

0185-1183_E_1V0_SM_3S



Safety Manual for Drives F1150-DS-UC-3S F1250-MI-UC-3S

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Table of Contents

1	Scope	9
1.1	Objective	9
1.2	Purpose of Document	9
1.3	Applicable Documents	9
1.4	Referenced Documents	9
2	Introduction / Preface	10
2.1	Legal Notices	10
2.1.1	Warning Concept	10
2.1.2	Proper Use of LinMot Products	10
2.1.3	Read the Documentation	11
2.1.4	Qualified Personnel	11
2.1.5	Intended Use	11
2.1.6	Prohibited Use	11
2.1.7	Brands	12
2.1.8	Non-Safety function	12
2.1.9	Disclaimer	12
2.2	Preface	12
2.2.1	Technical Support Contacts	12
2.2.2	Target group	12
2.2.3	Benefits	12
2.2.4	Standard scope	12
3	Standards and Regulations	13
3.1	Aims	13
3.2	Functional Safety	13
3.3	Considered Standards	14
3.4	Country specific Regulations	14
4	Fundamental Safety Instructions	15
4.1	General Safety Instructions	15
4.2	Liability	15
4.3	Industrial Security	15
5	General Safety Notes LinMot Products	16
5.1	Products and Life Cycles	16
5.2	Overview Life Cycle, Safety Notes and Products	16
5.3	Safety Notes	17
5.4	Fundamental Safety Instructions	20
5.5	Residual Risk	21
6	LinMot Safety Drives with 3S STO	22
6.1	Drive Types and Nomenclature	24
6.2	Safety relevant Drive Installation Instructions	25
6.2.1	Physical Dimensions, Mounting, Environment	25
6.2.2	Supply and Grounding	28
6.2.2.1	Signal Power Supply	29
6.2.2.2	Motor Power Supply	30
6.2.2.3	Regeneration	30
6.2.3	Connectors and Wiring	30
6.2.3.1	PE: Protective Earth	30
6.2.3.2	X1: Motor Supply	31

6.2.3.3	X2/X3: Motor Connection	31
6.2.3.4	X4: Logic Supply / IO Connection	33
6.2.3.5	X13: External Position Sensor	34
6.2.3.6	X15: System Config	34
6.2.3.7	X16: System Config (only on F1250)	34
6.2.3.8	X17 – X18: Real Time Ethernet 10/100 Mbit/s	35
6.2.3.9	X70 – X71: LIDStream GB (only on F1250)	35
6.2.3.10	X79: CANopen (only on F1150)	35
6.2.3.11	S1 - S2: Address Selectors	36
6.2.3.12	S14: Reset Button	36
6.2.3.13	System LEDs	36
6.2.3.14	RT Bus LEDs	37
6.3	Drive Ordering Information	37
7	Safety Function 3S STO	38
7.1	Overview and Compatibility	38
7.2	Boundary of the Safety Compliant System	38
7.3	Constraints of the use of the Safety Compliant System	38
7.4	Safety Characteristics	38
7.5	Failure Modes	39
7.6	Implemented Measures against Systematic Errors	39
7.7	Used Technologies and architecture	39
7.8	Regarded Safety Related Errors taken Measures	40
7.9	Periodic Proof Tests	40
7.10	Predictable User Errors	40
7.11	Functional Description	41
7.11.1	STO Control Signals	41
7.11.2	Activation	41
7.11.3	Deactivation	42
7.11.4	STO Input levels and Timings	42
7.11.5	Feedback	42
7.11.6	Functional test	42
7.11.7	Fault Reaction	43
7.11.8	Example for the use of STO	43
7.11.9	Verification and Validation	43
8	Planning a Safety Project with LinMot Components	44
8.1	Identifying the risks and hazards	44
8.2	Determining the PLr / SIL	44
8.3	Specification of the safety functions	45
8.4	Specification of the measures	45
8.5	Implementation of the safety functions	45
8.6	Proof of achievement of the Performance Level	45
8.7	Validation of the safety functions	46
8.8	Instructions for checking the SF	46
9	Commissioning	48
9.1	HW Installation	48
9.2	Acceptance Tests	48
10	Acceptance Tests and Protocols	49
10.1	Introduction	49
10.1.1	Requirements	49

10.1.2	Requirements for the acceptance test	50
10.1.3	Acceptance Test	50
10.1.4	Documentation	50
10.2	Acceptance Tests	51
10.3	Complete Acceptance Test	52
10.3.1	Documentation	52
10.3.2	Functional and diagnostic safety tests	52
10.3.3	Conclusion of the Report	52
10.4	Partial Acceptance Test	53
10.4.1	Documentation	53
10.4.2	Functional and diagnostic safety tests	53
10.4.3	Conclusion of the Report	53
10.5	Test Scope for Specific Measures	53
11	Operation and Maintenance	54
11.1	Operation	54
11.2	Maintenance	54
12	Appendix	55
12.1	Terms and abbreviations	55
12.1.1	Additional Abbreviations	55
12.2	Change History	55

Table of Figures

Figure 1: F1150 Drive System

Figure 2: F1250 Drive System

Figure 3: F1150 Drive Physical Dimensions

Figure 4: F1250 Drive Physical Dimensions

Figure 5: F1150 Supply and Grounding

Figure 6: F1250 Supply and Grounding

Figure 7: Safety related block diagram

Figure 8: STO Timing

Table of Tables

Table 1: Applicable Documents
Table 2: Referenced Documents
Table 3: Life Cycle and Safety Notes
Table 4: Supported drives
Table 5: Drive nomenclature
Table 6: Drive physical dimensions, mounting and environment
Table 7: PE Connector: Protective Earth
Table 8: X1 Connector: Motor Supply
Table 9: X2 Connector: Motor Phases1
Table 10: X3 Connector: Motor Sensor / Non Safe Brake
Table 11: X4 Connector: Logic Supply / IO Connection
Table 12: X13 External Position Sensor
Table 13: X15: Config ETH
Table 14: X16: Config ETH
Table 15: X17/X18 Real Time Ethernet 10/100 Mbit/s
Table 16: X70/X71 LIDStream
Table 17: X79: CANopen
Table 18: S1 - S2: Address Selectors
Table 19: S14: Reset Button
Table 20: System LEDs
Table 21: RT Bus LEDs
Table 22: Drive Ordering Information
Table 23: Drives and safety functions
Table 24 : Characteristics of safety functions according to IEC 61508
Table 25: Characteristics of safety functions according to /ISO13849-1/
Table 26: Regarded safety related errors and taken measures
Table 27: Periodic proof tests
Table 28: Predictable User Errors and Measures
Table 29: STO Control Signals
Table 30: STO Input Levels and Timings
Table 31: STO Example
Table 32: Implementation of the safety functions
Table 33: Acceptance tests after replacements
Table 34: Checks during operation
Table 35: Additional abbreviations
Table 36: Change History

1 Scope

1.1 Objective

The NTI AG / LinMot drives are designed to control linear and rotary motors. The drives are components that are built into electrical plants or machines and can only be operated as integral components of these plants or machines.

The drive series F1150-3S and F1250-3S support the safe torque off function (STO).

1.2 Purpose of Document

The purpose of this document is to provide the necessary information about the safety products (drive series F1150-3S and F1250-3S) for a safe and compliant use of them.

1.3 Applicable Documents

The listed documents provided input to this document. Other documents are not listed here. When referenced to this table, the text in the column Ref is used, e.g. /SMRS/ or /ISO13849-1/.

Ref	Doc-Identification	Document Title	Version/Release
/SMRS/	<u>SMRS</u>	SMRS, Safety Manual Requirement Specification	1.0 / SVN 16897
/IEC61508-1/	EN IEC 61508-1	Functional Safety of Electrical/Electronic/Programmable Electronic Safety Related Systems - General requirements	Ed. 2.0, April 2010
/IEC61508-2/	EN IEC 61508-2	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 2: Requirements for electrical/electronic/programmable electronic safety-related systems	Ed. 2.0, April 2010
/ISO13849-1/	EN ISO 13849-1:2023	Safety of machinery - Safety-related parts of control systems - Part1: General principles for design	2023
/ISO13849-2/	EN ISO 13849-2:2012	Safety of machinery - Safety-related parts of control systems - Part2: Validation	2012

Table 1: Applicable Documents

1.4 Referenced Documents

These documents may contain further details of this document (information, which is outsourced from this document).

Ref	Doc-Identification	Document Title	Version
/LinMotTalk/	LinMot-Talk Manual	0185-1059-E_7V0_MA_LinMotTalk.pdf	7V0 or newer

Table 2: Referenced Documents

2 Introduction / Preface

2.1 Legal Notices

2.1.1 Warning Concept

This manual contains notices you must observe to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.



DANGER

DANGER

indicates that death or severe personal injury will result if proper precautions are not taken.



WARNING

WARNING

indicates that death or severe personal injury may result if proper precautions are not taken.



CAUTION

CAUTION

indicates that minor personal injury can result if proper precautions are not taken.



NOTICE

NOTICE

indicates that property damage can result if proper precautions are not taken

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used.

2.1.2 Proper Use of LinMot Products



CAUTION

Use of LinMot-Products

LinMot products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by LinMot. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

2.1.3 Read the Documentation



CAUTION

Read the Documentation

Read the available documentation before installation and commissioning. Improper handling of the servo motor and linear actuator can cause harm to people or damage to property. The operator must therefore ensure that all persons entrusted to work on the actuator have read and understood the manual and that the safety notices in this safety guide are observed.

2.1.4 Qualified Personnel

The 3S safety system described in this documentation may be operated only by personnel qualified for the specific task (such as storage & transport, commissioning, operation, maintenance, repair, modification, decommissioning or disposal), in accordance with the relevant documentation, its warning notices and safety instructions.

Qualified personnel are those who, based on their training and experience, can identify risks and prevent potential hazards when working with these products/systems.

2.1.5 Intended Use

The products and equipment are designed and intended for specific purpose as described. Each product may only be used with equipment and under operating conditions described in relevant documentation. Users must be qualified to handle the devices and be aware of the hazards potentially associated with the process. Some processes may require the workplace be equipped with additional safety features (such as protective clothing, eyeglasses and gloves) or that precautions be otherwise taken to protect personnel and working environment. Generally, all country and industry-specific statutory or otherwise mandatory laws and regulations apply. Safety and warning instructions given in this document only apply to the product or equipment or devices and supplement the rules and regulations the operator stipulates at the workplace for the respective process. The user is solely responsible for applications, which go beyond the intended use described here and for each individual product or equipment or device, which are not described in instructions sets. Company does not accept any liability beyond the intended usage.

Furthermore, individual restrictions and product or equipment or device specifications in the offer description from the manufacturer also found in the delivery contract and such warranty terms also apply. Intended use also means that all specifications in these instructions must be followed. Any use beyond the intended use is considered to be misuse.

2.1.6 Prohibited Use

Commissioning the motor is prohibited if the machine, in which it was installed,

- does not meet the requirements of the EC Machinery Directive,
- does not comply with the EMC Directive,
- does not comply with the Low Voltage Directive.

2.1.7 Brands

All names identified by ® are registered trademarks of LinMot / NTI AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

2.1.8 Non-Safety function

The non-safety functions are described in the LinMot-Talk manual and in the online manuals under <https://linmot.com/download/>.

2.1.9 Disclaimer

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

2.2 Preface

2.2.1 Technical Support Contacts

NTI AG – LinMot & MagSpring	
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CH-8957 Spreitenbach	
Switzerland	
Technical Support:	+41 56 544 71 00
Email:	support@linmot.com
Support website	http://www.linmot.com/support

2.2.2 Target group

This documentation is intended for machine manufacturers, commissioning engineers, and service personnel who use the LinMot drive system.

2.2.3 Benefits

This manual provides all the information, procedures and operator actions required for the particular life cycles.

2.2.4 Standard scope

For reasons of clarity, this documentation does not contain all the detailed information on all the products and cannot take into consideration every conceivable setup.

3 Standards and Regulations

3.1 Aims

Manufacturers and operating companies of equipment, machines, and products are responsible for ensuring the required level of safety. This means that plants, machines, and other equipment must be designed to be as safe as possible in accordance with the current state of the art. For this purpose, companies describe in the various standards the current state of the art covering all aspects relevant to safety. If it can be justifiably assumed that all the relevant standards are complied with, this ensures that state-of-the-art technology has been utilized and, in turn, a plant builder or a manufacturer of a machine or a piece of equipment has fulfilled his appropriate responsibility.

Safety systems are designed to minimize potential hazards for both people and the environment by means of suitable technical equipment, without restricting industrial production and the use of machines more than is necessary. The protection of man and environment must be assigned equal importance in all countries based on internationally harmonized rules and regulations. This is also intended to avoid competitive advantages or disadvantages due to different safety requirements in different countries.

There are different concepts and requirements in the various regions and countries of the world when it comes to ensuring the appropriate degree of safety. The legislation and the requirements of how and when proof is to be given and whether there is an adequate level of safety are just as different as the assignment of responsibilities.

The most important thing for manufacturers of machines and companies that set up plants and systems is that the legislation and regulations in the country where the machine or plant is being operated apply. For example, the control system for a machine that is to be used in the US must fulfill local US requirements even if the machine manufacturer (OEM) is based in the European Economic Area (EEA).

3.2 Functional Safety

Safety, from the perspective of the object to be protected, cannot be split-up. The causes of hazards and, in turn, the technical measures to avoid them can vary significantly. Therefore, a differentiation is made between different types of safety (e.g. by specifying the cause of possible hazards). "Functional safety" is involved if safety depends on the correct function.

To ensure the functional safety of a machine or plant, the safety-related parts of the protection and control devices must function correctly. In addition, the systems must behave in such a way that either the plant remains in a safe state, or it is brought into a safe state if a fault occurs. In this case, it is necessary to use specially qualified technology that fulfills the requirements described in the associated standards. The requirements to implement functional safety are based on the following basic goals:

- Avoiding systematic faults
- Controlling random faults or failures

Benchmarks for establishing whether a sufficient level of functional safety has been achieved include the probability of hazardous failures, the fault tolerance, and the quality that is to be ensured by avoiding systematic faults. This is expressed in the standards using specific classification. In IEC/EN 61508, IEC/EN 62061 "Safety Integrity Level" (SIL) and /ISO13849-1/ "Category" and "Performance Level" (PL).

3.3 Considered Standards

The following standards and regulations must be considered:

- EN ISO 13849-1:2023-04: Safety of machinery - Safety-related parts of control systems
- EN ISO 13849-2:2012: Safety of machinery - Safety-related parts of control systems, part 2 Validation
- EN IEC 61508: 2010, parts 1 to 7, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems
- EN 61800-5-2:2016-04, Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional

3.4 Country specific Regulations

Additional to the regulations listed above to comply with, additional country specific regulations can be relevant. It is necessary to verify for the specific application and place of action, which local regulations must be fulfilled.

4 Fundamental Safety Instructions

4.1 General Safety Instructions



DANGER

Danger to life if the safety instructions and residual risks are not observed

If the safety instructions and residual risks in the associated documentation are not observed, accidents involving severe injuries or death can occur.

- Observe the safety instructions given in the documentation.

Consider the residual risks for the risk evaluation.



WARNING

Malfunctions of the machine because of incorrect or changed parameter settings

because of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization (parameter assignments) against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off

4.2 Liability

NTI AG (as manufacturer of LinMot linear motors and MagSpring products) excludes all liability for damages and expenses caused by incorrect use of the products. This also applies to false applications, which are caused by NTI AG's own data and notes, for example in the course of sales, support or application activities. It is the sole responsibility of the user to verify that the information and data provided by NTI AG are accurate in terms of safety. In addition, the entire responsibility for safety-related product functionality lies exclusively with the user. Product warranties are void if products are used with stators, sliders, servo drives or cables not manufactured by NTI AG unless such use was specifically approved by NTI AG.

NTI AG's warranty is limited to repair or replacement as stated in our standard warranty policy as described in our "terms and conditions" previously supplied to the purchaser of our equipment (please request copy of same if not otherwise available). Further reference is made to our general terms and conditions.

Application examples are not binding and do not claim to be complete regarding configuration, equipment or any eventuality which may arise. Application examples do not represent specific customer solutions, they are only intended to provide support for typical tasks.

As a user, you are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

4.3 Industrial Security

The STO safety function is implemented in hardware only. Neither software nor parameters are involved. This means that the device cannot be compromised.

5 General Safety Notes LinMot Products

5.1 Products and Life Cycles

The following safety notes must be generally regarded to guarantee safety during all life cycles. The focused products are the drives. The life cycles are:

- Storage & Transport
- Machine Integration (Commissioning)
- Operation
- Maintenance & Repair
- Modification
- Decommissioning & Disposal

The safety notes address the different danger source, the relevant products and life cycles are indicated for each safety note.

5.2 Overview Life Cycle, Safety Notes and Products

The following table gives an overview over the safety notes, applicable life cycles for the drives. The items are described in the following chapters separately. Specific safety instructions and warnings are also placed. Check nearby chapters, where safety products or safety functions are described.

Safety Note	Storage & Transport	Machine Integration	Operation	Maintenance & Repair	Modification	Decommissioning & Disposal
High Temperatures	x	x	x	x	x	x
High Voltage	-	x	x	x	-	-
Mechanical Parts and Motion	-	x	x	x	-	-
Shock and Vibration	x	x	x	x	-	-
Dirt, IP	x	x	x	x	x	x
Corrosion	-	-	x	x	-	-
Hazardous Materials	-	-	-	-	-	x

Table 3: Life Cycle and Safety Notes

5.3 Safety Notes

This chapter contains the general safety notes.



DANGER

Danger to life if the safety instructions and residual risks are not observed

If the safety instructions and residual risks in the associated hardware documentation are not observed, accidents involving severe injuries or death can occur.

- Observe the safety instructions given in the hardware documentation.
- Consider the residual risks for the risk evaluation



WARNING

Malfunctions of the machine because of incorrect or changed parameter settings

If the safety instructions and residual risks in the associated hardware documentation are not observed, accidents involving severe injuries or death can occur.

- Observe the safety instructions given in the hardware documentation.
- Consider the residual risks for the risk evaluation



WARNING

High Temperatures

Avoid the drive from high temperatures and beware from hot parts.

Life Cycles:

- all

Safety measures:

- Avoid high temperature exposure
- Make correct dimensioning and mounting of cables.
- If necessary, install cooling
- Do not thermally insulate cables



DANGER

High Voltage

As the drive is an electrical part, make sure to implement the protection from electric shock.

Life Cycles:

- Machine Integration
- Operation
- Maintenance & Repair

Safety measures:

- All components must be well grounded.
- See installation guides of drives and motors



WARNING

Shock and Vibration

Components can be damaged by high shock or vibrations. This may lead to loss of function and can also cause dangers.

Life Cycles:

- Transport
- Machine Integration
- Operation
- Maintenance & Repair

Safety measures:

- Consider the limits defined in the installation guides



WARNING

Dirt, IP

Dirt, dust or liquids may cause a danger, because of electric shock or other scenarios.

Life Cycles:

- All (except for disposal)

Safety measures:

- Protect parts generally from dirt
- Consider information given in the installation guide about dirt and IP rating.
- The drive shall be mounted in a cabinet with an ingress protection of at least IP54



WARNING

Hazardous materials

The type and functionality of the products need implementations, which are based on some hazardous components. If handled correctly, no danger for persons and environment can occur.

Life Cycles:

- Decommissioning

Safety measures

- Drives contain electronics components. Decommissioning and disposal must be done environmentally friendly

 WARNING	EMC EMC must be regarded for avoiding disturbances with other equipment. Products: • Cables (cabling) Life Cycles: • Machine Integration • Operation Safety measures: • Make wiring, shielding and grounding according to the installation guides. • Comply with maximal cable length, cable type and cross section defined in installation guides
 CAUTION	Modification Protection Components, which are broken or worn out, must be replaced instead of repaired.
 WARNING	Power Supply • The logic supply of the LinMot drive must be supplied with 24 VDC by an SELV/PELV power supply unit with an output voltage limit U_{max} of 36 VDC. Failure to observe this can result in a loss of safety. • Use another power supply for the motor.
 CAUTION	Hazard Analysis A hazard analysis of the application must be performed prior to the use of the safety functions of the product in that application. The hazard analysis must be done by qualified personnel.

5.4 Fundamental Safety Instructions**NOTICE****Risk minimization by using safety**

Safety can be used to minimize the level of risk associated with machines and plants.

Machines and plants can only be operated safely when the machine manufacturer:

- Precisely knows and observes this technical user documentation, including the documented limitations, safety information and residual risks.
- Carefully constructs and configures the machine/plant. A careful and thorough acceptance test must then be performed by qualified personnel and the results documented.
- Implements and validates all the measures required in accordance with the machine/plant risk analysis by means of the programmed and configured safety functions or by other means.
- The use of safety functions does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the EC machinery directive.

In addition to using safety functions, further risk reduction measures must be implemented

**DANGER****Danger to life as a result of undesirable motor movement when automatically restarting**

The Emergency Stop function must bring the machine to a standstill according to Stop Category 0 or 1 (STO) (EN 60204-1).

It is not permissible that the motor automatically restarts after an emergency stop, as this represents danger to life as a result of the associated undesirable motor motion.

When individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when emergency stop is reset). An automatic start is permitted when a protective door is closed, for example.

- For the cases listed above, ensure that an automatic restart is absolutely not possible.

**DANGER****Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after changing or replacing hardware and/or software**

After hardware and/or software components have been modified or replaced, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after having made certain changes or replacements.
- Before personnel may re-enter the hazardous area, all the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both directions.
- When switching on carefully observed the following:
The Safety Integrated Functions are only available and can only be selected after the system has completely powered up.

5.5 Residual Risk



DANGER

Danger due to short, limited movements

If two power transistors simultaneously fail in the power unit (one in the upper and one in the lower inverter bridge), then this can cause a brief, limited movement.

The maximum movement can be:

- Synchronous rotary motors: Max. movement = 180° / no. of pole pairs
- Synchronous linear motors: Max. movement = pole width.
 - P01-23x: 10mm
 - P01-37x: 20mm
 - P01-48x: 30mm

6 LinMot Safety Drives with 3S STO

The drive series F1150 and F1250 are equipped with the safety function STO (safe torque off). The following chapters give a list of the supported safety products and their compatibility.

A detailed description for the 3S STO safety function can be found in chapter 7 - Safety Function 3S STO.

The figures show the drive series F1150 and F1250 with their peripheral components.

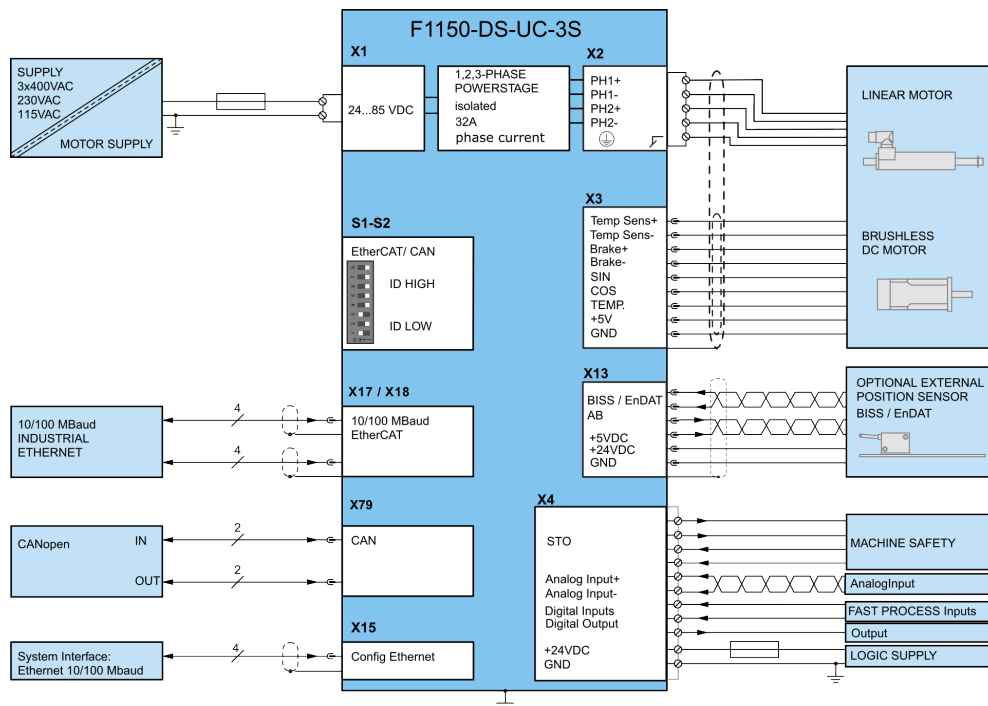


Figure 1: F1150 Drive System

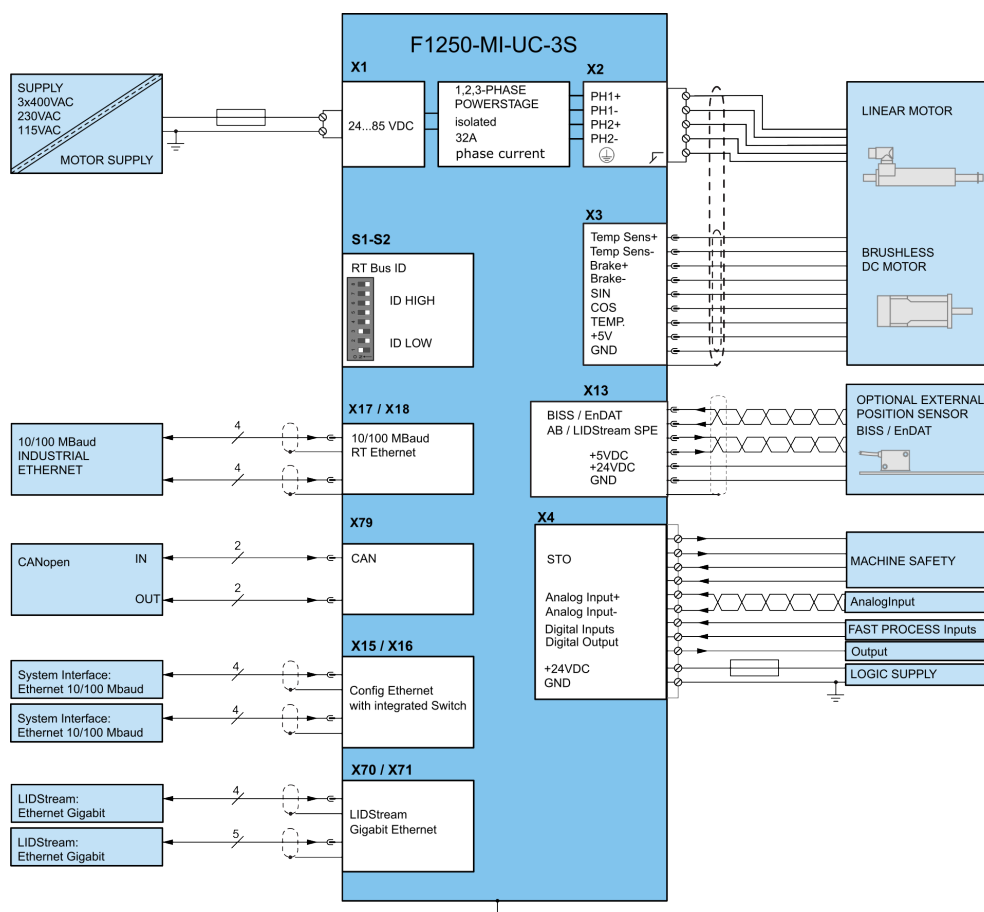


Figure 2: F1250 Drive System

6.1 Drive Types and Nomenclature

The following drives support the 3S functional safety:

Type	Article Number	Description	Version
F1150-DS-UC-3S-000	0150-6489	F1150 DS Drive (72V/32A)	V1RC2 and higher
F1150-DS-UC-3S-xxx	0150-XXXX	F1150 DS Drive (72V/32A), customer specific	V1RC2 and higher
F1250-MI-UC-3S-000	0150-6592	F1250 Multi Interface (72V/32A)	V1RA1 and higher
F1250-MI-UC-3S-xxx	0150-XXXX	F1250 Multi Interface (72V/32A), customer specific	V1RA1 and higher

Table 4: Supported drives

Remark: The version string e.g. "V1RA" consists of Version 1 "V1" and Revision A "RA". V1RA may be followed by a single digit, this represents the sub-revision (e.g. "V1RA3"). All sub-revisions are functional and software compatible.

The key for the drive nomenclature is given by the following table:

Variations of					Description
Base type	Fxxxx				72 VDC drive for P01 Motors - 1150: low-cost drive - 1250: high end drive
Interface		-XX			This part specifies the interface: - DS: DS402 profile, available on F1150 drives. - MI: Multi Interface on F1250 drives. Different interfaces are supported with the same hardware. All available interfaces can be loaded by the customer
Power class			-UC		72 VDC, 32 A peak
Safety-Functions				-3S	With safety function STO.
Extension				-xxx	The extension may consist of any three characters. It describes not safety related customer specific versions (for example configuration). -000 means default -xxx: The customer-specific versions differ only from the configurations. Each customer-specific version has its own article number. The extension is omitted in this document if it is not relevant.

Table 5: Drive nomenclature

The installation guides for the drives are provided with the product or are available on the LinMot Webpage and must be carefully implemented.

6.2 Safety relevant Drive Installation Instructions

This chapter focuses on the safety relevant topics, which must be regarded, when the drive is installed. There is additional information in the drive's installation guide.

6.2.1 Physical Dimensions, Mounting, Environment

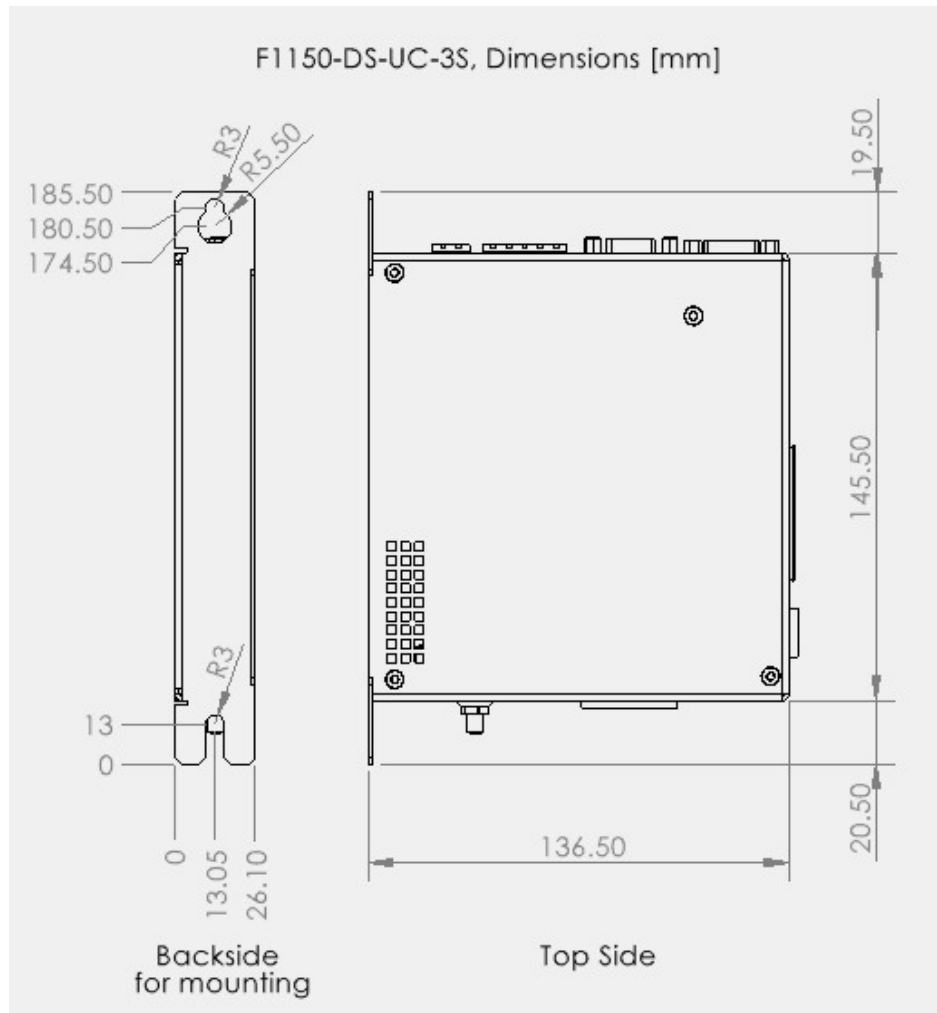


Figure 3: F1150 Drive Physical Dimensions

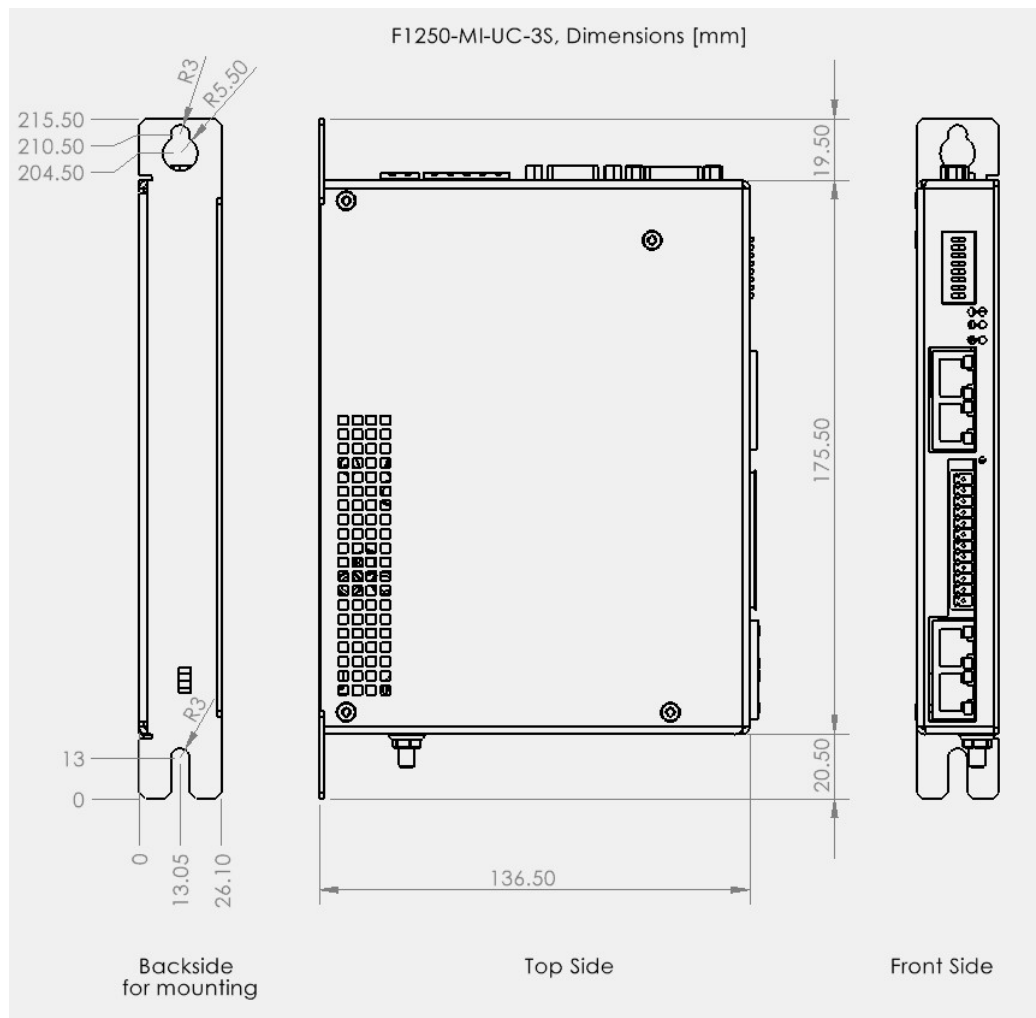


Figure 4: F1250 Drive Physical Dimensions

Series single axis drive	Unit	F1150-DS-UC-3S	F1250-MI-UC-3S
Width	mm (in)	26.1 (1.03)	26.1 (1.03)
Height	mm (in)	145.5 (5.73)	175.50 (6.91)
Height with fixings	mm (in)	185.5 (7.30)	215.50 (8.48)
Depth	mm (in)	136.5 (5.37)	136.5 (5.37)
Weight	g (lb)	765 (1.69)	890 (1.96)
Mounting Screws	mm (in)	2 x M5	2 x M5
Mounting Distance		167.5 (6.59)	197.5 (7.78)
Case, Degree of Protection	IP	20 Cover or mating connector must be placed on X79.	20
Storage Temperature	°C	-25 to 40, maximum change 20 K/hour	
Transport Temperature	°C	-20 to 70	
Operating Temperature	°C	5 to 40 at rated data	
Relative Humidity	% r.H.	10 to 85 (non-condensing)	
Air Pressure	hPa	700 to 1060	
Exposure to ionizing radiation		not acceptable	
Exposure to corrosive environment		not acceptable	
EMC		EN/IEC 61000-6-7 (Functional Safety)	
Pollution	IEC/EN 60664-1	Pollution degree 2	
Shock resistance (30 ms)	m/s ²	50	
Vibration resistance (10 - 150 Hz)	m/s ²	10	
Max. Case Temperature	°C	70	
Max. Power Dissipation	W	30	40
Mounting place		In the control cabinet (at least IP54)	
Mounting position		vertical, motor connection on top	
Distance between Drives	mm (in)	Without Power Derating *): 20 (0.80) horizontal / 50 (2.00) vertical With Power Derating *): 5 (0.20) horizontal / 20 (0.80) vertical	

Table 6: Drive physical dimensions, mounting and environment

*) The derating depends on the specific thermal conditions inside the cabinet. To ensure proper operation, the drive temperature should be checked under full load until it reaches a stable value, which may take an hour or more. This verification confirms whether sufficient thermal margin remains when the cabinet reaches its maximum allowable temperature of 40 °C. For example, if the drive temperature becomes stable at 45 °C while the cabinet is at 30 °C, the drive temperature can be expected to reach approximately 55 °C when the cabinet temperature rises to 40 °C. The default warning threshold of the drive is set to 75 °C and the error threshold to 80 °C. In this scenario, the operating conditions are well within acceptable limits. However, if the drive temperature remains above the warning level for extended periods, this may lead to a reduced lifetime of the drive.

6.2.2 Supply and Grounding

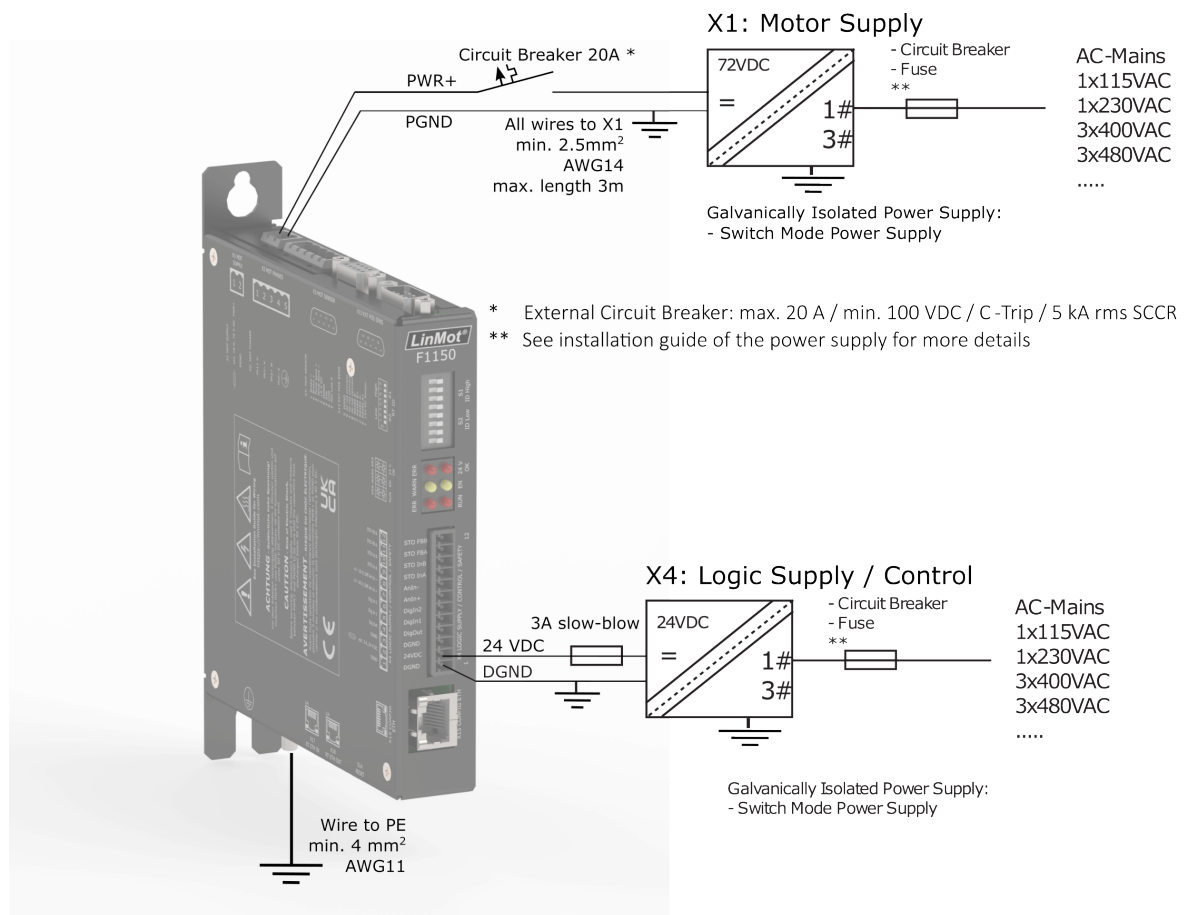


Figure 5: F1150 Supply and Grounding

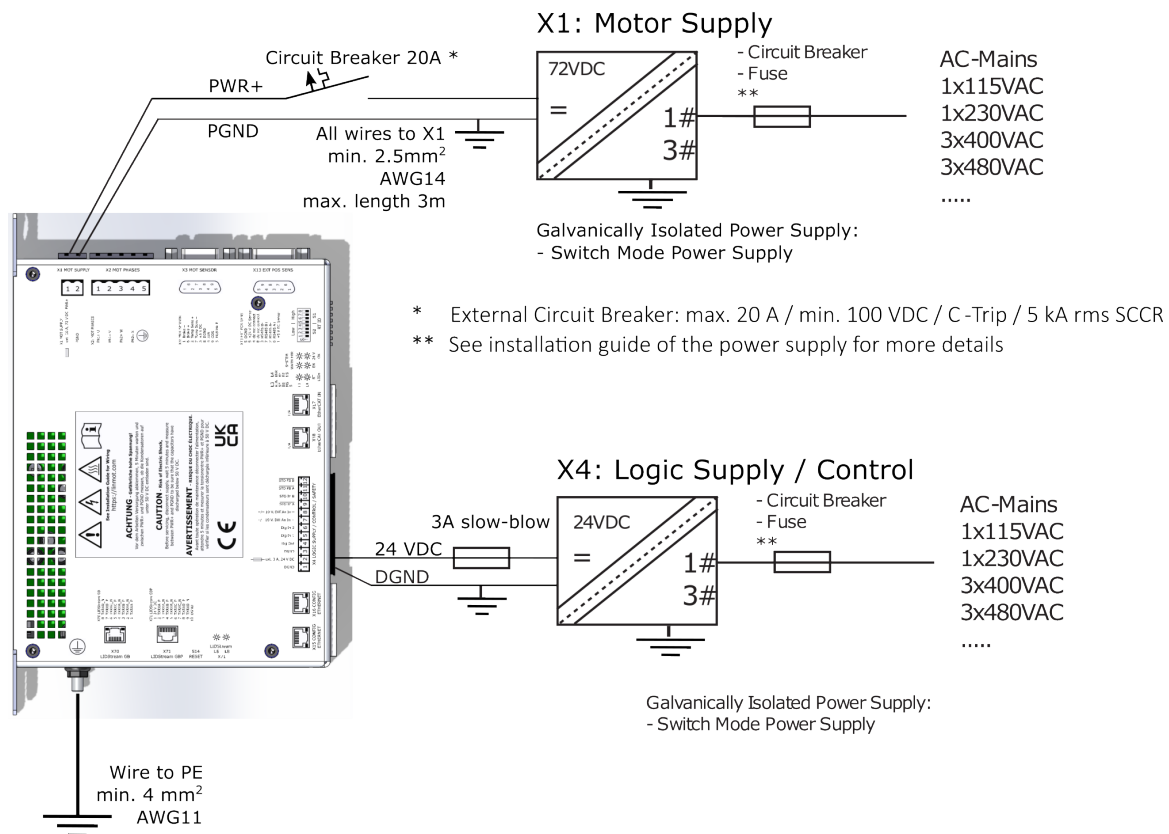


Figure 6: F1250 Supply and Grounding

6.2.2.1 Signal Power Supply

The logic supply needs a regulated power supply of a nominal voltage of 24 VDC. The voltage must be between 22 and 26 VDC.

Current to be provided from the supply:



CAUTION

Fuse Protection for 24 VDC Supply

The 24 VDC supply for the control circuit must be protected with an external fuse (3A slow blow).



WARNING

Signal Power Supply

The logic supply of the LinMot drive must be supplied with 24 VDC by an SELV/PELV power supply unit with an output voltage limit U_{max} of 60 VDC. Failure to observe this can result in a loss of safety.

Use another power supply for the motor.



WARNING

Do not connect or disconnect power supply while DC voltage is present!

Do not disconnect system components until all LinMot drive LEDs have turned off. (Capacitors in the power supply may not fully discharge for several minutes after input voltage has been disconnected).

Failure to observe these precautions may result in severe damage to electronic components in LinMot motors and/or drives.



WARNING

Do not switch Power Supply DC Voltage!

All power supply switching, and E-Stop breaks should be done to the AC supply voltage of the power supply. Failure to observe these precautions may result in severe damage to the drive.

6.2.2.2 Motor Power Supply

The calculation of the needed power for the Motor supply is depending on the application and the used motor.
The nominal supply voltage is 72 VDC.
The possible range is from 24 VDC to 85 VDC.



NOTICE

Use compatible Power Supplies

The motor supply can rise to 95 VDC when braking. This means that everything connected to that power supply needs a voltage rating of 100 VDC. (Additional capacitors, etc.)
Due to high braking voltage and sudden load variations of linear motor applications, only compatible power supplies can be used. See chapter [6.3 - Drive Ordering Information](#).



CAUTION

Circuit Breaker for Power Supply

The power supply for the motor must be protected with an external Circuit Breaker: 20 A / min. 100 VDC / C-Trip / 5 kA rms SCCR.

6.2.2.3 Regeneration

If the motor supply voltage rises too high, the power is regenerated within the motor (no regeneration resistor is required).

6.2.3 Connectors and Wiring

The following subchapters provide important information about the correct wiring of the different connectors.

6.2.3.1 PE: Protective Earth

PE	Protective Earth
	• Use min. 4 mm² (AWG11) • Tightening torque: 2 Nm (18 lbin) • M5

Table 7: PE Connector: Protective Earth

6.2.3.2 X1: Motor Supply

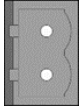
X1	Motor Supply
	PWR+ PGND
Connector must be ordered separately: see chapter 6.3)	Motor Supply: 72 VDC nominal, 24 VDC to 85 VDC Note: • Absolute max. Rating: 72 VDC + 20 %. • External Circuit Breaker: 20 A / min. 100 VDC / C-Trip / 5 kA rms SCCR • If motor supply voltage exceeds 90 VDC, the drive will go into error state. • PGND must be connected to Protective Earth (near the power supply). Mating connector is provided with the drive. • Use 60/75 °C copper conductors only. • Conductor Cross-Section: 2.5 mm² (AWG14) max. Length 3 m • Stripping length: 11 mm

Table 8: X1 Connector: Motor Supply

6.2.3.3 X2/X3: Motor Connection

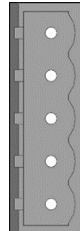
X2	Motor Phases		
	Ph 1+ U Ph 1- V Ph 2+ W Ph 2- X 	LinMot Motor: Motor Phase 1+ red Motor Phase 1- pink Motor Phase 2+ blue Motor Phase 2- grey Protective Earth	3-phase EC-Motor: Motor Phase U red Motor Phase V pink Motor Phase W blue Motor Phase X grey Protective Earth
	Note: • Use 60/75 °C copper conductors only • Conductor Cross-Section: 0.5 - 2.5 mm² (depends on Motor current) / AWG 21 - 14		

Table 9: X2 Connector: Motor Phases1

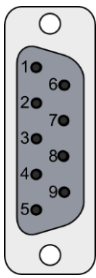
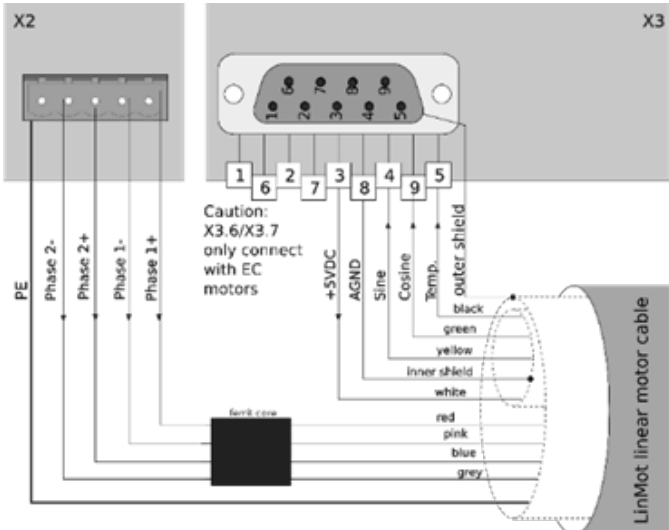
X3	Motor Phases	
	1 6 2 7 3 8 4 9 5 case	LinMot Motor: Do not connect Do not connect Do not connect Do no connect +5 V DC DGND Sensor Sine Sensor Cosine Mot Link P Shield EC Motor: Brake - Brake+ Temp Sens + Temp Sens - +5 V DC DGND Sensor Sine / Hall Switch U Sensor Cosine / Hall Switch V Hall Switch W Shield
DSUB-9 (f)	Note: - Use +5 V (X3.3) and AGND (X3.8) only for motor internal hall sensor supply (max. 100 mA). - Max. motor cable length: 50m for LinMot P0x motors. Please check restrictions of motor, encoder and cable as well. - Brake+: 24 V / max. 500 mA, Peak 1.4 A (will shut down if exceeded) the other terminal must be wired to Brake- (X3.1) Locking Screws: Tightening torque 0.4 Nm Caution: - Do NOT connect DGND (X3.8) to ground or earth! Temperature Sensor: - A resistive temperature sensor (PT1000, KTY) can be connected between Temp Sens+ (X3.2) and Temp Sens- (X3.7) Important Notes: - Use Y-style motor cables only (for example K15-Y/C)! A W-style cable has a different shielding, so it cannot be modified to a Y-style cable!	
X2 		

Table 10: X3 Connector: Motor Sensor / Non Safe Brake

6.2.3.4 X4: Logic Supply / IO Connection

X4		Logic Supply / IO Connection	
	12	/STO FB B	STO Feedback Channel B (active low)
	11	/STO FB A	STO Feedback Channel A (active low)
	10	/STO In B	STO input Channel B (active low)
	9	/STO In A	STO input Channel A (active low)
	8	An In-	Configurable +/- 10 V differential analog Input (with X4.7)
	7	An In+	Configurable +/- 10 V differential analog Input (with X4.8)
	6	Dig In 2	Configurable digital Input 2
	5	Dig In 1	Configurable digital Input 1
	4	Dig Out	Configurable digital Output
	3	DGND	Logic Ground for configurable Output
	2	+24 VDC	Logic Supply 22 to 26 VDC
	1	DGND	Logic Ground (typically connected to protective Earth)
		Digital Outputs: (X4.4): • 24 V / max. 100mA, Peak 1.4 A (will shut down if exceeded). The output is high side switching with integrated pull-down (1k7 to DGND) Digital Inputs (X4.5 & X4.6): • 24 V / 5 mA • Low Level: -0.5 to 5 VDC • High Level: 15 to 30 VDC) Analog inputs (X4.7/X4.8): • Differential analog input, +/- 10 V. • Common mode range: - 5 ... +10 V DC to GND, Input Resistance 28.0 k • 12-bit A/D converter /STO In A/B (X4.9/X4.10): STO Request • STO requested if Input <5VDC, STO deactivated if both inputs > 15 VDC • STO activation time < 1 ms, STO deactivation time < 5 ms • Input current @24 VDC < 5 mA /STO FB A/B (X4.11/X4.12): STO Feedback • STO active if Output < 5 VDC, STO deactivated if Output > 15 VDC • Max. Output current 80mA Rating Connector: • Use 60/75 °C copper conductors only. • Conductor cross-section max. 1.5 mm² (AWG 16) • Stripping length: 10 - 11 mm Important notes: • The 24 VDC logic supply for the control circuit (X4.2) must be protected with an external fuse (3 A slow blow) and it should be SELV/PELV with an output voltage limit U_{max} of 36 VDC.	

Table 11: X4 Connector: Logic Supply / IO Connection

6.2.3.5 X13: External Position Sensor

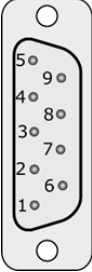
X13	External Position Sensor	
	5 9 4 8 3 7 2 6 1 case	BiSS-C (preferred) / SSI / BiSS-B / EnDat2.1 / EnDat2.2 / AB DGND +24V DC Sensor Do not connect Do not connect RS485 B- (MA- / Clock- / B-) RS485 B+ (MA+ / Clock+ / B+) RS485 A- (SLO- / Data- / A-) RS485 A+ (SLO+ / Data+ / A+) +5V DC Sensor Shield
DSUB-9 (m)	Position Encoder Inputs (RS422): Max. counting frequency: 20M counts / s with quadrature decoding. A minimum of 50ns edge separation must be guaranteed by the encoder under any circumstances! The maximal frequency of each signal is 5 MHz <u>Sensor Supply:</u> 5.15 VDC max 300 mA 24 VDC max 200 mA	

Table 12: X13 External Position Sensor

6.2.3.6 X15: System Config

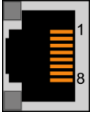
X15	System Config	
	X15 Config ETH	10 / 100 Mbit/s Ethernet RJ45, (F1250: with integrated switch to X16)

Table 13: X15: Config ETH

6.2.3.7 X16: System Config (only on F1250)

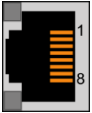
X16	System Config	
	X16 Config ETH	10 / 100 Mbit/s Ethernet RJ45, integrated switch with X15

Table 14: X16: Config ETH

6.2.3.8 X17 – X18: Real Time Ethernet 10/100 Mbit/s

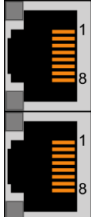
X17 – X18		Real Time Ethernet 10/100 Mbit/s	
	X17 RT ETH In	Specification depends on RT Bus. Please refer to according to documentation. In case of F1150 only EtherCAT is supported.	
	X18 RT ETH Out		
RJ-45	Warning: Do not connect the real time bus directly to the internet!		

Table 15: X17/X18 Real Time Ethernet 10/100 Mbit/s

6.2.3.9 X70 – X71: LIDStream GB (only on F1250)

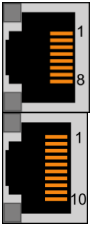
X70 – X71	LIDStream GB	
	X70 LIDStream GB RJ-45	LIDStream Gigabit.
	X71 LIDStream GBS RJ-50	LIDStream Gigabit with Power

Table 16: X70/X71 LIDStream

6.2.3.10 X79: CANopen (only on F1150)

X79	CANopen	
	1 CANL 2 CANH 3 CANL 4 CANH	CANopen in and out Termination resistor is not integrated
Card Edge	Edge Lock connector from Molex Mating connector: Molex 2008900104 together with the corresponding crimp terminals (Molex 2004490001)	
 NOTICE	IP20 is only fulfilled, if cover or mating connector is placed on X79.	

Table 17: X79: CANopen

6.2.3.11 S1 - S2: Address Selectors

S1 - S2		Address Selectors	
	S1 (5 .. 8)	Bus ID High (0x0 ... 0xF). Bit 5 is the LSB, bit 8 the MSB.	
	S21 (1 .. 4)	Bus ID Low (0x0 ... 0xF). Bit 1 is the LSB, bit 4 the MSB.	
	Setting the ID high & low to 0xFF on power up resets the drive to manufacturer settings!		
The use of these switches depends on the type of fieldbus which is used. Please see the corresponding manual for further information			

Table 18: S1 - S2: Address Selectors

6.2.3.12 S14: Reset Button

S14	Reset Button
	Pressing the Reset Button at power up for 5 seconds, the firmware and parameters are reset, and the system will be in a recovery mode. After this, the firmware must be reinstalled. The reset button is recessed (2mm hole) and must be operated with a tool (e.g. paper clip).

Table 19: S14: Reset Button

6.2.3.13 System LEDs

LEDs	State Displays		
	Signal	Color:	Description:
	24VOK	Green	24 VDC Logic Supply OK
	EN (enable)	Yellow	Motor Enabled / Error Code Low Nibble
	WARN	Yellow	Warning / Error Code High Nibble
	ERROR	Red	Error
The blink codes are described in the corresponding installation guide.			

Table 20: System LEDs

6.2.3.14 RT Bus LEDs

The blink codes are described in the corresponding interface manuals.

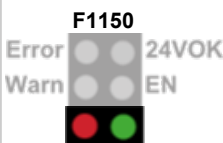
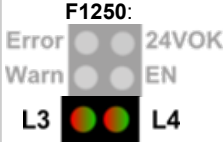
RT Bus LEDs	RT Bus State Displays		
	EtherCAT State	ERR (red)	RUN (green)
	BUS Type: EtherCAT PROFINET POWERLINK EtherNet/IP SERCOS CC-Link	L3 (bicolor) RUN (green) SF (red) BS (green) MS (green/red) S (green/red) RUN (green)	L4 (bicolor) ERR (red) BF (red) BE (red) NS (green/red) ERR (red)
	The blink codes are described in the corresponding interface manual.		

Table 21: RT Bus LEDs

6.3 Drive Ordering Information

Drive	Description	Article Number
F1150-DS-UC-3S-000	EtherCAT DS402 Drive (72 V / 32 A), STO	0150-6489
F1250-MI-UC-3S-000	MI Drive (72 V / 32 A). STO	0150-6592
Compatible Power Supplies		
S02-72/1000	Power Supply 72 V / 1000 W (3000 W Peak), 3x400-480 VAC	0150-4535
S02-72/600	Power Supply 72 V / 600 W (1500 W Peak), 1x120/230 VAC	0150-5700
S01-24/500	Power Supply 24 V / 500 W, 1x120/230 VAC	0150-2480

Table 22: Drive Ordering Information

Bold items are strongly recommended accessories!

	Ordering of Connectors The connectors X1 and X4 are delivered together with the drive! The connector X2 is included on the motor cable.
NOTICE	

7 Safety Function 3S STO

7.1 Overview and Compatibility

The 3S-drives support the STO safety function.

Drive	Function	Description	Documentation Chapter
F1150-DS-UC-3S	STO	Safe Torque Off	7.11 - Functional Description
F1250-MI-UC-3S	STO	Safe Torque Off	7.11 - Functional Description

Table 23: Drives and safety functions

The following subchapters contain general information for the safety functions, such as characteristics, boundaries, constraints etc.

7.2 Boundary of the Safety Compliant System

The safety part in the 3S drive system contains the following:

- Circuit for STO
- STO request inputs
- STO feedback outputs

7.3 Constraints of the use of the Safety Compliant System

Power supplies and IO signals must fulfill the requirements defined in the appropriate chapters.

7.4 Safety Characteristics

The complete 3S drive system with all its functions has the safety characteristics listed in the following tables.

Item	Value	Description / Comment
SIL	2	Safety Integrity Level
SFF	>= 60%	Safe Failure Fraction
PFHd	< 1 FIT	Probability of dangerous Failure per Hour
High demand mode		The system fulfills the high demand or continuous mode.
1oo2 architecture		The safety architecture realized in the drive is 1 out of 2.
Type B subsystem		The safety subsystem is of type B. (According to IEC 61508-2:2010 chapter 7.4.4.1.2 and 7.4.4.1.3)
Mission Time	20 years	Mission time for all safety functions
Proof Test Interval	20 years	Proof test interval for all safety functions
Diagnostic Test Interval	<= 8760h (1 year)	Test interval to verify the correct functionality of the diagnosis.

Table 24 : Characteristics of safety functions according to IEC 61508

Item	Value	Description / Comment
Cat	3	Category
PL	d	Performance Level
DC _{agv}	>= 60%	Diagnosis Coverage
MTTFd	>= 1500 years	Mean Time to Dangerous Failure per channel
CCF	> 65	Common Cause Failure: Fulfilled, according to ISO 13849-1:2023, table F.1

Table 25: Characteristics of safety functions according to /ISO13849-1/

7.5 Failure Modes

The failure model used assumes 50% of all failures are safe failures and 50% are dangerous failures. A more detailed investigation of the failure models is expected show more safe failures than the 50% assumed. Therefore this is a worst-case assumption causing an increased safety margin.

7.6 Implemented Measures against Systematic Errors

For the safety compliant system, for development and design, the following measures have been taken to prevent from systematic errors:

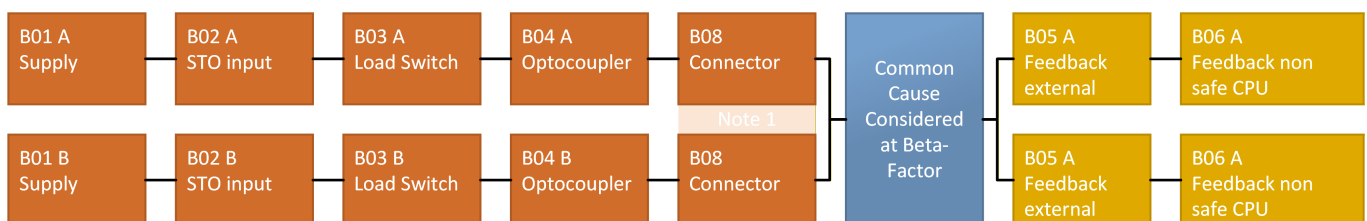
- implementation of tables under EN 61508-2 Appendix B

7.7 Used Technologies and architecture

For the implementation of the safety related function the following technologies are used.

- two channel architecture for safety related functions
- fault exclusion for single channel parts

The safety related block diagram of the implementation is:



Note 1: The connector X4 is calculated in the FMEDA per pin, so it's dual channel.

Figure 7: Safety related block diagram

Where a dual channel architecture is implemented the hardware fault tolerance (HFT) is 1:

- STO Switch off

Where a single channel architecture is implemented the HFT is 0.

- General Infrastructure (PCB, Power Stage...)

There are risk reduction measures implemented for single channel architecture parts, see chapter [7.5 - Failure Modes](#).

7.8 Regarded Safety Related Errors taken Measures

The following table lists safety related errors, possible error causes and the measures or advice for the handling.

Fault	Measures, Discussion
STO Hardware fault, cannot turn off the power stage	Dual channel architecture. The PWM pulse transmission for the power stage can be switched off on high and low side separately.
Short Circuit - between PWR and signal - Signals on PCB	Fault exclusion: The isolation between the PWR and signal circuits are HV tested. The cables are double isolated. - Each PCB is electrically tested in the production and the design rules are set the way the fault can be excluded.

Table 26: Regarded safety related errors and taken measures

7.9 Periodic Proof Tests

The following table shows the periodic proof tests, which are either automatically performed or must be done manually.

Test	Automatically on Startup	Automatically periodically	Instructions for user
STO circuit	no	no	The proof test must be performed at least once a year. The test must be implemented according to the description in chapter 7.11.6 - Functional test
Maintenance of System	no	no	No maintenance needed of the drive's safety function.

Table 27: Periodic proof tests

7.10 Predictable User Errors

The following list shows predictable user errors and the measures taken:

User Error	Measures, Description
Wiring fault on STO request signals.	The fault is detected, when performing the 7.11.6 - Functional test .
Wiring fault on STO feedback signals.	The fault is detected, when performing the 7.11.6 - Functional test .

Table 28: Predictable User Errors and Measures

7.11 Functional Description

The STO function is defined according to EN 61800-5-2.

When activating the STO signal, the motor is disabled and no or no reasonable motor current is driven.

On the drive, there is one instance of STO implemented, realized with two redundant channels.

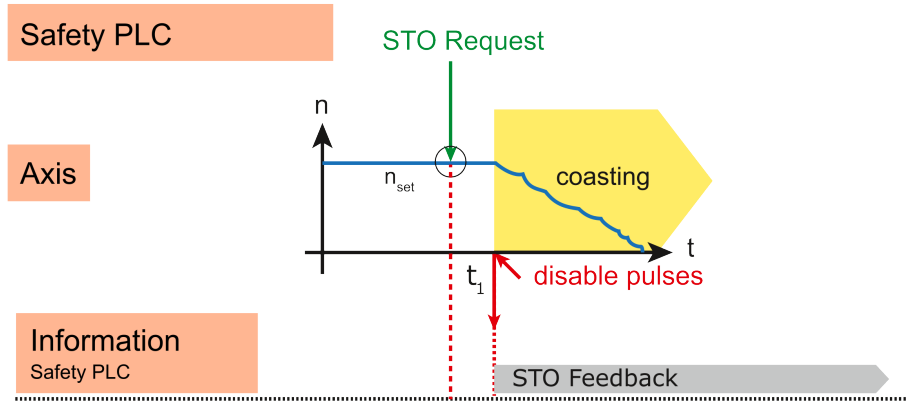


Figure 8: STO Timing

STO can be activated from safe digital inputs.

After the time t_1 (in figure above) STO becomes active, and the motor becomes free of force or torque. This time is only defined by the hardware reaction time.

For the detailed description of the STO hardware see the following chapters.

7.11.1 STO Control Signals

The STO function is controlled directly in hardware from the connector X4. The following signals are used:

Pin	Signal	Description
X4.9	/STO In A	STO request signal A
X4.10	/STO In B	STO request signal B
X4.11	/STO FB A	STO feedback signal A, corresponds with /STO In A.
X4.12	/STO FB B	STO feedback signal B, corresponds with /STO In B.

Table 29: STO Control Signals

7.11.2 Activation

STO is activated if at least one of following conditions is true:

- /STO In A is low
- /STO In B is low

7.11.3 Deactivation

The drive only deactivates STO when both inputs /STO In A and /STO In B are set high.

7.11.4 STO Input levels and Timings

The switching levels of the STO input signals are:

Item	Value
Nominal voltage	24 V DC
STO Release Voltage (Deactivation)	> 15 V DC
STO Activation Voltage	< 5 V DC
STO Activation Time	< 1 ms
STO Release Time	< 5 ms
STO Feedback on Activation Time	< 1 ms
STO Feedback on Release Time	< 5 ms

Table 30: STO Input Levels and Timings

7.11.5 Feedback

Each STO request signal has its own STO feedback.

- /STO In A corresponds with /STO FB A
- /STO In B corresponds with /STO FB B

7.11.6 Functional test

When commissioning the machine and each proof test interval (PTI) a functional test of STO must be performed. The test is according to the following sequence:

- /STO In A (X4.9) shall be switched high, /STO FB A (X4.11) must also switch to high.
- /STO In A (X4.9) shall be switched low, /STO FB A (X4.11) must also switch to low.
- /STO In B (X4.10) shall be switched high, /STO FB B (X4.12) must also switch to high.
- /STO In B (X4.10) shall be switched low, /STO FB B (X4.12) must also switch to low.
- A maximum delay of 1 ms per serial device is acceptable for a high to low edge (STO activation).
- A maximum delay of 5 ms per serial device is acceptable for a low to high edge (STO deactivation).

During operation, consistency of the STO request and feedback signals must be checked at least once a year (see diagnostic test interval) :

- /STO In A (X4.9) is set low --> /STO FB A (X4.11) must switch to low
- /STO In B (X4.10) is set high --> /STO FB B (X4.12) must switch to low

7.11.7 Fault Reaction

As the STO is the most basic safety function, there is no fault reaction.

7.11.8 Example for the use of STO

Example	Possible Solution
A protective door can only be opened if the torque or force of the motors is turned off	• Activate the STO in the drive • The pulses are suppressed, the motor has no torque or force, it slows down and comes to a stop.

Table 31: STO Example

7.11.9 Verification and Validation

For the verification for the STO function follow these steps:

- Configure complete drive.
- Startup the drive.
- Enable the motor.
- Activate STO.
- Test reaction time and feedback signals.
- Check if motor is forceless.

8 Planning a Safety Project with LinMot Components

This chapter provides an overview of the general planning process for a safety project using LinMot products. This section is general in nature and does not apply only to the 3S STO function.



CAUTION

EU Machinery Directive

This description applies only to machines as defined by the EU Machinery Directive.

Standards

The relevant standards must be available to the user. The following description cannot replace the standard. Typically, the current version of EN ISO 13849-1 and EN ISO 13849-2 or EN 62061 should be available as a minimum. Further useful information can be found in IFA report 2/2017



NOTICE

Type C standard

Before you start the following process, you should check whether a type C standard is available for your machine. If this is the case, please follow the steps and instructions given there. If no type C standard is available, you can use the process described below as a guide for the steps to be performed.

Use LinMot-Designer for Dimensioning

For a safe and reliable function of a machine, it is important, that the dimensioning of the used components is adequate. Use the LinMot-Designer to select the fitting components. Also consider a thermal margin.

8.1 Identifying the risks and hazards

DIN EN ISO 12100 defines an iterative process for risk minimization, for eliminating hazards or for reducing the risk at machines. It describes the process of risk minimization in a three-step method. In the first step, the machine should be designed to be inherently safe. If this is not possible, technical protective measures can be taken to minimize the risk. In the last step, user information about the residual risk can be provided. In the first step, the risks and hazards and thus the safety functions must be identified. machine manufacturers require precise knowledge of the operation of their machine in order to identify risks and hazards. Referring to Annex B of EN ISO 12100:2010 is helpful for this purpose. This risk and hazard analysis should be carried out by persons with knowledge in different areas (mechanics, electrics, hydraulics, software, maintenance, ...). All operating modes and conditions must be considered, including commissioning, maintenance/servicing, normal operation and decommissioning. The reasons for or against a particular decision should also be documented. Make sure that your arguments and justifications are understandable and conclusive. In this context, it is particularly important to note that safety measures must not yet be considered when assessing the risk. When all persons involved in the process agree with the result of the analysis, it should be signed by all.

8.2 Determining the PLr / SIL

For each safety function (SF) of the machine identified in the risk and hazard analysis, the machine manufacturer or user must determine the required Performance Level or SIL Level. The SIL level is determined based on the description in Annex A of EN 62061. The performance level is determined based on the risk graph for determining the PLr according to /ISO13849-1/. Information on the risk graph can be found in Annex A of /ISO13849-1/

8.3 Specification of the safety functions

For each safety function identified, it is necessary to specify how the risk should be reduced in accordance with the EN ISO 12100 strategy for risk reduction. Risks and hazards whose residual risk is to be reduced by inherently safe design or user information must be specified but are not part of this description. The following explanations refer only to safety functions, the residual risk of which is to be reduced by technical protective measures. For these safety functions, the iterative design process for safety-related parts of the control system (SRP/CS) is carried out in accordance with /ISO13849-1/.

8.4 Specification of the measures

The machine manufacturer should compile a detailed description of each identified safety function (SF) whose residual risk is to be reduced by means of technical protection measures. This description contains information about the hazard, the type of measures taken to reduce the hazard and the required Performance Level or SIL Level for this safety function. For each SF, the description of the measures must include the category according to /ISO13849-1/ and the components to be used, together with their safety parameters (MTTFd, DC, CCF, SFF). Information on operating states and characteristics is required. These include the operating modes, the cycle time, the response times or process safety time, the ambient conditions, the frequency of execution, the operating times, the behavior of the machine in the event of energy loss and more. More detailed information on this can be found in chapter 5.2 of EN 62061 and chapter 5 of /ISO13849-1/. The machine manufacturer must specify and document the description of the safety-related program for the PLC when using a safety PLC. In addition, the function blocks to be used and the sensors and actuators, the parameterization of the components must also be specified, since this can influence the maximum achievable PL.

8.5 Implementation of the safety functions

The following table gives the information about the safety function, their applicable standards and the link for the detailed information in this safety manual.

Safety Function	Applicable Standard	Link
STO (Safe Torque Off)	EN 61800-5-2	7.11 - Functional Description

Table 32: Implementation of the safety functions

The safety characteristics for safety functions are listed under [7.4 - Safety Characteristics](#)

8.6 Proof of achievement of the Performance Level

Once the safety project for the identified safety functions (SF) has been realized, the performance level achieved for these safety functions is calculated and verified. Support and examples for the calculation can be found with SISTEMA software assistant from IFA or Siemens Tool.

8.7 Validation of the safety functions

Extract from EN ISO 13849-2:2012, Chapter 4.1: validation guidelines.

- The purpose of the validation procedure is to confirm that the design of the safety-related parts of the control system (SRP/CS) supports the specification of the safety requirements of the machines. The validation must show that each SRP/CS meets the requirements of EN ISO 13849-1:2023, particularly with regard to the specified safety characteristics of the safety functions, as intended by the design.
- the requirements for the specified Performance Level (see EN ISO 13849-1:2023, 4.5):
 - the requirements for the specified category (see EN ISO 13849-1:2023, 6.2),
 - the measures for controlling and prevent systematic failures (see EN ISO 13849-1:2023, Annex G)
 - the software requirements, if applicable (see EN ISO 13849-1:2023, 4.6), and
 - the ability to provide a safety function under the expected conditions.
- the ergonomic design of the user interface, e.g. to discourage the user to act in a dangerous manner by circumventing the SRP/CS (see EN ISO 13849-1:2023, 4.8).

The validation should be carried out by persons who not involved in the SRP/CS design.

NOTE "Independent person" does not necessarily mean that a test by a third party is necessary.

Further information about the validation can be found in EN ISO 13849-2:2012, for example in figure 1, overview of the validation procedure, and in EN ISO 13849-1:2023.

8.8 Instructions for checking the SF

All implemented safety functions (SF) must be checked for correctness. This includes both normal operation and the function in the event of a fault. Some of the test cases can be read from the defined safety function with its described measures for risk minimization. For each function, the possible fault scenarios must be defined and checked accordingly. This information must be recorded in a test specification or acceptance protocol. The following list shows some fault scenarios to be considered:

- Discrepancy error of two safe inputs
- Line interruption of the fieldbus used.
- Feedback error of the actuators
- Failure of the power supply
- Cross-circuit / external feed / line interruption in the wiring
- Violation of a defined limit, e.g. speed limit for axis functions and checking of the defined error behavior.
- ...

The validation must also ensure that all hazards identified by the risk assessment are covered by appropriate measures and that these measures have been implemented.

This applies especially to the life cycle phases of installation/assembly and maintenance. It must be ensured that any necessary changes or extensions to the safety project are only made after the design engineer (machine manufacturer) has been notified and the safety specification has been changed by the manufacturer. A check to see whether an extension of the test specification is necessary must also be carried out. This applies in particular to machines that are assembled and put into operation at the end customer's premises. The test must cover the following points as a minimum:

- I/O Check of the safe inputs and outputs
- Verification of the parameterization of all safety components (watchdog times, sensor tests, safe fieldbus address, etc.)
- Check of the safety functions during normal operation.
- Check of the safety functions in the event of an error.
- Check of the safe drive functions during normal operation.
- Check of the safe drive functions outside the defined safety limits.
- Check of the safe drive functions in the event of a power failure

9 Commissioning

This chapter guides through the commissioning of a safety application. Precondition is that the safety application is planned and verified according to chapter [8 - Planning a Safety Project with LinMot Components](#) .



CAUTION

Qualified Personnel

Make sure the installation and parameterization is done by personnel, which is educated and familiar with the safety topic and the kind of work, which it is involved doing the commissioning.

9.1 HW Installation

For the hardware installation make sure the following guidelines and information is considered:

- Safety notes of this safety manual
 - Chapter [5 - General Safety Notes LinMot Products](#)
 - Chapter [6.2 - Safety relevant Drive Installation Instructions](#)
- Wiring: make sure the wiring done such that:
 - The cross sections are well dimensioned.
 - The isolation is sufficient.
 - Minimal bending radius are considered.
 - Moving cables are realized with trailing chain or robot cables.
 - The connections are correct.
 - Necessary fuses are placed.
- Mechanical mounting: make sure that:
 - Installation guides are implemented.
 - The minimal mounting distances (drives, sliders, etc.) are fulfilled.

9.2 Acceptance Tests

Before the machine can be operatively used fulfilling the functional safety requirements, the acceptance tests and the machine documentation must be done. This is described in chapter [10.2 - Acceptance Tests](#).

10 Acceptance Tests and Protocols

**WARNING**

Responsibilities

The machine manufacturer is responsible for carrying out and documenting the acceptance test.

10.1 Introduction

According to the EC Machinery Directive and DIN EN ISO 13849-1 it is necessary to verify the safety-related functions and machine parts after commissioning. This is done by a so-called acceptance test.

The acceptance test is used to check the functionality of the safety monitoring and stop functions used in the drive. The test objective is to verify proper implementation of the defined safety functions and test mechanisms (measures for forced checking procedure (test stop)) and to examine the response of specific monitoring functions to explicitly entered values outside tolerance limits. The test must cover all drive-specific safety functionality.

The purpose of the acceptance test is: The measured values (e.g. distance, time) and the system behavior identified (e.g. initiation of a specific stop) can be used for checking the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst-case values). They represent the behavior of the machine at the time of measurement. These measurements cannot be used to derive real values (e.g. maximum values for over-travel distances).

10.1.1 Requirements

The acceptance test requirements (configuration check) for electrical drive safety functions base on DIN EN 61800-5-2, Section 7.1 Point f). The acceptance test "configuration check" is cited in this standard.

- Description of the application including a picture.
- Description of the safety-relevant components, including software versions, that are used in the application.
- List of the safety related functions used.
- Results of all tests of these safety functions, using the specified testing procedure.
- List of all safety-relevant parameters and their values in the drive
- Checksum, test date and confirmation by testing personnel

A complete acceptance test is required when first commissioning the safety functionality on a machine. The acceptance tests must be carried out for each individual drive. Safety-related function expansions transfer of the commissioning settings to other series machines, hardware changes, software upgrades or similar activities permit the acceptance test to be performed with a reduced scope if necessary. A summary of conditions which determine the necessary test scope or proposals in this context is provided below

10.1.2 Requirements for the acceptance test

- The machine is properly wired, including 3S STO request and feedback lines.
- All safety equipment (such as protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.

10.1.3 Acceptance Test

The acceptance test comprises two parts:

- Checking whether the safety functions in the converter are correctly set:
 - Does the position control handle the configured application cases in the machine?
 - Do the set interface, times and monitoring functions match the configuration of the machine?
- Checking whether the safety-relevant functions in the plant or machine function correctly. This part of the acceptance test goes beyond the drive acceptance test:
 - Is all safety equipment such as protective door monitoring devices, light barriers or emergency-off switches connected and ready for operation?
 - Does the higher-level control correctly respond to the safety-relevant feedback signals of the drive?
 - Do the drive settings match the configured safety-relevant function in the machine?

10.1.4 Documentation

The documentation consists of the following parts:

- Description of the safety-relevant components and functions of the machine or plant.
- Report of the acceptance test results.
- The documentation must be signed by the person who carried out the acceptance test.

10.2 Acceptance Tests

The following list contains points which are required for the acceptance of the safety project. This list is not exhaustive. These points must be checked after the initial start-up and after each configuration modification:

- Implementation or changes must only be done by qualified personnel.
- Checking of the entire safety project for correctness according to the previous chapter
- Implementation and printout of the acceptance protocol
- Signature by programmer and customer
- This information should be added to the machine documentation.
- ...



WARNING

Authorized Persons

Personnel from the machine manufacturer, who, on account of their technical qualifications and knowledge of the safety functions, are in a position to perform the acceptance test in the correct manner.

Either a complete or a partial acceptance test must be performed. A complete acceptance test is required when first commissioning the safety functionality on a machine. The acceptance tests must be carried out for each individual drive. Safety-related function expansions transfer of the commissioning settings to other series machines, hardware changes, software upgrades or similar activities permit the acceptance test to be performed with a reduced scope if necessary. A summary of conditions which determine the necessary test scope or proposals in this context is provided below. A partial acceptance test must be performed on any replacement or minor changes on a machine.

10.3 Complete Acceptance Test

10.3.1 Documentation

Documentation of the machine and of safety functions

1. Machine description (with overview)
2. Specification of the used safety components (such as drive, emergency stop, light barrier, ...)
3. Function table:
 - a. Active monitoring functions depending on the operating mode and the protective door.
 - b. Other sensors with protective functions
 - c. The table is part or is the result of the configuring work.
4. Used safety functions for each drive.
5. Information about safety equipment
6. HW configurations

SOFTEMA and SISTEMA from IFA or similar tools may be used for documentation.

10.3.2 Functional and diagnostic safety tests

For the "Safe Torque Off" (STO), a detailed function test and evaluation of the safety function must be performed.

10.3.3 Conclusion of the Report

Report of the commissioning status tested and countersignatures:

1. Backup of the project
2. Countersignature

10.4 Partial Acceptance Test

10.4.1 Documentation

Documentation of the machine and of safety functions

1. Extending/changing the hardware data
2. Extending/changing the software data (specify version)
3. Extending/changing the function table:
 - a. Active monitoring functions depending on the operating mode and the protective door.
 - b. Other sensors with protective functions
 - c. The table is part or is the result of the configuring work.
4. Extending/changing the safety functions per drive
5. Extending/changing the specifications of the safety equipment
6. Extending/changing the drive configurations (safety and non-safety)
7. Extending/changing the HW configurations

10.4.2 Functional and diagnostic safety tests

For the "Safe Torque Off" (STO), a detailed function test and evaluation of the safety function must be performed.

10.4.3 Conclusion of the Report

Report of the commissioning status tested and countersignatures:

- Countersignature

10.5 Test Scope for Specific Measures

A complete acceptance test is required when first commissioning of the safety functionality on a machine or major modifications have been made. Major modifications mean functional changes, not only replacing components with the same functionality (which is typically for maintenance).

For the acceptance tests after maintenance measures the following table shows which tests must be repeated:

Measure	Chapter <u>10.3.1</u> - <u>Documentation</u>	Chapter <u>10.4.2</u> - <u>Functional and diagnostic</u> <u>safety tests</u>	Chapter <u>10.4.3</u> - <u>Conclusion of the</u> <u>Report</u>
Replacement of the drive	Yes Points 1 and 2	No	Yes
Replacement of Power supply	No	No	Yes
Transfer of project data into other machines (series commissioning)	Yes	Yes Only the safety functions	Yes

Table 33: Acceptance tests after replacements

11 Operation and Maintenance

To keep a machine as safe as possible, it is necessary to perform tests regularly. Some of them can be done during operation, others must be done during the maintenance window. Problems detected during operation must be evaluated if the safe operation can still be guaranteed.

11.1 Operation

During the operation different tests must be done. The following list shows what item must be checked and which action must be followed:

Item	Recommended test interval	Action required
Errors reported	Cyclically read by PLC	If the drive reports an error, it will stop and enter a safe state. The error must be checked, and adequate measures must be done.
Warnings reported	Cyclically read by PLC	A warning gives the possibility to react as long as full operation is still available. It is advisable to react on warnings adequately. E.g. if a temperature warning is present, slow down the machine or increase cooling.

Table 34: Checks during operation

11.2 Maintenance

No maintenance is required for the drive's safety function.

12 Appendix

12.1 Terms and abbreviations

For the application of this document, the terms and abbreviations are used according to IEC 61508-4.

12.1.1 Additional Abbreviations

Abbreviation	Description
3S	Stands for the STO functionality, which is electronically realized
FS	Functional Safety
LIDStream	Ethernet based communication for synchronization of sensors, motors and drives.
LMT	LinMot-Talk
PL	Performance Level
PLC	Programmable Logic Controller
PTI	Proof Test Interval
PWM	Pulse Width Modulation (control of the power stage)
PWR	Power (Supply for power circuit)
SF	Safety Function
STO	Safe Torque Off, safety function
/	before Signal name means inverted logic, e.g. /STO In A is active when low.

Table 35: Additional abbreviations

12.2 Change History

Version	Description of Changes	Date/ Signature
1.0	Initial version	14.04.2026 / Ro

Table 36: Change History