EAGLEHAWK Controller

Installation & Commissioning Instructions

CENTRA LINE® by Honeywell

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Trademark Information

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SAFETY INFORMATION

General Safety Information

► When performing any work, all instructions given by the manufacturer and in particular the safety instructions provided in these Installation and Commissioning Instructions are to be observed. Make sure that the local standards and regulations are observed at all times.

► The EAGLEHAWK System (including the EAGLEHAWK controller, Panel Bus I/O modules, manual disconnect modules, and auxiliary terminal packages) may be installed and mounted only by authorized and trained personnel.

► If the controller housing is damaged or missing, immediately disconnect it from any power.

► If the device is broken or defective, do not attempt to repair it yourself; rather, return it to the manufacturer.

► It is recommended that devices 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 EAGLEHAWK 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.

► In the case of vertical mounting on DIN rails, the EAGLEHAWK controller should be secured in place using a commercially-available stopper.

► If the EAGLEHAWK System is modified in any way, except by the manufacturer, all warranties concerning operation and safety are invalidated.

► Rules regarding electrostatic discharge should be followed.

► Use only accessory equipment which comes from or has been approved by Honeywell.

Information as per EN 60730

Purpose

The purpose of the device is: OPERATING CONTROL. The EAGLEHAWK controller is a multifunctional non-safety control device intended for HVAC in home (residential, commercial, and light-industrial) environments.

Construction

The EAGLEHAWK controller is an independently mounted electronic control unit with fixed wiring.

Mounting Method

The EAGLEHAWK controller is suitable for mounting as follows:

► in cabinets;

► in fuse boxes conforming with standard DIN43880, and having a slot height of max. 45 mm;

► in cabinet front doors (using accessory MVC-80-AC2);

► on walls (using accessory MVC-80-AC1).

Table 1. Information as per EN 60730

Shock protection	Class II
Pollution degree	2
Installation	Class 3
Rated impulse voltage	330 V for SELV, 2500 V for relay outputs
Automatic action	Type 1.C (micro-interruption for the relay outputs)
Software class	Class A
Ball-pressure test temperature	housing parts >75 °C terminals >125 °C

WEEE Directive

WEEE: Waste Electrical and Electronic Equipment Directive	
	▪ At the end of the product life, dispose of the packaging and product in an appropriate recycling center. ▪ Do not dispose of the device with the usual domestic refuse. ▪ Do not burn the device.

Standards, Approvals, etc.

Degree of Protection: IP20 (mounted on walls, with two accessory MVC-80-AC1 covers) IP30 (mounted in cabinet doors, with accessory MVC-80-AC2)
Device meets EN 60730-1, EN 60730-2-9, UL60730, and UL916.
Refer to Code of Practice standards IEC 61000-5-1 and -2 for guidance.
The device complies with Ethernet Protocol versions IEEEC 802.3.
The device supports BACnet IP and BACnet MS/TP communications as per ANSI / ASHRAE 135-2010.

3RD-PARTY SOFTWARE LICENSES

This product contains software provided by third parties. See also EAGLEHAWK Controller – Third-Party Software Licenses (Product Literature No.: EN2Z-1007GE51).

SPECIFICATIONS OF CONTROLLER

Table 2. EAGLEHAWK specifications

Power supply	19 … 29 VAC, 50/60 Hz or 20 … 30 VDC
Power consumption	typically dc: 5 W; max. 6 W typically ac: 9 VA; max. 11 VA
Current consumption	typically dc: 210 mA; max. 240 mA typically ac: 370 mA; max. 410 mA
Ambient temperature	0 … 40 °C (wall-mounting) 0 … 50 °C (cabinet/door mounting)
Storage temperature	-20 … +70 °C
Humidity	5 … 95% r.h. non-condensing
Dimensions	See Fig. 17 and Fig. 18.
Degree of protection	IP20 (mounted on walls, with two accessory MVC-80-AC1 covers) IP30 (mounted in cabinet doors, with accessory MVC-80-AC2)
Fire class	V0
Weight	0.6 kg (excl. packaging)

SYSTEM OVERVIEW
Overview of Hardware

Table 3. Overview of hardware

feature	description		max. cable length	order no.		
				CLAXEH00ND100A	CLAXEH14ND100A	CLAXEH26ND100A
UI	NTC10kΩ / NTC20kΩ / 0…10V / slow BI, 0.4 Hz		400 m	--	4	8
	NTC10kΩ / NTC20kΩ / 0…10V fix pull-up / slow BI, 0.4 Hz		400 m	--	-	2
BI	open = 24 V / closed 2.0 mA / totalizer 15 Hz		400 m	--	4	4
AO	0..11 V (max. 1 mA)		400 m	--	2	4
BO	Relay N.O. contact: 3 A, 250 VAC, 30 VDC		400 m	--	3	4
	Relay N.O. contact (high in-rush): 10 A, 250 VAC, 30 VDC		400 m	--	1	1
	Relay N.O. contact with one common: 3 A, 250 VAC, 30 VDC		400 m	--	-	3
bus interfaces	RS485-1, isolated, BACnet MS/TP, Panel Bus, or Modbus RTU Master or Slave communication		[1]1200 m	1	1	1
	RS485-2, non-isolated, BACnet MS/TP, Panel Bus, or Modbus RTU Master or Slave communication		[1]1200 m	1	1	1
	Ethernet Interface	e-mail communication, browser access	100 m	1	1	1
		BACnet IP communication	100 m	1	1	1
	USB 2.0 Device Interface (as Network Interface)		3 m	1	1	1
	USB 2.0 Host Interface (max. 500 mA)		3 m	1	1	1
	RS232 M-Bus communication via PW3 / PW20 / PW60 converters		[1]1000 m	1	1	1
LEDs	power LED (green)		--	1	1	1
	status LED (red, controllable by firmware)		--	1	1	1
	LED L1 (yellow) Heartbeat LED indicating platform is running		--	1	1	1
	LED L2 (yellow) indicating that station is starting up		--	1	1	1
	bus status LEDs (for isolated RS485-1 interface)		--	2	2	2

[1] Depending upon baud rate. For max. cable lengths, see section "RS485 Standard" on pg. 9. In the case of the Panel Bus, see also section "Panel Bus Considerations" on pg. 22. In the case of the BACnet MS/TP Bus, see also section "BACnet MS/TP Bus Considerations" on pg. 28. In the case of the Modbus, see also section "Modbus Considerations" on pg. 31.

System Architecture

An EAGLEHAWK System consists of the EAGLEHAWK controller and various Panel Bus I/O modules. The EAGLEHAWK controller provides interface connections, which allow connection to external systems (e.g., BACnet controllers). Via the IF-LON External Interface, the EAGLEHAWK can also communicate with LONWORKS systems, including CentraLine LONWORKS I/O Modules.

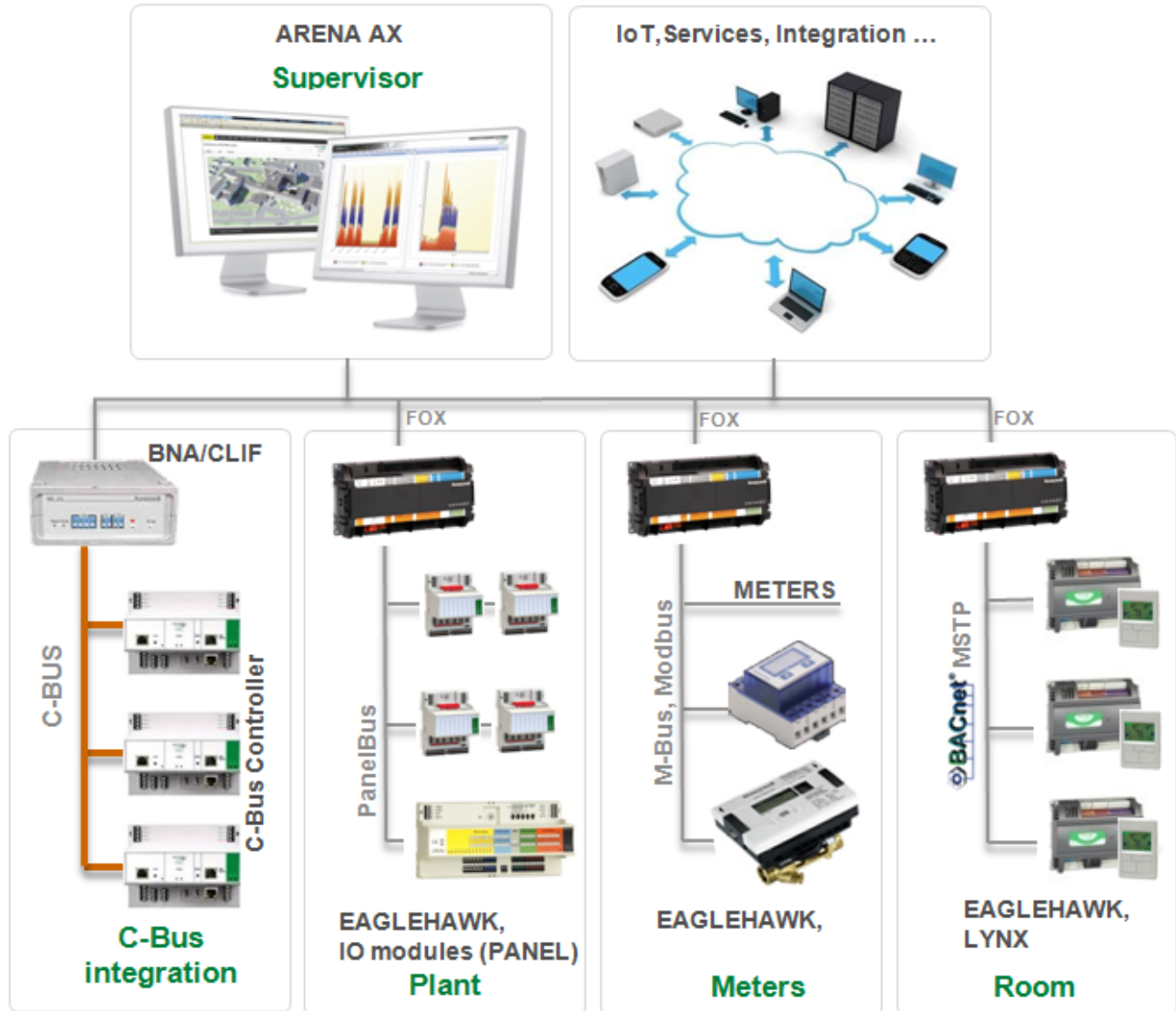Auxiliary parts (see section "Extra Parts" on page 20) enable special features.

Fig. 1. CentraLine BACnet System architecture

Bus and Port Connections
Overview

> ⚠ **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 the EAGLEHAWK controller or Panel Bus I/O modules.
>
> ► Do not reconnect the power supply until you have completed installation.
>
> ► Due to the risk of short-circuiting (see Fig. 20), it is strongly recommended that the EAGLEHAWK controller be supplied with power from a dedicated transformer. However, if the EAGLEHAWK controller is to be supplied by the same transformer powering other controllers or devices (e.g., the PW M-Bus Adapter), care must be taken to ensure that correct polarity is observed.
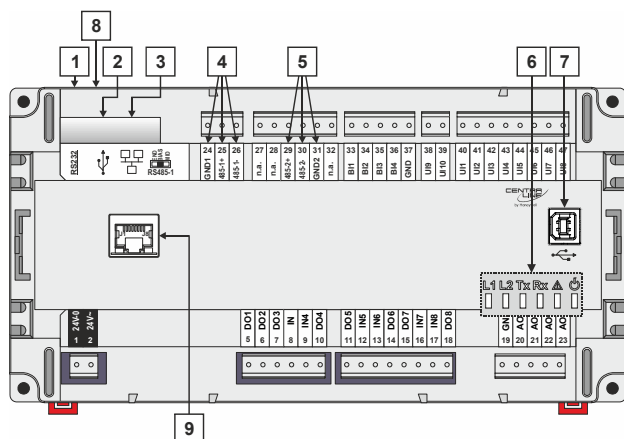>
> ► Observe the rules regarding electrostatic discharge.

Fig. 2. Top view (shown: model with onboard I/Os)
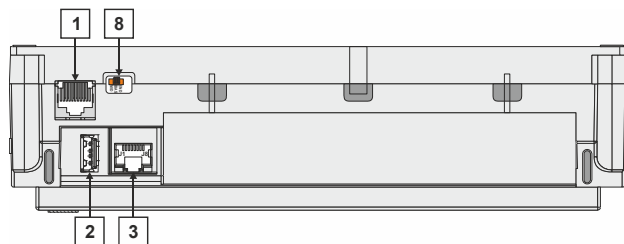
Fig. 3. Side view

Legend

1. RS232 / RJ45 socket (for connection of M-Bus and other RS232-based protocols; factory debugging)
2. USB 2.0 Host Interface (for connection of the IF-LON); max. 500 mA, high speed
3. Ethernet / RJ45 socket (for BACnet IP communication); 10/100 Mbit/s; 1 "link" LED and 1 "activity" LED
4. RS485-1* (isolated; for BACnet MS/TP, Panel Bus, or Modbus RTU communication)
5. RS485-2* (non-isolated; for BACnet MS/TP, Panel Bus, or Modbus RTU communication)
6. LEDs
7. USB 2.0 Device Interface (for connection to COACH^{AX} web browsers, and 3rd-party touch panels)
8. Three-position slide switch (for setting bias and termination resistance of RS485-1)
9. Future functionality

*Modbus RTU Master/Slave communication is possible on either or both of the two RS485 interfaces.

> ⚠ **WARNING**
>
> **Risk of electric shock or equipment damage!**
>
> ► It is prohibited to connect any of the RJ45 sockets of the EAGLEHAWK controller to a so-called PoE-enabled device ("**P**ower **o**ver **E**thernet").

RS232 / RJ45 Socket

Via its RS232 / RJ45 socket, the EAGLEHAWK controller can be connected (using an XW586 cable) to a PW M-Bus Adapter and thus to M-Bus networks. See also section "M-Bus Connection" on pg. 34.

RS232-RJ45 SOCKET

Fig. 4. RS232 / RJ45 socket

USB 2.0 Host Interface

Via its USB 2.0 Host interface, the EAGLEHAWK controller can be connected to, e.g., the IF-LON External Interface Adapter and thus to LONWORKS networks. Max. 500 mA, high speed. See also section "LonWorks Communications" on pg. 27.

USB 2.0 Host Interface

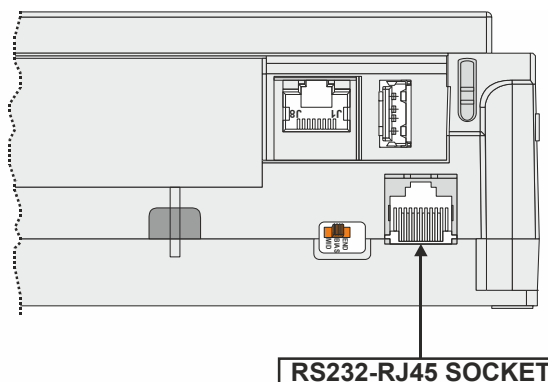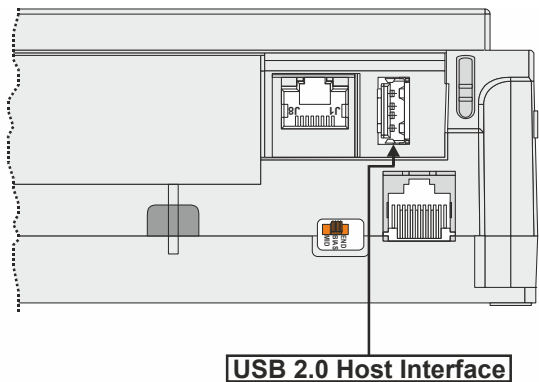**Fig. 5. USB 2.0 Host interface**
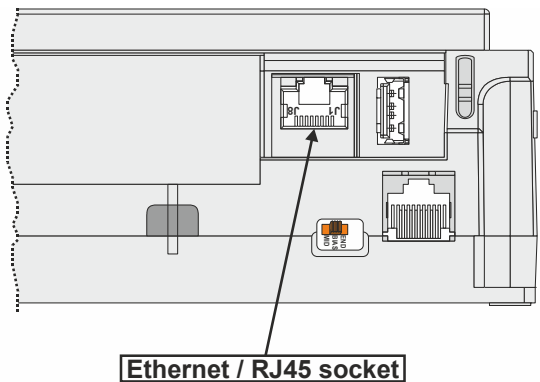
USB 2.0 Device Interface

All models of the EAGLEHAWK controller are equipped with a USB 2.0 Device Interface at the front. This interface is for connection to COACH^AX and web browsers, or 3rd-party touch panels.

USB 2.0 Device Interface
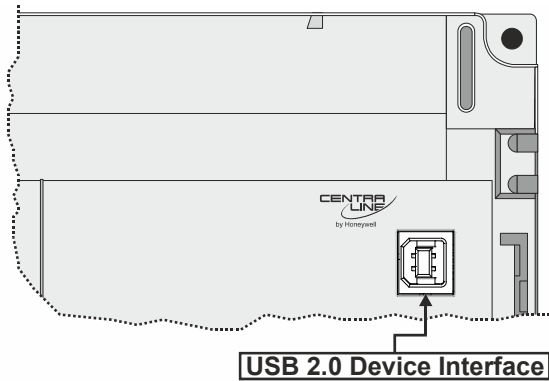
Fig. 6. USB 2.0 Device Interface

A standard USB type-B connector can be inserted into this USB 2.0 Device Interface. This USB 2.0 Device Interface is the recommended interface for connection to COACH^AX.

Ethernet / RJ45 Socket

The EAGLEHAWK controller is equipped with an Ethernet / RJ45 socket featuring one LED.

Ethernet / RJ45 socket

Fig. 7. Ethernet / RJ45 socket

This Ethernet / RJ45 socket is a 10/100-Mbaud Ethernet interface permitting communication (as per IEEEC 802.3) on any supported IP network, e.g.: BACnet (IP), FOX, etc.

LINK/ACT.
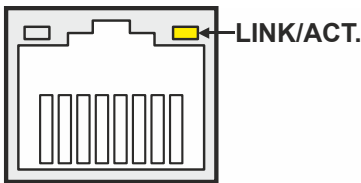
Fig. 8. Ethernet / RJ45 socket

NOTE: The Ethernet / RJ45 socket is usually earth-grounded. For additional information on earth grounding, see also "Appendix 1: Earth Grounding" on pg. 39.

LEDs

The EAGLEHAWK controller features the following LEDs:

Fig. 9. EAGLEHAWK controller LEDs

Table 4. EAGLEHAWK controller LEDs

symbol	color	function, description
L1	yellow	Heartbeat LED indicating platform is running
L2	yellow	LED indicating that station is starting up
Tx	yellow	RS485-1 status LED indicating transmission of communication signals
Rx	yellow	RS485-1 status LED indicating reception of communication signals.
⚠	red	status LED indicating hardware problems
⏻	green	power LED

See also section "EAGLEHAWK Controller Troubleshooting" on page 37 for a detailed description of the behaviors of the LEDs and their meanings.

RS485 Interfaces

General

The EAGLEHAWK controller features two RS485 interfaces:

- RS485-1 (consisting of push-in terminals 24 [GND-1], 25, and 26) is isolated and can be used for any RS485-based communication protocol available within Niagara Ecosystems, e.g.: Panel Bus, BACnet MS/TP, etc.

- RS485-2 (consisting of push-in terminals 29, 30, and 31 [GND-2]) is non-isolated (i.e. GND-2 is internally connected with terminal 1 [24V~0]) and can be used for any RS485-based communication protocol available within Niagara Ecosystems, e.g.: Panel Bus, BACnet MS/TP, etc.

RS485-1 Bias and Termination Resistors

RS485-1 is equipped with a three-position slide switch which can be used to switch its bias resistors OFF (position "MID" – this is the default), ON (position "BIAS"), and ON with an additional 150Ω termination resistor (position "END").
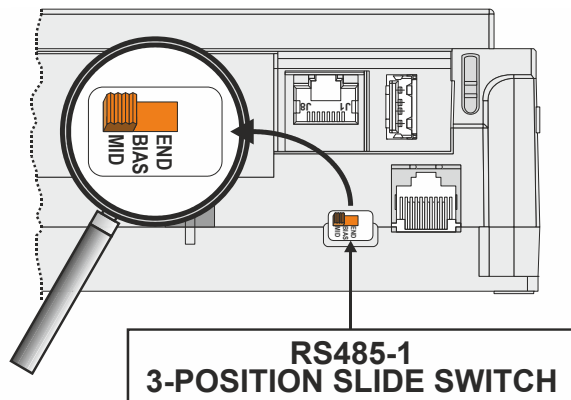
Fig. 10. RS485-1 three-position slide switch

The recommended slide switch setting depends upon the location and usage of the given EAGLEHAWK – see Fig. 11 through Fig. 13 and Table 5; it also depends upon the selected communication protocol (BACnet MS/TP, Panel Bus, or Modbus RTU Master communication, respectively).

Table 5. Recommended slide switch settings

setting	remarks
END	Controllers located on either end of bus should have this setting.
BIAS	In small bus networks, a min. of one and a max. of two controllers should have this setting.
MID	All other controllers (not set to "END" or "BIAS") on bus should have this setting (which is the default).
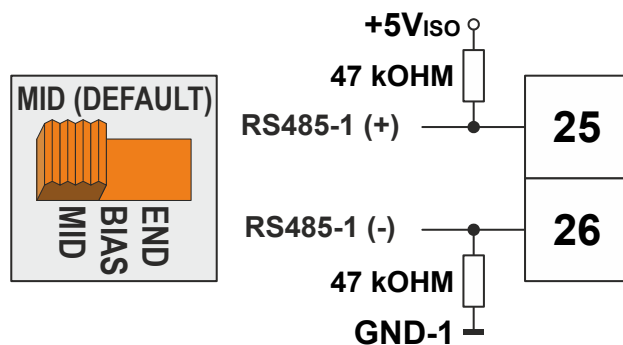
Fig. 11. RS485-1 three-position slide switch setting MID
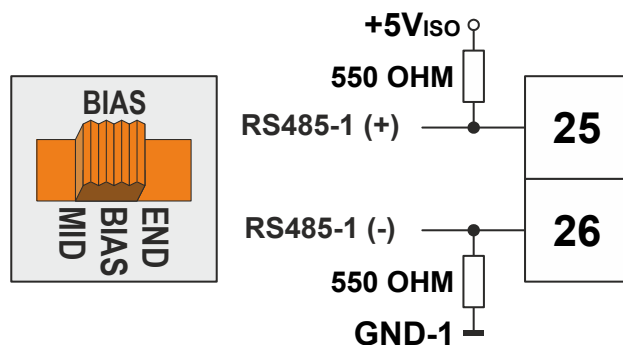
Fig. 12. RS485-1 three-position slide switch setting BIAS
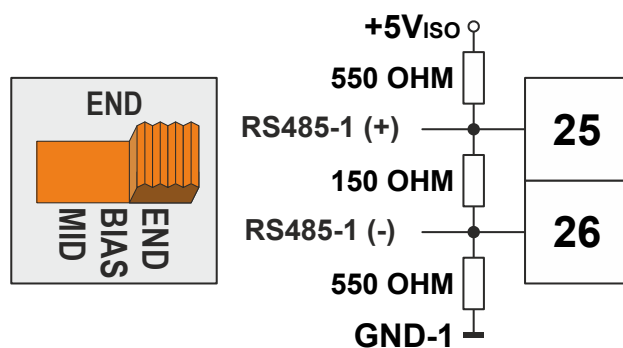
Fig. 13. RS485-1 three-position slide switch setting END

NOTE: All terminals are protected (up to 24 Vac) against short-circuiting and incorrect wiring – except when the 3-position slide switch is set to "END," in which case the terminals of the RS485-1 bus (24, 25, and 26) have no such protection. Higher voltages may damage the device.

NOTE: According to BACnet standards, a minimum of one and a maximum of two BACnet devices must have its/their bias resistors switched ON. In the case of the RS485-1 interface of the EAGLEHAWK, setting its slide switch to either "BIAS" or "END" fulfills this requirement.

RS485-2 Bias and Termination Resistors

The RS485-2 interface is not affected by the aforementioned three-position slide switch. The 550Ω bias resistors and 130Ω termination resistor of the RS485-2 are thus always ON.
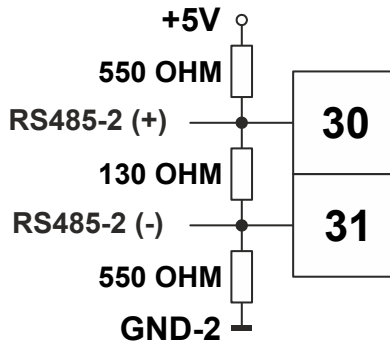
Fig. 14. RS485-2 bias and termination resistors

NOTE: GND-2 is internally connected with 24V-0 (terminal 1)

RS485 Standard

According to the RS485 standard (TIA/EIA-485: "Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems"), only one driver communicating via an RS485 interface may transmit data at a time. Further, according to U.L. requirements, each RS485 interface may be loaded with a max. of 32 unit loads. E.g., CentraLine devices have as little as ¼ unit load each, so that up to 128 devices can be connected.

BACnet MS/TP connections to the RS485 interfaces must comply with the aforementioned RS485 standard. Thus, it is recommended that each end of every connection be equipped with one termination resistor having a resistance equal to the cable impedance (120 Ω / 0.25 – 0.5 W).

RS485 systems frequently lack a separate signal ground wire. However, the laws of physics still require that a solid ground connection be provided for in order to ensure error-free communication between drivers and receivers – unless all of the devices are electrically isolated and no earth grounding exists.

IMPORTANT

*In the case of new EAGLEHAWK controller installations, we strongly recommend using a separate signal ground wire. Doing otherwise may possibly lead to unpredictable behavior if other electrically non-isolated devices are connected and the potential difference is too high.*

In the case of the installation of EAGLEHAWK controllers in already-existent RS485 two-wire systems (e.g., when replacing PANTHER or LION controllers with EAGLEHAWK controllers), not using a separate signal ground wire will probably have no undesirable effects.

The cable length affects the baud rate. Table 6 provides a few examples.

Table 6. Baud rate vs. max. cable length for RS485

Baud rate	Max. cable length (L)
9.6 - 76.8 kbps	1200 m
*115.2 kbps	1000 m
** In the case of configuration of RS485-2 for Panel Bus, the communication rate is set to 115.2 kbps.	

For information on wire gauge, max. permissible cable length, possible shielding and grounding requirements, and the max. number of devices which can be connected to a bus, refer to standard EIA-485.

Modbus Connection

The EAGLEHAWK controller can function as a Modbus Master or Slave. In general, the RS485 wiring rules must be followed.

Wiring Topology

Only daisy-chain wiring topology is allowed.
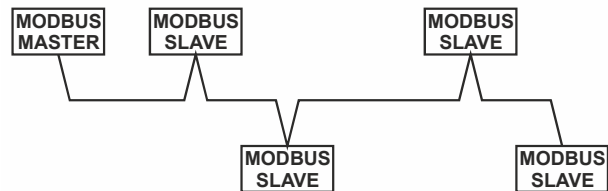
Fig. 15. Allowed Modbus wiring topology

Other wiring topologies (e.g., star wiring, or mixed star wiring and daisy chain wiring) are prohibited; this is to avoid communication problems of the physical layer.
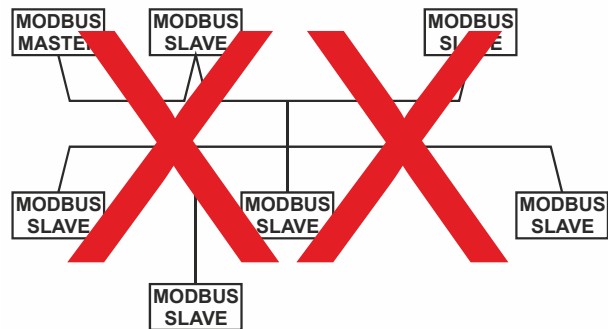
Fig. 16. Prohibited Modbus wiring topology (example)

Cables

See also section "EIA 485 Cable Specifications" on pg. 25.

Use shielded twisted pair cable J-Y-(St)-Y 2 x 2 x 0,8.

You **must** use three wires:

- One wire for D1 = Modbus +

- One wire for D0 = Modbus –

- One wire for the signal common

When using one pair for D1 and D0 and one wire of another pair for the signal common, CAT5 cable may also be used.

For connection details, see section "Modbus Connection" on pg. 31.

Shielding

Shielding is especially recommended when the Modbus cable is installed in areas with expected or actual electromagnetic noise. Avoiding such areas is to be preferred.

Use shielded twisted pair cable shielded twisted pair cable J-Y-(St)-Y 2 x 2 x 0,8 and connect the Modbus to a noise-free earth ground – only once per Modbus connection.

RS485 Repeaters

RS485 repeaters are possible, but have not been tested by Honeywell. Hence it is within responsibility of the installing / commissioning person to ensure proper function.

NOTE: Each Modbus segment will require its own line polarization and line termination.

Modbus Master Specifications

Modbus Compliance

As per the Modbus standard, the EAGLEHAWK controller is a conditionally compliant "regular" Modbus device.

The EAGLEHAWK controller differs from an unconditionally compliant "regular" Modbus device in that it does not support communication rates of 1.2, 2.4, and 4.8 kBaud (because these communication rates are not market-relevant).

Physical Layer

2-wire serial line RS485 (EIA-485) (with additional common)

Communication rates: 9.6, 19.2, 38.4, 57.6, 76.8, and 115.2 kBaud supported.

Max. number of devices: 32

Cable and wiring specifications: See section "Wiring and Set-Up" on pg. 12.

Communication Mode

Typically: Modbus Master.

Transmission Mode

RTU (Remote Terminal Unit) and (via Ethernet) TCP/IP.

Address Range

Modbus slaves can have an address between 1 and 247.

Discrete Inputs, Coils, Input Registers and Holding Registers can have an address between 1 and 65534.

Further Information

For further information, please refer to the Modbus Driver documentation (docModbus.pdf).

MOUNTING/DISMOUNTING

Before Installation

IMPORTANT

To allow the evaporation of any condensation resulting from low shipping / storage temperatures, keep the controller at room temperature for at least 24 h before applying power.

US requirement, only: This device must be installed in a UL-listed enclosure offering adequate space to maintain the segregation of line voltage field wiring and Class 2 field wiring.

In the case of vertical mounting on DIN rails, the EAGLEHAWK controller should be secured in place using a commercially-available stopper. See also the EAGLEHAWK - Mounting Instructions (MU1Z-1006GE51).
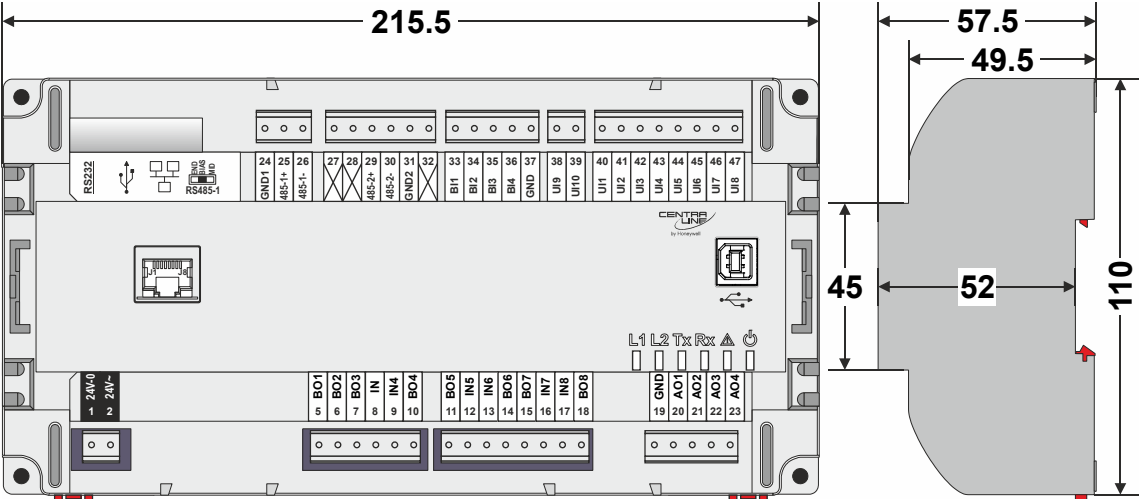
Dimensions

Fig. 17. EAGLEHAWK Controller (shown: model with onboard I/Os), dimensions (in mm)
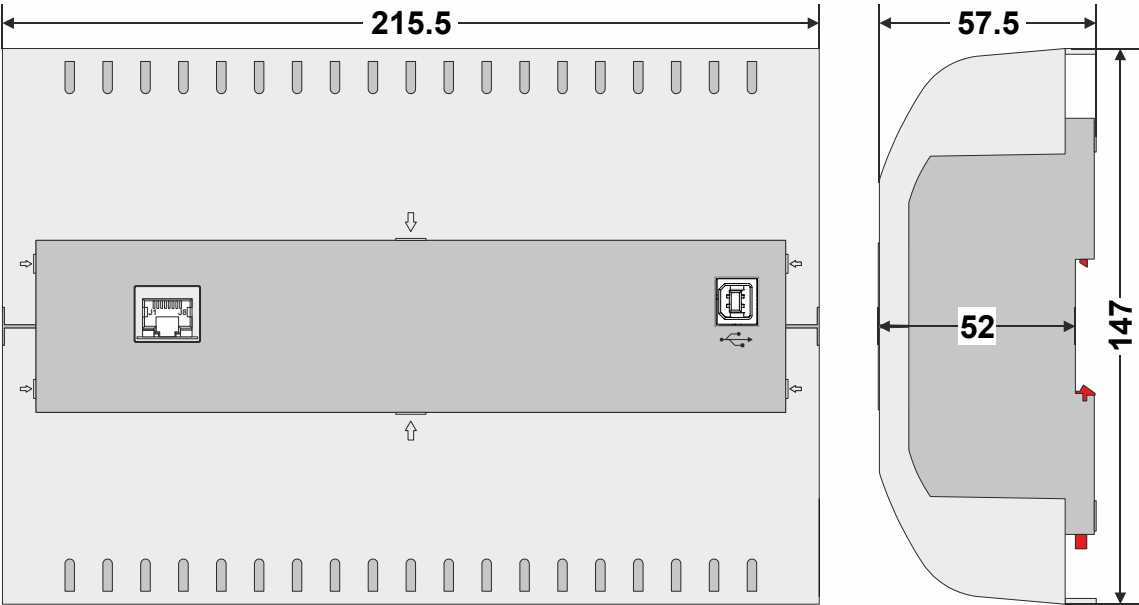

Fig. 18. EAGLEHAWK controller with covers, dimensions (in mm)

NOTE: Use of the covers (MVC-80-AC1) obstructs access to the Ethernet and USB 2.0 Host Interfaces and RS232 socket.

WIRING AND SET-UP
General Safety Considerations

- All wiring must comply with applicable electrical codes and ordinances, including VDE, National Electric Code (NEC) or equivalent, and any local regulations must be observed. Refer to job or manufacturer's drawings for details. Local wiring guidelines (e.g., IEC 364-6-61 or VDE 0100) may take precedence over recommendations provided here.
- Electrical work should be carried out by a qualified electrician.
- Electrical connections must be made at terminal blocks.
- 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!
- ► Observe precautions for handling electrostatic sensitive devices.
- ► Do not touch any live parts in the cabinet.
- ► Do not open the controller housing.
- ► Disconnect the power supply before making connections to or removing connections from terminals of the EAGLEHAWK controller and devices wired to it.
- ► Do not use spare terminals as wiring support points.
- ► To prevent risk of injury due to electrical shock and/or damage to the device due to short-circuiting, low-voltage and high-voltage lines must be kept separate from one another.
- ► All terminals are protected (up to 24 Vac) against short-circuiting and incorrect wiring (unless the 3-position slide switch is set to "END," in which case the terminals of the RS485-1 bus [24, 25, and 26] have no such protection). Higher voltages may damage the device.
- ► Do not reconnect the power supply until you have completed the installation.
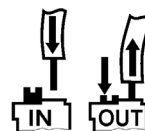

Fusing Specifications
System Fusing
We recommend that the system be equipped with an external fuse.

Fusing of Active Field Devices
F2 (depends upon given load).

Wiring Terminals
The EAGLEHAWK is equipped with push-in terminal plugs.

use Cu only

Fig. 19. Inserting/removing wires from push-in terminals

NOTE: With solid conductors, ferrules are prohibited.

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

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

Table 7. EAGLEHAWK push-in terminal wiring specifications

plug gauge	0.2 … 1.50 mm²
solid conductor H05(07) V-K	0.2 … 1.50 mm²
stranded conductor H05(07) V-K	0.2 … 1.50 mm²
stranded conductor with wire end ferrules (w/o plastic collar)	0.2 … 1.50 mm²
stripping length	10.0 +1.0 mm

Terminal Assignment
Table 8. Terminal assignment

term.	signal	description
1	24V-0	supply voltage (GND), internally connected with terminal 31
2	24V~	supply voltage (24V)
24	GND-1	reference GND of RS485-1 (isolated)
25	485-1+	"+" signal for RS485-1 (isolated)
26	485-1-	"-" signal for RS485-1 (isolated)
27,28		not used
29	485-2+	"+" signal for RS485-2 (non-isolated)
30	485-2-	"-" signal for RS485-2 (non-isolated)
31	GND-2	reference GND of RS485-2, internally connected with 24V-0 (terminal 1)
32	-	not used

Power Supply
Powering EAGLEHAWK
Power is supplied via a removable terminal plug (attached to terminals 1 and 2).

The power supply of the EAGLEHAWK controller must conform to Safety Class II. To reduce overall current consumption, the EAGLEHAWK can be powered by a switch power supply (rather than by a transformer). See also Table 2 on pg. 3.

Due to the risk of short-circuiting (see Fig. 20), it is strongly recommended that the EAGLEHAWK controller be supplied with power from a dedicated transformer. However, if the EAGLEHAWK controller is to be supplied by the same transformer powering other controllers or devices (e.g., the PW M-Bus Adapter), care must be taken to ensure that correct polarity is observed.
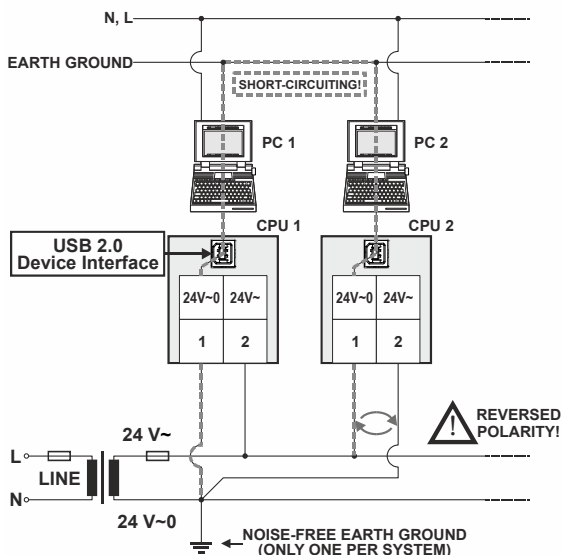

Fig. 20. Incorrect polarity → SHORT-CIRCUITING!

Transformer Data

In Europe, if the EAGLEHAWK is powered by transformers, then such transformers must be safety isolating transformers conforming to IEC61558-2-6. In the U.S. and Canada, if the EAGLEHAWK is powered by transformers, then such transformers must be NEC Class-2 transformers.

Table 9. 1450 series transformers data

part # 1450 7287	primary side	secondary side
-001	120 Vac	24 Vac, 50 VA
-002	120 Vac	2 x 24 Vac, 40 VA, 100 VA from separate transformer
-003	120 Vac	24 Vac, 100 VA, 24 Vdc, 600 mA
-004	240/220 Vac	24 Vac, 50 VA
-005	240/220 Vac	2 x 24 Vac, 40 VA, 100 VA from separate transformer
-006	240/220 Vac	24 Vac, 100 VA, 24 Vdc, 600 mA

Table 10. Overview of CRT Series AC/DC current

transformer	primary side	max. AC current	max. DC current
CRT 2	230 Vac	2 A	500 mA
CRT 6	230 Vac	6 A	1300 mA
CRT 12	230 Vac	12 A	2500 mA
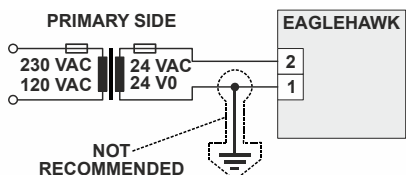
Fig. 21. Connection of EAGLEHAWK controller

RIN-APU24

The RIN-APU24 Uninterruptable Power Supply can be directly wired to an EAGLEHAWK controller.

See RIN-APU24 Uninterruptable Power Supply – Mounting Instructions (EN0B-0382GE51) for a detailed wiring diagram.

Powering Panel Bus I/O Modules and Field Devices

The EAGLEHAWK, Panel Bus I/O modules, and field devices can be powered by either separate transformers (see Fig. 22, and Fig. 23) or by the same transformer.

NOTE: Use a min. distance of 10 cm between power cables and 0…10 V / sensor cables in order to prevent signal disturbances on the 0…10 V / sensor cables. See also section "Addressing Panel Bus I/O Modules" on page 25.

Powering Field Devices and Panel Bus I/O Module via Separate Transformers

- 24 V actuator connected to, e.g., an analog output module
- Field device located 100 … 400 m from the analog output module
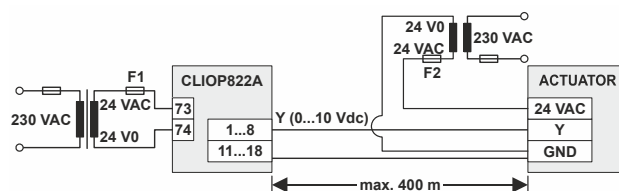
Fig. 22. Power supply via a separate transformer

Powering Field Devices via Panel Bus I/O Module

- 24 V actuator connected to, e.g., an analog output module
- Field device located max. 100 m from the analog output module

Fig. 23. Power supply via Panel Bus I/O Module

Lightning Protection

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

EN1Z-1005GE51 R0918

CLAXEH26ND100A Connection Examples
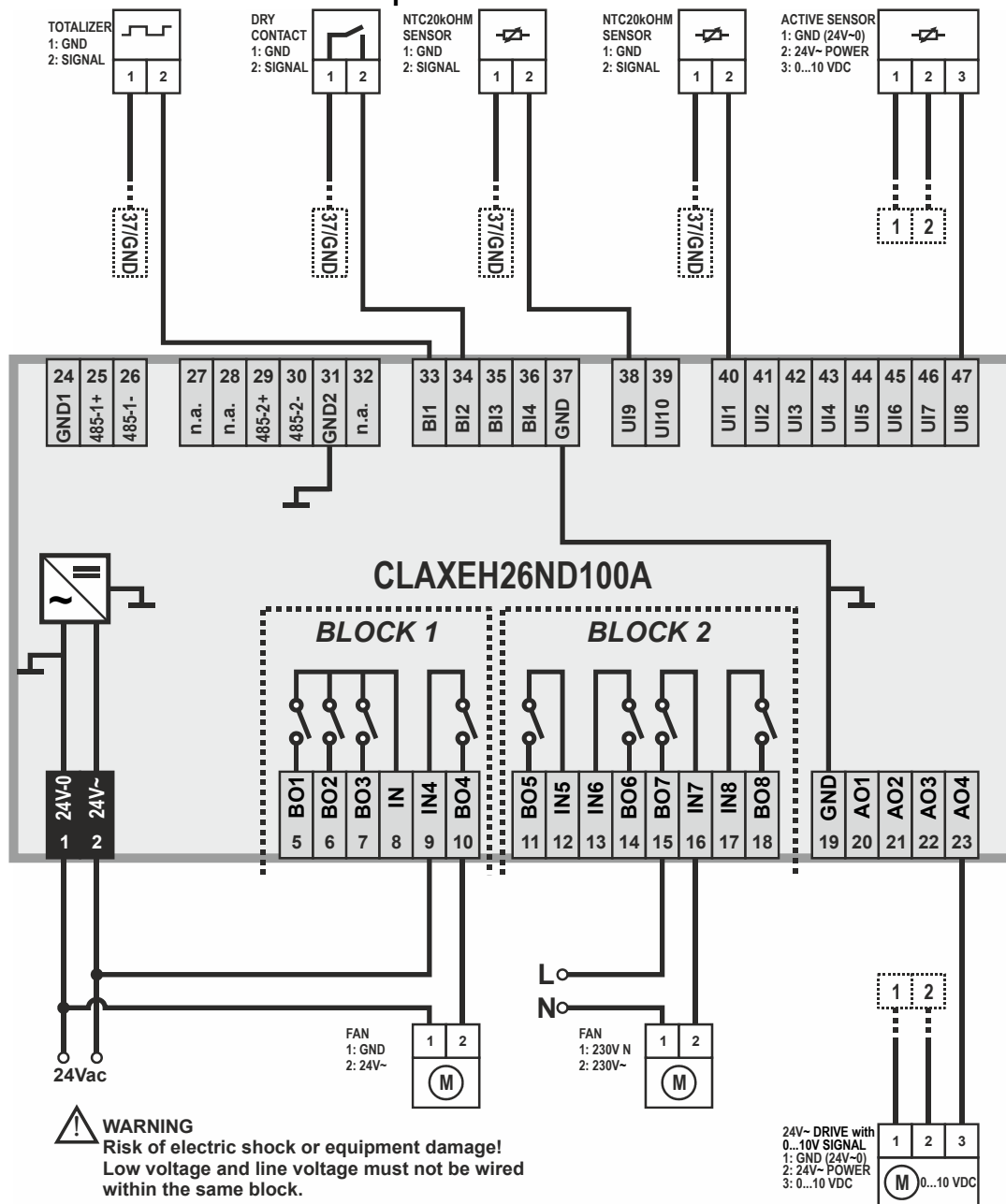
Fig. 24. CLAXEH26ND100A connection example

For fusing specifications see section "**Fusing** Specifications" on page 12.

NOTE: Use a min. distance of 10 cm between power cables and 0…10 V / sensor cables in order to prevent signal disturbances on the 0…10 V / sensor cables.
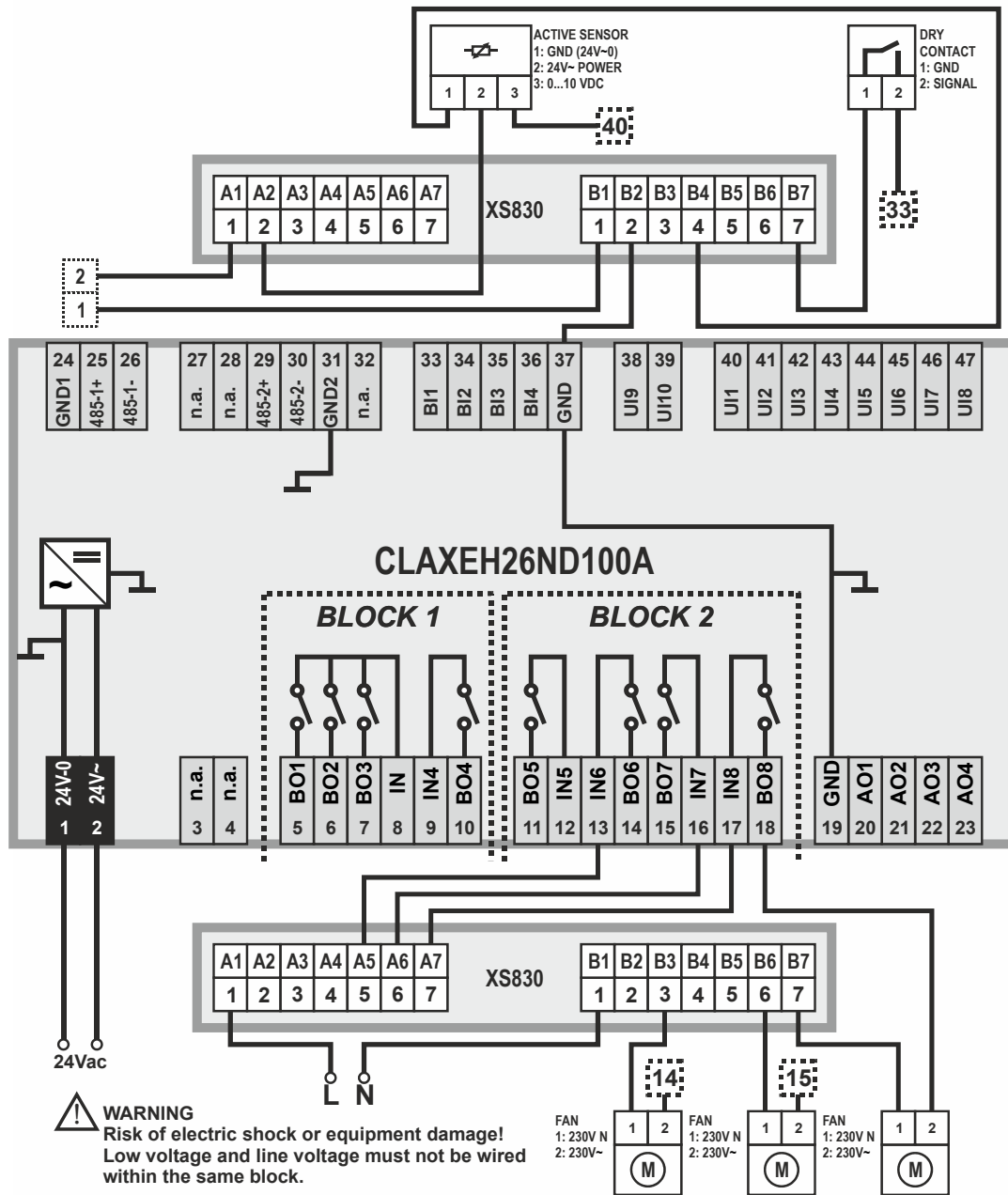
Fig. 25. CLAXEH26ND100A connection example (with two XS830 Auxiliary Terminal Packages)

The XS830 and XS831 Auxiliary Terminal Packages are optional accessories which can be mounted onto the top and/or bottom of the EAGLEHAWK Controller in order to equip them with additional terminals for the connection of, e.g., shields, sensors, GND, N, 230 V, or 24 V (but not earth!).

NOTE: Use a min. distance of 10 cm between power cables and 0…10 V / sensor cables in order to prevent signal disturbances on the 0…10 V / sensor cables.

Internal I/Os of the EAGLEHAWK

The CLAXEH00ND100A is not equipped with inputs or outputs. The following sub-sections thus apply only to the CLAXEH26ND100A and CLAXEH14ND100A.

Universal Inputs

The CLAXEH26ND100A is equipped with ten (CLAXEH14ND100A: four) universal inputs (UIs) configurable (in COACH[AX]).

For information on the accuracy of the sensor inputs, their differential measurement error, the characteristics (i.e., resistances and resultant voltages in dependence upon temperature) of the various different sensor types which can be connected to them, and on the thresholds at which sensor failures are recognized, see section "Appendix 2" on pg. 41.

Table 11. Specifications of UIs

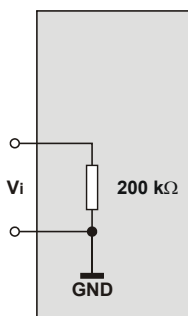| criteria	value
voltage input	• UI1-UI10: 0 … 10 VDC with pull-up resistor (default) • UI1-UI8: 0…10 VDC w/o pull-up resistor • UI1-UI8: 2…10 VDC w/o pull-up resistor
current input	• UI1-UI10: 0 … 10 VDC w/o pull-up resistor, external 499Ω resistor required to measure 0…20 mA • UI1-UI8: 2…10 VDC w/o pull-up resistor, external 499Ω resistor required to measure 4…20 mA
supported sensor types	• NTC10kΩ (-30…+100 °C) • NTC20kΩ (-50…+150 °C) • Slow binary input (static, dry-contact), 0.4 Hz
resolution	12-bit resolution
accuracy	±75 mV (0 ... 10 V)
protection	against short-circuiting, 24 VAC

Fig. 26 Internal wiring of UI1-UI8 configured for voltage input (without pull-up resistor)
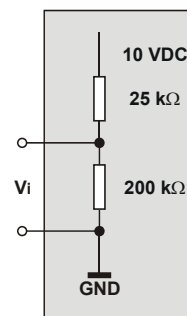
Fig. 27. Internal wiring of UI1-UI10 configured for input from NTC10kΩ / NTC20kΩ / voltage input (with pull-up resistor)

Slow Binary Input Specifications

When configured as slow binary inputs, the universal inputs of the EAGLEHAWK have the following specifications:

open contact	≥ 100 kΩ
closed contact	≤ 100 Ω

The polarity (normal = N.O. contact or reverse = N.C. contact) configuration defines if a logical 1 or a logical 0 is detected for a closed contact. This is done by selecting (in COACH[AX]) one of the following options:

normal (default)	closed external contact →	state=1
	open external contact →	state=0
reverse	closed external contact →	state=0
	open external contact →	state=1

Pulse Counter Specifications

Using COACH[AX], the universal inputs of the EAGLEHAWK can be configured as pulse counters (totalizers).

If the duty cycle is 50% / 50%, the pulse counter supports up to 0.4 Hz. Counting is done on the rising edge.

Table 12. UIs of EAGLEHAWK configured as slow BIs

frequency	max. 0.4 Hz
pulse ON	min. 1.25 s
pulse OFF	min. 1.25 s
bounce	max. 50 ms

Analog Outputs

The CLAXEH26ND100A is equipped with four (CLAXEH14ND100A: two) analog outputs (AOs).

In the event of an application stop (e.g., during application download), the analog outputs assume the safety positions configured in COACH[AX].

The analog outputs can be configured in COACH[AX] as binary outputs (with an output of 0 V or 10 V, as the case may be).

Table 13. Specifications of AOs

criteria	value
output type	• 0…10 V (default) • 2…10 V
max. output range	0 … 11 VDC (1 mA)
min. resolution	8 bit
min. accuracy	± 150 mV
max. wire length	400 m
wire cross section	See Table 7 on pg. 12.
protection	against short-circuiting, 24 VAC

Binary Inputs / Pulse Counters

Both the CLAXEH26ND100A and the CLAXEH14ND100A are equipped with four binary inputs (static dry-contact inputs) / pulse counters (fast totalizers).

Table 14. Specifications of BIs

criteria	value
input type	• binary input (static dry-contact) • pulse counter (fast totalizer)
current rating (closed input)	2 mA
open contact voltage	24 VDC
protection	against short-circuiting, 24 VAC

Binary Input Specifications

The binary inputs of the EAGLEHAWK are static dry-contact inputs. This reduces the wiring effort, as it is then not necessary to distribute an auxiliary voltage signal.

open contact	≥ 3000 Ω (24 VDC on BI terminal)
closed contact	≤ 500 Ω (short-circuit current: 2.0 mA)

The polarity (normal = N.O. contact or reverse = N.C. contact) configuration defines if a logical 1 or a logical 0 is detected for a closed contact. This is done by selecting (in COACH[AX]) one of the following options:

normal (default)	closed external contact → state=1
	open external contact → state=0
reverse	closed external contact → state=0
	open external contact → state=1

Pulse Counter Specifications

Using COACH[AX], the binary inputs of the EAGLEHAWK can be configured as pulse counters (fast totalizers) for operation in conjunction with devices equipped with an open collector output.

If the duty cycle is 50% / 50%, the pulse counter supports up to 15 Hz. Counting is done on the rising edge.

Table 15. BIs of EAGLEHAWK configured as fast totalizers

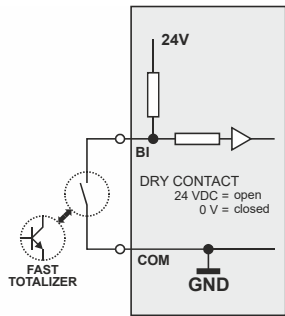| **frequency**	max. 15 Hz
pulse ON	min. 25 ms
pulse OFF	min. 25 ms
bounce	max. 5 ms

Fig. 28. Internal wiring of BI

Binary Outputs

The EAGLEHAWK features eight (CLAXEH26ND100A) or four (CLAXEH14ND100A) binary outputs arranged in two blocks (BO1…4 and BO5..8, respectively).

⚠ **WARNING**

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

In the event of an application stop (e.g., during application download), the binary outputs assume the safety positions configured in COACH^{AX}.

The polarity (normal = N.O. contact or reverse = N.C. contact) configuration defines if a relay is open or closed, depending upon whether there is a logical 1 or a logical 0. This is done by selecting (in COACH^{AX}) one of the following options:

normal (default)	state=1 →	relay contact is closed
	state=0 →	relay contact is opened
reverse	state=0 →	relay contact is closed
	state=1 →	relay contact is opened

Table 16. Relay specifications of the EAGLEHAWK

	block 1		block 2
	BO1…3	**BO4**	**BO5…8**
contact volt. AC	5…253 V	5…253 V	5…253 V
contact volt. DC	5…30 V	20…30 V	5…30 V
max. contact current AC (resistive)	3 A	10 A	3 A
max. contact current AC (induct.)	0.3 A*	10 A	0.3 A*
max. contact current AC (induct.)	2 A**	10 A	2 A**
max. contact current DC	3 A	7 A	3 A
min. load	100 mA / 5 Vdc	40 mA / 24 Vdc	100 mA / 5 Vdc
* typically 250,000 cycles; ** typically 50,000 cycles			

NOTE: The total max. sum load for all binary outputs (BO1…8) equals 14 A.

NOTE: Binary output 4 supports the switching of high inrush currents (e.g., motors, incandescent lights, etc.). The max. allowed switch current is 80 A for a duration of max. 20 ms.

ENGINEERING, COMMISSIONING

Please refer also to ARENA^{AX} / COACH^{AX} - User Guide (Product Literature No.: EN2Z-0996GE51) for detailed information.

Required Preparations

In order to access (with a laptop or PC) the EAGLEHAWK controller via Ethernet/IP for the first time, the default passwords are used. For IP connections, you may employ any one of the following two options:

Option 1: USB 2.0 Device (recommended)

This USB 2.0 Device interface is the recommended interface for downloading applications and firmware via COACH^{AX}. An "A-Male to B-Male" USB cable is required.
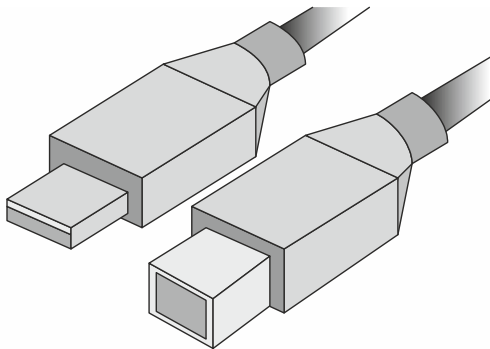
Fig. 29. A-male to B-male USB cable

For access via USB, the EAGLEHAWK controller has a permanent default IP address 192.168.255.241. Your PC's IP address must match the EAGLEHAWK controller's default IP address subnet: We recommend using DHCP or "Obtain an automatic IP address".

Option 2: Standard Ethernet Interface

The default IP address is 192.168.200.20. In any case, your PC's IP address must match the EAGLEHAWK controller's default IP address subnet. We recommend using DHCP or "Obtain an automatic IP address".

Behavior of Outputs during Download
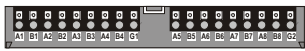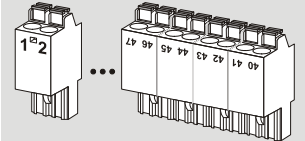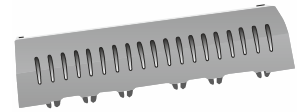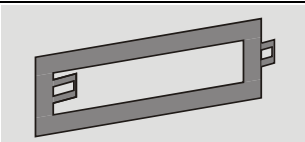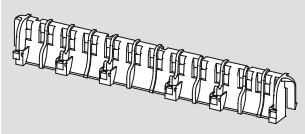
Table 17. Behavior of outputs during firmware download / application download

analog, binary, and floating outputs	output behavior during firmware / Linux download	output behavior during application download
outputs of Panel I/O modules (CLIOP82x)	As soon as "receive heartbeat" (the value of which CANNOT be altered using COACH^{AX}) expires, outputs go to safety position.	Outputs remain in the previous position / state
outputs of LONWORKS I/O modules (CLIOL82x)	As soon as "receive heartbeat" (the value of which can be altered using COACH^{AX}) expires, outputs go to safety position.	Outputs remain in the previous position / state.

NOTE: These behaviors were determined using a test application with a cycle time of 10 seconds. A value update was triggered every 10 seconds.

EXTRA PARTS

Table 18. Extra parts

	order no.	description
	XS830	Set of ten terminals. Each package consists of two groups of nine internally connected push-in terminals, for distributing signals / power.
	XS831	Set of ten terminals. Each package 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.
	TPU-11-01	Removable terminal plugs, push-in type; complete set of 3 plugs (for terminals 1, 2, 24-32); for the CLAXEH00ND100A.
	TPU-45-01	Removable terminal plugs, push-in type; complete set of 9 plugs (for terminals 1 - 47); for the CLAXEH14ND100A and CLAXEH26ND100A.
	MVC-80-AC1	Terminal cover (color: RAL9011); package of ten.
	MVC-80-AC2	Front door mounting accessory (color: RAL9011); package of 10.
	MVC-40-AC3	Strain relief; package of ten.

SOFTWARE LICENSES AND UPGRADES

Table 19. Software Licenses and Upgrades

model	Honeywell Panel Bus devices	onboard I/O and Honeywell Panel Bus points	integrated devices	integrated points
CLAXEH00ND100A (EAGLEHAWK hardware with base license; no onboard I/Os, no display)	128	102	5	25
CLAXEH14ND100A (EAGLEHAWK hardware with 14 onboard I/O, with base license; no display)	128	102	5	25
CLAXEH26ND100A (EAGLEHAWK hardware with 26 onboard I/O, with base license; no display)	128	102	5	25
CLAXEHPB100UP (EAGLEHAWK upgrade license for an additional 102 Panel Bus points)	128	+102	--	--
CLAXEH3PTY25UP (EAGLEHAWK upgrade license for an additional 25 integrated points)	--	--	+5	+25
CLAXEHRLON150UP (EAGLEHAWK upgrade license for an additional 30 Honeywell / CentraLine LONWORKS controllers with 150 LONWORKS points)	--	--	30	150
CLAXEHRBAC150UP (EAGLEHAWK upgrade license for an additional 30 Honeywell / CentraLine BACnet controllers with 150 BACnet points)	--	--	30	150

NOTE: The maximum permitted number of Honeywell Panel Bus points is 408. The maximum recommended number of integrated points is 400. The maximum recommended number of total points is 408.

For more details on the licenses, please refer to the Release Bulletin.

PANEL BUS CONNECTION

The EAGLEHAWK controller features two RS485 interfaces to which Panel Bus modules can be connected: RS485-1 (consisting of push-in terminals 24 [GND-1], 25, and 26) and/or RS485-2 (consisting of push-in terminals 29, 30, and 31 [GND-2]).

NOTE: GND-2 is internally connected with 24V-0 (terminal 1)
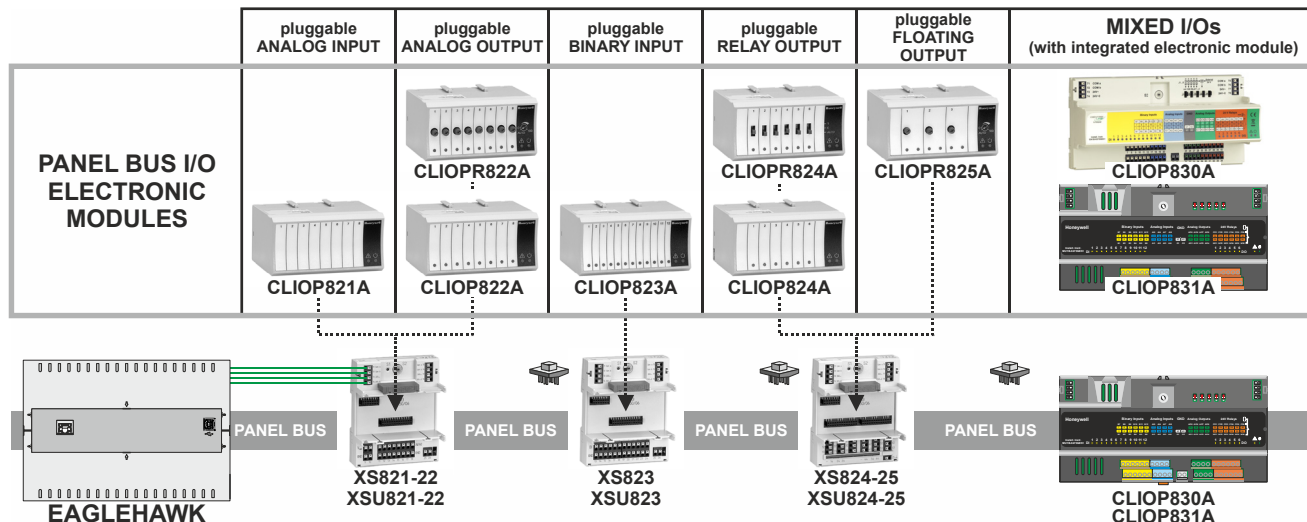
Overview of Panel Bus I/O Modules

Fig. 30. Overview of Panel Bus I/O Modules

Panel Bus Considerations

- **RS485-1 (isolated)**
  - Max. Panel Bus length:
    - o 40 meters. Any type of cabling and topology (including star and loop topology) possible. No additional end termination permitted.
    - o 1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps) (see also section "RS485 Standard" on pg. 9). Mandatory twisted-pair or telephone cable and daisy chain topology. The EAGLEHAWK must be positioned at one end of the Panel Bus, and an end termination (120 Ω) at the other end. Further, the three-position slide switch (see Fig. 10 on pg. 8) must be set to "END."
- **RS485-2 (non-isolated)**
  - Max. Panel Bus length:
    - o 40 meters. Any type of cabling and topology (including star and loop topology) possible. No additional end termination permitted.
    - o 1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps) (see also section "RS485 Standard" on pg. 9). Mandatory twisted-pair or telephone cable and daisy chain topology. The EAGLEHAWK controller must be positioned at one end of the Panel Bus, and an end termination (120 Ω) at the other end.
  - Must not extend beyond a single building or building floor
- **Max. no. of Panel Bus I/O modules per RS485 interface**
  - Max. no. of Panel Bus I/O modules of a given model: 16
  - Total max. no. of Panel Bus I/O modules: 64
- **Max. no. of Panel Bus I/O modules per EAGLEHAWK**
  - Max. no. of Panel Bus I/O modules of a given model: 32
  - Total max. no. of Panel Bus I/O modules: 128
- **Max. no. of hardware I/O points per EAGLEHAWK: 400 (given a normal polling rate of 10 seconds)**

Refer to CentraLine I/O Modules - Installation & Commissioning Instructions (EN1Z-0973GE51) for more information about connection, current requirements, power supply, overvoltage protection, cable specifications, fusing, effects of manual overrides, etc. of Panel Bus I/O modules and field devices connected to them.

Connecting EAGLEHAWK via its RS485-1 Interface to a Panel Bus

NOTE: When connecting an EAGLEHAWK via its RS485-1 to a Panel Bus I/, it is recommended that the slide switch be set to "END."

Fig. 31. Connecting an EAGLEHAWK controller via its RS485-1 interface to a Panel Bus (single transformer)

Fig. 32. Connecting an EAGLEHAWK controller via its RS485-1 interface to a Panel Bus (two transformers)

Connecting EAGLEHAWK via its RS485-2 Interface to a Panel Bus
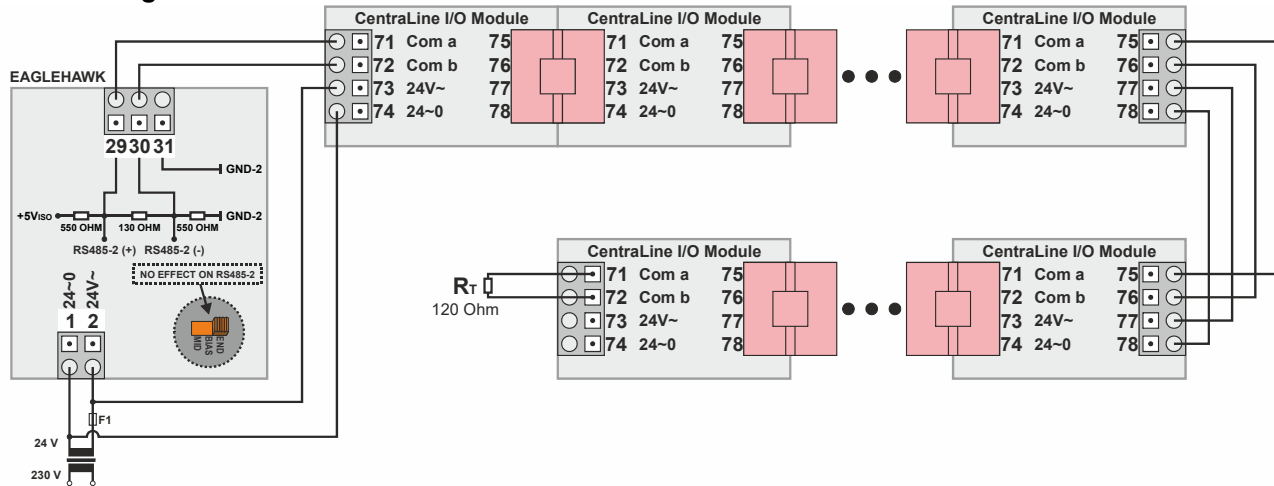

Fig. 33. Connecting an EAGLEHAWK controller via its RS485-2 interface to a Panel Bus (single transformer)
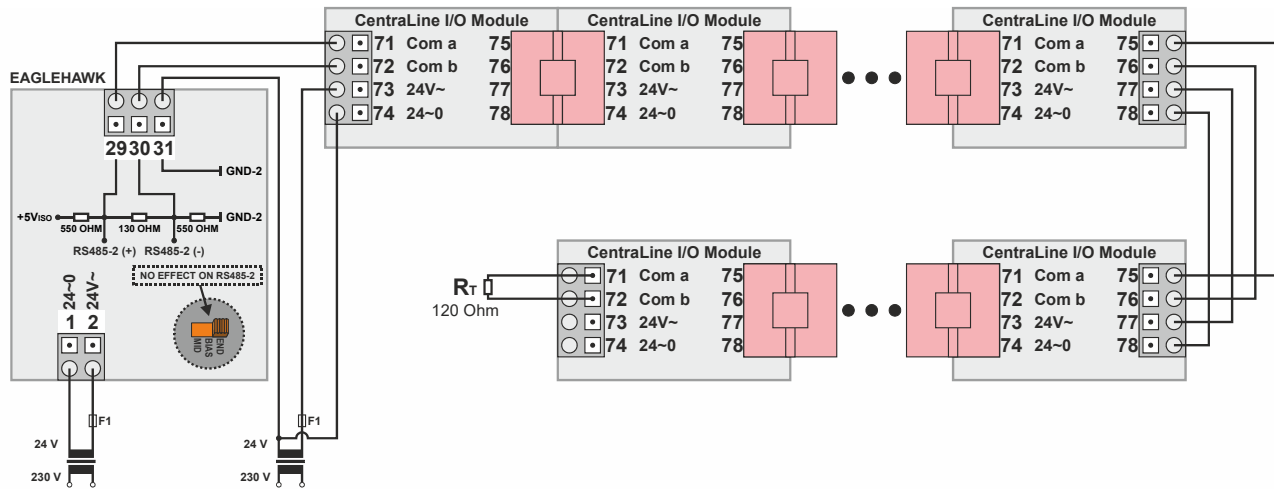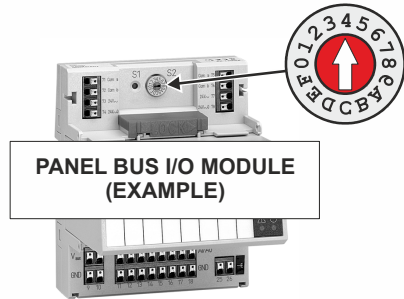

Fig. 34. Connecting an EAGLEHAWK controller via its RS485-2 interface to a Panel Bus (two transformers)

Addressing Panel Bus I/O Modules

Each Panel Bus I/O Module must be addressed manually using its HEX switch (S2). The HEX switch setting is defined using the COACH^AX engineering tool.

Fig. 35. Location of HEX switch on Panel Bus I/O Module

NOTE: A HEX switch setting of "0" corresponds to an address in COACH^AX of "1," a setting of "1" corresponds to an address of "2," and so on.

During commissioning, a max. of 16 Panel Bus I/O Modules of each type (AI, DO, etc.) can be assigned addresses. In doing so, no two modules of the same type (e.g., no two Analog Input Modules, no two Digital Output modules, etc.) may be assigned the same address. See also Fig. 36.
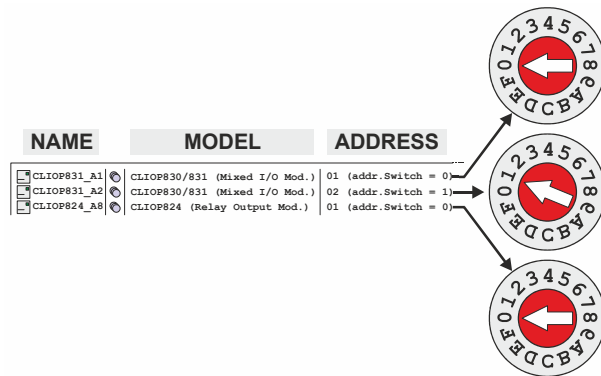
Fig. 36. HEX switch setting and corresponding address

Failing to observe this requirement will cause a "Fail [date] timeout" error message to appear in the "Health" column, and the device status "down" to appear in the "Status" column. This same error message will likewise appear if an address is assigned to a module with which the controller cannot, for any reason (e.g., due to defective wiring, or because the module has not been physically installed, etc.), communicate.

Cable Specifications

Panel Bus I/O Modules

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

Table 20. Power supply cable specifications

max. length	3 m (from transformer to final module)
cross section	min. 0.75 mm^2 (AWG 18)

EIA 485 Cable Specifications

The following cable specification is valid for all EIA 485 buses (e.g., Panel Bus and BACnet MS/TP).

Table 21. EIA 485 cable specifications

max. length	1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps).
cable type	twisted pair, shielded (foil or braided shields are acceptable)
characteristic impedance	100…130 Ω
distributed capacitance between conductors	Less than 100 pF per meter (30 pF per foot)
distributed capacitance between conductors and shield	Less than 200 pF per meter (60 pF per foot)

The following cables fulfill this requirement:

- AWG 18;
- shielded, twisted pair cable J-Y-(St)-Y 2 x 2 x 0,8;
- CAT 5,6,7 cable (use only one single pair for one bus);
- Belden 9842 or 9842NH.

Field Devices

Depending on the distance from the controller, field devices can be supplied with power by the same transformer used for the Panel Bus I/O Modules, or by a separate transformer, using cables as specified in Table 22.

Table 22. Power / communication cable specifications

type of signal	cross-sectional area	
	≤ 100 m (Fig. 23) single transformer	≤ 400 m (Fig. 22) sep. transformers
24 VAC power	1.5 mm^2 (16 AWG)	not allowed for > 100 m (300 ft)
0…10 V signals	0.081 – 2.08 mm^2 (28 – 14 AWG)	

For wiring field devices, see section "Powering Panel Bus I/O Modules and Field Devices" on page 13.

Routing Cables to Field Devices

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

Table 23. Minimum 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).

- 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 one end.

  – Do not connect the shield to the EAGLEHAWK controller.

LONWORKS COMMUNICATIONS

General Information

The EAGLEHAWK can be connected to LONWORKS networks. This requires the use of an IF-LON (see section "IF-LON" below), which is then plugged into to the EAGLEHAWK's USB 2.0 Host Interface (see also section "USB 2.0 Host Interface" on pg. 6).

This permits individual EAGLEHAWK controllers to be connected / disconnected from the LONWORKS network without disturbing the operation of other devices.

The LONWORKS network is insensitive to polarity, eliminating the possibility of installation errors due to miswiring.

Different network configurations (daisy-chain, loop, and star configurations, or any combination thereof) are possible (see also Excel 50/500 LONWORKS Mechanisms Interface Description, EN0B-0270GE51).

Connecting to a LONWORKS Network

IMPORTANT

> Do not bundle wires carrying field device signals or LONWORKS communications together with high-voltage power supply or relay cables. Specifically, maintain a min. separation of 3 inches (76 mm) between such cables. Local wiring codes may take precedence over this recommendation.

IMPORTANT

> Try to avoid installing in areas of high electromagnetic noise (EMI).

Cable Types

The unit must be wired to the LONWORKS network using either

- level IV 22 AWG (Belden part number 9D220150)

or

- plenum-rated level IV 22 AWG (Belden part number 9H2201504) non-shielded, twisted-pair, solid-conductor wire.

When possible, use Honeywell AK3781, AK3782, AK3791, or AK3792 cable (US part numbers). See Excel 50/5000 LONWORKS Mechanisms, EN0B-0270GE51, for details, including maximum lengths.

Use wire with a minimum size of 20 AWG (0.5 mm^2) and a maximum size of 14 AWG (2.5 mm^2).

IF-LON

Optionally, communication with physical I/O modules, with room and zone controllers, and with CentraLine PANTHER, TIGER, and LION controllers can utilize LonTalk.

The IF-LON is equipped with a free-topology transceiver (FTT10A) for communication (at a data transmission rate of 78 Kbaud) on LONWORKS® networks (using the LonTalk protocol).

The LONWORKS network is insensitive to polarity, eliminating the possibility of installation errors due to miswiring. Different network configurations (daisy-chain, loop, and star con-figurations, or any combination thereof) are possible. See Excel 50/5000 LONWORKS Mechanisms (EN0B-0270GE51) for details.

Fig. 37. IF-LON

See also IF-LON – Mounting Instructions (MU1B-0545GE51).

Depending upon the chosen network configuration, one or two terminations may be required.

The following LONWORKS termination module is available:

- LONWORKS connection / termination module (mountable on DIN rails and in fuse boxes), order no.:   **XAL-Term2**
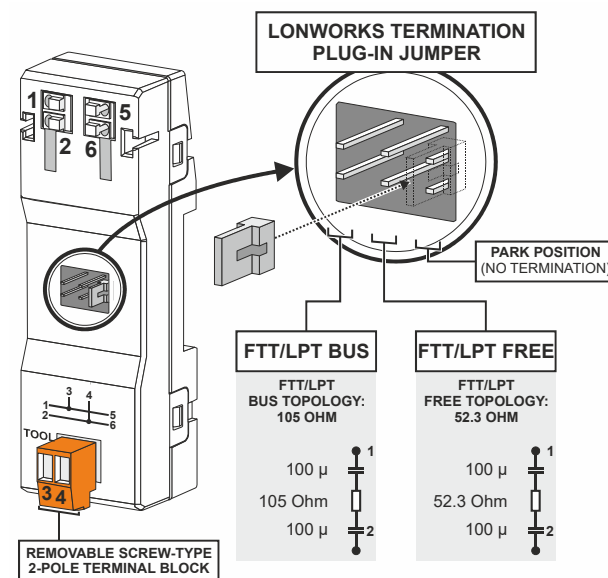

Fig. 38. LONWORKS connection and termination module

BACNET MS/TP BUS CONNECTION

The EAGLEHAWK controller features two RS485 interfaces to which BACnet MS/TP devices can be connected: RS485-1 (consisting of push-in terminals 24 [GND-1], 25, and 26) and/or RS485-2 (consisting of push-in terminals 29, 30, and 31 [GND-2]).

NOTE: GND-2 is internally connected with 24V-0 (terminal 1)

BACnet MS/TP Bus Considerations

- **RS485-1 (isolated)**
  - Max. BACnet MS/TP bus length: 1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps) (see also section "RS485 Standard" on pg. 9).
  - Use only shielded, twisted-pair cable and daisy-chain topology.
  - Must conform to EIA-RS485 cabling guidelines (see section "EIA 485 Cable Specifications" on pg. 25).
- **RS485-2 (non-isolated)**
  - Max. BACnet MS/TP bus length: 1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps) (see also section "RS485 Standard" on pg. 9).
  - Use only shielded, twisted-pair cable and daisy-chain topology.
  - Ground noise should not exceed the EIA-485 common mode voltage limit.
  - Must conform to EIA-RS485 cabling guidelines.
  - Should not extend beyond a single building.

Connecting EAGLEHAWK via its RS485-1 Interface to a BACnet MS/TP Bus

With regards to Fig. 39 through Fig. 41, please note the following:

NOTE: Always power each EAGLEHAWK controller and the connected BACnet MS/TP modules via separate transformers.

NOTE: For "L," see section "RS485 Standard" on pg. 9.

NOTE: If any of the devices are electrically isolated, it is recommended that those devices be connected to signal ground. See section "RS485 Standard" on pg. 9).

Example 1: Single EAGLEHAWK Controller and Connected BACnet Modules (with inserted termination resistor)

Fig. 39. Connection of a single EAGLEHAWK controller via its RS485-1 interface to a BACnet MS/TP Bus

The termination resistor must be inserted directly into the terminals of the last BACnet MS/TP module.

Example 2: Multiple EAGLEHAWK Controllers and Connected BACnet Modules

Fig. 40. Connection of multiple EAGLEHAWK controllers via their RS485-1 interfaces to a BACnet MS/TP Bus

Example 3: Multiple EAGLEHAWK Controllers and Connected BACnet Modules (with inserted termination resistor)

Fig. 41. Connection of multiple EAGLEHAWK controllers via their RS485-1 interfaces to a BACnet MS/TP Bus

The termination resistor must be inserted directly into the terminals of the last BACnet MS/TP module (in this example, that is the rightmost EAGLEHAWK, the 3-position slide switch of which has been set to "BIAS.")

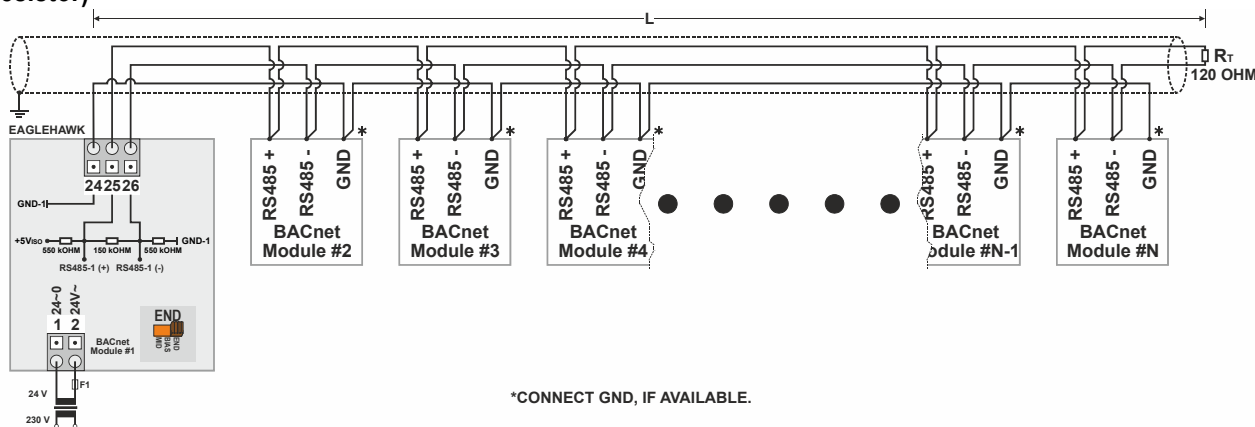## Connecting EAGLEHAWK via its RS485-2 Interface to a BACnet MS/TP Bus

With regards to Fig. 42 and Fig. 43, please note the following:

NOTE: Always power each EAGLEHAWK controller and the connected BACnet MS/TP modules via separate transformers.

NOTE: For "L," see section "RS485 Standard" on pg. 9.

NOTE: If any of the devices are electrically isolated, it is recommended that those devices be connected to signal ground. See section "RS485 Standard" on pg. 9).

NOTE: Between devices equipped with non-isolated RS485 bus interfaces, potential differences of max. ±7 V are allowed. Further, this bus should not extend beyond a single building.

Example 1: Single EAGLEHAWK Controller and Connected BACnet Modules (with inserted termination resistor)

Fig. 42. Connection of a single EAGLEHAWK controller via its RS485-2 interface to a BACnet MS/TP Bus

The termination resistor must be inserted directly into the terminals of the last BACnet MS/TP module.

Example 2: Multiple EAGLEHAWK Controllers and Connected BACnet Modules
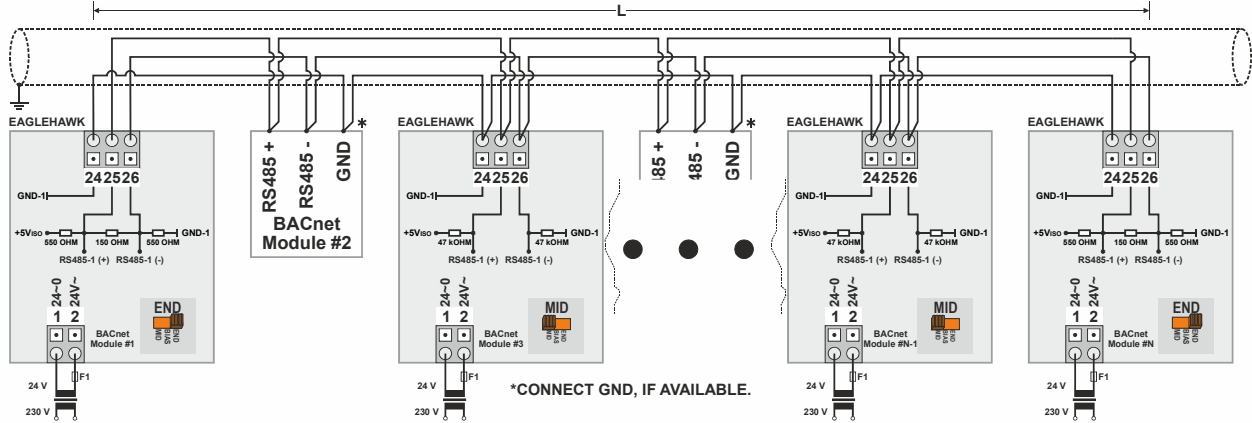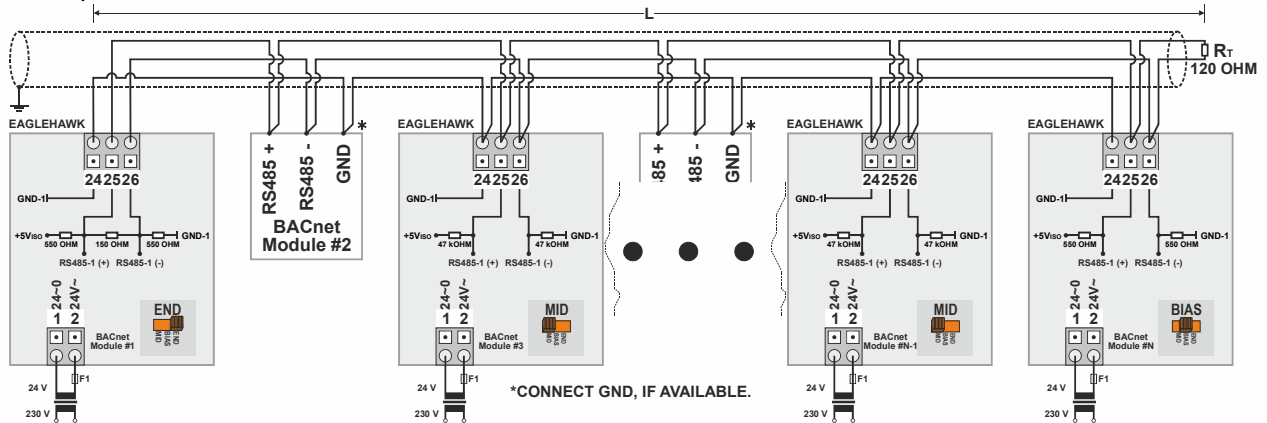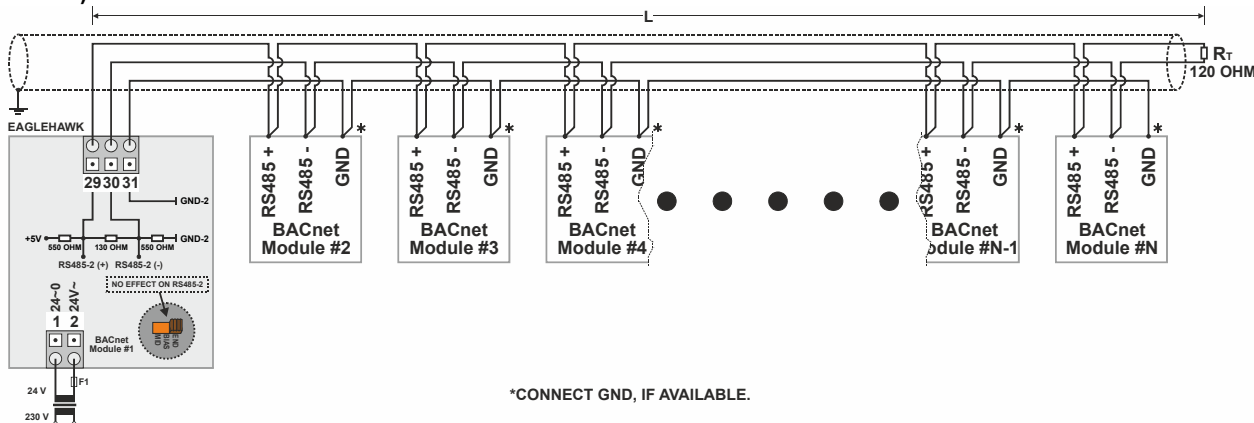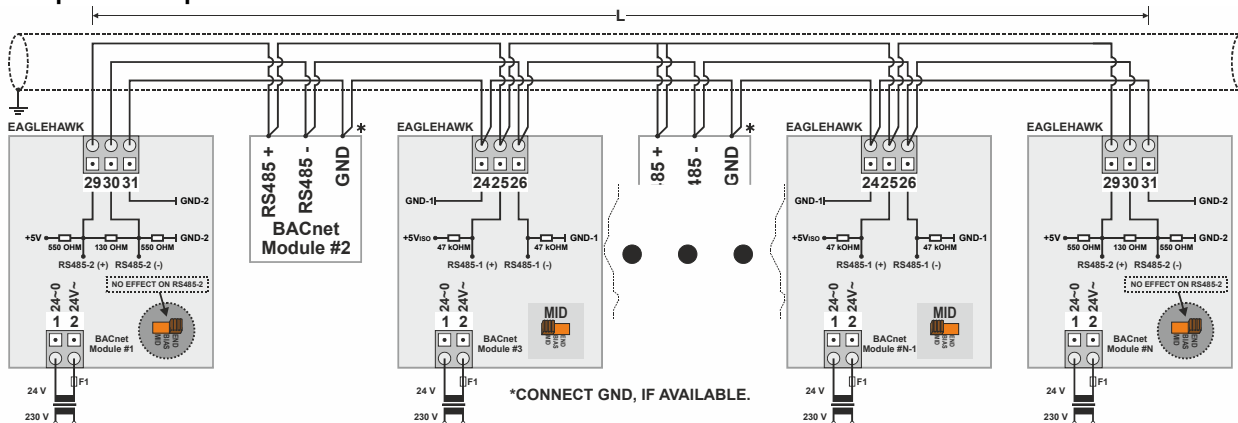

Fig. 43. Connection of multiple EAGLEHAWK controllers via their RS485-2 interfaces to a BACnet MS/TP Bus

MODBUS CONNECTION

The EAGLEHAWK controller supports both Modbus RTU master and Modbus RTU slave functionality.

Modbus slaves can be connected to either or both of the two onboard RS485 interfaces: RS485-1 (consisting of push-in terminals 24 [GND-1], 25, and 26) or RS485-2 (consisting of push-in terminals 29, 30, 31 [GND-2]).

NOTE: GND-2 is internally connected with 24V-0 (terminal 1)

Modbus Considerations

- **RS485-1 (isolated)**
    - Max. Modbus length: 1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps) (see also section "RS485 Standard" on pg. 9).
    - Use only shielded, twisted-pair cable and daisy-chain topology.
    - Must conform to EIA-RS485 cabling guidelines (see section "EIA 485 Cable Specifications" on pg. 25).
- **RS485-2 (non-isolated)**
    - Max. Modbus length: 1200 meters (9.6 – 78.8 kbps) or 1000 meters (115.2 kbps) (see also section "RS485 Standard" on pg. 9).
    - Use only shielded, twisted-pair cable and daisy-chain topology.
    - Ground noise should not exceed the EIA-485 common mode voltage limit.
    - Must conform to EIA-RS485 cabling guidelines (see section "EIA 485 Cable Specifications" on pg. 25).
    - Should not extend beyond a single building.
- **Max. no of Modbus devices per EAGLEHAWK: 32 (including the EAGLEHAWK, itself, which is counted twice)**

Connecting EAGLEHAWK via its RS485-1 Interface to a Modbus

With regards to Fig. 44, please note the following:

NOTE: Always power each EAGLEHAWK controller and the connected Modbus slaves via separate transformers.

NOTE: For "L," see section "RS485 Standard" on pg. 9.

NOTE: If any of the devices are electrically isolated, it is recommended that those devices be connected to signal ground. See section "RS485 Standard" on pg. 9).

Example: EAGLEHAWK Modbus Master Controller and Connected Modbus Slaves (with inserted termination resistor)
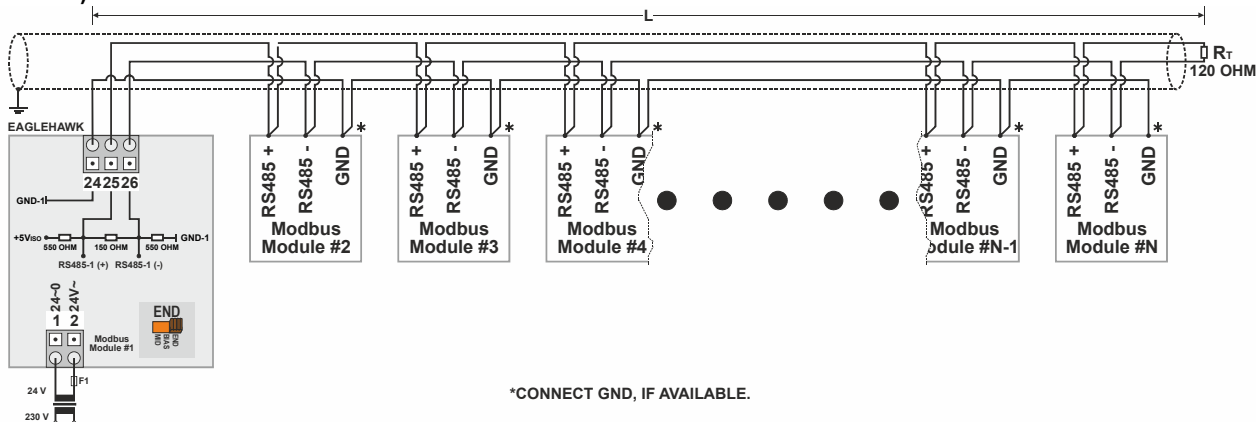
Fig. 44. Connection of an EAGLEHAWK Modbus master controller via its RS485-1 interface to a Modbus with slaves

The termination resistor must be inserted directly into the terminals of the last Modbus slave.

NOTE: If an EAGLEHAWK connected to a Modbus via its RS485-1 interface is itself to be used as a Modbus RTU slave, and if it is situated in a position other than the beginning or end of the Modbus, then its 3-position slide switch must be set to "Mid" (see Fig. 11). When situated at the beginning or end of the Modbus, then its 3-position slide switch must be set to "End" (see Fig. 13).

Connecting EAGLEHAWK via its RS485-2 Interface to a Modbus

With regards to Fig. 45, please note the following:

NOTE: Always power each EAGLEHAWK controller and the connected Modbus slaves via separate transformers.

NOTE: For "L," see section "RS485 Standard" on pg. 9.

NOTE: If any of the devices are electrically isolated, it is recommended that those devices be connected to signal ground. See section "RS485 Standard" on pg. 9).

NOTE: Between devices equipped with non-isolated RS485 bus interfaces, potential differences of max. ±7 V are allowed. Further, this bus should not extend beyond a single building.

Example: EAGLEHAWK Modbus Master Controller and Connected Modbus Slaves (with inserted termination resistor)
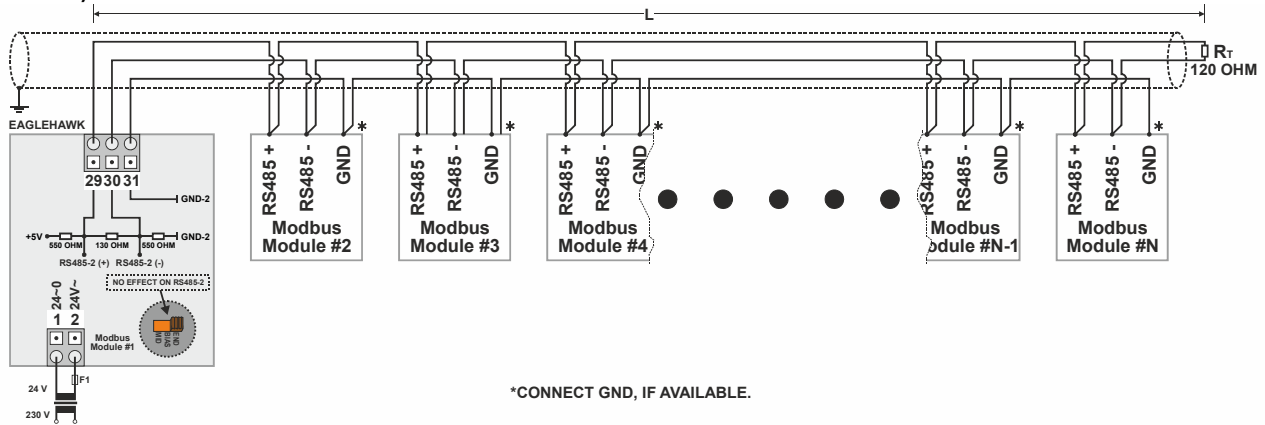
Fig. 45. Connection of an EAGLEHAWK Modbus master controller via its RS485-2 interface to a Modbus with slaves

The termination resistor must be inserted directly into the terminals of the last Modbus slave.

NOTE: If an EAGLEHAWK connected to a Modbus via its RS485-2 interface is itself to be used as a Modbus RTU slave, then it must be situated in a position at the beginning or at the end of the Modbus; this is because the bias and termination resistors of its RS485-2 interface are always ON (see Fig. 14).

M-BUS CONNECTION

The EAGLEHAWK controller supports M-Bus Master functionality via its onboard RS232 / RJ45 socket.

It uses standard PW3/PW20/PW60 converters to connect to the M-Bus devices.

M-Bus Considerations

Max. no. of M-Bus devices per EAGLEHAWK: 60.

Bus Length

- Max. M-Bus length: 350 meters from PW3 / PW20 / PW60, at baud rates of 9.6 kbaud or slower with shielded, twisted pair cable: J-Y-(St)-Y 2 x 2 x 0,8.
- The M-Bus can be extended to 1,000 meters, depending upon the baud rate, and provided that the following electrical limitations are observed:
  - Bus voltage must at no point fall below 12 VDC
  - Maximum cable capacitance of 180 nF

For bus length extension, M-Bus repeaters can be used, but have not been tested by Honeywell. Hence, it is the responsibility of the installing / commissioning personnel to ensure proper functioning.

Wiring Topology
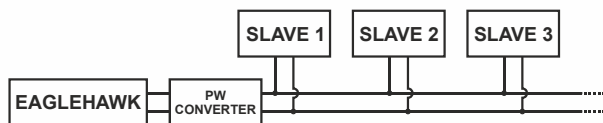
M-Bus meters are connected to the bus cable in parallel.

Fig. 46. Allowed M-Bus wiring topology

Cabling EAGLEHAWK to PW3/PW20/PW60

- Use the XW586 cable between the RS232 / RJ45 socket of the EAGLEHAWK and the PW adapters.
- The XW586 cable has a length of 1.8 m, and the pin-out listed in Table 25.
- In case a third-party cable is used instead of the XW586 cable, the third-party cable must have a max. length of 15 meters and a max. cable capacitance of 2,500 pF.

Table 24. EAGLEHAWK RS232 / RJ45 socket specifications

RJ45 plug, pin no.	RS232 function
1	
2	RxD
3	TxD
4	
5	GND
6	
7	
8	
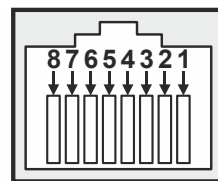
Fig. 47. EAGLEHAWK RS232 / RJ45 socket

Table 25. RS232-to-PW cable specifications

RJ45 plug, pin no.	RS232 function	9-Pin sub-D connector pin no.
1	DCD	1
2	RxD	2
3	TxD	3
4	DTR	4
5	GND	5
6	DSR	6
7	RTS	7
8	CTS	8
--	Not used	9
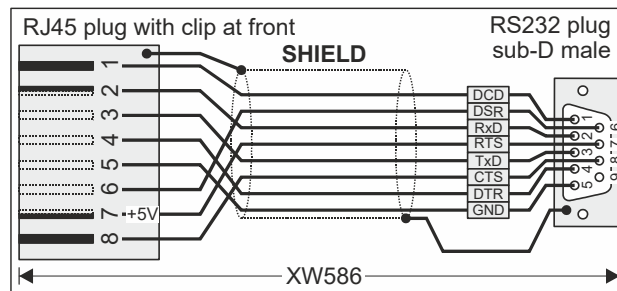
Fig. 48. XW586 power / communication cable details

Cabling PW3/PW20/PW60 to M-Bus

- Use shielded, twisted pair cable J-Y-(St)-Y 2 x 2 x 0,8.
- Shielding is especially recommended when the M-Bus cable is installed in areas with expected or actual electro-magnetic noise. Avoiding such areas is to be preferred.
- Connect the shield to a noise-free earth ground – only once per M-Bus connection.
- Power the EAGLEHAWK controller and the PW M-Bus Adapter with separate transformers – see WARNING below.

NOTE: If, alternatively, only a single transformer is available, when connecting a laptop, PC, web browser, CL-Touch, or 3rd-party touch panel to the USB 2.0 Device Interface on the front of the EAGLEHAWK controller, use an optical isolator for the USB connection or substitute an M-Bus Mikro-Master USB (Relay GmbH, D-33106 Paderborn) for the PW M-Bus Adapter.

M-Bus Connection Procedure

1. Install the PW M-Bus Adapter on DIN rail. Insert a screwdriver into the slot in the DIN rail clamp on the underside of the PW and pry downward to loosen clamp until the unit snaps onto the rail.
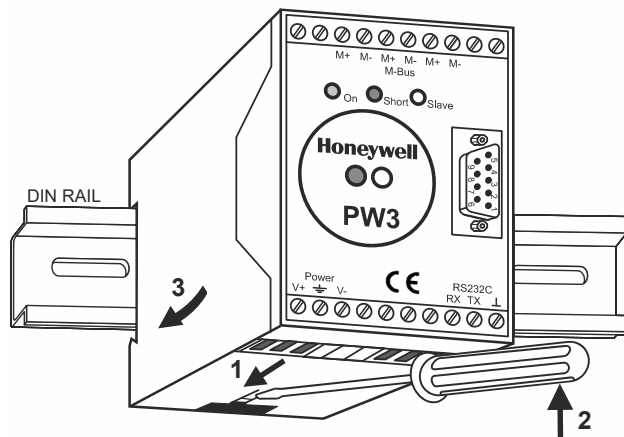
Fig. 49. Mounting of PW (PW3 shown here)

2. Connect the M-Bus devices to the PW M-Bus Adapter. All M+ and M- terminals are connected in parallel in the PW M-Bus Adapter.
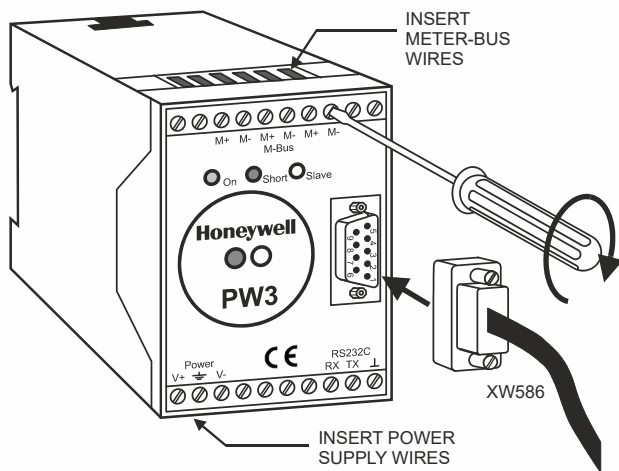
Fig. 50. PW M-Bus adapter connections

3. Connect the PW M-Bus Adapter to the RS232 / RJ45 socket of the EAGLEHAWK using the XW586 cable.
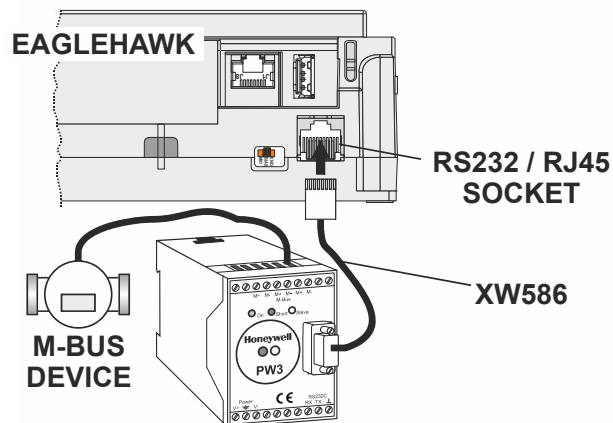
Fig. 51. Connecting the EAGLEHAWK to the PW M-Bus adapter

4. Connect 24 V power to the M-Bus Adapter.

⚠ WARNING

Risk of electric shock or equipment damage!
► Due to the risk of short-circuiting (see Fig. 20), it is strongly recommended that the EAGLEHAWK controller be supplied with power from a dedicated transformer. However, if the EAGLEHAWK controller is to be supplied by the same transformer powering other controllers or devices (e.g., the PW M-Bus Adapter), care must be taken to ensure that correct polarity is observed.
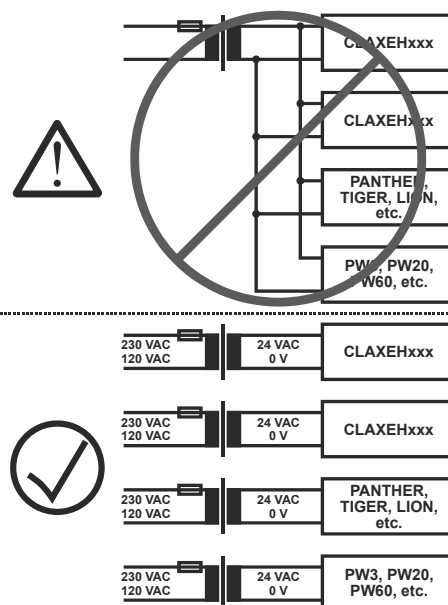
Fig. 52. Connecting power to the PW M-Bus adapter

EFFECT OF POLL RATE + SUBSCRIBED POINTS ON CPU LOAD

The poll rate set for the EAGLEHAWK and the chosen number of subscribed points both make a demand on the CPU load. The EAGLEHAWK has been verified to support the following scenario.
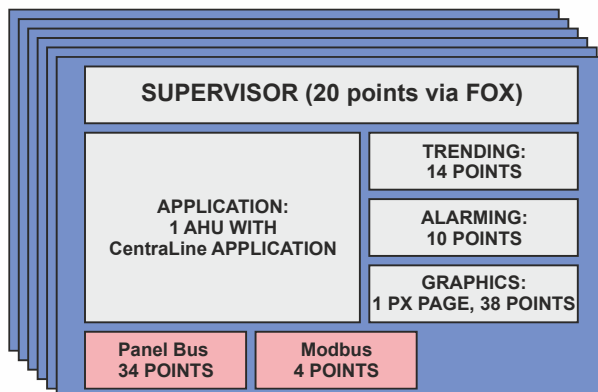
Fig. 53. Example application

In this scenario, the EAGLEHAWK is controlling 6 AHU plants which are using CentraLine Macros.

In this scenario, the following is assumed:

- Each EAGLEHAWK is connected to one Mixed I/O Panel Bus module (with 34 points), with a normal poll rate (10s);
- There are 4 Modbus points, with a normal poll rate (5s);
- 10 Panel Bus and 4 Modbus points are in trend;
- 1 PX graphic with 38 points;
- 10 alarm extensions;
- 20 points have been exported to Niagara Supervisor;
- All points on the Supervisor are subscribed;
- All Modbus points are subscribed;
- One graphic is visible on the screen.

The following table provides information on the effect of the number of subscribed points and the poll rate upon the CPU load. In all cases, it is assumed that the given bus is without control logic, alarming, or trending, and that it is the only bus running at the EAGLEHAWK.

Table 26. Effects of poll rate and no. of subscribed points on CPU load

bus	no. of subscribed points	poll rate	value change-time	CPU load (approx.)
Panel Bus	400	10 sec (normal)	N/A	52%
Panel Bus	400	1 sec (fast)	N/A	71%
BACnet MS/TP	400	10 sec (normal)	N/A	60%
BACnet MS/TP	200	COV	20 sec	58%
C-Bus	100	COV	15 sec	29%

NOTE: The CPU load should never exceed 80% on a continuous basis. The default load (with an empty station) is approx. 15%.

TROUBLESHOOTING

EAGLEHAWK Controller Troubleshooting

The following LEDs of the EAGLEHAWK controller can be used for troubleshooting purposes:

- Power LED (green)
- Status LED (red)
- L1 and L2 LEDs (yellow)
- Tx (sending data on RS485-1) and Rx (receiving data on RS485-1) LEDs

Power LED (green) of EAGLEHAWK

Table 27. EAGLEHAWK controller power LED

case	power LED	meaning	remedy
1	ON	Normal operation	No action necessary.
2	OFF	Power supply not OK.	► Check power supply voltage. ► Check wiring. ► If problem persists, replace hardware.

Status LED (red) of EAGLEHAWK

Table 28. EAGLEHAWK controller status LED

case	status LED	meaning	remedy
1	OFF after power-up	Normal operation.	No action necessary.
2	ON continuously after power-up	– No or invalid firmware, or – No or corrupt application.	► Try powering down and then powering up the EAGLEHAWK controller. ► If problem persists, replace hardware.

L1 LED

Table 29. EAGLEHAWK controller bus L1 LED

case	bus LEDs	meaning	remedy
1	ON continuously after power-up	Normal operation; this may continue for several minutes until the platform is running	No action necessary.
2	Flashes constantly	The platform is running	No action necessary.
3	Dark	Severe software problems.	► Contact TAC.

L2 LED

Table 30. EAGLEHAWK controller bus L2 LED

case	bus LEDs	meaning	remedy
1	ON continuously after power-up	Station is starting up. It may take several minutes until the station is ready to communicate.	No action necessary. ► If you are unable to establish communication, consult "Application Director Output" in COACH^{AX}.
2	Dark	Station is not running	► Contact TAC.

Tx and Rx LEDs

Table 31. EAGLEHAWK controller bus LEDs Tx and Rx

case	bus LEDs	meaning	remedy
1	Both Tx and Rx are flashing	Normal operation; RS485-1 is functioning properly.	No action necessary
2	Both Tx and Rx are OFF	No communication on RS485-1.	► Switch ON communication on RS485-1. L1 should then flash. Further handling like case 4 (below).
3	Rx is flashing and Tx is OFF	Communication on RS485-1 has been switched OFF, but the EAGLEHAWK is receiving data from other controllers.	► Switch ON communication on RS485-1. If this proves unsuccessful, the hardware may be defective.
4	Tx is flashing and Rx is OFF	The EAGLEHAWK controller is attempting to establish communication on RS485-1, but there is no answer.	► The communication rate (Kbaud) on RS485-1 has not been correctly set; other controllers on the bus may have been incorrectly assigned the same device number; wiring problem or hardware defect.

Panel Bus I/O Module Troubleshooting

Please refer to CentraLine I/O Modules - Installation & Commissioning Instructions (EN1Z-0973GE51) for more information about Panel Bus I/O module troubleshooting.

APPENDIX 1: EARTH GROUNDING

EAGLEHAWK Systems and SELV

In order to avoid distribution of noise or earth ground potential differences over networks or other connections, the EAGLEHAWK controller is designed to be in compliance with SELV (Safety Extra-Low Voltage).

Furthermore, SELV offers the greatest possible safety against electrical impact.

To support SELV, all Honeywell external (CRT series) or internal transformers comply with standard EN60742.

Earth grounding is therefore not recommended.

EAGLEHAWK Systems and Standard EN60204-1

However, if compliance with EN60204-1 is required, note the following:

General Information about EN60204-1

EN60204-1 defines electrical safety for a complete application / machine including controllers, sensors, actuators and any connected/controlled electrical device.

EN60204-1 requires controllers to be powered by PELV (Protective Extra-Low Voltage) and earth grounding of the secondary side of the used transformers or earth grounding of the system ground.

Earth grounding is prescribed to prevent unexpected start-up of connected rotating/moving machines due to an insulation fault and double earth grounding somewhere in the plant.

In order to fulfill PELV (if earth grounding is prohibited), the use of an earth leakage monitor is also possible.

When is EN60204-1 Applicable to EAGLEHAWK Systems?

- **Safety against electrical impact**
    - EN60204-1 is not mandatory; this is because electrical safety is provided by the use of SELV and transformers according to standard EN60742.

- **Safety against unexpected start-up of rotating/moving machines**
    - If the application/plant does not contain machines that can be harmful to the operator due to an unexpected start-up, the standard EN60204-1 is not applicable.

If such machines are encountered, then EN60204-1 must be followed. Grounding is required.

Earth Grounding of EN60204-1 Applicable Systems

NOTE: We strongly recommend that each CPU be supplied with electricity from its own dedicated transformer.

► If system protective earth grounding is planned, use a cable as short as possible for grounding: min. 1.5 mm² (16 AWG).

► For connection details, refer to the following examples.

Example 1

The following explains how to connect and earth multiple CPUs (e.g., multiple EAGLEHAWKs, PANTHERs, TIGERs, LIONs, etc. or any combination thereof) earth-grounded as per EN60204-1.

NOTE: Use a noise-free earth ground inside the cabinet.

NOTE: If a field device that prohibits earth grounding is connected to the system ground, an isolation monitoring device must be used instead of earth grounding.

► Connect earth ground to the respective terminal of the CPU, see Fig. 55.
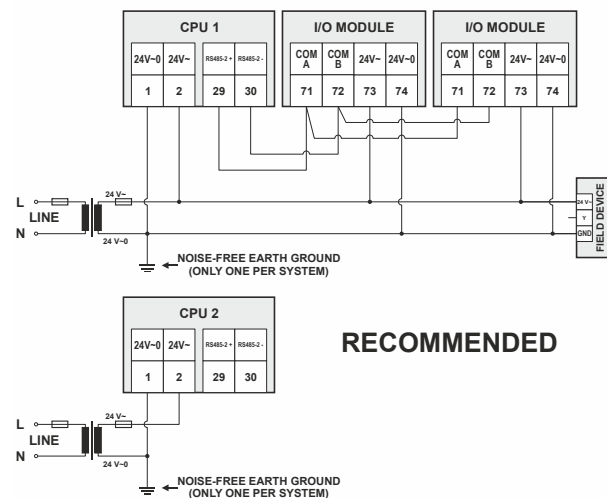
Fig. 54. Connecting and earthing multiple CPUs (RECOMMENDED USE OF SEPARATE TRANSFORMERS)

Example 2

When connecting multiple CPUs to a single transformer, it is imperative that the polarity of the power supply terminals of the CPUs and the polarity of the transformer always correspond (namely: 24V-0 of the transformer must always be connected to 24V-0 of the CPU, and 24V~ of the transformer must always be connected with 24V~ of the CPU).

Depending upon the individual CPU, the numbering of the corresponding two terminals may possibly deviate from the norm (which is usually "terminal 1 = 24V-0" and "terminal 2 = 24V~"). In the following example, CPU 3 has a deviating numbering and must be connected accordingly.

NOTE: When using a single transformer for several CPUs, each CPU ground must be wired separately to the star-point.

NOTE: If the field device transformer is physically far away from the CPUs, earth grounding must still be performed for the controller.

NOTE: Use one star-point to split power for multiple CPUs and field devices.

► Connect earth ground to the proper terminal of the CPU.
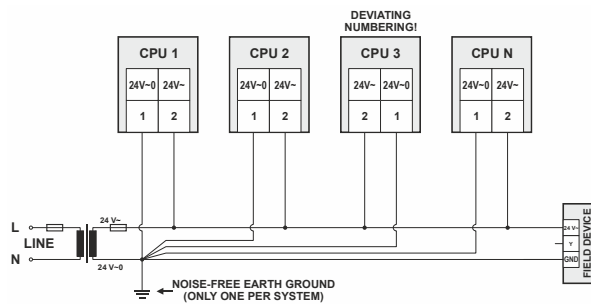
Fig. 55. Connecting and earthing multiple CPUs

APPENDIX 2
Sensor Input Accuracy

The internal sensor inputs of the EAGLEHAWK Controller support both NTC10kΩ and NTC20kΩ sensors (see also section "Universal Inputs" on page 16). The following table lists the typical minimum accuracies of the hardware and software for temperature sensors.

Table 32. Accuracies of internal NTC20kΩ sensor inputs of the EAGLEHAWK

range	measurement error (excl. sensor characteristics)	
	NTC10kΩ sensors[1	**NTC20kΩ sensors**
-50 … -20 °C (-58 … -4 °F)	≤ 5.0 K	≤ 5.0 K
-20 … 0 °C (-4 … +32 °F)	≤ 1.0 K	≤ 1.0 K
0 … 30 °C (32 … 86 °F)	≤ 0.5 K	≤ 0.3 K
30 … 70 °C (86 … 158 °F)	≤ 0.5 K	≤ 0.5 K
70 … 100 °C (158 … 212 °F)	≤ 1.0 K	≤ 1.0 K
100 … 130 °C (212 … 266 °F)	--	≤ 3.0 K
130 … 150 °C (266 … 302 °F)	--	≤ 5.5 K
150 … 400 °C (302 … 752 °F)	--	--
[1 NTC10kΩ specified for -30 … +100 °C, only.		

NOTE: This is the accuracy of the internal sensor input (hardware + software [linearization]), only. This table does not include the characteristics of the sensors, themselves (see section "Sensor Characteristics" below). If a different sensor or sensor accuracy is required, one may instead use the inputs of, e.g., a connected Panel I/O module.

Recognition of Sensor Failure of Sensor Inputs

The thresholds at which sensor failures – i.e., sensor breaks (SB) and short-circuits (SC) – are recognized depends upon the given sensor type. In the event of a recognized sensor failure, the sensor inputs assume the safety values configured in COACH[AX]. Table 33 lists the measurement ranges and the corresponding thresholds for the recognition of sensor failure for the various different sensor types:

Table 33. Thresholds for short-circuit (SC) and sensor-break (SB) recognition

I/O configuration	measurement range	recognition thresholds
2…10 V	2…10 V / 4…20 mA (without pull-up)	SC: < 1.5 V / 3 mA; SB: no recognition
NTC10kΩ	-30 … +100 °C	SC: < 20 Ω; SB: < -70 °C
NTC20kΩ	-50 … +150 °C	SC: < 20 Ω; SB: < -70 °C

NOTE: In the case of temperatures lying *outside* the aforementioned ranges, the lowest/highest value *within* the range, instead, will be communicated. Thus a temperature of -51 °C will be communicated as "-50 °C."

Sensor Characteristics

The characteristics (resistance in relation to temperature) of the sensors and the resultant voltage are listed on the following pages. The stated values 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.

NTC 20 kΩ (same voltages for inputs of Panel Bus I/O Modules and onboard inputs of EAGLEHAWK)

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]	Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]	Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]	Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
-50.0	1659	8.78	6.0	51.1	6.20	62.0	4.18	1.41	118.0	0.64	0.252
-49.0	1541	8.77	7.0	48.5	6.10	63.0	4.03	1.37	119.0	0.63	0.245
-48.0	1432	8.76	8.0	46.0	6.00	64.0	3.88	1.32	120.0	0.61	0.238
-47.0	1331	8.75	9.0	43.7	5.90	65.0	3.73	1.28	121.0	0.59	0.231
-46.0	1239	8.74	10.0	41.6	5.80	66.0	3.59	1.24	122.0	0.57	0.225
-45.0	1153	8.72	11.0	39.5	5.70	67.0	3.46	1.20	123.0	0.56	0.219
-44.0	1073	8.71	12.0	37.6	5.59	68.0	3.34	1.16	124.0	0.54	0.213
-43.0	1000	8.70	13.0	35.7	5.49	69.0	3.21	1.13	125.0	0.53	0.207
-42.0	932	8.69	14.0	34.0	5.38	70.0	3.10	1.09	126.0	0.51	0.201
-41.0	869	8.67	15.0	32.3	5.28	71.0	2.99	1.06	127.0	0.50	0.196
-40.0	811	8.66	16.0	30.8	5.17	72.0	2.88	1.02	128.0	0.49	0.191
-39.0	757	8.64	17.0	29.3	5.07	73.0	2.78	0.991	129.0	0.47	0.186
-38.0	706	8.62	18.0	27.9	4.96	74.0	2.68	0.960	130.0	0.46	0.181
-37.0	660	8.60	19.0	26.6	4.85	75.0	2.58	0.929	131.0	0.45	0.176
-36.0	617	8.58	20.0	25.3	4.75	76.0	2.49	0.900	132.0	0.43	0.171
-35.0	577	8.56	21.0	24.2	4.64	77.0	2.41	0.872	133.0	0.42	0.167
-34.0	539	8.54	22.0	23.0	4.53	78.0	2.32	0.844	134.0	0.41	0.162
-33.0	505	8.52	23.0	22.0	4.43	79.0	2.24	0.818	135.0	0.40	0.158
-32.0	473	8.49	24.0	21.0	4.32	80.0	2.17	0.792	136.0	0.39	0.154
-31.0	443	8.47	25.0	20.0	4.22	81.0	2.09	0.767	137.0	0.38	0.150
-30.0	415	8.44	26.0	19.1	4.12	82.0	2.02	0.744	138.0	0.37	0.146
-29.0	389	8.41	27.0	18.2	4.01	83.0	1.95	0.720	139.0	0.36	0.142
-28.0	364	8.38	28.0	17.4	3.91	84.0	1.89	0.698	140.0	0.35	0.139
-27.0	342	8.35	29.0	16.6	3.81	85.0	1.82	0.676	141.0	0.34	0.135
-26.0	321	8.32	30.0	15.9	3.71	86.0	1.76	0.655	142.0	0.33	0.132
-25.0	301	8.28	31.0	15.2	3.62	87.0	1.70	0.635	143.0	0.32	0.128
-24.0	283	8.25	32.0	14.5	3.52	88.0	1.65	0.616	144.0	0.32	0.125
-23.0	266	8.21	33.0	13.9	3.43	89.0	1.59	0.597	145.0	0.31	0.122
-22.0	250	8.17	34.0	13.3	3.33	90.0	1.54	0.578	146.0	0.30	0.119
-21.0	235	8.13	35.0	12.7	3.24	91.0	1.49	0.561	147.0	0.29	0.116
-20.0	221	8.08	36.0	12.1	3.15	92.0	1.44	0.544	148.0	0.29	0.113
-19.0	208	8.04	37.0	11.6	3.06	93.0	1.40	0.527	149.0	0.28	0.110
-18.0	196	7.99	38.0	11.1	2.97	94.0	1.35	0.511	150.0	0.27	0.107
-17.0	184	7.94	39.0	10.7	2.89	95.0	1.31	0.496			
-16.0	174	7.89	40.0	10.2	2.81	96.0	1.27	0.481			
-15.0	164	7.83	41.0	9.78	2.72	97.0	1.23	0.466			
-14.0	154	7.78	42.0	9.37	2.64	98.0	1.19	0.452			
-13.0	146	7.72	43.0	8.98	2.57	99.0	1.15	0.439			
-12.0	137	7.66	44.0	8.61	2.49	100.0	1.11	0.425			
-11.0	130	7.60	45.0	8.26	2.42	101.0	1.08	0.413			
-10.0	122	7.53	46.0	7.92	2.34	102.0	1.05	0.401			
-9.0	116	7.46	47.0	7.60	2.27	103.0	1.01	0.389			
-8.0	109	7.39	48.0	7.29	2.20	104.0	0.98	0.378			
-7.0	103	7.32	49.0	7.00	2.14	105.0	0.95	0.367			
-6.0	97.6	7.25	50.0	6.72	2.07	106.0	0.92	0.356			
-5.0	92.3	7.17	51.0	6.45	2.01	107.0	0.90	0.346			
-4.0	87.3	7.09	52.0	6.19	1.94	108.0	0.87	0.336			
-3.0	82.6	7.01	53.0	5.95	1.88	109.0	0.84	0.326			
-2.0	78.2	6.93	54.0	5.72	1.82	110.0	0.82	0.317			
-1.0	74.1	6.85	55.0	5.49	1.77	111.0	0.79	0.308			
0.0	70.2	6.76	56.0	5.28	1.71	112.0	0.77	0.299			
1.0	66.5	6.67	57.0	5.08	1.66	113.0	0.75	0.290			
2.0	63.0	6.58	58.0	4.88	1.61	114.0	0.73	0.282			
3.0	59.8	6.49	59.0	4.69	1.56	115.0	0.70	0.274			
4.0	56.7	6.40	60.0	4.52	1.51	116.0	0.68	0.266			
5.0	53.8	6.30	61.0	4.35	1.46	117.0	0.66	0.259			

NTC10kΩ (same voltages for inputs of Panel Bus I/O Modules and onboard inputs of EAGLEHAWK)

Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]	Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]	Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]	Temp. [°C]	Resistance [kΩ]	Terminal voltage [V]
-30	177	7.904	12	18.087	3.998	54	3.099	1.092	96	0.765	0.297
-29	166.35	7.848	13	17.252	3.894	55	2.986	1.057	97	0.743	0.289
-28	156.413	7.790	14	16.46	3.792	56	2.878	1.023	98	0.721	0.280
-27	147.136	7.730	15	15.708	3.690	57	2.774	0.990	99	0.7	0.276
-26	138.47	7.666	16	14.995	3.591	58	2.675	0.959	100	0.68	0.265
-25	130.372	7.601	17	14.319	3.492	59	2.579	0.928			
-24	122.8	7.534	18	13.678	3.396	60	2.488	0.898			
-23	115.718	7.464	19	13.068	3.300	61	2.4	0.870			
-22	109.089	7.392	20	12.49	3.207	62	2.316	0.842			
-21	102.883	7.318	21	11.94	3.115	63	2.235	0.815			
-20	97.073	7.241	22	11.418	3.025	64	2.158	0.790			
-19	91.597	7.161	23	10.921	2.937	65	2.083	0.765			
-18	86.471	7.080	24	10.449	2.850	66	2.011	0.740			
-17	81.667	6.996	25	10	2.767	67	1.943	0.718			
-16	77.161	6.910	26	9.572	2.684	68	1.877	0.695			
-15	72.932	6.821	27	9.165	2.603	69	1.813	0.673			
-14	68.962	6.731	28	8.777	2.524	70	1.752	0.652			
-13	65.231	6.639	29	8.408	2.447	71	1.694	0.632			
-12	61.723	6.545	30	8.057	2.372	72	1.637	0.612			
-11	58.424	6.448	31	7.722	2.299	73	1.583	0.593			
-10	55.321	6.351	32	7.402	2.228	74	1.531	0.575			
-9	52.399	6.251	33	7.098	2.159	75	1.481	0.557			
-8	49.648	6.150	34	6.808	2.091	76	1.433	0.541			
-7	47.058	6.047	35	6.531	2.025	77	1.387	0.524			
-6	44.617	5.943	36	6.267	1.962	78	1.342	0.508			
-5	42.317	5.838	37	6.015	1.900	79	1.299	0.493			
-4	40.15	5.732	38	5.775	1.840	80	1.258	0.478			
-3	38.106	5.624	39	5.546	1.781	81	1.218	0.464			
-2	36.18	5.516	40	5.327	1.724	82	1.179	0.450			
-1	34.363	5.408	41	5.117	1.669	83	1.142	0.436			
0	32.65	5.299	42	4.917	1.616	84	1.107	0.423			
1	31.027	5.189	43	4.726	1.564	85	1.072	0.411			
2	29.494	5.079	44	4.543	1.514	86	1.039	0.399			
3	28.047	4.969	45	4.369	1.465	87	1.007	0.387			
4	26.68	4.859	46	4.202	1.418	88	0.976	0.375			
5	25.388	4.750	47	4.042	1.373	89	0.947	0.365			
6	24.166	4.641	48	3.889	1.329	90	0.918	0.354			
7	23.01	4.532	49	3.743	1.286	91	0.89	0.344			
8	21.916	4.423	50	3.603	1.244	92	0.863	0.334			
9	20.88	4.316	51	3.469	1.204	93	0.838	0.324			
10	19.898	4.209	52	3.34	1.166	94	0.813	0.315			
11	18.968	4.103	53	3.217	1.128	95	0.789	0.306			

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