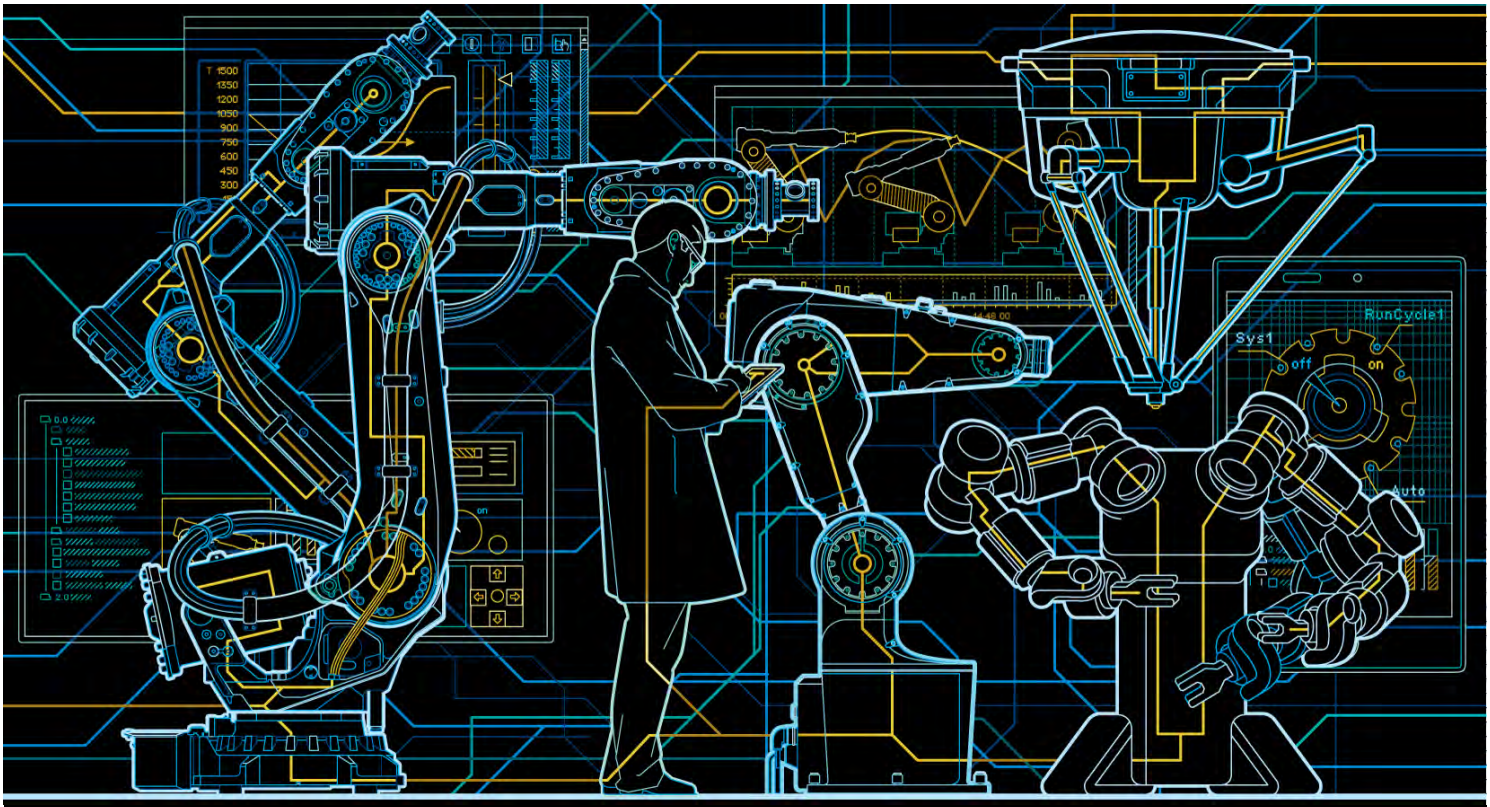

Application manual
Electronic Position Switches

Power and productivity
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Application manual

Electronic Position Switches

RobotWare 6.04

Document ID: 3HAC050996-001

Revision: B

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The original language for this publication is English. Any other languages that are supplied have been translated from English.

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Table of contents

Overview of this manual

About this manual

This manual describes the *Electronic Position Switches* option and contains installation descriptions of the hardware. It also describes the add-in software, which is added to RobotStudio and used for configuration of Electronic Position Switches.

Usage

This manual should be used during installation and configuration of *Electronic Position Switches*.

Who should read this manual?

This manual is mainly intended for:

- personnel that are responsible for installations and configurations of hardware/software
- personnel that make configurations of the I/O system
- system integrators

Prerequisites

The reader should have the required knowledge of:

- mechanical installation work
- electrical installation work
- working with industrial robots
- using RobotStudio
- personal safety, see the safety chapter in *Product manual - IRC5*.

Organization of chapters

The manual is organized in the following chapters:

Chapter	Contents
1 Introduction	This chapter gives an overview of the Electronic Position Switches option, and describes the purpose.
2 Electronic Position Switches functions	Descriptions of all functions included in Electronic Position Switches.
3 Installation	Workflows for how to install hardware and software for Electronic Position Switches.
4 Configuration	Workflows for how to configure Electronic Position Switches.
5 Synchronization	Describes some considerations for the required synchronization.
6 Running in production	Information that is useful after installation, such as performance specifications, what to do if the supervision triggers and virtual signals that can be used in a RAPID program.
7 Example application	Example of a typical problem that is solved with Electronic Position Switches.
8 Safety aspects for Electronic Position Switches	Describes how Electronic Position Switches complies with relevant safety standards and regulations.

Continues on next page

Continued

References

Reference	Document ID
Operating manual - RobotStudio	*3HAC032104-001*
Product manual - IRC5 IRC5 of design M2004	*3HAC021313-001*
Product manual - IRC5 IRC5 of design 14	*3HAC047136-001*
Technical reference manual - RAPID Instructions, Functions and Data types	*3HAC050917-001*
Technical reference manual - System parameters	*3HAC050948-001*
Operating manual - Getting started, IRC5 and RobotStudio	*3HAC027097-001*
Application manual - Additional axes and stand alone controller	*3HAC051016-001*

Revisions

Revision	Description
-	Released with RobotWare 6.0.
A	Released with RobotWare 6.01. Updated to current standards in *Safety requirements on page 98*. Minor corrections thoughout the manual.
B	Released with RobotWare 6.04. Minor corrections.

Product documentation, IRC5

Categories for user documentation from ABB Robotics

The user documentation from ABB Robotics is divided into a number of categories. This listing is based on the type of information in the documents, regardless of whether the products are standard or optional.

All documents listed can be ordered from ABB on a DVD. The documents listed are valid for IRC5 robot systems.

Product manuals

Manipulators, controllers, DressPack/SpotPack, and most other hardware is delivered with a **Product manual** that generally contains:

- Safety information.
- Installation and commissioning (descriptions of mechanical installation or electrical connections).
- Maintenance (descriptions of all required preventive maintenance procedures including intervals and expected life time of parts).
- Repair (descriptions of all recommended repair procedures including spare parts).
- Calibration.
- Decommissioning.
- Reference information (safety standards, unit conversions, screw joints, lists of tools).
- Spare parts list with exploded views (or references to separate spare parts lists).
- Circuit diagrams (or references to circuit diagrams).

Technical reference manuals

The technical reference manuals describe reference information for robotics products.

- *Technical reference manual - Lubrication in gearboxes*: Description of types and volumes of lubrication for the manipulator gearboxes.
- *Technical reference manual - RAPID overview*: An overview of the RAPID programming language.
- *Technical reference manual - RAPID Instructions, Functions and Data types*: Description and syntax for all RAPID instructions, functions, and data types.
- *Technical reference manual - RAPID kernel*: A formal description of the RAPID programming language.
- *Technical reference manual - System parameters*: Description of system parameters and configuration workflows.

Continues on next page

Continued

Application manuals

Specific applications (for example software or hardware options) are described in **Application manuals**. An application manual can describe one or several applications.

An application manual generally contains information about:

- The purpose of the application (what it does and when it is useful).
- What is included (for example cables, I/O boards, RAPID instructions, system parameters, DVD with PC software).
- How to install included or required hardware.
- How to use the application.
- Examples of how to use the application.

Operating manuals

The operating manuals describe hands-on handling of the products. The manuals are aimed at those having first-hand operational contact with the product, that is production cell operators, programmers, and trouble shooters.

The group of manuals includes (among others):

- *Operating manual - Emergency safety information*
- *Operating manual - General safety information*
- *Operating manual - Getting started, IRC5 and RobotStudio*
- *Operating manual - IRC5 Integrator's guide*
- *Operating manual - IRC5 with FlexPendant*
- *Operating manual - RobotStudio*
- *Operating manual - Trouble shooting IRC5*

Safety

Safety of personnel

When working inside the robot controller it is necessary to be aware of voltage-related risks.

A danger of high voltage is associated with the following parts:

- Devices inside the controller, for example I/O devices, can be supplied with power from an external source.
- The mains supply/mains switch.
- The power unit.
- The power supply unit for the computer system (230 VAC).
- The rectifier unit (400-480 VAC and 700 VDC). Capacitors!
- The drive unit (700 VDC).
- The service outlets (115/230 VAC).
- The power supply unit for tools, or special power supply units for the machining process.
- The external voltage connected to the controller remains live even when the robot is disconnected from the mains.
- Additional connections.

Therefore, it is important that all safety regulations are followed when doing mechanical and electrical installation work.

Safety regulations

Before beginning mechanical and/or electrical installations, ensure you are familiar with the safety regulations described in *Operating manual - General safety information*[1].

[1] This manual contains all safety instructions from the product manuals for the manipulators and the controllers.

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1 Introduction

1.1 Overview of Electronic Position Switches

Purpose

Electronic Position Switches is a safety controller in the robot system. The purpose of the safety controller is to ensure a high safety level in the robot system using electronic position switches and safe digital output signals.

The output signals can be connected to, for instance, a safety PLC that will generate stops in the robot system by opening the safety chain. The safety controller also sends status signals to the main computer, that is the standard IRC5 robot controller.

Some examples of applications:

- Monitoring of all robot axes.
- Replacing mechanical position switches.

WARNING

The safety controller has passive monitoring, i.e. it does not stop the robot. If an axis is outside its configured range, an output signal goes low. It is the responsibility of the installation personnel to connect the output signals in such a way that the robot is stopped if there is a risk of a dangerous situation.

What is included

The following is included with the option Electronic Position Switches [810-1]:

- Safety controller (3HAC026271-001)
- 14 pole plug contact for I/O connections.

The option *Electronic Position Switches* gives you access to EPS Configuration Wizard functionality in RobotStudio.

With EPS Configuration Wizard you can:

- set up monitoring of all robot axes
- quickly modify the monitoring settings.

Basic approach

This is the general approach for setting up *Electronic Position Switches*. For more detailed instructions of how this is done, see chapters *Installation* and *Configuration*.

1. Connect I/O connections to sync switch and safety PLC, or similar.
2. Create a safety user in the User Authorization System, UAS (using RobotStudio).
3. Configure the settings for Electronic Position Switches functions via the EPS Configuration Wizard and restart the controller.
4. Log on as safety user and set the PIN code on the FlexPendant. Restart the controller.

Continues on next page

5 Synchronize the safety controller, using a sync switch or software synchronization.

   Now the monitoring functions are activated.

6 Validate the configuration.

Limitations

Electronic Position Switches can only monitor one additional axis. This axis must be connected to SMB link 1.

Continuously rotating axes cannot be monitored.

Drive units cannot be shared, for instance between positioner axes.

Electronic Position Switches uses only passive monitoring, that sets output signals but does not stop the robot.

Supported robots

The following robot families are supported by Electronic Position Switches:

- IRB 140
- IRB 260
- IRB 460
- IRB 660
- IRB 760
- IRB 1600
- IRB 2400
- IRB 2600
- IRB 4400
- IRB 4600
- IRB 5400
- IRB 5500
- IRB 6620
- IRB6620LX
- IRB 6640
- IRB 6660
- IRB 6650S
- IRB 6700
- IRB 7600
- IRB 8700

Other robot models are not supported.

Electronic Position Switches cannot be used for parallel arm robots, such as IRB 360.

Continues on next page

Supported additional axes

Basically the option Electronic Position Switches only supports ABB track motion units. Non ABB track motion units and non ABB positioners may be supported by Electronic Position Switches if the customer configures the appropriate parameters. Electronic Position Switches only supports additional axes that are single axis mechanical units. For example, two axes positioners cannot be supported.

Further, there are always the following upper and lower work area limitations:

- Track unit length (arm side) max ± 100 m
- Rotating axis (arm side) max ± 25 700 degrees or ± 448 radians

On the motor side there is also a limitation of ± 10 000 revolutions.

Requirements

Robust monitoring function in Electronic Position Switches requires correct settings of payload and additional axes, since this will affect the calculated accepted servo lag. Please also note that external forces applied on the manipulator can cause a negative influence on the monitoring functions, since the servo lag might differ from the calculated values, due to such external forces.

DANGER

An Electronic Position Switches configuration must always be validated to verify that the desired safety is achieved. If no validation is performed, or the validation is inadequate, the configuration cannot be relied on for personal safety.

1.2 Terminology

About these terms

Some words have a specific meaning when used in this manual. It is important to understand what is meant by these words. This manual's definitions of these words are listed below.

Term list

Term	Definition
Monitoring	Passive monitoring with signaling function only.
Occupationally safe	Safe for a person to be in an area.
Operationally safe	Safe for the machinery but not safe for persons to enter the area.
Safe input	Dual monitored digital input.
Safe output	Dual monitored digital output.
Safety controller	A safety board used with IRC5. Can be an Electronic Position Switch safety controller or a SafeMove safety controller.
Antivalent signal	Same as complementary signal. The logical value of one channel is the complement of the other in a dual channel signal.
Equivalent signal	The logical value of one channel is equivalent to the other in a dual channel.

2 Electronic Position Switches functions

2.1 Monitor Axis Range

Monitor Axis Range

Monitor Axis Range is a monitoring function that determines if all axes are within the defined ranges. Safe digital output signals are used to indicate when all axes are within their defined ranges.

> **Note**
>
> Monitor Axis Range can only safely determine that the monitored axes are within the defined ranges (i.e. when the output signal is high). It is not safe to assume that an axis is outside the defined range when the signal is low.

Monitoring functionality

The positions of the axes can be monitored as follows:

- Up to five safe digital output signals can be defined.
- For each safe digital output signal, a combination of up to seven axis ranges can be defined.

If an axis is outside its defined range, a safe digital output signal goes low. Each set of axes can be allocated an output signal.

Borderline positions

In very rare cases an error message (elog 20473) might be presented if the robot is stopped for a longer time (> 40 min) in a position exactly on the border of the defined range due to internal design.

Settings

The following settings need to be configured for Monitor Axis Range:

- Axis ranges (degrees or mm) for each axis.
- Assignment of safe digital output for each set of axis ranges.
- Invert range for each axis.
- Allow inside for each set of axis ranges.

Limitations

Continuously rotating additional axes cannot be monitored. If an additional axis is continuously rotating, it must not be configured for monitoring.

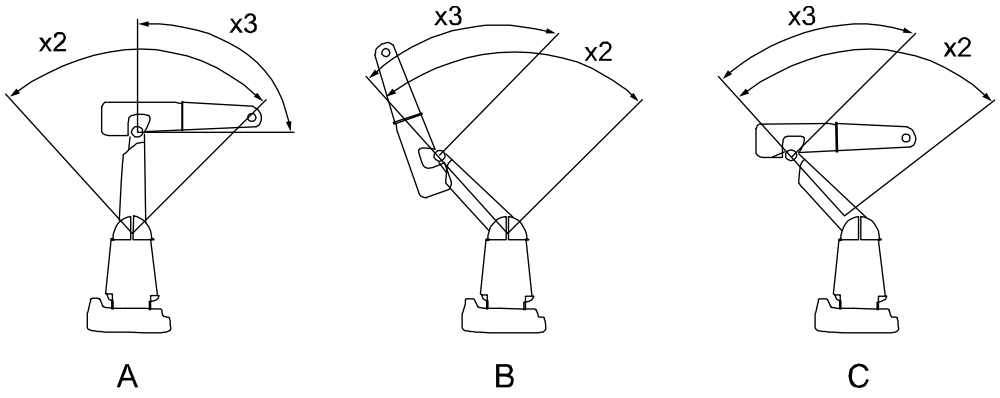
If you have a continuously rotating robot axis (using independent axis for axis 4 or 6) monitoring is not used for that axis. Other robot axes can still be monitored, but the independent axis must be specified in the configuration (see *Select mechanical unit on page 40*).

Continues on next page

Example of ranges

This example shows a robot with defined axis ranges for axes 2 and 3 in three different positions. The function Monitor Axis Range monitors that axis 2 is within range x2 and that axis 3 is within range x3.

In positions A and B, all monitored axes are within the defined ranges. In position C, axis 3 is not within the defined range.



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x2	Defined axis position range for axis 2.
x3	Defined axis position range for axis 3.
A	Robot position A. Both axis 2 and axis 3 are within the defined ranges.
B	Robot position B. Both axis 2 and axis 3 are within the defined ranges.
C	Robot position C. Axis 2 is within the defined range but axis 3 is not within its defined range.

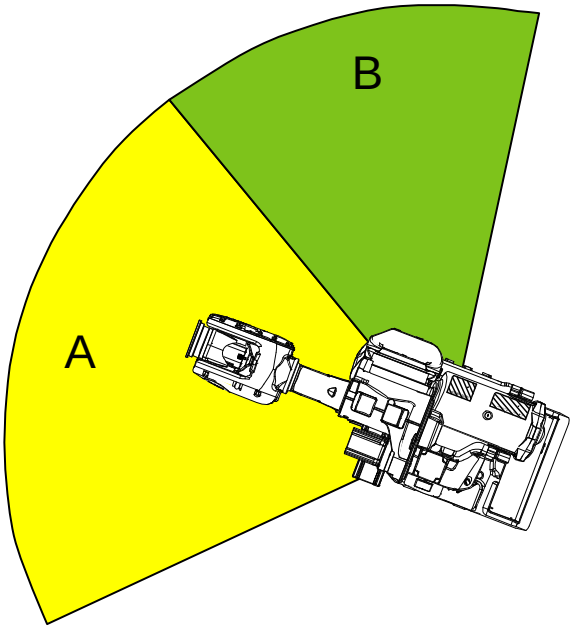
In this example, if range x2 and x3 are defined for the same signal, this signal will go low if any of the axes is outside its defined range.

Note! The ranges define axis angles, not the position of the TCP. In robot position C, the TCP is still within what seems to be a safe range, but axis 3 is outside its defined range.

Continues on next page

Example of usage

Define two ranges for axis 1 and let a safety PLC decide when the axis must be inside range A and when it must be inside range B.



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A	Range for axis 1 defined for safe output signal 1.
B	Range for axis 1 defined for safe output signal 2.

2.2 Cyclic Sync Check

Cyclic Sync Check

Cyclic Sync Check is a function that makes sure that the robot calibration is correct by using a physical switch.

Unsynchronized state can, for example, occur:

- When Cyclic Sync Check has timed out.
- When Control Error Supervision has triggered (for example a too large servo lag due to a collision).

Functionality

The robot must move to a safe sync position to ensure that the safety controller and the robot controller are synchronized. The safe sync position is defined during configuration and stored in the safety controller.

With a defined interval (sync cycle time), the robot must move to the safe sync position and activate a switch. If the sync check is not performed within the sync cycle time, all output signals will go low (which should stop the robot if implemented correctly). A warning is shown on the FlexPendant a pre-defined time (pre-warning time) before the sync cycle time has passed.

When the switch is activated, the safety controller assumes that the robot revolution counters are correct. It also calculates the arm position from the motor positions, the gear ratio, and its internal revolution counter. If the position matches the stored sync position within half a motor revolution, then the synchronization is assumed to be correct.

If the synchronization is correct, the safety controller then sends elog 20452 to the robot controller, telling that the safety controller is synchronized to its mechanical units, and continues with its regular operation.

Settings

The following settings need to be configured for Cyclic Sync Check:

- Sync cycle time, 12-720 hours.
- Pre-warning time, 1-11 hours.
- Angles and positions of robot (and additional axes) at sync position.

How to define these settings is described in *Set sync position on page 47*.

Virtual output signals from main computer

A virtual output signal is set when the prewarning time has expired. Another virtual signal will correspond to the sync status.

Limitations

- The safe sync position must be within reach for the robot. It must not be a singularity, that is all six axis must have unique positions.

Related information

Synchronization guidelines for Cyclic Sync Check on page 63.

2.3 Software Sync Check

Software Sync Check

Software Sync Check is a function that makes sure that the robot calibration is correct. If wrong robot calibration easily can be detected by the application, then it is generally possible to execute the synchronization check by software. In that case it is done when required, not cyclically.

Unsynchronized state can, for example, occur:

- When Control Error Supervision has triggered (for example a too large servo lag due to a collision).

Functionality

Software synchronization is performed by running the service routine `SoftwareSync`. How to run the service routine is described in section *Use service routine to perform synchronization on page 65*.

If the safety controller has not been synchronized before, and the synchronization attempt was unsuccessful, the user has to check and confirm on the FlexPendant that both the robot controller and the safety controller have the same opinion about robot axes positions.

Settings

The following settings need to be configured for Software Sync Check:

- Angles and positions of robot (and additional axes) at sync position.

How to define these settings is described in *Set sync position on page 47*.

Virtual output signals from main computer

A virtual output signal corresponds to the sync status. See *Virtual signals on page 69*.

Limitations

Software Sync Check is only available for EPS board 3HAC026271-001 revision 06 or later.

Related information

Synchronization guidelines for Software Sync Check on page 65.

2.4 Control Error Supervision

Control Error Supervision

Control Error Supervision is a function that monitors the difference between the reference value and the measured value of the motor position of each axis. Control Error Supervision is required to ensure the accuracy in the monitoring functions.

Supervision functionality

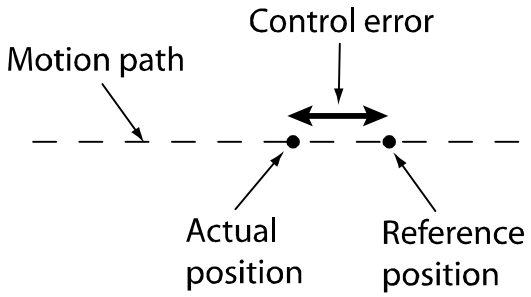
The control error (servo lag) is the absolute value of the difference between the reference value and the measured value of the motor position of each axis.

Control Error Supervision is activated automatically after the safety controller has been synchronized with the robot position.

When Control Error Supervision trips the following happens:

- All output signals go low.
- An elog message (20454) is sent to the robot controller.
- A new synchronization is required.

Illustration of control error



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Function activation

Control Error Supervision is always active. It can only be relaxed by Operational Safety Range.

Dependencies to other functions

If Operational Safety Range is active, then Control Error Supervision is relaxed according to user definitions.

Settings

Control Error Supervision settings are only required for additional axes.

For additional axes, the following settings need to be configured:

- Servo Lag
- Servo Delay Factor

How to define these settings is described in *Configure additional axis on page 41*.

Related information

Operational Safety Range on page 23.

2.5 Operational Safety Range

Operational Safety Range

Operational Safety Range relaxes the monitoring of the servo lag if ALL configured axes are within a defined axis range.

Functionality

Operational Safety Range is a special definition of an axis range that relaxes the Control Error Supervision (servo lag) to a higher value if ALL configured axes are within (inclusive) the defined axis range. It can be used, for instance, in machine tending, when the servo loop gain is reduced (soft servo) or during Force Control. It is also useful when external forces are applied to the robot.

If the robot is within the defined range, then the safety level is considered to be operationally safe rather than occupationally safe. That means it is not safe for personnel to be in the range defined for Operational Safety Range.

To activate the relaxed control error, all of the following conditions must be true:

- The reference values for ALL configured axes must be within the range defined by the Operational Safety Range function.
- The measured values for ALL configured axes must be within the range defined by the Operational Safety Range function.

The function is automatically activated after the safety controller has been synchronized with the robot position. No dynamic activation is possible.

Up to 7 axes can be monitored simultaneously.

Settings

The following settings need to be configured for Operational Safety Range:

- Axis range definition for each axis, physical position in degrees or mm on arm side.
- Permissible control error for each axis, in degrees or mm on arm side.

The definition of axis range consists of:

- Minimum axis limit (degrees or mm).
- Maximum axis limit (degrees or mm).

How to define these settings is described in *Configure the Operational Safety Range on page 47*.

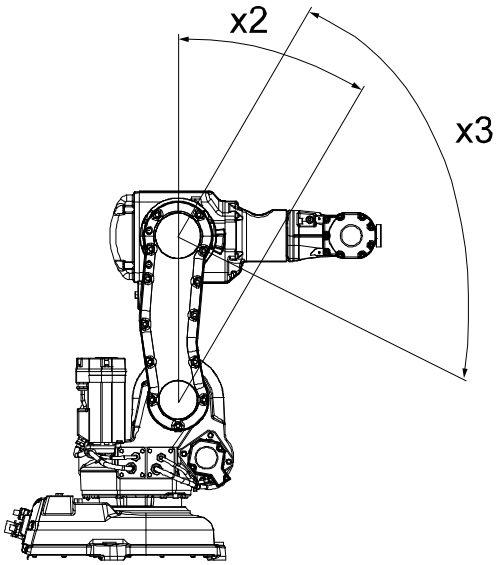
Related information

Control Error Supervision on page 22.

Continues on next page

Examples

This example shows a robot with defined axis ranges for axes 2 and 3. The function Operational Safety Range monitors if axis 2 is within the range x2 and if axis 3 is within the range x3. As long as the measured values and the reference values for both axes are within these ranges, the Control Error Supervision is relaxed.



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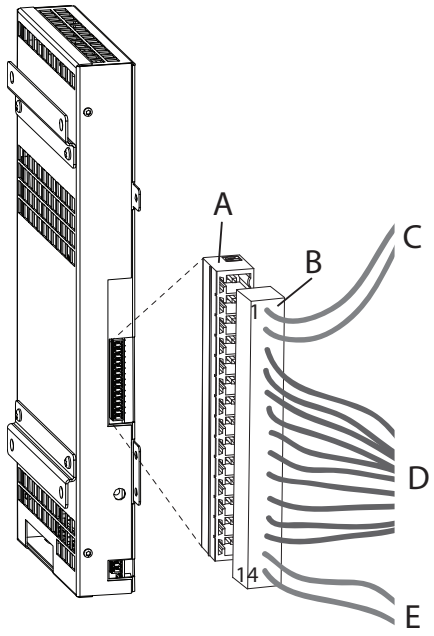
3 Installation

3.1 Hardware installation

3.1.1 I/O connector data

Location



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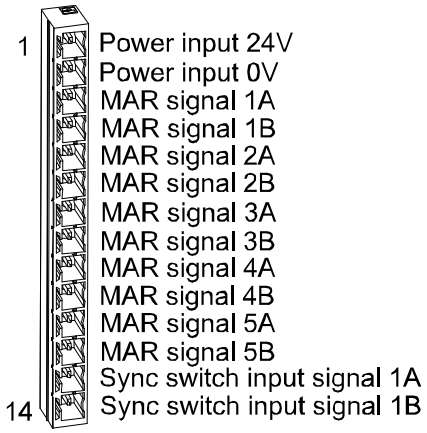
A	I/O Connector on the safety controller
B	Plug contact
C	Power supply
D	5 safe outputs (10 signals)
E	Sync switch (dual signal)

Continues on next page

3.1.1 I/O connector data
Continued

I/O connector pin descriptions



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Pin	Signal	Description
1	Power input 24 V	Plus pole for power to the I/O connector.
2	Power input 0 V	Minus pole for power to the I/O connector.
3	MAR signal 1A	Monitored high side output signal for Monitor Axis Range. The signals are configured in the EPS Configuration Wizard. Switches on or off 24 Volts supplied by the power input (pin 1 and 2).
4	MAR signal 1B	-"-
5	MAR signal 2A	-"-
6	MAR signal 2B	-"-
7	MAR signal 3A	-"-
8	MAR signal 3B	-"-
9	MAR signal 4A	-"-
10	MAR signal 4B	-"-
11	MAR signal 5A	-"-
12	MAR signal 5B	-"-
13	Sync switch input signal 1A	Input signal for synchronization check. A synchronization pulse is defined by this signal connected to ground (0 V). When there is no synchronization pulse, this signal should be open or connected to 24 V.
14	Sync switch input signal 1B	Input signal for synchronization check. A synchronization pulse is defined by this signal connected to 24 V. When there is no synchronization pulse, this signal should be open or connected to ground (0 V).

Voltage and current data

Description	Min value	Max value
Voltage for I/O power supply	21.6 V	26.4 V
Voltage for low value on digital input	-3 V	+2 V

Continues on next page

Description	Min value	Max value
Voltage for high value on digital input	+21 V	+27 V
Max output current by one digital output	-	0.8 A
Sum of output current by all digital outputs	-	2.2 A

Signal redundancy

All output signals have redundancy as a safety measure, i.e. output signal 1A and output signal 1B should always be identical. If they differ for more than approximately 100 ms, there is an internal error. Always handle this error by stopping all mechanical units.

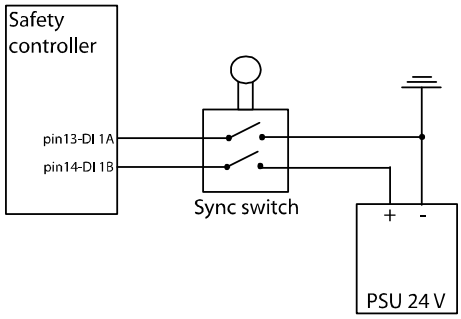
The input signal used for sync check uses redundancy where input signal 1A is the inverted signal of input signal 1B. Here you have the choice of only using input signal 1B, but this must be defined in the EPS Configuration Wizard.

3.1.2 I/O signals

Using the input signal

The safety controller requires an input signal for Cyclic Sync Check. Connect a signal from a sync switch. When the robot is in its sync position, pin 14 should be set high and pin 13 should be set low. If dual channel wiring is not used, connect only pin 14.

Principle for sync switch connected to the safety controller using dual input signal:



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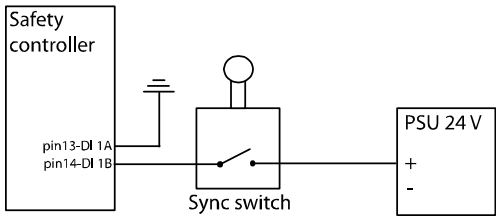
Principle for sync switch connected to the safety controller using single input signal:



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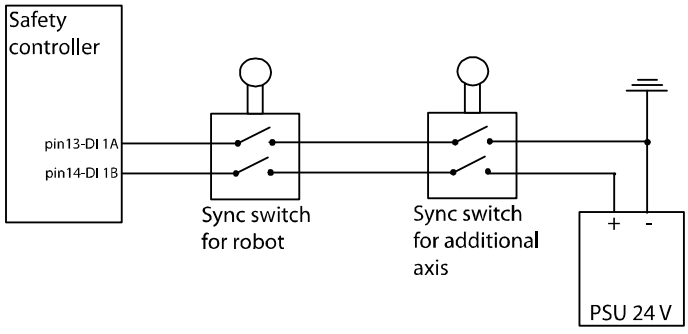
Additional axis

When synchronizing an additional axis and a robot, use a separate sync switch for the additional axis and connect it in series with the sync switch for the robot.



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Exception: If the additional axis is a track motion or a robot-held tool, it can use the same sync switch as the robot. These types of additional axes can be treated as a 7th robot axis. Note that this makes it more complicated to find a non-singularity sync check position.

Continues on next page

Using the output signals

The safety controller has 5 dual output signals that indicate if all axes are inside the defined range. When performing the installation, it is the responsibility of the installation personnel to make sure that these signals will stop the robot if an axis goes out of its allowed range. Connect the output signals to a PLC, or similar equipment, that can stop the robot when a signal goes low.

The safety controller works with redundancy (dual processors, dual output signals, etc.). Safe robot behavior (inside defined range) is indicated by high value on the output signal, so that a power failure will be interpreted as unsafe and stop the robot.

Make sure that the output signals from the safety controller are connected in such a way that the redundancy is preserved (if one of the dual signals goes from 24 V to 0 V, the system should stop). Also make sure that a low signal always represents the safe state that stops the robot, so that a power failure on the PLC also stops the robot.

What the different output signals indicate is defined in the EPS Configuration Wizard, see *EPS Configuration Wizard on page 39*.

Test pulses on output signals

Test pulses during start-up

At the beginning of each system start-up there are test pulses on the outputs present. This must be considered at installation and commissioning so that it is not interpreted as an axis being outside its defined range.

Test pulses during operation

Due to safety reasons there are test pulses on the output signals during operation. The pulses have a maximum length of 2 ms and are only present when the outputs are high. This must be considered at installation and commissioning so that it is not interpreted as an axis being outside its defined range. Make sure the PLC or safety relay does not react on pulses shorter than 2 ms.

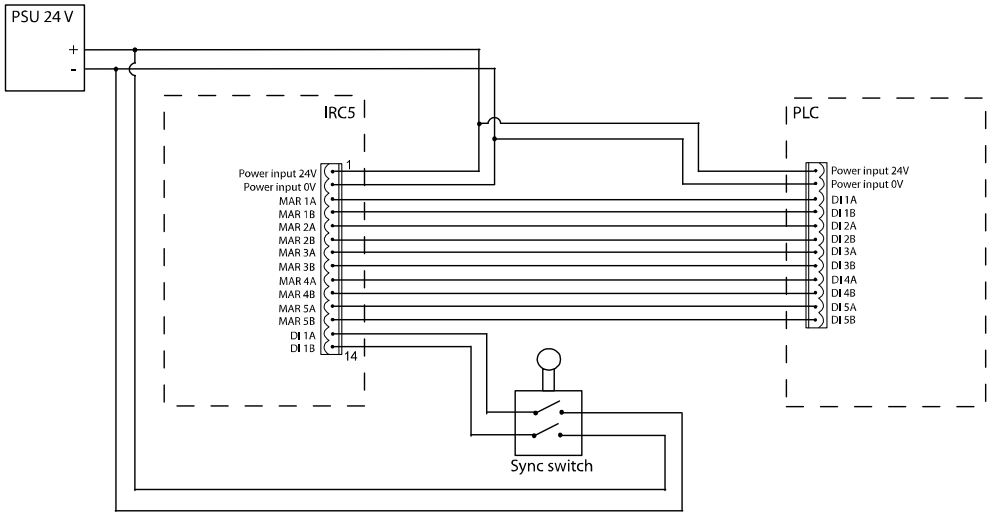
Max inductive load

The inductive load on the outputs must be less than 200 mH.

Continues on next page

3.1.2 I/O signals
Continued

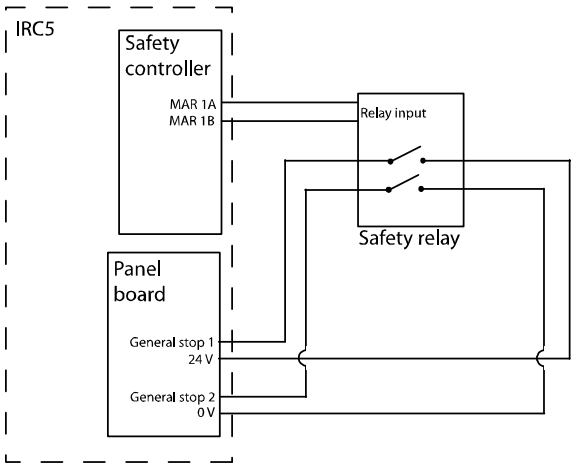
Principle for connecting signals to PLC



en0600003223

Using a safety relay

An output signal from the safety controller can be connected to a safety relay which can stop the robot immediately. This can be implemented by letting the safety relay open the circuit for, for example, the general stop signal 1 and 2 on the panel board of the IRC5 controller.



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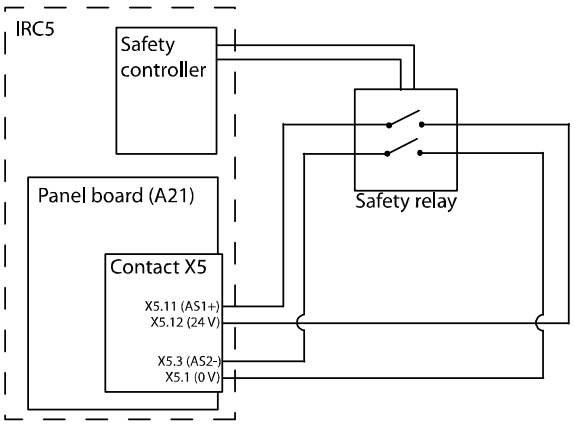
Connect to Auto Stop on the panel board

A signal from a safety relay or a PLC can be connected to the Auto Stop signal of the panel board in the IRC5 controller. If the Auto Stop circuit is open, the robot cannot move in auto mode. However, it is still possible to move the robot in manual mode.



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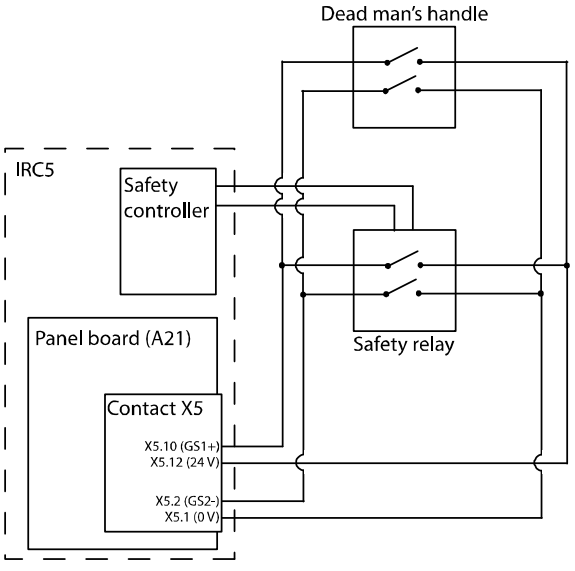
Connect to General Stop on the panel board

A signal from a safety relay or a PLC can be connected to the General Stop signal of the panel board in the IRC5 controller. If the General Stop circuit is open, the robot cannot move either in auto or manual mode.

Note that when the General Stop circuit is open, there is no way of jogging the robot back to the defined range. Therefore, using the General Stop signal requires an additional switch to close the circuit while jogging the robot back inside the defined range. For safety reasons, the switch used to override the relay needs to be of safety level category 3 or higher according to EN954–1 (safety level is dependant of the required safety level for the installation). Use, for example, a dead man's handle.



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3.1.3 Power supply

Use IRC5 ground or isolate the I/O

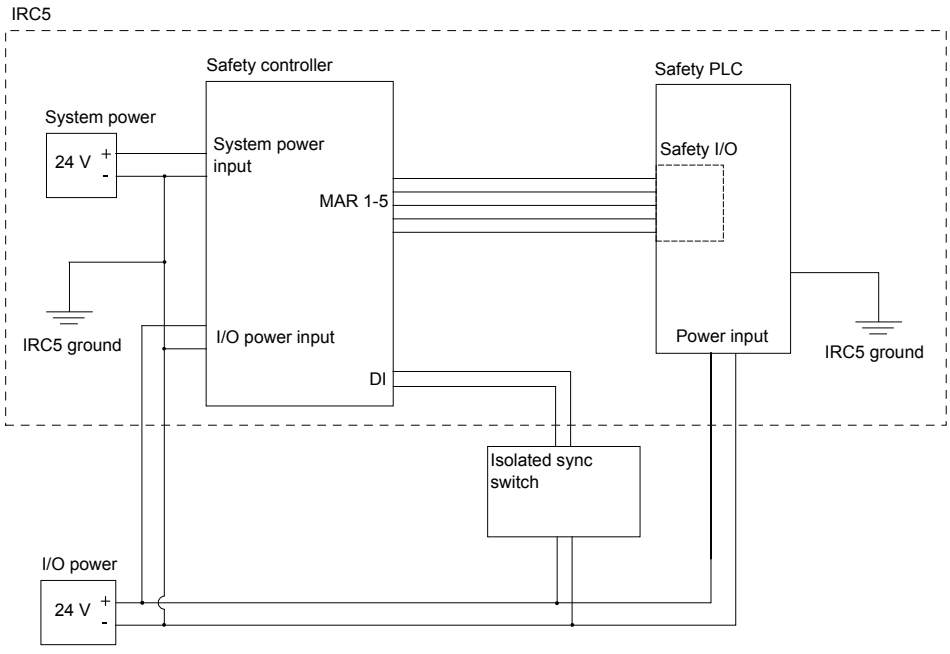
The safety controller requires one system power supply and one I/O power supply. These two power supplies must have a common ground potential.

The I/Os of the safety PLC must either have the same ground potential as the safety controller (i.e. as the IRC5 cabinet), or the I/Os of the safety PLC must be galvanically isolated from the safety controller. This can be achieved in different ways as seen in the examples below.

Example with common ground

In this example the I/Os of the safety controller, the sync switch, and the safety PLC has a common ground potential. The ground of the I/O power supply is connected to the ground of the system power supply (i.e. the ground of the IRC5 power supply).

This setup is usable up to a distance of 30 meters between the IRC5 cabinet and the safety PLC.



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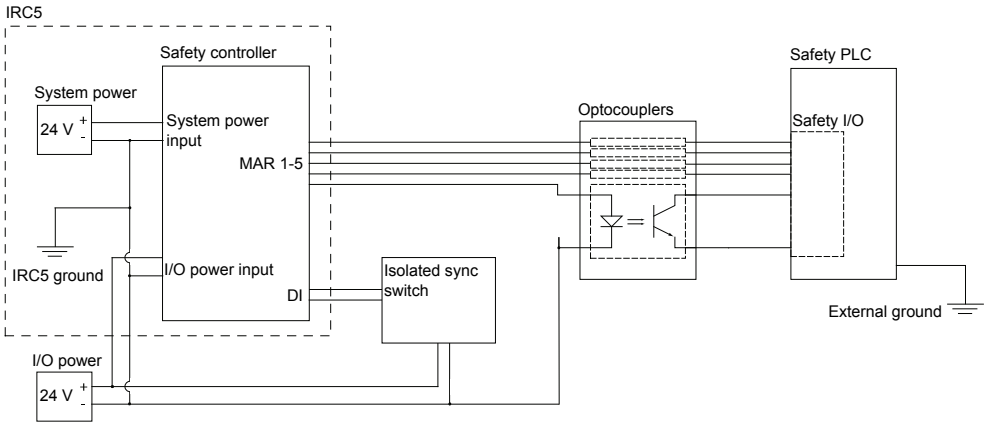
For a single cabinet IRC5 controller, the I/O power supply can be an internal power supply located in the IRC5 cabinet. For a dual cabinet IRC5 controller, an external power supply needs to be used.

Continues on next page

Example with isolated I/O

In this example the I/O connector of the safety controller is isolated from the safety PLC with optocouplers. The ground of the safety controller (i.e. the ground of the IRC5 power supply) is isolated from the ground of the safety PLC

This setup is usable up to a distance of 30 meters between the IRC5 cabinet and the safety PLC.



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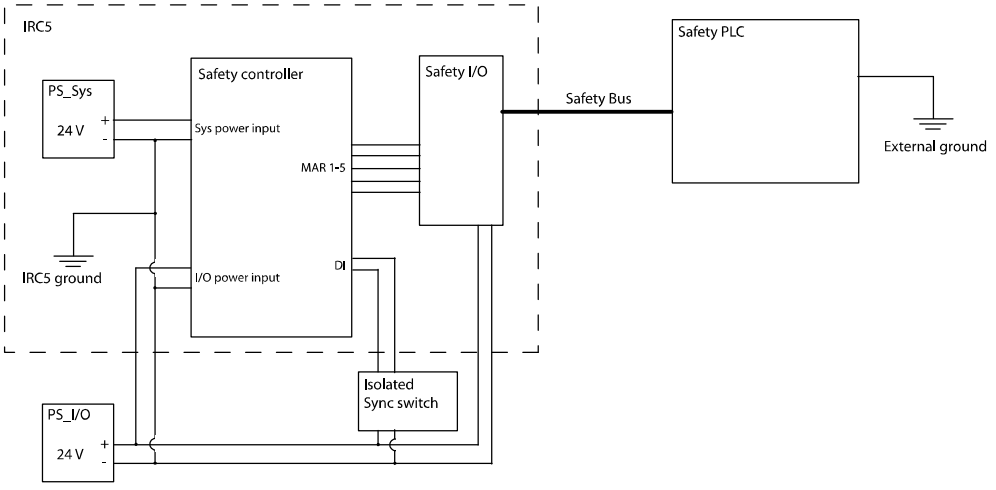
Example with safety bus

A solution with a safety bus will automatically solve the problem of galvanic isolation from the PLC. It will also allow the distance between the IRC5 and PLC to be greater than 30 meters. The maximum distance for this solution depends on the safety bus used by the PLC.



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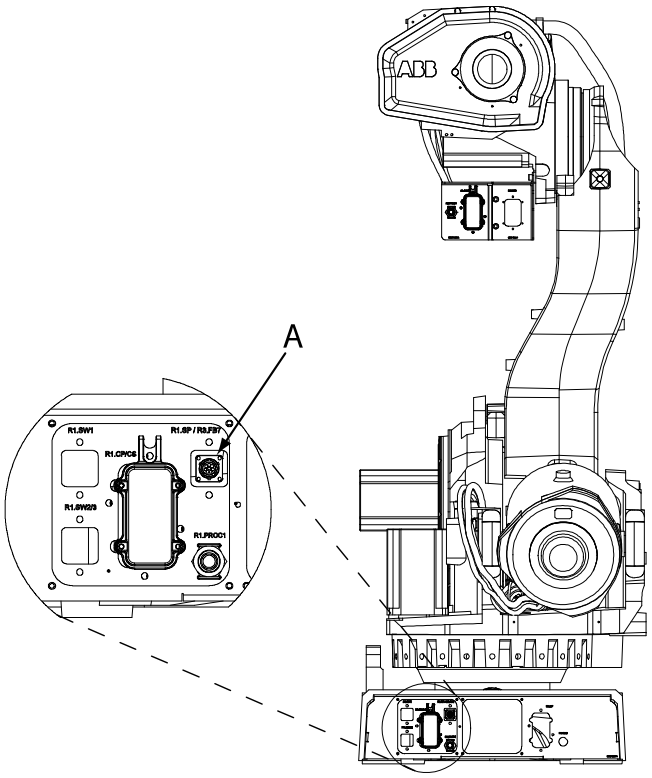
3.1.4 SMB connection for additional axis

About SMB connections

For Electronic Position Switches, you can only use SMB link 1. This means that you can only connect one additional axis. The additional axis must be connected to the robot SMB.

Connect additional axis directly to the robot

Connect the SMB cable from the additional axis to the SMB connection on the robot. By connecting the additional axis here, it will be read as axis 7 on the SMB cable from the robot to the safety controller.



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A	SMB connection on robot base, where the additional axis can be connected as the 7th axis in SMB link 1.

3.2 Software installation

3.2.1 Installing required software

> **Note**
>
> RobotStudio must be of the same version or later than the RobotWare used.

Install RobotStudio

The EPS Configuration Wizard is installed with RobotStudio. Install RobotStudio as described in *Operating manual - Getting started, IRC5 and RobotStudio*.

RobotStudio can be installed with the options *Minimal* or *Full*, and the EPS Configuration Wizard is installed with either of these installation options. The EPS Configuration Wizard is available in the Online tab of RobotStudio.

Create a robot system

Create a robot system as described in *Operating manual - Getting started, IRC5 and RobotStudio*. Use a drive module key that gives access to Electronic Position Switches and select the option *810-1 Electronic Position Switches*.

Configure IRC5

Configure the robot system (coordinate systems, tools, work objects, robot cell layout, etc.) before configuring Electronic Position Switches.

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4 Configuration

4.1 Create a safety user

Why do you need a safety user

Configuring Electronic Position Switches is normally done initially and then never changed (until the robot is used for a different purpose). It is vital that the safety configuration is not changed by unauthorized personnel. It is therefore recommended to have specific safety users who are granted the right to configure Electronic Position Switches.

Prerequisites

You must have created a robot system with the option 810-1 Electronic Position Switches. How to create a system is described in *Operating manual - RobotStudio*.

How to create a safety user

	Action
1	Request write access from RobotStudio: In the **Online** browser, right-click on the controller and select **Request Write Access**. If in manual mode, confirm the write access on the FlexPendant.
2	Start UAS Administrative Tool: In the **Online** browser, right-click on the controller and select **Authenticate** and then **Edit User Accounts**.
3	Select the tab **Groups**.
4	Click **Add** and type a name for the group, e.g. "Safety".
5	Select the group you have created and select the check boxes for the controller grants: • **Execute program** • **Safety Controller configuration** • **Write access to controller disks** • **Remote warm start** The group may have more grants, but these are the minimum required.
6	Select the tab **Users**.
7	Click **Add** and type a name for the user, e.g. "SafetyUser", and a password for the user.
8	Select the user you have created and check the group you previously created, e.g. **Safety**. The user may belong to more groups.
9	Click **OK**.
10	Restart the controller.

Continues on next page

Tip

Create different user groups as described in *Operating manual - RobotStudio*, section *Managing the user authorization system*. Make sure that one administrator has the grant *Manage UAS settings* and that the regular users (operators, Default user, etc.) do not have the grants *Safety Controller configuration*, *Write access to controller* or *Manage UAS settings*.

Granting right to perform software synchronization

There must always be a safety user with the right to everything that has to do with the safety controller. The safety user can always perform a software synchronization. If you want someone else to be allowed to perform a software synchronization, this grant can be given to them.

	Action
1	Request write access, open the UAS Administrative tool and select tab **Groups** as described in *How to create a safety user on page 37*.
2	Select the group that should have the grant (for example Operator).
3	Select Application grants in the drop-down box.
4	Select the check box for **SafeMove/EPS software sync service routine**.
5	Click **OK**.

4.2 EPS Configuration Wizard

What is the EPS Configuration Wizard

In the EPS Configuration Wizard you configure the ranges and tolerances used by the functions of Electronic Position Switches.

Prerequisites

Only a safety user is allowed to download a configuration. A safety user must be created before configuring Electronic Position Switches (see *Create a safety user on page 37*).

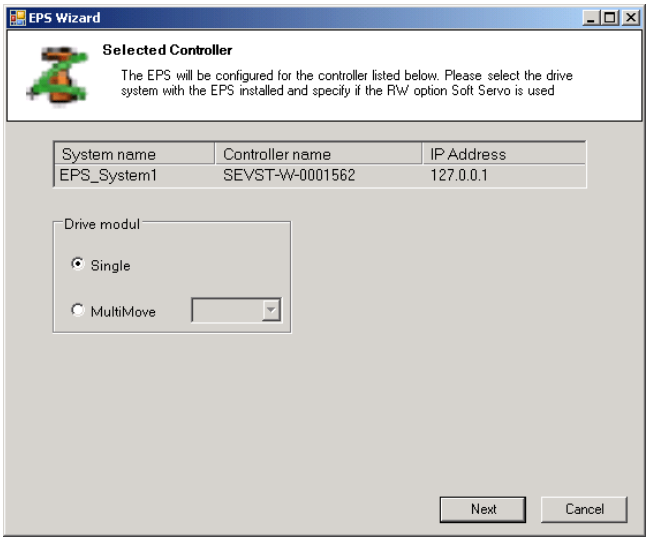
Start the EPS Configuration Wizard

	Action
1	In RobotStudio's **Online** browser, right click on the controller and select **Authenticate** and then **Login as Different User**.
2	Select the safety user, e.g. **SafetyUser**. Type the password and click **Login**.
3	Select the controller you wish to configure. In the **Online** browser, right click on the controller and select **Safety Configuration** and then **EPS Wizard**. In the menu **Tools**, select **EPS Configuration Wizard**.
4	Click **Next**.

Select drive module

Select if you are configuring a single robot system or a MultiMove system.

If you configure a MultiMove system you must select which drive module you want to configure. The configuration procedure must be repeated for each drive module. For information about configuration of a MultiMove system, see *Configuration for MultiMove on page 55*.



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Click on **Next**.

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Select configuration format

In the EPS Wizard you need to select the configuration format. Version 1.1.0 is the standard format and the recommended selection, which also appears as a default setting in the dialog box. In some rare cases, for example when you receive a new EPS unit as a replacement of an old unit that is supporting the version 1.0.0 format, select the version 1.0.0.

Select mechanical unit

Check the mechanical unit you want to configure.

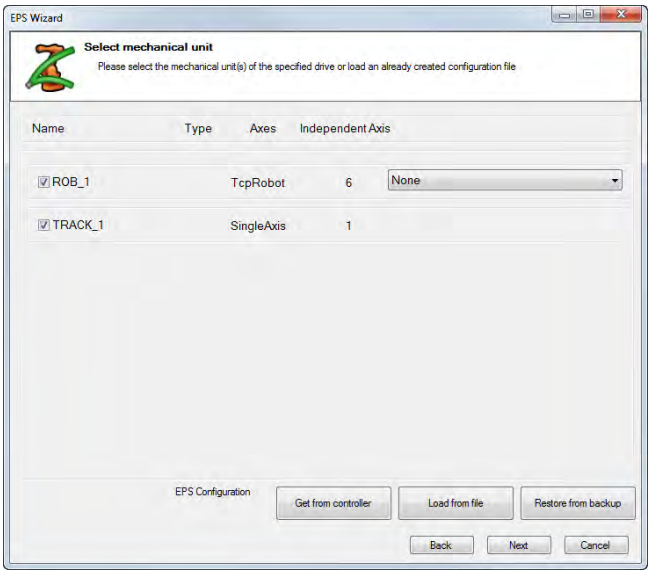
If you want to configure a robot and an additional axis, select both. There is a maximum of 7 axes per drive module, so if you configure a robot you cannot configure more than one additional axis for that drive module.

If one axis is used as an independent axis, there can be no monitoring of that axis. Under **Independent Axis**, you have the following choices regarding the option Independent Axes [610-1]:

- **None**: Monitoring possible on all axes, but you cannot use the option Independent Axes.
- **Axis_4**: Monitoring is possible on axes 1-3, but not on axes 4-6. You can now use the option Independent Axes for axis 4 and/or axis 6.
- **Axis_6**: Monitoring is possible on axes 1-5, but not on axis 6. You can now use the option Independent Axes for axis 6, but not for axis 4.

It is possible to open an existing configuration and make modifications to it. To get the current configuration from the controller, click on **Get from controller**. To get a configuration that is previously saved to file, click on **Load from file**.

If a system backup is available then the EPS safety configuration can be restored from the backup without the need of a validation, see *Restore configuration from backup on page 50*.



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Click on **Next**.

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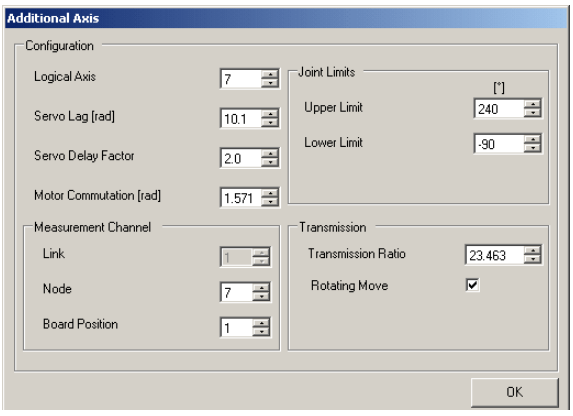
Configure additional axis

If an additional axis was checked in the previous step, specify configuration parameters for the additional axis (many of them are the same as some system parameters defined in the topic *Motion*):

- **Logical Axis** - see system parameter *Logical Axis* in type *Joint*.
- **Servo Lag** - calculated lag (in radians on motor side) for the additional axis.
- **Servo Delay** - calculated delay factor (number of 4 ms units) when moving the additional axis.
- **Motor Commutation** - see system parameter *Commutator Offset* in type *Motor Calibration*.
- **Link** - see system parameter *Measurement Link* in type *Measurement Channel*.
- **Node** - see system parameter *Measurement Node* in type *Measurement Channel*.
- **Board Position** - see system parameter *Board Position* in type *Measurement Channel*.
- **Upper Limit** - upper limit of the axis (in mm or degrees on arm side, depending on if **Rotating Move** is checked). See system parameter *Upper Joint Bound* in type *Arm*, but notice that *Upper Joint Bound* is specified in radians on motor side.
- **Lower Limit** - lower limit of the axis (in mm or degrees on arm side, depending on if **Rotating Move** is checked). See system parameter *Lower Joint Bound* in type *Arm*, but notice that *Lower Joint Bound* is specified in radians on motor side.
- **Transmission Joint** - see system parameter *Transmission Gear Ratio* in type *Transmission*.
- **Rotating Move** - should be checked for rotational additional axis and not checked for linear additional axis.



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Click on **OK**.

> **Note**
>
> Accurate values for the additional axis are important to avoid problems with too large servo lag.

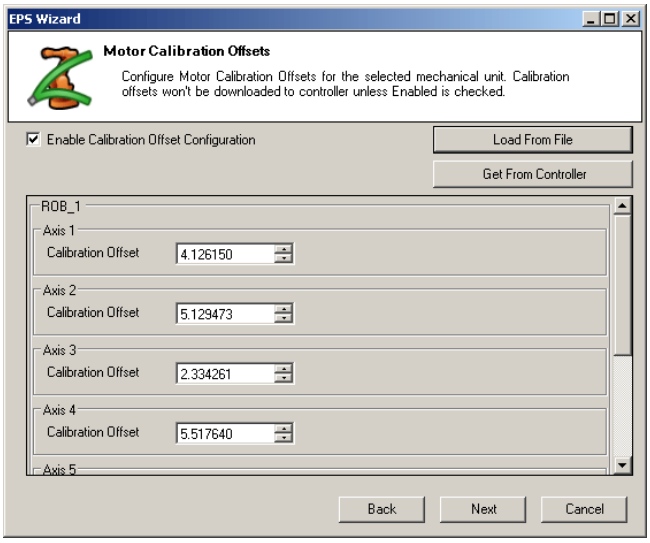
Configure motor calibration offsets

The first time you configure a new robot you must provide the motor calibration offsets. These values are required to achieve a high precision in the monitoring of the axes positions.

The calibration offset parameters are found in the system parameter *Calibration Offset* in type *Motor Calibration*, topic *Motion*.

To set the motor calibration values, check the box **Enable Calibration Offset Configuration** and then press the button **Get From Controller** or enter the values.

If the motor calibration values have already been set and downloaded to the controller, leave **Enable Calibration Offset Configuration** unchecked and continue.



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Click on **Next**.

> **Note**
>
> Observe that the motor calibration values need to be set both for the robot controller and for Electronic Position Switches. Therefore this dialog must be filled in even if the calibration offsets already are set in the robot controller. Every time the calibration values are changed in the robot controller they also need to be changed in the EPS Configuration Wizard. Also remember to download the calibration file as described in *EPS Configuration Wizard on page 39*.

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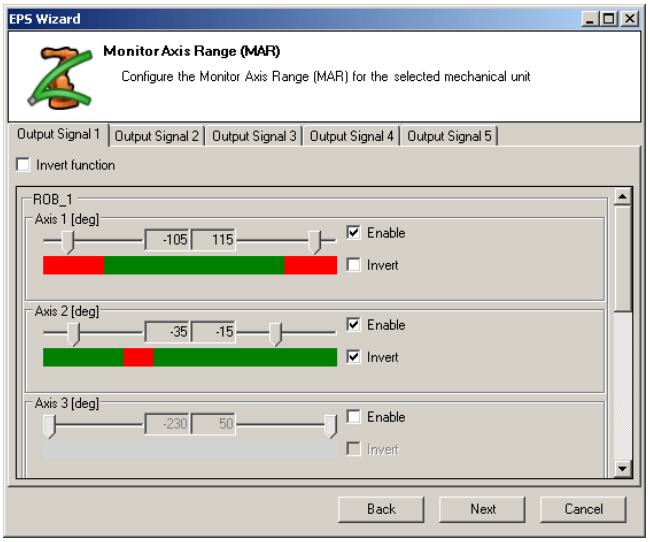
Configure the Monitor Axis Range

You can define up to five different safe output signals. For each signal you can define a range for each axis. Select output signal to configure by clicking on the corresponding tab.

For each axis where you want to define an axis range, check the box **Enable** and set the range by dragging the markers along the slide bar. The defined range is marked green on the scale.

By checking the box **Invert** for an axis the range between the markers is now outside the defined range, shown as red on the scale.

The output signal is high when all axes are within the defined range, and low when one (or more) axis is outside.



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Click on **Next**.

Inverted function

By checking **Invert function**, a robot position is only considered hazardous if all axes are inside their defined ranges.

Not inverted axis ranges and not inverted function:

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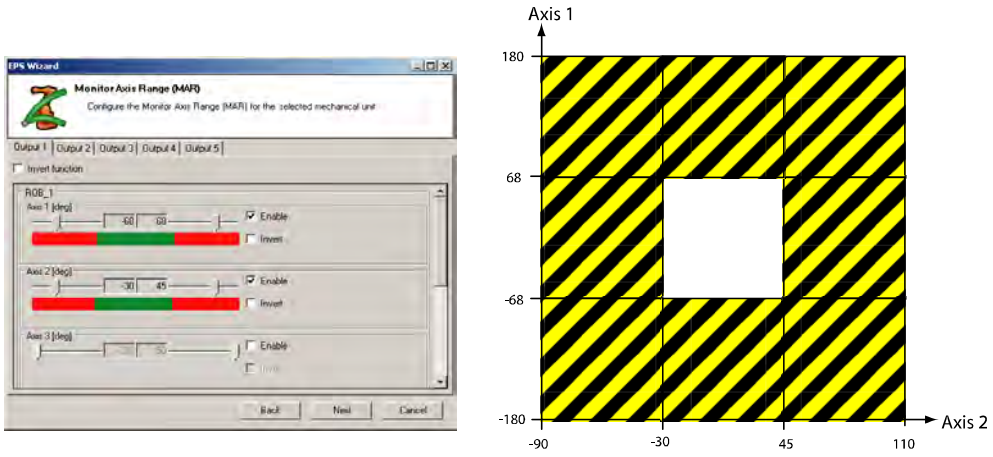
If neither the axis ranges or the function is inverted, the safe zone (where no signal is set low) is when all axes are inside their defined ranges. This safe zone corresponds to the white area in the right picture below.



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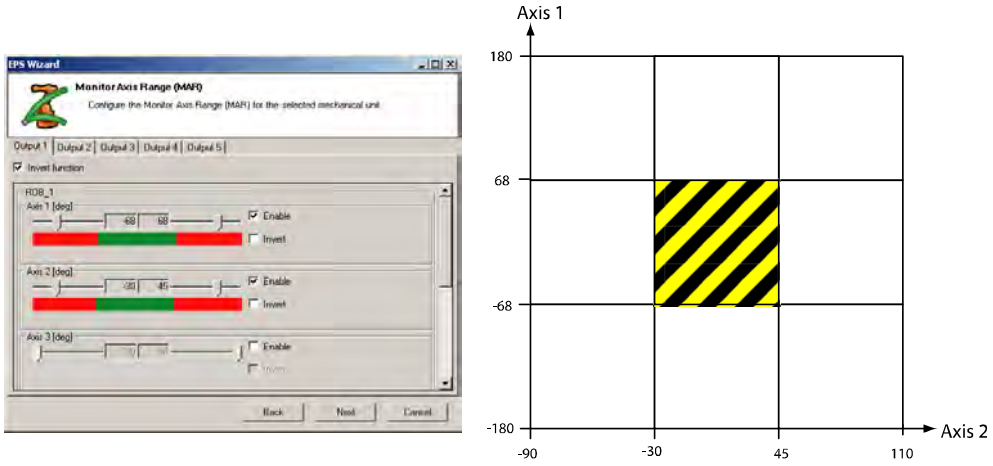
Not inverted axis ranges and inverted function:

If the axis ranges are not inverted, but the function is inverted, the safe zone (where no signal is set low) is everywhere except where all axes are inside their defined ranges. This safe zone corresponds to the white area in the right picture below.



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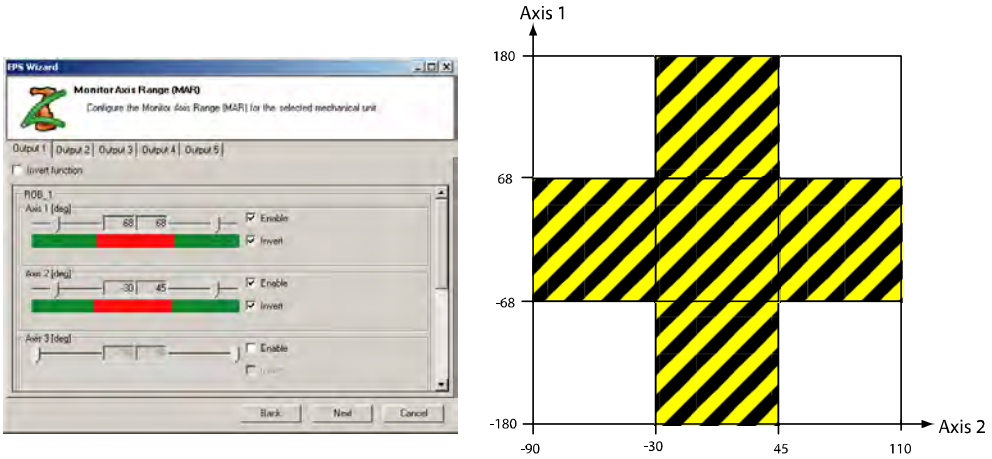
Inverted axis ranges and not inverted function:

If the axis ranges are inverted but not the function, the safe zone (where no signal is set low) is when all the axes are inside their defined ranges, i.e. when none of

Continues on next page

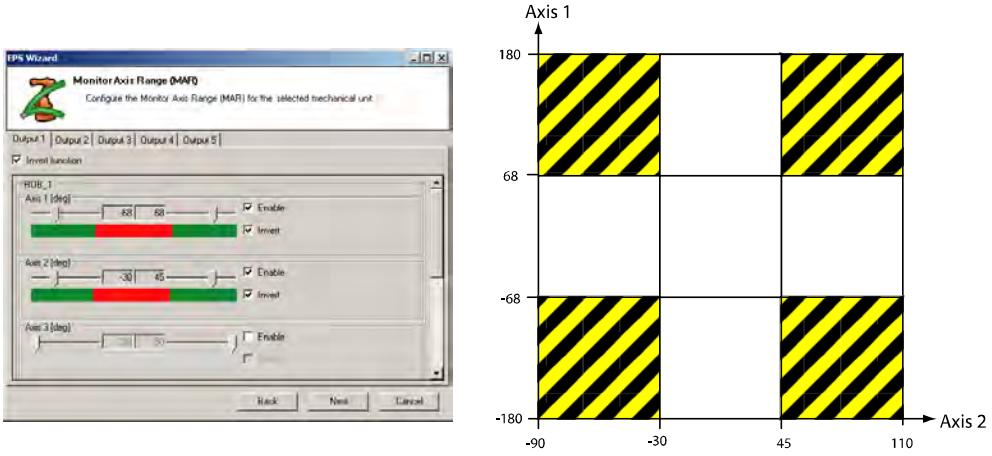
the axes are inside the undefined range in the middle. This safe zone corresponds to the white area in the right picture below.



xx0700000437

Inverted axis ranges and inverted function:

If the axis ranges are inverted and the function is inverted, the safe zone (where no signal is set low) is when one of the axes is inside the undefined range in the middle. This safe zone corresponds to the white area in the right picture below.



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Example of how to use the inverted function:

A robot may have two working areas defined by axis ranges for axis 1 (MAR1 and MAR2). To be able to move between these two working areas, axis 1 may be in the range in between, under the condition that axis 2 is pointing up or backwards. By defining MAR3 as axis one being between MAR1 and MAR2 and axis 2 pointing

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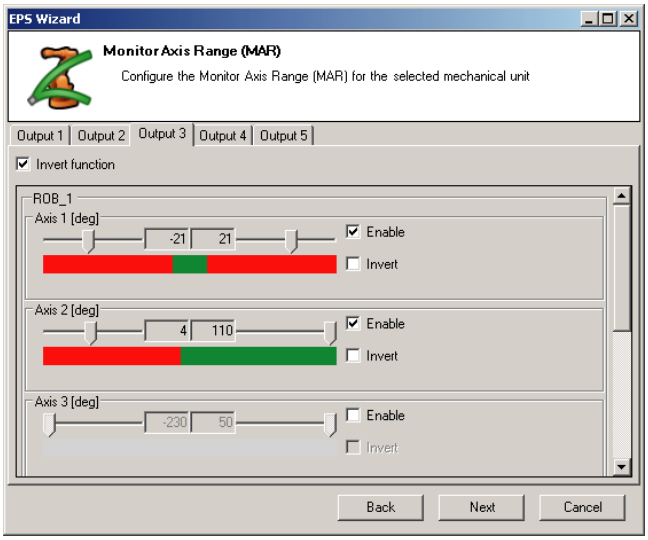
forward, and inverting the function, the MAR3 signal will go low if both axis 1 and axis 2 are pointing straight forward.



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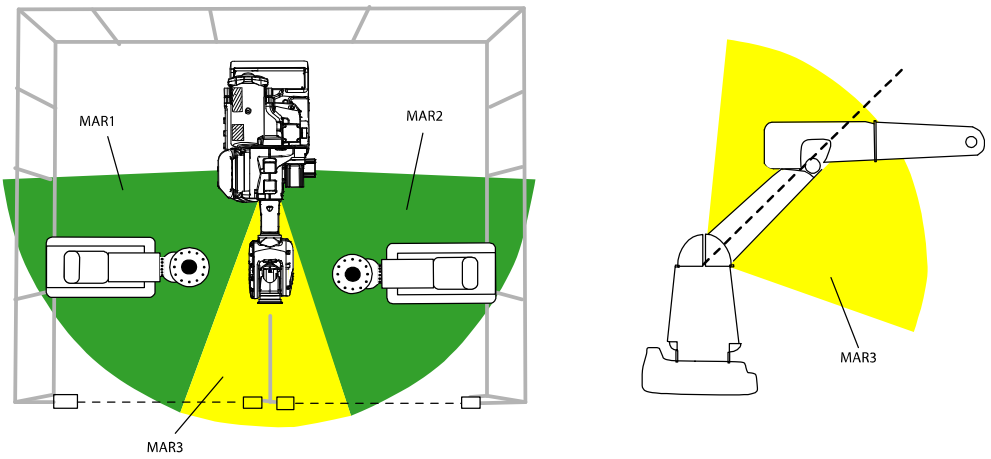

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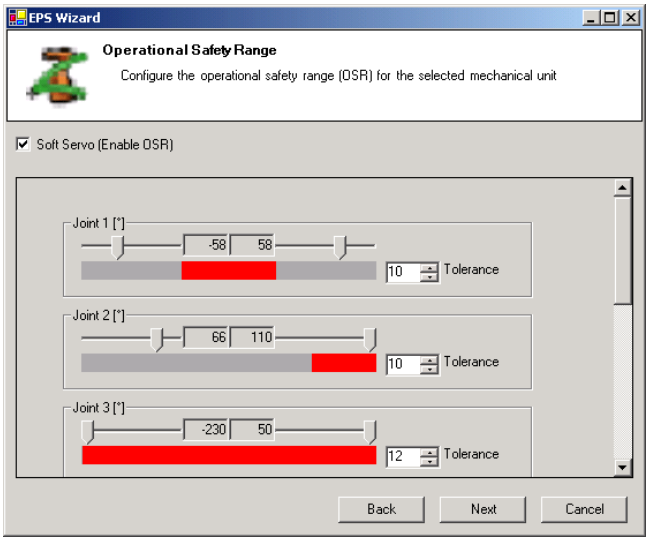
Configure the Operational Safety Range

If using soft servo, the servo lag can easily exceed the limits for the function Control Error Supervision. In this step of the wizard you can set axis ranges where the tolerance for Control Error Supervision is higher.

For each axis, set the range where the tolerance should be higher (the red area). Also set how high the tolerance should be. The tolerance (in degrees on arm side) is specified in **Tolerance**.



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Click on **Next**.

Set sync position

Jog the robot to the synchronization position used by Cyclic Sync Check or Software Sync Check and click on **Get actual position**.

Sync Check Cycle defines the maximum allowed time (in hours) between synchronization checks.

Before the cycle time has expired, a warning will be shown on the FlexPendant. **Pre-warning** defines how long before the cycle time is up this warning should occur.

When the cycle time has expired without a sync check, all output signals will go low.

If a dual input signal is used for the synchronization check, connected to pin X10.5 and X10.6 on the I/O connector, select **Dual Channel** in the drop-down box. If a single input signal is used, connected to pin X10.6, select **Single Channel**. If the

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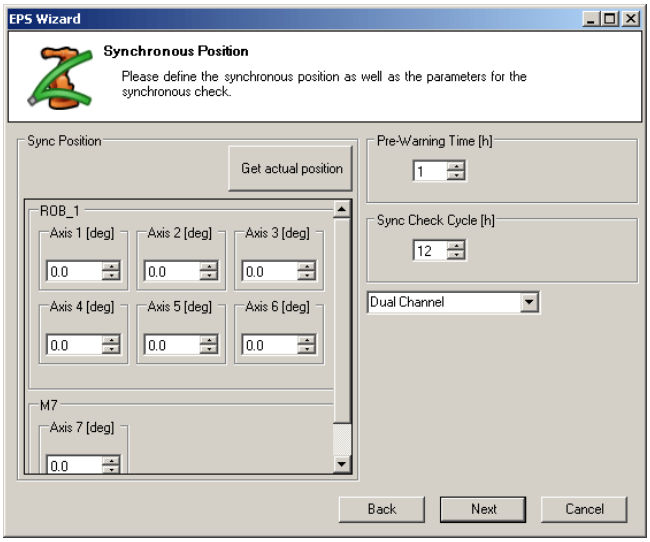
Software Sync Check function is used, select **Software Synchronization** (only available for EPS board 3HAC026271-001 revision 06 or later).



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Click on **Next**.

Tip

Save the synchronization position as a `robtarget` in your RAPID program. Also, in the RAPID program, create a timer and program the robot to perform a synchronization. Use a shorter cycle than the configured **Check Cycle** minus **Pre-Warning** to avoid warnings on the FlexPendant.

Save and download to controller

From the last dialog in the wizard, you can:

- Save the motor calibration file. If no motor calibration has been performed, this button is grayed out.
- Save the safety configuration file.
- Download the motor calibration to the controller.
- Download the safety configuration to the controller.

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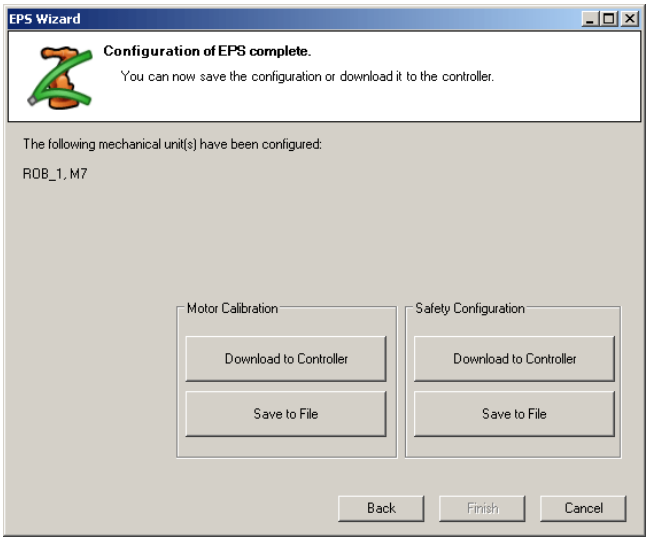

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Save motor calibration file

Save the motor calibration file so that you can load the values later, if required:

1. Click on **Save to File** under **Motor Calibration**. If no motor calibration has been performed, this button is grayed out.
2. Select a file name and location for the file.

Save safety configuration file

Save the safety configuration file so that you can load the values later, if required:

1. Click on **Save to File** under **Safety Configuration**.
2. Select a file name and location for the file.

Download motor calibration to controller

Download the motor calibration to the controller:

1. Click on **Download to Controller** under **Motor Calibration**. If no motor calibration has been performed, this button is grayed out.
2. A dialog informs you when the download is complete. Click **OK**.

Download safety configuration to controller

Download the safety configuration to the controller:

1. Click on **Download to Controller** under **Safety Configuration**.
2. A report of the safety configuration is shown, see picture below. The report can be saved by clicking the **Save** button. By default the report is saved in the folder C:\Documents and Settings\Username\Local Settings\Application Data on the computer where EPS Configuration Wizard is running. The report can be printed by right-clicking and selecting **Print** (it is recommended to print the report since it should be used when validating the configuration as described in *Validate the configuration on page 59*). Click **OK** to close the report.
3. A dialog informs you when the download is complete. Click **OK**.
4. A PIN code for the configuration file is shown (which is also included in the safety report). Write this PIN code down. You will need it when activating the

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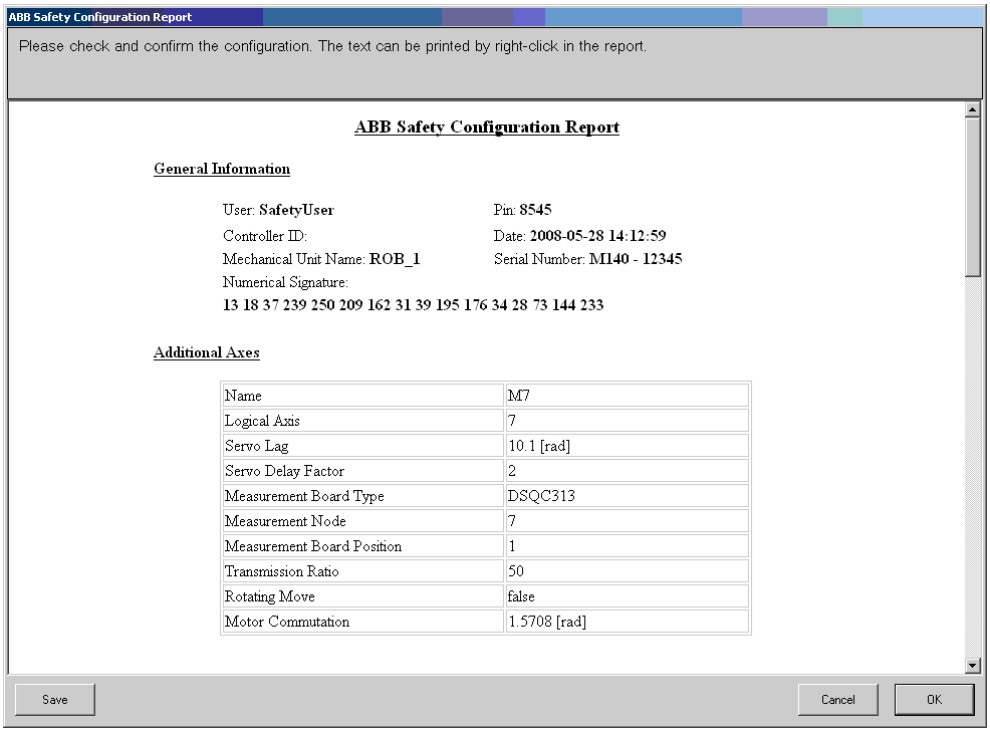
safety configuration on your system, see *Activating the safety configuration on page 57*.



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Finish the EPS Configuration Wizard

1 Click on the button **Finish**.
2 Restart the controller.

Restore configuration from backup

When performing a system backup, an EPS safety configuration file is included. This file gives the possibility to restore the EPS safety configuration without changing it. The advantage is that the configuration and the pin code is identical, so the EPS safety configuration does not have to be validated and no new safety report has to be generated.

The file has to be restored separately from the backup by using the **Restore from backup** function in the EPS wizard.

	Action
1	Open the **EPS Wizard**.
2	Perform all initial steps in the **EPS Wizard** until the **Select mechanical unit** screen is displayed.
3	On the **Select mechanical unit** screen, click **Restore from backup**.
4	Browse to the *BACKINFO* folder in the backup. The EPS safety configuration file is named *psc_user_1.sxml*. For a MultiMove system there will be one file for each controller, numbered from 1 to 4.
5	Select the correct *psc_user_ .sxml* file, and click **Open**.

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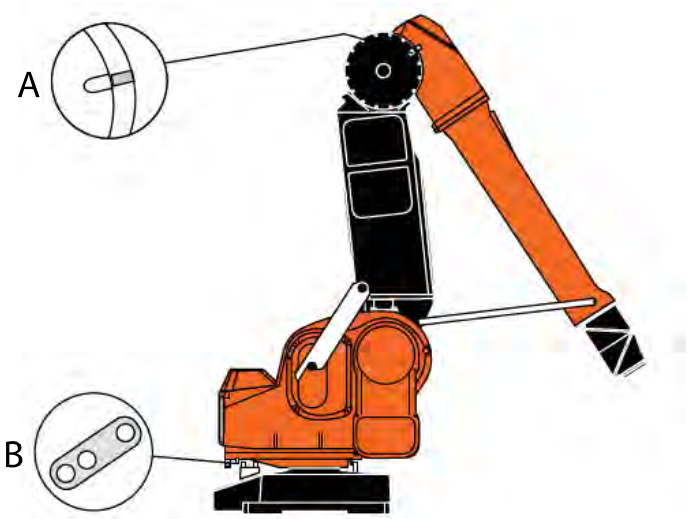
	Action
6	The **Numeric Signature** dialog is shown. Verify that the numeric signature is the same as in the safety report. Click **Yes** to download the configuration.
7	Restart the controller.
8	The safety configuration must now be activated on the controller. Follow the instructions in section *Activating the safety configuration on page 57*.

4.3 Configuration for robots with non-zero calibration position

Calibration position axis angles

Some robots have calibration positions with one or more axis angles that is not zero.



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A	Calibration marks, axis 3
B	Calibration position, axis 1

Examples of non-zero calibration positions:

	Calibration position values					
Robot type	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**
IRB 5400-12 - Slim arm	40°	0°	58.7°	0°	0°	0°
IRB 5400-22 - Process arm	40°	0°	60°	0°	0°	0°

To find the exact axis angles for a robot, look at the system parameter *Calibration Position* in topic *Motion*, type *Arm*.

Effects on the EPS configuration

For robots with non-zero calibration position it is necessary to perform manual corrections during the EPS configuration. Follow the description in *EPS Configuration Wizard on page 39* but adjust axis limits and sync position according to the following descriptions.

Continues on next page

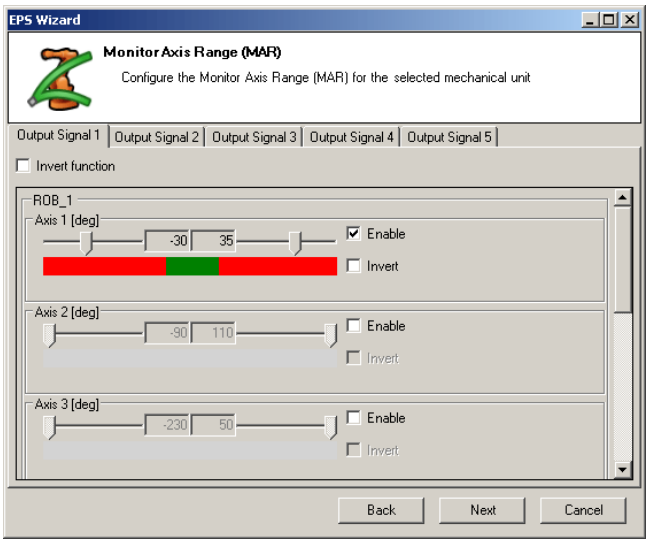
Adjust axis limits

Adjust the axis limits by subtracting the calibration offset value from the real axis limits you want to set up.

Example

A robot has a calibration position with a 40° calibration offset for axis 1.

Limit	Desired axis limit	Configured axis limit
Low	10°	10° - 40° = -30°
High	75°	75° - 40° = 35°



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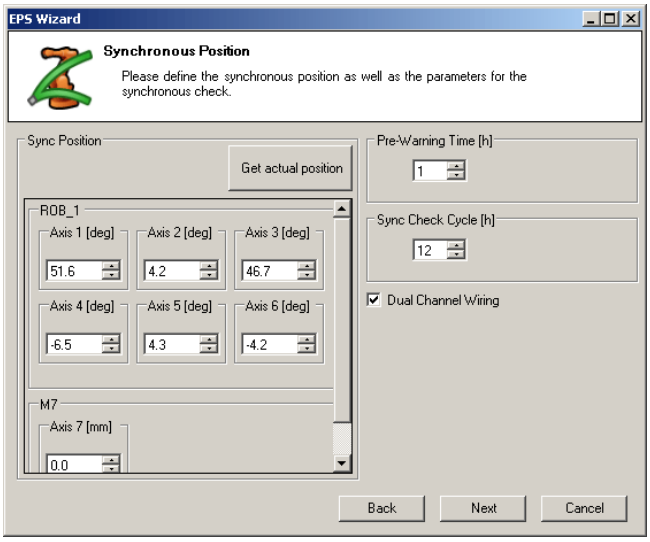
Adjust the sync position

Adjust the axis degree values of the sync position by subtracting the calibration offset.

Example

A robot has a calibration offset of 40° for axis 1 and 60° for axis 3.

Click on **Get actual position** and get the following values:



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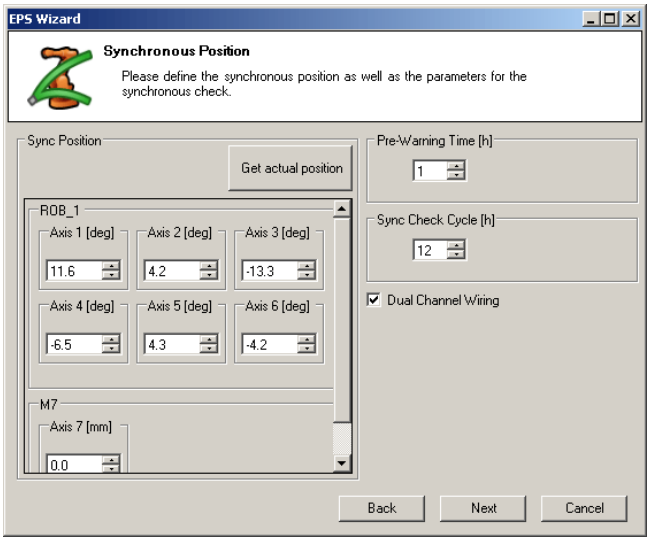
Adjust the sync position by subtracting 40° from axis 1 and 60° from axis 3:



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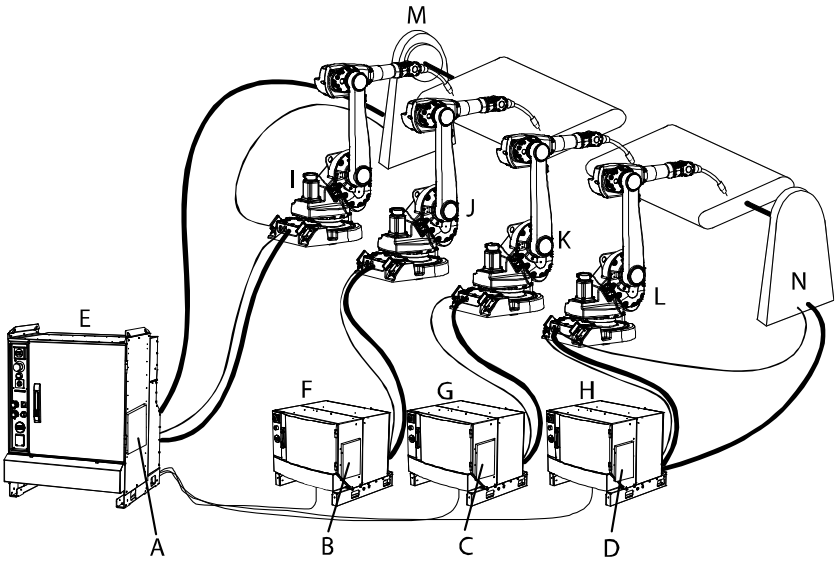
4.4 Configuration for MultiMove

Configuration file corresponding to drive module

In a MultiMove system there is one safety controller for each drive module that uses Electronic Position Switches. A configuration file must be downloaded to each safety controller. It is important that the configuration file downloaded to a safety controller contains the configuration for those mechanical units controlled by that drive module.

MultiMove system with 4 safety controllers



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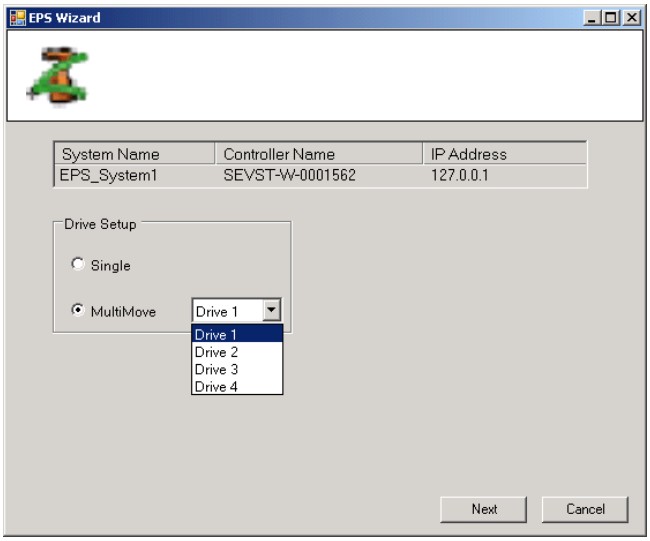
A	Safety controller 1 placed in the controller cabinet. Used to monitor robot 1 and additional axis 1.
B	Safety controller 2 placed in drive module 2. Used to monitor robot 2.
C	Safety controller 3 placed in drive module 3. Used to monitor robot 3.
D	Safety controller 4 placed in drive module 4. Used to monitor robot 4 and additional axis 2.
E	Controller cabinet
F	Drive module 2
G	Drive module 3
H	Drive module 4
I	Robot 1
J	Robot 2
K	Robot 3
L	Robot 4
M	Additional axis 1
N	Additional axis 2

Continues on next page

How to configure EPS for MultiMove

When configuring a MultiMove system, follow the same procedure as described in *EPS Configuration Wizard on page 39* for the first safety controller (in the example above: robot 1 and additional axis 1). When the configuration file is downloaded to the controller, click on **Finish** and then start the EPS Configuration Wizard again. Repeat this procedure once for every safety controller and make sure the selected drive module corresponds to the mechanical units configured.



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You will get one unique PIN code for each safety configuration file. Write these PIN codes down.

Note

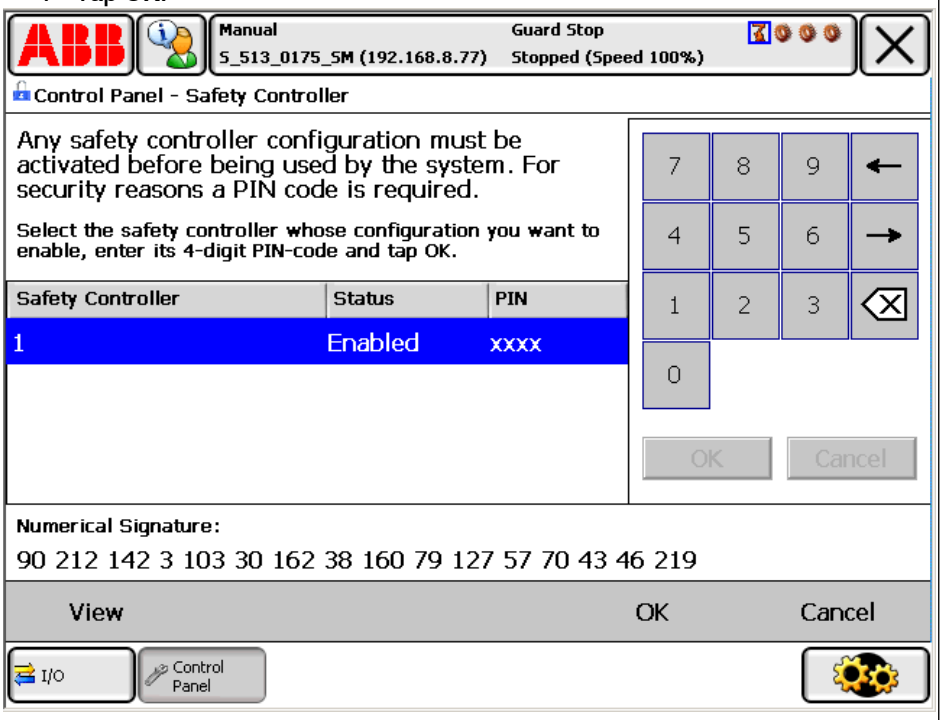
Make sure that, for every configuration file, the configured mechanical units belong to the selected drive module. The EPS Configuration Wizard will allow you to configure any mechanical unit for any selected drive unit, but the result will be an unexpected behavior.

4.5 Activating the safety configuration

Prerequisite

Before activating the safety configuration you must create the safety configuration file and remember the PIN code for that file (see *EPS Configuration Wizard on page 39*).

Activation procedure

	Action
1	When a safety configuration is downloaded to your robot system, the controller must be restarted.
2	When the controller starts up, an elog message (20266) will ask for a safety controller PIN code. Acknowledge this message.
3	Change user on the FlexPendant: 1 On the **ABB** menu, select **Log off**. 2 Tap **Yes** to confirm. 3 Select the safety user, type the password and tap on **Login**.
4	Make sure the controller is in manual mode.
5	On the FlexPendant: 1 On the **ABB** menu, tap **Control Panel** and then **Safety Controller**. 2 Tap the line and type the PIN code for the safety configuration file (see *EPS Configuration Wizard on page 39*). Tap **OK**. 3 For a MultiMove system, enter one PIN code for each configuration file. 4 Tap **OK**.  en0600003332

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4.5 Activating the safety configuration
Continued

	Action
6	When the PIN code is entered, a dialog will tell you if the PIN is correct. Tap **Restart** in this dialog and the controller will restart. If you typed an incorrect PIN code, the controller will restart anyway. Then you must start over from step 2 of this procedure.
7	When the controller starts up, an elog message (20451) will say that a synchronization is required. Acknowledge this message. Perform a sync check. Note that the output signals are low until the sync check is performed. This means that if you have connected to the Auto Stop on the panel board, sync check must be performed in manual mode. If you have connected to General Stop, the circuit must be closed in a safe way during the sync check. See *Connect to Auto Stop on the panel board on page 31* and *Connect to General Stop on the panel board on page 31*. When the sync check is performed, an elog message (20452) will say that the robot is synchronized. The Electronic Position Switches functionality is now active.

Safety configuration and restart modes

Once activated, the safety configuration is constantly active. None of the restart modes **Restart**, **Reset RAPID**, or **Reset system** will affect the safety configuration. However, if the current system is removed (from the boot application) all safety configurations for that system will also be deactivated and removed.

4.6 Validate the configuration

DANGER

An Electronic Position Switches configuration must always be validated to verify that the desired safety is achieved. If no validation is performed, or the validation is inadequate, the configuration cannot be relied on for personal safety.

Tip

Do the following checks before you start the validation procedure:

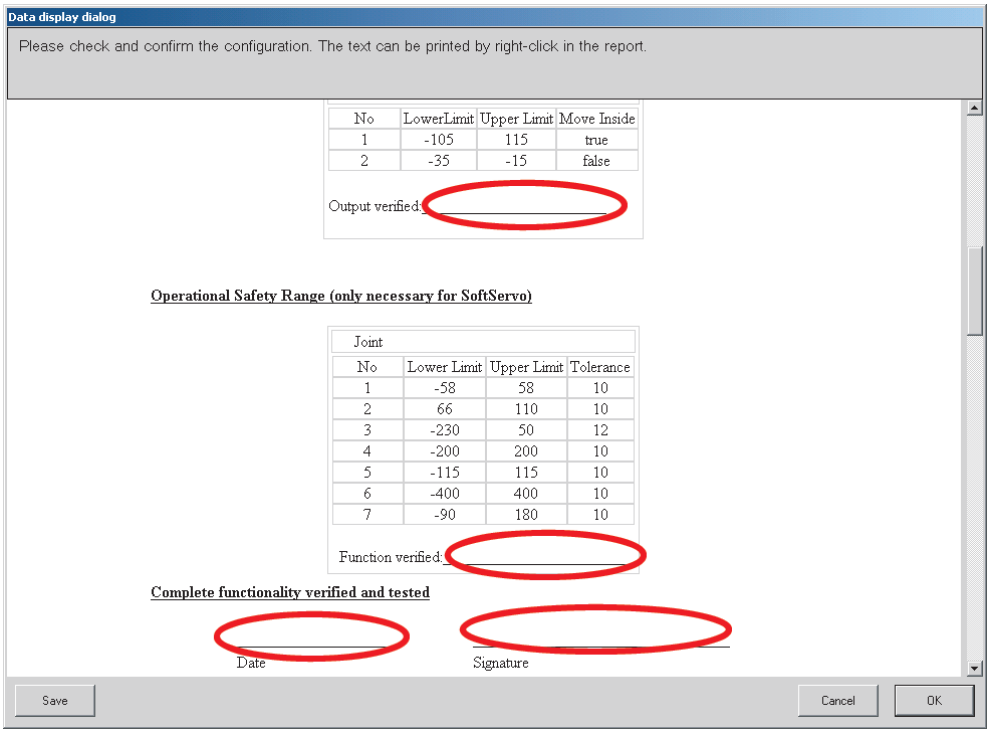
1. Check the I/O signals according to section *I/O connector data on page 25*.
2. Create a safety user in the user authorization system and log in as a safety user.
3. Carry out the synchronization procedure and connect the sync switch according to description in section *I/O connector data on page 25*.
4. Set up the synchronization position in the EPS Configuration Wizard. Also carry out a calibration offset.
5. Run the service routine for the function Cyclic Break Check.
6. Start the validation procedure.

Continues on next page

4.6 Validate the configuration
Continued

About the validation

The safety configuration must be validated by the customer. This validation must be performed every time a safety controller is configured. It is recommended that the ABB Safety Configuration Report is printed and used as a formal document for the verification. The document has rows where dates and signatures should be written when the configuration is verified.



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How to validate

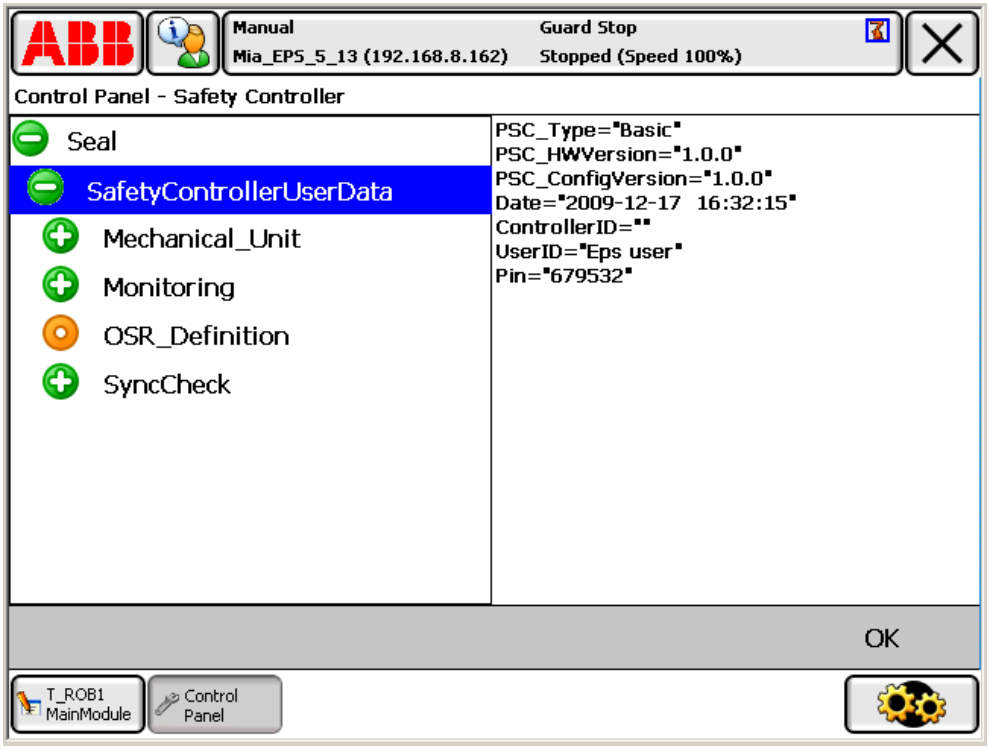
Move the robot in and out of the configured zones and make sure all signals behave the way they are supposed to.

4.7 Viewing the configuration on the FlexPendant

Accessing the configuration information

	Action
1	On the **ABB** menu, tap **Control Panel** and then **Safety Controller**.
2	Tap the line for the safety controller you wish to view.
3	Tap **View**.

Configuration presentation



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5 Synchronization

5.1 Synchronization guidelines for Cyclic Sync Check

Dual channel or single channel

Verify that the right type of synchronization (dual channel or single channel) was selected in the configuration.

See *Set sync position on page 47*.

Uniquely defined position

The robot position for the sync check must be chosen so that the position of the robot axes are unambiguously defined. One way to make sure the sync check position is well-defined for all axes is to use the instruction `MoveAbsJ` to move to the sync position. See *Technical reference manual - RAPID Instructions, Functions and Data types*.

Note that the sync position should be within the axis ranges configured for Monitor Axis Range to avoid that the robot stops on the way to the sync position.

Small sync switch surface

For physical synchronization, the sync switch surface that the robot touches must be small. The surface of the tool touching the sync switch must also be small. If any robot axis moves one motor revolution, the robot must be out of reach for the sync switch.

Always activate sync switch in the same way

For physical synchronization, always use the same tool. The robot should always touch the sync switch with the same point on the tool.

Create RAPID program for synchronization

Create a RAPID program to perform a synchronization.This can be initiated from a PLC or the main RAPID program. Perform the synchronization when the digital output signal `PSC1CSPREWARN` goes high. The `PSC1CSPREWARN` signal is only activated when Dual channel or Single channel synchronization has been selected in the configuration. When Software synchronization has been selected, it is only necessary to do a synchronization if the safety controller or the robot controller has become asynchronous.

Write the program so that the robot first goes to a position close to the sync switch and then approach it slowly from the desired direction. If the approach is too fast, the accuracy of the robot position may be too low.

Example

In a system module elog 20470 is caught and an output signal is set. This signal can be used by a PLC or a RAPID program.

```
MODULE SYNCINIT (sysmodule)
  LOCAL VAR intnum irSyncPreWarn;
```

Continues on next page

5.1 Synchronization guidelines for Cyclic Sync Check
Continued

```
LOCAL TRAP tpSyncPreWarn
  setDO doSyncPreWarn, 1;
  TPWrite "SYNCHRONIZATION PRE WARNING. ";
  RETURN;
ENDTRAP

PROC initSync()
  CONNECT irSyncPreWarn WITH tpSyncPreWarn;
  ! 20470 SC 1 Synchronization Pre-warning
  IError SYSTEM_ERR\ErrorId := 470,TYPE_ALL,irsyncPreWarn;
ENDPROC

ENDMODULE
```

Synchronization on closing edge

The synchronization is executed 1 second after the sync switch is closed. The 1 second delay is implemented to avoid synchronization pulses before the manipulator has stopped in its synchronization position.

Nothing happens when the sync switch is opened again.

Cyclic Sync Check output

Virtual output signals can be connected to physical output signals for communication with a PLC. See also *Virtual signals on page 69*.

5.2 Synchronization guidelines for Software Sync Check

Selecting software synchronization

Verify that **Software Synchronization** was selected in the configuration.

See *Set sync position on page 47*.

Uniquely defined position

The robot position for the sync check must be chosen so that the position of the robot axes are unambiguously defined. One way to make sure the sync check position is well-defined for all axes is to use the instruction `MoveAbsJ` to move to the sync position. See *Technical reference manual - RAPID Instructions, Functions and Data types*.

Note that the sync position should be within the axis ranges configured for Monitor Axis Range to avoid that the robot stops on the way to the sync position.

Use easily verified sync position

Select a sync position where it is easy to verify the position of the robot axes. It is helpful to use a position where the TCP touches a spike or something where it is easy to see if the robot is in the correct position or not.

Use service routine to perform synchronization

WARNING

If the robot position is not visually verified, to make sure all robot axes are in correct position, the synchronization can jeopardize the safety.

Note

Software synchronization can only be performed by a user with grants that allow this, see *Create a safety user on page 37*.

	Action	
1	Move the robot to its sync position (for example with `MoveAbsJ`).	
2	Visually verify that the robot is in its sync position (all axes must be in correct position).	If an axis is in wrong position, the revolution counters are most likely incorrect.
3	In the program view, tap **Debug** and select **Call Routine**.	
4	Select the service routine **SoftwareSync** and tap **Go to**.	
5	Follow the instructions in the service routine.	

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6 Running in production

6.1 Reaction time

Output signal response time

When a robot axis moves outside its configured range, the reaction time until the safe digital output signal goes low is maximum 4 ms.

6.2 Recovery after safety violation

Auto Stop or General Stop

When an axis is outside its defined range, Electronic Position Switches sets an output signal low. What is done with this signal depends on the installation. One recommended way of connecting the output signals is so that they affect the Auto Stop signal or the General Stop signal. See *Connect to Auto Stop on the panel board on page 31* and *Connect to General Stop on the panel board on page 31*.

Recovery from Auto Stop

If an axis is outside its defined range and causes an Auto Stop:

1. Switch the controller to manual mode.
2. Jog the robot back within the defined ranges for all axes.

   As soon as all axes are within their defined range, the Auto Stop is released and you can continue.

Recovery from General Stop

If an axis is outside its defined range and causes a General Stop:

1. Switch the controller to manual mode.
2. Safely close the safety circuit (e.g with a dead man’s handle) while jogging the robot back within the defined ranges for all axes.

   As soon as all axes are within their defined range, the General Stop is released and you can continue.

6.3 Virtual signals

What is a virtual signal

The virtual signals can be viewed on the FlexPendant, but they are communicated over the Ethernet connection and not a physical signal. They show the status of signals from the safety controller and cannot be set by the user, which is why the are represented as digital inputs (DI).

The virtual signals can be used by a RAPID program to produce helpful hints to the operator of why the robot has stopped.

WARNING

The virtual signals must not be used for safety implementation. Only the physical signals can be used for safety implementation.

List of signals

Signal name	Description
PSC1CSC	Representation of the input signal from the sync switch to the safety controller.
PSC1MAR1	Representation of the MAR1 signal from the safety controller.
PSC1MAR2	Representation of the MAR2 signal from the safety controller.
PSC1MAR3	Representation of the MAR3 signal from the safety controller.
PSC1MAR4	Representation of the MAR4 signal from the safety controller.
PSC1MAR5	Representation of the MAR5 signal from the safety controller.
PSC1CSPREWARN	Request to do synchronization check. The value is 1 if the prewarning time for Cyclic Sync Check has expired.

All other virtual signals starting with PSC (Positional Safety Controller) are for internal use. Do not use them for customer applications.

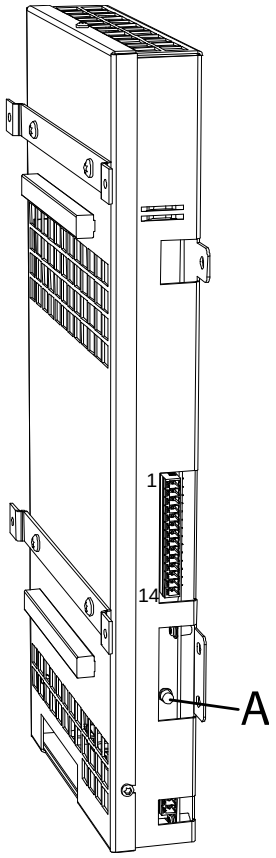
Signals for MultiMove system

In a MultiMove system there is one set of signals from each safety controller, i.e. from each drive module that is equipped with a safety controller. Signals from drive module 1 have names starting with PSC1, signals from drive module 2 have names starting with PSC2, etc.

6.4 Status LED

Location of the status LED

A red/green status LED is placed on the front panel of the safety controller. It indicates the status of the safety controller.



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A	Status LED

Status indications

LED indication	Description
Solid green	Safety controller CPU is running and communication is ok.
Solid red	Internal hardware failure. Replace the safety controller.
Flashing green	Communication failure or I/O power supply missing.

7 Safemove Visualizer

7.1 Introduction

Safemove Visualizer

SafeMove Visualizer is a FlexPendant application that works both for SafeMove and EPS. *SafeMove Visualizer* gives assistance to the robot operator or programmer in using EPS and provides quick access to all EPS-related signals and data.

The following data is displayed in tabular form for this purpose:

- Safety signals
- Safety messages
- Synchronization and brake check (definition, status and call-up of service routines)

The following data is shown in graphical or tabular form:

- Axis ranges for MAR

The permitted and prohibited axis ranges are displayed together with the current positions of the individual axes in the graphical display of the axis ranges, so that you can also recognize the cause of a range violation here.

7.2 Starting the graphical user interface

The user interface

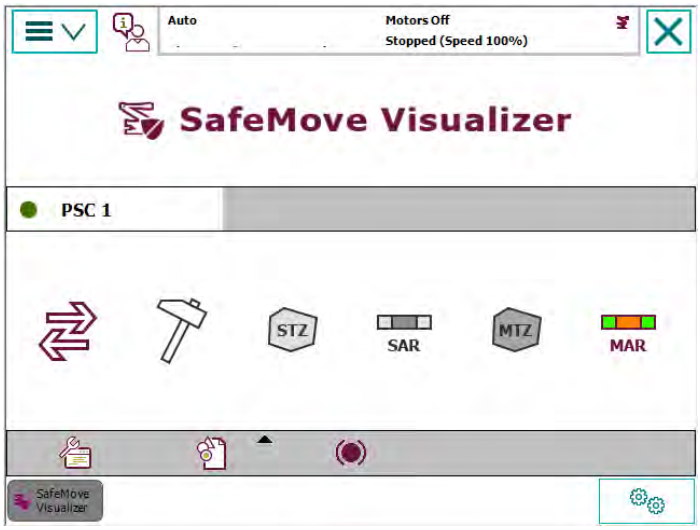
Use this procedure to start the graphical user interface

	Action
1	Tap the ABB menu.
2	Tap Safemove Visualizer.
3	The main menu of Safemove Visualizer is displayed.

For more information on how to use the FlexPendant in general, see *Operating manual - IRC5 with FlexPendant*.

Main menu for single controller

When the graphical user interface starts up, the main menu is displayed.



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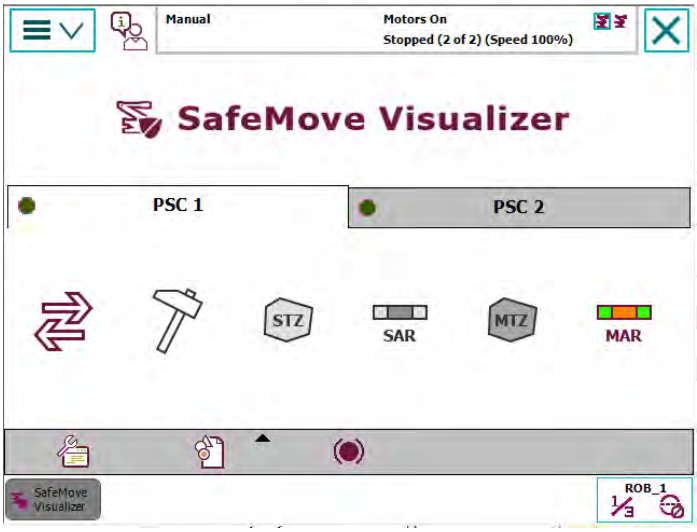
Main menu for MultiMove applications

For MultiMove applications, several tabs will be displayed for viewing individual safety functions depending on the number of safety controllers that are used.



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Using Safemove Visualizer in a virtual robot system

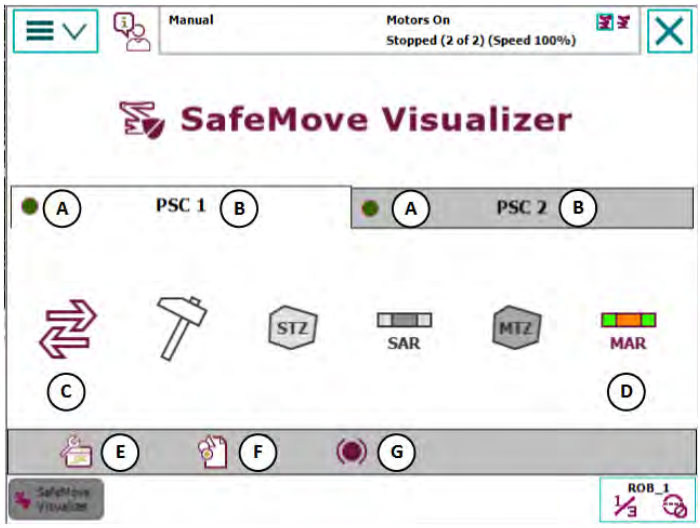
Safemove Visualizer can also be used on a virtual robot system in RobotStudio. To do this, it is necessary that the safety configuration is available in the virtual system.

Additional SafeMove-signals with prefix "v", (e.g. “vPSC1DI1") are loaded for each robot because the standard SafeMove-signals are set as read only.

All functions of the Safemove Visualizer in the virtual controller are related to these new signals (only digital outputs) which can be set or reset manually or program controlled.

7.3 The main menu

Overview of the main menu



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	Parts	Description
A	Status LED of safety controller(s)	No faults (green) Warning, e.g. brake check required (yellow) Safety violation (red)
B	Name of safety controller	Selection of safety controller whose data is to be displayed.
C	Safety signals	Safety signal display.
D	Monitor Axis Range (MAR)	Graphical display of the monitor axis ranges and their configuration data.
E	Configuration	Safety configuration display and input of the security PIN.
F	Safety messages	Display of SafeMove-related event messages.
G	Synchronisation and brake check	Display synchronization and brake check configuration

Safety Status

Green LED

No warning and no safety violation (error).

Yellow LED (warning)

A warning is displayed if one of the following signals assumes the specified value.

Safety signal	Description	Value
PSCxCSPREWARN	Pre warning for synchronization	1

Continues on next page

Red LED (error or safety violation)

An error is displayed if one of the following signals assumes the specified value.

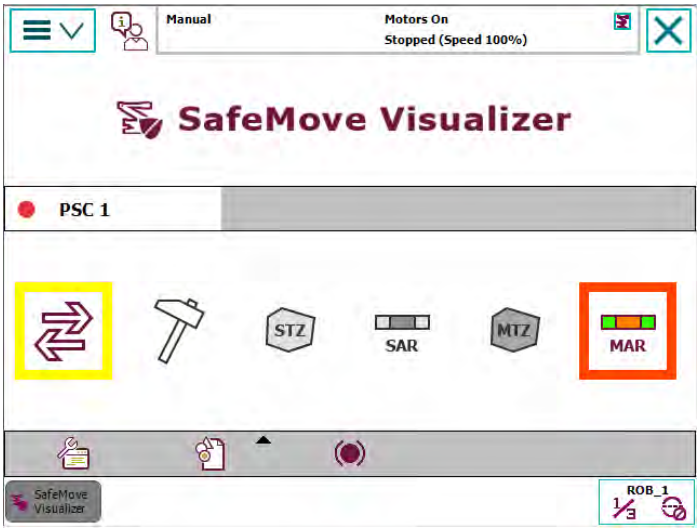
Safety signal	Description	Value
PSCxMAR1	Safety violation MAR1	1
PSCxMAR2	Safety violation MAR2	1
PSCxMAR3	Safety violation MAR3	1
PSCxMAR4	Safety violation MAR4	1
PSCxMAR5	Safety violation MAR5	1

Operator guidance in the event of a safety violation

Since a safety violation can be caused by different safety functions, the buttons that contain further information about the cause of the problem have a colored background.

In case of:

- a warning, the button for the safety signals shows a yellow background.
- a violation or an error, the button for safety signals shows a red background.
- a violation of a passive supervised function, like monitor axis range (MAR), the respective button shows an orange-red background.



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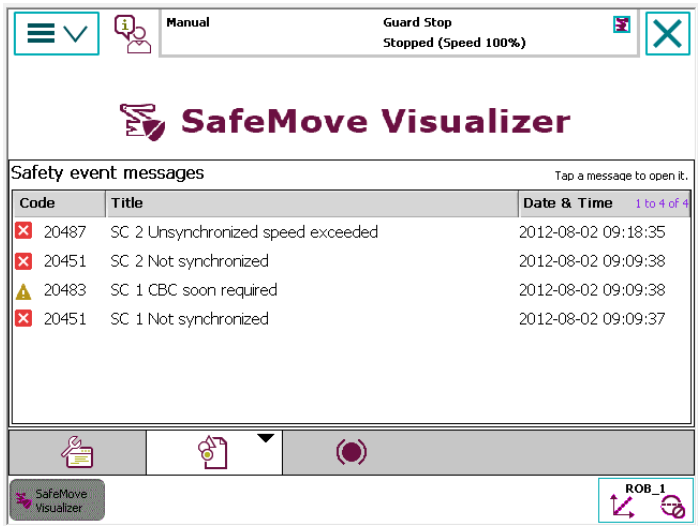
This means that the system operator can see immediately which button he has to press during fault analysis in order to obtain the required information.

7.4 Safety controller event messages

Overview of the safety controller event messages window

The event messages from the safety controller(s) for events that have occurred since the last restart of the robot controller or within the last 24 hours are displayed in the Safemove Visualizer, whereby the last message that occurred is always at the beginning of the list.

Tapping the safety messages button in the main menu causes the event message list to be displayed, tapping the button again hides the list.



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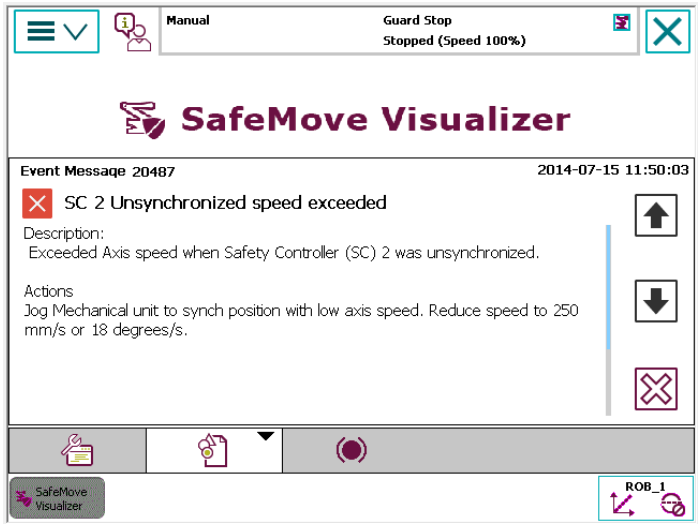
Clicking on an event message in the list opens up the detail window for the message containing all of the relevant message data.



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The following buttons are located at the right-hand edge of the detail window, and are used to navigate through the messages:


Display previous message

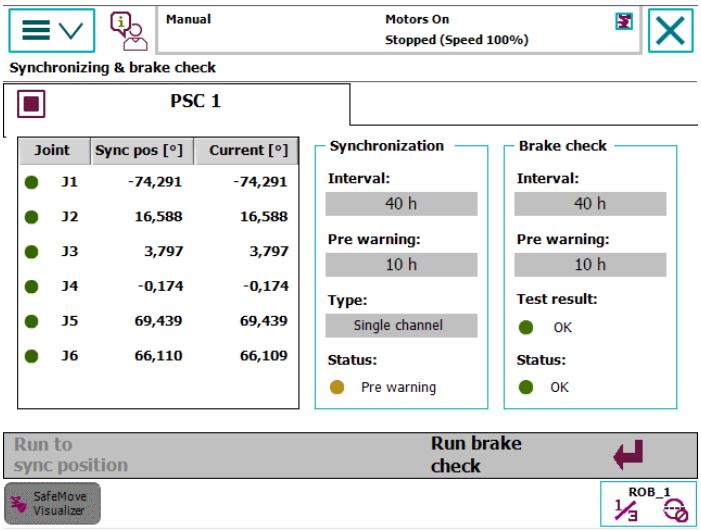

Display next message


Back to message list

7.5 Synchronization and brake check

Overview of the synchronization and brake check window

The window for synchronization and brake check is opened from the main menu and is used to display the adjusted parameters, the current status, and for calling up the required service routines.



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Synchronization

The monitoring and supervision functions are only active if SafeMove is not synchronized. In an unsynchronized state, movement is only possible with restricted speed and duration.

See *Cyclic Sync Check on page 20* and *Software Sync Check on page 21*.

Safe calibration position

The axis angle of the robot's safe calibration position is displayed in the table together with the current axis angles.

The status of the calibration position is displayed with a LED in front of the axis number with the following colors:

- Green LED - the axis is in calibration position
- Red LED - the axis is not in calibration position

Software synchronization status

If a switch is used for synchronization, the sync cycle time that is set in the configuration (12 - 720 hours) and the advance warning time (1 - 11 hours) are displayed as well as the type of synchronization.

The status of the synchronization is displayed with a LED with the following colors:

- Green LED - Synchronization okay
- Yellow LED - Pre warning time elapsed
- Red LED - Synchronization necessary

Continues on next page

Cyclic brake check

Cyclic brake check is only used for SafeMove.

7.6 Service routines

Introduction

Movement to the calibration position, software synchronization and the brake check take place by executing **Service routines**.

As well as the facility that is provided by the robot system, the **Synchronization and brake check** window also provides a facility for performing the required service routines.

Service routine processing status

The processing status of a service routine is indicated separately for each safety controller by the following icons on the tab page.


Service routine is executable.


Service routine is being executed.


Service routine was stopped.


Service routine is blocked (Robot program is being executed).

Move to safe calibration position

The **Run to sync position** menu is active if the robot is not in the calibration position, and the operating mode of the robot is configured to *Manual ≤ 250 mm/s*.

This menu is used to call up service routine `RunToSyncPos`, with which the robot is moved to the calibration position.

As soon as the motors are switched on by pressing the three-position enabling device on the FlexPendant, the service routine can be started by tapping the menu and then pressing the **Yes** button in the dialog that follows.

If one or more movement tasks are used for axes 7-9 (e.g. for a positioner), the dialogue for moving to the calibration position of the next mechanical unit is displayed by tapping the **No** button.

This can be used if a certain order is required to move to the calibration position (e.g. the positioner must be in the calibration position before the robot can be moved there).

If only the robot task is used and the **No** button or the **Cancel** button is tapped, the move to the calibration position is aborted.

Generate routine RunToSyncPos

If the `RunToSyncPos` routine is not present in the movement task, a dialogue is displayed to create the routine.

Continues on next page

If the **Yes** button is tapped, the `RunToSyncPos` routine is created for the robot in the `SafetyVisu` system module with the required calibration position and the active tool.

```
PROC RunToSyncPos()
CONST jointtarget jtSyncPos:=[[…]];
MoveAbsJ jtSyncPos, v100, fine, tool0;
Waittime 0.5;
ENDPROC
```

If a positioner is used, the routine is created in its movement task.

```
PROC RunToSyncPos()
CONST jointtarget jtSyncPos:=[[…]];
MoveExtJ jtSyncPos\UseEOffs, v500, fine;
Waittime 0.5;
ENDPROC
```

Start software synchronization

If the *Software Sync Check* is used and the robot is in the calibration position, the *Software Sync* service routine can be executed by tapping on the **Run software sync** menu.

> **Note**
>
> The robot controller must be in *Manual ≤ 250 mm/s* mode and the motors must be switched on.

The service routine is started as soon as the dialogue has been confirmed with the **Yes** button.

Perform brake check

If the robot is in a safe position, the brake check can be started directly from Safemove Visualizer.

In order to do this, tap on the **Run brake check** menu, and after confirmation the `CyclicBrakeCheck` service routine is performed.

> **Note**
>
> The robot controller must be in *Manual ≤ 250 mm/s* mode and the motors must be switched on.

7.7 Safety controller status

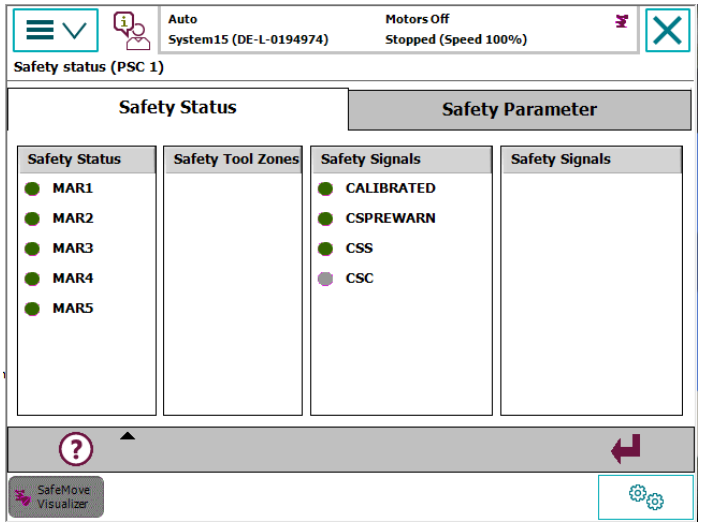
Safety signals

The status of the safety controller is indicated using virtual signals.

Depending on the functionality of a signal, the logical value 1 or 0 can indicate a safety violation. For example, an axis range has been violated if the signal PSCxMAR1 signal is 0.

In order to be able to quickly interpret the status of the safety controller on the basis of the signals, it is not the logical signal statuses but the safety status that is indicated via a red LED and green LED.

This means that signal PSCxMAR1 is green if it has a logical value of 1 and red if it has a value of 0.



xx1400001308

The PSCxCSC signal is not safety-related, since it indicates the current status of a switch. For this reason, the LED is grey if the switch is not operated, and green if it is operated.

Virtual signals of the safety controller, EPS

Safety signal	Description	LED	
		0	1
PSCxCSC	Display of input signal from Sync switch at safety controller.		
PSCxMAR1	Display of MAR1 signal from safety controller.		
PSCxMAR2	Display of MAR2 signal from safety controller.		
PSCxMAR3	Display of MAR3 signal from safety controller.		
PSCxMAR4	Display of MAR4 signal from safety controller.		

Continues on next page

Safety signal	Description	LED	
		0	1
PSCxMAR5	Display of MAR5 signal from safety controller.		
PSCxCSPREWARN	Synchronization test request. The value is 1 if the advance warning time for *Cyclic Sync Check* has elapsed.		

Safety parameters

Some safety functions are permanently activated via the safety configuration, and are displayed in the **Safety parameter** tab.

The calibration values for the individual motor axes that are stored in the safety configuration and in the robot controller system parameters are also displayed.

A red LED next to the axis number marks the axes for which the calibration values are different.

Explanation of terms / help

Tap the help button and a list of the most common SafeMove abbreviations will be displayed. Tap the button again to hide the help.

7.8 Axis range

7.8.1 Displaying the axis ranges

Description

All axes that are defined in an axis range group are visualized on the FlexPendant.

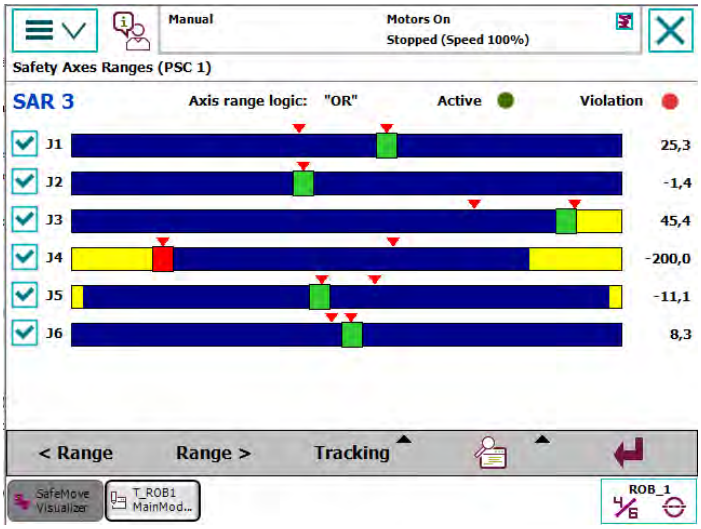
Axes 1 - 6 are always displayed, whereby non-configured axes are greyed out. Axes 7 - 9 are displayed if needed.

The permitted range of an axis is displayed in blue and the prohibited range in yellow. The current position of the axis is represented by a rectangle (pointer) and as text next to the axis range.

If axis range monitoring is active, the pointer is displayed in green if the axis is within the permitted range. If the axis has left this range the pointer is displayed in red.

If axis range monitoring is inactive, the pointer is displayed in grey.

Each configured axis can be deactivated for the display via the check box to the left of the axis range. However, deactivation does not affect the monitoring function and the recording of the axis ranges that are used.



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The following options are available from the menu buttons:

- Display previous axis range group
- Display next axis range group
- Record the used axis range limits
- Detailed view
- Close window

7.8.2 Safe Axis Range activation

Description

Safe Axis Range is either permanent or activated via a safe input. Activation is indicated via a LED at the top edge of the window with the following colors:

- Grey - Axis range supervision is inactive
- Green - Axis range supervision is active

Note

Monitor Axis Ranges are always active and therefore have no activation LED.

7.8.3 Exceeding the axis range limits

Monitor Axis Range

If an axis leaves the defined range of a *Monitor Axis Range*, the defined safety output is set to "0". This output is displayed as a LED at the top edge of the window with the following colors:

- Green - All axes are inside the displayed axis range.
- Red - At least one axis has exceeded the limits of the displayed axis range.

7.8.4 Axis range logic

Description

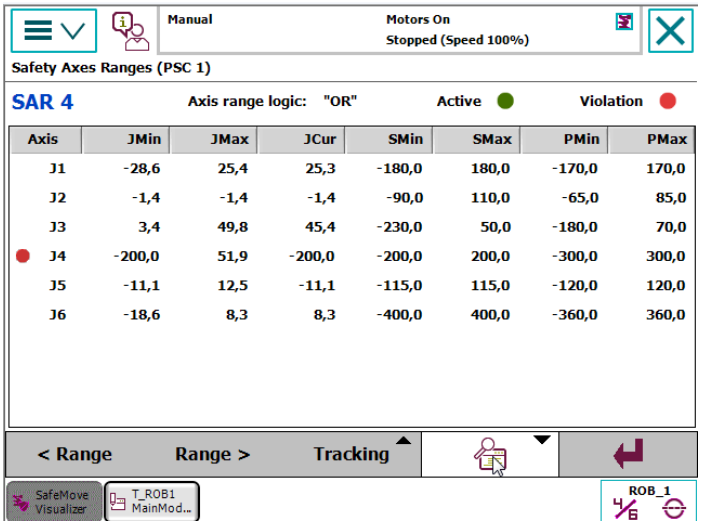
Axis ranges can be defined as allowed inside or allowed outside. If an axis range is allowed inside, a violation occur if only one axis is outside the defined range (OR-logic).

If an axis range is allowed outside, each range for an axis is shown inverted (means yellow and blue color is exchanged). A violation occurs if all axes are outside the defined range (AND-logic).

7.8.5 Tabular display of the axis ranges

Overview of the tabular display

By tapping the **Display details** menu, the display is switched between the graphical and the tabular display.



xx1400001362

Note

If an axis exceeds the selected limit, a red LED will be displayed in the table next to the axis number.

Data

The following data of the configured axes is displayed in the table:

Column	Description
Axis	Axis 1 to 9.
JMin	Minimum axis value that was moved to during robot movement.
JMax	Maximum axis value that was moved to during robot movement.
JCur	Current axis value.
SMin	Lower limit that was set in the safety configuration.
SMax	Upper limit that was set in the safety configuration.
PMin	Lower axis limit from the system parameters of the robot controller.
PMax	Upper axis limit from the system parameters of the robot controller.

Note

If you tap a table column in the window header, the description of the column is displayed. If you press the button again the help will disappear.

7.8.6 Recording the used axis range limits

Description

In order to check or optimize the selected axis range limits, it may be useful to record the axis limits that have actually been used.

This takes place using the logging functionality, using drag pointers (red triangles) which track the axis position and mark the minimum and maximum values that have been used.

In order to log the axis limits, the following settings and functions can be used:

- Reset axis limits
- Save recorded axis limits
- Show or hide drag pointer
- Switch logging on/off

Resetting the axis limits

The logged axis limits for the displayed axis range group can be deleted by tapping on **Tracking** and then selecting **Reset values**.

When this occurs, the minimum value is set to the upper limit and the maximum value to the lower limit of the axis.

The limits may need to be reset if, for example, the axis limits are to be re-determined.

Display/ hide drag pointers

The drag pointers can be hidden or displayed if necessary.

Note

The drag pointers are always displayed when the page is opened.

Switch logging on/off

The logging of the axis limits can be switched on or off if required, and is only active for as long as this page is open and visible.

If you switch to a different application (e.g. the production window), the recording of the limits is interrupted and continues as soon as the *SafeMove Visualizer* application is displayed again.

Only the axis limits of active axis range groups are recorded, which also occurs if they are not currently being displayed.

Note

Logging is switched off when the page is opened.

Continues on next page

7.8.6 Recording the used axis range limits
Continued

Save recorded axis limits

The axis limits for all axis range groups can be saved in a safety control-related file (e.g. *psc_axisranges_1.xml* for the safety controller PSC1) in directory *HOME:SafetyVisu*.

However, it is also possible to save the axis limits in any other file using the file dialogue.

Note

The saved axis limits in files *HOME:SafetyVisu/psc_axisranges_n.xml* are loaded when the application starts and displayed as limits.

7.8.7 Format of XML file for axis ranges

Description

The data for limits for the axis ranges are saved together in an XML file with the following format:

- The version of the SafeMove Visualizer and the date of saving are stored in the header.
- All MAR data limits are saved in the `MARS` section.
- Each axis group is saved with the number that was used in the safety configuration. For example, MAR1: `<MAR Range-ID="1">`
- The axis number and the logged minimum and maximum value are specified for each configured axis. For example, axis 1:

  ```
  <Joint JointID="1" JMin="0.028" JMax="97.344" />
  ```

Example

```
<?xml version="1.0" encoding="utf-16"?>
<!--SafeMove visualizer V1.0-->
<!--Tracking value for axis range supervision-->
<!---->
<JointRangeTracking Date="Friday, 11. May 2014">
  <MARS>
    <MAR RangeID="1">
      <Joint JointID="1" JMin="180.000" JMax="-180.000" />
      <Joint JointID="2" JMin="110.000" JMax="-90.000" />
      <Joint JointID="3" JMin="50.000" JMax="-230.000" />
    </MAR>
    <MAR RangeID="2">
      <Joint JointID="1" JMin="9E+09" JMax="-9E+09" />
    </MAR>
    <MAR RangeID="3">
      <Joint JointID="1" JMin="9E+09" JMax="-9E+09" />
    </MAR>
  </MARS>
</JointRangeTracking>
```

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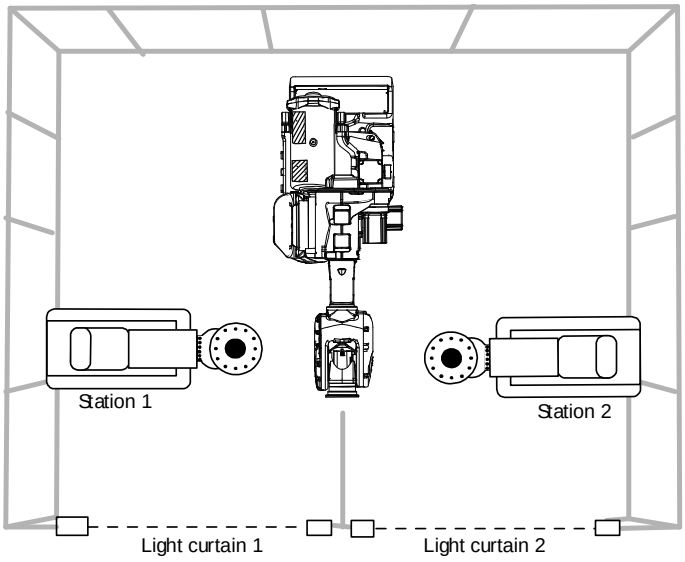
8 Example application

8.1 Example with two work zones

Assignment

A robot cell consists of one robot and two positioners. The robot should be able to work on a work piece held by one positioner while an operator change work piece held by the other positioner.

There are two light curtains protecting that no personnel enters the station where the robot is working.



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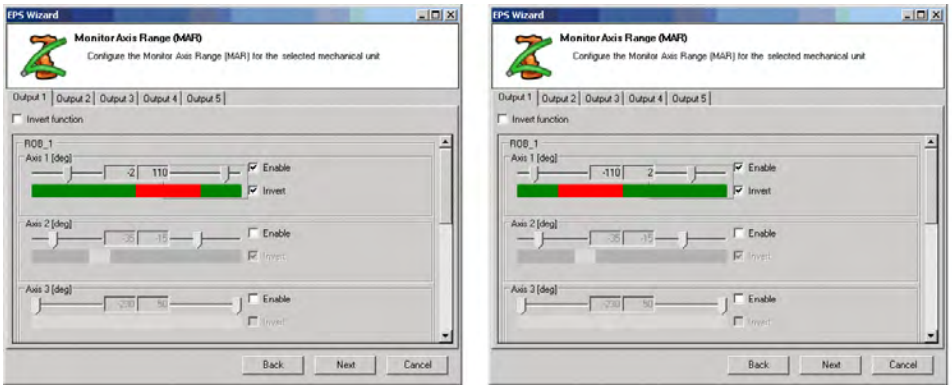
Configure Monitor Axis Range signals

To implement the safety solution, two Monitor Axis Range signals must be configured. The first signal should be high as long as the robot is not in station 1 (when it is safe for personnel to enter station 1). The second signal should be high when the robot is not in station 2.

The following picture illustrates how these two signals are configured for robot axis 1 in the EPS Configuration Wizard.



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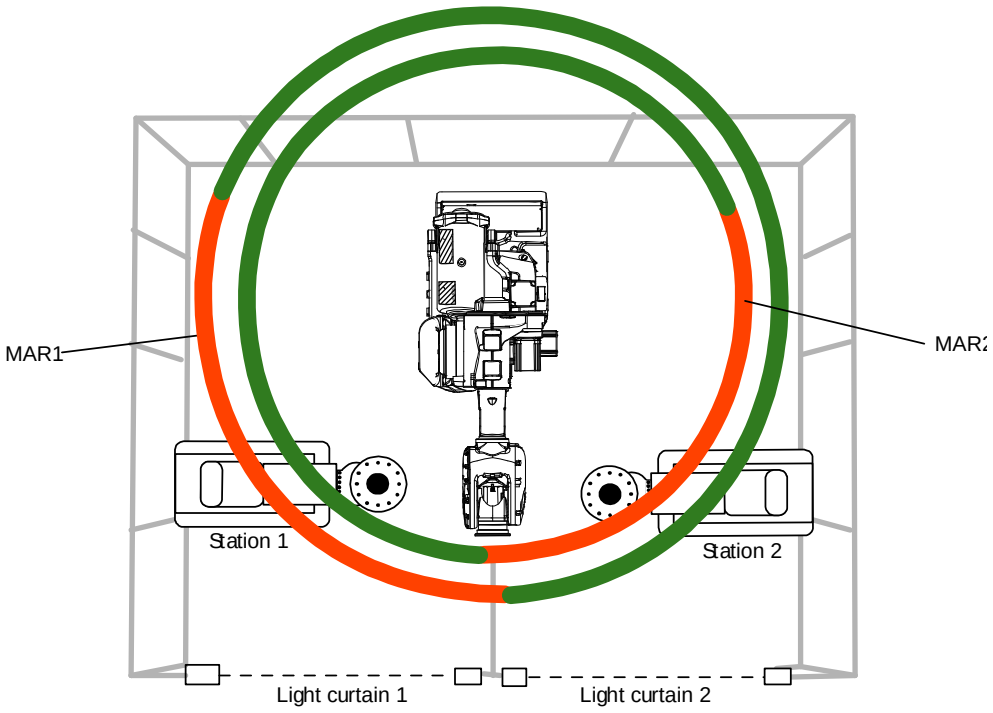
The following picture shows the angles for robot axis 1 where the signals (MAR1 and MAR2) are high (green) and where they are low (red).



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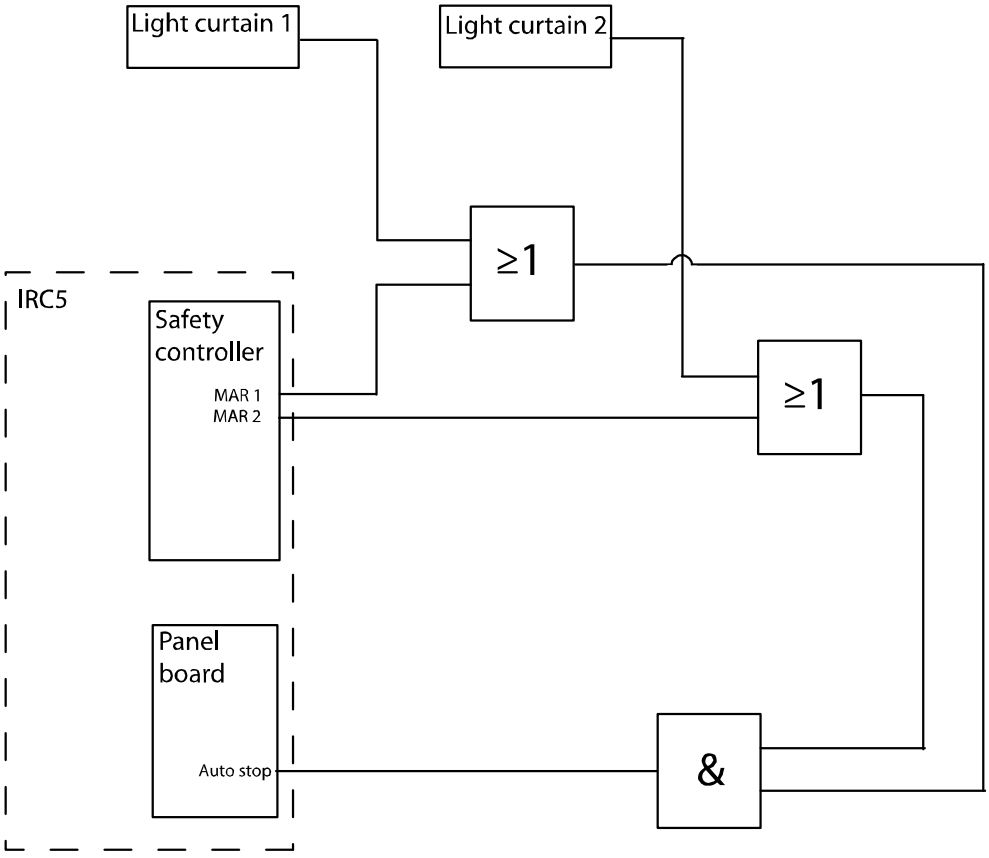
Connecting signals to Auto Stop

This is a description of the principle for how to connect the signals. The light curtains signals are high when they are untouched and low when the operator is in the station. The safety condition that is to be implemented is that the operator and the robot must not be in the same station.

Note that this illustration only shows single channels. In reality duplication will be used for the following:

- dual output signals from the safety controller (e.g. MAR 1A and MAR 1B)
- dual output signals from the light curtains
- dual Auto Stop signals (Auto Stop 1 and Auto Stop 2)
- implement the logical gates with two channel safety relays, two channel safety PLC, or similar equipment



en0700000213

For more details about the connections, see section *Hardware installation on page 25*.

Note

The logical blocks in the picture are principal blocks. To make a safe installation these blocks must be realized using safety components fulfilling relevant safety standards for the installation.

Continues on next page

Note

If other safety equipment is connected to Auto stop, make sure that the safety chain can be broken by any of the safety implementations.

Note

Use dual channels in the real implementation.

9 Safety aspects for Electronic Position Switches

9.1 Overview

Overview

Electronic Position Switches, EPS, is an additional safety computer in the IRC5 robot controller, with the purpose of providing safe output signals representing the position of robot axes. The output signals are typically connected to cell safety circuitry and/or a safety PLC which takes care of interlocking in the robot cell, for example, in order to prevent robot and operator to enter a common area simultaneously.

In this chapter we describe how EPS comply with relevant safety standards and regulations.

9.2 Safety requirements

9.2.1 Standards conformance

Standards

EPS has been designed to fulfill applicable parts of the following standards.

- EN ISO 12100-1:2010 Safety of machinery - General principles for design - Risk assessment and risk reduction
- EN 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- EN ISO 10218-1:2011, Robots for industrial environments - Safety requirements - Part 1: Robot
- EN 61000-6-2 EMC, Generic immunity
- EN 61000-6-4 EMC, Generic emission
- EN ISO 13849-1:2008 Safety of machinery - Electrical equipment of machines - Part 1: General requirements

9.2.2 Specific safety requirements

Specific safety requirements for Electronic Position Switches

Electronic Position Switches complies with EN ISO 10218-1 in general and specifically complies with chapter 5.4.2, that is, the following requirements.

When safety related control systems are required, the safety related parts shall be designed so that:

- A single fault in any of these parts shall not lead to the loss of the safety function.
- Whenever reasonably practicable, the single fault shall be detected at or before the next demand upon the safety function.
- When the single fault occurs, the safety function is always performed and a safe state shall be maintained until the detected fault is corrected.
- All reasonably foreseeable faults shall be detected.

This requirement is considered to be equivalent to structure category 3 as described in ISO 13849-1:2006. Category 3 is normally fulfilled by redundant circuits, such as dual channels, which is the case for EPS. EPS together with the robot controller also complies with performance level (PL) "d" according to EN ISO 13849-1:2006. This safety level is equivalent to SIL 2 as defined in IEC 61508.

9.3 Safe design of Electronic Position Switches

Overview

Electronic Position Switches, EPS, has two important supervision functions.

The first one being to ensure that the axis computer and the drive system are working correctly, making the robot follow the ordered value from the main computer as expected.

The second being to supervise the robot position and setting outputs low to indicate if the robot is in a hazardous area.

Supervision of axis computer and drive system

EPS is a separate and from the IRC5 independent device mounted in the drive part, close to the axis computer.

The EPS board is connected to the communication link between the main computer and the axis computer, thus reading the absolute motor position values sent as reference to the axis computer. The EPS board is also connected to the communication link between the Serial Measurement Board (SMB) and the axis computer, and thereby reading the actual rotational motor position values. Since these values are within one revolution, the absolute position is calculated by adding values from internal revolution counters in both the axis computer and in EPS.

By comparing these values, that is the ordered motor position and the actual motor position, Electronic Position Switches can detect any difference (outside a permitted lag deviation) between the two positions, thereby ensuring that the drive system is working properly according to the first supervision function as described above.

It is important to ensure that the safety controller and the robot controller are synchronized. The safe sync position is defined during configuration and stored in the safety controller. Synchronization can be done by activation of a switch or by software depending on the application.

To detect such errors, the robot can be ordered to go regularly to a synchronization switch, which will generate a synchronization pulse to EPS confirming that the robot revolution counter is correct. In some applications it is more feasible to do the synchronization check by software.

In this position EPS will also calculate the robot joint positions and check against a stored value to confirm that the synchronization is correct, covering the following points.

- EPS is working correctly with the right revolution counter value.
- The right manipulator is used.
- The calibration value is correct.
- The SMB is working correctly.

Continues on next page

Category 3 supervision

The supervision complies with category 3, that is, two separate channels shall always give the same result. One channel consists of the axis computer with the drive system, motors, resolvers, and measurement system. The second channel consists of the ordered value from the main computer. These channels are compared using the EPS evaluation circuits, which in itself is dual channel, see illustration below.

Additional safety design

Additional safety, over and above what is formally required, is brought to the concept by the inherent dual channel character of the resolver, thanks to its dual sine and cosine output, where the square sum is supervised to be close to 1.

Also the single channel synchronization check is complying with category 3, even if only one synch signal channel is used. The two channel requirement is in this case fulfilled in two ways:

1. Check that the input signal is changing its value, that is has a flank, indicating that the switch is working.
2. The double check of both receiving a physical synch pulse and the check that the actual robot position corresponds to the stored value for the sync position.

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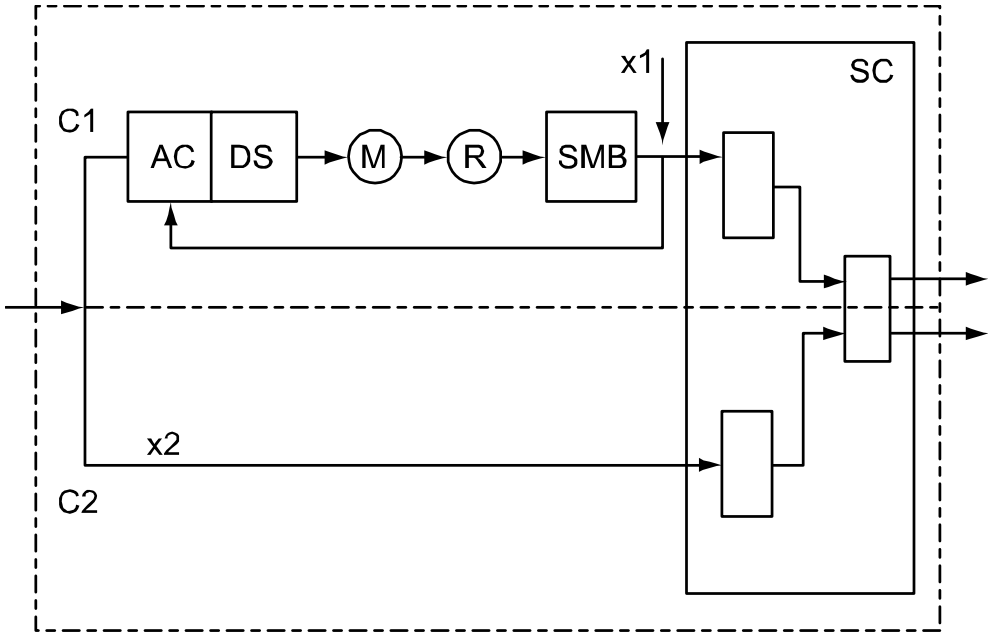
9.3 Safe design of Electronic Position Switches
Continued

Illustration, dual channel concept



xx0800000198

C1	Channel 1
C2	Channel 2
x1	Actual value
x2	Ordered value
AC	Axis computer
DS	Drive system
M	Motor
R	Resolver
SMB	Serial measurement board
SC	Safety controller (EPS board)

Supervision of robot position

The second supervision function (to supervise the robot position and setting outputs low to indicate if the robot is in a hazardous area) is fulfilled by letting EPS compare the robot position with limit values configured by an authorized user (so called Safety User). If any axis (or combination of axes) is outside its defined safe area, the supervision will activate an output. Active outputs are set to low, so that they are valid also at power failure. There are five outputs which each can represent an arbitrary combination of all robot axes (as selected by the Safety User).

To ensure that also this supervision complies with the category 3 requirement, EPS is inside working with a two channel microprocessor based system, where one channel is handling the actual position and the other the ordered position. The outputs from EPS are also each consisting of two channels, thus preserving the category 3 requirement.

9.4 Certifications

Overview

EPS has been certified by external organizations as described below.

BGIA concept certification

Berufsgenossenschaftliche Institut für Arbeitsschutz in Germany made a concept certification with the following result.

The concept of EPS complies with:

- Category 4 according to EN 954-1
- SIL 3 according to EN 61508
- Cat. 4 and PL e according to ISO 13849-1

Note

Electronic Position Switches as a part of the IRC5 controller is category 3 and PL d, even though the unit itself fulfills category 4 and PL e.

UL certification

EPS is approved by UL according to the following standards:

- UL 1740
- UL 1998
- ANSI / RIA R15.06
- CAN / CSA Z434-03
- ANSI / RIA 10218-1:2007 (which is the US harmonized ISO 10218-1:2006)

Note

Since ISO 10218-1:2006 thus is harmonized in EU as well as in North Americas, the UL certification clearly shows that EPS fulfills the EU Machinery Directive. In addition to this and since ISO 10218-1 refers to ISO 13849-1:1999 as a normative reference, it is also shown that EPS complies with the category 3 requirements.

SafeMove is also assessed to be compliant with updated versions of standards (see *Standards conformance on page 98*) and thus fulfills the current version of the EU Machinery Directive.

9.5 Conclusion

Conclusion

As has been shown above and confirmed by third party certifications, Electronic Position Switches fulfills all relevant current safety standards globally.

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