APPLICATIVE SYSTEM REDUNDANCY

Applicative system redundancy

AUTOMATION

Application note
8134_en_00

1 Introduction

With applicative system redundancy it is possible to design two PROFINET IO controllers from Phoenix Contact as a redundant system. A PROFINET IO controller (called IO controller in the following) is configured as primary PROFINET IO controller (called primary IO controller in the following), the other as backup PROFINET IO controller (called backup IO controller in the following).

On the field level, non-redundantly designed PROFINET IO devices (called IO devices in the following) operate with and/or without control functions (e.g., small controller of the 100 controller class with PROFINET IO device function and/or PROFINET bus coupler).

Depending on the process, the IO device concerned receives valid data either from the primary controller or from the backup IO controller. If none of the two IO controller provides valid data, substitute values will be output at the outputs of the IO device. The preset default value is "0".

Two typical application examples are described in Section "Applicative system redundancy - Application examples" on page 3. In the examples, an ILC 170 ETH 2TX controller functions as a PROFINET IO device with control function in a PROFINET network, with two redundant higher-level IO controllers. One of the IO controllers functions as a primary controller the other as a backup IO controller. The process data exchange between primary/backup IO controller and lower-level IO device is a primary element of applicative system redundancy. The reading in and outputting of process data at the IO device depends on the application program which runs on the ILC 170 ETH 2TX controller and is determined by the user.

The application monitors the redundancy between primary controller and backup IO controller. For this purpose, there are special PC WorX function blocks available for different controllers from Phoenix Contact. For more information, please contact your nearest Phoenix Contact representative.

Make sure you always use the latest documentation.
It can be downloaded at www.phoenixcontact.net/catalog.

This application note is valid for all products listed on the following page:

2 Products that can be used

Applicative system redundancy can be implemented in a PROFINET network using the following products from Phoenix Contact.

PROFINET IO controller:

– ILC 370 PN 2TX-IB (/M)
– ILC 390 PN 2TX-IB
– RFC 470 PN 3TX

PROFINET IO devices with control function:

– ILC 170 ETH 2TX
– ILC 190 ETH 2TX

PROFINET IO devices without control function:

– IL PN BK DI8 DO4 2TX-PAC
– IL PN BK DI8 DO4 2TX/NC
– FLM BK PN M12 DI8 M12-2TX

Infrastructure components with PROFINET IO device function:

– FL NP PND-4TX IB
– FL NP PND-4TX IB-LK
– FL SWITCH GHS 12G/8
– FL SWITCH GHS 4G/12
– FL SWITCH MM HS
– FL SWITCH MCS 16TX
– FL SWITCH SMCS 8GT
– FL SWITCH SMCS 8TX
– FL SWITCH SMCS 6GT/2SFP
– FL SWITCH SMCS 6TX/2SFP
– FL SWITCH SMCS 4TX-PN
– FL SWITCH SMCS 8TX-PN

3 Ordering data

Products

Description	Type	Order No.	Pcs./Pkt.
Inline controller	ILC 170 ETH 2TX	2916532	1
Inline controller	ILC 190 ETH 2TX	2700527	1
Inline controller	ILC 370 PN 2TX-IB	2876915	1
Inline controller	ILC 390 PN 2TX-IB	2985314	1
Remote Field Controller	RFC 470 PN 3TX	2916600	1
PROFINET bus coupler with I/O connector	IL PN BK DI8 DO4 2TX-PAC	2703994	1
PROFINET bus coupler without I/O connector	IL PN BK DI8 DO4 2TX/NC	2692649	1
PROFINET bus coupler	FLM BK PN M12 DI 8 M12-2TX	2736741	1
Proxy for PROFINET IO-RT	FL NP PND-4TX IB	2985974	1
Proxy for PROFINET IO-RT, INTERBUS proxy for fiber optics	FL NP PND-4TX IB-LK	2985929	1
Gigabit Modular Switch	FL SWITCH GHS 12G/8	2989200	1
Gigabit Modular Switch	FL SWITCH GHS 4G/12	2700271	1
Modular switch system, head station	FL SWITCH MM HS	2832328	1
Managed switch (16 twisted pair ports)	FL SWITCH MCS 16TX	2832700	1
Smart Managed Compact Switch (8 RJ45 Gigabit ports)	FL SWITCH SMCS 8GT	2891123	1
Smart Managed Compact Switch (8 RJ45 Fast Ethernet ports)	FL SWITCH SMCS 8TX	2989226	1
Smart Managed Compact Switch (6 RJ45 Gigabit ports)	FL SWITCH SMCS 6GT/2SFP	2891479	1
Smart Managed Compact Switch (6 RJ45 Fast Ethernet ports and fiber optics)	FL SWITCH SMCS 6TX/2SFP	2989323	1
Smart Managed Compact Switch (4 RJ45 Fast Ethernet ports)	FL SWITCH SMCS 4TX-PN	2989093	1
Smart Managed Compact Switch (8 RJ45 Fast Ethernet ports)	FL SWITCH SMCS 8TX-PN	2989103	1

Documentation

Description	Type	Order No.	Pcs./Pkt.
PROFINET basics user manual	UM EN PROFINET SYS	–	1
PROFINET controller/device functions user manual	UM EN PROFINET CTRL DEV	–	1

4 Applicative system redundancy - Application examples

This section provides two examples for applicative system redundancy. In both examples, an IO device with control function and an IO device without control function is connected to a PROFINET network by means of a switch. Identical application programs run on both higher-level IO controllers.

4.1 Connection with Ethernet

In this network, two RFC 470 PN 3TX IO controllers operate as higher-level controllers. To achieve synchronization both IO controllers are connected with a switch via an Ethernet connection. IO controller A functions as a primary IO controller, IO controller B functions as a backup IO controller.

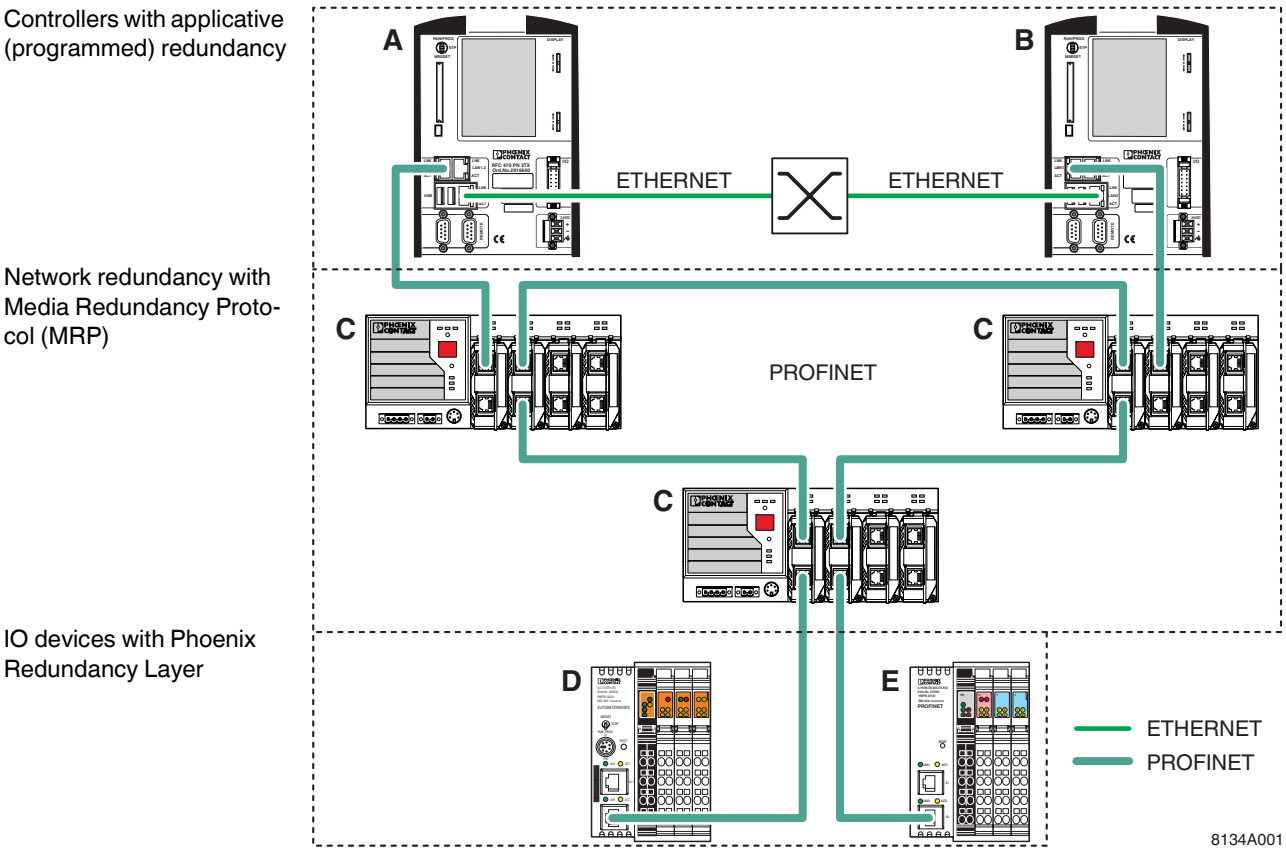

Figure 1 Applicative system redundancy – IO devices in a PROFINET network, with two higher-level IO controllers (RFC 470 PN 3TX) connected with a switch for synchronization.

Key:

A Primary IO controller (in the example: RFC 470 PN 3TX)

B Backup IO controller (in the example: RFC 470 PN 3TX)

C Managed Switches

D IO device with control function
(in the example: ILC 170 ETH 2TX with IO device function and Phoenix Redundancy Layer)

E IO device without control function
(in the example: IL PN BK DI8 DO4 2TX with IO device function and Phoenix Redundancy Layer)

4.2 Connection with INTERBUS

In this network, two ILC 370 PN 2TX-IB IO controllers operate as higher-level controllers. To achieve synchronization both IO controllers are connected with a switch via INTERBUS. IO controller A functions as a primary IO controller IO controller B functions as a backup IO controller.

Controllers with applicative (programmed) redundancy

Network redundancy with Media Redundancy Protocol (MRP)

IO devices with Phoenix Redundancy Layer

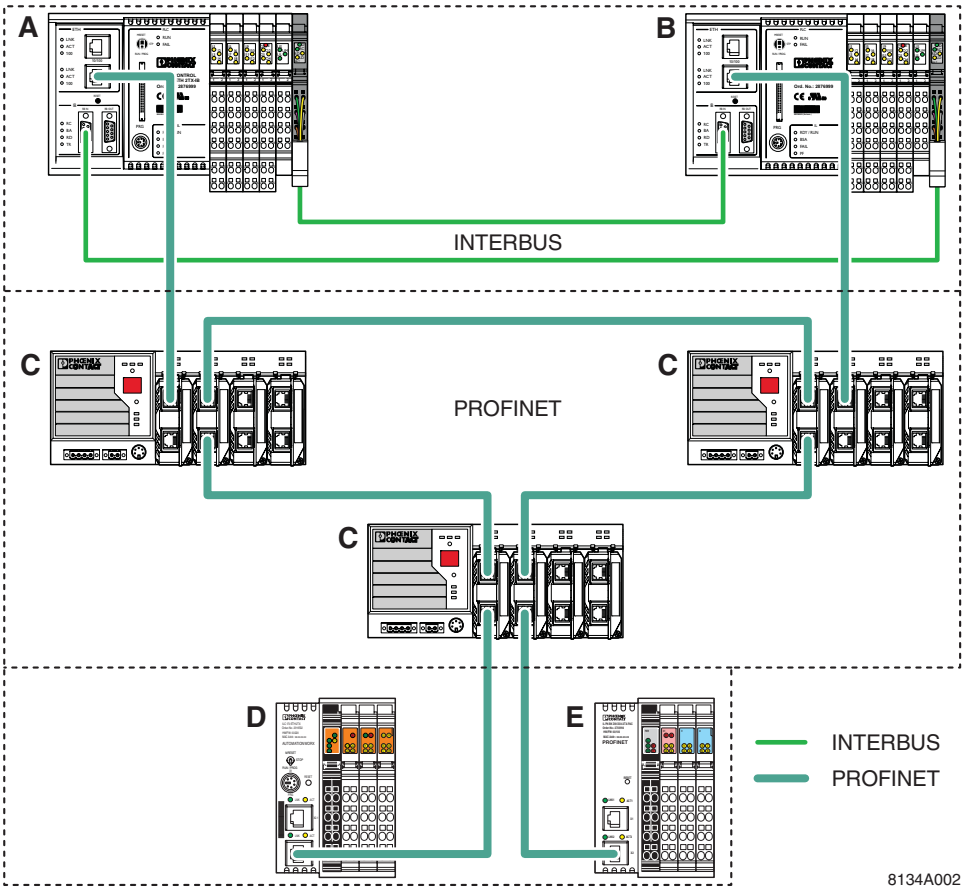

Figure 2 Applicative system redundancy – IO devices in a PROFINET network, with two higher-level IO controllers (ILC 370 PN 2TX-IB) connected with INTERBUS for synchronization.

Key:

A Primary IO controller (in the example: ILC 370 PN 2TX-IB)

B Backup IO controller (in the example: ILC 370 PN 2TX-IB)

C Managed Switches

D IO device with control function
(in the example: ILC 170 ETH 2TX with IO device function and Phoenix Redundancy Layer)

E IO device without control function
(in the example: IL PN BK DI8 DO4 2TX with IO device function and Phoenix Redundancy Layer)

5 Description of the Phoenix Redundancy Layer on PROFINET IO devices from Phoenix Contact

5.1 Communication structures

The following Figure 3 provides an overview of the communication structures of applicative system redundancy with Phoenix Redundancy Layer.

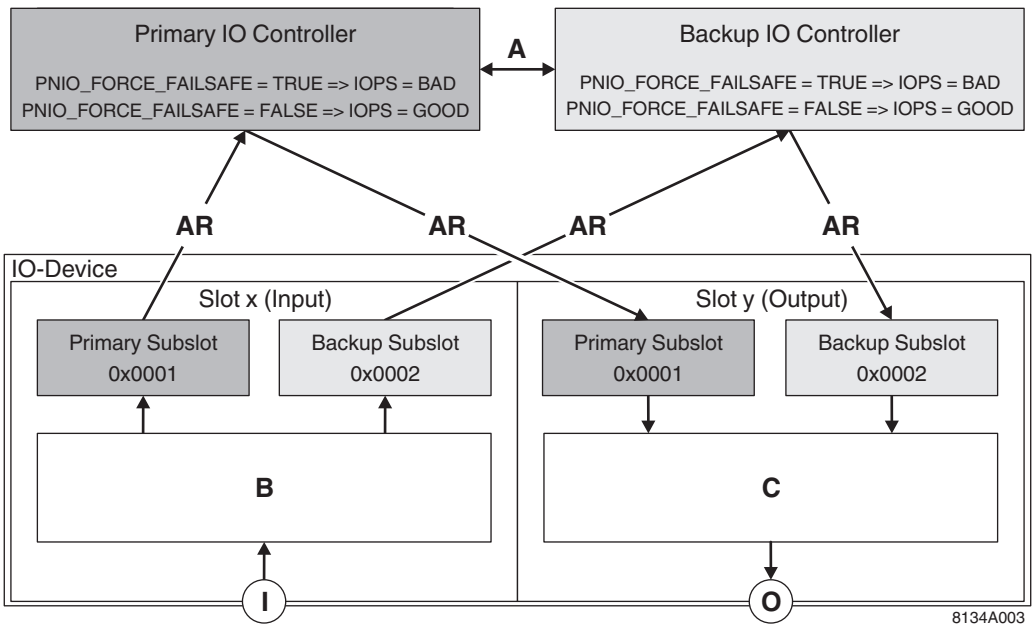

Figure 3 Phoenix Redundancy Layer – Communication structures

Key:

A	Connection for synchronizing of primary IO controller and backup IO controller
AR	Application relationship (transmission of, for example, process data and process data status (IOPS) in direction of the arrow)
B	Transmission of input process data to the primary subslot as well as to the backup subslot
C	Transmission (distribution) of data to the outputs according to the priority rules (see Section "Priority rules" on page 6)
I	Inputs
O	Outputs
IOPS	Process data status of the outputs (system variable: PND_S1_OUTPUT_STATUS_GOOD)
PNIO_FORCE_FAILSAFE	System variable of the higher-level IO controller; all IO devices are asked to set/assume their substitute values ("0").

The primary controller and backup IO controller each establish an application relation with the local IO device. As only one IO controller is permitted to write outputs for each subslot, the subslots are duplicated.

One subslot is used by the primary IO controller. The index of primary subslots starts at 1(0x0001), to ensure compatibility with the previous IO controllers.

One subslot is used by the backup IO controller. Backup subslots follow the primary subslots. That means that the backup subslot gets the index 0x0002, if there is a primary subslot and the IO device supports redundancy.

The physical inputs (I, input process data) is transmitted to both subslots with the Phoenix Redundancy Layer. Output process data is transmitted to the physical outputs (O) according to certain priority rules (see Section "Priority rules" on page 6).

The application program of the higher-level IO controller (primary or backup) controls the process data status (IOPS) with the PNIO_FORCE_FAILSAFE system variable. When the variable is set (PNIO_FORCE_FAILSAFE = TRUE) all PROFINET devices are requested to set/assume their substitute values ("0"). In this case, the output process data of all subslots of the IO controller are set to invalid (IOPS = BAD).

When the variable is reset (PNIO_FORCE_FAILSAFE = FALSE) the output process data is valid (IOPS = GOOD). The output process data is also set to invalid (BAD) when the IO controller stops.

5.2 Redundancy switch-over

The application has to switch the redundancy between primary and backup IO controller (A in Figure 3 on page 5).

There are special PC WorX function blocks for various controllers from Phoenix Contact, implementing communication monitoring between primary controller and backup IO controller via a second connection path (INTERBUS, see Figure 2 on page 4 or second Ethernet connection, see Figure 1 on page 3).

5.3 Priority rules

These rules define under which conditions the IO device processes the output process data.

1. The outputs are driven by the IO controller whose process data status (IOPS) is set to GOOD.
2. If the process data status (IOPS) of both IO controllers is set to GOOD, the outputs are driven by the primary subslot (0x0001). Output data of the backup IO controller is rejected.
3. If the process data status (IOPS) of both IO controllers is set to BAD, the substitute value is output at all outputs (for all slots = "0").
4. If the process data status of the primary IO controller changes from GOOD to BAD, the outputs will keep their last valid value for a maximum of two seconds (data hold time). During this time, the backup IO controller take over the outputs provided that is process data status is set to GOOD.
   If, within the data hold time of two seconds, the outputs are not controlled by an IO controller (process data status GOOD), the outputs will output the substitute value "0" after this time.
5. If only one application relationship (AR) is active and if no second application relationship is being established, the outputs will immediately accept the substitute value "0" when the process data status changes from GOOD to BAD.
6. If an application relationship (AR) is aborted due to a timeout, while the process data status is BAD for the other application relationship, the outputs will keep the last valid value for the data hold time.
   If, within the data hold time of two seconds, the outputs are not controlled by an IO controller (process data status GOOD), the outputs will output the substitute value "0" after this time.
7. If there is a timeout (PROFINET monitoring time) on both ARs, the outputs will output the substitute value (for all slots = 0).

A special feature of PROFINET IO devices with control function from Phoenix Contact is, that the states of primary IO controller and backup IO controller can be accessed and responded to directly from the application.

The application accesses the input and output data with system variables that are provided by the firmware. The programmer has to implement this in PC WorX accordingly.

6 Applicative system redundancy in PC WorX

6.1 IO controller level

The redundancy behavior of the IO controller and the update times of inputs and outputs of the lower-level IO device have to be set in the higher-level project.

1. Redundancy behavior of the IO controller:

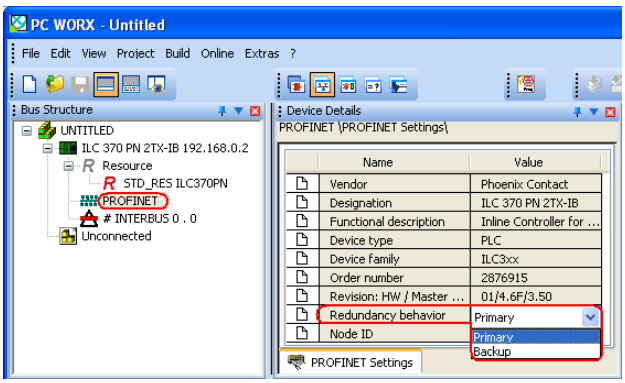

Figure 4 IO controller: Redundancy behavior

2. Update time of inputs and outputs of the lower-level IO devices:

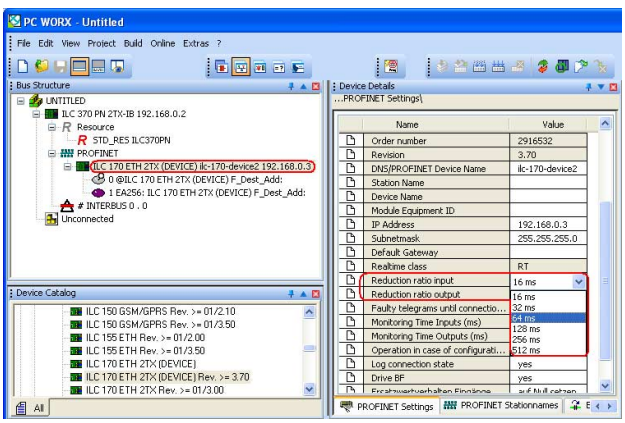

Figure 5 IO device: Update time of inputs and outputs

6.2 IO device level

This section applies to IO devices with control function only.

In PC WorX, Version 6.10 Service Pack 1 or later, the following system variables are available for the IO device in redundancy mode:

PND_S1_PLC_RUN	BOOL	Status of the higher-level control system
PND_S1_VALID_DATA_CYCLE	BOOL	IO Controller has established the connection
PND_S1_OUTPUT_STATUS_GOOD	BOOL	IOP status of the higher-level control system
PND_S1_DATA_LENGTH	WORD	Process data length
PND_S1_OUTPUTS	PND_IO_256	Output process data
PND_S1_INPUTS	PND_IO_256	Input process data
PND_IO_DRIVEN_BY_PLC	INT	Number of the PLC currently connected with the PNIO Device

Figure 6 IO device: System variables

For additional information, please refer to the UM EN ILC 1XX user manual.

In normal mode, both IO controllers have established a connection to the lower-level IO device. The PND_IO_DRIVEN_BY_PLC system variable shows from which higher-level IO controller (A or B; see Figure 1 on page 3 and Figure 2 on page 4) the data in the IO device comes from.

Meaning:

0: No IO controller

1: Controller A (see Figure 1 on page 3/Figure 2 on page 4)

2: Controller B (see Figure 1 on page 3/Figure 2 on page 4)

The following table provides an overview from which IO controller the lower-level IO device receives the process data, depending on the status of the IO controller.

Controller (Status)	**2** (GOOD)	**2** (BAD)	**2** (NA)
1 (GOOD)	1	1	1
1 (BAD)	2	0	0
1 (NA)	2	0	0

NA: Not available

The update of system variables can be assigned to a user task. This is done in the resource settings (see Figure 7).

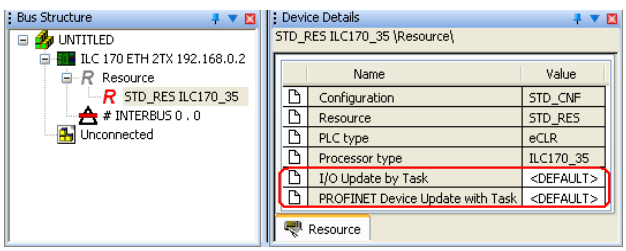

Figure 7 Update times

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