absolutlage	Safely limited absolute position	Safe limit positions (SE)	3.5
-	Safe Cam	Safe cams (SN)	3.6

Note:
1): Not a function (see Section 3.1 Safety-relevant input/output signals (SGE/SGA))
2): Not a function (see Section 2.5 Safe reaction via pulse disable paths and stops)

Safety-relevant I/O signals (SGEs/SGAs)

Safety-relevant I/O signals (SGEs/SGAs) are digital signals that are output to or arrive at the monitoring system via two channels and a range of different I/O devices. These signals are available in each monitoring channel and for each axis/spindle that has integrated safety functions.

Application example: Select/deselect safe functions, output cam signals

Safe stop (extract from DKE-AK 226.03 dated January 17, 1996)

With a safe stop, the energy supply to the drive is interrupted. The drive cannot produce any torque or generate any hazardous motion. The motion is not monitored. Electrical isolation to the power supply can be used, but is not necessary. Suitable measures for implementing a safe stop are:

- Contactor between line and drive system (line contactor)
- Contactor between power section and drive motor (motor contactor)
- Safe disabling of pulses of power semi-conductors (safe pulse disabling)

If there is the possibility of force being applied by external means (e.g. dropping of vertical axes), then additional measures must be taken to safely prevent such movements (e.g. mechanical brakes).

Note

According to EN 60204-1, Section 5.3 machines must be provided additionally with a main switch.

Safe operational stop

(extract from DKE-AK 226.03 dated January 17, 1996)

In certain cases, it is necessary to stop (operational stop) the drive system at a natural point in the product process. This operational stop corresponds to the category 2 stop according to EN 60204-1, Section 9.2.2 (see also prEN 1921 Section 5.11.4). All control functions between the electronic control and the drive motor remain active (torque, speed, position, etc.). Using the operational stop without any additional safety measures is purely functional in nature and is irrelevant with regard to safety.

The safe operational stop uses additional control-related measures to prevent the drive from executing any dangerous motions as the result of errors.

When the safe operational stop state is cancelled, e.g. through closing of a protective device and issue of a start command, the motion of the drive can be continued immediately at the point at which it was interrupted (see also CEN TC 143 WG3/4).

Example of application: Setup mode/starting programs on automatic lathes, machining centres, automated manufacturing systems

Safely reduced speed

(extract from DKE-AK 226.03 dated January 17, 1996)

Control-related measures are implemented to safely prevent the drive from exceeded a specified speed limit. The control electronics of the drive system must be devised such that the speed limit values cannot be changed by intervention from unauthorized persons.

Example of application: Setup mode on automatic lathes, machining centres, automated manufacturing systems

Safe stopping process

(extract from DKE-AK 226.03 dated January 17, 1996)

The safe stopping process brings the drive to a safe standstill in a way appropriate to the hazardous situation requiring the stop reaction. To implement this safety measure, the electrical, electronic and electromechanical devices responsible for braking the drive must be included in the safety scheme (with further safety measures considered). To safely prevent the drive from restarting, measures such as those described under Safe Standstill and Safe Operational Stop must be implemented immediately the drive has reached a standstill.

Example of application: Enabling switch, electrical interlock of moving protective devices, emergency STOP

Note

At the present time, EN 60204 Section 9.2.2 stipulates that the energy supply must also be disconnected for the emergency STOP function.

Safely limited absolute position

(extract from DKE-AK 226.03 dated January 17, 1996)

Control-related measures are implemented to ensure that the drive system switches to the "Safe standstill" or "Safe operational stop" state on reaching a specified absolute position limit value. When the limit value is set, the maximum overtravel that is technically possible must be taken into account.

Measures must be taken to deal with unexpected movements of the drive below the limit value. Provided that the movement is executed in JOG mode, fault-free continuation of the motion will be tolerated on release of the command key. However, a safe stopping process must be initiated as soon as the absolute limit value is reached. The control electronics of the drive system must be devised such that the position limit values cannot be altered through intervention by unauthorized persons.

Example of application: Safe electronic limit positions

Safe cams

The drive generates a safe output signal when the position actual value corresponds to a specified limit value. This output signal can be processed further in other system components. The circuitry for further processing must comply with the same safety category as the drive system itself. Measures must be taken to safely preclude the possibility of limit value manipulation by unauthorized persons.

Example of application: Safe electronic cams,
Safe zone sensing,
Working area/protection zone delimitation

2.3 Fundamental principals of SINUMERIK Safety Integrated

2.3.1 Safety category 3

General

The safety-related parts of the control systems

- SINUMERIK 840C with SIMODRIVE 611D and
- SINUMERIK 840D with SIMODRIVE 611D

comply with category 3 of EN 954-1.

Table 2-5 Categories of safety-related parts of control systems

Category	Summary of requirements	System response [1]	Main principle for provision of safety
B	The safety-related components of machine controls and/or their protective equipment and components must be designed, constructed, selected, assembled and combined in compliance with all applicable standards such as to be capable of withstanding all potentially hazardous influences.	If a fault/error occurs, it can lead to loss of the safety functions.	Selection of components
1	The requirements of B must be fulfilled. Use of components and principles that have proven to be effective in terms of safety.	As described for category B, but with a greater safety-related reliability of safety functions.	
2	The requirements of B must be fulfilled. The use of principles that have proven to be effective in terms of safety. The safety function(s) must be tested at appropriate intervals by the machine control. Please note: The suitability of the measure depends on the application and type of the machine.	– The occurrence of a fault/error can lead to a loss in safety functions in-between tests. – The loss of safety function(s) is detected in the course of testing.	Structure-based
3	The requirements of B must be fulfilled. Use of principles that have proven to be effective in terms of safety. The controls must be designed such that: – a single fault/error in the control system does not cause a loss of the safety function(s) and – the single fault/error is detected whenever such a scheme can be appropriately implemented.	– If the single fault/error occurs, the safety function always remains operational. – Some, but not all, faults/errors are detected. – An accumulation of undetected faults/errors can lead to a loss of the safety function(s).	
4	The requirements of B must be fulfilled. The use of principles that have proven to be effective in terms of safety. A control system must be designed such that: – a single fault/error in the control system does not cause a loss of the safety function(s) and – The single fault/error is detected before or as the safety function is required to take effect. If such a response cannot be implemented, then the accumulation of faults/errors must not result in a loss of the safety function(s).	If faults/errors occur, the safety function always remains operational. Faults/errors are detected promptly enough to prevent any loss of safety functions.	Structure-based

1): The risk assessment states whether the total or partial loss of the safety function(s) as a result of faults/errors is acceptable.

2.3.2 Basic characteristics of SINUMERIK Safety Integrated

Characteristics of two-channel, diverse structure

A two-channel, diverse structure is characterized by the following features:

- Two-channel structure with at least 2 independent computers (i.e. computers with different hardware and software)
- Cross-check of results and data with forced dormant error detection for the purpose of detecting internal errors even in functions that are seldom used (dormant errors).
- Accessing of data at common interfaces (e.g. actual value input) by computers is fully decoupled.

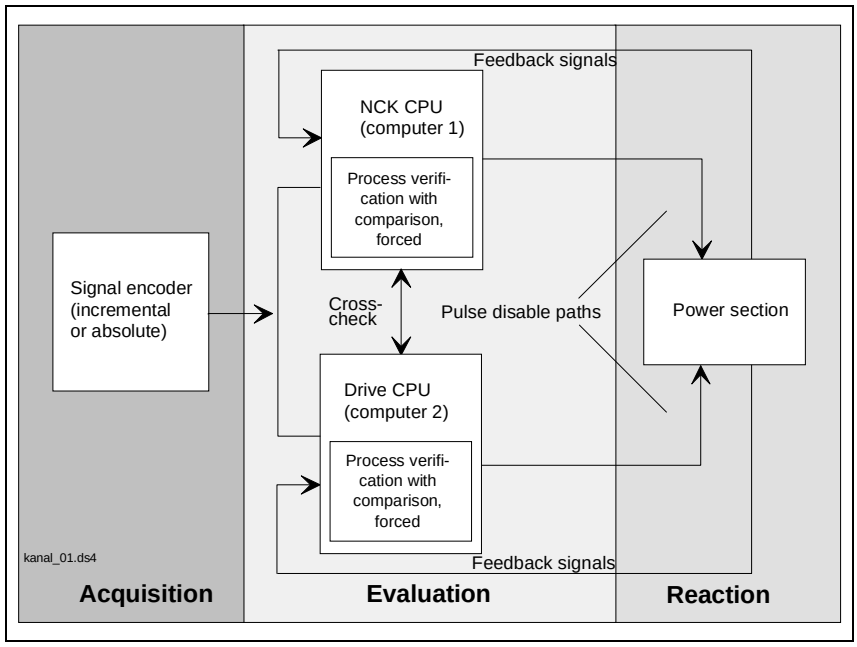

Fig. 2-1 Two-channel structure: Acquisition, evaluation and reaction

Acquisition

The actual values are acquired by the 611D performance closed-loop control module via the 1st actual value input (with a single-encoder system) or via the 1st and 2nd actual value inputs (with a 2-encoder system) and supplied to the control system and the drive via 2 separate actual value channels.

Evaluation

The safe functions are monitored by the NCK-CPU and the drive CPU on a mutually independent basis. Both CPUs carry out a mutual comparison (cross-check) of their data and results in a specified cycle. A test that can be initiated by either of the CPUs can be carried out on the pulse disable paths (forced dormant error detection).

Reaction

When monitoring functions responds, the NCK and/or the drive can send control commands to the power section via pulse disable paths, thus shutting down the axis or spindle correspondingly.

2.3.3 Forced dormant error detection and cross-checking

Forced dormant error detection

This detection process allows dormant errors in the software and hardware of the two monitoring channels to be discovered. To do so, all safety-relevant branches of the safety-relevant parts in both channels must be processed at least once within a "Time frame for dormant errors".

An error in a monitoring channel will cause a deviation in the results which will be detected during the cross-check.

Note

The forced detection of dormant errors in the pulse disable path (test stop) must be initiated by the user (e.g. when axes are stationary after system has been switched on, when the protective door is opened or in a prespecified rhythm in each case (e.g. in an 8-hour rhythm).
This detection process is not a mandatory requirement while the system is operating in automatic mode (when protective door is shut).

Cross-checking

Dormant errors in the safety-relevant data of the two monitoring channels are discovered in the course of cross-check operations.

In the case of "variable data", there are tolerance values defined via machine data by which amount the results of the two channels may deviate from one another without initiating a reaction (e.g. tolerance for cross-check of actual positions).

Note

Errors that are discovered as a result of forced dormant error detection or cross-check operations lead to a STOP F reaction (see Section 2.5.4 Stop reactions) and initiate a further stop reaction when Safety Integrated is active.

2.3.4 Safety monitoring cycle and cross-check cycle

The safe functions are monitored cyclically in the monitoring cycle that can be set jointly for all axes/spindles via the following machine data:

Setting the monitoring cycle time

On 840D MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO
The specified clock cycle is checked and rounded to the next possible value when the control powers up and every time the machine data changes. The resulting monitoring cycle is displayed via MD 10091: $MN_INFO_SAFETY_CYCLE_TIME
(see Section 4.1 Machine data for SINUMERIK 840D).

On 840C MD 40010 (ratio between monitoring cycle and position control cycle)
(see Section 4.2 Machine and service data for SINUMERIK 840C)

On 611D MD 1300: $MD_SAFETY_CYCLE_TIME
(see Section 4.3 Machine data for Simodrive 611D)

Warning

The monitoring cycle determines the reaction time of the safe functions. It must therefore be selected as ≤ 25 ms. The greater the monitoring cycle setting, the greater the amount by which the monitored limit value is violated in the event of an error.

The cross-check cycle specifies the period within which all data to be cross-checked are compared. It is displayed via the following machine data:

Display of cross-check cycle

On 840D MD 10092: $MN_INFO_CROSSCHECK_CYCLE_TIME

On 840C MD 40002 (display of cross-check cycle)

2.3.5 User agreement

Description

"User agreement" is the confirmation by an appropriately authorized person that the currently displayed SI actual position of an axis corresponds to the actual position on the machine. To check whether this is the case, the axis can be traversed, for example, to a known position (e.g. a visual mark) or measured and the SI actual position in the "User agreement" display compared with the measurement result.

An axis/spindle with integrated safety functions can have the following status:
User agreement = yes or
User agreement = no

The "User agreement" window always displays the following data for each axis/spindle with activated Safety Integrated:

- Machine axis name
  - SI position
  - User agreement

When does user agreement need to be given?

- User agreement need only be given when safe end positions (SE) and/or safe cams (SN) are being monitored for an axis/spindle.
  - When the axis/spindle is started up for the first time.
  - When the user intends or needs to re-reference the axis/spindle reliably by hand.
  - If the check of the zero-speed position against the current position after POWER ON was not correct and the user agreement has been cancelled by the control system.
  - After an axis/spindle has been parked
    (only if the change in position is greater than defined via MD: Tolerance actual value comparison (referencing)).
  - After a gear change.

Note

An axis/spindle must have the status "User agreement = yes" before the functions SN and SE can be used.

For further information about the user agreement function, please refer to Section 2.4.2 Adjustment, measurement, axis states and previous history.

Applicable to 840D with SW 3.6 and later
840C with SW 5.7 and later

In the case of axes and spindles that do not have configured safety functions “SE” and “SN”, the stored zero-speed position is not evaluated if user agreement has not been given.

Warning

If the axis is not reliably referenced and user agreement has not been given, then the following applies:
- The safe cams are active, but not yet safe
- The safe end positions are not yet active

User agreement interlock

Before user agreement can be given, the protective interlock must be cancelled:

- Keyswitch in position 3 $\rightarrow$ user agreement can be given

The interlock must be activated again (e.g. by removal of the key) afterwards.

2.3.6 Enabling individual safe functions

Global enable

Safe operation using safe functions SH/SBH/SG/SE/SN is enabled via an option.

The SH function is operative if at least one safe function is activated.

The enabling command determines the number of axes/spindles for which SINUMERIK Safety Integrated can be activated.

Ordering data option

SINUMERIK Safety Integrated can operate only if the appropriate option is installed.

Enabling of monitoring functions

It is possible to select which of the monitoring functions (SBH/SG/SE/SN) is to be active for each individual axis with the following machine data:

On 840D MD 36901: $MA_SAFE_FUNCTION_ENABLE
(see Section 4.1 Machine data for SINUMERIK 840D)

On 840C MD 4500* (Enable function SBH/SG/SE)
MD 4504* (Cam enable safe operation)
(see Section 4.2 Machine and service data for SINUMERIK 840C)

On 611D MD 1301: $MD_SAFE_FUNCTION_ENABLE
(see Section 4.3 Machine data for Simodrive 611D)

In addition to other settings, the following functions can be enabled individually in these MD:

- SBH/SG
- SE
- SN1+ , SN1 -, SN2 +, SN2 -, SN3 +, SN3 - SN4 +, SN4-
- SG correction
- Cam synchronization

Note

- To ensure that SBH is always available in the event of an error, the function SBH/SG must be activated and correctly parameterized when the function SE and/or SN is enabled.
- The axis-specific enabling data in the NCK must be identical to those in the drive or else an error message will be output when the data are cross-checked.
- An axis is treated as 1 axis in terms of the global option if at least one safety function is activated via the axis-specific enabling data.
- The maximum number of axes that may operate using the safe functions is determined by the number that has been enabled by the global option.

2.4 Encoder mounting conditions

2.4.1 Encoder types

Basic types

The following basic types of encoder can be used on a drive module for the purpose of safe operation:

- Incremental encoder
  with sinusoidal voltage signals A and B (signal A in quadrature with signal B) and a reference signal R
  E.g.: ERN 1387, LS 186, SIZAG2
- Absolute encoder
  with EnDat interface and incremental, sinusoidal voltage signals A and B (signal A in quadrature with signal B)
  E.g.: EQN 1325, LC 181

Combinations of encoder types

Various combinations can be derived from the basic types.

Table 2-6 Combinations of encoder types

Incremental encoder		Absolute encoder		
on motor	**on load**	**on motor**	**on load**	**Remarks**
x				1-encoder system
		x		1-encoder system
x	x			2-encoder system
	x	x		2-encoder system
x			x	2-encoder system
		x	x	2-encoder system
Note: x → Encoder connection				

1-encoder system

With a 1-encoder system, the incremental or absolute encoder on the motor is used for the actual values of the NC and drive.

The 611D performance closed-loop control module supplies one actual value to the NCK and drive via 2 separate actual value channels.

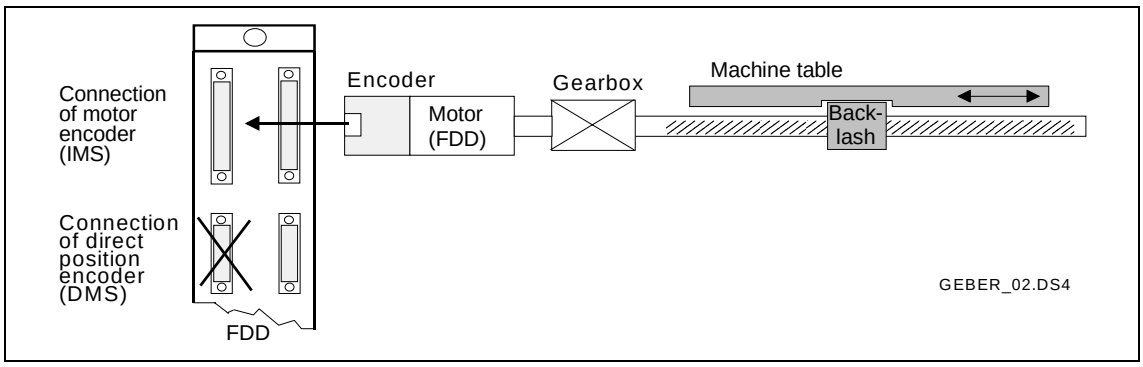

Fig. 2-2 1-encoder system on feed drive

Note

The connection of the direct position encoder (DMS) cannot be used for the measuring system of another axis with a 1-encoder system.

2-encoder system

With this type of system, the actual values for one axis are used by 2 separate encoders. In standard applications, the drive evaluates the motor encoder and the NC, for example, the measuring system connected to the 2nd actual value input. The 611D performance closed-loop control module supplies the 2 actual values to the NCK and drive via 2 separate actual value channels.

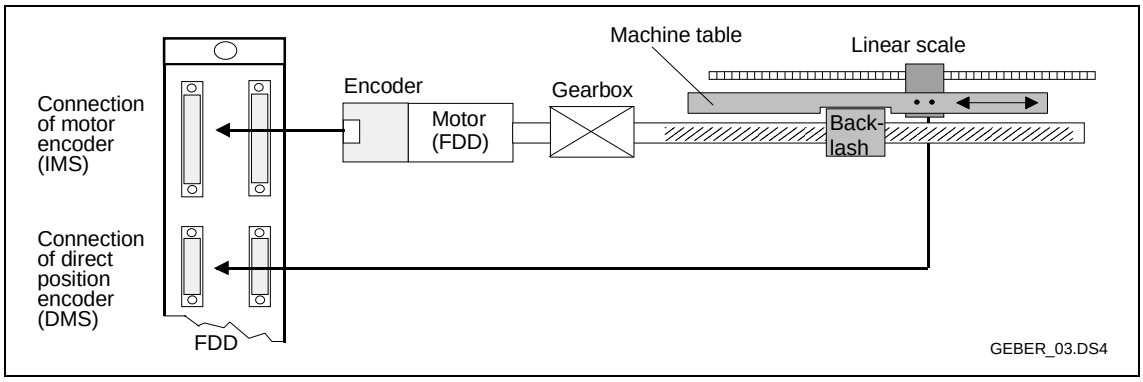

Fig. 2-3 2-encoder system on feed module (FDD)

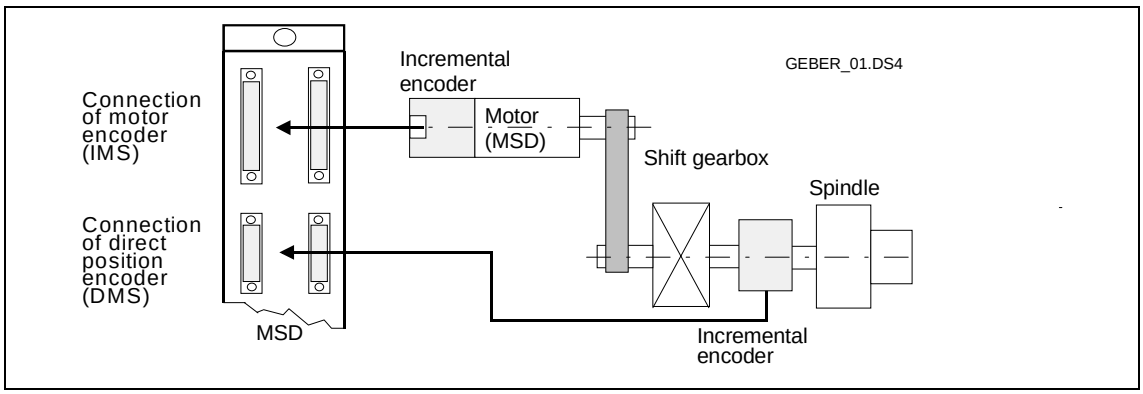

Fig. 2-4 2-encoder system on main spindle (MSD)

Note

If the gear ratio between the motor and load is not slip-free, the 1-encoder system must be selected. The 2nd spindle encoder is connected to another drive module via an actual-value input. SE and SN cannot be configured in such cases (see Section 2.9.3 “Application: Spindle with 2 encoders and slip caused by V-belt drive”).

2.4.2 Adjustment, measurement, axis states and previous history

Adjustment of motor encoder

In 1-encoder systems, the built-in encoder is generally an integral component of the motor (the encoder is adjusted to match the motor). The information about distance, speed and rotor position (on synchronous drives) is obtained from one encoder. It is no longer possible to adjust the encoders in motor measuring systems in the conventional sense.

Measurement of machine

The machine zero and encoder zero are adjusted purely on the basis of the offset value (the machine must be measured). This process must be carried out for both incremental encoders (e.g. of type ERN) and absolute encoders (e.g. type EQN).

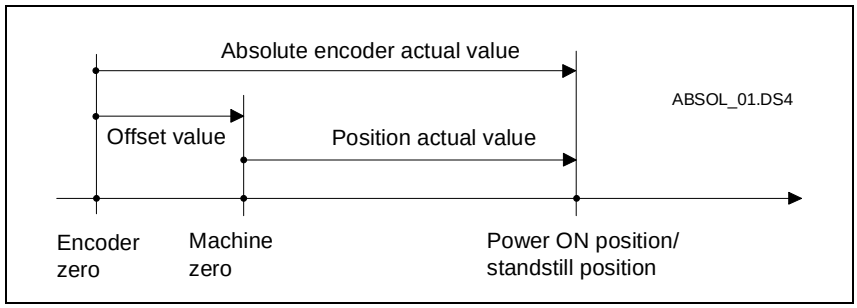

Fig. 2-5 Positions and actual values

When the machine is measured, a known or measured position is approached by means of a clock gauge, fixed stop, etc. and the offset value then calculated. This offset is then entered in the appropriate machine data. The machine must always be measured for a position-controlled axis/spindle.

References: /IAD/, SINUMERIK 840D Installation and Start-Up Guide
/IAC/, SINUMERIK 840C Installation and Start-Up Guide
/FBD/, SINUMERIK 840D, Descriptions of Functions R1, "Reference Point Approach"

Axis state "Axis not referenced "

The axis state "Axis not referenced" is reached after the power supply has been connected and the drive and control system have finished powering up. This state is indicated via the axis-specific interface signal "Reference point reached" as follows:

Interface signal
"Reference point reached" = "1" Axis state "Axis referenced"
"Reference point reached" = "**0**" Axis state "**Axis not referenced**"

On 840D DB31-48, DBX60.4 / DBX60.5
On 840C DB32, D0.12, D4.12, etc.

The function SBH/SG can be used only when this state has been reached. (see Fig. 2-6 Axis state during referencing)

Axis state "Axis referenced"

With **incremental encoders**, the position actual value is lost when the NC is switched off. When the NC is switched on, a reference point approach must be carried out. If it is done correctly, then the axis is referenced and in the "Axis referenced" state (see Fig. 2-6 Axis state during referencing).

Unlike incremental encoders, **absolute encoders** do not require a reference point approach after connection of the NC power supply. These encoders keep a record of the absolute position by means of, for example, a mechanical gear unit, in both the power ON and power OFF states. The absolute position is transmitted implicitly via a serial interface (EnDat interface on type EQN) when the NC is switched on. After transmission of the position and calculation of the offset value, the axis is also in the "Axis referenced" state (see Fig. 2-6 Axis state during referencing).

The "Axis referenced" state is displayed via the axis-specific interface signal "Referenced point reached" as follows:

Interface signal
"Reference point reached" = "**1**" Axis state "**Axis referenced**"
"Reference point reached" = "0" Axis state "Axis not referenced"

On 840D DB31-48, DBX60.4 / DBX60.5
On 840C DB32, D0.12, D4.12, etc.

References: /IAD/, SINUMERIK 840D Installation and Start-Up Guide
/IAC/, SINUMERIK 840C Installation and Start-Up Guide

Axis state "Axis safely referenced"

In order to obtain the "Axis safely referenced" state, the axis state must already be "Axis referenced" plus one of the following:

- The user must confirm the current position by means of the user agreement function

  or

- a previous history (stored and set user agreement and a stored standstill position on power OFF) must be available. In this case, the position specified in the previous history must tally with the current position within a tolerance window. This position data are checked in the drive and the NC.

The axis state "Axis safely referenced" is displayed via the SGA "Axis safely referenced". Only when this state is reached can reliable evaluation of position data be guaranteed for the functions SE and SN
(see Fig. 2-6 Axis state during referencing).

User agreement

The user agreement function (protected via keyswitch) allows the user to confirm that the current position on the machine corresponds to the position displayed in the NC.

User agreement is confirmed via a softkey. Before this can be done, the axis state "Axis referenced" must have been reached. If the axis is in this state and the user has confirmed the position by means of the agreement function, then the "Axis safely referenced" state is also reached.

If user agreement is given without the axis being in the "Axis referenced" state, then alarm "Defect in a monitoring channel" is output with error code 1004.

User agreement can only be given by an authorized user.

The user agreement can be cancelled by the user or as the result of a function selection (e.g. new gear step) or an erroneous status (e.g. inconsistency in user agreement between NC and drive). When the user agreement is cancelled, the axis state "Axis safely referenced" is always reset (see Fig. 2-6 Axis state during referencing).

Stored user agreement

The status of the user agreement function is stored in non-volatile memories. This agreement data constitutes the previous history in combination with the standstill position data that is also in non-volatile storage.

Stored standstill position

The stored standstill position data are combined with the permanently stored user agreement to form the previous history.

The following must be noted when the standstill position is stored:

- The standstill position is stored when a safe operational stop (SBH) is selected via the SGE "SBH/SG deselection".
- The following applies when SE/SN is active:
  The standstill position is also cyclically stored.
- If the axis is moved with the power supply disconnected, then the stored standstill position no longer tallies with the current position.

Previous history

The previous history consists of the stored user agreement and the stored standstill position (see "Stored user agreement" and "Stored standstill position").

As described under paragraph heading "Axis safely referenced", a previous history can be used to obtain the axis state "Axis safely referenced"

The following conditions must be fulfilled:

- The stored user agreement must be available.
- The difference between the "Reference position" (power ON position with EQN or reference position with ERN) and the stored standstill position (including traversing distance to reference point with ERN) must be within a tolerance window specified via machine data.

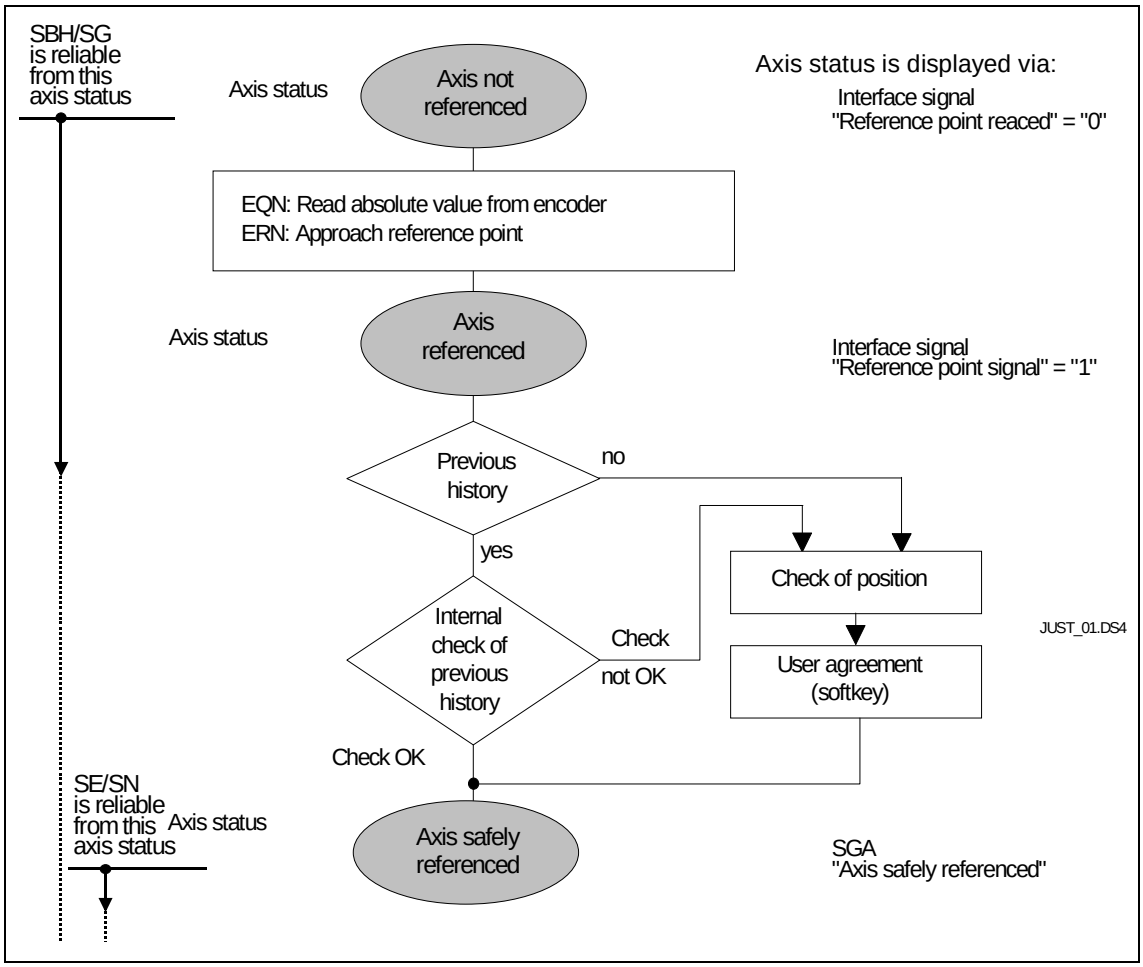

Fig. 2-6 Axis states during referencing

Encoder replacement

With 1-encoder systems, it is advisable to replace the entire motor in the case of a defect in the motor measuring system (indirect measuring system).

Warning

After the measuring system has been replaced - regardless of whether it is a direct or indirect system - the relevant axis must be re-measured.

The user can suppress the automatic, internal actual value check by resetting the "User agreement" and thus request re-measurement of the axis with user agreement.

2.4.3 Overview of data for encoder mounting

Overview of MD for 840D

Table 2-7 Overview of machine data for 840D

Number	Identifier
36910	SAFE_ENC_SEGMENT_NR
36911	SAFE_ENC_MODULE_NR
36912	SAFE_ENC_INPUT_NR
36915	$MA_SAFE_ENC_TYPE
36916	$MA_SAFE_ENC_IS_LINEAR
36917	$MA_SAFE_ENC_GRID_POINT_DIST
36918	$MA_SAFE_ENC_RESOL
36920	$MA_SAFE_ENC_GEAR_PITCH
36921	$MA_SAFE_ENC_GEAR_DENOM[n]
36922	$MA_SAFE_ENC_GEAR_NUMERA[n]
36925	$MA_SAFE_ENC_POLARITY
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 2-8 Overview of machine data for 840C

Number	Name
4100*	Actual value assignment for safe operation
4104*	Grid spacing linear scale for safe operation
4108*	Encoder marks per rev for safe operation
4112*	Spindle pitch for safe operation
4116*	Denominator gear unit 1 Encoder/load for safe operation
4120*	Denominator gear unit 2 Encoder/load for safe operation
to	to
4144*	Denominator gear unit 8 Encoder/load for safe operation
4148*	Numerator gear unit 1 Encoder/load for safe operation
4152*	Numerator gear unit 2 Encoder/load for safe operation
to	to
4176*	Numerator gear unit 8 Encoder/load for safe operation
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 2-9 Overview of machine data for 611D

Number	Identifier
1316	$MD_SAFE_ENC_CONFIG
1317	$MA_SAFE_ENC_GRID_POINT_DIST
1318	$MA_SAFE_ENC_RESOL
1320	$MA_SAFE_ENC_GEAR_PITCH
1321	$MA_SAFE_ENC_GEAR_DENOM[n]
1322	$MA_SAFE_ENC_GEAR_NUMERA[n]
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

2.5 Safe reaction via pulse disable paths and stops

2.5.1 Pulse disable paths

Pulse disable path for pulse suppression

The drive pulses must be suppressed via two channels. The machine manufacturer needs to complete a pulse disable path in the NCK monitoring channel and another in the drive monitoring channel (see Fig. 2-7 Pulse disable path of drive CPU and Fig. 2-8 Pulse disable path of NCK CPU).

The pulse disable paths are utilized by the highest priority stop functions STOP A and STOP B with SINUMERIK Safety Integrated. These stop functions can be initiated from any monitoring channel (for example, if an active STOP C, STOP D or STOP E function has not been able to shut down the drives). It is therefore absolutely essential to ensure that the pulse disable paths operate properly (emergency anchor) and must be checked at the specified intervals (e.g. after power ON).

Pulse disable path of drive CPU

The pulse disabling test is initiated via the PLC-SGE "Test stop selection" (it can also be initiated internally in the case of an error). The SGE can be supplied by an assigned PLC HW input or by a signal (memory bit) from the PLC user program. The comparator in the drive CPU activates pulse disabling directly via the drive bus in the drive module (internal signal "Disable pulses"). The checkback signal is also output directly by the drive module via the drive bus (internal signal "Pulses disabled status). No additional wiring is required. The comparator in the drive channel is supplied via a PLC interface data block (see Section 4.4 Interface signals).

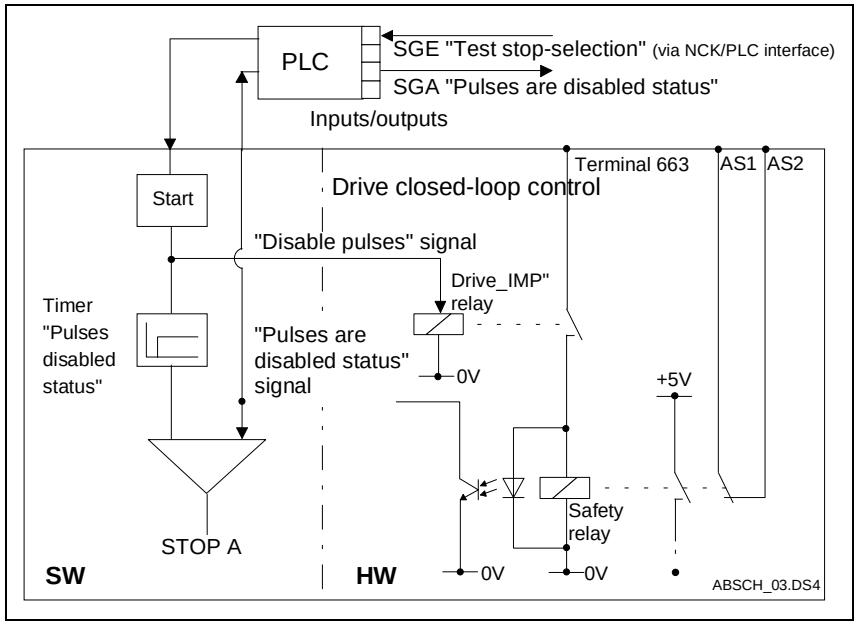

Fig. 2-7 Pulse disable path of drive CPU

Pulse disable path of NCK CPU

Pulse disabling is initiated via the NCK SGE "Test stop selection (can also be initiated internally in the case of an error). The comparator uses the SGA "Enable pulses" to cancel the enabling command at terminal 663 on the drive module. The disabled state is signalled back to the comparator in the NCK CPU via terminals AS1/AS2 of the drive module and the SGE "Pulses disabled status". The SGEs/SGAs are assigned to the NCK HW inputs/outputs via machine data.

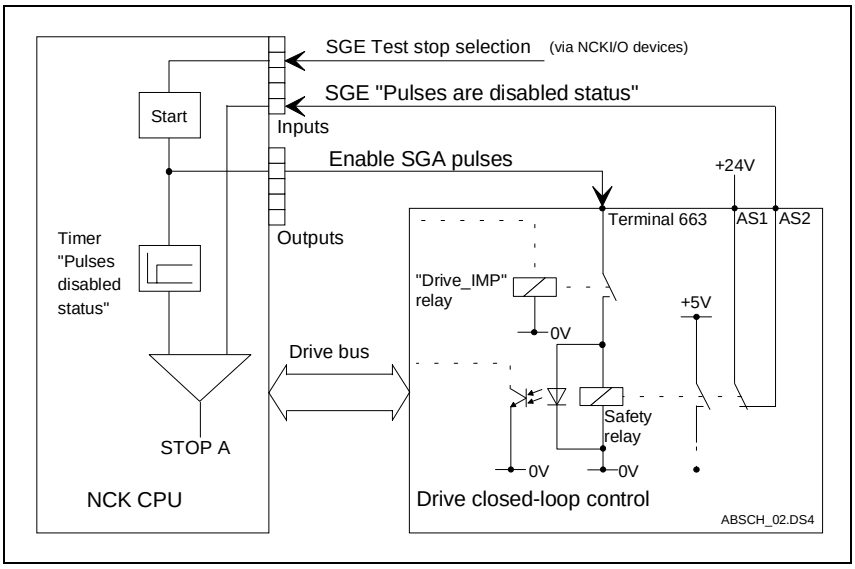

Fig. 2-8 Pulse disable path of NCK CPU

Note

To set up the pulse disable path for the NCK CPU, the machine manufacturer must provide external wiring for drive terminals 663 and AS1/AS2.

2.5.2 Testing pulse disable paths

Description

The test stop carries out a test of the entire pulse disable path plus external wiring for each monitoring channel. In the course of the test, the comparators and stop modules of the two monitoring channels that are responsible for the stop function are processed in succession.

When must a test stop be carried out?

The pulse disabling paths must be tested (forced detection of dormant errors) after the machine is switched on and thereafter in setup mode once every 8 hours at most (corresponds to safety category 3). It is advisable to carry out the test before the protective device is opened or operating personnel enter the danger area (e.g. on selection of setup mode) if the pulse disable paths have not been tested within the last 8 hours.

Note

The time "Test pulse disable path in setup mode within 8 hours" is not monitored by the system software. The machine manufacturer must create a monitor for this time period within his PLC user program and ensure that a warning is output or the test stop automatically initiated if the monitored time limit is exceeded.

Preconditions for the test stop

- All drives must be at a standstill.
- The pulses must still be enabled at the outset.
- The manufacturer must ensure that suspended axes are securely locked in the STOP position.
- When the test stop is selected, the "Pulses are disabled status" signal must not be present at the PLC SGA or the "Status pulses disabled" signal at the NCK SGE or else stop reaction STOP F will be activated.

Which SGEs/SGAs are needed for the test stop ?

The following SGEs/SGAs are needed in each monitoring channel and for each axis/spindle for the purpose of the test stop:

- For a test stop in the NCK monitoring channel:
  NCK SGE "Test stop selection“
  NCK SGE "Pulses disabled status"
  NCK SGA "Pulses enabled"
- For a test stop in the drive monitoring channel:
  PLC SGE "Test stop selection"
  PLC SGA "Pulses are disabled status“

Message

The message "Test stop in progress" is displayed on the screen while a "test stop" is being executed.

Note

To ensure that the pulse disable paths have been tested reliably, the "Test stop" must be executed twice, once for the drive and once for the NC. In this way, it can be ensured that each channel is operating correctly up to the point of pulse disabling.

On a 2-axis closed-loop control module, the pulse disable path must be tested for specific axes, i.e. for each axis on the module.

Test stop sequence

The test stop can be initiated as a hardware function, i.e. via a pushbutton, or as a software function, i.e. via a user-generated function block in the PLC user program (see Section 7 Configuring Example).

A **pulse disable** is requested in the **drive monitoring channel** (see Fig. 2-7 Pulse disable path of drive CPU) via the PLC SGE "Test stop selection". The timer "Pulses disabled status" is started and the message "Test stop in progress" is displayed on the screen. The pulse disable signal remains active until the timer has run out and the user cancels the "Test stop selection" signal at the PLC SGE. The checkback is returned via the PLC SGA "Pulses are disabled status". This checkback signal must appear before the timer started at the beginning has run out or else a "STOP A" is activated.

The PLC is able to activate the test stop in the NCK monitoring channel if the checkback signal at the PLC SGA "Pulses are disabled status" is appropriately programmed to a PLC output.
Precondition:
There is a wiring connection between this PLC output and the NCK SGE "Test stop selection".
The pulses must be enabled again before the test stop in the NCK monitoring channel is selected.

A **pulse disable** is requested in the **NCK monitoring channel** (see Fig. 2-8 Pulse disable path of NCK CPU) via the NCK SGE "Test stop selection". The timer "Pulses disabled status" is started, the NCK SGA "Enable pulses" (connected to terminal 663) output and the message "Test stop in progress" is displayed on the screen. The checkback is returned via the NCK SGE "Pulses disabled status" (arrives via terminal AS2). This checkback signal must appear before the timer started at the beginning has run out or else a "STOP A" is activated.

Testing the pulse disable paths with several axes

The test stop is executed internally in the drive monitoring channel (via the NC/PLC interface). To implement the test stop for the NCK monitoring channel, the SGEs/SGAs must be wired up appropriately for each axis.

A large number of inputs and outputs are required in the NCK for this purpose when there are several axes. It is possible to group or distribute signals using an input/output assigned via machine data (see Section 4 Data Descriptions).

To obtain the "Test stop selection" signal of a certain axis, it must be possible to evaluate the checkback signal "Pulses are disabled status" clearly for the same axis in order to be able to detect any existing errors.

Testing the pulse disable paths on a double-axis module

On a double-axis module, there is only one terminal 663 and one AS1/AS2 for both axes. The pulse disable path in the NCK and drive monitoring channels must still be tested in succession for both axes.

The following example (see Fig. 3-10 Time response on violation of limit value with active SG) shows a circuit for testing the pulse disable path of the NCK with four axes, axes 3 and 4 being provided by a double-axis module.

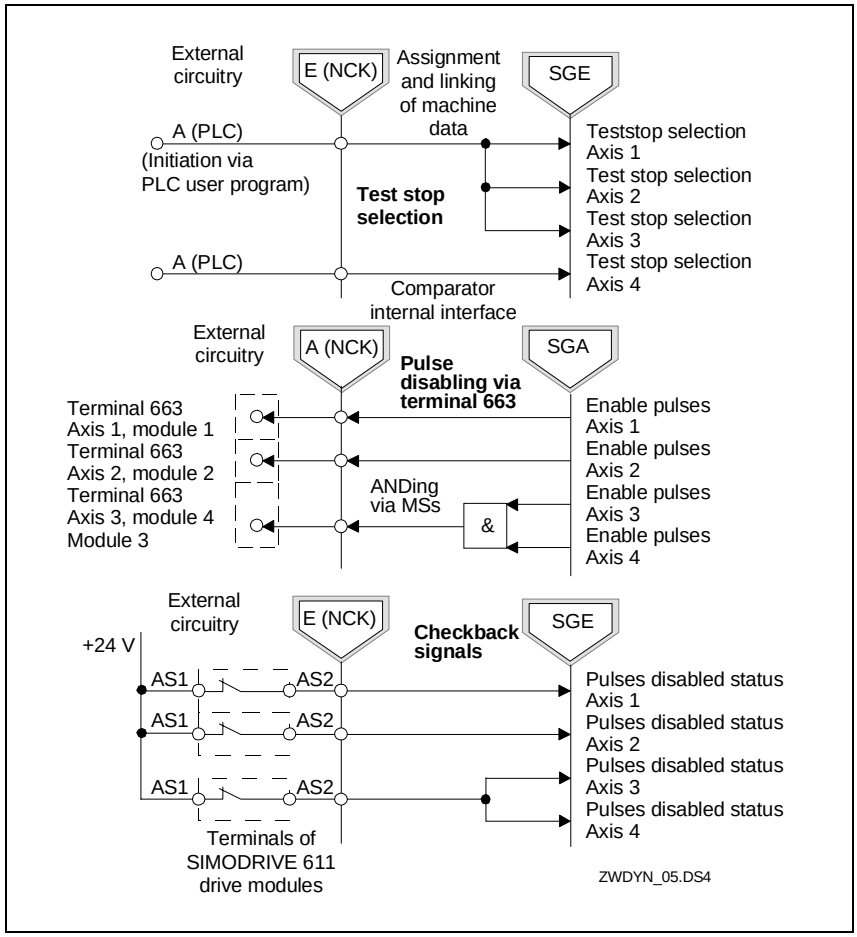

Fig. 2-9 Testing the pulse disable path (NCK monitoring channel) for several axes

To test the pulse disable path in the drive monitoring channel, it is possible to access the input and output signals of all axes from the PLC program via the PLC interface.

2.5.3 Overview of machine data for pulse disable paths

Overview of MD for 840D

Table 2-10 Overview of machine data for 840D

Number	Identifier
36957	$MA_SAFE_PULSE_DIS_CHECK_TIME
36975	$MA_SAFE_STOP_REQUEST_INPUT
36976	$MA_SAFE_PULSE_STATUS_INPUT
36986	$MA_SAFE_PULSE_ENABLE_OUTPUT
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 2-11 Overview of machine data for 840C

Number	Name
4272*	Time for testing pulse disable
4608*	Input assignment "Pulses disabled" status
4660*	Input assignment "Test stop selection"
4740*	"Enable pulses" output assignment
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 2-12 Overview of machine data for 611D

Number	Identifier
1357	$MD_SAFE_PULSE_DIS_CHECK_TIME
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

Note

The input and output assignments of the SGEs/SGAs for the drive channel are made via data blocks in the PLC user program (see Section 4.4 Interface signals).

2.5.4 Stop reactions

Description

A high degree of protection against errors is afforded by the two-channel monitoring structure with its continuous data cross-checking function. Alarms and stop reactions are the system response to the detection of differences between the two monitoring channels. The purpose of the stop reactions is to shut down the drives in a controlled manner according to the actual conditions on the machine and thus to protect the operator, machine and workpiece. There are stop reactions STOP A, B, C, D, E, F as well as the test stop. The type of stop reaction that occurs in the event of an error can either be predetermined by the system or configured by the machine manufacturer.

Note

Protection of operating personnel must be given top priority when stop reactions are configured. The objective must be to shut the spindle down as fast as possible (without the risk of parts flying around) and to prevent the axes from making uncontrolled traversing motions of more than 10 mm in distance.

Table 2-13 Overview of stop reactions

STOP	Action	Effect	Initiated in response to	Changes to	Alarm
A	Immediate disabling of pulses	Drive coasts to standstill	SBH	SH	POWER ON
B	Immediate input of 0 speed setpoint + start timer t_B t_B =0 or $n_{act} < n_{disable}$: ⇨ STOP A	Drive is braked along current limit Transition to STOP A	SBH	SH	POWER ON
C	Immediate input of 0 speed setpoint + start timer t_C t_C =0: ⇨ Activation of SBH monitoring	Drive is braked along current limit SBH monitoring active On 840C: Cancellation of mode group ready signal	SG/SE	SBH	RESET
D	Brake motor along acceleration limit + start timer t_D t_D =0: ⇨ Activation of SBH	Drive is braked in combination along set traversing path SBH monitoring active	SG/SE	SBH	RESET
E	ESR (840C) is activated + start timer t_E t_E =0: ⇨ Activation of SBH monitoring	Drive combination is shut down in best possible way SBH monitoring active	SG/SE	SBH	RESET
F	Depending on situation: **a)** Safety monitoring **inactive**: Maintained message to operator **b)** Safety monitoring **active**: Initiation of STOP B/A (configurable) **c)** Safety monitoring **active** and initiation of **STOP C, D or E:** Maintained message to operator	**a)** NC start and traversing lockout **b)** Transition to STOP B/A **c)** NC start and traversing lockout	Data cross-check	SH	**a)** RESET **b)** POWER ON **c)** RESET
Note: The timers can be set in machine data. 1) Available only on SINUMERIK 840C					

Stop reactions SBH and SH

The following diagram shows the relationship between the stop reactions and the safe operational stop (SBH) or the safe standstill (SH).

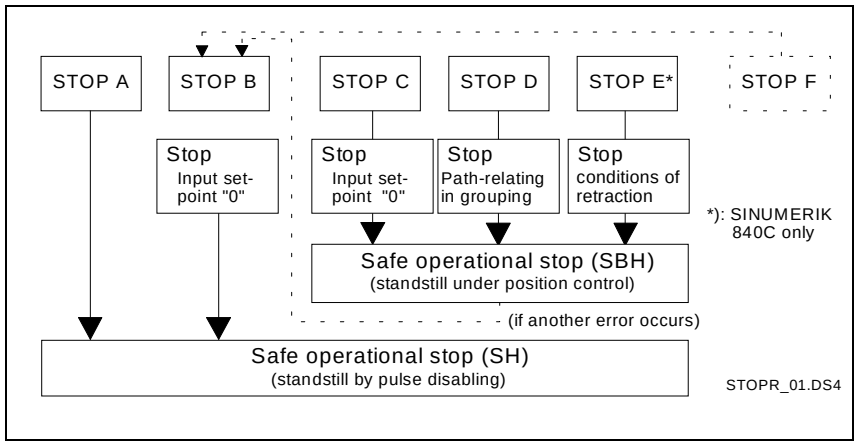

Fig. 2-10 Stop reactions, safe operational stop (SBH), safe standstill (SH)

Configurable stop reactions

The stop reactions that occur in response to the violation of the limit values of safety functions SBH, SG, SE and SN defined in machine data can be selected as follows via machine data by the machine manufacturer:

Table 2-14 Configurable stop reactions

Safe function	Configurable stop reactions
SBH	STOP A or B
SG	STOP C,D or E
SE	STOP C,D or E
SN	No internal stop reaction. The user must configure appropriately safe reactions via the SGAs SN1 - SN4.
Note: Stop reaction STOP F is the predefined system response to discrepancies detected by the data cross-check.	

Assignment table for stop reactions

Table 2-15 Stop reactions provided by SINUMERIK Safety Integrated to EN 60204-1

Stop reaction provided by SINUMERIK Safety Integrated	Stop function to EN 60204-1
STOP A	Category 0
STOP B, STOP F [1)]	Category 1
STOP C, STOP D, STOP E	Category 2
Note: 1): STOP F triggers STOP B if at least one safety function is active.	

Priority of stop reactions

Table 2-16 Stop reaction priorities

Priority level	Stop reaction
Highest priority	STOP A
. . . . .	STOP B
. . . . .	SGE test stop selection
. . . . .	STOP C
. . .	STOP D
.	STOP E
Lowest priority	STOP F

Note

- The stop reactions listed in Table 2-16 "Stop reaction priorities" can be initiated only if at least one safety function is active (except for STOP F).
- Once a stop reaction has occurred, the sequence of operations it involves will be carried out, even if the cause of the stop no longer exists.
- It is possible to proceed to higher-priority stop reactions, but not to reactions of a lower priority.
- Please refer to Section 2.5.1 Pulse disable paths for an explanation of how to use the SGE test stop selection.

Internal response to stop reactions

If a stop reaction is initiated in the drive, a signal is sent to the NC that responds by initiating the same stop reaction (two-channel safety). Likewise, if a stop reaction is initiated in the NC, the drive is automatically informed and responds by requesting the same stop reaction (exception: Test stop).

This mechanism ensures that stop reactions are managed with a high degree of safety.

Description of STOP A

Action in drive monitoring channel:
Immediate disabling of pulses via the internal signal "Disable pulses" (see Section 2.5.1 Pulse disable paths). In addition, the pulses in the trigger set are disabled by a software function.

Action in NCK monitoring channel:
Disabling of pulses via the SGA "Enable pulses" (must be connected to drive terminal 663 (pulse enable).

Effect:

The drive coasts to a standstill if no external braking mechanism such as an armature short-circuit and/or holding brake is used. The axial alarm results in a mode group stop, i.e. as the result of the error in one axis, all axes and spindles in a mode group are shut down. "Safe standstill" becomes operative at the end of STOP A.

Alarm message:

The alarm message "STOP A active" is displayed.

Acknowledgement:

The drive cannot be restarted unintentionally after a STOP A because the error can only be acknowledged by a drive and control system POWER ON.

Description of STOP B

Action in drive and NCK monitoring channels:
The drive is braked along the current limit as the result of a 0 speed setpoint that is input instantaneously either directly or from the NCK via the drive bus.

Action in drive monitoring channel:
If the speed actual value drops below the value set in $MD_SAFE_STANDSTILL_VELO_TOL or if the timer set in $MD_SAFE_PULSE_DISABLE_DELAY has expired, the stop mode changes automatically to STOP A.

Action in NCK monitoring channel:
Analogous to the drive channel, the stop mode changes automatically to STOP A when the actual speed drops below the value in $MA_SAFE_STANDSTILL_VELO_TOL (840D) or "Creep speed pulse disabling" (840C) or on expiry of the timer set in $MA_SAFE_PULSE_DISABLE_DELAY (840D) or "Delay time pulse disable" (840C).

Effect: The drive is braked along the current limit under speed control and finally brought to a safe standstill.

Alarm message: The alarm message "STOP B active" is displayed.

Acknowledgement: If the cause is not eliminated, another error message is output. The drive cannot be started unintentionally after a STOP B since the error can only be acknowledged by a drive and control system POWER ON.

Note

If the timer in machine data $MA_SAFE_PULSE_DISABLE_DELAY (840D) or "Delay time pulse disable" (840C) is set to zero, then the stop mode switches immediately from STOP B to STOP A.

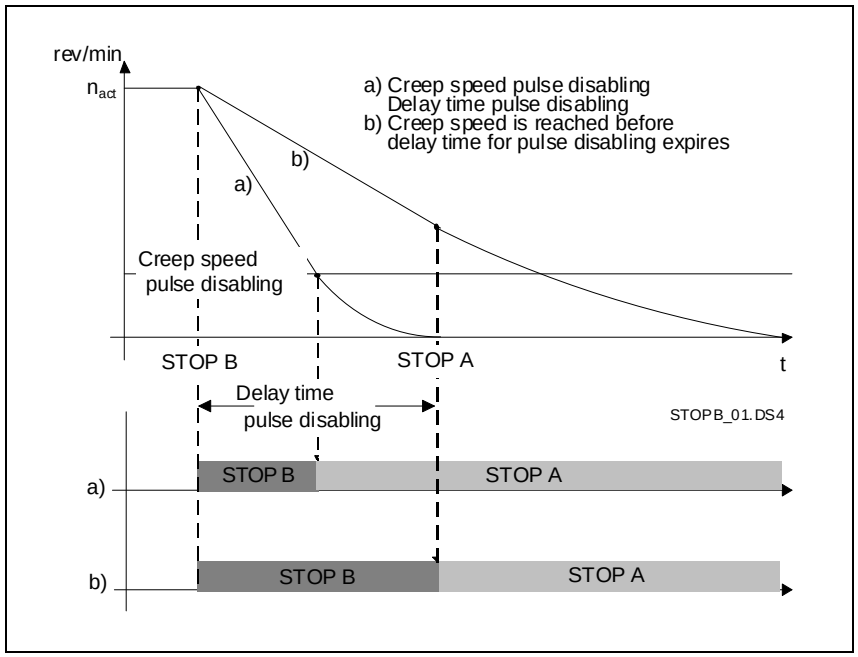

Fig. 2-11 Transition from STOP B to STOP A

Description of STOP C

Action in drive monitoring channel:
The drive is braked along the current limit in response to a zero speed setpoint while the timer set in $MD_SAFE_STOP_SWITCH_TIME_C is started in parallel. On expiry of the timer, the SBH function is automatically activated.

Action in NCK monitoring channel:
Analogous to the drive channel, the control specifies a zero speed setpoint and interface signal “Position controller active” (DB 31, ... DBX 61.5) set to zero (only the affected drive in 840D, all drives in the mode group in 840C). At the same time, the timer set in $MA_SAFE_STOP_SWITCH_TIME_C (840D) or "Transition time STOP C to safe operational stop" (840C) is started. As soon as the timer expires, the SBH function is automatically activated.

Effect: The drive is braked along the current limit under speed control and finally brought to a safe standstill.

Alarm message: The alarm message "STOP C active" is displayed (see Section 6 Alarms).

Acknowledgement: The drive cannot be started unintentionally after a STOP C. The error can be acknowledged by the NC RESET key

Note for SINUMERIK 840C

The "Mode group ready" signal is cancelled with in the STOP C mode, i.e. the controller enabling command for all axes in the mode group is cancelled.

Description of STOP D

Action in drive monitoring channel:
The drive monitoring channel requests "Path stop" or "Brake along acceleration curve (NC-MD)". The timer set in $MD_SAFE_STOP_SWITCH_TIME_D is started at the same time. The SBH function is automatically activated on expiry of the timer.

Action in NCK monitoring channel:
Analogous to the drive channel, the control system monitoring channel requests "Path stop" or "Brake along acceleration curve (NC_MD)". The timer set in $MA_SAFE_STOP_SWITCH_TIME_D (840D) or "Transition time STOP D to safe operational stop" (840C) is started. The SBH function is automatically activated on expiry of the timer.

Effect: The drive is braked in combination including simultaneous axes along the set traversing path. Endlessly turning axes are braked along the acceleration limit. The SBH function is automatically activated on expiry of the timer.

Alarm message: The alarm message "STOP D active" is displayed.

Acknowledgement: The drive cannot be unintentionally started after a STOP D. The error can be acknowledged with the NC-RESET key

Description of STOP E (available only on 840C)

Action in drive monitoring channel:
The drive monitoring channel requests “Extended stopping and retraction, ESR”. The timer “STOP E transition time to safe operational stop” is started at the same time. When the timer setting has expired, the SBH function is automatically activated.

Action in NCK monitoring channel:
Analogous to the response in the drive channel, the control monitoring channel requests “Extended stopping and retraction, ESR”. The timer “Transition time STOP E to safe operational stop” is started at the same time. The SBH function is automatically activated on expiry of the timer setting.

References: /IAC/, SINUMERIK 840C Installation and Start-Up Guide

Effect: The drive combination is brought to a standstill under position control and finally switched to the safe operational stop state.

Alarm message: The alarm message "STOP E active" is displayed.

Acknowledgement: The drive system cannot be restarted unintentionally after a STOP E. The error can be acknowledged with the NC-RESET key.

Description of STOP F The STOP F reaction is permanently assigned to the result and data cross-check function. Dormant errors in the drive and control systems are detected.

Effect: The system reactions to the detection of a discrepancy between the drive and NCK monitoring channels are as follows:

Reaction if no safety functions are active: Dormant errors are detected even if there is no safety function active. The maintained message "Defect in a monitoring channel" is output on both the drive and control sides and can only be acknowledged by means of the NC-RESET key. The message does not cause any processing routines to be aborted. A system restart is prevented by an internal NC start/traversing lockout.

Reaction if one safety function is active: Dormant errors are detected. A STOP B/A reaction is initiated in the drive and control system (see description of STOP B).
Exception: If a STOP C/D/E is already active.
(see Table 2-14 Configurable stop reactions).

Alarm message: The alarm "Defect in a monitoring channel" is displayed. An entry is made in the following machine data for fine decoding of errors

Table 2-17 Machine data for error fine decoding with STOP F

MD number	Control	Meaning
-	840D	On the 840D system, the error code is displayed when the alarm is output.
301	840C	Diagnosis for STOP F
1395	611D	$MD_SAFE_STOP_F_DIAGNOSIS
Note: The meaning of the error codes can be found in Section 6.1 Alarms for SINUMERIK 840D or in Section 6.2 Alarms for SINUMERIK 840C under alarm "Defect in a monitoring channel".		

Acknowledgement: The maintained alarm can be reset with the NC-RESET key. The drive cannot be restarted unintentionally after a STOP B/A since the error can only be acknowledged by a drive and control system POWER ON.

2.5.5 Overview of machine data for stop reactions

Overview of MD for 840D

Table 2-18 Overview of machine data for 840D

Number	Identifier
36952	$MA_SAFE_STOP_SWITCH_TIME_C
36953	$MA_SAFE_STOP_SWITCH_TIME_D
36954	$MA_SAFE_STOP_SWITCH_TIME_E
36956	$MA_SAFE_PULSE_DISABLE_DELAY
36960	$MA_SAFE_STANDSTILL_VELO_TOL
36961	$MA_SAFE_VELO_STOP_MODE
36962	$MA_SAFE_POS_STOP_MODE
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 2-19 Overview of machine data for 840C

Number	Name
4276*	Transition time from STOP C to safe operational stop
4280*	Transition time from STOP D to safe operational stop
4284*	Transition time from STOP E to safe operational stop
4268*	Delay time pulse disable
4288*	Creep speed pulse disabling
4508* bit 5	Stop reaction safe speed
4508* bit 4	Stop reaction safe speed
4508* bit 3	Stop reaction safe limit positions
4508* bit 2	Stop reaction safe limit positions
301	Diagnosis for STOP F
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 2-20 Overview of machine data for 611D

Number	Identifier
1352	$MD_SAFE_STOP_SWITCH_TIME_C
1353	$MD_SAFE_STOP_SWITCH_TIME_D
1354	$MD_SAFE_STOP_SWITCH_TIME_E
1356	$MD_SAFE_PULSE_DISABLE_DELAY
1360	$MD_SAFE_STANDSTILL_VELO_TOL
1361	$MD_SAFE_VELO_STOP_MODE
1362	$MD_SAFE_POS_STOP_MODE
1395	$MD_SAFE_STOP_F_DIAGNOSIS
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

2.5.6 Safe braking ramp (SBR) (840D from SW4.2, 840C from SW6.1)

Description

This function operates on the assumption that the actual speed must decrease after a Stop request (speed characteristic monitoring).

Note

Re: 840D/611D:
The function is available in both monitoring channels and must also be parameterized in both channels.

Re: 840C/611D:
The function is available in only one channel, i.e. the drive monitoring channel. However, it must be parameterized in both channels.

Characteristics of function

The main characteristics of this function are as follows:

- Fastest possible detection of re-acceleration of the axis during the braking process
- SBR monitoring is automatically activated when
  - a STOP B or C has been activated
- A STOP A is activated when the SBR monitoring responds

Activation of SBR monitoring function

When a stop request is output, the current speed plus a speed tolerance set via machine data are activated as a speed limit. This limit is compared cyclically with the actual speed (must remain the same or lower) and corrected. The monitor can therefore respond promptly if the axis starts to accelerate again during the braking operation.

Machine data for the SBR speed tolerance:

On 840D MD 36948: $MA_SAFE_STOP_VELO_TOL
(actual speed tolerance for SBR)

On 840C MD 4296*: Actual speed tolerance for SBR

On 611D MD 1348: $MD_SAFE_STOP_VELO_TOL

The speed limit values are corrected until the speed drops below the value entered in the following machine data. The limit is then frozen at the value set in MD 36946/1346 or MD 4292*/1346 plus the value set in MD 36948/1348 or MD 4296*/1348.

On 840D MD 36946: $MA_SAFE_VELO_X (speed limit n_x)

On 840C MD 4292*: (speed limit n_x)

On 611D MD 1346: $MD_SAFE_VELO_X

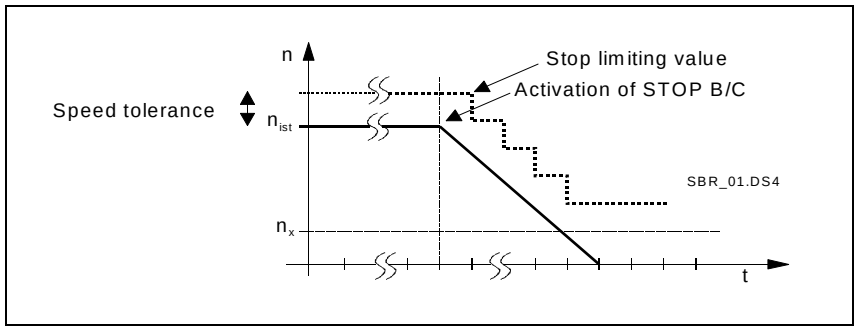

Fig. 2-12 Characteristic of stop limiting value for SBR

Deactivation of SBR monitoring function

The SBR monitoring function is deactivated by setting the maximum value in MD 36948/1348: $MA_/$MD_SAFE_STOP_VELO_TOL or 4296*/1348 (actual speed tolerance for SBR).

Calculation of actual speed tolerance for SBR (at 840D and 840C)

Please note the following when parameterizing the SBR tolerance:

The potential increase in speed after activation of a STOP B/C is determined by the effective acceleration rate and the period of acceleration. The period of acceleration corresponds to one position control cycle (PCC) (delay between detection of STOP B/C and $n_{set} = 0$):

SBR tolerance
Actual speed for SBR = Acceleration * Acceleration period

The following rules for setting therefore apply:

On linear axis:
SBR tolerance [mm/min] = a [m/s^2] * PCC [s] * 1000 [mm/m] * 60 [s/min]

On rotary axis/spindle:
SBR tolerance [rev/min] = a [rev/s^2] * PCC [s] * 60 [s/min]

a: Acceleration
PCC: Position control cycle

The following machine data settings must be taken into account in calculating the rate of acceleration:

On 840D
MD 32300: MAX_AX_ACCEL
MD 35200: GEAR_STEP_SPEEDCTRL_ACCEL
MD 35210: GEAR_STEP_POSCTRL_ACCEL
MD 35410: SPIND_OSCILL_ACCEL

at 840C:
MD 276*, 3364* to 3388*

Recommendation:
The value entered for SBR tolerance should be about 20% higher than the calculated value.

Caution

Speed overshoots must not cause the SBR monitoring to respond involuntarily in “normal” operation. Measurements must be taken to determine the level of overshoot.

2.5.7 Overview of machine data for SBR function

Overview of MD for 840D

Table 2-21 Overview of machine data for 840D

Number	Identifier
36948	$MA_SAFE_STOP_VELO_TOL
32300	$MA_MA_AX_ACCEL
35200	$MA_GEAR_STEP_SPEEDCTRL_ACCEL
35210	$MA_STEP_POSCTRL_ACCEL
35410	$MA_SPIND_OSCILL_ACCEL
Note: These data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 2-22 Overview of machine data for 840C

Number	Name
4296*	Actual speed tolerance for SBR
276*	Acceleration
3364*	Acceleration, parameter set 2
3368*	Acceleration, parameter set 3
3372*	Acceleration, parameter set 4
3376*	Acceleration, parameter set 5
3380*	Acceleration, parameter set 6
3384*	Acceleration, parameter set 7
3388*	Acceleration, parameter set 8
Note: These data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 2-23 Overview of machine data for 611D

Number	Identifier
1348	$MD_SAFE_STOP_ VELO_TOL
Note: These data are described in Section 4.3 Machine data for SIMODRIVE 611D	

2.6 System requirements

Requirements of SINUMERIK 840D with SIMODRIVE 611D

The hardware and software requirements are as follows:

- Drive modules with 611D performance closed-loop control
  MLFB: 6SN1118-0DG23-0AA0 1-axis version, voltage signals
  MLFB: 6SN1118-0DH23-0AA0 2-axis version, voltage signals
  Performance closed-loop control, 1-axis or 2-axis version, each with additional measuring system for direct position sensing with voltage signals
- Indirect (1-encoder system) or direct measuring system (2-encoder system) Incremental encoder, absolute encoder (see Section 2.4.1 Encoder types)
- NCK I/O devices (NCU terminal block) and PLC I/O devices (S7 I/O) for the safety-relevant input/output signals (SGEs/SGAs)
- Applies to SN: The axis must not be an endlessly turning rotary axis (this condition no longer applies with SW 4.2 and higher)
- Applies to SE and SN:
  - The 2-encoder system must be configured for suspended axes (this condition no longer applies when the Performance closed-loop control module, version B or later, is used).
  - The axis must not be a rotary axis with indexing mechanism.
  - SE and SN cannot be configured for an OP030 (without MMC100/MMC102).
- Software version with SINUMERIK Safety Integrated (SW 3.4 and higher)
- Safety Integrated option

Requirements of SINUMERIK 840C with SIMODRIVE 611D

The hardware and software requirements are as follows:

- Drive modules with 611D performance closed-loop control
  MLFB: 6SN1118-0DG23-0AA0 1-axis version, voltage signals
  MLFB: 6SN1118-0DH23-0AA0 2-axis version, voltage signals
  Performance closed-loop control, 1-axis or 2-axis version, each with additional measuring system for direct position sensing with voltage signals
- Indirect (1-encoder system) or direct measuring system (2-encoder system) Incremental encoder, absolute encoder (see Section 2.4.1 Encoder types)
- NCK I/O devices (CSB module, mixed I/O module 1/2) and PLC I/O devices (S5 I/O module) for the safety-relevant input/output signals (SGEs/SGAs)
- Applies to SE and SN:
  - The 2-encoder system must be configured for suspended axes (this condition no longer applies when the Performance closed-loop control module, version B or later, is used).
  - The axis must not be an endlessly rotating axis.
  - The axis must not be a rotary axis with indexing mechanism.
- Software version with SINUMERIK Safety Integrated (SW 5.4 and higher)
- Safety Integrated option

2.7 Switching the control system on and off

What to remember when switching on the control

The safety functions are available and ready to be activated only after the control system has powered up fully.

We recommend that you select the "Safe operational stop" (SBH) function.

Warning

The safety functions are not active while the control system is powering up. The operator may not enter any protection zones during this period.

After the control has been switched on

the pulse disable paths must be tested (see Section 2.5 Safe reaction via pulse disable paths and stops).

What to remember when switching off control?

- The position at which axes with safety functions reach a standstill is stored in a non-volatile memory when safe operational stop (SBH) is selected. On axes configured with SE and SN, the position data is used for an internal position checked when the system is switched on again.
- The following applies when SE/SN is active:
  The standstill position is also stored cyclically. For this reason, the user should only switch off the control when the axes/spindles with safety functions have stopped moving.

Note

If the axis is moved while the control is switched off, the stored standstill position is no longer the same as the current position. In such cases, when the control is switched on again, user agreement must again be given after the position check for axes with safety functions SE and SN.

2.8 Error analysis

Monitoring functions

The SINUMERIK 840D, SINUMERIK 840C and SIMODRIVE 611D are equipped with various monitoring functions (see documentation for relevant control system) that detect system errors and initiate appropriate reactions. These standard functions do not comply with safety category 3 according to EN 954-1.

The safety functions provided by the SINUMERIK Safety Integrated option that are based on data cross-checks and forced detection of dormant errors are capable of detecting system errors and of rendering the machine safe (see Section 2.5 Safe reaction via pulse disable paths and stops).

Error analysis

A detailed error analysis function based on directives and standards has been carried out with SINUMERIK Safety Integrated. The following summary of this analysis shows which of the disturbances and system errors that have been experienced to date can be controlled by SINUMERIK Safety Integrated with no or very little residual risk.

Table 2-24 Error analysis in setup mode

Assumed error	Error causes	Counteraction	MDIR, App. 1	Remarks
Spindle speed too high	Defect in drive or control system, encoder fault in 2-encoder operation, operator error on control system, or similar cause	Safe limitation of speed or axis velocity with SG function; configurable stop function according to Cat. 2	Section 1.2.4 Section 1.2.7 Section 1.3.6	According to currently applicable standards (TC143), the SG function is technology-dependent, permissible only in combination with agreement, JOG mode, start button and emergency stop
Axis velocity too high				According to currently applicable standards (TC143), the SG function is technology-dependent, permissible only in combination with JOG mode, start button and emergency stop
Axis or spindle has illegally moved away from standstill position	Defect in drive or control system, operator error on control system, or similar cause	Safe zero speed monitoring for position control with SBH; Configurable stop function Cat. 0/1	Section 1.2.6 Section 1.2.7 Section 1.3.6 Section 1.4.2 Section 1.4.3	Low-wear, safe disconnection of power supply to drive, function does not replace machine main switch with respect to electrical isolation
		Safe standstill with SH Stop function Cat. 0		
Axes have illegally exited operating area	Defect in drive or control system, operator error on control system, or similar cause	Safe monitoring of absolute position with SE; configurable stop functions according to Cat. 2	Section 1.2.4 Section 1.2.7 Section 1.3.7 Section 1.3.8	Main purpose is to protect machine, can also be used to delimit working area in connection with operator protection
Reaction of machine control to erroneous position signal	Defect in control system, operator error on control system, or similar cause	Safe monitoring of absolute position with SN; safe signal and position data output	Section 1.2.4 Section 1.2.7 Section 1.3.8 Section 1.4.2 Section 1.4.3	Wear-free, safe cams, for reliable acquisition of axis positions, can be used to separate areas
Error on the input/output of process data	Defective line, faulty information, or similar cause	Two-channel input/output of safety-relevant signals (SGE/SGA), data cross-check; initiation of stop functions according to Cat. 1	Section 1.2.5 Section 1.3.8 Section 1.4.2 Section 1.4.3	External two-channel inputs or further processing required if function is intended to protect operating personnel

Table 2-25 Error analysis in test mode

Assumed error	Error causes	Counteraction	MDIR, App. 1	Remarks
Spindle speed too high	Defect in drive or control system, encoder fault in 2-encoder operation, operator error on control system, part program error, or similar cause	Safe limitation of speed or axis velocity with SG; configurable stop functions according to Cat. 2	Section 1.2.4 Section 1.2.7 Section 1.3.6	According to currently applicable standards (TC143), the SG function is technology-dependent, permissible only in combination with agreement, JOG mode, start button and emergency stop
Axis velocity too high				According to currently applicable standards (TC143), the SG function is technology-dependent, permissible only in combination with JOG mode, start button and emergency stop
Axis or spindle has illegally moved away from standstill position	Defect in drive or control system, operator error on control system, part program error, or similar cause	Safe zero speed monitoring for position control with SBH; configurable stop function according to Cat. 0/1	Section 1.2.6 Section 1.2.7 Section 1.3.6 Section 1.4.2 Section 1.4.3	Low-wear, safe disconnection of power supply to drive to allow manual intervention in danger area; function does not replace machine main switch with respect to electrical isolation
		Safe standstill with SH Stop function Cat. 0		
Axes have illegally exited operating area	Defect in drive or control system, operator error on control system, part program error, or similar cause	Safe monitoring of absolute position with SE; configurable stop functions according to Cat. 2	Section 1.2.4 Section 1.2.7 Section 1.3.7 Section 1.3.8	Wear-free, safe limit switches, main purpose is to protect machine, can also be used to delimit working area in connection with operator protection
Reaction of machine control to erroneous position signal	Defect in drive or control system, operator error on control system, part program error, or similar cause	Safe monitoring of absolute position with SN; safe signal and position data output	Section 1.2.4 Section 1.2.7 Section 1.3.8 Section 1.4.2 Section 1.4.3	Wear-free, safe cams, for reliable acquisition of axis positions, can be used to separate areas
Error on the input/output of process data	Defective line, faulty information, or similar cause	Two-channel input/output of safety-relevant signals (SGE/SGA), data cross-check; initiation of stop functions according to Cat. 1	Section 1.2.5 Section 1.3.8 Section 1.4.2 Section 1.4.3	External two-channel inputs or further processing required if function is intended to protect operating personnel

Table 2-26 Error analysis in automatic mode

Assumed error	**Error causes**	**Counteraction**	**MDIR, App. 1**	**Remarks**
Spindle speed or axis velocity too high	Defect in drive or control system, encoder fault in 2-encoder operation, operator error on control system, part program error, or similar cause	Safe limitation of speed or axis velocity with SG; configurable stop functions according to Cat. 2	Section 1.2.4 Section 1.2.7 Section 1.3.6	According to currently applicable standards (TC143), the SG function is permissible only in conjunction with effective protective devices (e.g. protective doors)
Axis or spindle has illegally moved away from standstill position	Defect in drive or control system, operator error on control system, part program error, or similar cause	Safe zero speed monitoring for position control with SBH; configurable stop function according to Cat. 0/1	Section 1.2.6 Section 1.2.7 Section 1.3.6 Section 1.4.2 Section 1.4.3	Low-wear, safe disconnection of power supply to motor to allow manual intervention in danger area (safe location); function does not replace machine main switch with respect to electrical isolation
		Safe standstill with SH Stop function Cat. 0		
Axes have illegally exited operating area	Defect in drive or control system, operator error on control system, part program error, or similar cause	Safe monitoring of absolute position with SE; configurable stop functions according to Cat. 2	Section 1.2.4 Section 1.2.7 Section 1.3.7 Section 1.3.8	Wear-free, safe limit switches, main purpose is to protect machine, can also be used to delimit working area in connection with operator protection
Reaction of machine control to erroneous position signal	Defect in drive or control system, operator error on control system, part program error, or similar cause	Safe monitoring of absolute position with SN; safe signal and position data output	Section 1.2.4 Section 1.2.7 Section 1.3.8 Section 1.4.2 Section 1.4.3	Wear-free, safe cams, for reliable acquisition of axis positions, can be used to separate areas
Error on the input/output of process data	Defective line, faulty information, or similar cause	Two-channel input/output of safety-relevant signals (SGE/SGA), data cross-check; initiation of stop functions according to Cat. 1	Section 1.2.5 Section 1.3.8 Section 1.4.2 Section 1.4.3	External two-channel inputs or further processing required if function is intended to protect operating personnel

Table 2-27 General error analysis

Assumed error	Error causes	Counteraction	MDIR, App. 1	Remarks
Error has not been detected because function is not active	Defect in drive or control system, or similar cause	Time-controlled request or automatic execution of forced detection or dormant errors and data cross-check, initiation of stop functions acc. to Cat. 0	Section 1.2.7	Forced detection of dormant errors must be supported by user as a function of the process
Incorrect safety-related machine data (MD)	Faulty information, unintentional operator error, or similar cause	Visual check with transfer softkeys, data cross-check, checksum generation, initiation of stop functions according to Cat. 0/1	Section 1.2.7	Must be confirmed by acceptance test during start-up
Incorrect absolute position of axis or spindle	Incorrect information, axis incorrectly referenced, or similar cause	User agreement after referencing or power ON	Section 1.2.7 Section 1.3.8	Encoder must be assigned to machine zero point during start-up

The counteractive measures (tables) generally comply with safety category 3 according to EN 954-1. They are devised such that the safety requirements stipulated in Machinery Directive 89/392/EEC (column headed MDIR, App. 1) can be implemented simply and economically.

Topics of section headings of MDIR, App. 1

1.2.4 Stopping, normal stopping and stopping in emergency

1.2.5 Mode selection

1.2.6 Failure of power supply

1.2.7 Failure of control circuit

1.3.6 Risks relating to variations in rotational speed of tools

1.3.7 Preventing risks relating to moving parts

1.3.8 Choice of protection against risks related to moving parts

1.4.2 Special requirements of isolating protective equipment

1.4.3 Special requirements of non-isolating protective equipment

Residual risk

As a result of the error analysis, the machine manufacturer is in the position to determine the residual risk on his machine with respect to the control system. The following residual risks are known:

- SINUMERIK Safety Integrated is not active until the control system and drive have fully powered up. SINUMERIK Safety Integrated cannot be activated if any one of the components of the control or drive is not switched on.
- Faults in the absolute track (C-D track), cyclically interchanged phases of motor connections (V-W-U instead of U-V-W) and a reversal in the control direction can cause an increase in the spindle speed or acceleration of axis motion. The category 1 and 2 STOP functions according to EN 60204-1 (defined as STOPS B to E in Safety Integrated) that are provided do not, however, take effect in response to the error. The category 0 stop function according to EN 60204-1 (defined as STOP A in Safety Integrated) is not activated until the transition or delay time set via machine data has expired.

When SBR is active, these errors are detected (STOP B/C) and the category 0 stop function according to EN 60204-1 (A in Safety Integrated system) is activated as early as possible irrespective of this delay (see Section 2.5.6 “Safe braking ramp”). Electrical faults (defective components etc.) can also result in the response described above.

- When incremental encoders are used, the axis/spindle must be properly referenced for the safe limit positions (SE) and safe cams (SN) functions to operate reliably.
- When no user agreement has been given (see Section 2.3.5 User agreement), the safe end positions (SE) are not operative; the safe cams are operative, but not reliable as defined by Safety Integrated.
- The simultaneous failure of two power transistors in the inverter may cause the axis to move briefly (motion dependent on number of pole pairs of motor).
  Example:
  A 6-pole synchronous motor can cause the axis to move by a maximum of 30 degrees. With a leadscrew that is directly driven by, e.g. 20 mm per revolution, this corresponds to a maximum linear motion of approximately 1.6 mm.
- With a 1-encoder system, encoder faults are detected at one channel only, but by various HW and SW monitoring functions. These monitors may not be deactivated and must be parameterized carefully. Depending on the error type and which monitor responds, a category 0 or category 1 stop function according to EN 60204-1 (defined as STOP A or B in Safety Integrated) is activated.
- The category 0 stop function according to EN 60204-1 (defined as STOP A in Safety Integrated) means that the spindles/axes are not braked to zero speed, but coast to a stop (this may take a very long time depending on the level of kinetic energy involved). This must be noted, for example, when the protective door locking mechanism is opened.
- When a limit value is violated, the speed may exceed the set value briefly or the axis/spindle overshoot the setpoint position to a greater or lesser degree during the period between error detection and system reaction depending on the dynamic response of the drive and the parameter settings (see Section 3 Safe Functions).
- A position-controlled axis may be forced out of the safe operational stop state (SBH) by mechanical forces that are greater than the axis torque. In such cases, a safe standstill (SH) is activated.
- SINUMERIK Safety Integrated is not capable of detecting errors in parameterization and programming made by the machine manufacturer. The required level of safety can only be assured by thorough and careful acceptance testing.
- Drive power modules and motors must always be replaced by the same equipment type or else the parameters will no longer match the actual configuration and cause SINUMERIK Safety Integrated to respond incorrectly. The machine must be re-measured after an encoder replacement.

2.9 Miscellaneous

2.9.1 General notes

Parking an axis

The pulse enabling command must be cancelled via drive terminal 663 before the park state is activated (via interface signal "Park"). This can be done by means of the NCK-SGE "Test stop selection" (the message "Test stop active" is then displayed). The pulse enable signal may not be applied again until the park state has been deselected.

Vertical axis

The machine manufacturer must take various measures (see Section 2.6 System requirements) to prevent vertical axes from dropping when the safe standstill function is activated (e.g. after STOP B/A).

Measuring system switchover on 840D and 840C

When the measuring systems are switched over via interface signals
“Position measuring system 1“ (DB 31..., DBX1.5) on 840D
“Position measuring system 2“ (DB 31..., DBX1.6)
or
“Measuring system 1, 2“ (DB 32, D(K+2) Bit 12) on 840C,
the following applies:

Note

The encoder with which the position control is operating is switched over. However, the Safety Integrated system continues to operate with the parameterized encoder.

Gantry axes on 840D and 840C

Stop reaction STOP D should be configured for gantry axes with Safety Integrated since STOP C can cause an illegal deviation in the current positions of the axes in the gantry grouping.

Note

Depending on the specific application (e.g. end position monitoring), it may be necessary to stop the gantry axes as quickly as possible with STOP C.

2.9.2 Information for OEM users

SINUMERIK 840D:

Information for MMC-OEM users

Please note the following if you are intending to use SINUMERIK Safety Integrated (SI) in combination with OEM applications (on MMC):

!

Important

1. Writing PLC interface signals using the Variable service
   PLC interface signals (DB31, ...) with safety-related inputs and outputs for drives must not be written using the Variable service of the NCDDE server.
2. Writing machine data using the Variable service
   An acceptance test must be carried out if SI machine data are modified by means of the Variable service of the NCDDE server.
3. Changing alarm priorities
   The alarm priorities selected for SINUMERIK Safety Integrated must not be changed.
4. Modifying alarm texts
   The alarm texts of SI alarms may be modified. Modifications of this type must be clearly documented for the user's purposes.
5. "Carry out acceptance test" message box
   The "Carry out acceptance text" message box must not be modified!
6. User agreement
   Functions relating to user agreement (e.g. call, protection mechanism) must not be altered.

SINUMERIK 840C: Information for MMC-OEM users

Please note the following if you are intending to use SINUMERIK Safety Integrated (SI) in combination with OEM applications (Windows and Flexos variants):

!

Important

1. Writing PLC interface signals by means of i codes
   The PLC interface signals for SGEs/SGAs (DB 28) must not be written or influenced via i codes.
2. Writing machine data by means of i codes
   If SI machine data are accidentally modified by means of i codes, the input is either rejected or interpreted as an error because special sequences have not been observed.
   When i codes are intentionally used to modify SI machine data, the modified data must be acceptance-tested!
3. Modifying alarms
   For the sake of ensuring reliable error interpretation, the alarm priorities defined for SINUMERIK Safety Integrated should not be altered!
   The texts of SI alarms can be modified. Modifications must be properly documented for reference by the user!
4. “Carry out acceptance test” message box
   The “Carry out acceptance text” message box must not be modified!
5. User agreement
   Functions associated with the call, protection mechanism, etc. of the user agreement must not be modified.

2.9.3 Application: Spindle with 2 encoders and slip caused by V-belt drive

General

The cross-check function monitors the actual values between the NCK and drive for an actual-value tolerance band set in a machine data.
If this tolerance band is violated, a STOP F is activated.

Note

It is not possible to activate safety functions SE and SN for an axis/spindle with which slip can occur between the motor and load.

System response

The system responds as follows when the configuration illustrated in Fig. 2-13 is used:
The SI actual value for the drive is supplied by one encoder and the SI actual value for the NCK by the other. The slip resulting from the V-belt causes the actual values supplied by the two encoders to diverge. The actual value tolerance band is consequently violated, initiating the corresponding stop reaction.

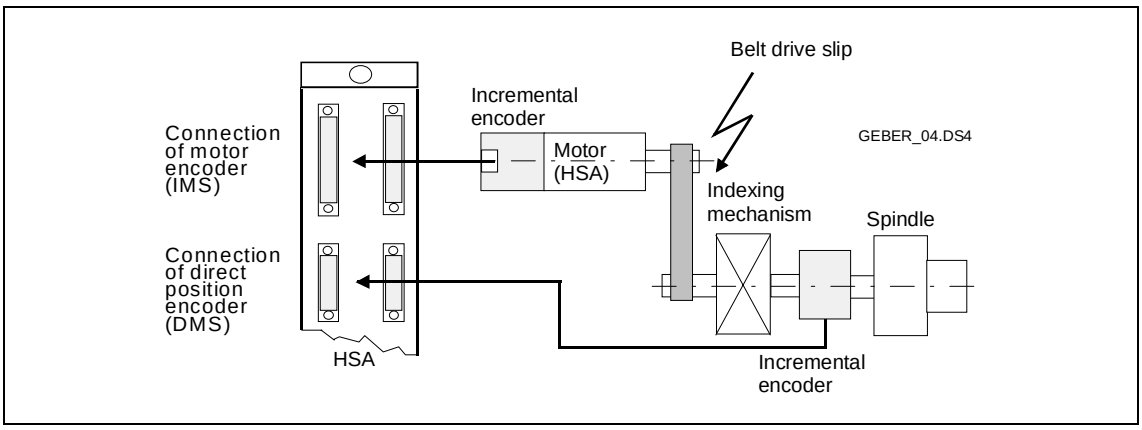

Fig. 2-13 Problem with belt drive, slip between load and motor

Configuration options

In the configuration illustrated in Fig. 2-14, the SI actual values for the NCK and drive are supplied by one encoder (i.e. motor encoder).

Since the actual value supplied by the motor encoder is used in both monitoring channels with this configuration, the slip is ignored (operating characteristics identical to single-encoder system).

If all actual-value inputs have already been assigned, an additional module must be installed.

An actual value input on another drive module must be used to position the spindle. This drive must not be an SI axis.

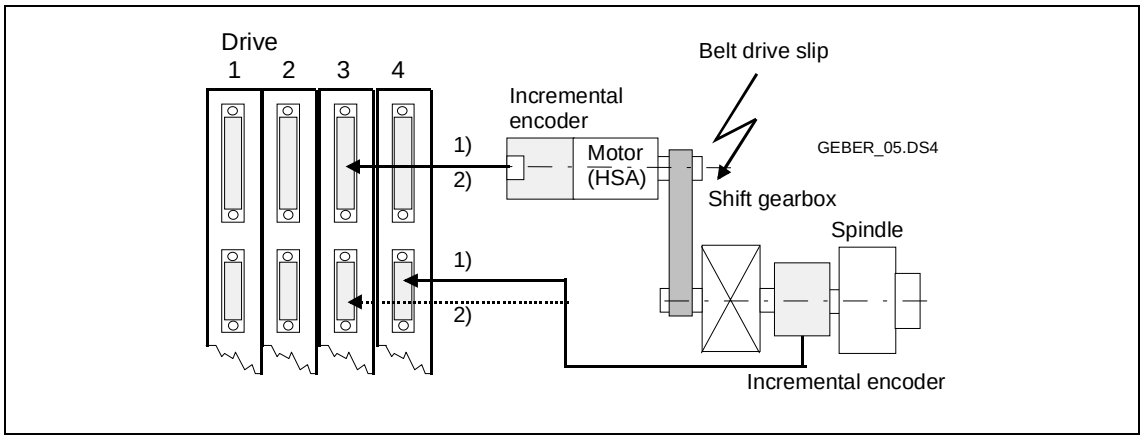

Fig. 2-14 Configuration for spindle with belt drive and 2 encoders

Machine data for 840D/611D

These MD values apply to 2 situations (see Fig. 2-14 “Configuration for spindle with belt drive and 2 encoders”):

1) Slip may exist between load and motor (belt drive) and is ignored

2) Slip may not exist between load and motor (toothed belt)

Table 2-28 Machine data for SINUMERIK 840D

MD No.	MD name	MD value	
		For 1)	For 2)
30110	CTRLOUT_MODULE_NR[0]	3	3
30200	NUM_ENCS	1	1
30220	ENC_MODULE_NR[0]	4	3
30230	ENC_INPUT_NR[0]	2	2
32110	ENC_FEEDBACK_POL[0]	-1	-1
36912	SAFE_ENC_INPUT_NR	1	2
36925	SAFE_ENC_POLARITY	1	-1
1316	SAFE_ENC_CONFIG	0	4

Note

As from SW 6.3, please also consider the "Actual value sychronisation" function, Section 3.7.

■

Notes

Safe Functions

3

3.1 Safety-relevant input/output signals (SGE/SGA) 3-72
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3.1 Safety-relevant input/output signals (SGE/SGA)

Description

The safety-relevant input and output signals (SGEs and SGAs) are digital signals that are sent or received by the system to or from a variety of I/O devices via two channels. These signals allow the following to be requested or signalled in each monitoring channel for each axis/spindle with safety functions:

- Selection and deselection safety functions
- Selection and switchover speed limit value
- Selection and switchover position limit value
- Feedback of status signals relating to safe operation
- Output of cam signals

Features of function

- Processing in two channels for SGEs and SGAs
  - Processing in NCK monitoring channel
  - Processing in drive monitoring channel
- Selection/deselection of safety functions independently of NC operating mode
- Differences between the active SGEs in the monitoring channels are detected by the result cross-check process

Two-channel processing of I/O signals

A two-channel structure (see Fig. 3-1 NCK and drive monitoring channels) is provided for the input/output and processing of safety-relevant input/output signals. All requests and checkback signals relating to safety functions must be input or picked up on a 2-channel basis via both monitoring channels.

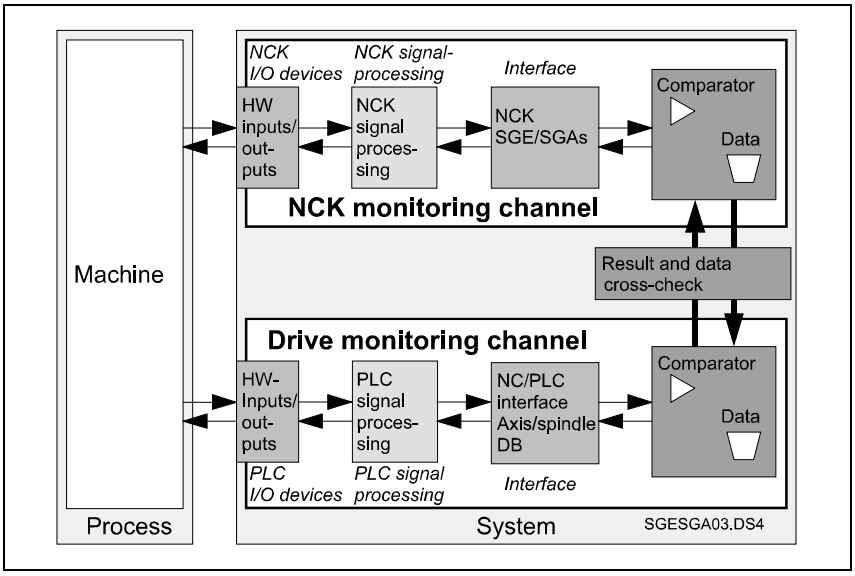

Fig. 3-1 NCK and drive monitoring channels

With the NCK monitoring channel, the signals are input and output via the NCK I/O devices, processed by the NCK logic operations block and mapped in the SGE/SGA interface.

The signals from the drive monitoring channel are input/output via the PLC I/O devices, processed by the PLC user program and transferred to the drive or the PLC via the NC/PLC interface.

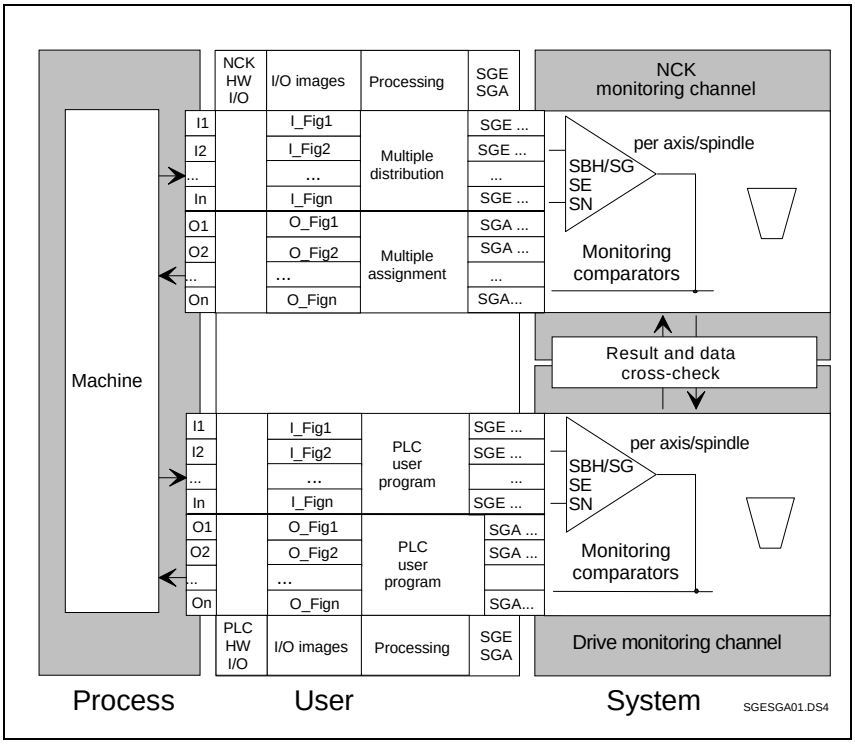

Fig. 3-2 Two-channel processing of I/O signals

The data and results in the two mutually independent monitoring channels are cross-checked. If any discrepancy is found, STOP F is activated.

Note

Due to the two-channel structure, **SGE**s and **SGA**s must be **supplied** in both the **NCK monitoring channel** and the **drive monitoring channel** by the machine manufacturer.

The current status of the SGEs/SGAs is shown in display "Axis service display.

Basic principle of reliable signal processing

With a two-channel control structure, only a single-channel signal checkback by means of the PLC is needed.
In contrast, when a single-channel control structure is used, a redundant, i.e. a two-channel checkback structure is required.

What SGEs/SGAs are provided?

The following SGEs and SGAs are provided for each axis/spindle in each of the two monitoring channels:

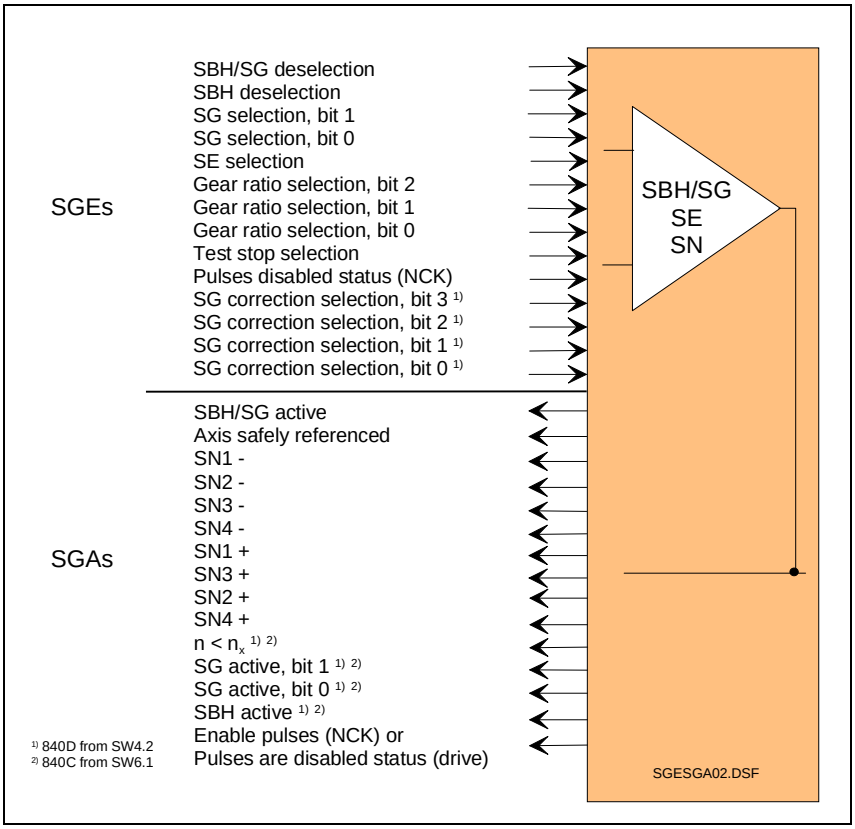

Fig. 3-3 SGEs and SGAs in each monitoring channel for each axis/spindle

What is the minimum number of SGEs/SGAs required?

Of the total number of SGEs/SGAs provided, only some will be required. The actual number depends on the individual application.

Note

SGEs that are not needed must be set to a defined signal status.
In the NCK monitoring channel:
By presetting the assigned machine data to appropriate values
(e.g. preset input permanently to 0 (default) or 1)
In the drive monitoring channel:
By appropriate programming of the interface signals in the PLC user program

Table 3-1 Minimum SGE/SGA requirements

Function	Minimum SGE requirements	Minimum SGA requirements
Safe operational stop (SBH)	• SBH/SG deselection • SBH deselection • Test stop selection • Pulses disabled status (NCK)	• SBH/SG active • Enable pulses (NCK) Pulses are disabled status (drive)
Safe velocity (SG)	• SBH/SG deselection • SBH deselection • SG selection, bit 1 (for SG switchover only) SG selection, bit 0 (for SG switchover only) • Gear ratio selection, bit 2 (for ratio selection only) Gear ratio selection, bit 1 (for ratio selection only) Gear ratio selection, bit 0 (for ratio selection only) • Test stop selection • Pulses disabled status (NCK)	• SBH/SG active • Enable pulses (NCK) Pulses are disabled status (drive)
Safe end positions (SE)	• SE selection (for SE switchover only) • Test stop selection • Pulses disabled status (NCK) • SBH/SG deselection (at least for test during start-up)	• Axis safely referenced • Enable pulses (NCK) Pulses are disabled status (drive)
Safe cams (SN)	• Test stop selection • Pulses disabled status (NCK) • SBH/SG deselection (at least for test during start-up)	• Axis safely referenced • SN1 -, SN2 -, SN3 -, SN4 - (only if required) SN1 +, SN2 +, SN3 +, SN4 + (only if required) • Enable pulses (NCK) Pulses are disabled status (drive)

Different signal transit times in channels

The time response of the signal characteristic in the two monitoring channels varies (the PLC cycle time takes up most of the available time in the drive monitoring channel. To prevent the result and data cross-check function from being activated immediately after a signal change, a tolerance time is defined via the following machine data:

On 840D MD 36950: $MA_SAFE_MODE_SWITCH_TIME

On 840C MD 4260*: (tolerance time for SGE switchover)

On 611D MD 1350: $MD_SAFE_MODE_SWITCH_TIME

This data specifies the time period for which different signals states may be tolerated after the switchover of SGEs before an error message is output.

Note

System-dependent minimum tolerance time:
2 x PLC cycle time (maximum cycle) + 1 x IPO cycle time

The variations in transit time in the external circuitry (e.g. relay operating times) must also be taken into account.

NCK SGEs/SGAs

There are SGEs and SGAs for each axis/spindle (see Fig. SGEs and SGAs in each monitoring channel for each axis/spindle").

The signals are assigned to the NCK inputs and outputs via machine data. Only those NCK SGEs that are required for the application in question may be assigned to an NCK input.
In the case of axes, for example, without a gear speed change, there is no need to assign any HW inputs for the NCK SGEs "Gear ratio selection, bits 2 to 0. The relevant MD must be set to "0" (i.e. the NCK SGE does not have a HW assignment and is set definitively to "0").

PLC SGEs/SGAs

The NC/PLC interface (axis/spindle DB) acts as the SGE/SGA interface between the PLC and drive for the drive monitoring channel. The PLC user program must supply this interface. The standard PLC I/O devices must be used to input/output signals to/from the machine.

The machine manufacturer defines in the PLC user program whether the SGEs/SGAs are processed via the PLC I/O devices or whether they are generated and evaluated internally in the software. His choice depends upon the application.

Only the PLC SGEs that are required for the application in question may be processed in the PLC user program. Any unused SGEs must be set definitively to the value "0".

3.1.1 Signal processing for NCK monitoring channel

Note

The SGEs/SGAs must be supplied in both the NCK monitoring channel and in the drive monitoring channel by the machine manufacturer.

Signal processing for NCK monitoring channel with SINUMERIK 840D

Digital NCK inputs/outputs on 840D

The following digital NCK inputs/outputs for SGEs/SGAs are available on the SINUMERIK 840D:

Table 3-2 Digital NCK inputs/outputs for SGEs/SGAs on 840D

	Number of digital NCK inputs/outputs
NCU 572/573	128 DI/128 DO (via NCU terminal block, see the following note)

References: /FB/, A4, Digital and Analog NCK I/Os

References: /HDB/, NCU Manual, SINUMERIK 840D

Please note the following with regard to NCK I/O devices:

- The NCK I/O devices are implemented by means of 2 NCU terminal blocks and DMP compact modules.
- In comparison to "normal" NCK inputs/outputs (see References: /FB/, A4, Digital and Analog NCK I/Os), other additional NCK inputs/outputs are used for the Safety Integrated option.
- The "normal" NCK inputs and those for the Safety Integrated option may also be used for both purposes. An appropriate alarm is generated for NCK outputs that are assigned twice.

Note

The digital inputs/outputs are reserved byte-serially for SGEs/SGAs. If at least 1 input/output is used for SGEs/SGAs, then the remaining inputs/outputs of the byte concerned cannot be used for other functions.

The machine manufacturer is responsible for ensuring that digital NCK inputs are not assigned twice (resulting in conflict) by configuring them correctly.

The number of NCK SGEs/SGAs is limited on the SINUMERIK 840D only by the maximum available number of NCK I/O device slots.

Processing of NCK-SGEs on 840D (multiple distribution)

Axis-specific/spindle-specific machine data are used to define which input is to be used for which function and which axis/spindle. On condition that certain axes/spindles belong to the same safety grouping, it is possible to implement multiple distribution (1 input is assigned, for example, to 3 axes with the same function). In addition, when an NCK input is selected via MD, it is also possible to define whether the signal is to be inverted for processing.

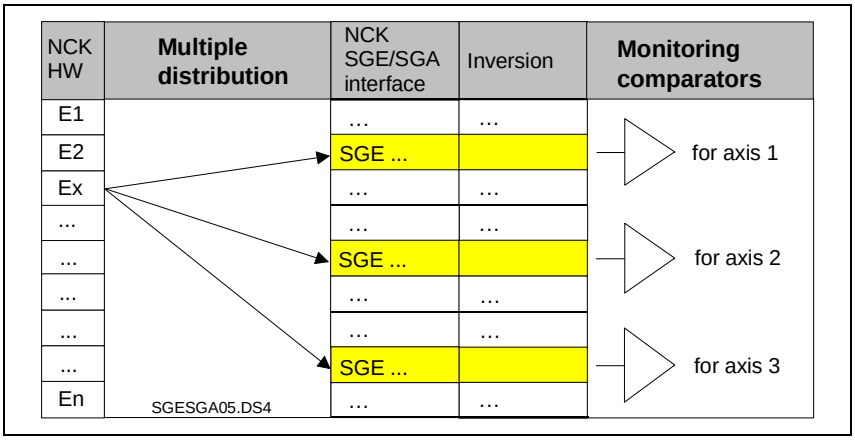

Fig. 3-4 Multiple distribution of NCK inputs

Example

It must be possible to switch over between safe end positions 1 and 2 for axes 1, 2 and 3 as a group via an NCK input "x". To do so, the following machine data must be parameterized:

Axis 1: MD 36973: $MA_SAFE_POS_SELECT_INPUT = input x
Axis 2: MD 36973: $MA_SAFE_POS_SELECT_INPUT = input x
Axis 3: MD 36973: $MA_SAFE_POS_SELECT_INPUT = input x
(input x = ss mm xx nn,
see Section 4.1 Machine data for SINUMERIK 840D)

Processing of NCK SGAs on 840D (multiple assignment)

Axis-specific/spindle-specific machine data are used to define which SGA from which axis/spindle must be assigned to which NCK output. It is possible to implement a multiple assignment (SGAs from several axes, for example, are assigned to 1 output) provided that certain axes/spindles belong to the same safety group.

The SGAs are then ANDed and the result output at the NCK output. In addition, when an NCK output is selected via MD, it is also possible to define whether the signal is to be output in inverted form before it is ANDed.

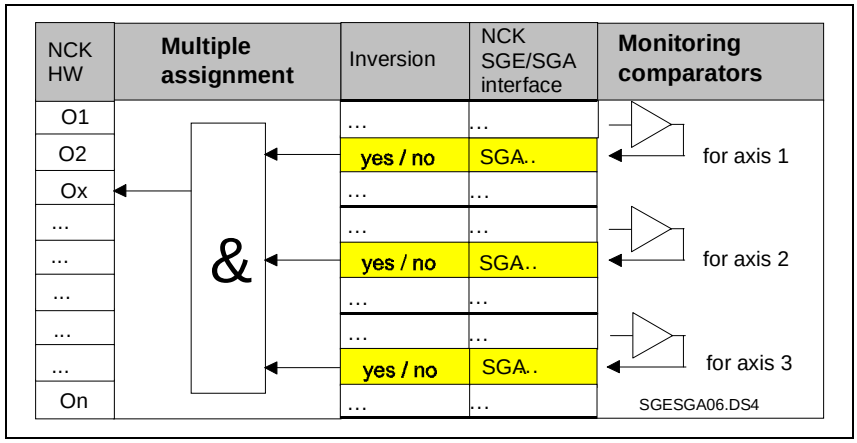

Fig. 3-5 Multiple assignment to NCK outputs

Example

Axes 1, 2 and 3 belong to one safety area. The message "Axes safely referenced" must be output at one NCK output for these axes (i.e. the message appears at the output if the message is active for all 3 axes). The machine data must be parameterized as follows:

Axis 1: MD 36987: $MA_SAFE_REFP_STATUS_OUTPUT = output x
Axis 2: MD 36987: $MA_SAFE_REFP_STATUS_OUTPUT = output x
Axis 3: MD 36987: $MA_SAFE_REFP_STATUS_OUTPUT = output x
(output x = ss mm xx nn,
see Section 4.1 Machine data for SINUMERIK 840D)

Signal processing in NCK monitoring channel with SINUMERIK 840C

Digital NCK inputs/outputs on 840C

NCK inputs and outputs for SGEs/SGAs can be implemented on the SINUMERIK 840C by means of the following modules:

- CSB module and
- mixed I/O module

The following digital inputs/outputs are available with the SINUMERIK 840C:

Table 3-3 Digital NCK inputs/outputs for SGEs/SGAs on 840C

Module	Number of digital inputs/outputs
CSB module	8 DI
Mixed I/O module 1	16 DI/16 DO
Mixed I/O module 2	16 DI/16 DO

References: /NAC/, Interface Description Part 2: Terminal Conditions

References: /IAC/, Installation and Start-Up Guide

Screen for NCK inputs and outputs on 840C

With a SINUMERIK 840C, it must be defined via the following machine data which NCK inputs and outputs are to be used on the CSB module and mixed I/O module 1 or 2 for safety functions:

MD 45800, 45802, 45803, 45804, 45805, 45808, 45809, 45810 and 45811 (see Section 4.2 Machine and service data for SINUMERIK 840C).

Note

The NCK inputs and outputs that are not reserved for safety functions can be used for other functions.

The machine manufacturer is responsible for ensuring that digital NCK inputs are not assigned twice (resulting in conflict) by configuring them correctly.

Processing of NCK input signals on 840C (multiple distribution)

Axis-specific/spindle-specific machine data are used to define which input is to be used for which function and which axis/spindle. On condition that certain axes/spindles belong to the same safety grouping, it is possible to implement multiple distribution (1 input is assigned, for example, to 3 axes with the same function) (see Fig. 3- 4 Multiple distribution of NCK inputs). In addition, when an NCK input is selected via MD, it is also possible to define whether the signal is to be inverted for processing.

Example

It must be possible to select limit position 1 or 2 for axes 1, 2 and 3 on an axis-specific basis via an NCK input "x". The following machine data must be parameterized for this purpose:

Axis 1: MD 46480 = input x
Axis 2: MD 46481 = input x
Axis 3: MD 46482 = input x
(input x = s mm xx nn y,
see Section 4.2 Machine and service data for SINUMERIK 840C)

Processing of NCK output signals on 840C (multiple assignment)

Axis-specific/spindle-specific machine data are used to define which SGA from which axis/spindle must be assigned to which NCK output. It is possible to implement a multiple assignment (SGAs from several axes, for example, are assigned to 1 output) (see Fig. 3-5 Multiple assignment to NCK outputs) provided that certain axes/spindles belong to the same safety group. The SGAs are then ANDed and the result output at the NCK output. In addition, when an NCK output is selected via MD, it is also possible to define whether the signal is to be output in inverted form before it is ANDed.

Example

Axes 1, 2 and 3 belong to one safety area. The message "Axes safely referenced" must be output at one NCK output for these axes (i.e. the message appears at the output if the message is active for all 3 axes). The machine data must be parameterized as follows:

Axis 1: MD 47360 = output x
Axis 2: MD 47361 = output x
Axis 3: MD 47362 = output x
(output x = s mm xx nn y,
see Section 4.2 Machine and service data for SINUMERIK 840C)

3.1.2 Signal processing for drive monitoring channel

General

The safety-relevant input and output signals (SGEs and SGAs) are signals that are sent to and received from the system via two channels:

- Via the NCK monitoring channel
  <--> NCK I/O devices <--> signal processing <-->
  NCK SGE/SGA interface <-> NCK-CPU
- Via the drive monitoring channel
  <--> PLC I/O devices <--> signal processing via PLC <-->
  NC/PLC interface <--> drive CPU

Note

The SGEs/SGAs must be supplied by the machine manufacturer in both the drive monitoring channel and the NCK monitoring channel.

Signal processing for drive monitoring channel with SINUMERIK 840D

Digital PLC inputs/outputs on 840D

Digital PLC inputs and outputs are implemented on the SINUMERIK 840D by means of SIMATIC S7-300 I/O devices.

References: /S7H/, SIMATIC S7-300

Processing of signals on 840D

A PLC module that is compatible with the SIMATIC S7 AS314 is used as the PLC on the SINUMERIK 840D. Signals are processed according to the PLC user program.
(see Section 4.4.1 Interface signals for SINUMERIK 840D).

References: /FB/, P3, "Basic PLC Program"

PLC SGE/SGA interface on 840D

The machine status is transferred to the monitoring comparators for specific axes/spindles via the PLC inputs and the PLC user program. The PLC SGE/SGA interface is imaged by the following axis-/spindle-specific data blocks:

DB 31-48 (for bit assignment of data block, see Section 4.4.1 Interface signals for SINUMERIK 840D)

Signal processing for drive monitoring channel with SINUMERIK 840C

Digital PLC inputs/outputs on 840C

Special input/output modules are available for implementing digital PLC inputs and outputs on the SINUMERIK 840C.

References: /NAC/, SINUMERIK 840C, Interface Description, Part 2: Terminal Conditions

Processing of signals on 840C

The module PLC-CPU 135WD is used as the PLC on the SINUMERIK 840C. The system is program in commands that are compatible with SIMATIC S5.

The signals for the safety functions are processed by the PLC user program (see Section 4.4.2 Interface signals for SINUMERIK 840C).

References: /WDC/, Planning Guide PLC 135 WB/WB2/WD

PLC-SGE/SGA interface on 840C

The machine status is transferred to the monitoring comparators for specific axes/spindles via the PLC inputs and the PLC user program. The PLC SGE/SGA interface is imaged by the following axis-/spindle-specific data block:

DB 28 (for bit assignment of data block
see Section 4.4.2 Interface signals for SINUMERIK 840C)

3.1.3 Example of application

Examples of applications in the following sections show how SGEs and SGAs are connected up, processed and defined in the NCK and drive monitoring channels:

- Section 3.4.8 Example of application for safe sensing of gear ratios
- Section 3.6.2 Example of application for safe cams

3.1.4 Overview of machine data for SGE/SGA

Overview of MD for 840D

Table 3-4 Overview of machine data for 840D

Number	Identifier
36950	$MA_SAFE_MODE_SWITCH_TIME
36970	$MA_SAFE_SVSS_DISABLE_INPUT
36971	$MA_SAFE_SS_DISABLE_INPUT
36972	$MA_SAFE_VELO_SELECT_INPUT[n]
36973	$MA_SAFE_POS_SELECT_INPUT
36974	$MA_SAFE_GEAR_SELECT_INPUT[n]
36975	$MA_SAFE_STOP_REQUEST_INPUT
36976	$MA_SAFE_PULSE_STATUS_INPUT
36980	$MA_SAFE_SVSS_STATUS_OUTPUT
36986	$MA_SAFE_PULSE_ENABLE_OUTPUT
36987	$MA_SAFE_REFP_STATUS_OUTPUT
36988	$MA_SAFE_CAM_PLUS_OUTPUT[n]
36989	$MA_SAFE_CAM_MINUS_OUTPUT[n]
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 3-5 Overview of machine data for 840C

Number	Name
4260*	Tolerance time for SGE switchover
45800	SGE screen CSB (low)
45802	SGE screen MIXED I/O 1 (low)
45803	SGE screen MIXED I/O 1 (high)
45804	SGE screen MIXED I/O 2 (low)
45805	SGE screen MIXED I/O 2 (high)
45808	SGA screen MIXED I/O 1 (low)
45809	SGA screen MIXED I/O 1 (high)
45810	SGA screen MIXED I/O 2 (low)
45811	SGA screen MIXED I/O 2 (high)
4600*	Input assignment SBH/SG deselection
4604*	Input assignment SBH deselection
4608*	Input assignment "Pulses disabled" status
4612*	Input assignment SG selection, bit 0
4616*	Input assignment SG selection, bit 1
4632*	Input assignment gear ratio selection, bit 0
4636*	Input assignment gear ratio selection, bit 1
4640*	Input assignment gear ratio selection, bit 2
4648*	Input assignment SE selection
4660*	Input assignment "Test stop selection"
4700*	Output assignment SN1 +
4704*	Output assignment SN1 -
4708*	Output assignment SN2 +
4712*	Output assignment SN2 -
4716*	Output assignment SN3 +
4720*	Output assignment SN3 -
4724*	Output assignment SN4 +
4728*	Output assignment SN4 -
4732*	Output assignment SBH/SG active
4736*	Output assignment "Axis safely referenced"
4740*	"Enable pulses" output assignment
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

3.2 Safe standstill (SH)

Description

The "Safe standstill" function is based on the pulse disabling function integrated in the drive modules of the SIMODRIVE 611A/D.

References: /PJ1/, Planning Guide SIMODRIVE 611

A second pulse disable path has been added to the existing pulse disabling function on the SIMODRIVE 611D performance closed-loop control.
The safe standstill function safely disconnects the power supply to the motor in the event of a fault or in connection with a machine function.

A safe standstill is executed in two channels, i.e. through the de-energization of an internal relay via a signal path of the drive bus on the one hand and through the isolation of terminal 663 on the drive module on the other. The two-channel checkback structure is implemented via the drive bus and drive terminals AS1/AS2.

Caution

The machine manufacturer must take measures to ensure that the machine remains immobile after disconnection of the motor power supply (e.g. to prevent vertical axes from dropping).

Features of function

The main features of the safe standstill function are as follows:

- The motor cannot be started unintentionally or by accident
- The power supply to the motor is reliably disconnected
- The motor is not electrically isolated from the drive module

Requirements

The safe standstill function requires the following SW and HW (see Section 2.6 System requirements):

- 611D performance closed-loop control module
- Software version with SINUMERIK Safety Integrated

Selection/deselection of SH

The "safe standstill" function cannot be selected or deselected. It is initiated and terminated internally.

- "Safe standstill" is activated after STOP A or STOP B.
- "Safe standstill" is automatically activated from each monitoring channel (via single channel) during testing of pulse disable paths.

Important

After the machine has been switched on, the "Safe standstill" function must always be tested for all axes/spindles with Safety Integrated by means of a pulse disable path test (see Section 2.5 Safe reactions via pulse disable paths and stops).

3.2.1 Overview of machine data for SH function

Overview of MD for 840D

Table 3-6 Overview of machine data for 840D

Number	Identifier
36956	$MA_SAFE_PULSE_DISABLE_DELAY
36957	$MA_SAFE_PULSE_DIS_CHECK_TIME
36960	$MA_SAFE_STANDSTILL_VELO_TOL
36976	$MA_SAFE_PULSE_STATUS_INPUT
36986	$MA_SAFE_PULSE_ENABLE_OUTPUT
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 3-7 Overview of machine data for 840C

Number	Name
4268*	Delay time pulse disable
4272*	Time for testing pulse disable
4288*	Creep speed pulse disabling
4608*	Input assignment "Pulses disabled" status
4740*	"Enable pulses" output assignment
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 3-8 Overview of machine data for 611D

Number	Identifier
1356	$MD_SAFE_PULSE_DISABLE_DELAY
1357	$MD_SAFE_PULSE_DIS_CHECK_TIME
1360	$MD_SAFE_STANDSTILL_VELO_TOL
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

3.3 Safe operational stop (SBH)

Description

The purpose of the SBH function is to safely monitor the standstill position of an axis/spindle operating in position or speed control mode.

When this monitoring function is active (SGA “SBH active“ = 1), operating personnel can, for example, enter protected machine areas in setup mode without switching off the machine.

An incremental encoder is sufficient to implement the function. The axis/spindle is monitored for a change in the actual position value.

Features of function

The features of the SBH function are as follows:

- Axis remains under closed-loop control
- Parameterizable standstill tolerance window
- Configurable stop reaction after monitor has responded (STOP B/A)

Standstill tolerance

The standstill position of the axis/spindle is monitored via a standstill tolerance window that is parameterized via the following machine data:

On 840D MD 36930: $MA_SAFE_STANDSTILL_TOL

On 840C MD 4180*: (standstill tolerance for safe operation)

On 611D MD 1330: $MD_SAFE_STANDSTILL_TOL

Note

The size of the standstill tolerance window should be based on the standard standstill (zero speed) monitoring limits and should exceed them slightly in either direction. The standard monitors in the control system are otherwise rendered ineffective.

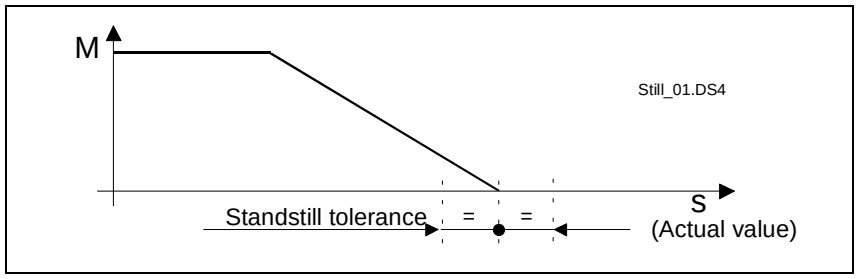

Fig. 3-6 Standstill tolerance

Requirements

The following requirements must be fulfilled
(see Section 2.6 System requirements):

- The option and the function enable in the axis-specific machine data must be present
- The SGEs "SBH/SG deselection" and "SBH deselection" must be supplied in the NCK and drive monitoring channels

3.3.1 Selection/deselection of safe operational stop

Selection of SBH

The safe operational stop function is selected via the following SGEs:

Table 3-9 Selection/deselection of SBH

SGE		SGA	
SBH/SG deselection	**SBH deselection**	**SBH active**	**Meaning**
= 1	x [2)]	0	SBH and SG are deselected
= 0	= 0	1	SBH is selected
= 0	= 1	0	SG is selected (see Section 3.4 Safe velocity (SG)), - SBH can be activated - SBH is activated internally in control in the event of error

Note:
1) 840D ≥ SW4.2, 840C ≥ SW6.1
2) x → Signal state optional

Note

- If a safe velocity was not active prior to the selection of SBH, any moving axis/spindle is stopped with STOP B/A.
- The current actual status of the function is displayed via the SGA "SBH/SG active" and “SBH active“.
- The SGEs and SGAs are described in Section 3.1 Safety-relevant input/output signals (SGE/SGA).

Internal control request for SBH

When the monitoring of SG or SE responds, the drive is switched to the safe operational stop state internally in the control. In such cases, the external circuit state of the SGEs (SBH/SG deselection and SBH deselection) is ignored and both are set to "0" internally.

Selection of SBH from SG state

The changeover from safe velocity mode to the safe operational stop state is initiated via the SGE "SBH deselection". A delay time that is parameterized in the following machine data is started simultaneously with switchover to SBH (signal "SBH deselection"=0):

On 840D MD 36951: $MA_SAFE_VELO_SWITCH_DELAY

On 840C MD 4264*: (delay time speed switchover)

On 611D MD 1351: $MD_ SAFE_VELO_SWITCH_DELAY

SBH is activated as soon as the delay time expires.

Note

If the SBH function is selected while an axis/spindle is moving, the machine manufacturer must initiate the braking process such that the axis/spindle is in position, i.e. stationary, on expiry of the delay time. If the axis moves out of the standstill tolerance window after expiry of the delay, an alarm is generated (on 840D: 27010, on 840C: 1324*, on 611D: 300907) and STOP A or B initiated!

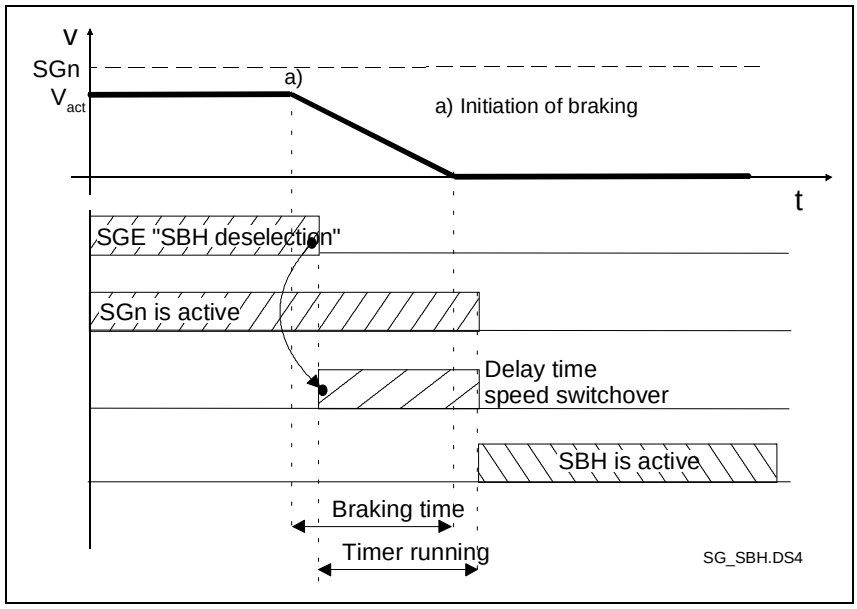

Fig. 3-7 Time response on selection of SBH from SG mode

Deselection of SBH

The safe operational stop state can be deselected with SGE "SBH/SG deselection" (="1" signal), resulting in general deactivation of SBH and SG. The SBH function is also deselected when the SG function is selected via the SGE "SBH deselection".

Note

The delay time must be selected as a function of the distance to the hazardous location. The speeds to be taken into account in this respect are stipulated in safety standard EN999.

SGA "SBH active" (840D ≥ SW4.2 840C ≥ SW6.1)

If this SGA is set, then safe operational stop (SBH) is active, i.e. the axis is safely monitored for zero speed. This signal can be used, for example, to implement protective door interlocks.

Configuring of NCK SGA

NCK SGA "SBH active" is configured via the following machine data:

On 840D MD 36981: $MA_SAFE_SS_STATUS_OUTPUT

On 840C MD 4744*: (output assignment for SBH active)

3.3.2 Effects of tolerance window violation

If the axis/spindle is being monitored (SGA "SBH/SG active" = 1 or SGA “SBH active“ = 1) and leaves, for example, the standstill tolerance window as the result of external influences or an undefined setpoint input, the effects are as follows:

Effects

- The axis switches to STOP A/B configured via the following MDs:
  On 840D 36956: $MA_SAFE_PULSE_DISABLE_DELAY
  on 840C 4268*: Delay time pulse disable
  on 611D 1356: $MD_SAFE_PULSE_DISABLE_DELAY
  and
  on 840D 36960: $MA_SAFE_STANDSTILL_VELO_TOL
  on 840C 4288*: Creep speed pulse disabling
  on 611D 1360: $MD_SAFE_STANDSTILL_VELO_TOL
- An alarm is generated (on 840D: 27010, on 840C: 1324*, on 611D: 300907)

Time response on violation of limit value

The time response of the system is as follows if the limit value is violated when the safe operational stop function is active:

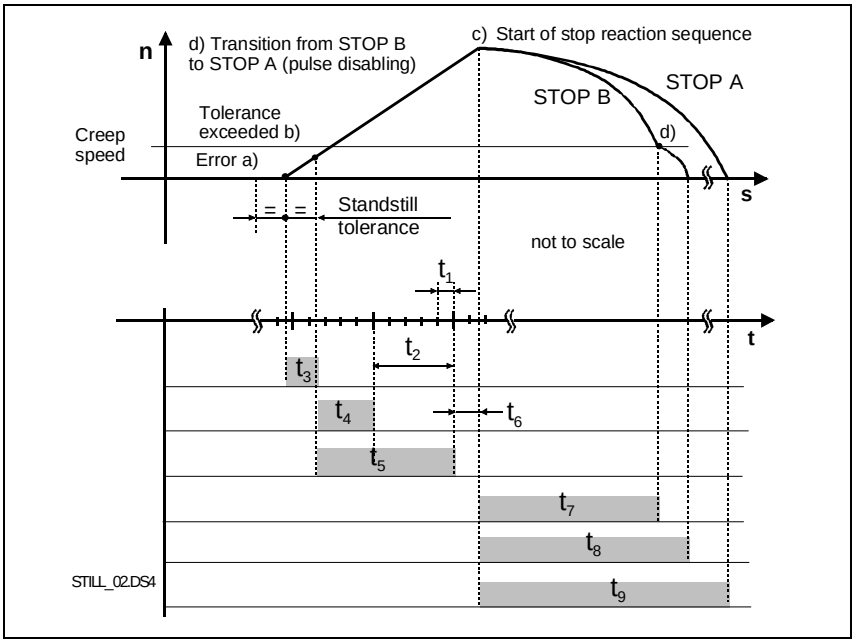

Fig. 3-8 Time response on violation of limit value with active SBH

Table 3-10 Explanations on the figure

Time	Explanation
t_1	Position control clock cycle defined by the following MDs: On 840D: MD 10050: $MN_SYSCLOCK_CYCLE_TIME MD 10060: $MN_POSCTRL_SYSCLOCK_TIME_RATIO On 840C: MD 155: Position control basic clock cycle
t_2	Monitoring clock cycle defined by the following MDs: On 840D: MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO On 840C: MD 40010: Ratio between monitoring clock cycle and position control basic clock cycle On 611D: MD1300: $MD_SAFETY_CYCLE_TIME
t_3	Time prior to violation of standstill tolerance value
t_4	Delay before violation of standstill tolerance value is detected (maximum 1 one monitoring clock cycle)
t_5	Reaction time required to initiate the configured stop reaction (maximum 2 monitoring clock cycles)
t_6	Delay before initiated stop reaction sequence commences (time = 0, depends on configured stop reaction, see Section 2.5.4 Stop reactions)
t_7	Time required to reach pulse disabling speed with STOP B.
t_8	Time required to stop the axis with STOP B.
t_9	Time required to stop the axis with STOP A.
Note: Each axis must be measured during start-up to determine the distance it travels between violation of the limit value and immobilization.	

3.3.3 Overview of machine data for SBH function

Overview of MD for 840D

Table 3-11 Overview of machine data for 840D

Number	Identifier
36901	$MA_SAFE_FUNCTION_ENABLE
36930	$MA_SAFE_STANDSTILL_TOL
36951	$MA_SAFE_VELO_SWITCH_DELAY
36956	$MA_SAFE_PULSE_DISABLE_DELAY
36960	$MA_SAFE_STANDSTILL_VELO_TOL
36970	$MA_SAFE_SVSS_DISABLE_INPUT
36971	$MA_SAFE_SS_DISABLE_INPUT
36980	$MA_SAFE_SVSS_STATUS_OUTPUT
36981	$MA_SAFE_SS_STATUS_OUTPUT (as from SW4.2)
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 3-12 Overview of machine data for 840C

Number	Name
4500*	Function enable for safe operation
4180*	Standstill tolerance for safe operation
4264*	Delay time speed switchover
4268*	Delay time pulse disable
4288*	Creep speed pulse disabling
4600*	Input assignment SBH/SG deselection
4604*	Input assignment SBH deselection
4732*	Output assignment SBH/SG-active
4744*	Output assignment for SBH active (as from SW6.1)
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 3-13 Overview of machine data for 611D

Number	Identifier
1301	$MD_SAFE_FUNCTION_ENABLE
1330	$MD_SAFE_STANDSTILL_TOL
1351	$MD_SAFE_VELO_SWITCH_DELAY
1356	$MD_SAFE_PULSE_DISABLE_DELAY
1360	$MD_SAFE_STANDSTILL_VELO_TOL
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

3.4 Safe velocity (SG)

Description

The purpose of the SG function is to safely monitor the load-side speed of an axis or spindle. The monitor operates by cyclically comparing the current speed of the axis/spindle with the speed limit value selected via SGEs. The speed limit values are defined in the following machine data:

On 840D MD 36931: $MA_SAFE_VELO_LIMIT[n]

On 840C MD 4184*: (limit value for safe velocity 1)
MD 4188*: (limit value for safe velocity 2)
MD 4192*: (limit value for safe velocity 3)
MD 4196*: (limit value for safe velocity 4)

On 611D MD 1331: $MD_SAFE_VELO_LIMIT[n]

The speed limit values for SG1, SG2, SG3 or SG4 allow various applications/operating states on the machine to be monitored. The safe velocity function can therefore be used to implement protection for operating personnel and machine in setup mode or in automatic operation.

!

Important

The user must be careful to select the correct gear ratio for axes with shift gearbox.

Features of function

The features of the SG function are as follows:

- Safe monitoring of load-side speed limit values
- Adjustment of monitoring limit values to various operating states (e.g. test, setup, automatic modes)
- Configurable stop reaction after response of monitoring

Requirements

The following requirements must be fulfilled (see Section 2.6 System requirements):

- The option and the function enable in the axis-specific machine data must be present
- The SGEs "SBH/SG deselection" and "SBH deselection" must be configured

Specification of velocities and speeds

The requirements regarding speeds and velocities that are stipulated for individual processes (e.g. milling, turning, grinding, etc.) vary depending on standards (e.g. ISO 11161) or standardizing activities (e.g. CEN TC 143). As an example, standards stipulated for setup mode are as follows:
"Safely reduced speed" at 2 m/min for feed drives or
50 rev/min for spindle drives or standstill within 2 revolutions.

The machine manufacturer must parameterize SINUMERIK Safety Integrated in such a way as to ensure full compliance with all applicable standards.

Variables that influence parameterization are, for example, the dynamic performance of the drive, the set parameters with their delay times, electrical and mechanical gear ratios and all other mechanical characteristics.
(see Fig. 3-10 Time response on violation of limit value with active SG) shows the correlations between the dynamic response of the drive and the internal delay times of SINUMERIK Safety Integrated.

Speed monitoring, encoder limit frequency

When SBH/SG is active in a configuration with 1 encoder, the speed is monitored for violation of a maximum encoder limit frequency. An appropriate alarm is output when the limit frequency is exceeded.
Depending on the number of encoder pulses, the limit values are as follows for a ratio of, e.g. motor : load = 1 : 1:

Table 3-14 Encoder limit frequency and speed

Encoder pulses/rev.	Speed at maximum encoder limit frequency	
	200 kHz	300 kHz [1)]
2 048	5 800 rev/min	8 700 rev/min
1 024	11 600 rev/min	17 400 rev/min
512	22 200 rev/min	34 800 rev/min
Note: 1) 840D ≥ SW3.6, 840C ≥ SW5.7		

3.4.1 Selection/deselection of safe velocity

Selection of SG

The following SGEs are used to select the safe velocity monitoring function:

Table 3-15 Selection/deselection of SG

SGE		Meaning
SBH/SG deselection	SBH deselection	
= 1	x	SBH and SG are deselected
= 0	= 0	SBH is selected (See Section 3.3 Safe operational stops (SBH)
= 0	= 1	SG is selected - SBH mode can be activated - SBH activated internally in control in the case of an error
Note: x → Signal state optional		

Note

- The current status of the function is displayed via the SGA "SBH/SG active" and SGA “SBH active“.
- Before the SG function is activated, it must be ensured that the speed of the axis/spindle is lower than the selected speed limit value. If it is higher, an alarm is generated that leads to shutdown of the drive.
- The SGEs and SGAs are described in Section 3.1 (Safety-relevant input/output signals (SGE/SGA).

Selection of speed limit values

The maximum permissible speed of an axis/spindle in setup mode is defined for individual machine types in C standards (product standards). The machine manufacturer is responsible for ensuring that the correct speed limit value is selected as a function of operating mode and application.

The desired speed limit value is selected as follows by combining the following SGEs:

Table 3-16 Selection of speed limit values for SG

SGE		
SG selection Bit 1	**SG selection Bit 0**	**Meaning**
= 0	= 0	Speed limit value for SG1 active
= 0	= 1	Speed limit value for SG2 active[1)]
= 1	= 0	Speed limit value for SG3 active
= 1	= 1	Speed limit value for SG4 active[1)]

Note:
1) On the SINUMERIK 840D system with SW4.2 and later, the SG limit value can be set in finer steps by means of an SG override (see Section 3.4.5 Override for safe velocity).

Switching over between speed limit values

The switchover from a lower to a higher speed limit value takes effect without delay.

When switchover takes place from a high to a lower limit value, then a delay time parameterized via machine data is started
(see Fig. 3-9 Time response on swiitchover from a high to a lower speed limit value).

On 840D MD 36951: $MA_SAFE_VELO_SWITCH_DELAY

On 840C MD 4264*: (Delay time speed switchover)

On 611D MD 1351: $MD_SAFE_VELO_SWITCH_DELAY

The axis/spindle must be braked sufficiently during the delay time so that it has reached the reduced speed that is below the new limit value when the delay time expires. If, however, the current speed is higher than the new limit value on expiry of the timer, an alarm is output followed by the configurable stop reaction.

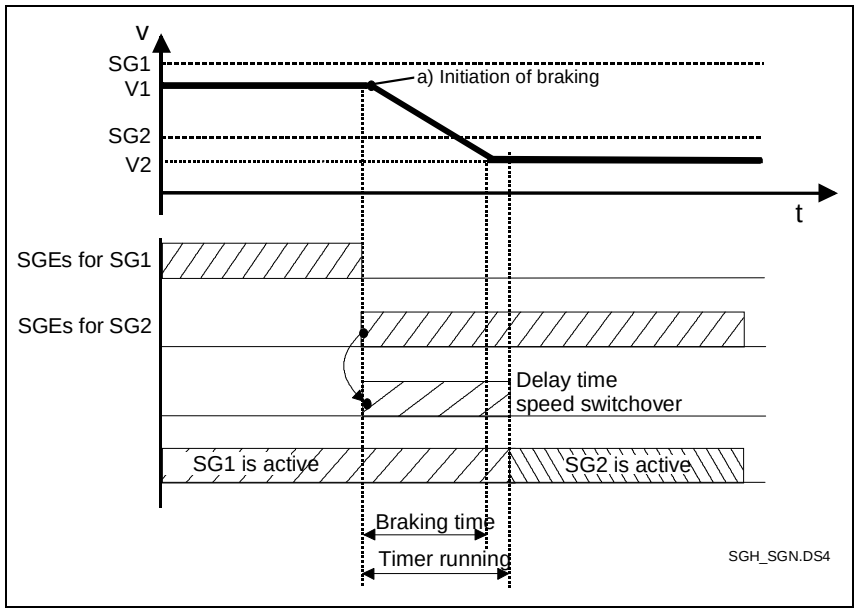

Fig. 3-9 Time response on switchover from a high to a lower speed limit value

Deselection of SG

The SG function can be deselected from operation at any speed through activation of the "SBH/SG deselection".

Warning

The delay time must be selected as a function of the distance to the hazardous location. The speeds to be taken into account in this respect are stipulated in safety standard EN999.

3.4.2 Safe velocity function on spindles with shift gearboxes

Note with respect to shift gearboxes

The following points must be noted with respect to shift gearboxes.

- When a 1-encoder system is used, gear ratios (gear stage selection) must be selected via two channels (see Section 3.4.8 Example of application for safe sensing of gear ratios).
- The user agreement (if set) is cancelled during a gear change and the SGA "Axis safely referenced" set to "0". The gear shift is detected by means of SGEs with gear stage selection via PLC and/or through the selection of a new gear ratio.
- The spindle must be re-synchronized after a gear change.
- The user must put the spindle into the "Axis safely referenced" state if it is configured with SN.

- The value for the actual value comparison tolerance (cross-check) must be set higher than the oscillation actual value in oscillation mode.
  On 840D MD 36942: $MA_SAFE_POS_TOL
  On 840C MD 4256*: Actual value comparison tolerance (cross-check)
  On 611D MD 1342: $MD_SAFE_POS_TOL
- A delay timer is started on switchover from a high to a lower speed limit value. While this timer is running, the speed is monitored for violation of the last valid speed limit value. On switchover from a low to a higher speed limit value, the higher value becomes effective immediately.

Note

Changing the gear speed, parking an axis or making changes to the mounted equipment (e.g. replacing encoder or motor) means decoupling the load and encoder and cannot be detected by the NC and drive. The "Axis safely referenced" state is then lost. The user is responsible for ensuring that the axis is returned to the "Axis safely referenced" state if SE or SN are in use.

3.4.3 Effects of speed limit violation

Configurable stop reaction

When the selected speed limit value is violated, a stop reaction configured in the following machine data is generated:

On 840D MD 36961: $MA_SAFE_VELO_STOP_MODE
MD 36963: $MA_SAFE_VELO_STOP_REACTION[n] (SW4.2 and higher)

On 840C MD 4508*: (axis-specific bits for safe operation)
Bit 4: Selection of STOP D/E for SG (Bit = 0: STOP C)
Bit 5: Selection of STOP E for SG

On 611D MD 1361: $MD_SAFE_VELO_STOP_MODE
MD 1363: $MD_SAFE_VELO_STOP_REACTION[n] (840D, SW4.2 and higher)

Note

- An alarm is displayed (on 840D: 27011, on 840C: 1328*, on 611D: 300914). After elimination of the error cause, the alarm can be acknowledged with RESET. The monitoring function is then active again.
- Depending on the set monitoring clock cycle, the dynamic drives may cause a brief increase in speed on the monitored axis/spindle before the stop reaction sequence commences.
- In traversing modes which use a transformation with singularity points (e.g. 5-axis transformation and TRANSMIT), relatively high axial speeds occur at these points. These speeds can initiate stop reactions even though the Cartesian motion of the tool center point (TCP) is below the select speed limit value. The monitoring functions provided by SINUMERIK Safety Integrated are basically axis-specific. It is therefore not possible to monitor the TCP.

Time response on violation of limit value

When the safe velocity function is active, then the time response is as follows when the limit value is violated:

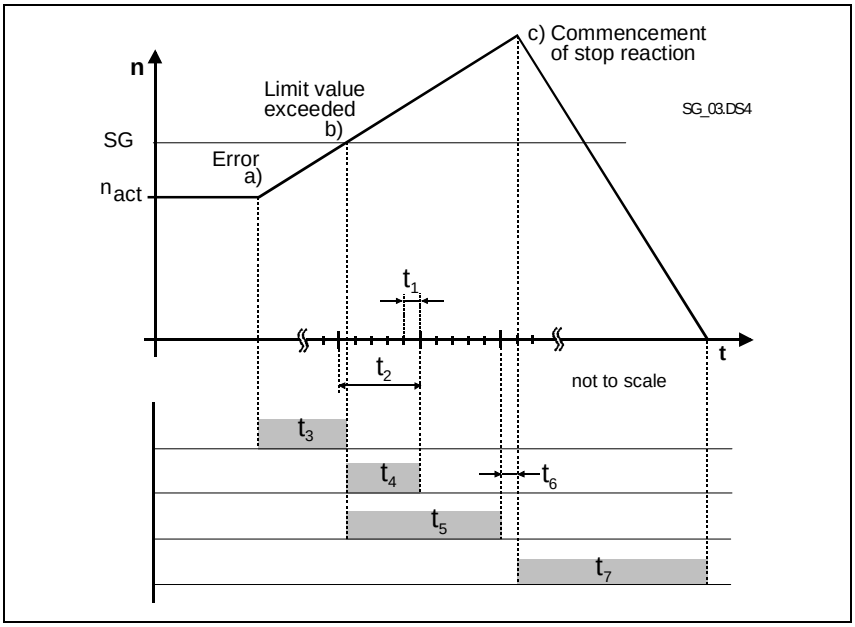

Fig. 3-10 Time response on violation of limit value with active SG

Table 3-17 Explanations on the figure

Time	Explanation
t_1	Position control clock cycle defined by the following MDs: On 840D: MD 10050: $MN_SYSCLOCK_CYCLE_TIME MD 10060: $MN_POSCTRL_SYSCLOCK_TIME_RATIO On 840C: MD 155: Position control basic clock cycle
t_2	Monitoring clock cycle defined by the following MDs: On 840D: MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO On 840C: MD 40010: Ratio between monitoring clock cycle and position control basic clock cycle On 611D: MD1300: $MD_SAFETY_CYCLE_TIME
t_3	Time between occurrence of error and violation of limit value
t_4	Delay before violation of limit value is detected (maximum 1.5 monitoring clock cycles)
t_5	Reaction time required to initiate the configured stop reaction (maximum 2.5 monitoring clock cycles)
t_6	Delay before initiated stop reaction sequence commences (time = 0, depends on configured stop reaction, see Section 2.5.4 Stop reactions)
t_7	Time required to bring axis to standstill. This time period and thus the residual distance travelled by the axis is determined by the axis construction (motor, mass, friction, ...) and the configured stop reaction (STOP C is faster than STOP D or STOP E).
Note: Each axis must be measured during start-up to determine the distance it travels between violation of the limit value and immobilization.	

3.4.4 Stop reactions specific to SG (840D, SW4.2 and higher)

Configurable SG-specific stop reaction

The configurable SG-specific stop reaction allows different types of braking operation to be set for each SG level in response to violation of the respective speed limit value.

Example of possible setting:
Level SG2 is active with configured stop reaction STOP C in SETUP mode and level SG4 with configured stop reaction STOP D in AUTOMATIC mode.

Activation

The function is active whenever
MD 36961/1361: $MA_/$MD_SAFE_VELO_STOP_MODE = 5.

Setting the configurable SG-specific stop reaction

SG-specific stop reactions can be set via the following machine data:

On 840D MD 36963: $MA_SAFE_VELO_STOP_REACTION[n]
(SG-specific stop reaction)

On 611D MD 1363: $MD_SAFE_VELO_STOP_REACTION[n]

3.4.5 Override for safe velocity (840D with SW4.2 and higher)

General

It is possible to specify 16 overrides for the limit values of safe velocitys 2 and 4 by means of SGEs, allowing the limit values for SG2 and SG4 to be monitored in finer steps.
An override factor of between 1 and 100% can be assigned to each of the selected overrides via the following machine data:

On 840D MD 36932: $MA_SAFE_VELO_OVR_FACTOR[n]
(override factor for safe velocity)

On 611D MD 1332: $MD_SAFE_VELO_OVR_FACTOR[n]

Example of application

For grinding applications, the limit value for the safe velocity can be adjusted to the variations in grinding wheel peripheral speed by means of the SG override.

Activation

The following conditions must be fulfilled before the function can be used:

- Function is enabled via MD 36901(MD 1301):
  $MA($MD)_SAFE_FUNCTION_ENABLE, bit 5
- The “SBH/SG” monitoring is enabled
- The required SGEs “SG override selection, bits 3, 2, 1, 0” are fully or partially configured
- SG override factors have been set in the corresponding machine data
- Safe velocity 2 or 4 is activated

Switchover between SG overrides

SG override values are switched over subject to the same conditions as applied to speed limit values.

Table 3-18 Switchover of SG override values

Switchover	Description
from smaller to greater	Instantaneous
from greater to smaller	A delay timer parameterized in MD 36951/MD 1351 is started. The axis/spindle must be braked within this delay time.
Note: See Section 3.4.1 Selection/deselection of safe velocity	

Note

Switching between SGEs “SG override selection, bits 3, 2, 1, 0” continuously may cause activation of a STOP F.

Selection of SG overrides

The active speed limit value (SG 1, 2, 3 or 4) is selected via SGEs “SG selection bits 1 and 0”. The desired override is selected by combining SGEs “Override selection bits 3, 2, 1 and 0”. The override is valid only for the speed limit value for SG2 and SG4.

Table 3-19 Selection of SG override values for safe velocitys

SGE						
SG selection bit 1	**SG selection bit0**	**SG override selection bit 3**	**SG override selection bit 2**	**SG override selection bit 1**	**SG override selection bit 0**	**Meaning**
= 0	= 0	x	x	x	x	Speed limit value for SG1 active
= 0	= 1	= 0	= 0	= 0	= 0	Speed limit value for SG2 active with override 0
- „ -		= 0	= 0	= 0	= 1	... with override 1
- „ -		= 0	= 0	= 1	= 0	... with override 2
- „ -		= 0	= 0	= 1	= 1	... with override 3
- „ -		= 0	= 1	= 0	= 0	... with override 4
- „ -		= 0	= 1	= 0	= 1	... with override 5
- „ -		= 0	= 1	= 1	= 0	... with override 6
- „ -		= 0	= 1	= 1	= 1	... with override 7
- „ -		= 1	= 0	= 0	= 0	... with override 8
- „ -		= 1	= 0	= 0	= 1	... with override 9
- „ -		= 1	= 0	= 1	= 0	... with override 10
- „ -		= 1	= 0	= 1	= 1	... with override 11
- „ -		= 1	= 1	= 0	= 0	... with override 12
- „ -		= 1	= 1	= 0	= 1	... with override 13
- „ -		= 1	= 1	= 1	= 0	... with override 14
- „ -		= 1	= 1	= 1	= 1	... with override 15
= 1	= 0	x	x	x	x	Speed limit value for SG3 active
= 1	= 1	= 0	= 0	= 0	= 0	Speed limit value for SG4 active with override 0
- „ -		= 0	= 0	= 0	= 1	... with override 1
- „ -		= 0	= 0	= 1	= 0	... with override 2
- „ -		= 0	= 0	= 1	= 1	... with override 3
- „ -		= 0	= 1	= 0	= 0	... with override 4
- „ -		= 0	= 1	= 0	= 1	... with override 5
- „ -		= 0	= 1	= 1	= 0	... with override 6
- „ -		= 0	= 1	= 1	= 1	... with override 7
- „ -		= 1	= 0	= 0	= 0	... with override 8
- „ -		= 1	= 0	= 0	= 1	... with override 9
- „ -		= 1	= 0	= 1	= 0	... with override 10
- „ -		= 1	= 0	= 1	= 1	... with override 11
- „ -		= 1	= 1	= 0	= 0	... with override 12
- „ -		= 1	= 1	= 0	= 1	... with override 13
- „ -		= 1	= 1	= 1	= 0	... with override 14
- „ -		= 1	= 1	= 1	= 1	... with override 15
x: Signal status is optional since override values do not apply to SG1 and SG3						

Configuring of NCK SGEs

NCK SGEs (override selection bits 3, 2, 1, 0) are configured by means of the following machine data:

On 840D MD 36978: $MA_SAFE_OVR_INPUT[n]
(input assignment for override selection)

Definition of SG override factors

The SG override factors themselves (percentage values) are defined via the following machine data:

On 840D MD 36932: $MA_SAFE_VELO_OVR_FACTOR[n]
(override factor for safe velocity)

On 611D MD 1332: $MD_SAFE_VELO_OVR_FACTOR[n]

Example: Override for safe velocity

Task

When safe velocitys are selected, the speed limit values must be set as follows.

Table 3-20 Example of application of override value for safe velocity

SGE SG selection		SGE override selection				Effective speed limit value	
Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0		Assumed speeds
0	0	x	x	x	x	Limit value 1	1000 mm/min
0	1	0	0	0	0	Limit value 2 with override 0	100 % = 2000 mm/min
	- " -	0	0	0	1	Limit value 2 with override 1	80 % = 1600 mm/min
	- " -	0	0	1	0	Limit value 2 with override 2	50 % = 1000 mm/min
	- " -	0	0	1	1	Limit value 2 with override 3	30 % = 600 mm/min
1	0	x	x	x	x	Limit value 3	4000 mm/min
1	1	0	0	0	0	Limit value 4 with override 0	100 % = 5000 mm/min
	- " -	0	0	0	1	Limit value 4 with override 1	80 % = 4000 mm/min
	- " -	0	0	1	0	Limit value 4 with override 2	50 % = 2500 mm/min
	- " -	0	0	1	1	Limit value 4 with override 3	30 % = 1500 mm/min

Notes:

- x: Signal status is optional since override values do not apply to SG1 and SG3
- SGEs "SG override selection bits 3 and 2" are not needed to select an override, i.e. they do not need to be configured (they are set to "0" internally).

Assumed conditions for example above

- The example applies to the 1st axis on a SINUMERIK 840D/611D.
- Definition of SGEs in NCK monitoring channel

Logical slot for terminal block:	6
Slot number of submodule with SGEs:	4
I/O number for signal "SG selection bit 1":	2
I/O number for signal "SG selection bit 0":	1
I/O number for signal "Override selection bit 1":	4
I/O number for signal "Override selection bit 0":	3

Definition of machine data

Table 3-21 Supply of MDs for speed limit values

	On 840D		On 611D	
Limit value	MD no.	Setting	MD no.	Setting
SG1	36931[0]	1000	1331[0]	1000
SG2	36931[1]	2000	1331[1]	2000
SG3	36931[2]	4000	1331[2]	4000
SG4	36931[3]	5000	1331[3]	5000

Table 3-22 Supply of MDs for SGEs

Signal SGE	Assignment MD no.	Setting	Remarks
SG selection bit 1	36972[0]	01 06 04 02	
SG selection bit 1	36972[1]	01 06 04 01	
SG override selection bit 3	36978[0]	00 00 00 00	Not configured
SG override selection bit 2	36978[1]	00 00 00 00	Not configured
SG override selection bit 1	36978[2]	01 06 04 04	
SG override selection bit 0	36978[3]	01 06 04 03	

Table 3-23 Supply of MDs for override values

Override	**On 840D**		**On 611D**	
	MD no.	**Setting**	**MD no.**	**Setting**
0	36932[0]	100	1332[0]	100
1	36932[1]	80	1332[1]	80
2	36932[2]	50	1332[2]	50
3	36932[3]	30	1332[3]	30

3.4.6 SGA "n < n_x" and “SG active“ (840D with SW4.2, 840C with SW6.1)

Description of SGA “n < n_x“

This SGA is used to indicate whether the absolute actual velocity value is above or below a speed limit specified via a machine data.

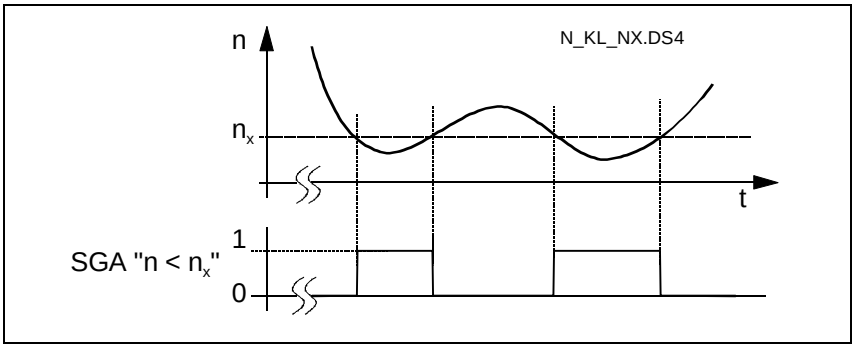

Fig. 3-11 Signal n < n_x as a function of speed characteristic

Application

The chuck is not put into operation until the spindle has reached zero speed (SGA “n < n_x“ = 0).

Definition of limit velocity n_x

Limit velocity n_x is defined via the following machine data:

On 840D MD 36946: $MA_SAFE_VELO_X

On 840C MD 4292*: (speed limit n_x for safe operation)

On 611D MD 1346: $MD_SAFE_VELO_X

Configuring of NCK SGA “n < n_x“

NCK SGA “n < n_x“ is configured via the following machine data:

On 840D MD 36985: $MA_SAFE_VELO_X_STATUS_OUTPUT

On 840C MD 4760*: (output assignment for n < n_x)

Note

If the axis/spindle is operating at speed n_x, SGA “n < n_x“ may assume different states due to differences in actual value in the two monitoring channels.
These differences in signal state must be taken into account in subsequent processing of the SGA.

Description of SGA "SG active bits 1, 0"

SGAs "SG active bits 1, 0" are used to indicate which safe velocity, and thus which speed limit value, is being actively monitored. These SGAs are updated only if the "SBH/SG" function is enabled and SG is active (SGE "SBH/SG deselection" = 0 and "SBH deselection" = 1).

Table 3-24 Display of active safe velocity

SGA SG active Bit 1	SG active Bit 0	SBH/SG active	SBH active	Meaning
= 0	= 0	1	1	SBH is active (no safe velocity active)
= 0	= 0	0	0	Speed limit value for SG1 active
= 0	= 1	1	0	Speed limit value for SG2 active
= 1	= 0	1	0	Speed limit value for SG3 active
= 1	=1	1	0	Speed limit value for SG4 active
= 0	= 0	0	0	None

Note:
The status "SG active bits 1, 0" = "00" has two different meanings. Which meaning is relevant can be determined through additional evaluation of SGA "SBH active".

Configuring of NCK SGA "SG active, bits 1, 0"

NCK SGAs "SG active bits 1, 0" are configured via the following machine data:

On 840D MD 36982: $MA_SAFE_VELO_STATUS_OUTPUT[n]

On 840C MD 4752*: (output assignment for SG active bit 0)
MD 4756*: (output assignment for SG active bit 1)

Extended output for active SG (840C)

The active SG level can be output in the following ways:

Bit-coded: Output via SGA "SG active, bits 1,0"
Parameterization of NCK SGAs via MD 4752*, 4756* (see above)

Extended Output of each SG level via NCK SGA "SG1, 2, 3, 4 active"
Parameterization via MD 4772*, 4776*, 4780* and 4784*

With the extended output method, the status of the active SG monitoring function without external additional logic can be output directly at the NCK I/Os.

For example, SGA "SGA active" is set only when SGA "SBH/SG active" = 1, "SBH active" = 0 and "SG active bits 1, 0" = 0.

Note

If, for example, a lock may be opened only when 2 axes are being monitored for SG1 and 1 axis for SG2, then this status can be output at an NCK output (multiple assignment and ANDing of individual axis signals).

3.4.7 Example of application for SG function

Please refer to Section 7.2 Example circuits for Safety Intergated for an example of how the safe velocity monitoring function can be applied.

3.4.8 Example of application for safe sensing of gear ratios

Task assignment

The gear ratio (encoder/load) must be sensed on a spindle with a four-stage gearbox.
Two examples are given, one with a
2-encoder system (example 1, see Fig. 3-12 Spindle with 2-encoder system)
and one with a
1-encoder system (example 2, see Fig 3-13 Spindle with 1-encoder system)

Example 1: Spindle with a 2-encoder system

Monitoring in two channels is achieved by comparing the speed sensed by the second encoder with the speed of the motor encoder, taking the gear ratio into account. The ratio selection need not be monitored by a safety function and can be a single-channel operation.

Conditions for example 1

- The gear stage is selected from an NC program with an H function via the PLC user program.
- The second encoder system is connected to the "Direct measuring system" input on the performance closed-loop control module.
- The machine data for the "Input assignment gear ratio selection (bits 0, 1, 2)" for the NCK are described in
  Section 4.1 Machine data for SINUMERIK 840D or in
  Section 4.2 Machine and service data for SINUMERIK 810C
- The PLC SGEs for selecting gear ratios are described in
  Section 4.4 Interface signals.
- The example must apply to the 1st drive.
- The motor encoder system is parameterized in the drive machine data. The second encoder system is parameterized in the NCK machine data of the control system.

Table 3-25 Overview of encoder data for 840D

Number	Identifier
36910	$MA_SAFE_ENC_SEGMENT_NR
36911	$MA_SAFE_ENC_MODULE_NR
36912	$MA_SAFE_ENC_INPUT_NR
36915	$MA_SAFE_ENC_TYPE
36916	$MA_SAFE_ENC_IS_LINEAR
36917	$MA_SAFE_ENC_GRID_POINT_DIST
36918	$MA_SAFE_ENC_RESOL
36920	$MA_SAFE_ENC_GEAR_PITCH
36921	$MA_SAFE_ENC_GEAR_DENOM[n]
36922	$MA_SAFE_ENC_GEAR_NUMERA[n]
36925	$MA_SAFE_ENC_POLARITY
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Table 3-26 Overview of encoder data for 840C

Number	Name
4100*	Actual value assignment for safe operation
4104*	Grid spacing linear scale for safe operation
4108*	Encoder marks per rev for safe operation
4112*	Spindle pitch for safe operation
4116*	Denominator gear unit 1 Encoder/load for safe operation
4120*	Denominator gear unit 2 Encoder/load for safe operation
to	to
4144*	Denominator gear unit 8 Encoder/load for safe operation
4148*	Numerator gear unit 1 Encoder/load for safe operation
4152*	Numerator gear unit 2 Encoder/load for safe operation
to	to
4176*	Numerator gear unit 8 Encoder/load for safe operation
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Table 3-27 Overview of encoder data for 611D

Number	Identifier
1316	$MD_SAFE_ENC_CONFIG
1317	$MA_SAFE_ENC_GRID_POINT_DIST
1318	$MA_SAFE_ENC_RESOL
1320	$MA_SAFE_ENC_GEAR_PITCH
1321	$MA_SAFE_ENC_GEAR_DENOM[n]
1322	$MA_SAFE_ENC_GEAR_NUMERA[n]
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

- The tolerance for the actual value comparison of the two encoders is defined in the following machine data:
  On 840D MD 36942: $MA_SAFE_POS_TOL
  On 840C MD 4256*: Actual value comparison tolerance (cross-check)
  On 611D MD 1342: $MD_SAFE_POS_TOL
- Definition of SGEs/SGAs in NCK monitoring channel
  - On 840D
    Logical slot for terminal block: 5
    Slot number of submodule for SGEs: 3
    I/O number for signal "Gear ratio selection bit 0": 1
    I/O number for signal "Gear ratio selection bit 1": 2
  - On 840C
    Module: Mixed I/O
    Module number: 1
    I/O number for signal "Gear ratio selection bit 0": 1
    I/O number for signal "Gear ratio selection bit 1": 2

Note

The SGEs/SGAs used in the NCK monitoring channel must also be supplied in the drive monitoring channel by the machine manufacturer.

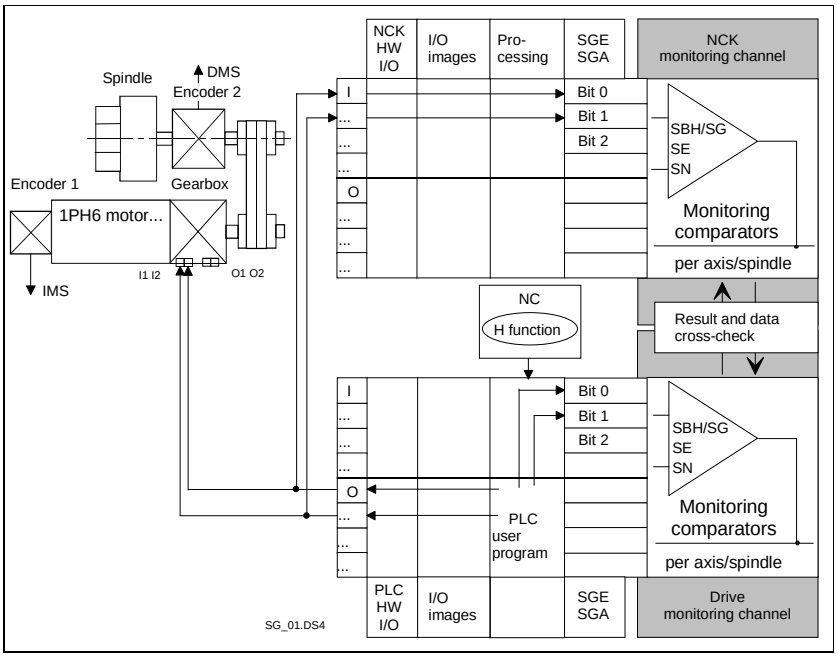

Fig. 3-12 Spindle with 2-encoder system

Table 3-28 Assignment between active gear stage/gear ratio selection

Selection and checkback of active gear stage					**Assignment between ratio selection for NCK and PLC/drive**			**Spindle motor/ load**
					SGE transm. ratio selection			
Gear stage	**E1**	**E2**	**A1**	**A2**	**Bit 2**	**Bit 1**	**Bit 0**	
1	0	0	0	0	0	0	0	4 : 1
2	0	1	0	1	0	0	1	2.5 : 1
3	1	0	1	0	0	1	0	1.6 : 1
4	1	1	1	1	0	1	1	1 : 1

- Input assignment of gear ratio selection

Table 3-29 Supply of machine data for SGEs on 840D

Signal SGE/SGA	**Name**	**Assignment MD No.**	**Value**
SGE	Gear ratio selection, bit 0	36974[0]	01 05 03 01
SGE	Gear ratio selection, bit 1	36974[1]	01 05 03 02

Table 3-30 Supply of machine data for SGEs on 840C

Signal SGE/SGA	**Name**	**Assignment**		**SGE/SGA mask**	
		MD No.	**Value**	**MD No.**	**Value**
SGE	Gear ratio selection, bit 0	4632*	30 10 00 10	45802.0	1
SGE	Gear ratio selection, bit 1	4636*	30 10 00 20	45802.1	1

Table 3-31 Input of gear ratios into machine data.

	Stage	840D		840C		611D	
		MD No.	Value	MD No.	Value	MD No	Value
Denominator of gearbox encoder/load	1	36921[0]	10	4116*	10	1321.0	250
	2	36921[1]	10	4120*	10	1321.1	400
	3	36921[2]	10	4124*	10	1321.2	625
	4	36921[3]	10	4128*	10	1321.3	1000
Numerator of gearbox encoder/load	1	36922[0]	40	4148*	40	1322.0	1000
	2	36922[1]	25	4152*	25	1322.1	1000
	3	36922[2]	16	4156*	16	1322.2	1000
	4	36922[3]	10	4160*	10	1322.3	1000

Example 2: Spindle with a 1-encoder system

Conditions for example 2

- The gear stage is selected from an NC program with an H function via the PLC user program.
- Gear ratios are selected via a single channel.
- The encoder system is connected to the "Direct measuring system" input on the 611D performance closed-loop control module.
- The PLC user program selects the gear stage via peripheral outputs and supplies the PLC SGE/SGA interface internally. This creates a state of expectancy in the drive monitoring channel that must be fulfilled in the NCK monitoring channel with the checkback of the selected gear stage via SGEs.
  The varying signal transit times in the monitoring channels must be taken into account via the following MD:
  On 840D MD 36950: $MA_SAFE_MODE_SWITCH_TIME
  On 840C MD 4260*: Tolerance time for SGE switchover
  On 611D MD 1350: $MD_SAFE_MODE_SWITCH_TIME
- The machine data for the "Input assignment gear ratio selection (bits 0, 1, 2)" for the NCK are described in
  Section 4.1 Machine data for SINUMERIK 840D or in
  Section 4.2 Machine and service data for SINUMERIK 840C.
- The PLC SGEs for selecting gear ratios are described in
  Section 4.4 Interface signals.
- The motor encoder system is parameterized identically in the drive machine data and in the NCK machine data.
- The example must apply to the 1st drive.

Table 3-32 Overview of encoder data for 840D

Number	Identifier
36910	$MA_SAFE_ENC_SEGMENT_NR
36911	$MA_SAFE_ENC_MODULE_NR
36912	$MA_SAFE_ENC_INPUT_NR
36915	$MA_SAFE_ENC_TYPE
36916	$MA_SAFE_ENC_IS_LINEAR
36917	$MA_SAFE_ENC_GRID_POINT_DIST
36918	$MA_SAFE_ENC_RESOL
36920	$MA_SAFE_ENC_GEAR_PITCH
36921	$MA_SAFE_ENC_GEAR_DENOM[n]
36922	$MA_SAFE_ENC_GEAR_NUMERA[n]
36925	$MA_SAFE_ENC_POLARITY
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Table 3-33 Overview of encoder data for 840C

Number	Name
4100*	Actual value assignment for safe operation
4104*	Grid spacing linear scale for safe operation
4108*	Encoder marks per rev for safe operation
4112*	Spindle pitch for safe operation
4116*	Denominator gear unit 1 Encoder/load for safe operation
4120*	Denominator gear unit 2 Encoder/load for safe operation
to	to
4144*	Denominator gear unit 8 Encoder/load for safe operation
4148*	Numerator gear unit 1 Encoder/load for safe operation
4152*	Numerator gear unit 2 Encoder/load for safe operation
to	to
4176*	Numerator gear unit 8 Encoder/load for safe operation
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Table 3-34 Overview of encoder data for 611D

Number	Identifier
1316	$MD_SAFE_ENC_CONFIG
1317	$MA_SAFE_ENC_GRID_POINT_DIST
1318	$MA_SAFE_ENC_RESOL
1320	$MA_SAFE_ENC_GEAR_PITCH
1321	$MA_SAFE_ENC_GEAR_DENOM[n]
1322	$MA_SAFE_ENC_GEAR_NUMERA[n]
Note: The data are described in Section 4.3 Machine data for SIMODRIVE	

- Definition of SGEs/SGAs in NCK monitoring channel
  - On 840D
    Logical slot for terminal block: 5
    Slot number of submodule for SGEs: 3
    I/O number for signal "Gear ratio selection bit 0": 1
    I/O number for signal "Gear ratio selection bit 1": 2
  - On 840C
    Module: Mixed I/O
    Module number: 1
    I/O number for signal "Gear ratio selection bit 0": 1
    I/O number for signal "Gear ratio selection bit 1": 2

Note

The SGEs/SGAs used in the NCK monitoring channel must also be supplied in the drive monitoring channel by the machine manufacturer.

Parameter set changes via SGEs must be linked to a parameter set change in the NC.

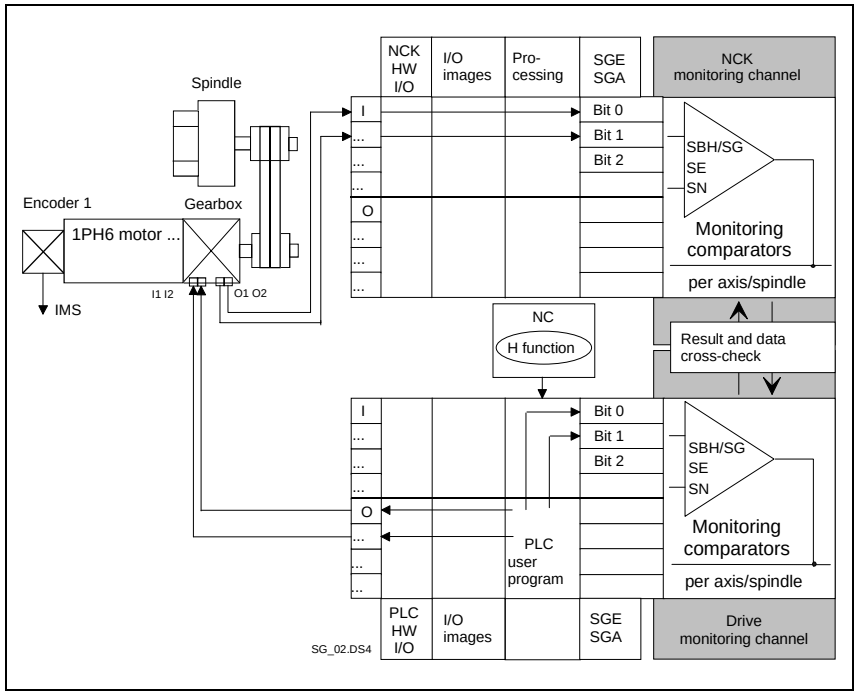

Fig. 3-13 Spindle with 1-encoder system

Table 3-35 Assignment between active gear stage/gear ratio selection

Selection and checkback of active gear stage					**Assignment between ratio selection for NCK and PLC/drive**			**Spindle motor/ load**
					SGE gear ratio selection			
Gear stage	**E1**	**E2**	**A1**	**A2**	**Bit 2**	**Bit 1**	**Bit 0**	
1	0	0	0	0	0	0	0	4 : 1
2	0	1	0	1	0	0	1	2.5 : 1
3	1	0	1	0	0	1	0	1.6 : 1
4	1	1	1	1	0	1	1	1 : 1

- Input assignment of gear ratio selection

Table 3-36 Supply of machine data for SGEs on 840D

Signal SGE/SGA	**Name**	**Assignment MD No.**	**Value**
SGE	Gear ratio selection, bit 0	36974[0]	01 05 03 01
SGE	Gear ratio selection, bit 1	36974[1]	01 05 03 02

Table 3-37 Supply of machine data for SGEs on 840C

Signal SGE/SGA	Name	Assignment		SGE/SGA mask	
		MD No.	Value	MD No.	Value
SGE	Gear ratio selection, bit 0	4632*	30 10 00 10	45802.0	1
SGE	Gear ratio selection, bit 1	4636*	30 10 00 20	45802.1	1

Table 3-38 Input of gear ratios into machine data

	Stage	840D		840C		611D	
		MD No.	Value	MD No.	Value	MD No	Value
Denominator of gearbox encoder/load	1	36921[0]	10	4116*	10	1321.0	250
	2	36921[1]	10	4120*	10	1321.1	400
	3	36921[2]	10	4124*	10	1321.2	625
	4	36921[3]	10	4128*	10	1321.3	1000
Counter of gearbox encoder/load	1	36922[0]	40	4148*	40	1322.0	1000
	2	36922[1]	25	4152*	25	1322.1	1000
	3	36922[2]	16	4156*	16	1322.2	1000
	4	36922[3]	10	4160*	10	1322.3	1000

3.4.9 Overview of machine data for SG function

Overview of MD for 840D

Table 3-39 Overview of machine data for 840D

Number	Identifier
36901	$MA_SAFE_FUNCTION_ENABLE
36921	$MA_SAFE_GEAR_DENOM[n]
36922	$MA_SAFE_GEAR_NUMERA[n]
36931	$MA_SAFE_VELO_LIMIT[n]
36946	$MA_SAFE_VELO_X (SW4.2 and higher)
36951	$MA_SAFE_VELO_SWITCH_DELAY
36961	$MA_SAFE_VELO_STOP_MODE
36963	$MA_SAFE_VELO_STOP_REACTION[n] (SW4.2 and higher)
36970	$MA_SAFE_SVSS_DISABLE_INPUT
36972	$MA_SAFE VELO_SELECT_INPUT[n]
36974	$MA_SAFE_GEAR_SELECT_INPUT[n]
36980	$MA_SAFE_SVSS_STATUS_OUTPUT
36982	$MA_SAFE_VELO_STATUS_OUTPUT [n] (SW4.2 and higher)
36985	$MA_SAFE_VELO_X_STATUS_OUTPUT (SW4.2 and higher)
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 3-40 Overview of machine data for 840C

Number	Name
4500*	Function enable for safe operation
4508*	Axis-specific bits for safe operation Bit 4: Selection STOP D/E for SG Bit 5: Selection STOP E for SG
4184*	Limit value for safe velocity 1
4188*	Limit value for safe velocity 2
4192*	Limit value for safe velocity 3
4196*	Limit value for safe velocity 4
4264*	Delay time speed switchover
4292*	Speed limit n_x for safe operation (SW6.1 and higher)
4600*	Input assignment SBH/SG deselection
4612*	Input assignment SG selection, bit 0
4616*	Input assignment SG selection, bit 1
4732*	Output assignment SBH/SG active
4752*	Output assignment for SG active, bit 0 (SW6.1 and higher)
4756*	Output assignment for SG active, bit 1 (SW6.1 and higher)
4760*	Output assignment for $n < n_x$ (SW6.1 and higher)
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 3-41 Overview of machine data for 611D

Number	Identifier
1301	$MD_SAFE_FUNCTION_ENABLE
1331	$MD_SAFE_VELO_LIMIT[n]
1351	$MD_SAFE_VELO_SWITCH_DELAY
1361	$MD_SAFE_VELO_STOP_MODE
1363	$MD_SAFE_VELO_STOP_REACTION[n] (840D from SW4.2)
1364	$MD_SAFE_VELO_X (840D from SW4.2, 840C from SW6.1)
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

3.5 Safe limit positions (SE)

Description

The safe limit positions (SE) function can be used to implement protection for operating personnel and machinery or working area/protection zone delimitation for specific axes. Hardware limit switches, for example, can be replaced by this function.

Two safe position limit pairs (SE1 and SE2) of safe limit positions are available for each axis. If the "SE" function is active, limit position pair SE1 or SE2 can be selected as a function of SGE "SE selection".

Definition of upper and lower limit values

The position limit values for limit position pairs 1 and 2 are defined in the following machine data:

On 840D MD 36934: $MA_SAFE_POS_LIMIT_PLUS[n]
MD 36935: $MA_SAFE_POS_LIMIT_MINUS[n]

On 840C MD 4200*/4208*: Upper/lower limit value for safe limit position 1
MD 4204*/4212*: Upper/lower limit value for safe limit position 2

On 611D MD 1334: $MD_SAFE_POS_LIMIT_PLUS[n]
MD 1335: $MD_SAFE_POS_LIMIT_MINUS[n]

Note

The upper and lower position limit values must be selected such that the axis reaches the software limit switches that installed as standard beforehand when traversing towards the limit position.

The SE safety monitoring function is effective only if user agreement has been given see Section 2.3.5 User agreement).

Features of function

The most important features of the function are as follows:

- Safe definition and evaluation of limit positions as a software function
- Configurable stop reaction when limit positions are crossed
- Stop reaction is implemented internally in software (and is therefore faster than hardware limit switch response) when limit position is crossed

Requirements

The "Safe limit positions" function is dependent on fulfilment of the following conditions (see Section 2.6 System requirements):

- Function for safe limit switches must be enabled
- Axis/axis must be in safely referenced state (user agreement)
- SGE "SE selection" must be provided (configured) in both channels

Warning

The safe limit positions are effective only if user agreement has been given.

3.5.1 Effects of position limit monitoring response

Warning

The SE function does not monitor the limit positions on a lookahead basis, i.e. the axis stops after crossing the limit position. The distance travelled after the limit position is dependent on

- how the function is parameterized (monitoring clock cycle, stop reaction...),
- the current traversing speed and
- the design of the axis.

Configurable stop reactions

When an axis crosses a limit position, a stop reaction configured in the following machine data is generated:

On 840D MD 36962: $MA_SAFE_POS_STOP_MODE

On 840C MD 4508*: (axis-specific bits for safe operation)
Bit 2: Selection STOP D/E for SE
Bit 3: Selection STOP E for SE

On 611D MD 1362: $MD_SAFE_POS_STOP_MODE

The user can choose between STOP C, STOP D and STOP E.

Effect

- The configured stop reaction is initiated.
- The alarm associated with the configured stop reaction is displayed.

Acknowledge and exit limit area

- Traverse the axis to a position in which the monitor does not respond (see description of alarm "Safe limit position crossed" in Section "). The "User agreement" must be cancelled first (SE monitoring is then deactivated)
  or
  switch over to the other safe limit position.
- Acknowledge the error message according to the configured stop reaction (see Section 2.5 Safe reaction via pulse disable paths and stops)

Time response when safe end position is crossed

If the "Safe limit positions" function is active, the time response of the system is as follows when the limit position is crossed:

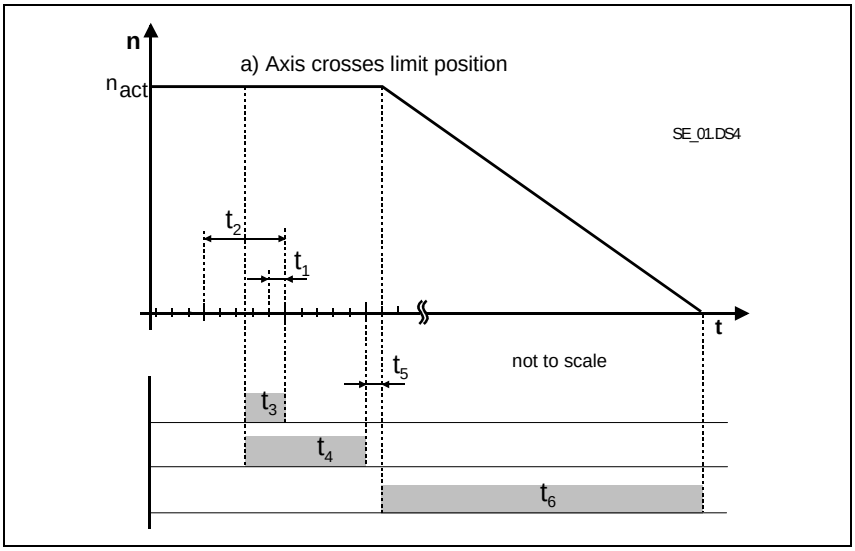

Fig. 3-14 Time response when limit position is crossed

Table 3-42 Explanations on the figure

Time	Explanation
t_1	Position control clock cycle defined by the following MDs: On 840D: MD 10050: $MN_SYSCLOCK_CYCLE_TIME MD 10060: $MN_POSCTRL_SYSCLOCK_TIME_RATIO On 840C: MD 155: Position control basic clock cycle
t_2	Monitoring clock cycle defined by the following MDs: On 840D: MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO On 840C: MD 40010: Ratio between monitoring clock cycle and position control basic clock cycle On 611D: MD1300: $MD_SAFETY_CYCLE_TIME
t_3	Time until crossing of limit position is detected (maximum 1 monitoring clock cycle)
t_4	Delay before configured stop reaction is output (maximum 2 monitoring clock cycles)
t_5	Delay before configured stop reaction takes effect (time = 0, depends on configured stop reaction, see Section 2.5.4 Stop reactions)
t_6	Time required to bring axis to standstill. This time period and thus the residual distance travelled by the axis is determined by the axis construction (motor, mass, friction, ...) and the configured stop reaction (STOP C is faster than STOP D or STOP E).
Note: Each axis must be measured during start-up to determine the distance it travels between violation of the limit value and immobilization.	

3.5.2 Overview of machine data for SE function

Overview of MD for 840D

Table 3-43 Overview of machine data for 840D

Number	Identifier
36901	$MA_SAFE_FUNCTION_ENABLE
36934	$MA_SAFE_POS_LIMIT_PLUS[n]
36935	$MA_SAFE_POS_LIMIT_MINUS[n]
36962	$MA_SAFE_POS_STOP_MODE
36973	$MA_SAFE_POS_SELECT_INPUT
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 3-44 Overview of machine data for 840C

Number	Name
4500*	Function enable for safe operation
4200*	Upper limit value for safe limit position 1
4204*	Upper limit value for safe limit position 2
4208*	Lower limit value for safe limit position 1
4212*	Lower limit value for safe limit position 2
4508*	Axis-specific bits for safe operation Bit 2: Selection STOP D/E for SE Bit 3: Selection STOP E for SE
4648*	Input assignment SE selection
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 3-45 Overview of machine data for 611D

Number	Identifier
1301	$MD_SAFE_FUNCTION_ENABLE
1334	$MD_SAFE_POS_LIMIT_PLUS[n]
1335	$MD_SAFE_POS_LIMIT_MINUS[n]
1362	$MD_SAFE_POS_STOP_MODE
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

3.6 Safe cams (SN)

Description

The "Safe cams" (SN) function can be used to implement safe, electronic cams, safety zone sensing or working area/protection zone delimitation for specific axes and thus to replace the "hardware solution".

There are 4 pairs of cams (SN1, SN2, SN3, SN4) available for each axis. Each cam pair consists of a plus cam (SN1 +, SN2 +, SN3 +, SN4 +) and a minus cam (SN1 -, SN2 -, SN3 -, SN4 -). Each cam signal can be enabled and configured individually via machine data. The cam signals are output via SGAs.

!

Important

The enabled cam signals are output immediately the control system is switched on, but are only reliable for monitoring purposes after safe referencing (signalled via the SGA "Axis safely referenced").
To ensure reliable evaluation of cam signals, the SGA "Axis safely referenced" must be taken into account.

Features of function

The most important features of the function are:

- Safe definition and evaluation of cam positions as software function
- Definition of working areas

Requirements

The following requirements must be fulfilled for the "Safe cams" function to operate:

- The axis/axes must have been safely referenced (user agreement)
- The safe cams must be configured (enabling of required cams, specification of cam positions, definition of output assignment)

Specification of cam positions

The cam positions for SN1 +, SN2 +, SN3 +, SN4 + and
SN1 -, SN2 -, SN3 -, SN4 - are specified in the following machine data:

On 840D MD 36936: $MA_SAFE_CAM_POS_PLUS[n]
MD 36937: $MA_SAFE_CAM_POS_MINUS[n]

On 840C MD 4216* - 4228*: Plus cam position for safe cams 1 - 4
MD 4232* - 4244*: Minus cam position for safe cams 1 - 4

On 611D MD 1336: $MD_SAFE_CAM_POS_PLUS[n]
MD 1337: $MD_SAFE_CAM_POS_MINUS[n]

Tolerance for SN

Owing to variations in clock cycle and signal transit times, the cam signals of the two monitoring channels do not switch simultaneously or not exactly at the same position. A tolerance band can therefore be specified for all cams via the following machine data. Within this band, the signal states for the same cam may be different in the two monitoring channels:

On 840D MD 36940: $MA_SAFE_CAM_TOL

On 840C MD 4248*: (tolerance for safe cams)

On 611D MD 1340: $MD_SAFE_CAM_TOL

Note

The smallest possible tolerance band (less than 5-10 mm) must be selected for the safe cams.

Special feature of SN function

If the axis is being positioned exactly at the parameterized cam position, the cam signals may have different states owing to system-related variations in actual value between the two monitoring channels. This must be taken into account in the further processing of the cam signals, e.g. through filtering the different signal states by means of a logic circuit (see “Synchronization of cam signals“).

Synchronization of cam signals
840D from SW4.2
840C from SW6.1

When cam signal synchronization is activated, the cam results calculated by one monitoring channel are ANDed with the cam results of the other monitoring channel before they are output.
The cam signals in both channels therefore have the same signal status at axis zero speed (after a transition period resulting from different transit times)

Cam signal synchronization is enabledby means of the following machine data:s

On 840D MD 36901: $MA_SAFE_FUNCTION_ENABLE, bit 7

On 840C MD 4500*, bit 7: Enable cam synchronization

On 611D MD 1301: $MD_SAFE_FUNCTION_ENABLE, bit 7

Hysteresis of cam SGAs

When cam synchronization is active, cam signals are output with a hysteresis that takes the direction of travel into account (see Fig. 3-15 “Hysteresis of cam SGAs). This helps to prevent the SGAs from “flickering” if the axis is positioned exactly on the cam.
The magnitude of the hysteresis is determined by the following data:

On 840D MD 36940: $MA_SAFE_CAM_TOL (tolerance for safe cams)

On 840C MD 4248*: (tolerance for safe cams)

On 611D MD 1340: $MD_SAFE_CAM_TOL (tolerance for safe cams)

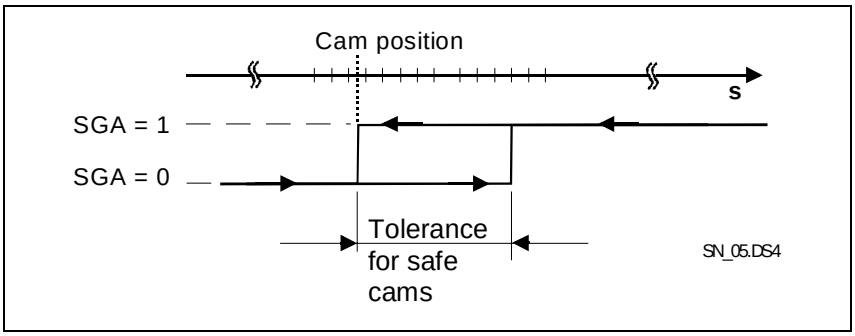

Fig. 3-15 Hysteresis of cam SGAs

Note

Dynamic deviations in the cam signals at I/O devices themselves still occur as a result of the different signal transit times between the NCK and PLC I/O devices. These deviations must be taken into account.

Output assignment for SN

The status of the individual cams is displayed via SGAs SN1 +, SN2 +, SN3 +, SN4 + and SN1 -, SN2 -, SN3 -, SN4 -.

In the **NCK monitoring channel**, the NCK SGAs are assigned to output terminals via the following machine data:

On 840D MD 36988: $MA_SAFE_CAM_PLUS_OUTPUT[n]
MD 36989: $MA_SAFE_CAM_MINUS_OUTPUT[n]

On 840C MD 4700* - 4724*: Output assignment SN1 + to SN4 +
MD 4704* - 4728*: Output assignment SN1 - to SN4 -

In the **drive monitoring channel**, the PLC SGAs are mapped in the NC/PLC interface (see Section 4.4 Interface signals) and output via the PLC I/O by the PLC user program.

Modulo display of safe actual value (840D from SW4.2)

The modulo display of the safe actual value is selected and parameterized for rotary axes via the following machine data:

MD 30300: $MA_IS_ROT_AX
MD 30320: $MA_DISPLAY_IS_MODULO
MD 30330: $MA_MODULO_RANGE

Safe cams for endlessly turning rotary axes (840D from SW4.2)

The modulo range (cam actual value range) for rotary axes with cam can be set via the following machine data:

MD 36902/1302: $MA_/$MD_SAFE_IS_ROT_AX
MD 36905/1305: $MA_/$MD_SAFE_MODULO_RANGE

The size of the cam actual value range should be selected to match the modulo display of the safe actual value.

Note

Restriction of cam positions
When cam positions are parameterized, the following conditions must be observed in the vicinity of modulo limits:

- When cam synchronization is not active:
  Lower modulo value + POS_TOL ≤ cam position
  Upper modulo value - POS_TOL > cam position
- When cam synchronization is active:
  Lower modulo value + POS_TOL ≤ cam position
  Upper modulo value - POS_TOL - CAM_TOL > cam position

Meanings:
POS_TOL:
Actual value tolerance (MD 36942/1342: $MA_/$MD_SAFE_POS_TOL)
CAM_TOL:
Cam tolerance (MD 36940/1340: $MA_/$MD_SAFE_CAM_TOL)
Lower/upper modulo value:
MD 36905/1305: $MA_/$MD_SAFE_MODULO_RANGE
Cam position:
MD 36936/1336: $MA_/$MD_SAFE_CAM_POS_PLUS[n]
MD 36937/1307: $MA_/$MD_SAFE_CAM_POS_MINUS[n]
The parameter settings are checked in each monitoring channel during power up. In the case of parameterization errors (condition not fulfilled), a corresponding alarm is output after the control has powered up.

3.6.1 Effects of safe cam monitoring response

!

Important

The machine manufacturer must safely gate the SGAs SN1 -, SN1 + to SN4 -, SN4 + that are output via the NCK and PLC I/O devices in accordance with the Safety Integrated principle, i.e. in two channels.

If a reaction to the cam signals is required, then the machine manufacturer must implement it on the basis of SGA processing. The SGAs must be processed redundantly, i.e. in the NCK monitoring channel and drive monitoring channel (PLC).

When defining cam positions, please note that the function only monitors the actual position, making "lookahead" sensing of cam signals impossible.

Time response when cam position is crossed

If the "Safe cams" function is active, the time response of the system is as follows when the cam position is crossed:

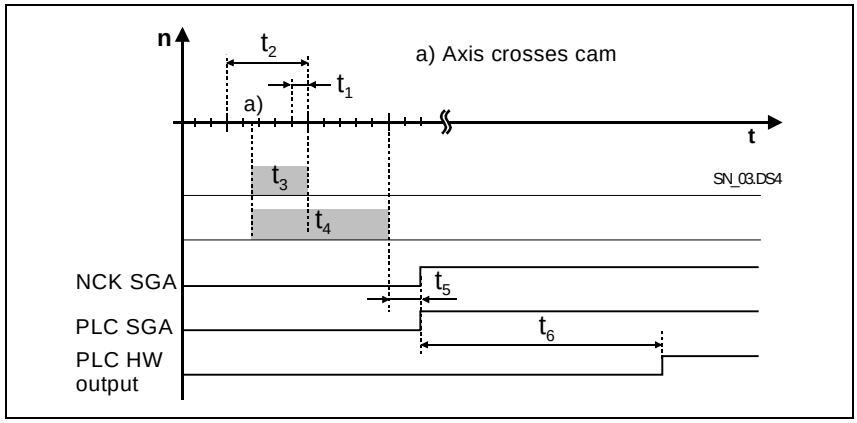

Fig. 3-16 Time response when cam position is crossed

Table 3-46 Explanations on the figure

Time	Explanation
t_1	Position control clock cycle defined by the following MDs: On 840D: MD 10050: $MN_SYSCLOCK_CYCLE_TIME MD 10060: $MN_POSCTRL_SYSCLOCK_TIME_RATIO On 840C: MD 155: Position control basic clock cycle
t_2	Monitoring clock cycle defined by the following MDs: On 840D: MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO On 840C: MD 40010: Ratio between monitoring clock cycle and position control basic clock cycle On 611D: MD1300: $MD_SAFETY_CYCLE_TIME
t_3	Time until crossing of cam position is detected (maximum 1 monitoring clock cycle)
t_4	Delay before corresponding cam signal is output internally (maximum 2 monitoring clock cycles)
t_5	Delay until the corresponding cam signal is transferred to the NCK I/O devices and the NC/PLC interface (on SINUMERIK 840D: Time = 0, on SINUMERIK 840C: 1 IPO cycle).
t_6	Delay before the PLC-SGA is output to the PLC I/O devices (PLC cycle time, in drive monitoring channel only)
Note: Each axis must be measured during start-up to determine how long it takes for cam signals to be output to I/O devices after the cam position has been crossed.	

3.6.2 Example of application for safe cams

Description of task

The axis speed must be monitored for violation of various speed limit values based on position areas 1, 2 and 3 of the axis, i.e. if the axis is in area 1, 2, 3, then its speed must be monitored for violation of speed limit value 1, 3, 4.

The position areas are defined via cam signals SN1- and SN1+.

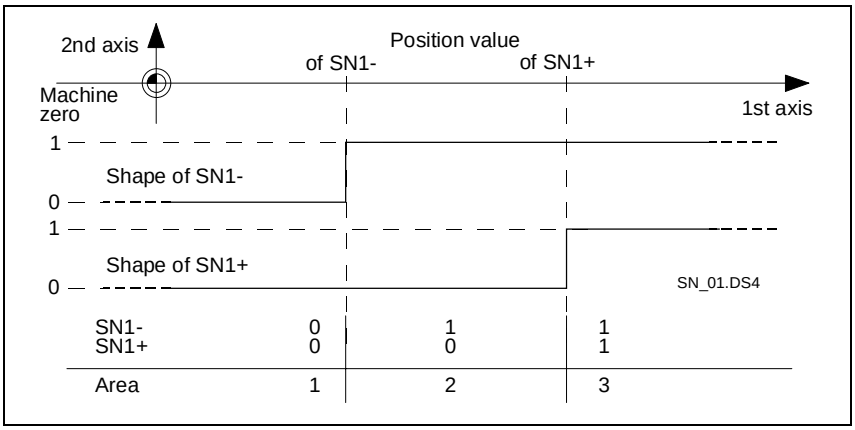

Fig. 3-17 Signal shapes, positions and areas

Note

In this example, cam synchronization must be enabled via the following machine data:

On 840D MD 36901, bit 7: $MA_SAFE_FUNCTION_ENABLE

On 840C MD 4500*, bit 7: Enable cam synchronization

On 611D MD 1301, bit 7: $MD_SAFE_FUNCTION_ENABLE

Applicable from: SW4.2 on 840D/611D
SW6.1 on 840C/611D

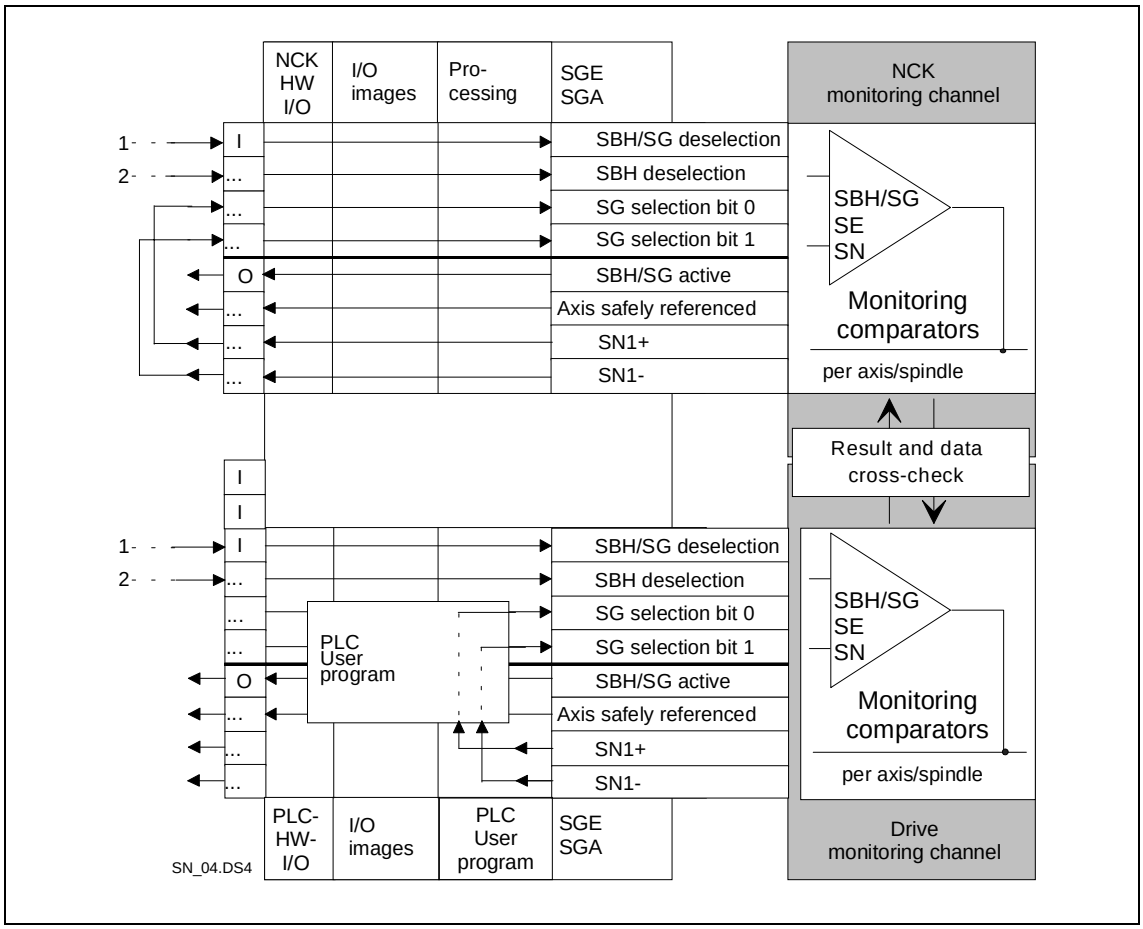

Fig. 3-18 Interconnection of required SGEs/SGAs

Assumptions for the example

- The example applies to the 1st axis.
- Position values: SN1- = 300 mm, SN1+ = 600 mm
- Speed limit values:

  Area 1 = 1000 mm/min
  Area 2 = 2000 mm/min
  Area 3 = 4000 mm/min

- Definition of SGEs/SGAs in NCK monitoring channel
  - On 840D

Logical slot for terminal block:	9
Slot number of submodule with SGEs:	1
Slot number of submodule with SGAs:	2
I/O number for signal SN1+:	7
I/O number for signal SN1-:	6
I/O number for signal "Axis safely referenced":	5
I/O number for signal "SBH/SG active":	4
I/O number for signal "SBH/SG deselection":	2
I/O number for signal "SBH deselection":	3
I/O number for signal "SG selection bit 1":	6
I/O number for signal "SG selection bit 0":	7

– On 840C

Module:	Mixed I/O
Module number:	1
I/O number for signal SN1+:	7
I/O number for signal SN1-:	6
I/O number for signal "Axis safely referenced":	5
I/O number for signal "SBH/SG active":	4
I/O number for signal "SBH/SG deselection":	2
I/O number for signal "SBH deselection":	3
I/O number for signal "SG selection bit 1":	6
I/O number for signal "SG selection bit 0":	7

If the axis is being positioned exactly at the parameterized cam position, the cam signals may have different states owing to variations in actual value between the two monitoring channels. If the SGAs "SNx" were directly connected to the SGEs "SG selection", the result and data cross-check would signal an error. When cam synchronization is activated, the cam signals are output with the same signal status in both channels when the axis has reached zero speed.

Note

The machine data for the safe velocity function are described in Section 4 Data Descriptions.

Definition of machine data

Table 3-47 Supply of MD for cam positions

	On 840D		On 840C		On 611D	
	MD No.	Value	MD No.	Value	MD No.	Value
SN1-	36937	300	42320	300	1337[0]	300
SN1+	36936	600	42160	600	1336[0]	600

Table 3-48 Supply of MD for speed limit values

	On 840D		On 840C		On 611D	
Limit value	MD No.	Value	MD No.	Value	MD No.	Value
1	36931[0]	1000	41840	1000	1331[0]	1000
2	36931[1]	0	41880	0	1331[1]	0
3	36931[2]	2000	41920	2000	1331[2]	2000
4	36931[3]	4000	41960	4000	1331[3]	4000

Table 3-49 Assignment of speed limit values to areas

Speed limit value			Area	Remarks
	SG selection			
	Bit 1	Bit 0		
1	0	0	1	SG1 active
2	0	1	-	Not used
3	1	0	2	SG3 active
4	1	1	3	SG4 active

Table 3-50 Supply of MD for SGEs/SGAs on 840D

Signal		Assignment	
SGE/SGA	Name	MD No.	Value
SGA	SN1+	36988[0]	01 09 02 07
SGA	SN1-	36989[0]	01 09 02 06
SGA	Axis safely referenced	36987	01 09 02 05
SGA	SBH/SG active	36980	01 09 02 04
SGE	SBH/SG deselection	36970	01 09 01 02
SGE	SBH deselection	36971	01 09 01 03
SGE	SG selection bit 1	36972[1]	01 09 01 06
SGE	SG selection bit 0	36972[0]	01 09 01 07

Table 3-51 Supply of MD for SGEs/SGAs on 840C

Signal		Input/output assignment		Read/write mask	
SGE/SGA	**Name**	**MD No.**	**Value**	**MD No.**	**Value**
SGA	SN1+	47000	30 10 00 70	45808.7	1
SGA	SN1-	47040	30 10 00 60	45808.6	1
SGA	Axis safely referenced	47360	30 10 00 50	45808.5	1
SGA	SBH/SG active	47320	30 10 00 40	45808.4	1
SGE	SBH/SG deselection	46000	30 10 00 20	45802.2	1
SGE	SBH deselection	46040	30 10 00 30	45802.3	1
SGE	SG selection bit 1	46160	30 10 00 60	45802.6	1
SGE	SG selection bit 0	46120	30 10 00 70	45802.7	1

Note

The corresponding signals must be processed similarly by the PLC in the drive monitoring channel (see Section 3.1.2 Signal processing for drive monitoring channel).

To ensure that cam signals are evaluated reliably, the SGA "Axis safely referenced" must also be taken into account. The SGA "Axis safely referenced" can be gated by means of the SGA "SBH/SG active" if the signal is used to enable a protection zone (see Section 7.2 Example circuits for Safety Integrated)
Advantage:
An AND operation in the NCK monitoring channel can then be implemented by means of machine data (see Section 4.1 Machine data for SINUMERIK 840D or Section 4.2 Machine and service data for SINUMERIK 840C).

3.6.3 Overview of machine data for SN function

Overview of MD for 840D

Table 3-52 Overview of machine data for 840D

Number	Identifier
36901	$MA_SAFE_FUNCTION_ENABLE
36905	$MA_SAFE_MODULO_RANGE (from SW4.2)
36936	$MA_SAFE_CAM_POS_PLUS[n]
36937	$MA_SAFE_CAM_POS_MINUS[n]
36988	$MA_SAFE_CAM_PLUS_OUTPUT[n]
36989	$MA_SAFE_CAM_MINUS_OUTPUT[n]
36940	$MA_SAFE_CAM_TOL
Note: The data are described in Section 4.1 Machine data for SINUMERIK 840D	

Overview of MD for 840C

Table 3-53 Overview of machine data for 840C

Number	Name
4500* bit 7	Enable cam synchronization (from SW6.1)
4504*	Cam enable safe operation
4216*	Plus cam position for safe cams 1
4220*	Plus cam position for safe cams 2
4224*	Plus cam position for safe cams 3
4228*	Plus cam position for safe cams 4
4232*	Minus cam position for safe cams 1
4236*	Minus cam position for safe cams 2
4240*	Minus cam position for safe cams 3
4244*	Minus cam position for safe cams 4
4700*	Output assignment SN1 +
4708*	Output assignment SN2 +
4716*	Output assignment SN3 +
4724*	Output assignment SN4 +
4704*	Output assignment SN1 -
4712*	Output assignment SN2 -
4720*	Output assignment SN3 -
4728*	Output assignment SN4 -
4248*	Tolerance for safe cams
Note: The data are described in Section 4.2 Machine and service data for SINUMERIK 840C	

Overview of MD for 611D

Table 3-54 Overview of machine data for 611D

Number	Identifier
1301	$MD_SAFE_FUNCTION_ENABLE
1305	$MD_SAFE_MODULO_RANGE (840D from SW4.2)
1336	$MD_SAFE_CAM_POS_PLUS[n]
1337	$MD_SAFE_CAM_POS_MINUS[n]
1340	$MD_SAFE_CAM_TOL
Note: The data are described in Section 4.3 Machine data for SIMODRIVE 611D	

3.7 Actual value synchronization (drift/slip on two-encoder system) (SW 6.3 and higher)

Description

A frequent problem of spindles with V-belt is the occurring slip and a coupling factor which cannot be defined exactly. In order to enable an exact positioning nevertheless, a direct measuring system is implemented in addition to the motor encoder. For SI this involves the problem that the actual value of the drive (of the motor encoder) continuously drifts away from the actual value of the NC (of the direct measuring system). In the cross-check data comparison this is then recognized to be an error. For axes with necessary absolute reference (e.g. monitoring of limit switch or cams) this is correct and necessary. If, however, merely the velocity of the spindle shall be monitored, a slow drift-away of the two absolute actual values can be tolerated.

From SW 6.3 and higher

From SW 6.3, the absolute actual value is synchronized cyclically in the cross-check monitoring cycle. Both components thereby "correct" their absolute actual value by half of the calculated actual value difference. Consequently, the SI actual value will, therefore, drift away from the correct actual value of the NC. However, as the absolute reference is not required, this will not disturbe velocity monitoring.

Activation

The actual value synchronization is activated in bit 3 of the machine data 4500* "Function enable SS/SG, SE, actual value synchronization and cam synchronization".

The maximum slip or drift is defined in the machine data 4300* "Two-encoder drift/slip tolerance".

Installation

The function is activated with bit 3 in the machine data 4500*. Enter the maximum value in the machine data 4300*. Use the servo trace signal "SI velocity difference" to record the state, in which, by experience, the biggest slip occurs, e.g. during acceleration/deceleration of the spindle. Enter the calculated slip speed with sufficient surplus in the machine data 4300* "Two-encoder drift/slip tolerance".

Note

The slip can increase after a certain time, caused by e.g. aging or belt tension.

In the menu SI service the actual and the maximum actual value difference can be read from the service data 309 and 310.

Restrictions

Functions which require an absolute value (e.g. safe limit position (SE)), are not possible in combination with the actual value synchronization.

■

Notes

Data Descriptions

4

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4.1 Machine data for SINUMERIK 840D

4.1.1 Overview of machine data

Table 4-1 Overview of machine data for SINUMERIK 840D

Number	Identifier	Name	Reference
General ($MN_ ...)			
10050	SYSCLOCK_CYCLE_TIME	Basic system cycle	/FBD/, G2
10060	POSCTRL_SYSCLOCK_TIME_RATIO	Factor for position control cycle	/FBD/, G2
10090	SAFETY_SYSCLOCK_TIME_RATIO	Factor for monitoring cycle	
10091	INFO_SAFETY_CYCLE_TIME	Display of monitoring cycle	
10092	INFO_CROSSCHECK_CYCLE_TIME	Display of cross-check cycle	
13010	DRIVE_LOGIC_NR	Logical drive number	/FBD/, G2
10200	INT_INCR_PER_MM	Calculation accuracy for linear positions	/FBD/, G2
10210	INT_INCR_PER_DEG	Calculation accuracy for angular positions	/FBD/, G2
10366	HW_ASSIGN_DIG_FASTIN	Hardware assignment of external digital NCK inputs	/FBD/, A4
10368	HW_ASSIGN_DIG_FASTOUT	Hardware assignment of external digital NCK outputs	/FBD/, A4
Axis/spindle-specific ($MA_ ...)			
30300	$MA_IS_ROT_AX	Rotary axis/spindle	/FBD/, R2
30320	$MA_DISPLAY_IS_MODULO	Modulo 360 degrees display for rotary axis/spindle	/FBD/, R2
30330	$MA_MODULO_RANGE	Size of modulo range	/FBD/, R2
32300	$MA_MA_AX_ACCEL	Axis acceleration	/FBD/, B2
35200	$MA_GEAR_STEP_SPEEDCTRL_ACCEL	Acceleration in speed control mode	/FBD/, S1
35210	$MA_STEP_POSCTRL_ACCEL	Acceleration in position control mode	/FBD/, S1
35410	$MA_SPIND_OSCILL_ACCEL	Acceleration during reciprocating	/FBD/, S1
36060	STANDSTILL_VELO_TOL	Maximum velocity/speed "Axis/spindle stopped"	/FBD/, A2
36901	SAFE_FUNCTION_ENABLE	Enable safe functions	
36902	SAFE_IS_ROT_AX	Rotary axis	
36905	SAFE_MODULO_RANGE	Modulo value safe cams (from SW4.2)	
36910	SAFE_ENC_SEGMENT_NR	Actual value assignment: Drive type	
36911	SAFE_ENC_MODULE_NR	Actual value assignment: Drive no./measuring circuit no.	
36912	SAFE_ENC_INPUT_NR	Actual value assignment: Input to drive module/measuring-circuit board	
30240	ENC_TYPE	Encoder type, actual value sensing method	/FBD/, G2
36915	SAFE_ENC_TYPE	Encoder type	
36916	SAFE_ENC_IS_LINEAR	Linear scale	
36917	SAFE_ENC_GRID_POINT_DIST	Grid spacing linear scale	
36918	SAFE_ENC_RESOL	Encoder markings per revolution	
36920	SAFE_ENC_GEAR_PITCH	Spindle pitch	
36921	SAFE_ENC_GEAR_DENOM[n]	Denominator gearbox encoder load	
36922	SAFE_ENC_GEAR_NUMERA[n]	Numerator gearbox encoder load	
36925	SAFE_ENC_POLARITY	Direction reversal actual value	
36930	SAFE_STANDSTILL_TOL	Standstill tolerance	
36931	SAFE_VELO_LIMIT[n]	Limit value for safe velocity	
36932	SAFE_VELO_OVR_FACTOR[n]	Override factor for SG (from SW4.2)	
36934	SAFE_POS_LIMIT_PLUS[n]	Upper limit value for safe limit position	
36935	SAFE_POS_LIMIT_MINUS[n]	Lower limit value for safe limit position	
36936	SAFE_CAM_POS_PLUS[n]	Plus cam position for safe cams	
36937	SAFE_CAM_POS_MINUS[n]	Minus cam position for safe cams	
36940	SAFE_CAM_TOL	Tolerance for safe cams	
36942	SAFE_POS_TOL	Actual value comparison tolerance (cross-check)	
36944	SAFE_REFP_POS_TOL	Actual value comparison tolerance (reference)	
36946	SAFE_VELO_X	Velocity limit n_x (from SW4.2)	

Number	Identifier	Name	Reference
36948	SAFE_STOP_VELO_TOL	Actual speed tolerance for SBR (from SW4.2)	
36950	SAFE_MODE_SWITCH_TIME	Tolerance time for SGE switchover	
36951	SAFE_VELO_SWITCH_DELAY	Delay time velocity switchover	
36952	SAFE_STOP_SWITCH_TIME_C	Transition time STOP C to safe operational stop	
36953	SAFE_STOP_SWITCH_TIME_D	Transition time STOP D to safe operational stop	
36954	SAFE_STOP_SWITCH_TIME_E	Transition time STOP E to safe operational stop	Available soon
36956	SAFE_PULSE_DISABLE_DELAY	Delay time pulse disable	
36957	SAFE_PULSE_DIS_CHECK_TIME	Time for testing pulse disable	
36960	SAFE_STANDSTILL_VELO_TOL	Creep speed pulse disabling	
36620	SERVO_DISABLE_DELAY_TIME	Cutout delay servo enable	/FBD/, A2
36961	SAFE_VELO_STOP_MODE	Stop reaction safe velocity	
36962	SAFE_POS_STOP_MODE	Stop reaction safe limit position	
36963	SAFE_VELO_STOP_REACTION[n]	SG-specific stop reaction (from SW4.2)	
36970	SAFE_SVSS_DISABLE_INPUT	Input assignment SBH/SG deselection	
36971	SAFE_SS_DISABLE_INPUT	Input assignment SBH deselection	
36972	SAFE_VELO_SELECT_INPUT[n]	Input assignment SG selection	
36973	SAFE_POS_SELECT_INPUT	Input assignment SE selection	
36974	SAFE_GEAR_SELECT_INPUT[n]	Input assignment gear ratio selection	
36975	SAFE_STOP_REQUEST_INPUT	Input assignment "Test stop selection"	
36976	SAFE_PULSE_STATUS_INPUT	Input assignment "Pulses disabled" status	
36978	SAFE_OVR_INPUT[n]	Input assignment for SG override selection (from SW4.2)	
36980	SAFE_SVSS_STATUS_OUTPUT	Output assignment SBH/SG active	
36981	SAFE_SS_STATUS_OUTPUT	Output assignment for SBH active (≥SW4.2)	
36982	SAFE_VELO_STATUS_OUTPUT[n]	Output assignment for SG active (≥ SW4.2)	
36985	SAFE_VELO_X_STATUS_OUTPUT	Output assignment for $n < n_x$ (≥ SW4.2)	
36986	SAFE_PULSE_ENABLE_OUTPUT	"Enable pulses" output assignment	
36987	SAFE_REFP_STATUS_OUTPUT	Output assignment "Axis safely referenced"	
36988	SAFE_CAM_PLUS_OUTPUT[n]	Output assignment SN1 + to SN4 +	
36989	SAFE_CAM_MINUS_OUTPUT[n]	Output assignment SN1 - to SN4 -	
36995	SAFE_STANDSTILL_POS	Standstill position	
36997	SAFE_ACKN	User agreement	
36998	SAFE_ACT_CHECKSUM	Actual checksum	
36999	SAFE_DES_CHECKSUM	Setpoint checksum	

4.1.2 Description of machine data

General

General information about machine data and explanations of their contents such as unit, data type, protection level, effectiveness, etc. can be found in the following references:

References: /LID/, Lists SINUMERIK 840D

10090 MD number	**$MN_SAFETY_SYSCLOCK_TIME_RATIO** Factor for monitoring cycle		**840D**
Default: 3	Min. input value: 1	Max. input value: 50	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	Ratio between monitoring cycle and basic system cycle. The monitoring cycle is the product of this data and $MN_SYSCLOCK_CYCLE_TIME.		
Special cases, errors	The monitoring cycle is checked during power-up: • It must be an integral multiple of the position control cycle • It must be ≤ 25 ms If these conditions are not fulfilled, the factor is rounded to the next possible value. The monitoring cycle that is actually set is displayed via $MN_INFO_SAFETY_CYCLE_TIME. The value for the cross-check cycle that is displayed via $MN_INFO_CROSSCHECK_CYCLE_TIME also changes. Note: The monitoring cycle time also determines the monitor reaction time. Remember that a short monitoring cycle time increases the load on the CPU.		
Related to ...	MD 10050: $MN_SYSCLOCK_CYCLE_TIME MD 10091: $MN_INFO_SAFETY_CYCLE_TIME MD 10092: $MN_INFO_CROSSCHECK_CYCLE_TIME		

10091 MD number	**$MN_INFO_SAFETY_CYCLE_TIME** Display of monitoring cycle		**840D**
Default: -	Min. input value: -	Max. input value: -	
Change valid after POWER ON	Protection level (R/W): 7/-	Unit: ms	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	This data displays the monitoring cycle time that is actually effective. It is a pure display data and cannot be written.		
Related to ...	MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO		
References	See Section 2.3.4 Safety monitoring cycle and cross-check cycle		

10092 MD number	**$MN_INFO_CROSSCHECK_CYCLE_TIME** Display of cross-check cycle			**840D**
Default: -	Min. input value: -		Max. input value: -	
Change valid after POWER ON	Protection level (R/W): 7/-		Unit: ms	
Data type: DOUBLE	Valid as from SW version: 3.4			
Meaning	This data displays the effective time for one full execution of the cross-check cycle. It is a pure display data and cannot be written.			
Related to ...	MD 10090: $MN_SAFETY_SYSCLOCK_TIME_RATIO			
References	See Section 2.3.4 Safety monitoring cycle and cross-check cycle			

36901 MD number	**$MA_SAFE_FUNCTION_ENABLE** Enable safe functions							**840D**
Default: 0	Min. input value: 0			Max. input value: FF 03, FF E3 (≥ SW4.2)				
Change valid after POWER ON	Protection level (R/W): 7/2			Unit: Hexadecimal				
Data type: DWORD	Valid as from SW version: 3.4							
Meaning	The functions for safe operation can be enabled for one axis/spindle with this data. It is only possible to enable on an axis-specific basis as many axes/spindles for safe operation as have been enabled by the global option. If one of the bits 1, 8...15 is set, then bit 0 must also be set because the control switches the drive to a safe operational stop with STOP C, D, and E. This condition is checked (configuration alarm 27033 is output in the event of an error). The more partial functions set, the more computing time the safe functions require.							
High byte	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 19	Bit 9	Bit 8
	Enable safe functions							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
Low byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Enable (≥ SW4.2)			Reserved, bits must be 0			Enable	
	Cam synchro-nization	Reserved	Override for safe velocity	0	0	0	SE	SBH/ SG
Special cases, errors	• If bit 1 or a higher bit is set, then bit 0 must also be set since the control system switches to a safe operational stop in response to STOP C, D or E (a configuration alarm is output if an error is detected). • If an insufficient number of axes/spindles have been enabled for safe operation by means of the global option, then this data may be overwritten with the value 0000 during power-up							
Related to ...	Global option							
References	See Section 2.3.6 Enabling individual safe functions							

36902 MD number	**$MA_SAFE_IS_ROT_AX** Rotary axis		**840D**
Default: 0	Min. input value: 0	Max. input value: 1	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BOOLEAN	Valid as from SW version: 3.4		
Meaning	Data specifies whether the axis for safe operation is a rotary axis/spindle or linear axis. = 0: Linear axis = 1: Rotary axis/spindle The value set in this MD must be the same as the value set in MD: $MA_IS_ROT_AX. A parameterization error is displayed if they are not identical.		

36905 MD number	**$MA_SAFE_MODULO_RANGE** Modulo value for SN		**840D**
Default: 0.0	Min. input value: 0.0	Max. input value: 737280.0	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Degrees	
Data type: DOUBLE	Valid as from SW version: 4.2		
Meaning	Actual value range in which safe cams for rotary axes are calculated. The axis must be a rotary axis ($MA_/$MD_SAFE_IS_ROT_AX = 1). Setting = 0: Modulo correction after +/- 2048 revolutions (i.e. after 737 280 degrees) Setting > 0 and multiples of 360 degrees: Modulo correction after this setting (e.g. setting = 360 → the actual value range is between 0 and 359.999 degrees, i.e. a modulo correction is carried out after every revolution.		
Special cases, errors	• If the value set in this data is not 0 or a multiple of 360 degrees, then an appropriate alarm is output during power-up. • The cam positions are also checked with respect to the parameterized actual value range during power-up. An appropriate alarm is output if parameterization errors are detected. • Actual value ranges set in $MA_SAFE_MODULO_RANGE and $MA_MODULO_RANGE must be divisible as integers without remainder.		
Related to ...	MD 1305: $MD_SAFE_MODULO_RANGEMD 30330: $MA_MODULO_RANGEMD 36935/1336: $MA_/$MD_SAFE_CAM_POS_PLUS[n]MD 36937/1337: $MA_/$MD_SAFE_CAM_POS_MINUS[n]		

36910 MD number	**$MA_SAFE_ENC_SEGMENT_NR** Actual value assignment: Drive type		**840D**
Default: 1	Min. input value: 0	Max. input value: 1	
Change valid after POWER ON	Protection level (R/W): 0/0	Unit: -	
Data type: BYTE	Valid as from SW version: 3.4		
Meaning	Number of bus segment via which the SI encoder is addressed. =1: Drive bus of SIMODRIVE 611D (always present)		

36911 MD number	**$MA_SAFE_ENC_MODULE_NR** Actual value assignment: Drive no./measuring circuit no.		**840D**
Default: 1	Min. input value: 1	Max. input value: NCU 572: 31	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BYTE	Valid as from SW version: 3.4		
Meaning	Module no. within a segment via which the SI encoder is addressed. The logical drive number of the drive assigned to the axis via $MN_DRIVE_LOGIC_NR is entered here. For standard applications with a 2-encoder system, the encoder for Safety Integrated is connected to the second encoder connection (bottom input) of the same drive module.		
Special cases, errors	Any actual value input in the 611D grouping can be used for the second encoder as the measuring system on the NC side.		
Related to ...	MD 36910: $MA_SAFE_ENC_SEGMENT_NR MD 36912: $MA_SAFE_ENC_INPUT_NR MD 36010: $MN_DRIVE_LOGIC_NR		

36912 MD number	**$MA_SAFE_ENC_INPUT_NR** Actual value assignment: Input to drive module/measuring circuit board		**840D**
Default: 1	Min. input value: 1	Max. input value: 2	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BYTE	Valid as from SW version: 3.4		
Meaning	Number of the actual value input of a module via which the SI encoder is addressed. = 1: SI encoder is connected to top input (motor encoder) = 2: SI encoder is connected to bottom input (2nd encoder) For standard applications with a 2-encoder system, the encoder for Safety Integrated is connected to the second encoder connection (bottom input) of the same drive module.		
Special cases, errors	Any actual value input in the 611D grouping can be used for the second encoder as the measuring system on the NC side.		
Related to ...	MD 36911: $MA_SAFE_ENC_MODULE_NR		

36915 MD number	**$MA_SAFE_ENC_TYPE** Encoder type		**840D**
Default: 0	Min. input value: 0	Max. input value: 4	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BYTE	Valid as from SW version: 3.4		
Meaning	The type of SI encoder connected is specified here. = 0: Reserved = 1: Raw signal encoder (1V peak-to-peak) = 4: Absolute encoder with EnDat interface		
Special cases, errors	• The value is coded in the same way as in data $MA_ENC_TYPE. • Only the value 1 or 4 is permitted. • An incorrect configuration (e.g. entry of values 0, 2, 3 or 5) is displayed with alarm 27033.		
Related to ...	MD 30240: $MA_ENC_TYPE		

36916 MD number	**$MA_SAFE_ENC_IS_LINEAR** Linear scale		**840D**
Default: 0	Min. input value: 0	Max. input value: 1	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BOOLEAN	Valid as from SW version: 3.4		
Meaning	This is used to specify whether the connected encoder is rotary or linear. = 0: Rotary encoder is connected Its resolution is defined in $MA_SAFE_ENC_RESOL and converted to the load side with $MA_SAFE_ENC_GEAR_PITCH, $MA_SAFE_ENC_GEAR_DENOM[n] and $MA_SAFE_ENC_GEAR_NUMERA[n]. MD: $MA_SAFE_ENC_GRID_POINT_DIST has no meaning. = 1: Linear encoder is connected Its resolution is defined in $MA_SAFE_ENC_GRID_POINT_DIST. The MDs: $MA_SAFE_ENC_RESOL, $MA_SAFE_ENC_GEAR_PITCH, $MA_SAFE_ENC_GEAR_DENOM[n] and $MA_SAFE_ENC_GEAR_NUMERA[n] have no meaning.		
Related to ...	With 0: $MA_SAFE_ENC_RESOL $MA_SAFE_ENC_GEAR_PITCH $MA_SAFE_ENC_GEAR_DENOM[n] $MA_SAFE_ENC_GEAR_NUMERA[n] With 1: $MA_SAFE_ENC_GRID_POINT_DIST		

36917 MD number	**$MA_SAFE_ENC_GRID_POINT_DIST** Grid spacing linear scale		**840D**
Default: 0.01	Min. input value: 0.000 01	Max. input value: 8	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The grid spacing of the linear scale used is specified here.		
MD irrelevant for ...	A rotary encoder		

36918 MD number	**$MA_SAFE_ENC_RESOL** Encoder markings per revolution		**840D**
Default: 2 048	Min. input value: 1	Max. input value: 100 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	The number of markings per revolution on a rotary encoder is specified here.		
MD irrelevant for ...	A linear encoder		

36920 MD number	**$MA_SAFE_ENC_GEAR_PITCH** Spindle pitch		**840D**
Default: 10	Min. input value: 0.1	Max. input value: 10 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	Gear ratio of gearbox between encoder and load for a linear axis with rotary encoder.		

36921 MD number	**$MA_SAFE_ENC_GEAR_DENOM [n]** Denominator the gearbox encoder/load		**840D**
Default: 1	Min. input value: 1	Max. input value: 2 147 000 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	Denominator of the gearbox between encoder and load, i.e. the denominator of the fraction No. of encoder revolutions / **No. of load revolutions** n = 0, 1, ... ,7 stands for gear stage 1, 2, ... 8 The current value is selected via safety-relevant input signals (SGEs).		
Related to ...	MD 36922: $MA_SAFE_ENC_GEAR_NUMERA [n]		

36922 MD number	**$MA_SAFE_ENC_GEAR_NUMERA [n]** Numerator gearbox encoder/load		**840D**
Default: 1	Min. input value: 1	Max. input value: 2 147 000 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	Numerator of the gearbox between encoder and load, i.e. the numerator of the fraction **No. of encoder revolutions** / No. of load revolutions n = 0, 1, ... 7 stands for gear stage 1, 2, ... 8 The current value is selected via safety-relevant input signals (SGEs).		
Related to ...	MD 36921: $MA_SAFE_ENC_GEAR_DENOM [n]		

36925 MD number	**$MA_SAFE_ENC_POLARITY** Direction reversal actual value		**840D**
Default: 1	Min. input value: -1	Max. input value: 1	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	A direction reversal in the actual value can be set in this data. = -1: Direction reversal = 0 or = 1: No direction reversal		

36930 MD number	**$MA_SAFE_STANDSTILL_TOL** Standstill tolerance		**840D**
Default: 1 mm	Min. input value: 0	Max. input value: 100	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The tolerance for the safe operational stop is set in this data. If the difference between the position setpoint and position actual value is greater than the tolerance set here when safe operational stop is selected, then the control system activates alarm 27010 with STOP A or B.		
Related to ...	MD 36956: $MA_SAFE_PULSE_DISABLE_DELAY		

36931 MD number	**$MA_SAFE_VELO_LIMIT[n]** Limit value for safe velocity		**840D**
Default: 2 000 mm/min	Min. input value: 0	Max. input value: *	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm/min inches/min, rev/min	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The limit values for safe velocities 1, 2, 3 and 4 are set in this data. When SG1, SG2, SG3 or SG4 is selected and the current speed exceeds the limit set here, then the control system activates alarm 27011 with the stop reaction configured in $MA_SAFE_VELO_STOP_MODE. n = 0, 1, 2, 3 stands for limit value of SG1, SG2, SG3, SG4		
Special cases, errors	With active SBH/SG and a 1-encoder system, the speed is monitored on the basis of an encoder limit frequency of 200 kHz. An appropriate alarm is output when the limit is exceeded.		
Related to ...	MD 36961: $MA_SAFE_VELO_STOP_MODE		

36932 MD number	**$MA_SAFE_VELO_OVR_FACTOR**[**n**] Override factor for SG		**840D**
Default: 100	Min. input value: 1	Max. input value: 100	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: %	
Data type: DWORD	Valid as from SW version: 4.1		
Meaning	It is possible to select overrides via SGEs for safe velocities 2 and 4 and to set the associated override value (percentage) in this machine data. n = 0, 1, ... , 15 stands for overrides 0, 1, ... 15		
Application example	$MA_SAFE_VELO_OVR_FACTOR[0]=30 (override 0) $MA_SAFE_VELO_OVR_FACTOR[1]=50 (override 1) $MA_SAFE_VELO_OVR_FACTOR[2]=80 (override 2) $MA_SAFE_VELO_OVR_FACTOR[3]=100 (override 3) Depending on whether override 0, 1, 2 or 3 is selected, safe velocities 2 and 4 are monitored for 30, 50, 80 or 100% of the set limit value.		
Special cases, errors	• The “Override for safe velocity” function is enabled via MD 36901 (MD 1301): $MA($MD)_SAFE_FUNCTION_ENABLE. • This override is not applied to the limit values for safe velocities 1 and 3.		
Related to ...	MD 36978: $MA_SAFE_OVR_INPUT[n] MD 36931: $MA_SAFE_VELO_LIMIT[n]		
References	See Section 3.4.5 “Override for safe velocity“		

36934 MD number	**$MA_SAFE_POS_LIMIT_PLUS[n]** Upper limit value for safe limit position		**840D**
Default: 100 000 mm	Min. input value: -2 147 000	Max. input value: 2 147 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The upper limit value for safe limit positions 1 and 2 is specified here. If SE1 or SE2 is selected and the current actual position exceeds the limit set in this data, the control system activates alarm 27012 with the stop reaction configured in $MA_SAFE_POS_STOP_MODE and switches over to SBH mode. A violation of the SBH tolerance window initiates stop reaction STOP B and A. n = 0, 1 stands for upper limit value of SE1, SE2		
Related to ...	MD 36962: $MA_SAFE_POS_STOP_MODE MD 36935: $MA_SAFE_POS_LIMIT_MINUS[n] MD 36901: $MA_SAFE_FUNCTION_ENABLE		
Special cases, errors	A parameterization error is displayed if the value entered in MD: $MD_SAFE_POS_LIMIT_PLUS[n] is lower or the same as the value set in MD: $MA_SAFE_POS_LIMIT_MINUS[n].		

36935 MD number	**$MA_SAFE_POS_LIMIT_MINUS[n]** Lower limit value for safe limit position		**840D**
Default: -100 000 mm	Min. input value: -2 147 000	Max. input value: 2 147 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The lower limit value for safe limit positions 1 and 2 is specified here. If SE1 or SE2 is selected and the current actual position drops below the limit set in this data, the control system activates alarm 27012 with the stop reaction configured in $MA_SAFE_POS_STOP_MODE and switches over to SBH mode. A violation of the SBH tolerance window initiates stop reaction STOP B and A. n = 0, 1 stands for lower limit value of SE1, SE2		
Related to ...	MD 36962: $MA_SAFE_POS_STOP_MODE MD 36934: $MA_SAFE_POS_LIMIT_PLUS[n] MD 36901: $MA_SAFE_FUNCTION_ENABLE		
Special cases, errors	A parameterization error is displayed if the value entered in MD: $MD_SAFE_POS_LIMIT_PLUS[n] is lower or equal to the value set in MD: $MA_SAFE_POS_LIMIT_MINUS[n].		

36936 MD number	**$MA_SAFE_CAM_POS_PLUS[n]** Plus cam position for safe cams		**840D**
Default: 10 mm	Min. input value: -2 147 000	Max. input value: 2 147 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The plus cam position for safe cams SN1 +, SN2 +, SN3 + and SN4 + is specified in this data. If the actual position is ≤ the value set here when the safe cam function is active, then the appropriate safety-relevant output signal (SGA) is set to 0 and to 1 if the actual position is > this value. n = 0, 1, 2, 3 stands for plus cam position of SN1 +, SN2 +, SN3 +, SN4 +		
Related to ...	MD 36988: $MA_SAFE_CAM_PLUS_OUTPUT[n] MD 36901: $MA_SAFE_FUNCTION_ENABLE		

36937 MD number	**$MA_SAFE_CAM_POS_MINUS[n]** Minus cam position for safe cams		**840D**
Default: -10 mm	Min. input value: -2 147 000	Max. input value: 2 147 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The minus cam position for safe cams SN1 -, SN2 -, SN3 - and SN4 -. If the actual position is ≤ the value set here when the safe cam function is active, then the appropriate safety-relevant output signal (SGA) is set to 0 and to 1 if the actual position is > this value. n = 0, 1, 2, 3 stands for minus cam position of SN1 -, SN2 -, SN3 -, SN4 -		
Related to ...	MD 36989: $MA_SAFE_CAM_MINUS_OUTPUT[n] MD 36901: $MA_SAFE_FUNCTION_ENABLE		

36940 MD number	**$MA_SAFE_CAM_TOL** Tolerance for same cams		**840D**
Default: 0.1 mm	Min. input value: 0.001	Max. input value: 10 mm	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	Owing to the different mounting locations of the encoders and variations in clock cycle and signal transit times, the cam signals of the two monitoring channels never switch at exactly the same position and never simultaneously. This data specifies the tolerance for all cams as a load-side distance. The monitoring channels may have different signal states for the same cam within this tolerance band without generation of alarm 27001.		
Special cases, errors	Recommendation: Enter identical or slightly higher value to setting in MD 36942.		

36942 MD number	**$MA_SAFE_POS_TOL** Actual value comparison tolerance (cross-check)		**840D**
Default: 0.1 mm	Min. input value: 0.001	Max. input value: 10 mm or 360 degrees	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	Owing to the fact that encoders are not mounted in identical locations and the effects of backlash, torsion, leadscrew errors, etc., the actual positions sensed simultaneously by the NCK and drive may not be exactly the same. The tolerance band for the actual position cross-check in the two monitoring channels is specified in this data.		
Special cases, errors	• "Finger protection" (about 10 mm) is the primary consideration when setting this tolerance value. • Stop reaction STOP F is activated when the tolerance band is violated.		

36944 MD number	**$MA_SAFE_REFP_POS_TOL** Actual value comparison tolerance (reference)		**840D**
Default: 0.01 mm	Min. input value: 0	Max. input value: 1 mm or 36 degrees	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm, inches, degrees	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The tolerance for the actual value check after referencing (with an incremental encoder) or power ON (with an absolute encoder) is set in this data (see Section 2.4.2 Adjustment measurement, axis states and previous history) A second absolute actual position is calculated from the last standstill position to be stored prior to control power OFF and the distance traversed since power ON. The control system checks the actual values after referencing on the basis of the two actual positions, the traversed distance and this data. The following factors must be taken into consideration when calculating tolerance values: Backlash, leadscrew errors, compensations (max. compensation values for LEC, sag and temperature compensation), temperature errors, torsion (2-encoder system), gear play on shift gearboxes, lower resolution (2-encoder system), oscillating distance for shift gearboxes.		
Special cases, errors	If these two actual positions deviate from one another by more than the value set in this data with valid user agreement, then alarm 27001 is displayed with error code 1003 and user agreement will need to be given again for referencing.		

36946 MD number	**$MA_SAFE_VELO_X** Velocity limit n_x		**840D**
Default: 20.0	Min. input value: 0.0	Max. input value: 1 000.0	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm/min inch/min, rev./min	
Data type: DOUBLE	Valid as from SW version: 4.2		
Meaning	This data defines limit speed n_x for SGA "$n < n_x$".		
Related to ...	MD 1346: $MD_SAFE_VELO_X		
References	See Section 3.4.6 "SGA "$n < n_x$" and "SG active""		

36948 MD number	**$MA_SAFE_STOP_VELO_TOL** Actual speed tolerance for SBR		**840D**
Default: 300.0	Min. input value: 0.0	Max. input value: 20 000.0	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm/min inch/min, rev./min	
Data type: DOUBLE	Valid as from SW version: 4.2		
Meaning	After the safe braking ramp has been activated, the current speed plus the speed tolerance set in this machine data are applied as a velocity limit.		
Related to ...	MD 1348: $MD_SAFE_STOP_VELO_TOL		
References	See Section 2.5.6 "Safe braking ramp (SBR)" (a recommended setting and setting formula are specified in this Section).		

36950 MD number	**$MA_SAFE_MODE_SWITCH_TIME** Tolerance time for SGE switchover		**840D**
Default: 0.5	Min. input value: 0	Max. input value: 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: s	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	SGE switchovers do not take effect simultaneously owing to variations in transit times for SGE transmission in the two monitoring channels. A data cross-check would output an error message in this case. This data is used to specify the period of time after SGE switchovers during which no cross-check of actual values and monitoring results is carried out (cross-comparison of machine data continues!). The selected monitoring functions continue to operate unhindered in both monitoring channels. A safe function is activated in a monitoring channel immediately selection or switchover is detected in this channel. The variation in transit time is mainly determined by the PLC cycle time.		
Special cases, errors	System-dependent minimum tolerance time: 2 x PLC cycle time (maximum cycle) + 1 x IPO cycle time The variations in transit time in the external circuitry (e.g. relay operating times) must also be taken into account.		
References	See Section 3.1 Safety-relevant input/output signals (SGE/SGA)		

36951 MD number	**$MA_SAFE_VELO_SWITCH_DELAY** Delay time speed switchover		**840D**
Default: 0.1	Min. input value: 0	Max. input value: 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: s	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	A timer with the value in this data is started on transition from a high to a lower safe velocity or when safe operational stop is selected when the safe velocity function is active. While the timer is in operation, the speed continues to be monitored for the last selected velocity limit value. During this period, the axis/spindle can be braked, for example, via the PLC user program without the monitor signalling an error and initiating a stop reaction.		

36952 MD number	**$MA_SAFE_STOP_SWITCH_TIME_C** Transition time STOP C to safe operational stop		**840D**
Default: 0.1	Min. input value: 0	Max. input value: 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: s	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	This data defines the time period between the initiation of a STOP C and the activation of the safe operational stop function. Once the time has expired, the drive is monitored for safe operational stop. If the axis/spindle has still not been stopped, STOP A or B is initiated.		

36953 MD number	**$MA_SAFE_STOP_SWITCH_TIME_D** Transition time STOP D to safe operational stop		**840D**
Default: 0.1	Min. input value: 0	Max. input value: 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: s	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	This data defines the time period between the initiation of a STOP D and the activation of the safe operational stop function. Once the time has expired, the drive is monitored for safe operational stop. If the axis/spindle has still not been stopped, STOP A or B is initiated.		

36956 MD number	**$MA_SAFE_PULSE_DISABLE_DELAY** Delay time pulse disable		**840D**
Default: 0.1	Min. input value: 0	Max. input value: 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: s	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	In STOP B mode, the axis is braked along the current limit with speed setpoint 0. After the delay time defined in this data, the braking mode changes to STOP A for pulse disabling.		
Special cases, errors	The pulses are disabled earlier than defined in this data if the condition for pulse disabling is defined in 36960: $MA_SAFE_STANDSTILL_VELO_TOL or in MD 36620: $MA_SERVO_DISABLE_DELAY_TIME. If the timer in this data is set to zero, STOP A (immediate pulse disabling) is activated immediately from STOP B mode.		
Related to ...	MD 36960: $MA_SAFE_STANDSTILL_VELO_TOL MD 36620: $MA_SERVO_DISABLE_DELAY_TIME MD 36060: $MA_STANDSTILL_VELO_TOL		

36957 MD number	**$MA_SAFE_PULSE_DIS_CHECK_TIME** Time for testing pulse disable		**840D**
Default: 0.1	Min. input value: 0	Max. input value: 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: s	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	The time limit for disabling of pulses after pulse disabling has been requested is set in this data. The time that elapses between setting of the "Enable pulses" SGA and detection of the "Pulses disabled status" SGE must not exceed the time limit set in this data.		
Special cases, errors	STOP A is initiated if this time limit is exceeded.		

36960 MD number	**$MA_SAFE_STANDSTILL_VELO_TOL** Creep speed pulse disabling		**840D**
Default: 0	Min. input value: 0	Max. input value: 1 000	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: mm/min, inches/min, rev/min	
Data type: DOUBLE	Valid as from SW version: 3.4		
Meaning	When the axis/spindle speed drops below this limit, it is judged to be at a "standstill". In STOP B mode, the pulses are then disabled (through transition to STOP A mode).		
Related to ...	MD 36956: $MA_SAFE_PULSE_DISABLE_DELAY		

36961 MD number	**$MA_SAFE_VELO_STOP_MODE** Stop reaction for safe velocity		**840D**
Default: 5	Min. input value: 0	Max. input value: 5	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BYTE	Valid as from SW version: 3.4		
Meaning	When a limit value for safe velocity 1, 2, 3 or 4 is exceeded, the stop reaction set in this data is initiated. = 0, 1, 2, 3 means that STOP A, B, C and D are set for each SG level = 5 means that the stop reaction can be configured SG-specifically in MD 36963/1363		
Special cases, errors	A setting of 4 causes an alarm to be output.		
Related to ...	MD 36931: $MA_SAFE_VELO_LIMIT[n] MD 36963: $MA_SAFE_VELO_STOP_REACTION[n]		

36962 MD number	**$MA_SAFE_POS_STOP_MODE** Stop reaction safe velocity		**840D**
Default: 2	Min. input value: 2	Max. input value: 3	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BYTE	Valid as from SW version: 3.4		
Meaning	The stop reaction specified in this data is initiated when the axis crosses safe limit position 1 or 2. = 2, 3, 4 stands for STOP C, D, E that is activated in the event of error		
Related to ...	MD 36934: $MA_SAFE_POS_LIMIT_PLUS[n] MD 36935: $MA_SAFE_POS_LIMIT_MINUS[n]		

36963 MD number	**$MA_SAFE_VELO_STOP_REACTION[n]** SG-specific stop reaction		**840D**
Default: 2	Min. input value: 0	Max. input value: 3	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: -	
Data type: BYTE	Valid as from SW version: 4.2		
Meaning	When a limit value for safe velocity 1, 2, 3 or 4 is exceeded, the stop reaction set in this data is initiated. n = 0, 1, 2, 3 stands for SG1, SG2, SG3, SG4 Setting = 0, 1, 2, 3 corresponds to STOP A, B, C, D		
Application example	STOP B must be initiated at SG1, STOP C at SG2 and SG3 and STOP D at SG4. To achieve this response, the MD must be supplied as follows: $MA_SAFE_VELO_STOP_REACTION[0]=1 STOP B applies at SG1 $MA_SAFE_VELO_STOP_REACTION[1]=2 STOP C applies at SG2 $MA_SAFE_VELO_STOP_REACTION[2]=2 STOP C applies at SG3 $MA_SAFE_VELO_STOP_REACTION[3]=3 STOP D applies at SG4		
Special cases, errors	This function is active only when MD 36961 and MD 1361 are set to 5.		
Related to ...	MD 36931: $MA_SAFE_VELO_LIMIT[n] MD 36961: $MA_SAFE_VELO_STOP_MODE		

36970 MD number	**$MA_SAFE_SVSS_DISABLE_INPUT** Input assignment SBH/SG deselection		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		

Meaning

This data defines the NCK input for selection/deselection of the SBH and SG functions.

Structure:

Ss mm xx nn		Perm. values	Explanation
nn =	I/O no.	01-10	Bit number on submodule
xx =	Submodule no.	01-08	Slot no. of submodule within terminal block
mm =	Module no.	01-1E	Number of logical slot in which terminal block with external I/O devices is inserted (drive number)
ss =	Segment no.	01, 81	01: Identifier for 611D bus 81: Signal processed as inverted signal

A single bit is connected to a terminal with each entry. The structure is the same as $MN_HW_ASSIGN_ANA_FASTIN.

Signal	means
= 0	SG or SBH is selected
= 1	SG and SBH are selected

Special cases, errors

- Input value "0" means:
  There is no assignment, the input remains at 0, SG and SBH cannot be deselected.
- Input value "80 00 00 00" means:
  There is no assignment, the input remains at 1
- If MD bit 31 is set, then the signal is inverted for processing (ss = 81).

References

/FB/, A4, Digital and Analog NCK I/O Devices
MD 10366: $MN_HW_ASSIGN_DIG_FASTIN
MD 13010: $MN_DRIVE_LOGIC_NR

36971 MD number	**$MA_SAFE_SS_DISABLE_INPUT** Input assignment SBH deselection		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		

Meaning

Assignment of the NCK input for deselecting the safe operational stop function.

Structure: See $MA_SAFE_SVSS_DISABLE_INPUT

Assignment of terminal signal level to safe functions if safe velocity or safe operational stop has been activated.

Signal	means
= 0	Safe operational stop is selected
= 1	Safe velocity is selected (only if STOP C, D or E has not been activated by other functions)

Special cases, errors

- If MD bit 31 is set, then the signal is inverted for processing (ss = 81).
- This input has no meaning if SG and SBH have been deselected (see $MA_SAFE_SVSS_DISABLE_INPUT).

References

MD 36970: $MA_SAFE_SVSS_DISABLE_INPUT

36972 MD number	**$MA_SAFE_VELO_SELECT_INPUT[n]** Input assignment SG selection		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	The two inputs for selecting SG1, SG2, SG3 or SG4 are defined in this data. Structure: See $MA_SAFE_SVSS_DISABLE_INPUT n = 1, 0 stands for bits 1, 0 for selecting SG1 to SG4 Assignment of input bits to safe velocities: Bit 1 Bit 0 Selected SG 0 0 SG1 0 1 SG2 1 0 SG3 1 1 SG4		
Special cases, errors	If the MD bits 31 are set, then the signal is inverted for processing (ss = 81).		
References	MD 36971: $MA_SAFE_SVSS_DISABLE_INPUT		

36973 MD number	**$MA_SAFE_POS_SELECT_INPUT** Input assignment SE selection		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data defines the input for selecting safe limit position 1 or 2. Structure: See $MA_SAFE_SVSS_DISABLE_INPUT Signal means = 0 SE1 is active = 1 SE2 is active		
Special cases, errors	If the MD bit 31 is set, then the signal is inverted for processing (ss = 81).		
References	MD 36970: $MA_SAFE_SVSS_DISABLE_INPUT		

36974 MD number	**$MA_SAFE_GEAR_SELECT_INPUT[n]** Input assignment gear ratio selection		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	Assignment of input terminals for selecting the gear ratio (gear stage). Structure: See $MA_SAFE_SVSS_DISABLE_INPUT n = 2, 1, 0 stands for bits 2, 1, 0 for selecting gear stages 1 to 8 Bit 2 Bit 1 Bit 0 Active gear stage 0 0 0 Stage 1 0 0 1 Stage 2 0 1 0 Stage 3 ... ... 1 1 1 Stage 8		
Special cases, errors	If MD bits 31 are set, then the signals are inverted for processing (ss = 81).		
References	MD 36970: $MA_SAFE_SVSS_DISABLE_INPUT		

36975 MD number	**$MA_SAFE_STOP_REQUEST_INPUT** Input assignment "Test stop selection"		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data defines the input for selecting the test stop. Structure: See $MA_SAFE_SVSS_DISABLE_INPUT Signal means = 0 Test stop is deactivated = 1 Test stop is executed		
Special cases, errors	If MD bit 31 is set, then the signal is inverted for processing (ss = 81)		
References	MD 36970: $MA_SAFE_SVSS_DISABLE_INPUT		

36976 MD number	**$MA_SAFE_PULSE_STATUS_INPUT** Input assignment "Pulses disabled" status		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data defines the input for reading back the "pulse disabled" status signal. Structure: See $MA_SAFE_SVSS_DISABLE_INPUT Signal means = 0 Pulses are enabled = 1 Pulses are disabled		
Special cases, errors	If MD bit 31 is set, then the signal is inverted for processing (ss = 81)		
References	$MA_SAFE_SVSS_DISABLE_INPUT		

36978 MD number	**$MA_SAFE_OVR_INPUT[n]** Input assignment for SG override selection		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 4.2		
Meaning	Assignment of NCK inputs for override of limit value of safe velocities 2 and 4. Structure:: See $MA_SAFE_SVSS_DISABLE_INPUT n = 3, 2, 1, 0 stand for override selection bits 3, 2, 1, 0 Assignment of input bits to SG override values: Bit 3 Bit 2 Bit 1 Bit 0 0 0 0 0 Override 0 is selected 0 0 0 1 Override 1 is selected to 1 1 1 1 Override 15 is selected The override factor itself (percentage) is defined via the following machine data: On 840D MD 36932: $MA_SAFE_VELO_OVR_FACTOR[n] On 611D MD 1332: $MD_SAFE_VELO_OVR_FACTOR[n]		
Special cases, errors	• The “Override for safe velocity” function is enabled via MD 36901 (MD 1301): $MA($MD)_SAFE_FUNCTION_ENABLE. • If MD bit 31 is set, then the signals are processed in inverted form (ss = 81).		
Related to ...	MD 36970: $MA_SAFE_SVSS_DISABLE_INPUT MD 36932: $MA_SAFE_VELO_OVR_FACTOR[n]		
References	See Section 3.4.5 “Override for safe velocity“		

36980 MD number	**$MA_SAFE_SVSS_STATUS_OUTPUT** Output assignment SBH/SG active		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		

Meaning

Assignment of the output for signalling the status of the safe velocity or safe operational stop function.

Structure:

ss mm xx nn		Perm. values	Explanation
nn =	I/O no.	01-10	Bit number on submodule
xx =	Submodule no.	01-08	Slot no. of submodule within terminal block
mm =	Module no.	01-1E	Number of logical slot in which terminal block with external I/O devices is inserted (drive number)
ss =	Segment no.	01, 81	01: Identifier for 611D bus 81: Signal processed as inverted signal

Every entry connects a single output bit to a terminal. The data has the same structure as $MN_HW_ASSIGN_ANA_FASTOUT.

Signal	means
= 0	SG and SBH are not active (only if STOP C, D or E has not been activated by other functions)
= 1	SG or SBH is active

Special cases, errors

- Input value "0" means:
  There is no assignment, the output remains unaffected by status changes
- Input value "80 00 00 00" means:
  There is no assignment, the output remains at "1"
- If a single output signal is connected to a terminal, the following applies:
  If MD bit 31 is set, then the signal is inverted for processing (ss = 81)
- If several output signals are connected to the same terminal, the following applies:
  If MD bit 31 is set (ss = 81), the relevant signal is initially inverted. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

References

/FB/, A4, Digital and Analog NCK I/O Devices
MD 10368: $MN_HW_ASSIGN_DIG_FASTOUT
MD 13010: $MN_DRIVE_LOGIC_NR

36981 MD number	**$MA_SAFE_SS_STATUS_OUTPUT** Output assignment for SBH active		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 01 00 20	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 4.2		
Meaning	This data determines the output or system variable for the “SBH active” signal. Structure: See $MA_SAFE_EXT_STOP_INPUT Signal means = 0 SBH is not active = 1 SBH is active		
Special cases, errors	• If a single output signal is applied to a terminal, then the following applies: If MD bit 31 is set, then the signal is processed in inverted form (ss = 81). • If several output signals are applied to the same terminal, then the following applies: If MD bit 31 is set (ss = 81), then the relevant signal is initially inverted. The output signals (which may be inverted) are then ANDed and the result output at the terminal.		

36982 MD number	**$MA_SAFE_VELO_STATUS_OUTPUT[n]** Output assignment for SG active		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 01 00 20	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 4.2		
Meaning	This data determines the outputs or system variables for the “SG active bit 0” and “SG active bit 1” signals. Structure: See $MA_SAFE_EXT_STOP_INPUT n = 1, 0 stands for SG active, bits 1, 0 SG active Bit 1 Bit 0 means = 0 = 0 SG1 active if SBH/SG is active and SBH is not active SBH active if SBH/SG and SBH are active = 1 = 0 SG2 active = 0 = 1 SG3 active = 1 = 1 SG4 active		
Special cases, errors	• If a single output signal is applied to a terminal, then the following applies: If MD bit 31 is set, then the signal is processed in inverted form (ss = 81). • If several output signals are applied to the same terminal, then the following applies: If MD bit 31 is set (ss = 81), then the relevant signal is initially inverted. The output signals (which may be inverted) are then ANDed and the result output at the terminal.		

36985 MD number	**$MA_SAFE_VELO_X_STATUS_OUTPUT** Output assignment for $n < n_x$		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 01 00 20	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 4.2		
Meaning	This data determines the output or system variable for the “$n < n_x$“ signal. Structure: See $MA_SAFE_SVSS_STATUS_OUTPUT Signal means = 0 Actual speed is higher than limit speed in $MA_SAFE_VELO_X = 1 Actual speed is lower or equal to limit speed		
Related to ...	$MA_SAFE_VELO_X		
Special cases, errors	• If a single output signal is applied to a terminal, then the following applies: If MD bit 31 is set, then the signal is processed in inverted form (ss = 81). • If several output signals are applied to the same terminal, then the following applies: If MD bit 31 is set (ss = 81), then the relevant signal is initially inverted. The output signals (which may be inverted) are then ANDed and the result output at the terminal.		
References	MD 36980: $MA_SAFE_SVSS_STATUS_OUTPUT		

36986 MD number	**$MA_SAFE_PULSE_ENABLE_OUTPUT** "Enable pulses" output assignment		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data defines the output for the "Enable pulses" request. Structure: See $MA_SAFE_SVSS_STATUS_OUTPUT Signal means = 0 Request for pulse disable = 1 Request for pulse enable		
Special cases, errors	• If a single output signal is connected to a terminal, the following applies: If MD bit 31 is set, then the signal is inverted for processing (ss = 81) • If several output signals are connected to the same terminal, the following applies: If MD bit 31 is set (ss = 81), the relevant signal is initially inverted. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.		
References	MD 36980: $MA_SAFE_SVSS_STATUS_OUTPUT		

36987 MD number	**$MA_SAFE_REFP_STATUS_OUTPUT** Output assignment "Axis safely referenced"		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data specifies the output for the "Axis safely referenced" signal. Structure: See $MA_SAFE_SVSS_STATUS_OUTPUT Signal means = 0 Axis is not safely referenced (i.e. the safe end position monitoring function is deactivated) = 1 Axis is safely referenced		
Special cases, errors	• If a single output signal is connected to a terminal, the following applies: If MD bit 31 is set, then the signal is inverted for processing (ss = 81) • If several output signals are connected to the same terminal, the following applies: If MD bit 31 is set (ss = 81), the relevant signal is initially inverted. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.		
References	MD 36980: $MA_SAFE_SVSS_STATUS_OUTPUT		

36988 MD number	**$MA_SAFE_CAM_PLUS_OUTPUT[n]** Output assignment SN1 + to SN4 +		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data specifies the outputs for plus cams SN1 + to SN4 +. Structure: See $MA_SAFE_SVSS_STATUS_OUTPUT n = 0, 1, 2, 3 stands for the assignment of plus cams SN1 +, SN2 +, SN3 +, SN4 + Signal means = 0 Axis is to the left of cam (actual value ≤ cam position) = 1 Axis is to the right of cam (actual value > cam position)		
Special cases, errors	• If a single output signal is connected to a terminal, the following applies: If MD bit 31 is set, then the signal is inverted for processing (ss = 81) • If several output signals are connected to the same terminal, the following applies: If MD bit 31 is set (ss = 81), the relevant signal is initially inverted. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.		
References	MD 36980: $MA_SAFE_SVSS_STATUS_OUTPUT		

36989 MD number	**$MA_SAFE_CAM_MINUS_OUTPUT[n]** Output assignment SN1 - to SN4 -		**840D**
Default: 0	Min. input value: 0	Max. input value: 81 1E 08 10	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data defines the outputs for minus cams SN1 - to SN4 -. Structure: See $MA_SAFE_SVSS_STATUS_OUTPUT n = 0, 1, 2, 3 stands for the assignment of minus cams SN1 -, SN2 -, SN3 -, SN4 - Signal means = 0 Axis is to left of cam (actual value ≤ cam position) = 1 Axis is to the right of cam (actual value > cam position)		
Special cases, errors	• If a single output signal is connected to a terminal, the following applies: If MD bit 31 is set, then the signal is inverted for processing (ss = 81) • If several output signals are connected to the same terminal, the following applies: If MD bit 31 is set (ss = 81), the relevant signal is initially inverted. The (in some cases) inverted output signals are then ANDed and the result output at the terminal. • If the plus cam is negated and applied to an output with the minus cam, then the signals are ANDed, resulting in a single cam signal for area sensing purposes.		
References	MD 36980: $MA_SAFE_SVSS_STATUS_OUTPUT		

36995 MD number	**$MA_SAFE_STANDSTILL_POS** Standstill position		**840D**
Default:0	Min. input value: -2 147 483 647	Max. input value: 2 147 483 647	
Change valid after POWER ON	Protection level (R/W): 0/0	Unit: -	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	The position at which the axis has currently stopped is displayed in this MD. To be able to perform a plausibility check on the axis referencing when the control system is next switched on, the current axis position is stored permanently when the following events take place: • When safe operational stop (SBH) is selected • Cyclically when SE/SN is active		
Special cases, errors	Any manual changes to the MD are detected the next time the control is switched on and the axis reference checked for plausibility. "User agreement" must be given again after referencing.		

36997 MD number	**$MA_SAFE_ACKN** User agreement		**840D**
Default: 0	Min. input value: 0	Max. input value: FF FF FF FF	
Change valid after POWER ON	Protection level (R/W): 7/2	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	The user agreement status is displayed in this machine data. The user can confirm or cancel his "user agreement" via an appropriate screen display. If it is detected internally in the software that the reference to the machine has been lost, then the "user agreement" is automatically cancelled (e.g. during gear changes, or if the plausibility comparison with the stored standstill position fails during referencing).		
Special cases, errors	Any manual changes to the MD are detected the next time the control is switched on and the axis reference checked for plausibility. "User agreement" must be given again after referencing.		

36998 MD number	**$MA_SAFE_ACT_CHECKSUM** Actual checksum		**840D**
Default: 0	Min. input value: 0	Max. input value: FF FF FF FF	
Change valid after POWER ON	Protection level (R/W): 7/-	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	The actual checksum of the current values of safety-relevant machine data which is calculated after POWER ON or on RESET is entered in this data.		

36999 MD number	**$MA_SAFE_DES_CHECKSUM** Setpoint checksum		**840D**
Default: 0	Min. input value: 0	Max. input value: FF FF FF FF	
Change valid after POWER ON	Protection level (R/W): 7/1	Unit: Hexadecimal	
Data type: DWORD	Valid as from SW version: 3.4		
Meaning	This data contains the setpoint checksum of the current values of safety-relevant machine data that was stored during the last machine acceptance test.		

4.2 Machine and service data for SINUMERIK 840C

4.2.1 Overview of machine data

Table 4-2 Overview of nmachine data for SINUMERIK 840C

Number	Identifier	Reference
General		
155	Position control basic cycle	/IAC/
168	Drive basic cycle time	/IAC/
40000	Display of checksum of SI NCK MD	
40001	Checksum of SI NCK MD	
40002	Display cross-wise reference cycle	
40010	Ratio between monitoring cycle and position control basic cycle	
Axis-specific		
1224*	Cutout delay servo enable	/IAC/
200*	Assignment axis actual value	/IAC/
276*	Acceleration	/IAC/
3364*	Acceleration, parameter set 2	/IAC/
3368*	Acceleration, parameter set 3	/IAC/
3372*	Acceleration, parameter set 4	/IAC/
3376*	Acceleration, parameter set 5	/IAC/
3380*	Acceleration, parameter set 6	/IAC/
3384*	Acceleration, parameter set 7	/IAC/
3388*	Acceleration, parameter set 8	/IAC/
4100*	Actual value assignment for SI operation	
4104*	Grating of linear scale for SI operation	
4108*	Encoder marks per rev for SI operation	
4112*	Spindle pitch for SI operation	
4116*	Denominator of encoder/load gear 1 for SI operation	
4120*	Denominator of encoder/load gear 2 for SI operation	
to	to	
4144*	Denominator of encoder/load gear 8 for SI operation	
4148*	Numerator of encoder/load gear 1 for SI operation	
4152*	Numerator of encoder/load gear 2 for SI operation	
to	to	
4176*	Numerator of encoder/load gear 8 for SI operation	
4180*	Standstill tolerance for SI operation	
4184*	Limit value for safe velocity 1	
4188*	Limit value for safe velocity 2	
4192*	Limit value for safe velocity 3	
4196*	Limit value for safe velocity 4	
4200*	Upper limit value for safe limit position 1	
4204*	Upper limit value for safe limit position 2	
4208*	Lower limit value for safe limit position 1	
4212*	Lower limit value for safe limit position 2	
4216*	Plus cam position for safe cams 1	
4220*	Plus cam position for safe cams 2	
4224*	Plus cam position for safe cams 3	
4228*	Plus cam position for safe cams 4	
4232*	Minus cam position for safe cams 1	
4236*	Minus cam position for safe cams 2	
4240*	Minus cam position for safe cams 3	
4244*	Minus cam position for safe cams 4	
4248*	Tolerance for safe cams	
4252*	Actual value comparison tolerance (referencing)	
4256*	Actual value comparison tolerance (cross-check)	
4260*	Tolerance time for SGE switchover	
4264*	Delay time SG switchover	
4268*	Delay time pulse disable	
4272*	Time for testing pulse disable	
4276*	Transition time STOP C to SBH	

Number	Identifier	Reference
4280*	Transition time STOP D to SBH	
4284*	Transition time STOP E to SBH	
4288*	Creep speed pulse disabling	
4292*	Velocity limit n_x for safe operation (from SW6.1)	
4296*	Actual velocity tolerance for SBR (from SW6.1)	
4500*	Enable SBH/SG/SE function	
4504*	Cam enable safe operation	
4508*	Axis-specific bits for safe operation Bit 7: Display inches/metric Bit 6: Rotary axis Bit 5: Select STOP E for SG Bit 4: Select STOP D/E for SG Bit 3: Select STOP E for SE Bit 2: Select STOP D/E for SE	
4512*	Axis-specific bits for safe operation Bit 1: Sign change Bit 0: Linear scale	
Activation of NCK I/O for SI		
45800	SGE screen CSB (low)	
45802	SGE screen mixed I/O 1 (low)	
45803	SGE screen mixed I/O 1 (high)	
45804	SGE screen mixed I/O 2 (low)	
45805	SGE screen mixed I/O 2 (high)	
45808	SGA screen mixed I/O 1 (low)	
45809	SGA screen mixed I/O 1 (high)	
45810	SGA screen mixed I/O 2 (low)	
45811	SGA screen mixed I/O 2 (high)	
Input/output assignment		
4600*	Input assignment SBH/SG deselection	
4604*	Input assignment SBH deselection	
4608*	Input assignment "Pulses disabled" status	
4612*	Input assignment SG selection, bit 0	
4616*	Input assignment SG selection, bit 1	
4632*	Input assignment gear ratio selection, bit 0	
4636*	Input assignment gear ratio selection, bit 1	
4640*	Input assignment gear ratio selection, bit 2	
4648*	Input assignment SE selection	
4660*	Input assignment "Test stop selection"	
4700*	Output assignment SN1 +	
4704*	Output assignment SN1 -	
4708*	Output assignment SN2 +	
4712*	Output assignment SN2 -	
4716*	Output assignment SN3 +	
4720*	Output assignment SN3 -	
4724*	Output assignment SN4 +	
4728*	Output assignment SN4 -	
4732*	Output assignment SBH/SG active	
4736*	Output assignment "Axis safely referenced"	
4740*	"Pulse enable" Output assignment	
4744*	Output assignment for SBH active (from SW6.1)	
4752*	Output assignment for SG active, bit 0 (from SW6.1)	
4756*	Output assignment for SG active, bit 1 (from SW6.1)	
4760*	Output assignment for $n < n_x$ (from SW6.1)	
4772*	Output assignment for SG1 active (from SW6.1)	
4776*	Output assignment for SG2 active (from SW6.1)	
4780*	Output assignment for SG3 active (from SW6.1)	
4784*	Output assignment for SG4 active (from SW6.1)	
Note: The * is a dummy for axis machine data (* = 0 stands for axis 1, * = 1 stands for axis 2, etc.).		

4.2.2 Description of machine data

General General information about machine data and explanations of their contents such as unit, effectiveness, etc. can be found in the following references:

References: /LIC/, Installation and Start-Up Guide Lists, SINUMERIK 840C

40000	Display of checksum of SI NCK MD		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
-	-	-	-

Meaning: The control system calculates a checksum of machine data 40010 to 49999 during power-up and enters it in this machine data.

40001	Checksum of SI NCK MD		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
-	-	-	-

Meaning: The checksum of machine data for safe operation is automatically calculated on selection of softkey "Accept SI + NCKPO" and entered in this data.

Related to: MD 40000

40002	Display cross-check cycle		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
-	-	-	Position control basic cycle

Meaning: This data shows the time required for full execution of the cross-check cycle. It is the product of this data and the position control basic cycle in MD 155. It is a pure display data and cannot be written.

Related to: MD 40000

40010	Ratio between monitoring cycle and position control basic cycle		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
4	1	200	Position control basic cycle

Meaning: Ratio between monitoring cycle and position control basic cycle. The monitoring cycle is the product of this data and the position control basic cycle in MD 155. The position control basic cycle is derived from the drive basic cycle time in MD 168.

Related to: MD 1300 (is an MD for 611D)

Notes

- If the set monitoring cycle is not a multiple of the axial position control cycle in MD1396* for all axes with a least one enabled safety function, then the alarm "Parameterization error NC-MD) with service number 300 is output.
- The monitoring cycle defines the reaction time of the monitoring functions. It must be noted that the load on the CPU is increased when a short monitoring cycle is set.

4100*	**Actual value assignment for SI operation**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	30 20 01 61	Hexadecimal

Meaning: The actual value assignment of the encoder for safe operation is entered via this data.

Structure: See also MD 200*

ss	**mm**	**xx**	**nn**		**Permitted values**	**Explanation**
			nn=	Local axis number	0	Reserved
		xx=		Identifier of digital drive (user input)	10	Address assignment 611D (measuring circuit/digital setpoint channel)
	mm=			Number of measuring circuit connection	01 02	Slot 1 Slot 2
ss=				Logical drive no./ Measuring circuit board no.	00 01 to 30	No module installed Logical drive number

4104*	**Grating of linear scale for SI operation**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
10 000	1	8 000 000	0.01 µm

Meaning: This data defines the grating pitch of the linear scale used.

Note

This MD is not relevant for rotary encoders.

4108*	**Encoder marks per rev for SI operation**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
2 048	1	10 000	-

Meaning: This data defines the number of markings per revolution for rotary encoders.

Note

This MD is not relevant for linear encoders.

4112*	Spindle pitch for SI operation		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
1 000	1	1 000 000	0.01 mm/rev

Meaning: Gear ratio of the gearbox between encoder and load for a linear axis with rotary encoder.

4116* 4120* to 4144*	Denominator of encoder/load gear 1 for SI operation Denominator of encoder/load gear 2 for SI operation to to Denominator encoder/load gear 8 for SI operation		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
1	1	99 999 999	-

Meaning: Denominator of the gearbox between encoder and load, i.e. the denominator of the fraction "No. of encoder revolutions / **No. of load revolutions**

Related to: MD 4148* to 4176*, MD 4632*, 4636* and 4640*

Note

The current gear ratio is selected via safety-relevant input signals (SGE).

4148* 4152* to 4176*	Numerator of encoder/load gear 1 for SI operation Numerator of encoder/load gear 2 for SI operation to to Numerator of encoder/load gear 8 for SI operation		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
1	1	99 999 999	-

Meaning: Numerator of the gearbox between encoder and load, i.e. the numerator of the fraction "**No. of encoder revolutions** / No. of load revolutions"

Related to: MD 4116* to 4144*, MD 4632*, 4636* and 4640*

Note

The current gear ratio is selected via safety-relevant input signals (SGE).

4180*	Standstill tolerance for SI operation		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
1 000	1	100 000	µm or 0.001 degrees

Meaning: The tolerance band for safe operation stop is specified via this data. If the difference between the position setpoint and actual value leaves this band when the SBH function is selected, then the control system activates alarm 1324* with the appropriate system reaction.

4184* **4188*** **4192*** **4196***	**Limit value for safe velocity 1** **Limit value for safe velocity 2** **Limit value for safe velocity 3** **Limit value for safe velocity 4**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
5 000	1	99 999 999	0.01 mm/min or 0.01 rev/min

Meaning: Definition of limit values for safe velocities 1, 2, 3 or 4. If SG1, SG2, SG3 or SG4 is selected and the current speed exceeds this limit value, then the control system activates alarm 1328* with the stop reaction configured in MD 4508*.

Related to: MD 4500*, MD 4612*, MD 4616*

Note

When the SBH/SG function is active and a 1-encoder system installed, the speed is monitored on the basis of an encoder limit frequency of 200 kHz (300 kHz as from SW 6.1). An appropriate alarm is output when this frequency limit is exceeded.

4200* **4204***	**Upper limit value for safe limit position 1** **Upper limit value for safe limit position 2**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100 000	-2 147 483	2 147 483	mm or degrees

Meaning: The upper limit value for safe limit positions 1 and 2 is specified in this data.

If SE1 or SE2 is selected and the current actual position exceeds this limit value, then the control system activates alarm 1332* with the stop reaction configured in MD 4508* and then switches over to SBH mode. If the SBH tolerance window is violated, stop reactions STOP B and A are initiated.

Special cases, errors: If the value entered in MD 4200*, 4204* is lower than or equal to the value entered in MD 4208*, 4212*, then a parameterization error message is output.

Related to: MD 4208* and 4212*, MD 4500*, MD 4648*

4208* **4212***	**Lower limit value for safe limit position 1** **Lower limit value for safe limit position 2**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
-100 000	-2 147 483	2 147 483	mm or degrees

Meaning: This data specifies the lower limit value for safe limit positions 1 and 2.

If SE1 or SE2 is selected and the current actual position drops below this limit value, then the control system activates alarm 1332* with the stop reaction configured in MD 4508* and then switches over to SBH mode. If the SBH tolerance window is violated, stop reactions STOP B and A are initiated.

Special cases, errors: If the value entered in MD 4200*, 4204* is lower than or equal to the value entered in MD 4208*, 4212*, then a parameterization error message is output.

Related to: MD 4200* and 4204*, MD 4500*, MD 4648*

4216* 4220* 4224* 4228*	Plus cam position for safe cams 1 Plus cam position for safe cams 2 Plus cam position for safe cams 3 Plus cam position for safe cams 4		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
10	- 2 147 483	2 147 483	mm or degrees

Meaning: The plus cam position for safe cams SN1 +, SN2 +, SN3 + and SN4 + is specified in this data.

If the actual position is ≤ the value set here when the safe cam function is active, then the appropriate safety-relevant output signal (SGA) is set to 0 and to 1 if the actual position is > this value.

Related to: MD 4700* to 4728*, MD 4504*

Note

If the cam is not active, the output signal is set to 0.

4232* 4236* 4240* 4244*	Minus cam position for safe cams 1 Minus cam position for safe cams 2 Minus cam position for safe cams 3 Minus cam position for safe cams 4		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
-10	-2 147 483	2 147 483	mm or degrees

Meaning: The minus cam position for safe cams SN1 -, SN2 -, SN3 - and SN4 - is specified in this data.

If the actual position is ≤ the value set here when the safe cam function is active, then the appropriate safety-relevant output signal (SGA) is set to 0 and to 1 if the actual position is > this value.

Related to: MD 4700* - 4728*, 4504*

Note

If the cam is not active, the output signal is set to 0.

4248*	Tolerance for safe cams		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100	1	10 000	µm or 0.001 degrees

Meaning: Owing to the different mounting locations of the encoders and variations in clock cycle and signal transit times, the cam signals of the two monitoring channels never switch at exactly the same position and never simultaneously.

This data specifies the tolerance for all cams as a load-side distance. The monitoring channels may have different signal states for the same cam within this tolerance band.

4252*	Actual value comparison tolerance (referencing)		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
10	1	1 000 or 36 000	µm or 0.001 degrees

Meaning:

The tolerance for the actual value check after referencing (with an incremental encoder) or power ON (with an absolute encoder) is set in this data (see Section 2.4.2 Adjustment, measurement, axis states and previous history).
A second absolute actual position is calculated from the last standstill position to be stored prior to control power OFF and the distance traversed since power ON. The control system checks the actual values after referencing on the basis of the two actual positions, the traversed distance and this data.

Note

If these two actual positions deviate from one another by more than the value set in this data when SN or SE is selected, then alarm 1340* is displayed and user agreement must be given for referencing.

The following factors must be taken into consideration when calculating tolerance values:
Backlash, leadscrew errors, temperature errors, torsion with 2-encoder system, gear play on shift gearboxes, lower resolution with 2-encoder system, oscillating distance for shift gearboxes.

4256*	Actual value comparison tolerance (cross-check)		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100	1	10 000 or 360 000	µm or 0.001 degrees

Meaning:

Owing to the fact that encoders are not mounted in identical locations and the effects of backlash, torsion, leadscrew errors, etc., the actual positions sensed simultaneously by the NCK and drive may not be exactly the same.

The tolerance band for the actual position cross-check in the two monitoring channels is specified in this data.

Note

- "Finger protection" (about 10 mm) is the primary consideration when setting this tolerance value.
- Stop reaction STOP F is activated when the tolerance band is violated.

4260*	Tolerance time for SGE switchover		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
500	0	10 000	ms

Meaning: SGE switchovers do not take effect simultaneously owing to variations in transit times for SGE transmission in the two monitoring channels. A data cross-check would output an error message in this case.

This data is used to specify the period of time after SGE switchovers during which no cross-check of actual values and monitoring results is carried out (cross-comparison of machine data continues!). The selected monitoring functions continue to operate unhindered in both monitoring channels.

Note

System-dependent minimum tolerance time:
2 x PLC cycle time (maximum cycle) + 1 x IPO cycle time

The variations in transit time in the external circuitry (e.g. relay operating times) must also be taken into account.

4264*	Delay time SG switchover		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100	0	10 000	ms

Meaning: A timer with the value in this data is started on transition from a high to a lower safe velocity or when safe operational stop is selected when the safe velocity function is active.

!

Important

While the timer is in operation, the speed continues to be monitored for the last selected velocity limit value. During this period, the axis/spindle can be braked, for example, via the PLC user program without the monitor signalling an error and initiating a stop reaction.

4268*	Delay time pulse disable		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100	0	10 000	ms

Meaning: In STOP B mode, the axis is braked along the current limit with speed setpoint 0. After the delay time defined in this data, the braking mode changes to STOP A for pulse disabling.

Special cases, errors: The pulses are disabled earlier than defined in this data if the condition for pulse disabling is defined in MD 4288* (Creep speed pulse disabling) or in MD 1224* (Cutout delay servo enable).
If the timer in this data is set to zero, STOP A (immediate pulse disabling) is activated immediately from STOP B mode.

4272*	Time for testing pulse disable		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100	0	10 000	ms

Meaning: The time limit for disabling of pulses after pulse disabling has been requested (e.g. after Test stop selection) is set in this data. STOP A is activated if pulse disabling has not taken place within the set time.

!

Important

The time that elapses between setting of the "Enable pulses" SGA and detection of the "Pulses disabled status" SGE must not exceed the time limit set in this data.

4276* 4280* 4284*	Transition time STOP C to SBH Transition time STOP D to SBH Transition time STOP E to SBH		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
100	0	10 000	ms

Meaning: This data defines the time period between the initiation of a STOP C, D or E and the activation of the safe operational stop function.

Once the time has expired, the drive is monitored for safe operational stop. If the axis/spindle has still not been stopped, STOP A or B is initiated.

Note

If a STOP C or STOP E is selected, pulse disabling takes place via the drive after the timers set in MD 1224* (or MD 156) and the drive MD 1404* have expired.

Safe disabling of the pulses via the SGA or switchover to safe operational stop mode takes place after the timers in the machine data for safe operation have expired.

4288*	Creep speed pulse disabling		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	1	100 000	0.01 mm/min or 0.01 rev/min

Meaning: When the axis/spindle speed drops below this limit, it is judged to be at a "standstill". In STOP B mode, the pulses are then disabled (through transition to STOP A mode).

4292*	Limit speed n_x for safe operation		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
2 000	1	100 000	0.01 mm/min or 0.01 rev/min

Meaning: This data is set to define the limit speed n_x for SGA “$n < n_x$“..

Related to: MD 1346: (velocity limit n_x)

4296*	Actual speed tolerance for SBR		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
30 000	0	2 000 000	0.01 mm/min or 0.01 rev/min

Meaning: The value in this data is cross-checked with the setting in MD 1348.
This MD has no function in the NCK monitoring channel. MD 1348 is used for the “safe braking ramp” function in the drive monitoring channel.

4300*	2-encoder drift/slip tolerance (from SW 6.3)		Effective POWER ON
Default	Lower input limit	Upper input limit	Units
600	0	100 000	0.01 mm/min or 0.01 rev/min

If bit 3 is set in MD 4500*, the difference between the velocities of NC and drive is monitored to the value as parameterized here. In case of exceeding, STOP F is triggered with error sensing 3 (actual value comparison) or 44-57 (comparison of dynamic data deriving from the actual value).

	Bit No.							
NC MD	7	6	5	4	3	2	1	0
4500*	Enable	Reserved, the bits must be 0.					Enable	
	Cam synchro-nization (from SW6.1)	0	0	0	0	0	SE	SBH/SG
Note: If bit 1 is set, bit 0 must be set as well because the control switches to SBH mode with reactions STOP C, D and E.								

Bit 0 + Bit 1, Meaning: This data is used to enable safe functions for an axis or spindle. The number of axes to be enabled for safe operation must be less or equal to the number specified in the global option and in this axis-specific enabling data, i.e. it is not possible to enable more axes/spindles for safe operation on an axis-specific basis than have been enabled in the global option.

Related to: Global option

Note

If an insufficient number of axes/spindles has been enabled for safe operation by means of the global option, the corresponding error message is output.

Bit 3
1: Enable of actual value synchronization
0: No enable

Bit 7
1: Enable of cam synchronization
0: No enable

NC-MD	Bit No. 7	6	5	4	3	2	1	0
4504*	Enable safe cams							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
Note: If one of these bits is set, then bit 0 in MD 4500* must also be set.								

Meaning: The partial function safe cams 1, 2, 3 and 4 can be enabled for an axis/spindle in this data.

It is only possible to enable on an axis-specific basis as many axes/spindles for safe operation as have been enabled by the global option. The more bits set, the more computing time the safe functions require.

Related to: Global option

MD bit	means
= 0	Safe cam is not enabled
= 1	Safe cam is enabled

Note

If an insufficient number of axes/spindles has been enabled for safe operation by means of the global option, the error message "Too many axes, safe operation" is output.

NC-MD	Bit No. 7	6	5	4	3	2	1	0
4508*	Inches/metric display	Rotary axis	Select STOP E for SG	Select STOP D/E for SG	Select STOP E for SE	Select STOP D/E for SE	Reserved	Reserved

Bit 2
1: Select STOP D or E when the active limit value for safe limit position is exceeded
0: STOP C

Bit 3
1: Select STOP E (effective only when bit 2 = 1)
0: Select STOP D (effective only when bit 2 = 1)

Bit 4
1: Select STOP D or E when the active limit value for safe velocity is exceeded
0: STOP C

Bit 5
1: Select STOP E (effective only when bit 4 = 1)
0: Select STOP D (effective only when bit 4 = 1)

Bit 6
1: Axis is rotary axis
0: Axis is linear axis

Bit 7
1: Display in inches
0: Display metric

Notes

- The following applies to parameterization of bits 2 to 5:
  If STOP E is selected, but not configured, then STOP C takes effect automatically, but with the parameterized switchover times of STOP E (see MD 4284*).
- If bit 6 is set, the actual position is converted without any allowance for the parameterized spindle pitch (see MD 4112*).
- If bit 7 is set, all NC machine data for safe operation are displayed in inches.

NC-MD	Bit No. 7	6	5	4	3	2	1	0
4512*	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Sign change	Linear scale

Bit 0 1: Linear encoder is connected
2: Rotary encoder is connected

Bit 1 1: Change in sign of actual value
0: No change in sign

45800	**SGE screen CSB (low)**	Effective after POWER ON

Default	Lower input limit	Upper input limit	Units
0000 0000	0000 0000	1111 1111	Binary

Meaning: This data defines the NCK inputs (SGE screen) that are available for safe functions.
Nondefined inputs can be used for other functions.

Table 4-3 Definition of SGE screen for CSB module

	Machine data bits Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
MD status	*	*	*	*	*	*	*	*
CSB input	7	6	5	4	3	2	1	0

Note:
* = 1: Input can be used for safe functions
* = 0: Input can be used for other types of function

Related to: MD 45802 and MD 45803

Example MD 45800 = 0000 1100
Inputs 3 and 2 on the CSB module can be used as NCK inputs for safe functions.

Note

Inputs 0 and 1 on the CSB module are used by the control system for specific functions such as measurement and deletion of distance to go. If the inputs are used for Safety Integrated, these other functions will no longer be available.

45802 45803 45808 45809	**SGE screen mixed I/O 1 (low)** **SGE screen mixed I/O 1 (high)** **SGA screen mixed I/O 1 (low)** **SGA screen mixed I/O 1 (high)**	Effective after POWER ON

Default	Lower input limit	Upper input limit	Units
0000 0000	0000 0000	1111 1111	Binary

Meaning: These machine data are used to define the NCK inputs (SGE screen) and NCK outputs (SGA screen) that are available on the mixed I/O module 1 for safe functions. Any nondefined inputs and outputs can be used for other functions.

Table 4-4 Definition of SGE and SGE screens for mixed I/O module 1

	MD 45803, Bit No.								**MD 45802**, Bit No.							
	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
MD status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Input	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	MD 45809								**MD 45808**							
MD status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Output	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Note: * = 1: Input/output can be used for safe functions
* = 0: Input/output can be used for other functions

Related to: MD 45804, MD 45805, MD 45810, MD 45811

Example MD 45802 = 0000 0011
MD 45808 = 0000 0111
On mixed I/O module no. 1, inputs 1 and 0 and outputs 2, 1 and 0 can be used for safe functions.

45804 45805 45810 45811	**SGE screen mixed I/O 2 (low)** **SGE screen mixed I/O 2 (high)** **SGA screen mixed I/O 2 (low)** **SGA screen mixed I/O 2 (high)**	Effective after POWER ON

Default	Lower input limit	Upper input limit	Units
0000 0000	0000 0000	1111 1111	Binary

Meaning: These machine data are used to define the NCK inputs (SGE screen) and NCK outputs (SGA screen) that are available on the mixed I/O module 2 for safe functions.
Any nondefined inputs and outputs can be used for other functions.

Table 4-5 Definition of SGE and SGE screens for mixed I/O module 2

	MD 45805, Bit No.								**MD 45804**, Bit No.							
	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
MD status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Input	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	MD 45811								**MD 45810**							
MD-Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Output	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Note: * = 1: Input/output can be used for safe functions
* = 0: Input/output can be used for other functions

Related to: MD 45802, MD 45803, MD 45808, MD 45809

4600*	Input assignment SBH/SG deselection		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the NCK input for selecting/deselecting the SBH and SG functions.

Structure:

s	mm	xx	nn	y		Permitted values	Explanation
				y=	Inversion	0 1	Not inverted for processing Inverted for processing
			nn=		I/O No.	01-06 01-16	On CSB On MIXED I/O
		xx=			Reserved	00	Reserved
	mm=				Module number	01 01-02	On CSB On MIXED I/O
s=					Module	0 1 2 3	0 or 1 is processed (y=0 or 1) depending on inversion Reserved CSB MIXED I/O

Each entry connects an individual bit to a terminal.

Signal	Meaning
= 0	SG or SBH is selected.
= 1	SG and SBH are deselected (only if a STOP C, D or E has not been activated by other functions)
Note: • If digit is 0 (y) = 1, then the signal is inverted for processing. • An inputs value of 0 00 00 00 1 means: There is no assignment, the input remains permanently at 1	

4604*	Input assignment SBH deselection		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: Assignment of input for deselection of safe operational stop function.

Structure: See MD 4600*

Assignment: Terminal signal level to safe functions if either safe velocity or safe operational stop has been activated.

Signal	Meaning
= 0	SBH is selected.
= 1	SG is selected (only if a STOP C, D or E has not been activated by other functions)
Note: If digit is 0 (y) = 1, then the signal is inverted for processing. If SG and SBH have been deselected (see (MD 4600*), then this input has no meaning.	

4608*	**Input assignment "Pulses disabled" status**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the input for reading back the "pulse disabled" status signal.

Structure: See MD 4600*

Signal	**means**
=0	Pulses are enabled
=1	Pulses are disabled
Note: If digit is 0 (y) = 1, then the signal is inverted for processing.	

4612* **4616***	**Input assignment SG selection, bit 0** **Input assignment SG selection, bit 1**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning This data defines the two inputs for selecting SG1, SG2, SG3 or SG4.

Structure: See MD 4600*

Assignment: Inputs bits to safe velocities:

Bit 1	**Bit 0**	**Selected safe velocity**
0	0	SG 1
0	1	SG 2
1	0	SG 3
1	1	SG 4
Note: If digit is 0 (y) = 1, then the signal is inverted for processing.		

4632* **4636*** **4640***	**Input assignment gear ratio selection, bit 0** **Input assignment gear ratio selection, bit 1** **Input assignment gear ratio selection, bit 2**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: Assignment of input terminals for safe selection of gear stage.

Structure: See MD 4600*

Assignment: Input bits to selected gear stage:

Bit 2	**Bit 1**	**Bit 0**	**Active gear stage**
0	0	0	Stage 1
0	0	1	Stage 2
0	1	0	Stage 3
to			to
1	1	1	Stage 8
Note: If digit is 0 (y) = 1, then the signal is inverted for processing.			

4648*	Input assignment SE selection		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: The data defines the input for selecting safe limit position 1 or 2.

Structure: See MD 4600*

Signal	means
= 0	SE1 is selected
= 1	SE2 is selected
Note: If digit is 0 (y) = 1, then the signal is inverted for processing.	

4660*	Input assignment "Test stop selection"		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the input for selecting the test stop.

Structure: See MD 4600*

Signal	Meaning
=0	Test stop is deactivated
=1	Test stop is executed
Note: If digit is 0 (y) = 1, then the signal is inverted for processing.	

4700* 4708* 4716* 4724*	Output assignment SN1 + Output assignment SN2 + Output assignment SN3 + Output assignment SN4 +		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the outputs for plus cams SN1 + to SN4 +.

Structure: See MD 4732*

Signal	Meaning
=0	Axis is to the left of cam (actual value ≤ cam position)
=1	Axis is to the right of cam (actual value > cam position)

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.
- If the plus cam is negated and applied to an output with the minus cam, then the signals are ANDed and a single cam signal is produced for area sensing purposes.

4704* 4712* 4720* 4728*	**Output assignment SN1 - Output assignment SN2 - Output assignment SN3 - Output assignment SN4 -**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: The outputs for minus cams SN1 - to SN4 - are set with this data.

Structure: See MD 4732*

Signal	**Meaning**
=0	Axis is to the left of cam (actual value ≤ cam position)
=1	Axis is to the right of cam (actual value > cam position)

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.
- If the plus cam is negated and applied to an output with the minus cam, then the signals are ANDed and a single cam signal is produced for area sensing purposes.

4732*	**Output assignment SBH/SG active**		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: Assignment of output for signal indicating status of functions SBH and SG.

Structure:

s	**mm**	**xx**	**nn**	**y**		**Permitted values**	**Explanation**
				y=	Inversion	0 1	Not inverted for processing Inverted for processing
			nn=		I/O No.	01-16	On MIXED-I/O
		xx=			Reserved	00	Reserved
	mm=				Module number	01-02	On MIXED-I/O
s=					Module	0 1 2 3	Not processed Reserved Reserved MIXED-I/O

Each entry connects an individual output bit to a terminal.

Signal	**Meaning**
=0	SG and SBH are deactivated (unless STOP C, D or E have been activated by other functions)
=1	SG or SBH is active
Note: Input value “0 00 00 00 1" means: If there is not assignment, then the output stays permanently at 1	

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4736*	Output assignment "Axis safely referenced"		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the output for the "Axis safely referenced" signal.

Structure: See MD 4732*

Signal	Meaning
= 0	Axis is not safely referenced (i.e. the safe limit position monitor is deactivated)
= 1	Axis is safely referenced

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4740*	Output assignment "Pulse enable"		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the output for the "Pulse disable" request.

Structure: See MD 4732*

Signal	Meaning
= 0	Request for "Pulse disable"
= 1	Request for " Pulse enable "

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4744*	Output assignment for SBH active		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the output for the “SBH active” signal.

Structure:: See MD 4732*

Signal	Meaning
= 0	SBH is not active
= 1	SBH is active

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4752* 4756*	Output assignment for SG active, bit 0 Output assignment for SG active, bit 1		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the output for the “SG active, bit 0” and “SG active, bit 1” signals.

Structure: See MD 4732*

SG active Bit 0	SG active Bit 1	Meaning
= 0	= 0	SG1 active if SBH/SG is active and SBH is not active SBH active if SBH/SG and SBH are active
= 0	= 1	SG2 active
= 1	= 0	SG3 active
= 1	= 1	SG4 active

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4760*	Output assignment for $n < n_x$		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the output for the "$n < n_x$" signal.

Structure:: See MD 4732*

Signal	Meaning
= 0	Actual speed is greater than limit speed set in MD 4292*
= 1	Actual speed is lower or equal to limit speed

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4772* 4776* 4780* 4784*	Output assignment for SG1 active Output assignment for SG2 active Output assignment for SG3 active Output assignment for SG4 active		Effective after POWER ON
Default	Lower input limit	Upper input limit	Units
0	0	3 02 00 16 1	Decimal

Meaning: This data defines the output for the "SG1, 2, 3, 4 active" signal.

Structure:: See MD 4732*

Signal	Meaning
= 0	SG1, 2, 3, 4 is not active
= 1	SG1, 2, 3, 4 is active

Note

- If a single output signal is applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing.
- If several output signals are applied to a terminal, then the following applies: If digit is 0 (y) = 1, then the signal is inverted for processing. The (in some cases) inverted output signals are then ANDed and the result output at the terminal.

4.2.3 Overview of SI service data

Table 4-6 Overview of SI service data for SINUMERIK 840C

Number	Identifier
300	Actual value safe functions NC
301	Diagnosis for STOP F
302	Actual value safe functions drive
303	SI power-up position, NCK monitoring channel (from SW6.1)
304	SI power-up position, drive monitoring channel (from SW6.1)
305	SGE image, NCK monitoring channel (from SW6.1)
306	SGE image, drive monitoring channel (from SW6.1)
307	SGA image, NCK monitoring channel (from SW6.1)
308	SGA image, drive monitoring channel (from SW6.1)
1000	Parameterization error safe functions
1001	SGE image 1 in NCK monitoring channel
1002	SGE image 1 in drive monitoring channel
1003	SGA image 1 in NCK monitoring channel
1004	SGA image 1 in drive monitoring channel
1005	SGE image 2 NCK monitoring channel (from SW6.1)
1006	SGE image 2 drive monitoring channel (from SW6.1)
1007	SGA image 2 NCK monitoring channel (from SW6.1)
1008	SGA image 2 drive monitoring channel (from SW6.1)

4.2.4 Description of service data

Display of service data The following service data for SINUMERIK Safety Integrated are output in the SI service display.

300	Actual value safe functions NC		Effective immediately
Default	Lower input limit	Upper input limit	Units
-	-	-	µm/min or 0.001 rev/min

The actual value for the safe functions on the NC side is displayed in this service data. It is updated in MD 40010 "Ratio between monitoring cycle and position control basic cycle".

301	Diagnosis for STOP F		Effective immediately
Default	Lower input limit	Upper input limit	Units
-	-	-	-

The fine diagnosis for alarm 1336 "Defect in a monitoring channel" is displayed in this service data in the form of a number (appropriate error code).

A table listing the errors codes that might be displayed can be found in Section 6.2 Alarms for SINUMERIK 840C

302	Actual value safe functions drive		Effective immediately
Default	Lower input limit	Upper input limit	Units
-	-	-	µm/min or 0.001 rev/min

The actual value for the safe functions on the drive side is displayed in this service data. It is updated in MD 40002 "Display cross-wise reference cycle".

303 304	SI power-up position NCK monitoring channel (≥ SW6.1) SI power-up position drive monitoring channel (≥ SW6.1)		Effective immediately
Default	Lower input limit	Upper input limit	Units
-	-	-	-

These service data facilitate error diagnosis in the event of alarm “Defect in a monitoring channel” with error fine code 1003 or 3.

These data contain the zero-speed position, which was read out of the SRAM on the last power-up, of the axis or drive.
The last stored value is displayed here is no user agreement was given.

305 306 307 308	SGE image NCK monitoring channel (≥ SW6.1) SGE image drive monitoring channel (≥ SW6.1) SGA image NCK monitoring channel (≥ SW6.1) SGA image drive monitoring channel (≥ SW6.1)		Effective immediately
Default	Lower input limit	Upper input limit	Units
-	-	-	-

These data display the 32-bit SGE/SGA images. Each data is compiled of the following information:

Table 4-7 Compilation of service data 305 to 308

Service data	Bit 31 16	15 0
305	1005	1001
306	1006	1002
307	1007	1003
308	1008	1004

309	SI speed difference (from SW 6.3)		Effective immediately
Default	Lower input limit	Upper input limit	Units
0	-	-	mm/min or rev/min

Display of actual SZ speed difference established between NC and drive. The calculation takes place in the cross-check cycle (NC MD 40002).

310	Maximum SI speed difference (from SW 6.3)		Effective immediately
Default	Lower input limit	Upper input limit	Units
0	-	-	mm/min or rev/min

Display of maximum SZ speed difference between NC and drive. The calculation takes place in the cross-check cycle (NC MD 40002). The maximum value since the last NC POWER ON is displayed.

1000	**Parameterization errors safe functions**	
Bit No.	Cause	Remedy
8 (from SW6.1)	Certain conditions must be observed with respect to cam positions when cam synchronization is used. The cam parameter settings (MD 4216* to 4244*) +/- tolerance (minimum tolerance from MD 4248* and 4256*) are too close to the actual value overrange (linear axis: 737.280 m, rotary axis: +/- 2048 revolutions)	Reduce settings in MD 4216* to 4244* or reduce tolerance
7	Tolerance values have been input incorrectly (MD 4248* - 4260*, 4180*).	Enter MDs correctly.
6	The maximum input values for limit switches or cams has been exceeded (MD4200* - 4244*).	Enter MDs correctly.
5	Activation of a safety function for an analog drive.	Safe functions cannot be used for analog drives.
4	The HW required for safe functions is not available.	Install drive module with 611D performance closed-loop control module.
3	Error in actual value assignment (MD 4100*): – No digital drive selected – Incorrect measuring circuit or connection number	Enter 4100* correctly.
2	Conversion of the encoder data is producing impermissible conversion factors.	Check MD 4104* - 4176*.
1	The monitoring cycle set in MD 40000 for safe operation is not a multiple of the position control cycle of this axis.	Check the position control cycle and monitoring cycle of this axis (MDs 168, 155, 1396*, 40000).
0	The measuring circuit connection (MD 4100*) assigned for safe operation is already occupied by another axis/spindle.	Assign another measuring circuit Caution: In safe operation with 1 encoder, the 2nd measuring circuit connection cannot be assigned to other functions.

1001	**SGE image 1 in NCK monitoring channel**							
High byte	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
						Gear ratio selection		
	Test stop selection	Reserved	Reserved	SE selection	Reserved	Bit 2	Bit 1	Bit 0
Low byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
				SG selection				
	Reserved	Reserved	Reserved	Bit 1	Bit 0	Pulses disabled status	SBH deselec-tion	SBH/SG deselec-tion
Note: These signals are output in the Status display.								

1002	**SGE image 1 in drive monitoring channel**							
High byte	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
						Gear ratio selection		
	Test stop selection	Reserved	Reserved	SE selection	Reserved	Bit 2	Bit 1	Bit 0
Low byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
				SG selection				
	Reserved	Reserved	Reserved	Bit 1	Bit 0	Reserved	SBH deselec-tion	SBH/SG deselec-tion
Note: These signals are output in the Status display.								

1003	SGA image 1 in NCK monitoring channel							
High byte	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
	Cam signals of plus and minus cams							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
Low byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Axis safely referenced	Reserved	Reserved	Reserved	Reserved	Enable pulses	Reserved	SBH/SG active

Note:
These signals are output in the Status display.

1004	SGA image 1 in drive monitoring channel							
High byte	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
	Cam signals of plus and minus cams							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
Low byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Axis safely referenced	Reserved	Reserved	Reserved	Reserved	Pulses are disabled status	Reserved	SBH/SG active

Note:
These signals are output in the Status display.

1005 1006	SGE image 2 in NCK monitoring channel (from SW6.1) SGE image 2 in drive monitoring channel (from SW6.1)							
High byte	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
	0	0	0	0	0	0	0	0
Low byte	**Bit 7** 0	**Bit 6** 0	**Bit 5** 0	**Bit 4** 0	**Bit 3** 0	**Bit 2** 0	**Bit 1** 0	**Bit 0** 0

Note:
The setting must always be 0.

1007 1008	SGA image 2 in NCK monitoring channel (from SW6.1) SGA image 2 in drive monitoring channel (from SW6.1)							
High byte	**Bit 15**	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
Low byte	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Reserved	Reserved	$n < n_x$	SG active bit 1	SG active bit 0	Reserved	SBH active	Reserved

4.3 Machine data for SIMODRIVE 611D

4.3.1 Overview of machine data

Table 4-8 Machine data for SIMODRIVE 611D

No.	Identifier on 611D	Equivalent MD on 840D
	Name	**MD on 840C**
1300	$MD_SAFETY_CYCLE_TIME	10090: $MA_SAFETY_SYSCLOCK_TIME_RATIO
	Monitoring cycle	40010: Ratio monitoring cycle to position control basic cycle
1301	$MD_SAFE_FUNCTION_ENABLE	36901: $MA_SAFE_FUNCTION_ENABLE
	Enable safe functions	4500*: Enable SBH/SG/SE function 4504*: Cam enable safe operation
1302	$MD_SAFE_IS_ROT_AX	36902: $MA_SAFE_IS_ROT_AX
	Axis-specific bits for safe functions Bit 0: Axis type Bit 1: Inches system	4508*: Axis-specific bits for safe functions Bit 6: Axis type Bit 7: Inches display
1305	$MD_SAFE_MODULO_RANGE	36905: $MA_SAFE_MODULO_RANGE
	Modulo value for SN	Not available on 840C
1316	$MD_SAFE_ENC_CONFIG	36916: $MA_SAFE_ENC_IS_LINEAR 36925: $MA_SAFE_ENC_POLARITY
	Motor encoder configuration safe functions Bit 0: Linear scale Bit 1: Sign change Bit 2: 2-encoder system	4512*: Axis-specific bits for safe functions Bit 0: Linear scale 4512*: Axis-specific bits for safe functions Bit 1: Sign change
1317	$MD_SAFE_ENC_GRID_POINT_DIST	36917: $MA_SAFE_ENC_GRID_POINT_DIST
	Grid spacing linear scale	4104*: Grid spacing linear scale for safe functions
1318	$MD_SAFE_ENC_RESOL	36918: $MA_SAFE_ENC_RESOL
	Encoder marks per revolution	4108*: Encoder marks per revolution for safe functions
1320	$MD_SAFE_ENC_GEAR_PITCH	36920: $MA_SAFE_ENC_GEAR_PITCH
	Spindle pitch	4112*: Spindle pitch for safe operation
1321	$MD_SAFE_ENC_GEAR_DENOM[n]	36921: $MA_SAFE_ENC_GEAR_DENOM[n]
	Denominator of encoder/load gear	4116*: Denominator of encoder/load gear 1 for SI functions 4120*: Denominator of encoder/load gear 2 for SI operation to 4144*: Denominator of encoder/load gear 8 for SI safe operation
1322	$MD_SAFE_ENC_GEAR_NUMERA[n]	36922: $MA_SAFE_ENC_GEAR_NUMERA[n]
	Numerator of encoder/load gear	4148*: Numerator of encoder/load gear 1 for SI operation 4152*: Numerator of encoder/load gear 2 for SI operation to 4176*: Numerator of encoder/load gear 8 for SI operation
1330	$MD_SAFE_STANDSTILL_TOL	36930: $MA_SAFE_STANDSTILL_TOL
	Standstill tolerance	4180*: Standstill tolerance for SI operation
1331	$MD_SAFE_VELO_LIMIT[n]	36931: $MA_SAFE_VELO_LIMIT[n]
	Limit values for safe velocity	4184*: Limit value for safe velocity 1 4188*: Limit value for safe velocity 2 4192*: Limit value for safe velocity 3 4196*: Limit value for safe velocity 4
1332	$MD_SAFE_VELO_OVR_FACTOR[n] (from SW4.2)	36932: $MA_ SAFE_VELO_OVR_FACTOR[n] (from SW4.2)
	Override factor for SG	Not available on 840C
1334	$MD_SAFE_POS_LIMIT_PLUS[n]	36934: $MA_SAFE_POS_LIMIT_PLUS[n]
	Upper limit value for safe limit position	4200*: Upper limit value for safe limit position 1 4204*: Upper limit value for safe limit position 2
1335	$MD_SAFE_POS_LIMIT_MINUS[n]	36935: $MA_SAFE_POS_LIMIT_MINUS[n]
	Lower limit value for safe limit position	4208*: Lower limit value for safe limit position 1 4212*: Lower limit value for safe limit position 2
1336	$MD_SAFE_CAM_POS_PLUS[n]	36936: $MA_SAFE_CAM_POS_PLUS[n]
	Plus cam position for safe cams	4216*: Plus cam position for safe cams 1 4220*: Plus cam position for safe cams 2 4224*: Plus cam position for safe cams 3 4228*: Plus cam position for safe cams 4

No.	Identifier on 611D	Equivalent MD on 840D
	Name	**MD on 840C**
1337	$MD_SAFE_CAM_POS_MINUS[n]	36937: $MA_SAFE_CAM_POS_MINUS[n]
	Minus cam position for safe cams	4232*: Minus cam position for safe cams 1 4236*: Minus cam position for safe cams 2 4240*: Minus cam position for safe cams 3 4244*: Minus cam position for safe cams 4
1340	$MD_SAFE_CAM_TOL	36940: $MA_SAFE_CAM_TOL
	Tolerance for safe cams	4248*: Tolerance for safe cams
1342	$MD_SAFE_POS_TOL	36942: $MA_SAFE_POS_TOL
	Actual value comparison tolerance (cross-check)	4256*: Actual value comparison tolerance (cross-check)
1344	$MD_SAFE_REFP_POS_TOL	36944: $MA_SAFE_REFP_POS_TOL
	Actual value comparison tolerance (referencing)	4252*: Actual value comparison tolerance (referencing)
1346	$MD_SAFE_VELO_X (840D from SW4.2, 840C from SW6.1)	36946: $MA_SAFE_VELO_X (from SW4.2)
	Velocity limit n_x	4292*: Velocity limit n_x for safe operation (from SW6.1)
1348	$MD_SAFE_STOP_VELO_TOL (840D from SW4.2, 840C from SW6.1)	36948: $MA_SAFE_STOP_VELO_TOL (from SW4.2)
	Actual velocity tolerance for SBR	4296*: Actual velocity tolerance for SBR (from SW6.1)
1350	$MD_SAFE_MODE_SWITCH_TIME	36950: $MA_SAFE_MODE_SWITCH_TIME
	Tolerance time for SGE switchover	4260*: Tolerance time for SGE switchover
1351	$MD_SAFE_VELO_SWITCH_DELAY	36951: $MA_SAFE_VELO_SWITCH_DELAY
	Delay time velocity switchover	4264*: Delay time velocity switchover
1352	$MD_SAFE_STOP_SWITCH_TIME_C	36952: $MA_SAFE_STOP_SWITCH_TIME_C
	Transition time STOP C to SBH	4276*: Transition time STOP C to SBH
1353	$MD_SAFE_STOP_SWITCH_TIME_D	36953: $MA_SAFE_STOP_SWITCH_TIME_D
	Transition time STOP D to SBH	4280*: Transition time STOP D to SBH
1354	$MD_SAFE_STOP_SWITCH_TIME_E	36954: $MA_SAFE_STOP_SWITCH_TIME_E
	Transition time STOP E to SBH	4284*: Transition time STOP E to SBH
1356	$MD_SAFE_PULSE_DISABLE_DELAY	36956: $MA_SAFE_PULSE_DISABLE_DELAY
	Delay time pulse disable	4268*: Delay time pulse disable
1357	$MD_SAFE_PULSE_DIS_CHECK_TIME	36957: $MA_SAFE_PULSE_DIS_CHECK_TIME
	Time for testing pulse disable	4272*: Time for testing pulse disable
1360	$MD_SAFE_STANDSTILL_VELO_TOL	36960: $MA_SAFE_STANDSTILL_VELO_TOL
	Creep velocity pulse disabling	4288*: Creep velocity pulse disabling
1361	$MD_SAFE_VELO_STOP_MODE	36961: $MA_SAFE_VELO_STOP_MODE
	Stop reaction safe velocity	4508*: Axis-specific bits for safe functions Bit 4: Selection STOP D/E for SG
1362	$MD_SAFE_POS_STOP_MODE	36962: $MA_SAFE_POS_STOP_MODE
	Stop reaction safe limit position	4508*: Axis-specific bits for safe functions Bit 2: Selection STOP D/E for SE
1363	$MD_SAFE_VELO_STOP_REACTION[n] (840D from SW4.2)	36961: $MA_SAFE_VELO_STOP_REACTION[n] (from SW4.2)
	SG-specific stop reaction	Not available on 840C
1390	Firmware version Safety Integrated (from SW 6.3)	
1391	$MD_SAFE_DIAG_NC_RESULTLIST1 Diagnosis NC result list 1	Not available on 840D Not available on 840C
1392	$MD_SAFE_DIAG_611D_RESULTLIST1 Diagnosis 611D result list 1	Not available on 840D Not available on 840C
1393	$MD_SAFE_DIAG_NC_RESULTLIST2 Diagnosis NC result list 2	Not available on 840D Not available on 840C
1394	$MD_SAFE_DIAG_611D_RESULTLIST2 Diagnosis 611D result list 2	Not available on 840D Not available on 840C
1395	$MD_SAFE_STOP_F_DIAGNOSIS	Integrated in alarm text in 840D
	Diagnosis for STOP F	301: Diagnosis for STOP F
1396	$MD_SAFE_ACKN_WRITE	Not available on 840D
	User agreement	Not available on 840C
1397	$MD_SAFE_ACKN_READ	Not available on 840D
	611D internal agreement	Not available on 840C

No.	Identifier on 611D	Equivalent MD on 840D
	Name	**MD on 840C**
1398	$MD_SAFE_ACT_CHECKSUM	$MA_SAFE_ACT_CHECKSUM
	Display checksum of machine data for safe functions	40000: Display checksum of machine data for safe functions
1399	$MD_SAFE_DES_CHECKSUM	$MA_SAFE_DES_CHECKSUM
	Display checksum of machine data for safe functions	40001: Display checksum of machine data for safe functions

Note:

- The drive machine data are copied to the drive after selection of softkey COPY TO DRIVE.

13xx Drive machine data marked in this way are **not taken into account** during the **copy operation**. The machine data must enter these data by hand.

- The same description as given for equivalent machine data of the 840D and 840C systems apply to the machine data copied to the drive.

Loading the motor default data

When the motor default data are loaded, some drive machine data are overwritten. If another type of motor is mounted in the course of servicing and the associated motor default data are loaded, then the encoder data must be changed back to their original value.

4.3.2 Description of machine data

1300	$MD_SAFETY_CYCLE_TIME				611D
	Monitoring cycle			Relevant for: FDD/MSD	
Unit: 31.25 µs	Default: 384 (= 12 ms)	Minimum value: 16	Maximum value: 800	Data type: short integer	Effective after: POWER ON

This data sets the monitoring cycle for safe operation.
Position control cycle ≤ monitoring cycle ≤ 25ms

The monitoring cycle defines the reaction time of the monitoring functions. It must be noted that the load on the CPU is increased when a short monitoring cycle is set.

1301	$MD_SAFE_FUNCTION_ENABLE				611D
	Enable safe functions			Relevant for: FDD/MSD	
Unit: Hexadecimal	Default: 0	Minimum value: 0	Maximum value: FF 03 FF E3 (from SW 4.2)	Data type: Binary	Effective after: POWER ON

This data enables the partial functions for safe operation on an axis-specific or spindle-specific basis. The bit assignment is as follows:

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
High byte	Enable safe cams							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Low byte	Enable (840D from SW4.2)			Reserved, bits must be 0			Enable	
	Cam synchro-nization	Stopping via SGE	Override for safe velocity	0	0	0	SE	SBH/SG

1302	$MD_SAFE_IS_ROT_AX				611D
	Axis-specific bits for safe functions			Relevant for: FDD/MSD	
Unit: -	Default: 0	Minimum value: 0	Maximum value: 00 03	Data type: Binary	Effective after: POWER ON

Safety-function bits that are specific to axis and encoder

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
High byte	Reserved, these bits must be set to "0"							
	0	0	0	0	0	0	0	0
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Low byte	Reserved, these bits must be set to "0"							
	0	0	0	0	0	0	Inch system	Axis type

Bit 0 1: Rotary axis/spindle
0: Linear axis

Bit 1 1: Inches system
0: Metric system

1305	$MD_SAFE_MODULO_RANGE				611D
	Modulo value for SN			Relevant: for: FDD/MSD	Valid as of: SW4.2 in 840D
Unit: mdegree	Default: 0	Minimum value 0	Maximum value 737 280 000	Data type: long integer	Effective after: POWER ON

Actual value range within which safe cams for rotary axes are calculated. The axis must be a rotary axis ($MA_/$MD_SAFE_IS_ROT_AX = 1).

Setting = 0: Modulo correction after +/- 2048 revolutions (i.e. after 737 280 degrees)

Setting > 0 and multiples of 360 000 mdegree:
Modulo correction after this setting (e.g. setting = 360 → the actual value range is between 0 and 359.999 degrees, i.e. a modulo correction is carried out after every revolution.

Related machine data:
MD 36905: $MA_SAFE_MODULO_RANGE
MD 36936/1336: $MA_/$MD_SAFE_CAM_POS_PLUS[n]
MD 36937/1337: $MA_/$MD_SAFE_CAM_POS_MINUS[n]

1316	$MD_SAFE_ENC_CONFIG				611D
	Motor encoder configuration safe functions			Relevant for: FDD/MSD	
Unit: -	Default: 0	Minimum value: 0	Maximum value: 00 07	Data type: Binary	Effective after: POWER ON

Safety-function bits that are specific to axis and encoder.

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
High byte	Reserved							
	0	0	0	0	0	0	0	0
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Low byte	0	0	0	0	0	2-encoder system	Sign change	Motor encoder (IMS)

Bit 0 1: Linear motor encoder (e.g.: linear scale for linear motor)
0: Rotary motor encoder

Bit 1 1: Sign change
0: No sign change

Bit 2 1: 2-encoder system (no monitoring for encoder limit frequency)
0: 1-encoder system (monitoring for encoder limit frequency)

1317	$MD_SAFE_ENC_GRID_POINT_DIST				611D
	Grid spacing linear scale			Relevant for: FDD/MSD	
Unit: µm	Default: 10	Minimum value: 0.010	Maximum value: 8 000	Data type: float	Effective after: POWER ON

Grid spacing of encoder (applies only to linear encoders)

1318	$MD_SAFE_ENC_RESOL				611D
	Encoder marks per revolution			Relevant for: FDD/MSD	
Unit:	Default: 2 048	Minimum value: 1	Maximum value: 100 000	Data type: -	Effective after: POWER ON

Number of marks per encoder revolution (applies only to rotary encoders)

1320	$MD_SAFE_ENC_GEAR_PITCH				611D
	Spindle pitch			Relevant for: FDD/MSD	
Unit: mm/rev	Default: 10	Minimum value: 0.1	Maximum value: 8 388.00	Data type: float	Effective after: POWER ON

Gear ratio of gear unit between encoder and load (applies to linear axes with rotary encoder)

1321	$MD_SAFE_ENC_GEAR_DEMON[n]				611D
	Denominator of encoder/load gear			Relevant for: FDD/MSD	
Unit: -	Default: 1	Minimum value: 1	Maximum value: 8 388 607	Data type: long integer	Effective after: POWER ON

Denominator of gear unit between encoder and load, i.e. the denominator of the fraction "No. of encoder revolutions / **No. of load revolutions**"

There are a total of 8 values (n = 0 ... 7); the current value is selected by means of SGEs.

1322	$MD_SAFE_ENC_GEAR_NUMERA[n]				611D
	Numerator of encoder/load gear			Relevant for: FDD/MSD	
Unit: -	Default: 1	Minimum value: 1	Maximum value: 8 388 607	Data type: long Integer	Effective after: POWER ON

Numerator of gear unit between encoder and load, i.e. the numerator of the fraction "**No. of encoder revolutions** / No. of load revolutions"

There are a total of 8 values (n = 0 ... 7); the current value is selected by means of SGEs.

1330	$MD_SAFE_STANDSTILL_TOL				611D
	Standstill tolerance			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: 1 000	Minimum value: 1	Maximum value: 100 000	Data type: long integer	Effective after: POWER ON

Limit value for safe standstill monitoring.

This machine data positions the standstill tolerance window for the SBH monitoring. The actual value must remain within this window or else an alarm (tolerance band for safe operational stop exceeded) is output and the drive is switched to a safe operational stop.

1331	$MD_SAFE_VELO_LIMIT[n]				611D
	Limit values for safe velocity			Relevant for: FDD/MSD	
Unit: mm/min or rev/min	Default: 2 000	Minimum value 0	Maximum value: 1 000 000	Data type: float	Effective after: POWER ON

Limit values for safe monitoring of the velocity

n = 0, 1, 2, 3, stands for limit value of SG1, 2, 3, 4

If the current actual speed exceeds this limit value, the drive activates an alarm and stop reaction (that can be parameterized in MD 1361: $MD_SAFE_VELO_STOP_MODE) and then switches to safe operational stop mode.

With active SBH/SG and a 1-encoder system, the speed is monitored on the basis of an encoder limit frequency of 200 kHz (300 kHz, 840D from SW3.6, 840C from SW5.7). The parameterized stop reaction is output when the limit is exceeded.

1332	$MD_SAFE_VELO_OVR_FACTOR[n]				611D
	Override factor for SG			Relevant for: FDD/MSD	Valid as of: SW version: 4.2
Unit: %	Default: 100	Minimum value: 1	Maximum value: 100	Data type: short Integer	Effective after: POWER ON

It is possible to select overrides via SGEs for safe velocities 2 and 4 and to set the associated override value (percentage) in this machine data.

n = 0, 1, ... , 15 stand for overrides 0, 1, ... 15

The “Override for safe velocity” function is enabled via MD 36901(MD 1301): $MA($MD)_SAFE_FUNCTION_ENABLE (see Section 3.4.5 “Override for safe velocity“).

1334	$MD_SAFE_POS_LIMIT_PLUS[n]				611D
	Upper limit value for safe limit position			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: 100 000 000	Minimum value: -2 147 000 000	Maximum value: 2 147 000 000	Data type: long integer	Effective after: POWER ON

Upper (positive) limit value for safe monitoring of limit position

n = 0, 1 stands for safe limit position 1, 2

When the active upper limit value is exceeded, the drive activates an alarm and stop reaction (that can be parameterized in MD 1362: $MD_SAFE_POS_STOP_MODE) and then switches to safe operational stop mode.

1335	$MD_SAFE_POS_LIMIT_MINUS[n]				611D
	Lower limit value for safe limit position			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: -100 000 000	Minimum value: -2 147 000 000	Maximum value: 2 147 000 000	Data type: long integer	Effective after: POWER ON

Lower (negative) limit value for safe limit position monitoring.

n = 0, 1 stands for safe limit position 1, 2

When the active lower limit value is exceeded, the drive activates an alarm and stop reaction (that can be parameterized in MD 1362: $MD_SAFE_POS_STOP_MODE) and then switches to safe operational stop mode.

1336	$MD_SAFE_CAM_POS_PLUS[n]				611D
	Plus cam position for safe cams			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: 10 000	Minimum value: -2 147 000 000	Maximum value: 2 147 000 000	Data type: long integer	Effective after: POWER ON

Operating threshold for positive cams.

n = 0, 1, 2, 3 stands for positive cams SN1 +, SN2 +, SN3 +, SN4 +

If the safe actual position exceeds the position set in the machine data, then the SGA assigned to the relevant cam is set to 1.

1337	$MD_SAFE_CAM_POS_MINUS[n]				611D
	Minus cam position for safe cams			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: -10 000	Minimum value: -2 147 000 000	Maximum value: 2 147 000 000	Data type: long integer	Effective after: POWER ON

Operating threshold for negative cams.

n = 0, 1, 2, 3 stands for negative cams SN1 -, SN2 -,SN3 -, SN4 -

If the safe actual position exceeds the position set in the machine data, then the SGA assigned to the relevant cam is set to 1.

1340	$MD_SAFE_CAM_TOL				611D
	Tolerance for safe cams			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: 100	Minimum value: 1	Maximum value 10 000	Data type: long integer	Effective after: POWER ON

Tolerance threshold for all cams.

As a result of minute measuring, computational and transit-time deviations, the two monitoring channels (NC and drive) rarely detect the crossing of a cam position at exactly the same time and in exactly the same position. This data creates a tolerance window within which cam results in the two monitoring channels may deviate without causing an error alarm.

1342	$MD_SAFE_POS_TOL				611D
	Actual value comparison tolerance (cross-check)			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: 100	Minimum value: 1	Maximum value: 10 000 or 360 000	Data type: long integer	Effective after: POWER ON

Tolerance threshold for the cross-check of the position actual value between the NC and drive. This machine data creates a tolerance window within which the position actual values of the NC and drive may deviate from one another.

"Finger protection" (about 10 mm) is the primary consideration when setting this tolerance value.

If the deviation between the position actual values is greater than the tolerance window, an alarm with error code is output.

1344	$MD_SAFE_REFP_POS_TOL				611D
	Actual value comparison tolerance (referencing)			Relevant for: FDD/MSD	
Unit: µm or 0.001 degrees	Default: 10	Minimum value: 0	Maximum value: 1 000 or 36 000	Data type: long integer	Effective after: POWER ON

Tolerance threshold for the actual value check after referencing. A second absolute actual position is calculated from the last standstill position to be stored prior to encoder power OFF and the distance traversed since power ON. These two actual positions must be within the tolerance window or else the axis cannot be referenced without "user agreement". If this agreement has not been given, an alarm with error code is output.

The following factors must be taken into consideration when calculating tolerance values:
Backlash, leadscrew errors, temperature errors, torsion with 2-encoder system, gear play on shift gearboxes, lower resolution with 2-encoder system, oscillating distance for shift gearboxes.

1346	$MD_SAFE_VELO_X				611D
	Velocity limit n_x			Relevant for: MSD/FDD	Valid as of: SW4.2 on 840D SW6.1 on 840C
Unit: mm/min rev/min	Default: 20	Minimum value: 0	Maximum value: 1 000	Data type: float	Effective after: POWER ON

This data defines the velocity limit n_x for SGA “$n < n_x$“.

Setting 0 means: $n < n_x$ is not active.

1348	$MD_SAFE_STOP_VELO_TOL				611D
	Actual velocity tolerance for SBR			Relevant for: FDD/MSD	Valid as of: SW4.2 on 840D SW6.1 on 840C
Unit: mm/min, inch/min, rev./min	Default: 300.0	Minimum value: 0.0	Maximum value: 20 000.0	Data type: DOUBLE	Effective after: POWER ON

After the safe braking ramp has been activated, the current speed plus the speed tolerance set in this machine data are applied as a velocity limit.

Recommended settings: See Section 2.5.6 “Safe braking ramp“

1350	$MD_SAFE_MODE_SWITCH_TIME				611D
	Tolerance time for SGE switchover			Relevant for: FDD/MSD	
Unit: ms	Default: 500	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

Timer for SGE changes. The timer is started every time new SGEs are accepted. The new monitoring functions are instantly active, but the cross-check of time-variable data (i.e. actual values and result lists) must be postponed for a short period since the two monitoring channels do not detect the SGE changes at exactly the same time.

Note

System-dependent minimum tolerance time:
2 x PLC cycle time (maximum cycle) + 1 x IPO cycle time

The variations in transit time in the external circuitry (e.g. relay operating times) must also be taken into account.

1351	$MD_SAFE_VELO_SWITCH_DELAY				611D
	Delay time velocity switchover			Relevant for: FDD/MSD	
Unit: ms	Default: 100	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

The timer is started on transition from the safe velocity function to safe operational stop mode or when the speed monitoring limit is reduced to a lower speed. During this period, the last selected safe velocity limit remains active.

1352	$MD_SAFE_STOP_SWITCH_TIME_C				611D
	Transition time STOP C to SBH			Relevant for: FDD/MSD	
Unit: ms	Default: 100	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

On expiry of the timer set in this data, the system switches from STOP C mode (initiated by the SG or SE monitoring function) to safe operational stop mode.

After the time period has elapsed, the axis/spindle is monitored for safe operational stop. If it has still not reached zero speed, a STOP A or STOP B is initiated.

1353	$MD_SAFE_STOP_SWITCH_TIME_D				611D
	Transition time STOP D to SBH			Relevant for: FDD/MSD	
Unit: ms	Default: 100	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

On expiry of the timer set in this data, the system switches from STOP D mode (initiated by the SG or SE monitoring function) to safe operational stop mode.

After the time period has elapsed, the axis/spindle is monitored for safe operational stop. If it has still not reached zero speed, a STOP A or STOP B is initiated.

1354	$MD_SAFE_STOP_SWITCH_TIME_E				611D
	Transition time STOP E to safe operational stop			Relevant for: FDD/MSD	
Unit: ms	Default: 100	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

On expiry of the timer set in this data, the system switches from STOP E mode (initiated by the SG or SE monitoring function) to safe operational stop mode.

After the time period has elapsed, the axis/spindle is monitored for safe operational stop. If it has still not reached zero speed, a STOP A or STOP B is initiated.

1356	$MD_SAFE_PULSE_DISABLE_DELAY				611D
	Delay time pulse disable			Relevant for: FDD/MSD	
Unit: ms	Default: 100	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

Delay time for disabling of pulses after activation of a STOP B.

The pulses are disabled earlier than defined in this data if the condition for pulse disabling is defined in MD 1360: $MD_SAFE_STANDSTILL_VELO_TOL.

If the timer in this data is set to zero, STOP A (immediate pulse disabling) is activated immediately from STOP B mode.

1357	$MD_SAFE_PULSE_DIS_CHECK_TIME				611D
	Time for testing pulse disable			Relevant for: FDD/MSD	
Unit: ms	Default: 100	Minimum value: 0	Maximum value: 10 000	Data type: float	Effective after: POWER ON

On expiry of the timer set in this data, the drive pulses must be disabled if requested by the SGE "Test stop selection".

If the pulses are not disabled on time, a STOP A reaction is activated.

1360	$MD_SAFE_STANDSTILL_VELO_TOL				611D
	Creep speed pulse disabling			Relevant for: FDD/MSD	
Unit: mm/min or rev/min	Default: 0.0	Minimum value: 0.0	Maximum value: 1 000.0	Data type: float	Effective after: POWER ON

When the axis speed drops below this limit, it is judged to be at a "standstill". In STOP B mode, the pulses are then disabled (through transition to STOP A mode).

MD 1356: $MD_SAFE_PULSE_DISABLE_DELAY must be noted. If the delay time expires before the speed drops below the limit set in the above data, then the drive pulses are disabled prematurely.

1361	$MD_SAFE_VELO_STOP_MODE				611D
	Stop reaction safe velocity			Relevant for: FDD/MSD	
Unit: -	Default: 2	Minimum value: 2	Maximum value: 4	Data type: short integer	Effective after: POWER ON

If a selected limit value for safe velocity 1, 2, 3 or 4 is exceeded, the stop reaction set in the above data is initiated.

= 0, 1, 2, 3 correspond to STOP A, B, C, D as error reactions.
= 5 means that the stop reaction can be configured for specific SGs in MD 36963/1363.

1362	$MD_SAFE_POS_STOP_MODE				611D
	Stop reaction safe limit position			Relevant for: FDD/MSD	
Unit: -	Default: 5	Minimum value: 0	Maximum value: 5	Data type: short integer	Effective after: POWER ON

When the activated safe limit position 1 or 2 is exceeded, the stop reaction specified in this data is initiated.

= 2, 3, 4 stands for STOP C, D or E that is initiated in response to an error.

1363	$MD_SAFE_VELO_STOP_REACTION[n]				611D
	SG-specific stop reaction			Relevant for: FDD/MSD	840D from SW4.2
Unit: -	Default: 2	Minimum value: 0	Maximum value: 3	Data type: BYTE	Effective after: POWER ON

The stop reaction programmed in this data is initiated when a selected limit value for safe velocity 1, 2, 3 or 4 is exceeded.

n = 0, 1, 2, 3 stand for SG1, SG2, SG3, SG4

Value = 0, 1, 2, 3 corresponds to STOP A, B, C, D

This function is active only if MD 36961 and MD 1361 have been set to 5.

1390	Firmwarestand Safety Integrated (from SW 6.3)		Effective after POWER ON
Default	Minimum value	Maximum value	Units
-	-	-	-

This only readable machine data is used to display the current SI version of the drive.

1391 1392	$MD_SAFE_DIAG_NC_RESULTLIST1 $MD_SAFE_DIAG_611D_RESULTLIST1				611D
	Diagnosis NC result list 1 Diagnosis 611D result list 1			Relevant for: FDD/MSD	
Unit: -	Default: 0	Minimum value: 0	Maximum value: FFFF FFFF	Data type: Long Integer	Effective after: POWER ON

These machine data are used to decode errors in result list 1.

Bit No.	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
Function	-	-	-	-	-	-	-	-
Bit No.	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
Function	-	-	-	-	-	-	-	-
Bit No.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Function	-	-	SG4	SG4	SG3	SG3	SG2	SG2
Bit No.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Function	SG1	SG1	SE2	SE2	SE1	SE1	SBH	SBH

The bits assigned to SI functions have an identical status in error-free operation, but have different statuses when an error has occurred.

In the case of a difference between 1391 and 1392, an error has occurred in the SI function that is assigned to this bit.

Example:
MD 1391 = 0000 1556_{Hex} = 0000 0000 0000 0000 0001 0101 0101 0110_{Binary}
MD 1392 = 0000 1557_{Hex} = 0000 0000 0000 0000 0001 0101 0101 0111_{Binary}
--> bit 0 is different --> error in result cross-check of safe operational stop (SBH function. All data that are relevant for the safe operational stop function must be checked in the NCK and drive channels.

Explanation of the gray-shaded last two places:

01	invalid, i. e. not selected
10	selected and correct
00	value not reached, boundaries violated
11	value exceeded

1393 1394	$MD_SAFE_DIAG_NC_RESULTLIST2 $MD_SAFE_DIAG_611D_RESULTLIST2				611D
	Diagnosis NC result list 2 Diagnosis 611D result list 2			Relevant for: FDD/MSD	
Unit: -	Default: 0	Minimum value: 0	Maximum value: FFFF FFFF	Data type: Long Integer	Effective after: POWER ON

These machine data are used to decode errors in result list 2.

Bit No.	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
Function	-	-	-	-	-	-	-	-
Bit No.	Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
Function	-	-	Cam modulo range	Cam modulo range	n_x lower limit	n_x lower limit	n_x upper limit	n_x upper limit
Bit No.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Function	SN4 -	SN4 -	SN4 +	SN4 +	SN3 -	SN3 -	SN3 +	SN3 +
Bit No.	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Function	SN2 -	SN2 -	SN2 +	SN2 +	SN1 -	SN1 -	SN1 +	SN1 +

The bits assigned to SI functions have an identical status in error-free operation, but have different statuses when an error has occurred.

In the case of a difference between 1393 and 1394, an error has occurred in the SI function that is assigned to this bit.

Example:
MD 1393 = 0000 1547_{Hex} = 0000 0000 0000 0000 0001 0101 0100 0111_{Binary}
MD 1394 = 0000 1557_{Hex} = 0000 0000 0000 0000 0001 0101 0101 0111_{Binary}
--> Bit 4 is different --> error in result cross-check of safe cam (SN2 +). All data that are relevant for this cam must be checked in the NCK and drive channels.

1395	$MD_SAFE_STOP_F_DIAGNOSIS				611D
	Diagnosis for STOP F			Relevant for: FDD/MSD	
Unit: -	Default: 32 767	Minimum value: 0	Maximum value: 32 767	Data type: Integer	Effective immediately

The fine diagnosis for the following alarms is displayed in this data:
On 840D Alarm 27001 "Defect in a monitoring channel"
On 840C Alarm 1336 "Defect in a monitoring channel"
On 611D Alarm 300911 "Defect in a monitoring channel"

With error code = 1: Evaluate fine decoding of errors in MDs 1391 and 1392
With error code = 2: Evaluate fine decoding of errors in MD 1393 and 1394

The error code is output with the alarm display on the SINUMERIK 840D.

A table listing the possible error codes for the SINUMERIK 840C can be found in Section 6.2 Alarms for SINUMERIK 840C

The error code is output with the alarm display on the 611D.

1396	$MD_SAFE_ACKN_WRITE				611D
	User agreement			Relevant for: FDD/MSD	
Unit: Hexadecimal	Default: 00 00	Minimum value: 00 00	Maximum value: FF FF	Data type: Binary	Effective immediately

The user must input his agreement (acknowledgement) manually to switch the axis from the "Axis referenced" (IS) state to the "Axis safely referenced" (SGA) state. User agreement does not have to be given when the axis is referenced again provided that the comparison of the standstill position and the "reference position" that is automatically made during power-up produces a positive result.

Bit 15 ... 0	Meaning
= 00AC	Agreement set
= 0	Agreement not set

1397	$MD_SAFE_ACKN_READ				611D
	611D internal agreement			Relevant for: FDD/MSD	
Unit: Hexadecimal	Default: 00 00	Minimum value: 00 00	Maximum value: FF FF	Data type: Binary	Effective immediately

Display data indicating that an axis is in the "Axis safely referenced" state after user agreement has been set.

Bit 15 ... 0	Meaning
= 00AC	Agreement set
= 0	Agreement not set

1398	$MD_SAFE_ACT_CHECKSUM				611D
	Display checksum of machine data for safe functions			Relevant for: FDD/MSD	
Unit:	Default: 00 00 00 00	Minimum value: 00 00 00 00	Maximum value: FF FF FF FF	Data type: long integer	Effective after: POWER ON

This machine data contains the actual checksum of the current values of the SI machine data that is calculated after POWER ON.

If the actual checksum is not the same as the setpoint checksum in MD 1399: $MD_SAFE_DES_CHECKSUM, then the alarm 300744 "Checksum error safety monitors" is displayed.

1399	$MD_SAFE_DES_CHECKSUM				611D
	Checksum of machine data for safe functions			Relevant for: FDD/MSD	
Unit:	Default: 00 00 00 00	Minimum value: 00 00 00 00	Maximum value: FF FF FF FF	Data type: long integer	Effective after: POWER ON

This data contains the setpoint checksum of the current values of the SI machine data that was stored during the last acceptance test.

The actual checksum is calculated after POWER ON, entered in MD 1398: $MD_SAFE_ACT_CHECKSUM and compared with the setpoint checksum stored in this data.
When the values are not identical, the data have either been changed or there is an error present and alarm 300744 "Checksum error safety monitors" is displayed.

4.4 Interface signals

General

The safety-relevant input and output signals (SGEs and SGAs) are signals that are sent to and arrive from the system via two channels:

- Via the NCK monitoring channel
  <--> NCK I/O devices <--> signal processing <-->
  NCK SGE/SGA interface <-> NCK CPU
- Via the drive monitoring channel
  <--> PLC I/O devices <--> signal processing via PLC <-->
  NC/PLC interface <-->drive CPU

Note

The SGEs/SGAs in the drive monitoring channel are mapped in an area of the NC/PLC interface (signals to/from drive) and must be supplied in the PLC user program.
Owing to the two-channel structure of Safety Integrated, the machine manufacturer must supply the SGEs and SGAs in both the NCK monitoring channel and the drive monitoring channel.
Unused SGEs must be set to a defined status.

4.4.1 Interface signals for SINUMERIK 840D

Table 4-9 Interface signals on 840D

DB 31 ...	**Signals to/from drive**							
Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
...	...							
...	...							
...	...							
22	Reserved	Reserved	Reserved	SG selection		Reserved	SBH-deselection	SBH/SG-deselection
				Bit 1	Bit 0			
23	Teststop selection	Reserved	Reserved	SE selection	Reserved	Gear ratio selection		
						Bit 2	Bit 1	Bit 0
	SGE (signals to drive)							
32	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
33	Override selection (from SW4.2)							
	Bit 3	Bit 2	Bit 1	Bit 0	Reserved	Reserved	Reserved	Reserved
...	...							
...	...							
...	...							
108	Axis safely referenced	Reserved	Reserved	Reserved	Reserved	"Pulses are disabled" status	Reserved	SBH/SG active
109	Cam signals of plus and minus cams							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
	SGA (signals from drive)							
110	Reserved	Reserved	$n < n_x$	SG active (as from SW4.2)			SBH active	
			(as from SW4.2)	Bit 1	Bit 0	Reserved	(as from SW4.2)	Reserved
111	Reserved							

Note:
DB 31 / 32 / 33 ... contains the interface signals for axis/spindle 1 / 2 / 3 ...

4.4.2 Interface signals for SINUMERIK 840C

Note

Interface signals are organized as follows. Example shows axis 1 signals:

Signals	Bytes in DB 28
SGAs (signals from drive)	In SW5.4: DL0, DR0 From SW5.7: DL0, DR0, DL60, DR60
SGEs (signals to drive)	In SW5.4: DL1, DR1 from SW5.7: DL1, DR1, DL61, DR61

Table 4-10 Interface signals on 840C

DB 28	**SGA/SGE (signals from/to drive)**							
DL ...	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
DW ...	**Bit No.**							
DR ...	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
DL 0	Axis safely referenced	Reserved	Reserved	Reserved	Reserved	"Pulses are disabled" status	Reserved	SBH/SG active
DW 0	**SGA (signals from drive, axis 1)**							
DR 0	Cam signals of plus and minus cams							
	SN4 -	SN4 +	SN3 -	SN3 +	SN2 -	SN2 +	SN1 -	SN1 +
DL 1	Reserved	Reserved	Reserved	SG selection		Reserved	SBH deselection	SBH/SG deselection
				Bit 1	Bit 0			
DW 1	**SGE (signals to drive, axis 1)**							
DR 1	Teststop selection	Reserved	Reserved	SE selection	Reserved	Gear ratio selection		
						Bit 2	Bit 1	Bit 0
DL 2								
DW 2	**SGA (signals from drive, axis 2)**							
DR 2								
DL 3								
DW 3	**SGE (signals to drive, axis 2)**							
DR 3								
to	to							
DL 58								
DW 58	**SGA (signals from drive, axis 30)**							
DR 58								
DL 59								
DW 59	**SGE (signals to drive, axis 30)**							
DR 59								
DL 60	Reserved	Reserved	$n < n_x$ (from SW6.1)	SG active (from SW6.1)		Reserved	SBH active (from SW6.1)	Reserved
				Bit 1	Bit 0			
DW 60	**SGA (Signals from drive, axis 1)**							
DR 60	Reserved							
DL 61	Reserved							
DW 61	**SGE (Signals to drive, axis 1)**							
DR 61	Reserved							
DL 62								
DW 62	**SGA (Signals from drive, axis 2)**							
DR 62								
DL 63								
DW 63	**SGE (Signals to drive, axis 2)**							
DR 63								
to	to							
DL 118								
DW 118	**SGA (Signals from drive, axis 30)**							
DR 118								
DL 119								
DW 119	**SGE (Signals to drive, axis 30)**							
DR 119								

4.4.3 Description of interface signals

Description of signals to drive

SGE
SBH/SG deselection
SBH deselection

These signals are used to select/deselect the SBH and SG functions.

Table 4-11 Selection/deselection of SBH and SG

SGE		
SBH/SG deselection	**SBH deselection**	**Meaning**
= 1	x	SBH and SG are deselected
= 0	= 0	SBH is selected (see Section ????)
= 0	= 1	SG is selected - The drive can be switched to SBH mode manually - The drive is switched over to SBH mode internally in control in the event of an error.
x: Signal state optional		

SGE
SG selection, bits 1, 0

By combining these signals, it is possible to select the velocity limit value for SG1, 2, 3 or 4 when the SG function is activated.

Table 4-12 Selection of velocity limit values for SG

SGE		
SG selection Bit 1	**SG selection Bit 0**	**Meaning**
= 0	= 0	Velocity limit value for SG1 is selected
= 0	= 1	Velocity limit value for SG2 is selected
= 1	= 0	Velocity limit value for SG3 is selected
= 1	= 1	Velocity limit value for SG4 is selected

SGE
Gear ratio selection, bits 1, 0

The combination of these signals determines the selected gear ratio 1, 2, ... ,8.

Table 4-13 Gear ratio selection

SGE gear ratio selection			
Bit 2	**Bit 1**	**Bit 0**	**Meaning**
0	0	0	Gear stage 1 is selected
0	0	1	Gear stage 2 is selected
0	1	0	Gear stage 3 is selected
...			...
1	1	1	Gear stage 8 is selected

SGE
SE selection

SE1 or SE2 is selected when this SGE is activated and the SE function is active.

0 signal: SE1 is selected
1 signal: SE2 is selected

SGE
Test stop selection

This signal initiates testing of the pulse disable path in the drive monitoring channel (see Section 2.5 Safe reaction via pulse disable paths and stops).

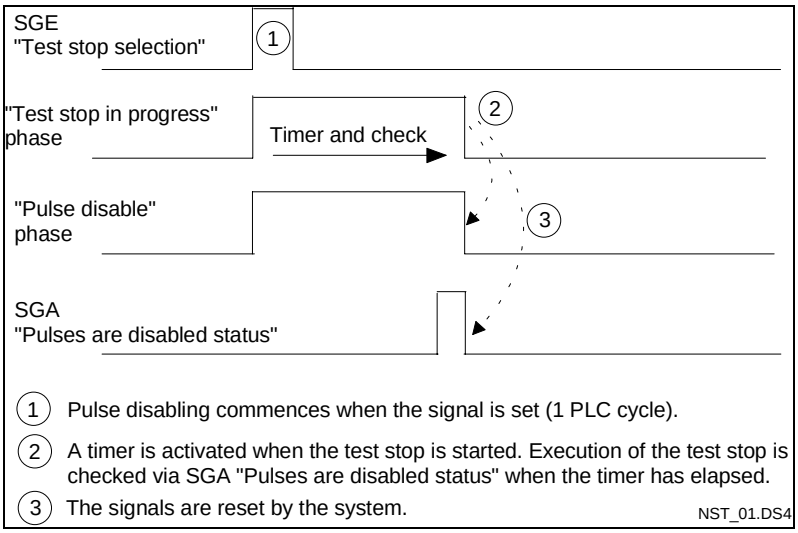

Fig. 4-1 Signal shape of SGE Test stop selection

Description of signals from drive

SGA
SBH/SG active

This SGA is used by the drive monitoring channel to signal the status of the SBH and SG functions in the following way:

0 signal: SBH/SG is not active

1 signal: SBH/SG is active

SGA
Pulses are disabled status

After the disable path test has been initiated via the SGE "Test stop selection" or in the event of a limit-value violation with a STOP A reaction, this SGA is output to indicate that the drive pulses have been internally disabled (see Section 2.5.1 Pulse disable paths).

0 signal: Other status

1 signal: "Pulses are disabled" status

SGA
Axis safely referenced

This SGA indicates whether the relevant axis/spindle is safely referenced (see Section 2.4.2 Adjustment measurement, axis states and previous history).

0 signal: Axis is not safely referenced

1 signal: Axis is safely referenced

SGA
SN1 +, SN1 -
SN2 +, SN2 -
SN3 +, SN3 -
SN4 +, SN4 -

These signals are used to indicate which plus or minus cam of cam pair 1, 2, 3 or 4 is "actuated".

0 signal: Axis/spindle to left of cam
(actual value ≤ cam position)

1 signal: Axis/spindle to right of cam
(actual value > cam position)

SGA
$n < n_x$

(840D from SW4.2
840C from SW6.1)

This SGA indicates whether the absolute actual speed is higher or lower than a velocity limit set via a machine data (see Section 3.4.6 “SGA “$n < n_x$“ and “SG active““).

1 signal: Actual speed is lower than limit speed

0 signal: Actual speed is higher or equal to limit speed

SGA
SG active, bits 1,0

(840D from SW4.2
840C from SW6.1)

These SGAs indicate which safe velocity, and therefore which velocity limit value, is being actively monitored (see Section 3.4.6 “SGA “$n < n_x$“ and “SG active““).

SGA
SBH active

(840D from SW4.2
840C from SW6.1)

This signal indicates the status of safe operational stop (SBH) (see Section 3.3 “Safe operational stop (SBH)“.

1 signal: SBH is active

0 signal: SBH is not active

4.5 System variables

4.5.1 System variables for SINUMERIK 840D

System variable $VA_IS

This variable allows the safe actual value used by SINUMERIK Safety Integrated for each axis/spindle to be read and processed further from the NC part program.

Example:
When an NC part program is started, a check must be made to determine whether the X axis would come close to limit positions as the result of zero offsets during execution of the program. The part program can, for example, be programmed as follows:

```
IF ($VA_IS[X] < 10000) GOTOF POS_OK      ; if actual value too large,
MESG („Axis has nearly reached limit switch!“)  ; then message,
POS_OK:                                  ; otherwise continue here
...
```

The variable can also be used in synchronous actions in order to reduce the override when the axis is nearly at the limit switch.

Difference between $VA_IS and $AA_IM

Apart from variable $VA_IS, it is also possible to use variable $AA_IM to read actual values.

Table 4-14 Difference between $VA_IS and $AA_IM

Variable	Meaning
$VA_IS	Read the actual value used by SINUMERIK Safety Integrated
$AA_IM	Read the setpoint (position control setpoint) used by the closed-loop control

References: /PAD/, Programming Guide

■

Installation and Start-Up

5

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5.1 General information about installation and start-up

Note

If SI functions SH, SBH and SG have been enabled, then they become operational after the control system has powered up (basic display on screen). Cam and limit positions can be evaluated reliably for the SN and SE functions once the axes have been "safely" referenced.

Caution

Protection of operating personnel must be the primary consideration when machine data for the SINUMERIK Safety Integrated option are configured. For this reason, calculate and optimize the parameterizable tolerances, limit values and delay times for start-up purposes on the basis of the performance characteristics of the machine concerned.

5.1.1 Acceptance test and report

Acceptance test

The machine manufacturer must perform an acceptance test of the activated SI functions on the machine. This test must provoke violation of all limit values enter for the enabled SI functions to ensure that they are operating correctly.

Note

Some of the standard NC monitoring functions, such as zero speed monitoring, software limit switches, etc. must be deactivated (by reducing monitoring limits to prevent response of monitor) before the acceptance test is carried out. The operational sequence of the safe functions can be measured and logged via servo trace (840C, 840D as from SW 4.2) or DAC outputs.

References /IAD/, Installation and Start-Up Guide SINUMERIK 840D
/IAC/, Installation and Start-Up Guide SINUMERIK 840C

Acceptance report

Each SI function must be tested by an appropriately authorized person and recorded in the acceptance report. The report must be signed by the person who has performed the tests and filed in the machine logbook.

Note

If the machine data of SI functions are changed, a new acceptance test must be carried out on the altered SI function and recorded in the acceptance report.

Section 5.3.9 “Acceptance report” lists the information which should be specified in an acceptance report.

Testing the SGAs and SGEs

The data cross-check operation can be tested by removing the connectors on the NCK I/O equipment (NCU terminal block or mixed I/O modules).

Checking the test stop

The NCK and drive test stops can be checked by means of interface signal "Pulse enable".
On SINUMERIK 840D: DB31-48, DBX21.7
On SINUMERIK 840C: DB29, D120.7, D124.7, etc.

Negative test:
Remove the terminal block for AS1/ AS2 from the drive and carry out the NCK test stop. Stop reaction STOP A must be activated.

Testing the SBH SI function

Testing the SI function SBH by provoking violation of monitoring limits

- Execute numerically controlled traversing motion (JOG).
- Provide positive feedback in position closed-loop control through polarity reversal of position actual value via machine data.
- Start function generator with speed controller/setpoint specification
  References /IAD/, Installation and Start-Up Guide SINUMERIK 840D
  /IAC/, Installation and Start-Up Guide SINUMERIK 840C

The distance travelled by the axis until it is stopped by the configured stop reaction can be found in the actual value display. The time required to stop the axis can be calculated by recording the actual speed value via DACs.

Testing the SG SI function

The following cases need to be tested.

- Good case
  When the actual speed has exceeded the active speed limit value, the axis is brought to a safe operational stop (SBH) by the configured stop reaction within the switchover time.
- Bad case
  When the actual speed has exceeded the active speed limit, the axis is **not** brought to an SBH by the configured stop reaction within the switchover time, resulting in a transition from the STOP B state to the STOP A state.
- Switchover between the safe speed limit values (if set). Selection of a limit value that is lower than the current axis speed.
- Switchover between the SG and SBH functions.

Testing the SN SI function

Testing the cams by traversing them at various axis speeds.

- Position the cam at the centre of the axis. Traverse the cam at various axis speeds and in rapid traverse mode. Calculate the time and distance travelled by the axis until the desired cam signal (NCK-SGA, PLC-SGA) is output.

Testing the SE SI function

Testing the limit positions by traversing them at various axis speeds.

Place the limit position at the centre of the axis. Traverse the position at various axis speeds and in rapid traverse mode. Calculate the remaining distance travelled by the axis until it is brought to a standstill by the configured stop reaction. Position the safe limit stop in front of the axis fixed stop at a distance corresponding to the calculated remaining distance plus a safety clearance defined by the machine manufacturer.

Note

Owing to the large number of possible encoder combinations (see Table "Combination of encoder type"), the SI encoder data must be entered separately for the NC and for the drive (also applies with 1-encoder system). For details, please see marked data in Table 4-8 Machine data for SIMODRIVE 611D.

5.1.2 Data copy function

In order to avoid the need to copy SI machine data twice, i.e. into the NCK and drive machine data displays, softkeys have been provided that transfer NC machine data relating to SI functions from the NCK component into the appropriate drive machine data. The softkey is labelled COPY SI DATA and can be found in the "Drive configuration" display on the 840D and COPY -> DRIVE in the "SI configuration" display on the 840C.

Note

The SI machine data that define the encoder characteristics must be entered separately for the NCK and drive by the start-up engineer. The copy function cannot be used to transfer the drive machine data that are marked in Table 4-8 Machine data for SIMODRIVE 611D.

5.1.3 Altering data

The user must enter the correct password before he can transfer the machine data for SI functions to the system. After the data for SI functions have been altered, a new acceptance test must be performed on the affected SI function(s) and then recorded and confirmed in the acceptance report.

5.2 Start-up of SI functions on SINUMERIK 840D

5.2.1 Operator inputs during start-up

Configuration of safe functions

To start up SI functions, select the display "Start-up/Machine configuration" in the basic display of the control system by means of softkey START-UP. The screenshot below is an example of the display that then appears:

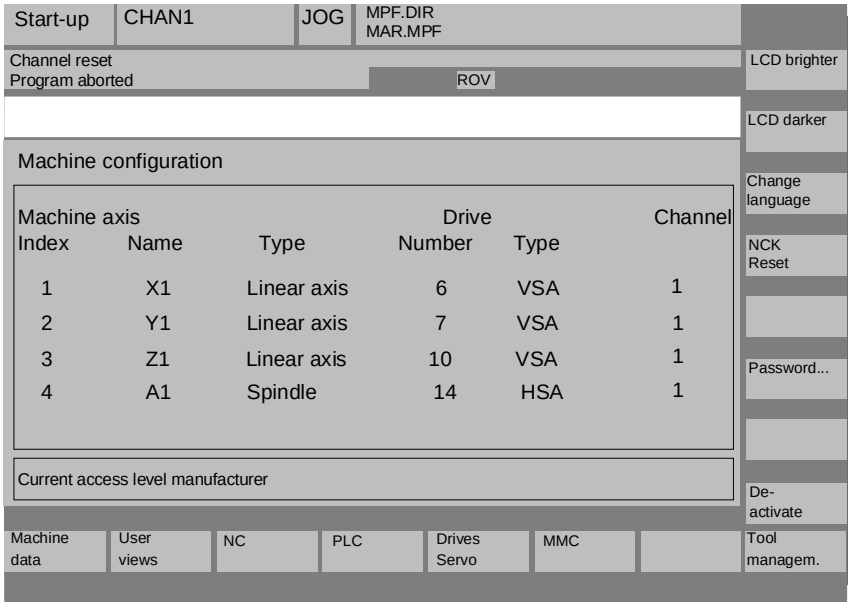

Fig. 5-1 Example of display for "Start-up/Machine configuration" on 840D

An NCK RESET can be executed in this display.

The softkey "MACHINE DATA" must be selected to allow SI data to be entered.

To copy and confirm SI data, select the softkey labelled DRIVE CONFIG. to call the appropriate display. The following screenshot is an example of this display:

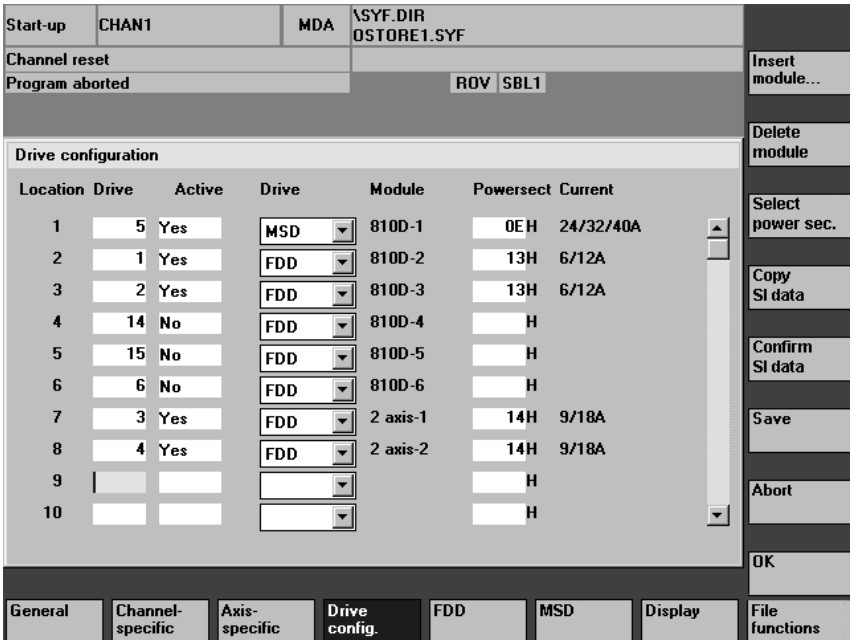

Fig. 5-2 Example of display for "Start-up/Drive configuration" on 840D

Softkey COPY SI DATA

When this softkey is selected, all NC machine data that are relevant for SI functions are transferred to the corresponding drive machine (exception: Encoder data, see Table 4-8 Machine data for SIMODRIVE 611D). The bootfiles are automatically saved after the data have been copied.

Softkey CONFIRM SI DATA

Perform an NCK RESET and then store the current checksum by selecting the softkey labelled CONFIRM SI DATA in the "Drive configuration" display and acknowledging the following dialog box with "OK". The SI data will be monitored for changes from now on. After you have confirmed the SI data, the bootfiles are automatically saved.

5.2.2 Initial start-up

It is advisable to start up the machine to the extent that axes can be moved. The safety monitors can then be tested immediately after entry of the SI data. This type of test is absolutely essential in order to find any data input errors. It is referred to as the "acceptance test".

The following steps must be taken in the order given to start up SI functions:

Step 1
Enable option

Enable option

- "Start-up" basic display: Set the password (at least machine manufacturer password) by selecting softkeys PASSWORD\SET PASSWORD
- "General machine data" display:
  Enter the number of axes for which safety monitors need to be activated in the option machine data

Step 2
Monitoring cycle

Enter the monitoring cycle

- "General machine data" display:
  Enter the factor for the monitoring cycle in data $MN_SAFETY_SYSCLOCK_TIME_RATIO (see Section 2.3.4 Safety monitoring cycle and cross-check cycle).
- The actual monitoring time is displayed immediately in data $MN_INFO_SAFETY_CYCLE_TIME.

Note

Before you perform an NCK RESET, you must copy the current monitoring cycle to machine data $MD_SAFETY_CYCLE_TIME of the drive by selecting softkey COPY SI DATA in the "Drive configuration" display.

Step 3
Set axis monitor

Set the monitor for all axes that need to be monitored.

Enter the following in the order given in the "Axis-specific machine data" display

- Function enabling bits
- Axis characteristics (rotary or linear axis)
- Measuring-circuit assignment, i.e. which encoder will supply the "safety" actual value, what type of encoder is it and what type of mechanical flange-mounting has been used.
- You must perform an NCK RESET now for rotary axes.
- Monitoring limit and tolerances
- Switchover and monitoring times
- Stop reactions after a monitor has responded

- Assignment of safety-relevant inputs and outputs, i.e. which hardware terminals are supplying the drive signals for the NC monitoring channel and where are the checkback and cam signals being sent (the PLC accepts this link for the drive monitoring channel, i.e. there are no corresponding drive machine data).

Recommendation:
The limits monitored by software switches should be set to lower values during start-up.

Step 4
Actual value and measuring circuit assignment

Assignment of measuring circuits and actual values to axes/spindles

- Select the softkey labelled COPY SI DATA in the "Drive configuration" display
- Enter the measuring circuit assignment, i.e. which encoder will supply the "safety" actual value", what type of encoder is it and what type of mechanical flange-mounting has been used, for each drive in the "FDD machine data" display. This need not be done for encoders of type ERN 1387; only the data for the absolute encoder need be set for encoders of type EQN 1325. The data copied with the softkey can be checked visually at the same time.
- If you alter anything in the "FDD or MSD" display, select the softkey SAVE BOOTFILES to transfer the setting to the non-volatile memory.
- Perform an NCK RESET.

Step 5
Confirm/save monitoring data

Confirm and save the monitoring data

- Select the CONFIRM SI DATA in the "Drive configuration" display. A dialog box describing the effect of the softkey then appears. Select OK to acknowledge the box. The current checksum of the safe-relevant data is then stored in both monitoring channels and monitored for changes from that point onwards.
  The drive data are also saved to a non-volatile memory automatically (as with SAVE BOOTFILES).
  A dialog box is now displayed on the screen requesting you to perform an acceptance test. You must acknowledge the box.
- The safety monitoring functions are now ready to operate and can be activated as described in Section 2.3.4 Safety monitoring cycle and cross-check cycle.

Step 6
User agreement

Enter user agreement (see 2.3.5 User agreement)

- The safe limit position monitoring and safe cams are now activated (provided that they have been enabled, see Section 2.3.6 "Enabling the individual safe function"). This step can be omitted if you do not wish to use either of these functions.
- Keyswitch position 3 must be set for “User agreement”.

Step 7
Machine start-up

Carry out general machine tests.

- Optimize axes/spindle.
- Adjust SI functions (monitoring limits, timers).

Step 8
Acceptance test

Carry out acceptance test and enter report in logbook.

- A function test must be performed on all enabled safety monitors for each axis/spindle. For suggestions on how to test activated SI functions, please refer to Section 5.1.1 Acceptance test and report.

Step 9
Activate standard monitors again

All standard monitoring functions (e.g. zero-speed monitor, software limit switches) that were deactivated or altered for the purpose of the acceptance test must now be re-activated/returned to original settings.

Step 10
Save machine data

Save machine data.

- Use softkeys SERVICES\DATA OUTPUT to save all machine data to an external computer or the hard disk in the MMC. These data can be used to carry out a series start-up.

To be able to carry out series start-ups, the machine data of the NCK and drive must be available as separate data sets (the softkey COPY SI DATA may not be used for the purpose of series start-ups).

Caution

On completion of the acceptance test, all illegal (old) MD files must be removed from the hard disk (to avoid confusion between old and new data). The data which correspond to the acceptance test data must be backed up.

Step 11
Delete password

Delete password.

To delete the password, go to display "Start-up/Machine configuration" and select the softkey labelled PASSWORD...\DELETE PASSWORD.

5.2.3 Series start-up

The settings for the safety monitoring functions are automatically transferred with other data in the course of a normal series start-up process. The following steps need to be taken in addition to the normal start-up procedure:

1. Enter user agreement
2. Perform acceptance test
   (individual monitors must be tested at random)

Note

When series machines are started up, two separate data sets for the drive and NCK must be imported to the control system. The copy function may be used after machine data have been altered.

Sequence of operations for series start-up

The following sequence of operations is advisable for series start-ups:

- Load the data set for the series machine (separate sets for NCK and drive) into the control system.
- Calibrate absolute encoder
- Carry out a POWER ON.
  This ensures that any errors, i.e. deviations in data content, that may exist between the NCK and drive will be detected by the checksum check and data cross-check. The data must be checked if an error is detected. If no error is discovered, then the data are unaltered and identical to the acceptance test data. The copy function may be used if data are altered subsequently.
- Perform random function tests
  The tests are required for acceptance of the new machine.
- Set special features
  When special features are set, each altered safety data must be checked. The copy functions may be used.

5.2.4 Software upgrade

Important

Please read the instructions in the relevant Upgrade Guide carefully before upgrading the software.

5.2. 5 Trouble-shooting procedure

- The alarms that are activated in response to an error are output in the "DIAGNOSIS - ALARMS" display.
- When the alarm "Defect in a monitoring channel" is output, the code for the error cause is displayed directly in alarm "Diagnosis for STOP F" for the NCK monitoring channel.
- The cause for the alarm in the drive monitoring channel can be found in MD 1395: MD_SAFE_STOP_F_DIAGNOSIS in the START-UP - MACHINE DATA - FDD OR MSD" display.

Note

Different error codes may be displayed for the NCK and drive monitoring channels.

The following is displayed in the "DIAGNOSIS - SERVICE DISPLAYS - SERVICE AXIS" display:

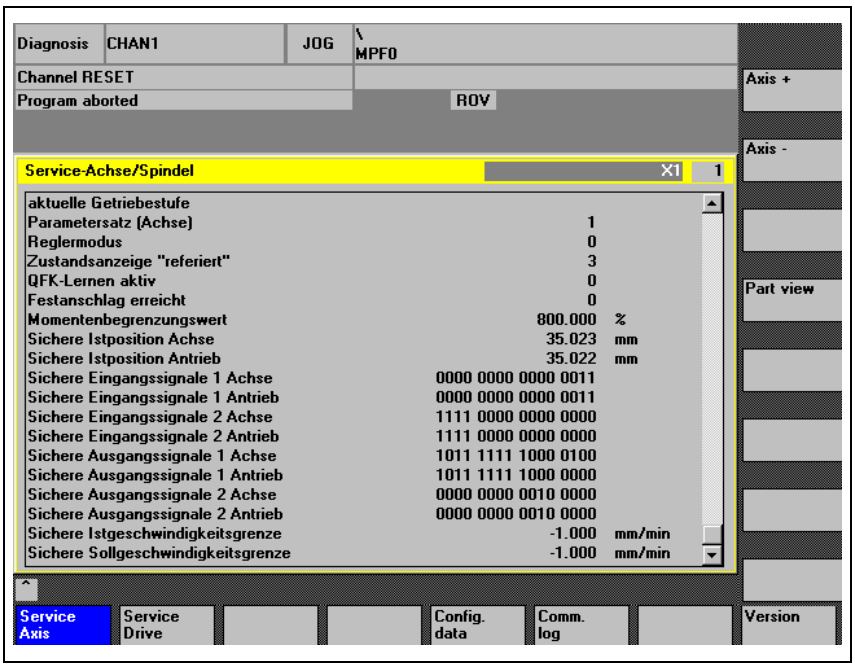

Fig. 5-3 Diagnostics display on SINUMERIK 840D

Note

- Safe setpoint speed limit (available soon)
- The safe input and output signals are shown individually in the following diagram.

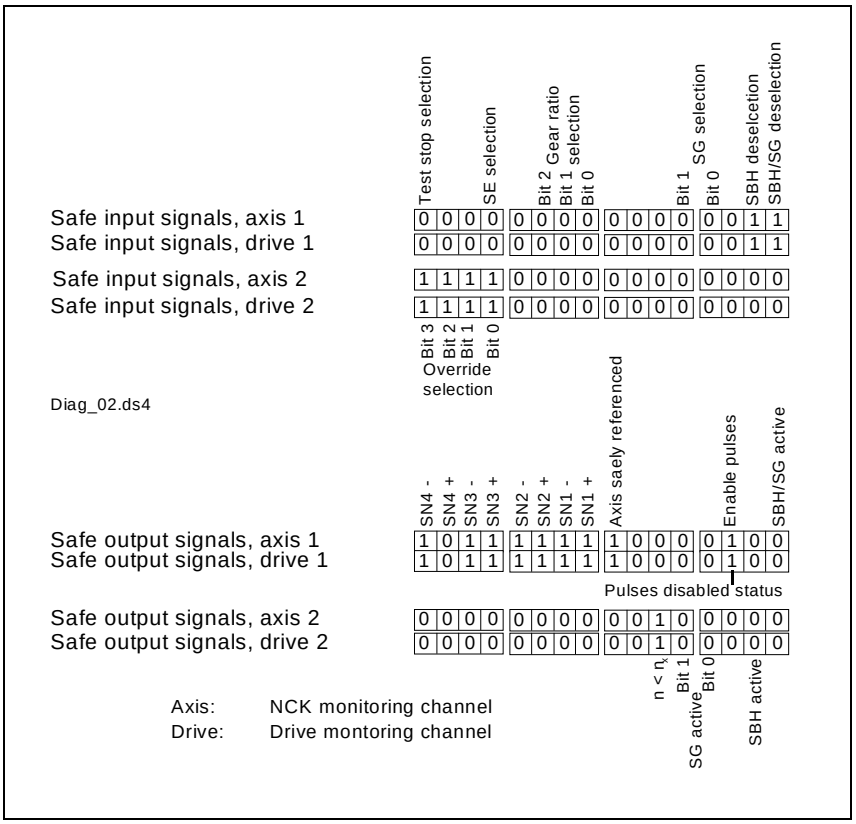

Fig. 5-4 Status display of safe input/output signals

5.3 Starting up SI functions on SINUMERIK 840C

5.3.1 Operator inputs during start-up

Configuration of safe functions

To start up and diagnose SI functions, call the DIAGNOSIS display, press the ETC key and then the softkey labelled SAFE FUNCTIONS. The following display then appears:

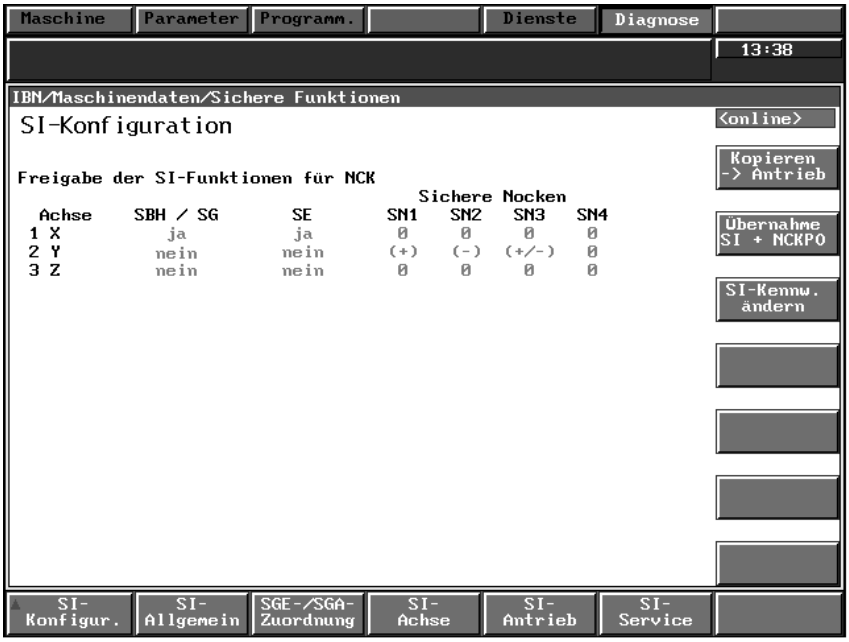

Fig. 5-5 Configuration for SINUMERIK Safety Integrated

Softkey COPY –> DRIVE

When you select the softkey COPY --> DRIVE, all NC machine data that are related to SI functions are transferred to the corresponding drive machine data (exception: Encoder data, see Table 4-8 Machine data for SIMODRIVE 611D).

Softkey ACCEPT SI + NCKPO

When you select softkey ACCEPT SI + NCKPO, the following happens:

- The bootfiles for all drives are saved
- An NCK POWER ON is executed
- Checksums of the SI machine data of the NCK and drive are calculated
- The calculated checksum is copied to the comparison machine data (NCK and drive)
- An NCK-POWER ON is executed

Softkey CHANGE SI PASSWORD

After the CHANGE SI PASSWORD softkey has been selected, it is possible to change the password that protects the SI function data. The previous password must be known before it can be changed.

5.3.2 Initial start-up

It is recommended that the machine be started up to the extent that axes can be moved. The safety monitors can then be tested immediately after entry of the SI data. This type of test is absolutely essential in order to find any data input errors. It is referred to as the "acceptance test".

The following steps must be taken in the order given to start up SI functions:

Step 1 Enable option

Enable option

- Go to the option display
- Set the option password
- Set the number of axes
- Define a spindle with SI functions as a C axis.
- Increase the alarm log size for start-up.

Step 2 Define monitoring cycle

Define monitoring cycle

- Enter the monitoring cycle time in MD 40010: Monitoring cycle in the "SI General" display
  (see Section 2.3.4 Safety monitoring cycle and cross-check cycle).

Step 3 Configure SI functions

Define SI functions for individual axes

- Select the "SI configuration" display and set the desired safe functions for each axis.

Step 4 SGE/SGA assignment

Assignment of safety-relevant inputs and outputs.

- The safety-relevant inputs and outputs are assigned in the "SGE/SGA assignment" display. This assignment defines which hardware terminals will supply the drive signals for the NC monitoring channel and where the checkbacks and cam signals will be sent. These links must be accepted by the user program in the PLC for the drive monitoring channel, i.e. there are no corresponding drive machine data.

Step 5
Actual value and measuring circuit assignment

Assignment of measuring circuits and actual values to axes

- The actual value assignment for the NC is entered in the "SI drive" display.
- The axis characteristics (linear or rotary) are defined in the "SI drive" display.
- The gear factors and encoder data must be entered separately for the NCK and drive.

Step 6
Set axis monitoring functions

Set the monitoring functions for all selected axes with SI functions.

Enter the following parameters in the order given in the "SI axis" display:

- Switchover and monitoring times
- Monitoring thresholds and tolerances (set "nonsensitive" values to start with).
- Stop reactions after a monitor has responded.

Recommendation:
The limits monitored by software switches should be set to lower values during start-up.

Step 7
Save monitoring data

Transfer the set monitoring limits to system

- Select the softkey COPY -> DRIVE in the "SI Configuration" display

Step 8
Check/save monitoring data

Check the copied data (step 7) in the "SI drive" display.

Select the softkey ACCEPT SI + NCKPO in the "SI configuration" display to activate the following sequence of operations:

- The bootfiles for all drives are saved.
- NCK-POWER ON
- The checksum of the SI machine data of the NCK and drive is calculated.
- The calculated checksum is copied to the comparison machine data (NCK and drive).
- NCK-POWER ON

After the control system has powered up, a dialog box with the message PERFORM ACCEPTANCE TEST appears on the user interface. This box must be acknowledged with the softkey OK.

Delete the data for Safety Integrated by selecting softkey FORMAT USER MEMORY in the general reset state. The following SI data of the NCK and drive are then erased in the SRAM:

- SBH positions
- "User agreement given" flag

Note

If the deviation between the actual values is so great that the actual value cross check monitor has responded (MD 4256*: Actual value comparison (cross-check) tolerance), the contents of the actual value memory can be reset with the function "Format user memory".

Step 9
User agreement

Give user agreement (see Section 2.3.5 User agreement)

- The safe limit position monitors and safe cams are now activated (provided they have been enabled, see Section 2.3.6 Enabling individual safe functions). This step can be omitted if neither of these functions is used.
- The "User agreement" display can be selected started from the JOG mode.

Step 10
Machine start-up

Perform general machine tests.

- Optimize axes/spindle.
- Adjust SI functions (monitoring limits, timers).

Step 11
Acceptance test

Perform acceptance test and enter in logbook.

- A function test must be performed on all enabled safety monitors for each axis/spindle. For suggestions on how to test activated SI functions, please refer to Section 5.1.1 Acceptance test and report.

Step 12
Activate standard monitors again

All standard monitoring functions (e.g. zero-speed monitor, software limit switches) that were deactivated or altered for the purpose of the acceptance test must now be re-activated/returned to original settings.

Step 13
Data save

Save machine data.

- Once you have completed the acceptance test, all machine data must be saved as ASCII files on the hard disk. the servo-trace recordings made during the acceptance test can also be saved on the hard disk. You should also save all machine data to an external storage medium via the "Services, "Data output" area. These data can be used for series start-ups.
- To be able to carry out series start-ups, the machine data of the NCK and drive must be available as separate data sets (the softkey COPY - DRIVE may not be used for the purpose of series start-ups).

Caution

On completion of the acceptance text, all illegal (old) MD files must be removed from the hard disk (to avoid confusion between old and new data). The data which correspond to the acceptance test data must be backed up..

Step 14
Delete password

Delete password.

The password is automatically deleted after the MMC has powered up.

5.3.3 Software update

Important

Please read the instructions in the relevant Update Guide carefully before updating the software.

5.3.4 Trouble-shooting procedure

- Check the overview of alarms or the alarm log to find out which alarm has been activated.
- When the alarm "Defect in a monitoring channel" is output, refer to machine data MD 301: Diagnosis for STOP F in the "SI service" display for the cause of the alarm in the NCK monitoring channel. If the alarm has occurred in the drive monitoring channel, refer to MD 1395: MD_SAFE_STOP_F_DIAGNOSIS in the "SI drive" display for the cause of the alarm. Note that the error fine identifier may not always be the same in the NCK and drive monitoring channels. Generally speaking, the NC and drive signal the same error (two-channel structure).
- An overview of the service data is given in Section 4.2.3 Overview of SI service data.

5.3.5 Interrogation of a password for safe operation

As with previous software versions, changes to machine data are protected by the start-up password. A special password is used additionally to protect copying of SI machine data to TEA3 and the transfer of boot files.

5.3.6 Options

Options are entered in the standard option display on the SINUMERIK 840C.

"Number of axes with SI functions" option
A check to determine whether the number of axes with enabled SI functions exceeds the permissible maximum, i.e. more than the number specified in the option display, is activated through selection of the ACTIVATE OPTIONS softkey. If the actual number of axes exceeds the specified number, then the number is reduced accordingly "from the back" (i.e. from axis 30 to axis 1). This option is therefore handled in the same way as the "Total number of axes" and "Total number of main spindles" options.

The softkey ACTIVATE OPTIONS does not activate SI functions for any axes. This is done in the appropriate enabling machine data.
Every time a safety function relating to an axis or spindle is activated, a check is made to ensure that the "Number of axes with SI functions" will not be exceeded by activation of another SI function or has not already been exceeded. The appropriate option data is read for this purpose. If it is determined that the maximum number of axes with SI functions has been exceeded, then an error text "Max. ... axes with SI functions" is output. It is permissible to enter more safety axes in the option than have actually been assigned SI functions.

5.3.7 NC machine data

Axis - spindle

There are two types of machine data on the SINUMERIK 840C, i.e. axis-related and spindle-related. No distinction is made between them with respect to safe operation. In this case, all machine data are axis-related. If, for example, a safe speed limit must be applied to a spindle, then a C axis must be assigned to the spindle concerned.

5.3.8 Series start-up

As previously, a complete memory dump of the MMC hard disk can be made for the purpose of performing a series start-up. The checksum monitors are active when this method is used. In addition to the normal start-up procedure, the following steps must be taken:

1. Input user agreement
2. Carry out acceptance test
   (individual monitors must be tested at random)

Note

When series machines are started up, 2 separate data sets for the drive and NCK must be imported to the control system. The copy function may be used after machine data have been altered.

Sequence of operations for series start-up

The following sequence of operations is advisable for series start-ups:

- Load the data set for the series machine (separate sets for NCK and drive) into the control system.
- Perform POWER ON.
  This ensures that any errors, i.e. deviations in data content, that may exist between the NCK and drive will be detected by the checksum check and data cross-check. The data must be checked if an error is detected. If no error is discovered, then the data are unaltered and identical to the acceptance test data. The copy function may be used if data are altered subsequently.
- Perform random function tests
  The tests are required for acceptance of the new machine.
- Set special features
  When special features are set, each altered safety data must be checked. The copy functions may be used.

5.3.9 Acceptance report

Acceptance report

The machine manufacturer must carry out an acceptance test of the activated SINUMERIK Safety Integrated (SI functions) safe functions on the machine.

The acceptance test must be designed to trigger violation of all specified limit values of the enabled SI functions so that it is possible to check and verify that they are operating correctly.

Authorized person, acceptance report

All SI functions must be acceptance-tested by an authorized person and the test results recorded in a test report. The report must be signed by the person who carried out the acceptance tests. The acceptance test report must be attached to the logbook of the relevant machine.

Note

- Please read the information in
  Section 5.2 “Start up of SINUMERIK 840D“ and
  Section 5.3 “Start up of SINUMERIK 840C“.
- The acceptance report presented below is both an example and recommendation. The specified values apply to the plant chosen for this particular example.
- Template for acceptance report:
  An electronic template for acceptance reports is available
  - in the Toolbox for SINUMERIK 840D
  - on the DOCONCD for SINUMERIK 840D and 840C
  - on the Service CD for SINUMERIK 840D and 840C

Description of plant

The plant description must include the following information:

- Details about machine
- Details about control system

Table 5-1 Machine details

Type	Description
Designation	Machining center
Type	Three linear
Serial no.	97-05-23
Electrical axes	Three linear axes and one rotary axis
Other axes	-
Spindles	One spindle

Table 5-2 Control system details

Type	**Description**			
Type and SW version	840D with SW35/13_00			
NC type	NCU 572			
PLC type	AS 314			
Operator panel	MMC 102			
SW versions	NCK version	Drive version	PLC version	BP version
	32.06.H5	03.20.03	35.03.04	3.4
Clock cycles	Basic system cycle	IPO cycle	Monitoring cycle	
(enter values from relevant MD)	4 ms	12 ms	12 ms	

Configuration plan Details of how the axis/spindle is configured are specified in the configuration plan.

Table 5-3 Configuration details

Chan.	**Axis/ spindle**	**Motor measuring system**	**Direct measuring system**	**SI functions**
1	X1	ERN	LS481C / 0.004 mm	SBH/SG, SE, SN
1	Y1	ERN	LS481C / 0.004 mm	SBH/SG, SE, SN
1	Z1	ERN	LS481C / 0.004 mm	SBH/SG, SE, SN
1	SP1	ERN		SBH/SG
1	B1	ERN		SBH/SG

SI functions per axis/spindle

This table contains full details about safe functions enabled for individual axes/spindles.

Table 5-4 Details of safe functions

Axis/ spindle	SI function	Limit value	Active when
X1	SE1+	0.2 mm	User agreement is set
X1	SE1-	-75.2 mm	User agreement is set
X1	SN1+	-30.0 mm	Always
X1	SN1-	-45.0 mm	Always
X1	SG1	2 200 mm/min	Door to operating area open and enabling button
X1	SBH	1.0 mm	Door to operating area open
Y1	SE1+	0.2 mm	User agreement is set
Y1	SE1-	-550.2 mm	User agreement is set
Y1	SN1+	-30.0 mm	Always
Y1	SN1-	-520.0 mm	Always
Y1	SG1	2 200 mm	Door to operating area open and enabling button
Y1	SBH	1.0 mm	Door to operating area open
Z1	SE1+	0.2 mm	User agreement is set
Z1	SE1-	-300.2 mm	User agreement is set
Z1	SN1+	-30.0 mm	Always
Z1	SN1-	-270.0 mm	Always
Z1	SG1	2 200 mm	Door to operating area open and enabling button
Z1	SBH	1.0 mm	Door to operating area open
SP1	SG1	2 200 rev/min	Door to operating area open and enabling button
SP1	SBH	1.0 deg.	Door to operating area open
B1	SG1	2 200 rev/min	Door to operating area open and enabling button
B1	SBH	1.0 deg.	Door to operating area open

Description of safety strategy This table contains full details about the safety strategy employed.

Table 5-5 Details of safety strategy

Functions SE and SN are always active when user agreement is set.
The safe cams (SN) are used to define the direction of travel for axis referencing. They ensure that axes
can only be referenced in the direction that is further than 30 mm away from the limit position
(depending on stored axis positions).
The “Safe operational stop” function (SBH) is activated when the protective door is opened. This function is replaced
by the “Safe speed” function (SG1) when the enabling button is actuated.

Execution of test

Initial start-up [x]

Series start-up [ ]

(please tick)

Table 5-6 Test of pulse disable paths

Test initiated by	**Remarks**
e.g. external circuit	
The “Open protective door” button is pressed to test all pulse disable paths	To check that the pulse disable paths were properly tested, MD 36957: SAFE_PULS_DIS_CHECK_TIME was set to “1 s” and reset to “0.1s” again after the test.

Table 5-7 Cross-check test

Test initiated by	**Alarm number and error code**
E.g. SGEs supplied by different inputs	
Drive SGE for SG disconnected	27001, 300911, 300901, 27023 and 27024

Table 5-8 Test of switchover between SI functions

Test initiated by	**Remarks**
E.g. open protective door	
Open protective door	The “SBH” function is activated immediately, travel commands are disabled in one channel by the PLC.
Actuate enabling button at max. setup speed	The “SBH” function is activated after elapse of the delay set in MD 36951: SAFE_VELO_SWITCH_DELAY (= 0.2 s), all axes are stopped without error within this delay period by the PLC.

Table 5-9 Test of safe speeds (SG)

SG no.	**Axis/ spindle**	**Test initiated by**	**Excess speed**	**Reaction time**	**Over-travel**	**Displayed alarm numbers**	**System**	
							yes	**no**
		E.g. increase MD “JOG velocity“						
SG1	X1	MD 32020: JOG_VELO = 3 000 mm/min	3 000 mm/min	25 ms	1.2 mm	27011, 27022, 300908 and 300914	B1	
SG1	Y1	MD 32020: JOG_VELO = 3 000 mm/min	3 000 mm/min	26 ms	1.3 mm	As above, but for master and following axes	B2	
SG1	Z1	MD 32020: JOG_VELO = 3 000 mm/min	3 000 mm/min	30 ms	1.5 mm	As above	B5	
SG1	SP1	MD 32020: JOG_VELO = 3 000 rev/min	3 000 rev/min	27 ms	1.3 degrees	As above	B3	
SG1	B1	MD 32020: JOG_VELO = 3 000 rev/min	3 000 rev/min	30 ms	1.5 degrees	As above	B4	

Table 5-10 Test of SBH

Axis/ spindle	Test initiated by	Excess speed	Reaction time	Over-travel	Displayed alarm numbers	System	
						yes	no
X1	Function generator	10 000 mm/min	20 ms	3.8 mm	27010, 27023, 27024, 300907, 300901 and 300900	B6	
Y1	Function generator	10 000 mm/min	34 ms	6.3 mm	As above	B7	
Z1	Function generator	10 000 mm/min	24 ms	2.2 mm	As above	B8	
SP1	Function generator	10 000 rev/min	20 ms	5.5 degrees	As above	B9	
B1	Function generator	10 000 rev/min	20 ms	2.9 degrees	As above	B10	

Table 5-11 Test of SE

SE no.	Axis/spindle	Speed	Reaction time	Overtravel	System	
					yes	no
SE1+	X1	600 mm/min [1)]	-	0.098 mm		X
SE1-	X1	600 mm/min [1)]	-	0.059 mm		X
SE1+	Y1	600 mm/min [1)]	-	0.097 mm		X
SE1-	Y1	[2)]	-			
SE1+	Z1	600 mm/min [1)]	-	0.149 mm		X
SE1-	Z1	600 mm/min [1)]	-	0.172 mm		X

Note:

1. Due to the risk of mechanical damage to the machine, the safe limit stops were approached at 30% of setup velocity on request.
2. It was not possible to test SE1- on the Y1 axis since a device for dressing the grinding wheel was mounted in this area.

Table 5-12 Test of SN

SN no.	Axis/spindle	Position	Reaction
SN1+	X1	+30.0 mm	Determines direction of travel for referencing
SN1-	X1	-45.0 mm	Determines direction of travel for referencing
SN1+	Y1	+30.0 mm	Determines direction of travel for referencing
SN1-	Y1	-520.0 mm	Determines direction of travel for referencing
SN1+	Z1	+30.0 mm	Determines direction of travel for referencing
SN1-	Z1	-90.0 mm	Determines direction of travel for referencing

SI machine data

Table 5-13 Machine data for SINUMERIK Safety Integrated

	Preset limit values checked		System	
	yes	no	yes	no
Drive	X		X	
NC	X		X	

Checksum

Table 5-14 Checksums for SINUMERIK Safety Integrated

Axis/spindle		Checksum (8 HEX)	
Name	Drive number	NC	Drive
X1	1	E8F0FFD	115135
Y1	2	CCF7E113	115E16
Z1	3	59E5E6FE	1161F4
SP1	4	6E566E30	115E16
B1	5	FB4469DD	1161F4

Backup data

Table 5-15 Backup data for SINUMERIK Safety Integrated

	Storage medium			
	Type	**Label**	**Date**	**Stored where (location)?**
Machine data	Diskette	NCK.IBN	July 3, 1997	Machine and manufacturer
PLC program	Diskette	PLC.IBN	July 3, 1997	Machine and manufacturer
Circuit diagrams	_ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _	July 3, 1997	Machine and manufacturer

Counter-signature of start-up engineer Provides confirmation that the above tests and checks have been carried out according to specifications.

Table 5-16 Counter-signature of start-up engineer

Date	**Name**	**Company/Dept.**	**Signature**
July 3, 1997	Start-up engineer	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Counter-signature of machine manufacturer Provides confirmation that the limit values specified and recorded above are correct.

Table 5-17 Counter-signature of machine manufacturer

Date	**Name**	**Company/Dept.**	**Signature**
July 3, 1997	Manufacturer	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

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Notes

6 Alarms

6.1 Alarms for SINUMERIK 840D 6-232

6.2 Alarms for SINUMERIK 840C 6-241

6.3 SIMODRIVE 611D alarms 6-252

6.1 Alarms for SINUMERIK 840D

Alarms for SINUMERIK 840D/611D

Detailed explanations of all alarms that are not described here can be found in the following References for the SINUMERIK 840D system with SIMODRIVE 611D:

References: /DAD/, Diagnostics Guide

Note

In systems with MMC 101/102, the alarms are also explained in the online help.

Alarms for SINUMERIK Safety Integrated

The alarms that can occur in connection with the SINUMERIK Safety Integrated option are listed below:

27000 Axis %1 is not safely referenced

Explanation: The axis must be referenced and the position obtained after referencing confirmed by the user (user agreement). The axis might already be referenced, but in this case, there is still no confirmation that the referencing process has supplied the right result. This can happen, for example, if the axis was moved after the machine was switched off. The standstill position stored before power OFF is no longer valid.

Reaction: Alarm is displayed. Display at the NC/PLC interface. The SGA "Axis safely referenced" is not set. The safe limit position monitoring function is deactivated. The safe cams are calculated and output, but their significance is limited because referencing has not been confirmed.

Remedy: Traverse axes to a known position, change to the "Referencing" operating mode and select softkey "Agreement". Check the positions displayed in the "Agreement" display on the machine. If they are what you expect them to be at the known position, confirm "safely referenced axis" by entering "User agreement".

To continue program: The alarm disappears automatically when user agreement is given.

Warning

If the axis is not yet safely referenced and user agreement have not been given, then the following applies:
- The safe cams are active, but no yet reliable
- The safe limit positions are not yet active

27001 Axis %1: Defect in a monitoring channel, error code %2

Explanation: The cross-check between the two monitoring channels has detected a difference in the input data or results of the monitoring functions. One of the monitors is no longer operating reliable, i.e. operation of the drive is no longer being monitored reliably.

Reaction: Alarm is displayed. A STOP F process is initiated, i.e. a message is generated and an NC starting lockout activated (if only the data cross-check is active). Alternatively, if the safety monitoring functions are active, an immediate transition to STOP B is made. Display at the NC/PLC interface.

Remedy: Find the difference between the monitoring channels. The cause of the error is indicated by error code %2. The safety-relevant machine data might not be identical or the SGEs (safety-relevant input signals) might not be at the same level (check by measuring). If the error is not caused by one of the above, there may be a CPU error, e.g. a "toggled memory cell". This type of error may be temporary (eliminate by a POWER ON) or permanent (appears again after POWER ON, replace hardware).

To continue program: Eliminate the error and press the RESET key. The program is then aborted. If a safety monitor was active, STOP B is automatically activated. The control system must then be switched off and on again (POWER ON).

Table 6-1 Error code for STOP F on 840D/611D

No.	Name	Explanation	Cause, remedy
0	No error	There is no error in this channel. There may be one in the other channel.	Look for the cause in the other channel and interpret error code
1	Result list 1	Differences in the evaluation of SBH/SG/SE functions in the NCK and drive monitoring channels	E.g. SGEs have not activated functions identically in the two channels, analyse fine error coding in 611D-MD 1391 and 1392
2	Result list 2	Differences in the evaluation of the SN function in the NCK and drive monitoring channels	Check cam tolerance Analyse fine error coding in 611D-MD 1393 and 1394
3	Position actual value	Difference between position actual values in drive and NCK monitoring channels exceeds setting in MD 36942: $MA_SAFE_POS_TOL (actual value cross-check) or MD 1342: $MD_SAFE_POS_TOL	Incorrect evaluation of encoder (check MDs). Difference in stored standstill positions
4	No cross-check	-	-
5	Function enabling signals	MD 36901 and MD 1301 are not identical	Set MDs to identical values
6	Limit value for SG1	MD 36931[0] and MD 1331[0] are not identical	Set MDs to identical values
7	Limit value for SG2	MD 36931[1] and MD 1331[1] are not identical	Set MDs to identical values
8	Limit value for SG3	MD 36931[2] and MD 1331[2] are not identical	Set MDs to identical values
9	Limit value for SG4	MD 36931[3] and MD 1331[3] are not identical	Set MDs to identical values
10	Standstill tolerance	MD 36930 and MD 1330 are not identical	Set MDs to identical values
11	Upper limit value SE1	MD 36934[0] and MD 1334[0] are not identical	Set MDs to identical values
12	Lower limit value SE1	MD 36935[0] and MD 1335[0] are not identical	Set MDs to identical values
13	Upper limit value SE2	MD 36934[1] and MD 1334[1] are not identical	Set MDs to identical values
14	Lower limit value SE2	MD 36935[1] and MD 1335[1] are not identical	Set MDs to identical values
15	Safe cam 1+ (+ tolerance)	MD 36936[0] + MD 36940 and MD 1336[0] + MD 1340 are not identical	Set MDs to identical values
16	Safe cam 1+	MD 36936[0] and MD 1336[0] are not identical	Set MDs to identical values
17	Safe cam 1- (+ tolerance)	MD 36937[0] + MD 36940 and MD 1337[0] + MD 1340 are not identical	Set MDs to identical values
18	Safe cam 1-	MD 36937[0] and MD 1337[0] are not identical	Set MDs to identical values
19	Safe cam 2+ (+ tolerance)	MD 36936[1] + MD 36940 and MD 1336[1] + MD 1340 are not identical	Set MDs to identical values

No.	Name	Explanation	Cause, remedy
20	Safe cam 2+	MD 36936[1] and MD 1336[1] are not identical	Set MDs to identical values
21	Safe cam 2- (+ tolerance)	MD 36937[1] + MD 36940 and MD 1337[1] + MD 1340 are not identical	Set MDs to identical values
22	Safe cam 2-	MD 36937[1] and MD 1337[1] are not identical	Set MDs to identical values
23	Safe cam 3+ (+ tolerance)	MD 36936[2] + MD 36940 and MD 1336[2] + MD 1340 are not identical	Set MDs to identical values
24	Safe cam 3+	MD 36936[2] and MD 1336[2] are not identical	Set MDs to identical values
25	Safe cam 3- (+ tolerance)	MD 36937[2] + MD 36940 and MD 1337[2] + MD 1340 are not identical	Set MDs to identical values
26	Safe cam 3-	MD 36937[2] and MD 1337[2] are not identical	Set MDs to identical values
27	Safe cam 4+ (+ tolerance)	MD 36936[3] + MD 36940 and MD 1336[3] + MD 1340 are not identical	Set MDs to identical values
28	Safe cam 4+	MD 36936[3] and MD 1336[3] are not identical	Set MDs to identical values
29	Safe cam 4- (+ tolerance)	MD 36937[3] + MD 36940 and MD 1337[3] + MD 1340 are not identical	Set MDs to identical values
30	Safe cam 4-	MD 36937[3] and MD 1337[3] are not identical	Set MDs to identical values
31	Position tolerance	MD 36942 and MD 1342 are not identical	Set MDs to identical values
32	Reference position tolerance	MD 36944 and MD 1344 are not identical	Set MDs to identical values
33	Delay time speed switchover	MD 36951 and MD 1351 are not identical	Set MDs to identical values
34	Tolerance time for SGE switchover	MD 36950 and MD 1350 are not identical	Set MDs to identical values
35	Delay time pulse disable	MD 36956 and MD 1356 are not identical	Set MDs to identical values
36	Time for testing pulse disable	MD 36957 and MD 1357 are not identical	Set MDs to identical values
37	Transition time STOP C to SBH	MD 36952 and MD 1352 are not identical	Set MDs to identical values
38	Transition time STOP D to SBH	MD 36953 and MD 1353 are not identical	Set MDs to identical values
39	Transition time STOP E to SBH	MD 36954 and MD 1354 are not identical	Set MDs to identical values
40	Stop reaction after SG	MD 36961 and MD 1361 are not identical	Set MDs to identical values
41	Stop reaction after SE	MD 36962 and MD 1362 are not identical	Set MDs to identical values
42	Creep speed pulse disabling	MD 36960 and MD 1360 are not identical	Set MDs to identical values
43	Memory test stop reaction	-	-
44	Position actual value + limit value SG1	Position actual values (error code 3) are different or MD 36931[0] and MD 1331[0] are not identical (error code 6)	-
45	Position actual value - limit value SG1	Position actual values (error code 3) are different or MD 36931[0] and MD 1331[0] are not identical (error code 6)	-
46	Position actual value + limit value SG2	Position actual values (error code 3) are different or MD 36931[1] and MD 1331[1] are not identical (error code 7)	-
47	Position actual value - limit value SG2	Position actual values (error code 3) are different or MD 36931[1] and MD 1331[1] are not identical (error code 7)	-
48	Position actual value + limit value SG3	Position actual values (error code 3) are different or MD 36931[2] and MD 1331[2] are not identical (error code 8)	-
49	Position actual value - limit value SG3	Position actual values (error code 3) are different or MD 36931[2] and MD 1331[2] are not identical (error code 8)	-
50	Position actual value + limit value SG4	Position actual values (error code 3) are different or MD 36931[3] and MD 1331[3] are not identical (error code 9)	-
51	Position actual value - limit value SG4	Position actual values (error code 3) are different or MD 36931[3] and MD 1331[3] are not identical (error code 9)	-
52	Standstill position + tolerance	Position actual values (error code 3) are different or MD 36930 and MD 1330 are not identical (error code 10)	-

No.	Name	Explanation	Cause, remedy
53	Standstill position - tolerance	Position actual values (error code 3) are different or MD 36930 and MD 1330 are not identical (error code 10)	-
54	Position actual value "+ n_x" + tolerance	Position actual values (error code 3) are different or MD 36946 and MD 1346 are not identical (error code 75) or MD 36942 and MD 1342 are not identical (error code 31)	-
55	Position actual value "+ n_x"	Position actual values (error code 3) are different or MD 36946 and MD 1346 are not identical (error code 75)	-
56	Position actual value "- n_x"	Position actual values (error code 3) are different or MD 36946 and MD 1346 are not identical (error code 75)	-
57	Position actual value "- n_x" - tolerance	Position actual values (error code 3) are different or MD 36946 and MD 1346 are not identical (error code 75) or MD 36942 and MD 1342 are not identical (error code 31)	-
58	Current Stop request	Available soon	-
59	SG override factor 1	MD 36932 [0] and MD 1332[0] are not identical	Set both MD identically
60	SG override factor 2	MD 36932[1] and MD 1332[1] are not identical	Set both MD identically
61	SG override factor 3	MD 36932[2] and MD 1332[2] are not identical	Set both MD identically
62	SG override factor 4	MD 36932[3] and MD 1332[3] are not identical	Set both MD identically
63	SG override factor 5	MD 36932[4] and MD 1332[4] are not identical	Set both MD identically
64	SG override factor 6	MD 36932[5] and MD 1332[5] are not identical	Set both MD identically
65	SG override factor 7	MD 36932[6] and MD 1332[6] are not identical	Set both MD identically
66	SG override factor 8	MD 36932[7] and MD 1332[7] are not identical	Set both MD identically
67	SG override factor 9	MD 36932[8] and MD 1332[8] are not identical	Set both MD identically
68	SG override factor 10	MD 36932[9] and MD 1332[9] are not identical	Set both MD identically
69	SG override factor 11	MD 36932[10] and MD 1332[10] are not identical	Set both MD identically
70	SG override factor 12	MD 36932[11] and MD 1332[11] are not identical	Set both MD identically
71	SG override factor 13	MD 36932[12] and MD 1332[12] are not identical	Set both MD identically
72	SG override factor 14	MD 36932[13] and MD 1332[13] are not identical	Set both MD identically
73	SG override factor 15	MD 36932[14] and MD 1332[14] are not identical	Set both MD identically
74	SG override factor 16	MD 36932[15] and MD 1332[15] are not identical	Set both MD identically
75	Speed limit "n_x"	MD 36946 and MD 1346 are not identical	Set both MD identically
76	Stop reaction for SG1	MD 36963[0] and MD 1363[0] are not identical	Set both MD identically
77	Stop reaction for SG2	MD 36963[1] and MD 1363[1] are not identical	Set both MD identically
78	Stop reaction for SG3	MD 36963[2] and MD 1363[2] are not identical	Set both MD identically
79	Stop reaction for SG4	MD 36963[3] and MD 1363[3] are not identical	Set both MD identically
80	Modulo value for safe cams	MD 36905 and MD 1305 are not identical	Set both MD identically
81	Speed tolerance for safe braking ramp	MD 36948 and MD 1348 are not identical	Set both MD identically
1000	Check timer has expired	The timer for SGE changes has not run down within the check timer period (e.g. the SGEs are switching too frequently in direct sequence).	E.g. contact problems (loose contact).
1001	Check timer initialization error	The timer for SGE changes has not started the check timer (applies only to 611D)	-
1002	User agreement timer has expired	The user agreement status on the drive is not the same as on the NCK	-
1003	Reference tolerance violated	The comparison between the stored standstill position and the current position has detected a greater deviation than set in MD 36944: $MA_SAFE_REFP_POS_TOL (Actual value comparison tolerance (referencing)) or MD1344: $MD_SAFE_REFP_POS_TOL	-

No.	Name	Explanation	Cause, remedy
1004	Plausibility violation of user agreement	User agreement has been given for an axis that - is already safely referenced - is not yet referenced	-
1005	Pulses are already disabled on selection of test stop	The "Pulses are disabled" signal is already present when the test stop is selected	The test stop has been selected when no pulse enabling signal is present, mistake in wiring of SGE "Pulses are disabled"
1006	Error in forced dormant error detection on SGAs	An error has been detected during a cyclic check of the SGAs (applies only to 611D).	-
1007	Communications failure between PLC and drive	If a communications failure is signalled by the drive, then either the PLC or the NC has failed.	-
1008	Errors in data transmission between PLC and drive	Transmission of the SGEs/SGAs between the PLC and drive is protected by a checksum. In the event of an error, the calculated checksum is not identical to the transferred checksum. If the stop is initiated by the drive, then either the PLC or NC has failed.	-
Note: Example: If the error code contains, for example, the value "12", then the cross-check operation has detected a difference between the NCK and drive monitoring channels in the MD for lower limit value SE1.			

27002 Axis %1: Test stop in progress

Explanation: A function check is currently being carried out on the disable path through setting of the "Test stop selection" SGE.

Reaction: Alarm is displayed.

Remedy: No remedial action need be taken. The message merely informs the user that a check is in progress.

To continue program: The alarm automatically disappears when the delay time defined in MD: $MA_SAFE_PULSE_DIS_CHECK_TIME has expired and the SGE "Test stop selection" is cancelled when the control detects pulse disabling, i.e. the test has been successful (a failed test is indicated by alarm 27001 with error code 1005 or alarm 27024).

27010 Axis %1: Tolerance for safe operational stop exceeded

POWER ON

Explanation: The axis has moved too far away from the setpoint position, i.e. by further than the amount specified in MD: $MA_SAFE_STANDSTILL_TOL.

Reaction: Alarm is displayed. NC program execution is halted. The axis is stopped with a zero speed setpoint (STOP B). As soon as the speed actual value drops below the speed set in MD: $MA_SAFE_STANDSTILL_VELO_TOL, but at the latest after expiry of the time set in MD: $MA_SAFE_PULSE_DISABLE_DELAY:

- Drive pulses are disabled (STOP A)
- NC START is locked out
- Display at the NC/PLC interface
- Mode group not ready
- Channel not ready

Remedy: Check the tolerance of the standstill monitor: Has the value been set in accordance with the accuracy and dynamic control response of the drive?
If not, increase tolerance.
If yes, check machine for any damage and repair if necessary.

To continue program: Program cannot be continued. Alarm can only be acknowledged by means of POWER ON.

27011 Axis %1: Safe speed exceeded RESET

Explanation	The axis has moved too quickly, i.e. more quickly than is permitted by the setting in MD $MA_SAFE_VELO_LIMIT. With the SBH and SG functions active and a 1-encoder system, the speed that corresponds to an encoder limit frequency of 200 kHz (300 kHz from SW4.2) has been exceeded.
Reaction	Alarm is displayed. NC program execution is halted. The axis is stopped with STOP A, B, C, D or E depending on configuration in MD 36961: $MA_SAFE_VELO_STOP_MODE or MD 36963: $MA_SAFE_VELO_STOP_REACTION. NC START lockout. Display at the interface.
Remedy	If the operator has not made an obvious error: Check the input value of the MD. Check the SGEs: Of the 4 available speed limits, was the correct speed selected? If the MDs and SGEs are correct, check the machine for any damage and repair if necessary.
To continue program	Clear the error and press the RESET key (the program is aborted).

27012 Axis %1: Safe limit position crossed RESET

Explanation	The axis has crossed the limit position that is entered in MD: $MA_SAFE_POS_LIMIT_PLUS or MD: $MA_SAFE_POS_LIMIT_MINUS.
Reaction	Alarm is displayed. NC program execution is halted. The axis is stopped with STOP C, D or E depending on what is configured in MD: $MA_SAFE_POS_STOP_MODE. NC START lockout. Display at the NC/PLC interface.
Remedy	If the operator has not made an obvious error: Check the input value of the machine data. Check the SGEs: Of the 2 available limit positions, was the correct limit position selected? If the MDs and SGEs are correct, check machine for damage and repair if necessary.
To continue program	Cancel the user agreement for this axis. Then press the RESET key. The program is aborted and the alarm reset. Traverse the axis in JOG mode into the valid traversing area. After the error in the NC program has been cleared and the axis position checked, user agreement can be given and the program started again.

27013 Safe braking ramp exceeded POWER ON

Explanation	After activation of STOP B or C, the speed has exceeded the tolerance setting programmed in MD 36948: $MA_SAFE_STOP_VELO_TOL.
Reaction	Alarm is displayed. Disabling of pulses (via SGA). NC program execution is halted. NC START is disabled. Display at NC/PLC interface. Mode group in “Not ready” state. Channel in “Not ready” state.
Remedy	Check setting in MD 36948. Check braking response of affected drive.
To continue program	Program cannot be continued. Alarm can only be acknowledged with POWER ON.

27020 Axis %1: Stop E activated RESET

Explanation: This alarm is displayed at the same time as alarms "Safe speed exceeded" or "Safe limit position crossed" (when appropriately configured in MD: $MA_SAFE_VELO_STOP_MODE or MD: $MA_SAFE_POS_STOP_MODE). It indicates that a LIFTFAST-ASUP has been started and that a safe operational stop (SBH) has been internally activated.

Reaction: Alarm is displayed. NC program execution is halted. The axis is stopped with STOP E. NC START is locked out. Display at the NC/PLC interface.

Remedy: Eliminate causes for "Safe speed exceeded" or "Safe limit position crossed" (see description of alarms).

To continue program: Clear the error and press the RESET key (the program is aborted).

27021 Axis %1: Stop D activated RESET

Explanation: This alarm is displayed at the same time as alarms "Safe speed exceeded" or "Safe limit position crossed" (when appropriately configured in MD: $MA_SAFE_VELO_STOP_MODE or MD: $MA_SAFE_POS_STOP_MODE). It indicates that a "Brake on path" operation has been started and that a safe operational stop (SBH) has been internally activated.

Reaction: Alarm is displayed. NC program execution is halted. The axis is stopped with STOP D. NC START is locked out. Display at the NC/PLC interface.

Remedy: Eliminate causes for "Safe speed exceeded" or "Safe limit position crossed" (see description of alarms).

To continue program: Clear the error and press the RESET key (the program is aborted).

27022 Axis %1: Stop C activated RESET

Explanation: This alarm is displayed at the same time as alarms "Safe speed exceeded" or "Safe limit position crossed" (when appropriately configured in MD: $MA_SAFE_VELO_STOP_MODE or MD: $MA_SAFE_POS_STOP_MODE). It indicates that a "Brake along current limit" operation has been started and that a safe operational stop (SBH) has been internally activated.

Reaction: Alarm is displayed. NC program execution is halted. The axis is stopped with STOP C. NC START is locked out. Display at the NC/PLC interface.

Remedy: Eliminate causes for "Safe speed exceeded" or "Safe limit position crossed" (see description of alarms).

To continue program: Clear the error and press the RESET key (the program is aborted).

27023 Axis %1: Stop B activated POWER ON

Explanation: This alarm is output with alarm "Tolerance for safe operational stop exceeded" or after alarm "STOP F activated". It indicates that a "Brake along current limit" operation has been started and that the timer for switchover to STOP A (see MD: $MA_SAFE_PULSE_DISABLE_DELAY) has been internally activated.

Reaction: Alarm is displayed. NC program execution is halted. The axis is stopped with STOP B. Switchover timer to STOP A is started. NC START is locked out. Display at the NC/PLC interface. Mode group is not ready, channel is not ready.

Remedy: Eliminate causes for "Tolerance for safe operational stop exceeded" or "STOP F activated" (see description of alarms).

To continue program: Program cannot be continued. Alarm can only be acknowledged by means of POWER ON.

27024 Axis %1: Stop A activated POWER ON

Explanation	This alarm is output with alarm "Tolerance for safe operational stop exceeded" or after a STOP B reaction or a failed test stop. It indicates that "pulse disabling" has been activated.
Reaction	Alarm is displayed. NC program execution is halted. The axis is stopped with STOP A. Pulses are disabled (via SGA). NC START is locked out. Display at the NC/PLC interface. Mode group is not ready, channel is not ready.
Remedy	Eliminate causes for "Tolerance for safe operational stop exceeded" or "STOP F activated" (see description of alarms).
To continue program	Program cannot be continued. Alarm can only be acknowledged by means of POWER ON.

27030 Axis %1: Function not available with this 611D control module POWER ON

Explanation	The SINUMERIK Safety Integrated option requires 611D performance closed-loop control modules with two measuring circuits per drive and a pulse-disabling relay. An attempt has been made to activate a safety function even though a module of this type is not installed.
Reaction	Alarm is displayed. Pulses are disabled. NC START is locked out. Display at the NC/PLC interface. Mode group is not ready, channel is not ready.
Remedy	Replace module or deactivate safety functions in MD: $MA_SAFE_FUNCTION_ENABLE again.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

27031 Axis %1: Limit value for safe speed %2 with gear ratio %3 too high (max. %4) POWER ON

Explanation	All limit values in MD: $MA_SAFE_VELO_LIMIT must be set such that the limit frequency of the amplitude monitor in the measuring-circuit hardware (200 KHz, from SW 4.2 300 kHz) is not exceeded. The limit value that does not fulfil this condition is specified here as the second parameter (1 for SG1, 2 for SG2, etc.). The third parameter specifies the gear stage, e.g. 1 for gear stage 1, 2 for gear stage 2, etc. The fourth parameter defines the maximum speed that may be input to ensure that the frequency remains just below the permissible limit in safe operation.
Reaction	Alarm is displayed. Pulses are disabled (via SGA). NC START is locked out. Display at the NC/PLC interface. Mode group is not ready, channel is not ready.
Remedy	Reduce the limit value in MD: $MA_SAFE_VELO_LIMIT[x], x = (2nd alarm parameter) - 1 or correct the gear stage setting.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

27032 Axis %1: Checksum error safety monitors. Confirmation and acceptance test are needed! POWER ON

Explanation	The MDs $MA_SAFE ... are protected by a checksum after the control system has been accepted. Alarm 27032 indicates that the current checksum is no longer the same as the stored setpoint checksum, i.e. that an MD value has either been changed illegally or that a data is defective.
Reaction	Alarm is displayed. Pulses are disabled (via SGA). NC START is locked out. Display at the NC/PLC interface.
Remedy	Check MDs. Perform a new checksum calculation. Carry out new acceptance test on safety functions.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

27033 Axis %1: Parameter setting of machine data %2[%3] invalid POWER ON

Explanation	The MD with the specified name and index has been set to an invalid value. The cause can be found in the description of the machine data.
Reaction	Alarm is displayed. Pulses are disabled (via SGA). NC START is locked out. Display at the NC/PLC interface. Mode group is not ready, channel is not ready.
Remedy	Check and alter the MD named in the alarm text. Perform a new checksum calculation. Carry out new acceptance test on safety functions.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

300xxx SIMODRIVE 611D alarms

Explanation	Alarms with the **Number 300xxx** can be generated by the drive and are described in Section 6.3 SIMODRIVE 611D alarms

6.2 Alarms for SINUMERIK 840C

Alarms for SINUMERIK 840C/611D

Detailed explanations of all alarms that are not described here can be found in the following References for the SINUMERIK 840C system:

References: /DAC/, Diagnostics Guide

Alarms for SINUMERIK Safety Integrated

Alarms that may occur in connection with SINUMERIK Safety Integrated are listed below.

Note

If several alarm numbers are specified, the following applies:
First No. / second No. is an axis-specific / spindle-specific alarm.

103 Initialization error NCK FB POWER ON

Alarm scan	During control system power-up
Effect	NC START is locked out Follow-up mode Cancellation of mode group ready signal
Explanation	The machine data for the SGE/SGA input/output assignments (46000 - 47999) have been entered incorrectly. The errored MD number is output in the alarm as block number Nxxxxx.
Remedy	Correct the machine data named in alarm text.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

Note

Alarm 103 is output only if the machine manufacturer has taken appropriate configuration measures. An error has occurred in the Safety NCK FB. Please refer to the machine manufacturer's documentation for explanation of the alarm and remedial measures.

104 Error in machine data POWER ON

Alarm scan	During control system power-up After a warm restart After a change to a machine data
Effect	NC START is locked out Follow-up mode Cancellation of mode group ready signal
Explanation	A machine data has been set to an implausible value. The errored machine data is output in the alarm text as block number N.
Remedy	Interpret the block number and correct the relevant machine data.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

105 Error in NCK FB POWER ON

Alarm scan	When control is operating in cyclical mode
Effect	NC START is locked out Follow-up mode Cancellation of mode group ready signal Interruption of machining operation
Explanation	The cyclic routines of the NCK FB has supplied a return value other than zero and requested alarm class POWER ON. The return value is output in the alarm as block number Nxxxxx.
Remedy	Interpret the block number and check the NCK FB.
To continue program	No program can be started. Alarm can only be acknowledged by means of POWER ON.

Note

Alarm 105 is output only if the machine manufacturer has taken appropriate configuration measures. An error has occurred in the Safety NCK FB. Please refer to the machine manufacturer's documentation for explanation of the alarm and remedial measures.

110 Checksum error safety monitors POWER ON

Alarm scan	During control system power-up
Effect	NC START is locked out
Explanation	The MDs for safety functions are protected by a checksum after the control system has been acceptance-tested. Alarm 110 indicates that the current checksum is no longer the same as the stored setpoint checksum, i.e. that an MD value has either been changed illegally or that a data is defective.
Remedy	Check MDs. Perform a new checksum calculation. Carry out new acceptance test on safety functions.
To continue program	The alarm is activated during power-up. No program can be started. Alarm can only be acknowledged by means of POWER ON.

2505 Error in NCK FB RESET

Alarm scan	When control system is operating in cyclic mode
Effect	NC START is locked out Follow-up mode Cancellation of mode group ready signal Interruption in machining operation
Explanation	The machine data for the SGE/SGA input/output assignments (46000 - 47999) have been entered incorrectly. The errored MD number is output in the alarm as block number Nxxxxx.
Remedy	Correct the machine data named in alarm text.
To continue program	No program can be started. Alarm can only be acknowledged by means of RESET.

Note

Alarm 2505 is output only if the machine manufacturer has taken appropriate configuration measures. An error has occurred in the Safety NCK FB. Please refer to the machine manufacturer's documentation for explanation of the alarm and remedial measures.

2506 Extended function output in target block

RESET

Alarm scan: During block search in AUTOMATIC or MDA mode
Effect: NC START is locked out
Explanation: The target block of the block search must not be a G501 block because the output of a collection of auxiliary functions and the extended function output contain in the G501 block will collide functionally.
Remedy: Select another target block.
To continue program: Acknowledge the alarm by means of RESET.

3262 Error in NCK FB

CANCEL

Alarm scan: When control is operating in cyclical mode
Effect: None
Explanation: The cyclic routines of the NCK FB has supplied a return value other than zero and requested alarm class CANCEL. The return value is output in the alarm as block number N.
Remedy: Interpret the block number and check the NCK FB.
To continue program: Acknowledge the alarm by CANCEL.

Note

Alarm 3262 is output only if the machine manufacturer has taken appropriate configuration measures. An error has occurred in the Safety NCK FB. Please refer to the machine manufacturer's documentation for explanation of the alarm and remedial measures.

3263 Illegal axis position

CANCEL

Alarm scan: During execution in AUTOMATIC or MDA modes
Effect: NC START is locked out
Interruption of machining operation
Explanation: The position of the material entry coordinate is outside the traversing path of the block.
Remedy: Alter part program.
To continue program: Acknowledge the alarm by CANCEL.

1012* / 2019* Parameterization error in NC MD

Alarm scan: During control system power-up
Effect: NC START is locked out
Follow-up mode
Cancellation of mode group ready signal
Interruption in machining operation
Explanation: The service number for parameterization errors, and thus the exact cause of errors, is output in the service display AXIS. Invalid values in the SI machine data may be the reason for the following service numbers being displayed. In this case, more detailed information will be shown in the SI SERVICE DISPLAY.

Service No.	Cause	Remedy
300	The monitoring cycle set in MD 40010 for Safety Integrated is not a multiple of the position control cycle of this axis	Check the position control cycle of this axis as well as the monitoring cycle (MD 168, 155, 1396*, 40010)
329	The measuring circuit connection (MD 4100*) assigned to SI is already occupied by another	Assign a different measuring circuit: Note: In safe operation with 1 encoder, the 2nd measuring circuit connection

Service No.	Cause	Remedy
	axis/spindle.	cannot be assigned to other functions.
331	Error has occurred in the conversion of SI MDs. This can affect the following MDs: MD 4184* to 4196*, MD 4200* to 4244*, 4248* to 4260*, 4180*	Check machine data, interpret detailed information in SI SERVICE DISPLAY (data 1000)

Remedy Check and re-enter the relevant machine data.
To continue program Program cannot be continued

1324* / 2094* Tolerance for safe operation stop exceeded POWER ON

Alarm scan After selection of SBH
After activation of STOP C, D, E and expiry of timer
Effect Alarm is displayed
Activation of STOP B and A
Explanation The axis has moved too far away from the setpoint position, i.e. by further than the amount specified in MD 4180*: (Standstill tolerance for safe operation).
Remedy Check the tolerance of the standstill monitor:
Has the value been set in accordance with the accuracy and dynamic control response of the drive?
If not, increase tolerance.
If yes, check machine for any damage and repair if necessary.

1328* / 2095* Safe speed exceeded RESET

Alarm scan After selection of SG
Effect Alarm is displayed
Activation of STOP C, D, E (depending on configuration)
Explanation The axis has moved too quickly, i.e. more quickly than is permitted by the setting in MD 4184*, 4188*, 4192*, 4196*: (Limit value for safe speed 1, 2, 3, 4).
With the SBH and SG functions active and a 1-encoder system, the speed that corresponds to an encoder limit frequency of 200 kHz (from SW 5.7 300 kHz) has been exceeded.
Remedy If the operator has not made an obvious error: Check the input value of the MD. Check the SGEs: Of the 4 available speed limits, was the correct speed selected? If the MDs and SGEs are correct, check the machine for any damage and repair if necessary.

1332* / 2096* Safe limit position crossed RESET

Alarm scan	After enabling of safety function SE
Effect	Alarm is displayed Activation of STOP C, D, E (depending on configuration)
Explanation	The axis has crossed the limit position that is entered in MD 4200*, 4204*: (Upper limit value for safe limit position 1, 2) or MD 4208*, 4212*: (Lower limit value for safe limit position 1, 2).
Remedy	If the operator has not made an obvious error: Check the input value of the machine data. Check the SGEs: Of the 2 available limit positions, was the correct limit position selected? If the MDs and SGEs are correct, check machine for damage and repair if necessary.
To continue program	Cancel the user agreement for this axis. Then press the RESET key. The program is aborted and the alarm reset. Traverse the axis in JOG mode into the valid traversing area. After the error in the NC program has been cleared and the axis position checked, user agreement can be given and the program started again.

1336* / 2097* Defect in a monitoring channel

RESET

Alarm scan	After selection of at least one safety function
Effect	Alarm is displayed NC START is locked out STOP F STOP B and A when SI function is active
Explanation	The cross-check between the two monitoring channels has detected a difference in the input data or results of the monitoring functions. One of the monitors is no longer operating reliable, i.e. operation of the drive is no longer being monitored reliably.
Remedy	Find the difference between the two monitoring channels. The error code that specifies the cause is displayed in the following machine data: On 840C SSD 301: Diagnosis for STOP F (SI service display) On 611D MD 1395: Diagnosis for STOP F (SI drive display) The meaning of the error code can be found in Table 6-2 Error code for STOP F on 840C/611D. The safety-relevant machine data might not be identical (re-load if necessary) or the SGEs (safety-relevant input signals) might not be at the same level (measure again or check in SI service display). If the error is not caused by one of the above, there may be a CPU error, e.g. a "toggled memory cell". This type of error may be temporary (eliminate by a POWER ON) or permanent (appears again after POWER ON, replace hardware).
To continue program	Eliminate the error and press the RESET key. The program is then aborted. If a safety monitor was active, STOP B is automatically activated. The control system must then be switched off and on again (POWER ON).

Table 6-2 Error code for STOP F on 840C/611D

No.	Name	Explanation	Cause, Remedy
0	No error	There is no error in this channel. There may be one in the other channel.	Look for the cause in the other channel and interpret error code
1	Result list 1	Differences in the evaluation of SBH/SG/SE functions in the NCK and drive monitoring channels	E.g. SGEs have not activated functions identically in the two channels, analyse fine error coding in 611D-MD 1391 and 1392
2	Result list 2	Differences in the evaluation of the SN function in the NCK and drive monitoring channels	Check cam tolerance Analyse fine error coding in 611D-MD 1393 and 1394
3	Position actual value	Difference between position actual values in drive and NCK monitoring channels exceeds setting in MD 4256*: Tolerance actual value cross-check or MD 1342	Incorrect evaluation of encoder (check MDs). Difference in stored standstill positions
4	No cross-check	-	-
5	Function enabling signals	MD 4500*, 4504* and MD 1301 are not identical	Set MDs to identical values
6	Limit value for SG1	MD 4184* and MD 1331[0] are not identical	Set MDs to identical values
7	Limit value for SG2	MD 4188* and MD 1331[1] are not identical	Set MDs to identical values
8	Limit value for SG3	MD 4192* and MD 1331[2] are not identical	Set MDs to identical values
9	Limit value for SG4	MD 4196* and MD 1331[3] are not identical	Set MDs to identical values
10	Standstill tolerance	MD 4180* and MD 1330 are not identical	Set MDs to identical values
11	Upper limit value SE1	MD 4200* and MD 1334[0] are not identical	Set MDs to identical values
12	Lower limit value SE1	MD 4208* and MD 1335[0] are not identical	Set MDs to identical values
13	Upper limit value SE2	MD 4204* and MD 1334[1] are not identical	Set MDs to identical values
14	Lower limit value SE2	MD 4212* and MD 1335[1] are not identical	Set MDs to identical values
15	Safe cam 1+ (+ tolerance)	MD 4216* + MD 4248* and MD 1336[0] + MD 1340 are not identical	Set MDs to identical values
16	Safe cam 1+	MD 4216* and MD 1336[0] are not identical	Set MDs to identical values
17	Safe cam 1- (+ tolerance)	MD 4232* + MD 4248* and MD 1337[0] + MD 1340 are not identical	Set MDs to identical values
18	Safe cam 1-	MD 4232* and MD 1337[0] are not identical	Set MDs to identical values
19	Safe cam 2+ (+ tolerance)	MD 4220* + MD 4248* and MD 1336[1] + MD 1340 are not identical	Set MDs to identical values
20	Safe cam 2+	MD 4220* and MD 1336[1] are not identical	Set MDs to identical values
21	Safe cam 2- (+ tolerance)	MD 4236* + MD 4248* and MD 1337[1] + MD 1340 are not identical	Set MDs to identical values
22	Safe cam 2-	MD 4236* and MD 1337[1] are not identical	Set MDs to identical values
23	Safe cam 3+ (+ tolerance)	MD 4224* + MD 4248* and MD 1336[2] + MD 1340 are not identical	Set MDs to identical values
24	Safe cam 3+	MD 4224* and MD 1336 are not identical	Set MDs to identical values
25	Safe cam 3- (+ tolerance)	MD 4240* + MD 4248* and MD 1337[2] + MD 1340 are not identical	Set MDs to identical values
26	Safe cam 3-	MD 4240* and MD 1337[2] are not identical	Set MDs to identical values
27	Safe cam 4+ (+ tolerance)	MD 4228* + MD 4248* and MD 1336[3] + MD 1340 are not identical	Set MDs to identical values
28	Safe cam 4+	MD 4228* and MD 1336[3] are not identical	Set MDs to identical values
29	Safe cam 4- (+ tolerance)	MD 4244* + MD 4248* and MD 1337[3] + MD 1340 are not identical	Set MDs to identical values
30	Safe cam 4-	MD 4244* and MD 1337[3] are not identical	Set MDs to identical values
31	Position tolerance	MD 4256* and MD 1342 are not identical	Set MDs to identical values
32	Reference position tolerance	MD 4252* and MD 1344 are not identical	Set MDs to identical values
33	Delay time speed switchover	MD 4264* and MD 1351 are not identical	Set MDs to identical values
34	Tolerance time for SGE switchover	MD 4260* and MD 1350 are not identical	Set MDs to identical values
35	Delay time pulse disable	MD 4268* and MD 1356 are not identical	Set MDs to identical values

36	Time for testing pulse disable	MD 4272* and MD 1357 are not identical	Set MDs to identical values
37	Transition time STOP C to SBH	MD 4276* and MD 1352 are not identical	Set MDs to identical values
38	Transition time STOP D to SBH	MD 4280* and MD 1353 are not identical	Set MDs to identical values
39	Transition time STOP E to SBH	MD 4284* and MD 1354 are not identical	Set MDs to identical values
40	Stop reaction after SG	MD 4508*.4, 4508*.5 and MD 1361 are not identical	Set MDs to identical values
41	Stop reaction after SE	MD 4508*.2, 4508*.3 and MD 1362 are not identical	Set MDs to identical values
42	Creep speed pulse disabling	MD 4288* and MD 1360 are not identical	Set MDs to identical values
43	Memory test stop reaction	-	-
44	Position actual value + limit value SG1	Position actual values (error code 3) are different or MD 4184* and MD 1331[0] are not identical (error code 6)	-
45	Position actual value - limit value SG1	Position actual values (error code 3) are different or MD 4184* and MD 1331[0] are not identical (error code 6)	-
46	Position actual value + limit value SG2	Position actual values (error code 3) are different or MD 4184* and MD 1331[1] are not identical (error code 7)	-
47	Position actual value - limit value SG2	Position actual values (error code 3) are different or MD 4184* and MD 1331[1] are not identical (error code 7)	-
48	Position actual value + limit value SG3	Position actual values (error code 3) are different or MD 4184* and MD 1331[2] are not identical (error code 8)	-
49	Position actual value - limit value SG3	Position actual values (error code 3) are different or MD 4184* and MD 1331[2] are not identical (error code 8)	-
50	Position actual value + limit value SG4	Position actual values (error code 3) are different or MD 4184* and MD 1331[3] are not identical (error code 9)	-
51	Position actual value - limit value SG4	Position actual values (error code 3) are different or MD 4184* and MD 1331[3] are not identical (error code 9)	-
52	Standstill position + tolerance	Position actual values (error code 3) are different or MD 4180* and MD 1330 are not identical (error code 10)	-
53	Standstill position - tolerance	Position actual values (error code 3) are different or MD 4180* and MD 1330 are not identical (error code 10)	-
54	Position actual value + n_x + Tol	Position actual values (error code 3) are different or MD 4292* and MD 1346 are not identical (error code 75) or MD 4256* and MD 1342 are not identical (error code 31)	-
55	Position actual value + n_x	Position actual values (error code 3) are different or MD 4292* and MD 1346 are not identical (error code 75)	-
56	Position actual value - n_x	Position actual values (error code 3) are different or MD 4292* and MD 1346 are not identical (error code 75)	-
57	Position actual value - n_x - Tol	Position actual values (error code 3) are different or MD 4292* and MD 1346 are not identical (error code 75) or MD 4256* and MD 1342 are not identical (error code 31)	-
58	Stop request	MD 1301 Bit 6 is not 0	Set bit to 0
59	SG override factor 1	MD 1301 Bit 5 is not 0	Set bit to 0
60	SG override factor 2	MD 1301 Bit 5 is not 0	Set bit to 0
61	SG override factor 3	MD 1301 Bit 5 is not 0	Set bit to 0
62	SG override factor 4	MD 1301 Bit 5 is not 0	Set bit to 0
63	SG override factor 5	MD 1301 Bit 5 is not 0	Set bit to 0
64	SG override factor 6	MD 1301 Bit 5 is not 0	Set bit to 0
65	SG override factor 7	MD 1301 Bit 5 is not 0	Set bit to 0
66	SG override factor 8	MD 1301 Bit 5 is not 0	Set bit to 0

No.	Name	Explanation	Cause, Remedy
67	SG override factor 9	MD 1301 Bit 5 is not 0	Set bit to 0
68	SG override factor 10	MD 1301 Bit 5 is not 0	Set bit to 0
69	SG override factor 11	MD 1301 Bit 5 is not 0	Set bit to 0
70	SG override factor 12	MD 1301 Bit 5 is not 0	Set bit to 0
71	SG override factor 13	MD 1301 Bit 5 is not 0	Set bit to 0
72	SG override factor 14	MD 1301 Bit 5 is not 0	Set bit to 0
73	SG override factor 15	MD 1301 Bit 5 is not 0	Set bit to 0
74	SG override factor 16	MD 1301 Bit 5 is not 0	Set bit to 0
75	Speed limit n_x	MD 4292* and MD 1346 are not identical	Set both MD identically
76	Stop reaction for SG1	MD 4508*.4, 4508*.5 and MD 1361 are not identical	Set both MD identically
77	Stop reaction for SG2	MD 4508*.4, 4508*.5 and MD 1361 are not identical	Set both MD identically
78	Stop reaction for SG3	MD 4508*.4, 4508*.5 and MD 1361 are not identical	Set both MD identically
79	Stop reaction for SG4	MD 4508*.4, 4508*.5 and MD 1361 are not identical	Set both MD identically
80	SI modulo value for SN	MD 1367 is not 0	Set MD to 0
81	Speed tolerance for SBR	MD 4296* and MD 1348 are not identical	Set both MD identically
1000	Check timer has expired	The timer for SGE changes has not run down within the check timer period (e.g. the SGEs are switching too frequently in direct sequence).	E.g. contact problems (loose contact).
1001	Check timer initialization error	The timer for SGE changes has not started the check timer	-
1002	User agreement timer has expired	The user agreement status on the drive is not the same as on the NCK	-
1003	Reference tolerance violated	The comparison between the stored standstill position and the current position has detected a greater deviation than set in MD 4252*: Actual value comparison tolerance (referencing) or MD 1344	-
1004	Plausibility violation of user agreement	User agreement has been given for an axis that - is already safely referenced - is not yet referenced	-
1005	Pulses are already disabled on selection of test stop	The "Pulses are disabled" signal is already present when the test stop is selected	The test stop has been selected when no pulse enabling signal is present, mistake in wiring of SGE "Pulses are disabled"
1006	Error in forced dormant error detection on SGAs	An error has been detected during a cyclic check of the SGAs	-
1007	Communications failure between PLC and drive	If a communications failure is signalled by the drive, then either the PLC or the NC has failed.	-
1008	Errors in data transmission between PLC and drive	Transmission of the SGEs/SGAs between the PLC and drive is protected by a checksum. In the event of an error, the calculated checksum is not identical to the transferred checksum. If the stop is initiated by the drive, then either the PLC or NC has failed.	-

Note:
Example: If the error code contains, for example, the value "12", then the cross-check operation has detected a difference between the NCK and drive monitoring channels in the MD for lower limit value SE1.

1340* Axis is not safely referenced

Alarm scan	After selection of SE/SN
Effect	Alarm is displayed The SGA "Axis safely referenced" is not set The safe limit positions are not active The safe cam signals are output, but not reliable in terms of safe operation
Explanation	1.) The axis is not referenced or 2.) There is no user agreement for this axis or it has been cancelled. This can happen, for example, if the axis has been moved since the machine was switched off with the result that the standstill position stored before power OFF is not longer valid.
Remedy	For 1.) Reference axis For 2.) Input user agreement The alarm automatically disappears when user agreement has been given.

Warning

If the axis is not yet safely referenced and user agreement has not been given, then the following applies:
- The safe cams are active, but no yet reliable
- The safe limit positions are not yet active

1344* / 2088* Test stop in progress

Alarm scan	After selection of at least one safety function
Effect	Alarm is displayed
Explanation	A function check is currently being carried out on the disable path through setting of the "Test stop selection" SGE.
Remedy	No remedial action need be taken. The message merely informs the user that a check is in progress. The alarm automatically disappears when the delay time defined in MD: 4272*: (Time for testing pulse disable) has expired and when the control detects pulse disabling, i.e. the test has been successful (a failed test is indicated by alarm 27001 with error code 1005 or alarm 27024).

1348* / 2089* Stop E activated RESET

Alarm scan	After selection of SG, SE
Effect	NC START is locked out Initiation of ESR Activation of SBH Follow-up mode for all axes in this mode group Cancellation of mode group ready signal Interruption in machining operation
Explanation	This alarm is displayed at the same time as alarms "Safe speed exceeded" or "Safe limit position crossed" (when stop reactions are appropriately configured in MD 4508* bits 5 and 4 or 4508* bits 3 and 2). It indicates that a configured ESR has been initiated and that SBH mode has been internally activated.
Remedy	Eliminate causes for "Safe speed exceeded" or "Safe limit position crossed" (see description of alarms).
To continue program	Clear the error and press the RESET key (the program is aborted and must be restarted).

1352* / 2090* Stop D activated RESET

Alarm scan	After selection of SG, SE
Effect	NC START is locked out Axis is braked along path Activation of SBH Interruption in machining operation
Explanation	This alarm is displayed at the same time as alarms "Safe speed exceeded" or "Safe limit position crossed" (when stop reactions are appropriately configured in MD 4508* bits 5 and 4 or 4508* bits 3 and 2). It indicates that a configured ESR has been initiated and that SBH mode has been internally activated.
Remedy	Eliminate causes for "Safe speed exceeded" or "Safe limit position crossed" (see description of alarms).
To continue program	Clear the error and press the RESET key (the program is aborted and must be restarted).

1356* / 2091* Stop C activated RESET

Alarm scan	After selection of SG, SE
Effect	NC START is locked out Follow-up mode for all axes in this mode group Cancellation of mode group ready signal Interruption in machining operation
Explanation	This alarm is displayed at the same time as alarms "Safe speed exceeded" or "Safe limit position crossed" (when stop reactions are appropriately configured in MD 4508* bits 5 and 4 or 4508* bits 3 and 2). It indicates that "Braking along the path" has been initiated and that SBH mode has been internally activated.
Remedy	Eliminate causes for "Safe speed exceeded" or "Safe limit position crossed" (see description of alarms).
To continue program	Clear the error and press the RESET key (the program is aborted and must be restarted).

1360* / 2092* Stop B activated POWER ON

Alarm scan	After selection of SBH After initiation of STOP C, D, E After initiation of STOP F with activated SBH/SG or SE, SN
Effect	NC START is locked out Follow-up mode for all axes in this mode group Cancellation of mode group ready signal Interruption in machining operation Pulse disabling after timer expiry (SGA)
Explanation	This alarm is output at the same time as alarms "Tolerance for safe operational stop exceeded" or "STOP F activated". It indicates that "Braking along current limit" has been initiated and that the timer for switchover to STOP A (see MD 4268*: (Delay time pulse disable)) has been internally activated
Remedy	Eliminate causes for "Tolerance for safe operational stop exceeded" or "STOP F activated" (see description of alarms).
To continue program	Program cannot be continued. Alarm can only be acknowledged by means of POWER ON.

1364* / 2093* Stop A activated POWER ON

Alarm scan	After selection of SBH After initiation of STOP B
Effect	NC START is locked out Cancellation of mode group ready signal Interruption in machining operation Instantaneous pulse disabling (SGA)
Explanation	This alarm is output at the same time as alarms "Tolerance for safe operational stop exceeded" or after a STOP B reaction or a failed test stop. It indicates the "pulse disabling" has been activated.
Remedy	Eliminate causes for "Tolerance for safe operational stop exceeded" or "STOP F activated" (see description of alarms).
To continue program	Program cannot be continued. Alarm can only be acknowledged by means of POWER ON.

300xxx SIMODRIVE 611D alarms

Explanation	Alarms with the **Number 300xxx** can be generated by the drive and are described in Section 6.3 SOMODRIVE 611D alarms.

6.3 SIMODRIVE 611D alarms

Alarms for SINUMERIK Safety Integrated

Alarms that may occur in connection with SINUMERIK Safety Integrated are listed below.

300500 System error drive POWER ON

Alarm scan: In the appropriate clock cycle
Effect: On FDD: Generator-mode stop (equivalent to STOP B)
On MSD: Pulse and controller disable (equivalent to STOP A)
Explanation: This error occurs if the computing time available in the drive processor is not sufficient to process SI functions in the cycle specified in the additional info.

Error No.	Additional info	Explanation
...		
On 840D: 03 On 840C: F003	40	Monitoring cycle for SINUMERIK Safety Integrated too short
...		

Remedy: Increase the relevant cycle or subordinate cycle (e.g. current-control, speed-control or position-control cycle) or deselect any functions that are not required.

300743 Function not available with this 611D control module POWER ON

Alarm scan: During control system power-up.
Effect: Power-up process is interrupted, pulses remain disabled.
Explanation: The SINUMERIK Safety Integrated option can only be used in conjunction with 611D performance closed-loop control modules (see Section 2.6 System requirements). This alarm is activated if the appropriate hardware is not installed.
It is also output if motor types 1PH2/4/6 are connected and no 611D performance closed-loop control module is installed.
Remedy: Replace the 611D control module by the required module type.

300744 Checksum error safety monitors POWER ON

Alarm scan: During control system power-up.
Effect: Power-up process is interrupted, pulses remain disabled.
Explanation: The checksum of the safe-relevant machine data calculated by the drive and stored in MD 1398: $MD_SAFE_ACT_CHECKSUM is not the same as the setpoint checksum that was stored in MD 1399: $MD_SAFE_DES_CHECKSUM during the most recent machine acceptance test. The safety-relevant data have been changed or an error has occurred.
Remedy: Check all safety-relevant MDs and correct if necessary. Then execute a POWER ON. Carry out an acceptance test on the machine.

300745 Incorrect limit settings for safe limit positions

POWER ON

Alarm scan	During control system power-up.
Effect	Power-up process is interrupted, pulses remain disabled.
Explanation	The data for the upper limit for the SE monitor contains a lower value than the data for the lower limit.
Remedy	Check and alter the MDs MD 1334: $MD_SAFE_POS_LIMIT_PLUS[n] Upper limit value for safe limit position and MD 1335: $MD_SAFE_POS_LIMIT_MINUS[n] Lower limit value for safe limit position so that the upper limit value is higher than the lower limit value.

300746 SBH/SG function not enabled

POWER ON

Alarm scan	During control system power-up.
Effect	Power-up process is interrupted, pulses remain disabled.
Explanation	The SBH/SG function is not enabled in MD 1301: $MD_SAFE_FUNCTION_ENABLE (see Section 4.3 Machine data for SIMODRIVE 611D) although the SE/SN function is selected in the MD.
Remedy	Enable the SBH/SG function via MD 1301: $MD_SAFE_FUNCTION_ENABLE.

300747 Monitoring cycle MD 1300 invalid

POWER ON

Alarm scan	During control system power-up.
Effect	Power-up process is interrupted, pulses remain disabled.
Explanation	MD 1300: $MD_SAFETY_CYCLE_TIME has not been set to a multiple of the NC position control cycle.
Remedy	Set the monitoring cycle in MD 1300: $MD_SAFETY_CYCLE_TIME to n * NC position control cycle,. Note that n must be $\geq$ 1.

300748 Monitoring cycle not identical for both axes

POWER ON

Alarm scan	During control system power-up.
Effect	Power-up process is interrupted, pulses remain disabled.
Explanation	The monitoring cycle for the two axes of a 2-axis module has not been set to the same value.
Remedy	Set MD 1300: $MD_SAFETY_CYCLE_TIME to the same value on all drives of the module.

300749 Conversion factor between motor and load too large POWER ON

Alarm scan: During control system power-up.

Effect: Power-up process is interrupted, pulses remain disabled.

Explanation: The conversion factor from motor system [increments] to load system [µm/m°] is greater than 1 or the factor that converts the load system to the motor system is greater than 65535.

Conditions: The condition governing the load to motor system conversion factor is:
µm_to_incr ≤ 65535
The condition governing the motor to load system conversion factor is:
incr_to_µm ≤ 1

with $\mu m\_to\_incr = \frac{1}{incr\_to\_\mu m}$

Formula for rotary axis: With a rotary motor encoder and a rotary axis, the following applies:

$$incr\_to\_\mu m(n) = \frac{MD1321{:}\$MD\_SAFE\_ENC\_GEAR\_DENOM(n)}{MD1322{:}\$MD\_SAFE\_ENC\_NUMERA(n)} * incr\_to\_\mu m\_rot\_rot$$

with n = 0 ... 7 (gear stage) and

$$incr\_to\_\mu m\_rot\_rot = \frac{360000}{8192} * \frac{1}{MD1318{:}\$MD\_SAFE\_ENC\_RESOL}$$

Formula for linear axis: With a rotary motor encoder and a linear axis, the following applies:

$$incr\_to\_\mu m(n) = \frac{MD1321{:}\$MD\_SAFE\_ENC\_GEAR\_DENOM(n)}{MD1322{:}\$MD\_SAFE\_ENC\_NUMERA(n)} * incr\_to\_\mu m\_rot\_lin$$

with n = 0 ... 7 (gear stage) and

$$incr\_to\_\mu m\_rot\_lin = \frac{1000}{8192} * \frac{1}{MD1318{:}\$MD\_SAFE\_ENC\_RESOL} * MD1320{:}\$MD\_SAFE\_ENC\_GEAR\_PITCH$$

Remedy: Check the following safety-relevant MDs in relation to the motor encoder type or axis type and correct them if necessary.

- MD 1317: $MD_SAFE_ENC_GRID_POINT_DIST
  Grid spacing linear scale (for a linear encoder)
- MD 1318: $MD_SAFE_ENC_RESOL
  Encoder marks per revolution (for a rotary encoder)
  MD 1318: $MD_SAFE_ENC_RESOL
  MD 1320: $MD_SAFE_ENC_GEAR_PITCH
  (for a rotary encoder and linear axis)
- MD 1321: $MD_SAFE_ENC_GEAR_DENOM
  MD 1322: $MD_SAFE_ENC_GEAR_NUMERA
  (when gearbox is used)

The motor encoder type or axis type is defined in MD 1302: $MD_SAFE_IS_ROT_AX.

300776 Measuring circuit monitor motor (incremental) inactive RESET

Alarm scan: During control system power-up and cyclically

Effect: On FDD: Controllers are disabled, motor are braked, SIMODRIVE_READY and DRIVE_READY are cancelled
On MSD:
Pulses are disabled, motor coasts to a standstill, SIMODRIVE_READY and DRIVE_READY are cancelled
Note: The reaction (FDD, MSD) can be configured via 611D MD 1613.0.

Explanation: When the Safety Integrated option is active (MD 1301 ≠ 0), the measuring circuit motor (incremental) must be activated via 611D MD 1600.4.

Remedy: Activate the measuring circuit monitor motor (incremental).

300900 Stop A activated POWER ON

Alarm scan: In monitoring cycle.

Effect: The drive is brought to a stop by means of STOP A, the drive pulses are disabled simultaneously via the relay "Drive_IMP“.

Explanation: There are various reasons for the initiation of a STOP A reaction:

1. The timer in MD 1356: $MD_SAFE_PULSE_DISABLE_DELAY (see Section 4.3 Machine data for SIMODRIVE 611D) for STOP B has expired.
2. The actual speed has dropped below the speed threshold in MD 1360: $MD_SAFE_STANDSTILL_VELO_TOL (see Section 4.3 Machine data for SIMODRIVE 611D) for STOP B.
3. The user has requested a disable path test by means of the SGE "Test stop selection", but the pulses have still not been disabled after expiry of the timer set in MD 1357: $MD_SAFE_PULSE_DIS_CHECK_TIME.
4. The safe braking ramp function (SBR) has responded.
5. The “SG-specific stop reaction” is set to STOP A and has responded.

Remedy: The user must identify the proper cause and take appropriate measures.

300901 Stop B activated POWER ON

Alarm scan: In monitoring cycle

Effect: The drive is stopped by means of a STOP B reaction, the pulses are then disabled via the relay "Drive_IMP“.

Explanation: There are several reasons why a STOP B reaction may be initiated:

1. The safe operational stop window has been violated.
2. Called after STOP F, i.e. an error has been detected during the cross-check process.
3. The “SG-specific stop reaction” is set to STOP B and has responded.

Remedy: The user must identify the proper cause and take appropriate measures.

300906 Axis %1, drive %1 Safe braking ramp exceeded POWER ON

Alarm scan: In monitoring cycle

Effect: The drive is stopped by a STOP A.

Explanation: The actual speed of the axis has not decreased on braking with “$n_{set} = 0$“, but has increased again to the corrected speed limit.

Remedy: Check braking characteristics and adjust speed tolerance (MD 36948/1348, MD 4296*/1348) if necessary.
The system can only be restarted by POWER ON.

300907 Tolerance for safe operational stop exceeded POWER ON

Alarm scan: In monitoring cycle

Effect: The drive is stopped by means of a STOP A or STOP B reaction (depending on MD 1356: $MD_PULSE_DISABLE_DELAY). The drive pulses are disabled via the relay "Drive_IMP" at the same time.

Explanation: The deviation between the actual position and the setpoint/standstill position is too large (outside standstill tolerance window). The standstill window is parameterized in MD 1330: $MD_SAFE_STANDSTILL_TOL.

Remedy: The user must identify the proper cause and take appropriate measures.

300908 Stop C activated RESET

Alarm scan: In monitoring cycle

Effect: The drive is brought to a stop by means of a STOP C reaction. On completion of the stop sequence, the drive remains under closed-loop control while the axis is monitored for SBH.

Explanation: There may be various reasons (depending on configuration) for the activation of a STOP C:

1. The safe velocity monitoring has been
   (MD 1361: $MD_SAFE_VELO_STOP_MODE) or
   MD 1363: $MD_SAFE_VELO_STOP_REACTION (840D from SW 4.2)).
2. The safe limit position monitoring has been activated
   (MD 1362: $MD_SAFE_POS_STOP_MODE).

Remedy: The user must identify the proper cause and take appropriate measures.

300909 Stop D activated RESET

Alarm scan: In monitoring cycle

Effect: The drive is stopped by the NC and a STOP D reaction. On completion of the stop sequence, the drive remains under closed-loop control while the axis is monitored for SBH.

Explanation: There may be various reasons (depending on configuration) for the activation of a STOP D:

1. The safe velocity monitoring has been
   (MD 1361: $MD_SAFE_VELO_STOP_MODE) or
   MD 1363: $MD_SAFE_VELO_STOP_REACTION (840D from SW 4.2)).
2. The safe limit position monitoring has been activated
   (MD 1362: $MD_SAFE_POS_STOP_MODE).

Remedy: The user must identify the proper cause and take appropriate measures.

300910 Stop E activated RESET

Alarm scan: In monitoring cycle

Effect: The drive is stopped by the NC and a STOP E reaction. On completion of the stop sequence, the drive remains under closed-loop control while the axis is monitored for SBH.

Explanation: There may be various reasons (depending on configuration) for the activation of a STOP E:

1. The safe speed monitor has been
   (MD 1361: $MD_SAFE_VELO_STOP_MODE).
2. The safe limit position monitor has been activated
   (MD 1362: $MD_SAFE_POS_STOP_MODE).

Remedy: The user must identify the proper cause and take appropriate measures.

300911 Defect in a monitoring channel

RESET

Alarm scan	In monitoring cycle
Effect	If there are no Safety Integrated monitoring functions active, then STOP F does not initiate a braking process, but only displays the message "Defect in a monitoring channel". If, on the other hand, SBH/SG, SE or SN are active, then the drive is stopped by means of stop reactions STOP A/B.
Explanation	A difference has been found during the cross-check of data and results between the NC and drive. A STOP F reaction has therefore been initiated.
Remedy	Find the difference between the monitoring channels. The error code indicating the error cause is displayed as follows: On 840D Is output with the alarm text On 840C MD 301: Diagnosis for STOP F On 611D MD 1395: $MD_SAFE_STOP_F_DIAGNOSIS The meaning of the error code can be found in Table 6-1 Error code for STOP F on 840D/611D or in Table 6-2 Error code for STOP F on 840C/611D. The safety-relevant machine data might not be identical (re-load if necessary) or the SGEs (safety-relevant input signals) might not be at the same level (measure again or check in SI service display). If the error is not caused by one of the above, there may be a CPU error, e.g. a "toggled memory cell". This type of error may be temporary (eliminate by a POWER ON) or permanent (appears again after POWER ON, replace hardware).

300914 Safe speed exceeded RESET

Alarm scan	In monitoring cycle
Effect	The drive is stopped by the stop reaction configured in MD 1361: $MD_SAFE_VELO_STOP_MODE or MD 1363: $MD_SAFE_VELO_STOP_REACTION (840D from SW 4.2). On completion of the stop sequence, the drive remains under closed-loop control while the axis is monitored for SBH.
Explanation	The axis has moved quicker than specified in MD 1331: $MD_SAFE_VELO_LIMIT[n], i.e. the axis has exceeded the permissible speed limit value.
Remedy	The user must identify the proper cause and take appropriate measures.

300915 Safe limit position crossed RESET

Alarm scan	In monitoring cycle
Effect	The drive is stopped by the stop reaction configured in MD 1362: $MD_SAFE_POS_STOP_MODE. On completion of the stop sequence, the drive remains under closed-loop control while the axis is monitored for SBH.
Explanation	The axis has traversed beyond the safe limit position defined in MD 1334: $MD_SAFE_POS_LIMIT_PLUS[n] and MD 1335: $MD_SAFE_POS_LIMIT_MINUS[n].
Remedy	Check the input value of the machine data. Check the SGEs: Of the 2 available limit positions, was the correct limit position selected? If the MDs and SGEs are correct, check machine for damage and repair if necessary.

300950 Axis is not safely referenced

Alarm scan: In monitoring cycle

Effect: No stop reaction is initiated. When the functions SN/SE are enabled, the message remains active until the axis has reached the "Axis safely referenced" state.

Explanation: 1.) The axis is not referenced or
2.) No user agreement has been given for this axis or it has been cancelled again. This may occur, for example, if the axis is moved after the machine has been switched off with the result that the zero-speed position stored prior to POWER OFF is no longer applicable.
This message requests the user to confirm the current actual position. The user must therefore determine the position beforehand, for example, using one of the following methods:
1. Measure the position
2. Traverse axis to a known position

Remedy: If the axis cannot be automatically referenced in a reliable manner, then the user must enter "user agreement" for the new position by a softkey input. The user agreement confirms that the above position is a "safe reference", i.e. the axis has now reached the "Axis safely referenced" state.

Warning

If the axis is not yet safely referenced and user agreement has not been given, then the following applies:
- The safe cams are active, but no yet reliable
- The safe limit positions are not yet active

300951 Test stop in progress

Alarm scan: In monitoring cycle

Effect: The drive pulses are disabled.
1. A STOP A reaction is activated if a positive acknowledgement of pulse disabling has not arrived after the delay period configured in MD 1357: $MD_SAFE_PULSE_DIS_CHECK_TIME (Time for testing pulse disable).
2. If disabling of the drive pulses is acknowledged internally in the drive within the configured timer period, then no stop reaction is activated. When the test stop is selected via the SGE "Test stop selection", the message remains active until the test stop is deselected.

Explanation: The user has activated the test stop function by setting the SGE "Test stop selection". If he cancels this SGE, then the message is also deactivated.

Remedy: If a STOP A has been activated, then the drive system can only be restarted by a POWER ON.

301701 Limit value for SG too high POWER ON

Alarm scan: During control system power-up.
Effect: The power-up process is interrupted. The pulses remain disabled.
Explanation: The limit value set for the safe speed is higher than the speed that corresponds to a limit frequency of 200 kHz (300 kHz for 840D from SW 4.2 and for 840C from SW 6.1. The maximum permissible speed that can be monitored by the SG function is calculated as follows:

$$n_{\max}[\frac{rev}{\min}] = \frac{200000[Hz]*60}{No.of\ encoder\ markings}$$

Monitoring condition

$$MD1331:\$MD\_SAFE\_VELO\_LIMIT[n] \le \frac{1}{gear\ ratio}*n_{\max}$$

Remedy: Check input value in machine data MD 1331: $MD_SAFE_VELO_LIMIT[n], correct if necessary and execute a POWER ON.

301706 Axis %1, drive %2 invalid parameterization of cam position POWER ON

Explanation: At least one parameterized cam that is enabled via MD 1301: $MD_SAFE_FUNCTION_ENABLE is failing to comply with the rule that cam positions must not be located within the tolerance range around the modulo position.
The following tolerance ranges apply:

- When cam synchronizaton is not active (MD 1301 bit 7 = 0):

  Lower modulo value + POS_TOL ≤ cam position
  Upper modulo value - POS_TOL > cam position

- When cam synchronization is active (MD 1301 bit 7 = 1):

  Lower modulo value + POS_TOL ≤ cam position
  Upper modulo value - POS_TOL - CAM_TOL > cam position

  Explanations:
  POS_TOL: Actual value tolerance (MD 1342: $MD_SAFE_POS_TOL)
  CAM_TOL: Cam tolerance (MD 1340: $MD_SAFE_CAM_TOL)
  Lower/upper modulo values:
  Defined in MD 1305: $MD_SAFE_MODULO_RANGE

Reaction: Power-up process is aborted. Alarm is displayed. Pulses remain disabled.
Remedy: Check/correct parameter settings of cam positions in MD 1336: $MD_SAFE_CAM_POS_PLUS or MD 1337: $MD_SAFE_CAM_POS_MINUS and execute POWER ON.
Check MD 1305: $MD_SAFE_MODULO_RANGE.

301707 Axis %1, drive %2 invalid parameterization of modulo value for SN POWER ON

Explanation: The cam modulo range parameterized in MD 1305: $MD_SAFE_MODULO_RANGE for a rotary axis is failing to comply with the rule that only multiple integers of 360 degrees may be set for this range.
Reaction: An alarm is displayed. Pulses are disabled. NC START is disabled. Display at NC/PLC interface. Mode group and channel are in “Not ready” state.
Remedy: Alter parameter settings for cam modulo range in MD 1305: $MD_SAFE_MODULO_RANGE.
To continue program: The alarm is output during power-up. It must be acknowledged by a POWER ON.

301708 Actual value synchronization not permitted (from SW 6.3) POWER ON

Effect: The runup process is interrupted. The pulses remain disabled.

Explanation: $MD_SAFE_FUNCTION_ENABLE (safe function enable) is selected. This is only permitted for SBH/SG monitoring, as the absolute actual position is not important for these types of monitoring. However, at least one additonal monitoring function with required absolute reference SE/SN is selected.

Remedy: Deselect the actual value synchronization for drift/slip or the safe limit position monitoring and/or the safe cam monitoring in MD 1301: $MD_SAFE_FUNCTION_ENABLE (safe function enable).

■

Configuring Example

7

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7.1 General information about configuring

Please refer to the information in the following references for instructions on how to interconnect the SINUMERIK 840D/840C and SIMODRIVE 611D systems:

References for SINUMERIK 840D

References: /HBD/, NCU Manual
/IAD/, Installation and Start-Up Guide
/LID/, Lists

References for SINUMERIK 840C

References: /NAC/, Interface Description, Part 2: Connection Conditions
/IAC/, Installation and Start-Up Guide, Instructions
/LIC/, Installation and Start-Up Guide, Lists

References for SIMODRIVE 611

References: /PJ1/, SIMODRIVE 611, Configuring Guide for Inverters
/PJ2/, SIMODRIVE, Configuring Guide for Three-Phase AC Motors

References for switchgear

References: /ASI/, Low-Voltage Switchgear and Systems, Catalog 1995/1996

Note

- The EMERGENCY STOP function is not replaced by SINUMERIK Safety Integrated, i.e. the EMERGENCY STOP function must be implemented as in systems without SI functions.
- Please note that the wiring options for the incoming mains supply unit are not restricted in any way by the SINUMERIK Safety Integrated option. For example, three-wire or six-wire mains connections, star-delta operation and operation under power failure conditions can still be implemented as before.

Some basic configuring information

The following basic configuring options are available:

- SG/SBH active in all operating modes
- SG/SBH deactivated in automatic mode

SG/SBH active in all operating modes

If the safety functions "Safe speed" (SG) and "Safe operational stop" (SBH) are constantly active, then they can also be used in automatic mode to protect the machine (e.g. max. speed of grinding wheel). However, the signal stage of the SGA "SG/SGH" does not change at any time when this method is used. Interlocking devices such as protective doors cannot, therefore, be operated as a function of "SG/SBH active". The timers (delay times) must be adjusted in accordance with the maximum possible speed in this case.

SG/SBH deactivated in automatic mode

With this method, an interlock can be switched as a function of "SG/SBH active". The protective door can only be opened if it is monitored by a safety function. The functions SE and SN remain active.

7.2 Example circuits for Safety Integrated

General information

The circuit shown below is an example of a drive with an incremental measuring system. It is provided to illustrate the principle of how a safety zone on a machine can be monitored.

The following functions are implemented with Safety Integrated in the example:

- Monitoring of drive with opened protective door
- Monitoring of drive for a speed limit value with open protective door and actuated enabling key
- Testing of disable paths

Note

- This basic circuit must be adapted to the various safety zones (if applicable) and the number of axes according to the machine configuration.
- SINUMERIK Safety Integrated functions are used to monitor the drives for standstill or speed and to stop them in the event of an error.

Relationship between individual diagrams

The example circuit is divided into various individual diagrams that represent in total a functionally cohesive wiring arrangement.

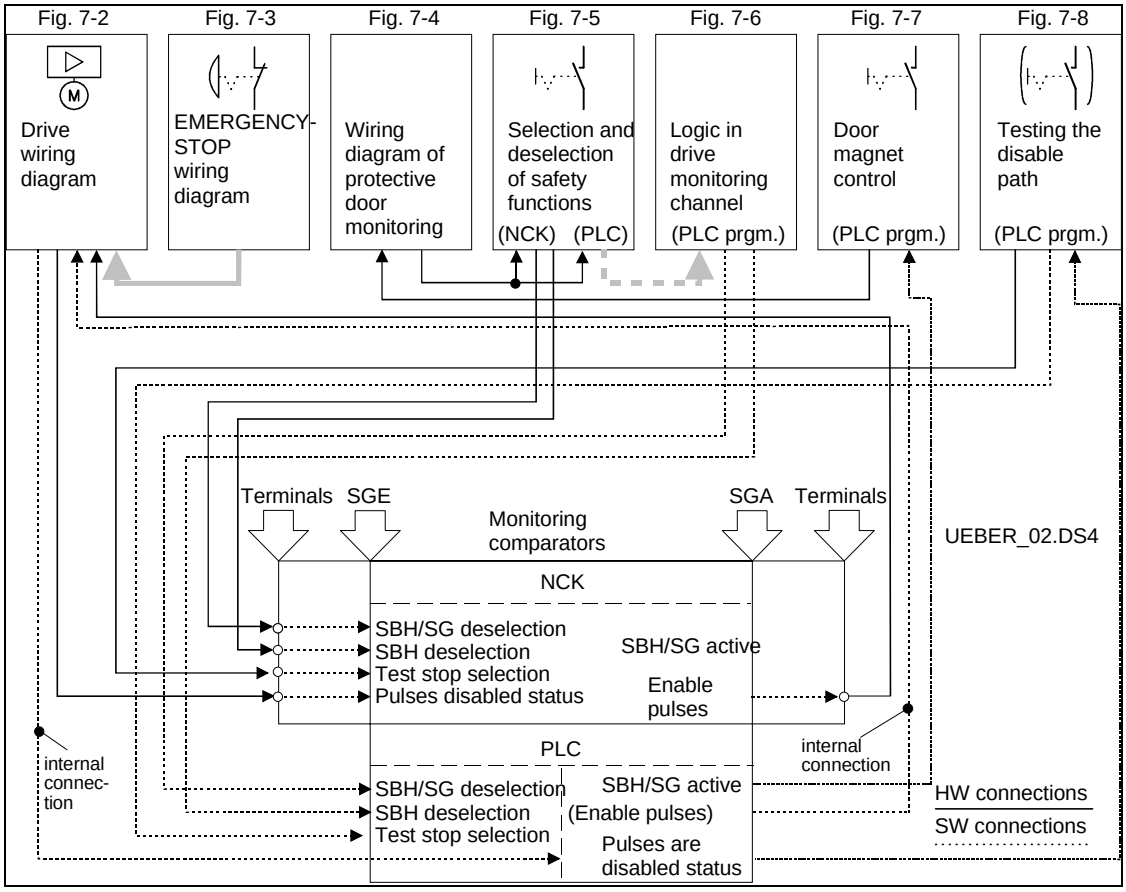

Fig. 7-1 Overview of individual diagrams in configuring example

7.2.1 Drive wiring

Description

The mains incoming supply module (NE module) is connected to the line via a three-wire connection. The line contactor integrated in the NE module is used to isolate the drives from the mains supply (an external line contactor is therefore not needed. The function at terminal 112 (setup mode) is no longer needed.

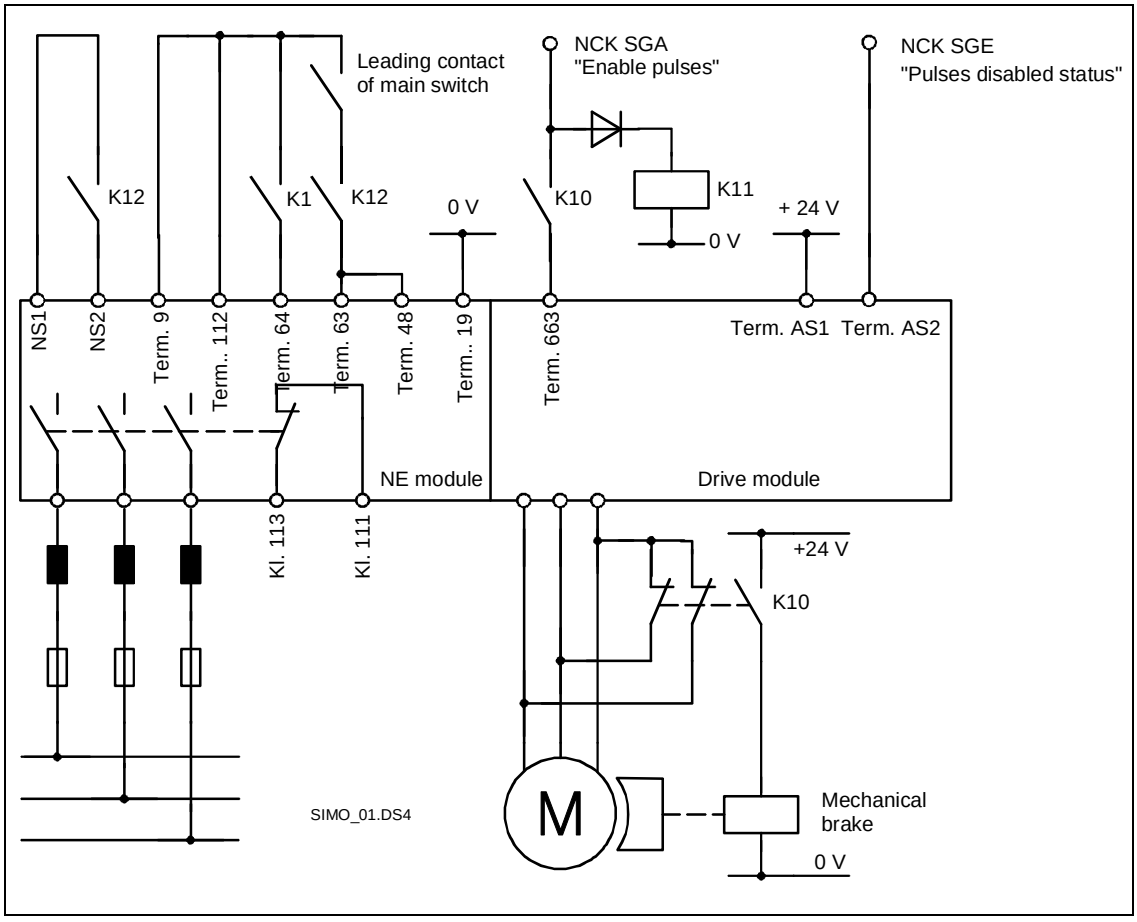

Fig. 7-2 Example of circuit for SIMODRIVE 611D drive

Reference to contactor contacts in other diagrams

K11, NO contact Fig. 7-2 Example of circuit for EMERGENCY STOP function

Note

A holding brake is used additionally for vertical axes.

7.2.2 EMERGENCY STOP function

Description

When an EMERGENCY STOP occurs, all the drives in the drive grouping are shut down via terminal 64 (controller disable) on the mains incoming supply module. The drives brake at maximum current (configurable).

After a certain delay (if, for example, the spindle has also braked and is stationary), the internal line contactor in the NE module is opened via terminal 48 (DIN EN 60204-1). As an additional safety measure to prevent the line contactor from closing again, the connection between terminals NS1, NS2 is opened (see Fig. 7-2 Example of circuit for SIMODRIVE 611D).

If "pulse disabling" is initiated via terminal 663 or terminal 48, the drives are disconnected from the power supply and would "coast" to a standstill if they were still moving. A short-circuit brake (K10 drops out with delay via K11) can be used here to make sure that the drives are stopped safely (applies only to permanent-field motors (e.g. 1FT6 ...), but not to induction motors (e.g. 1PH6 ...)).

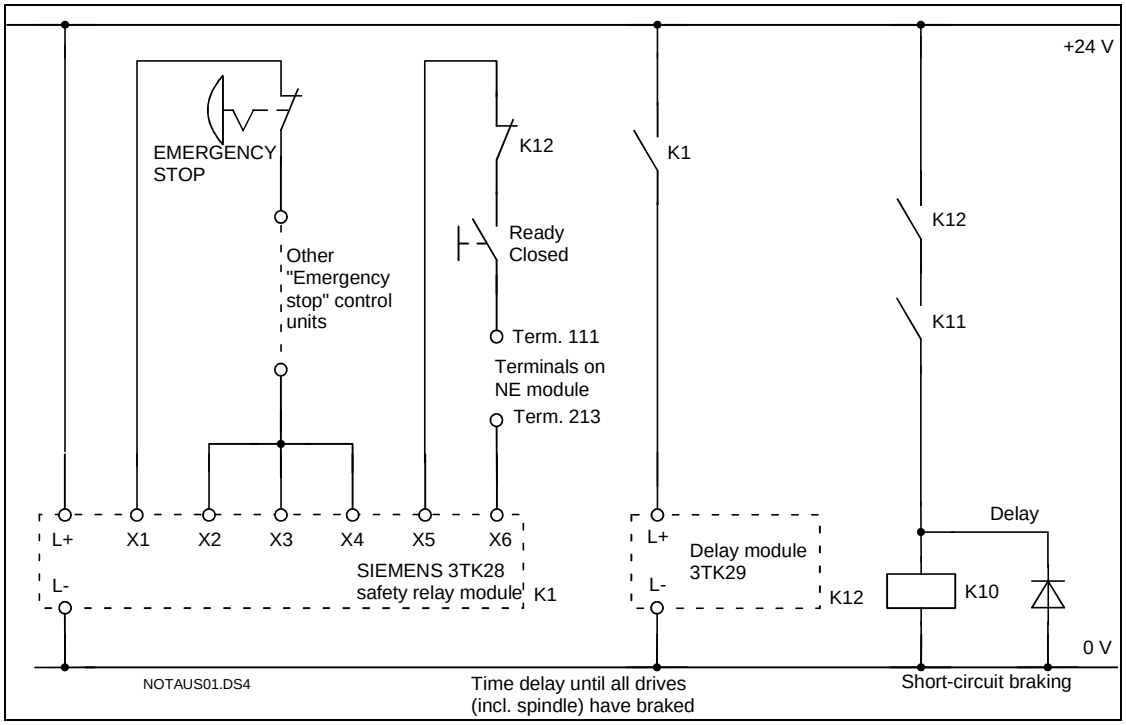

Fig. 7-3 Example of circuit for EMERGENCY STOP function

Reference to contactor contacts in other diagrams

K1, NO contact	Fig. 7-3 Example of circuit for EMERGENCY STOP function
K1, NO contact	Fig. 7-3 Example of circuit for SIMODRIVE 611D
K12, NC contact	Fig. 7-3 Example of circuit for EMERGENCY STOP function
K12, NO contact	Fig. 7-3 Example of circuit for EMERGENCY STOP function
K12, NO contact	Fig. 7-3 Example of circuit for SIMODRIVE 611D
K12, NO contact	Fig. 7-3 Example of circuit for SIMODRIVE 611D
K10, NO contact	Fig. 7-3 Example of circuit for SIMODRIVE 611D

7.2.3 Monitoring of protective door

Description

The following circuit is provided for monitoring the protective door:

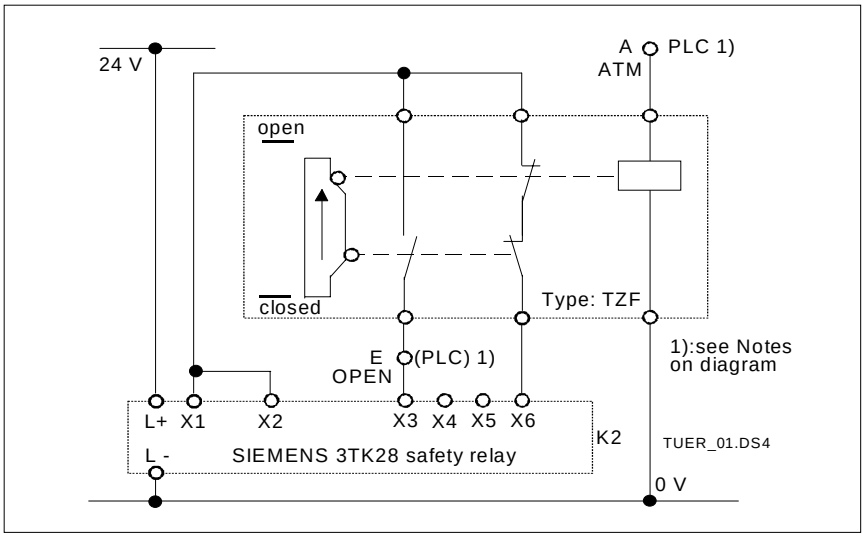

Fig. 7-4 Example of circuit for monitoring of protective door

Notes on diagram

1. The door solenoid is operated via the PLC user program as a function of the SGA "SBH/SG active (see Section 7.2.4 Selection/deselection of safe operation).

We recommend the use of a door release solenoid with a mechanical system (as shown) that drives the contacts of the checkback signals.

The door lock is evaluated as follows: Terminal X3 of the safety relay is activated when the door is open and terminal X6 on the safety relay when the door is closed.

Reference to contactor contacts in other diagrams

K2, NO contact	Fig. 7-5 Selection and deselection of safety functions
K2, NO contact	Fig. 7-5 Selection and deselection of safety functions

7.2.4 Selection/deselection of safe operation

Description

"Safe operation" for operating modes "Setup" and "Testing" means the following: The drives are monitored for standstill. When safe operation is selected, the SGA "SBH/SG active" is output. This SGA operates the door release solenoid and the door can therefore be opened. The example circuit shown below has a two-channel structure. Both channels are identical functionally. The NCK monitoring channel has a hardware construction based on contactors. Contactor 31 selects safe operation. Contactor K33 is activated to deselect safe operation.

The drive monitoring channel is constructed in the software on the basis of a PLC user program (the switch terminals are wired to PLC inputs).

Note

Any deviation between the two channels (NCK and drive) is detected by the data and result cross-check. This system responds accordingly if an error is found.

Selection of safe operation

The preconditions for the selection of safe operation are as follows:

- The drives must be stationary
- The user must have specified the machine operating mode (e.g. "Setup") in which the protective door can be opened
- The key "Selection of safety operation" must have been actuated
- The disable path must have been tested within the last 8 hours. If not, the user must carry out this test before selecting safety operation (see Section 7.2.5 Testing the pulse disable path).

Enabling key

SINUMERIK Safety Integrated offers a simple solution for operating modes that are required to have an enabling key by the state of the art. The enabling key influences the SGE "SBH deselection“ (see Fig. 7-5 Selection and deselection of safety functions) and can switch over between the SBH and SG modes. When the enabling key is selected, the axis is monitored for the configured safe speed limit (SG). When it is deselected, the axis is monitored for a safe operational stop (SBH) state.

Description

Contactor K31 picks up when the "Select safe operation" key is actuated, thereby causing K33 to drop out. The same function is linked via the PLC for the drive channel.

The state of the door lock is acquired via a safety relay (see Fig. 7-4 Example of circuit for monitoring of protective door). When the door is closed, the contacts of the safety relay are closed, i.e. when the protective door is open or the supply voltage (24 V) is not connected, the SGEs "SBH/SG deselection and "SBH deselection" are not set, thereby resulting in selection of the safety functions.

Deselection of safe operation

In order to deselect safe operation, the protective door must be closed. The user must also confirm that the safety zone is in order. Contactor K33 consequently picks up and the SGEs "SBH/SG deselection" and "SBH deselection"" of the NCK are set. The same link must be implemented for the PLC SGEs (drive monitoring channel) via the PLC user program.

The signal "SBH/SG active" is then reset and the door release solenoid is no longer operated (i.e. the door cannot be opened). The machine can now operate, for example, in automatic mode.

Note

The door locking solenoids are operated from one channel via the PLC because the door lock state is sensed reliably via a two-channel checkback (see safety relay K2). If the door were to be unlocked, the standstill monitor would be selected instantaneously causing an immediate shutdown of the drives.

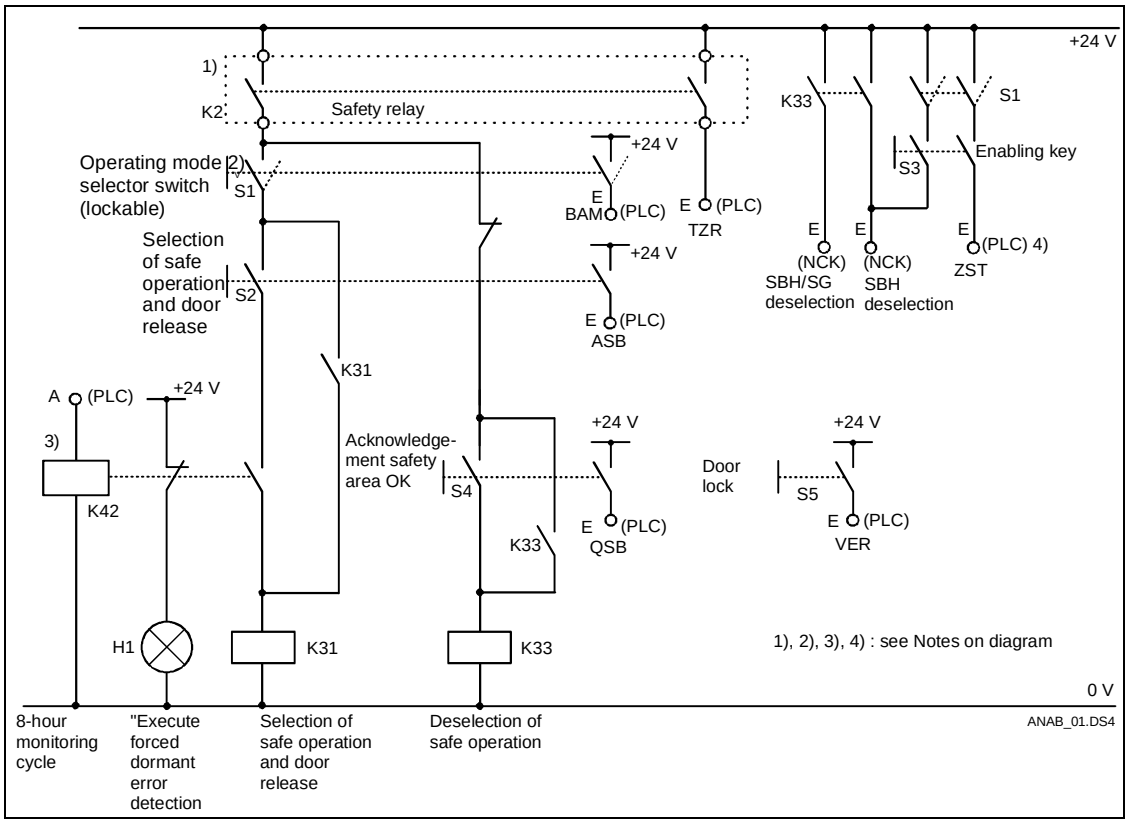

Fig. 7-5 Selection and deselection of safety functions

Notes on the Figure

1. When the protective door is closed, the contacts on the safety relay are closed.
2. It is recommended to link the safety relay to the operating mode selector switch on the machine which must also be protected by SI functions. This ensures that the safety functions and the door release can only be selected in the operating mode selected for this purpose by the user.
3. Explanations, see Section 7.2.5 Testing the pulse disable path.
4. If the enabling circuit is interrupted, then the axis must be stopped (e.g. via NC/PLC interface signal) or else the comparator would respond and initiate a stop reaction on expiry of the delay set in the MD.

Reference to contactor contacts in other diagrams

K42, NO contact Fig. 7-5 Selection and deselection of safety functions

K42, NC contact Fig. 7-5 Selection and deselection of safety functions

K33, NO contact Fig. 7-5 Selection and deselection of safety functions
K33, NC contact Fig. 7-5 Selection and deselection of safety functions

K33, NO contact Fig. 7-5 Selection and deselection of safety functions
K33, NO contact Fig. 7-5 Selection and deselection of safety functions
K33, NO contact Fig. 7-5 Selection and deselection of safety functions

Function block for drive monitoring channel

"Selection and deselection" of safe operation in the drive monitoring channel (PLC) must have an identical functional structure (see Fig. 7-5 Selection and deselection of safety fucntions).

Double contacts are therefore provided for the keys "Selection of safe operation and door release" and "Acknowledge safety zone OK".

A contact of safety relay K2 is also required for evaluation of the protective door status.

The logic in the drive monitoring channel is implemented by means of a block in the PLC user program.
The block requires and processes the following signals:

Table 7-1 Required PLC inputs/outputs

I: Input Q: Output	**Code**	**Switch**	**Meaning**
I	ASB	S2	Selection safety functions and door release
I	QSB	S4	Acknowledge safety zone OK
I	TZR	K2	"Door closed" message from safety relay
I	ZST	S3	Enabling key
I	BAM	S1	Machine operating mode

Table 7-2 Required internal signals (PLC memory bit)

Signals for	**Meaning**
K32	Status depends on contactor K31
K34	Status depends on contactor K33
T1	Status for time monitoring (8 hours, PLC timer, description see Section 7.2.5 Testing the pulse disable path

Table 7-3 Required PLC interface signals

Interface signal		Name
On 840D On 840C	DB 31-48, DBX22.0 DB 28, D2.0, D4.0, etc.	SBH/SG deselection
On 840D On 840C	DB 31-48, DBX22.1 DB 28, D2.1, D4.1, etc.	SBH deselection

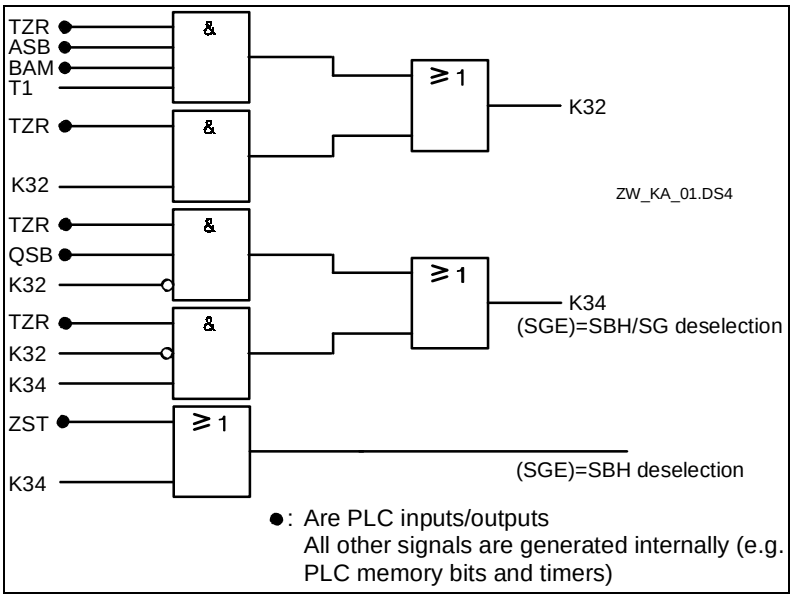

Fig. 7-6 Logic in drive monitoring channel (PLC user program)

Operation of door solenoid

The PLC SGA "SBH/SG active" is evaluated for the purpose of operating the door solenoid (see Fig. 7-5 Selection and deselection of safety functions). This signal is output after safe operation has been selected (see Fig. 7-5 Selection and deselection of safety functions).

In order to deselect safe operation again (e.g. after the protective door has been closed), the contact of safety relay K2 must be closed. However, the contact can only be closed if the door is shut and the release solenoid is de-energized.

The PLC user program shown below shows how a control circuit of this type can be implemented for the door solenoid. The PLC inputs/outputs are shown in Fig. 7-4 Example of circuit monitoring of protective door and Fig. 7-5 Selection and deselection of safety functions.

Table 7-4 Required PLC inputs/outputs

I: Inputs Q: Output	Code	Switch	Meaning
I	VER	S5	"Lock door" signal via key from user
I	AUF	-	"Door open" signal from door monitor
Q	ATM	-	Operation of door solenoid

Table 7-5 Required internal signals (PLC memory bits)

Signals for	Meaning
RSM	Reset door solenoid

Table 7-6 Required PLC interface signals

Interface signal		**Name**
On 840D On 840C	DB 31-48, DBX108.0 DB 28, D0.8, D2.8, etc.	SBH/SG active SBH/SG active

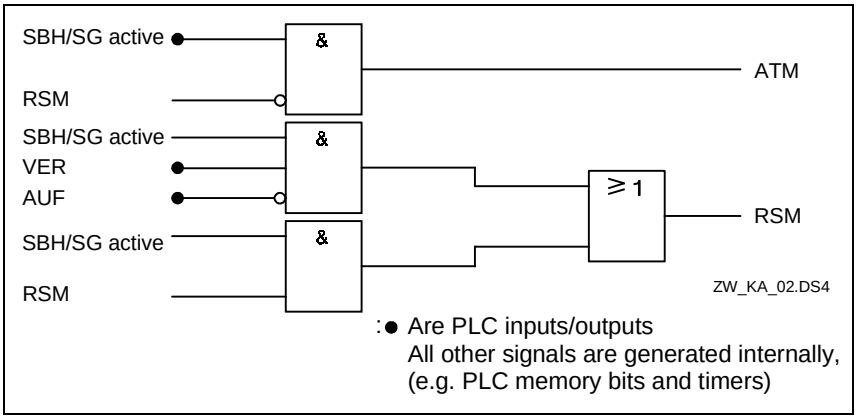

Fig. 7-7 Logic for control of door solenoid

7.2.5 Testing the pulse disable path

Description

The purpose of testing the pulse disable path is to determine when pulse disabling can still be executed correctly via both monitoring channels (see Section 2.5 Safe reaction via pulse disable paths and stops). This test must be carried out every time the machine is switched on and then, for example, repeated every 8 hours if the operator has access to the hazardous area. The test must be carried out separate only the pulse disable path in the NCK and in the drive (PLC). The test can be initiated via a single channel for the NCK and drive (PLC) successively.

The pulse disable path test can be implemented by means of a function block (PLC user program) in the PLC.

Test conditions

- The drives must be at a standstill.
- The SGE "Pulses disabled status" (NCK) and the SGA "Pulses are disabled status" (drive) must not be active.
- The test may only be activated if permitted by the process on the machine (operating mode, no program being processed).

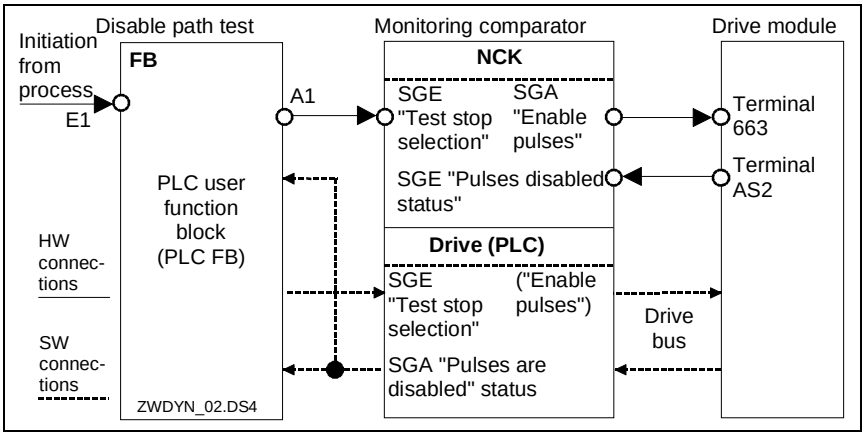

Fig. 7-8 Testing the pulse disable path

Start conditions for FB

The test of the pulse disable path should be initiated through an appropriate link with the process on the machine (PLC user program) (e.g. when a protective door is opened or a tool is changed).

FB structure

- Prevent restarting of this function block (set memory bit).
- Test the pulse disable path of the NCK:
  - Set the signal "Test stop selection" on the NCK.
  - Wait for the checkback via PLC SGE "Pulses are disabled status" (see Notes on structure of FB).
  - Reset the signal "Test stop selection" on the NCK.
  - Wait until the PLC SGE "Pulses are disabled status" disappears.

- Testing the pulse disable path of the drive:
  - Set the signal "Test stop selection" for the drive on the PLC interface.
  - Wait for the checkback via PLC SGE "Pulses are disabled status" (see Notes on structure of FB).
  - Reset the PLC signal "Test stop selection".
  - Wait until the PLC SGE "Pulses are disabled status" disappears.

- Restart the 8-hour monitoring cycle in the PLC (timer T1).
- Enable restarting of this function block (reset memory bit).
- End of function block

Notes on structure of FB

"Pulses disabled status" checkback:

- Disabling of the pulses is fed back by NCK SGE "Pulses disabled status" via terminal AS2 (611D performance closed-loop control module (see Fig. 7-2 Example of circuit for SIMODRIVE 611D).
- Disabling of the pulses via the drive bus is fed back simultaneously by PLC SGA "Pulses are disabled status". This signal can be evaluated by the function block.

Time monitoring

The time monitor T1 that operates in an 8-hour cycle and requests testing of the pulse disable path is implemented via the PLC. The status of the time monitor is signalled to the process via a PLC output and can prevent selection of protective door release via contactor K42 (see Fig. 7-5 Selection and deselection of safety functions).

PLC output = 1 signal: Monitoring timer running.
PLC output = 0 signal: Monitoring timer expired.

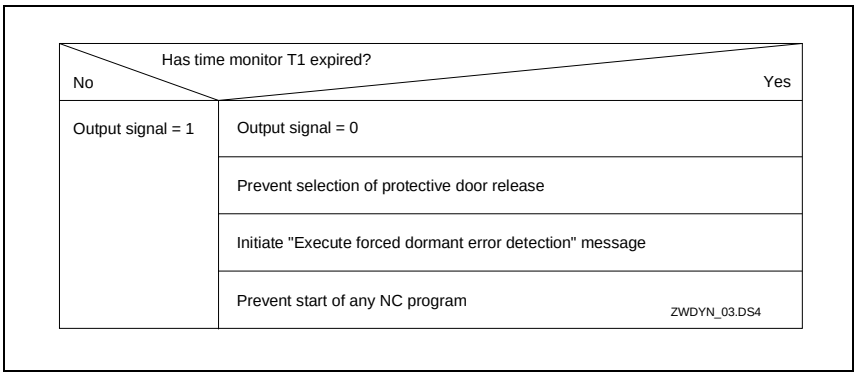

Fig. 7-9 Operating principle of time monitor

The time monitor T1 has expired as a result of the following:

- After the machine is switched on or
- If the pulse disable paths have not been tested for more than 8 hours.

Note

- Expiry of the time monitors is annunciated via a signalling device (the message on the signalling device can also be linked in the PLC to prevent any program from starting in the NC).
- When the time monitors have expired, a protective door cannot be opened until the pulse disable paths have been tested again.

Notes

Appendix

A

A.1 Abbreviations

AS1/AS2	Starting lockout 1/2 (terminals on 611D performance closed-loop control module)
ASIC	Application Specific Integrated Circuit
ASUP	Asynchronous subprogram
BG	Professional association
BIA	Berufsgenossenschaftliches Institut für Arbeitssicherheit (German Institute for Occupational Safety)
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
DAC	Digital/Analog Converter
DI	Digital Input
DKE-AK	German electrotechnical working committee
DL	Data Left
DMP	Distributed Machine I/Os
DMS	Direct Measuring System
DO	Digital Output

DPR	Dual Port RAM
DR	Data Right
DW	Data Word
EM	Encoder Marks (Per Rev)
ENDAT	Encoder Data (interface for absolute encoder)
EQN/ERN	Part of an order code for absolute/incremental encoders made by Heidenhain
ESD	Electrostatic Discharge
ESR	Extended Standstill and Retraction
FDD	Feed Drive
HHU	Hand-Held Unit
HMS	High-Resolution Measuring System
HW	Hardware
I/RF	Infeed/Regenerative Feedback Unit
IB	Input Byte
IMS	Indirect Measuring System
INST-SU	Installation and Start-Up
IPO	Interpolator
IS	Interface Signal
LEC	Leadscrew Error Compensation

LIFTFAST	Rapid Lift Off Contour
LL	Lower Limit
LSB	Least Significant Bit
MD	Machine Data
MDD	Machine Data Dialog
MDIR	Machinery Directive
Mixed I/O	I/O module with analog and digital signals
MLFB	Machine-readable product designation (corresponds to order number)
MMC	Man Machine Communication (operator interface for man-machine communication)
MSB	Most Significant Bit
MSD	Main Spindle Drive
MT	Machine Tool
NC	Numerical Control
NCK	NC Kernel
NCK FB	NC Kernel Function Block
NE	Mains Incoming Supply Module
QB	Output Byte
OI	Operator Interface

OP	Operator Panel
PD	Pulse Disable
PLC	Programmable Logic Controller
PS	Power Supply
RPM	Revolutions per Minute
SBH	Safe Operational Stop
SBR	Safe Braking Ramp
SE	Safe Limit Position
SF	Safety Function
SG	Safe Speed
SGA	Safety-Relevant Outputs
SGE	Safety-Relevant Inputs
SH	Safe Standstill
SI	Safety Integrated
SIZAG	Siemens gear wheel encoder
SK	Softkey
SN	Safe Cams
SO	Safe Operation
SSD	Servo Service Data

STOP A, B, C, D, E, F	Stop Reaction: In the event of a fault, the system reacts depending on the configured STOP reaction
SW	Software
TCP	Tool Center Point
TEA	Testing Data Active
UL	Upper Limit
Ü	Gear Ratio

A.2 List of References

A.2.1 List of references, general

/ASI/ Low-Voltage Switchgear and Systems
Catalog 1995/1996
Siemens Drives and Standard Products
Order No.: E20002-K1002-A101-A6

A.2.2 List of references for SINUMERIK 840D

/DAD/ SINUMERIK FM-NC/SINUMERIK 840D
Diagnostics Guide
Order No.: 6FC5 298-2AA20-0BP1

/HBD/ SINUMERIK 840D
NCU Manual
Order No.: 6FC5 297-2AC10-0BP1

/IAD/ SINUMERIK 840D
Installation and Start-Up Guide
Order No.: 6FC5 297-2AB10-0BP1

/LID/ SINUMERIK 840D
Lists
Order No.: 6FC5 297-2AB70-0BP0

/FBD/ SINUMERIK FM-NC/SINUMERIK 840D
Description of Functions, **Basic Machine** (Part 1),
Order No.: 6FC5 297-2AC20-0BP1

SINUMERIK FM-NC/SINUMERIK 840D
Description of Functions, **Extended Functions** (Part 2),
Order No.: 6FC5 297-2AC30-0BP1

SINUMERIK FM-NC/SINUMERIK 840D
Description of Functions, **Special Functions** (Part 3),
Order No.: 6FC5 297-2AC80-0BP0

/PAD/ SINUMERIK 840D
Programming Guide
Order No.: 6FC5 298-2AB00-0BP1

/S7H/ SIMATIC S7-300
Manual (HW Description)
Order No.: 6ES7030-0AA00-8AA0

A.2.3 List of References for SINUMERIK 840C

/DAC/ SINUMERIK 840C
Diagnostics Guide
Order No.: 6FC5 198-5AB40-0BP0

/NAC/ SINUMERIK 840C
Interface Description, Part 2: Connection Conditions
Order No. 6FC5 197-5AA10-0BP0

/BAC/ SINUMERIK 840C
Operator's Guide
Order No.: 6FC5 198-5AA00-0BP0

/IAC/ SINUMERIK 840C
Installation and Start-Up Guide, Instructions with 611D
Order No.: 6FC5 197-5AA50-0BP1

/LIC/ SINUMERIK 840C
Installation and Start-Up Guide, Lists
Order No.: 6FC5197-5AA60-0BP1

/WDC/ SINUMERIK 840C
Planning Guide PLC 135 WB/WB2/WD
Order No.: 6FC5 197-5AA80-0BP0

A.2.4 List of References for SIMODRIVE 611

/PJ1/ SIMODRIVE 611
Planning Guide
Transistor PWM Inverters for AC Feed Drives and
AC Main Spindle Drives
Order No.: 6SN1197-0AA00-0BP2

/PJ2/ SIMODRIVE
Planning Guide
AC Motors for Feed and Main Spindle Drives
Order No.: 6SN1 197-0AA20-0BP0

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Suggestions

Corrections

For Publication/Manual:

SINUMERIK 840 C/SIMODRIVE 611D

Safety Integrated

Manufacturer Documentation

From

Name:

Company/Department

Address: _____

_____

Telephone: _____ / _____

Telefax: _____ / _____

Description of Functions

Order No.: 6FC5 197-0AC50-0BP0
Edition: 05/99

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