Motion Control Products

Application note
Implementing safety functions on ABB servo drives

AN00206

Rev G (EN)

Introduction

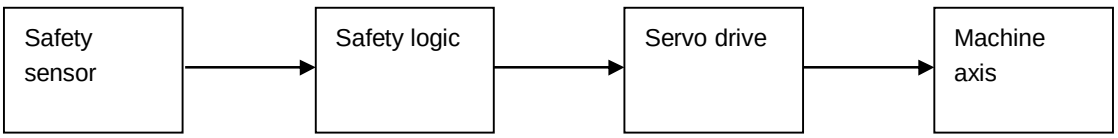
The purpose of this application note is to provide a guide to machine builders on functional safety and how it can be implemented on ABB servo drives. This document also contains a brief discussion on how other safety functions may be accomplished by integrating the drives with a safety PLC (e.g. ABB's AC500-S).

This documentation is meant only as a guide for implementing safety functions on ABB servo drives. It is the full responsibility of the machine builder to comply with all relevant standards and safety regulations. It is the responsibility of the machine builder to choose the required safety function based on a completed machine risk assessment.

This application note should be read in conjunction with ABB's Technical guide no.10 on Functional safety. The guide describes a procedure for risk assessment and how to derive the required safety levels. Different drive safety functions and stop functions are also described.

Implementing safety with ABB servo drives

The risk reduction strategy described in the functional safety guide will identify a hazard and a safety function that is deemed necessary to reduce this hazard to an acceptable level. The safety function will be structured in the following manner:



The safety sensor could be an emergency stop button, a light curtain etc. and its function is to detect a hazard. For the highest safety categories the sensor would need to have two separate channels wired into separate safety circuits. A failure on either channel would not prevent the operation of the safety function.

The safety logic would typically be a safety relay or safety PLC. For some drives there are safety functions built into the drive. An example of this is Safe Torque Off (STO) on the e150, e180 or ACSM1 drives. For drives without STO the safety function will be external to the drive. Removing power from the motor will be the mechanism for halting motion on the machine axis.

The safety function chosen will be a combination of the safe stop functions or safe motion functions described in the functional safety guide. The following sections illustrate examples of how these may be implemented using an ABB servo drive in combination with other safety devices.

Using the ABB Jokab RT7 safety relay

ABB Jokab manufacture a wide selection of safety devices, relays and PLCs. The RT7 relay can be used for safe stopping. Some examples of this are shown in following sections

It has the following features:

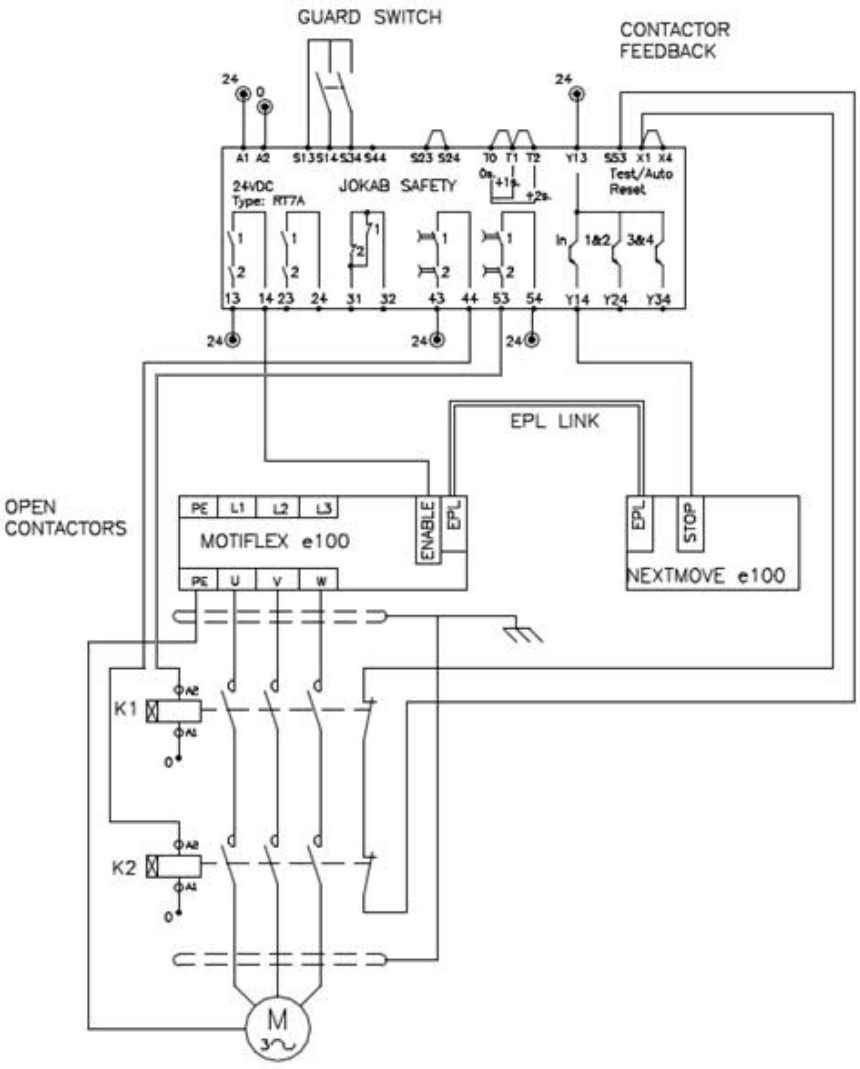
- 4 NO and 1 NC relay outputs,
- 2 NO outputs can be delayed for soft stops

Only one safety timer is required to implement STO externally on a MotiFlex e100 drive so this can be achieved via a single RT7 relay.

Two independent timers are required to implement Safe Stop Category 1 (SS1) on a MotiFlex e100. This could be achieved with two RT7 relays or a safety PLC.

For more information on Jokab RT7 - new.abb.com/jokabsafety

Safe Torque Off (STO) with a MotiFlex e100 and NextMove e100



We have used a legacy drive (MotiFlex e100) to illustrate how a drive with no built-in safety rated logic may be integrated into a safety related control system . In this example an STO function can be implemented by interfacing the MotiFlex e100 with external safety logic. This same interface may be used with other ABB servo drives

We'll assume that the required performance level (PLr) is e. This is the highest safety category. The MotiFlex e100 requires a drive enable input to be present to energize the motor. There is not sufficient redundancy in the drive to meet the performance level (PL) on its own. External safety devices are necessary.

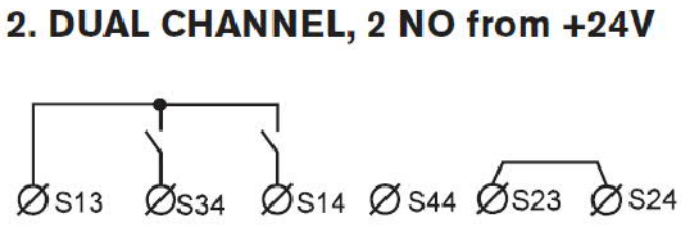
STO requires that power is removed from the motor and that it will coast to standstill. To remove power for such a high safety category two contactors need to be used in series to achieve the required level of redundancy. The drive retains charge across its DC link capacitors so it is not sufficient to disconnect its input supply as it will still be capable of supplying power for a period of time. It will be necessary to disconnect the drive output power from the motor to ensure that the motor coasts to a standstill. This requires the correct sequence of operation to be done safely.

If the contactors are opened while the drive is enabled the motor windings will generate a back EMF to keep current flowing. As the contactors disrupt this current, the back EMF will increase to a high voltage. This will draw an arc that could damage the drive output circuits or the contactors.

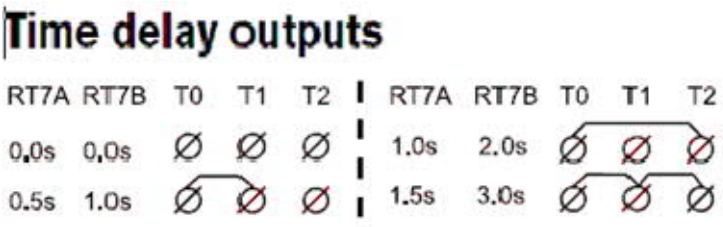
The correct procedure is for a safety relay to immediately remove the drive enable input but keep the output contactors initially closed. The relay's timer will then open the contactors after the drives IGBTs have had sufficient time to switch off. Auxiliary contacts from the contactors need to both open before the safety relay may be reset.

If the drive is controlled from a NextMove motion controller then the safety relay will immediately trigger the STOPINPUT wired to the NextMove. The drives will generate an error if they lose the enable input but the NextMove can use the stop signal to manage the event.

Guard switches or E-Stop buttons are wired into a 2 channel loop on the RT7 relay. Both input contacts must be closed (S14) and (S34) before the relay outputs can be activated. The safety relay contacts will open if one or both of the inputs change state or in the case of a short circuit between S14 and S34. Both inputs must be returned to their initial positions before the relay outputs can be reactivated.

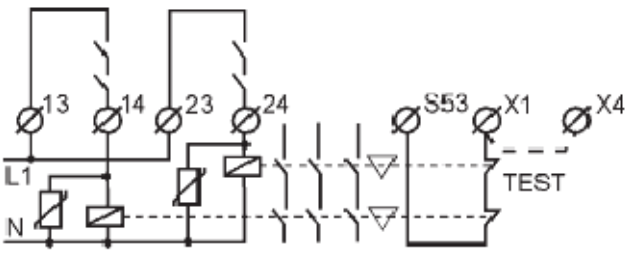


The relay output time delay is selected by linking the appropriate T0, T1 and T2 connections.

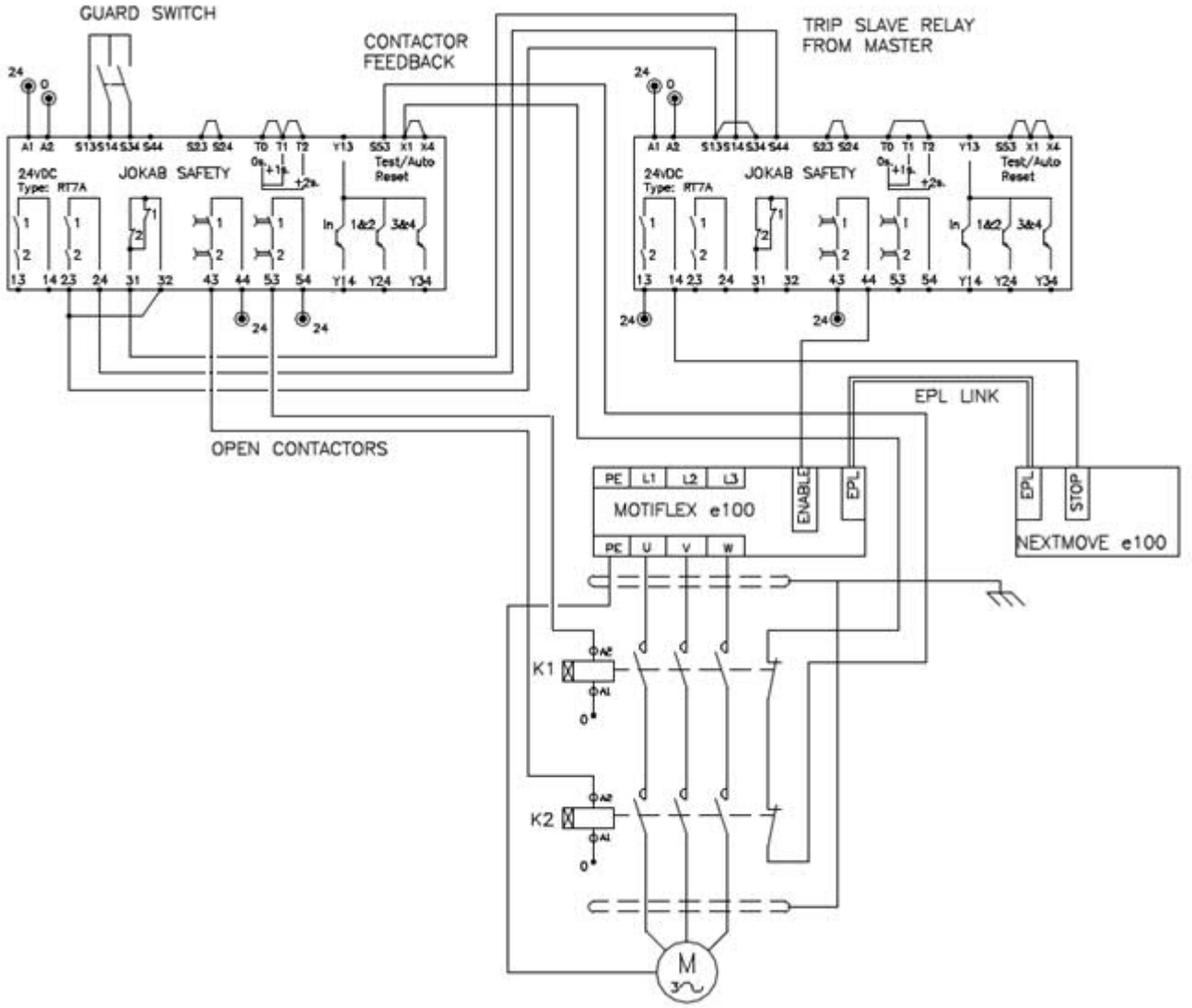


The relay may be reset automatically or manually. It is advisable to monitor the state of the motor contactors and to prevent the safety relay from being reset until both motor contactors have opened.

This is achieved by providing auxiliary contacts with the motor contactors and then connecting these in series between S53 and X1.



Safe Stop 1 (SS1) with a MotiFlex e100 and NextMove e100



Again for this example we have used MotiFlex e100 to illustrate the use of a drive with no built-in safety related features. For this stop category the MotiFlex e100 must decelerate the axis in a controlled fashion under power. In some implementations the speed of the axis is monitored by a safety encoder connected to a safety PLC. Alternatively power may be removed from the motor after a time delay long enough for the axis to stop. If the drive were to malfunction, the axis would still stop in a controlled period of time due to the interruption of power.

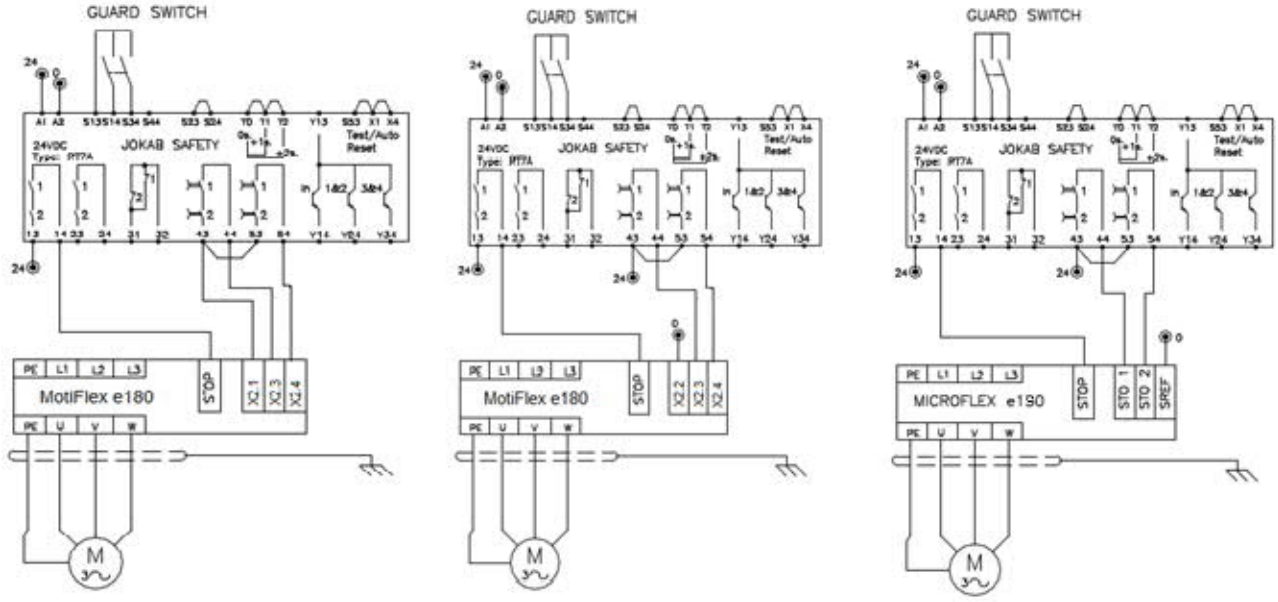
To interrupt motor output power from the MotiFlex e100 while the drive is enabled is a little more involved than for STO. Once the drive enable signal is removed it takes at least 10 ms for the IGBTs on the drives power circuit to fully switch off. Therefore two timer relays are required in the external safety logic. The master relay will monitor the safety circuit. Connect one of the spare non timed NO outputs from the master relay to S13 and S14 on the slave relay. The master relay will trip the slave relay immediately after a safety channel opens.

If the drive is controlled from a NextMove motion controller then the safety relay will trigger the STOPINPUT wired to the NextMove. The NextMove then controls the drives rundown to standstill. If the MotiFlex e100 is controlled by a NextMove e100 then the stopping profile could be controlled over Ethernet Power Link (EPL). This is non-safe network technology but it doesn't matter because the safety relay ensures that the motor will ultimately be powered off. If the MotiFlex e100 is a standalone drive then the stopinput will be on the drive rather than on the NextMove.

As soon as the safety circuit opens the safety relay will activate the stop input. This will cause the drive to decelerate the motor under power. The first time delay allows the drive to bring the motor to a controlled stop. Once this expires it removes the drive enable input. After the second timer has expired, the IGBTs are fully switched off and the drive output contactors may be

opened safely. A speed monitoring safety function in a safety PLC may be used instead of the first timer. The motor contactors must open before the safety relay may be reset.

Safe Stop 1 with a MicroFlex e190 or MotiFlex e180



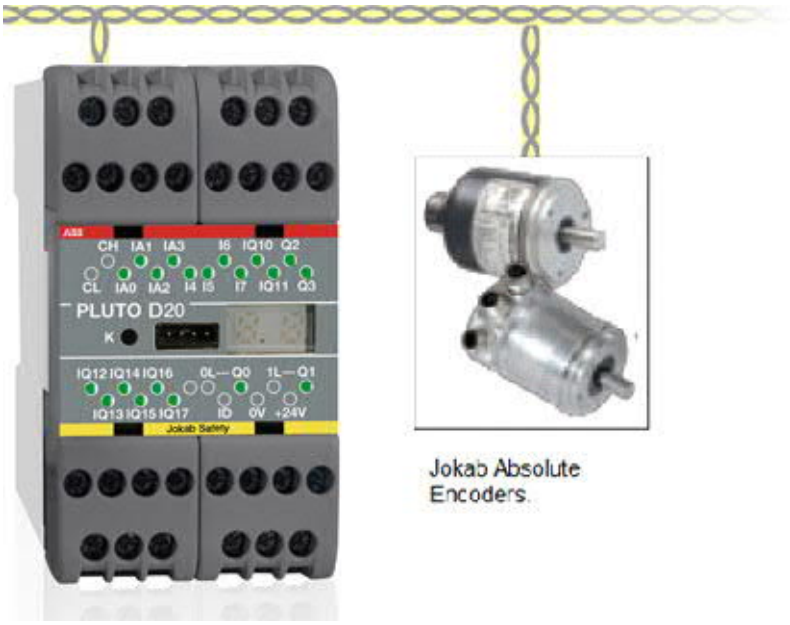
The MicroFlex e190 and MotiFlex e180 drives both have built in STO. This makes it much easier to safely disconnect power from the motor. To achieve SS1 all that is needed is one additional safe time delay.

For this stop category the drive must decelerate the axis in a controlled fashion under power. In some implementations the speed of the axis is monitored by a safety encoder connected to a safety PLC. Alternatively power may be removed from the motor after a time delay long enough for the axis to stop. If the drive were to malfunction, the axis would still stop in a controlled period of time due to the interruption of power.

As soon as the safety circuit opens the safety relay will activate the drive's defined STOPINPUT. This will cause the drive to decelerate the motor under power. The time delay allows the drive to bring the motor to a controlled stop. Once this expires the safety relay opens the drives STO inputs. A speed monitoring safety function in a safety PLC may be used instead of the timer.

Note that these drives can be wired in two configurations either utilising an external 24v supply or the drives internal 24v supply to the STO inputs (the diagram above illustrates this for MotiFlex e180). Please consult the installation manual (Appendix: Safe Torque Off) for further details.

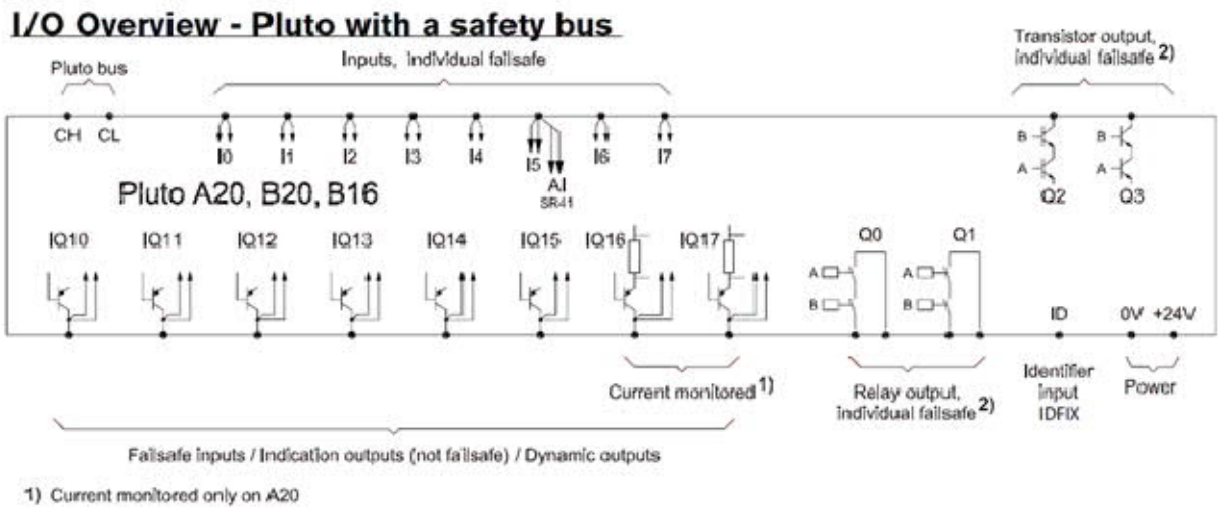
Using a Safety PLC for more advanced motion safety functions



For more information on Jokab RT7 - new.abb.com/jokabsafety

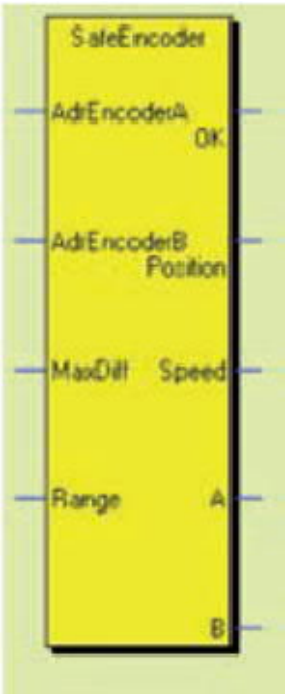
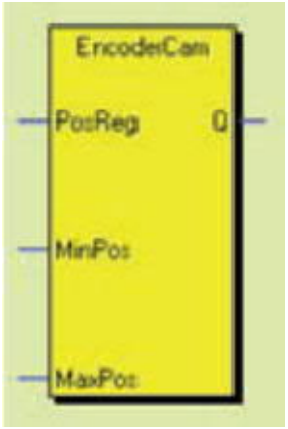
Most of the safety functions require the motor speed or position to be measured using an encoder with some redundancy in its design. ABB Jokab absolute encoders may be used in conjunction with an ABB Jokab Pluto safety PLC. The encoder is connected via a safety bus.

The Pluto PLC is programed using a package called Pluto manager. This contains certified safety functions which can be linked up using ladder logic or other programming methods.

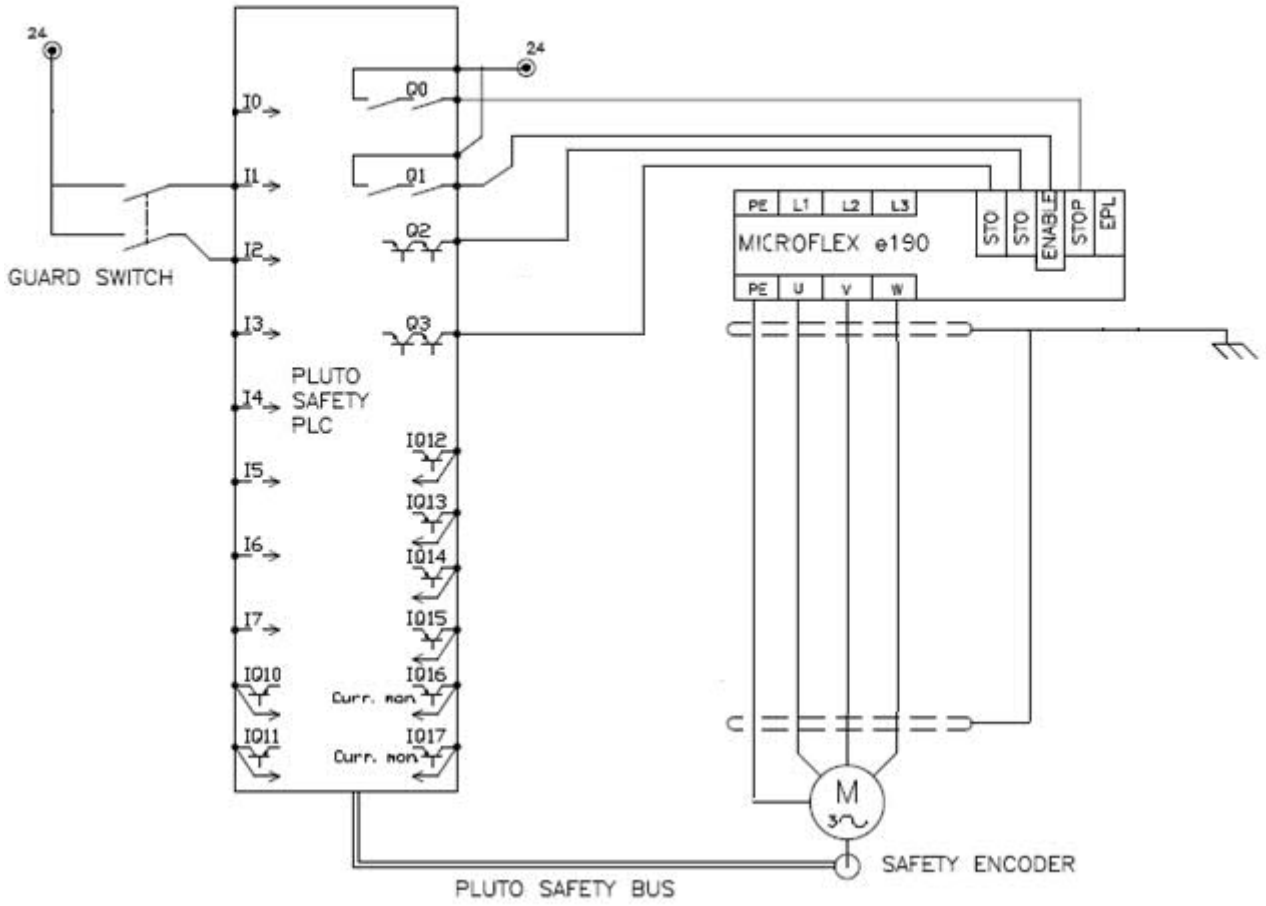


The safety PLC provides safety inputs and outputs. It replaces the RT7 relay used in the previous examples. Depending on the safety function, the safety PLC monitors the safety encoder speed or position. If there is a hazardous condition the drive may be shut down.

Table of Pluto functional blocks and how they relate to safety functions

safety function	Pluto function block	
Safe Stop 2 (SS2) Safely Limited Speed (SLS) Safe Speed Range (SSR) Safely Limited Position (SLP) Safely Limited Increment (SLI) Safe Direction (SDI) Safe Speed Monitoring (SSM)		The ‘Safe Encoder’ block reads and evaluates a safe speed and position value from two absolute encoders. These values may then be used on other safe function blocks in the PLC to achieve the required safety function.
Safe Cam (SCA)		In the ‘Encoder Cam’ block, output Q is activated if the value of the encoder is within limits.
Safely Limited Torque (SLT) Safe Torque Range (STR)	Motor torque is proportional to motor current. The Pluto PLC is able to monitor analogue inputs. To ensure the highest level of safety two inputs must be used.	

Safe Stop 2 (SS2) with a MicroFlex e190 (or MotiFlex e180), safe encoder and Pluto safety PLC



For this stop category the MicroFlex e190 (or MotiFlex e180) must decelerate the axis in a controlled fashion under power. Power is maintained after the motor stops but the safe encoder is continuously monitored by the safety PLC. If the motor does not stop in the required period or moves unexpectedly then an STO function is implemented.

As soon as the safety circuit opens the PLC will activate the drive's stop input. This will cause the drive to decelerate the motor under power (via a Mint program in the drive taking action on the stop input activating). The drive is allowed to bring the motor to a complete stop. The drive remains enabled but the drive speed is monitored.

This example showed a standalone drive. If the drive is controlled from a motion controller (e.g. NextMove e100) then the safety PLC will trigger the STOPINPUT wired to the NextMove rather than the drive. The NextMove then controls the drives rundown to standstill. In this case the stopping profile is controlled over Ethernet PowerLink (EPL). This is non-safe network technology but it doesn't matter because the safety PLC ensures that the motor will ultimately be powered off.

SS2 is the safety function shown in this example. This circuit can also be used for other safety functions where a safe encoder monitors the speed or position of the axis.

Products

ABB offers a complete range of safety products, designed to make your machine safety system easy to build. We develop these innovative products continuously, in cooperation with our customers.

Our offering

Programmable safety controllers

A unique All-Master safety PLC concept for dynamic and static safety circuits.

Safety controllers

Safety controllers for supervision of entire safety system based on the dynamic safety circuit

Safety relays

A wide range of safety relays for different protection purposes.

Safety adapter units

Adapter units for connecting safety devices to our dynamic circuits and bus systems

Optical safety devices

Light curtains and light beams for optical protection in an opening or around a risk area.

Stop time measurement and machine diagnostics

Tool for stop time measurement, annual maintenance and for troubleshooting machinery

Safety Sensors, switches and locks

Dynamic non-contact sensors, safety switches, magnetic switches and locks

Safety control devices

Our range of ergonomic and unique safety control devices.

Emergency stops and pilot devices

Emergency stops and pilot devices for dynamic and static safety circuits.

Contact strips and bumpers

Our range of contact edges and bumpers for protection against crush injuries.

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