

# Honeywell

## I/O MODULES

### HONEYWELL EXCEL 5000 OPEN SYSTEM

#### INSTALLATION AND COMMISSIONING INSTRUCTIONS

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# Safety Information

## General Safety Information

- ▶ When performing any work (installation, mounting, start-up), all instructions given by the manufacturer and in particular the safety instructions provided in these Installation and Commissioning Instructions are to be observed.
- ▶ The controller system (including the controller Module, I/O modules and the auxiliary terminal packages) may be installed and mounted only by authorized and trained personnel.
- ▶ Rules regarding electrostatic discharge should be followed.
- ▶ If the controller system is modified in any way, except by the manufacturer, all warranties concerning operation and safety are invalidated.
- ▶ Make sure that the local standards and regulations are observed at all times. Examples of such regulations are VDE 0800 and VDE 0100 or EN 60204-1 for earth grounding.
- ▶ Use only accessory equipment which comes from or has been approved by Honeywell.
- ▶ It is recommended that devices are to be kept at room temperature for at least 24 hours before applying power. This is to allow any condensation resulting from low shipping/storage temperatures to evaporate.
- ▶ The controller system must be installed in such a manner (e.g., in a lockable cabinet) as to ensure that uncertified persons have no access to the terminals.
- ▶ Investigated according to United States Standard UL916 (USL-listed).
- ▶ Investigated according to Canadian National Standard(s) C22.2 (CNL-listed).

## Safety Information as per EN60730-1

### Purpose

The controller system is an incorporated electronic control system for cabinet mounting.

It is used for the purpose of building HVAC control and is suitable for use only in non-safety controls for installation on or in appliances.

**Table 1. System data as per EN60730-1**

<b>Pollution degree</b>	Pollution Degree 2, suitable for use in residential controls, commercial controls, in a clean environment.
<b>Overvoltage category</b>	Category II for mains-powered (16A) controls Category I for 24 V powered controls
<b>Rated impulse voltage</b>	2500 VAC
<b>Automatic action</b>	Type 1.C (micro-interruption for the relay outputs)
<b>Software class</b>	Class A
<b>Ball-pressure test temperature</b>	75 °C for all housing and plastic parts 125 °C in the case of devices applied with voltage-carrying parts and connectors
<b>Electromagnetic interference</b>	Tested at 230 VAC, with the modules in normal condition.
<b>System transformer</b>	Europe: safety isolating transformers according to IEC61558-2-6 U.S.A. and Canada: NEC Class-2 transformers

# System Overview

## System Architecture

A controller system consists of the controller and various I/O modules.

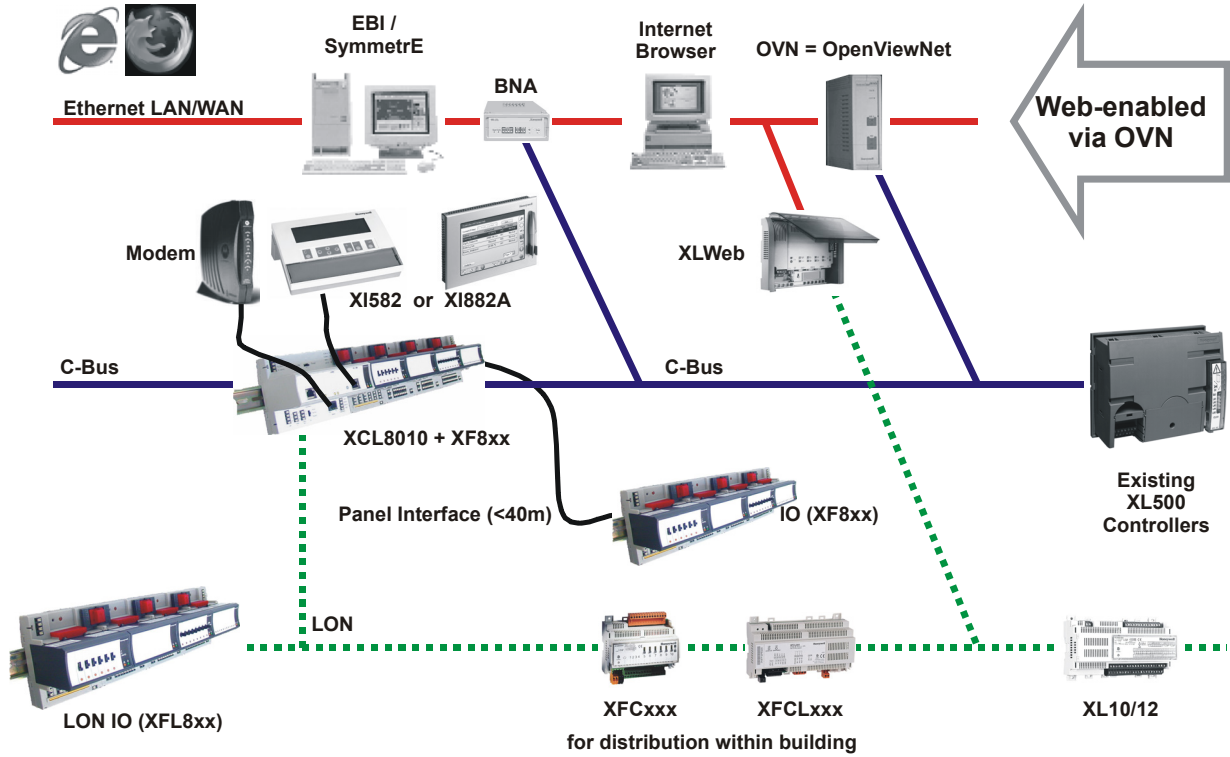


Fig. 1. Controller system architecture

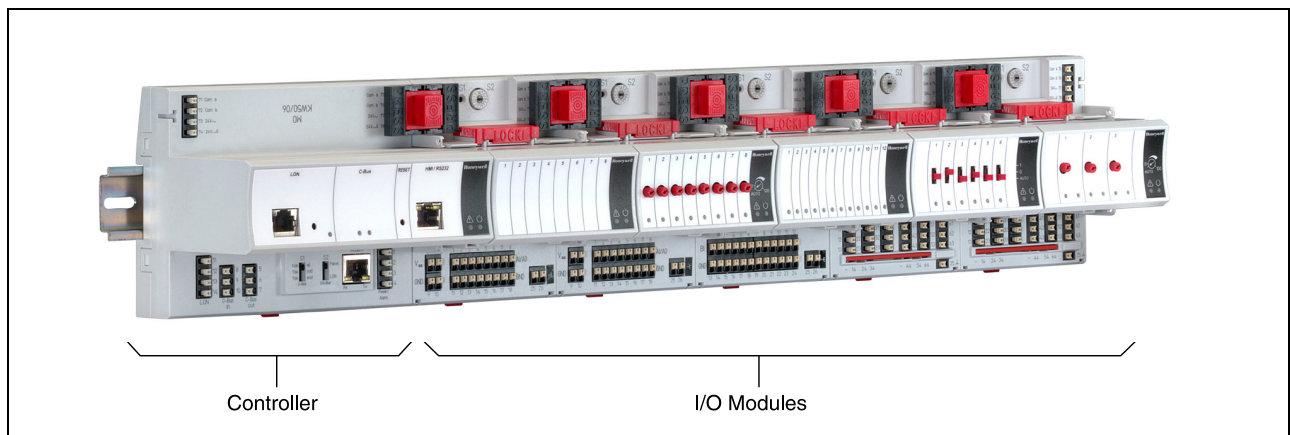


Fig. 2. Controller and I/O modules

## I/O Modules

### Pluggable Panel Bus and LonWorks I/O Modules

There are two variants of pluggable I/O modules (consisting of a terminal socket and a removable electronic module):

- Panel Bus I/O modules with communication via Panel Bus (light gray housings)
- LONWORKS Bus I/O modules (dark gray housings) with communication via LONWORKS (FTT10-A, link power compatible) for easy integration and use with 3<sup>rd</sup>-party controllers.

The firmware of pluggable I/O modules is automatically updated by the controller, and the controller automatically configures them as needed by the application.

### Mixed Panel Bus I/O Modules

Besides the *pluggable* Panel Bus I/O modules (consisting of a terminal socket and a removable electronic module), there are also *mixed* Panel Bus I/O modules. Specifically: the XF830A, XFU830A, and CPO-IO830 are mixed Panel Bus I/O modules, featuring an integrated terminal socket and a variety of inputs and outputs.

The XF830A, XFU830A have a light-gray housing and match the XL800 design, while the CPO-IO830 has a black housing and matches the CPO-PC-6A design. All three are automatically commissioned (with firmware download) by the controller.

### Terminal Sockets

Pluggable I/O modules must be mounted on the appropriate terminal sockets. Pluggable Panel Bus I/O modules and pluggable LONWORKS Bus I/O modules use the same terminal sockets. These terminal sockets are available with push-in terminals (XS82...) or with screw-type terminals (XSU82...).

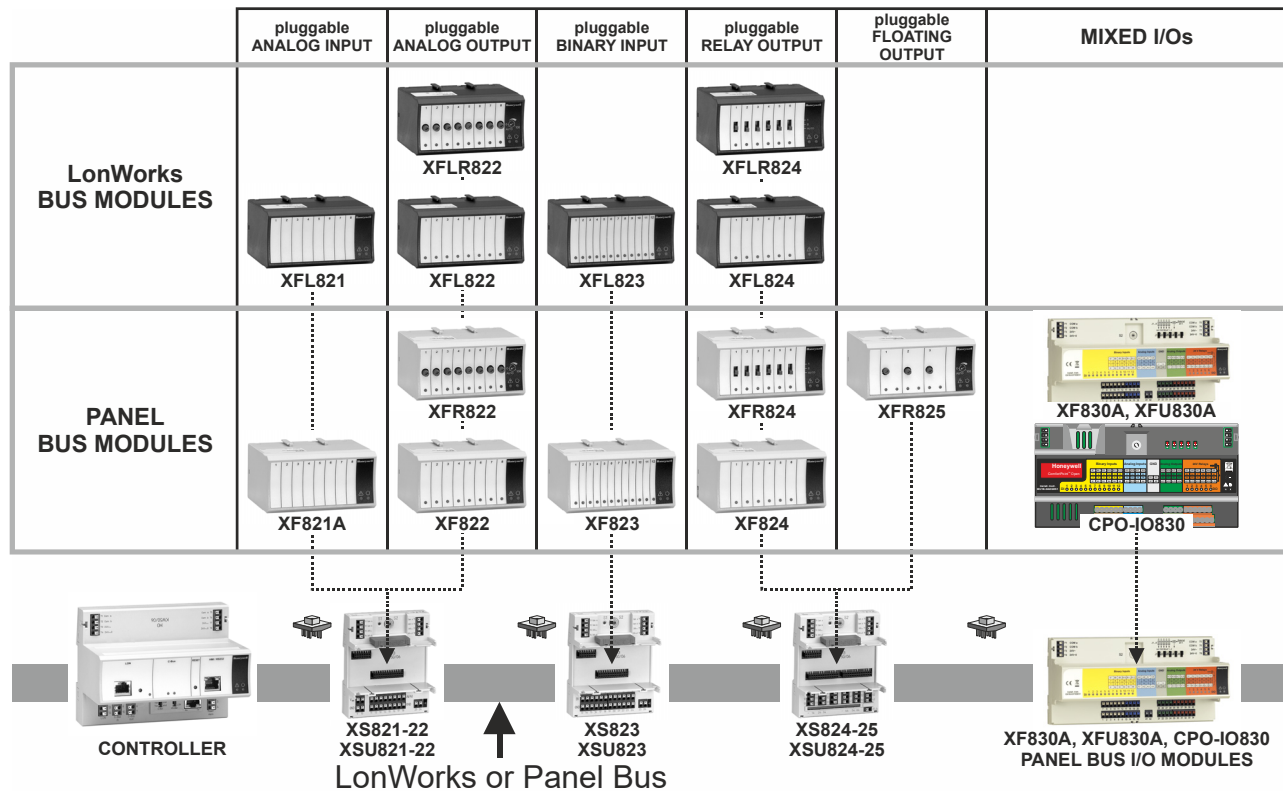
Mixed I/O modules feature an integrated terminal socket.

### Color Coding

To distinguish modules and components, the following color coding is used:

**Table 2. Color coding of Honeywell I/O modules**

Color	Part
Red	All of the user-accessible adjustable mechanical parts (i.e., bridge connectors and locking mechanism) and operating controls (manual overrides, etc.)
Light-gray	Panel Bus I/O modules XF830A and XFU830A
Black	Panel Bus I/O module CPO-IO830
Dark-gray	LONWORKS Bus I/O modules



**Fig. 3. Overview of Honeywell I/O modules**

Honeywell I/O Module Overview

Table 3. Overview of Panel Bus I/O modules

Panel Bus module	LONWORKS Bus module	Description	Inputs	Outputs	Manual controls	LEDs <sup>1)</sup>
XF821	XFL821	Analog input module	8	–	–	–
XF822	XFL822	Analog output module	–	8	–	8 status LEDs
XFR822	XFLR822	Analog output module	–	8	8 Manual overrides	8 status LEDs
XF823	XFL823	Binary input module	12	–	–	12 status LEDs
XF824	XFL824	Relay output module	–	6 <sup>2)</sup>	–	6 status LEDs
XFR824	XFLR824	Relay output module	–	6 <sup>2)</sup>	6 Manual overrides	6 status LEDs
XFR825	–	Floating output module	–	3	3 Manual overrides	3 pairs of status LEDs
XF830A	–	Mixed I/O module	20	14	–	18 status LEDs
XFU830A	–	Mixed I/O module	20	14	–	18 status LEDs
CPO-IO830	–	Mixed I/O module	20	14	–	18 status LEDs

<sup>1)</sup> In addition to the power LED and service LED

<sup>2)</sup> Changeover outputs

Corresponding Terminal Sockets

Table 4. Pluggable I/O modules and corresponding terminal sockets

I/O module XF...	Socket	Scope of delivery
...821	XS821-22 with push-in terminals XSU821-22 with screw-type terminals	1 terminal socket, 1 bridge connector 1 swivel label holder
...822		
...823	XS823 with push-in terminals XSU823 with screw-type terminals	1 terminal socket, 1 bridge connector 1 swivel label holder
...824		
...825	XS824-25 with push-in terminals XSU824-25 with screw-type terminals	1 terminal socket, 1 bridge connector 1 swivel label holder 1 cross connector

Manual Overrides as per EN ISO 16484-2:2004

The manual override switches and potentiometers of the output modules (...R822, ...R824, and XFR825) support direct operation as per EN ISO 16484-2:2004, section 5.4.3 "Local Priority Override/Indicating Units."




Specifically, the positions of the manual override switches and potentiometers directly control the outputs – independently of the controller and HMI. When a manual override switch or potentiometer is not in its default position ("auto"), the corresponding output LED will blink continuously, and the output module will send a feedback signal with the status "manual override" and the given override position to the controller (which will then also store this information in its alarm memory).

**NOTE:** When updating the firmware of output modules, their outputs are turned OFF – regardless of the position of their manual override switches and/or potentiometers.

**NOTE:** In the following, the Honeywell I/O modules (Panel Bus/LONWORKS Bus, with/without manual overrides) are referred to as, e.g., ...821, ...822, etc.




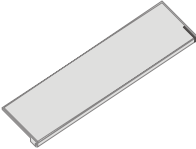
**Auxiliary Parts**

**Table 5. Auxiliary parts**

Module	Type	Figure	Corresponding I/O modules XF...	Information
Auxiliary terminal packages	XS814		For all pluggable Honeywell I/O modules.	Two groups of seven internally-connected push-in terminals, for distributing signals/power (see also Fig. 66).
	XS830		For mixed Panel Bus I/O modules, only.	Set of 10 auxiliary terminals, for mounting to top or bottom of XF830A and top of XFU830A and CPO-IO830. Each auxiliary terminal consists of two groups of 9 internally connected push-in terminals, for distributing signals / power (see also Fig. 68).
				Set of 10 auxiliary terminals, for mounting to top or bottom of XF830A and top of XFU830A and CPO-IO830. Each auxiliary terminal consists of two groups of four pairs of push-in terminals (each with a 499 Ω resistor), for converting 0...20 mA signals into 0...10 VDC signals, and one push-in ground terminal per group (see also Fig. 70).

**Spare Parts**

**Table 6. Spare parts**

Module	Type	Figure	Corresponding I/O modules XF...	Information
Cross connectors (red)	XS815		...824 ...825	Connects six relay commons.
Connector bridge	XS816		All Honeywell I/O modules	Connects XCL8010 and I/O modules.
Swivel label holder	XAL10		For all pluggable Honeywell I/O modules	Can be plugged into socket, for attaching label generated by CARE.
Swivel label holder	XAL11		XF830A, only	Can be plugged into module, for attaching label generated by CARE. NOTE: Phased out.

## Interfaces and Bus Connections

The Honeywell I/O Modules can be connected to the following devices and systems:

### Panel Bus

- For communication with up to 16 Panel Bus I/O modules
- Polarity-insensitive

### LONWORKS Bus

- For communication with other LONWORKS Bus devices within the building
- FTT10, link power compatible
- Polarity-insensitive

## Technical Data

### System Data

Table 7. System data

Operating voltage	24 VAC, ± 20 %, 21 ... 30 VDC
Current requirement	See Table 11
Push-in terminals	1.5 mm <sup>2</sup>
Screw-type terminals	1.5 mm <sup>2</sup>
Overvoltage protection	All analog and binary I/O modules are protected against 24 VAC and 40 VDC overvoltage as well as against short-circuiting. (The relay outputs of relay output modules, floating output modules, and the mixed I/O modules should be equipped with appropriate fusing to protect against short-circuiting of the load.)
Calculated lifetime of weakest component under typical operating conditions	MTBF ≥ 13.7 years

## System Constraints

Table 8. System constraints

Max. no. of I/O modules (any combination) connected to controller	depends upon controller type
Max. no. of I/O modules per row	10
Max. current (F1)	4 A
Max. current (F2)	12 A
Max. current (F3)	12 A
Max. row length	3 m
Max. distance between rows	40 m
Min. cross-section of GND (terminal 9) (protected by F2)	1.5 mm <sup>2</sup>

## Standards

Table 9. Standards

Protection class	IP20
Product standard (EMC)	EN 60730-1 EN 60730-2-9
Testing electrical components	IEC68
Certification	CE
System transformer	The system transformer(s) must be safety isolating transformers according to IEC 61558-2-6. In the U.S.A. and Canada, NEC Class 2 transformers must be used.
Low-Voltage Device Safety Assessment	EN 60730-1 EN 60730-2-9

## Operational Environment

Table 10. Operational environment

Ambient operating temperature	0 ... 50 °C (32 ... 122 °F)
Ambient operating humidity	5 ... 93 % rel. humidity (non-condensing)
Ambient storage temperature	-20 ... 70 °C (-4 ... +158 °F)
Ambient storage humidity	5 ... 95 % rel. humidity (non-condensing)
Vibration under operation	0.024" double amplitude (2 ... 30 Hz), 0.6 g (30 ... 300 Hz)
Dust, vibration	According to EN60730-1
RFI, EMI	Home environment

# Planning

## Overview

### Planning

In this step, the following has to be defined, if applicable:

- Power supply
- Fusing
- Earth grounding
- Lightning protection
- Panel Bus wiring
- Design of a LONWORKS network
- Useful accessories
- Cable selection

## Transformer Selection

**NOTE:** In Europe, the system transformer(s) must be safety isolating transformers according to IEC61558-2-6. In the U.S.A. and Canada, NEC Class-2 transformers must be used.

### Current Requirement

When selecting the appropriate transformer, take into account the number of individual modules, accessories, and field devices in determining the total current requirement.

**Table 11. Current requirement of controller system components depending on power supply**

Devices powered	Current requirement	
	24 VAC	24 VDC
...821	130 mA	80mA
...822	160 mA	90 mA
...823	180 mA	130 mA
...824	140 mA	90 mA
...825	140 mA	90 mA
XF830A	200 mA	95 mA
XFU830A	200 mA	95 mA
CPO-IO830	200 mA	95 mA

## Connectable Power Supplies

### Honeywell CRT Series (Europe)

**Table 12. Honeywell CRT series transformers data**

Transformer	Primary side	Secondary side
CRT 2	220/230 VAC	24 VAC, 50 VA, 2 A
CRT 6	220/230 VAC	24 VAC, 150 VA, 6 A
CRT 12	220/230 VAC	24 VAC, 300 VA, 12 A

### Honeywell 1450 Series (North America)

- 50/60 Hz
- Insulated accessory outputs
- Built-in fuses
- Line transient /surge protection
- AC convenience outlet
- NEC Class-2

**Table 13. Honeywell 1450 series transformers data**

Part number 1450 7287	Primary side	Secondary side
-001	120 VAC	24 VAC, 50 VA
-002	120 VAC	2 x 24 VAC, 40 VA, and 100 VA from separate transformer
-003	120 VAC	24 VAC, 100 VA, and 24 VDC; 600 mA
-004	240/220 VAC	24 VAC, 50 VA
-005	240/220 VAC	2 x 24 VAC, 40 VA, and 100 VA from separate transformer
-006	240/220 VAC	24 VAC, 100 VA, and 24 VDC, 600 mA

### Standard Transformers (Europe, North America)

Standard commercially available transformers used to supply power to Honeywell systems must fulfill the following specifications:

**Table 14. Requirements for standard transformers**

Output voltage	Impedance	AC current
24.5 VAC to 25.5 VAC	≤ 1.15 Ω	max. 2 A
24.5 VAC to 25.5 VAC	≤ 0.40 Ω	max. 6 A
24.5 VAC to 25.5 VAC	≤ 0.17 Ω	max. 12 A

### Standard 24 VDC power supply

Output voltage > 19 VDC, < 30 VDC

Current according to Table 11.

### RIN-APU24 Uninterruptable Power Supply

The RIN-APU24 Uninterruptable Power Supply can be wired to power Honeywell controller systems.

See also RIN-APU24 Uninterruptable Power Supply – Mounting Instructions (MU1B-0258GE51) for detailed wiring diagrams.



## Power Supply of Field Devices

Depending upon the power consumption of the field devices used, it is possible to use either a single transformer to power both the Honeywell controller and attached field devices, or it may be necessary to employ an additional transformer. See also section "Field Device Cables" on page 10 and connection examples on page 20.

## Fusing Specifications

Please see section "System Constraints" on pg. 7 and observe the following when selecting fusing (F1 / F2 / F3 / F4) for the Honeywell I/O modules and active field devices:

- Use separate fusing for different loads (e.g., for the controller and Honeywell I/O modules on one hand versus for active field devices on the other).
- Fuse ratings must always be calculated according to the loads connected. Refer to Table 11 and the load tables appearing in the documentation of your Honeywell devices provides.
- Use slow-acting fuses; this is because the controller, the Honeywell I/O modules, and active field devices have a high in-rush current due to their built-in capacitors (current typically limited by one internal 2 Ohm resistor per device).
- Fuses should be calculated to protect the transformer against overloading and the wiring against short-circuiting. The controller and the Honeywell I/O modules are protected by an internal fuse (not user-replaceable) against internal component defects.

For connection examples see description of the Honeywell I/O modules on page 22 and following.

## System Protective Earth Grounding

Honeywell controller systems comply with SELV (Safety Extra-Low Voltage). Earth grounding is therefore not recommended. However, if compliance with EN60204-1 is required, see "Appendix 1: System Protective Earth Grounding" of Excel 800 – Installation & Commissioning Instructions (EN1B-0375GE51).

## Lightning Protection

Please contact your local Honeywell representative for information on lightning protection.

## Panel Bus Topologies

- A single Excel 800 controller can control up to 16 Panel Bus I/O modules.
- Each of the four RS485 interfaces of a CPO-PC-6A Plant Controller can control up to 16 Panel Bus I/O modules.
- Each of the Excel Web II controller's two RS485 interfaces (max. one bus per interface) is limited to max. 16 Panel Bus I/O modules of a given type, and each interface is limited to a max. of 64 Panel Bus I/O modules. This yields a total max. of 128 Panel Bus I/O modules per controller.

- Panel Bus I/O modules must be addressed using the HEX switch (see section "Addressing Panel Bus I/O Modules" on pg. 20).
- Max. distance between controller and Panel Bus I/O module: 40 m (any type of cabling and topology, incl. star and loop topology, possible; no additional end termination permitted); 1200 meters (mandatory twisted-pair or telephone cable and daisy chain topology; controller must be positioned at one end of the Panel Bus, and an end termination of 120 Ω positioned at the other end)
- No bus termination
- Polarity-insensitive

## LONWORKS Bus Topologies

The LONWORKS Bus is a 78-kilobit serial link that uses transformer isolation so that the bus wiring does not have a polarity. I.e. it is not important which of the two LONWORKS Bus terminals are connected to each wire of the twisted pair.

The shield of the LONWORKS Bus must not be connected to any part of the controller. When connecting the LonWorks Bus via the RJ45 interface, use an isolated plastic plug.

The LONWORKS Bus can be wired in daisy chain, star, loop or any combination thereof as long as the max. wire length requirements are met.

### Configuration

The recommended configuration is a daisy chain with two bus terminations. This layout allows for max. LONWORKS Bus lengths, and its simple structure presents the least number of possible problems, particularly when adding on to an existing bus.

See also "LONWORKS Mechanisms", Product Literature no.: EN0B-0270GE51.

## LONWORKS Bus Termination Module

Table 15. LONWORKS Bus termination module

Type	Description
XAL-Term2	LONWORKS connection and termination module, which can be mounted on DIN rails and in fuse boxes

## Cable Specifications

### Power Supply Cables

When checking the length of the power supply cable, the connection cables to all I/O modules must be taken into account.

Table 16. Power supply cables specification

Max. length	3 m (per side of the controller), see Fig. 19 on page 17
Cross section	min. 0.75 mm <sup>2</sup> (AWG 18)

## Panel Bus Cables

**Table 17. Panel Bus cables specification**

<b>Max. length</b>	40 m (any type of cabling and topology, incl. star and loop topology, possible; no additional end termination permitted); 1200 m (mandatory twisted-pair or telephone cable and daisy chain topology; controller must be positioned at one end of the Panel Bus, and an end termination of 120 Ω positioned at the other end)
<b>Cable type</b>	twisted pair, e.g., J-Y-Y 2 x 2 x 0.8

## LONWORKS Bus Cables

**Table 18. Doubly-terminated bus specifications**

Cable type	Max. bus length
Belden 85102 (plenum)	2700 m (8900 ft)
Belden 8471 (non-plenum)	2700 m (8900 ft)
Level IV, 22 AWG	1400 m (4600 ft)
JY (St) Y 2 x 2 x 0.8	900 m (3000 ft)
TIA568A Cat. 5 24AWG, twisted pair	900 m (3000 ft)

**NOTE:** The above-listed cable types are as recommended by Echelon in their FTT-10A User Guide.

**NOTE:** Honeywell recommends the use of level IV, 22 AWG, solid core, non-shielded cable.

**NOTE:** Belden part numbers are 9H2201504 (plenum) and 9D220150 (non-plenum).

### FTT Specification

The FTT specification includes two components that must be met for proper system operation:

- The distance from each transceiver to all other transceivers and to the termination must not exceed the max. node-to-node distance.
- If multiple paths exist, the max. total wire length is the total amount of wire used.

**Table 19. Free topology (singly-terminated) specifications**

Cable type	Max. node-to-node distance	Max. total wire length
Belden 85102	500 m (1650 ft)	500 m (1650 ft)
Belden 8471	400 m (1300 ft)	500 m (1650 ft)
Level IV, 22AWG	400 m (1300 ft)	500 m (1650 ft)
JY (St) Y 2 x 2 x 0.8	320 m (1050 ft)	500 m (1650 ft)
TIA568A Cat. 5 24AWG, twisted pair	250 m (825 ft)	450 m (1500 ft)

## NOTICE

### Unpredictable reflections on the bus due to step change in line impedance characteristics!

- ▶ Do not use different wire types or gauges on the same LONWORKS network segment.

**NOTE:** In the event that the limit on the total wire length is exceeded, the FTT physical layer repeaters (FTT 10A) can be added to interconnect segments. This increases the overall length by an amount equal to the original specification for that cable type and bus type for each repeater used. For example, adding repeaters for a doubly-terminated bus using JY (St) Y 2 x 2 x 0.8 cable increases the max. length by 900 m (3000 ft) for each repeater.

## Field Device Cables

**Table 20. Cable sizing for connection of field devices**

Type of signal	Cross-sectional area	
	≤ 100 m (300 ft) (Fig. 26 on p. 20) one transformer	≤ 400 m (1300 ft) (Fig. 27 on p. 20) separate transformers
24 VAC power	1.5 mm <sup>2</sup> (16 AWG)	not allowed for > 100 m (300 ft)
0...10 V signals	0.081 – 2.08 mm <sup>2</sup> (28 – 14 AWG)	

For wiring field devices see page 20.

## Dimensions

### Pluggable I/O Modules

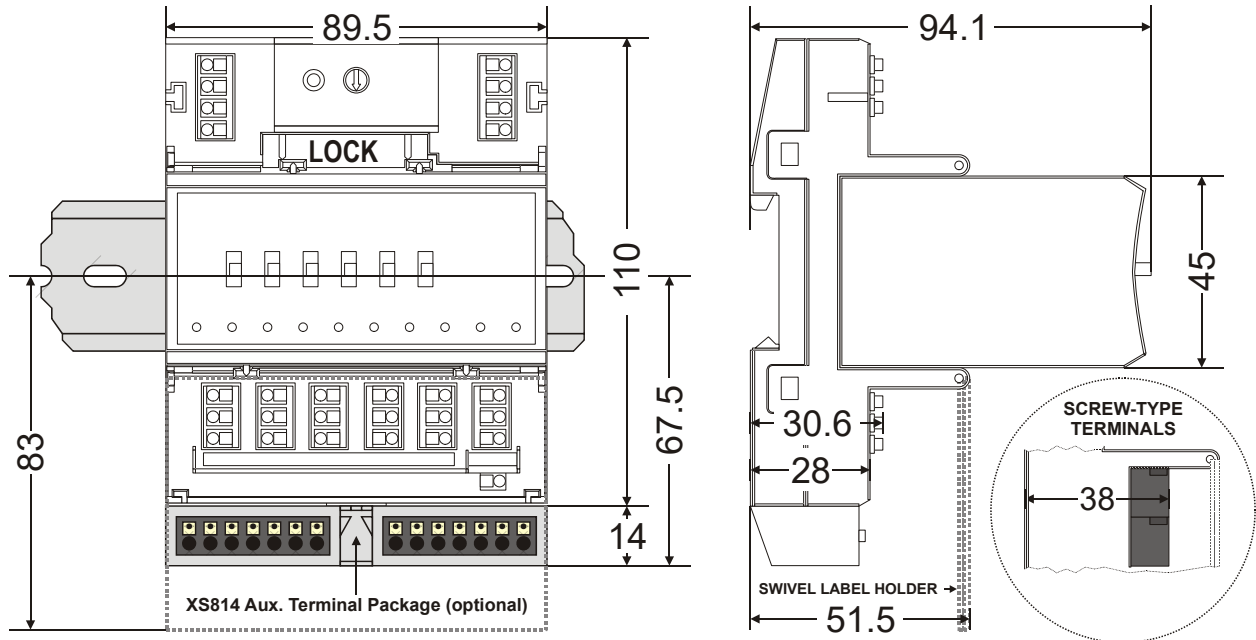


Fig. 4. Pluggable I/O modules (shown with manual overrides), including XS814 Aux. Terminal Package, dimensions (in mm)

### Mixed I/O Modules

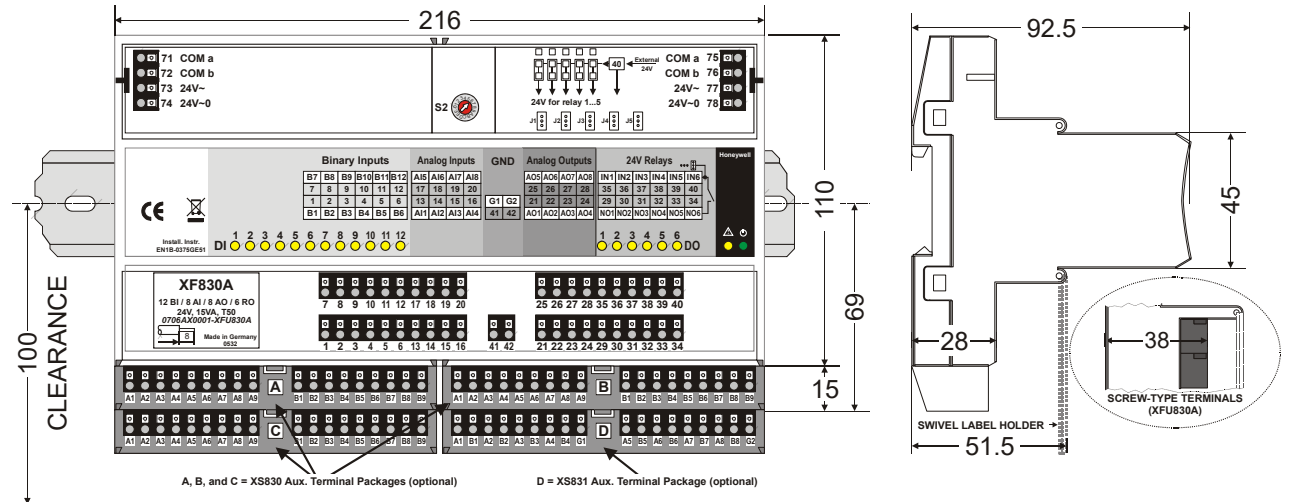


Fig. 5. Mixed Panel Bus I/O Modules (example shows XF830A with 4 auxiliary terminal packages), dimensions (in mm)

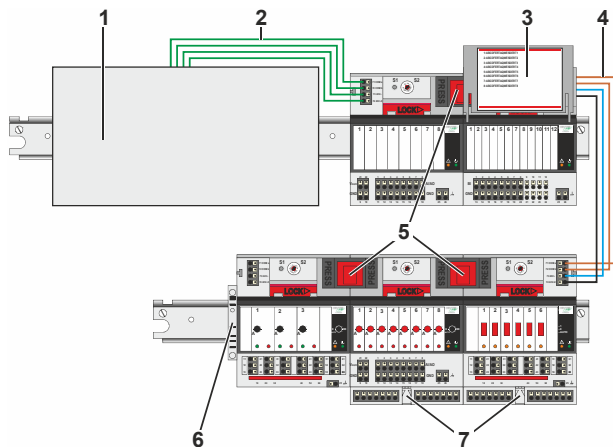
## Mounting/Dismounting Modules

### WARNING

#### Risk of electric shock or equipment damage!

- ▶ Do not touch any live parts in the cabinet.
- ▶ Disconnect the power supply before you start to install the controller system.  
More than one disconnect switch may be required to de-energize the system.
- ▶ Do not reconnect the power supply until you have completed the installation.
- ▶ Unused terminals must be closed (by completely screwing in the terminal screws), thus preventing the accidental touching of “live” parts.

**NOTE:** The terminal socket of each pluggable I/O module can be mounted and wired before inserting and locking the corresponding electronic module.



**Fig. 6. Honeywell I/O Modules on DIN rails**

#### Legend

- 1 Controller (e.g., XL800, XL Web II, CPO-PC-6A, etc.)
- 2 Cable (power, LONWORKS / Panel Bus) connection from controller to Honeywell I/O Modules
- 3 Swivel label holder
- 4 Cable connection between Honeywell I/O Modules on separate DIN rails
- 5 Bridge connectors between Honeywell I/O Modules on same DIN rail
- 6 Stopper (from 3<sup>rd</sup>-party supplier)
- 7 Auxiliary terminal packages

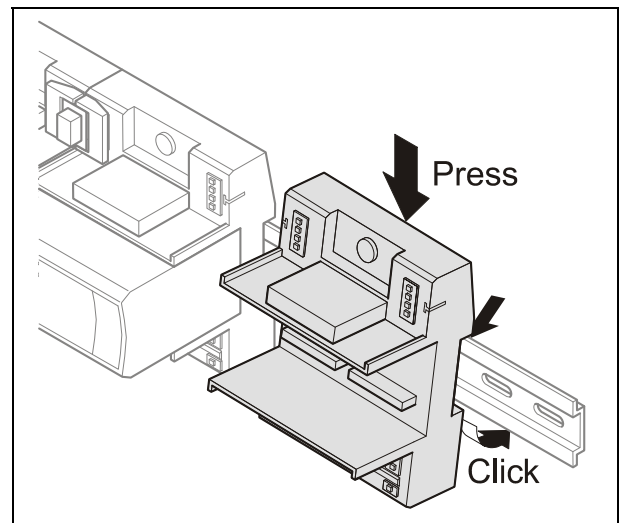
## Mounting/Dismounting Controller/Sockets

### Mounting Sockets

**NOTE:** When using both Panel Bus and LONWORKS Bus I/O modules in a Honeywell controller system, group both Panel Bus I/O modules (light gray) and LONWORKS Bus I/O modules (dark gray), e.g., on different rails.

**NOTE:** The mixed Panel Bus I/O module are mounted on the DIN rail in the same way as a terminal socket.

- ▶ Angle the terminal socket at the upper edge of the DIN rail until it snaps in.
- ▶ Swing the terminal socket down and apply gentle force until it snaps into position with an audible “click”.
- ▶ Position controller module and terminal sockets flush with one another along the rail.
- ▶ If desired, mount stoppers at the ends of the rail to prevent sliding.



**Fig. 7. Mounting terminal sockets**

**NOTE:** Take care to not bend the Omega clamp, which serves to establish the electrical contact with the DIN rail and which is located on the back of the terminal socket.

### Connecting Sockets

Controller, terminal sockets, and mixed I/O modules on the same DIN rail can be connected mechanically and electrically with bridge connectors.

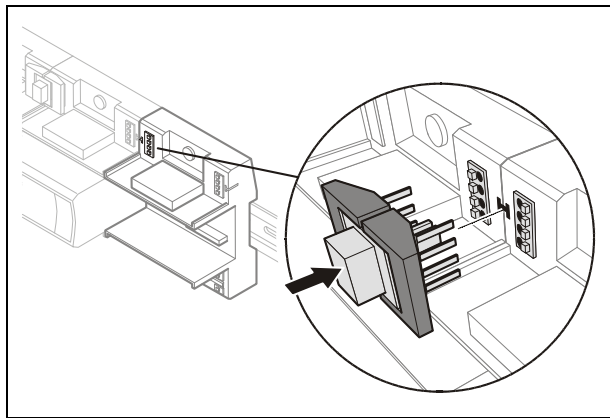
Controller and terminal sockets on different DIN rails must be connected using cables.

## NOTICE

### Risk of malfunction!

- ▶ Wire Panel Bus I/O modules and LONWORKS Bus I/O modules separately.
- ▶ When using both Panel Bus and LONWORKS Bus I/O modules in an controller system, LONWORKS Bus I/O modules must be connected to the controller via LON terminals 11 ... 14.

Position the bridge connector on terminals 71 ... 74 of the right-hand terminal socket or mixed I/O module or controller and on terminals 75 ... 78 of the left-hand terminal socket or mixed I/O module or controller. Then press the bridge connector down.



**Fig. 8. Connecting terminal sockets with bridge connector**

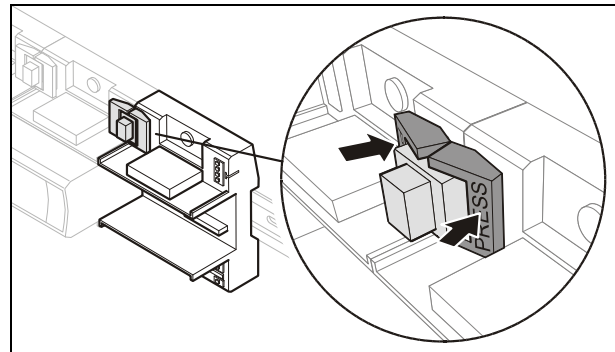
**NOTE:** Bridge connectors transmit both communication signals and power supply between modules. Removing bridge connectors will thus interrupt the transmission of both communication signals and power supply between the modules.

## Dismounting Sockets

### Disconnecting Sockets

Release all bridge connectors before removing the controller module and/or the terminal sockets and/or mixed I/O modules from the DIN rail.

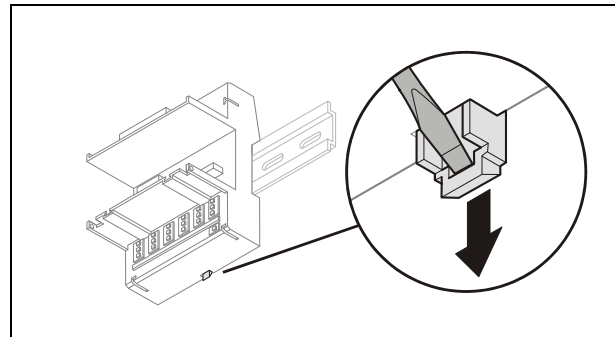
- ▶ Press down at the same time both the gray side wings next to the red button and then pull the bridge connector out of the module.



**Fig. 9. Releasing bridge connectors**

### Dismounting Controller / Terminal Sockets / Mixed I/O Modules

- ▶ Insert a screwdriver into the latch on the underside of the module and lever the red latch 2–3 mm downwards. The module can then be swung away from the rail.



**Fig. 10. Releasing latch**

## Mounting/Dismounting Electronic Modules

### Mounting Electronic Modules

**NOTE:** Electronic modules can be removed from the socket or inserted into the sockets without switching off the power supply, but the resultant behavior of connected field devices must be taken into consideration.

- ▶ Make sure that terminal socket and electronic I/O module match.
- ▶ Make sure that the red locking mechanism is in the open, i.e., left, position.
- ▶ Gently push the electronic module onto the terminal socket until snug.

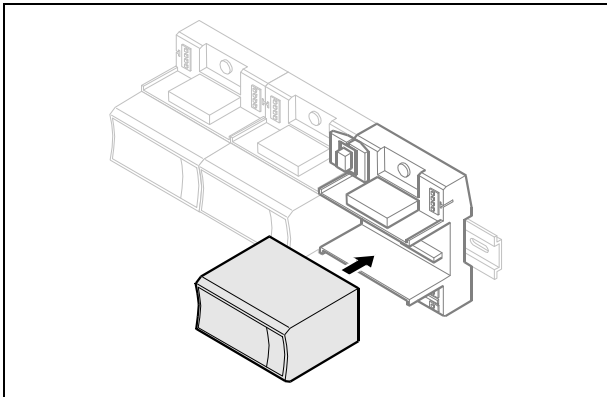


Fig. 11. Inserting the electronic module

- ▶ Lock the red locking mechanism by sliding it to the right.

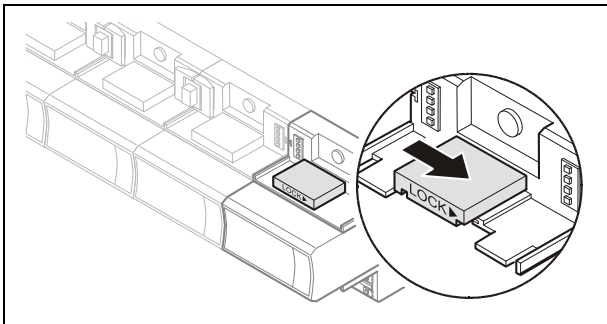


Fig. 12. Locking the electronic module

**NOTE:** The red locking mechanism will not close if the electronic module is not properly mounted.

### Dismounting Electronic Modules

**NOTE:** Electronic modules can be removed from the socket or inserted into the sockets without switching off the power supply, but the resultant behavior of connected field devices must be taken into consideration.

- ▶ Open the red locking mechanism by sliding it to the left and then gently pull the electronic module out of the terminal socket.

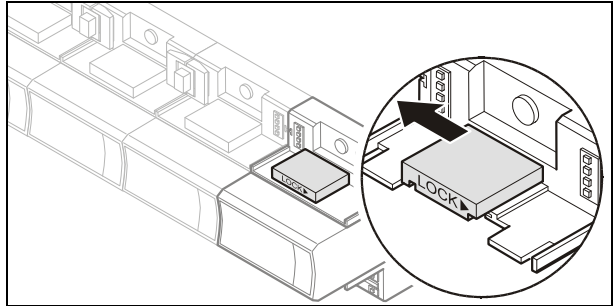


Fig. 13. Dismounting the electronic module

## Mounting/Dismounting Auxiliary Terminal Packages

The XS814 Auxiliary Terminal Package can be mounted on any pluggable I/O module.

The XS830 and XS831 Auxiliary Terminal Packages are suitable for mixed I/O modules, only. Specifically, they can be mounted on the top and/or bottom of the XF830A and on the bottom of the XFU830A and CPO-IO830.

For reasons of mechanical stability, a max. of two rows of Auxiliary Terminal Packages may be mounted together on any given I/O module.

### Mounting Auxiliary Terminal Packages

- ▶ Push the auxiliary terminal package onto the grooves of the corresponding terminal socket / the mixed I/O module.

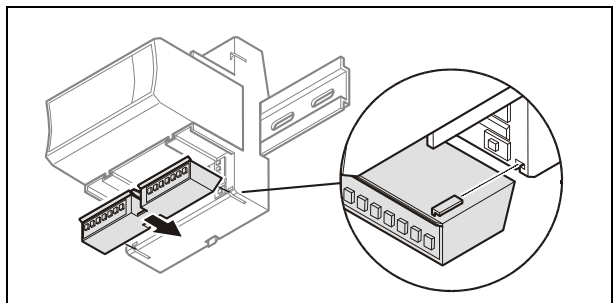


Fig. 14. Mounting the auxiliary terminal package onto the terminal socket / mixed I/O module

### Dismounting Auxiliary Terminal Packages

- ▶ Push down the catch of the auxiliary terminal package and pull it out of the grooves of the terminal socket / the mixed I/O module.

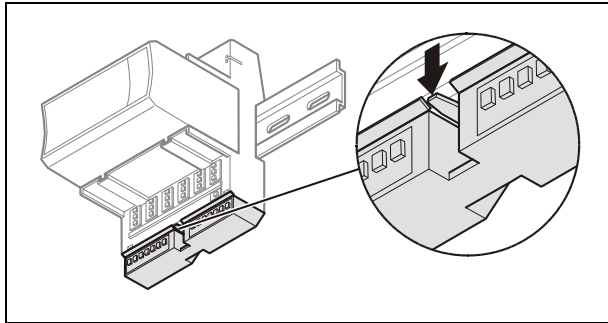


Fig. 15. Dismounting the auxiliary terminal package from the terminal socket / the mixed I/O module

### Mounting Swivel Label Holders

- ▶ Snap the swivel label holder onto the hinges of the terminal socket / mixed I/O module.
- ▶ Apply self-adhesive labels to the holders.

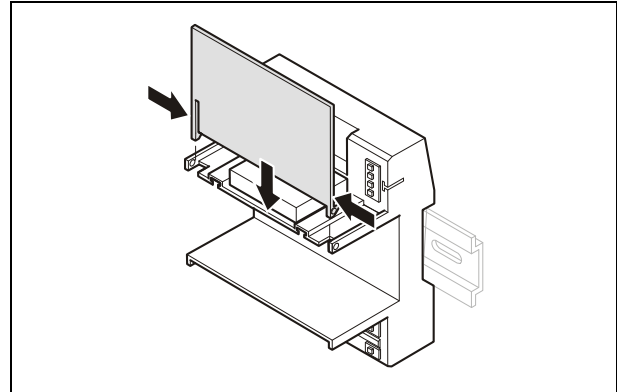


Fig. 17. Mounting the swivel label holder

### Mounting/Dismounting Cross Connectors

**NOTE:** The XS815 cross connector (incl. in the scope of the delivery) can be mounted to the XS824-25 or XSU824-25, as required. It is not permitted to replace these cross connectors with wire.

- ▶ Insert a screwdriver on one end of the cross connector and swivel it to the right and to the left.
- ▶ Insert a screwdriver on the other end of the cross connector and swivel it to the right and to left until the cross connector is released.

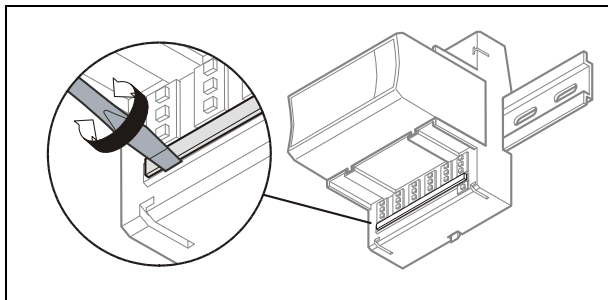


Fig. 16. Dismounting the cross connectors

### Dismounting Swivel Label Holders

- ▶ Press the hinges together and remove the swivel label holder.

### Mounting/Dismounting Swivel Label Holders

**NOTE:** A swivel label holder is included in the delivery of each module.

Use only the (short / long) swivel label holders appropriate for the given type (pluggable or mixed, respectively) of I/O module.

# Wiring and Setting Up the System

## General Safety Considerations

- When connecting the controller or Honeywell I/O modules, both VDE, National Electric Code (NEC) or equivalent, and any local regulations concerning grounding and zero voltage must be observed.
- Electrical work should be carried out by a qualified electrician.
- The electrical connections must be made at the terminal blocks. The corresponding connection diagrams are located on the individual controller module and I/O modules.
- For Europe only: To comply with CE requirements, devices with a voltage in the range of 50 ... 1000 VAC or 75 ... 1500 VDC, which are not provided with a supply cord and plug or with other means for disconnection from the supply having a contact separation of at least 3 mm in all poles, must have the means for disconnection incorporated in the fixed wiring.

 **WARNING**

**Risk of electric shock or equipment damage!**

- ▶ Do not touch any live parts in the cabinet.
  - ▶ Disconnect the power supply before making connections to or removing connections from terminals of controller or I/O modules.
  - ▶ Do not use spare terminals as wiring support points.
  - ▶ Do not reconnect the power supply until you have completed the installation.
  - ▶ Unused terminals must be closed (by completely screwing in the terminal screws), thus preventing the accidental touching of “live” parts.
- 
- ▶ Observe precautions for handling electrostatic sensitive devices.

## Wiring Terminals

### Wiring Push-In Terminals

The terminal sockets of the pluggable I/O modules are available in versions (XS821-22, XS823, and XS824-25) featuring convenient push-in terminals for easy wiring. Of the mixed I/O modules, the XF830A and CPO-IO830 likewise feature push-in terminals.

For correct wiring, cables must fulfill the following specifications according to IEC664-1 / VDE 0110 (4.97):

**Table 21. Push-in terminals wiring specifications**

<b>Max. plug gauge</b>	0.14 ... 1.50 mm <sup>2</sup>
<b>Solid conductor H05(07) V-U</b>	0.25 ... 1.50 mm <sup>2</sup>
<b>Stranded conductor H05(07) V-K</b>	0.25 ... 1.50 mm <sup>2</sup>
<b>Stranded conductor with wire end ferrules (without plastic collar)</b>	0.25 ... 1.50 mm <sup>2</sup>
<b>Stripping length</b>	8.0 +1.0 mm

**NOTE:** In the case of solid conductors, the use of ferrules is prohibited.

**NOTE:** Use only one conductor per push-in terminal.

**NOTE:** If two stranded wires are to be connected to a single push-in terminal, twin wire end ferrules must be used.

### Wiring Screw-Type Terminals

The terminal sockets of the pluggable I/O modules are available in versions (XSU821-22, XSU823, and XSU824-25) featuring screw-type terminals. The mixed I/O modules are likewise available in a version (the XFU830A) featuring screw-type terminals.

For correct wiring, cables must fulfill the following specifications according to IEC664-1 / VDE 0110 (4.97):

**Table 22. Screw-type terminals wiring specifications**

<b>Max. plug gauge</b>	0.14 ... 1.50 mm <sup>2</sup>
<b>Solid conductor H05(07) V-U</b>	0.25 ... 1.50 mm <sup>2</sup>
<b>Stranded conductor H05(07) V-K</b>	0.25 ... 1.50 mm <sup>2</sup>
<b>Stranded conductor with wire end ferrules (without plastic collar)</b>	0.25 ... 1.50 mm <sup>2</sup>
<b>Stripping length</b>	11.0 +1.0 mm



## Connecting Power Supply

The Honeywell controller system can be powered by one or more external transformers.

**NOTE:** The max. length for the power supply cable from a transformer is 3 m. This includes the length of the modules and the connection cables between the rails.

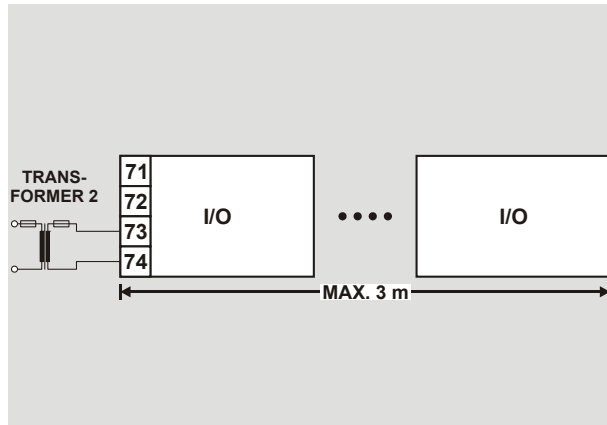


Fig. 18. Wiring the power supply from a transformer

### Additional Transformer

► Connect the additional transformer in a second room or cabinet to terminals 73 and 74 or 77 and 78 of an I/O module.

## NOTICE

### Equipment damage!

- Do not use bridge connectors to connect modules powered by different transformers.
- When connecting modules powered by different transformers using cables, be sure to not connect terminals 73 and 77.

## Connecting Single Bus Controller Systems

This section describes how to connect a controller system which uses **Panel Bus I/O modules, only** or **LONWORKS Bus I/O modules, only**.

### Controller and I/O Modules on a Single Rail

► Connect controller and Honeywell I/O modules using the bridge connectors.

This provides power supply and communication connection. No further wiring is necessary.

### Controllers not Supporting Bridge Connectors

► Connect the controller and Honeywell I/O modules which do not support bridge connectors using wire.

### Controller and I/O Modules on Several Rails in a Single Cabinet

The rails of a controller system are connected in series.

► Connect the rail ends as follows:

- **Power supply**  
via power supply terminals 73, 74 or 77, 78
- **Communication**  
via communication terminals 71, 72 or 75, 76

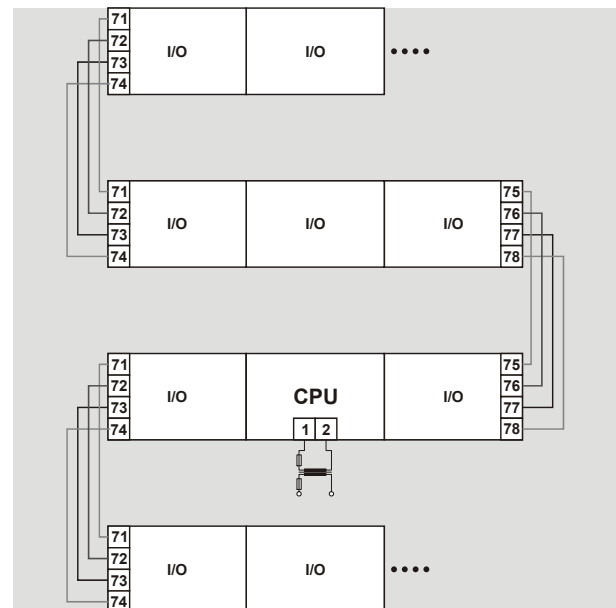


Fig. 19. Wiring the power supply and the communication lines to the Honeywell I/O modules

### Max. Power Cable Length

The max. length for power supply cable per side is 3 m. This also includes the connection cables between the rails, the lengths of the modules, and the cable from the transformer.

### Panel Bus I/O Modules in Separate Rooms

In this scenario, communication and reference voltage (24 V0) must be connected between the rooms.

► Connect the last module of room 1 to the first module of room 2:

- **Reference voltage**  
via power supply terminals 74 or 78  
terminals 73 and 77 must not be connected
- **Communication**  
via communication terminals 71, 72 or 75, 76

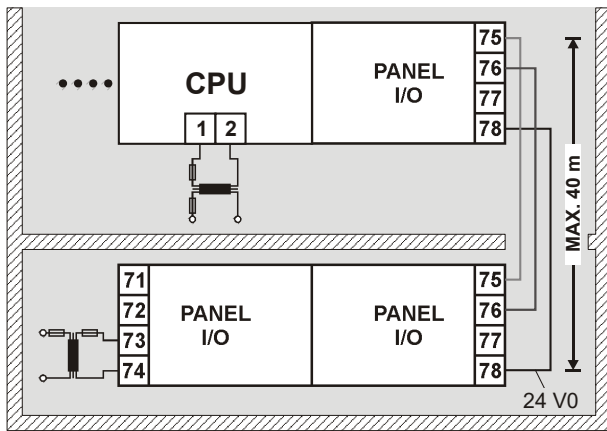


Fig. 20. Wiring the Panel Bus I/O modules in separate rooms

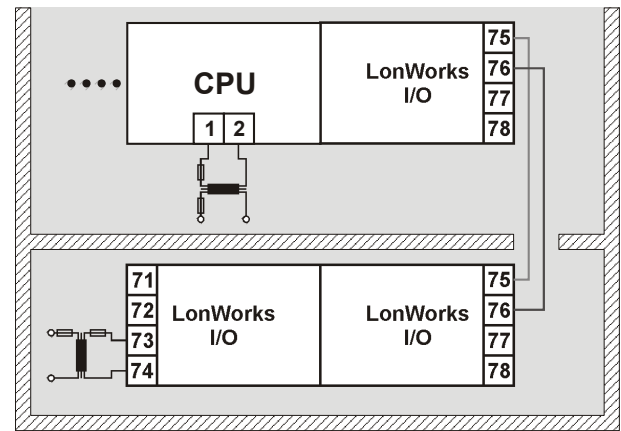


Fig. 21. Wiring the LONWORKS Bus I/O modules in separate rooms

### Max. Cable Length

The max. cable length for connecting room 1 and room 2 is:

- 40 m (any type of cabling and topology, incl. star and loop topology, possible; no additional end termination permitted);
- 1200 m (mandatory twisted-pair or telephone cable and daisy chain topology; controller must be positioned at one end of the Panel Bus, and an end termination of 120 Ω positioned at the other end).

### LONWORKS Bus I/O Modules in Separate Rooms

In this scenario, only communication lines must be connected between the rooms.

- ▶ Connect the last module of room 1 to the first module of room 2:
  - via communication terminals 71, 72 or 75, 76

### Max. Cable Length

For max. cable lengths and cable specifications of the communication lines, see Table 18 and Table 19 on page 10.

## Connecting Panel Bus and LONWORKS Bus Mixed Controller Systems

### Connecting I/O Modules with Each Other

For connecting the Honeywell I/O modules with each other, proceed as described for single bus controller systems on page 17.

### Connecting I/O Modules to the Controller

#### Panel Bus I/O Modules

- ▶ Connect communication terminals 71 ... 74 or 75... 78 of Panel Bus I/O modules to communication terminals 71 ... 74 or 75... 78 of the controller module using either
  - Bridge connectors (for flush mounting on a single DIN rail) or
  - Cables (for separate mounting, e.g., on multiple rails, separate cabinets, etc.).

#### LONWORKS Bus I/O Modules

- ▶ Connect communication terminals 71 ... 74 or 75 ... 78 of LONWORKS Bus I/O modules to LONWORKS terminals 11 ... 14 of the controller module using cables and terminate properly (see also section "LONWORKS Bus Termination Module" on pg. 9).

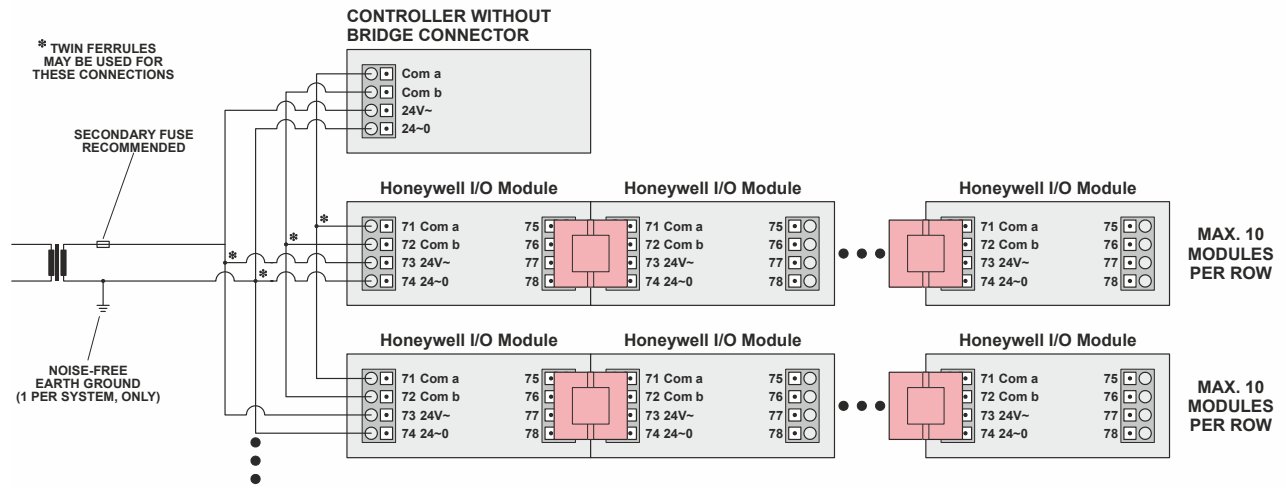


Fig. 22. Wiring controllers not supporting bridge connectors

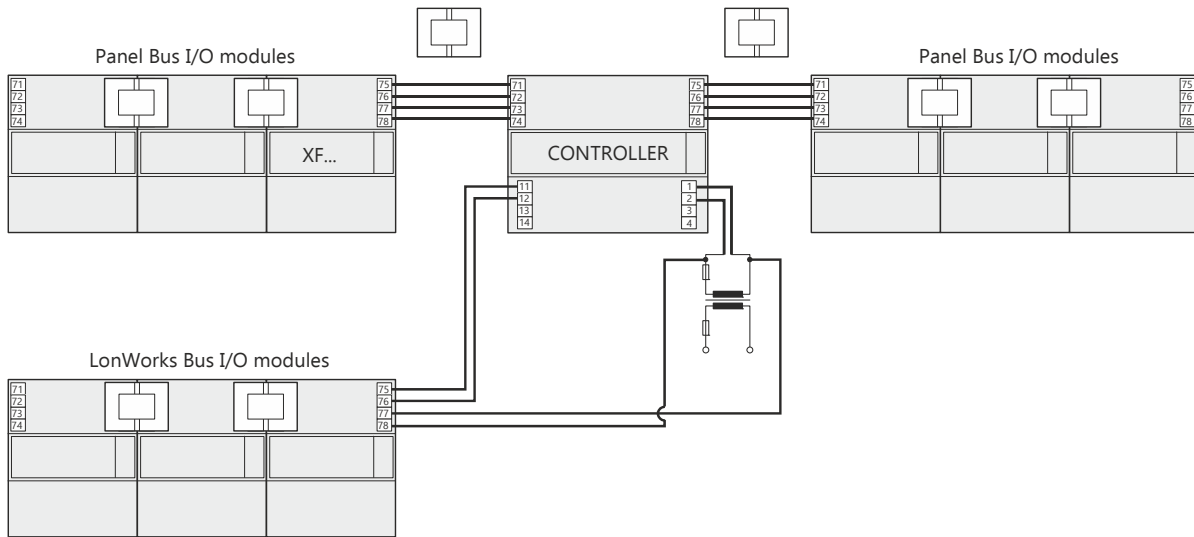


Fig. 23. Mixed bus system – correct wiring

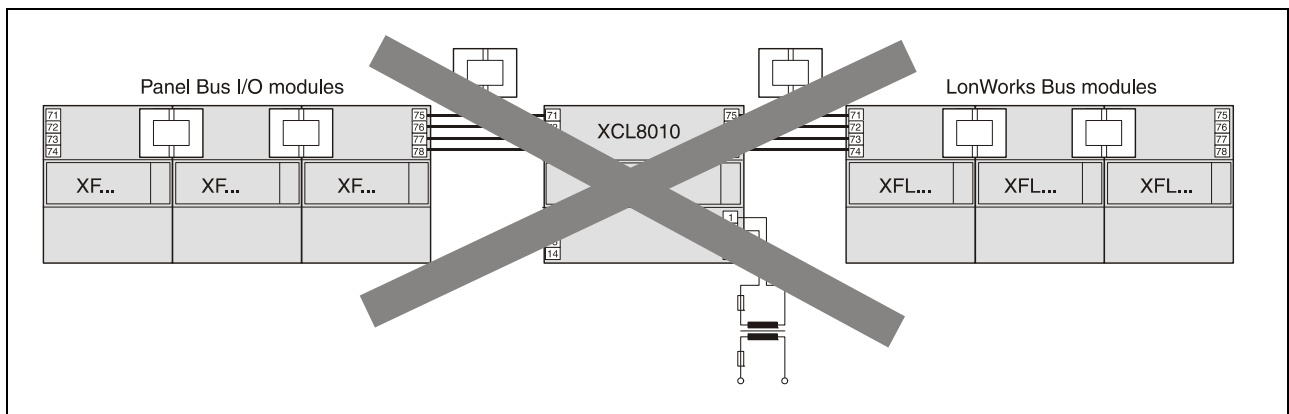


Fig. 24. Mixed bus system – incorrect wiring

## Addressing Panel Bus I/O Modules

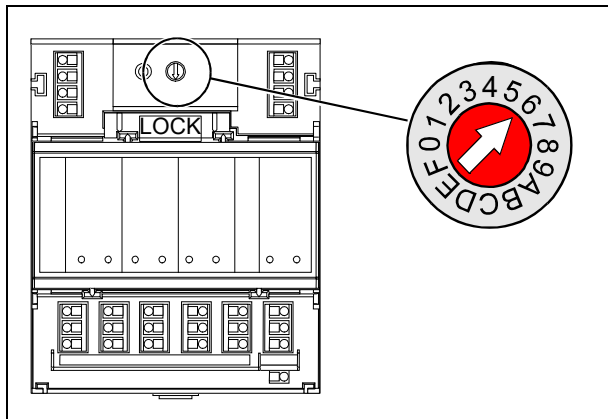
During CARE engineering, each Panel Bus I/O module (Excel 800, CPO-PC-6A) / each Panel Bus I/O module of a given type (Excel Web II) is assigned its own unique address. For the sake of clarity for maintenance personnel, it is recommended that you address the Panel Bus I/O modules in ascending order 0 through F.

**Table 23. HEX switch settings and addresses**

Hex switch	0	1	2	3	4	5	6	7
Address	01	02	03	04	05	06	07	08

Hex switch	8	9	A	B	C	D	E	F
Address	09	10	11	12	13	14	15	16

► Use the rotary HEX switch to set the address to the one already defined during CARE engineering.



**Fig. 25. HEX switch location**

**NOTE:** If the HEX switch is changed, the Panel Bus I/O module will revert to its default configuration.

**NOTE:** With LONWORKS Bus I/O modules, the HEX switch is without function.

## Connecting Field Devices

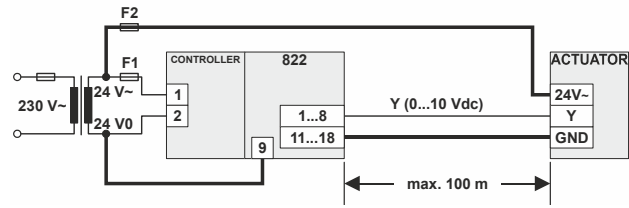
### Connecting Field Devices with Power Supply

Depending on the distance from the controller, field devices can be supplied by the controller or need a separate transformer, see Table 20 on page 10.

For fusing see section "Fusing Specifications" on page 9.

#### Example 1: Power Supply via Controller

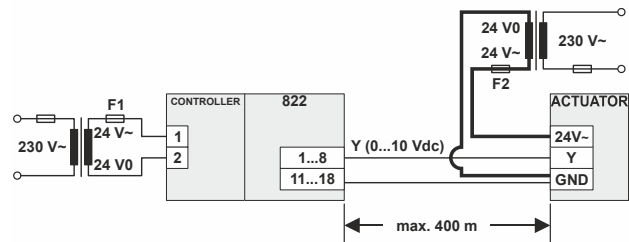
- 24 V actuator connected to an analog output module
- Less than 100 m away from the controller



**Fig. 26. Power supply of field devices via I/O module**

#### Example 2: Power Supply via Separate Transformer

- 24 V actuator connected to an analog output module
- 100 ... 400 m away from the controller



**Fig. 27. Power supply of field devices via a separate transformer**

## Cabling Field Devices

### Cable Routing

Route low-voltage signal and output cables separately from mains cables.

**Table 24. Min. distances to power mains cables**

Cable	Min. distance
Shielded	10 mm (0.4 in.)
Unshielded	100 mm (4 in.)

All low-voltage signal and output cables should be regarded as communication circuits in accordance with VDE 0100 and VDE 0800 (or NEC or other equivalent).

### Cable Shielding

- If the general guidelines for cable routing are observed, it is not necessary to shield field device signal and power supply cables.
- If, for whatever reason, the routing guidelines cannot be observed, the field device signal and power supply cables must be shielded.
  - Shielding of cables leading to field devices must be grounded only at the cabinet end.
  - The shield must not be terminated at the controller.

## **Commissioning and Updating Firmware**

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### **Commissioning Panel Bus I/O Modules**

During CARE engineering, the HEX address of the Panel I/O modules is defined.

**NOTE:** In the case of Panel Bus I/O modules, it is essential that the HEX switch be set to the address assigned during CARE engineering.

The Honeywell controller automatically commissions all Panel Bus I/O modules.

### **Commissioning LONWORKS Bus I/O Modules**

The commissioning of LonWorks Bus I/O modules is done using the engineering tool.

### **Updating Software with Panel Bus I/O Modules**

The controller's firmware includes the firmware for the Panel Bus I/O modules. Thus, whenever the controller's firmware is updated, the firmware of the Panel Bus I/O modules is automatically updated, too.

### **Updating Software with LONWORKS Bus I/O Modules**

The software of the LONWORKS I/O modules can be updated using CARE or EXCELON.

## Description of the I/O Modules

### Common Features

#### Switches Located on the Terminal Socket

Table 25. Switches located on the Terminal Socket

Feature	Function
Service button S1 (pluggable I/O modules, only)	<ul style="list-style-type: none"> <li>LED test, see section "Troubleshooting" on page 57</li> <li>LONWORKS service button functionality for LONWORKS Bus I/O modules</li> </ul>
Hex switch S2	<ul style="list-style-type: none"> <li>Module addressing for Panel Bus I/O modules</li> </ul>

#### LEDs Located on the I/O Module

Table 26. LEDs located on the I/O Module

Feature	Function
Service LED (yellow)	<ul style="list-style-type: none"> <li>Service information, see section "Troubleshooting" on page 57</li> </ul>
Power LED (green)	<ul style="list-style-type: none"> <li>Information on power supply, see section "Troubleshooting" on page 57</li> </ul>

For the location of these elements, see figures of the relative modules.

### Analog Input Modules

#### Types of Analog Input Modules, Terminal Socket

Table 27. Honeywell Analog Input Modules

Type	Description	Housing
XF821	Panel Bus analog input module	Light-gray
XFL821	LONWORKS Bus analog input module	Dark-gray
XS821-822 XSU821-822	Terminal socket	Light-gray

#### Features

- 8 analog inputs
- Sensor-break and short-circuit detection, see section "Troubleshooting" on page 57.

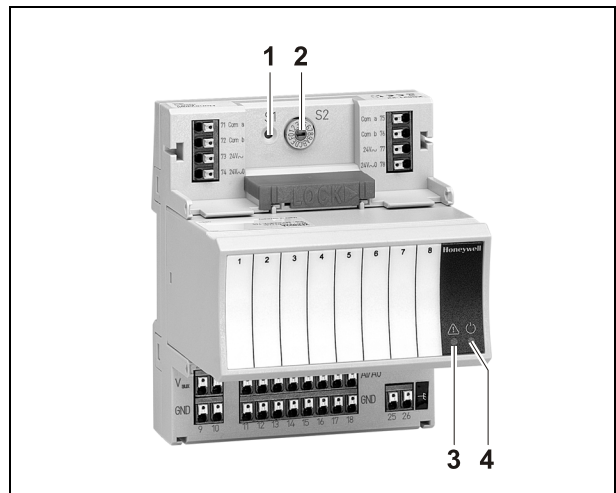


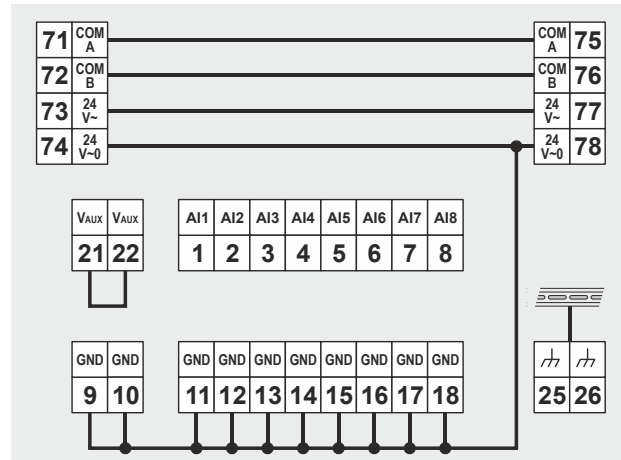
Fig. 28. XF821 Analog Input Module with terminal socket

#### Legend

- 1 Service button S1
- 2 Hex switch S2
- 3 Service LED
- 4 Power LED

Functionality of service LED and power LED: see Table 57 to Table 59 on page 57 and following.

**Terminals**



**Fig. 29. Terminal assignment and internal connections**

**Table 28. Description of analog input module terminals**

Terminal	SIGNAL	Comment
71, 75	COM a	2-wire communication bus (LON/Panel Bus)
72, 76	COM b	2-wire communication bus (LON/Panel Bus)
73, 77	24 V~	Power supply
74, 78	24 V-0	Power supply
1...8	AI1 ... AI8	Analog inputs 1...8
9...18	GND	Ground. All grounds are internally connected internally to each other.
21, 22	10 VDC/ 5 mA, ±2%	Auxiliary voltage signal (used, e.g., for supplying setpoint potentiometers)
25, 26	⌚	Shield connection (functional earth), internally connected to the DIN rail,

**NOTE:** Shield connection to be used for shielded I/O cables only. It is not allowed to connect a LONWORKS shield, since LONWORKS requires a resistor and a capacitor.

**NOTE:** If additional shield terminals are needed, the XS814 Auxiliary Terminal Package can be installed.

**Technical Data**

**Table 29. Analog input modules data**

<b>Input</b>	<ul style="list-style-type: none"> <li>• 0(2) ... 10 VDC</li> <li>• 0(4) ... 20 mA (via external 499 Ω/0.25% resistor)</li> <li>• NTC20kΩ (-50...+150 °C; default)</li> <li>• PT1000-1 (-50...+150 °C)</li> <li>• Johnson A99 PTC (-40...+120 °C)</li> <li>• PT1000-2 (0...+400 °C)</li> <li>• PT3000 (-50...+150 °C)</li> <li>• BALCO500 (-30...+120 °C)</li> <li>• NTC10kΩ (-30...+100 °C)</li> <li>• NI1000TK5000 (-30...+130 °C)</li> <li>• Slow binary input</li> </ul>
<b>Protection</b>	Protected against 24 VAC and 40 VDC overvoltage as well as against short-circuiting
<b>Resolution</b>	16-bit resolution
<b>Accuracy</b>	±75 mV (0 ... 10 V), without sensor

**Table 30. Accuracy of analog input sensors**

Range	PT1000-1 Johnson A99 PTC <sup>(1)</sup>	PT1000-2	Balco500 <sup>(2)</sup>	PT3000	NTC20kΩ (default)	NTC10kΩ <sup>(3)</sup>	NI1000TK5000 <sup>(4)</sup>
-50...-20 °C (-58...-4 °F)	≤ 1.2 K	-	≤ 1.2 K	≤ 1.2 K	≤ 5.0 K	≤ 5.0 K	≤ 1.2 K
-20...0 °C (-4...+32 °F)	≤ 0.7 K	-	≤ 0.7 K	≤ 0.7 K	≤ 1.0 K	≤ 1.0 K	≤ 0.7 K
0...30 °C (32...86 °F)	≤ 0.5 K	≤ 0.5 K	≤ 0.5 K	≤ 0.5 K	≤ 0.3 K	≤ 0.5 K	≤ 0.5 K
30...70 °C (86...158 °F)	≤ 0.7 K	≤ 0.7 K	≤ 0.7 K	≤ 0.7 K	≤ 0.5 K	≤ 0.5 K	≤ 0.7 K
70...100 °C (158...212 °F)	≤ 1.2 K	≤ 1.2 K	≤ 1.2 K	≤ 1.2 K	≤ 1.0 K	≤ 1.0 K	≤ 1.2 K
100...130 °C (212...266 °F)	≤ 1.2 K	≤ 1.2 K	≤ 1.2 K	≤ 1.2 K	≤ 3.0 K	-	≤ 1.2 K
130...150 °C (266...302 °F)	≤ 1.2 K	≤ 1.2 K	-	≤ 1.2 K	≤ 5.5 K	-	-
150...400 °C (302...752 °F)	-	≤ 1.2 K	-	-	-	-	-

<sup>(1)</sup> Johnson A99 PTC specified for -40...+120 °C, only  
<sup>(2)</sup> Balco specified for -30...+120 °C, only  
<sup>(3)</sup> NTC10kΩ specified for -30...+100 °C, only  
<sup>(4)</sup> NI1000TK5000 specified for -30...+130 °C, only

**NOTE:** The accuracy of the sensor itself is not included in this table.

Internal Impedance when Connecting Sensors

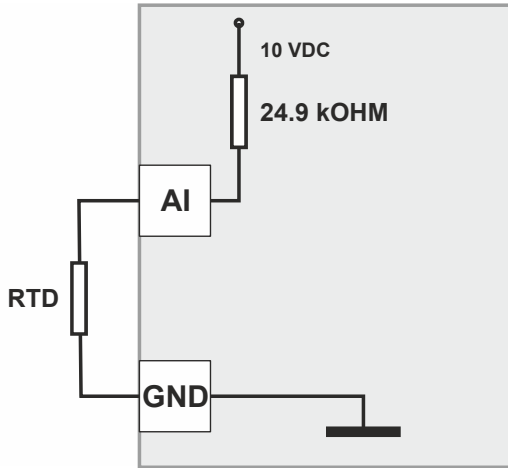


Fig. 30. Analog input low impedance (input circuit for PT1000, Johnson A99 PTC, Balco500, PT3000, NI1000TK5000, slow binary input)

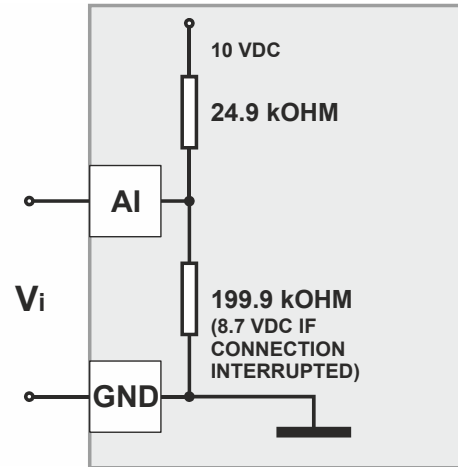


Fig. 32. Analog input impedance setpoint (input circuit for NTC10k $\Omega$ , NTC20k $\Omega$ , wall module setpoint)

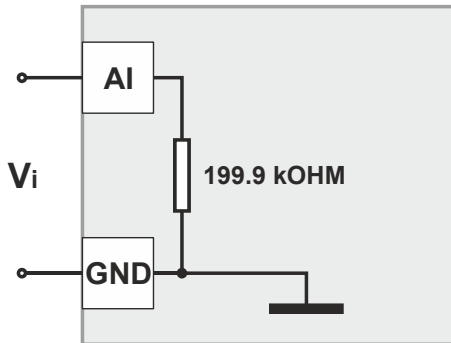
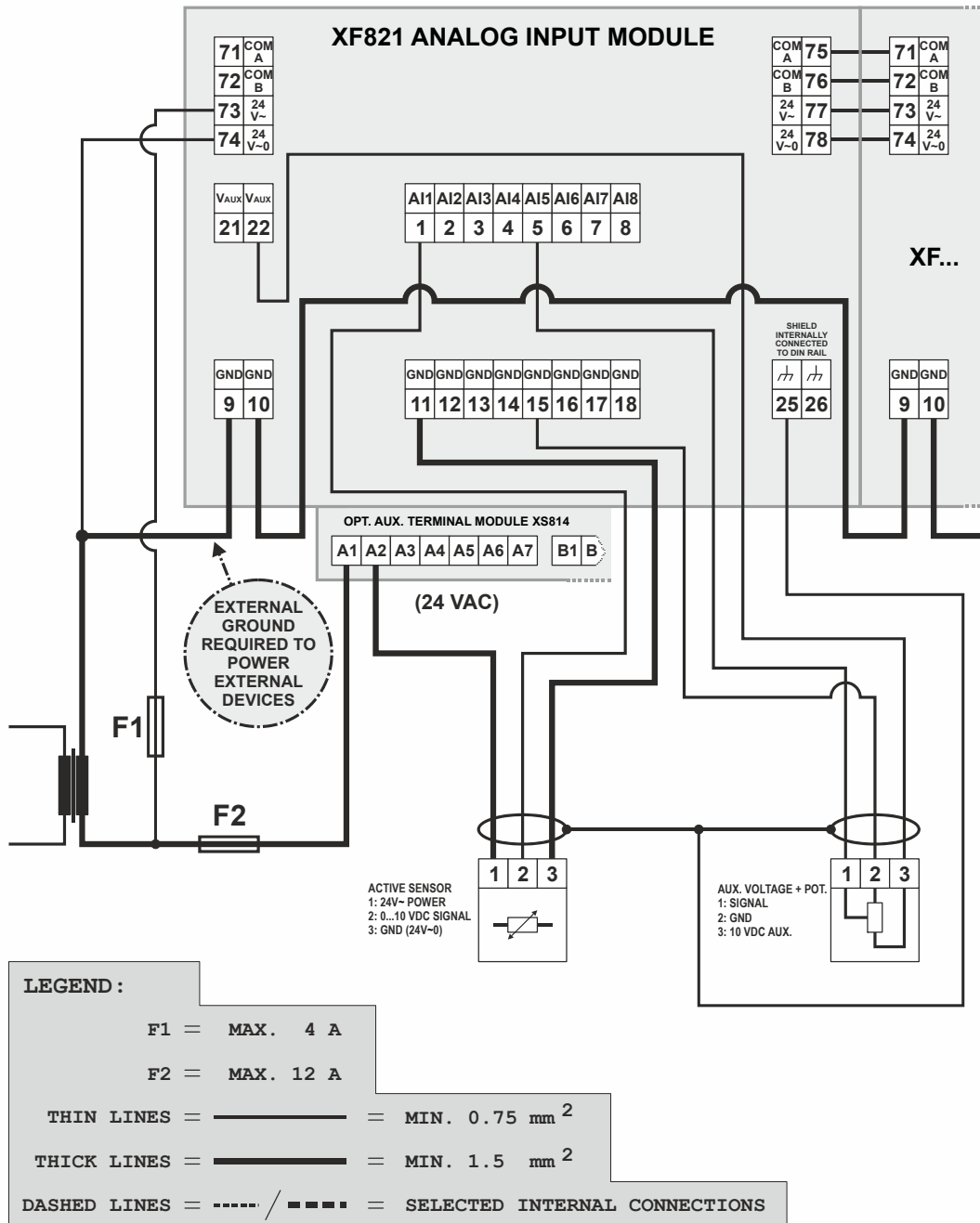


Fig. 31. Analog input high impedance (input circuit for voltage input for active sensors)



## Connection Examples

### Active Sensor and Potentiometer



**Fig. 33. Analog input module, wiring example 1**

For fusing specifications see section "Fusing Specifications" on page 9.

Passive Sensor and 0 (4) ... 20 mA Signal

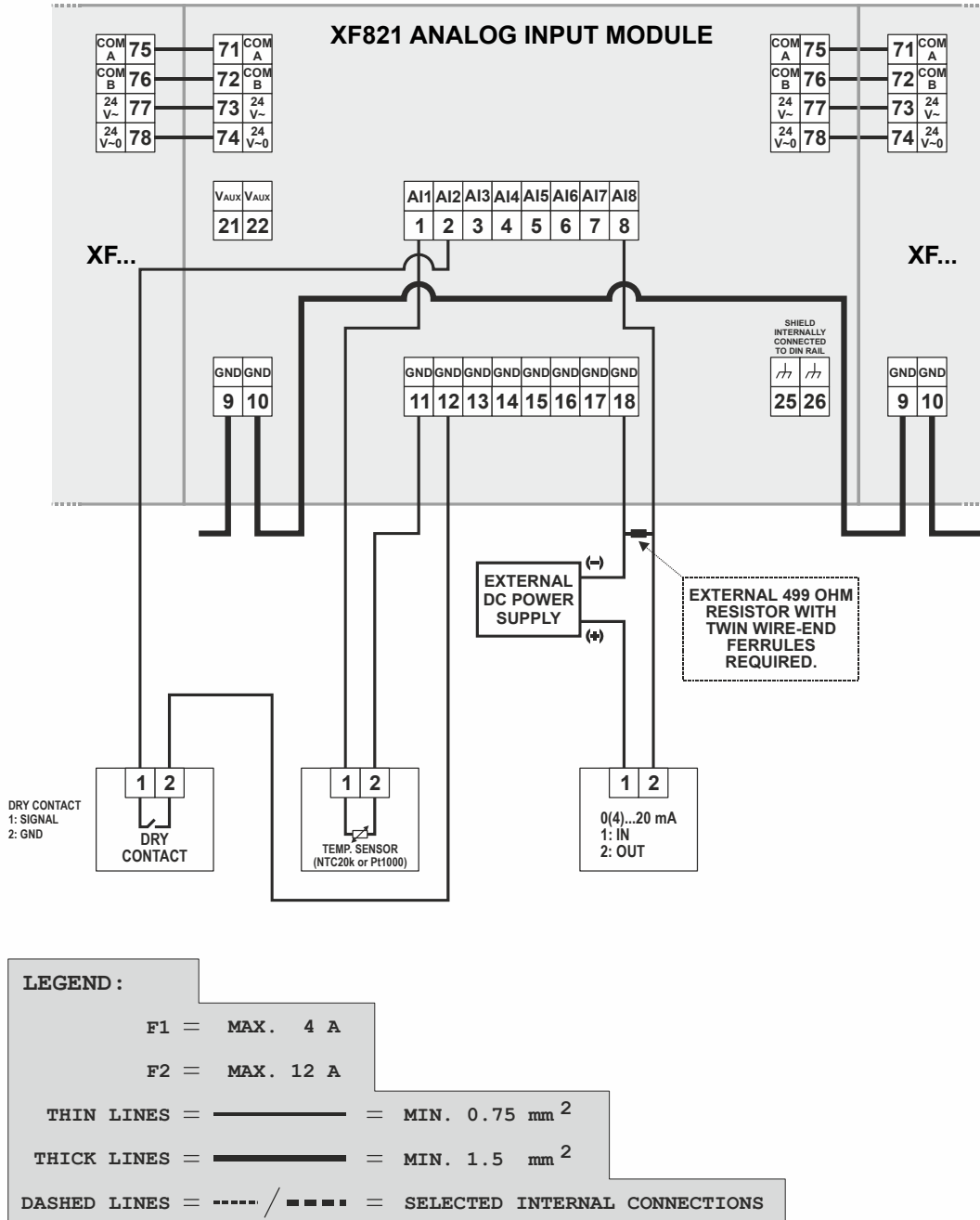


Fig. 34. Analog input module, wiring example 2

## Analog Output Modules

### Types of Analog Output Modules, Terminal Socket

Table 31. Honeywell analog output modules

Type	Description	Housing
XF822	Panel Bus analog output module	Light-gray
XFR822	Panel Bus analog output module with manual overrides	Light-gray
XFL822	LONWORKS Bus analog output module	Dark-gray
XFLR822	LONWORKS Bus analog output module with manual overrides	Dark-gray
XS821-22 XSU821-22	Terminal socket	Light-gray

### Features

- 8 analog outputs; can also be configured per output as binary outputs (0 ... 10 V, 2 ... 10 V, ON/OFF, or floating)
- Corresponding status LEDs (red)
- ...R822: 8 manual overrides, see figure below

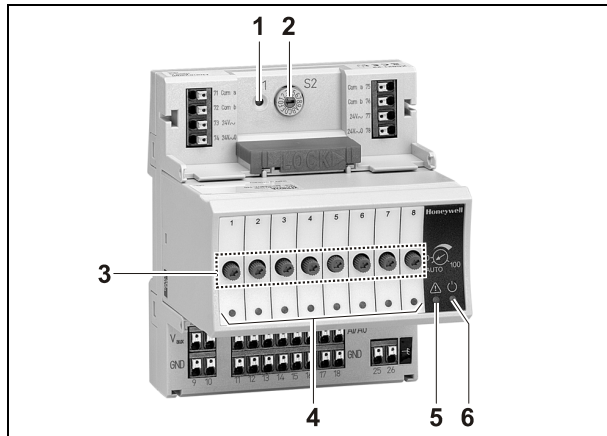


Fig. 35. XF822 Analog Output Module with terminal socket

### Legend

- 1 Service button S1
- 2 Hex switch S2
- 3 Manual overrides
- 4 Status LEDs
- 5 Service LED
- 6 Power LED

Functionality of service LED and power LED: see Table 57 to Table 59 on page 57 and following.

In the event of communication problems, the analog outputs will move to the safety positions you have configured in CARE, see analog output point description in the CARE – User Guide, EN2B-0182GE51 / 74-5587.

### Terminals

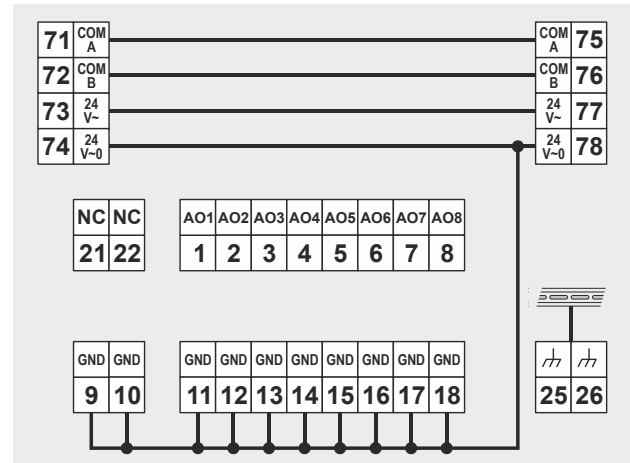


Fig. 36. Terminal assignment and internal connections

Table 32. Description of the analog output module terminals

Ter- mi- nal	Signal	COMMENT
71, 75	COM a	2-wire communication bus (LON/Panel Bus)
72, 76	COM b	2-wire communication bus (LON/Panel Bus)
73, 77	24 V~	Power supply
74, 78	24 V~0	Power supply
1...8	AO1...AO8	Analog outputs 1...8
9...18	GND	Ground. All grounds are internally connected to each other.
21, 22	N.C.	Do not use!
25, 26		Shield connection (functional earth), internally connected to the DIN rail

**NOTE:** Shield connection to be used for shielded I/O cables only. It is not allowed to connect a LONWORKS shield, since LONWORKS requires a resistor and a capacitor.

**NOTE:** If additional shield terminals are needed, the XS814 Auxiliary Terminal Package can be installed.

## Technical Data

Table 33. Analog output modules data

<b>Voltage rating</b>	0(2)...11 V (default)
<b>Current rating</b>	max. ±1 mA
<b>Resolution</b>	8-bit resolution
<b>Accuracy</b>	±150 mV
<b>Zero output voltage</b>	< 200 mV
<b>Protection</b>	Protected against 24 VAC and 40 VDC overvoltage as well as against short-circuiting
<b>Feedback signal</b>	automatic/manual mode and output value

## Status LED Behavior

Table 34. Analog output status LED behavior

<b>Automatic mode</b>	Brightness is proportional to the commanded output signal
<b>Override mode</b>	Flashes

## Status LEDs with Manual Overrides

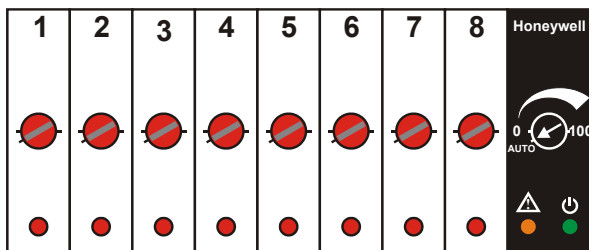


Fig. 37. Manual overrides (rotary knobs)

The XFR822/XFLR822 Analog Output Modules are equipped with manual overrides: one for each analog output. These rotary knobs can be manually set to either "AUTO" or "0...100%" (infinitely adjustable).

## NOTICE

### Damage to the electronic module!

- ▶ Do not use a tool to adjust the rotary knobs.
- ▶ Do not use excessive force. Adjust only by hand.

## Manual Override in the AUTO Position

When a manual override of the XFR822/XFLR822 is set to AUTO, and the corresponding analog output has been configured, the following applies:

- If the LONWORKS network is functioning properly, the output voltage of the analog output will be as commanded.
- If the LONWORKS network is not functioning properly, the output voltage of the analog output will be the safety position value.
- The brightness of the status LED (red) of the analog output will be proportional to the commanded output signal.

When a manual override of the XFR822/XFLR822 is set to AUTO, and the corresponding analog output has **not** been configured, the following applies:

- Regardless as to whether the LONWORKS network is functioning properly or not, the output voltage of the analog output will be 0 V (values from the LONWORKS Bus will be ignored, and there will be no heartbeat or safety position).
- The feedback signal on the LONWORKS network `nvoAoActPosnFb[ ]` will have a value of 0% and a state of 0.
- The analog output status LED will be unlit.

## Manual Override in the Override Position (0...100%)

When a manual override of the XFR822/XFLR822 is set to 0...100%, and the corresponding analog output has been configured, the following applies:

- The output voltage of the analog output will be 0...10 V (direct) or 10...0 V (reverse).
- The feedback signal on the LONWORKS network `nvoAoActPosnFb[ ]` will have a value of 0...100% and a state of -1.
- The status LED (red) of the analog output will flash to indicate "manual override."

When a manual override of the XFR822/XFLR822 is set to 0...100%, and the corresponding analog output has **not** been configured, the following applies:

- The output voltage of the analog output will be 0...10 V.
- The feedback signal on the LONWORKS network `nvoAoActPosnFb[ ]` will have a value of 0...100% and a state of -1.
- The status LED (red) of the analog output will flash to indicate "manual override."

## Analog Outputs Configured as Binary Outputs

Using CARE, the analog outputs can be configured individually as binary outputs. The voltage output is then 0 V or 10 V, depending upon the signal from the controller.

Connection Example

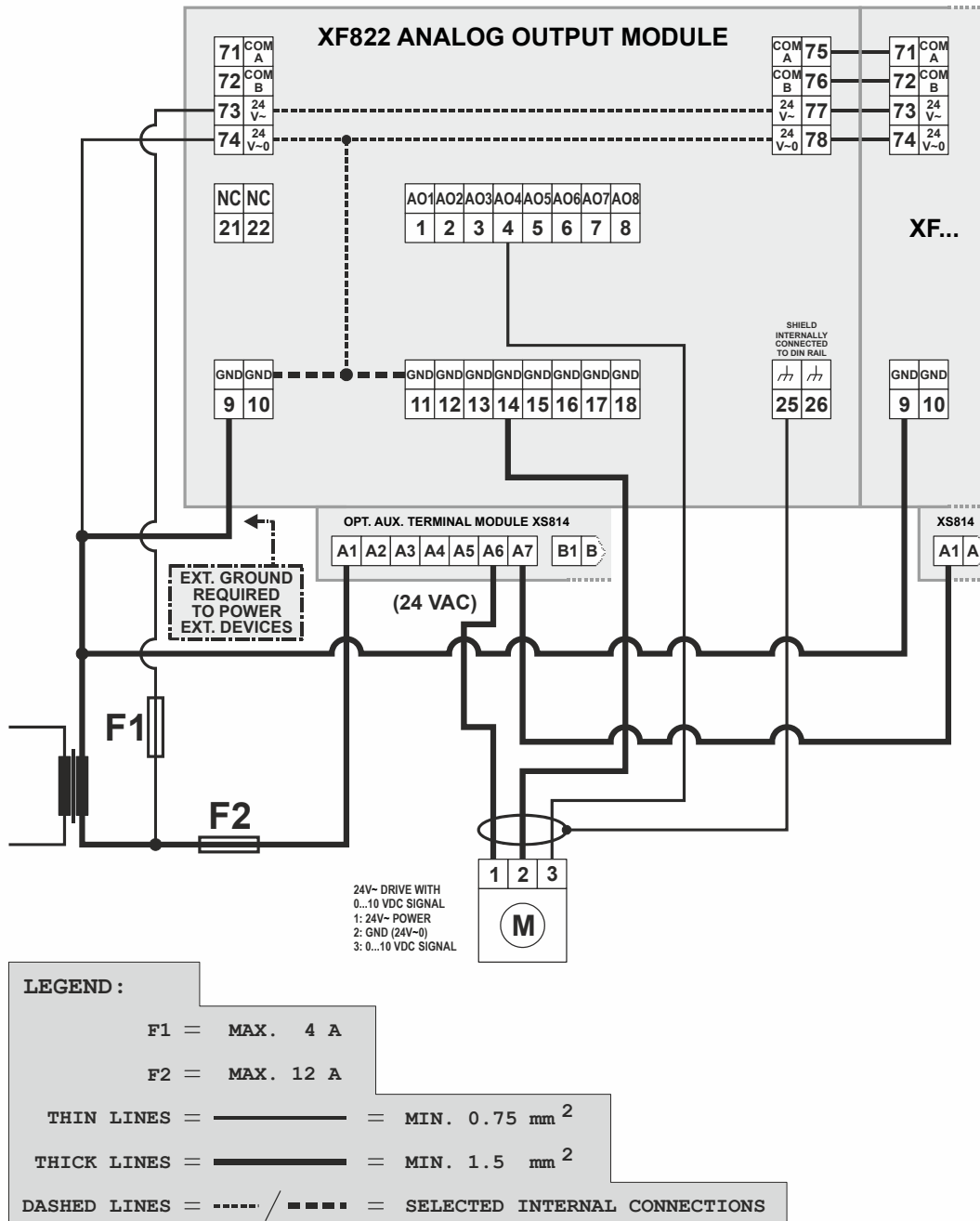


Fig. 38. Analog output connection example

For fusing specifications see section "Fusing Specifications" on page 9.

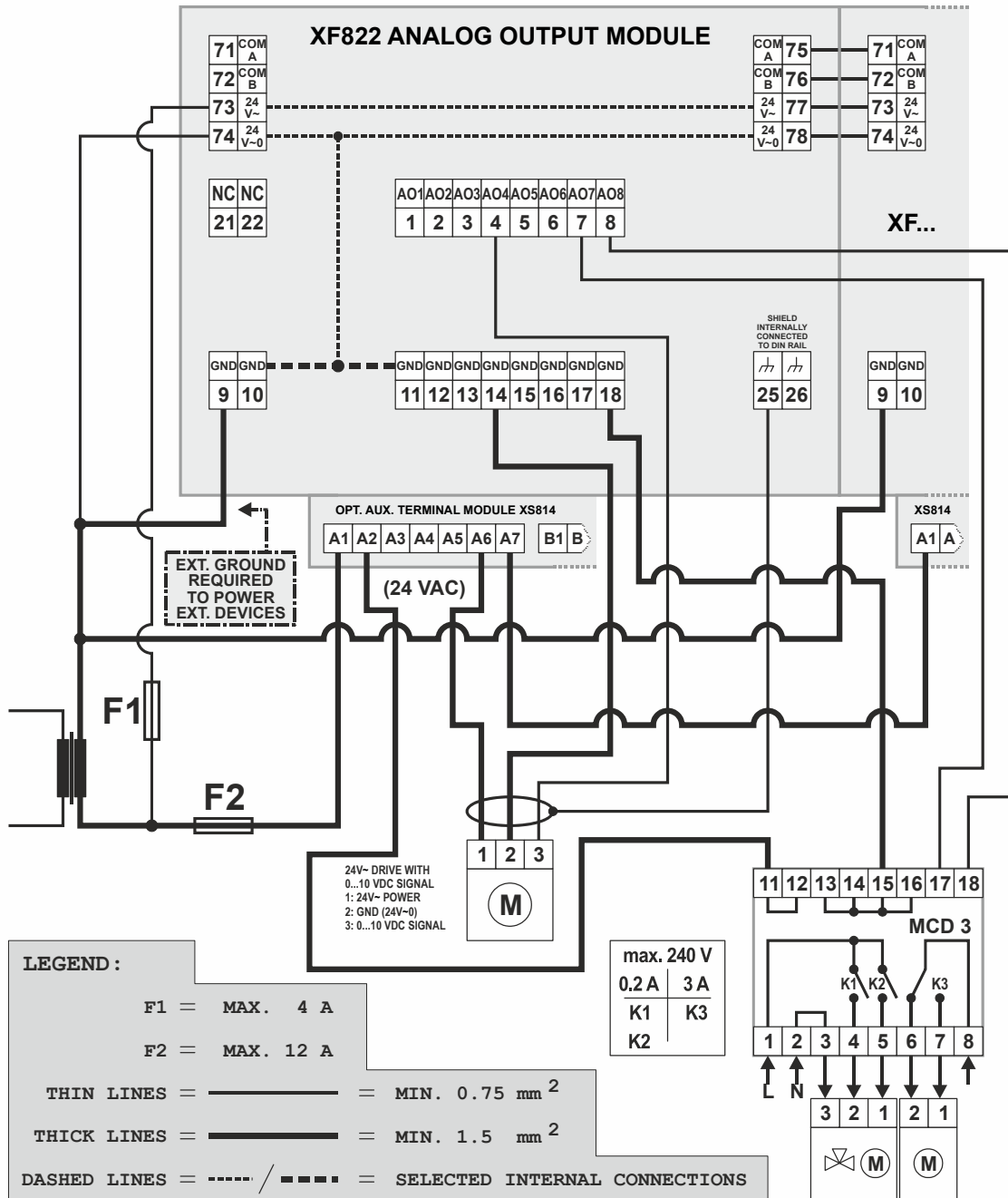
### **Synchronization Behavior of Analog Output Module Configured as Floating Output**

In order to regularly update the real actuator position with the calculated position and thus ensure that the actuator definitely reaches its end position, a synchronization process is performed by the analog output module.

During the synchronization process, the analog output module will continue running for the configured runtime once it reaches the calculated end position.

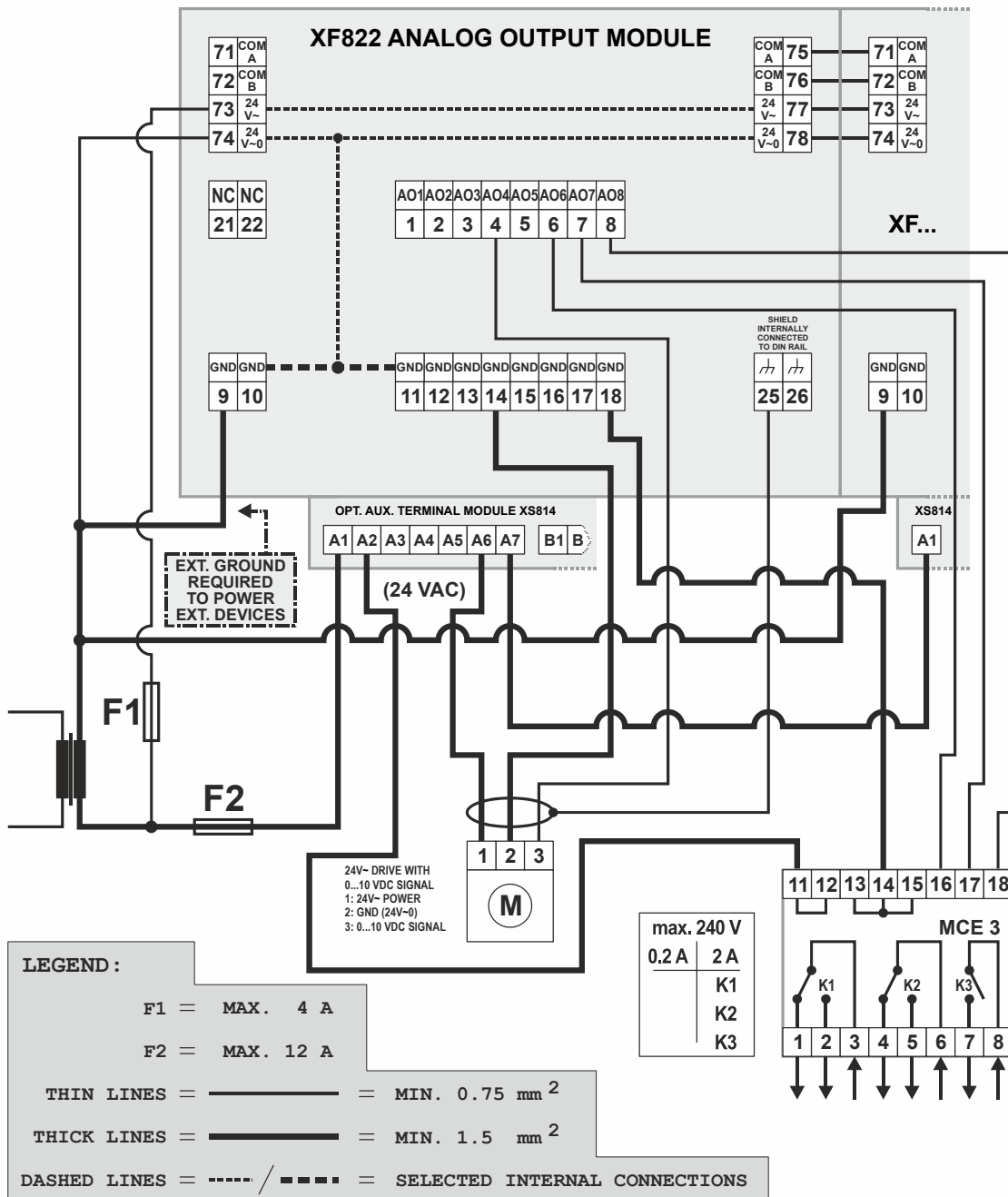
This updating (synchronization) is performed:

- If the calculated position of the actuator < lower synchronization threshold (2%) = synchronization towards 0%
- If the calculated position of the actuator > upper synchronization threshold (98%) = synchronization towards 100%
- Following any power-up or any reset



**Fig. 39. Connection example with Relay Module MCD 3**

- The relay module facilitates the control of peripheral devices with high load via the analog outputs.
  - Input terminal 17 of MCD3 controls changeover contact K3.
  - Relay terminal 18 of MCD3 controls the N.O. contacts (floating outputs) K1, K2.
- For fusing specifications, see section "Fusing Specifications" on page 9.



**Fig. 40. Connection example with Relay Module MCE 3**

The relay module facilitates the control of peripheral devices with high load via the analog outputs.

- Input terminal 16 of MCE3 controls the N.O. contact K3.
- Input terminal 17 of MCE3 controls the changeover contact K2.
- Input terminal 18 of MCE3 controls the changeover contact K1.

For fusing specifications, see section "Fusing Specifications" on page 9.



## Binary Input Modules

### Types of Binary Input Modules, Terminal Socket

Type	Description	Housing
XF823	Panel Bus binary input module	Light-gray
XFL823	LONWORKS Bus binary input module	Dark-gray
XS823 XSU823	Terminal socket	Light-gray

Table 35. Honeywell Binary Input Modules

### Features

- 12 binary inputs
- 12 configurable status LEDs (green/red, yellow/OFF)
- Binary inputs can be used as
  - Static digital inputs as dry-contacts (default)
  - Fast totalizers (up to 20 Hz)

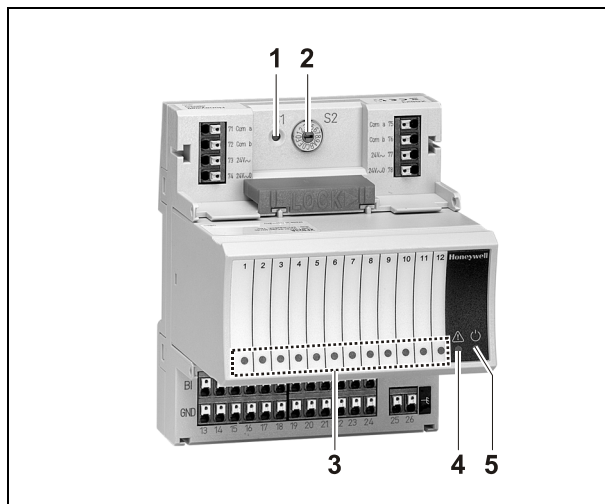


Fig. 41. XF823 Binary Input Module with terminal socket

### Legend

- 1 Service button S1
- 2 Hex switch S2
- 3 Status LEDs
- 4 Service LED
- 5 Power LED

Functionality of service LED and power LED: see Table 57 to Table 59 on page 57 and following.

## Terminals

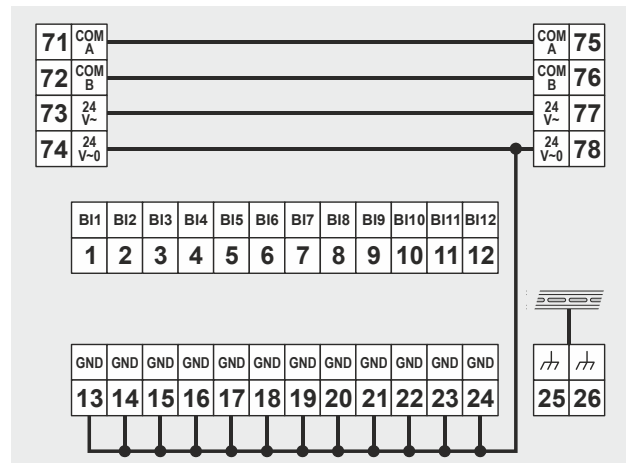


Fig. 42. Terminal assignment and internal connections

Ter-minal	Signal	COMMENT
71, 75	COM a	2-wire communication bus (LON/Panel Bus)
72, 76	COM b	2-wire communication bus (LON/Panel Bus)
73, 77	24 V~	Power supply
74, 78	24 V-0	Power supply
1...12	BI1...BI12	Binary inputs 1...12
13...24	GND	Ground. All grounds are internally connected to each other.
25, 26		Shield connection (functional earth), internally connected to the DIN rail.

Table 36. Description of binary input module terminals

**NOTE:** Shield connection to be used for shielded I/O cables only. It is not allowed to connect a LONWORKS shield, since LONWORKS requires a resistor and capacitor.

**NOTE:** If additional shield terminals are needed, the XS814 Auxiliary Terminal Package can be installed.

## Technical Data

**Table 37. Binary input module data**

<b>Input type</b>	Dry-contact or open collector
<b>Current rating (closed input)</b>	2 mA
<b>Open contact voltage</b>	16...22 VDC
<b>Protection</b>	Protected against 24 VAC and 40 VDC overvoltage as well as against short-circuiting

## Status LED Behavior

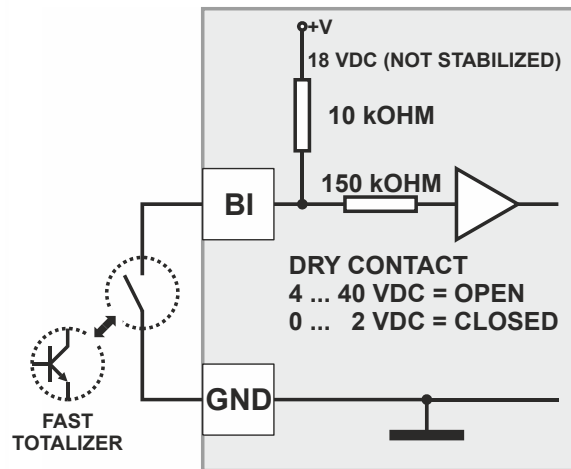
Using CARE, each of the twelve status LEDs can be configured individually for use as either alarm LEDs (red/green) or as status LEDs (yellow/OFF [default]). Given a logical state of "ON," the status LED will be lit (yellow or red).

## Configuration as Fast Totalizer

Using CARE, the binary inputs can be configured as fast totalizers for operation in conjunction with devices equipped with an open collector output.

**Table 38. Binary inputs used as fast totalizers**

<b>Frequency</b>	max. 20 Hz
<b>Pulse ON</b>	min. 25 ms
<b>Pulse OFF</b>	min. 25 ms
<b>Bounce</b>	max. 5 ms



**Fig. 43. Configuration of binary input as fast totalizer**

Connection Example

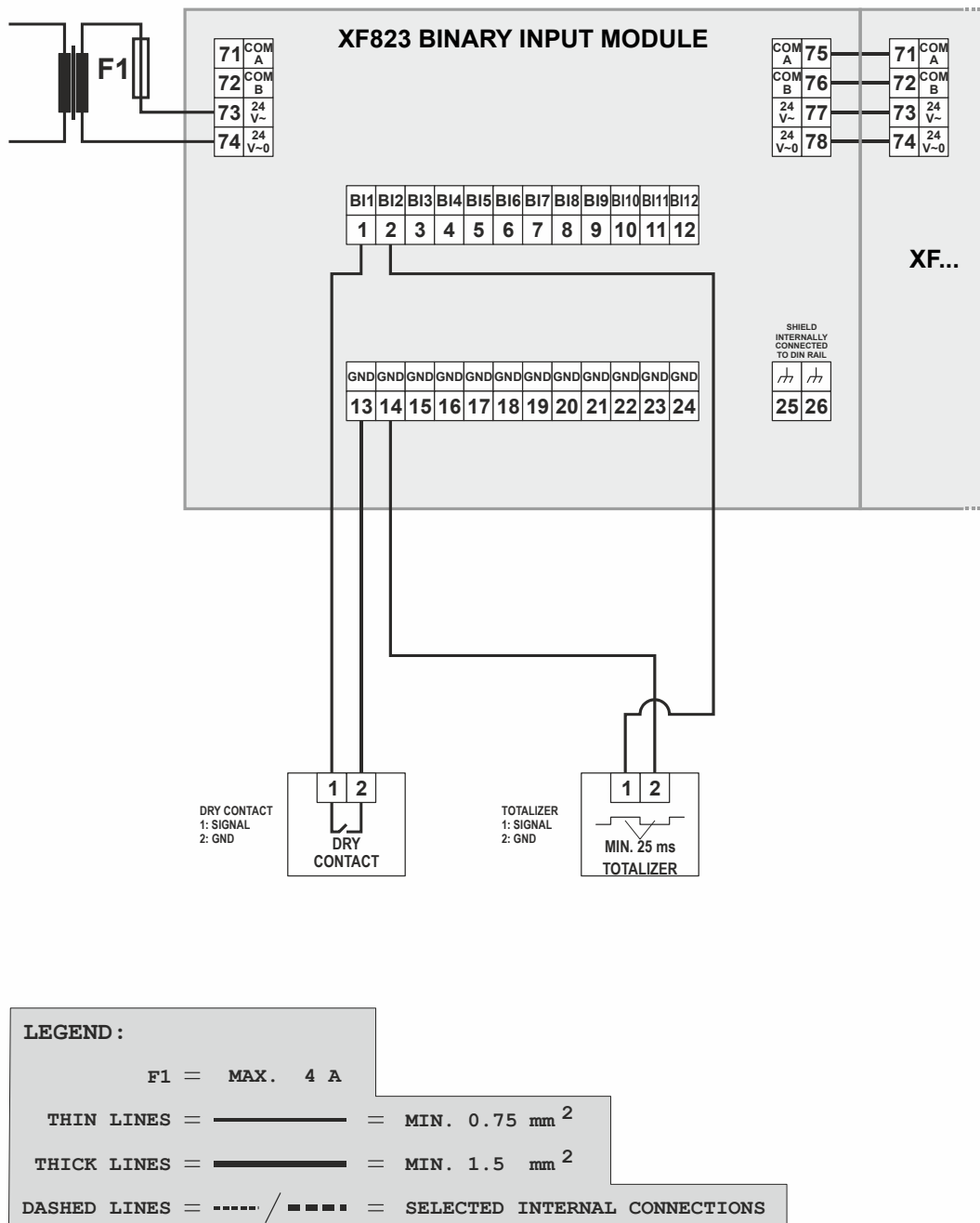


Fig. 44. XF823 connection examples

For fusing specifications, see section "Fusing Specifications" on page 9.

## Relay Output Modules

### Types of Relay Output Modules, Terminal Socket

Table 39. Honeywell Relay Output Modules

Type	Description	Housing
XF824	Panel Bus relay output module	Light-gray
XFR824	Panel Bus relay output module with manual overrides	Light-gray
XFL824	LONWORKS Bus relay output module	Dark-gray
XFLR824	LONWORKS Bus relay output module with manual overrides	Dark-gray
XS824-25 XSU824-25	Terminal socket; can be fitted with cross connector (incl. in scope of the delivery)	Light-gray

### Features

- 6 relays (changeover contacts), arranged in two blocks
- ...R824: 6 manual overrides
- Low and line voltage allowed, see WARNING.

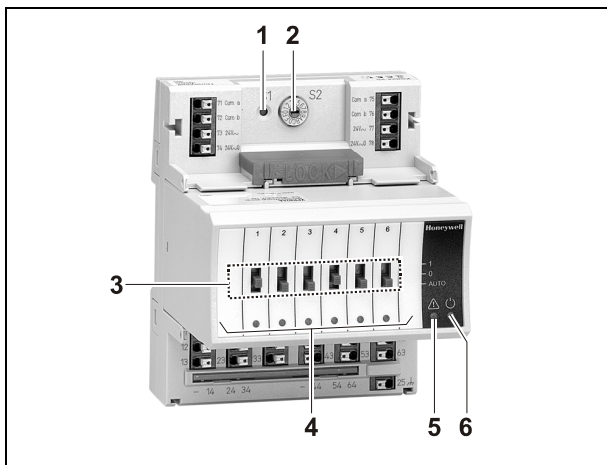


Fig. 45. XF824 Relay Output Module with terminal socket

### Legend

- 1 Service button S1
- 2 Hex switch S2
- 3 Manual overrides
- 4 Status LEDs
- 5 Service LED
- 6 Power LED

Functionality of service LED and power LED: see Table 57 to Table 59 on page 57 and following.

In the event of communication problems, the relay outputs will move to the safety positions you have configured in CARE,

see relay output point description in the CARE – User Guide, EN2B-0182GE51 / 74-5587.

### WARNING

**Risk of electric shock or equipment damage!**  
Low voltage and line voltage must not be wired within the same relay block.

- ▶ Wire low voltage e.g., to relay block 1 and line voltage to relay block 2 or vice versa. In this case, a cross connector must not be used; rather, each relay must be wired separately.

### NOTICE

**Risk of malfunction!**  
Cross connectors may only be used if the same voltage is used on all relays they connect.

- ▶ Do not use a cross connector if different voltages are used on any of the six relays. In such cases, each relay must be wired separately.

### Terminals

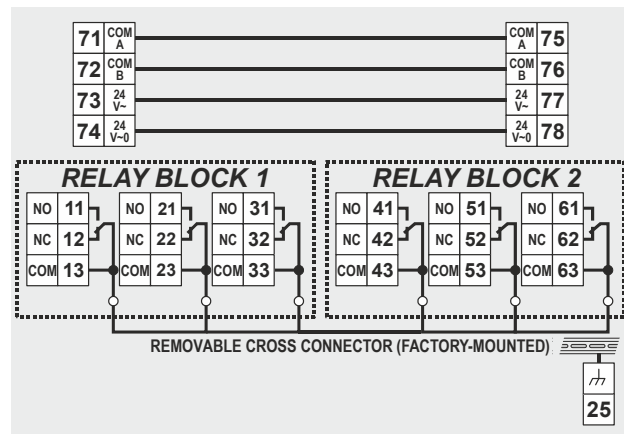



Fig. 46. Terminal assignment and internal connections

**Table 40. Description of relay output module terminals**

Terminal	Signal	Comment
71, 75	COM a	2-wire communication bus (LON/Panel Bus)
72, 76	COM b	2-wire communication bus (LON/Panel Bus)
73, 77	24 V~	Power supply
74, 78	24 V~0	Power supply
RELAY BLOCK 1	11	REL1 N.O. Relay 1 N.O. contact
	12	REL1 N.C. Relay 1 N.C. contact
	13	R1 COM relay 1 common contact
	14	R1 COM For connection of relay 1 common via cross connector*
	21	REL2 N.O. Relay 2 N.O. contact
	22	REL2 N.C. Relay 2 N.C. contact
	23	R2 COM Relay 2 common contact
	24	R2 COM For connection of relay 2 common via cross connector*
	31	REL3 N.O. Relay 3 N.O. contact
	32	REL3 N.C. Relay 3 N.C. contact
	33	R3 COM Relay 3 common contact
	34	R3 COM For connection of relay 3 common via cross connector*
RELAY BLOCK 2	41	REL4 N.O. Relay 4 N.O. contact
	42	REL4 N.C. Relay 4 N.C. contact
	43	R4 COM Relay 4 common contact
	44	R4 COM For connection of relay 4 common via cross connector*
	51	REL5 N.O. Relay 5 N.O. contact
	52	REL5 N.C. Relay 5 N.C. contact
	53	R5 COM Relay 5 common contact
	54	R5 COM For connection of relay 5 common via cross connector*
	61	REL6 N.O. Relay 6 N.O. contact
	62	REL6 N.C. Relay 6 N.C. contact
63	R6 COM Relay 6 common contact	
64	R6 COM For connection of relay 6 common via cross connector*	
25		Shield connection (functional earth), internally connected to the DIN rail

\* Do not connect by wire!

**Permissible Loads**

	Max. load	Min. load
<b>Per relay output module (total) (fuse F3)</b>	<b>19...250 VAC</b> current at $\cos \varphi \geq 0.6$ : 12 A <b>1...29 VDC</b> 12 A resistive, 3 A inductive	–
<b>Per normally open contact</b>	<b>19...250 VAC</b> current at $\cos \varphi \geq 0.6$ : 4 A <b>1...29 VDC</b> 4 A resistive, 1 A inductive	50 mW
<b>Per normally closed contact</b>	<b>19...250 VAC</b> current at $\cos \varphi \geq 0.95$ : 2 A, current at $\cos \varphi \geq 0.6$ : 1 A <b>1...29 VDC</b> 4 A resistive, 1 A inductive	50 mW

**Table 41. Permissible loads of relay output modules**

- NOTE:** In the case of voltages above 30 VAC/DC and if inductive components are to be connected to relays switching more often than once every 2 minutes, these components must be prevented from causing harmful interference to radio or television reception (conformance with EN 55014).
- NOTE:** Relays must not be used for electronic ballasts, energy-efficient lamps, or any other capacitive devices. Such devices may display a high in-rush current for which the relays were not designed. To prevent damage to the relay module, use power gates or a coupling relay.
- NOTE:** Max. voltage for UL 864-compliant applications is 24 V.

**Status LED Behavior**

**Table 42. Relay output status LED behavior**

Mode	LED	Relay output	
		N.O.* (direct)	N.C.* (reverse)
Automatic mode, logical state "ON"	ON	ON	OFF
Automatic mode, logical state "OFF"	OFF	OFF	ON
Override mode (setting "0")	Flashes	OFF	ON
Override mode (setting "1")	Flashes	ON	OFF

\*As configured using CARE.

### Status LEDs with Manual Overrides

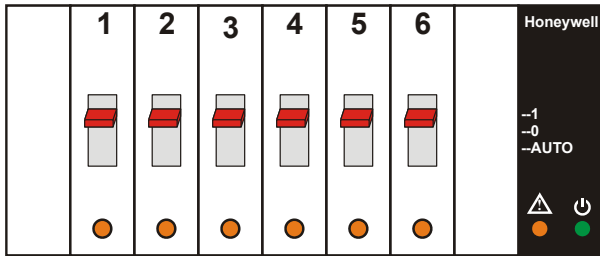


Fig. 47. Manual overrides (toggle switches)

The ...R824 Relay Output Modules are equipped with manual overrides: one for each relay output. These toggle switches can be manually set to either "AUTO" or "0" or "1".

#### Manual Override in the AUTO Position

When a manual override of the ...R824 Relay Output Module is set to the "AUTO" position, and the corresponding relay output has been configured, the following applies:

- If the LONWORKS network is functioning properly, the logical status of the relay output will be "AUTO."
- If the LONWORKS network is **not** functioning properly, the feedback signal will be switched to the safety position value.
- The feedback signal on the LONWORKS network: nvoDoActPosnFb[ ] will have a value of either 0% or 100%, and a state of -1.
- The status LED (yellow) will indicate the actual logical state of the relay output as commanded (by nviDoSwitch[ ]).

When a manual override of the ...R824 Relay Output Module is set to the "AUTO" position, and the corresponding relay output has **not** been configured, the following applies:

- Regardless as to whether the LONWORKS network is functioning properly or not, values from the LONWORKS Bus will be ignored, and there will be no heartbeat or safety position.
- The feedback signal on the LONWORKS network: nvoDoActPosnFb[ ] will have a value of 0% and a state of 0.
- The status LED will be unlit.

#### Manual Override in the ON Position

When a manual override of the ...R824 Relay Output Module is set to the "ON" position, the following applies:

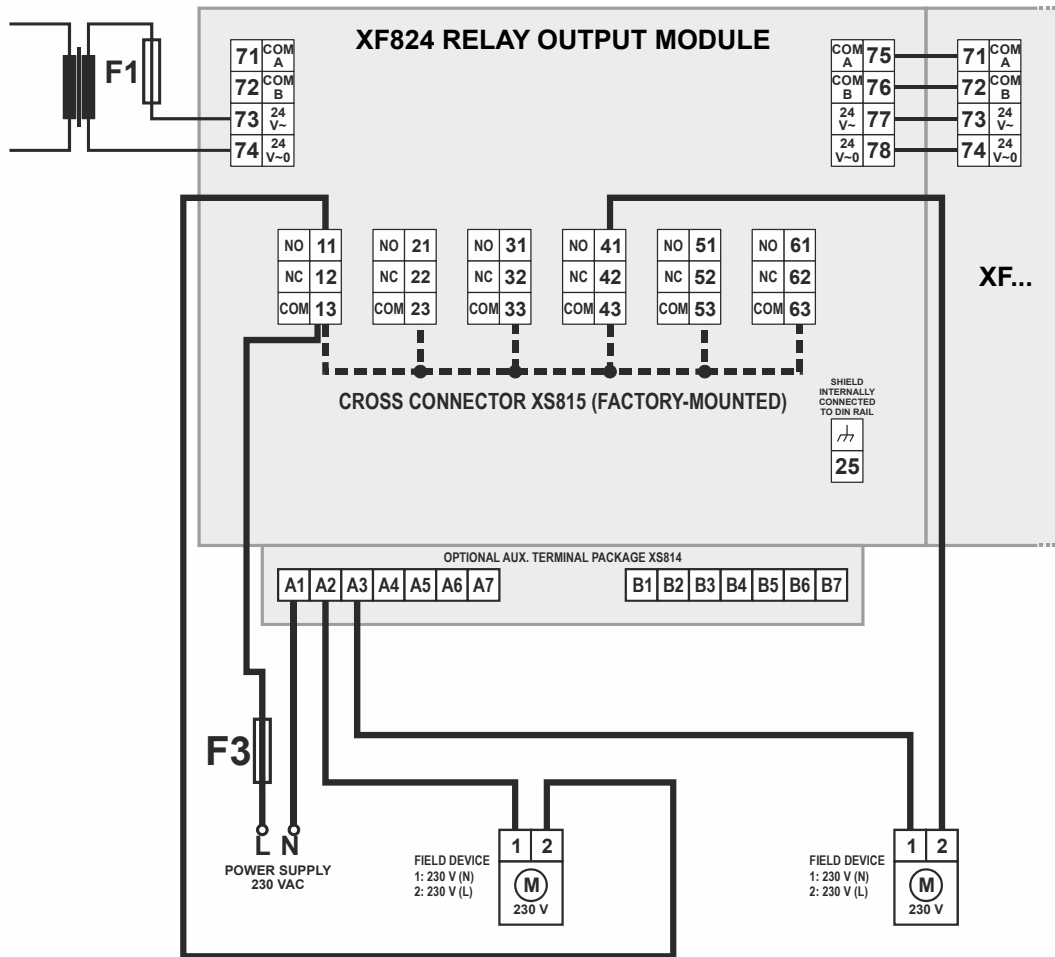
- If the relay output has been configured, its logical state will depend upon the actual output configuration.
- If the relay output is unconfigured, it will be switched ON.
- Regardless of configuration, the feedback signal on the LONWORKS network: nvoDoActPosnFb[ ] will have a value of 1000...0% and a state of -1.
- Regardless of configuration, the status LED (yellow) will flash to indicate "manual override."

#### Manual Override in the OFF Position

When a manual override of the ...R824 Relay Output Module is set to the "OFF" position, the following applies:

- If the relay output has been configured, its logical state will depend upon the actual output configuration.
- If the relay output is unconfigured, it will be switched OFF.
- Regardless of configuration, the feedback signal on the LONWORKS network: nvoDoActPosnFb[ ] will have a value of 0% (direct) or 100% (reverse) and a state of -1.
- Regardless of configuration, the status LED (yellow) will flash to indicate "manual override."

Connection Example

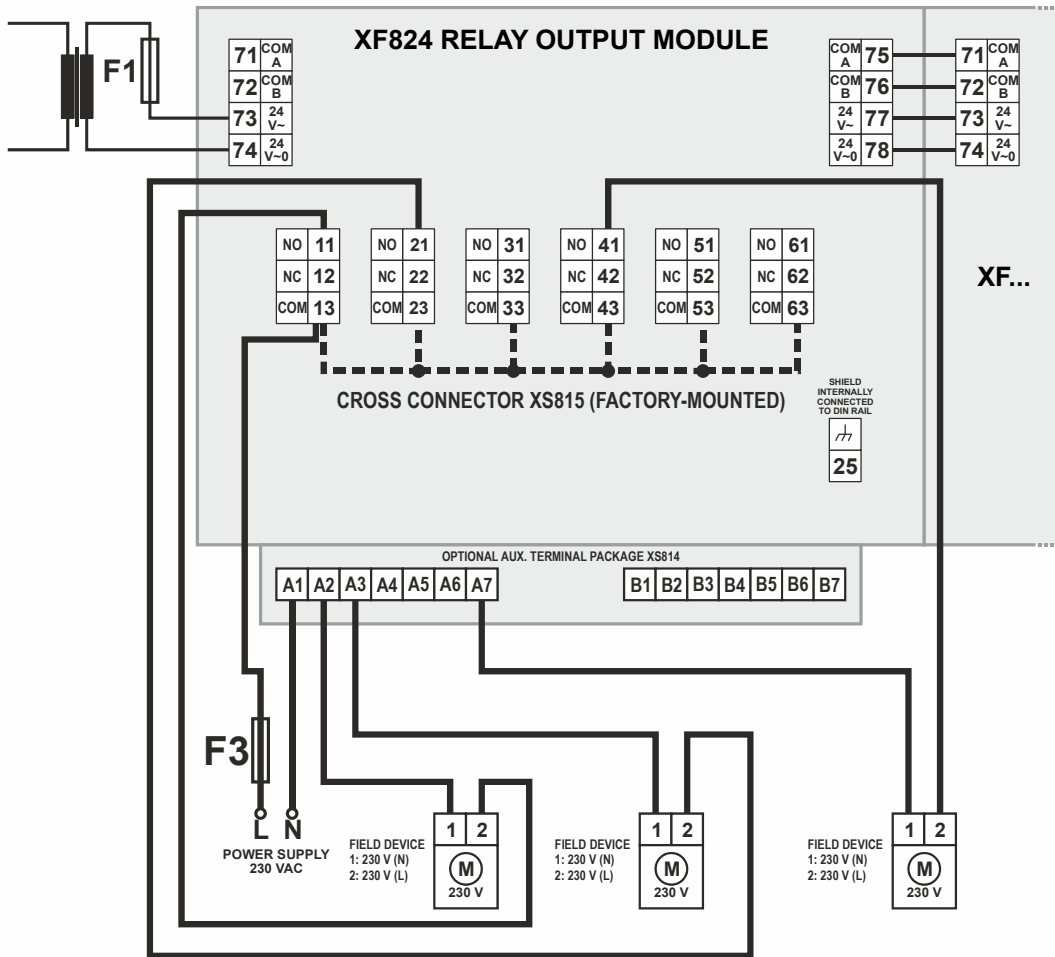


**LEGEND :**

F1	=	MAX.	4 A
F3	=	MAX.	12 A
THIN LINES	=	MIN.	0.75 mm <sup>2</sup>
THICK LINES	=	MIN.	1.5 mm <sup>2</sup> - or less, as per F3
DASHED LINES	=	SELECTED INTERNAL CONNECTIONS	

Fig. 48. XF824 connection example (both relay blocks with line voltage)

For fusing specifications see section "Fusing Specifications" on page 9.



**LEGEND :**

F1	=	MAX.	4	A
F3	=	MAX.	12	A
THIN LINES	=	—————	=	MIN. 0.75 mm <sup>2</sup>
THICK LINES	=	—————	=	MIN. 1.5 mm <sup>2</sup> - or less, as per F3
DASHED LINES	=	----- / - - - -	=	SELECTED INTERNAL CONNECTIONS

**Fig. 49. XF824 connection example (relay blocks with low and line voltage)**

For fusing specifications see section "Fusing Specifications" on page 9.



## Floating Output Module

### Features

- Type: XFR825 Floating Output Module
- Housing: light-gray
- Floating outputs sufficient for driving up to 3 floating actuators
- Manual overrides and 3 corresponding pairs of status LEDs

In the event of communication problems, the three floating outputs will move to the safety positions you have configured in CARE, see floating output point description in the CARE – User Guide, EN2B-0182GE51 / 74-5587.

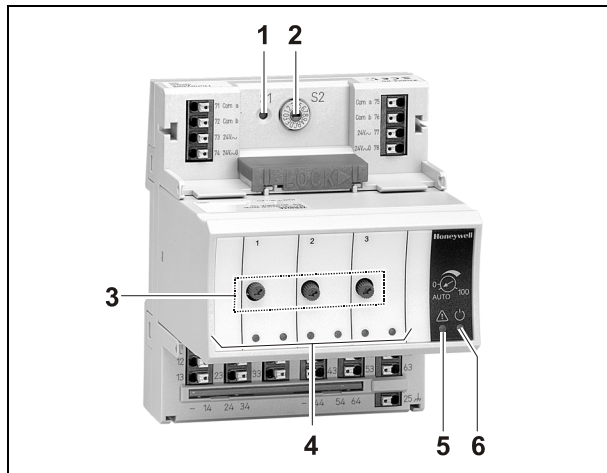


Fig. 50. XFR825 Floating Output Module with terminal socket

### Legend

- 1 Service button S1
- 2 Hex switch S2
- 3 Manual overrides
- 4 Status LEDs
- 5 Service LED
- 6 Power LED

Functionality of service LED and power LED: see Table 57 to Table 59 on page 57 and following.

### WARNING

**Risk of electric shock or equipment damage!**  
Low voltage and line voltage must not be wired within the same module.

### Permissible Loads

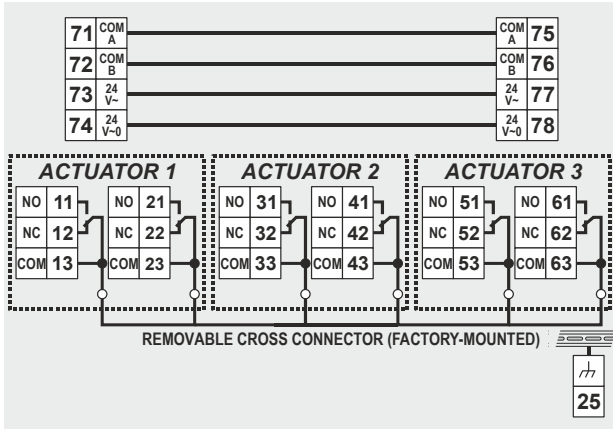
	Max. load	Min. load
<b>Per relay output module (total) (fuse F3)</b>	<b>19...250 VAC</b> current at $\cos \varphi \geq 0.6$ : 12 A <b>1...29 VDC</b> 12 A resistive, 3 A inductive	–
<b>Per normally open contact</b>	<b>19...250 VAC</b> current at $\cos \varphi \geq 0.6$ : 4 A) <b>1...29 VDC</b> 4 A resistive, 1 A inductive	50 mW
<b>Per normally closed contact</b>	<b>19...250 VAC</b> current at $\cos \varphi \geq 0.95$ : 2 A, current at $\cos \varphi \geq 0.6$ : 1 A <b>1...29 VDC</b> 4 A resistive, 1 A inductive	50 mW

Table 43. Permissible loads of floating output modules

**NOTE:** In the case of voltages above 30 VAC/DC and if inductive components are to be connected to relays switching more often than once every 2 minutes, these components must be prevented from causing harmful interference to radio or television reception (conformance with EN 55014).

**NOTE:** Max. voltage for UL 864-compliant applications is 24 V.

**Terminals**



**Fig. 51. Terminal assignment and internal connections**

Ter- minal	Signal	Comment
71, 75	COM a	2-wire communication bus (LON/Panel Bus)
72, 76	COM b	2-wire communication bus (LON/Panel Bus)
73, 77	24 V~	Power supply
74, 78	24 V~0	Power supply
ACTUATOR 1	11	REL1 N.O. Floating relay 1 N.O. contact
	12	REL1 N.C. Floating relay 1 N.C. contact
	13	R1 COM Floating relay 1 common contact
	14	R1 COM For connection of floating relay 1 common via cross connector*
	21	REL2 N.O. Floating relay 2 N.O. contact
	22	REL2 N.C. Floating relay 2 N.C. contact
ACTUATOR 2	23	R2 COM Floating relay 2 common contact
	24	R2 COM For connection of floating relay 2 common via cross connector*
	31	REL3 N.O. Floating relay 3 N.O. contact
	32	REL3 N.C. Floating relay 3 N.C. contact
	33	R3 COM Floating relay 3 common contact
	34	R3 COM For connection of floating relay 3 common via cross connector*
ACTUATOR 3	41	REL4 N.O. Floating relay 4 N.O. contact
	42	REL4 N.C. Floating relay 4 N.C. contact
	43	R4 COM Floating relay 4 common contact
	44	R4 COM For connection of floating relay 4 common via cross connector*
	51	REL5 N.O. Floating relay 5 N.O. contact
	52	REL5 N.C. Floating relay 5 N.C. contact
ACTUATOR 3	53	R5 COM Floating relay 5 common contact
	54	R5 COM For connection of floating relay 5 common via cross connector*
	61	REL6 N.O. Floating relay 6 N.O. contact
	62	REL6 N.C. Floating relay 6 N.C. contact
ACTUATOR 3	63	R6 COM Floating relay 6 common contact
	64	R6 COM For connection of floating relay 6 common via cross connector*
25		Shield connection (functional earth), internally connected to the DIN rail

\* Do not connect by wire!

**Table 44. Description of floating output module terminals**

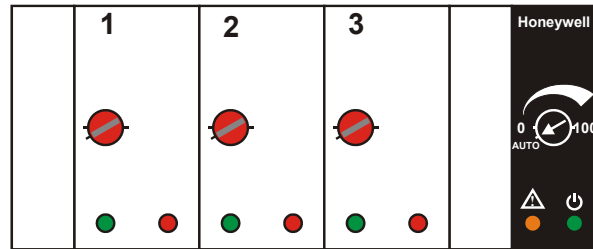
**Status LED Behavior**

The respective pair of status LEDs will display the following behavior:

Mode	LED	Actuator 1		
		Closing	Opening	Not moving
Auto	Green LED	ON	OFF	OFF
	Red LED	OFF	ON	OFF
Override	Green LED	Flashing	OFF	Flashing
	Red LED	OFF	Flashing	Flashing

**Table 45. LED behavior (for e.g., floating output 1)**

**Status LEDs with Manual Overrides**



**Fig. 52. Manual overrides (rotary knobs)**

The floating output module is equipped with manual overrides: one for each floating output. These rotary knobs can be manually set to either "AUTO" or "0 ... 100%" (infinitely adjustable).

**NOTICE**

**Damage to the electronic module!**

- ▶ Do not use a tool to adjust the rotary knobs.
- ▶ Do not use excessive force. Adjust only by hand.

**Manual Override in the AUTO Position**

When a manual override of the XFR825 is set to AUTO, the following applies:

- The output signal of the respective floating output (R1 + R2 or R3 + R4 or R5 + R6) will be as commanded.
- The respective pair of status LEDs will be ON/OFF as commanded.

**Manual Override in the Override Position (0...100%)**

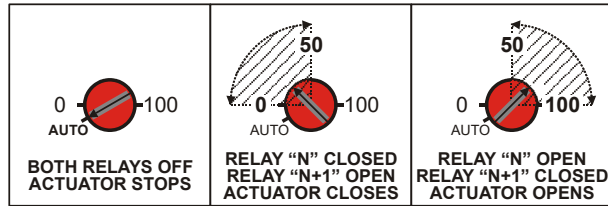
When a manual override of the XFR825 is set to 0...100%, the respective floating output will drive to the set position. The runtime depends upon the actuator runtime configured in CARE and on the actual position.

### Configured Floating Relay Output

If a floating relay output has been configured, the following applies:

The corresponding manual override can be used to adjust the respective floating actuator so that it drives to any desired position between fully closed (0%) and fully open (100%). The "open" relay or "closed" relay – as the case may be – is then switched ON for the time the actuator requires to drive to the desired position, whereupon it will stop. This required time depends upon the configured motor runtime (time to open / time to close,) while the direction of movement is dependent upon the configured direct/reverse setting.

### Unconfigured Floating Relay Output



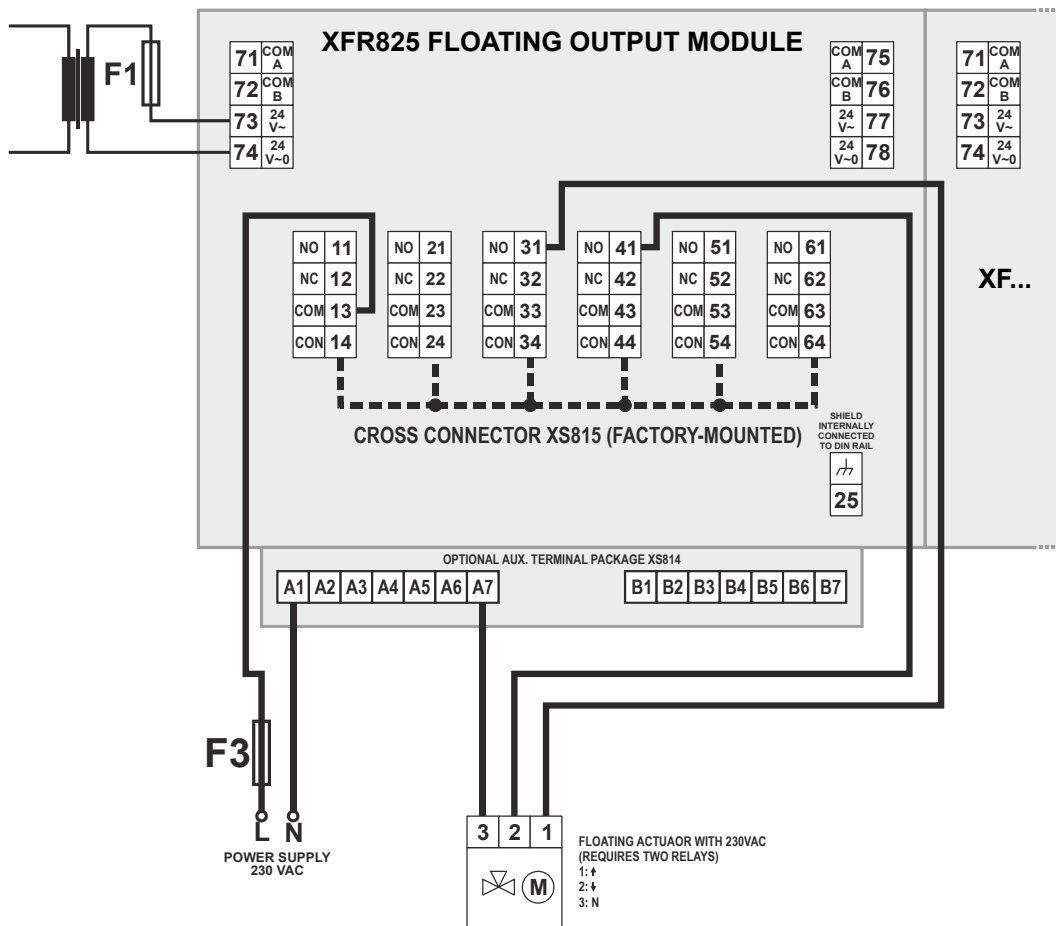
**Fig. 53. Use of manual override (floating relay output unconfigured)**

If a floating relay output has *not* been configured (see Fig. 53), the following applies:

Although the motor runtime is unknown to the XFR825, the corresponding manual override can be used during the commissioning phase to adjust the respective floating actuator so that it drives to any desired position between fully closed (0%) and fully open (100%).

The "open" relay (relay "n," i.e. "1," "3," or "5") and the "closed" relay (relay "n+1," i.e. "2," "4," or "6") are then switched ON and/or OFF, respectively, when the corresponding manual override is set to "0...100%." Specifically, the actuator will drive towards its closed position as long as the manual override is set to "0...50%," and it will drive towards its open position as long as it is set to "50...100%." Setting the manual override to "AUTO" stops the actuator.

Connection Example



**LEGEND :**

F1 =	MAX.	4 A
F3 =	MAX.	12 A
THIN LINES =	—	MIN. 0.75 mm <sup>2</sup>
THICK LINES =	—	MIN. 1.5 mm <sup>2</sup> - or less, as per F3
DASHED LINES =	----- / - - - -	SELECTED INTERNAL CONNECTIONS

Fig. 54. XFR825 Connection example (floating actuator)

For fusing specifications see section "Fusing Specifications" on page 9.

## Mixed Panel Bus I/O Modules

### Features

- Type: XF830A, XFU830A, and CPO-IO830 Mixed Panel Bus I/O Modules
- Housing: light-gray (XF830A, XFU830A) and black (CPO-IO830)



Fig. 55. XF830A, XFU830A, and CPO-IO830 Mixed Panel Bus Modules

In the event of communication problems, the relay outputs will move to the safety positions you have configured in CARE, see relay output point description in the CARE – User Guide, EN2B-0182GE51 / 74-5587.

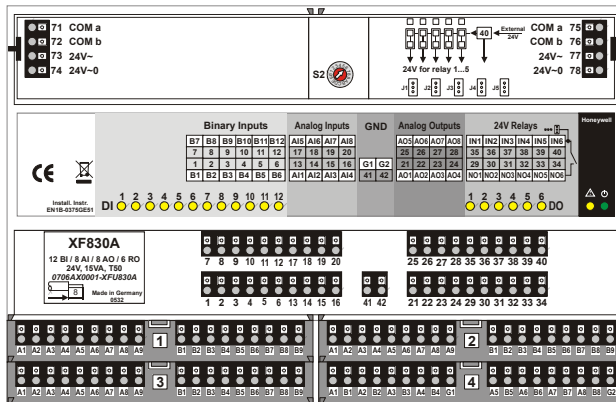


Fig. 56. XF830A Mixed I/O Module (shown with aux. terminal packages)

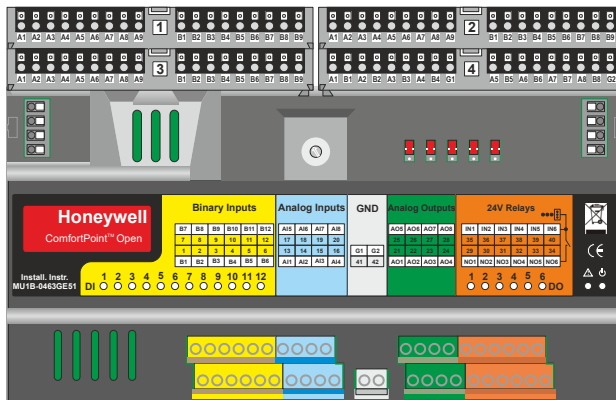


Fig. 57. CPO-IO830 mixed Panel Bus I/O module, shown with 4 optional aux. terminal blocks (top view)

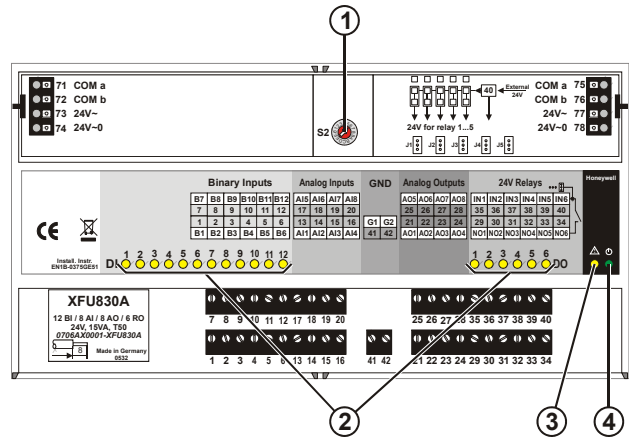


Fig. 58. XFU830A Mixed I/O Module

### Legend

- 1 Hex switch S2
- 2 Status LEDs
- 3 Service LED
- 4 Power LED

Functionality of service LED and power LED: see Table 57 to Table 59 on page 57.

### WARNING

**Risk of electric shock or equipment damage!**  
It is not permitted to wire the relays of the mixed Panel Bus I/O modules for anything other than low voltage.

### Permissible Loads

Table 46. Permissible loads of mixed Panel Bus I/O modules

	max. load	min. load
per module (total for all relay contacts)	19...29 VAC, 1...29 VDC 3 A resistive or inductive, $\cos \varphi \geq 0.6$ , no capacitive load, protected by fuse F4	–
per normally open contact	19...29 VAC, 1...29 VDC 0.5 A resistive or inductive, $\cos \varphi \geq 0.6$ , no capacitive load	>50 mW, 0.05 A res./ind., $\cos \varphi \geq 0.6$

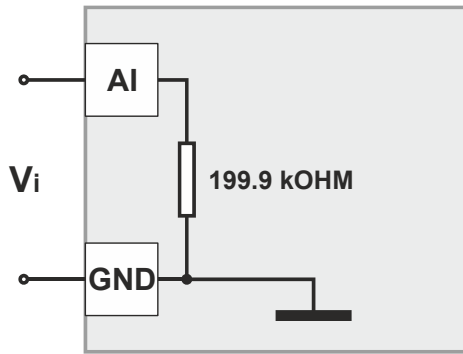


Fig. 59. Analog input high impedance (input circuit for voltage input for active sensors)

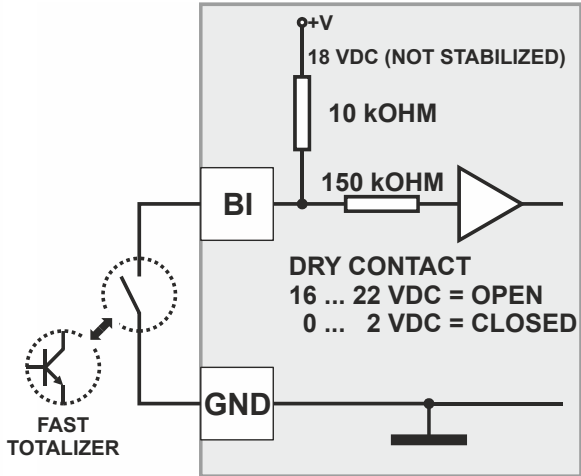


Fig. 61. Configuration of a binary input as a fast totalizer

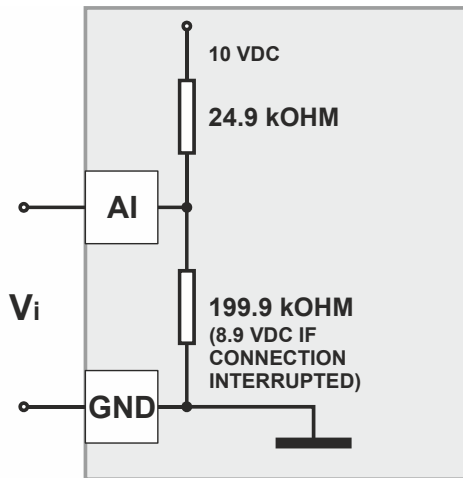


Fig. 60. Analog input impedance setpoint (input circuit for NTC10kΩ, NTC20kΩ, wall module setpoint)

Terminals

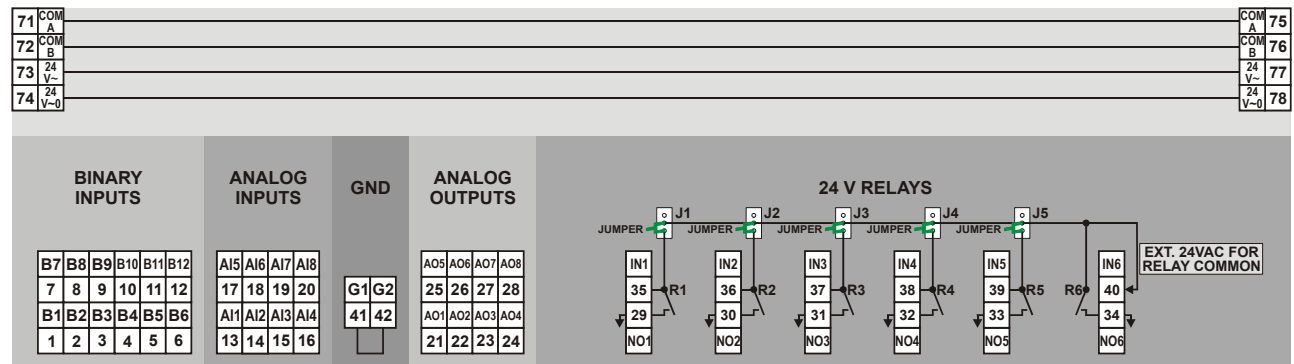


Fig. 62. Terminal assignment and internal connections of mixed Panel Bus I/O module terminals

Table 47. Description of mixed Panel Bus I/O module terminals

Terminal	Signal	LED	Comment
71, 75	COM a	status	2-wire communication bus (Panel Bus)
72, 76	COM b	status	2-wire communication bus (Panel Bus)
73, 77	24 V~	power	Power supply
74, 78	24 V~0	power	Power supply
1...7	BI1...7	1...7	Binary inputs 1...7
8...12	BI8...12	24...28	Binary inputs 8...12
13...20	AI1...8	--	Analog inputs 1...8
41, 42	GND	--	Ground. Both grounds are internally connected to each other and to 24 VAC0.
21...28	AO1...AO8	--	Analog outputs 1...8
29...34	NO1...6	29...34	Relays 1...6, normally-open contacts
35...39	IN1...5	--	Common contacts of relays 1...5. May be set to common supply voltage via terminal 40 by inserting jumpers J1...J5 into their <b>lower</b> positions. When, in contrast, a jumper is in the <b>upper</b> position (the so-called "parking position" = default setting), the corresponding relay receives no supply voltage from terminal 40.
40	IN6	--	Common contact of relay 6, internally connected to the middle contact of jumpers J1...J5. May be used to connect common supply voltage.

Table 48. Honeywell Mixed Panel Bus I/O module specifications

Analog Inputs	Analog Outputs	Binary Inputs	Relay Outputs
<p><b>Number:</b> 8</p> <p><b>Configurable types:</b></p> <ul style="list-style-type: none"> <li>NTC20kΩ (-30...+110 °C) (default)</li> <li>Linear Graph</li> <li>0..10 VDC with pull-up</li> <li>0(2)...10 VDC without pull-up</li> </ul> <p><b>Also configurable as:</b></p> <ul style="list-style-type: none"> <li>binary inputs (static, dry contact, only)</li> </ul> <p><b>Features:</b></p> <ul style="list-style-type: none"> <li>10-bit resolution</li> <li>configurable offset per input</li> </ul>	<p><b>Number:</b> 8</p> <p><b>Configurable types:</b></p> <ul style="list-style-type: none"> <li>0...11 VDC / ± 1 mA (default)</li> </ul> <p><b>Also configurable as:</b></p> <ul style="list-style-type: none"> <li>binary outputs (0 V / 10 V)</li> </ul> <p><b>Features:</b></p> <ul style="list-style-type: none"> <li>10-bit resolution (default)</li> <li>Safety position (remain, 0%, 50%, 100%)</li> </ul>	<p><b>Number:</b> 12 (requiring a gold contact or open collector)</p> <p><b>Configurable types:</b></p> <ul style="list-style-type: none"> <li>Static binary inputs (default: static, dry contact)</li> <li>ON: &lt; 1.6 kΩ to GND or &lt; 2.5 V to GND,</li> <li>OFF: &gt; 90 kΩ to GND or &gt; 4 V to GND</li> </ul> <p><b>Also configurable as:</b></p> <ul style="list-style-type: none"> <li>totalizers (15 Hz)</li> </ul> <p><b>Features:</b></p> <ul style="list-style-type: none"> <li>1 yellow LED per input</li> </ul>	<p><b>Number:</b> 6</p> <p><b>Configurable types:</b></p> <ul style="list-style-type: none"> <li>Relay outputs (default)</li> </ul> <p><b>Features:</b></p> <ul style="list-style-type: none"> <li>Voltage: 24 VAC/DC, P&gt;50 mW</li> <li>max. total current: 3 A (AC/DC)</li> <li>current per relay: 500 mA</li> <li>normally-open contacts: P &gt; 50 mW, voltage: 24 V (AC/DC)</li> <li>1 yellow LED per output</li> </ul>

Connection Example

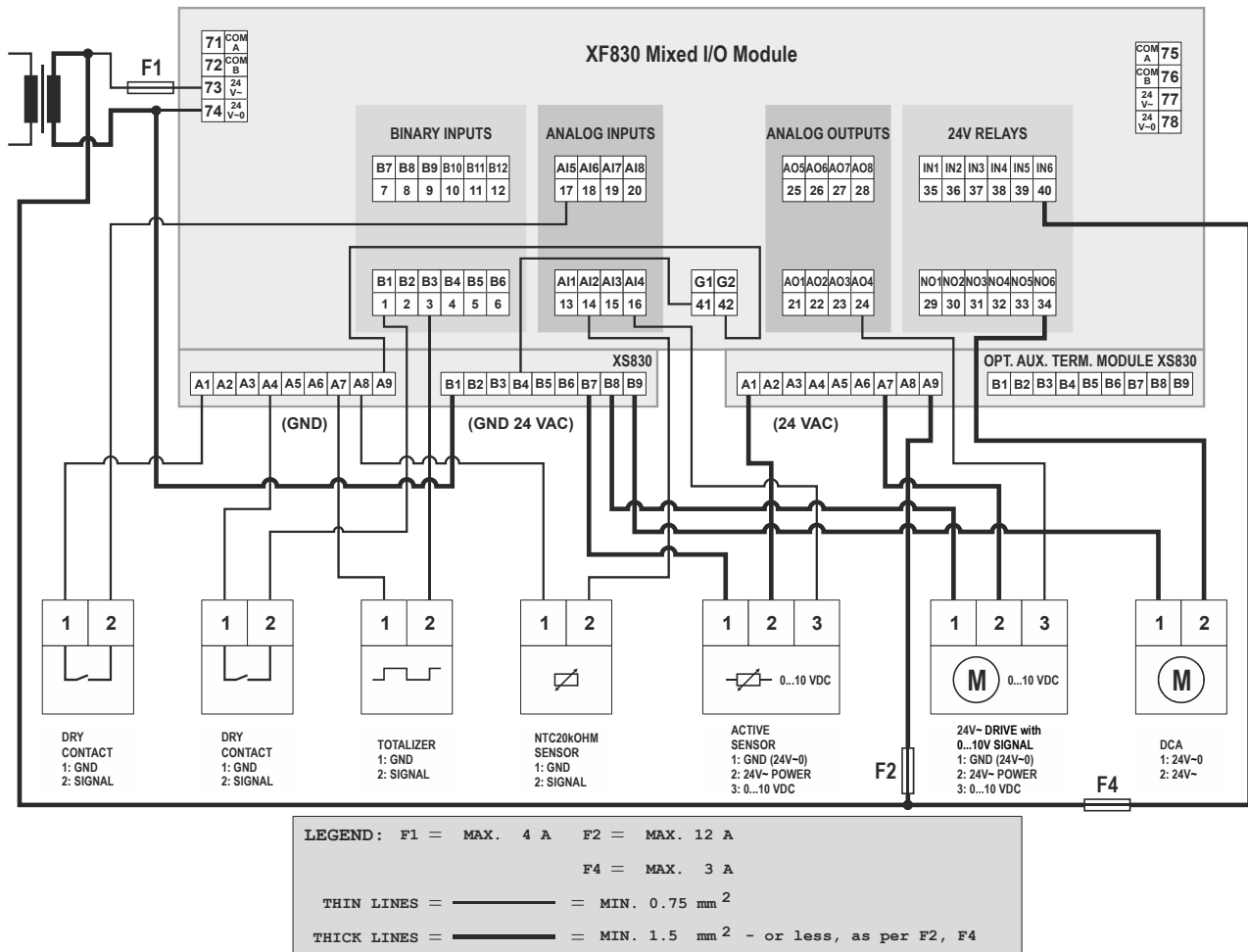


Fig. 63. XF830 Connection example

For fusing specifications see section "Fusing Specifications" on page 9. For internal connections of auxiliary terminal modules, see section "XS830 Auxiliary Terminal Package" and section "XS831 Auxiliary Terminal Package" on page 50.



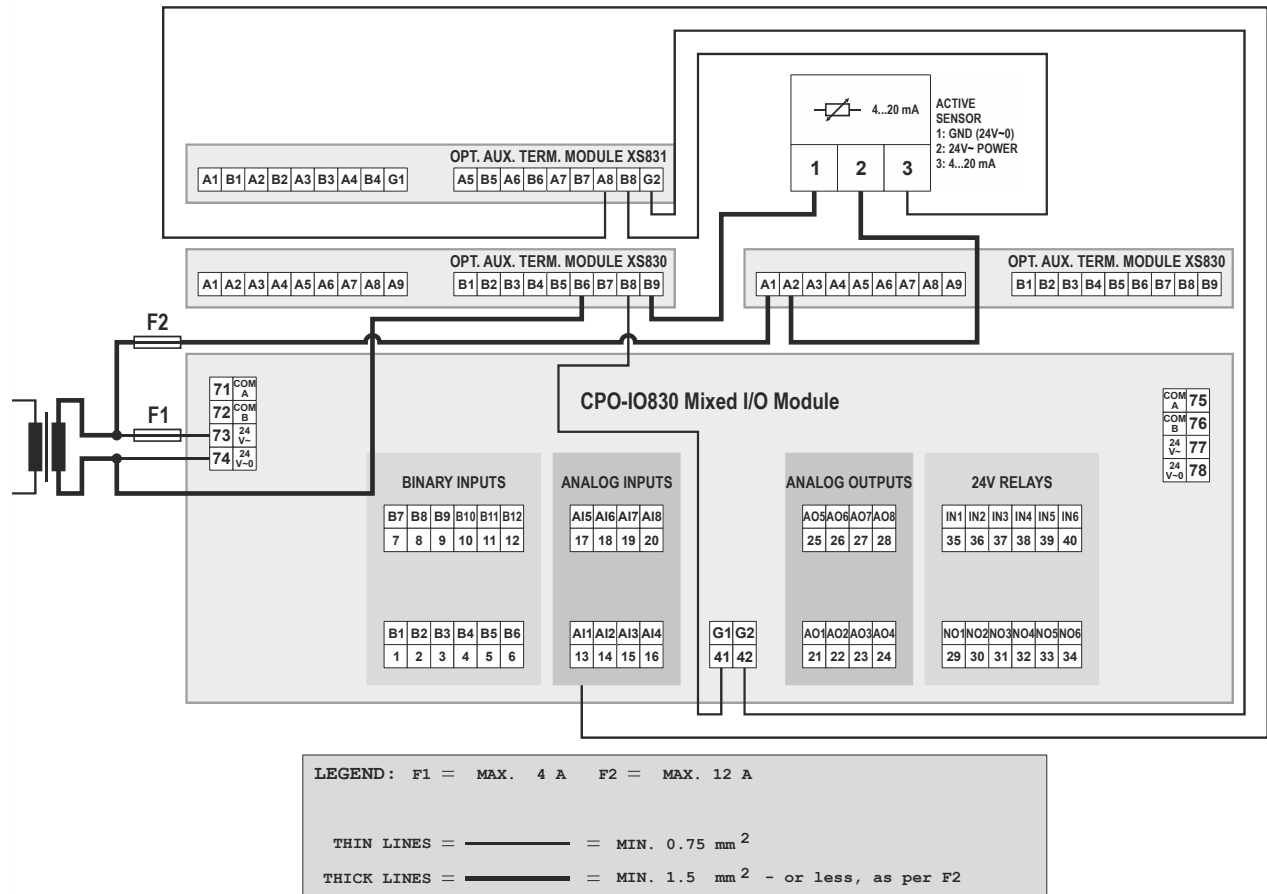


Fig. 64. CPO-IO830 Connection example (for current inputs)

## Description of Extra Parts

### XS814 Auxiliary Terminal Package

#### Features

- Type: XS814 Auxiliary Terminal Package
- For mounting onto already-installed pluggable I/O modules in order to equip them with additional terminals.
- Each unit consists of two terminal blocks (the "A" block and the "B" block), each with seven terminals with a max. load of 12 A.

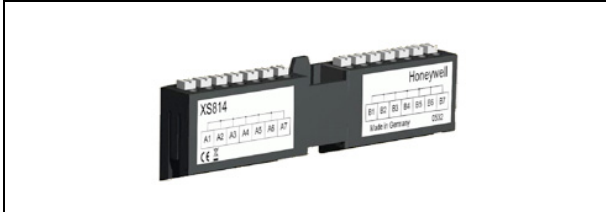


Fig. 65. XS814 Auxiliary Terminal Package

#### Terminal Assignment



Fig. 66. Terminal assignment and internal connections of XS814 Auxiliary Terminal Package

### XS830 Auxiliary Terminal Package

#### Features

- Type: XS830 Auxiliary Terminal Package
- For mounting onto the top and/or bottom of already-installed XF830A mixed I/O modules and the top of already-installed XFU830A and CPO-IO830 mixed I/O modules in order to equip them with additional terminals.
- Each unit consists of two groups of terminal blocks (the "A" block and the "B" block), each with nine internally-connected push-in terminals with a max. load of 12 A.



Fig. 67. XS830 Auxiliary Terminal Package

#### Terminal Assignment

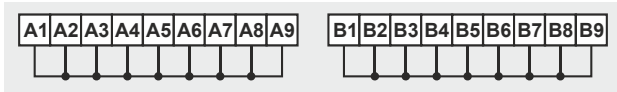


Fig. 68. Terminal assignment and internal connections of XS830 Auxiliary Terminal Package

### XS831 Auxiliary Terminal Package

#### Features

- Type: XS831 Auxiliary Terminal Package
- For mounting onto the top and/or bottom of already-installed XF830A mixed I/O modules and the top of already-installed XFU830A and CPO-IO830 mixed I/O modules in order to equip them with additional terminals.
- Two groups of four pairs of push-in terminals (A1B1, A2B2, ... A8B8, each with a 499Ω resistor) for converting 0...20 mA signals (max. load per resistor = 25 mA) into 0...10 VDC signals, and one push-in ground terminal per group. See also Fig. 63 and Fig. 64.

**NOTE:** The ground side of each of the eight incoming 0...20 mA signals (A1B1, A2B2, ... A8B8) must be connected to a ground terminal.

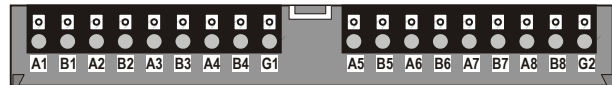


Fig. 69. XS831 Auxiliary Terminal Package

#### Terminal Assignment

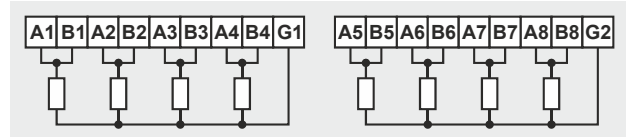


Fig. 70. Terminal assignment and internal connections of XS831 Auxiliary Terminal Package

## Cross Connectors

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### XS815 Cross Connector Features

- For connecting the common terminals of all six relays of the XFL824 and XFLR824 Relay Output Modules and XFR825 Floating Output Module. This is permitted when all six relays carry the same voltage.
- Long, red.
- Supplied with the terminal socket.



Fig. 71. XS815 Cross Connector

## XAL10 Swivel Label Holders

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- Type: XAL10 Swivel Label Holder.
- Supplied with the terminal socket.
- For applying self-adhesive labels with application information generated using CARE to the pluggable I/O modules.
- For use with standard commercially-available labels, e.g., AVERY 6572 or 6578

## XAL11 Swivel Label Holders (phased out)

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- Type: XAL11 Swivel Label Holder.
- Supplied with the XF830A and XFU830A mixed I/O module.
- For applying self-adhesive labels with application information generated using CARE to the mixed I/O modules.
- For use with standard commercially-available labels, e.g., AVERY 5444, 5523, 8253, 16163, or 15513

## XS816 Bridge Connectors

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- Type: XS816 Bridge Connectors
- Bridge connectors transmit both communication signals and power supply between Honeywell I/O modules.
- Supplied with the terminal socket / mixed I/O module.

# LonWorks Software Interface Description

## Overview

### LonTalk Protocol

Honeywell LONWORKS Bus I/O Modules use a LONTALK protocol communication with other nodes on the LONWORKS network, with commissioning tools und supervisory devices.

### Features

- Network variables for communications between nodes, but no explicit messages
- Configuration network variables
- LONMARK FPT protocol for downloading an Honeywell LONWORKS Bus I/O Module firmware via LON: loadable apbG file (supported by CARE and EXCELON)

### Commissioning

Honeywell LONWORKS Bus I/O Modules can be commissioned (i.e., addressed, bound, and configured) in either (but not both!) of two ways:

- when the Honeywell LONWORKS Bus I/O Modules are bound to controllers: using CARE;
- when the Honeywell LONWORKS Bus I/O Modules are bound to any other controllers not configured using CARE: using the “Honeywell I/O Module and XL12 LNS Plug-In” tool or any other standard LONWORKS commissioning tool based on LNS 2.0 and higher, e.g., LonMaker for Windows.

Specifically, controller Modules are commissioned using CARE, only. Thus, configuring Honeywell LONWORKS Bus I/O Modules bound to them (i.e., operating on the same LONWORKS bus with them) using anything but CARE will falsify settings (e.g., sensor types, sensor offset values, etc.).

**NOTE:** The “Honeywell I/O Module and XL12 LNS Plug-In” tool can be downloaded free of charge (URL: <http://plugin.ge51.honeywell.de/> ) and launched from any LNS (LNS3.08 or LNS Turbo) or LCA-based network management tool, e.g., LonMaker for Windows or CARE 8.02.

## XFL821 Analog Input Module

For the XFL821 Analog Input Module, the LONMARK Profile 520 “Analog Input” has been assigned per input.

Each input object has its own configuration properties, except for heartbeat configuration, which will be shared among all objects.

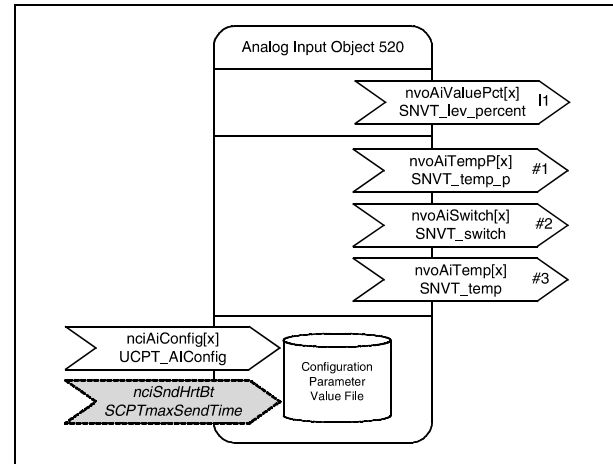


Fig. 72. LONMARK analog input object

### Input types and corresponding NVs

Input type	NV used
NTC10kΩ NTC20kΩ PT1000-1 NI1000TK5000 PT3000 BALCO500	nvoAiTempP
PT1000-2	nvoAiTemp
0(2)...10V	nvoAiValuePct
Slow binary input	nvoAiSwitch
Other Sensors	INVALID
Sensor break/short circuit	

Table 49. Input types and corresponding NVs

### Transmission/Updates

These variables are transmitted immediately when their value has been changed by a higher rate than the configured "send on delta" (default: 0.3 K).

These variables are also transmitted as heartbeat output (default: 60 sec) on a regular basis as dictated by the max. send time (nciSndHrtBt) configuration variable.

### Default Service Type

The default service type of these variables is unacknowledged.

### Analog Sensor Output – nvoAiValuePct[ ]

If configured for voltage input, this network variable output represents the percentage level for the appropriate input.

#### Valid Ranges for 0 ... 10 V Input

Value	Representation
< 0 V	0%
0 V ... 10 V	0 ... 100%
> 10 V	100%

Table 50. Analog input values: 0 ... 10 V

#### Valid Ranges for 2 ... 10 V Input

Value	Representation
< 1.5 V	Sensor break/short circuit
1.5 V ... 2 V	0%
2 V ... 10 V	0 ... 100%
> 10 V	100%

Table 51. Analog input values: 2 ... 10 V

#### Default Value

The default value is set after power-up or reset and remains until the module has measured a valid value.

nvoAiValuePct = INVALID = 0x7FFF (=163.835%)

The sensor failure behavior can be configured for 2 ... 10 V.

### Temperature Sensor Output – nvoAiTempP[ ]

If configured for temperature sensor input (but not from PT1000-2 temperature sensors), this network variable output represents the temperature for the appropriate input.

Range: see Table 29 and Table 30 on page 23.

#### Default Value

The default value is set after power-up or reset and remains until the module has measured a valid value.

nvoAiTempP = INVALID = 0x7FFF (= 327.67 °C)

### Slow Digital Input – nvoAiSwitch[ ]

This network variable output represents a slow digital input connected to the universal input terminals.

#### Valid Range

Sensor	Value	State
Enabled	100%	1
Disabled	0%	0
Not configured	0%	-1

Table 52. Slow digital input values

### Temperature#2 Sensor Output – nvoAiTemp[ ]

If configured for temperature sensor input (from PT1000-2 temperature sensors, only), this network variable output represents the temperature for the appropriate input.

Range: see Table 29 and Table 30 on page 23.

#### Default Value

The default value is set after power-up or reset and remains until the module has measured a valid value.

nvoAiTemp = INVALID = 0xFFFF (= 6279.5 °C)

## XFL(R)822 Analog Output Module

For the XFL822/XFLR822 Analog Output Module, the LONMARK open-loop actuator object has been assigned per output.

Each analog output object has its own configuration properties, except for heartbeat configuration and `nciAoConfig`, which will be shared among all objects.

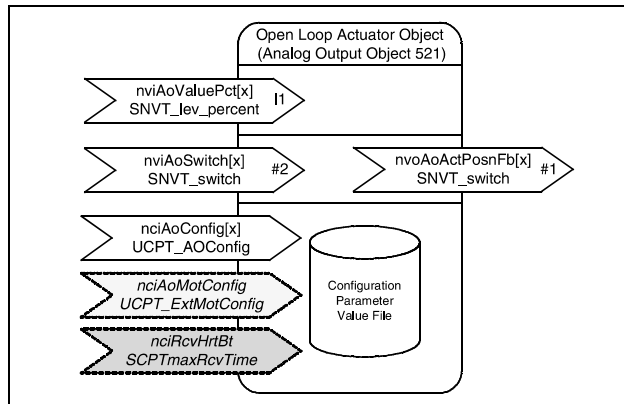


Fig. 73. LONMARK analog output object

### Receive Heartbeat

The default configuration for “Receive Heartbeat” is 300 sec. If no nvi update is received during this time, the actuators will go to their configured safety positions.

### Start-up Behavior

At start-up, i.e., power-up or reset, all nvi's will be initialized with INVALID, and after 1 minute, the actuators will go to their configured safety positions.

## Analog Output Control Level – `nviAoValuePct[ ]`

This network variable is used to drive the analog output to 0 ... 100%.

If both `nviAoSwitch[ ]` and `nviAoValuePct[ ]` receive valid values, `nviAoValuePct[ ]` will have priority.

### Valid Ranges

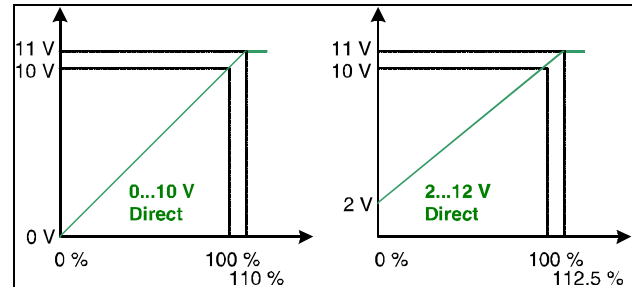


Fig. 74. Analog output control levels – direct actuator

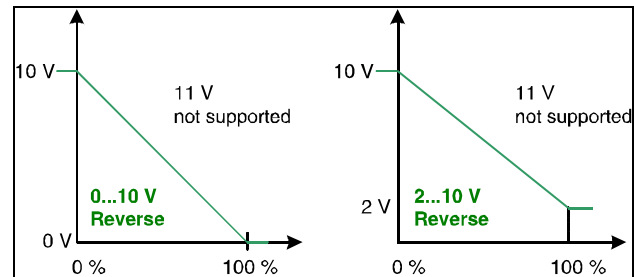


Fig. 75. Analog output control levels – reverse actuator

### Default Value

`nvoAoValuePct` = INVALID = 0x7FFF (=163.835%)

This will cause the actuator to adopt a predefined position defined for failure behavior.

### Analog Output Feedback – nvoAoPosnFb[ ]

This value represents the current status of the analog output including feedback related to manual override initiated from the manual override.

This is typically used for monitoring purposes at a supervisory station or for diagnostic purposes.

#### Valid Range

Value	State	Current analog output position
0.5 ... 100%	1	Analog output position due to normal control by nviAoSwitch or nviAoValuePct
0% (OFF)	0	
0 ... 100%	-1	Manual override position via the manual override panel
0xFF	-1	Current position unknown or synchronization active, analog output not configured

Table 53. Analog output feedback range

#### Transmission

This variable is transmitted immediately when the corresponding network input variable has changed more than 1% or immediately as an answer to an nviAoValuePct[ ] or nviAoSwitch[ ] update.

#### Default Service Type

The default service type is unacknowledged.

### Analog Output Command – nviAoSwitch[ ]

This network variable is used to drive the analog output to 0 ... 100%.

It is typically bound to a LONWORKS control device issuing an output level 0 ... 100%.

If both nviAoSwitch[ ] and nviAoValuePct[ ] receive valid values, nviAoValuePct[ ] will have priority.

#### Default Value

Value = 0

State = -1

## XFL823 Binary Input Module

One instance of the LONMARK open-loop sensor object has been assigned per input of the XFL823 Binary Input Module.

Each digital input object has its own configuration properties, except for heartbeat configuration, which will be shared among all objects.

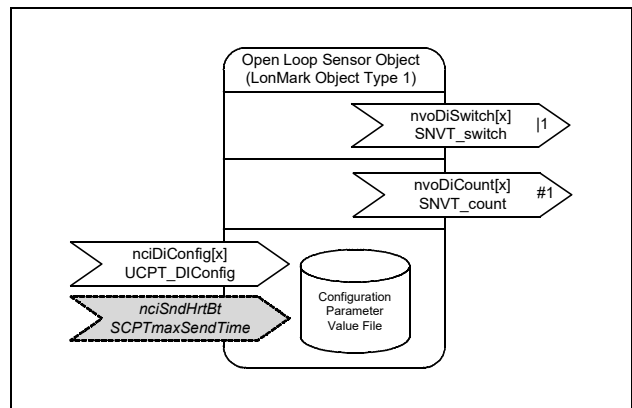


Fig. 76. LONMARK digital input object

#### Transmission

These variables are transmitted immediately when its value has been changed by a higher rate than the configured "send on delta" (in the case of the totalizer, "send on delta" has a default value of 5 counts).

These variables are also transmitted as a heartbeat output on a regular basis as dictated by the max. send time (nciSndHrtBt) (default = 0 = disabled) configuration variable.

#### Default Service Type

The default service type of these variables is unacknowledged.

### Fast Binary Input – nvoDiSwitch[ ]

This network variable output represents the logical state of a fast binary input connected to the binary input terminals.

#### Valid Range

Logical input state	Value	State
ON	100%	1
OFF	0%	0
Not configured	0%	-1

Table 54. Slow digital input values

#### Default Value

The default value is set after power-up or reset and remains until the module has measured a valid value.

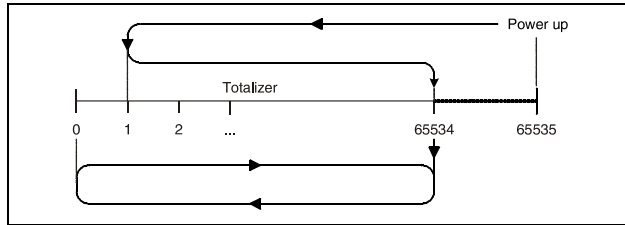
Value = 0

State = -1

### Totalizer Count – nvoDiCount[ ]

This network variable output indicates the total number of transitions from 0 to 1 since the last reset due to power-up or network reset.

**Valid Range**



**Fig. 77. Totalizer**

State	Value
For totalizer counts	0 ... 65534
For power-up/reset	65535

**Table 55. Totalizer counts**

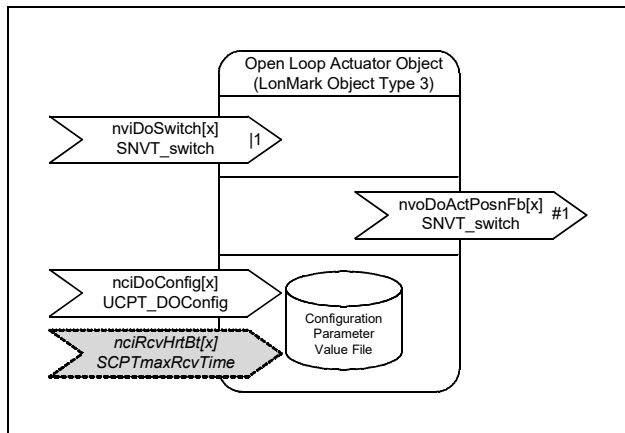
**Power-up/Reset**

After power-up and reset, the value 0xFFFF = 65535 will be sent to the network to indicate that previous count values have been lost due to a reset.

**XFL(R)824 Relay Output Module**

One instance of the LONMARK open-loop sensor object has been assigned per input of the XFL824/XFLR824 Relay Output Module.

Each output object has its own configuration properties, except for heartbeat configuration, which will be shared among all objects.



**Fig. 78. LONMARK output object**

**Relay Output Command – nviDoSwitch[ ]**

This network variable is used to drive the relay output.

It is typically bound to a LONWORKS control device issuing an output level ON/OFF, respectively 0 ... 100%.

**Valid Range**

Value	State	Action
N/a	0	OFF
0	1	OFF
0.5 ... 100%	1	Outputs are switched according to actual output type configuration
N/a	-1	INVALID: as defined for failure behavior

**Table 56. Relay output command values**

**Default Value**

Value = 0

State = -1

**Start-up Behavior**

At start-up, i.e., power-up or reset, all nvi's will be initialized with INVALID, leading the actuator to drive to the configured safety position after 1 minute.

**Receive Heartbeat**

The default configuration for "Receive Heartbeat" is 300 sec. If no nvi update is received during this time, the field devices will go to their configured safety positions.



## Troubleshooting

### Testing Wiring Connections

Push-in terminals feature small holes (1 mm in diameter) which can be used to measure the signals.

- ▶ Insert a probe (1) as shown on the right.

▶

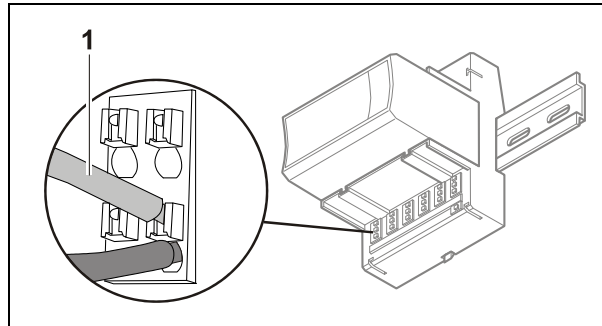


Fig. 79. Testing wiring connections

### I/O Modules Troubleshooting

- ▶ Check if the power supply voltage level is OK and that there is no high voltage (> 24 VAC or > 40 VDC) connected to the inputs/outputs of the ...821, ...822, ...823 I/O modules.
- ▶ Replace the problem I/O module with another module of the same kind.
  - If the problem persists, this is an indication that the problem is caused by the application or incorrect wiring.
  - If the problem is solved, this is an indication that the I/O module was defective.

For troubleshooting purposes, the following features can be used:

- Power LED (all Honeywell I/O modules)
- Service LED (all Honeywell I/O modules)
- Service button (pluggable I/O modules, only)

In addition, a module-specific troubleshooting may be necessary.

#### Power LED of Honeywell I/O Modules

case	Power LED	Meaning	Remedy
1	ON	I/O module is powered.	No action necessary.
2	OFF	No power.	▶ Check power supply.
3	Flashing continuously	If the I/O module's service LED is likewise flashing, the I/O module is in the boot mode.	▶ Wait until rebooting (firmware download) has been completed.

Table 57. Power LED of I/O modules

### Service LED of Honeywell I/O Modules

case	Service LED	Meaning	Remedy
1	LED remains OFF after power-up	If the power LED is also OFF, then <ul style="list-style-type: none"> <li>– Defective device hardware</li> <li>– Possible power supply problems, clock problems, defective processor</li> </ul>	<ul style="list-style-type: none"> <li>▶ Replace hardware.</li> </ul>
2	LED is lit continuously after first power-up	<ul style="list-style-type: none"> <li>• LONWORKS Bus I/O modules:                             <ul style="list-style-type: none"> <li>– Defective hardware</li> </ul> </li> <li>• Panel Bus I/O modules:                             <ul style="list-style-type: none"> <li>– I/O module has not yet been configured by controller</li> <li>– Boot loader is active</li> <li>– Failure during last firmware download</li> <li>– Checksum error</li> </ul> </li> </ul>	LONWORKS Bus I/O modules: <ul style="list-style-type: none"> <li>▶ Replace hardware.</li> </ul> Panel Bus I/O modules: <ul style="list-style-type: none"> <li>▶ Set the hex address to the position configured with CARE</li> <li>▶ Check the Panel Bus wiring:                             <ul style="list-style-type: none"> <li>- Check for cable breaks</li> <li>- Check for cable short-circuits</li> <li>- If using separate transformers: Check ground connection</li> </ul> </li> <li>▶ Eliminate any mixture of Panel Bus I/Os and LonWorks I/Os on same wire</li> <li>▶ Allow controller to configure I/O module</li> <li>▶ Unplug and replug the module</li> <li>▶ If problem persists, replace hardware</li> </ul>
3	Alternating flash between service LED and power LED	Panel Bus I/O modules , only: Download error or application checksum error. Boot loader is running	<ul style="list-style-type: none"> <li>▶ Panel Bus I/O modules: Wait until rebooting (firmware download) has been completed</li> </ul>
4	LED flashes at power up, goes OFF, and then is lit continuously	LONWORKS Bus I/O modules, only: LONWORKS Bus I/O module lacks application	<ul style="list-style-type: none"> <li>▶ Download application</li> </ul>
5	LED repeatedly blinks ON for 1 sec and OFF for 1 sec	LONWORKS Bus I/O modules, only: LONWORKS Bus I/O module is unconfigured, but has an application	<ul style="list-style-type: none"> <li>▶ Set module to configured mode</li> </ul>
6	LED remains OFF after a short ON duration	I/O module is configured and running normally	No action necessary
7	LED flashes continuously in following pattern: 4 x ON/OFF followed by pause	Sensor failure of analog input module (in case of LONWORKS Bus I/O modules, this behavior can occur only if the appropriate NV has been bound)	<ul style="list-style-type: none"> <li>▶ Check sensor or connection</li> <li>▶ Check sensor configuration</li> </ul>
8	LED flashes continuously in following pattern: 5 x ON/OFF followed by pause	LONWORKS Bus I/O modules, only: LONWORKS I/O Bus module has received the wink command from network, physical outputs are unaffected	No action necessary
9	LED flashes continuously in following pattern: 6 x ON/OFF followed by pause	Boot loader problem or hardware defect	<ul style="list-style-type: none"> <li>▶ Replace hardware</li> </ul>
10	LED flashes continuously in following pattern: 7 x ON/OFF followed by pause	Communications failure	<ul style="list-style-type: none"> <li>▶ Check bus wiring</li> <li>▶ Ensure that LONWORKS Bus I/O modules and Panel Bus I/O modules are not sharing same bus</li> <li>▶ In case of Panel Bus I/O modules, only: Check for incorrect HEX addresses (2 Panel Bus I/O modules using same HEX address)</li> <li>▶ In case of LONWORKS Bus I/O modules, only: Check heartbeat</li> </ul>

Table 58. Service LED of Honeywell I/O modules

### LED Test for I/O Modules (pluggable I/O modules, only)

- ▶ Press the service button S1 of the pluggable I/O module using, e.g., a paperclip.
  - The service LED and all other LEDs of that pluggable I/O module light up for as long as the service button is pressed.

LED	Correct behavior
Power LED	ON continuously (if it flashes, check the 24 VAC power supply)
Service LED	ON continuously
Analog output module status LEDs	ON continuously
Relay output module status LEDs	ON continuously
Digital input module status LEDs	Red -> green -> yellow -> red -> green -> yellow, cyclically every 0.5 sec

**Table 59. Effects of pressing and holding down service button of pluggable I/O modules**

An LED is defective if it is not lit as shown above.

### Analog Input Modules Troubleshooting

case	Problem	Possible causes	Remedy
1	Incorrect sensor measurement	Wrong sensor configuration	▶ Reconfigure sensor
		Incorrect wiring	▶ Rewire
		Sensor failure	▶ Replace sensor
		Negative voltage on at least one channel	▶ Check polarity of active sensor inputs.
2	Unstable sensor measurements	Incorrect grounding of active sensors	▶ Ground active sensors individually (see Fig. 33 and Fig. 34 on page 25 and following)
3	a voltage of about 8.88 V(*) is measured (with an external voltmeter) at an open analog input configured for: NTC20kΩ or Pt1000-1/-2 or Pt3000 or Balco 500 or NTC10kΩ or NI1000TK5000.	Sensor is not connected	▶ Connect the configured sensor
4	a voltage of about 8.88 V(*) is measured (with an external voltmeter) at an open analog input configured for: 0...10V with pull-up or slow Digital Input	Normal value for open input that is configured to listed types	▶ No action necessary

(\*): voltage may differ slightly depending on the input impedance of the used voltmeter

**Table 60. Failure modes of analog input modules**

### Analog Output Modules Troubleshooting

case	Problem	Possible causes	Remedy
1	All outputs always have zero voltage	Manual override settings	▶ Check manual override settings
		Outputs are in safety position	▶ Check communication
		Software problem	▶ Power down and then power up ▶ If problem persists, replace hardware
		Internal undervoltage detection has been activated	▶ Replace hardware
2	Unstable output voltage	Incorrect grounding of actuators	▶ Ground actuators individually (see Fig. 38 on page 29)

Table 61. Failure modes of analog output modules

### Binary Input Modules Troubleshooting

case	Problem	Possible causes	Remedy
1	Unexpectedly, all status LEDs are always OFF	Internal overload protection has been activated	▶ Power down and then power up

Table 62. Failure modes of binary input modules

### Relay Output Modules Troubleshooting

case	Problem	Possible causes	Remedy
1	Unexpectedly, all outputs are in unpowered position	Improper manual override settings	▶ Check manual override settings
		Outputs are in safety position	▶ Check communication
		Software problem	▶ Power down and then power up ▶ If problem persists, replace hardware
		Internal undervoltage detection has been activated	▶ Replace hardware

Table 63. Failure modes of relay output modules

### Floating Output Modules Troubleshooting

case	Problem	Possible causes	Remedy
1	Unexpectedly, all outputs are in unpowered position	Improper manual override settings	▶ Check manual override settings to check outputs
		Outputs are in safety position	▶ Check communication
		Software problem	▶ Power down and then power up ▶ If problem persists, replace hardware
		Internal undervoltage detection has been activated	▶ Replace hardware

Table 64. Failure modes of floating output modules

A “Frequently Asked Questions and Troubleshooting” document is available via the Honeywell Technical Assistance Center (TAC) or, for Honeywell employees, on the Intranet under:

<http://web.ge51.honeywell.de/tac>

## Appendix: Sensor Characteristics

**NOTE:** The following sensor characteristics do not include failures due to:

- sensor failures;
- wiring resistance or wiring failures;
- Misreadings due to a meter connected to measure resistance or voltage at the input.

### BALCO 500

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
-30.0	397	0.157
-29.0	399	0.158
-28.0	401	0.158
-27.0	403	0.159
-26.0	404	0.160
-25.0	406	0.160
-24.0	408	0.161
-23.0	410	0.162
-22.0	412	0.163
-21.0	413	0.163
-20.0	415	0.164
-19.0	417	0.165
-18.0	419	0.165
-17.0	421	0.166
-16.0	423	0.167
-15.0	425	0.168
-14.0	426	0.168
-13.0	428	0.169
-12.0	430	0.170
-11.0	432	0.171
-10.0	434	0.171
-9.0	436	0.172
-8.0	438	0.173
-7.0	440	0.174
-6.0	442	0.174
-5.0	444	0.175
-4.0	445	0.176
-3.0	447	0.176
-2.0	449	0.177
-1.0	451	0.178
0.0	453	0.179
1.0	455	0.179
2.0	457	0.180
3.0	459	0.181
4.0	461	0.182
5.0	463	0.183
6.0	465	0.183
7.0	467	0.184
8.0	469	0.185
9.0	471	0.186

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
10.0	473	0.186
11.0	475	0.187
12.0	477	0.188
13.0	479	0.189
14.0	481	0.190
15.0	483	0.190
16.0	485	0.191
17.0	487	0.192
18.0	489	0.193
19.0	491	0.193
20.0	493	0.194
21.0	495	0.195
22.0	497	0.196
23.0	499	0.196
24.0	501	0.197
25.0	503	0.198
26.0	506	0.199
27.0	508	0.200
28.0	510	0.201
29.0	512	0.201
30.0	514	0.202
31.0	516	0.203
32.0	518	0.204
33.0	520	0.205
34.0	522	0.205
35.0	524	0.206
36.0	527	0.207
37.0	529	0.208
38.0	531	0.209
39.0	533	0.210
40.0	535	0.210
41.0	537	0.211
42.0	539	0.212
43.0	542	0.213
44.0	544	0.214
45.0	546	0.215
46.0	548	0.215
47.0	550	0.216
48.0	553	0.217
49.0	555	0.218

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
50.0	557	0.219
51.0	559	0.220
52.0	561	0.220
53.0	564	0.221
54.0	566	0.222
55.0	568	0.223
56.0	570	0.224
57.0	572	0.225
58.0	575	0.226
59.0	577	0.226
60.0	579	0.227
61.0	581	0.228
62.0	584	0.229
63.0	586	0.230
64.0	588	0.231
65.0	590	0.231
66.0	593	0.233
67.0	595	0.233
68.0	597	0.234
69.0	600	0.235
70.0	602	0.236
71.0	604	0.237
72.0	607	0.238
73.0	609	0.239
74.0	611	0.240
75.0	614	0.241
76.0	616	0.241
77.0	618	0.242
78.0	621	0.243
79.0	623	0.244
80.0	625	0.245
81.0	628	0.246
82.0	630	0.247
83.0	632	0.248
84.0	635	0.249
85.0	637	0.249
86.0	639	0.250
87.0	642	0.251
88.0	644	0.252
89.0	647	0.253

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
90.0	649	0.254
91.0	651	0.255
92.0	654	0.256
93.0	656	0.257
94.0	659	0.258
95.0	661	0.259
96.0	664	0.260
97.0	666	0.261
98.0	668	0.261
99.0	671	0.262
100.0	673	0.263
101.0	676	0.264
102.0	678	0.265
103.0	681	0.266
104.0	683	0.267
105.0	686	0.268
106.0	688	0.269
107.0	691	0.270
108.0	693	0.271
109.0	696	0.272
110.0	698	0.273
111.0	701	0.274
112.0	703	0.275
113.0	706	0.276
114.0	708	0.276
115.0	711	0.278
116.0	713	0.278
117.0	716	0.280
118.0	718	0.280
119.0	721	0.281
120.0	724	0.283

## NTC 20 kΩ

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
-50.0	1659	8.78
-49.0	1541	8.77
-48.0	1432	8.76
-47.0	1331	8.75
-46.0	1239	8.74
-45.0	1153	8.72
-44.0	1073	8.71
-43.0	1000	8.70
-42.0	932	8.69
-41.0	869	8.67
-40.0	811	8.66
-39.0	757	8.64
-38.0	706	8.62
-37.0	660	8.60
-36.0	617	8.58
-35.0	577	8.56
-34.0	539	8.54
-33.0	505	8.52
-32.0	473	8.49
-31.0	443	8.47
-30.0	415	8.44
-29.0	389	8.41
-28.0	364	8.38
-27.0	342	8.35
-26.0	321	8.32
-25.0	301	8.28
-24.0	283	8.25
-23.0	266	8.21
-22.0	250	8.17
-21.0	235	8.13
-20.0	221	8.08
-19.0	208	8.04
-18.0	196	7.99
-17.0	184	7.94
-16.0	174	7.89
-15.0	164	7.83
-14.0	154	7.78
-13.0	146	7.72
-12.0	137	7.66
-11.0	130	7.60
-10.0	122	7.53
-9.0	116	7.46
-8.0	109	7.39
-7.0	103	7.32
-6.0	97.6	7.25
-5.0	92.3	7.17
-4.0	87.3	7.09
-3.0	82.6	7.01
-2.0	78.2	6.93
-1.0	74.1	6.85
0.0	70.2	6.76
1.0	66.5	6.67
2.0	63.0	6.58
3.0	59.8	6.49
4.0	56.7	6.40

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
5.0	53.8	6.30
6.0	51.1	6.20
7.0	48.5	6.10
8.0	46.0	6.00
9.0	43.7	5.90
10.0	41.6	5.80
11.0	39.5	5.70
12.0	37.6	5.59
13.0	35.7	5.49
14.0	34.0	5.38
15.0	32.3	5.28
16.0	30.8	5.17
17.0	29.3	5.07
18.0	27.9	4.96
19.0	26.6	4.85
20.0	25.3	4.75
21.0	24.2	4.64
22.0	23.0	4.53
23.0	22.0	4.43
24.0	21.0	4.32
25.0	20.0	4.22
26.0	19.1	4.12
27.0	18.2	4.01
28.0	17.4	3.91
29.0	16.6	3.81
30.0	15.9	3.71
31.0	15.2	3.62
32.0	14.5	3.52
33.0	13.9	3.43
34.0	13.3	3.33
35.0	12.7	3.24
36.0	12.1	3.15
37.0	11.6	3.06
38.0	11.1	2.97
39.0	10.7	2.89
40.0	10.2	2.81
41.0	9.78	2.72
42.0	9.37	2.64
43.0	8.98	2.57
44.0	8.61	2.49
45.0	8.26	2.42
46.0	7.92	2.34
47.0	7.60	2.27
48.0	7.29	2.20
49.0	7.00	2.14
50.0	6.72	2.07
51.0	6.45	2.01
52.0	6.19	1.94
53.0	5.95	1.88
54.0	5.72	1.82
55.0	5.49	1.77
56.0	5.28	1.71
57.0	5.08	1.66
58.0	4.88	1.61
59.0	4.69	1.56

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
60.0	4.52	1.51
61.0	4.35	1.46
62.0	4.18	1.41
63.0	4.03	1.37
64.0	3.88	1.32
65.0	3.73	1.28
66.0	3.59	1.24
67.0	3.46	1.20
68.0	3.34	1.16
69.0	3.21	1.13
70.0	3.10	1.09
71.0	2.99	1.06
72.0	2.88	1.02
73.0	2.78	0.991
74.0	2.68	0.960
75.0	2.58	0.929
76.0	2.49	0.900
77.0	2.41	0.872
78.0	2.32	0.844
79.0	2.24	0.818
80.0	2.17	0.792
81.0	2.09	0.767
82.0	2.02	0.744
83.0	1.95	0.720
84.0	1.89	0.698
85.0	1.82	0.676
86.0	1.76	0.655
87.0	1.70	0.635
88.0	1.65	0.616
89.0	1.59	0.597
90.0	1.54	0.578
91.0	1.49	0.561
92.0	1.44	0.544
93.0	1.40	0.527
94.0	1.35	0.511
95.0	1.31	0.496
96.0	1.27	0.481
97.0	1.23	0.466
98.0	1.19	0.452
99.0	1.15	0.439
100.0	1.11	0.425
101.0	1.08	0.413
102.0	1.05	0.401
103.0	1.01	0.389
104.0	0.98	0.378
105.0	0.95	0.367
106.0	0.92	0.356
107.0	0.90	0.346
108.0	0.87	0.336
109.0	0.84	0.326
110.0	0.82	0.317
111.0	0.79	0.308
112.0	0.77	0.299
113.0	0.75	0.290
114.0	0.73	0.282

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
115.0	0.70	0.274
116.0	0.68	0.266
117.0	0.66	0.259
118.0	0.64	0.252
119.0	0.63	0.245
120.0	0.61	0.238
121.0	0.59	0.231
122.0	0.57	0.225
123.0	0.56	0.219
124.0	0.54	0.213
125.0	0.53	0.207
126.0	0.51	0.201
127.0	0.50	0.196
128.0	0.49	0.191
129.0	0.47	0.186
130.0	0.46	0.181
131.0	0.45	0.176
132.0	0.43	0.171
133.0	0.42	0.167
134.0	0.41	0.162
135.0	0.40	0.158
136.0	0.39	0.154
137.0	0.38	0.150
138.0	0.37	0.146
139.0	0.36	0.142
140.0	0.35	0.139
141.0	0.34	0.135
142.0	0.33	0.132
143.0	0.32	0.128
144.0	0.32	0.125
145.0	0.31	0.122
146.0	0.30	0.119
147.0	0.29	0.116
148.0	0.29	0.113
149.0	0.28	0.110
150.0	0.27	0.107

PT 1000

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
-50.0	803	0.312
-49.0	807	0.314
-48.0	811	0.315
-47.0	815	0.317
-46.0	819	0.318
-45.0	823	0.320
-44.0	827	0.321
-43.0	831	0.323
-42.0	835	0.324
-41.0	839	0.326
-40.0	843	0.327
-39.0	847	0.329
-38.0	851	0.330
-37.0	855	0.332
-36.0	859	0.333
-35.0	862	0.335
-34.0	866	0.336
-33.0	870	0.338
-32.0	874	0.339
-31.0	878	0.341
-30.0	882	0.342
-29.0	886	0.344
-28.0	890	0.345
-27.0	894	0.347
-26.0	898	0.348
-25.0	902	0.350
-24.0	906	0.351
-23.0	910	0.353
-22.0	914	0.354
-21.0	918	0.356
-20.0	922	0.357
-19.0	926	0.359
-18.0	929	0.360
-17.0	933	0.361
-16.0	937	0.363
-15.0	941	0.364
-14.0	945	0.366
-13.0	949	0.367
-12.0	953	0.369
-11.0	957	0.370
-10.0	961	0.372
-9.0	965	0.373
-8.0	969	0.375
-7.0	973	0.376
-6.0	977	0.378
-5.0	980	0.379
-4.0	984	0.380
-3.0	988	0.382
-2.0	992	0.383
-1.0	996	0.385
0.0	1000	0.386
1.0	1004	0.388
2.0	1008	0.389
3.0	1012	0.391
4.0	1016	0.392
5.0	1020	0.394
6.0	1023	0.395
7.0	1027	0.396
8.0	1031	0.398
9.0	1035	0.399

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
10.0	1039	0.401
11.0	1043	0.402
12.0	1047	0.404
13.0	1051	0.405
14.0	1055	0.406
15.0	1058	0.408
16.0	1062	0.409
17.0	1066	0.411
18.0	1070	0.412
19.0	1074	0.413
20.0	1078	0.415
21.0	1082	0.416
22.0	1086	0.418
23.0	1090	0.419
24.0	1093	0.420
25.0	1097	0.422
26.0	1101	0.423
27.0	1105	0.425
28.0	1109	0.426
29.0	1113	0.428
30.0	1117	0.429
31.0	1121	0.431
32.0	1124	0.432
33.0	1128	0.433
34.0	1132	0.435
35.0	1136	0.436
36.0	1140	0.438
37.0	1144	0.439
38.0	1148	0.441
39.0	1152	0.442
40.0	1155	0.443
41.0	1159	0.445
42.0	1163	0.446
43.0	1167	0.448
44.0	1171	0.449
45.0	1175	0.451
46.0	1179	0.452
47.0	1182	0.453
48.0	1186	0.455
49.0	1190	0.456
50.0	1194	0.458
51.0	1198	0.459
52.0	1202	0.461
53.0	1205	0.462
54.0	1209	0.463
55.0	1213	0.465
56.0	1217	0.466
57.0	1221	0.467
58.0	1225	0.469
59.0	1229	0.470
60.0	1232	0.471
61.0	1236	0.473
62.0	1240	0.474
63.0	1244	0.476
64.0	1248	0.477
65.0	1252	0.479
66.0	1255	0.480
67.0	1259	0.481
68.0	1263	0.483
69.0	1267	0.484

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
70.0	1271	0.486
71.0	1275	0.487
72.0	1278	0.488
73.0	1282	0.490
74.0	1286	0.491
75.0	1290	0.493
76.0	1294	0.494
77.0	1297	0.495
78.0	1301	0.497
79.0	1305	0.498
80.0	1309	0.499
81.0	1313	0.501
82.0	1317	0.502
83.0	1320	0.503
84.0	1324	0.505
85.0	1328	0.506
86.0	1332	0.508
87.0	1336	0.509
88.0	1339	0.510
89.0	1343	0.512
90.0	1347	0.513
91.0	1351	0.515
92.0	1355	0.516
93.0	1358	0.517
94.0	1362	0.519
95.0	1366	0.520
96.0	1370	0.522
97.0	1374	0.523
98.0	1377	0.524
99.0	1381	0.525
100.0	1385	0.527
101.0	1389	0.528
102.0	1393	0.530
103.0	1396	0.531
104.0	1400	0.532
105.0	1404	0.534
106.0	1408	0.535
107.0	1412	0.537
108.0	1415	0.538
109.0	1419	0.539
110.0	1423	0.541
111.0	1427	0.542
112.0	1430	0.543
113.0	1434	0.545
114.0	1438	0.546
115.0	1442	0.547
116.0	1446	0.549
117.0	1449	0.550
118.0	1453	0.551
119.0	1457	0.553
120.0	1461	0.554
121.0	1464	0.555
122.0	1468	0.557
123.0	1472	0.558
124.0	1476	0.560
125.0	1479	0.561
126.0	1483	0.562
127.0	1487	0.564
128.0	1491	0.565
129.0	1494	0.566

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
130.0	1498	0.567
131.0	1502	0.569
132.0	1506	0.570
133.0	1510	0.572
134.0	1513	0.573
135.0	1517	0.574
136.0	1521	0.576
137.0	1525	0.577
138.0	1528	0.578
139.0	1532	0.580
140.0	1536	0.581
141.0	1539	0.582
142.0	1543	0.584
143.0	1547	0.585
144.0	1551	0.586
145.0	1554	0.587
146.0	1558	0.589
147.0	1562	0.590
148.0	1566	0.592
149.0	1569	0.593
150.0	1573	0.594
151.0	1577	0.596
152.0	1581	0.597
153.0	1584	0.598
154.0	1588	0.600
155.0	1592	0.601
156.0	1596	0.602
157.0	1599	0.603
158.0	1603	0.605
159.0	1607	0.606
160.0	1610	0.607
161.0	1614	0.609
162.0	1618	0.610
163.0	1622	0.612
164.0	1625	0.613
165.0	1629	0.614
166.0	1633	0.615
167.0	1636	0.617
168.0	1640	0.618
169.0	1644	0.619
170.0	1648	0.621
171.0	1651	0.622
172.0	1655	0.623
173.0	1659	0.625
174.0	1662	0.626
175.0	1666	0.627
176.0	1670	0.629
177.0	1674	0.630
178.0	1677	0.631
179.0	1681	0.632
180.0	1685	0.634
181.0	1688	0.635
182.0	1692	0.636
183.0	1696	0.638
184.0	1699	0.639
185.0	1703	0.640
186.0	1707	0.642
187.0	1711	0.643
188.0	1714	0.644
189.0	1718	0.645

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
190.0	1722	0.647
191.0	1725	0.648
192.0	1729	0.649
193.0	1733	0.651
194.0	1736	0.652
195.0	1740	0.653
196.0	1744	0.655
197.0	1747	0.656
198.0	1751	0.657
199.0	1755	0.658
200.0	1758	0.659
201.0	1762	0.661
202.0	1766	0.662
203.0	1769	0.663
204.0	1773	0.665
205.0	1777	0.666
206.0	1780	0.667
207.0	1784	0.669
208.0	1788	0.670
209.0	1791	0.671
210.0	1795	0.672
211.0	1799	0.674
212.0	1802	0.675
213.0	1806	0.676
214.0	1810	0.678
215.0	1813	0.679
216.0	1817	0.680
217.0	1821	0.681
218.0	1824	0.683
219.0	1828	0.684
220.0	1832	0.685
221.0	1835	0.686
222.0	1839	0.688
223.0	1843	0.689
224.0	1846	0.690
225.0	1850	0.692
226.0	1854	0.693
227.0	1857	0.694
228.0	1861	0.695
229.0	1865	0.697
230.0	1868	0.698
231.0	1872	0.699
232.0	1875	0.700
233.0	1879	0.702
234.0	1883	0.703
235.0	1886	0.704
236.0	1890	0.705
237.0	1894	0.707
238.0	1897	0.708
239.0	1901	0.709
240.0	1905	0.711
241.0	1908	0.712
242.0	1912	0.713
243.0	1915	0.714
244.0	1919	0.716
245.0	1923	0.717
246.0	1926	0.718
247.0	1930	0.719
248.0	1934	0.721
249.0	1937	0.722

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
250.0	1941	0.723
251.0	1944	0.724
252.0	1948	0.726
253.0	1952	0.727
254.0	1955	0.728
255.0	1959	0.729
256.0	1962	0.730
257.0	1966	0.732
258.0	1970	0.733
259.0	1973	0.734
260.0	1977	0.736
261.0	1980	0.737
262.0	1984	0.738
263.0	1988	0.739
264.0	1991	0.740
265.0	1995	0.742
266.0	1998	0.743
267.0	2002	0.744
268.0	2006	0.746
269.0	2009	0.747
270.0	2013	0.748
271.0	2016	0.749
272.0	2020	0.750
273.0	2024	0.752
274.0	2027	0.753
275.0	2031	0.754
276.0	2034	0.755
277.0	2038	0.757
278.0	2042	0.758
279.0	2045	0.759
280.0	2049	0.760
281.0	2052	0.761
282.0	2056	0.763
283.0	2060	0.764
284.0	2063	0.765
285.0	2067	0.766
286.0	2070	0.768
287.0	2074	0.769
288.0	2077	0.770
289.0	2081	0.771
290.0	2085	0.773
291.0	2088	0.774
292.0	2092	0.775
293.0	2095	0.776
294.0	2099	0.777
295.0	2102	0.778
296.0	2106	0.780
297.0	2110	0.781
298.0	2113	0.782
299.0	2117	0.784
300.0	2120	0.785
301.0	2124	0.786
302.0	2127	0.787
303.0	2131	0.788
304.0	2134	0.789
305.0	2138	0.791
306.0	2142	0.792
307.0	2145	0.793
308.0	2149	0.794
309.0	2152	0.796

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
310.0	2156	0.797
311.0	2159	0.798
312.0	2163	0.799
313.0	2166	0.800
314.0	2170	0.802
315.0	2173	0.803
316.0	2177	0.804
317.0	2181	0.805
318.0	2184	0.806
319.0	2188	0.808
320.0	2191	0.809
321.0	2195	0.810
322.0	2198	0.811
323.0	2202	0.812
324.0	2205	0.814
325.0	2209	0.815
326.0	2212	0.816
327.0	2216	0.817
328.0	2219	0.818
329.0	2223	0.820
330.0	2226	0.821
331.0	2230	0.822
332.0	2234	0.823
333.0	2237	0.824
334.0	2241	0.826
335.0	2244	0.827
336.0	2248	0.828
337.0	2251	0.829
338.0	2255	0.830
339.0	2258	0.831
340.0	2262	0.833
341.0	2265	0.834
342.0	2269	0.835
343.0	2272	0.836
344.0	2276	0.838
345.0	2279	0.839
346.0	2283	0.840
347.0	2286	0.841
348.0	2290	0.842
349.0	2293	0.843
350.0	2297	0.845
351.0	2300	0.846
352.0	2304	0.847
353.0	2307	0.848
354.0	2311	0.849
355.0	2314	0.850
356.0	2318	0.852
357.0	2321	0.853
358.0	2325	0.854
359.0	2328	0.855
360.0	2332	0.856
361.0	2335	0.857
362.0	2339	0.859
363.0	2342	0.860
364.0	2346	0.861
365.0	2349	0.862
366.0	2353	0.863
367.0	2356	0.864
368.0	2360	0.866
369.0	2363	0.867

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
370.0	2367	0.868
371.0	2370	0.869
372.0	2373	0.870
373.0	2377	0.871
374.0	2380	0.872
375.0	2384	0.874
376.0	2387	0.875
377.0	2391	0.876
378.0	2394	0.877
379.0	2398	0.878
380.0	2401	0.879
381.0	2405	0.881
382.0	2408	0.882
383.0	2412	0.883
384.0	2415	0.884
385.0	2419	0.885
386.0	2422	0.886
387.0	2426	0.888
388.0	2429	0.889
389.0	2432	0.890
390.0	2436	0.891
391.0	2439	0.892
392.0	2443	0.893
393.0	2446	0.894
394.0	2450	0.896
395.0	2453	0.897
396.0	2457	0.898
397.0	2460	0.899
398.0	2463	0.900
399.0	2467	0.901
400.0	2470	0.902



**NI1000TK5000**

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
-30	871.7	0.338
-29	875.8	0.340
-28	880	0.341
-27	884.1	0.343
-26	888.3	0.344
-25	892.5	0.346
-24	896.7	0.348
-23	900.8	0.349
-22	905.1	0.351
-21	909.3	0.352
-20	913.5	0.354
-19	917.7	0.355
-18	922	0.357
-17	926.2	0.359
-16	930.5	0.360
-15	934.7	0.362
-14	939	0.363
-13	943.3	0.365
-12	947.6	0.367
-11	951.9	0.368
-10	956.2	0.370
-9	960.6	0.371
-8	964.9	0.373
-7	969.3	0.375
-6	973.6	0.376
-5	978	0.378
-4	982.4	0.380
-3	986.7	0.381
-2	991.2	0.383
-1	995.6	0.384
0	1000	0.386
1	1004.4	0.388
2	1008.9	0.389
3	1013.3	0.391
4	1017.8	0.393
5	1022.3	0.394
6	1026.7	0.396
7	1031.2	0.398
8	1035.8	0.399
9	1040.3	0.401
10	1044.8	0.403
11	1049.3	0.404
12	1053.9	0.406
13	1058.4	0.408
14	1063	0.409
15	1067.6	0.411
16	1072.2	0.413
17	1076.8	0.415

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
18	1081.4	0.416
19	1086	0.418
20	1090.7	0.420
21	1095.3	0.421
22	1100	0.423
23	1104.6	0.425
24	1109.3	0.427
25	1114	0.428
26	1118.7	0.430
27	1123.4	0.432
28	1128.1	0.433
29	1132.9	0.435
30	1137.6	0.437
31	1142.4	0.439
32	1147.1	0.440
33	1151.9	0.442
34	1156.7	0.444
35	1161.5	0.446
36	1166.3	0.447
37	1171.2	0.449
38	1176	0.451
39	1180.9	0.453
40	1185.7	0.455
41	1190.6	0.456
42	1195.5	0.458
43	1200.4	0.460
44	1205.3	0.462
45	1210.2	0.463
46	1215.1	0.465
47	1220.1	0.467
48	1225	0.469
49	1230	0.471
50	1235	0.473
51	1240	0.474
52	1245	0.476
53	1250	0.478
54	1255	0.480
55	1260.1	0.482
56	1265.1	0.484
57	1270.2	0.485
58	1275.3	0.487
59	1280.3	0.489
60	1285.4	0.491
61	1290.6	0.493
62	1295.7	0.495
63	1300.8	0.496
64	1306	0.498
65	1311.1	0.500

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
66	1316.3	0.502
67	1321.5	0.504
68	1326.7	0.506
69	1331.9	0.508
70	1337.1	0.510
71	1342.4	0.512
72	1347.6	0.513
73	1352.9	0.515
74	1358.2	0.517
75	1363.5	0.519
76	1368.8	0.521
77	1374.1	0.523
78	1379.4	0.525
79	1384.8	0.527
80	1390.1	0.529
81	1395.5	0.531
82	1400.9	0.533
83	1406.3	0.535
84	1411.7	0.537
85	1417.1	0.538
86	1422.5	0.540
87	1428	0.542
88	1433.4	0.544
89	1438.9	0.546
90	1444.4	0.548
91	1449.9	0.550
92	1455.4	0.552
93	1460.9	0.554
94	1466.5	0.556
95	1472	0.558
96	1477.6	0.560
97	1483.2	0.562
98	1488.8	0.564
99	1494.4	0.566
100	1500	0.568
101	1505.6	0.570
102	1511.3	0.572
103	1517	0.574
104	1522.6	0.576
105	1528.3	0.578
106	1534	0.580
107	1539.7	0.582
108	1545.5	0.584
109	1551.2	0.586
110	1557	0.589
111	1562.8	0.591
112	1568.5	0.593
113	1574.4	0.595

Temp. [°C]	Resistance [Ω]	Terminal voltage [V]
114	1580.2	0.597
115	1586	0.599
116	1591.8	0.601
117	1597.7	0.603
118	1603.6	0.605
119	1609.5	0.607
120	1615.4	0.609
121	1621.3	0.611
122	1627.2	0.613
123	1633.2	0.616
124	1639.1	0.618
125	1645.1	0.620
126	1651.1	0.622
127	1657.1	0.624
128	1663.1	0.626
129	1669.1	0.628
130	1675.2	0.630

## NTC 10 kΩ

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
-30	177	7.904
-29	166.35	7.848
-28	156.413	7.790
-27	147.136	7.730
-26	138.47	7.666
-25	130.372	7.601
-24	122.8	7.534
-23	115.718	7.464
-22	109.089	7.392
-21	102.883	7.318
-20	97.073	7.241
-19	91.597	7.161
-18	86.471	7.080
-17	81.667	6.996
-16	77.161	6.910
-15	72.932	6.821
-14	68.962	6.731
-13	65.231	6.639
-12	61.723	6.545
-11	58.424	6.448
-10	55.321	6.351
-9	52.399	6.251
-8	49.648	6.150
-7	47.058	6.047
-6	44.617	5.943
-5	42.317	5.838
-4	40.15	5.732
-3	38.106	5.624
-2	36.18	5.516
-1	34.363	5.408
0	32.65	5.299
1	31.027	5.189
2	29.494	5.079
3	28.047	4.969
4	26.68	4.859
5	25.388	4.750
6	24.166	4.641
7	23.01	4.532
8	21.916	4.423
9	20.88	4.316
10	19.898	4.209
11	18.968	4.103

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
12	18.087	3.998
13	17.252	3.894
14	16.46	3.792
15	15.708	3.690
16	14.995	3.591
17	14.319	3.492
18	13.678	3.396
19	13.068	3.300
20	12.49	3.207
21	11.94	3.115
22	11.418	3.025
23	10.921	2.937
24	10.449	2.850
25	10	2.767
26	9.572	2.684
27	9.165	2.603
28	8.777	2.524
29	8.408	2.447
30	8.057	2.372
31	7.722	2.299
32	7.402	2.228
33	7.098	2.159
34	6.808	2.091
35	6.531	2.025
36	6.267	1.962
37	6.015	1.900
38	5.775	1.840
39	5.546	1.781
40	5.327	1.724
41	5.117	1.669
42	4.917	1.616
43	4.726	1.564
44	4.543	1.514
45	4.369	1.465
46	4.202	1.418
47	4.042	1.373
48	3.889	1.329
49	3.743	1.286
50	3.603	1.244
51	3.469	1.204
52	3.34	1.166
53	3.217	1.128

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
54	3.099	1.092
55	2.986	1.057
56	2.878	1.023
57	2.774	0.990
58	2.675	0.959
59	2.579	0.928
60	2.488	0.898
61	2.4	0.870
62	2.316	0.842
63	2.235	0.815
64	2.158	0.790
65	2.083	0.765
66	2.011	0.740
67	1.943	0.718
68	1.877	0.695
69	1.813	0.673
70	1.752	0.652
71	1.694	0.632
72	1.637	0.612
73	1.583	0.593
74	1.531	0.575
75	1.481	0.557
76	1.433	0.541
77	1.387	0.524
78	1.342	0.508
79	1.299	0.493
80	1.258	0.478
81	1.218	0.464
82	1.179	0.450
83	1.142	0.436
84	1.107	0.423
85	1.072	0.411
86	1.039	0.399
87	1.007	0.387
88	0.976	0.375
89	0.947	0.365
90	0.918	0.354
91	0.89	0.344
92	0.863	0.334
93	0.838	0.324
94	0.813	0.315
95	0.789	0.306

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
96	0.765	0.297
97	0.743	0.289
98	0.721	0.280
99	0.7	0.276
100	0.68	0.265

## PT 3000

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Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
-50	2.823	1.018
-45	2.868	1.033
-40	2.913	1.047
-35	2.957	1.061
-30	3.002	1.076
-25	3.046	1.090
-20	3.090	1.104
-15	3.134	1.118
-10	3.178	1.132
-5	3.222	1.146
0	3.266	1.160
5	3.310	1.173
10	3.353	1.187
15	3.397	1.200
20	3.440	1.214
25	3.484	1.227
30	3.527	1.241
35	3.570	1.254
40	3.613	1.267
45	3.656	1.280
50	3.699	1.293
55	3.742	1.306
60	3.784	1.319
65	3.827	1.332
70	3.869	1.345
75	3.912	1.358
80	3.954	1.370
85	3.996	1.383
90	4.038	1.395
95	4.080	1.408
100	4.122	1.420
105	4.164	1.433
110	4.206	1.445
115	4.247	1.457
120	4.289	1.469
125	4.330	1.481
130	4.371	1.493
135	4.413	1.505
140	4.454	1.517
145	4.495	1.529
150	4.536	1.541

## Johnson A99 PTC Thermistor

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
-40.0	613	0.240
-35.0	640	0.251
-30.0	668	0.261
-25.0	697	0.272
-20.0	727	0.284
-15.0	758	0.295
-10	789	0.307
-5	822	0.320
0	855	0.332
5	889	0.345
10	924	0.358
15	960	0.371
20	997	0.385
25	1035	0.399
30	1074	0.413
35	1113	0.428
40	1153	0.443
45	1194	0.458
50	1236	0.473
55	1279	0.489
60	1323	0.505
65	1368	0.521
70	1413	0.537
75	1459	0.554
80	1506	0.570
85	1554	0.587
90	1602	0.604
95	1652	0.622
100	1702	0.640
105	1753	0.658
110	1805	0.676
115	1857	0.694
120	1909	0.712





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