The heart of Robotics

Application manual

SafeMove

Controller software IRC5
RobotWare 5.0

ABB

Application manual

SafeMove

RobotWare 5.0

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Overview

About this manual

This manual describes SafeMove. It contains a description of the functionality and how to connect signals for that functionality. It also describes the SafeMove configuration functionality in RobotStudio.

Usage

This manual should be used during installation and configuration of SafeMove.

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 SafeMove option, and describes the purpose.
2. SafeMove functions	Descriptions of all functions included in SafeMove.
3. Installation	Workflows for how to install hardware and software for SafeMove.
4. Configuration	Workflows for how to configure SafeMove.
5. Guidelines for synchronization and brake check	Describes some considerations for the required synchronization and brake check.
6. Maintenance	Required recurrent maintenance.
7. 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.
8. Example applications	Examples of typical problems that are solved with SafeMove.

Continues on next page

References

Reference	Document ID
Operating manual - RobotStudio	3HAC032104-001
Product manual - IRC5	3HAC021313-001
Technical reference manual - RAPID Instructions, Functions and Data types	3HAC16581-1
Operating manual - Getting started, IRC5 and RobotStudio	3HAC027097-001
Product specification - IRB 6640	3HAC028284-001
Product specification - IRB 6620	3HAC025861-001
Product specification - IRB 660	3HAC023932-001
Product specification - IRB 7600	3HAC023934-001
Product specification - IRB 6660	3HAC028207-001
Product specification - IRB 6600/6650/6650S	3HAC023933-001
Product specification - IRB 4400/4450S	3HAC9117-1
Product specification - IRB 2400	3HAC9112-1
Product specification - IRB 260	3HAC025046-001
Product specification - IRB 1600	3HAC023604-001
Product specification - IRB 140	3HAC9041-1

Revisions

Revision	Description
-	First edition. RobotWare 5.10.02.
A	Second edition. RobotWare 5.11. The *Virtual signals* section is updated. New pictures of the SafeMove Configurator graphical user interface. Major changes in *Monitor Axes Range configuration* and *Safe Axis Range configuration* sections.

Product documentation, M2004

General

The robot documentation is divided into a number of categories. This listing is based on the type of information contained within the documents, regardless of whether the products are standard or optional. This means that any given delivery of robot products *will not contain all* documents listed, only the ones pertaining to the equipment delivered.

However, all documents listed may be ordered from ABB. The documents listed are valid for M2004 robot systems.

Product manuals

All hardware, robots and controllers, will be delivered with a **Product manual** that contains:

- Safety information
- Installation and commissioning (descriptions of mechanical installation, electrical connections)
- Maintenance (descriptions of all required preventive maintenance procedures including intervals)
- Repair (descriptions of all recommended repair procedures including spare parts)
- Additional procedures, if any (calibration, decommissioning)
- Reference information (article numbers for documentation referred to in Product manual, procedures, lists of tools, safety standards)
- Part list
- Foldouts or exploded views
- Circuit diagrams

Technical reference manuals

The following manuals describe the robot software in general and contain relevant reference information:

- **RAPID Overview**: An overview of the RAPID programming language.
- **RAPID Instructions, Functions and Data types**: Description and syntax for all RAPID instructions, functions and data types.
- **System parameters**: Description of system parameters and configuration workflows.

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, CD with PC software)
- How to use the application
- Examples of how to use the application

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Operating manuals

This group of manuals is aimed at those having first hand operational contact with the robot, that is production cell operators, programmers and trouble shooters. The group of manuals includes:

- **Emergency safety information**
- **General safety information**
- **Getting started, IRC5**
- **IRC5 with FlexPendant**
- **RobotStudio**
- **Introduction to RAPID**
- **Trouble shooting**, for the controller and robot

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:

- Units inside the controller, for example I/O units 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, make sure you are familiar with the safety regulations described in *Product manual - IRC5*.

1 Introduction

1.1. Overview of SafeMove

Purpose

SafeMove 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 supervision functions that can stop the robot and monitoring functions that can set safe digital output signals.

The supervision functions are activated by safe digital input signals. Both input and output signals can be connected to, for instance, a PLC that can control which behavior is allowed for the robot at different times.

The safety controller also sends status signals to the main computer, that is the standard IRC5 robot controller.

Note that SafeMove is one component in a cell safety system, normally complemented by other equipment, e.g. light barriers, for detecting the whereabouts of the operator.

Some examples of applications:

- Manual loading of gripper
- Manual inspection in robot cell during operation
- Optimization of cell size
- Protection of sensitive equipment
- Ensuring safe orientation of emitting processes

What is included

The following is included with the option SafeMove [810-2]:

- Safety controller, DSQC 647 (3HAC026272-001)
- Two 12 pole plug contacts and two 10 pole plug contacts for I/O connections.

The option SafeMove gives you access to SafeMove Configurator functionality in RobotStudio.

With SafeMove Configurator you can:

- configure supervision functions (active supervision that can stop the robot)
- configure activation signals for the supervision functions
- configure monitoring functions (passive monitoring, only sets output signals)
- configure output signals for the monitoring functions
- easily modify the configuration.

Prerequisites

RobotWare 5.10.02 or later version is necessary to run the IRC5 robot controller. The *SafeMove* option is the required RobotWare option to utilize SafeMove on the IRC5 controller.

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Basic approach

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

1. Connect I/O connections to sync switch and PLC, or similar.
2. Create a safety user in the User Authorization System, UAS (using RobotStudio).
3. Configure the settings for the SafeMove functions via the SafeMove Configurator and restart the controller.
4. Log on as safety user and set the PIN code on the FlexPendant. Restart the controller.
5. Synchronize the safety controller by moving the robot to the sync switch.
6. Make sure the activation input signals are activating the desired supervision functions.

   Now the SafeMove functions are activated.
7. Validate the configuration.

Requirements

Robust monitoring function in SafeMove 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!

A SafeMove 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. Limitations

Supported robots

The following robot families are supported by SafeMove:

- IRB 6640
- IRB 6620
- IRB 660
- IRB 7600
- IRB 6660
- IRB 6650S
- IRB 4400
- IRB 2400
- IRB 260
- IRB 1600
- IRB 140

Other robot models are not supported.

SafeMove cannot be used for parallel robots, such as IRB 360.

Supported additional axes

Basically the SafeMove option only supports ABB track motion units. Non ABB track motion units and non ABB positioners may be supported by the SafeMove option if the customer configures the appropriate parameters. The SafeMove option 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.

Stand alone controller

Stand alone controller or drive module without TCP-robot, are not supported by SafeMove.

Servo welding gun

SafeMove does not support supervision of servo welding guns.

Servo tool changer

SafeMove does not support more than one tool. If a robot is equipped with a tool changer it is recommended to configure the robot for the largest tool to be used. Note that there must be enough margin to allow for the largest tool that is being used.

Robot mounted on rotational axis

SafeMove does not support supervision or monitoring of a robot mounted on a rotational axis.

Continues on next page

No deactivation

All supervised and monitored axes must be active all the time. SafeMove does not support activation/deactivation of additional axis.

The ABB positioners normally use the activation/deactivation feature and therefore they are not supported by SafeMove.

Independent joint

SafeMove does not support a robot system comprising supervision or monitoring of continuously rotating axes (independent joints).

Shared drive modules

Drive units of supervised and monitored axes cannot be shared, for instance between positioner axes.

Track motion coordinates

When a robot is mounted on a track motion, the following limitations apply:

- It is only possible to define a rotation (no translation) of the robot base frame relative the track motion base frame.
- It is only possible to define a translation (no rotation) of the track motion base frame relative the world frame.

Limit switch override cannot be used

If the option SafeMove is used, it is not allowed to connect any signal to the limit switch override (X23 on the contactor board).

RAPID non motion execution

This test feature cannot fully be used together with the SafeMove option.

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Borderline positions

In very rare cases an error message, elog 20473, might be presented if the robot is stoppedfor a time longer than 40 min in a position exactly on the border of the defined range. This is because of the internal safe design of the SafeMove controller, using a safe two channel microprocessor solution.

TIP!

To avoid this, never leave the robot for a longer period in a position near the borders of Monitor Axis Range.

Alternative calibration position

The alternative calibration position, which can be used for robots and external axes, is not supported by SafeMove. The calibration position shall be defined to zero position.

NOTE!

Alternative calibration position can be set in the system parameter *Calibration Position*, which is found under topic *Motion* and type *Arm*.

MultiMove

It is not supported to use a mixture of EPS (Electronic Position Switches) and SafeMove in a MultiMove installation. However, robots can be used with or without SafeMove in a mixed setup.

1.3. 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
Category 0 stop	Stop by immediate removal of power to the actuators. Mechanical brakes are applied. A robot that is stopped with a category 0 stop does not follow its programmed path while decelerating.
Category 1 stop	Controlled stop with power available to the actuators to achieve the stop. Power is removed from the actuators when the stop is achieved. A robot that is stopped with a category 1 stop follows its programmed path while decelerating.
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.
Supervision	Active supervision with deactivation of robot if limit is exceeded.
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.

1.4. Abbreviations and acronyms

Overview

This section specifies typical abbreviations and acronyms used in this manual.

Abbreviatons/acronyms list

Abbreviation/acronym	Description
CES	Control Error Supervision
CSC	Cyclic Sync Check
MAR	Monitor Axis Range
MST	Monitor Stand Still
MTZ	Monitor Tool Zone
OSR	Operational Safety Range
SAR	Safe Axis Range
SAS	Safe Axis Speed
SST	Safe Stand Still
STS	Safe Tool Speed
STZ	Safe Tool Zone

2 SafeMove functions

2.1. Overview of SafeMove functions

Overview

The SafeMove functions can be divided into the following categories:

- general functions (e.g. verification of functionality)
- supporting functions (e.g. verification of brakes)
- supervision functions (active, can stop the robot)
- monitoring functions (passive, only sets output signals)

Supervision functions

Supervision functions can stop the robot (and additional axes) if a violation occurs.

Supervision functions must be activated and deactivated with safe digital input signals.

Monitoring function

Monitoring functions are permanently active and use digital output signals for signaling status to an external device, like a PLC, that can stop the robot.

Combining functions

The supervision and monitoring functions can be used separately, or in a variety of combinations.

2.2 General functions

2.2.1. Cyclic Sync Check

Cyclic Sync Check

Cyclic Sync Check is a function that makes sure that the robot calibration is correct.

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, the robot will stop and SafeMove goes to unsynchronized state. 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.

WARNING!

The supervision and monitoring functions can only be active while SafeMove is synchronized. When unsynchronized, only speed and time limited movement is possible. For more information, see *Recovery from unsynchronized state on page 127*.

TIP!

If a safe information is needed to see if SafeMove is in unsynchronized state or not, it is recommended to use a monitoring output signal for this purpose. For example, to configure a Monitor Axis Range where the axis range covers the whole working area. In this case the Monitor Axis Range output will be low only when SafeMove is unsynchronized.

Settings

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

- Sync cycle time, 12-99 hours.
- Pre-warning time, 1-11 hours.
- Angles and positions of robot (and additional axes) at sync position.

Dependencies to other supervision functions

Cyclic Sync Check has no dependencies to any other supervision function.

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. See also *Virtual output signals from main computer on page 130*.

Continues on next page

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.
- Additional axes must be handled separately. If the position of additional axes should be monitored, then each axis must be equipped with a separate sync switch. If more than one switch is used, they must be connected in series (logical "AND" wiring) and activated simultaneously. A robot on a track motion may use the same sync switch for robot and track motion, but it must be mounted so that no ambiguity of the safe sync position can occur. See *Additional axis on page 65*.

Related information

Synchronization guidelines on page 119.

2.2.2. Override Operation

Override Operation

Override Operation is a function that overrides all safety functions in SafeMove and allows movements at a maximum speed of 250 mm/s. This is necessary when a supervision function is triggered and the robot must be jogged back to a position that does not cause any safety violation.

Functionality

Override Operation overrides all safety functions by forcing the relays to close and outputs to be high.

While Override Operation is active, a supervision makes sure that the TCP, tool0 and elbow speed does not exceed 250mm/s.

Any SafeMove violations must be confirmed by pressing the motors on button before the robot can be jogged, even if Override Operation is active.

If Override Operation is active and the robot is jogged out of the violation and then into a supervision violation position again, the robot will stop again. The new violation must be confirmed by pressing the motors on button on the robot controller before the jogging can be resumed.

DANGER!

Using the function Override Operation compromises the safety and must be avoided in all cases except when an axis or TCP must be jogged out of its forbidden position.

Settings

There are no parameters that need to be configured for Override Operation.

Function activation

Override Operation is activated with the Override Operation safe digital input signal (X10.9 and X10.10).

As long as Override Operation is active, there will be a warning every two minutes (elog 20481).

Limitations

- If Override Operation input signals are active for more than 20 minutes, SafeMove will trigger a stop that needs to be confirmed with the motors on push button.
- If the Override Operation input signals are active for more than 24 hours, operation is stopped with an error message (elog 20482). The system will require a warm start before Override Operation can continue.

Dependencies to other supervision functions

Override Operation can be used in combination with all other SafeMove functions, but all other function will be temporarily inactive while Override Operation is active.

2.2.3. Operational Safety Range

Operational Safety Range

Operational Safety Range relaxes the supervision 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.

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 9 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 *Operational Safety Range configuration on page 78*.

Dependencies to other supervision functions

If Operational Safety Range is active, it overrides the Control Error Supervision function. That means that all other active safety controller functions work with relaxed Control Error Supervision.

Operational Safety Range can be used in combination with all other SafeMove functions, but the other function may be restricted due to relaxed Control Error Supervision. For example, Safe Stand Still must not be used within an active range of Operational Safety Range.

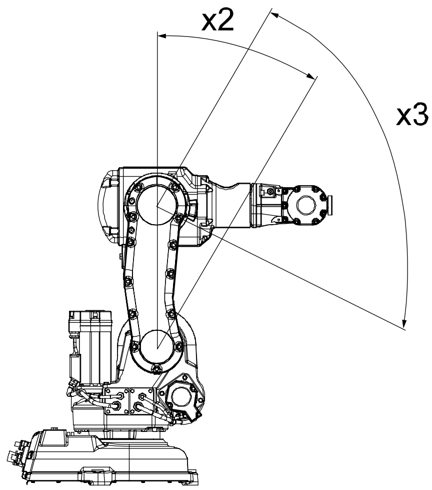
Related information

Control Error Supervision on page 36.

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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2.3 Supporting functions

2.3.1. Cyclic Brake Check

Cyclic Brake Check

Cyclic Brake Check is a function that verifies that the brakes work correctly.

NOTE!

After download of a new configuration it is recommended to run the Cyclic Brake Check function.

NOTE!

Before running the Cyclic Brake Check function the Safe Stand Still function shall be deactivated.

Functionality

The brake check is initiated by the robot controller or an external PLC. The robot moves to a safe position where the brakes are locked with servos engaged. The motors of the robot are then used to generate torque. If any axes moves, the system is set in reduced speed mode. A new successful brake check must be performed before the robot can be used again with normal speeds.

With a defined interval (brake cycle time), the robot must move to the safe position and perform a brake test. If the brake check is not performed within the brake cycle time an error message is generated, and depending on configuration the robot will be set to reduced speed or keep its normal supervision levels. A warning appears on the FlexPendant a predefined time (prewarning time) before the brake cycle time has passed.

Settings

The following parameters need to be configured for Cyclic Brake Check:

- Activation of Cyclic Brake Check.
- Brake check interval (between 12 and 720 hours).
- Prewarning time before brake check interval expires.
- It is possible to select Reduced max speed when the interval timer expires.
- It is possible to exclude individual axes from the brake checks.

How to define these settings is described in *Cyclic Brake Check configuration on page 76*.

Function activation

Cyclic Brake Check is always active, i.e. a constant supervision that a brake check has been performed within the configured time interval.

The actual brake check can be activated by the robot controller or an external PLC. See *Brake check guidelines on page 121*.

Dependencies to other supervision functions

The Safe Stand Still function is not dependent on the Cyclic Brake Check.

Continues on next page

Virtual output signal from main computer

A virtual output signal is set when the prewarning time has expired. See also *Virtual output signals from main computer on page 130*.

2.3.2. Safe Brake Ramp

Safe Brake Ramp

Safe Brake Ramp is an active supervision function that supervises category 1 stops initiated by the safety controller.

Supervision functionality

When a category 1 stop is triggered by SafeMove, the motors are used for a controlled deceleration. Safe Brake Ramp supervises this deceleration. If the deceleration is too slow, a category 0 stop is triggered.

NOTE!

Due to narrow tolerance for the deceleration ramp, a small number of category 1 stops caused by SafeMove will trigger the Safe Brake Ramp function and result in a category 0 stop. For a tilted robot, this number can be significantly higher.

Settings

For track motions and other additional axis the parameters **Brake Ramp Limit** and **Ramp Delay** have to be set in the SafeMove Configurator. The parameter **Start Speed Offset** is used for both manipulator and all additional axes.

Function activation

Safe Brake Ramp is always active.

Dependencies to other supervision functions

Safe Brake Ramp will be used in combination with all other SafeMove functions.

Limitations

- Safe Brake Ramp only supervises category 1 stops initiated by the safety controller. Stops initiated elsewhere, e.g. by the robot controller, are not supervised.
- Since brake ramps are set for worst case braking, in many situations only more serious defects in the category 1 stop will be detected.

Related information

Category 1 stop (see *Terminology on page 16*)

Category 0 stop (see *Terminology on page 16*)

2.4 Supervision functions

2.4.1. Safe Stand Still

Safe Stand Still

Safe Stand Still is an active supervision function ensuring that all supervised axes are standing still.

Supervision functionality

Safe Stand Still can supervise that a robot is standing still even if the servo and drive system are in regulation. If any supervised axis starts to move, Safe Stand Still will cause a category 0 stop.

When Safe Stand Still is active for all axes (including all additional axes), it is safe for a person to enter the robot cell.

4 different sets of up to 9 axes can be defined. When Safe Stand Still is activated for a set, all axes in that set are supervised.

DANGER!

Working under an axis affected by gravity which has no balancing may require a safety level of category 4, which is not provided by SafeMove. If this kind of work is intended, the risk must be added to the risk analysis of the installation and eliminated by other means (for example additional mechanical stops).

DANGER!

It is not recommended to activate the Safe Stand Still function within a range for Operational Safety Range because Control Error Supervision is relaxed in this range and is not reliable enough for personal safety.

DANGER!

For additional axes, a standstill reference tolerance must be configured.

NOTE!

If the robot tries to move due to an error during active Safe Stand Still supervision, SafeMove will detect this and initiate a stop. Since there is a certain reaction time involved a slight jerk may occur.

Settings

The following parameters need to be configured for Safe Stand Still:

- Assignment of safe digital inputs for activation of Safe Stand Still. See *Activation and I/O on page 72*.
- Which axes to supervise, with specified stand still measurement tolerance, for each stand still set. See *Safe Stand Still configuration on page 79*.
- For additional axes, a stand still tolerance must be configured. See *Additional axis on page 65*.

Continues on next page

Function activation

Safe Stand Still is activated by safe digital input signals.

If no safe digital input signal is assigned to Safe Stand Still during configuration, the function is inactive.

NOTE!

If SafeMove becomes unsynchronized the robot will stop and the Safe Stand Still function will be deactivated. A time limited movement with reduced speed is possible.

Dependencies to other supervision functions

Safe Stand Still can be used in combination with:.

- Safe Axis Speed
- Safe Axis Range
- Safe Tool Speed
- Safe Tool Zone
- all monitoring functions

2.4.2. Safe Axis Speed

Safe Axis Speed

Safe Axis Speed is an active supervision function that supervises the speed of robot axes and additional axes.

Supervision functionality

Supervision of the speed for up to 9 axes (robot axes and additional axes).

If any of the supervised axes exceeds its maximum speed, the safety controller will stop the robot. The speed violation will cause a category 0 stop or a category 1 stop, depending on the configuration.

Settings

The following parameters need to be configured for Safe Axis Speed:

- Which axes to supervise.
- Maximum speed, defined per axis.
- Category 0 stop or category 1 stop if an axis exceeds its maximum speed.
- Assignment of safe digital inputs for activation of Safe Axis Speed.

How to define these settings is described in *Safe Axis Speed configuration on page 80*.

Function activation

Safe Axis Speed is activated by a safe digital input signal.

If no safe digital input signal is assigned during configuration, the function is inactive.

Dependencies to other supervision functions

Safe Axis Speed can be used in combination with:

- Safe Stand Still
- Safe Axis Range
- Safe Tool Speed
- Safe Tool Zone
- all monitoring functions

Limitations

The highest maximum speed that can be configured is 3600 degrees/s for rotational axes and 10000 mm/s for linear axes.

2.4.3. Safe Tool Speed

Safe Tool Speed

Safe Tool Speed is an active supervision function that supervises the speed of the tool, robot flange and arm check point.

NOTE!

The resultant robot TCP speed could in some situations be higher than the programmed TCP speed. This could happen for some robot types if the move instructions are of type `MoveJ` or `MoveAbsJ`. If this occurs, either increase the STS **Max Speed**, or try to add intermediate robot targets in the RAPID program.

NOTE!

When the robot is running in manual mode, neither the elbow point nor the TCP point will exceed 250mm/s. When the robot is running in auto mode, IRC5 will not consider the elbow speed when generating the path, only the defined TCP speed and reorient speed. (If additional axis exists in the system, the speed data for this will also be considered.) The result from this is that the elbow speed is sometimes higher than the programmed TCP speed. Since STS supervises TCP, tool0 and the elbow, the speed of these points must be taken into account when configuring STS or creating the RAPID program.

Supervision functionality

Safe Tool Speed supervises the linear speed (in mm/s) for:

- TCP for the tool held by the robot
- Tool 0 (the robot flange)
- Arm check point (position depending on robot but located around axis 3)

If any of these points exceed the maximum speed, the safety controller triggers a stop. The speed violation will cause a category 0 stop or a category 1 stop, depending on the configuration.

Settings

The following parameters need to be configured for Safe Tool Speed:

- Maximum allowed speed (in mm/s) for TCP, tool0 and arm check point.
- Category 0 stop or category 1 stop if a point exceeds its maximum speed.
- Assignment of safe digital inputs for activation of Safe Tool Speed.

How to define these settings is described in *Safe Tool Speed configuration on page 81*.

Function activation

Safe Tool Speed is activated by a safe digital input signal.

If no safe digital input signal is assigned during configuration, the function is inactive.

Continues on next page

Dependencies to other supervision functions

Safe Tool Speed can be used in combination with:

- Safe Stand Still
- Safe Axis Speed
- Safe Axis Range
- Safe Tool Zone
- all monitoring functions

2.4.4. Safe Axis Range

Safe Axis Range

Safe Axis Range is an active supervision function that ensures that all axes are within the defined ranges.

When configuring the Safe Axis Range function there is a possibility to invert the function by unchecking the **Allow inside** check box.

Supervision functionality

Supervision of up to 9 axes (robot axes and additional axes) in each set. Up to 8 sets can be configured.

If an axis in an active set exceeds its allowed range, the safety controller triggers a stop. This violation will cause a category 0 stop or a category 1 stop, depending on the configuration.

Settings

The following parameters need to be configured for Safe Axis Range:

- Which axes to supervise.
- Axis ranges (degrees or mm) for each axis.
- Inclusive or exclusive range for each axis.
- Allow inside, i.e. to invert or not invert the result of the function.
- Category 0 stop or category 1 stop if an axis exceeds its maximum range.
- Assignment of safe digital inputs for activation of each set of axis ranges.

How to define these settings is described in *Safe Axis Range configuration on page 82*.

Function activation

Each set of axis ranges is activated by a safe digital input signal.

If no safe digital input signal is assigned during configuration, the set is inactive.

Dependencies to other supervision functions

Safe Axis Range can be used in combination with:

- Safe Stand Still
- Safe Axis Ranges
- Safe Tool Speed
- Safe Tool Zone
- all monitoring functions

The ranges are defined independently of the ranges defined in the function Monitor Axis Range.

Related information

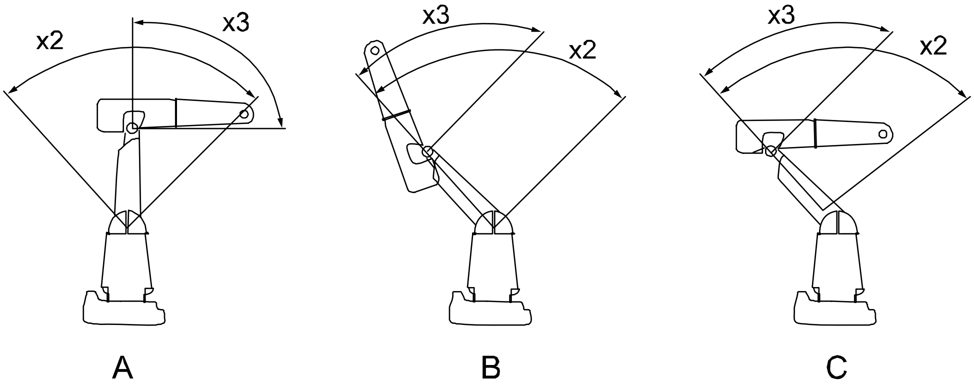
Monitor Axis Range on page 38

Continues on next page

Examples

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

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



xx0600003331

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

WARNING!

Be aware of that the braking starts when the axis exceeds the configured limit value. The next following braking distance depends on robot type, load, position and speed.

2.4.5. Safe Tool Zone

Safe Tool Zone

Safe Tool Zone is an active supervision function that supervises that the robot TCP and tool orientation are within their allowed zone, while moving at allowed speed.

Supervision functionality

Up to 8 zones can be configured. Each zone consists of:

- a geometrical shape in space, that the TCP should be inside or outside
- a tool orientation with an allowed tolerance
- a maximum speed for the TCP.

If the TCP, tool orientation or TCP speed is outside its allowed values, the safety controller triggers a stop. This violation will cause a category 0 stop or a category 1 stop, depending on the configuration.

Settings

The following parameters need to be configured for Safe Tool Zone:

- Tool zones (shape, height, position).
- Tool orientation and tolerance for each zone.
- Tool speed limit.
- Assignment of a safe digital input for activation of each zone.
- Category 0 stop or category 1 stop if the tool violates its zone limits.

How to define these settings is described in *Safe Tool Zone configuration on page 88*.

Function activation

Safe Tool Zone is activated by safe digital input signals.

If no safe digital input signal is assigned during configuration, the function is inactive.

Dependencies to other supervision functions

Safe Tool Zone can be used in combination with:

- Safe Stand Still
- Safe Axis Speed
- Safe Tool Speed
- all monitoring functions

Limitations

WARNING!

Be aware of that the braking starts when the tool exceeds the configured limit value. The next following braking distance has an effect on robot type, load, position and speed.

2.4.6. Control Error Supervision

Control Error Supervision

Control Error Supervision is a function that supervises 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 and supervision functions.

Supervision functionality

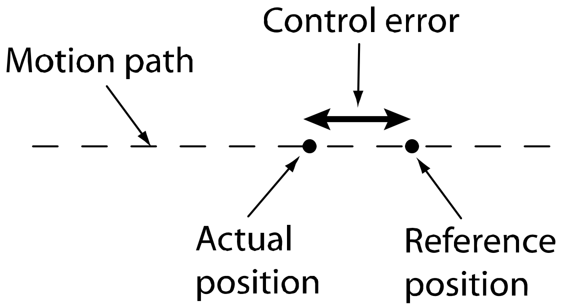
The control error (servo lag) is the absolute value of the difference between the reference value and the measured value of the motor position of each axis.

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:

- The robot is stopped with a category 1 stop.
- An elog message (20454) is sent to the robot controller.
- A new synchronization is required.

Illustration of control error



en0700000723

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 *Additional axis on page 65*.

Related information

Operational Safety Range on page 23.

2.5 Monitoring functions

2.5.1. Monitor Stand Still

Monitor Standstill

Monitor Stand Still is a passive monitoring function used to verify that none of the monitored axes are moving.

Monitoring functionality

Monitor Stand Still can monitor if all axes stand still. If any monitored axis starts to move, a safe digital output signal goes low. If the axis is moved outside the supervision limit and then stops, the output signal will go high after a short time.

4 different sets of up to 9 axes in each set can be defined. Monitor Stand Still monitors the axis position for all axes in a set.

Settings

For each set of axes the following parameters need to be configured for Monitor Stand Still:

- Assignment of safe digital output signal.
- Which axes to monitor.

How to define these settings is described in *Monitor Stand Still configuration on page 93*.

Function activation

Monitor Stand Still is always active.

Dependencies to other supervision functions

Monitor Stand Still can be used in combination with all other SafeMove functions.

2.5.2. 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

Monitoring of up to 9 axes (robot axes and additional axes) in each set. Up to 8 sets can be configured.

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.

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 axis for each axis.
- Allow inside for each set of axis ranges.

How to define these settings is described in *Monitor Axis Range configuration on page 94*.

Dependencies to other supervision functions

Monitor Axis Range can be used in combination with all other SafeMove functions.

The ranges are defined independently of the stop ranges defined in the function Safe Axis Range.

Related information

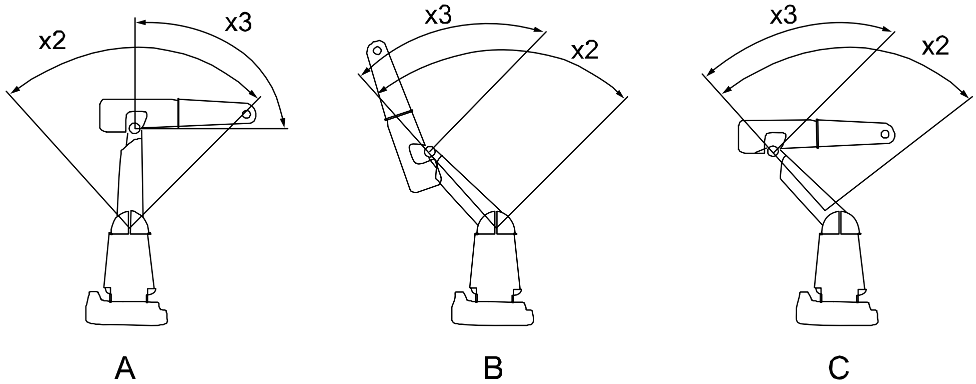
Safe Axis Range on page 33

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.



xx0600003331

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.

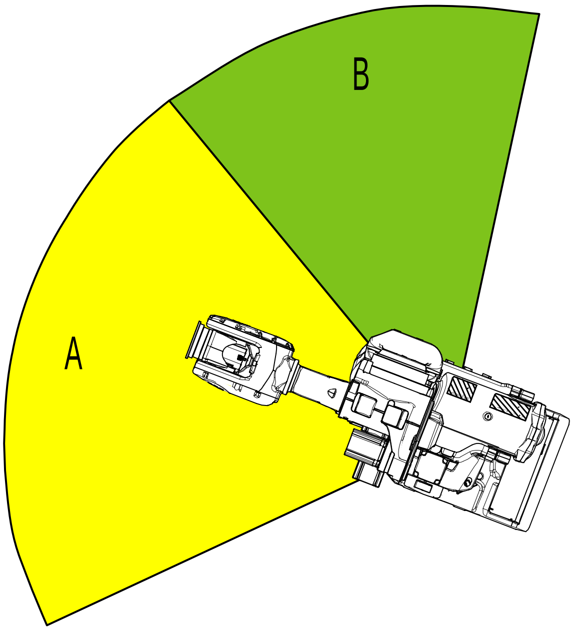
Note! The ranges define axis angles, not the position of the TCP. In robot position C, the TCP is still within what seems to be a safe range, but axis 3 is outside its defined range.

Continues on next page

Continued

Example of usage

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



xx0700000144

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

2.5.3. Monitor Tool Zone

Monitor Tool Zone

Monitor Tool Zone is a passive supervision function that determines if the robot TCP and tool orientation are within their defined zones, while moving at defined speed.

NOTE!

Monitor Tool Zone can only safely determine that the TCP is within the defined zone (i.e. when the output signal is high). It is not safe to assume that the TCP is outside the defined zone when the signal is low.

NOTE!

The resultant robot TCP speed could in some situations be higher than the programmed TCP speed. This could happen for some robot types if the move instructions are of type `MoveJ` or `MoveAbsJ`. If this occurs, either increase the MTZ **Max Speed**, or try to add intermediate robot targets in the RAPID program.

NOTE!

When the robot is running in manual mode, neither the elbow point nor the TCP point will exceed 250mm/s. When the robot is running in auto mode, IRC5 will not consider the elbow speed when generating the path, only the defined TCP speed and reorient speed. (If additional axis exists in the system, the speed data for this will also be considered.) The result from this is that the elbow speed is sometimes higher than the programmed TCP speed. Since MTZ supervises TCP, tool0 and the elbow, the speed of these points must be taken into account when configuring MTZ or creating the RAPID program.

Monitoring functionality

Up to 8 zones can be configured. Each zone consists of:

- a geometrical shape in space, that the TCP should be inside or outside
- a tool orientation with a tolerance
- a maximum speed for the TCP.

If the TCP, tool orientation or tool speed is outside its defined zone, a safe digital output signal goes low.

The functionality also includes axis ranges for external axes per zone.

Settings

The following parameters need to be configured for Monitor Tool Zone:

- TCP data and tool geometry.
- Tool zones (shape, height, position).
- Tool orientation and tolerance for each zone.
- Tool speed limit.
- Assignment of a safe digital output signal for each zone.

How to define these settings is described in *Monitor Tool Zone configuration on page 100*.

Function activation

Monitor Tool Zone is always active.

Continues on next page

Dependencies to other supervision functions

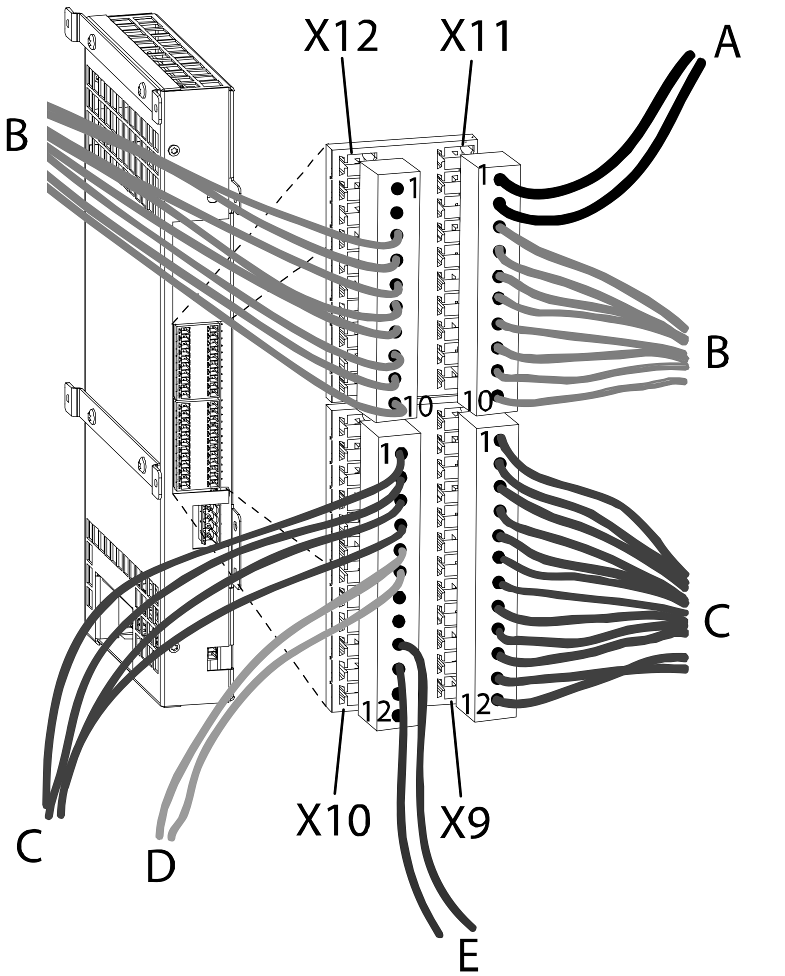
Monitor Tool Zone can be used in combination with all other SafeMove functions.

3 Installation

3.1 Hardware installation

3.1.1. I/O connector data

Location



xx0700000640

A	Power supply
B	8 safe outputs (16 signals)
C	8 safe inputs (16 signals)
D	Sync switch (dual signal)
E	Override operation input (dual signal)

NOTE!

Make sure the cables from X9-X12 are not damaged by the normally bunched cable cover, and vice versa. The cables from X9-X12 should be bunched with straps together with other cables against the controller wall.

Continues on next page

I/O connector pin descriptions

Contact X9

Pin	Signal	Description
1	Activation input signal 1A	Input signal used for activation of supervision functions. Which functions to activate with this signal is configured in the SafeMove Configurator. Signals 1A and 1B are equivalent signals, i.e. both are set low to activate the supervision functions.
2	Activation input signal 1B	-"-
3	Activation input signal 2A	-"-
4	Activation input signal 2B	-"-
5	Activation input signal 3A	-"-
6	Activation input signal 3B	-"-
7	Activation input signal 4A	-"-
8	Activation input signal 4B	-"-
9	Activation input signal 5A	Input signal used for activation of supervision functions. Which functions to activate with this signal is configured in the SafeMove Configurator. Signals 5A and 5B are antivalent signals, i.e. 5A is set high and 5B is set low to activate the supervision functions.
10	Activation input signal 5B	-"-
11	Activation input signal 6A	-"-
12	Activation input signal 6B	-"-

Continues on next page

Contact X10

Pin	Signal	Description
1	Activation input signal 7A	Input signal used for activation of supervision functions. Which functions to activate with this signal is configured in the SafeMove Configurator. Signals 7A and 7B are antivalent signals, i.e. 7A is set high and 7B is set low to activate the supervision functions.
2	Activation input signal 7B	-"-
3	Activation input signal 8A	-"-
4	Activation input signal 8B	-"-
5	Sync switch input signal A	Input signal for synchronization check. A synchronization pulse is defined by this signal connected to ground (0 V). If dual channel sync switch is not used, this signal is not used. See *Sync switch input signal on page 50*.
6	Sync switch input signal B	Input signal for synchronization check. A synchronization pulse is defined by this signal connected to 24 V.
7	Not used	
8	Not used	
9	Override operation input signal A	Override Operation is activated by having this signal connected to ground (0 V). For information about Override Operation, see *Override Operation on page 22*.
10	Override operation input signal B	Override Operation is activated by having this signal connected to 24 V.
11	Not used	
12	Not used	

Contact X11

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	Monitoring output signal 1A	Monitored high side output signal for monitoring functions. The monitoring output signals are configured in the SafeMove Configurator. Switches on or off 24 Volts supplied by the power input (pin 1 and 2 on contact X11). All monitoring outputs are equivalent signals, i.e. both signals are set high when the monitoring functions are not violated.
4	Monitoring output signal 1B	-"-
5	Monitoring output signal 2A	-"-
6	Monitoring output signal 2B	-"-

Continues on next page

Pin	Signal	Description
7	Monitoring output signal 3A	-"-
8	Monitoring output signal 3B	-"-
9	Monitoring output signal 4A	-"-
10	Monitoring output signal 4B	-"-

Contact X12

Pin	Signal	Description
1	Not used	
2	Not used	
3	Monitoring output signal 5A	Monitored high side output signal for monitoring functions. The monitoring output signals are configured in the SafeMove Configurator. Switches on or off 24 Volts supplied by the power input (pin 1 and 2 on contact X11).
4	Monitoring output signal 5B	-"-
5	Monitoring output signal 6A	-"-
6	Monitoring output signal 6B	-"-
7	Monitoring output signal 7A	-"-
8	Monitoring output signal 7B	-"-
9	Monitoring output signal 8A	-"-
10	Monitoring output signal 8B	-"-

Connecting to equivalent input signals

Activation input signals 1-4 are equivalent (both are set low to activate functions). SafeMove has no way of detecting if there is a short circuit between the A and B signal.

Connect these signals from a safety output that has a cross short detection.

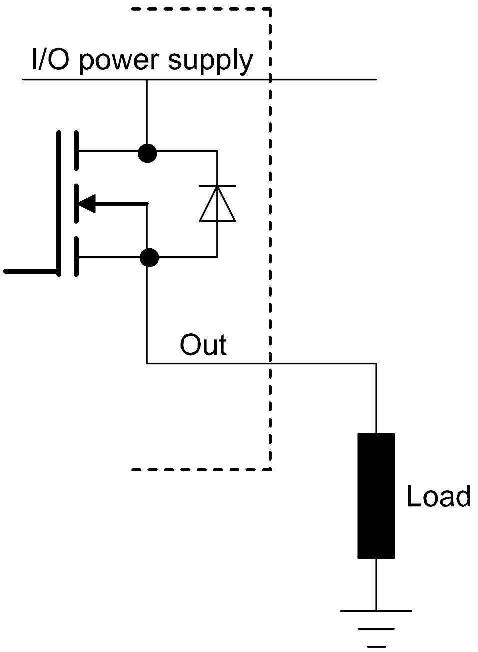
Continues on next page

Electrical data

Description	Min value	Max value
Voltage for I/O power supply[1)]	21.6 V	26.4 V
Voltage for low value on digital input	-3 V	+2 V
Voltage for high value on digital input	+21 V	+27 V
Current at high value for Sync switch input	~10 mA	~10 mA
Current at high value for all inputs except Sync switch	~2 mA	~2 mA
Max output current by one digital output	-	0.8 A
Sum of output current by all digital outputs	-	3.5 A
Output inductive load	-	200 mH

[1)]The I/O power supply must be fused with 3.5 A.

Output type: N-channel high side switch



en0800000063

Signal redundancy

Output signals

All monitoring 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 and the signals are set low. Always handle this error by stopping all mechanical units.

Continues on next page

Activation input signals

Activation input signals 1-4 use redundancy with equivalent input signals. That means input signal 1A and 1B should always be identical. The signals are set low to activate the supervision functions. If the A and B signals differ, the supervision functions are activated. However, if they differ for more than 2 seconds, there will be an I/O error elog and the error must be removed and a warm start performed.

Activation input signals 5-8 use redundancy with antivalent input signals. That means input signal 5A should always be the inverted signal of input signal 5B. Signal A is set high and signal B is set low to activate the supervision functions. If the A and B signals are identical, the supervision functions are activated. However, if they are identical for more than 2 seconds, there will be an I/O error elog and the error must be removed and a warm start performed.

If both the A and B input signal are open (unconnected) the assigned safety function will be activated. This is valid for both the equivalent and the antivalent activation input signals and will not be interpreted as an I/O error as long as both A and B are open.

Sync switch input signal

If configured for dual channel sync switch, the sync switch input signal uses redundancy with antivalent inputs. That means input signal A should always be the inverted signal of input signal B. Signal A is pulsed to low and signal B is pulsed to high to activate the function. The pulses on the A and B signals must be simultaneous and last for at least 16 ms. If the A and B signals are identical, the function is NOT activated. If they are identical for more than 2 seconds, there will be an I/O error elog and the error must be removed and a warm start performed.

Override Operation input signal

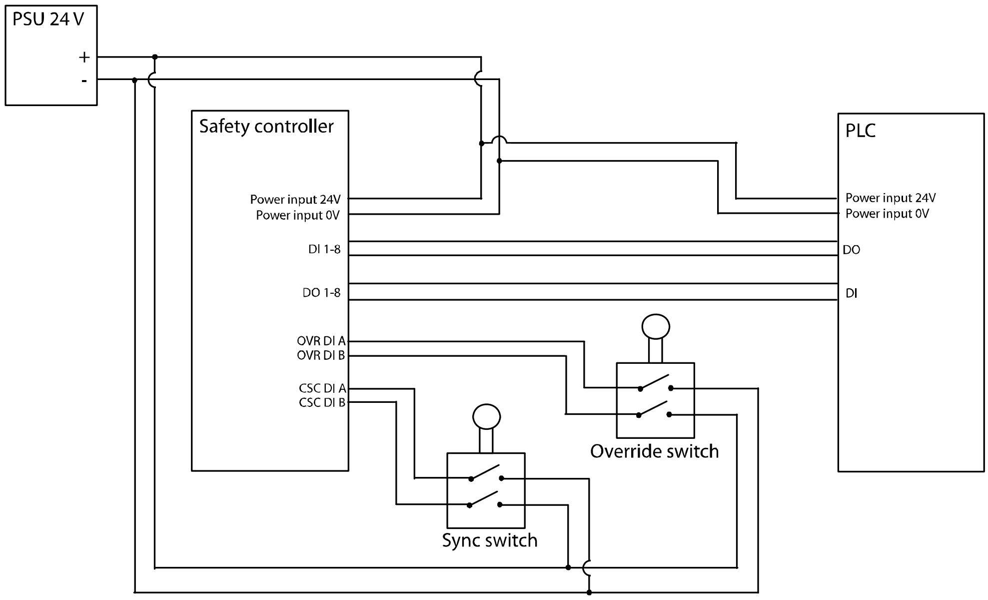
Override Operation input signal uses redundancy with antivalent inputs. That means input signal A should always be the inverted signal of input signal B. Signal A is set to low and signal B is set to high to activate the function. The function is active as long as the signals keep this state. If the A and B signals are identical, the function is NOT activated. If they are identical for more than 5 minutes, there will be an I/O error elog and the error must be removed and a warm start performed.

NOTE!

When SafeMove is in disabled state, also the redundancy supervision of the I/O signals is disabled. This is a way to prevent safety errors during commissioning.

3.1.2. Connecting to a PLC

Principle for connecting signals to a PLC



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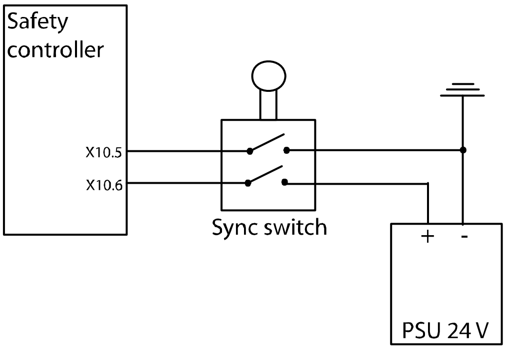
3.1.3. Sync switch input signal

Using the sync switch 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 sync position, pin X10.6 should be set high and pin X10.5 should be set low. If dual channel wiring is not used, connect only pin X10.6.

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



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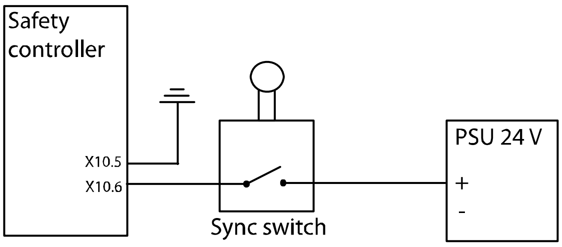
Principle for sync switch connected to the safety controller using single channel sync switch:



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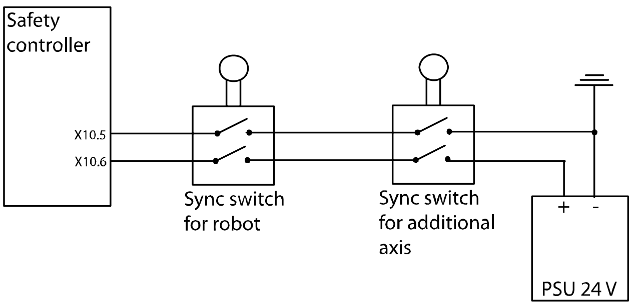
Additional axis

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.

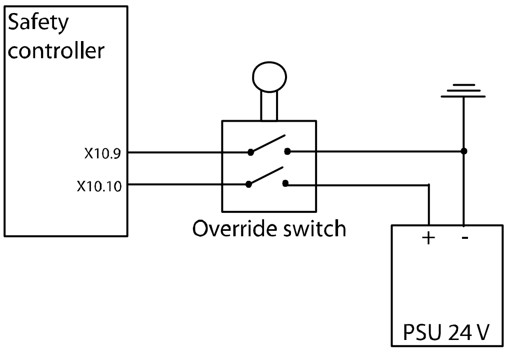
3.1.4. Override Operation input signal

Using the Override Operation input signal

To activate Override Operation, close an override switch. This switch can be implemented with, for example a key switch, button, contact strapping or PLC. When activating Override Operation, pin X10.9 should be set low (0 V) and pin X10.10 should be set high (24 V).

If the controller has the option for customer connection to operating mode selector (735-3, 735-4) these terminals ca be used to control the Override Operation function, for example, to keep it active when manual mode is selected. For more information, see *Product manual - IRC5* section *The MOTORS ON/MOTORS OFF circuit-Connection to operating mode selector*.

Principle for connecting the override switch to the safety controller:



en0700000713

3.1.5. Function activation input signals

Using the activation input signals

The safety controller has 8 dual input signals for activation of supervision functions. An activation input signal can be configured to activate one or several supervision functions. For configuration of input signals, see *Activation and I/O on page 72*.

The safety controller works with redundancy (dual input signals, dual processors, etc.). Unless both input signals indicate that a supervision function should be inactive, it will be active (for highest safety). Make sure that redundancy is used for the signals connected to the safety controllers input signals.

Power failure of an external equipment that sets all input signals low will result in all configured supervision functions being active.

A supervision function that is not configured to be activated by an input signal is permanently inactive.

Test pulses

The input signals filter signals with duration shorter than 2 ms. Test pulses can be used on these signals, as long as they are shorter than 2 ms, without affecting the SafeMove functions.

3.1.6. Monitoring output signals

Using the monitoring output signals

The safety controller has 8 dual output signals. These can be used to indicate status for the monitoring functions. They can be used to stop the robot if a dangerous status is detected. The robot cell responsible must make sure that the robot and all additional axes are stopped if there is a risk of danger. Connect the output signals to a PLC, or similar equipment, that can stop the robot based on signals from SafeMove and other safety equipment in the cell, e.g. light curtains.

The safety controller works with redundancy (dual processors, dual output signals, etc.). Safe robot behavior (e.g. robot 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 SafeMove Configurator, see *Configuring SafeMove on page 63*.

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, for example, an axis being outside its defined range.

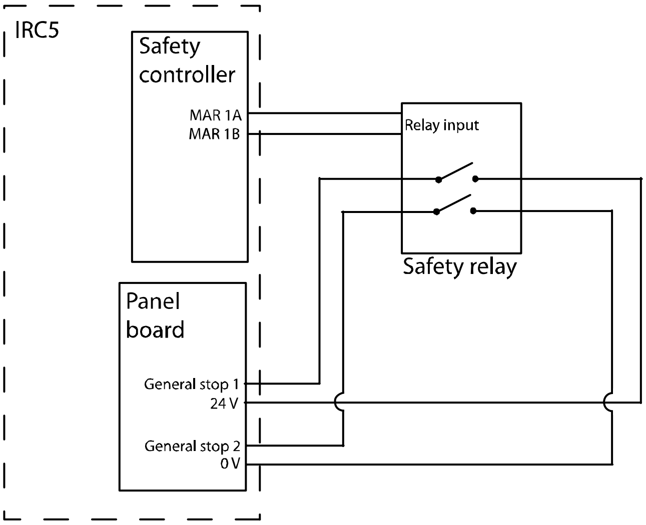
Test pulses during operation

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, for example, an axis being outside its defined range. Make sure the PLC or safety relay does not react on pulses shorter than 2 ms.

Continues on next page

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 is 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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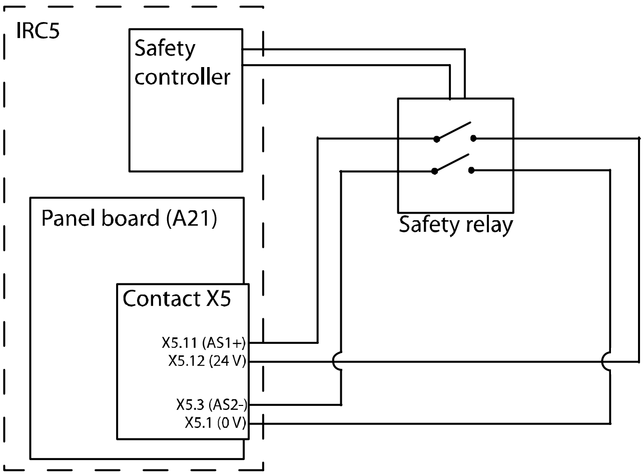
Connect to Auto Stop on the panel board

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.

The connection are the same as for Auto Stop except General Stop 1 is connected to X5.10 and General Stop 2 is connected to X5.2.

Note that when the General Stop circuit is open, there is no way of jogging the robot back to the defined range. Recovery from this state is performed in the same way as *Recovery after a supervision function has triggered on page 127*.

3.1.7. Power supply

Use IRC5 ground and isolate the I/O

The safety controller requires one system power supply and one I/O power supply. These two power sources must have a common ground potential. Besides, the I/O power supply must be fused with 3.5 A.

The I/O connector of the PLC must also have the same ground potential as the safety controller (i.e. as the IRC5 cabinet). Since the ground potential of the PLC is not necessarily the same as for IRC5, the I/O signals must be galvanically isolated from the PLC cabinet.

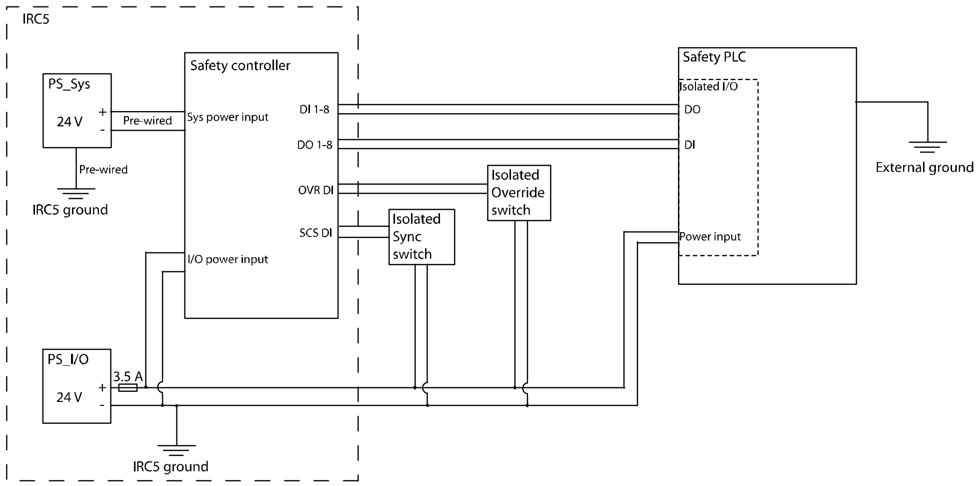
NOTE!

The I/O power supply must be connected with SafeMove to be able to close the limit switch chain when it is disabled. If the limit switch chain is open, the robot cannot operate.

Example of isolated I/O

In this example the I/O connector of the PLC is isolated from the PLC and receives its power supply from the same source as the safety controller's I/O connector. The Sync switch also uses the same power supply. 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 PLC.



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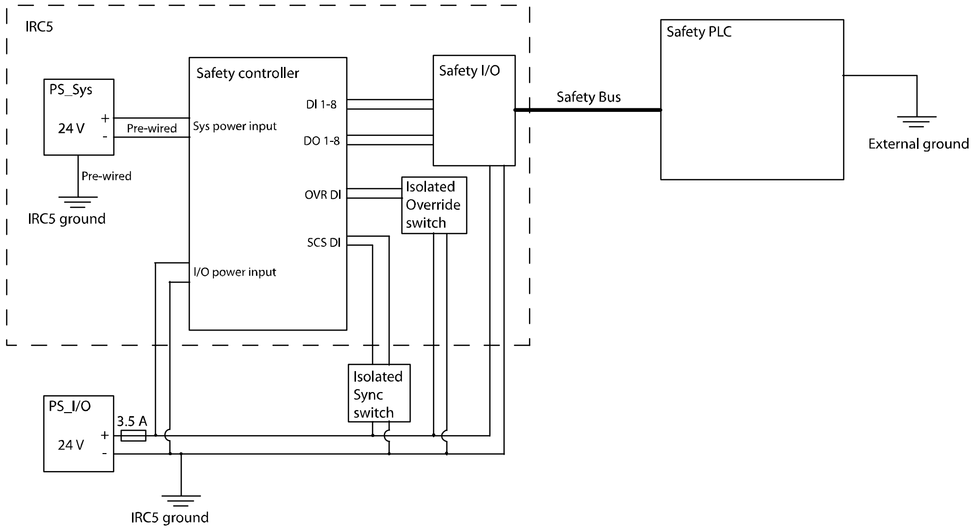
If you use a single cabinet IRC5 controller, the I/O power supply can use the internal power supply, located in the IRC5 cabinet. If you use a dual cabinet IRC5 controller, you need to use an external power source (for example I/O power supply in the control module).

Continues on next page

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.

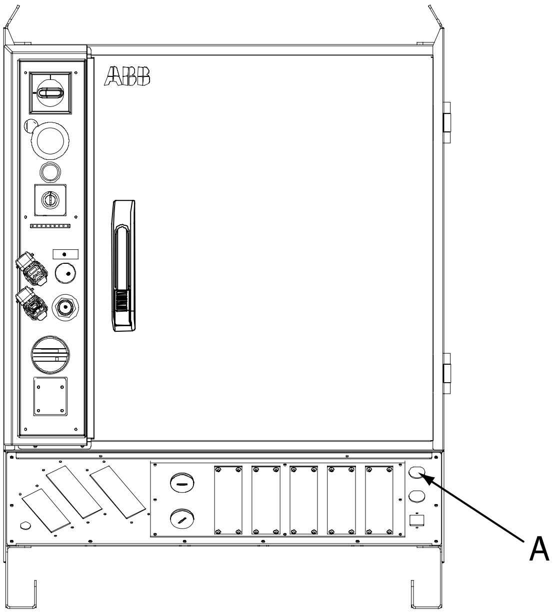


en0700000653

3.1.8. SMB connection for additional axis

Connect additional axis to SMB link 2

When a robot is ordered together with an additional axis, the drive module or single cabinet controller is equipped with a contact for SMB link 2 (A4.XS41). Connect the SMB cable from the additional axis to this connection.



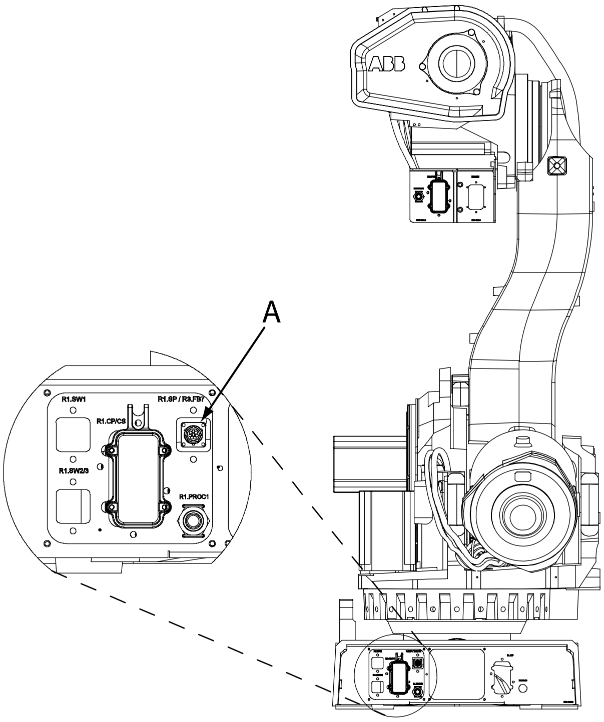
xx0700000715

A	Contact A4.XS41 for SMB link 2.

Continues on next page

Connect additional axis to SMB link 1 directly on 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.



xx0600003339

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

This contact may be present for IRB 660, IRB 66XX and IRB 7600.

A similar contact exists for IRB1600, but is on a cable coming out of the robot base.

For other robot models, there is no prepared contact for a 7th axis on SMB link 1.

More information about SMB connections

More descriptions of the SMB connections can be found in *Application manual - Additional axes and stand alone controller*.

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 SafeMove Configurator 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 SafeMove Configurator is installed with either of these installation options. The SafeMove Configuration tool 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 SafeMove and select the option *810-2 SafeMove*.

Configure IRC5

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

4 Configuration

4.1. Configure system parameters

About the system parameters

The configuration of system parameters required for a robot system should be made before starting with the safety configuration.

In addition to the system parameters that need to be configured for a robot system without SafeMove, there are a few parameters that are specific for SafeMove. These are described in this section.

Type Mechanical Unit

All mechanical units for additional axes shall have the parameters *Activate at Start Up* and *Deactivation Forbidden* set to On. (All mechanical units must always be active.)

Type Arm

If an axis should be excluded from Cyclic Brake Check, set the parameter *Deactivate Cyclic Brake Check for axis* to On. This must correspond with the axes that are deactivated in the configuration of Cyclic Brake Check. See *Cyclic Brake Check configuration on page 76*.

The maximum working area for axes has to be limited according to limitations specified in section *Supported additional axes on page 13*. This must be taken into consideration when entering the parameters *Upper Joint Bound* and *Lower Joint Bound*. (The parameter values in radians or meters on arm side.)

Type Brake

If Cyclic Brake Check is executed on an additional axis a lowest safe brake torque must be defined. A 5% margin is added during the test for setting the fail limit, the warning limit is plus 15%. The parameter used is *Max Static Arm Torque* defined in Nm on motor side.

System input signal, SafeMoveConfirmStop

The system input signal SafeMoveConfirmStop can be used as a complement to the Motors On button when restoring an error. See *Recovery after safety violation on page 127*. This system input can be configured as a physical or virtual I/O signal in IRC5. To configure SafeMoveConfirmStop, use the **Configuration Editor** in RobotStudio. For details about how to use the **Configuration Editor**, refer to *Operating manual - RobotStudio*.

NOTE!

It is recommended to use the system input signal for interconnection with a press button, or similar, in the first place. Use caution if the PLC is used to control the signal. Avoid situations when pulsing the signal, since this may lead to a security risk.

4.2. Create a safety user

Why do you need a safety user

Configuring SafeMove 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 SafeMove.

Prerequisites

You must have created a robot system with the option 810-2 SafeMove. 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 **Robot View Explorer**, 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 **Robot View Explorer**, 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 check **Safety Controller configuration** and **Write access to controller disks**. The group may have more grants, but these two 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.

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*.

4.3 Configuring SafeMove

4.3.1. About the SafeMove Configurator

What is the SafeMove Configurator

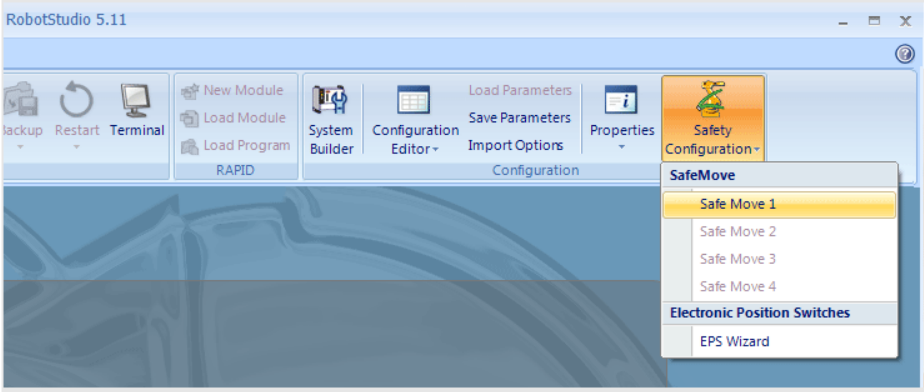
In the SafeMove Configurator you can configure the ranges, zones and tolerances used by the functions of SafeMove.

Prerequisites

Only a safety user is allowed to download a configuration. A safety user must be created before configuring SafeMove (see *Create a safety user on page 62*).

Start the SafeMove Configurator

	Action
1.	In RobotStudio's Robot View Explorer, right-click on the controller and select **Authenticate** and then **Login as a Different User**.
2.	Select the safety user, e.g. **SafetyUser**. Type the password and click **Login**.
3.	In the menu **Online**, select **Safety Configuration**, then select the safety controller, e.g. **SafeMove 1**.



en0700000566

Save before closing the SafeMove Configurator

By saving the configuration, you can later load the configuration and continue to work on it.

How to save and download a configuration to the safety controller is described in *Save and download to safety controller on page 105*.

NOTE!

If the SafeMove Configurator is closed, all information is lost. Make sure to save before you close the SafeMove Configurator.

NOTE!

The SafeMove Configurator cannot be used to configure Electronic Position Switches. Use EPS Configuration Wizard for that.

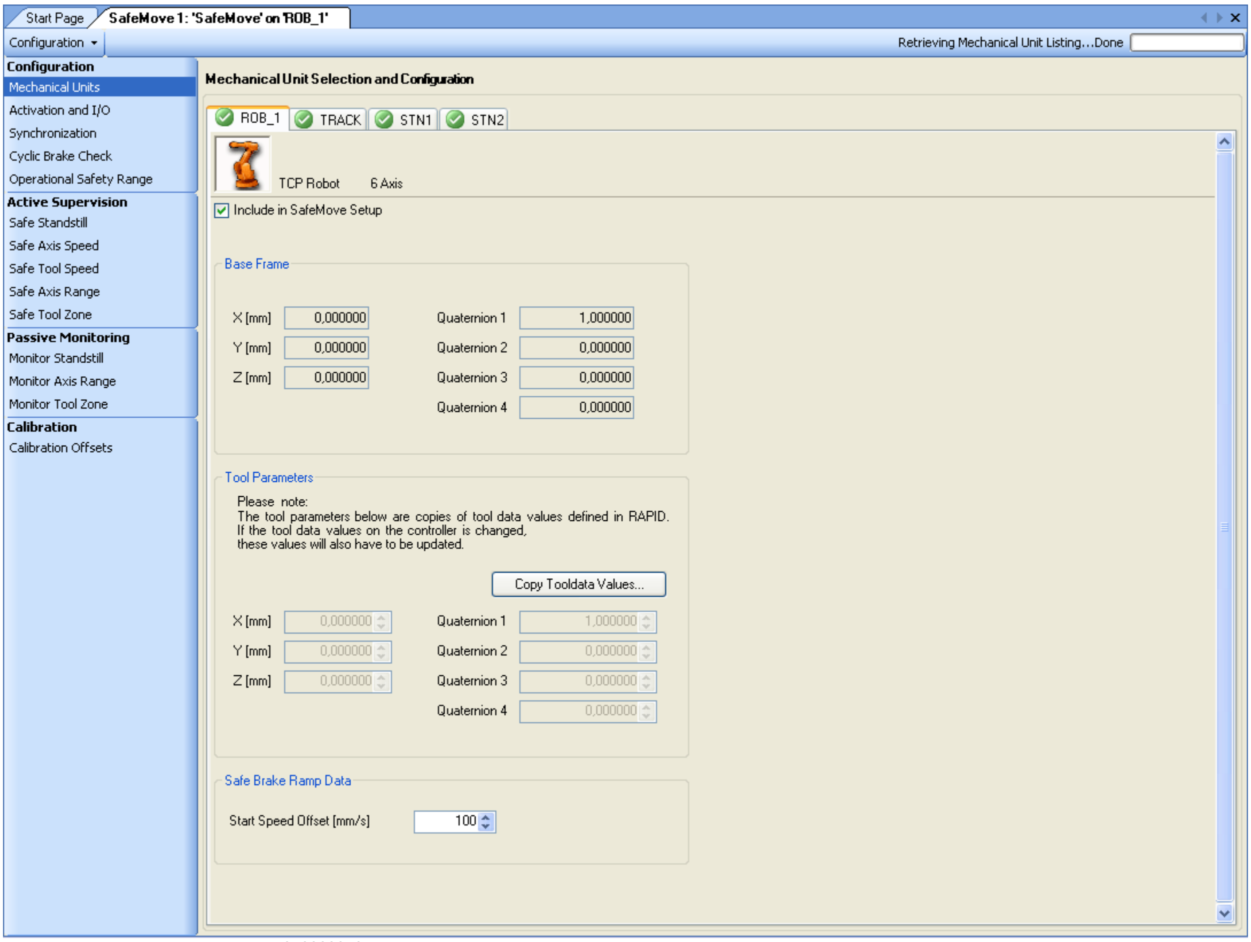
4.3.2. Mechanical Units configuration

About the dialog Mechanical Units

In the dialog **Mechanical Units**, there is one tab for each mechanical unit.

Robot

The tab that represents the robot looks like this:



en0700000567

Check the box **Include in SafeMove Setup** if you want to configure the robot.

Base Frame

All values for the base frame are automatically loaded from the robot controller.

X, Y, Z	X, Y and Z values for the base frame's origin, expressed in the world coordinate system.
Quaternion 1-4	Defines the orientation of the base frame, compared to the world coordinate system.

Continues on next page

Tool Parameters

Click on **Get Tooldata** and select the tool that this robot uses. All the fields in **Tool Parameters** are then automatically filled with the information from that tool.

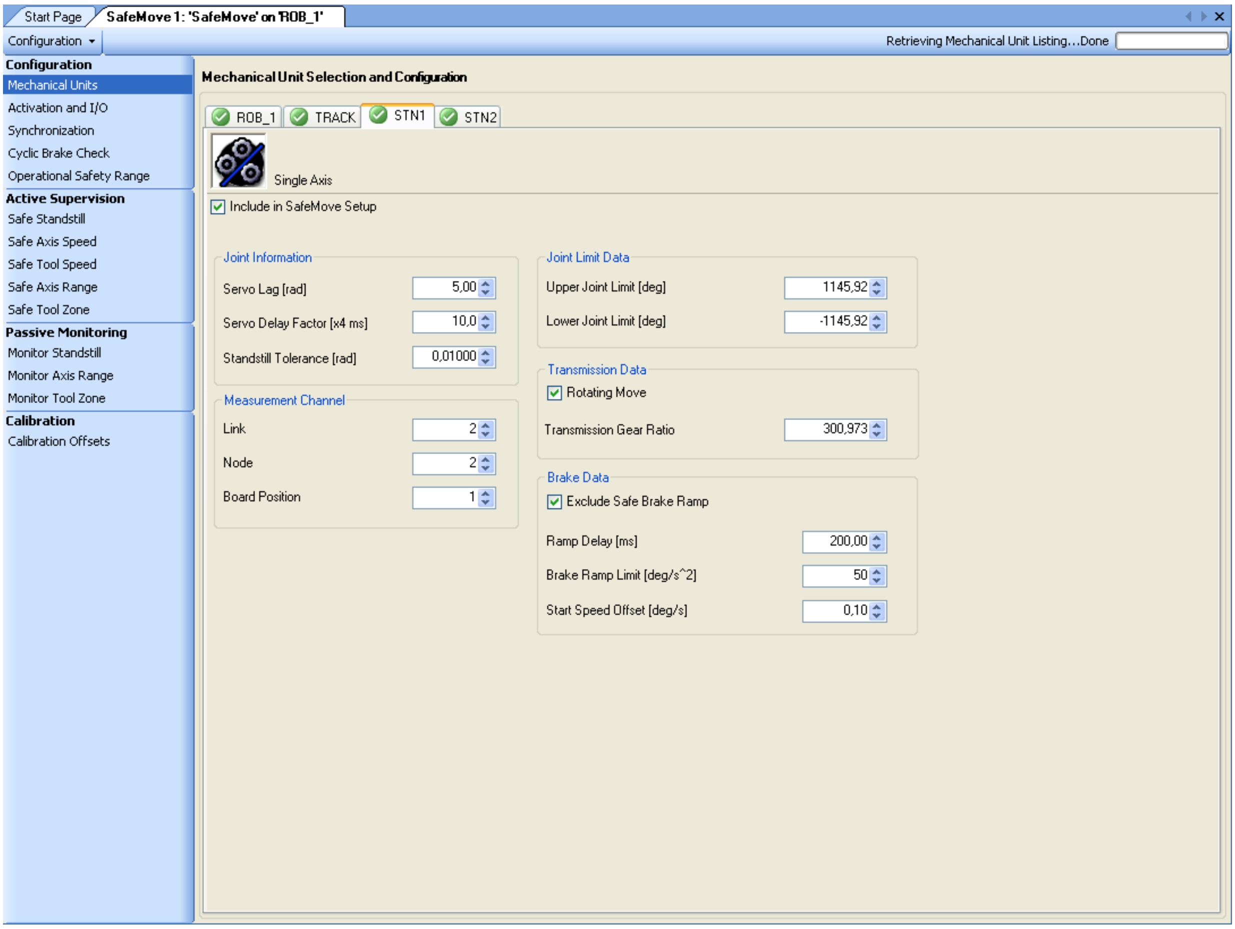
X, Y, Z	Coordinates for the tool center point (TCP) in relation to tool0 (the mounting flange).
Quaternion 1-4	Orientation of the tool coordinate system in relation to tool0.

Safe Brake Ramp Data

Start Speed Offset	Affects the Safe Brake Ramp function. See figure in section *Brake Data on page 66*. Default value: 100 mm/s.

Additional axis

A tab that represents an additional axis looks like this:



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Check the box **Include in SafeMove Setup** if you want to configure this additional axis.

Servo Lag	Estimated lag (in radians on motor side) for the additional axis.
Servo Delay Factor	Estimated delay factor between reference position and measured position (number of 4 ms units) when moving the additional axis. (See Test Signal Viewer, Signal Ident. 17 and 18.)

Continues on next page

Standstill Tolerance	Used for Safe Stand Still. The motor is in regulation during Safe Stand Still, and a small movement may be allowed. The size of the allowed movement is specified in **Standstill Tolerance** (in radians on motor side). Typical value is 0.50 radians.

Measurement Channel

Link	See system parameter *Measurement Link* in type *Measurement Channel*.
Node	See system parameter *Measurement Node* in type *Measurement Channel*.
Measurement Board Pos.	See system parameter *Board Position* in type *Measurement Channel*.

Joint Limits

Upper Limit	Upper limit of the axis (in degrees or mm on arm side, depending on if **Rotating Move** is checked). See system parameter *Upper Joint Bound* in type *Arm*. Maximum values: ± 25 668 degrees on arm side or ± 100 000 mm. (General limitation: Maximum ± 32000 revolutions on motor side.)
Lower Limit	Lower limit of the axis (in degrees or mm on arm side, depending on if **Rotating Move** is checked). See system parameter *Lower Joint Bound* in type *Arm*. Maximum values: ± 25 668 degrees on arm side or ± 100 000 mm. (General limitation: Maximum ± 32000 revolutions on motor side.)

For information about max/min limits for additional axes, refer to *Supported additional axes on page 13*.

Transmission

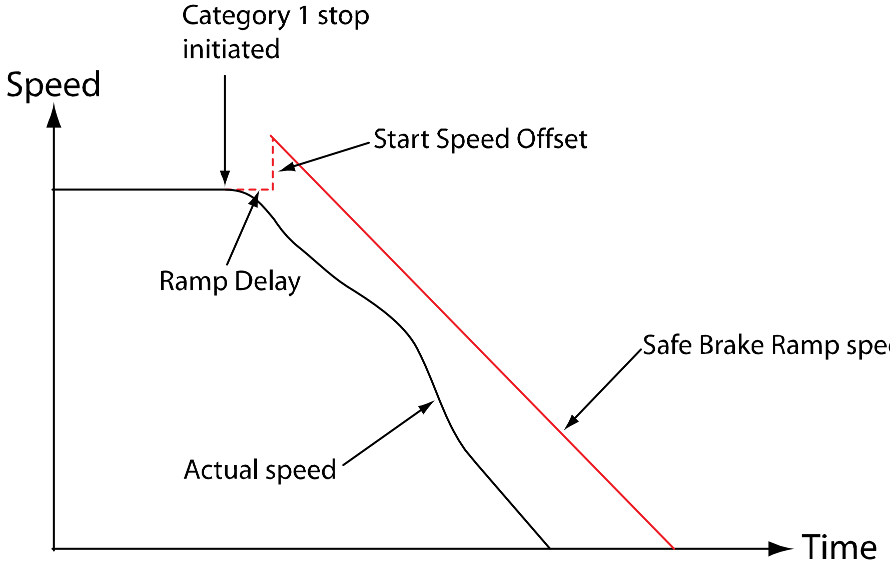
Transmission Gear Ratio	See system parameter *Transmission Gear Ratio* in type *Transmission*.

Brake Data

Ramp Delay	Delays the Safe Brake Ramp function. See figure below. Default value: 200 ms.
Brake Ramp Limit	Used for Safe Brake Ramp function. If the actual deceleration is lower than the specified Brake Ramp Limit, then Safe Brake Ramp will cause a category 0 stop. The value to type should be for the arm side.
Start Speed Offset	Affects the Safe Brake Ramp function. See figure below. Default value: 100 mm/s.

Continues on next page

The brake configuration affects the function Safe Brake Ramp. **Ramp Delay** and **Start Speed Offset** affect where the ramp should start and **Brake Ramp Limit** affects the gradient of the Safe Brake Ramp speed limit.



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For a category 1 stop, a drive module that controls both robot and additional axes will adjust the deceleration for all units to the unit with the slowest deceleration. The Safe Brake Ramp speed limit is also adjusted to the unit with the slowest deceleration. If one of the additional axes has Safe Brake Ramp deactivated, the Safe Brake Ramp speed limit will be calculated from the ramp delay time 1 second.

For a robot standing on a track motion, the Safe Brake Ramp speed limit is calculated from the slowest deceleration of the robot and the track motion.

-

NOTE!

Due to the Safe Brake Ramp functionality it is important that a correct value of Brake Ramp Limit is typed for the external axes.

Continues on next page

How to calculate the Brake Ramp Limit

The method described below is possible to use for external axes that are configured and tuned by the customer. Note that the values of ACC_DATA in the IRC5 configuration file for the external axes must be set correctly.

The value of wc_dec belonging to ACC_DATA is the deceleration value in rad/s^2 or m/s^2 on the arm side, and is used by IRC5 during a category 1 stop. Reduce this deceleration value by approximately 20% to get a suitable margin.

Example for rotational motor:

```
Brake Ramp Limit=0.8*wc_dec*180/pi
```

The Brake Ramp Limit parameter can also be obtained by doing the test on the system. Follow the steps in this procedure:

	Action	Note
1.	Configure the IRC5 to generate a category 1 stop when the emergency stop button is pressed.	See *Operating manual - IRC5 with FlexPendant*, section *Safety signals*.
2.	Start the Test Signal Viewer, and then log the joint speed.	
3.	Run the axis with maximum speed value (or near maximum).	
4.	Press the emergency stop button.	In the Test Signal Viewer, the resulting graph shows the speed (rad/s on motor side) versus time (s). The gradient of the deceleration part gives the deceleration.
5.	To get the deceleration value on the arm side, divide the motor deceleration value with the transmission ratio, and then convert the value to degrees/s^2.	
6.	To get a suitable margin, reduce the resulting deceleration by approximately 20%.	

Additional information for ABB track motions

The following table gives parameter values for the track motions (IRT 104, IRBT 4004, IRBT 6004, and IRBT 7004):

Part	Parameter	Parameter value
Measurement Channel	**Link**	**2**
	Bord Position	**1**
	Node	**1**
Transmission Data	**Transmission Gear Ratio**	**182.73096 (-182.73096)**

The following table gives parameter values for the robot travel track (RTT):

Part	Parameter	Parameter value
Measurement Channel	**Link**	**1**
	Bord Position	**2**
	Node	**7**
Transmission Data	**Transmission Gear Ratio**	**295.6793 (-295.6793)**

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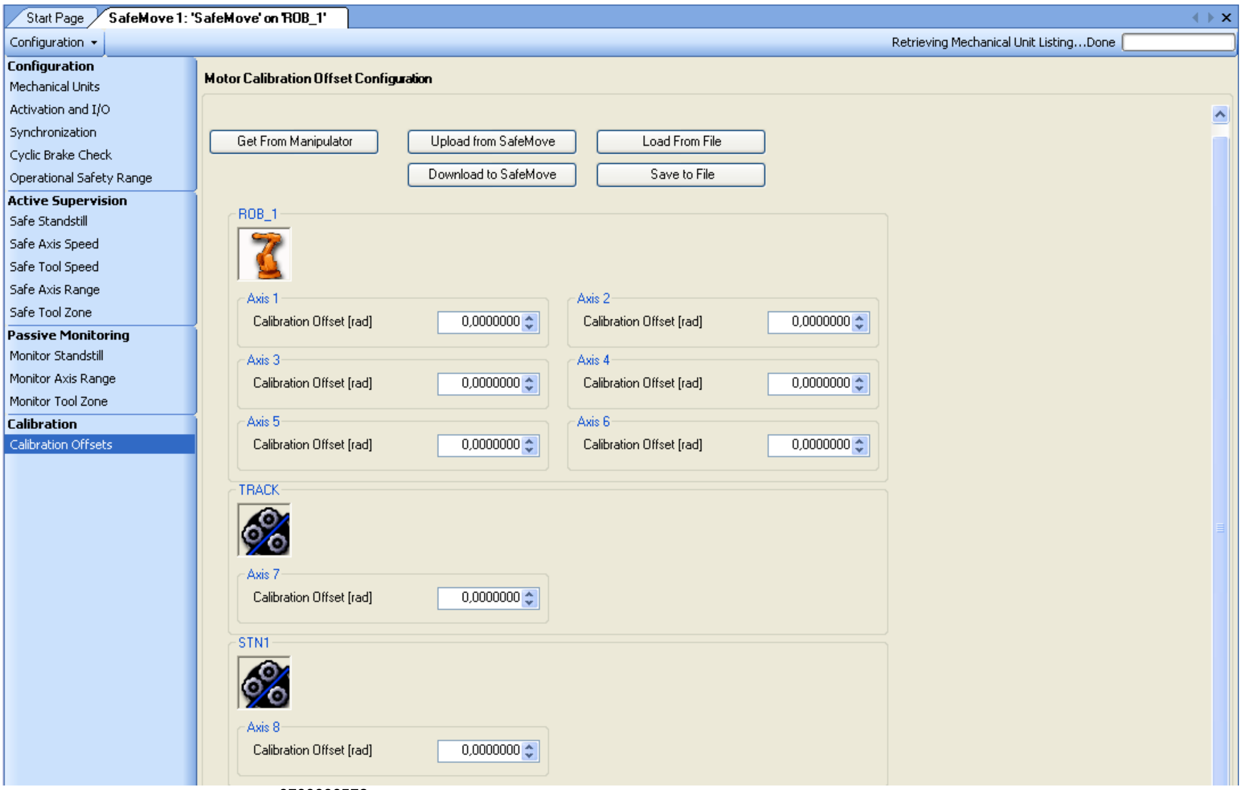
NOTE!

The negative sign for **Transmission Gear Ratio** means mirrored carriage or double carriage on the same track.

4.3.3. Calibration Offsets configuration

User interface appearance



en0700000573

About the 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 supervision of the axes positions.

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

NOTE!

Observe that the motor calibration values need to be set both for the robot controller and for the safety controller. 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 SafeMove Configurator.

Set the calibration offsets

To set the motor calibration values, click on the button **Get From Manipulator** or enter the values.

To download the offset values to the safety controller, click on **Download to SafeMove**.

If the motor calibration values are already set and downloaded to SafeMove, it is not necessary to do it again unless the values have changed.

If the values have changed, the old values can be uploaded by clicking **Upload from SafeMove**. Change the values and then click on **Download to SafeMove**.

Continues on next page

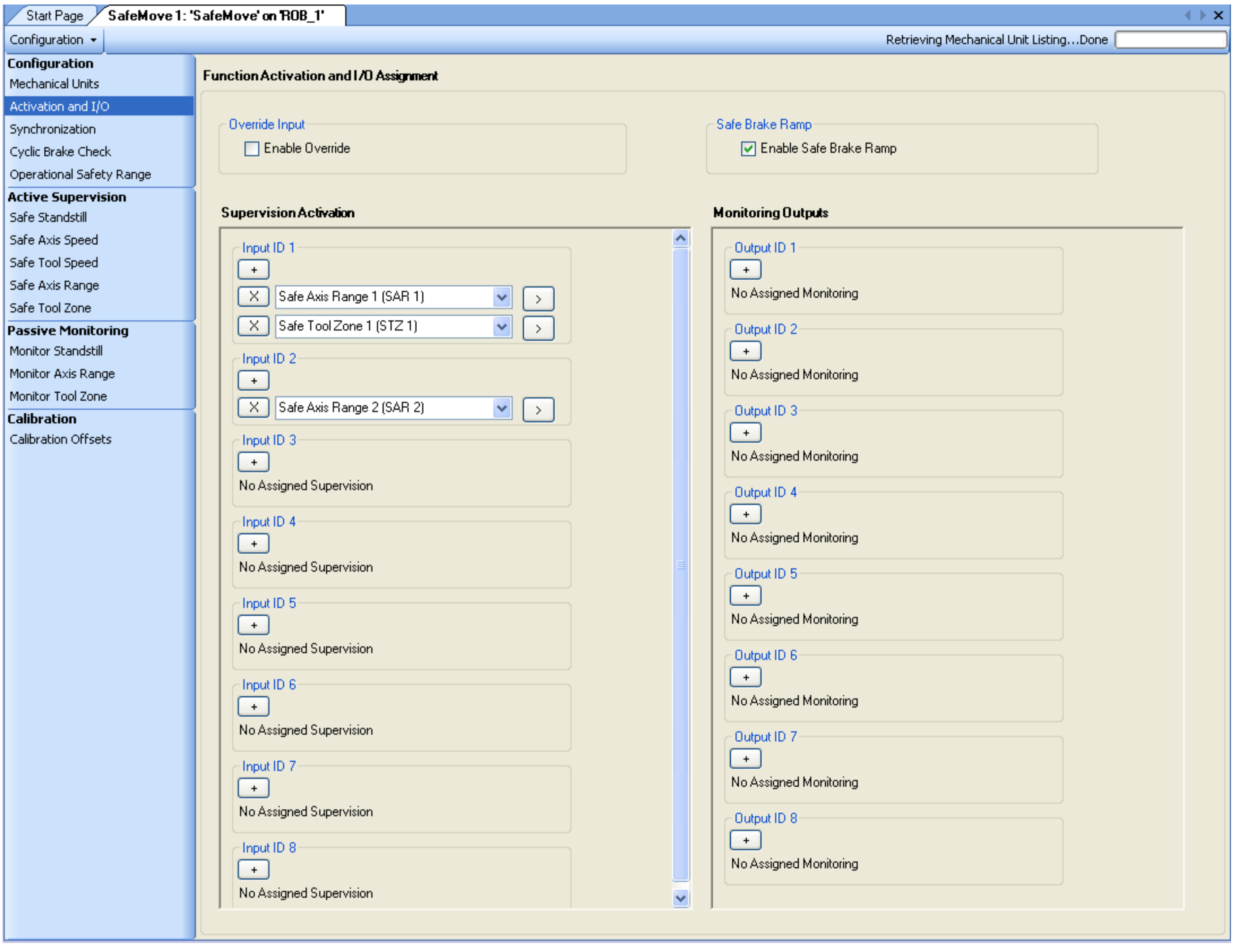
Save and load calibration offset

The offset data is saved to a file by clicking on **Save to File**. This does not download the data to the safety controller.

To load offset data from a previously saved file, click on **Load From File**.

4.3.4. Activation and I/O

User interface appearance



en0700000679

Override Input

To enable the override function, select the **Enable Override** check box.

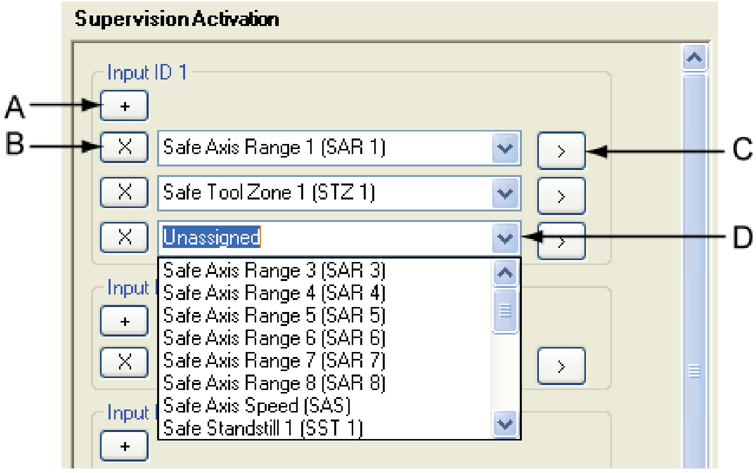
Continues on next page

Supervision Activation

Here you can specify which supervision functionality to be activated by each input signal. An input signal can be used to activate 1 or up to 5 supervision functions.

Example, using input 1

Specify the supervision functions that should be activated by input signal 1.



en0700000570

Add a supervision function by clicking on the + button (A in the picture). Then select a function from the drop down list (D in the picture).

Change a supervision function by selecting a new one in the drop down list (D in the picture).

Remove a supervision function by clicking on the **X** button in front of that function (B in the picture).

Go directly to the configuration of a selected supervision function by clicking on the > button after that function (C in the picture).

Monitoring Outputs

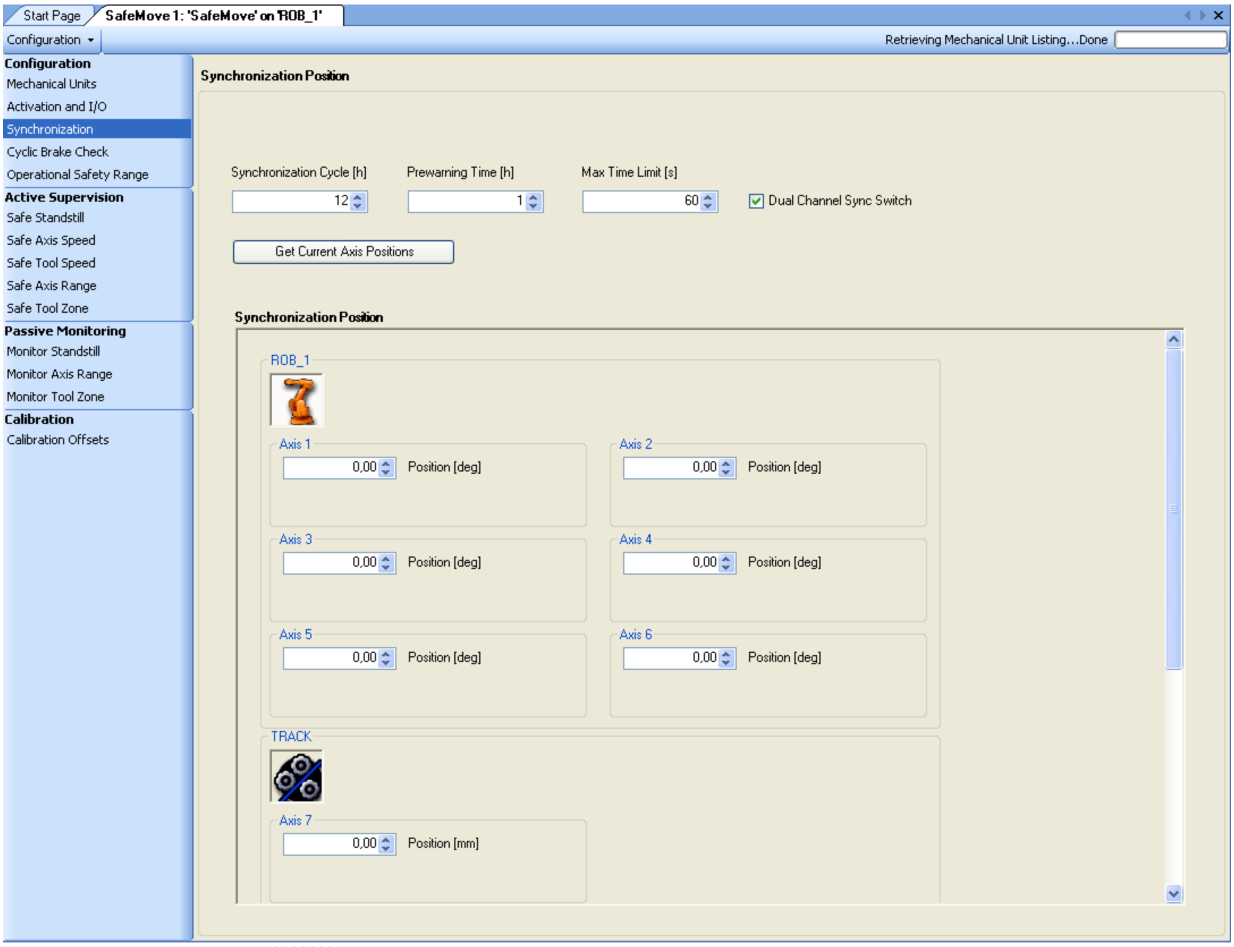
There are 20 different monitoring functions to choose from. Totally there are only 8 digital output signals, but it is possible to configure several monitoring signals of the same type to one digital output signal, for example, MAR1 and MAR2 to the same digital ouput signal. You must select here which monitoring functions to use and which output signals to connect them to.

For each output signal, select which monitoring function that should set the output value for that signal.

To select a monitoring function for an output signal, click on the + button and then select the function from the drop down list.

4.3.5. Synchronization configuration

User interface appearance



en0700000571

Set synchronization cycle

Synchronisation 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. **Prewarning Time** defines how long before the cycle time is up this warning should occur.

When the cycle time has expired without a sync check, the robot is stopped. By pressing the motors on button on the robot controller, the robot can be moved for a short period of time with reduced speed, which should be enough to perform a synchronization. **Max Time Limit** specifies the length of the period in which an unsynchronized robot can be moved after pressing the motors on button.

Continues on next page

Dual or single channel sync switch

Normally a dual input signal is used for the synchronization check, connected to pin X10.5 and X10.6 on the I/O connector. If **Dual Channel Sync Switch** is not selected, a single input signal is used, connected to pin X10.6.

It is recommended to use dual channel sync switch since it increases the possibilities to detect failures in the sync switch signal and increase the safety.

Set the synchronization positions

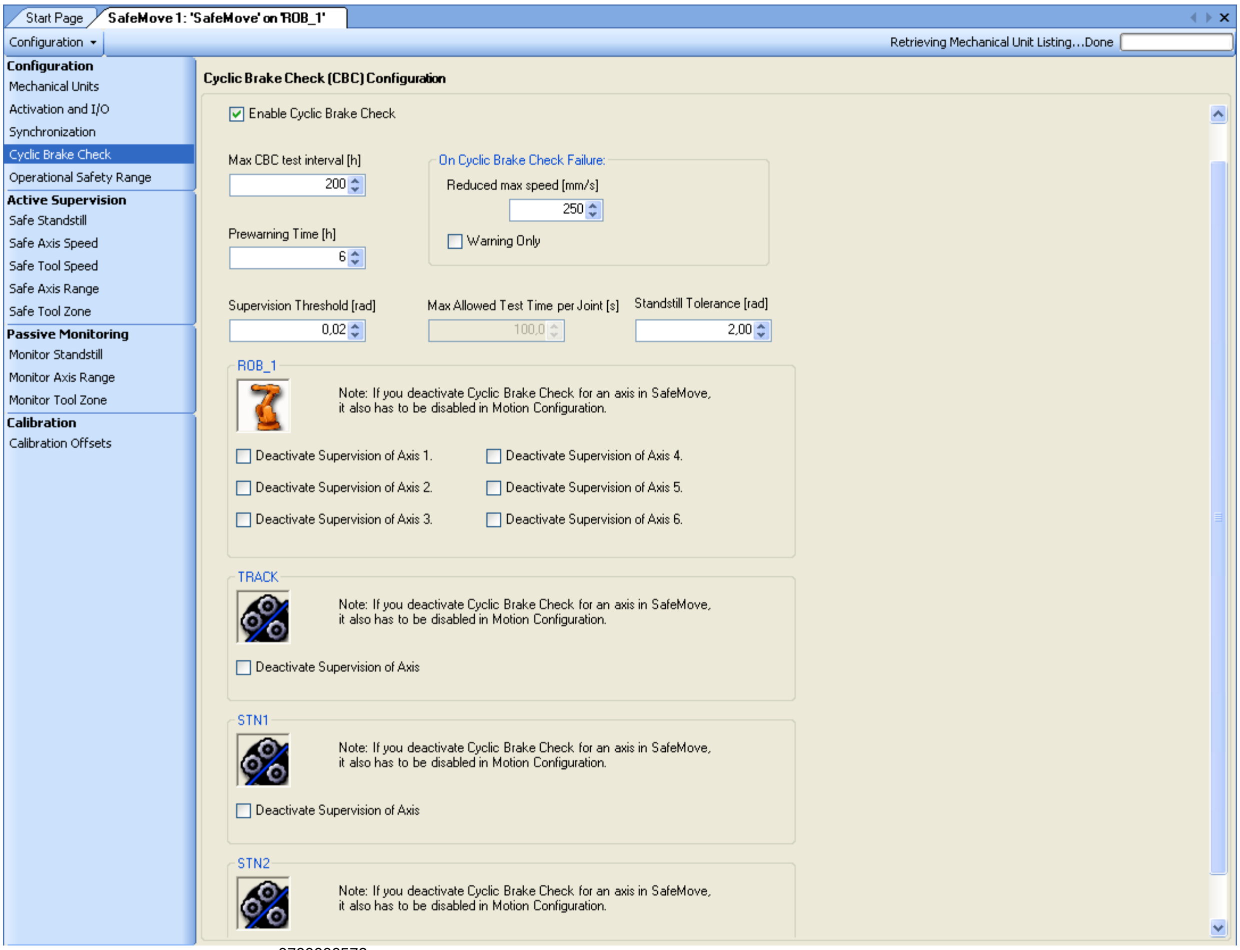
Jog the robot to the synchronization position used by Cyclic Sync Check and click on **Get Current Axis Positions**. It is also possible to specify the axis position values manually.

TIP!

Save the synchronization position as a `jointtarget` in your RAPID program. For more information, see *Create RAPID program for synchronization on page 119*.

4.3.6. Cyclic Brake Check configuration

User interface appearance



en0700000572

Cyclic Brake Check

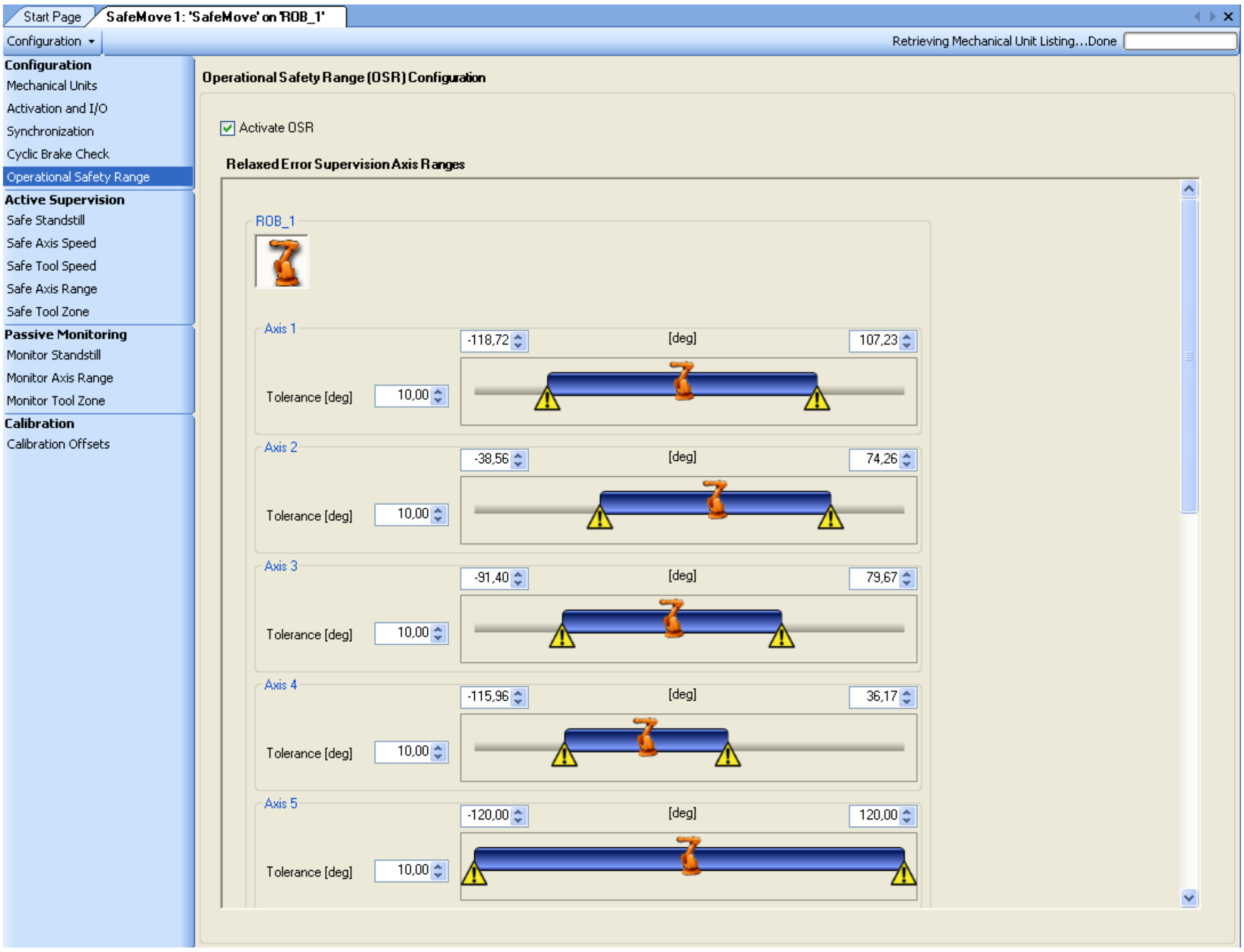
Enable Cyclic Brake Check	Activates the function Cyclic Brake Check.
Max CBC test interval	Defines the maximum allowed time (in hours) between brake checks.
Reduced max speed	Maximum allowed TCP speed if the brake test has failed.
Prewarning Time	Before the cycle time has expired, a warning will be shown on the FlexPendant. **Prewarning Time** defines how long before the cycle time is up this warning should occur.
Warning Only	If **Warning Only** is not checked, the robot is stopped when the cycle time has expired without a brake check. If **Warning Only** is checked, the robot will not be stopped. There will only be a warning when the cycle time has expired without a brake check.
Supervision Threshold	Threshold to verify that a brake check has been made.
Max Allowed Test Time per Joint	The maximum number of seconds that each axis is tested. Not to be changed by user.

Continues on next page

Standstill Tolerance	Used for Safe Stand Still during brake test. The motor is in regulation during brake test, and a small movement may be allowed. The size of the allowed movement is specified in **Standstill Tolerance** (in radians on motor side). Typical value is 2 radians.
Deactivate Supervision of Axis	If one axis should be excluded from the Cyclic Brake Check, select the axis that should be excluded. This must correspond with the axes that has the system parameter *Deactivate Cyclic Brake Check for axis* set to On. See *Type Arm on page 61*.

4.3.7. Operational Safety Range configuration

User interface appearance



en0700000574

Configure Operational Safety Range

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

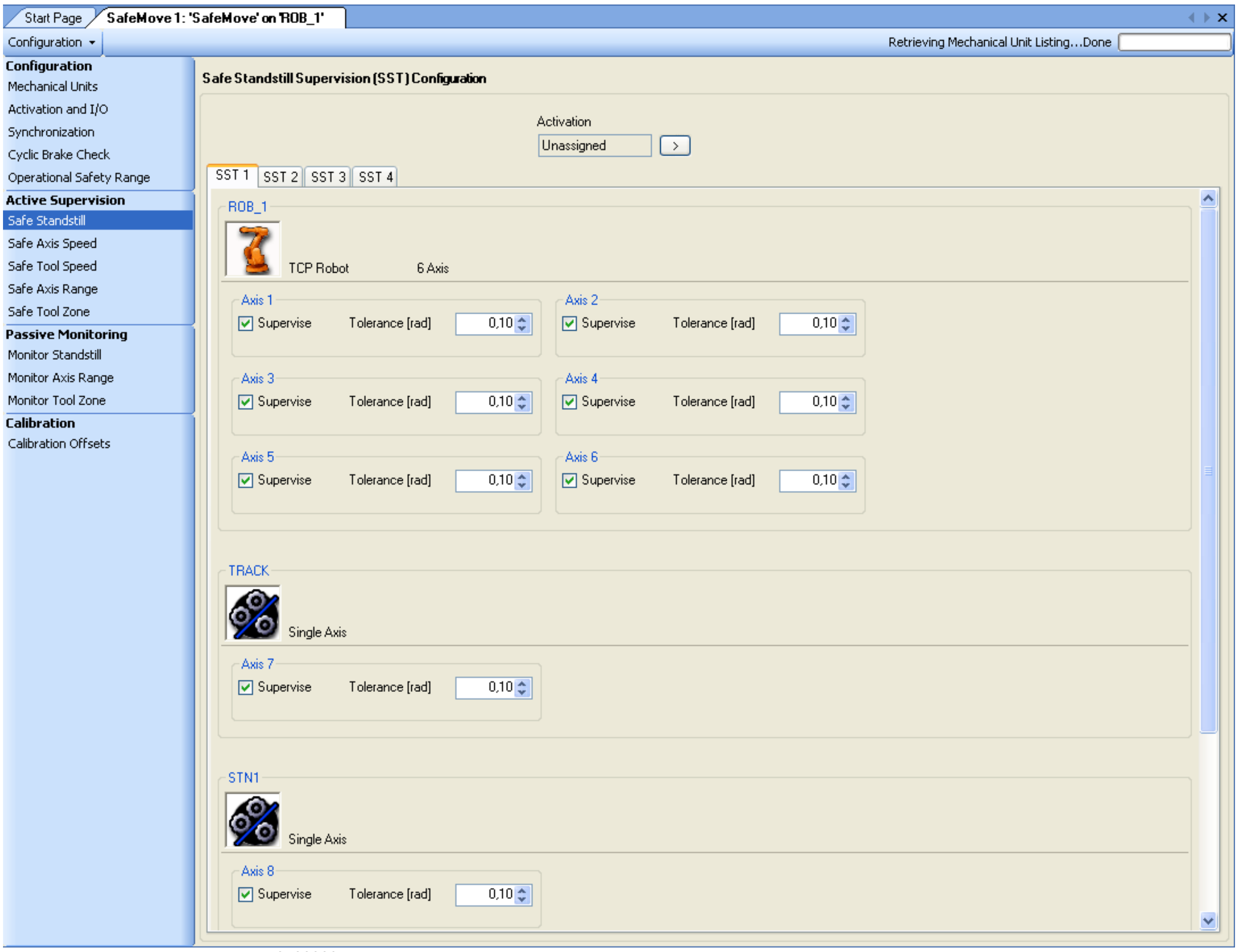
To activate Operational Safety Range, select the **Activate OSR** check box.

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

4.3.8. Safe Stand Still configuration

User interface appearance

Up to four Safe Stand Still sets can be configured and there is one tab for each set.



en0700000575

Select axes for the supervision set

Check the check box for all axes that should be supervised by the Safe Stand Still function.

Activation signal

The text box **Activation** shows the signal used to activate this function. The > button next to it is a short cut to **Activation and I/O**, where the activation signals are configured.

Set supervision tolerance for Safe Stand Still

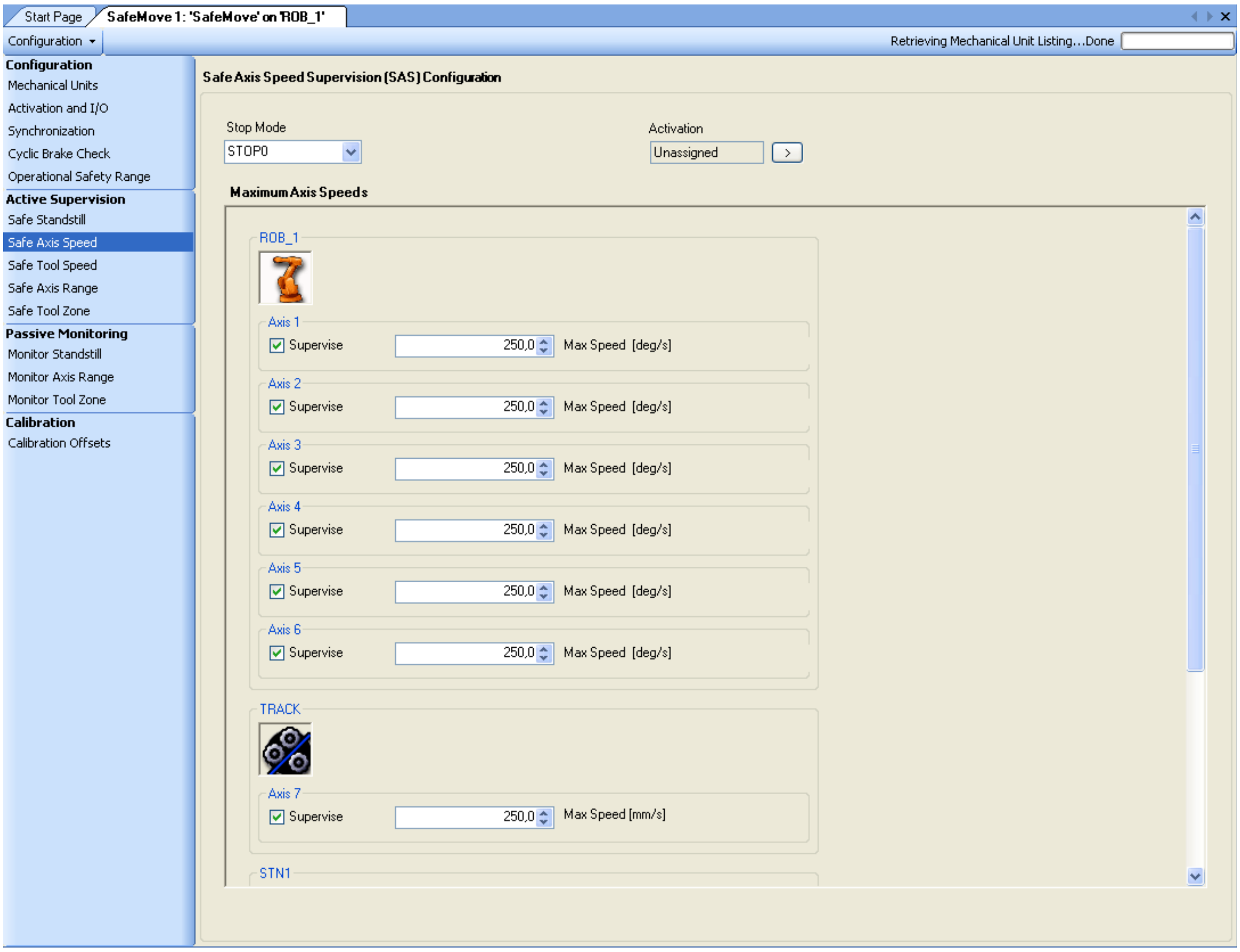
The supervision of movement limit is by default set to 0.1 radians on motor side. Depending on interference forces in Safe Stand Still mode (type loading forces), the limit can be set between 0.01 and 0.5 radians.

NOTE!

Do not use larger value than necessary. An increased value increases the robot movement if an error occurs.

4.3.9. Safe Axis Speed configuration

User interface appearance



en0700000576

Stop Mode

Select from **Stop Mode** if an axis speed violation should result in a category 0 stop or a category 1 stop. For descriptions of stop categories, see *Terminology on page 16*.

Activation signal

The text box **Activation** shows the signal used to activate this function. The > button next to it is a short cut to Activation and IO, where the activation signals are configured.

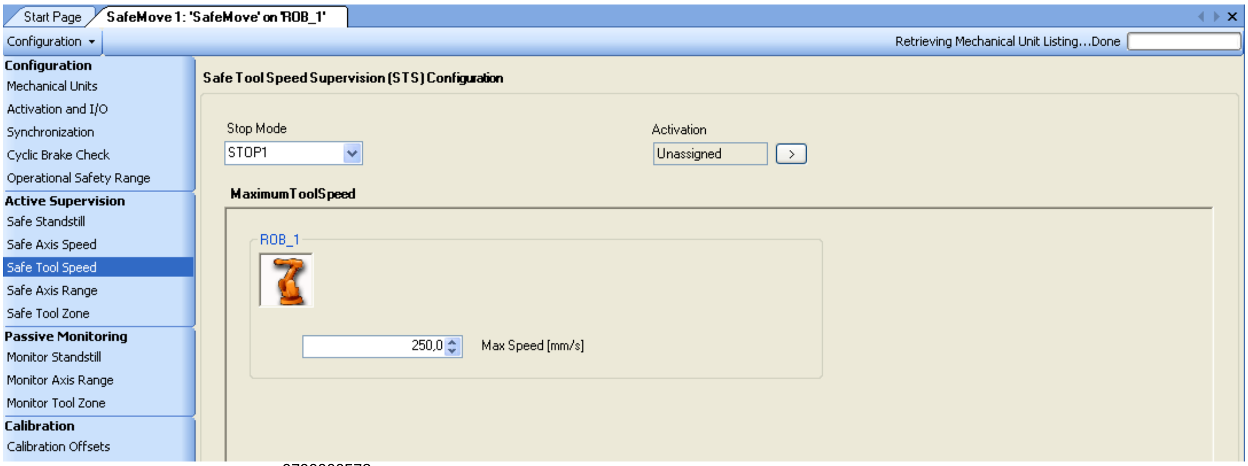
Set maximum speed for the axes

Check the check box **Supervise** for all axes that should be supervised by the Safe Axis Speed function. For each of those axes, set the maximum allowed speed, in degrees/s or mm/s.

The highest maximum speed that can be configured is 0-3600 degrees/s for rotational axes and 0-10000 mm/s for linear axes.

4.3.10. Safe Tool Speed configuration

User interface appearance



en0700000578

Stop Mode

Select from **Stop Mode** if a tool speed violation should result in a category 0 stop or a category 1 stop. For descriptions of stop categories, see *Terminology on page 16*.

Activation signal

The text box **Activation** shows the signal used to activate this function. The > button next to it is a short cut to Activation and IO, where the activation signals are configured.

Set maximum allowed tool speed

The maximum allowed speed (in mm/s) for the tool center point (TCP), tool0 and elbow relative to world coordinate system should be specified in **Max Speed**.

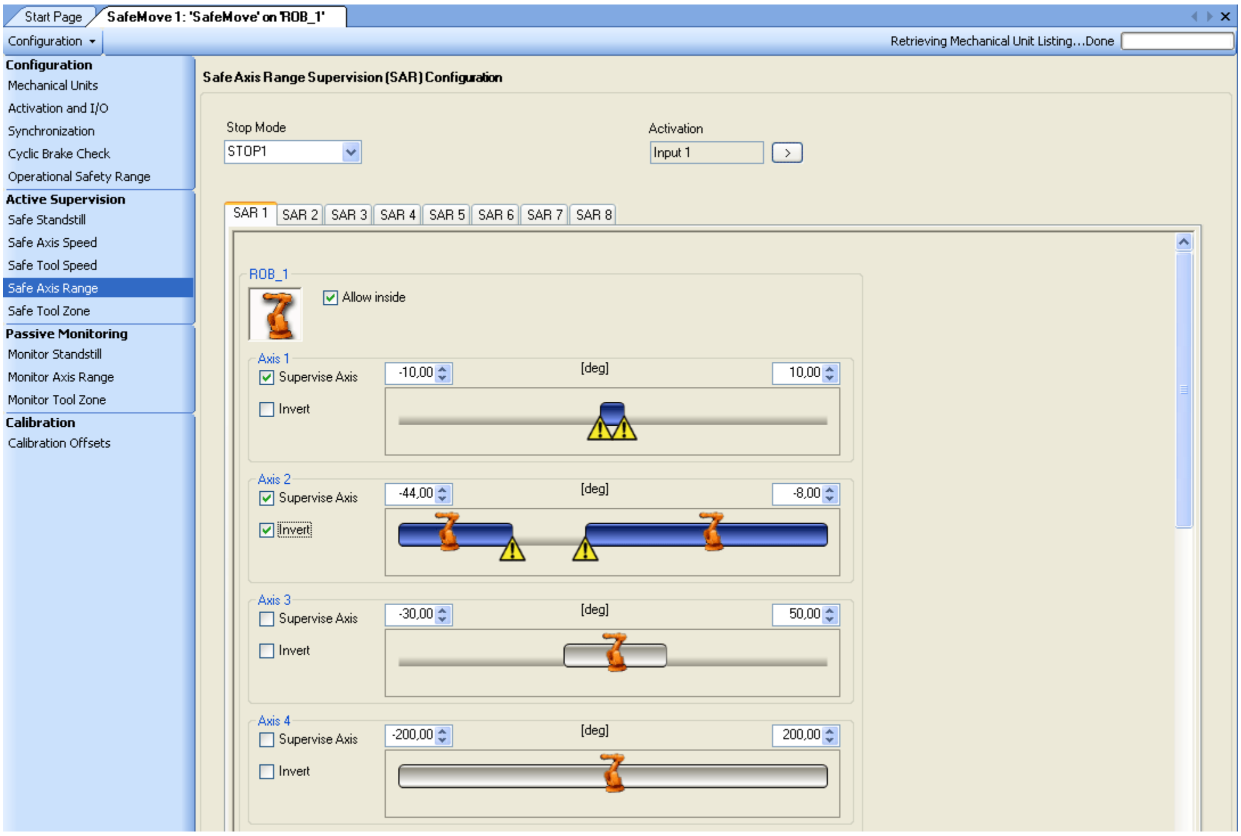
NOTE!

Note that the tool must be correctly declared in order for the TCP speed to be calculated correctly.

4.3.11. Safe Axis Range configuration

User interface appearance

Up to 8 Safe Axis Range sets can be configured and there is one tab for each set.



en0700000581

Stop Mode

Select from **Stop Mode** if an axis position violation should result in a category 0 stop or a category 1 stop. For descriptions of stop categories, see *Terminology on page 16*.

Activation signal

The text box **Activation** shows the signal used to activate this function. The > button next to it is a short cut to Activation and IO, where the activation signals are configured.

Set axis ranges

For each axis where you want to define an axis range, check the box **Supervise Axis**. Set the range by dragging the markers along the slide bar or write values in the boxes above the slide bar. The defined ranges is shown in blue on the scale.

By checking the box **Invert** for an axis the defined range is now outside the markers.

The defined range where the robot is allowed to be is illustrated with an icon of a robot.

The robot stops when one (or more) axis is outside its allowed range.

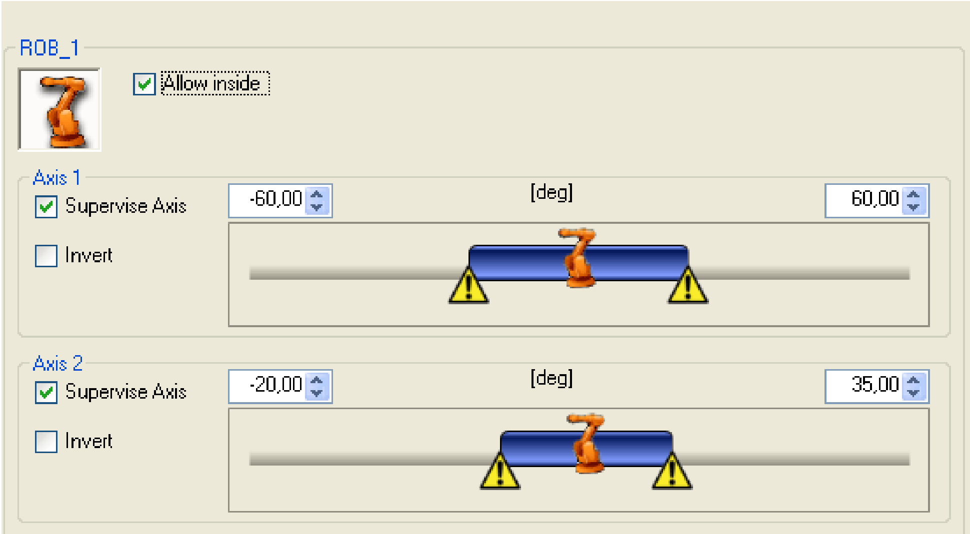
Continues on next page

Allow inside

By unchecking **Allow Inside**, the logical output of the function is inverted. This means that a robot position is only considered forbidden if all configured axes are inside their defined ranges.

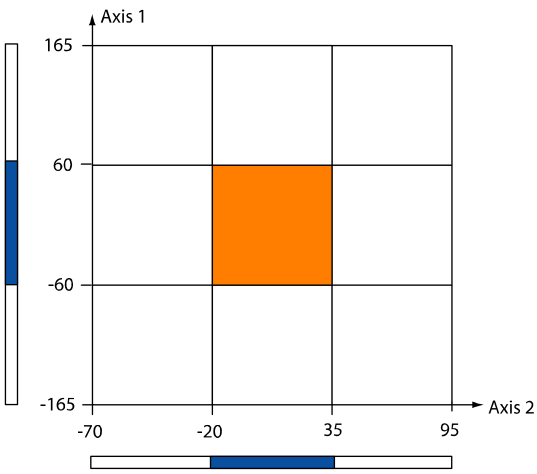
Allow inside checked and not inverted axis ranges

If **Allow inside** is checked and the axis ranges are not inverted, the robot's allowed zone (where the robot can move) is when all axes are inside their defined ranges.



en0700000680

The robot's allowed zone corresponds to the orange area in the graph below.



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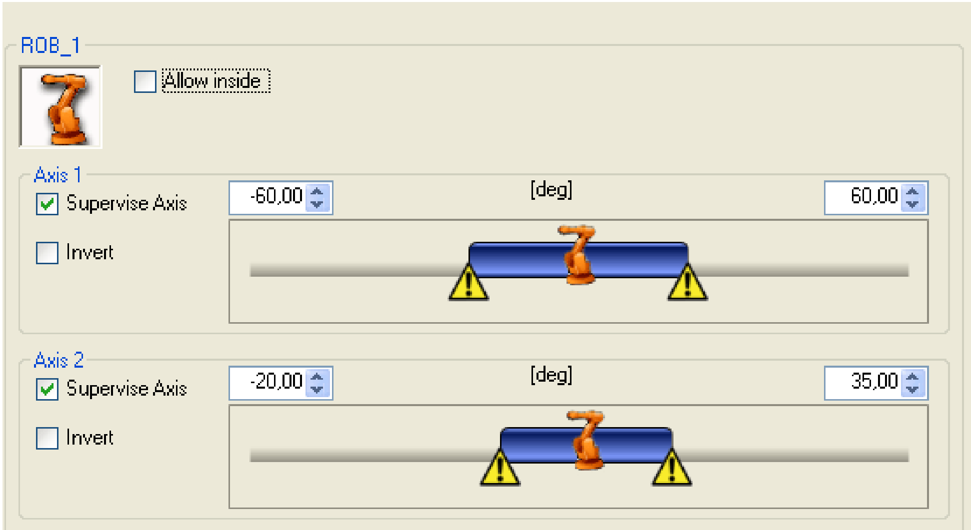
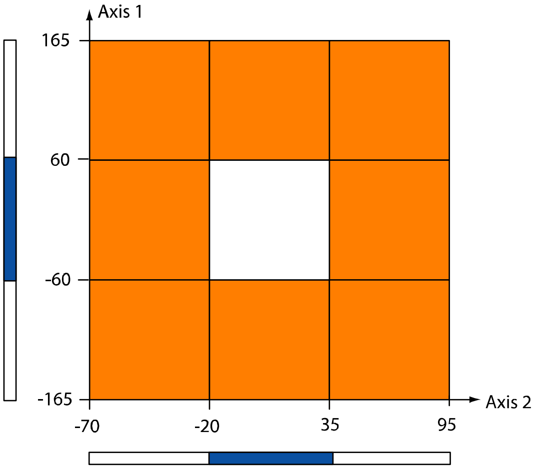
Allow inside unchecked and not inverted axis ranges

If **Allow inside** is unchecked and the axis ranges are not inverted, the robot's allowed zone is everywhere except where all axes are inside their defined ranges.



en0700000681

The robot's allowed zone corresponds to the orange area in the graph below.

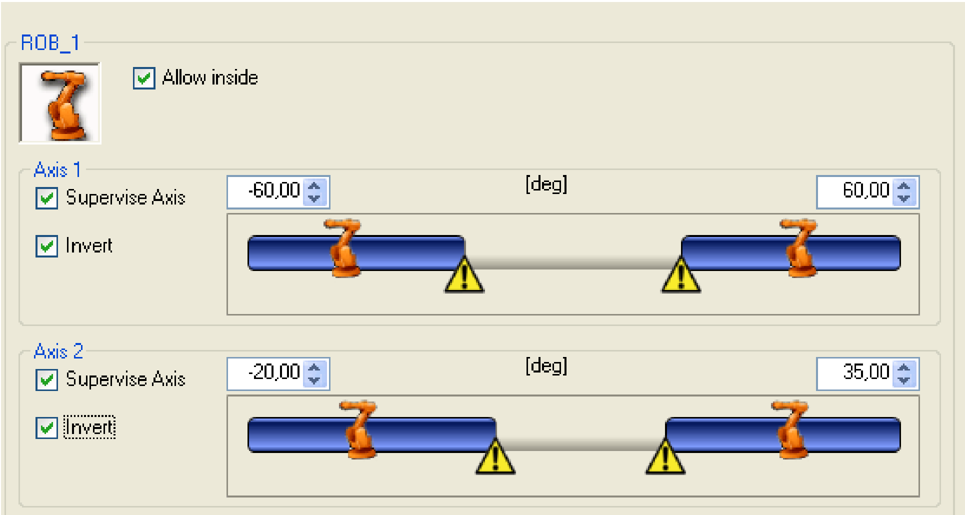


en0700000589

Continues on next page

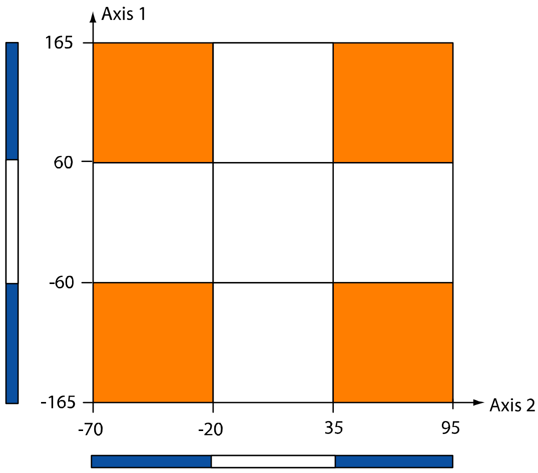
Allow inside checked and inverted axis ranges

If **Allow inside** is checked and the axis ranges are inverted, the robot's allowed zone is when all axes are inside their defined ranges (outside the markers of the slide bar).



en0700000682

The robot's allowed zone corresponds to the orange area in the graph below.

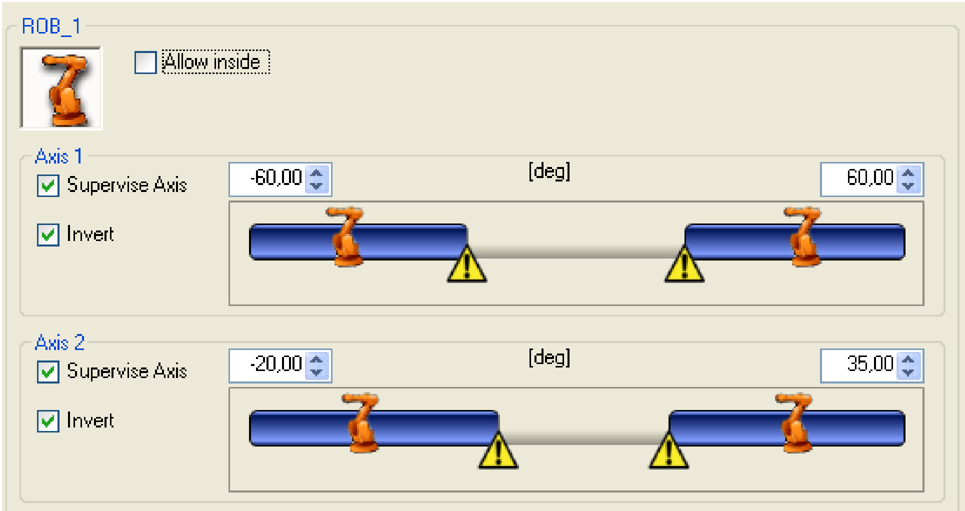


en0700000590

Continues on next page

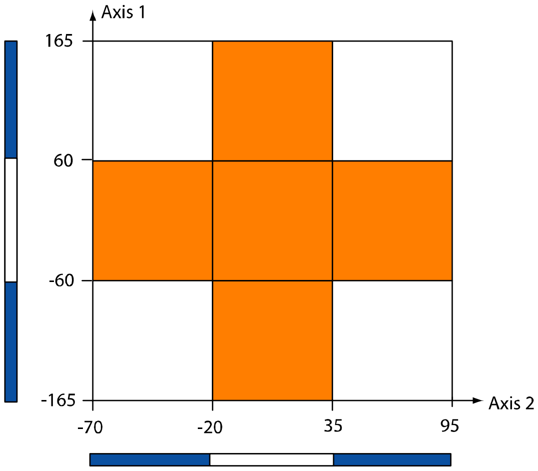
Allow inside unchecked and inverted axis ranges

If **Allow inside** is unchecked and the axis ranges are inverted, the robot's allowed zone is when one of the axes is outside the defined range (between the markers of the slide bar).



en0700000683

The robot's allowed zone corresponds to the orange area in the graph below.

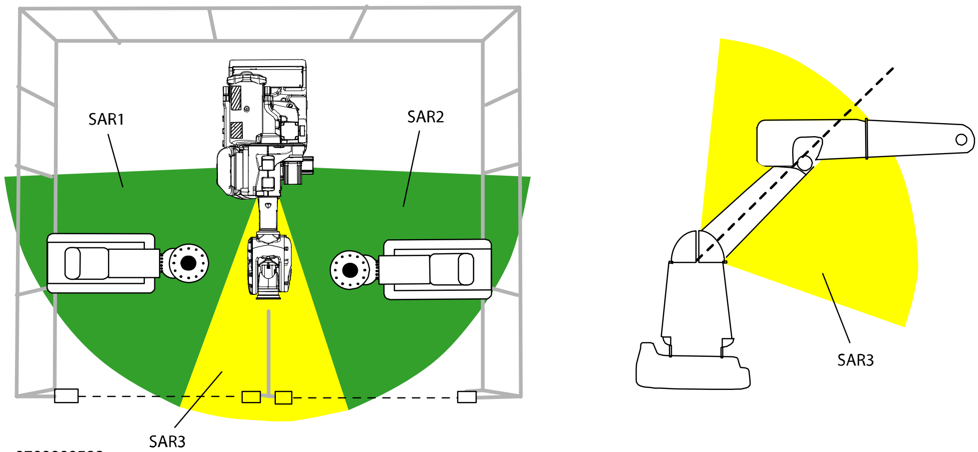


en0700000591

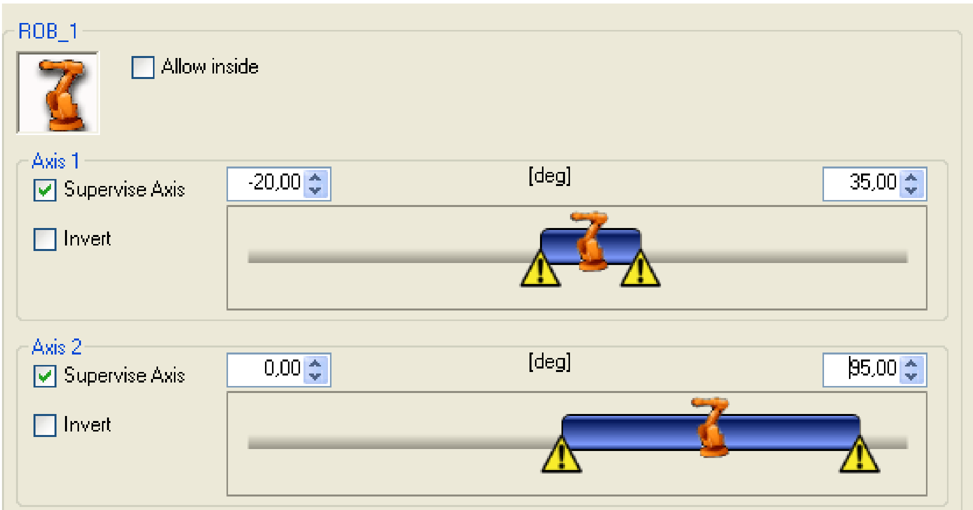
Continues on next page

Example of how to use allow inside

A robot may have two working areas defined by axis ranges for axis 1 (SAR1 and SAR2). 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 SAR3 as axis one being between SAR1 and SAR2 and axis 2 pointing forward, and inverting the function, the SAR3 function will stop the robot if both axis 1 and axis 2 are pointing strait forward.



xx0700000583

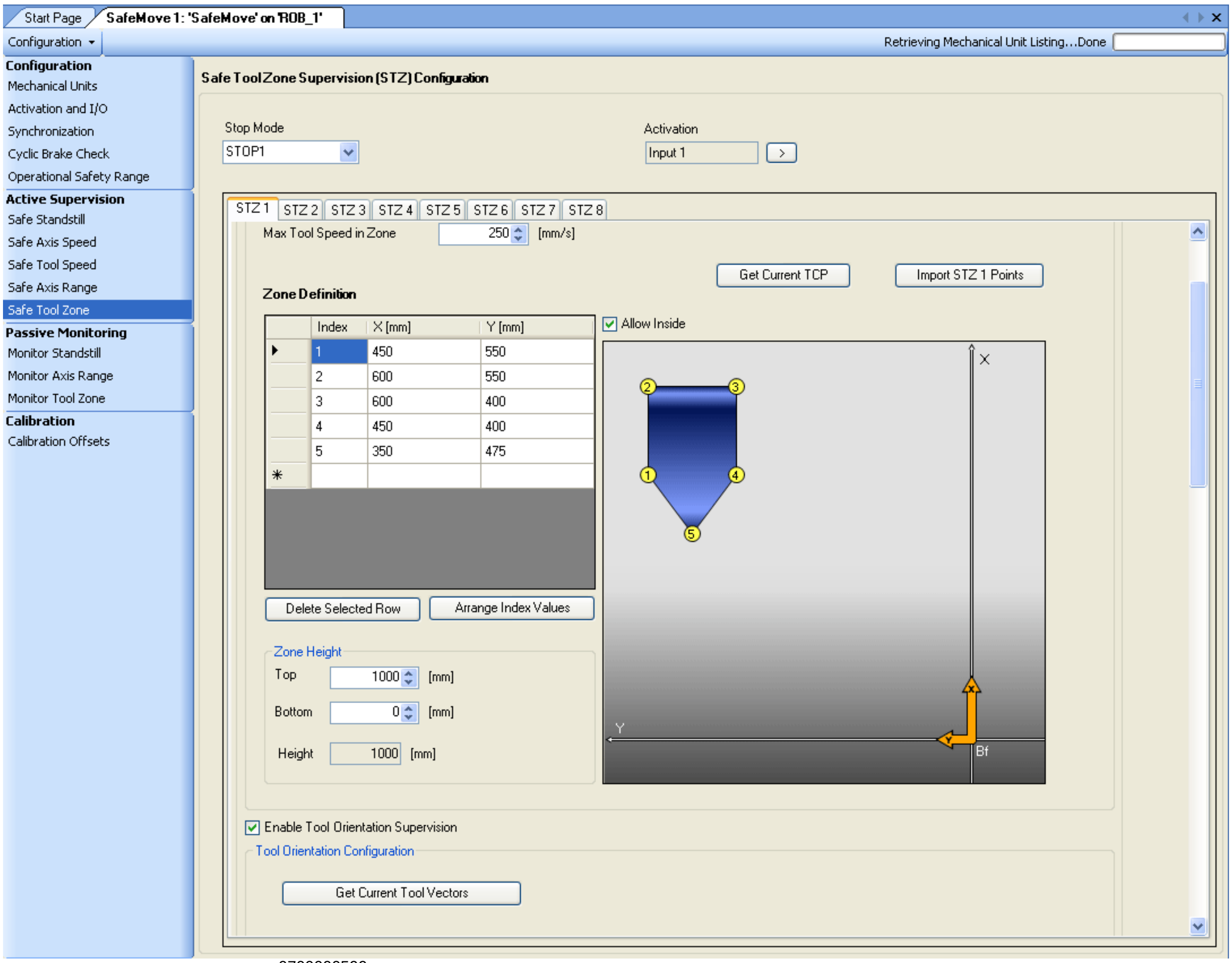


en0700000593

4.3.12. Safe Tool Zone configuration

User interface appearance

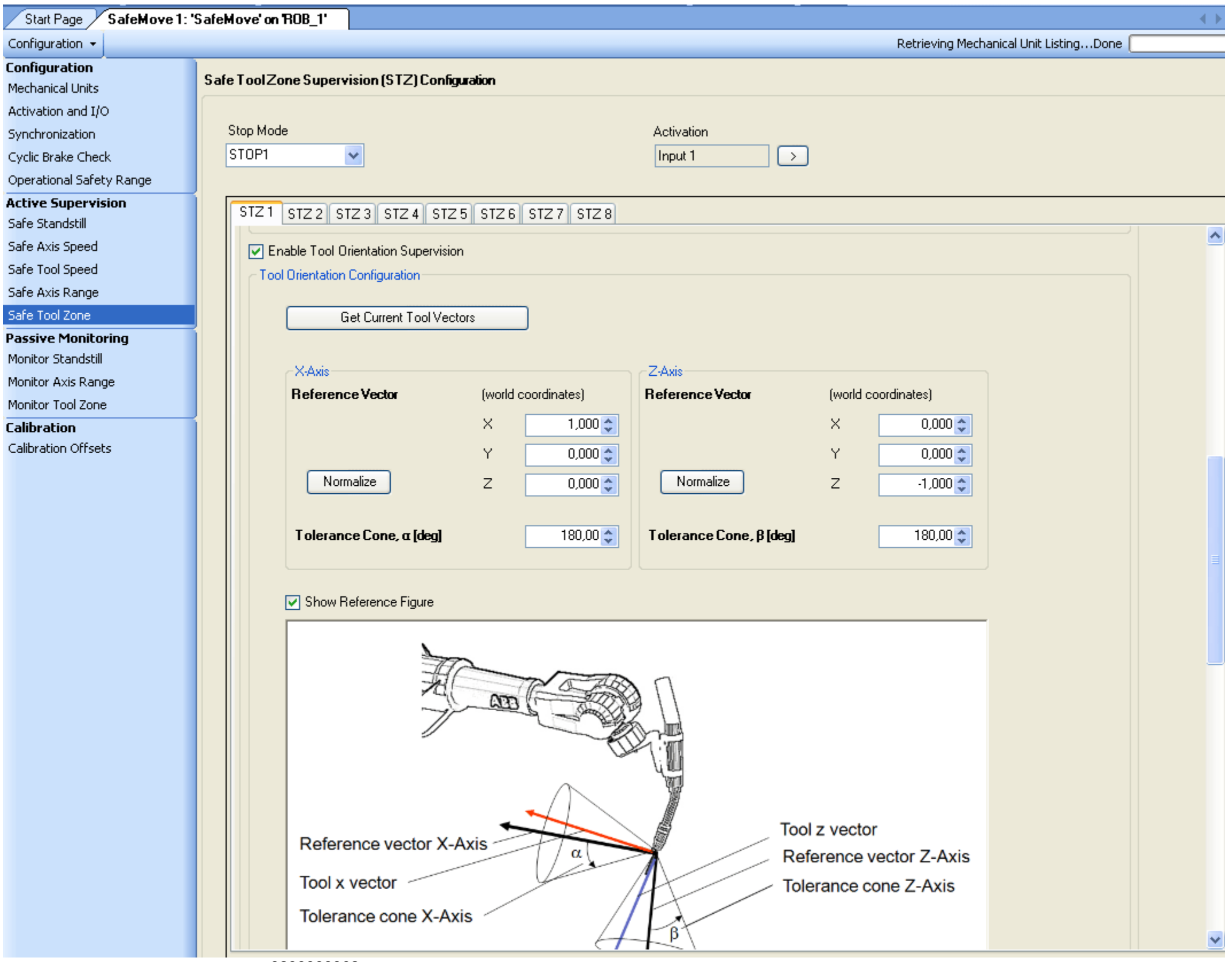
Up to 8 Safe Tool Zone sets can be configured and there is one tab for each set.



en0700000599

Continues on next page

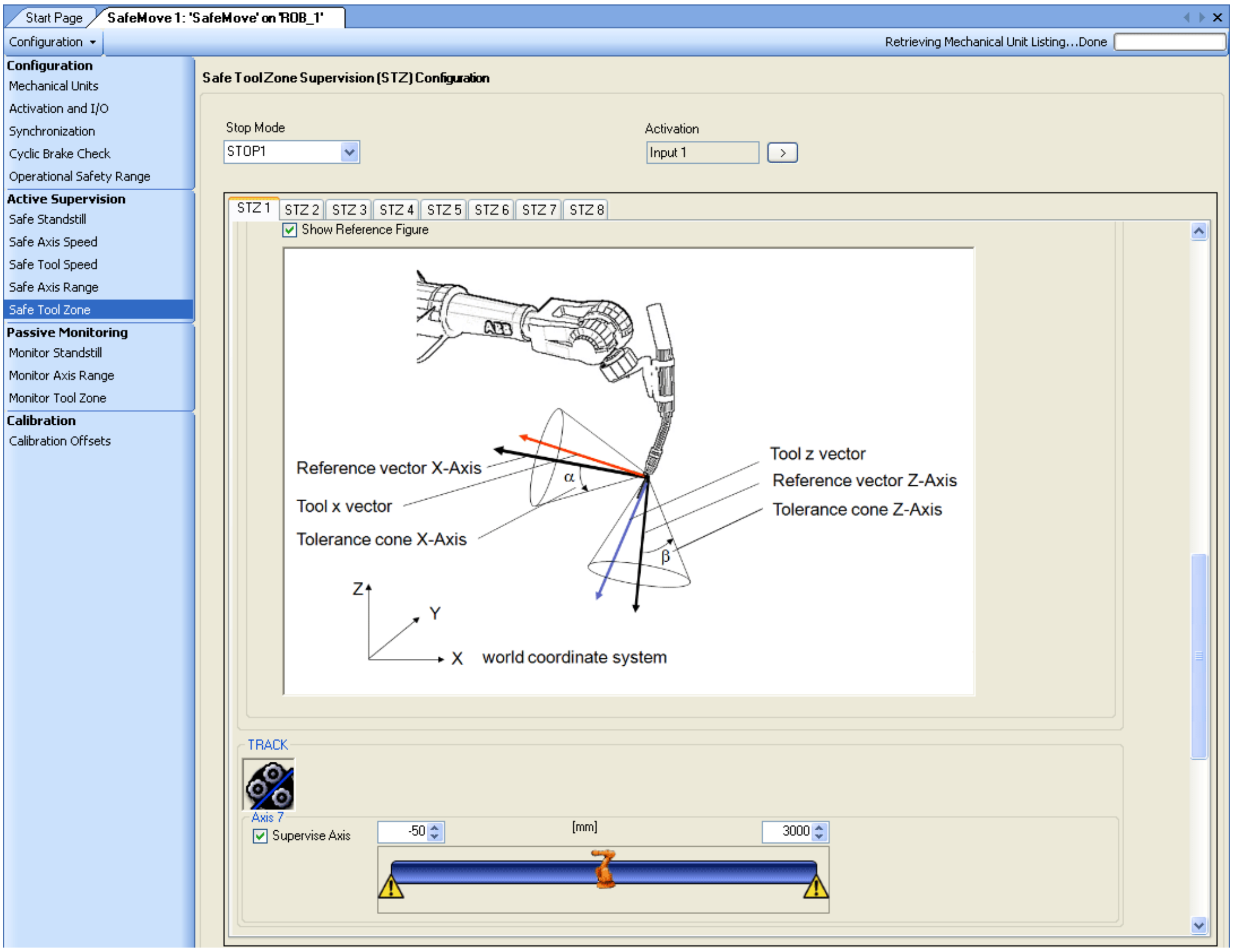
The following picture shows the tool orientation configuration.



en0800000068

Continues on next page

The following picture shows the working range for external axes.



en0800000069

NOTE!

Safe Tool Zone is defined in the world coordinate system. Values that are typed or imported from a file must be given in the world coordinate system.

NOTE!

Safe Tool Zone must always be configured for the same tool that should be supervised during production.

NOTE!

Safe Tool Zone cannot be used for more than one tool. If a robot is equipped with a tool changer it is recommended to configure Safe Tool Zone for tool0. Note that there must be enough margin to allow for the largest tool that is being used.

Stop Mode

Select from **Stop Mode** if a Safe Tool Zone violation should result in a category 0 stop or a category 1 stop. For descriptions of stop categories, see *Terminology on page 16*.

Activation signal

The text box **Activation** shows the signal used to activate this function. The > button next to it is a short cut to Activation and I/O, where the activation signals are configured.

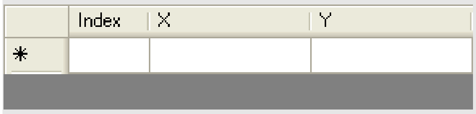
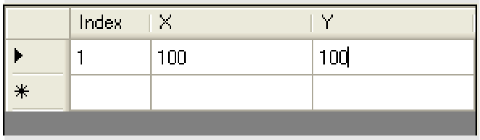
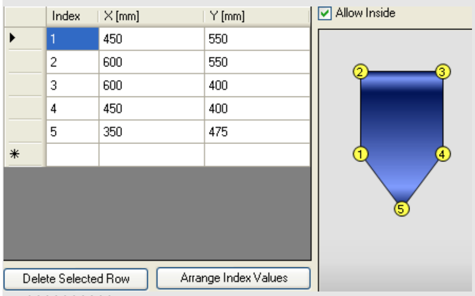
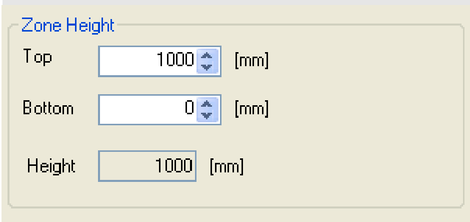
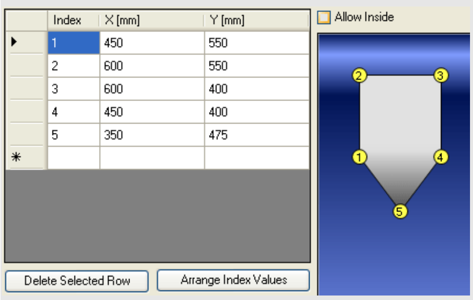
Continues on next page

Max tool speed

Set the maximum allowed tool speed in **Max Tool Speed in Zone**. The robot will stop if this speed is exceeded.

Zone Definition

The points that define the zone are typed manually.

	Action	Note/illustration
1.	Click on the first line and type "1" under **Index** and the first points x value under **X** and y value under **Y**.	 xx0700000698
2.	As the first line is filled out, a second line appears. Click on the second line and fill out index 2 and the x and y values for the second point.	 xx0700000699
3.	Fill out the rest of the points (3-8 points) needed to complete the zone. The shape of the zone is shown in the graphical display. To delete a row, select the row and click **Delete Selected Row**. To arrange the index values, click **Arrange Index Values**.	 en0800000209
4.	Under **Zone Height**, fill out the max and min values for z in **Top** and **Bottom**.	 en0800000066
5.	If the tool zone should be defined as outside the configured polygon, instead of inside, check the box **Allow Inside**.	 xx0700000700

Continues on next page

Get current TCP

When clicking the **Get Current TCP** button, the current TCP values appear in the table.

NOTE!

The TCP values are based on the active tool on the IRC5 controller and not the mechanical unit's defined TCP.

Importing points

The button **Import STZ 1 Points** can only be used if a RAPID system module has been installed.

Tool Orientation Configuration

The tool orientation does not have to be configured. To allow any tool orientation, clear the check box **Enable Tool Orientation Configuration**.

To configure an allowed tool orientation, check **Enable Tool Orientation Supervision**. Jog the robot so that the tool gets the orientation it should have. Click on **Get Current Tool Vectors**. Now the values for the **Reference Vectors** are updated, and these vectors coincide with the tool coordinate vectors for the current robot position and the current active tool on the IRC5 controller. Set the **Tolerance Cone** for both X and Z directions by defining the angles α and β.

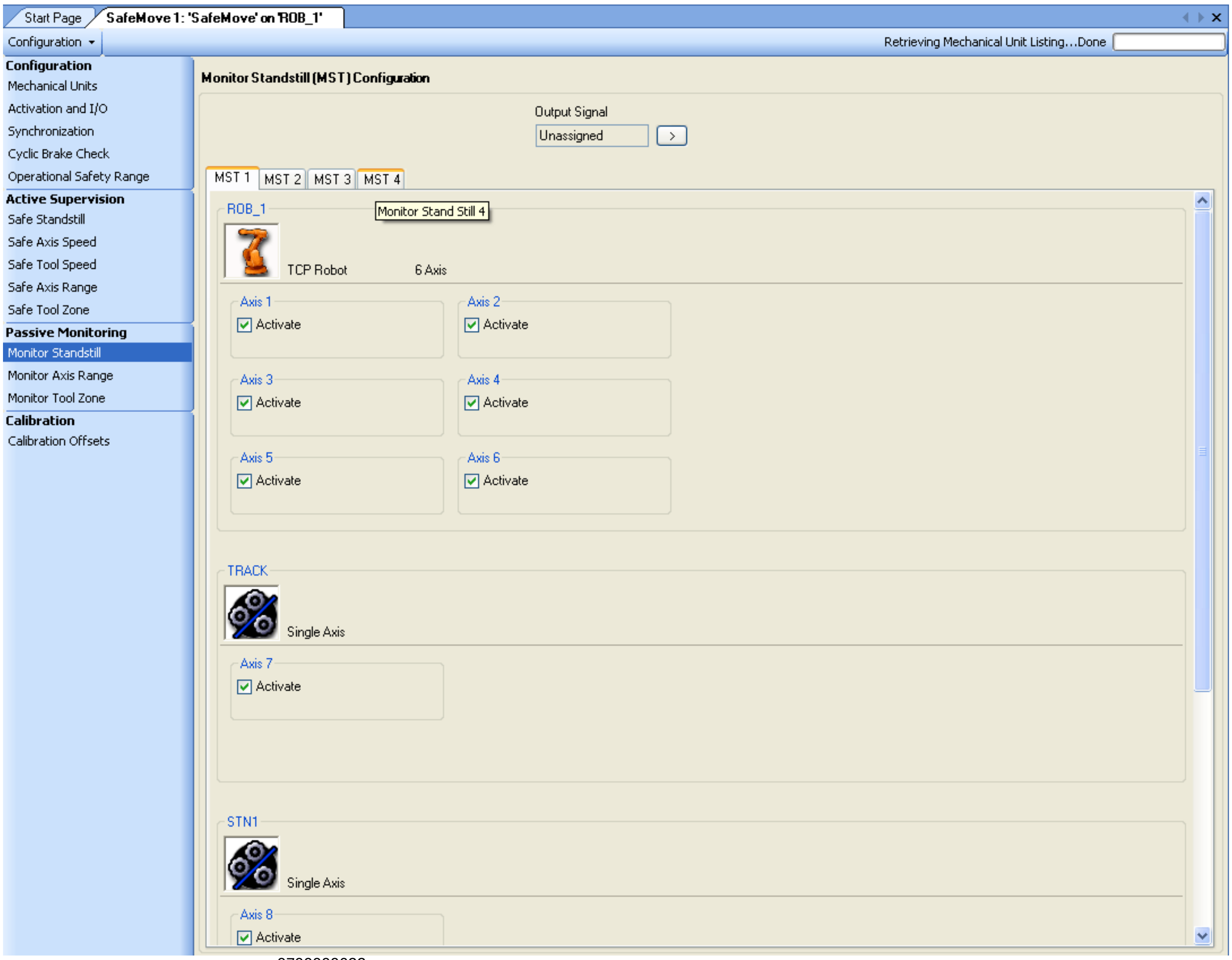
NOTE!

Tool reference vectors are defined in the world coordinate system.

4.3.13. Monitor Stand Still configuration

User interface appearance

Up to four Monitor Stand Still sets can be configured and there is one tab for each set.



en0700000622

Select axes for the monitoring set

Check the check box **Activate** for all axes that should be monitored by the Monitor Stand Still function.

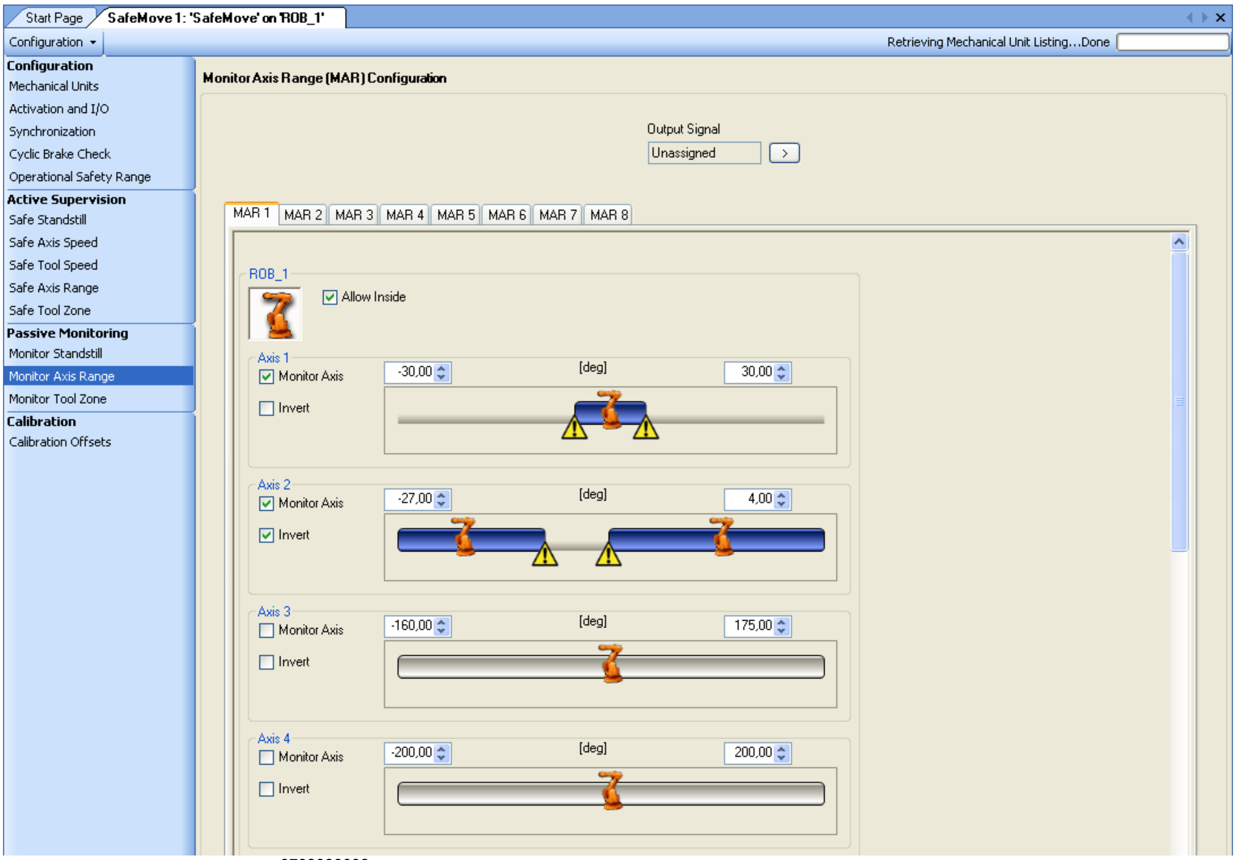
Output signal

The text box **Output Signal** shows the output signal set by this function. The > button next to it is a short cut to Activation and I/O, where the output signals are configured.

4.3.14. Monitor Axis Range configuration

User interface appearance

Up to 8 Monitor Axis Range sets can be configured and there is one tab for each set.



en0700000608

Output signal

The text box **Output Signal** shows the output signal set by this function. The > button next to it is a short cut to Activation and I/O, where the output signals are configured.

Set axis ranges

For each axis where you want to define an axis range, check the box **Monitor Axis**. Set the range by dragging the markers along the slide bar or write values in the boxes above the slide bar. The defined range is blue on the scale.

By checking the box **Invert** for an axis the defined range is now between the markers.

The output signal goes low when one (or more) axis is outside its defined range.

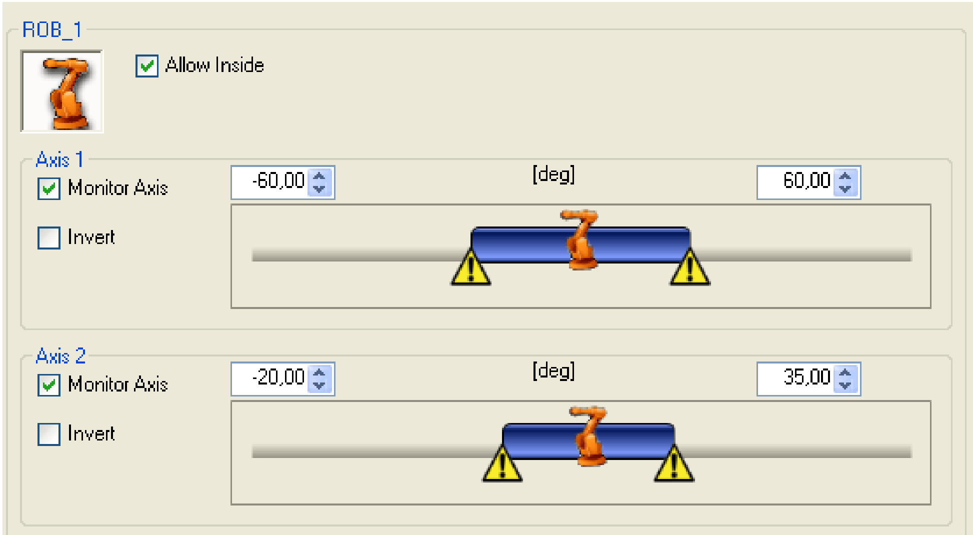
Continues on next page

Allow inside

By unchecking **Allow Inside**, the logical output of the function is inverted.

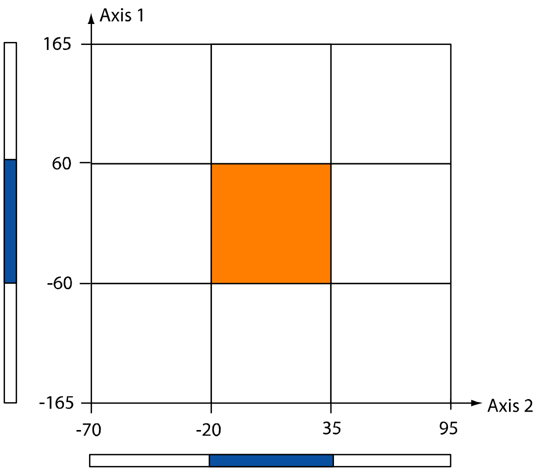
Allow inside checked and not inverted axis ranges

If **Allow inside** is checked and the axis ranges are not inverted, the output signal is set low when one axis is outside its defined range.



en0700000610

The signal stays high as long as the robot is in the orange area, and the signal goes low if the robot is in the white area, in the graph below.

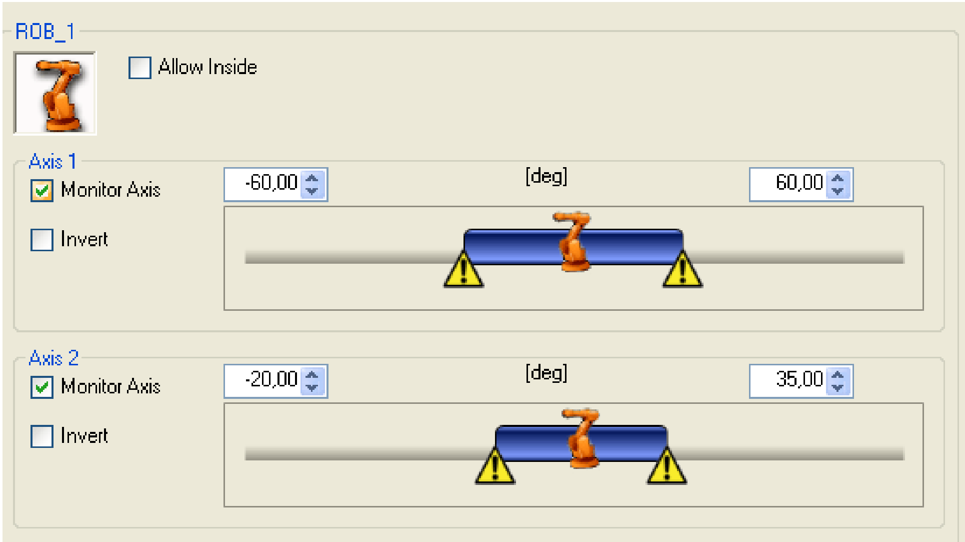


en0700000587

Continues on next page

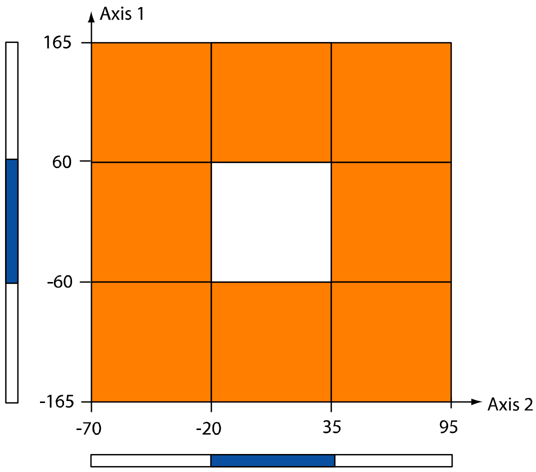
Allow inside unchecked and not inverted axis ranges

If **Allow inside** is unchecked and the axis ranges are not inverted, the output signal is set low when all configured axes are in the defined range.



en0700000686

The signal stays high as long as the robot is in the orange area, and the signal goes low if the robot is in the white area, in the graph below.

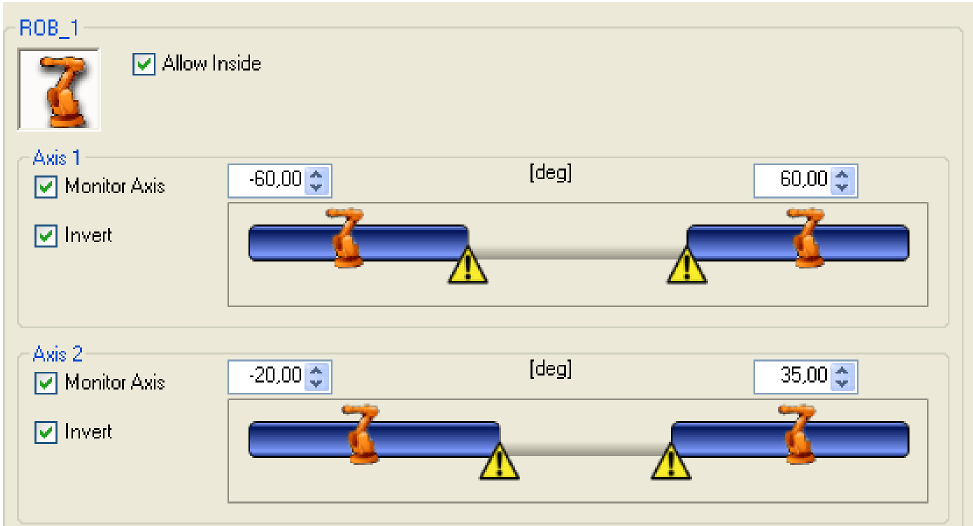


en0700000589

Continues on next page

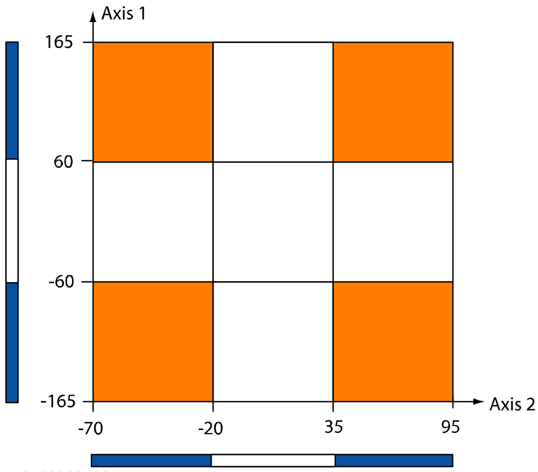
Allow inside checked and inverted axis ranges

If **Allow inside** is checked and the axis ranges are inverted, the signal goes low when one axis is in its undefined range (between the markers of the slide bar).



en0700000687

The signal stays high as long as the robot is in the orange area, and the signal goes low if the robot is in the white area, in the graph below.

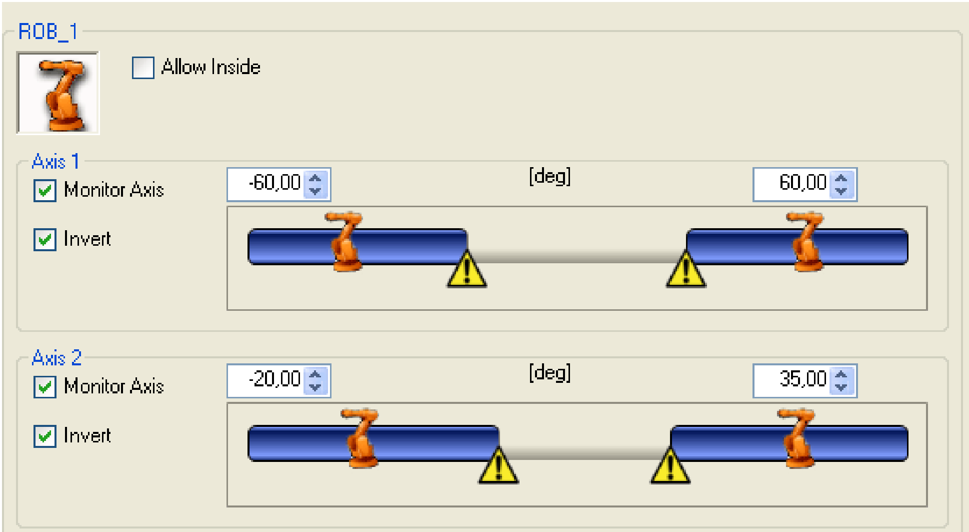


en0700000590

Continues on next page

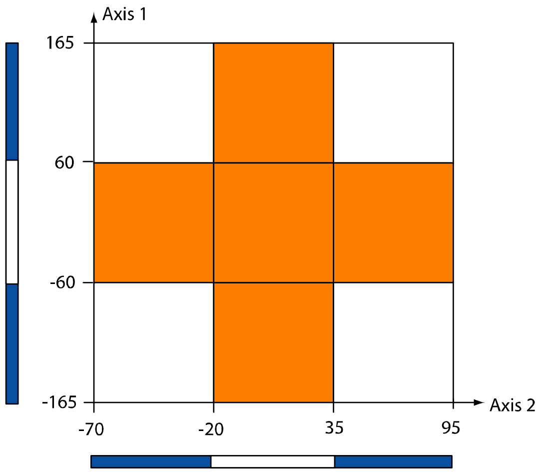
Allow inside unchecked and inverted axis ranges

If **Allow inside** is unchecked and the axis ranges are inverted, the signal will go low when all configured axes are in their defined ranges (outside the markers of the slide bar).



en0700000688

The signal stays high as long as the robot is in the orange area, and the signal goes low if the robot is in the white area, in the graph below.



en0700000591

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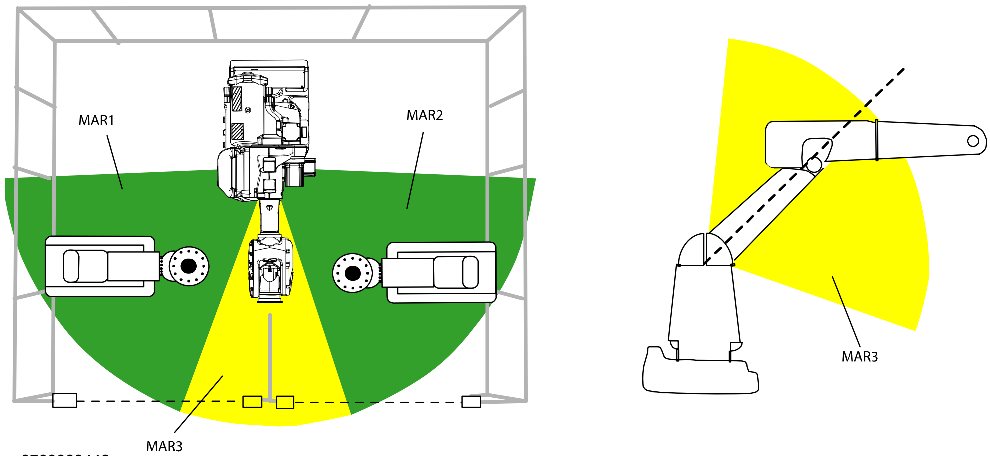
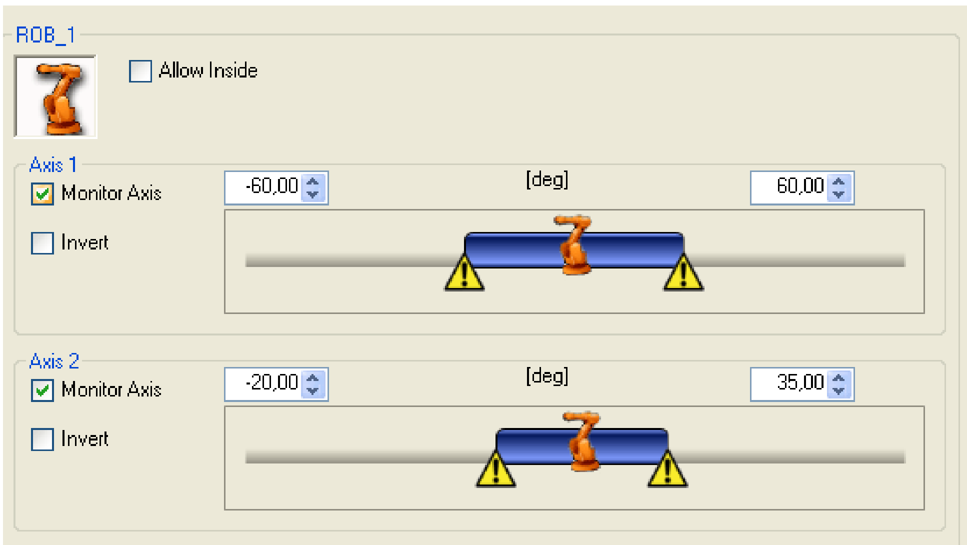
Example of how to use the allow inside

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 forward, and unchecking **Allow inside**, the MAR3 output signal will go low if both axis 1 and axis 2 are pointing strait forward.



xx0700000442

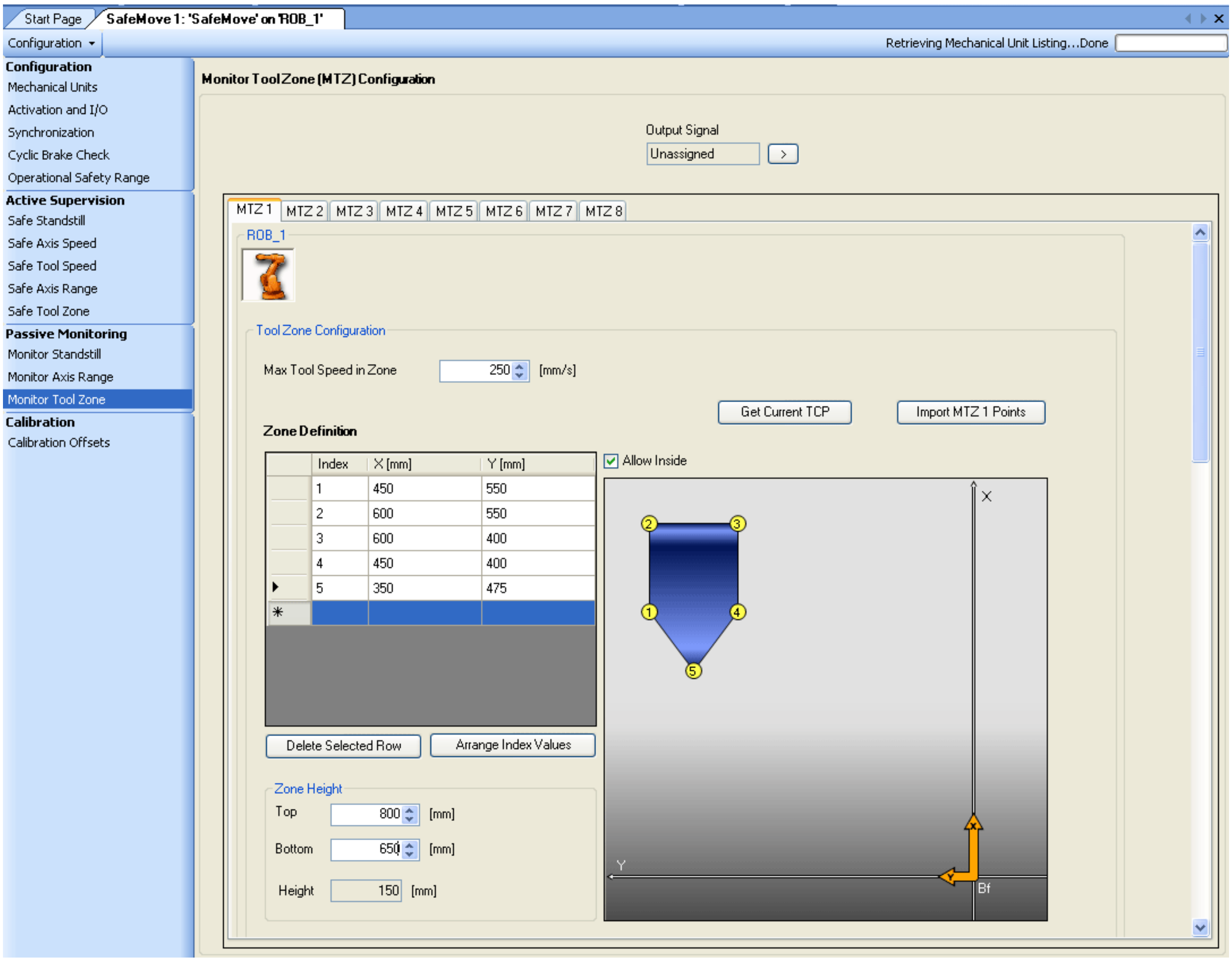


en0700000686

4.3.15. Monitor Tool Zone configuration

User interface appearance

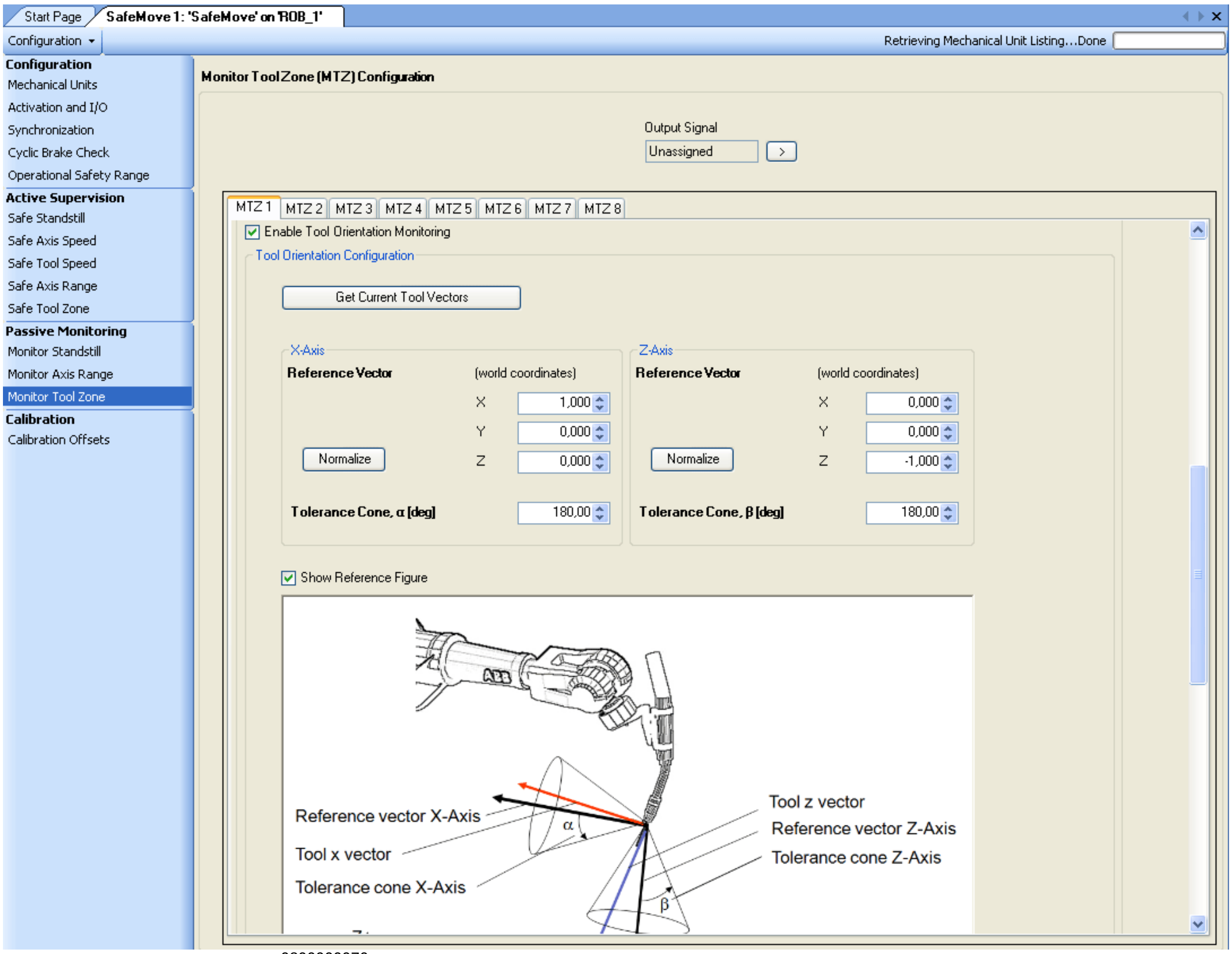
Up to 8 Monitor Tool Zone sets can be configured and there is one tab for each set.



en0700000701

Continues on next page

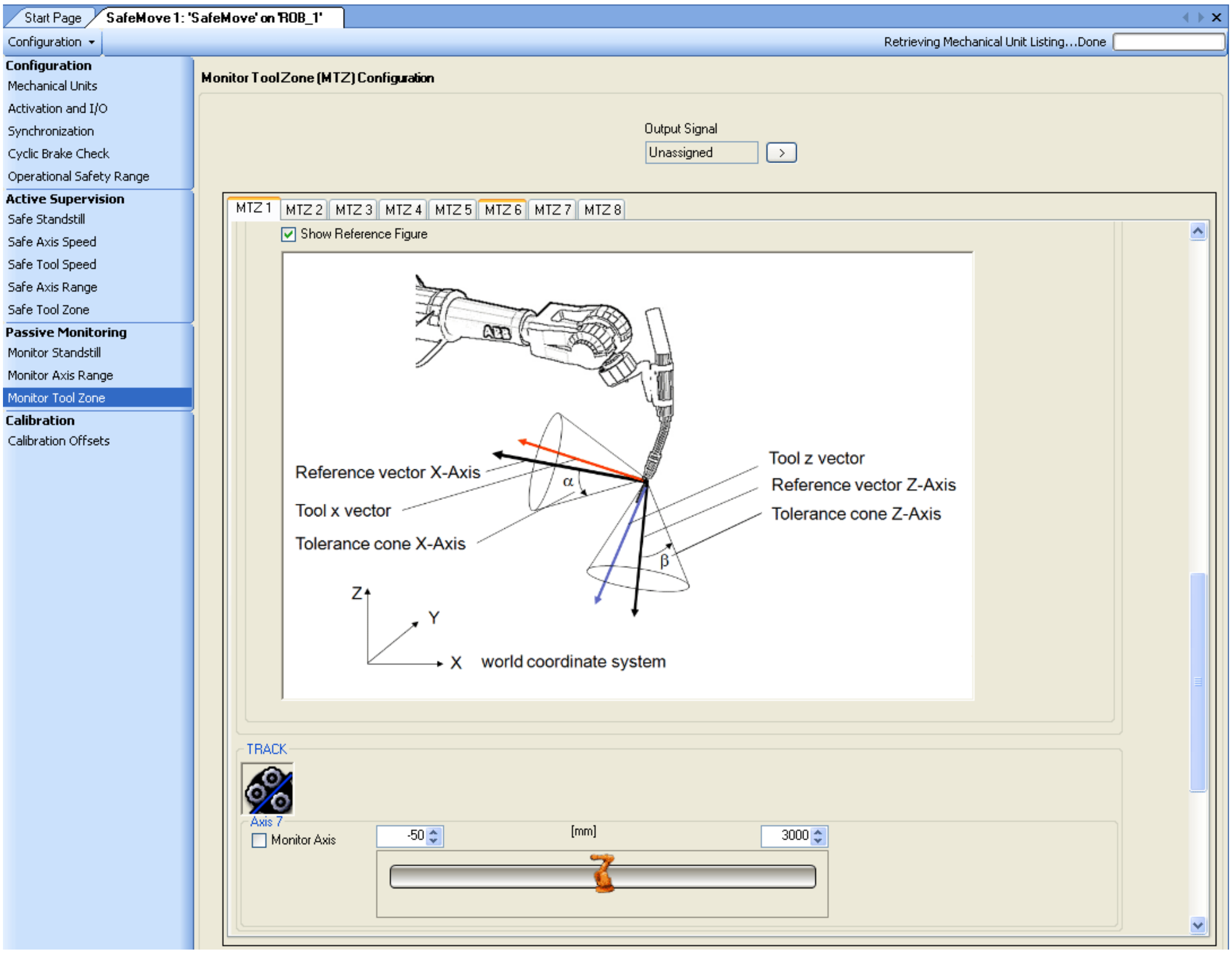
The following picture shows the tool orientation configuration.



en0800000070

Continues on next page

The following picture shows the working range for external axes.



en0800000071

NOTE!

Monitor Tool Zone is defined in the world coordinate system. Values that are typed or imported from a file must be given in the world coordinate system.

NOTE!

Monitor Tool Zone must always be configured for the same tool that should be supervised during production.

NOTE!

Monitor Tool Zone cannot be used for more than one tool. If a robot is equipped with a tool changer it is recommended to configure Monitor Tool Zone for tool0. Note that there must be enough margin to allow for the largest tool that is being used.

Output signal

The text box **Output Signal** shows the output signal set by this function. The > button next to it is a short cut to **Activation and I/O**, where the output signals are configured.

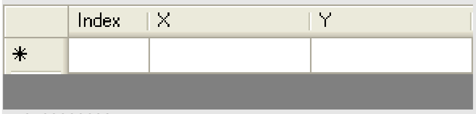
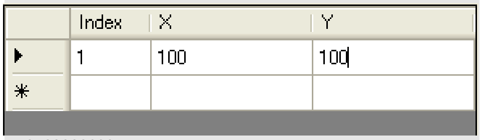
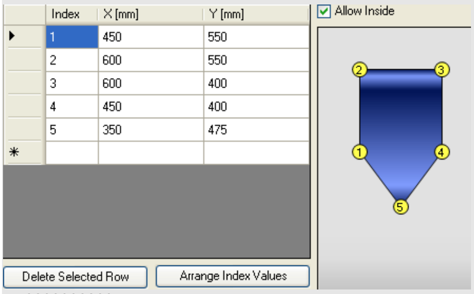
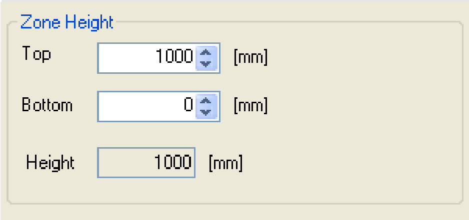
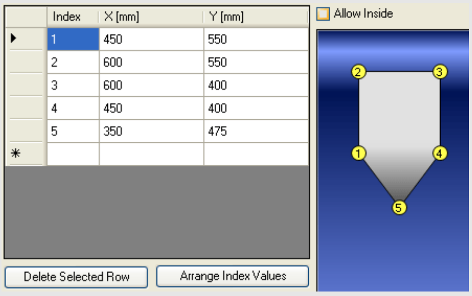
Max tool speed

Set the maximum tool speed in **Max Tool Speed in Zone**. The signal configured for this function will go low if the speed is exceeded.

Continues on next page

Zone Definition

The points that define the zone are typed manually.

	Action	Note/illustration
1.	Click on the first line and type "1" under **Index** and the first points x value under **X** and y value under **Y**.	 xx0700000698
2.	As the first line is filled out, a second line appears. Click on the second line and fill out index 2 and the x and y values for the second point.	 xx0700000699
3.	Fill out the rest of the points (3-8 points) needed to complete the zone. The shape of the zone is shown in the graphical display. To delete a row, select the row and click **Delete Selected Row**. To arrange the index values, click **Arrange Index Values**.	 en0800000209
4.	Under **Zone Height**, fill out the max and min values for z in **Top** and **Bottom**.	 en0800000066
5.	If the tool zone should be defined as outside the configured polygon, instead of inside, check the box **Allow Inside**.	 xx0700000700

Continues on next page

Get current TCP

When clicking the **Get Current TCP** button, the current TCP values appear in the table.

NOTE!

The TCP values are based on the active tool on the IRC5 controller and not the mechanical unit's defined TCP.

Importing points

The button **Import MTZ 1 Points** can only be used if a RAPID system module is imported.

Tool Orientation Configuration

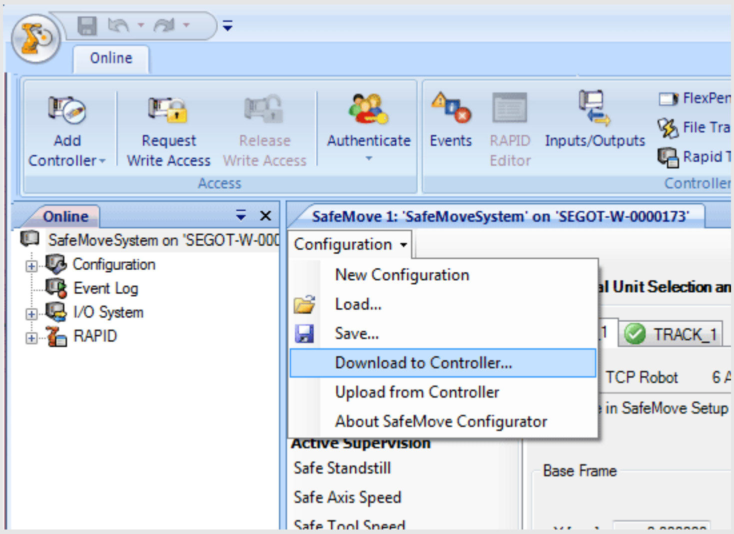
The tool orientation does not have to be configured. To exclude tool orientation from the monitoring, clear the check box **Enable Tool Orientation Configuration**.

To configure a tool orientation, check **Enable Tool Orientation Supervision**. Jog the robot so that the tool gets the orientation it should have. Click on **Get Current Tool Reference Vectors**. Set the **Tolerance Cone** for both X and Z directions.

4.3.16. Save and download to safety controller

Download configuration to the safety controller

	Action
1.	Click on **Configuration** and then select **Download to Controller**.

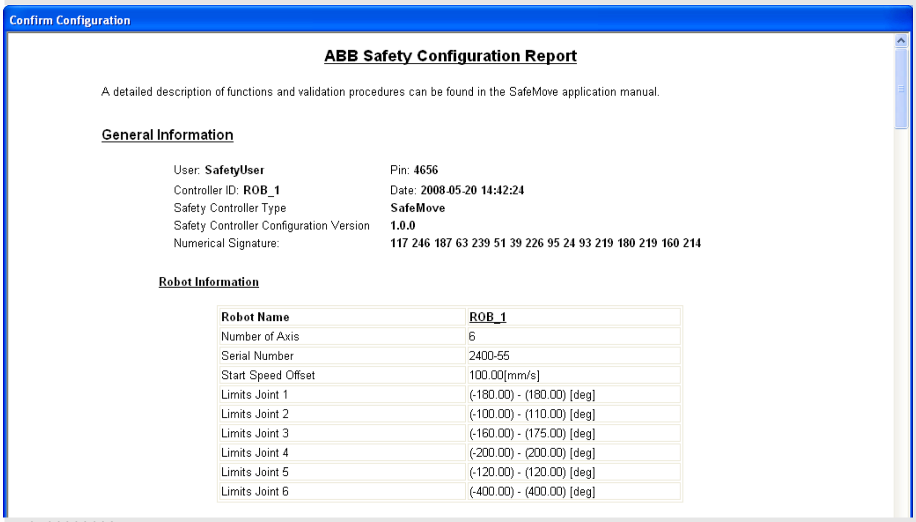


en0700000690

NOTE!

This does not download the calibration data. See also *Save and load calibration offset on page 71*.

	Action
2.	A report of the safety configuration is shown.



en0700000693

The report can be printed by clicking on **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 111*).

Click **OK** to close the report.

Continues on next page

	Action
3.	A dialog with the PIN code for the configuration file is shown. Write this PIN code down. You will need it when activating the safety configuration on your system, see *Activating the safety configuration on page 109*. The PIN code is also available in the Safety Configuration Report. Click **OK** to close the dialog.

Save the configuration

	Action
1.	Click on **Configuration** and then select **Save**. It is possible to store the current configuration on your local file system.
2.	Select a file name and location for the file. Click on **Save**.

Load a saved configuration

	Action
1.	Click on **Configuration** and then select **Load**. It is possible to load a saved configuration from your local file system
2.	Browse and select a file. Click on **Open**.

Get configuration from safety controller

It is possible to upload the configuration from the safety controller to the SafeMove Configurator. This makes it easy to view the configuration or to make changes to it and download it again.

Click on **Configuration** and then select **Upload from controller**.

Start a new safety configuration

To reset the SafeMove Configurator to its default values and start a new configuration:

Click on **Configuration** and then select **New Configuration**.

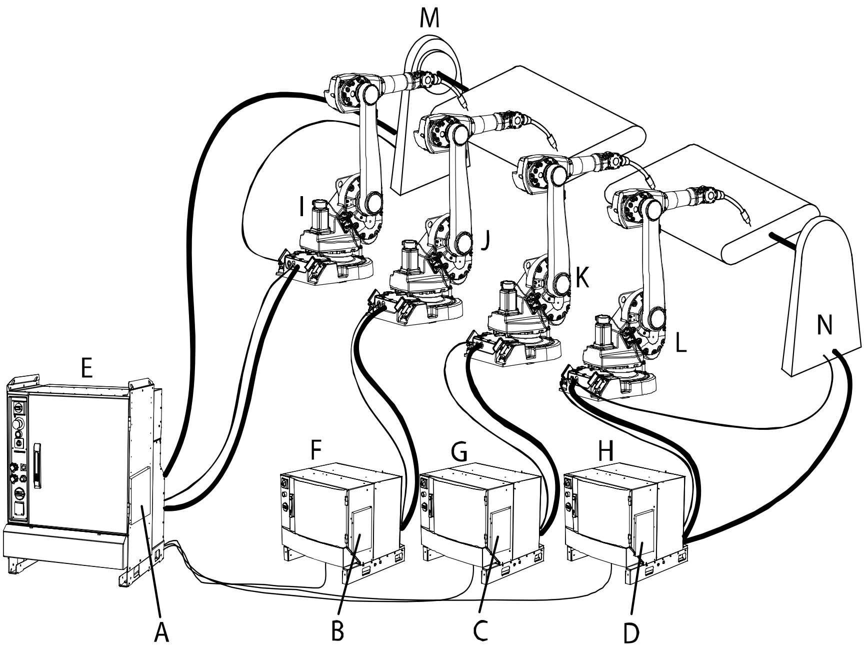
4.4 Configuration for MultiMove

4.4.1. Configuration for MultiMove

Configuration file corresponding to drive module

In a MultiMove system there is one safety controller for each drive module that uses SafeMove. 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



en0600003310

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 SafeMove for MultiMove

When configuring a MultiMove system, configure the first safety controller as described in *Configuring SafeMove on page 63* (in the example above: robot 1 and additional axis 1).

When the first configuration file is downloaded to the safety controller, click on the **Tools** menu and select **SafeMove Configurator** followed by **Safety Controller 2**. Configure the SafeMove functions for the mechanical units connected to drive module 2.

Repeat this procedure once for every safety controller and make sure the selected drive module corresponds to the mechanical units configured.

As default all axes in a MultiMove system are executed during brake test. If not all drive modules are equipped with safety controllers, it is possible to exclude brake test for axes not supervised in SafeMove. This is done by setting the motion configuration parameter *Deactivate Cyclic Brake Check for axis* to On. See *Configure system parameters on page 61*.

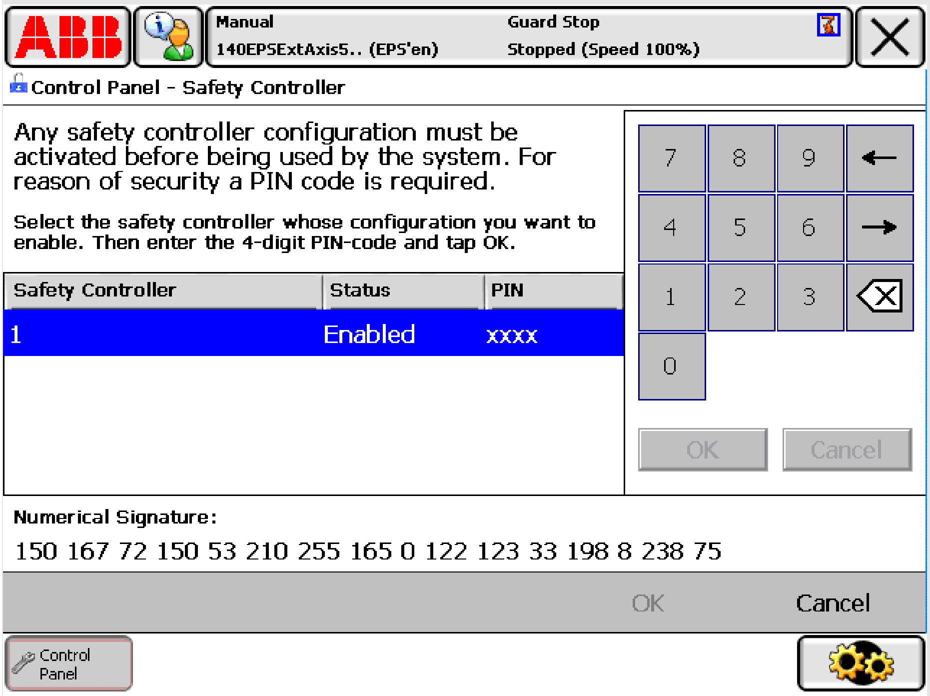
4.5 Activation of safety configuration

4.5.1. 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*Configuring SafeMove on page 63*).

Activation procedure

	Action
1.	When a safety configuration is downloaded to your robot system, the controller must be restarted (warm start).
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*Download configuration to the safety controller on page 105*). Tap **OK**. 3. For a MultiMove system, enter one PIN code for each configuration file. 4. Tap **OK**.  en0600003332

Continues on next page

	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.	The robot is now unsynchronized and cannot be moved. Press the motors on button to be allowed to move the robot in reduced speed for a configured time between 30 and 120 seconds.
8.	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 and supervision functions are deactivated until the sync check is performed. When the sync check is performed, an elog message (20452) will say that the robot is synchronized. The SafeMove functionality is now active (supervision functions only active if activation input signals are set).

Safety configuration active until cold start

Once activated, the safety configuration is constantly active. Neither warm start nor i-start of the controller will affect the safety configuration. However, a cold start of the controller will remove all safety configurations.

4.6 Validate the configuration

4.6.1. Validate the configuration

DANGER!

A SafeMove 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 43*.
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 43*.
4. Set up the synchronization position in the SafeMove Configurator. Also carry out a calibration offset.
5. Run the service routine for the function Cyclic Break Check.
6. Start the validation procedure.

About the validation

The safety configuration must be validated. This validation must be performed every time a safety controller is configured. The validation should verify that all axis ranges, tool zones, etc. are configured correctly in relation to the physical robot cell (operator stations, equipment, fences, etc.).

DANGER!

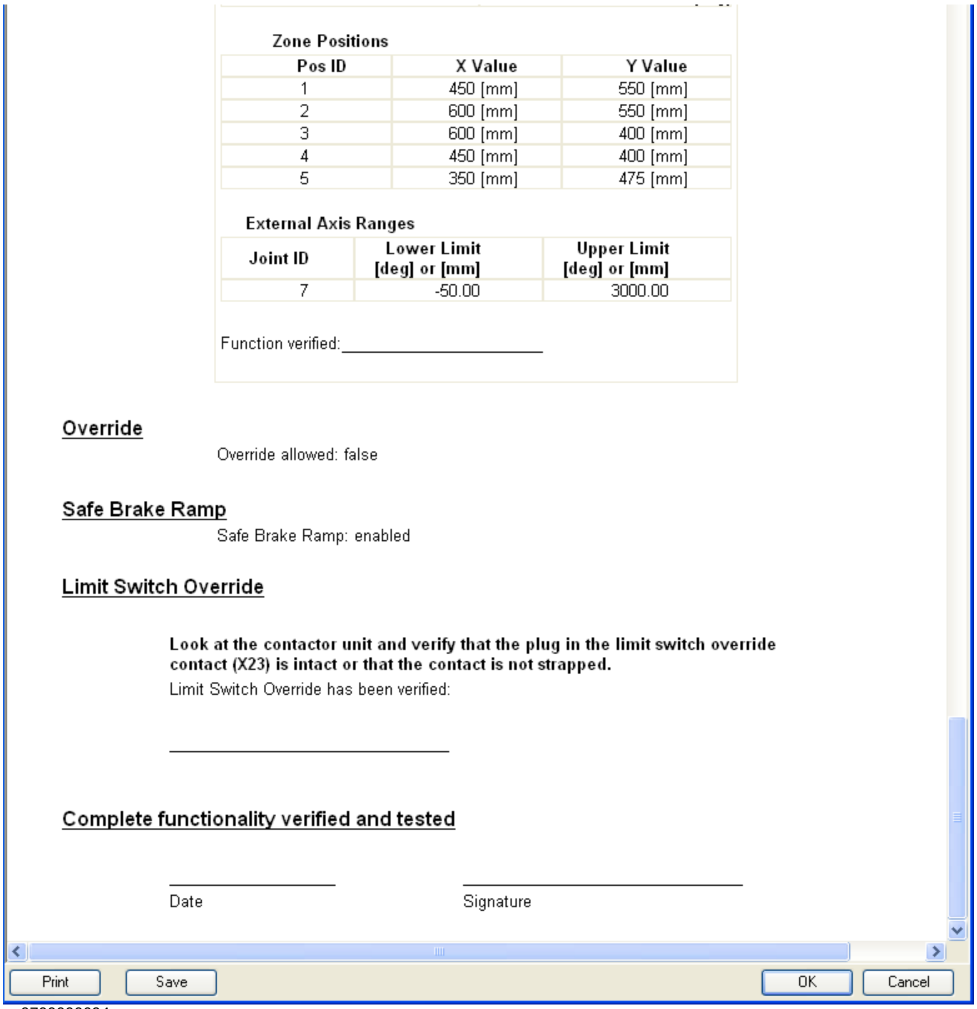
When validating the actual safety zones, brake distances must be taken into consideration, so that the SafeMove functions are configured with enough margin. If the robot hits the zone limit, it starts to brake and needs the brake distance to stop. This occurs outside the zone.

Note that if the robot starts accelerating strongly just before reaching a configurated speed zone or a position zone there will occur a speed overshoot before decelerating. This may result in a somewhat exceeded speed respective lengthened brake distance compared to a smoother speed situation.

Continues on next page

Sign the validation

The ABB Safety Configuration Report must be printed and used as a formal document for the validation. The document has rows where dates and signatures should be written when the configuration is validated.



Zone Positions

Pos ID	X Value	Y Value
1	450 [mm]	550 [mm]
2	600 [mm]	550 [mm]
3	600 [mm]	400 [mm]
4	450 [mm]	400 [mm]
5	350 [mm]	475 [mm]

External Axis Ranges

Joint ID	Lower Limit [deg] or [mm]	Upper Limit [deg] or [mm]
7	-50.00	3000.00

Function verified:____________________

Override

Override allowed: false

Safe Brake Ramp

Safe Brake Ramp: enabled

Limit Switch Override

Look at the contactor unit and verify that the plug in the limit switch override contact (X23) is intact or that the contact is not strapped.

Limit Switch Override has been verified:

____

Complete functionality verified and tested

________________ ____________________________

Date Signature

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Recovery after safety violation

The validation procedures test when the safety functions trigger. When a supervision function triggers, the robot will stop. Before you start this validation procedure make sure the robot system installation is ready, for example, cables must be connected etc.

To be able to move the robot again, the following must be performed:

	Action	Note
1.	Press the motors on button on the robot controller to confirm the violation.	For speed violations, it is enough with this confirmation. Steps 2-4 are not necessary.
2.	Activate the Override Operation input signal.	
3.	Jog the robot back to a position that does not trigger any supervision function.	
4.	Deactivate the Override Operation signal.	

Continues on next page

Operational Safety Range validation

Operational Safety Range only needs to be configured when using Soft Servo and Force Control. It cannot be verified unless Soft Servo is being used.

	Action	Expected result
1.	Make sure that Soft Servo is active and set the stiffness low.	
2.	Test the min limit of the axis range. Create RAPID program with a `MoveAbsJ` instruction moving the first configured axis with speed `vmax` from just inside the range for Operational Safety Range to a position outside the range.	
3.	Run the program. The Control Error Supervision will stop the robot as soon as the reference value reach the range limit of Operational Safety Range. Verify that this stop occurs where the min limit for this axis is supposed to be.	Elog 20464 shows that the robot has reached the limit of the range for Operational Safety Range.
4.	Test the max limit of the axis range. Create RAPID program with a `MoveAbsJ` instruction moving the first configured axis with speed `vmax` from just inside the range for Operational Safety Range to a position outside the range.	
5.	Run the program. The Control Error Supervision will stop the robot as soon as the reference value reach the range limit of Operational Safety Range. Verify that this stop occurs where the max limit for this axis is supposed to be.	Elog 20464 shows that the robot has reached the limit of the range for Operational Safety Range.
6.	Repeat the procedure for each axis configured for Operational Safety Range.	

Safe Stand Still validation

	Action	Expected result
1.	Activate the activation input signal for the Safe Stand Still set you want to validate. Deactivate all other supervision functions.	
2.	Jog the robot, one axis at a time, and verify that Safe Stand Still triggers every time an axis is moved.	Safe Stand Still will trigger.
3.	Jog all additional axes configured for Safe Stand Still, one axis at a time, and verify that Safe Stand Still triggers every time an axis is moved.	Safe Stand Still will trigger.

Continues on next page

Safe Axis Speed validation

TIP!

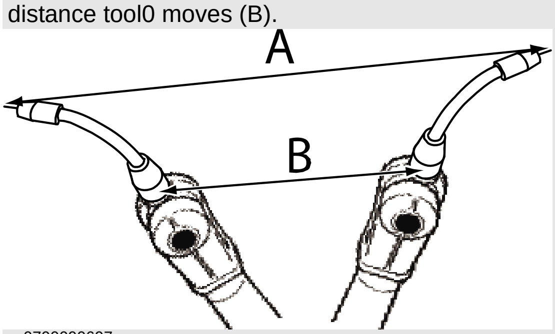
There is no easy way of ordering an axis to move at a specified angle speed. Use a `MoveAbsJ` instruction, rotating an axis 180 degrees, and clock the movement to get an estimated angle speed for the selected `speeddata`.

	Action	Expected result
1.	Activate the activation input signal for Safe Axis Speed. Deactivate all other supervision functions.	
2.	Create and run a RAPID program with a `MoveAbsJ` instruction moving the first configured axis with a speed slower than the configured Max Speed for that axis.	No triggered function.
3.	Change the program so that the axis is moved with a speed higher than the configured Max Speed.	Safe Axis Speed will trigger.
4.	Repeat the procedure for all axes configured for Safe Axis Speed.	

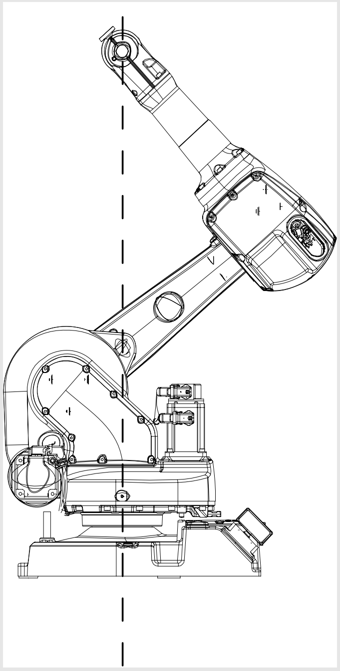
Safe Tool Speed validation

Validate all three points supervised by Safe Tool Speed:

- tool center point (TCP)
- tool0
- robot elbow (somewhere around axis 3)

	Action	Expected result
1.	Activate the activation input signal for Safe Tool Speed. Deactivate all other supervision functions.	
2.	Create and run a RAPID program with a `MoveL` instruction. The `Speed` argument should be slightly higher than the configured max speed. The `Tool` argument should be set to the tool that is to be supervised by Safe Tool Speed. To make sure it is the TCP that causes the speed violation, and not tool0, select the `robtargets` so that the TCP moves faster than the max speed, but tool0 does not. This can be accomplished if the distance the TCP moves (A) is greater than the distance tool0 moves (B).  xx0700000697	Safe Tool Speed will trigger.

Continues on next page

	Action	Expected result
3.	Change the RAPID program so that the `Tool` argument in the MoveL instruction is set to `tool0`. Set the speed so that tool0 moves slightly faster than the configured max speed.	Safe Tool Speed will trigger.
4.	Jog the robot to a position where the elbow is pointing out as much as possible, while the tool is close to the rotation axis of axis 1.  xx0700000696 Create and run a RAPID program with a `MoveAbsJ` instruction moving axis 1 fast enough for the elbow to exceed the configured max speed.	Safe Tool Speed will trigger.

Safe Axis Range validation

	Action	Expected result
1.	Activate the activation input signal for the Safe Axis Range set you want to validate. Deactivate all other supervision functions.	
2.	Jog the robot, one axis at a time, to the limit of the configured range. Verify that Safe Axis Range triggers when the axis is moved outside the configured range.	Safe Axis Range will trigger.
3.	Repeat this for all axes configured for Safe Axis Range, including additional axes.	

Continues on next page

Safe Tool Zone validation

	Action	Expected result
1.	Activate the activation input signal for the Safe Tool Zone set you want to validate. Deactivate all other supervision functions.	
2.	Jog the robot (linear jogging) to the border of the configured tool zone. Move the robot across all borders of the zone, including the max and min values in z direction. Verify that Safe Tool Zone triggers every time a border is crossed. If system is equipped with a track motion, check that the tool zone border is in correct position for different positions of the track motion.	Safe Tool Zone will trigger.
3.	Create and run a RAPID program with a `MoveL` instruction that moves inside the tool zone. The `Speed` argument should be slightly higher than the configured Max Tool Speed in Zone.	Safe Tool Zone will trigger.
4.	If a tool orientation supervision is configured, jog the robot (reorient jogging) to the tolerance limits of the tool orientation. Verify that Safe Tool Zone triggers for violation of both the tool's x direction and the tool's z direction.	Safe Tool Zone will trigger.
5.	Jog the configured additional axes, one axis at a time, to the limit of the configured range. Verify that Safe Tool Zone triggers when the axis is moved outside the configured range.	Safe Tool Zone will trigger.

Monitor Stand Still validation

	Action	Expected result
1.	Move the axis with medium high speed.	Monitor Stand Still output signals will go low.
2.	Stop movement of all axes.	After a short time the Monitor Stand Still output signals will go high.
3.	Move the axis with medium high speed.	Monitor Stand Still output signals will go low.
4.	Repeat the procedure for all axes configured for Safe Axis Speed.	

Monitor Axis Range validation

Jog the robot, one axis at a time, to the limit of the configured range. Verify that the signal configured for the Monitor Axis Range function goes low when the axis is moved outside the configured range.

Repeat this for all axes configured for Monitor Axis Range, including additional axes.

Continues on next page

Monitor Tool Zone validation

	Action	Expected result
1.	Jog the robot (linear jogging) to the border of the configured tool zone. Move the robot across all borders of the zone, including the max and min values in z direction. Verify that the signal configured for Monitor Tool Zone goes low every time a border is crossed. If system is equipped with a track motion, check that the tool zone border is in correct position for different positions of the track motion.	The signal configured for the Monitor Tool Zone function will go low.
2.	Create and run a RAPID program with a `MoveL` instruction that moves inside the tool zone. The `Speed` argument should be slightly higher than the configured Max Tool Speed in Zone.	The signal configured for the Monitor Tool Zone function will go low.
3.	If a tool orientation monitoring is configured, jog the robot (reorient jogging) to the tolerance limits of the tool orientation. Verify that the signal configured for Monitor Tool Zone goes low both when the tool's x direction exceeds its tolerance and when the tool's z direction exceeds its tolerance.	The signal configured for the Monitor Tool Zone function will go low.
4.	Jog the configured additional axes, one axis at a time, to the limit of the configured range. Verify that the signal configured for Monitor Tool Zone goes low when the axis is moved outside the configured range.	The signal configured for the Monitor Tool Zone function will go low.

Cyclic Brake Check validation

	Action	Expected result
1.	Call the service routine `CyclicBrakeCheck`.	No error messages.
2.	Wait the time specified in Brake Check Cycle, e.g. 24 hours, without performing a brake check.	
3.	If external axes are used, check the loaded brake parameters in the configuration.	

Safe Brake Ramp validation

If external axes are used, verify that the **Brake Data** parameters are configured according to descriptions in section *Brake Data on page 66*.

Verify that the contact for the limit switch override is plugged or not strapped

	Action	Note
1.	Look at the contactor unit and verify that the plug in the limit switch override contact (X23) is intact.	The limit switch override must be plugged and not used when using SafeMove.

5 Guidelines for synchronization and brake check

5.1. Synchronization guidelines

Dual channel or single channel

If dual channel switch is used, make sure that **Dual Channel Sync Switch** was checked in the configuration.

If single channel switch is used, make sure that **Dual Channel Sync Switch** was not checked in the configuration.

See *Synchronization guidelines on page 119*.

Avoid singularity

The robot position for the sync check must be chosen so that the position of the robot axes are unambiguously defined. The sync check position must not be in a singularity position if the robot is moved there with a move instruction with a fine point (e.g. `MoveL`).

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 allowed by all active functions. For example, all axes must be inside their defined ranges for the active Safe Axis Range functions.

Small sync switch surface

The sync switch surface that the robot must touch when synchronizing 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

Always use the same tool for synchronization. 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. When the digital output signal PSC1CSPREWARN goes high it is time to execute the program. This can be initiated from a PLC or the main RAPID program.

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.

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.

Continues on next page

Cyclic Sync Check output

Virtual output signals can be connected to physical output signals for communication with a PLC. See also *Virtual output signals from main computer on page 130*.

5.2. Brake check guidelines

Prerequisites for brake test

- The robot and all additional axes must be moved to a safe position (away from people and equipment) before performing a brake check. Normally the robot moves only a few centimeters during the brake tests.
- Move the robot to a stop point before performing a brake check.
- A brake check can only be performed at normal execution level (not from a trap routine, error handler, event routine or store path level).
- Brakes are tested consecutive order and each test takes 10-15 seconds.

For information about parameters used for additional axes, refer to *Configure system parameters on page 61*.

Activate brake check

There are three ways of initiating a brake check:

- Calling the service routine `CyclicBrakeCheck`. Robot system must be in manual mode.
- Using a system input connected to an interrupt that runs the procedure `CyclicBrakeCheck`. Robot system in Auto mode with stopped program.
- A RAPID program calls the procedure `CyclicBrakeCheck`.

Brake check for MultiMove system

One of the motion tasks call the routine `CyclicBrakeCheck` to perform a brake check for all mechanical units in all tasks.

The brake check must not be performed while any tasks are in synchronized mode.

Brake check output

An error or warning message is logged for each axes with low brake torque. A status message is also logged for each complete brake cycle. See also *Cyclic Brake Check configuration on page 76*.

Virtual output signals can be connected to physical output signals for communication with a PLC. See also *Virtual output signals from main computer on page 130*.

6 Maintenance

6.1. Required maintenance activities

Internal functions are self tested

All internal functionality in the SafeMove safety controller is subject to self tests and requires no maintenance activities.

Test the safety relays for category 0 stop

Verify that a category 0 stop opens the safety relays.

Perform this test every 6 months:

	Action	Note
1.	Turn off the power to the safety controller's I/O power input.	This will cause a category 0 stop.
2.	Verify that the robot is stopped.	
3.	Check elog list to verify that a normal category 0 stop was performed.	If only one relay opens, elog 20222 will be shown.

Verify that the contact for the limit switch override is plugged or not strapped

For information on how to do the verification, please refer to *Verify that the contact for the limit switch override is plugged or not strapped on page 117*.

Perform this activity every 6 months.

7 Running in production

7.1. Reaction time

Supervision function response time

When a supervision function is triggered, the reaction time until a stop is ordered is maximum 22 ms.

Monitor function response time

When a monitoring function is triggered, the reaction time until the safe digital output signal goes low is maximum 12 ms.

7.2. Restarting the controller

Warm start

A normal warm start of the robot controller does not affect the SafeMove safety configuration.

C-start

A C-start (cold start) of the robot controller deactivates the SafeMove safety configuration. The safety configuration must be downloaded to the safety controller again by an authorized user, and the configuration must be validated.

DANGER!

Performing a C-start without downloading the safety configuration to the safety controller leaves the robot system without any of SafeMove's safety functions. It can easily be perceived as if the robot system still has SafeMove active, which causes a dangerous situation.

TIP!

Set up the User Authorization System so that only the safety user is allowed to perform a C-start.

TIP!

When there is an active safety configuration in SafeMove and a C-start must be performed, the following procedure may be useful:

1. Load the current safety configuration in SafeMove to the SafeMove Configurator.
2. Perform a C-start and then install the robot system.
3. When the robot system has been installed successfully, and safety functions have been validated, download the safety configuration from SafeMove Configurator to SafeMove.
4. Activate the downloaded safety configuration and validate it according to the safety report.

Restarting in unsychronized mode

If the safety controller and the robot controller are not synchronized, the robot controller must not be in auto mode when performing a restart. Perform a synchronization in manual mode before switching to auto mode.

Backup restore

When performing a backup, SafeMove configuration is not included in the backup. To include SafeMove safety configuration a new configuration must be loaded to the safety controller.

WARNING!

When you perform a restore the limit switches are closed and it is possible to run the robot without any supervision of SafeMove. Be aware that there is no SafeMove supervision after a restore until SafeMove is configured again.

7.3. Recovery after safety violation

Recovery after a supervision function has triggered

When a supervision function triggers, the robot will stop. To be able to move the robot again, the following must be performed (all output signals will also be set high):

	Action	Note
1.	Press the motors on button on the robot controller, or activate the signal SafeMoveConfirmStop, to confirm the violation.	The stop can also be confirmed by a warm start. For speed violations, it is enough with this confirmation. Steps 2-4 are not necessary.
2.	Activate the Override Operation input signal.	
3.	Jog the robot back to a position that does not trigger any supervision function.	
4.	Deactivate the Override Operation signal.	

Recovery from unsynchronized state

Unsynchronized state can, for example, occur:

- When Cyclic Sync Check has timed out
- When Control Error Supervision has triggered

	Action	Note
1.	Press the motors on button on the robot controller, or activate the signal SafeMoveConfirmStop.	This allows the robot to be moved at reduced speed for a time period specified in **Max Time Limit** in the **Synchronization** configuration (30-120 seconds). Maximum reduced speed is 18 degrees/s.
2.	Perform a synchronization.	

Recovery after Cyclic Brake Check has timed out

When a Cyclic Brake Check has timed out the robot can still be moved, but not faster than the **Max TCP Speed** configured for Cyclic Brake Check.

	Action	Note
1.	Perform a brake check.	See *Brake check guidelines on page 121*.

Continues on next page

Recovery after Cyclic Brake Check has failed

When a Cyclic Brake Check has failed the robot can still be moved, but not faster than the **Max TCP Speed** configured for Cyclic Brake Check.

	Action	Note
1.	Repair the brake that failed.	
2.	Perform a new brake check.	See *Brake check guidelines on page 121*.

7.4. Virtual signals

What is a virtual signal

The virtual signals can be viewed on the FlexPendant or in a RAPID program, 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.

For information about the system input signal that is a virtual signal, see *System input signal, SafeMoveConfirmStop on page 61*.

WARNING!

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

NOTE!

The following virtual output signals from main computer are valid in combination with an executed Cyclic Brake Check operation:

- PSC1CBCOK
- PSC1CBCWAR
- PSC1CBCERR

List of signals

Virtual input signals

Signal name	Description	Virtual I/O state
PSC1DI1-PSC1DI8	Digital input.	0 = Physical input not driven 1 = Physical input driven
PSC1DIOVR	Override input.	0 = Physical input not driven 1 = Physical input driven
PSC1SST	Shows violation state of active supervision.	0 = Configured and violated 1 = All other cases
PSC1SAS	Shows violation state of active supervision.	0 = Configured and violated 1 = All other cases
PSC1SAR	Shows violation state of active supervision.	0 = Configured and violated 1 = All other cases
PSC1STS	Shows violation state of active supervision.	0 = Configured and violated 1 = All other cases
PSC1STZ	Shows violation state of active supervision.	0 = Configured and violated 1 = All other cases
PSC1OVERRIDE	Override operation. Even if signal PSC1DIOVR goes high (=1), the PSC1OVERRIDE signal can be forced to stay inactive (=0) by configuration data.	1 = Override active

Continues on next page

Signal name	Description	Virtual I/O state
PSC1CSC	Cyclic Sync Check function reacts on closing edge (0 to 1 transition).	0 = Physical input low 1 = Physical input high

Virtual output signals

Signal name	Description	Virtual I/O state
PSC1DO1-PSC1DO8	Digital output.	0 = Physical output low 1 = Physical output high
PSC1STOP0	Relay output.	0 = Stop active
PSC1STOP1	Soft stop.	0 = Stop active (edge trig)
PSC1CSS	Cyclic sync status.	0 = Not synchronized

Virtual output signals from main computer

These signals appear like digital output signals on the FlexPendant, and are useful during troubleshooting.

Signal name	Description	Virtual I/O state
PSC1CBCREQ	Request to do a brake test.	1 = Request (edge trig)
PSC1CBCACT	Brake test active.	1 = Test active
PSC1CBCOK	Brake test result.	1 = OK from brake test
PSC1CBCWAR	Brake test warning.	1 = Warning from brake test.
PSC1CBCERR	Brake test error.	1 = Error from brake test.
PSC1CSPREWARN	Request to do a synchronization.	1 = Request (edge trig)
PSC1CALIBRATED	Robot and external axes are calibrated.	1 = All axes are calibrated
PSC1RESETPB	Confirm from the motors on push button.	1 = Confirm (edge trig)

Other signals

All other virtual signals starting with PSC are for internal use. Do not use them for applications.

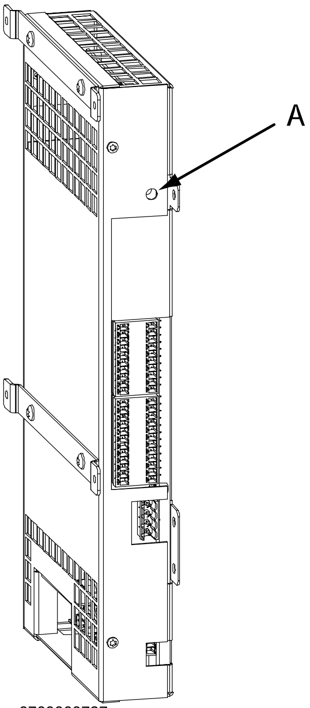
Signals for MultiMove system

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

7.5. 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.

7.6. Changes to robot or robot cell

Always update safety configuration

If the following is done the safety configuration must be updated and validated again:

- A new version of RobotWare is installed.

Update calibration file and perform synchronization

If the following is done the safety configuration must be updated and validated again:

- Fine calibration

Evaluate if the safety configuration needs to be updated

If any of the following is done, the safety responsible person must evaluate if the safety configuration needs to be updated and validated again:

- The tool is replaced.
- Any robot part is replaced.
- The robot cell is rebuilt in any way.
- The relation between the world coordinate system and the robot base coordinate system is changed.
- The tool coordinate system is changed.
- Changes to system parameters.

Perform synchronization

If any of the following is done, a new synchronization is required:

- Revolution counter update

8 Example applications

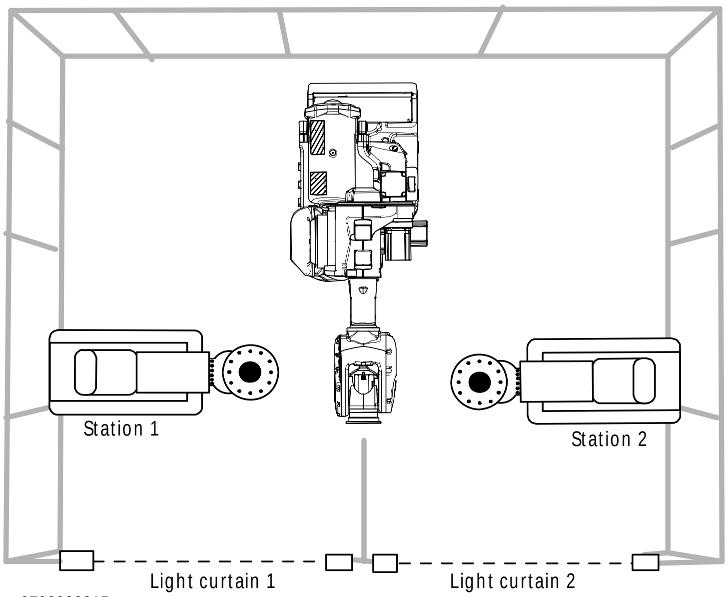
8.1 Safe Axis Range

8.1.1. Example with two work zones and light curtains

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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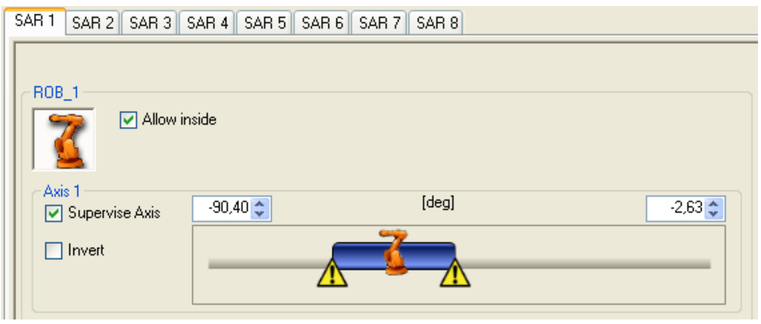
Configure Safe Axis Range

To implement the safety solution, two Safe Axis Range (SAR) functions must be configured. SAR1 should only allow the robot to be at station 1. SAR2 should only allow the robot to be at station 2.

The following picture illustrates how these two functions are configured for robot axis 1 in the SafeMove Configurator.



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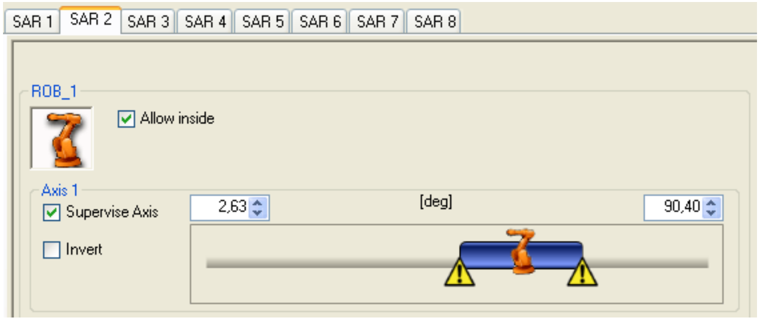

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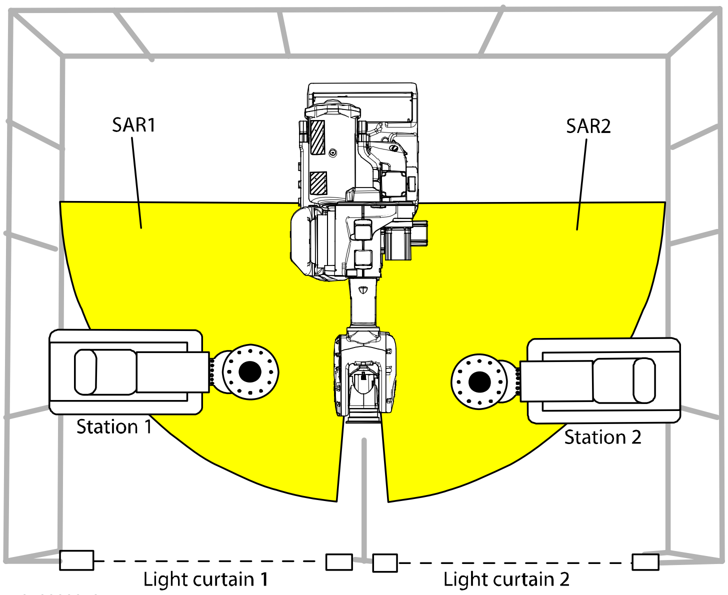
The following picture shows the angles for robot axis 1 where the SAR1 and SAR2 functions are shown with yellow where the robot is allowed to be.



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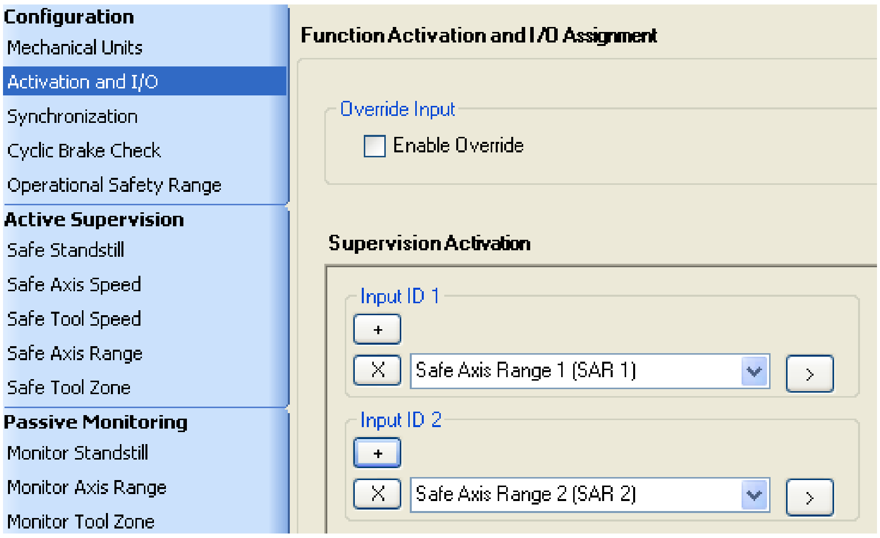
Configure activation input signals

Configure the SAR1 function to be activated by the activation input signal 1, and SAR2 to be activated by input signal 2.



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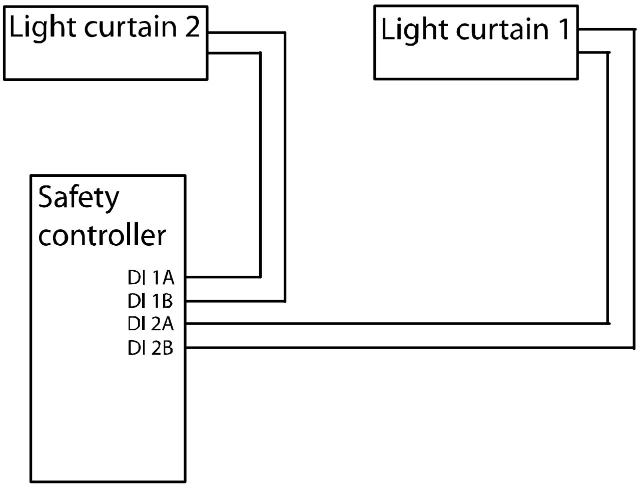
Connect the signals

Connect the output signals from the light curtains to the input signals of the safety controller. If light curtain 1 is broken, then SAR2 must be active (robot must be at station 2 when operator is at station 1). If light curtain 2 is broken, then SAR1 must be active (robot must be at station 1 when operator is at station 2).



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