ROBOTICS

Application manual

FlexLoader Standard Safety Center

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Application manual

FlexLoader Standard Safety Center

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Original instructions.

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Overview of this manual

About this manual

FlexLoader Standard Safety Center is a safety solution used for the FlexLoader product family. This manual describes how to install, operate, maintain, service and troubleshoot the FlexLoader Standard Safety Center.

Usage

This manual should be used during:

- installation and preparation work
- maintenance work
- repair work
- service work
- operation.

This manual is focused on countries where relevant ISO safety standards and safety regulations according to Machinery Directive 2006/42/EC with addendum apply.

Who should read this manual?

This manual is intended for:

- installation personnel
- maintenance personnel
- repair personnel
- service personnel
- operators.

Prerequisites

Operators and maintenance, repair and installation personnel working with an ABB robot must be trained by ABB and have the required knowledge of mechanical and electrical installation, service and maintenance work.

Trademarks

FlexLoader is a trademark of ABB.

References

- The product manual of the robot used together with FlexLoader Standard Safety Center.
- The product manual of the FlexLoader function package or standard cell used with FlexLoader Standard Safety Center.
- The product manual of the machine tool/s used together with the FlexLoader function package or standard cell.
- The Pluto product manuals.

Continues on next page

- Suggestion of applicable standards
  - EN ISO 13849-1 “Safety of machinery -- Safety related parts of control systems. General principles for design”
  - EN ISO 12100 “Safety of machinery – General principles for design – Risk assessment and risk reduction”
  - EN 62061 “Safety of machinery – Functional safety of safety-related electric, electronic and programmable electronic control systems”
  - EN ISO 14119 “Safety of machinery – Interlocking devices associated with guards – Principles for design and selection”
  - EN 60204-1 “Safety of machinery. Electrical equipment of machines. General requirements.”
  - Newer applicable standards and regulations supersede the above standards.

Revisions

Revision	Description
A	First edition.
B	Updated illustrations.
C	General update.
D	Include Profinet update. Improved information on master/slave interfaces.
E	Minor updates. Added section on response times.

1 Safety

1.1 Introduction

This chapter contains safety information for procedures where there is a risk of personal injury or damage to property.

Equipment that is part of a fully- or semi-automatic system must always be treated with care regarding safety.

The users of ABB industrial robots are responsible for ensuring that the applicable safety laws and regulations in the country concerned are observed, and that the safety devices necessary to protect people working with the robot system are designed and installed correctly. Personnel working with the robot must be familiar with the operation and handling of the robot, as described in the applicable documents.

- Only personnel with required training are authorized to use the system.
- All received training must be documented in writing.

Activity	Trained operator	Trained service and maintenance technician	Qualified electrician	System integrator
Commissioning				X
Operation	X	X		
Trouble-shooting		X	X	
Correction of mechanical fault		X		
Correction of electrical fault			X	
Service		X		
Maintenance		X		

x = Authorized to perform the activity.

1.2 Safety during installation, commissioning and decommissioning

Always check that the installation and maintenance instructions are supplied together with the machine. Carefully read the safety information, before unpacking and installing the equipment.

Personnel who are involved in the installation and commissioning must have relevant training for the respective robot and corresponding safety issues.

1.3 Safety during setup, maintenance, service and repair

Always ensure that FlexLoader Standard Safety Center cannot be started when working on the cell. The installed protection that belongs to the equipment must always remain installed during automatic operation.

Work on mechanical systems must only be carried out by qualified person or by a trained person under guidance and supervision of a qualified person according to the applicable technical regulations.

Work on electrical systems or operating material must only be carried out by a qualified electrician or by a trained person under guidance and supervision of a qualified electrician according to the applicable electrical technical regulations.

All safety and warning signs must be kept clean and legible. If necessary, replace them.

Always check the function of all safety devices after performing work that may have had an impact on the safety systems.

1.4 Limitation of liability

Any information given in this manual regarding safety must not be construed as a warranty by ABB that the FlexLoader Standard Safety Center will not cause injury or damage even if all safety instructions are complied with.

The information does not cover how to design, install and operate a complete system, nor does it cover all peripheral equipment that can influence the safety of the entire system.

In particular, liability cannot be accepted if injury or damage has been caused for any of the following reasons:

- Use of FlexLoader Standard Safety Center in other ways than intended.
- Incorrect operation or maintenance.
- Operation of FlexLoader Standard Safety Center when the safety devices are defective, not in their intended location or in any other way not working.
- When instructions for operation and maintenance are not followed.
- Non-authorized design modifications made in or around FlexLoader Standard Safety Center.
- Repairs carried out by in-experienced or non-qualified personnel.
- Foreign objects.
- Force majeure.

1.5 Nation and region specific regulations

To protect personnel, the complete system must be designed and installed in accordance with the safety requirements set forth in the standards and regulations of the country where FlexLoader Standard Safety Center is installed.

Within the EU, refer to the Machinery Directive 2006/42/EC with addendum.

In the US, refer e.g. to ANSI/RIA R15.06 (Industrial Robots and Robot Systems - Safety Requirements) and UL 1740 (Standard for Robots and Robotic Equipment).

In Canada, refer e.g. to CAN/CSA-Z434-03 (Industrial Robots and Robot Systems - General Safety Requirements).

Note

The supplied equipment must not be operated until the processing machine or system in which the equipment is included, has been approved according to national and regional laws and regulations.

1.6 To be observed by the supplier of the complete system

Overview

The integrator is responsible for making sure that the safety devices necessary to protect people working with FlexLoader Standard Safety Center are designed and installed correctly.

When integrating FlexLoader Standard Safety Center with external devices and machines:

- The supplier of the complete system must ensure that all circuits used in the protective stop function are interlocked in a safe manner, in accordance with the applicable standards for the protective stop function.
- The supplier of the complete system must ensure that all circuits used in the emergency stop function are interlocked in a safe manner, in accordance with the applicable standards for the emergency stop function.
- The supplier of the complete system must ensure that all circuits used in all other safety function are interlocked in accordance with the applicable standards for that function.

The integrator of the final application is required to perform an assessment of the hazards and risks (HRA).

Note

The integrator is responsible for the safety of the final application.

Safe access

The robot system shall be designed to allow safe access to all areas where intervention is necessary during operation, adjustment, and maintenance.

Where it is necessary to perform tasks within the safeguarded space there shall be safe and adequate access to the task locations.

Safety zones, which must be crossed before admittance, must be set up in front of the robot's working space. Light beams or sensitive mats are suitable devices.

Turn-tables or the like should be used to keep the operator out of the robot's working space.

A safety fence is recommended to ensure safeguarded space. Sufficient space must be provided around the manipulator to protect those working with or on it from hazards such as crushing.

The fence or enclosure must be dimensioned to withstand the force created if the load being handled by the robot is dropped or released at maximum speed. Determine the maximum speed from the maximum velocities of the robot axes and from the position at which the robot is working in the work cell (see the *Robot product specification*).

Also consider the maximum possible impact caused by a breaking or malfunctioning rotating tool or other device fitted to the robot or positioned stationary in the cell.

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The FlexLoader Standard Safety Center used with Eden door switches does not evaluate door locking in its safety function. This has to be considered in the risk assessment.

Safe handling

Make sure that the users cannot be exposed to hazards, including slipping, tripping, and falling hazards.

It must be possible to safely turn off tools, such as milling cutters, etc. Make sure that the guards remain closed until the cutters stop rotating.

It should be possible to release parts by manual operation.

Safe design

The emergency stop buttons must be positioned in easily accessible places so that the system can be stopped quickly. If any of the buttons do not stop all the robot workcell motion, each emergency stop button must be marked (if more than one is provided) to indicate its designated safety function.

Changes to Pluto program

Applicable for systems with the optional safety center.

WARNING

The Pluto program is a critical part of the automation cell's safety system.

Apart from configuration changes, no other changes may be made without qualified review and validation regarding safety risks, safety functions and the overall behavior of the safety system.

1.7 Safety signals in the manual

Introduction to safety signals

This section specifies all safety signals used in the user manuals. Each signal consists of:

- A caption specifying the hazard level (DANGER, WARNING, or CAUTION) and the type of hazard.
- Instruction about how to reduce the hazard to an acceptable level.
- A brief description of remaining hazards, if not adequately reduced.

Hazard levels

The table below defines the captions specifying the hazard levels used throughout this manual.

For more information, see standard ISO 13849.

Symbol	Designation	Significance
	DANGER	Signal word used to indicate an imminently hazardous situation which, if not avoided, will result in serious injury.
	WARNING	Signal word used to indicate a potentially hazardous situation which, if not avoided, could result in serious injury.
	ELECTRICAL SHOCK	Signal word used to indicate a potentially hazardous situation related to electrical hazards which, if not avoided, could result in serious injury.
	CAUTION	Signal word used to indicate a potentially hazardous situation which, if not avoided, could result in slight injury.
	ELECTROSTATIC DISCHARGE (ESD)	Signal word used to indicate a potentially hazardous situation which, if not avoided, could result in severe damage to the product.
	NOTE	Signal word used to indicate important facts and conditions.

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Symbol	Designation	Significance
	TIP	Signal word used to indicate where to find additional information or how to do an operation in an easier way.

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2 Description of the product

General

WARNING

Applicable training is required in order to use the product. Incorrect use of the product can lead to personal injury and material damage. Before commissioning the product, it is your responsibility to carefully read the chapter *Safety on page 9*, and to be familiar with the safety devices.

FlexLoader Standard Safety adds safety features needed for a complete robot cell.

It is based on the ABB Pluto programmable safety controller.

It handles emergency stops and protective stops in the cell and ensures safe and reliable interaction with external equipment.

FlexLoader Standard Safety can be configured and covers a broad range of safety interface needs.

DANGER

The Pluto program is a critical part of the safety system of the cell. No changes may be carried out without a qualified inspection and verification of the safety risks and the behavior of the safety system as a whole.

Area of use

FlexLoader Standard Safety must only be used in cells with intended safety classification and on the condition that the applicable safety requirements and standards are followed.

Performance level

The safety functions for ABB's components (emergency stop and protective stop) according to this description fulfil the performance level PLd in accordance with EN ISO 13849:1.

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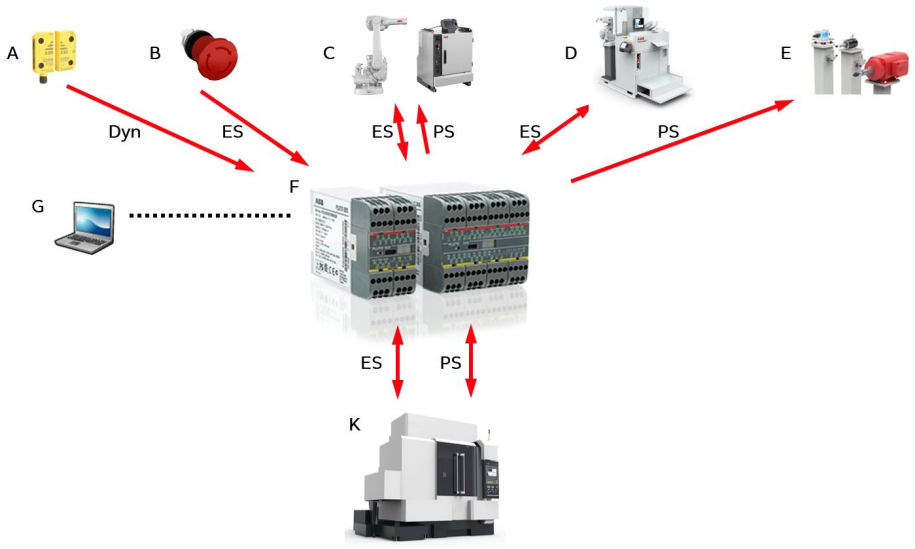
Typical integration example

The equipment can be integrated in several different ways. Below is a typical example of how the safety center can be integrated with other equipment. The example shows the FlexLoader Standard Safety Center with all connected devices.



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Pos.	Description	Pos.	
A	Internal door safety chain (single chain)	G	Service PC
B	Internal emergency stop chain		
C	Robot controller with robot(s)	Dyn	Dynamic safety signal
D	FlexLoader function package	ES	Emergency stop, two-channel, potential free
E	Equipment with elevated risk level, e.g. deburring, cutting, air cleaning.	PS	Protective stop, two-channel, potential free
F	FlexLoader Standard Safety	K	Connected system

3 Installation

Introduction

This section describes how to install the equipment. If the cell contains further parts, safety instructions may also be found in other documentation.

Configurations

FlexLoader Standard Safety Center is pre-installed (optional) in FlexLoader function packages. During installation, the configuration must be changed according to project needs

The Pluto configuration is described in the appendix, see *Pluto configurations on page 53*

Internal safety connections

Internal safety connections are pre-installed (optional) in FlexLoader function packages and standard cells.

All safety functions must be tested after installation before the machine is used for the first time.

For general information on internal safety connections see *Internal safety interface on page 38*.

External safety connections

Connection to the machine tool or other external safety equipment must be carried out according to the wiring diagram.

All safety functions must be tested after installation before the machine is used for the first time.

For general information on external safety connections see *External safety interface to connected system on page 31*.

Internal communication connections

FlexLoader Standard Safety Center communication is pre-installed and pre-configured in FlexLoader function packages and standard cells.

It can be connected to the PROFINET network by means of the Pluto Gate-PN, in order to make safety system information accessible for the robot controller. For

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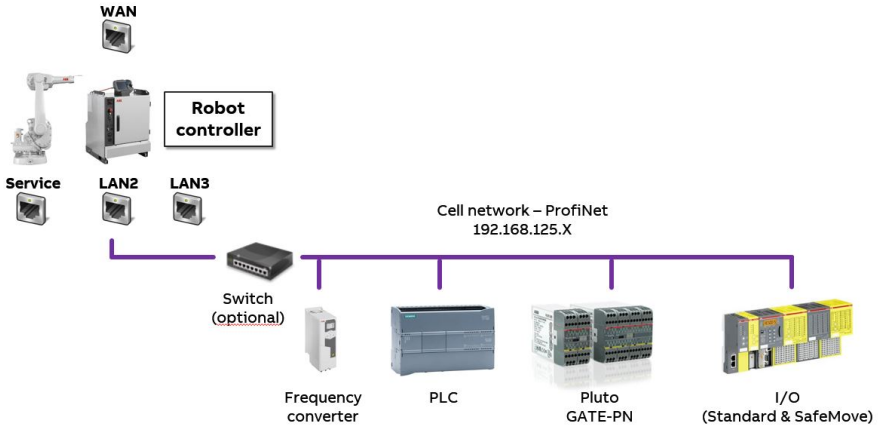
PROFINET setup, see *Network overview on page 23*. The Gate-PN cannot be used to transfer safety-rated signals.



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DANGER

Installation and electrical connection of safety devices may only be performed by authorized personnel.

Requirements for external equipment

The safety functions for external equipment are dependent on the design of that equipment. General safety related information is transmitted and received in such a way that the safety level PLd can also be fulfilled for the combined system, on the condition that the external equipment fulfils PLd.

In order for the external equipment in the safety function ”emergency stop of all equipment” to fulfil the PLd, the equipment must fulfil all PLd requirements.

In order for the external equipment in the safety function ”protective stop of all equipment” to fulfil the PLd, the equipment must fulfil all PLd requirements.

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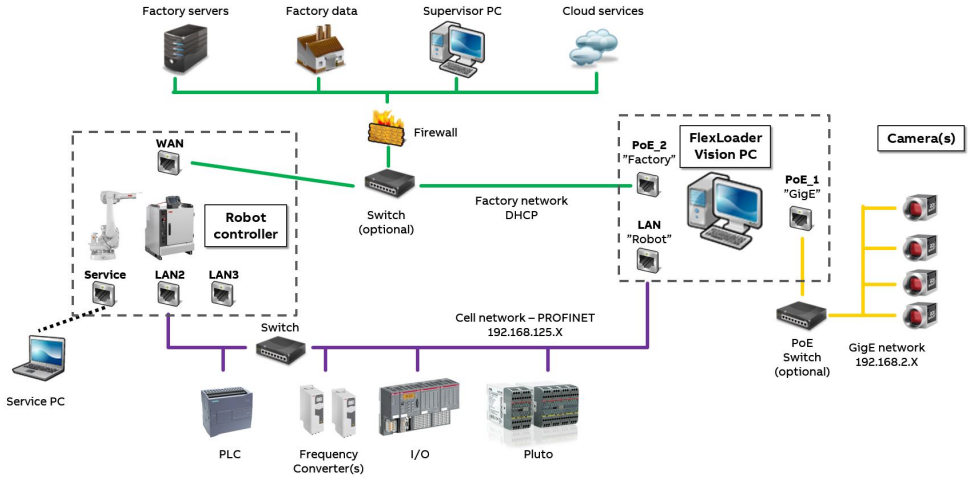
Network overview

The standard network setup with its three main networks is configured as shown below.



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- The factory network connects to both the FlexLoader Vision PC and the robot. This network is optional.
- The camera network is reserved for FlexLoader Vision cameras.
- The internal cell network connects all internal components, mainly through PROFINET communication (using robot option 888-2).

PROFINET configuration

The FlexLoader function package has pre-configured PROFINET settings. If any changes are needed, at least some of the steps below must be performed.

Changes to PROFINET configurations shall only be done by trained technicians. Technicians shall have a good knowledge of I/O settings both in general and in RobotStudio.

	Action
1	Set your PROFINET network in the robot to **Private network** in RobotStudio. Use **Controller** -> **Configuration**. Modify IP settings to fit the pricate network.
2	Configure devices for your robot controller in RobotStudio I/O configurator (IOC). Use **Controller** -> **Configuration**. Import all necessary GSDML files or modify the IPPNIO.xml file. Locate devices with the RobotStudio ScanTool and add relevant devices to the controller. Modify names and addresses if necessary, see *Standard network IP settings on page 25*. All sub-modules are needed when adding PLUTO devices.
3	If relevant, configure Safe I/O. As general recommendation, two channel signals can be defined as separate single channel signals that are combined by PreLogic in SafeMove. Ensure correct safety checksum by using **Controller** -> **Configuration** -> **Vendor Tool**. The generated checksum is then used in the SafeMove configuration.

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	Action
4	Set device names on devices with RobotStudio ScanTool. Modify the devices names if necessary, see *Standard network IP settings on page 25*. Other tools can be used if desired.

The PROFINET controllers in FlexLoader function packages normally uses DCP (Discovery Configuration Protocol), i.e. that they will configure devices when they found them.

The key property for this method is the device name (same as station name). The controller is told which devices to handle and communicate with and which device names they have. With this information, the controller finds the actual devices with the right names on the network and automatically assigns IP addresses that are pre-configured in the controller.

ABB CI502 I/O nodes will get its name depending on the switches/knobs on the module, e.g. **ci502-pn-01** if knobs are put in positions 0 (x10H) and 1 (x01H). A cold start is needed to read new name. Do not use knob positions 0 and 0, as these are used for user-defined names.

Robot PROFINET devices such as I/O nodes and Pluto gateway will get their IP address as warm start as defined in robot I/O configurator.

Internal cell network

The internal cell network connects the FlexLoader Vision PC, robot, safety devices, I/O devices, frequency converters and other internal cell components to each other.

This network is the robots private network, and both robot **LAN2** and **LAN3** as well as the service port are connected to this network. The robot is acting as PROFINET master.

Tip

The FlexLoader Vision PC can only be connected to **LAN2**.

A separate network connection to the robot network can be made by using **LAN3** network isolation.

In this case, the service port remains internally connected to **LAN2**.

See robot documentation for further information.

Note

Do not connect the internal network directly to the factory network.

Limitations

Currently, the PROFINET master functionality of the robot does not allow to configure a connection to a Siemens IDevice, i.e. direct connection to another Siemens PLC acting as PROFINET master is not possible.

The robot PROFINET functionality can be used on only one of the following connections: **WAN**, private network (service port, **LAN2**, **LAN3**), or isolated **LAN3** network.

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The private network of two robot controllers cannot be directly connected.

For connecting two robot controllers or an external master PLC to the cell, see *External PROFINET connections on page 26*.

Note

Robot option 841-1 Ethernet/IP™ cannot be combined with the FlexLoader function packages and standard cells.

If Ethernet/IP™ communication is needed, the robot option 840-1 Ethernet/IP™ fieldbus adapter must be used instead.

Standard network IP settings

Internal machine network

Equipment	IP address	Gateway	Device name
PC	192.168.125.150	192.168.125.1	-/-
Robot	192.168.125.1	192.168.125.1	irc5-pnio
PLC camera 1	192.168.125.151	192.168.125.1	e.g. plc-fp100
PLC camera 2	192.168.125.152	192.168.125.1	e.g. plc-fp300
PLC camera 3	192.168.125.153	192.168.125.1	e.g. plc-fp400
PLC camera 4	192.168.125.154	192.168.125.1	e.g. plc-fp600
Pluto gateway	192.168.125.160	192.168.125.1	gatepn
I/O board 1	192.168.125.161	192.168.125.1	ci502-pn-01
...	...	...	
I/O board 9	192.168.125.169	192.168.125.1	e.g. ci502-pn-09
Frequency converter 1	192.168.125.171	192.168.125.171	e.g. bufferbelt2, separationbelt, camerabelt, pallettipper
...	...	...	...
Frequency converter 9	192.168.125.179	192.168.125.179	
Project specific equipment 1	192.168.125.180	192.168.125.1	
...	...	...	
Project specific equipment 20	192.168.125.199	192.168.125.1	

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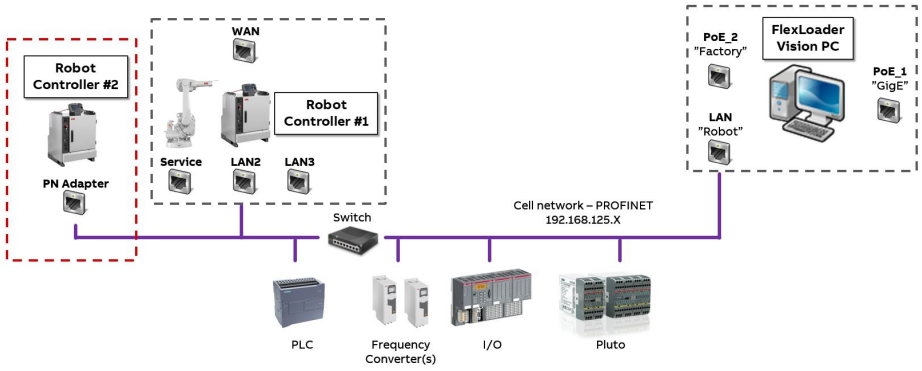
External PROFINET connections

In some cases external PROFINET connections are needed during integration of a FlexLoader function package or standard cell.

A second robot controller can be connected through PROFINET by using a PROFINET fieldbus adapter in the second controller (robot option 840-3).



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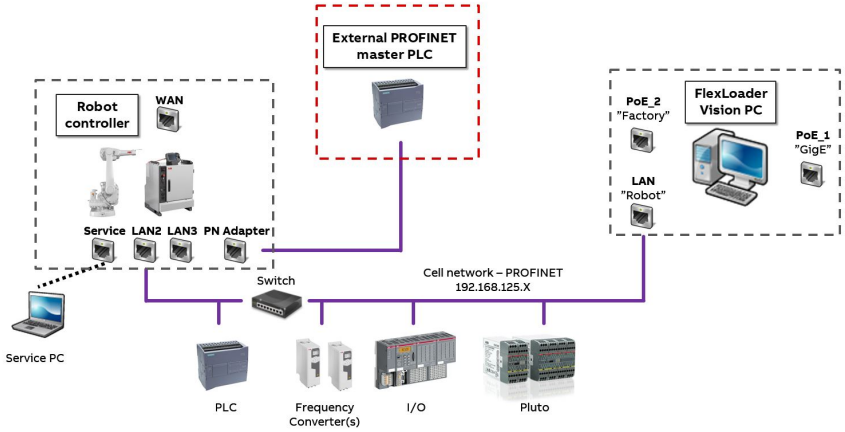
A master PLC be connected through PROFINET by using a PROFINET fieldbus adapter in the first controller (robot option 840-3).



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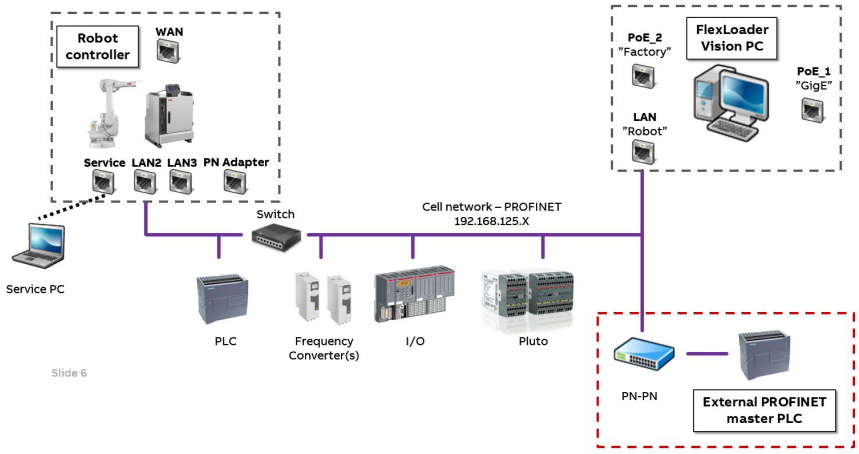
Alternatively, the master PLC can be connected by using a PNPN-coupler.



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Note

The connections can in principle be routed through the WAN port as well, with all internal network components connected to **WAN** instead of **LAN2**.

However, this will expose all components to an external network. We recommend to avoid this system setup.

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4 Maintenance

Maintenance schedule

This sections covers both maintenance of equipment and options that are not included in all cells. If the installation contains further parts, maintenance instruction may also be found in other documentation.

Below is a summary of the maintenance intervals and the corresponding corrective actions.

Maintenance intervals	Corrective action
Every week	Check for dirt.
Every month	Check the safety functions. Check the safety sensors and actuators
Every 3 months	Check the cables and cable racks.

Maintenance intervals

DANGER

Service of safety devices may only be performed by authorized personnel.

Check the safety functions

What: Test all safety functions.

When: Every month.

How: Go through all safety functions, that is all emergency stop buttons, all door switches, and any other safety devices.

Other safety devices can include e.g. light guards, external machine actuators, pneumatic safety valves, SafeMove restrictions, and laser scanners.

Check the safety sensors and actuators

What: Check the safety sensors and actuators

When: Every month.

How: In the event of wear or damage, the breaker, key switch, magnetic lock or other safety-related parts must be replaced in its entirety.

Check for dirt

What: Check for dirt.

When: Every week.

How: Breakers, key switch, magnetic lock and other safety-related parts must be clean. Remove any dirt.

Check the cables and cable racks

What: Check the cables and cable racks

When: Every 3 months.

How: Inspect the entire cable rack (installation points, dirt deposits, wear) and remedy any breaks. Check all cables. Replace damaged cables. Extend cables that rub against sharp edges.

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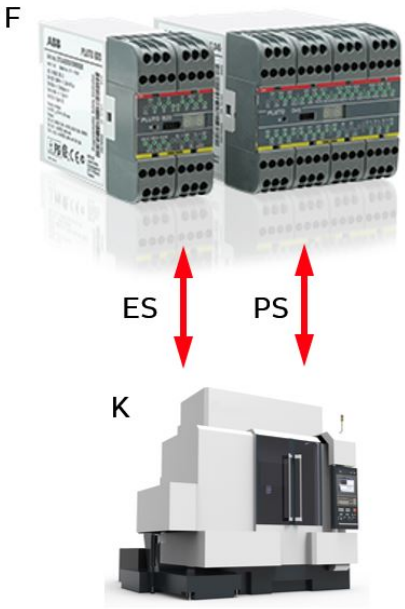
5 Interface

5.1 External safety interface to connected system

Introduction

The connected system is, for example, the customer's machine tool or the main safety system in the robot cell. Most often, the connected system is the master of the safety system and FlexLoader Standard Safety Center is a slave.

FlexLoader Standard Safety Center can also assume the role of the master in the safety system, either to other slaves or as a master cooperating with another master.



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Pos.	Description	Pos.	
F	FlexLoader Standard Safety Center	ES	Emergency stop
K	Connected system	PS	Protective stop

The connected system(s) must achieve sufficiently high PL (performance level) and PFH values (average probability of dangerous failures per hour) in order to achieve the necessary PL for all affected safety functions.

It is generally recommended that all protective functions are internally monitored and doubled.

The emergency stop and protective stop on FlexLoader Standard Safety Center's side fulfils the requirements according to category 3 and PLd.

For more information on performance levels and PFH values, see EN ISO 13849:1.

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Protective stop

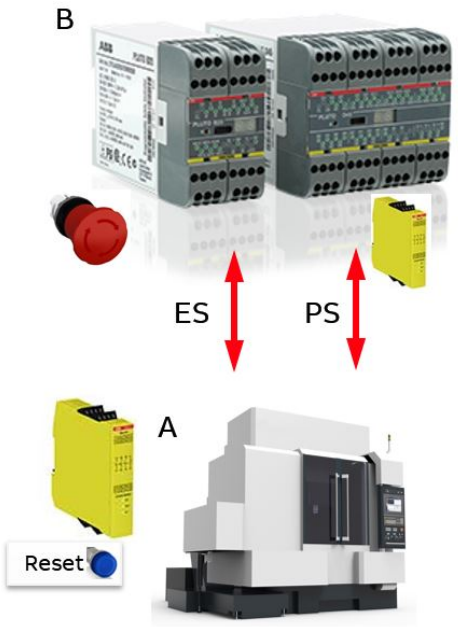
Protective stop is transmitted via a two-channel, potential free signal to the connected system from the safety relay of the FlexLoader Standard Safety Center.

Optionally, the connected system transmits a protective stop via a two-channel , potential free signal to FlexLoader Standard Safety Center using a two channel safety device. FlexLoader Standard Safety Center can be configured to accept a dynamic signal instead.

FlexLoader Standard Safety Center is always the protective stop master.

The connected system is emergency stop master

Emergency stop is transmitted via a potential free, two-channel signal to the connected system acting as an emergency stop button.



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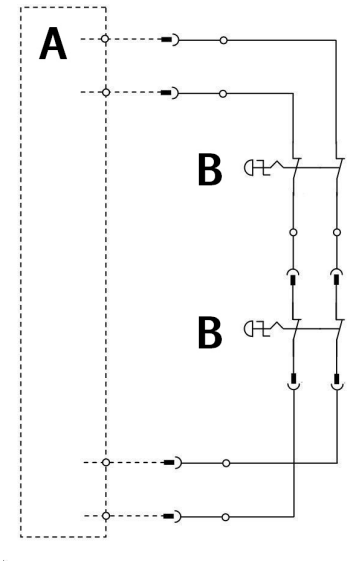

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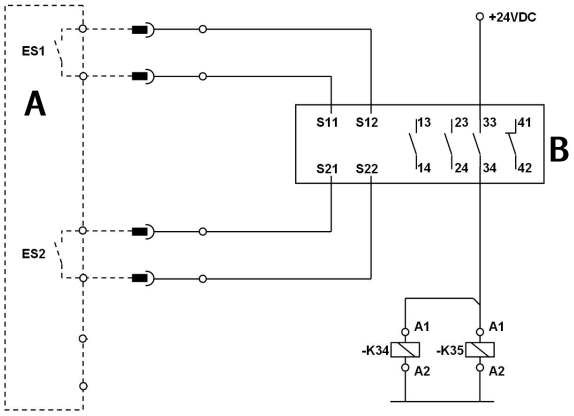
Pos.	Description
A	Connected system is emergency stop master
B	FlexLoader Standard Safety Center acting as emergency stop button
ES	Emergency stop
PS	Protective stop

The connected system transmits the master emergency stop via a two-channel, potential free signal from its safety relay to FlexLoader Standard Safety Center.



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Pos.	Description
A	Connected system is emergency stop master
B	FlexLoader Standard Safety Center receiving a two-channel, potential free signal

The connected system is responsible for resetting the emergency stop. FlexLoader Standard Safety Center resets the emergency stop automatically.

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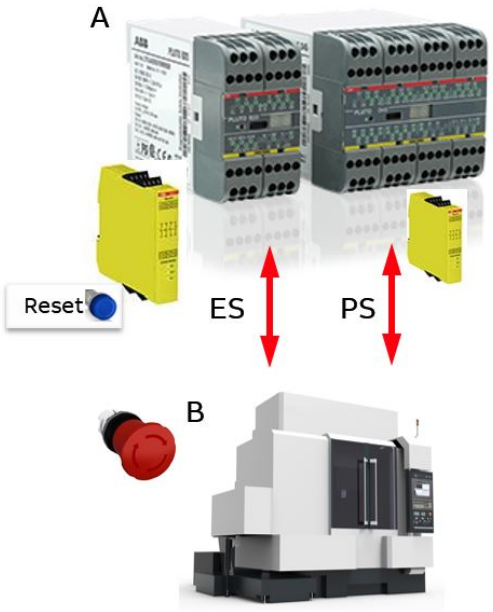
5.1 External safety interface to connected system
Continued

The connected systems are emergency stop slaves

The connected system transmits the emergency stop via a two-channel , potential free signal to FlexLoader Standard Safety Center acting as an emergency stop button.



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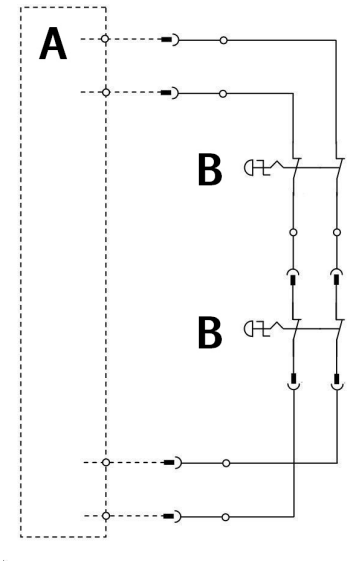

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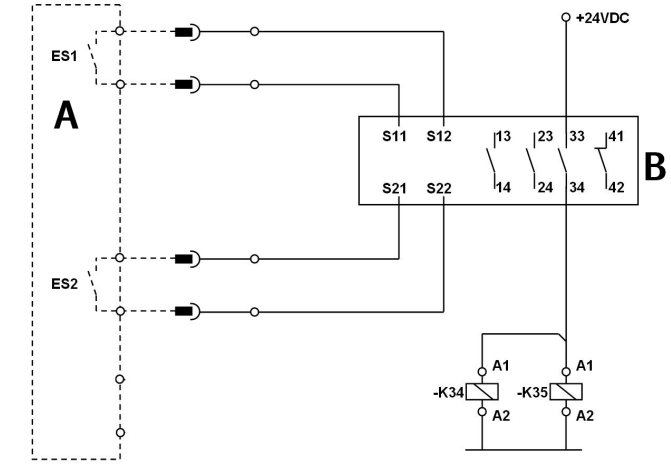
Pos.	Description
A	FlexLoader Standard Safety Center is emergency stop master
B	Connected system acting as emergency stop button
ES	Emergency stop
PS	Protective stop

FlexLoader Standard Safety Center transmits the emergency stop via a two-channel, potential free signal from its safety relay to the connected system.



xx1800000176

Pos.	Description
A	FlexLoader Standard Safety Center is emergency stop master
B	Connected system receiving a two-channel, potential free signal

FlexLoader Standard Safety Center is responsible for resetting the emergency stop. The connected system resets the emergency stop automatically.

Continues on next page

FlexLoader Standard Safety Center and connected systems are master

WARNING

This operating mode should be avoided because there can be small residual risks in the communication between the masters.

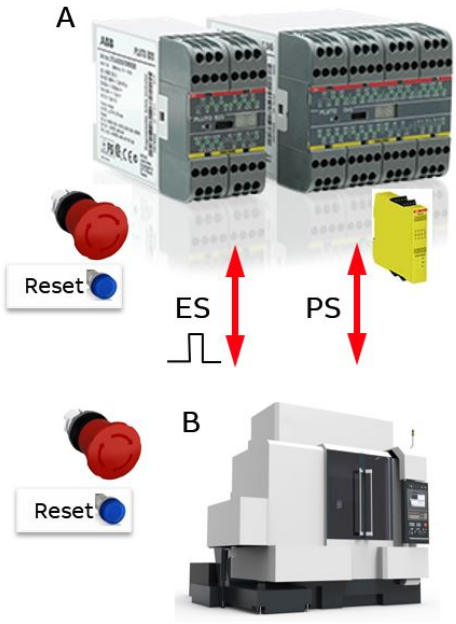
If possible, select a system where only FlexLoader Standard Safety Center is master.

FlexLoader Standard Safety Center transmits emergency stop via a two-channel, potential free signal to other systems. The emergency stop is transmitted as long as the safety center emergency stop button is pressed), the emergency stop signal then returns to its normal operating mode again.

FlexLoader Standard Safety Center is responsible for resetting its own emergency stop.

Other masters transmit the emergency stop via a two-channel, potential free signal to the FlexLoader Standard Safety Center. Emergency stop for further masters in the system is transmitted by signalling a 2 second emergency stop. This is to avoid locking modes in the emergency stop circuits.

In a system with several masters, each master is responsible for resetting its own emergency stop circuit.



xx1800002559

Pos.	Description	Pos.	
A	FlexLoader Standard Safety Center	ES	Emergency stop
B	Connected system	PS	Protective stop

Continues on next page

DANGER

Do not restart the cell until **all** masters are reset.

Parts of the call could be restarted while one of the connected master systems is still in emergency stop.

If a dangerous situation occurs, no new emergency command can be issued from the master that already is in emergency stop.

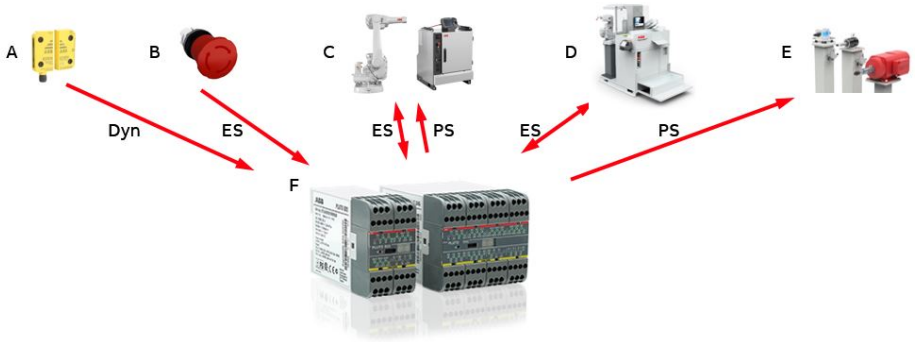
This behavior depends on the exact emergency stop implementation in the connected master systems and must be risk assessed for every cell.

5.2 Internal safety interface

Introduction

The FlexLoader Standard Safety Center is the safety master towards all internal equipment, e.g. feeding devices, robot, safety doors and other equipment.

The following interfaces are provided by FlexLoader Standard Safety Center.



xx1800002554

Pos.	Description	Pos.	
A	Internal door safety chain (single chain)	F	FlexLoader Standard Safety Center
B	Internal emergency stop chain		
C	Robot controller with robot(s)	Dyn	Dynamic safety signal
D	FlexLoader function package	ES	Emergency stop, two-channel, potential free
E	Equipment with elevated risk level, e.g. deburring, cutting, air cleaning.	PS	Protective stop, two-channel, potential free

Door safety chain

Door openings are safeguarded by Eden DYN safety switches. Up to three serial Eden DYN switches (which can be Magne units with integrated magnetic locking) can be directly connected to the FlexLoader.

There are two basic versions of the Pluto program: one for an even number of serially connected Eden switches in the protective stop chain (**PlutoStandardEven**),

Continues on next page

and another for an odd number of serially connected Eden switches in the protective stop chain (**PlutoStandardOdd**).

> **Note**
>
> The FlexLoader Standard Safety does not handle entry control. The application RAPID code is expected to handle entry requests and related operator interaction through it's I/O system.
>
> The door locking is not part of the safety control system and is intended for process reliability only.
>
> Risk assessment must confirm safety distances from door openings to hazard areas.

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Enable door lock

If Magne locks are used, the robot typically locks the door through it's I/O system (application specific). This signal can be routed through the Pluto system, which automatically unlocks the doors in case of protective and emergency stop with the help of its **EnableLockDoor** signal.

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Emergency stop chain

All internal emergency stop buttons and functions are connected to FlexLoader Standard Safety Center in a single two-channel, potential free signal chain. This includes the robot and the feeders.

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Safety interface to robot

Emergency stop

Internal emergency stop to the robot is transmitted via a two-channel, potential free signal from a safety relay.

Internal emergency stop from the robot is accepted via a two-channel, potential free signal (part of the internal emergency stop input chain).

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Protective stop

Protective stop to the robot is transmitted via a two-channel, potential free signal from a safety relay.

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Continues on next page

MotorsOn

The MotorsOn signal from the robot is transmitted via a two-channel, potential free signal from the robot contactors.

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Safety interface to FlexLoader function package

Emergency stop

Emergency stop to the FlexLoader function package is transmitted via a two-channel, potential free signal from a safety relay.

Internal emergency stop from the FlexLoader function package is accepted via a two-channel, potential free signal (part of the internal emergency stop input chain).

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Protective stop

There is no protective stop to the FlexLoader function package (e.g. FlexLoader FP 400 or FlexLoader FP 600).

Interface to dangerous equipment

Emergency stop

No separate emergency stop is transmitted to other dangerous equipment. The emergency stop is handled through the protective stop interface.

Protective stop

Protective stop to other dangerous equipment (see function description) is transmitted via a two-channel, potential free signal from a safety relay.

The cables are connected to terminals in the FlexLoader cabinet. For more detailed information see the wiring diagram.

Continues on next page

Safety valve

Dangerous pneumatic equipment can be controlled in this way. Connection points to a two-channel safety valve with two supervision channels are provided, as shown below.

We recommend the use of the following valve: Festo MS6-SV-1/2-D-10V24P-2M8-SO-AD1 (or compatible).

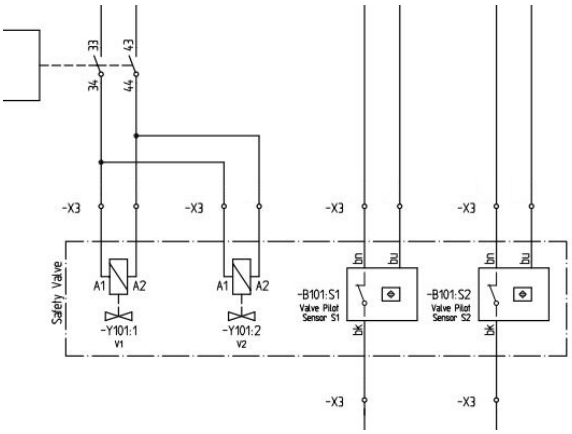


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Figure 5.1:

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6 Function description

Introduction

FlexLoader Standard Safety Center adds overall safety features to a FlexLoader cell. Emergency stop and protective stop to and from the FlexLoader equipment are gathered in one place and evaluated and managed according to the configuration.

In the following function description “internal” refers to a component or machine that is part of the FlexLoader function package or standard cell, e.g. the robot, FlexLoader FP 400, a rotation unit or similar. “External” refers in a typical case to the customer’s machine tool(s) (for example a transfer machine, lathe, press or similar).

For detailed functional specification see *Safety functions on page 54*

Protective stop

A protective stop is triggered by opening a cell door or opening (internal protective stop) or giving access to the cell through a connected system (external protective stop).

Emergency stop

An emergency stop is triggered by pressing any cell emergency stop button in the system (internal emergency stop) or putting any connected system into emergency stop (external emergency stop).

Entry and door lock

Door entry request and locking management are non-safety rated functions that are normally checked and controlled by the robot. They are not part of the FlexLoader Standard Safety Center.

The robot is responsible for locking the door when necessary. The FlexLoader Standard Safety Center provides a possibility to override door locking in case of emergency stop or protective stop.

Controlled exit

The protective stop is normally reset by a key switch positioned at every door. Sometimes not all the cell can be seen from the doors locations.

In this case, a pre-reset button shall be placed in the cell at a location that ensures unobstructed view into the whole cell. FlexLoader Standard Safety Center must then be configured for ControlledExit.

Protective stop can then only be reset if the pre-reset button is pressed prior to final reset by the key switch positioned at the door, within a time limit of 30 s.

Handling dangerous equipment

If there is dangerous equipment in the cell, it will be deactivated at a protective stop. In some cases you may want to activate this equipment during a protective stop, e.g. for test operation.

Continues on next page

Continued

The dangerous equipment can be enabled by means of the enabling device on the FlexPendant combined with the reset key switch at a door.

A dedicated risk analysis must be performed prior to using this functionality.

7 Operation

7.1 Starting from a non-powered status

1 Turn on the main power supply. Wait until all devices have started up.
2 Perform a power on safety check:
   - Press and restore at least one internal FlexLoader Standard Safety Center emergency stop button.
   - Reset the emergency stop.
   - Open and close at least one internal FlexLoader Standard Safety Center cell door.
   - Reset the door status by shortly turning the reset key.

     Optionally, if a light curtain is present, a long light curtain reset may be needed (0.5 s) first, followed by a second reset for the whole cell.
3 Check the function of the external emergency stop
4 Check the function of the external protective stop (if present).

DANGER

Do not continue to work until the safety circuits are functioning correctly.

7.2 Protective stop

Introduction

The FlexLoader Standard Safety handles protective stop and manual operation of dangerous equipment. The protective stop mode ensures safe stop of equipment upon cell entry and prevents the equipment from being started while the cell is accessible.

Standard operation

The example below shows a typical operator panel made by an integrator, handling entry request, door reset and restart. Only emergency stop, emergency stop reset and door reset key switch interacts with the safety center.

xx1900000172

Pos.	Description
A	Emergency stop
B	Start button (integrator dependent)
C	Entry request button
D	Key switch
E	Emergency stop reset button (if master)

Protective stop

Request entry to the robot cell through routines provided by the robot program.

DANGER

When entering the cell, the operator must bring the key that is used to confirm the protection door. This is to prevent somebody else from confirming and restarting FlexLoader Standard Safety Center when the operator is inside the cell. There may only be one key for the entire cell.

Take the key (D) and carry out the work in the cell.

Continues on next page

Close the door and turn the reset key switch (D) to confirm that the work in the cell is finished.

Restart the the robot cell through routines provided by the robot program.

The robot cell is in protective stop mode from the moment the door opens until the key switch (D) has been turned.

DANGER

Always make sure that nobody is inside the cell and that the system can be restarted without any risk of injury before confirming with the key switch and restarting the system.

Emergency stop

Press any of the robot cells emergency stop buttons (e.g. (A)) in case of emergency.

The cell will stop as designed, and the emergency reason can be handled.

Release the emergency stop button (e.g. (A)).

Push the emergency stop system reset button at the emergency stop master(s) (depends on system configuration, e.g. (E)).

Turn the reset key switch (D) to confirm that the work in the cell is finished.

Restart the robot cell through routines provided by the robot program.

Manual operation of dangerous equipment

By default the protective stop is activated as soon as any FlexLoader Standard Safety Center door is opened. This deactivates dangerous equipment in the cell. Sometimes, such equipment must be activated for test operation.

Therefore the FlexLoader Standard Safety Center electrical cabinet allows for using an alternate protective stop configuration (protective stop with override-function). This possibility should only be used by integrators and never in normal operation.

Press the enabling device on the FlexPendant and switch the door reset switch. The protective stop sent to the dangerous equipment is now overridden until the enabling device on the FlexPendant is released.

DANGER

It is the integrators responsibility to perform a suitable risk assessment for this mode of operation.

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8 Decommissioning

8.1 General

Introduction

This section contains information to consider when taking a product, robot or controller, out of operation.

It deals with how to handle potentially dangerous components and potentially hazardous materials.

Disposal of storage media

Before disposal of any storage equipment (anything from an SD card to a complete controller), make sure that all sensitive information has been deleted.

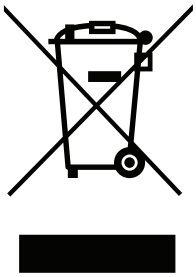
8.2 Environmental information

General

All used grease/oils and dead batteries **must** be disposed of in accordance with the current legislation of the country in which the robot and the control unit are installed.

Symbol

The following symbol indicates that the product must not be disposed of as common garbage. Handle each product according to local regulations for the respective content.



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For professional users in the European Union

The crossed –out wheeled bin symbol on the product(s) and / or accompanying documents means that used electrical and electronic equipment (WEEE) should not be mixed with general household waste.

If you wish to discard electrical and electronic equipment (EEE), please contact your dealer or supplier for further information.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

For disposal in countries outside of the European Union

The crossed –out wheeled bin symbol is only valid in the European Union (EU) and means that used electrical and electronic equipment (WEEE) should not be mixed with general household waste.

If you wish to discard this product please contact your local authorities or dealer and ask for the correct method of disposal.

Disposing of this product correctly will help save valuable resources and prevent any potential negative effects on human health and the environment, which could otherwise arise from inappropriate waste handling.

Oil and grease

Where possible, arrange for oil and grease to be recycled. Dispose of via an authorized person/contractor in accordance with local regulations. Do not dispose of oil and grease near lakes, ponds, ditches, down drains, or onto soil. Incineration must be carried out under controlled conditions in accordance with local regulations.

Continues on next page

Also note that:

- Spills can form a film on water surfaces causing damage to organisms. Oxygen transfer could also be impaired.
- Spillage can penetrate the soil causing ground water contamination.

Hazardous material

The table specifies some of the materials in the FlexLoader function package and their respective use throughout the product.

Dispose of the components properly to prevent health or environmental hazards.

Material	Example application
Batteries, Lithium	Main computer Serial measurement board
Copper	Cables Motors
Steel	Cabinet structure, plates, screws, etc.
Plastic/rubber (PVC)	Cables, connectors, etc.
Aluminium	Heat sinks on power supplies and drive units
Lead	Electronics
Brominated flame retardants	Electronics
Oil, grease	Gearboxes
Neodymium brakes	Motors

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A Technical data

A.1 Introduction

CPU configuration and expansion units

Pluto B20, with GATE-PN (Profinet signal exchange with the robot).

Pluto configurations

When transferring the Pluto program to the Pluto unit, one of the following options must be selected:

- Pluto is emergency stop slave (**IsEmergencyStopSlave**)
- Pluto is emergency stop master (**IsEmergencyStopMaster**)
- Pluto is emergency stop master among other emergency stop masters (**ManyEmergencyStopMasters**)

FlexLoader Standard Safety Center is always protective stop master. This means that protective stops can be reset at the FlexLoader doors.

The following additional options can be specified for special needs:

- If necessary, the external protective stop can be supplied as a single channel dynamic signal (e.g. Eden) (**IsDynamicExternalAutostop**). In this case the correct polarity on input I0.2 must be defined in the I/O configuration.
- If necessary, a controlled exit of the cell is required (**IsControlledExit**). In this case the signal **ControlledExitButton** must be pulsed by pressing a suitably placed button at most 30 s prior to activating **ResetAutostop**.

Password

Passwords used in FlexLoader Standard Safety Center:

Usage	Password
Main password for full access to the Pluto program	main123
For changing the configuration settings	config123
For downloading to Pluto	svia

Checksum

The checksum for the current version can be found in the release notes.

A.2 Safety functions

Protective stop

Protective stop safety function

If any of the signals **InAutoStopExternalChA** /**B** (not always used) or **AutoStopDoorChain** are **0**, the safe outputs **OutAutoStopInternalExternal** and **OutAutoStopInternalRiskComponents** are set to **0**.

The protective stop is also activated by emergency stop (see above).

If external protective stop is communicated via a single channel dynamic signal (**IsDynamicExternalAutostop**), only **InAutoStopExternalChB** is evaluated.

Resetting the protective stop safety function

When the first supervision signal (from the expansion relay) **SupervisionAutoStop** is **1** and both **InAutoStopExternalChA**/**B** and **AutoStopDoorChain** are **1**, the safe output **OutAutoStopInternalExternal** and **OutAutoStopInternalRiskComponents** are reset as soon as the input **ResetAutostop** has been pulsed to **1** (at least 0.2 s).

If controlled exit of the cell is activated (**IsControlledExit**) the **ControlledExitButton** signal must be pulsed to **1** (and returned to **0**) within 30 s before **ResetAutostop** is set to **1**.

EnableLockDoor

EnableLockDoor is a signal that can ensure that the door always unlocks regardless of the robot's lock command.

If any of the safe outputs is set to **0**, the output **EnableLockDoor** is also set to **0**. **EnableLockDoor** is only set to **1** when all safe outputs are set to **1**.

It can be used to route a lock signal from the robot through a relay,

Protective stop safety function of dangerous equipment

During an ongoing protective stop the output **OutAutoStopInternalRiskComponents** is set to **1** when **MotorsOnChA**/**B** are both **1** and **ResetAutostop** is pulsed to **1**. As soon as one of the signals **MotorsOnChA**/**B** is **0**, **OutAutoStopInternalRiskComponents** is set to **0**.

Note that no monitoring occurs on the function which is tied to **OutAutoStopInternalRiskComponents**, so this function must have its own monitoring.

Emergency stop: Pluto is slave

In this operating mode, the safety center emergency stop acts as emergency stop buttons towards the external equipment.

Emergency stops from the external equipment are expected to come from the emergency stop relays. The emergency stops must be reset on the external equipment.

Continues on next page

Regardless of the external equipment, the FlexLoader equipment continues in emergency stop on activation of any internal emergency stop button.

Emergency stop safety function

At internal emergency stop, that is **InEmergencyStopInternalChA/B** becomes **0**, all safe outputs, that is **OutEmergencyStopExternal**, **OutEmergencyStopInternal**, **OutAutoStopInternalRiskComponents**, and **OutAutoStopInternalExternal**, are set to **0**.

At external emergency stop, that is **InEmergencyStopExternalChA/B** becomes **0**, all internal safe outputs, that is **OutEmergencyStopInternal**, **OutAutoStopInternalRiskComponents** and **OutAutoStopInternalExternal**, are set to **0**.

At an emergency stop, the protective stop function is also force activated.

Resetting the emergency stop safety function

If there is an internal emergency stop, that is **InEmergencyStopInternalChA/B** is **0**, the cause of the internal emergency stop must be rectified. It requires a check of the supervision signal (from the expansion relay), that is **SupervisionEmergencyStopExternal** is **1**, and that **InEmergencyStopInternalChA/B** then turns to **1**. The safe output **OutEmergencyStopExternal** is then reset to **1**.

When the supervision signal (from the expansion relay) **SupervisionEmergencyStopInternal** is **1** and the external emergency stop cause is rectified, that is **InEmergencyStopExternalChA/B** is **1**, the emergency stop output **OutEmergencyStopInternal** is reset to **1**.

Protective stop can then be reset according to the rules for protective stop.

Emergency stop: Pluto is master

In this operating mode, the external emergency stop is evaluated as if it was an emergency stop button.

The emergency stop to the external equipment comes from the emergency stop relays outputs. The emergency stop must be reset on the FlexLoader equipment.

Emergency stop safety function

If an external or internal emergency stop is made, that is if one of the signals **InEmergencyStopInternalChA/B** or **InEmergencyStopExternalChA/B** becomes **0**, all safe outputs, that is **OutEmergencyStopExternal**, **OutEmergencyStopInternal**, **OutAutoStopInternalRiskComponents** and **OutAutoStopInternalExternal**, are set to **0**. The output **ResetEmergencyStopLamp** is set to **1**.

At emergency stop, the protective stop function is also forcibly activated.

Resetting the emergency stop safety function

When all emergency stop inputs, that is **InEmergencyStopInternalChA/B** and **InEmergencyStopExternalChA/B** are **1** the output **ResetEmergencyStopLamp** starts to flash.

Before resetting, both supervision signals (from expansion relay) **SupervisionEmergencyStopInternal** and **SupervisionEmergencyStopExternal** must be **1**. When the **ResetEmergencyStop** signal has been pulsed to **1** (at least

Continues on next page

0.2 s) all safe emergency stop outputs, that is **OutEmergencyStopExternal** and **OutEmergencyStopInternal**, are set to **1**.

Protective stop can then be reset according to the rules for protective stop.

Emergency stop: Pluto is master among other masters

Emergency stop safety function

If an internal emergency stop is made, that is if the signals **InEmergencyStopInternalChA/B** become **0**, all safe outputs, that is **OutEmergencyStopExternal**, **OutEmergencyStopInternal**, **OutAutoStopInternalRiskComponents** and **OutAutoStopInternalExternal**, are set to **0**. The output **ResetEmergencyStopLamp** is set to **1**.

If an external emergency stop is made, that is if the signals **InEmergencyStopExternalChA/B** become **0**, all safe outputs, that is **OutEmergencyStopInternal** and **OutAutoStopInternalExternal**, are set to **0**. The safe output **OutEmergencyStopExternal** is set to **0** for 2 seconds. The output **ResetEmergencyStopLamp** is set to **1**.

Resetting the signals to other masters

As soon as the internal emergency stop cause is rectified, when the signals **InEmergencyStopExternalChA/B** become **1** again, the safe outputs, **OutEmergencyStopInternal** can be set to **1**.

A condition for the safe outputs **OutEmergencyStopExternal** to be returned to **1** is that the supervision signal (from the expansion relay) **SupervisionEmergencyStopExternal** is **1**.

OutEmergencyStopExternal must be **0** for at least 2 seconds, even if the internal emergency stop cause is rectified before this.

Resetting the emergency stop safety function

When all emergency stop inputs, that is **InEmergencyStopInternalChA/B** and **InEmergencyStopExternalChA/B** are **1**, the output **ResetEmergencyStopLamp** starts to flash.

Before resetting, the supervision signal (from expansion relay) **SupervisionEmergencyStopInternal** must be **1**. When the **ResetEmergencyStop** signal has been pulsed to **1** (at least 0.2 s) **OutEmergencyStopInternal** is set to **1**.

Protective stop can then be reset according to the rules for protective stop.

A.3 Error messages

The following error codes are used in the Pluto display (**UE** (User Error) followed by the error code). These are added together if several conditions are met.

Value	Description
1	An external emergency stop is activated
2	An internal emergency stop is activated
4	An internal protective stop is activated
8	An external protective stop is activated
16	Supervision emergency stop (internal or external) gives incorrect signal
32	Supervision protective stop gives incorrect signal
64	Safety circuit ready for resetting, for example after door opening

Example:

- Error code 6: A door to the cell is open and an internal emergency stop is pressed.
- Error code 5: External emergency stop is active and the protective stop circuit is broken.
- Error code 77: Error when selecting basic configuration. None or several of the basic configurations have been selected. Only select one during transfer.

In the event of a two-channel fault in one of the two-channel inputs, one of the associated inputs flashes. Two-channel faults occur when, for example, only one channel is activated and then reset.

All two-channel inputs have concurrency requirements, meaning that the signal in both channels must switch signal within 0.2 s.

If the two-channel requirement is not fulfilled, the associated input LED on Pluto flashes twice. Two-channel faults can be resolved by opening both channels and then closing them again.

A.4 Starting from a non-powered status

When starting from a non-powered status the safety functions must be checked. All safe outputs are set to **0**. Message **94**, **95**, **96**, **97**, **98** or **99** is displayed, indicating how Pluto is configured (see table below).

Before a safe output can be set to **1** it must be verified that the internal emergency stop and protective stop fulfil its intended function. This occurs by both **InEmergencyStopInternalChA/B** and **AutoStopDoorChain** having been set to both **0** and to **1**.

Pluto is in the initiation sequence after start from a non-powered status. The protective stop chain and internal emergency stop chain must be interrupted once and reset. The value indicates Pluto's basic configuration.

For more information, see *Operation on page 45*.

Configuration	Odd number of doors/switches	Even number of doors/switches
Pluto as slave	94	97
Pluto as master	95	98
Pluto as master among other masters.	95	99

A.5 Pluto I/O

All inputs have filtering activated.

In	Out	Designation	Comments
I 0		InEmergencyStopInternalChA	Emergency stop In (FlexLoader buttons and robot) (static)
I 1		InEmergencyStopInternalChB	Emergency stop In (FlexLoader buttons and robot) (**DynA Non_inv**)
I 2		InAutoStopExternalChA	Protective stop In (from external machine, option) (static, bridged to 24 V if not used)
I 3		InAutoStopExternalChB	Protective stop In (from external machine, option) (**DynA Non_inv**, bridged to **DynA** if not used). Option: Can be configured as sole dynamic input, set correct inversion.
I 4		InEmergencyStopExternalChA	Emergency stop In (from external machine) (static, bridged to 24 V if not used)
I 5		InEmergencyStopExternalChB	Emergency stop In (from external machine) (**DynA Non_inv**, bridged to **DynA** if not used)
I 6		InMotorsOnChA	**MotorsOn** signal from the FlexPendant through the motor contactors (static, bridged to 24 V if not used)
I 7		InMotorsOnChB	**MotorsOn** signal from FlexPendant through the motor contactors (**DynA Non_inv**, bridged to **DynA** if not used)
IQ 10		ResetAutoStop	Reset protective stop (static)
IQ 11	IQ 11	ResetEmergencyStop ResetEmergencyStopLamp	Reset emergency stop (**DynA NonInv**, option) Lamp in reset button (static, option)
IQ 12		AutoStopDoorChain	Protective stop in door chain • Even numbers of doors: **DynA Noninv** • Odd numbers of doors: **DynA**
IQ 13		SupervisionAutoStop	Supervision expansion, protective stop (static)
IQ 14		SupervisionEmergencyStopInternal	Supervision expansion, emergency stop internal (static)
IQ 15	IQ 15	ControlledExitButton EnableLockDoor	Push button inside the cell that must be activated within the correct time window before **ResetAutostop** is accepted. Doubling signal that indicates that the doors can be locked. Activated as soon as neither protective stop nor emergency stop are active.
IQ 16		SupervisionEmergencyStopExternal	Supervision expansion, external emergency stop (static, option)
	IQ 17	DynA	Generates signal **DynA**
	Q 0	OutEmergencyStopExternal	Emergency stop for external equipment via expansion relay

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A.5 Pluto I/O
Continued

In	Out	Designation	Comments
	Q 1	OutAutoStopInternalRiskComponents	Protective stop for internal equipment that requires a three position device on the FlexPendant and deliberate resetting, via expansion relay
	Q 2	OutAutoStopInternalExternal	Protective stop for both internal and external equipment via expansion relay
	Q 3	OutEmergencyStopInternal	Emergency stop for internal equipment via expansion relay

A.6 Safety center response times

Subsystem response times

The following reaction times are estimated for the system. They have to be considered when calculating stopping distances.

Response times Pluto

- Program execution time: ~5 ms (~10 µs per instruction, estimated number of instructions < 500)
- Static or DynA input to any output: < 20.5 ms + program execution time
- Bus response time: + 10 ms

Response times external components

- Response time safety relay (Sentry BSR-series and SSR-series, E1T, RT9): < 20 ms
- Light guard (Orion 2 Base): 16 ms
- Eden DYN / Magne safety switch: < 30 ms

Resulting system stop times

Typical total response times for initiating robot stop motion

- Protective stop due to light beam violation: < 61.5 ms
  (< 16 ms + 20.5 ms + 5 ms + 20 ms)
- Protective stop due to door opening violation: < 75.5 ms
  (< 30 ms + 20.5 ms + 5 ms + 20 ms)

Typical response times for external emergency stop

- External emergency or protective stop transfer to other equipment: < 45.5 ms
  (< 20.5 ms + 5 ms + 20 ms)

Typical response times for internal emergency stop

- Response time: < 25.5 ms
  (< 20.5 ms + 5 ms + 20 ms)

A.7 Installation guide

Working method

1. Ensure that the programming cable is connected between the computer and Pluto #0.
2. Open the desired program in Pluto Manager.
3. Verify the checksum for the program according to the release notes.
4. Configure the appropriate Pluto program according to the cell specification for the actual FlexLoader cell.
5. Load the program to Pluto.
6. Carry out the test for start up from non-powered status.
7. Check all safety functions.

CAUTION

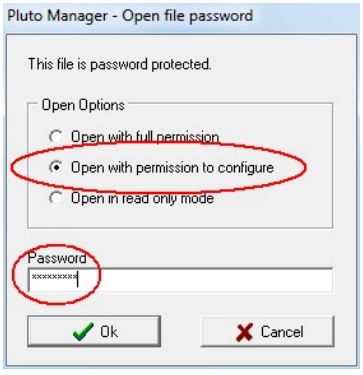
In case of changes or deviations: Update cell specification.

A new validation is necessary if functional changes are made to the Pluto program.

Configuring

1. Ensure that the programming cable is connected between the computer and Pluto #0.
2. Open the desired program in Pluto Manager.

   There are two basic versions of the Pluto program: One for an even number of serially connected Eden DYN switches in the protective stop chain (**PlutoStandardEven**), and another for an odd number of serially connected Eden DYN switches in the protective stop chain (**PlutoStandardOdd**).
3. Select **Open with permission to configure** and enter the password **config123**. Click **OK**.



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4. Verify the checksum for the program according to the release notes.

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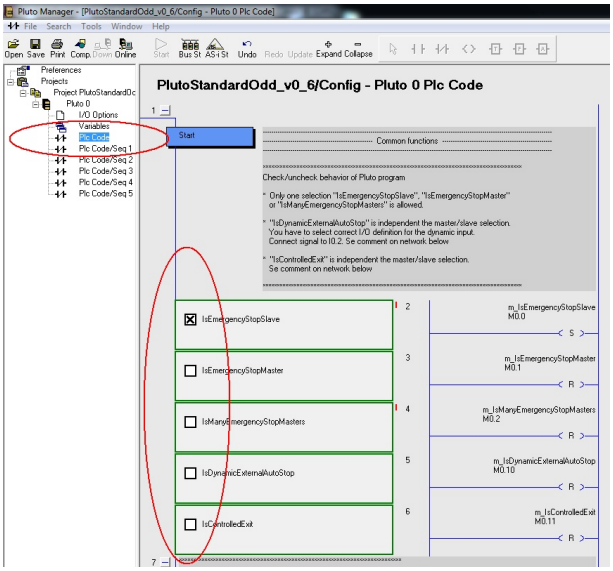
5 Open the Pluto project and highlight **PLC Code**. Then select Pluto behavior according to the information on the wiring diagram for the corresponding FlexLoader cell.



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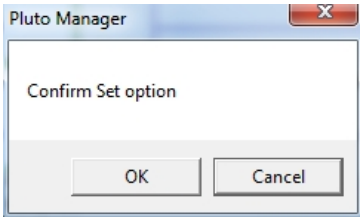
6 Click **OK** to confirm your selection of Pluto behavior. Repeat until all options are set according to the specification.



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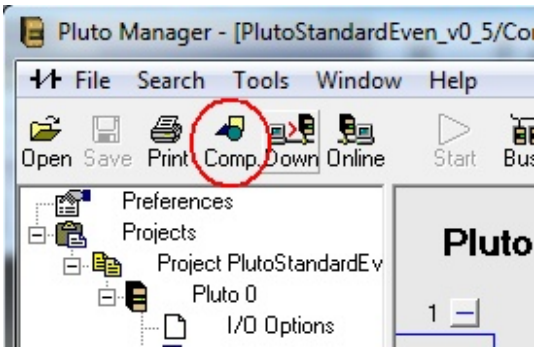
7 The next step is to compile the program. Click **Comp.**



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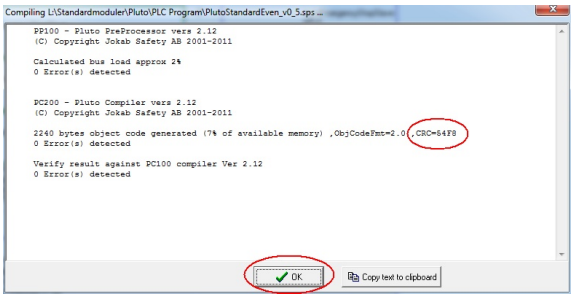
8 Click **OK** to confirm the successful compilation.



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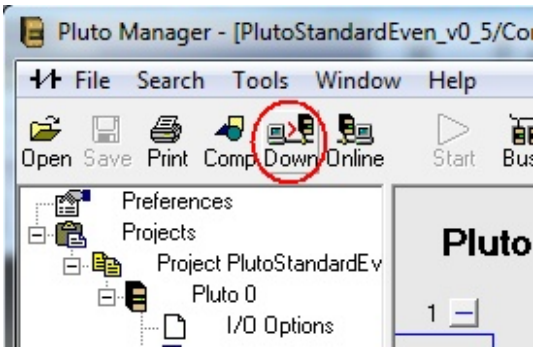
Downloading

1 Click **Down** to commence downloading the Pluto program.



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2 Enter a password for downloading (twice at the first download). Always enter the password **svia** when downloading. For later downloading the correct password must be used to download a new program in Pluto.

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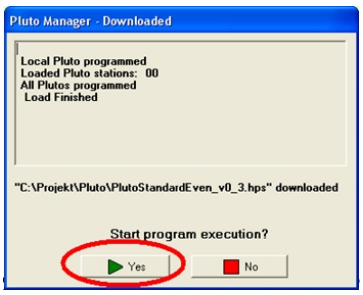
3 When downloading programs in Pluto, the execution of program operation is stopped. Therefore, click **Yes** to restart execution.



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4 Perform the same sequence as at restart from unpowered status.

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