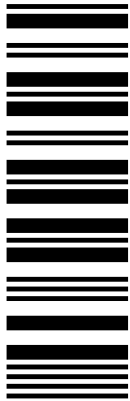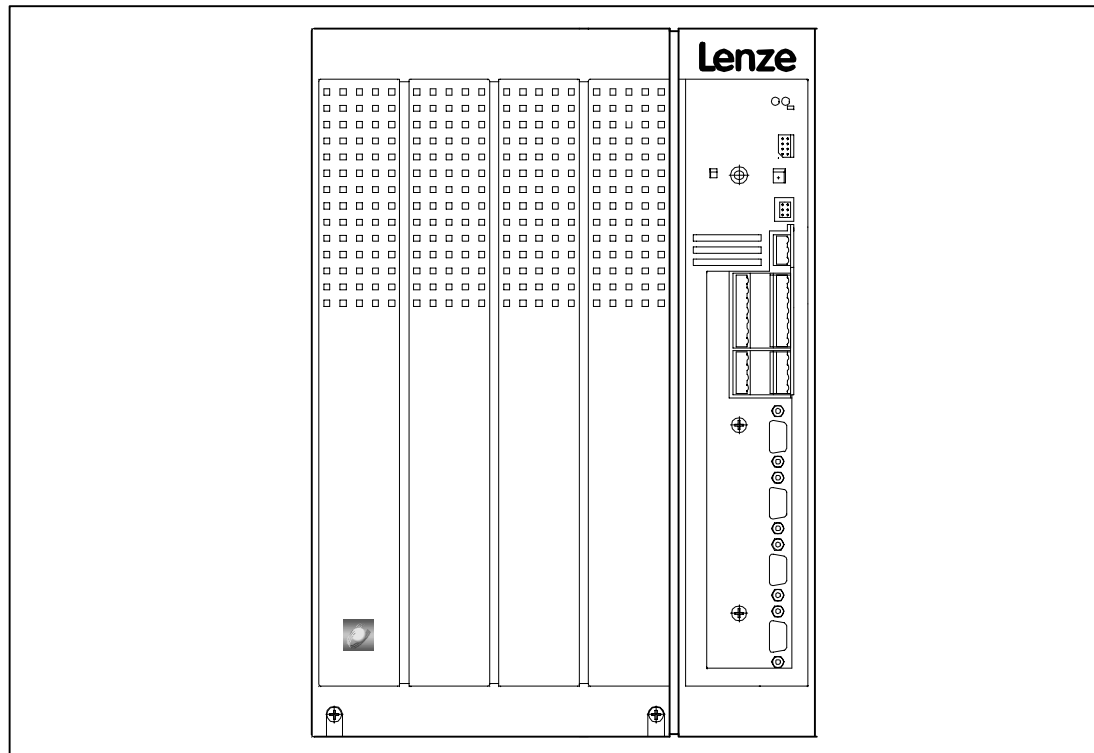# Lenze

Installation
Commissioning

Global Drive

9300 series

Variant V004 - "Safe standstill"

These Instructions are only valid for 93XX controllers with the following nameplates:

EVS93XX-	X	S	V004	9300 servo inverter
EVS93XX-	X	P	V004	9300 servo positioning controller
EVS93XX-	X	CW	V004	9300 servo register controller
EVS93XX-	X	K	V004	9300 cam profiler
EVS93XX-	X	I	V004	9300 servo PLC
EVF93XX-	X	V	V004	9300 vector control

Type

Design:
E = Enclosure IP20
C = Cold Plate

Technology:
I = to IEC 1131
K = Cam profiler
P = Positioning controller
R = Register controller
S = Servo inverter
V = Vector control

Version

Explanation

Version   3.0   12/2001
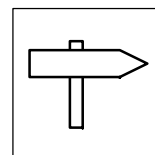
Contents

Contents

1 Preface and general information

1.1 Principle of operation

The V004 variant of the 9300 range of controllers supports the "Safe standstill" safety function and protects against unexpected start-up according to the requirements of EN 954-1 "Control category 3" and EN 1037.

The controllers are therefore equipped with an integrated safety relay with feedback contact. The safety relay isolates the supply voltage of the optocouplers for pulse transmission to the IGBTs. An external +24V DC is required.

This solution offers the following advantages:

- no external motor contactor
- reduced wiring expenses
- saves space
- improved EMC: the motor cable screen must not be interrupted

1.2 About these Instructions

- **These Instructions are only valid together with the Operating Instructions for the corresponding controller. All information given in the Operating Instructions still applies and must be observed.**
- **These Instructions only describe the additional measures to be taken to activate the "Safe standstill" function:**
  – **wiring of the safety relay**
  – **correct sequence for switching the controllers on and off.**
- **All information given in these Instructions must be observed without exception.**

1.3 General safety and application notes for Lenze controllers

(according to Low-Voltage Directive 73/23/EEC)

1. General

Lenze controllers (frequency inverters, servo inverter, DC controllers) can carry a voltage or parts of the controllers can rotate during operation. Surfaces can be hot.

If the required cover is removed, the controllers are used inappropriately or installed or operated incorrectly, severe damage to persons or material assets can occur.

For more information please see the documentation.

All operations concerning transport, installation, and commissioning as well as maintenance must be carried out by qualified, skilled personnel (IEC 364 and CENELEC HD 384 or DIN VDE 0100 and IEC report 664 or DIN VDE 0110 and national regulations for the prevention of accidents must be observed).

According to this basic safety information qualified, skilled personnel are persons who are familiar with the assembly, installation, commissioning, and operation of the product and who have the qualifications necessary for their occupation.

2. Intended use

Drive controllers are components which are designed for the installation into electrical systems or machinery. They are not to be used as domestic appliances, but only for industrial purposes according to EN 61000-3-2. The documentation contains information about the compliance of the limit values to EN 61000-3-2.

When installing controllers into machines, commissioning of the drive controllers (i.e. the starting of operation as directed) is prohibited until it is proven that the machine corresponds to the regulations of the EC Directive 98/37/EG (Machinery Directive); EN 60204 (VDE 0113) must be observed.

Commissioning (i.e. starting of operation as directed) is only allowed when there is compliance with the EMC Directive (89/336/EEC).

The drive controllers meet the requirements of the Low-Voltage Directive 73/23/EEC. The harmonised standards EN 50178/DIN VDE 0160 apply to the controllers.

The technical data as well as the connection conditions can be obtained from the nameplate and the documentation. The instructions given must be strictly observed.

Warning: Controllers are products with restricted availability according to EN 61800-3. These products can cause interferences in residential premises. If controllers are used in residential premises, corresponding measures are required.

3. Transport, storage

The notes on transport, storage and appropriate handling must be observed.

Climatic conditions according to EN 50178 apply.

4. Installation

The controllers must be installed and cooled according to the regulations given in the corresponding Instructions.

Ensure careful handling and avoid mechanical overload. Do not bend any components and do not change the insulation distances during transport and storage. Electronic components and contacts must not be touched.

Controllers contain electrostatically sensitive components which can easily be damaged by inappropriate handling. Do not damage or destroy any electrical components since this could mean hazards for your health!

5. Electrical connection

When working on live controllers, the valid national regulations for the prevention of accidents (e. g. VBG 4) must be observed.

The electrical installation must be carried out in compliance with the corresponding regulations (e.g. cable cross-sections, fuses, PE connection). Additional notes and information can be obtained from the corresponding Instructions.

The Instructions contain notes concerning wiring according to EMC regulations (shielding, earthing, filters and cable routing). These notes must also be observed when using CE-marked controllers. The compliance with limit values required by the EMC legislation is the responsibility of the manufacturer of the machine or system.

6. Operation

If necessary, systems including controllers must be equipped with additional monitoring and protection devices according to the applying safety regulations (e.g. regulation for technical equipment, regulation for the prevention of accidents). The controller can be adapted to your application. Please observe the corresponding information given in the Instructions.

After a controller has been disconnected from the voltage supply, all live components and power connections must not be touched immediately because capacitors can still be charged. Please observe the corresponding stickers on the controller.

All protection covers and doors must be shut during operation.

Note for UL-approved systems with integrated controllers: UL warnings are notes which only apply to UL systems. The Instructions give UL-related information.

7. Safe standstill

The variant V004 of 9300 and 9300 vector, and the variant Bx4x of 8200 vector controllers support the function "Safe standstill", protection against unexpected start, according to the requirements of Annex I No. 1.2.7 of the EC Directive "Machinery" 98/37/EG, DIN EN 954-1 category 3 and DIN EN 1037. Please observe the notes on the function "Safe standstill" given in the corresponding Instructions.

8. Maintenance and service

Please observe the Instructions given by the manufacturer,

and the product-specific safety and application notes in these Instructions.
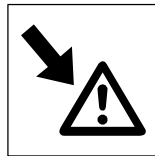
1.4 Additional safety notes for the "Safe standstill" function

- Only qualified personnel are permitted to install and set up the "Safe standstill" function.

- All safety-relevant external cables (e.g. control cable for the safety relay, feedback contact) must be protected, for instance by a cable duct. Short circuits between signal and ground and between signal cables must be avoided.

- In the event of external forces acting on the axis, additional brakes are required. Please take into account the gravitational force on hanging loads!

Warning!

When using the "Safe standstill" function additional measures are required for "Emergency off": Motor and controller are not isolated and not equipped with a 'service switch' or 'repair switch'!

An "Emergency off" requires potential isolation, e.g. by a central mains contactor.

During operation

Safety circuits must be checked after first commissioning and subsequently at regular intervals.

1.5 Residual hazards

In the event of a short circuit of two power transistors, a residual movement of up to 180 °/pole pair number can occur at the motor! (Example: 4-pole motor residual movement max. 180 °/2 = 90 °)

This residual movement must be taken into account for the risk analysis, e.g. safe standstill for main spindle drives.
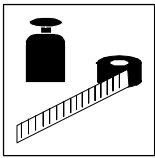
2 Technical data

2.1 Safety relay - Technical data/wiring

The safety relay is connected to the front of the controller by means of the 4-pole plug X11. The safety relay is equipped with a freewheeling diode and a reverse voltage protection diode.
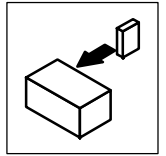
Terminal assignment for plug X11		Data for the safety relay	
		Coil voltage at +20 °C	+24 V DC (+19.5 ... 36.0 V)
		Coil resistance at +20 °C	823 Ω ±10%
		Switching voltage	max. 250 V AC or 200 V DC
		Continuous current at max. permissible ambient temperature (ohmic load)	max. 1.5 A (250 V AC) max. 1.5 A (60 V DC) max. 0.5 A (200 V DC)
		Control voltage - contact $\rightarrow$ coil Control voltage - contact $\rightarrow$ contact	AC 1500 V_{rms} for 1 min AC 1500 V_{rms} for 1 min
Wiring of plug X11		Electrical life time at rated load	$\sim 10^5$ operating cycles
		Mechanical life time	$\sim 10^7$ operating cycles

Wiring of plug X11:

- Max. permissible cable cross-section = 1.5 mm^2
- Screw tightening torque = 0.5...0.6 Nm (4.4...5.3 lbin)

Warning!

The electrical reference point for the the safety relay coil must be connected to the PE conductor system (DIN EN 60204-1 paragraph 9.4.3)!

This is the only way to protect the unit from earth faults.

Lenze

3 Installation

3.1 Circuit for "Safe standstill with safety relay"

The example shows minimum wiring of the components. This ensures the troublefree operation of the "Safe standstill" function of 93XX-V004 controllers.
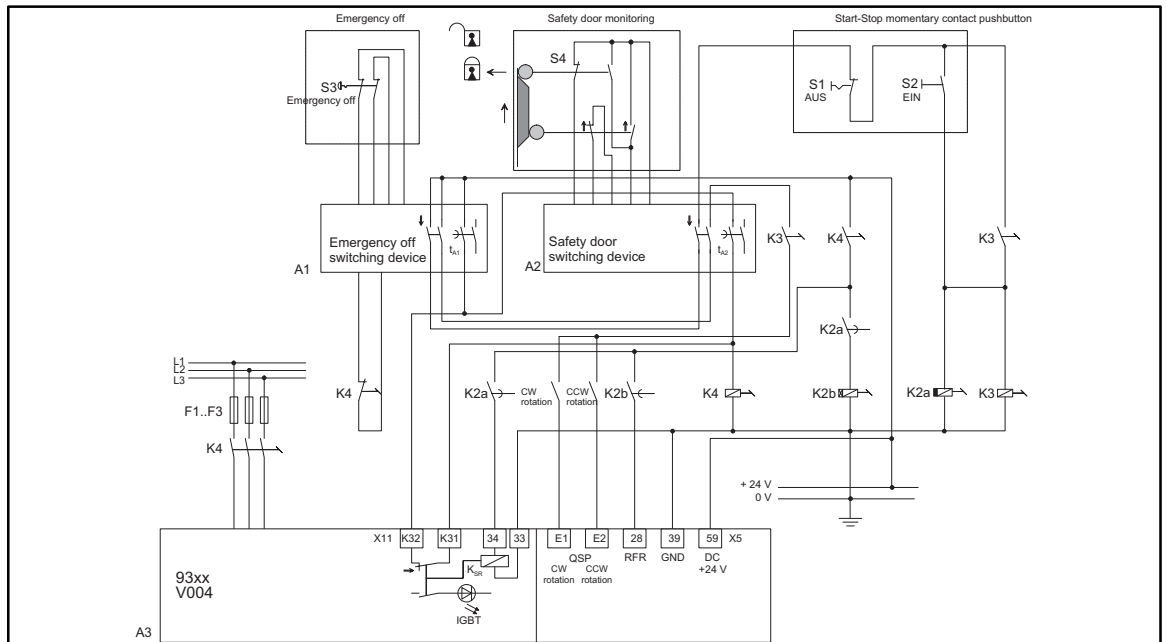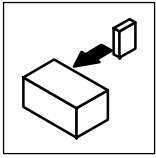

Fig. 1   Minimum wiring for 93XX-V004 controllers with safety relay
to EN 954-1 control category 3 and EN 1037, stop category 1 to EN 60204-1

3.1.1 Description

For a circuit with a safety relay for emergency off and door lock follow EN 954-1 control category 3 and EN 1037. The circuit in Fig. 1 shows a stop function of stop category 1 to EN 60204-1:

- The circuits for emergency off and door locking are two-channel circuits protected against short circuits between signal cables. The integrated switching devices are equipped with positively driven contacts.

- The 24 V DC supply for the start/stop button (S1 "OFF", S2 "ON") flows through the contacts of A1 (emergency off) and A2 (safety door).

- A1 and A2 and the relay K3 have an additive effect on the input "Quick-Stop" (QSP) of the controller (A3) via terminal E1 (CW rotation) and terminal E2 (CCW rotation).

- The appropriate control devices must be integrated to ensure a reversal of the direction of rotation.

- If the safety door is opened during operation, there will be an off-delay on the mains contactor and also the power supply to the controller. This will not occur if the feedback contact K31 - K32 of the safety relay (K_{SR}) indicates activation of the external pulse inhibit via X11 (2nd switch-off circuit).
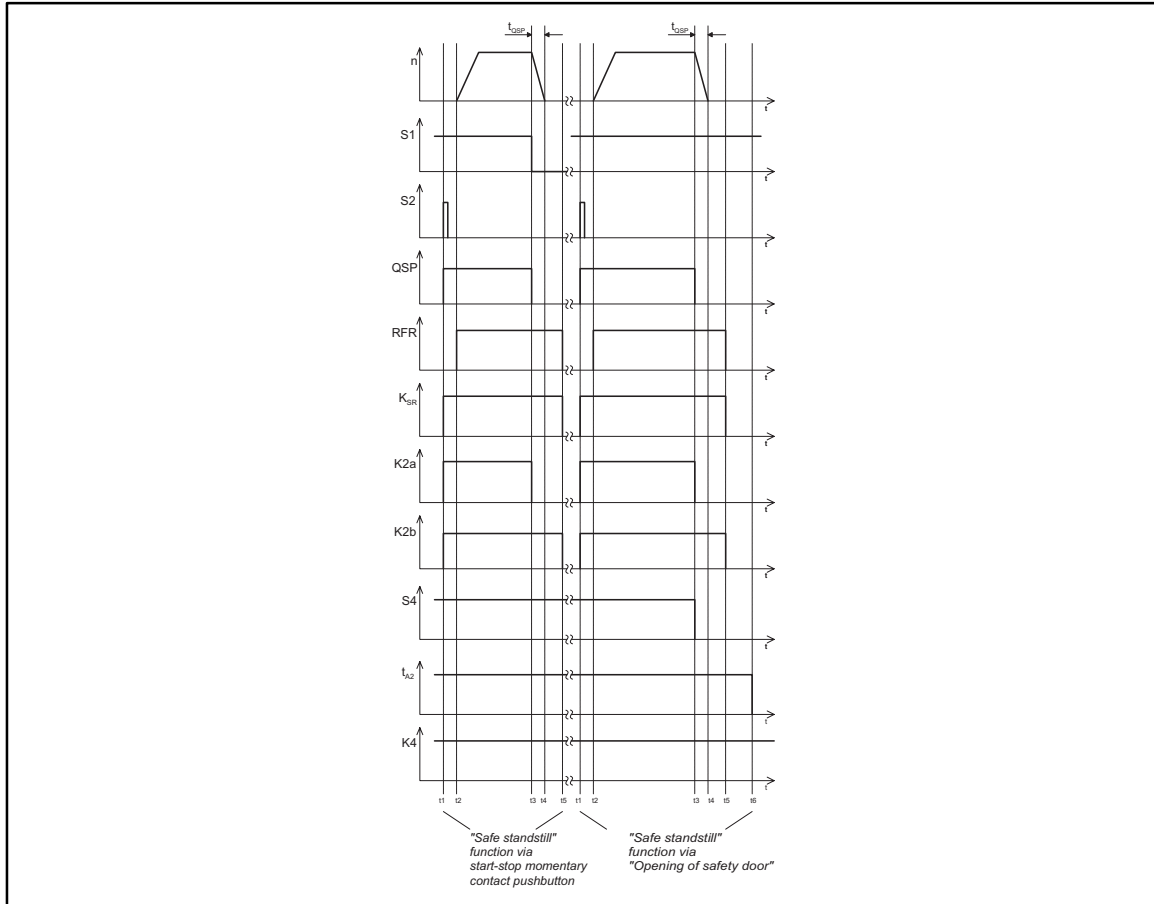
3.1.2 Time chart

Fig. 2   Time characteristic for switching on and off "safe standstill with safety relay"

3.1.3 Time settings

- t1 to t2 $\geq$ 50 msec
  Set the time relay K2b so that the controller is enabled at least 50 ms after K_{SR} has been switched.

- t3 to t4
  t_{QSP} = Time for controller-internal QSP ramp
  The time interval set must ensure that the controller can always be braked to a controlled standstill when running at max. speed (t3 to t4).

- t3 to t5 = t_{QSP} + min. 100 ms (guide value)
  Set the time relay K2a so that t_{QSP} + min. 100 ms safety time will always be achieved. This ensures a controlled standstill according to stop category 1 of EN 60204-1. The controller will only be enabled again (t5) once the motor has been braked to a controlled standstill (t4).

- t3 to t6 = Internal time of A1, A2 (t_{A1}, $t_{A2)}$
  t_{A1} and t_{A2} must be selected to ensure that the controller brakes the motor to standstill along the QSP ramp within T_{QSP} before the power supply is disconnected via the mains contactor (K4) (t6). This will be required if

  – the emergency off button (S3) is pressed during operation.

  – the safety door is opened and the feedback contact of K_{SR} in the controller is not closed because of an error in the drive (t6) (2nd switch-off circuit).
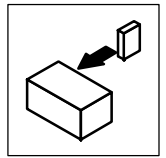
3.1.4 "Safe standstill" function

The "Safe standstill" function is activated by pressing the key "S1" (OFF):

- Opening the NO contact of K3 (t3) via terminal E1 or E2 at X5 immediately triggers a quick stop (QSP) at the controller.
- The motor is decelerated to standstill (t4) by the controller with t_{QSP} along the QSP ramp.
  - the external pulse inhibit is activated with delay (t5) in the controller (terminal 34, X11) after the time set in time relay K2a.
 - opening the NO contact of K2b enables the controller again (t5).

The external pulse inhibit of the controller (safety relay K_{SR}) ensures that the motor cannot start unexpectedly if the safety doors are opened.

3.1.5 "Emergency off" function

If "S3" (EMERGENCY STOP) is pressed, the drive will be braked to a controlled standstill according to stop category 1 of EN 60204-1:

- The Quick Stop input (QSP) is set immediately at the controller by opening the NO contact of K3 (t3) via terminal E1 or E3 at the controller.
- The controller brakes with t_{QSP} until the motor is brought to a controlled standstill (t4).
- The mains contactor (K4) safely disconnects the controller (A3) from the power supply with a delay (t_{A1}) if
  - the external pulse inhibit (safety relay K_{SR}, terminal 34, plug X11) is set with a time delay through the normally open contact of K2a (t5),
  - the controller is enabled again via the NO contact of K2b at terminal 28 at the same time (t5).

The feedback contact of K4 prevents the switching of the enable contacts at the emergency off unit (A1) when the power supply is switched on again if the switching contacts 'stick'.
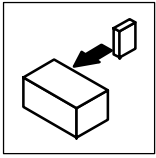
3.2 Circuit for "Safe standstill with safety relay and standard PLC control"

The example shows minimum wiring of the components. This ensures the troublefree operation of the "Safe standstill" function of 93XX-V004 controllers.
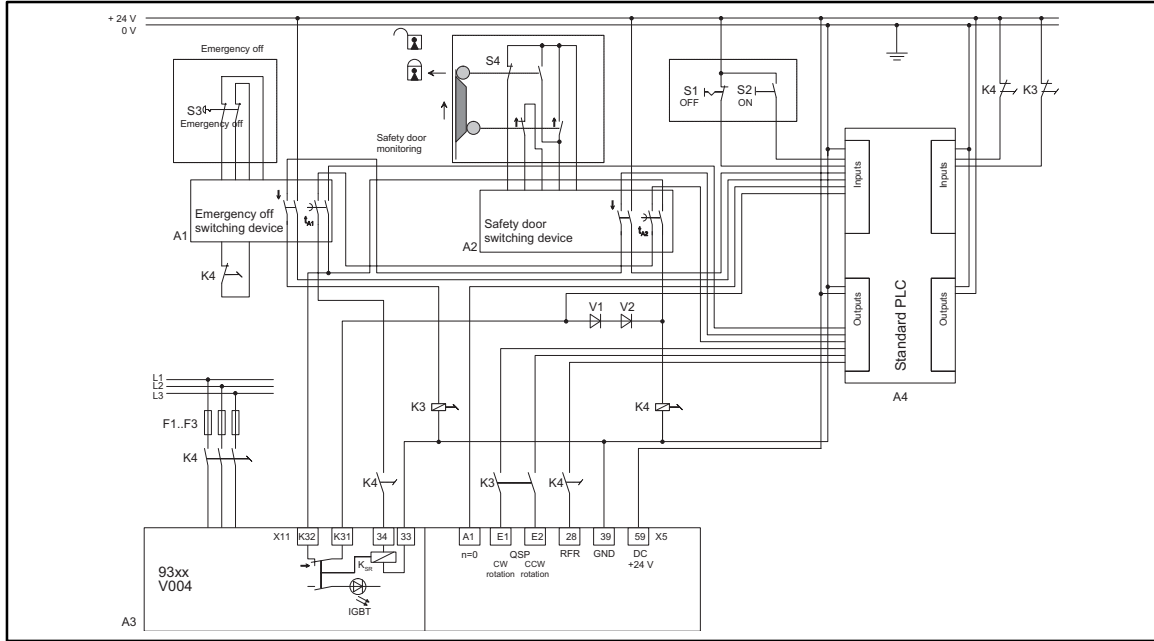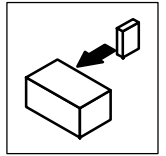

Fig. 3   Minimum wiring for 93XX-V004 controllers with safety relay and standard PLC control
to EN 954-1 control category 3 and EN 1037, stop category 1 to EN 60204-1

3.2.1 Description

For a circuit with standard PLC control and safety relay follow EN 954-1 control category 3 and EN 1037. The circuit in Fig. 3 shows a stop function of stop category 1 to EN 60204-1 (with safety door monitoring):

- The circuits for emergency off and door lock are two-channel circuits protected against short circuits between signal cables. The integrated switching devices are equipped with positively driven contacts.

- A1 and A2 and the relay K3 have an additive effect on the input "Quick-Stop" (QSP) of the controller (A3) via terminal E1 (CW rotation) and terminal E2 (CCW rotation). The wiring enables a reversal of the direction of rotation for the drive.

- The PLC control detects if the mains contactor (K4) or the start/stop relay (K3) is not released:
  – when checking the configuration of the NC contact
  – before restarting the machine.

- If the PLC or the controller fails, the two independent switch-off circuits ensure that the motor braked to a standstill if an emergency stop is triggered, or if the safety doors are opened.

Note for the PLC programmer!

In the event of faulty operation of the safety relay for the external pulse inhibit, the power supply for the controller must be switched off via the mains contactor (K4) (2nd switch-off circuit).

The circuit for the "Safe standstill" function has its own contacts and is independent of the standard PLC. This means that even if the PLC fails, the "safe standstill" function will still operate.
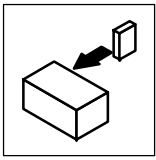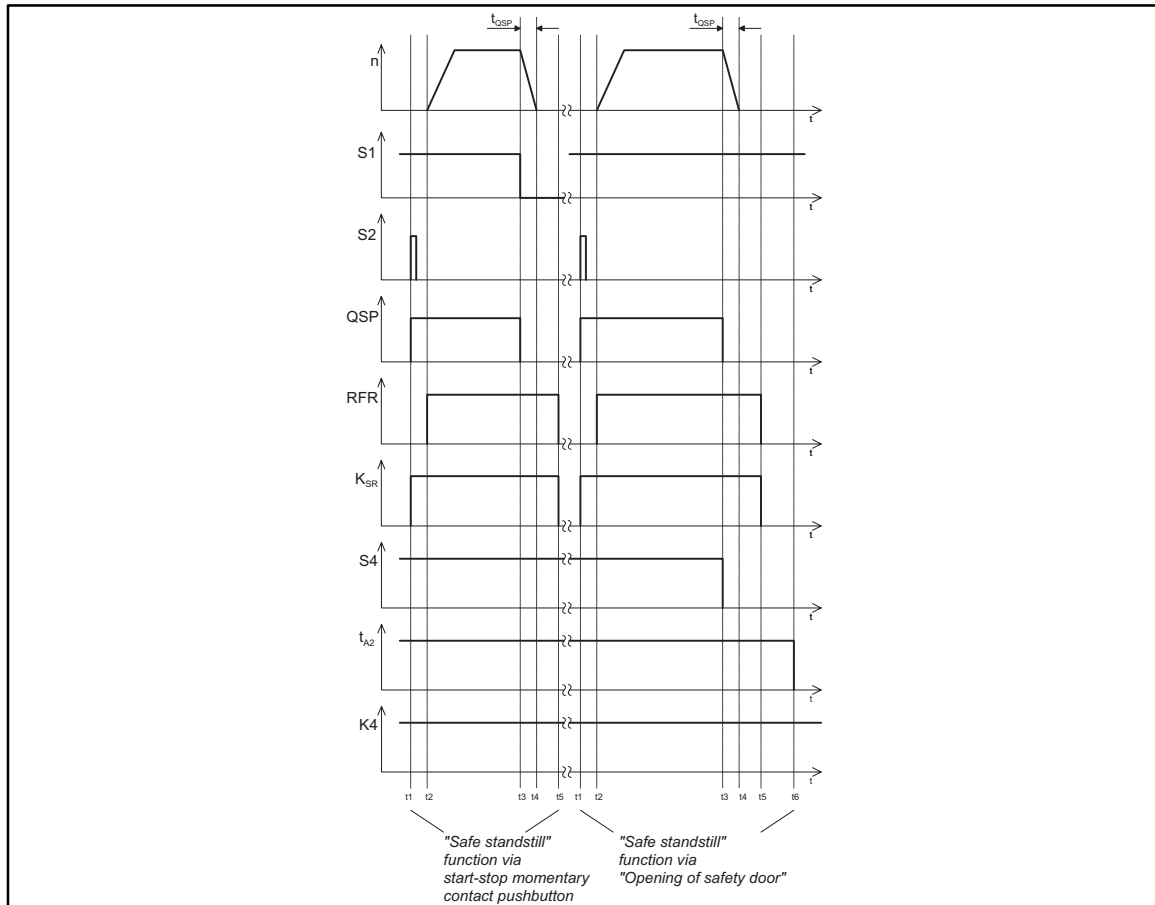

3.2.2 Time chart

Fig. 4   Time characteristic for switching on and off "safety relay and standard PLC control"

3.2.3 Time settings

- t1 to t2 $\geq$ 50 ms
  Set the time delay in the PLC so that the controller will be enabled at least 50 ms after K_{SR}.

- t3 to t4
  t_{QSP} = Time for controller-internal QSP ramp
  The time interval set must ensure that the controller can always be braked to a controlled standstill when running at max. speed (t3 to t4).

- t3 to t5 = t_{QSP} + min. 100 ms (standard value)
  Set the time (t3 to t5) so that t_{QSP} + min. 100 ms ensures safety.
  This ensures a controlled standstill according to stop catergory 1 of EN 60204-1. The controller will only be enabled again (terminal 28) (t5) once the motor as been braked to a controlled standstill (t4).

- t3 to t6 = Internal time of A1, A2 (t_{A1}, t_{A2})
  t_{A1} and t_{A2} must be selected to ensure that the controller brakes the motor to a controlled standstill along the QSP ramp within T_{QSP} before the power supply is disconnected via the mains contactor (K4) (t6). This will be required if

  – the emergency off button (S3) is pressed during operation.

  – the safety door is opened and the feedback contact of K_{SR} in the controller is not closed because of an error in the drive (t6) (2nd switch-off circuit).
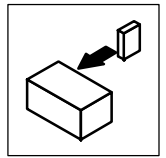
3.2.4 "Safe standstill" function

The "Safe standstill" function is activated by pressing the key "S1" (OFF):

- A Quick Stop (QSP) is set immediately via terminals E1 and E2 of the controller.

- The controller brakes the motor to a controlled standstill (t4) within t_{QSP}

- If the controller sends the signal "n = 0" (terminal A1) to indicate that the motor has been stopped, the PLC will disable the controller (terminal 28) and set a delayed pulse inhibit via KSR (terminal 34, X11).

This procedure corresponds to standstill according to stop category 1 of EN 60204-1.

The external pulse inhibit of the controller (safety relay K_{SR}) ensures that the motor cannot start unexpectedly if the safety doors are open.

3.2.5 "Emergency off" function

If "S3" (EMERGENCY STOP) is pressed, the drive is braked to a controlled standstill according to stop category 1 of EN 60204-1:

- A Quick Stop (QSP) is set immediately via terminals E1 and E2 of the controller.

- The controller brakes with t_{QSP} in a controlled mode until the motor has been stopped (t4).

- If the controller sends the signal "n = 0" (terminal A1) to indicate motor standstill
    – the PLC sets the external pulse inhibit via K_{SR} (terminal 34, X11),
    – after an additional delay time $\geq$ of 100 ms (guide value), the PLC deactivates the mains contactor (K4) and thus interrupts the power supply to the controller (A3) (2nd switch-off circuit).

The emergency off unit (A1) ensures the emergency off function in the event of a PLC failure:

- Quick Stop (QSP) is set independently of the PLC.

- After the internal time t_{A1} for A1 (t3 to t6) the power supply for the controller is switched off via K4.

- The positively driven NO contact in A1 activates the external pulse inhibit via K_{SR}.

The feedback contact of K4 prevents the switching of the enable contacts at the emergency off unit (A1) when the power supply is switched on again if the switching contacts 'stick'.
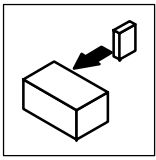
3.3 Circuit for "Safe standstill with safety-oriented PLC"

The example shows minimum wiring of the components. This ensures the troublefree operation of the "Safe standstill" function of 93XX controllers.
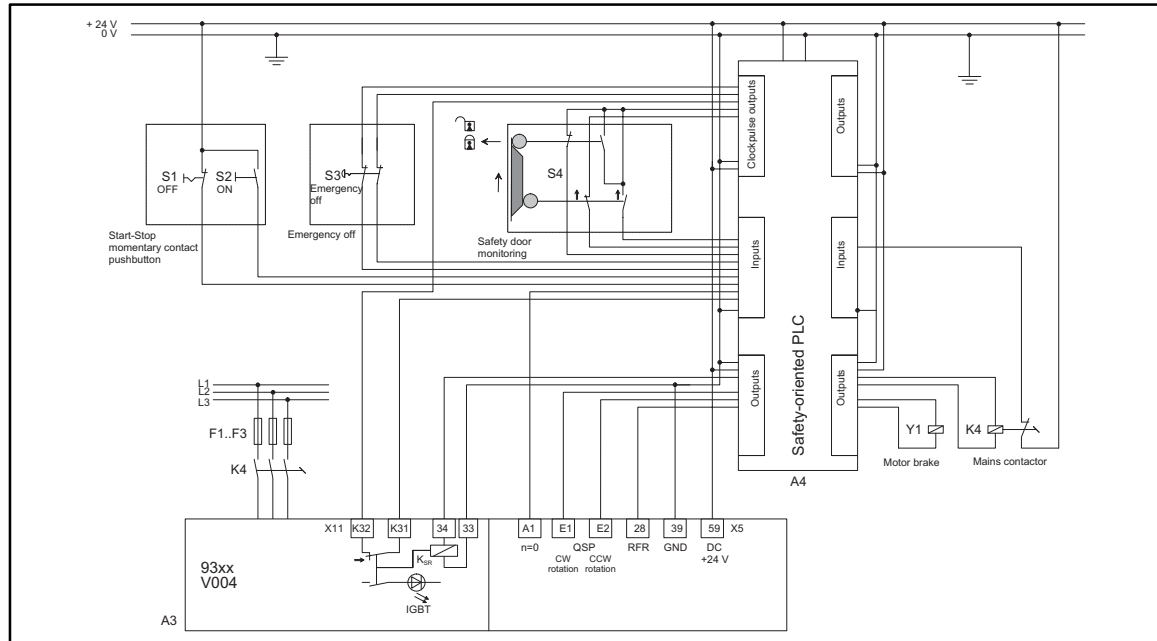

Fig. 5   Minimum wiring for 93XX-V004 controllers with safety-oriented PLC
to EN 954-1 control category 3 and EN 1037, stop category 1 to EN 60204-1

3.3.1 Description

For a circuit with safety-oriented PLC control follow EN 954-1 control category 3 and EN 1037. The circuit in Fig. 5 shows a stop category 1 stop function according to EN 60204-1 (with safety door monitoring).
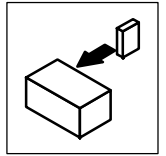
- The circuit is positively dynamic for the emergency off function (S3), door locking (S4) and feedback contact of the safety relay (K_{SR}), i. e. proper and correct functioning of the external circuit of the PLC and PLC inputs can be ensured through a clock signal.
  The circuits for emergency off and door lock are two channel circuits protected against short circuits between signal cables.

- The integrated switching devices are equipped with positively driven contacts.

- The PLC outputs for motor brake (Y1) and mains contactors (K4) are two-channel circuits. The safe activation of the functions is ensured by the second switch-off circuit in the output module of the PLC. Additionally, the PLC reads the NC contact of K4.

Note for the PLC programmer!

In the event of faulty operation of the safety relay for the external pulse inhibit, the power supply for the controller must be switched off via the mains contactor (K4) (2nd switch-off circuit).

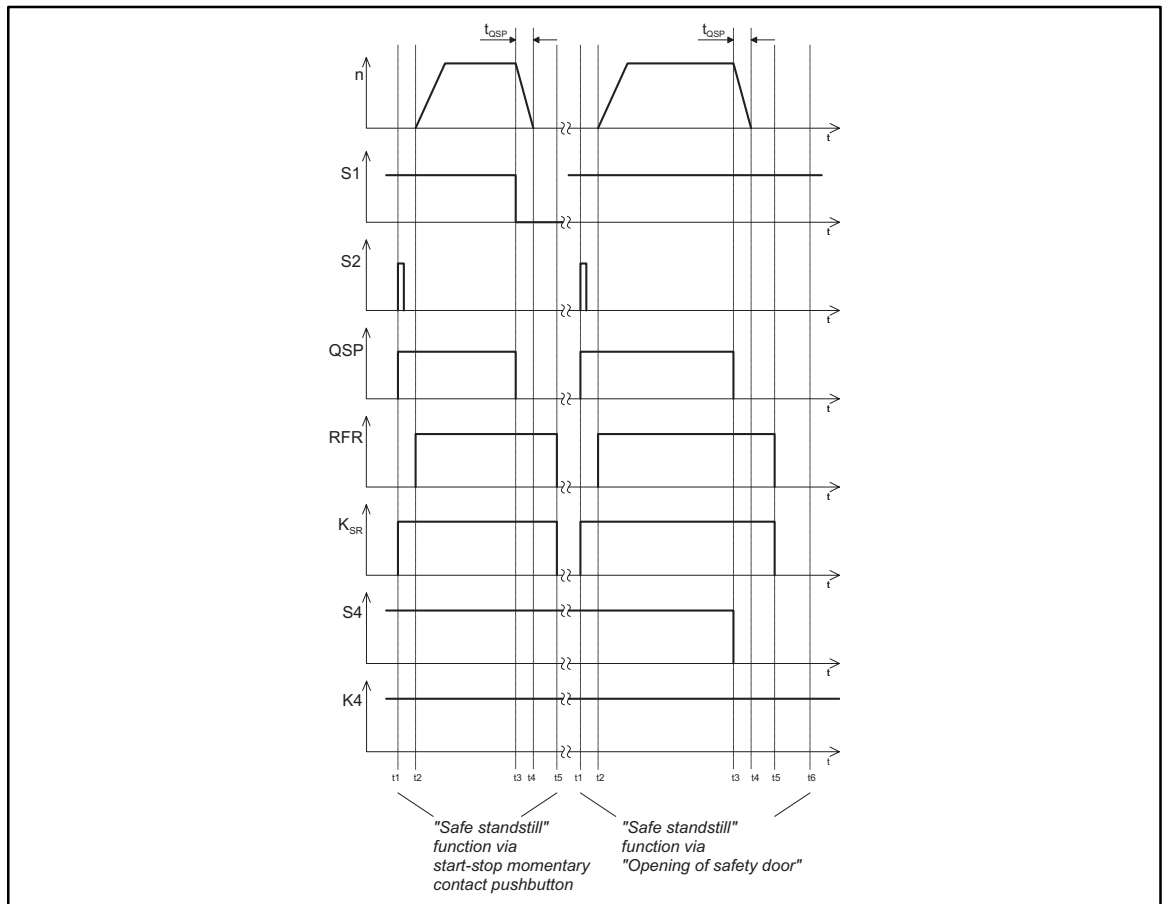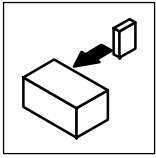The wiring instructions shown in Fig. 1 must be considered accordingly!

3.3.2 Time chart

Fig. 6   Time characteristic for switching "with safety-oriented PLC on and off"

3.3.3 Time settings

- t_1 to $t_2 \geq 50$ msec
  Set the delay time in the PLC so that the controller will be enabled at least 50 ms after K_{SR}.

- t_3 to t_4
  t_{QSP} = Time for controller-internal QSP ramp
  The time interval set must ensure that the controller can always be braked to a controlled standstill when running at max. speed (t_3 to t_4).

- t_3 to $t_5 = t_{QSP}$ + min. 100 ms (standard value)
  Set the time (t_3 to t_5) so that t_{QSP} + min. 100 ms ensures safety.
  This ensures a controlled standstill according to stop category 1 of EN 60204-1: Controller enable is reset (t_5) after the motor has been braked to standstill. Only then will K4 disconnect the controller from the power supply.

- t_4 to t_5 = Internal time for safety door monitoring
  The selection of the internal time for the safety door monitoring must ensure that the controller can brake the motor to a controlled standstill along the QSP ramp and within t_{QSP} before the controller is disconnected via k4. This will be required if

  – the emergency off button (S3) is pressed during operation

  – the safety door is opened during operation and the feedback contact of K_{SR} in the controller is not closed because of an error in the drive (2nd switch-off circuit).

3.3.4 "Safe standstill" function

The "Safe standstill" function is activated by pressing the key "S1" (OFF):

- A Quick Stop (QSP) is set immediately via terminals E1 and E2 (X5) of the controller.

- The motor is braked to standstill by the controller with t_{QSP} along the QSP ramp.

- If the controller sends the signal "n = 0" (terminal A1, X5) to indicate that the motor has been stopped, the PLC will disable the controller (terminal 28, X5) and set a delayed pulse inhibit via K_{SR} (terminal 34, X11).

The external pulse inhibit of the controller (safety relay K_{SR}) ensures that the motor cannot start unexpectedly if the safety doors are open.

3.3.5 "Emergency off" function

If "S3" (EMERGENCY OFF) is pressed, the drive is braked to a controlled standstill according to stop category 1 of EN 60204-1:

- A Quick Stop (QSP) is set immediately via terminals E1 and E2 (X5) of the controller.

- The controller brakes the motor to a controlled standstill (t4) within $t_{QSP.}$

- If the controller sends the signal "n = 0" to indicate that the motor as been stopped, te PLC will disable the controller (terminal A1, X5) and set a delayed pulse inhibit via K_{SR} (terminal 34, X11).

- If the feedback contact of K_{SR} (K31 - K32, X11) indicates activation of the pulse inhibit, the PLC deactivates the signal for controller enable (terminal 28, X5), mains contactor (K4) and motor brake (Y1). The controller power supply is interrupted.
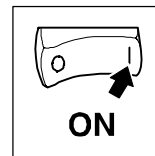
4 Commissioning

4.1 Conditions

4.1.1 Electrical requirements

The external voltage source must be able to drive a current > 1 A because it supplies the control electronics of the controller (back-up in the event of power failure): Even after the power supply has been disconnected:

- actual values are recorded and processed
- the control electronics remain reliable

4.1.2 Necessary changes to the default setting

For troublefree operation of the examples (📖 5, ff) the default setting of the controller must be changed as follows:

- Motor standstill must be assigned to the digital output terminal A1   Code C0117/1, selection 10650
- TRIP display must be assigned to the digital output terminal A2   Code C0117/2, selection 15000
- "HIGH" active must be assigned to digital output terminal   Code C0118/1, selection 0

Excerpt from code table

| Code		Possible settings				IMPORTANT	
No.	Name	Lenze	Selection				
[C0117]		*			Signal configuration DIGOUT	*	depending on C0005
1	CFG: DIGOUT	15000	DCTRL-TRIP		X5/A1		
2	CFG: DIGOUT	10650	CMP1-OUT		X5/A2		
3	CFG: DIGOUT	500	DCTRL-RDY		X5/A3		
4	CFG: DIGOUT	5003	MCTRL-MMAX		X5/A4		
C0118					Terminal polarity DIGOUT		
1	DIGOUT pol	1	0	High active	X5/A1		
2	DIGOUT pol	1	1	Low active	X5/A2		
3	DIGOUT pol	0			X5/A3		
4	DIGOUT pol	0			X5/A4		

⚠️ **Caution!**

Time for controller-internal QSP ramp = t_{QSP} (code C0105) must not be set too short!

If t_{QSP} is too short, TRIP can be activated.

- The drive idles to standstill.
- Controlled standstill is not possible.
- Only stop category 0 can be reached.
- Safe standstill is not possible, the safety door is not secured.

t_{QSP} and the QSP ramp must always be adapted to the system being used.
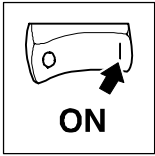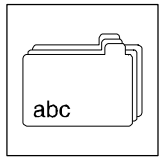
Warning!

The "Safe standstill" function, protection against unintended start" must always be checked for correct operation when

- setting up the system for the first time
- having worked on the wiring of the system
- having replaced one or several system components

4.2 Operating test

Proceed as follows:

1. All drives taking part in the operation must be set to standstill.

2. Hanging loads must be mechanically fastened (blocked).

3. Safety relay K_{SR} ("Safe standstill function, protection against unintended start") must be controlled.

4. Circuit breakers (S4) open when the controller (A3) is supplied with power (K4).

5. Interrupt the feedback circuit of safety relay K_{SR} at X11, K31-K32.
   The mains contactor (K4) is released after the time t_{A2} defined in A2.

6. Connect the feedback circuit of safety relay K_{SR} to X11, K31-K32.
   Mains contactor (K4) picks up again.

7. Repeat steps 3 to 6 for every controller.

5 Appendix

5.1 PLC program

This section describes the operating principle of safety relay K_{SR} for the "Safe standstill" function of the V004 variants. The specified programming is part of a PLC program according to IEC 61131-3.

⚠️ **Warning!**

The following PLC program is a basic programming solution. The program must always be adapted to the respective application.

If the safety relay K_{SR} fails, the mains contactor (K4) interrupts the power supply to the drive controller via the second switch-off circuit.

5.1.1 "Motor on" and "Motor off" flow charts (basic sequence)
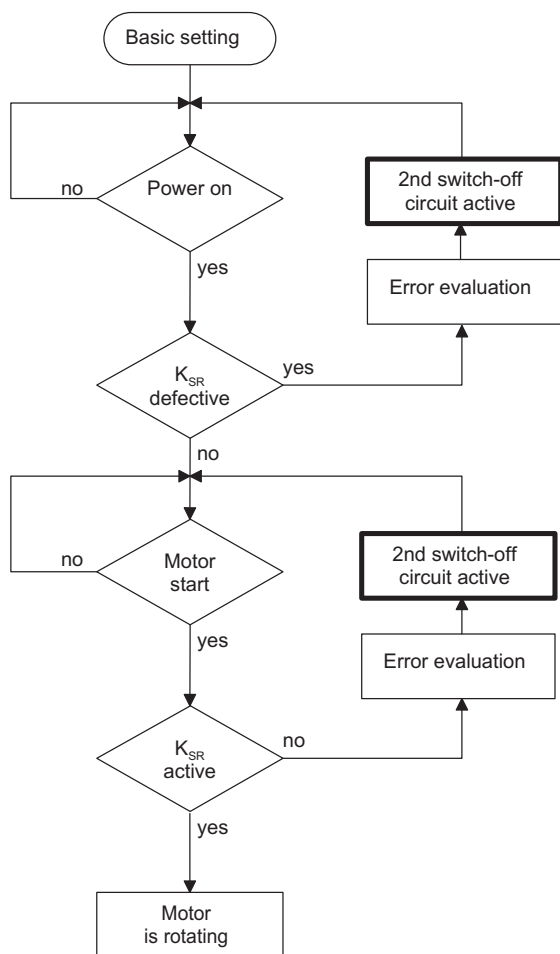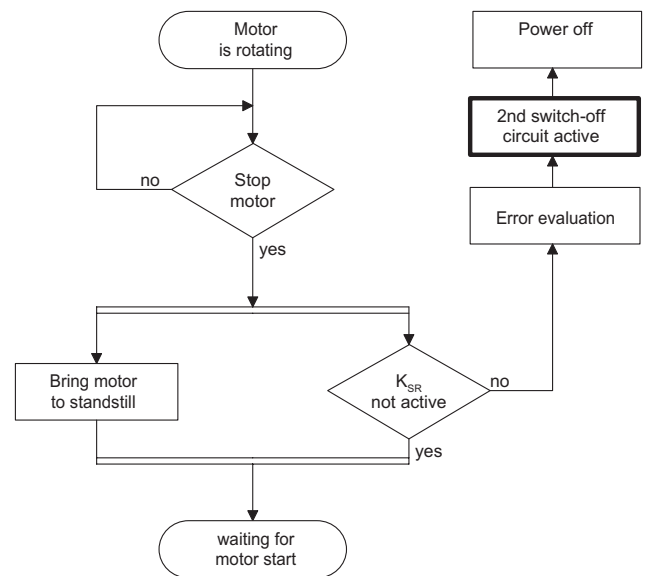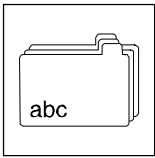

| Fig. 7 | Operational sequence "motor on" | Fig. 8 | Operational sequence "motor off" |

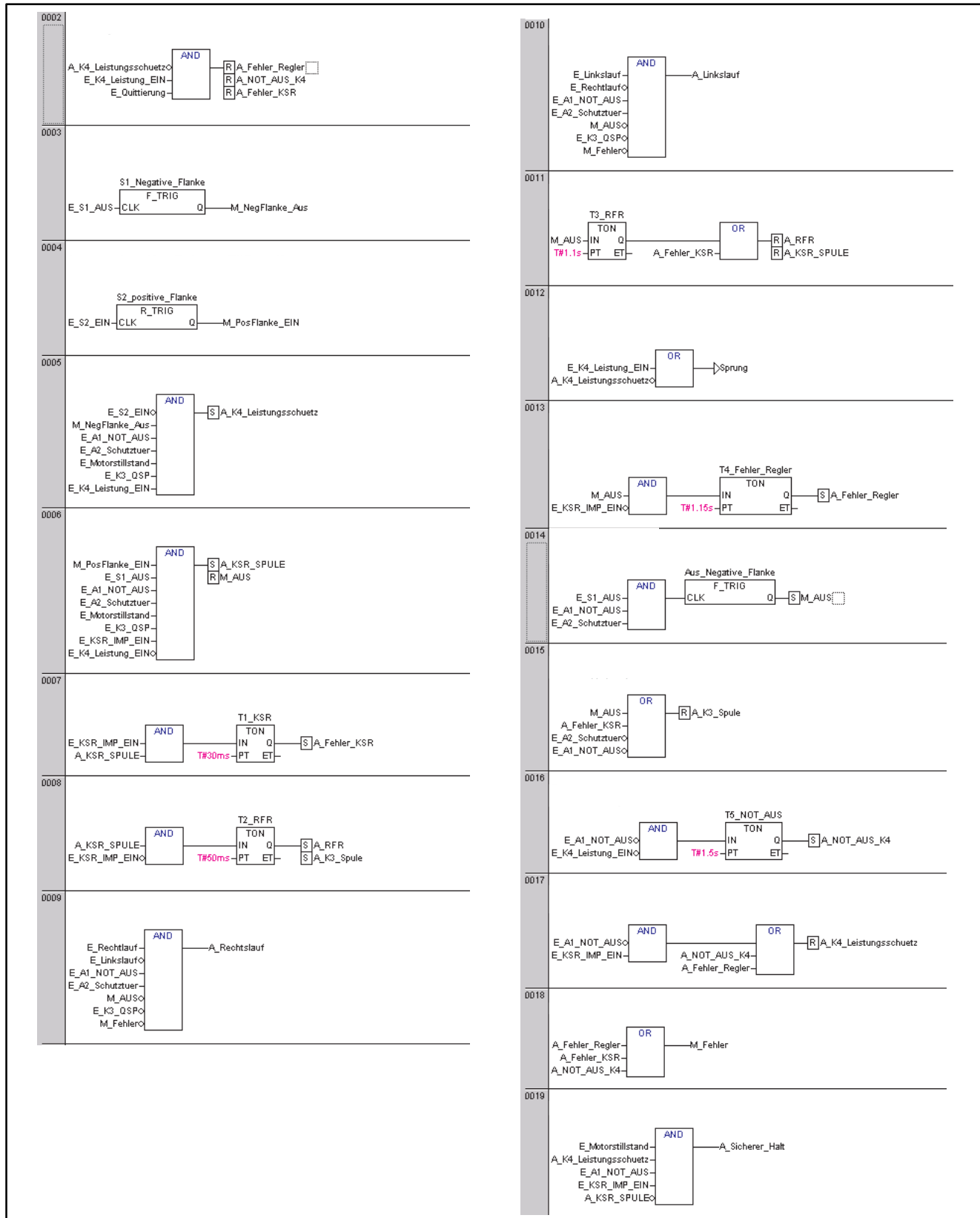## 5.1.2   Safe standstill with a standard PLC control
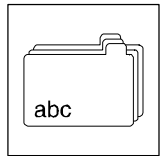
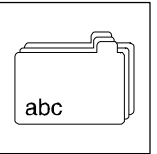Fig. 9   PLC program "Safe standstill with a standard PLC control"

5.1.3 Declaration

Network		Variables		
No.	**Description**	**Name**	**Type**	**Description**
0002	Error acknowledgement	A_K4_Leistungsschuetz (A_K4_power contactor)		Output coil power contactor K4
		E_K4_Leistung_EIN (E_K4_power_ON)		Feedback contact power contactor K4
		E_Quittierung (E_acknowledgement)	BOOL	Input for acknowledgement
		A_Fehler_Regler (A_fault_controller)		Output fault KSR safety relay controller
		A_NOT_AUS_K4 (A_EMERGENCY_OFF_K4)		Output fault K4 power disconnection
		A_Fehler_KSR (A_fault_KSR)		Output fault KSR safety relay
0003	Evaluation of the negative edge from OFF switch S1 Single pulse to switch on K4 contactor	E_S1_AUS (E_S1_OFF)	BOOL	Input switch S1 off
		S1_Negative_Flanke (S1_negative_edge)	F_TRIG	Edge evaluation for switch S1 off
		M_NegFlanke_Aus (M_NegEdge_off)	BOOL	Flag negative edge switch S1 off
0004	Evaluation of the positive edge from ON switch S1 Single pulse to switch the KSR safety relay	E_S2_EIN (E_S2_ON)	BOOL	Input switch S2 on
		S2_Positive_Flanke S2_positive_edge	F_TRIG	Edge evaluation for switch S2 ON
		M_PosFlanke_EIN M_PosEdge_ON	BOOL	Flag positive edge switch S2 ON
0005	Power ON contactor K4	E_S2_EIN (E_S2_ON)		Input switch S2 on
		M_NegFlanke_Aus (M_NegEdge_off)		Flag negative edge switch S1 off
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		E_A2_Schutztuer (E_A2_safety door)		Signalling contact safety door switch unit A2
		E_Motorstillstand (E_motor standstill)	BOOL	Output controller motor has stopped
		E_K3_QSP		Feedback contact auxiliary relay K3
		E_K4_Leistung_EIN (E_K4_power_ON)		Feedback contact power contactor K4
		A_K4_Leistungsschuetz (A_K4_power contactor)		Output coil power contactor K4
0006	Power ON contactor K4	M_PosFlanke_EIN (M_PosEdge_ON)		Flag positive edge switch S2 ON
		E_S1_AUS (E_S1_OFF)		Input switch S1 off
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		E_A2_Schutztuer (E_A2_safety door)		Signalling contact safety door switch unit A2
		E_Motorstillstand (E_motor standstill)	BOOL	Output controller motor has stopped
		E_K3_QSP		Feedback contact auxiliary relay K3
		E_KSR_IMP_EIN (E_KSR_IMP_ON)		Input feedback contact KSR safety relay
		E_K4_Leistung_EIN (E_K4_power_ON)		Feedback contact power contactor K4
		A_KSR_SPULE (A_KSR_COIL)		Output coil KSR safety relay
		M_AUS (M_OFF)		Flag request motor off
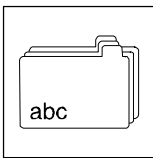
No.	Description	Name	Type	Description
0007	KSR safety relay monitoring KSR damaged upon switch on?	E_KSR_IMP_EIN (E_KSR_IMP_ON)	BOOL	Input feedback contact KSR safety relay
		A_KSR_SPULE (A_KSR_COIL)		Output coil KSR safety relay
		T1_KSR	TON	KSR safety relay monitoring
		A_Fehler_KSR (A_fault_KSR)	BOOL	Output fault KSR safety relay
0008	Controller enable ctrl. enable on (A_ctrl. enable) Quick stop QSP off (A_K3_coil)	A_KSR_SPULE (A_KSR_COIL)	BOOL	Output coil KSR safety relay
		E_KSR_IMP_EIN (E_KSR_IMP_ON)		Input feedback contact KSR safety relay
		T2_ctrl. enable	TON	Delay controller enable on and QSP off
		A_ctrl. enable	BOOL	Controller output controller enable
		A_K3_Spule (A_K3_coil)		Output auxiliary relay K3 quick stop QSP
0009	Drive motor clockwise rotation on	E_Rechtslauf (E_clockwise rotation)	BOOL	Input preselection drive motor clockwise rotation
		E_Linkslauf (E_counter-clockwise rotation)		Input preselection drive motor counter-clockwise rotation
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		E_A2_Schutztuer (E_A2_safety door)		Signalling contact safety door switch unit A2
		M_AUS (M_OFF)		Flag request motor off
		E_K3_QSP		Feedback contact auxiliary relay K3
		M_Fehler (M_fault)		Flag for composite fault
		A_Rechtslauf (A_clockwise rotation)		Output controller motor clockwise rotation
0010	Drive motor counter-clockwise rotation on	E_Linkslauf (E_counter-clockwise rotation)	BOOL	Input preselection drive motor counter-clockwise rotation
		E_Rechtslauf (E_clockwise rotation)		Input preselection drive motor clockwise rotation
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		E_A2_Schutztuer (E_A2_safety door)		Signalling contact safety door switch unit A2
		M_AUS (M_OFF)		Flag request motor off
		E_K3_QSP		Feedback contact auxiliary relay K3
		M_Fehler (M_fault)		Flag for composite fault
		A_Rechtslauf (A_counter-clockwise rotation)		Output controller motor counter-clockwise rotation
0011	Controller enable (ctrl. enable) off Safety relay (KSR) off	M_AUS (M_OFF)	BOOL	Flag request motor off
		T3_ctrl. enable	TON	Delay ctrl. enable and KSR safety relay on
		A_Fehler_KSR (A_fault_KSR)		Output fault KSR safety relay
		A_ctrl. enable	BOOL	Controller output controller enable
		A_KSR_SPULE (A_KSR_COIL)		Output coil KSR safety relay
0012	Jump function (error monitoring) to network 012 A_fault_controller need not be checked when switching off or switching on the power contactor K4	E_K4_Leistung_EIN (E_K4_power_ON)	BOOL	Feedback contact power contactor K4
		A_K4_Leistungsschuetz (A_K4_power contactor)		Output coil power contactor K4
0013	KSR safety relay monitoring KSR damaged when switching on power contactor K4 KSR damaged upon switch off	M_AUS (M_OFF)	BOOL	Flag request motor off
		A_NOT_AUS_K4 (A_EMERGENCY_OFF_K4)		Output fault K4 power disconnection
		T4_fault_controller	TON	Controller monitoring KSR safety relay
		A_Fehler_Regler (A_fault_controller)	BOOL	Output fault KSR safety relay controller

No.	Description	Name	Type	Description
0014	Jump	E_S1_AUS (E_S1_OFF)	BOOL	Input switch S1 off
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		E_A2_Schutztuer (E_A2_safety door)		Signalling contact safety door switch unit A2
		Aus_Negative_Flanke (Off_negative_edge)	F-TRIG	Edge evaluation during switch off
		M_AUS (M_OFF)	BOOL	Flag request motor off
0015	Quick stop (QSP) controller on	M_AUS (M_OFF)	BOOL	Flag request motor off
		A_Fehler_KSR (A_fault_KSR)		Output fault KSR safety relay
		E_A2_Schutztuer (E_A2_safety door)		Signalling contact safety door switch unit A2
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		A_K3_Spule (A_K3_coil)		Output auxiliary relay K3 quick stop QSP
0016	Switch off monitoring power contactor K4 EMERGENCY OFF switch unit A1 and terminal K4 contactor	E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)	BOOL	EMERGENCY OFF signalling contact switch unit A1
		E_K4_Leistung_EIN (E_K4_power_ON)		Feedback contact power contactor K4
		T5_NOT_AUS (T5_EMERGENCY_OFF)	TON	Delay in power disconnection upon EMERGENCY OFF and/or door
		A_NOT_AUS_K4 (A_EMERGENCY_OFF_K4)	BOOL	Output fault K4 power disconnection
0017	Controller power supply off	E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)	BOOL	EMERGENCY OFF signalling contact switch unit A1
		E_KSR_IMP_EIN (E_KSR_IMP_ON)		Input feedback contact KSR safety relay
		A_NOT_AUS_K4 (A_EMERGENCY_OFF_K4)		Output coil power contactor K4
		A_Fehler_Regler (A_fault_controller)		Output fault KSR safety relay controller
		A_K4_Leistungsschuetz A_K4_power contactor		Input preselection drive motor clockwise rotation
0018	Fault evaluation	A_Fehler_Regler (A_fault_controller)	BOOL	Output fault KSR safety relay controller
		A_Fehler_KSR (A_fault_KSR)		Output fault KSR safety relay
		A_NOT_AUS_K4 (A_EMERGENCY_OFF_K4)		Output coil power contactor K4
		M_Fehler (M_fault)		Flag for composite fault
0019	Output pilot lamp safe standstill	E_Motorstillstand (E_motor standstill)	BOOL	Output controller motor has stopped
		A_K4_Leistungsschuetz (A_K4_power contactor)		Output coil power contactor K4
		E_A1_NOT_AUS (E_A1_EMERGENCY_OFF)		EMERGENCY OFF signalling contact switch unit A1
		E_KSR_IMP_EIN (E_KSR_IMP_ON)		Input feedback contact KSR safety relay
		A_KSR_SPULE (A_KSR_COIL)		Output coil KSR safety relay
		A_Sicherer_Halt (A_safe_standstill)		Output pilot lamp safe standstill
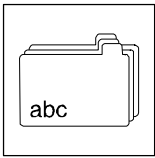
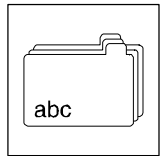# *Appendix*

5.1.4 Timers

Note!

The set times are standard values. They depend on the machine parameters, the configuration of the drive controllers and the setting of the internal times of the control units for the emergency off circuit and the safety door.

Timer	Function	Remark
T1_KSR	Monitors the feedback contacts K11 - K12 of safety relay K_{SR}	
T2_ctrl. enable	Delayed switch-on of controller enable ctrl. enable	Resets the Quick Stop Signal QSP at the drive controller after the safety relay K_{SR} has been activated. Required time setting: ≥ 50 ms (t1 after t2)
T3_ctr. enable	Delayed switch-off of controller enable ctrl. enable at the drive controller	Switches off ctrl. enable once K_{SR} safety relay has been deactivated. Required time setting: Time t_{QSP} for Quick Stop ramp set in the controller + safety of ≥ 100 ms as standard value (t3 after t5)
T4_fault_controller	Time-out monitoring of the drive controller	After activation of the S1 switch (OFF), feedback contact K31 - K32 signals to the PLC in time interval t3 to t5 that the drive controller is in operating state "Safe standstill". Required time setting: Time t_{QSP} for Quick Stop ramp set in the controller + safety of ≥ 100 ms as standard value (t3 after t5)
T5_EMERGENCY_OFF_door	Monitors the control units for • Emergency off circuit • Safety door	When the mains contactor is switched on, the power supply of the drive controller (A3) is switched off by mains contactor (K4) • after activation of the S3 emergency off switch. • after opening of safety door S4. (DOES NOT APPLY if feedback contact K 31 - K 32 signals "safe standstill" in time interval t3 to t5) Required time setting: Time t_{QSP} for Quick Stop ramp set in the controller + safety of ≥ 1 s as standard value (t3 after t6)

5.2 Glossary

5.2.1 Electrical equipment used

Name	Electrical equipment
A1	Emergency off switching device, two-channel signal cable short-circuit monitoring, with two positively driven and two delayed contacts
A2	Safety door switching device, two-channel signal cable short-circuit monitoring, with two positively driven and two delayed contacts
A3	Drive controller 93XX-V004
A4	PLC
S1	OFF switch with manual reset
S2	ON switch
S3	EMERGENCY OFF switch
S4	Safety door contact
K2a	Time relay (drop-out delayed)
K2b	Time relay (pick-up delayed)
K3	Auxiliary relay (positively driven)
K4	Mains contactor (positively driven)
F1 ... F3	Mains fuses
V1 ... V2	Diodes (decoupling)

5.2.2 Important terms

Term	Meaning
Safe	*Safe* in conjunction with drive functions (e.g. *safe stop*, *safe standstill*) means that in case of an error, the behaviour of the control elements will be subject to a control category according to EN 954-1 pertinent to the risk analysis in accordance with EN 1050. In some cases, the categories to be applied are specified in machine-specific standards (C-standards).
Standstill	*Standstill* is the state, in which the mechanical component is at a standstill. The drive is no longer supplied with energy.
Safe standstill [1], [2]	At a *safe standstill*, the power supply to the controller is safely interrupted according to EN 1037, section 4.1. The controller need not be able to generate a torque and thus dangerous rotations (see EN 1037, section 5.3.1.3). The standstill position must not be monitored. A contactor can be used to disconnect the power supply. If at *a safe standstill* an external force is likely to act, e.g. stalling of hanging loads, additional measures have to be provided that safely prevent these movements (e.g. mechanical brakes). The following measures can be taken to ensure a *safe standstill* : • Contactor between mains and drive system = mains contactor • Contactor between power unit and motor = motor contactor • Safe blocking of the pulses of the power semi-conductors = safe pulse inhibitor
Controller enable (ctrl. enable)	Internal controller function, e.g. for the pulse blocking of the the final power stages **Controller enable = $\overline{\text{Controller inhibit}}$** If controller inhibit is active the power stages are inhibited. All controllers are reset. • Controller enable can be controlled from 6 inputs. • Terminal X5/28 (LOW = controller inhibit) • Control word CAN-CTRL, bit 9 of CAN-IN1 • Control word AIF-CTRL, bit 9 of AIF-IN • Control word C0135, bit 9 • Free inputs: DCTRL-CINH1, DCTRL-CINH2 • All inputs are OR linked. • C0136/1 displays the control word C013. 5
Quick Stop (QSP)	Internal drive controller function for the operational stop **Quick Stop** The drive is braked to standstill via the deceleration ramp C105 and generates a holding torque. • Quick Stop can be controlled from 3 inputs. • Control word CAN-CTRL, bit 3 of CAN-IN1 • Control word AIF-CTRL, bit 3 of AIF-IN • Control word C0135, bit 3 • All inputs are OR linked. • C0136/1 displays the control word C013. 5

[1] According to the national and the European preface to EN 60204-1, electronic equipment for emergency off installations may be used, if it corresponds to the standards EN 954-1 and /or IEC 61508. If this is the case, the function "Safe standstill" can be used for emergency off functions, provided that EN 954-1 and IEC 61508 are applied.

[2] According to EN 60204-1, section 5.3, machines have to be additionally equipped with a mains switch.

5.3 Important standards and categories

5.3.1 Applied standards

Directive / standard	Title
RL 98/37/EG	Directive 98/37/EG of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the member states relating to machinery
EN 292-1/2	Safety of machinery. Basic concepts, general principles for design; part 1: Basic terminology, methodology; part 2: Technical principles and specifications
EN 418	Emergency stop equipment, functional aspects. Principles of design
EN 954-1	Safety of machinery; safety-related parts of control systems; part 1: General principles for design
EN 1050	Safety of machinery. Principles for risk assessment
EN 1070	Safety of machinery. Terminology
EN 60204-1	Safety of machinery. Electrical equipment of industrial machines. Part 1: Specification for general requirements
EN 1037	Safety of machinery. Prevention of unexpected start-up
Draft IEC 22G/52/CD	Adjustable speed electrical power drive systems; part 5: Electrical, thermal and functional safety requirements, electrically adjustable speed power drive systems
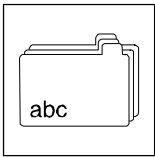
5.3.2 Categories according to EN 60204-1

5.3.2.1 Stop categories (chapter 9.2.2)

Stop category	Requirements	System reaction	Remark
0	Stopping by immediate disconnection of the power supply for the drive elements of the machine	**uncontrolled stopping**	Uncontrolled stopping means stopping a machine movement by disconnecting the power supply for the drive elements of the machine, operating all brakes and/or other mechanical stopping devices.
1	Stopping, with the power supply for the drive elements of the machine being maintained to come to a standstill. The power supply is only interrupted, when the drive elements have come to a standstill.	**controlled stopping**	Controlled stopping means to stop a machine movement, for example, by resetting the electrical command signal to "0" as soon as the stop signal has been recognised by the control. The electrical power supply for the drive elements of the machine is maintained during stopping.
2	Stopping, with the power supply for the drive elements for the machine being maintained.	**controlled stopping**	

Tip!

Depending on the assessment of risks, electromechanical devices or semi-conductors may be used for power disconnection.

This does not apply to emergencies!

5.3.2.2 Definitions

Term	Requirements	According to EN 60204-1
Stop	Stop functions of category 0, 1, 2 always have to be provided according to the risk assessment and the functional requirements of the machine. • Stop functions of category 0, 1 must be operational in all operating modes. • A stop of category 0 must have priority. • Stop functions must have priority over assigned start functions.	Chapter 9.2.5.3
Emergency stop	In addition to the requirements to be met for the function "Stop", the following requirements have to be fulfilled for the function "Emergency stop": • "Emergency stop" must be effective as "Stop" of category 0 or category 1. The category for "Emergency stop" must be determined by means of a risk assessment for the machine. • Use only permanently wired, electromechanical equipment for the function "Emergency stop", stop category 0. The function must not depend on an electronic logic (hardware or software). • For the function "Emergency stop", stop category 1, the following applies to disconnecting power for the drive elements of the machine: – disconnection must be ensured. – disconnection must be made by means of electromechanical equipment. After operation of the actuator for the emergency off unit, the function "Emergency stop" must make sure that the danger is automatically averted or reduced in the best possible way. [1]	Chapter 9.2.5.4.2

[1] "in the best possible way" includes:

- Selection of the shortest deceleration rate
- Selection of the right "stop" category according to the risk assessment

"automatic" means: if defined accordingly, the emergency off function can be activated when the actuator of the emergency off unit is operated

The emergency off function must be effective after stop category 0 or stop category 1.

EDB9300 V004 EN 3.0 Lenze
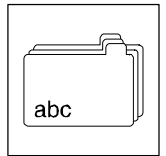
5.3.3 Categories according to EN 954-1

5.3.3.1 Control categories (paragraph 6 and following)

If an error occurs, the standard EN 954-1 classifies the performance of the safety-related parts of a control into 5 categories: B, 1, 2, 3, 4. These categories are used as a reference for the selection of the relevant control category:

- The selected category depends on the machine and the extent to which the control units are used for the protective measures.

- The selection of the category for the individual safety-related parts of the control mainly depends on the following factors:
  – the risk reduction reached through the safety function to which this part contributes,
  – the probability that an error occurs in this part,
  – the risk resulting from the occurrence of errors in this part,
  – the possibilities of preventing the occurrence of errors in this part,
  – the technologies used.

5.3.3.2 Notes for selection
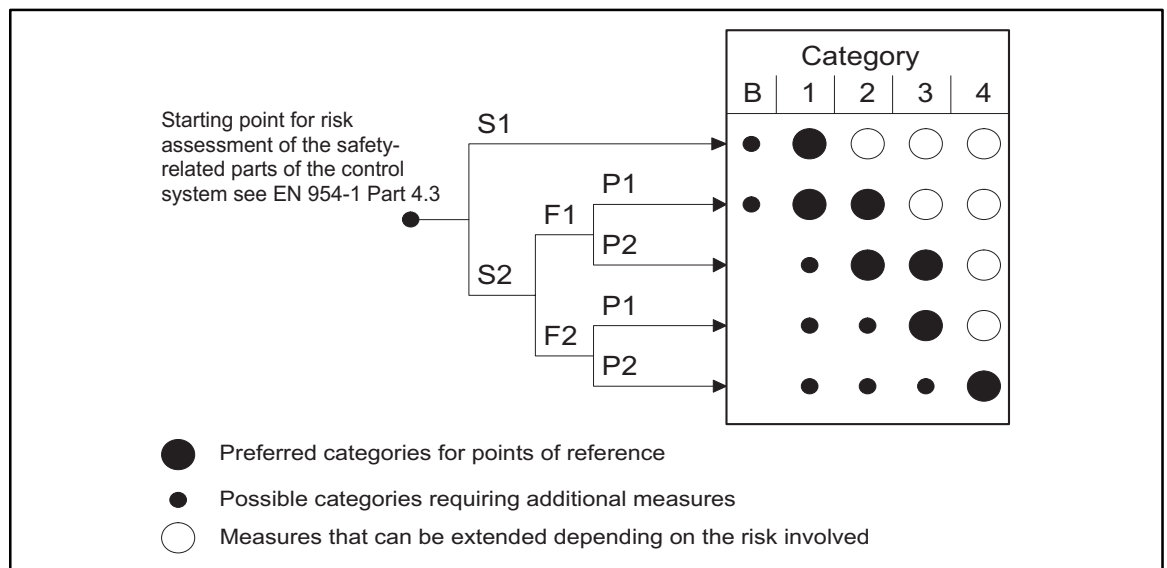
S	Degree of injury
S1	small injury (usually reversible)
S2	serious injury (usually irreversible)
F	**Frequency and/or time of the exposure to danger**
F1	rarely to frequently and/or short time of exposure
F2	frequently to permanently and/or long time of exposure
P	**Possibility of avoiding the exposure to danger**
P1	possible under certain conditions
P2	hardly possible
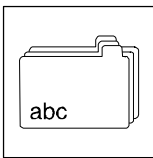
5.3.3.3 Requirements on the control categories

Short description of the requirements on the individual categories according to EN 954-1			
(Full version of the requirements: EN 954-1 paragraph 6)			
Category [1]) (EN954-1, ...)	**Requirements**	**System reaction[2])**	**Principles to ensure safety**
B (6.2.1)	All safety-related parts and components of controls and/or their protective devices must be designed, built, selected, assembled and combined in accordance with the relevant standards to ensure that they can resist to the influences to be expected.	The occurrence of an error can lead to the loss of the safety function.	Mainly characterised by the selection of components.
1 (6.2.2)	• The requirements of "B" must be fulfilled. • Proven components have to be used. • The official safety regulations have to be observed.	The occurrence of an error can lead to the loss of a safety function, it is, however, less likely that an error will occur than in category B.	
2 (6.2.3)	• The requirements of "B" must be fulfilled. • The official safety regulations have to be observed. • The safety function must be checked at appropriate intervals by the machine control.	• The occurrence of an error can lead to the loss of the safety function between the test intervals. • The loss of the safety function is recognised by the test function.	
3 (6.2.4)	• The requirements of "B" must be fulfilled. • The official safety regulations have to be observed. • Safety-related parts must be designed as follows: – in none of the parts, a single error may lead to the loss of the safety function, – the individual errors are recognised and removed accordingly (not time-critical).	• The safety function is always maintained, if the individual error occurs. • Some, but not all errors are recognised. • The accumulation of unrecognised errors can lead to the loss of the safety function.	Mainly characterised by the structure.
4 (6.2.5)	• The requirements of "B" must be fulfilled. • The official safety regulations have to be observed. • The safety-related parts must be designed as follows: – in none of the parts, a single error may lead to the loss of the safety function, – the individual errors must be recognised before or during the next application of the safety function. If this is not possible, the accumulation of errors must not lead to the loss of the safety function.	• The safety function is always maintained when errors occur. • Errors are recognised in time to prevent the loss of the safety function.	

[1] The categories have not been defined in the intention to be applied in a specified order or in a hierarchical order with regard to safety requirements.

[2] The risk assessment shows, whether the entire or partial loss of the safety function(s) due to errors can be accepted.

5.4 Certificate of Adequacy issued by the German trade association "Berufsgenossenschaft"

The above Certificate of Adequacy was issued by the Technical Committee for Iron and Metal of the German Trade Association "Deutsche Berufgenossenschaft, Fachausschuß für Eisen und Metall" on 13/06/2000 for:

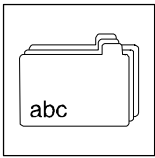**Lenze GmbH & Co KG, Hans-Lenze-Str. 1, D-31855 Aerzen**

It certifies that the technical documentation "Safe standstill" for drive controller series 9300, variant 004 - "Safe standstill" corresponds to the provisions laid down in the directive 98/37/EC (Machinery).

Testing was based on the following standards:

- DIN EN 60204-1; "Electrical equipment of industrial machines, part 1: General requirements", 11.98

- DIN EN 954-1; "Safety of machinery - Safety-related parts of control systems, part 1: General principles for design; category 3" 03.97

- DIN EN 1037; "Safety of machinery - Prevention of unexpected start-up"; 04.96

Remarks: Test report No.: 2993-2/00
Reference of Test and Certification Body: 612.17-EM II koe.-swk.

5.5   Table of keywords

Appendix

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