

KSM[®]

Starter Guide



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Part Number 903-200026-00

Keep all manuals as a product component during the life span of the product.
Pass all manuals to future users/owners of the product.

KOLLMORGEN[®]

Because Motion Matters™

Record of Document Revisions:

Revision	Remarks
A, 10/13/2014	First edition.

Technical changes which improve the performance of the device may be made without prior notice.

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1 Important Notes

1.1 Objectives and Limitations of the Starter Guide

This document describes typical machine examples of a safety system consisting of Kollmorgen safety components. The intention of this document is to simplify the safety engineering for specific motion related safety functions. This document delivers guidance and recommendations on how to achieve the required safety level. The required safety level should be already defined based on the risk assessment of the machine.

The safety chain of a specific safety function is described with the safety block diagram of all safety components. The safety level of typical safety chains is determined in combination with the wiring diagram.

This document is limited only to a typical subset of safety systems. For example, the wiring diagram describes only the connection to AKD servo drives and AKM motors. In order to achieve the specified safety level, the AKM motor should be ordered with the Sick Hyperface safe encoder option.

This document describes only the safety hardware. All software related information and configuration is provided in the Safe PLC programming manual.

The communication between the KSM safety controller and standard controller is not part of this guide since the communication to the PLC should provide only KSM status information. Safe communication between KSM safety controller and standard controller is not possible.

1.2 Definition of Individual Target Groups

The following target groups include:

- Project engineers for secure drive systems.
- Assembling, electrical installation, maintenance and replacement of device plant electricians and service engineers.
- Commissioning, operation and configuration: Technicians and engineers.

1.3 Definitions

The designation KSM is used as a generic term for all derivatives from the KSM product range. Wherever this description refers to a certain derivative, the complete designation is used.

The term “safe” used in the following text in any case refers to the classification as a safe function for applications up to PL e acc. to EN ISO 13849-1 or SIL3 acc. to EN 61508.

The system software “SafePLC ” serves the purpose of configuring and programming the KSM modules.

The modules of the KSM series are internally built with two independent processing units. In the following these are referred to as system A and system B.

1.4 Co-Valid Documents

Description	Reference
Configuration of the KSM module	SafePLC Programming Manual
Installation of KSM module	KSM Installation Manual

Description	Reference
Validation report for implemented parameterization and PLC-program	Safety inspection with acceptance protocol
Acceptance test for general safety related applications	Certificate for type approval test for fail-safe control system acc. to machine directive 2006/42/EC for the product groups

NOTE

- Thoroughly read all the manuals before starting the installation and the commissioning of any KSM safety modules.
- Adhering to the documentation is a prerequisite for safe operation and fulfilment of possible warranty claims.

1.5 Abbreviated Terms Used

Abbreviation	Description
AC	Alternating Voltage
IL	Instruction List
ELIA	Employer's Liability Insurance Association
CLK	Clock (cycle)
CPU	Central Processing Unit
DC	Direct Voltage
DI1..DI14	Digital Input
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DO	Digital Output
EMU	Emergency Monitoring Unit
EMC	Electromagnetic Compatibility
ELC	Emergency Limit Control
EN	European Standard
HISIDE	Output with 24VDC nominal level switching to plus
IP20	Degree of protection for housing
ISO	International Organisation for Standardisation
LED	Light Emitting Diode
PIA	Process image of outputs
P1,P2	Pulse Outputs
PLC	Programmable Logic Controller
POR	Power on Reset
PSC	Position Supervision Control
SDDC	Safe Device To Device Communication
SELV	Safety Extra Low Voltage
SSI	Synchronous Serial Interface

Abbreviation	Description
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik e. V. (association for electrical engineering, electronics and information technology)

2 Safety Regulations

This chapter describes the safety regulations for the KSM compact and modular safety modules.

2.1 Intended Use

The KSM series safety modules are programmable fail-safe control systems intended for the establishment of emergency shut-down features and functions. The devices are intended for use:

- in emergency stop facilities.
- as a safety component as defined by the EC machine directive 2006/42/EC.
- in PES for risk reduction as defined by EN 61508.
- in safety circuits acc. to EN 60204 and EN 60204-32.
- in PES for functional safety as defined by EN 62061.
- in SRP/CS as defined by EN 13849.
- as a device for establishing the safety functions acc. to EN 61800-5-2s.
- in logic units for converting and processing signals in two-hand control acc. to EN 574.

2.2 Safety Standards

2.2.1 General Safety Regulations

CAUTION

- In order to avoid damage to persons and property only qualified personnel is entitled to work on the device. The term qualified personnel refers to persons who have successfully completed electro technical training and are fully familiar with the applicable rules and standards of electrical engineering.
- The qualified person must become familiar with the operating instructions (IEC364, DIN VDE0100).
- The qualified must have profound knowledge of the national accident prevention regulations.
- The use of the device must be strictly limited to the intended use as specified in the installation manual.
- Commissioning (i.e. starting up the intended operation) is only permitted in strict compliance with the EMC-directive.
- Compliance with the conditions acc. to EN 60068-2-6 related to the values specified under "Technical characteristics" is mandatory for storage and transport.
- The wiring and connecting instructions of the installation manual must be strictly followed.
- The applicable regulations and other special safety regulations of relevance for the application must be strictly followed.
- Inputs and outputs for standard functions or digital and analog data transmitted by using communication modules must not be used for safety relevant applications.

DANGER

Using our devices contrary to the rules and conditions specified hereunder can lead to injuries or fatalities as well as damage to connected devices and machines!

2.2.2 ISO 13849 Safety Standard and Categories

This document is based on ISO 13849 safety standard. This new standard differentiates different safety architectures called categories similar to the previous standard EN954-1. In addition this standard integrates aspects regarding the probability of a failure. Both aspects together are merged to the performance level PL.

NOTE

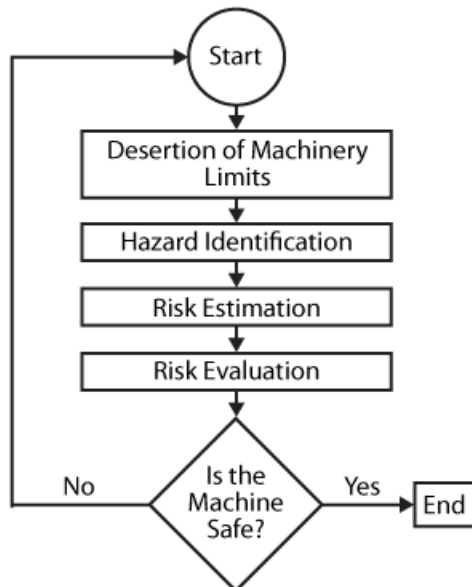
This document describes two different safety designs in order to achieve performance level PL d and PL e.

2.2.3 Relationship Between Performance Level PL and SIL

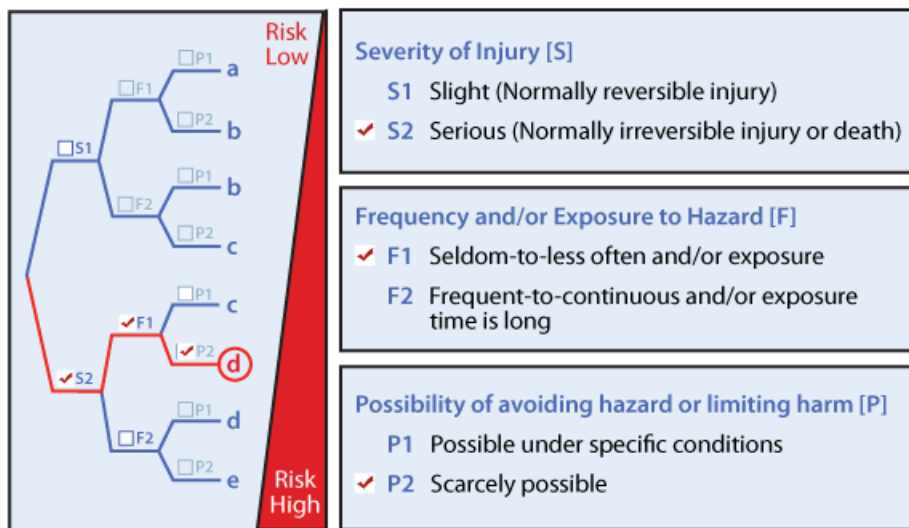
The standard ISO13849 simplifies the safety engineering compared to the standard IEC 61508, however the performance level is related to the safety integrity level SIL. For the PL d performance level, the probability of a dangerous failure PFH is between 10^{-7} and 10^{-6} . This is the same value for SIL 2. The PL e performance level describes the same safety level as SIL 3 based on IEC 61508-1.

2.2.4 Risk Assessment and Risk Reduction

The standards ISO14121 and ISO12100-1 describes a systematic procedure for risk assessment so that adequate and constant safety measures are adopted. These are appropriate during the design, construction, modification, use and destruction of the machine. The safety of machines can be determined in five steps. Documentation of the risk assessment process must be observed.



The standard ISO 13849-1 describes a simple procedure how to determine the required safety level based first on the severity of injury, second on the frequency or exposure to the hazard, and third on the possibility of avoiding the hazard as shown in the following diagram.



The determination of the specific risk at a machine is typically done as a team and the investigation results provide a performance level of a specific risk. In the event a machine has several risks and the determination of the required safety level has to be done for each risk separately, it could be possible that the same machine has different required performance levels for different safety functions.

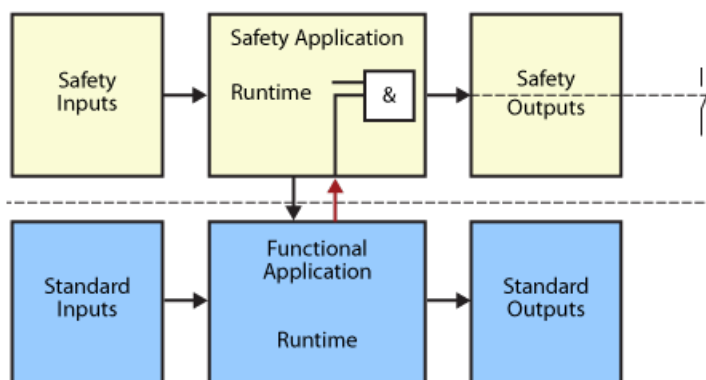
3 KSM Safety System

3.1 Overview of Connections

This document describes the complete safety chain from the sensor to the safe logic controller and actuators for several safety function. For example, Safe Stop.

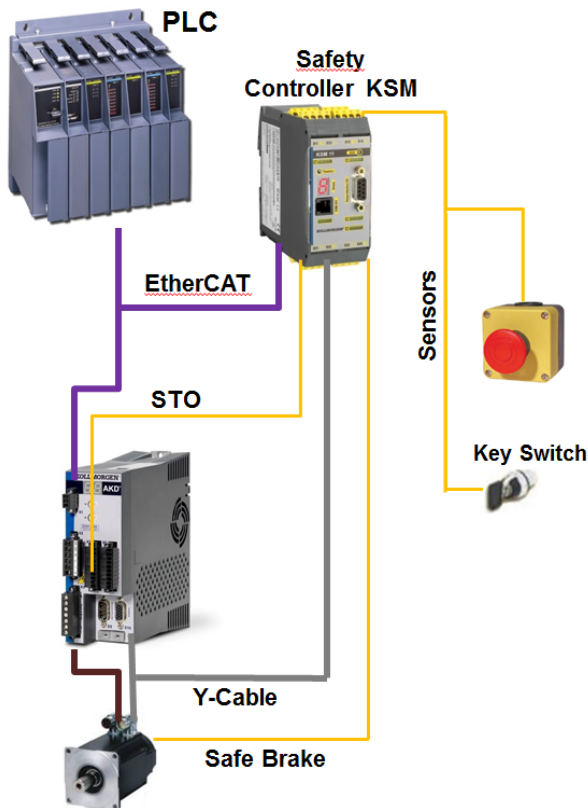
NOTE All safety signals are hard wired.

As a general rule the safety application is separated from standard control function, this is valid for software and hardware. A data exchange is required in order to interact between both encapsulated software parts. This could be accomplished by hard wiring or networking using EtherCAT.



The KSM safety module reads various safety sensors such as emergency stop switches, door guarding switches, and proximity switches by using safe digital inputs.

The KSM safety module controls safe actuators such as contactors and brakes by using digital outputs and relays. The STO signal of the drives are activated by using transistor outputs or relays.



To monitor safe motion functions such as SS1 and SLS, the KSM safety module reads continuously the actual position or actual speed by using the motor encoder or proximity switches. Therefore a splitter cable is required to provide the encoder signal to the drive as well as to the KSM safety module.

Using a communication bus the automation controller can read all data of the KSM safety module such as the status of the sensors and actuators, flags and alarms. This information can be displayed to the HMI for the operator or used for trouble shooting.

In addition to the Safe signals the KSM safety module controls standard signals for the drive. For example, Enable or the C-Stop signals are required for the correct execution of the SS1 function. For more information, see Chapter 5: "KSM 12-2 and KSM 31 Wiring Examples" (→ p. 22)

3.2 Dual Channel (PL e) vs. Single Channel (PL d)

For all application with the highest safety level PL e or SIL 3 a redundant hardware design is required, that means the architecture follows minimum category 3 or better category 4. Redundant hardware is also called dual-channel design. With a dual-channel safety design the complete safety chain consisting of Sensor, logic and actuator, is executed twice in parallel.

Due to the fact that dual-channel designs raises the cost significantly, a single channel design is desirable. For lower and mid-risk applications that require PL d or SIL 2, the single channel architecture is sufficient, assumed that there are measures for good diagnostic coverage (medium DC value) and good reliability of the hardware (high MTTFd value).

3.3 AKD Safety Functions

The Kollmorgen AKD drive has Safe Torque Off (STO) as a standalone function. This means, for STO with a safety level of PL d there is no additional component required. The STO safety chain consists of sensor (emergency stop switch), safety logic controller and safe STO input of the drive. This single channel design permits a safety level up to PL d, assumed that all instructions of the AKD installation manual are observed.

In case the risk assessment requires a STO safety level of PL e or SIL 3, a second channel with a circuit breaker is required, in order to switch off the power line.

For more information, see "Safe Torque Off (STO)" on p.18 and also see "External Device Monitoring (EDM)" on p.19

For all other safe motion functions such as SS1 and SLS, an additional KSMsafety module is required.

NOTE

A single KSM safety module can monitor up to 12 servo axes.

3.4 Safe Motion with Motor, Encoder, and Brake

The motor itself is not part of the safety chain; therefore any servo motor can be used for safe motion functions. However, the encoder as a speed and position sensor is a crucial part of the safety chain. Therefore a possible encoder failure must be considered based on a FMEA. In addition, fault exclusion for coupling between motors and encoders is mandatory for the case of only a single encoder. Typically an encoder is a dual channel device, because there is a signal line A, and a second signal line B. The MTTFd value determines the safety level.

In order to simplify the safety engineering process, Kollmorgen offers AKM motors with Safe Encoder. For more information, visit www.kollmorgen.com .

3.5 Integration of Automation Controllers in KSM System

In order to reduce wiring efforts between the PLC and the KSM safety module, it is possible to add a communication module to the KSM safety controller such as EtherCAT. This option enables the PLC to display the status of all safety functions and safe I/O to an HMI. In addition, debugging and remote monitoring is possible.

Typically the PLC reads the status of the safety functions, sensors and actuators. Reading data from the KSM safety module does not have any impact to the safety function.

For some applications, it is desirable to write data from the PLC to the KSMsafety module.

NOTE

In the logic of the safety function, only a logical AND between PLC data and KSM data is acceptable. For this reason it is not possible to download files or safety relevant parameters from the PLC.

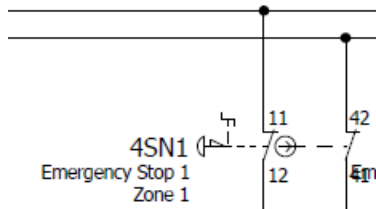
4 Safety Functions for Wiring and Software

4.1 General Machine Safety Functions (Sensor Inputs)

This chapter describes the wiring and software safety functions for the KSM compact and modular safety modules.

Closed-Circuit Principle

The safety sensors should be wired according to the closed-circuit principle in general. For example, when the motor is running the contact should be closed, so that any interrupts are detected putting the machine into a safe state.



Diagnostic

In addition, the KSM safety module ensures far reaching diagnostics functions for the partial input system. These are carried out permanently. For example; cross-shorting monitoring by means of pulse identifier, dual-channel sensors with time-out, start-up tests, etc.

Cross-Shorting Monitoring

The KSM modules have pulse signal outputs, identified by an unambiguous signature. When performing the cross-shorting tests the switching elements of the digital sensors and input elements are supplied with auxiliary voltage by the KSM-module by using the pulse signal outputs. The signature is then stamped on the High signal level of the sensors and input elements, and verified by the KSM module. With signature tests, short-circuits and cross-shorting to High signals can be recognized. With alternating use of the pulse signals of multi-contacts, parallel signal lines or adjacent terminal assignment, cross-shorting between the respective input elements is detected.

SIL and PL e Applications

For SIL 3 or PL e applications, the sensors and input element should have two pole contacts, sometimes a time-out function in the KSM logic is required. Meaning the change of the input state is observed within a time window of 0.5 seconds. Different levels over a time period of > 0.5 seconds will trigger a module alarm. For SIL 2 or PL d; single channel sensors are sufficient, assumed that all test and diagnostic measures described are implemented.

Start Test

Each time the KSMsafety module is switched on, the input element must be tested in direction of the low signal status (defined Safe State). For example, by actuating the emergency stop button or a door lock after the system has been started.

4.1.1 KSM Emergency Stop Wiring

This section describes the emergency stop wiring for the KSM safety module.



NOTE The standard ISO 13850 defines all aspects of the emergency stop functions. The installation of the emergency stop must be compliant to ISO 13850 in order to achieve the required performance level according to ISO 13849.

NOTE The following basic safety rules should be observed.

The emergency stop activates a stop of all hazardous movements according to stop category 0, 1 or 2. The required stop-category must be specified for each intended safety function as a result of the risk assessment.

Basic emergency stop design rules:

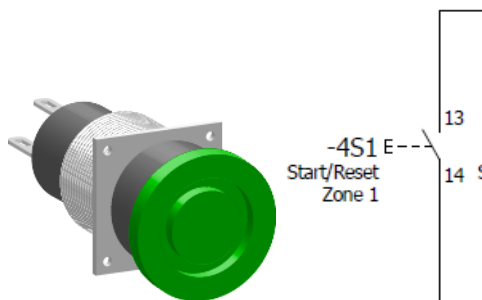
- The emergency stop is an add-on function; it does not replace specific safety measures for specific risks.
- The emergency switch is a forced opening contact.
- The emergency stop execution has priority over all other functions.
- For initiation of the emergency stop command, the machine must be in a stop state until a manual reset command.
- The reset of the emergency stop switch does not activate directly a restart.
- Short circuit and interrupt of wiring should be monitored.

4.1.2 Start and Restart Function (Alarm Reset)

Basic reset design rules:

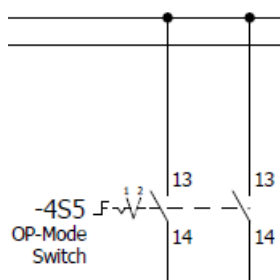
- After activation of a safety sensor, the machine should not start automatically. It must be reset manually by a push button.
- Since the reset function is a safety signal, the reset can't be activated by the controller.

- The design and the wiring of the reset function should not reduce the safety level of the corresponding safety functions (consider short circuit and interrupt of wiring, etc.).
- The reset should not work static, but reset should be executed after release of the reset switch (edge triggered).
- The reset button has to be placed outside the risk area.



4.1.3 Operating Mode Switch

The Operating Mode Switch (OMS) is required to select the mode for Safe Limited Speed. The Operating Mode Switch is designed according to the closed-circuit principle. Therefore, SLS mode is activated when the contact is closed.



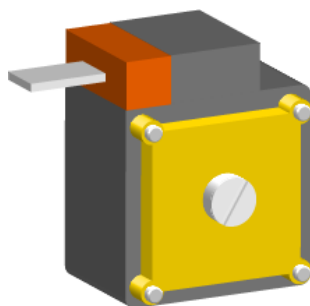
NOTE

The OMS safety design should meet the required safety level of the SLS function according to the risk assessment.

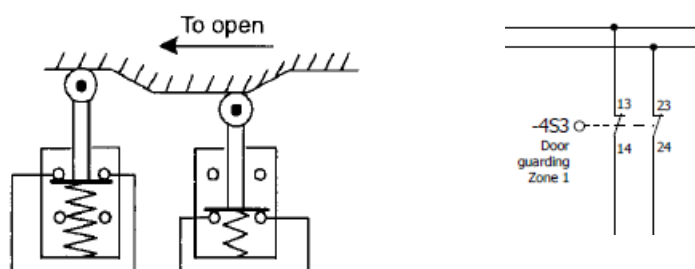
4.1.4 Door Guarding

Movable guards are often required on machinery in order to enable the operator to enter hazardous areas. For example, maintenance or loading and unloading material. In most cases the hazard are related to the movement of the machine and no longer exists when the machine has stopped moving, or runs with limited speed.

The required level of protection must be provided by the addition of interlocking devices that are actuated as the guard moves from safe position. The interlocking switches must provide the safety level according to the risk assessment.



In general for safe door guarding, combined mode interlocking switches should be used. Combined mode means that there is a negative mode switch in addition to a positive mode switch; both switches are internally wired in serial.



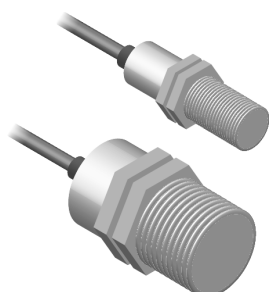
Basic design rules:

- The switches must be force guided opening contacts.
- For SIL 3 or PL e two switches are required.
- The mounting of the device should have a form fit.
- Protection measures against manipulation are recommended.

Interlocking with guard locking should be applied when it is essential that a machine stops before the guard is opened. For example, machines with long run-down time. In this scenario the interlocking system is controlled from the KSM safety module.

4.1.5 Proximity Switches

Proximity switches operate through two parts, one containing the operating mechanism and the other the actuator. There are no physical contacts between these parts. They are resistant to a wide range of operating environments; therefore they are particularly suitable for use where regular wash down of equipment is necessary, such as food or pharmaceutical industry.



For safety applications the sensor units should have self checking facilities. Kollmorgen recommends PDDDB devices. Proximity devices with defined behavior under fault conditions according to IEC 60947-5-3.

4.2 Safe Torque Off (STO)

The safety circuit implementation (STO) of the AKD drive is suited for SIL 2 according to IEC 61508-2 and PL d / CAT3 according to ISO 13849-1.

The digital input (STO) releases the power output stage of the drive as long as a 24 V signal is applied to this input. If the STO input goes open-circuit or to 0 V signal level, then power will no longer be supplied to the motor, and the drive will lose all torque coasting to a stop.

You can achieve a category 0 stop by using the STO input without switching a mains contactor. Advantages of the STO function are:

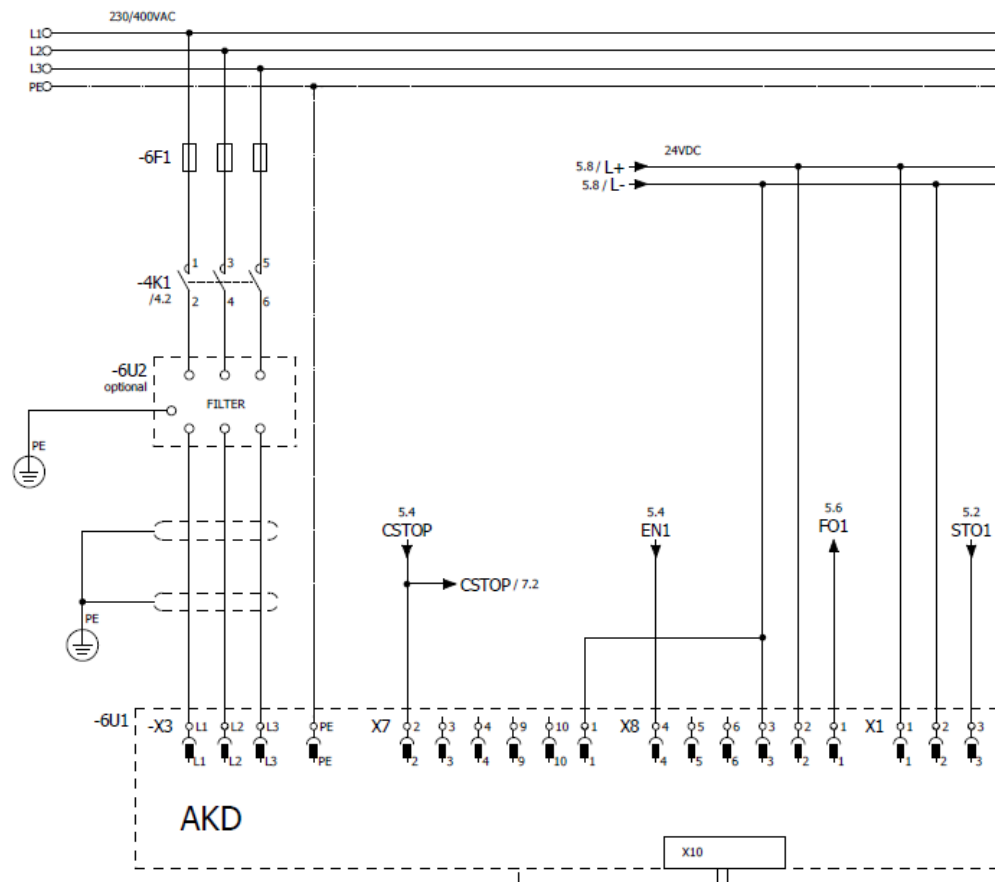
- The DC bus link remains charged, since the mains supply line remains active.
- Only low voltages are switched, so there is no contact wear.
- Minimal wiring is required.

NOTE

All details in the AKD Installation Guide should be observed!

NOTE

It is strongly recommended to install the KSM safety module in the same cabinet with the AKD drive. As indicated in the KSM wiring example, it is mandatory to mount the KSM module in the same cabinet to achieve SIL 2 or PL d safety level. For more information, "KSM 12-2 and KSM 31 Wiring Examples" (→ p. 22)



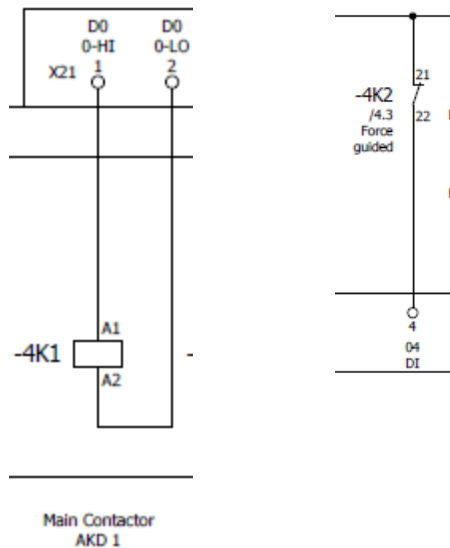
If the application requires the highest safety level SIL 3 or PL e, a second channel for the STO function is required. The recommended solution is to control the main power supply of the AKD drive by using KSM High side and Low side outputs as described in the wiring example. Monitoring the main contactors by using additional force guided contact is the crucial requirement to meet the highest safety level. The KSM safety module supports this requirement with the External Device Monitoring (EDM) safety function.

4.3 External Device Monitoring (EDM)

The KSM module can take over the function of external device monitoring for the power circuit breakers. This contactor monitoring software function monitors the external relays by means of their normally closed contacts which are force guided.

If the main contactors are located in the same cabinet with the KSM safety module, single channel monitoring is sufficient.

The safety software must consider the time delay between switching off the contactor coil and the opening of the monitor contact. For more information, see the wiring example below.



4.4 Safe Stop 1 (SS1)

This function block initiates and monitors a stop of a drive system in accordance with stop category 1. Stop function category 1 is a controlled stop with power available to the machine actuators to achieve the stop.

Safe Stop 1 initiates and controls deceleration within set limits to stop the motor and initiates the STO function when the motor has stopped; or initiates the motor deceleration and initiates the STO function after an application specific time delay, and removes power when the stop is achieved.

4.5 Safe Brake Control (SBC)

For most vertical applications Safe Brake Control is required. To meet the highest safety level a dual channel design is required. The use of two brakes in most applications is not required, because SIL 2 or PL d is sufficient, the standard motor brake could be used.

The motor brake is controlled by using a combination of AKD brake control and KSM brake control. The brake signal must be wired in serial as described in the KSM wiring example.

In any event, a sophisticated brake test function is required. In specific time intervals the KSM safety module requests a brake test by activating a test signal to the PLC. The KSM safety module opens the brake after successful test procedure.

4.6 Safe Limited Speed (SLS)

The SLS function prevents the motor from exceeding the specified speed limit.

This function block initiates and monitors the PLC system to get enabled by an enabling switch to move slower than the permitted safely limited speed. This function can be activated only when the normal operation mode is not activated. That is no functional safety function is active and must be ensured by other measures similar to a door guard.

The SLS function requires a safe measurement of the motor speed. For more information, see the following section "Recommended Feedback Devices and Motors".

4.7 Recommended Feedback Devices and Motors

By using a splitter cable the encoder signal connects to the AKD drive and to the KSM module.

For SIL 2 or PL d applications a standard encoder could be used in case the encoder manufacturer provides the MTTFd data with a high level. Typically encoders are dual channel measurement devices for speed measuring. Therefore, a single encoder is sufficient when there is a reliable coupling of the encoder to the motor shaft. This coupling must be designed and manufactured according to the IEC 61800-5-2 safety standard. Kollmorgen recommends the AKM motor with a Hyperface safety encoder.

SIL 3 or PL e applications will need a second speed measurement device. The KSM wiring example describes the connection of two additional proximity switches.

5 KSM 12-2 and KSM 31 Wiring Examples

5.1 Application Example for SIL 3 or PL e Safety Level Requirement

The following wiring example shows a typical SIL 3 and PL e safety application of an automation system consisting of KSM safety modules, AKD servo drives, and AKM motors with a brake.

In order to achieve the highest safety level a redundant design with dual-channel sensors and actuators is required. Due to the significant effort of a dual-channel safety system, it is strongly recommended to perform a risk assessment, because for most applications a single channel safety design is sufficient to reduce the risk to an acceptable level.

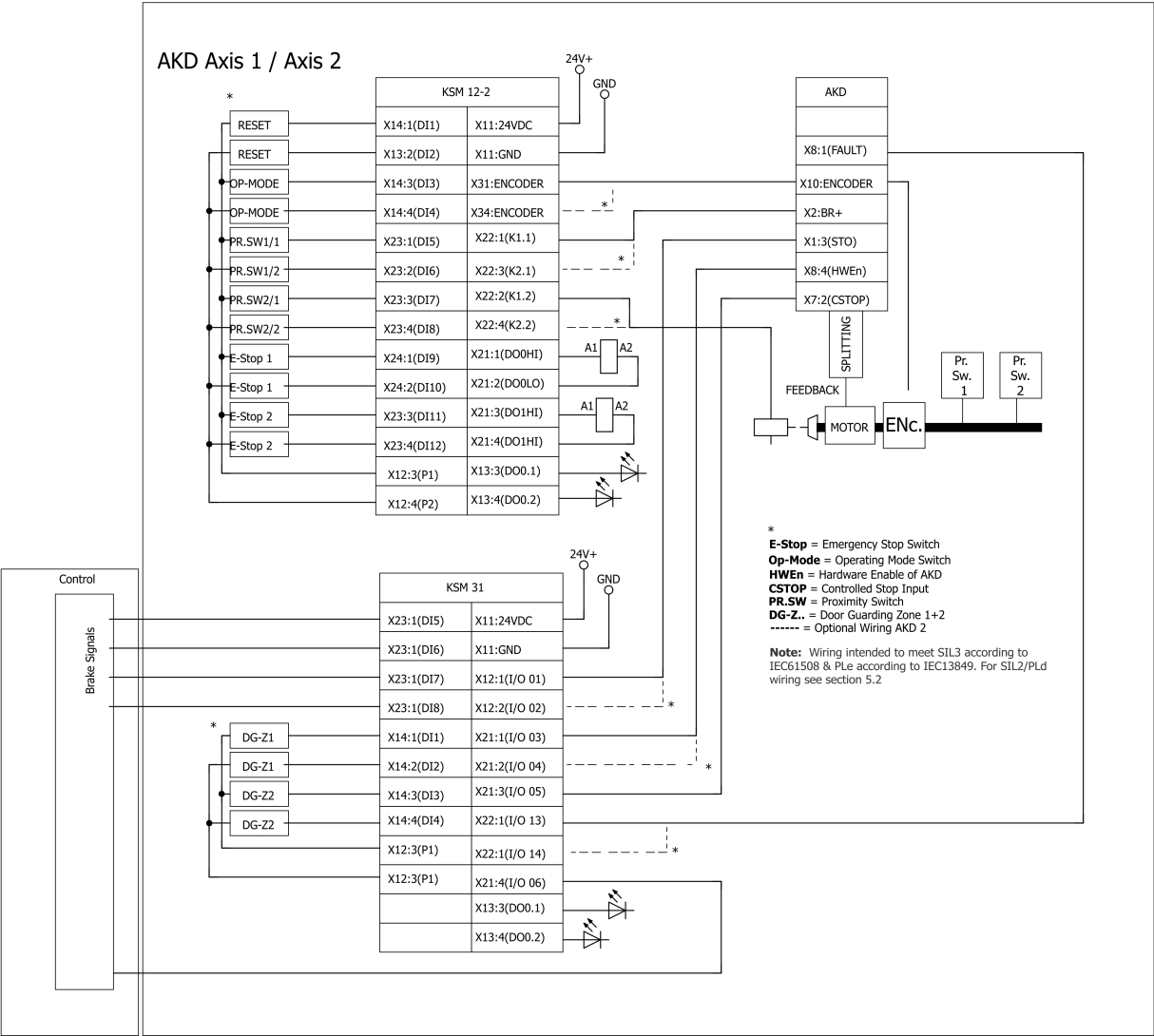
The safe brake example is designed for SIL 2 and PL d level with the standard motor brake. A dual-channel brake is only required for special vertical axis applications with a heavy load and no fences.

5.2 Application Example for SIL 2 or PL d Safety Level Requirement

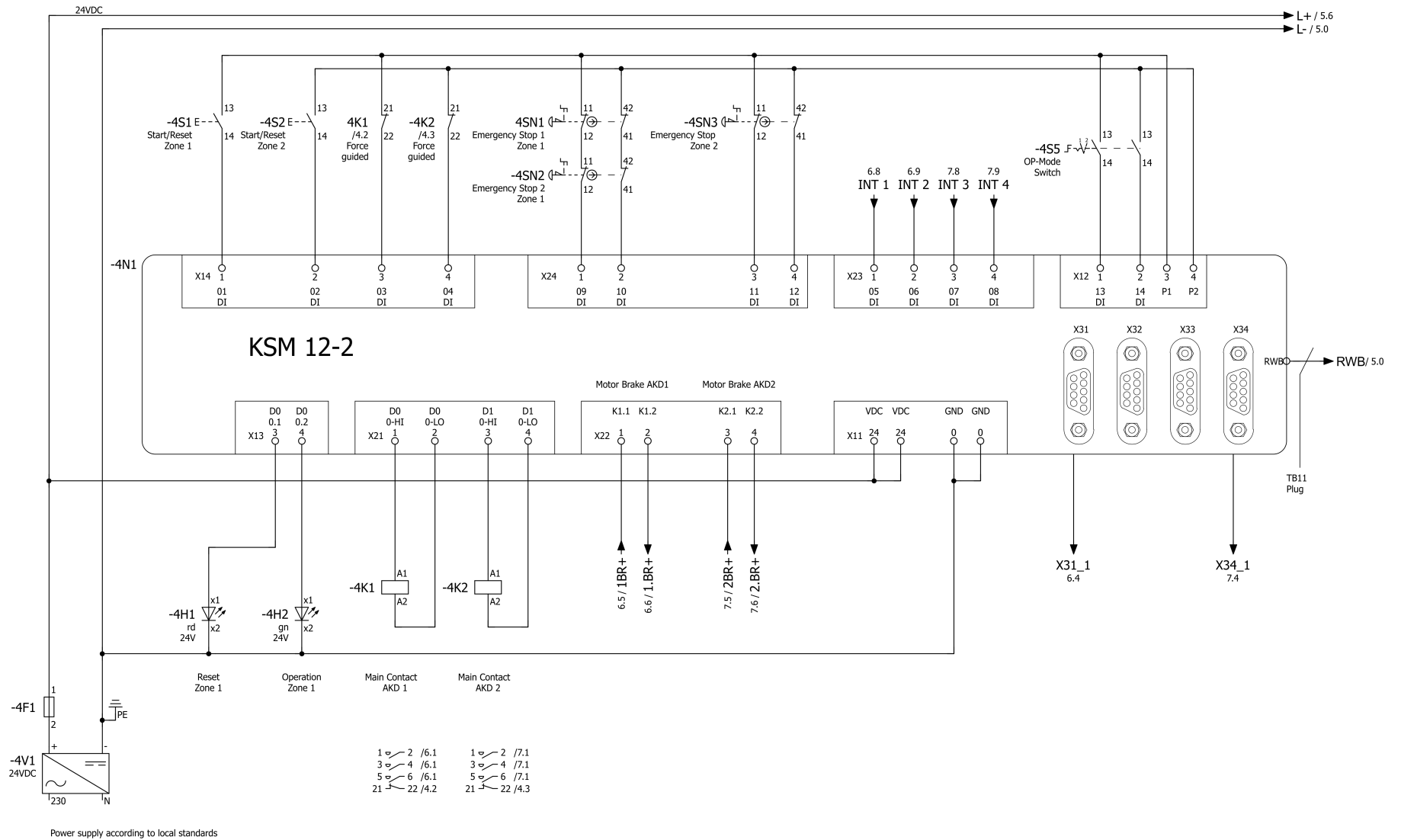
As discussed previously, most users have only a SIL 2 or PL d safety level requirements. In this scenario the wiring diagram can be simplified by changing all dual-channel signals to a single signal design.

The STO function for SIL 2 or PL d requirement is simplified by eliminating the power contactors, including the monitoring signal of the contactors. Only a single wire from a safe output to the STO input of the AKD is sufficient, no monitoring required provided that the KSM safety module is located in the same cabinet as the AKD drives.

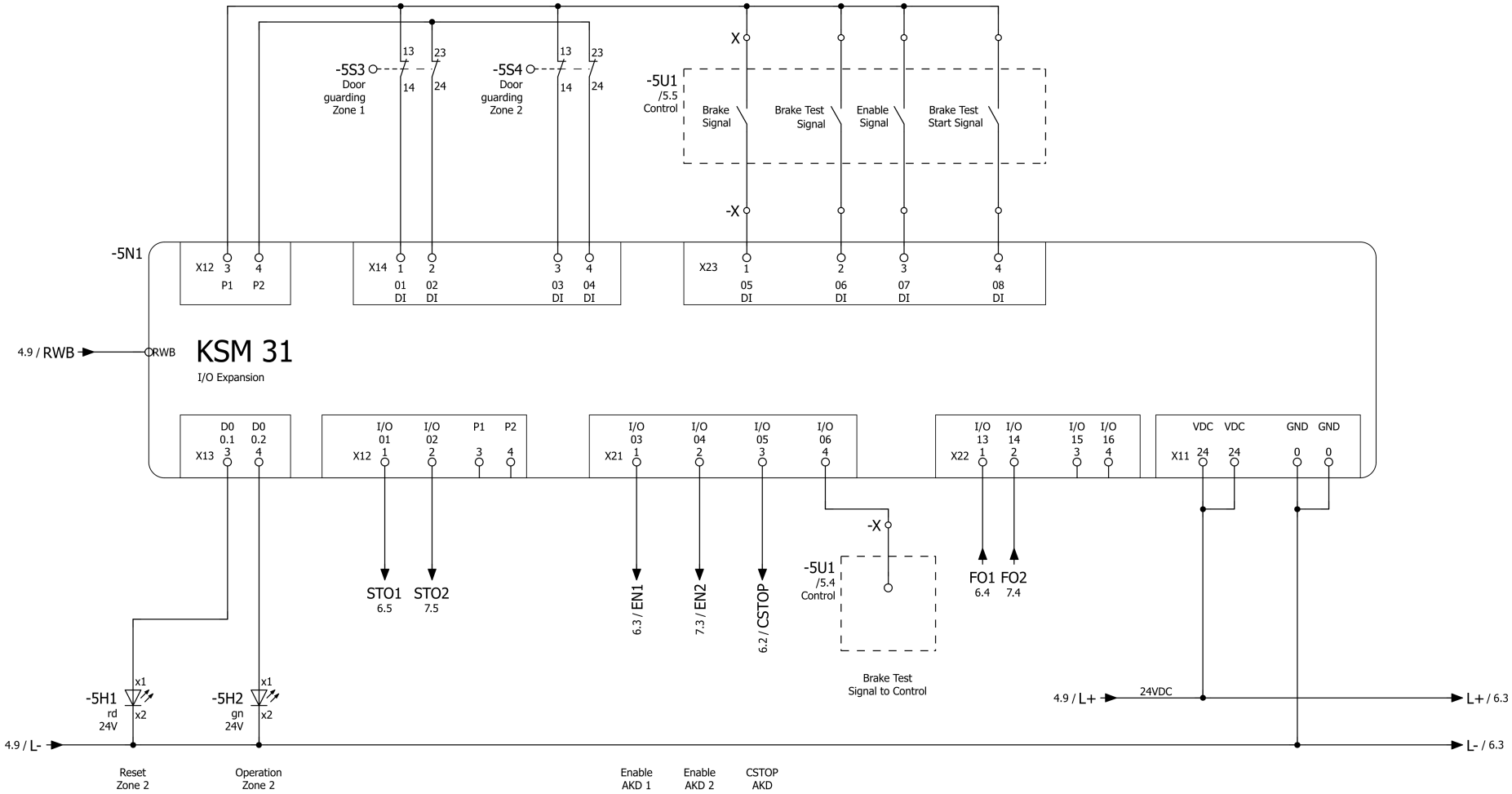
5.3 KSM 12-2 + KSM 31 Overview Wiring Diagram



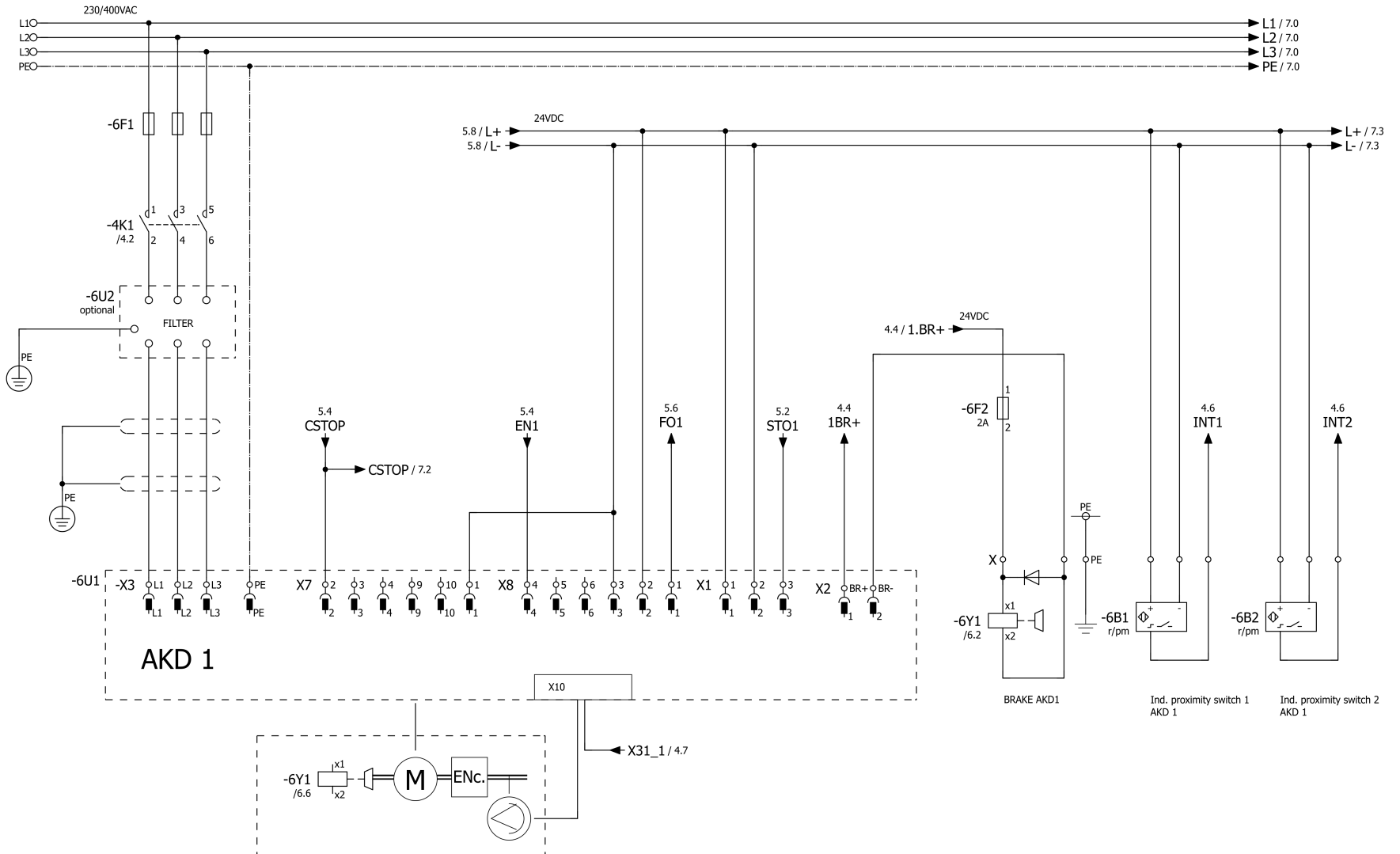
5.4 KSM 12-2 Compact 2 Axis Module Wiring Diagram



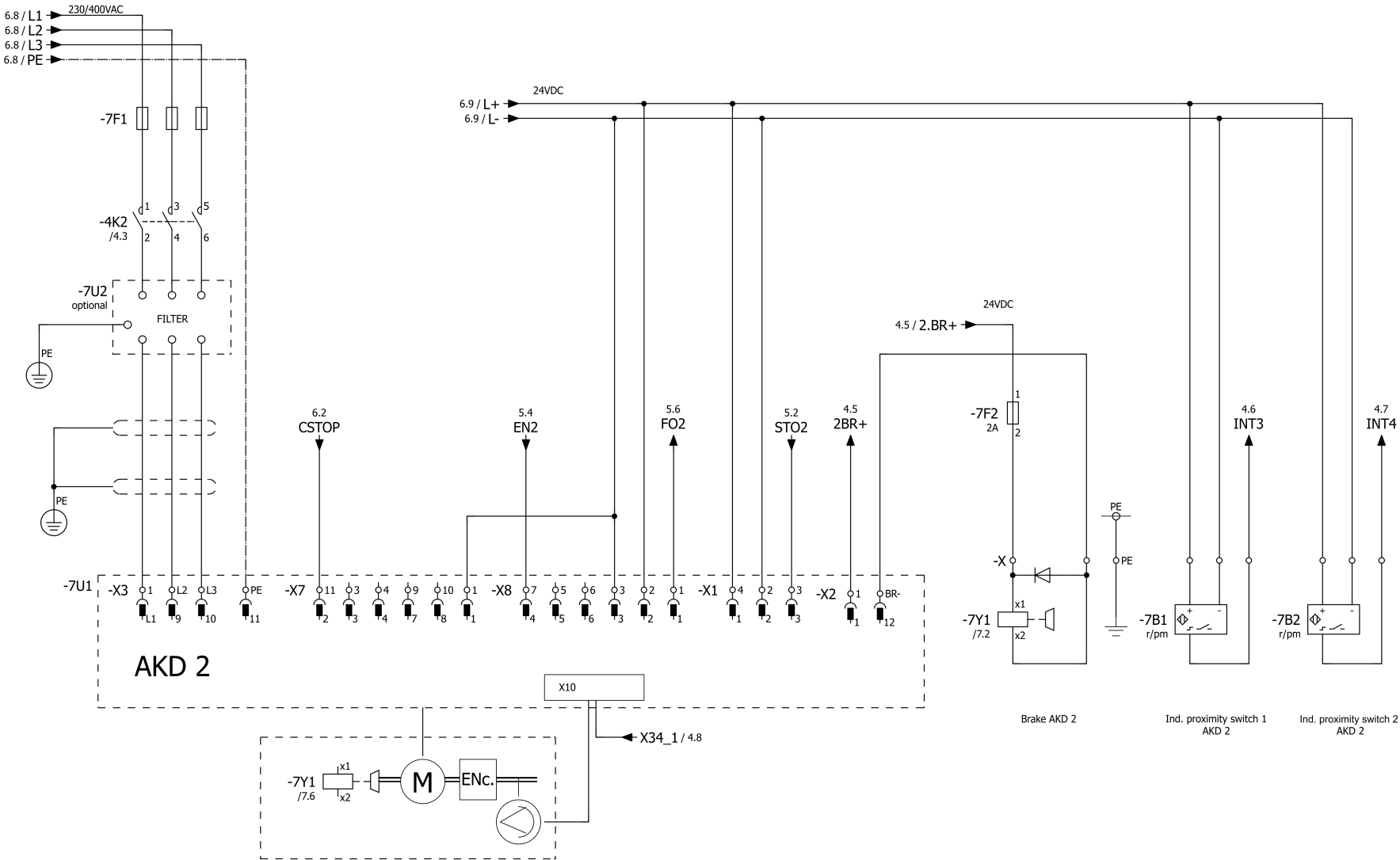
5.5 KSM 31 Wiring Diagram



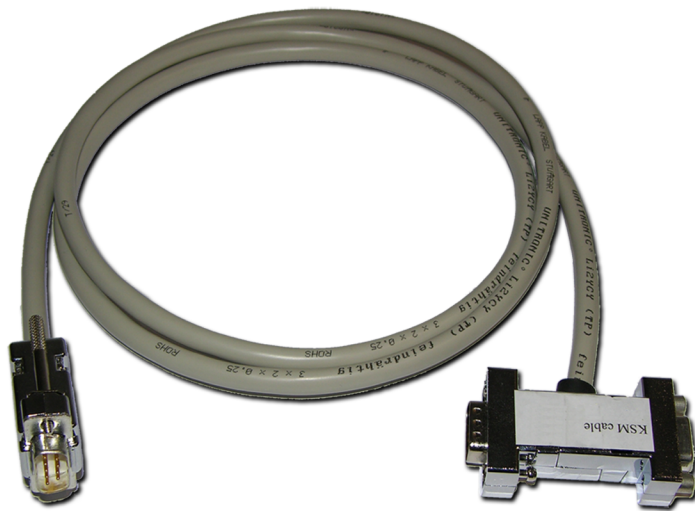
5.6 KSM 12-2 + KSM 31 Power Circuit AKD1



5.7 KSM 12-2 + KSM 31 Power Circuit AKD2

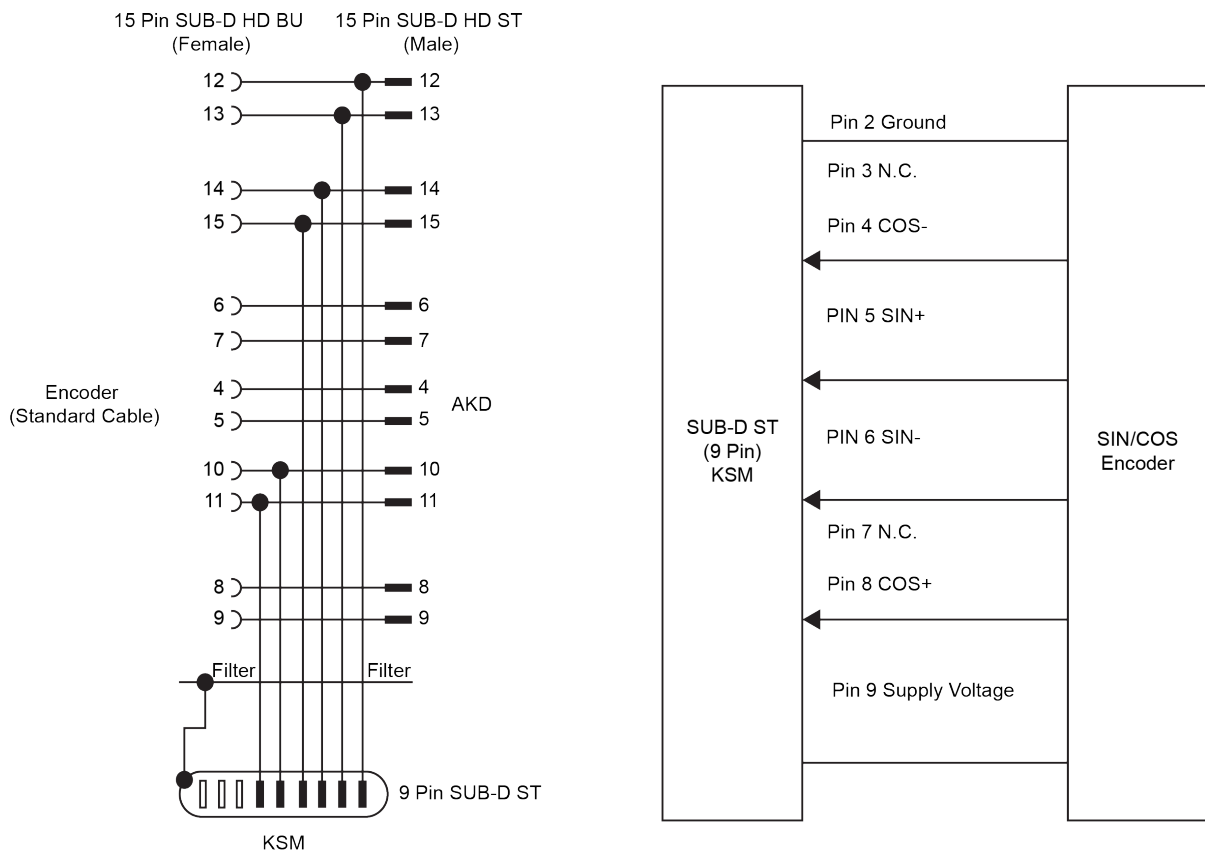


5.8 KSM Encoder Cable



9 Pin SUB-D ST 15 Pin SUB-D HD ST 15 Pin SUB-D HD BU

5.9 KSM 12-2 and KSM 31 Encoder Pin-Wiring Diagram



About KOLLMORGEN

Kollmorgen is a leading provider of motion systems and components for machine builders. Through world-class knowledge in motion, industry-leading quality and deep expertise in linking and integrating standard and custom products, Kollmorgen delivers breakthrough solutions that are unmatched in performance, reliability and ease-of-use, giving machine builders an irrefutable marketplace advantage.

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