# Epec 3720 Control Unit

## Technical Manual and Cabling Instructions

MAN000673




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**3720-01**

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Epec Oy
Postal address
PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland
Phone
+358-(0)20-7608 111
Internet
www.epec.fi

# 1 PREFACE

## 1.1 Use of Symbols

This manual uses the following symbols to point out important information or safety instructions:



The information icon indicates important information and issues to be noted for the reader.



The caution icon indicates very important information or a warning. If the advices are ignored, it can result in personal injury or damage to software or equipment.



The (electrical) warning icon indicates a hazard which could cause an electrical danger and/or a personal injury.

This product uses the following symbols to point out important information or safety instructions:



CE compatibility
This symbol indicates that the product complies with the requirements set in the CE Standard.



WEEE symbol
This symbol indicates that the product must be sent to separate collection facilities for recovery and recycling when the end-user wishes to discard the product.




E17 Approval
This symbol indicates that the product is certified with normal automotive (E17) EMC (electromagnetic compatibility) standards.

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## 1.2 Basic Skills Required

The user of this document must have basic knowledge of machine controlling, CAN communication, PLCopen programming according to IEC61131-3 and should have skills to use CODESYS 3.5 programming environment.

Refer to CODESYS manual for further information concerning the programming environment and required installations.

Refer to CAN and CANopen documentation from CAN in Automation (CiA) for further information on communication issues.

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PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland

Phone
+358-(0)20-7608 111

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### 1.3 Safety Guidelines

The user of this documentation should follow general machine safety guidelines, directives and regulation appropriate to their country or market area.

A separate safety analysis is always recommended for the machine and its control system. The features of this product should be well documented in machine and control system documents so that the machine operator has the right information how to operate the machine correctly and safely.

This product is designed to be used only for machine controlling purposes. The manufacturer does not assume any responsibility for this product being fit for any particular application, unless otherwise expressly stated in writing by the manufacturer.

This product complies with those certifications and standards that are mentioned in this manual. The manufacturer does not guarantee that this product complies with any other certification, standard or test other than mentioned in this manual.

This product is not field serviceable, so it should not be opened at any situation.

External fuses should be installed for the product or the system power supply.

The system should be designed and constructed according to the Epec general mounting and cabling instruction document.

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Phone
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## 1.4 Warranty

The manufacturer does not assume any responsibility for the products being fit for any particular purpose, unless otherwise expressly stated in writing by the manufacturer.

The manufacturer gives the warranty of twelve (12) months to the products and thereto related firmware from commissioning or eighteen (18) months from the date of delivery of the products which ever occurs first.

The manufacturer is during the warranty period responsible for defects in the products and thereto related firmware resulting from faults in material, design or workmanship. The manufacturer's only obligation under this warranty is to, at its sole discretion, either to replace the products and/or thereto related firmware or to repair the defective products. The manufacturer shall, at its sole option, repair the products at its manufactory in Seinäjoki, Finland.

The warranty does not cover any costs related to removing or fastening of devices related to the products. Neither does the warranty cover the expenses of sending devices to or from the manufacturer for repairs. The warranty does not cover possible expenses relating to travelling, accommodation, daily benefits, etc. of installers.

The warranty becomes null and void if the buyer and/or a third party alters the products or the firmware in any way or if they are not used in accordance with the Manufacturer's operating instructions.

All claims with respect to defects in the products shall be made to the manufacturer without delay and no later than on the seventh (7th) day after the defect has been or should have been discovered by the buyer. The manufacturer strives to reply to the claim in writing within two (2) weeks from the receipt of the claim. The buyer shall attach to the claim a possible error report or equivalent explanation of the grounds for the claim.

The manufacturer gives no other warranties whatsoever for the products than the warranty set out in this section and thus the warranty given in this section sets forth the warranty given by the manufacturer in its entirety.

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FIN-60101 Seinäjoki, Finland
Phone
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### 1.5 Limited Liability

The manufacturer shall under no circumstances be liable for loss of production, loss of profit, loss of use or any other consequential damages and/or indirect losses, whatever their cause may be. In case claims based on product liability are brought against the Manufacturer for which claims the manufacturer may be liable, the manufacturer's liability is limited to the extent normally covered under normal product liability insurances.

The buyer shall compensate the manufacturer to the extent that the manufacturer might be liable to pay damages as a result of claims based on product liability according to paragraph above.

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PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland
Phone
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### 1.6 Environmental Statement

The manufacturer uses ISO14001 environmental certified processes and materials to manufacture products. The manufacturer undertakes to arrange for the recycling and scrapping of the products that are returned to the manufacturer by the buyer and/or the products that are received by the Manufacturer in connection with maintenance services performed as a result of that repairing of the products is deemed by the Manufacturer to be inappropriate.

The manufacturer will charge a scrapping fee from the buyer according to the manufacturer's price list in force from time to time. No scrapping fee will, however, be charged for products that are received by the manufacturer during the warranty period.

**WEEE**
This product complies with the European Community Directive 2012/19/EU on waste electrical and electronic equipment (WEEE) encouraging and setting specific criteria for the collection, handling and recycling of electric and electronic waste.

**RoHS**
This product complies with the European Community Directive 2011/65/EU (RoHS) restricting hazardous substances such as quicksilver and lead in electrical and electronic equipment.

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FIN-60101 Seinäjoki, Finland
Phone
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# 2 PRODUCT OVERVIEW



Epec 3720 Control Unit is a compact and robust multifunction controller with 16-bit processor and high calculating power. Epec 3000 product platform is fully compatible to the existing Epec product portfolio. Some of the advances of the Epec 3720 Control Unit are listed below.

**Multifunctional Efficiency**

- A multifunction controller
  - 16/32 bit processor
  - high calculating power
- Can be used used in a CAN control unit system as a controller with different kinds of sensors and actuators, such as
  - proportional valves,
  - servo motors, and
  - electro-hydraulic components
- Provides control system solutions for both centralized and distributed intelligence systems
- Fully compatible with the existing Epec product portfolio

**Mechanics & hardware**

- Robust, light and leak proof aluminum cover has been widely tested against different chemicals and environmental conditions
- The shape of the casing works to protect the electronics inside against mechanical wear.
- Equipped with gold plated, heavy duty AMPSEAL connectors
- Each connector is color coded and mechanically keyed to fit only to the correct, corresponding place
- Made in Finland

**Versatile I/O capabilities**

- Total of 59 I/O pins
- Most pins have multipurpose features
- All I/O pins are equipped with a short-circuit protection

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**Application programming**

- Application downloading is possible through CAN bus
- Epec products are based on PLCopen and CANopen®, which make them easily scalable to meet requirements for both small and large machines
- Open I/O and communication interface, thus making it possible to connect
    - sensors,
    - actuators,
    - joysticks, and
    - other devices

  from other manufacturers to optimize the whole machine environment, both technically and ergonomically.
- Internal diagnostics which makes it possible to
    - detect e.g. overvoltage and overtemperature alarms and
    - program customized log applications

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# 3 TECHNICAL DATA

| | |
|---|---|
| **Processor** | 16/32 bit CPU, 100 MHz |
| **Memory** | Flash memory: total 1600 kbytes<br>RAM memory: 1024 kbyte + 138 kbyte<br>(112kbyte for PLCopen application variables)<br>Non-volatile memory: 8 kbyte<br><br>PLCopen application size up to 768 kbyte |
| **Power** | Nominal supply voltage 12/24 VDC systems (8,5 ... 33 VDC)<br>Idle power consumption 1,5 W (+24 VDC, no external load) |
| **REF voltage outputs** | +5 V |
| **Diagnostics** | Supply voltage<br>Unit temperature<br>REF voltage monitoring<br>Internal voltage monitoring |
| **Protection functions** | Overvoltage protection<br>Short-circuit protection for outputs |
| **Programming** | CODESYS 2.3 |
| **Software installation** | Download via CAN1 |
| **Protection class** | IP67 |
| **Size / Outer dimensions** | 147 x 113 x 46 mm<br>5.787 x 4.448 x 1.811 in |
| **Weight** | 0,70 kg<br>1.54 lbs |
| **Case material** | Aluminum |
| **Operating temperature** | -40... +85˚C<br>-40...+185˚F |
| **Storage temperature** | -40... +85˚C<br>-40...+185˚F |
| **Connectors** | 3 x AMP23<br>1 x AMP8 |
| **Communications/ Interfaces** | 2 x CAN 2.0B |
| **I/O pins total** | 59 |

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| | | |
|---|---|---|
| **Outputs** | 24 x | PWM/DO/DI<br>(sourcing, up to 3 A, PWM frequency by application) |
| **Inputs** | 20 x<br>(10 pairs) | FB/AI<br>(current measuring feedback,0-1 A) |
| | 6 x | AI/DI<br>(0-5 V / 0-22 mA selection by application) |
| | 9 x | DI/PI<br>(pull-up to +5 V) |

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PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland

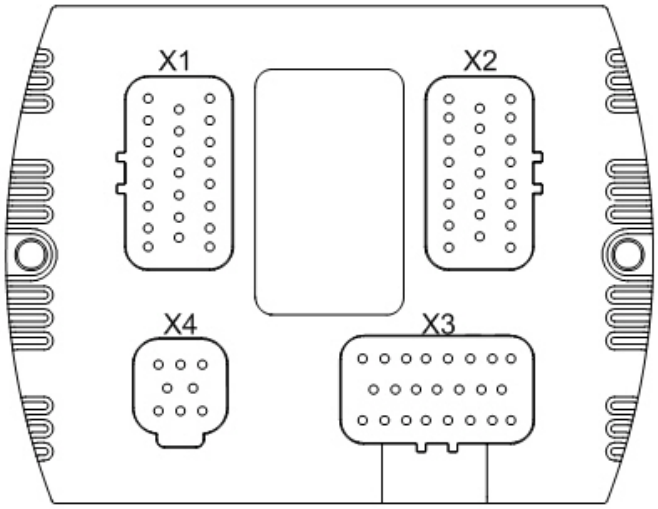
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+358-(0)20-7608 111

Internet
www.epec.fi

# 4 INPUT/OUTPUT SPECIFICATIONS

## 4.1 I/O List

The four connectors are placed in the control unit according to the following figure:




The following table lists the pins according their pin number. Other columns offer quick information about the pin and links for more information.

The group column:
* **smaller case characters** indicate the input groups (the pins in the same group have the same configurations)
**UPPER CASE CHARACTERS** indicate the output groups (the pins in the same group have the same configurations)

**Connector 1:**

| Pin number | Pin type | Details | Group* | Current / Voltage | Description |
|---|---|---|---|---|---|
| **First row:** | | | | | |
| X1.1 | PWM/DI/DO_Type051 | 10 kΩ GND | | Nominal current 3 A | |
| X1.2 | PWM/DI/DO_Type051 | 10 kΩ GND | | Nominal current 3 A | |
| X1.3 | FB/AI_Type065_6 | 0,22 Ω GND | a | 0-1 A | |
| X1.4 | Cross connected FB/AI | | a | | |
| X1.5 | FB/AI_Type065_6 | 0,22 Ω GND | b | 0-1 A | |
| X1.6 | Cross connected FB/AI | | b | | |
| X1.7 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |
| X1.8 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |
| **Second row:** | | | | | |
| X1.9 | PWM/DI/DO_Type051 | 10 kΩ GND | B | Nominal current 3 A | |
| X1.10 | FB/AI_Type065_6 | 0,22 Ω GND | c | 0-1 A | |

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| | | | | | |
|---|---|---|---|---|---|
| X1.11 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | | Nominal current 3 A | |
| X1.12 | GND | | | | |
| X1.13 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | | Nominal current 3 A | |
| X1.14 | FB/AI_Type065_6 | 0,22 Ω GND | d | 0-1 A | |
| X1.15 | PWM/DI/DO_Type051 | 10 kΩ GND | B | Nominal current 3 A | |
| **Third row:** | | | | | |
| X1.16 | PWM/DI/DO_Type051 | 10 kΩ GND | B | Nominal current 3 A | |
| X1.17 | Cross connected FB/AI | | c | | |
| X1.18 | PWM/DI/DO_Type051 | 10 kΩ GND | B | Nominal current 3 A | |
| X1.19 | PWM/DI/DO_Type051 | 10 kΩ GND | B | Nominal current 3 A | |
| X1.20 | FB/AI_Type065_6 | 0,22 Ω GND | e | 0-1 A | |
| X1.21 | Cross connected FB/AI | | e | | |
| X1.22 | Cross connected FB/AI | | d | | |
| X1.23 | PWM/DI/DO_Type051 | 10 kΩ GND | B | Nominal current 3 A | |

**Connector 2:**

| Pin number | Pin type | Details | Group* | Current / Voltage | Description |
|---|---|---|---|---|---|
| **First row:** | | | | | |
| X2.1 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | | Nominal current 3 A | |
| X2.2 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | | Nominal current 3 A | |
| X2.3 | FB/AI_Type065_6 | 0,22 Ω GND | f | 0-1 A | |
| X2.4 | Cross connected FB/AI | | f | | |
| X2.5 | FB/AI_Type065_6 | 0,22 Ω GND | g | 0-1 A | |
| X2.6 | Cross connected FB/AI | | g | | |
| X2.7 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | B | Nominal current 3 A | |
| X2.8 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | B | Nominal current 3 A | |
| **Second row:** | | | | | |
| X2.9 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |
| X2.10 | FB/AI_Type065_6 | 0,22 Ω GND | h | 0-1 A | |
| X2.11 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | | Nominal current 3 A | |
| X2.12 | GND | | | | |
| X2.13 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | | Nominal current 3 A | |
| X2.14 | FB/AI_Type065_6 | 0,22 Ω GND | i | 0-1 A | |
| X2.15 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |

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| | | | | | |
|---|---|---|---|---|---|
| **Third row:** | | | | | |
| X2.16 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |
| X2.17 | Cross connected FB/AI | | h | | |
| X2.18 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |
| X2.19 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |
| X2.20 | FB/AI_Type065_6 | 0,22 Ω GND | j | 0-1 A | |
| X2.21 | Cross connected FB/AI | | j | | |
| X2.22 | Cross connected FB/AI | | i | | |
| X2.23 | PWM/DI/DO_Type051_8 | 10 kΩ +24 V | A | Nominal current 3 A | |

**Connector 3:**

| Pin number | Pin type | Details | Group* | Current / Voltage | Description |
|---|---|---|---|---|---|
| **First row:** | | | | | |
| X3.1 | AUX OUT (U = $U_{in}$) | 10 kΩ GND | | max. 4 A | Shared current with pin 3.9 |
| X3.2 | REF +5V_Type041_4 | | | +5 V 270 mA | |
| X3.3 | AI/DI_Type064_2 | 2,2 kΩ +5 V / 220 Ω GND | | 0-5 V / 0-22 mA | |
| X3.4 | AI/DI_Type064_3 | 82 kΩ GND / 220 Ω GND | | 0-5 V / 0-22 mA | |
| X3.5 | AI/DI_Type064_3 | 82 kΩ GND / 220 Ω GND | | 0-5 V / 0-22 mA | |
| X3.6 | AI/DI_Type064_3 | 82 kΩ GND / 220 Ω GND | | 0-5 V / 0-22 mA | |
| X3.7 | AI/DI_Type064_3 | 82 kΩ GND / 220 Ω GND | | 0-5 V / 0-22 mA | |
| X3.8 | AI/DI_Type064_3 | 82 kΩ GND / 220 Ω GND | | 0-5 V / 0-22 mA | |
| **Second row:** | | | | | |
| X3.9 | AUX OUT (U = $U_{in}$) | 10 kΩ GND | | max. 4 A | Shared current with pin 3.1 |
| X3.10 | GND | | | | |
| X3.11 | GND | | | | |
| X3.12 | GND | | | | |
| X3.13 | GND | | | | |
| X3.14 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.15 | LOADER BSL | | | | |
| **Third row:** | | | | | |
| X3.16 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.17 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |

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| | | | | | |
|---|---|---|---|---|---|
| X3.18 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.19 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.20 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.21 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.22 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |
| X3.23 | DI/PI_Type046_1 | 10 kΩ +5 V | | | |

**Connector 4:**

| Pin number | Pin type | Details | Group* | Current / Voltage | Description |
|---|---|---|---|---|---|
| X4.1 | GND | Supply GND | | | |
| X4.2 | CAN1 H | | | | |
| X4.3 | GND | Supply GND | | | |
| X4.4 | Power Supply | | | | |
| X4.5 | Power Supply | | | | |
| X4.6 | CAN1 L | | | | |
| X4.7 | CAN2 H | | | | |
| X4.8 | CAN2 L | | | | |

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## 4.2 Configurable I/Os

Control unit contains inputs and outputs or, in other words, I/O pins of many different types. There are, for example, outputs which source current and outputs which sink current. Furthermore, there are I/O pins which can be used as inputs or as outputs at the control of the application programmer.

The following table contains a summary of configurable I/O pins in Epec 3720 control unit:

| Max Amount | Pin Type | Info | DI | AI | FB | PI | DO | | PWM |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | PNP (sourcing) | NPN (sinking) | |
| 8 | PWM/DO/DI_Type051 | 3 A, pull-down to GND | x | | | | x | | x |
| 16 | PWM/DI/DO_Type051_8 | 3 A, pull-up to +24 V | x | | | | x | | x |
| 20 (10 pairs) | FB/AI_Type065_6 | 0-1 A | | | x | | | | |
| 1 | AI/DI_Type064_2 | 0-5 V / 0-22 mA | x | x | | | | | |
| 5 | AI/DI_Type064_3 | 0-5 V / 0-22 mA | x | x | | | | | |
| 9 | DI/PI_Type046_1 | pull-up to +5 V | x | | | x | | | |

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## 4.3 PWM/DI/DO_Type051

### 4.3.1 Output (PWM/DO)

- These pins are current sourcing outputs.
  - In other words, pin connects the load to positive supply voltage.
- The application program can also simultaneously monitor the actual state of the pin.
  - This feature makes it possible to detect short circuits to the ground and short circuits to the power supply.
  - Open loads can not be detected because the internal load resistor is connected to the ground.

- These kind of outputs are also capable to generate pulse width modulated (PWM) output signals.
  - This feature is useful when driving proportionally controlled loads, e.g. proportional hydraulic valves.

- PWM frequencies can be configured under software control in groups of outputs.
  - The setting is done by a PWM channel, setting the frequency of one channel sets also the frequencies of all the other channels in the same group.
  - The groups are indicated with upper case characters in the pin table's Group column in section ).

- These outputs have integrated protection features (overload, overcurrent)
- This kind of pin can be used with a step motor (for more information refer to the Programming and Libraries manual)



If you want to use current measuring, connect the other end of the load to the feedback pin.



It is recommended to use the function blocks in *DigitalOutputDiagnostics* library to protect and diagnose outputs when used as digital outputs. For more information, refer to *Epec Programming and Libraries Manual*.

### 4.3.2 Input (DI)

- This pin can be used as a digital input (DI)
- A pin of this type can also be used as an input by using the output state monitoring feature.
  - In this case, the output functionality of the pin must be kept in the off state.



Closed circuit loops are mandatory when you are using DO or PWM pin as an input.
Closed circuit loop means that the current from the control unit to the sensor must return to the same control unit, see the figures in section *I/O Cabling*.

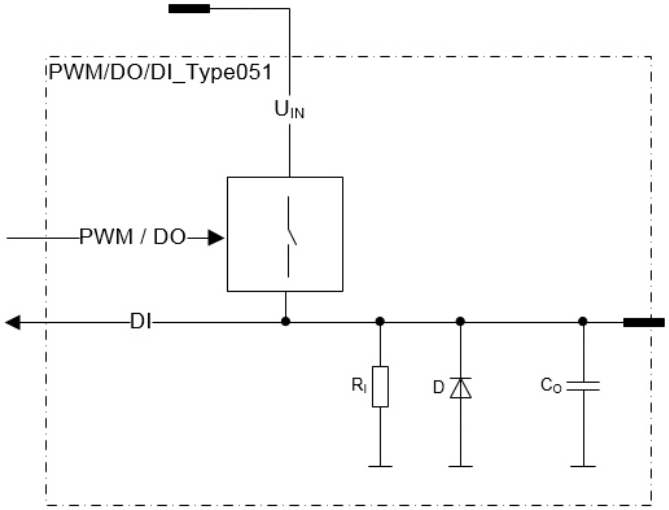
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| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $R_O$ | Output Resistance | Output On | | 0,2 | Ω |
| $I_O$ | Output Current | Output On | 0 | 3 | A |
| $I_{o\text{-}lim}$ | Internal current limitation | Output On (Note 2, 3) | typ. 12 | | A |
| $f_{PWM}$ | PWM Frequency | (Note 1) | 10 | 3000 | Hz |
| $Duty_{PWM}$ | Duty Cycle | (Note 4, 9) | 0 to 100,0 | | % |
| $Res_{PWM}$ | PWM Resolution | (Note 1, 8) | 0,1 | | % |
| **Digital status input** | | | | | |
| $R_I$ | Input Resistance | Output Off; Referenced to GND | | | kΩ |
| $V_{IH}$ | Input High Voltage | Output Off (Note 7) | 3,5 | $U_{in}$ | V |
| $V_{IL}$ | Input Low Voltage | Output Off | -0,5 | 1,5 | V |
| $f_I$ | Input frequency (digital input) | 50% duty cycle (Note 4, 5) | | 1/ 2tC | Hz |
| $t_I$ | Digital Status Input Pulse Width | (Note 5, 6) | > tC | | ms |
| $C_O$ | Output pin capacitance | | typ. 1 | | nF |

**Note 1:** PWM capable outputs are divided into groups. All outputs in the same group share the same PWM frequency (default value 10 Hz). The groups are indicated with upper case characters in the pin table's Group column in section.
**Note 2:** Current limit for short circuit protection to protect cabling and to limit internal power dissipation.
**Note 3:** When the limit is exceeded, the output voltage circuit starts to limit the current by switching the output voltage. The switching does not effect the application software.
**Note 4:** The duty cycle is defined as the percentage of digital 'high' to digital 'low' signals present during a PWM period.
**Note 5:** tC denotes the software cycle time.
**Note 6:** The pulse width must be greater that the software cycle time. For example, with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)
**Note 7:** Exceeding the max value might cause permanent damage.
**Note 8:** The PWM resolution is defined as a maximum number of pulses that you can pack into a PWM period.
**Note 9:** When the frequency increases, the actual duty cycle may be bigger than the value that has been set.

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### 4.3.3 Functional Block Diagram




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## 4.4 PWM/DI/DO_Type051_8

### 4.4.1 Output

- This type of pin is a current sourcing output with a pull-up resistor
  - In other words, the pin connects the load to a positive supply voltage
- The pull-up feature is for open load detection when the pin is used as an output.
- These outputs have integrated protection features (overload, overcurrent)
- These outputs are capable to generate pulse width modulated (PWM) output signals.
- When used as an output, the input feature indicates the output FET's state
- This kind of pin can be used with a step motor (for more information refer to the Programming and Libraries manual)



If you want to use current measuring, connect the other end of the load to the feedback pin.



It is recommended to use the function blocks in *DigitalOutputDiagnostics* library to protect and diagnose outputs when used as digital outputs. For more information, refer to *Epec Programming and Libraries Manual*.

### 4.4.2 Input

- This pin can be used as a digital input (DI)
- This pin can be used also with NPN-type sensors – sensors with open collector/open drain.
- A pin of this type can also be used as an input by using the output state monitoring feature.
  - In those cases the output functionality of the pin must be kept in off state.
- It must be taken care in system design that the output unintentionally switching to on state causes no harm to the system.
- It's highly recommended to use closed loop connections when the output pin is used as input. By keeping this simple principle in your mind you will avoid many unknown problems later on.

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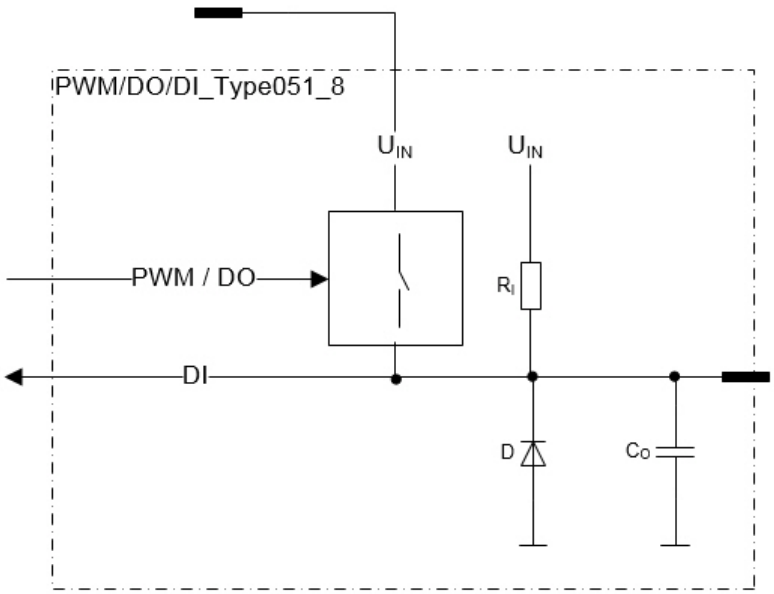
## Electrical characteristics

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $R_O$ | Output Resistance | Output On | | 0,2 | Ω |
| $I_O$ | Output Current | Output On | 0 | 3 | A |
| $I_{o\text{-}lim}$ | Internal current limitation | Output On (Note 1, 2) | typ. 12 | | A |
| $f_{PWM}$ | PWM Frequency | (Note 6) | 10 | 3000 | Hz |
| $Duty_{PWM}$ | Duty Cycle | (Note 3, 9) | 0 | 100,0 | % |
| $Res_{PWM}$ | PWM Resolution | (Note 8) | | 0,1 | % |
| **Digital status input** | | | | | |
| $R_I$ | Input Resistance | Output Off; Referenced to $U_{in}$ | typ. 10 | | kΩ |
| $V_{I\text{-}level}$ | Input voltage level | Output Off; Unconnected pin | $U_{in}$ | | V |
| $V_{IH}$ | Input High Voltage | Output Off (Note 7) | 3,5 | $U_{in}$ | V |
| $V_{IL}$ | Input Low Voltage | Output Off | -0,5 | 1,5 | V |
| $f_I$ | Input frequency (digital input) | 50% duty cycle (Note 3, 4) | | $1/ 2t_C$ | Hz |
| $t_I$ | Digital Status Input Pulse Width | (Note 4, 5) | $> t_C$ | | ms |
| $C_O$ | Output pin capacitance | | typ. 1 | | nF |

**Note 1:** Current limit for short circuit protection to protect cabling and to limit internal power dissipation.
**Note 2:** When the limit is exceeded, the output voltage circuit starts to limit the current by switching the output voltage. The switching does not effect the application software
**Note 3:** The duty cycle is defined as the percentage of digital 'high' to digital 'low' signals present during a PWM period.
**Note 4:** $t_C$ denotes the software cycle time.
**Note 5:** The pulse width must be greater that the software cycle time. For example with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)
**Note 6:** PWM capable outputs are divided into groups. All outputs in the same group share the same PWM frequency (default value 10 Hz). The groups are indicated with upper case characters in the pin table's Group column in section .
**Note 7:** Exceeding the max value might cause permanent damage.
**Note 8:** The PWM resolution is defined as a maximum number of pulses that you can pack into a PWM period.
**Note 9:** When the frequency increases, the actual duty cycle may be bigger than the value that has been set.

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### 4.4.3 Functional block diagram




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### 4.5 FB/AI_Type065_6

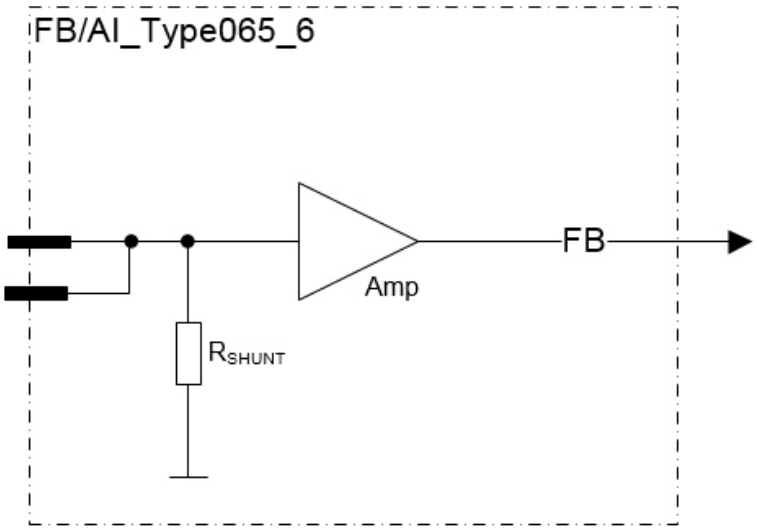
- This type of pin is 0-1 A current measuring feedback
- These pins are normally used as a return path for the loads of PWM outputs (current measuring feedback)
- These kinds of pins have a small shunt resistor connected to ground
  - The shunt resistor is used to measure the current flowing through the load
- Nothing prevents using these pins to measure currents from other sources as well
- These pins are paired and are indicated with lower case characters in section *I/O List*

**Electrical characteristics**

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $R_I$ | Input Resistance | | 0,21 | 0,23 | Ω |
| $I_I$ | Input Current | Analog measuring range | 0 | 1,03 | A |
| | | (Note 1) | | 1,4 | A |
| BW | Input Low Pass Filter Bandwidth | -3 dB cut-off frequency (Note 2) | typ. 27 | | Hz |
| $I_E$ | Input Error | $I_I$ = 1 A; Calculated | | 65 | mA |

**Note 1:** Exceeding the max value might cause damage to input.
**Note 2:** 2nd order low pass filter

#### 4.5.1 Functional block diagram




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### 4.6 AI/DI_Type064_2

- These pins are analog inputs
- There is an internal 2,2 kΩ resistor connected to +5 V in the unit.
  - It provides appropriate measuring current for the external sensor. Any resistive sensor with reasonable resistance range can be used.

- The pins can be configured either as a current input or as a voltage input.
- There is a control signal for selecting:
  - Voltage mode: High impedance input for signal from 0 to 5 V
  - Current mode: Low impedance input for signal from 0 to 22 mA

- The input impedance of each pin is controlled by a bit in output memory (%Q)



When configured to current mode, analog inputs can be protected against overvoltage by using *3000AnalogInputProtection* programming library. For more information, refer to *Epec Programming and Libraries Manual*.

#### 4.6.1 DI

- These pins can also be used as digital inputs by using an application library.
- The pin must be configured to voltage mode when using as digital input

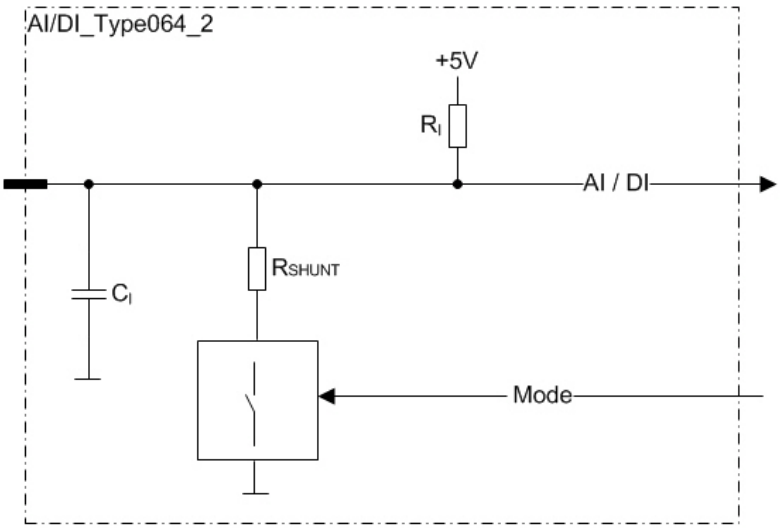
**Electrical characteristics**

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $V_I$ | Input Voltage measuring range | | 0 | 5 | V |
| $R_I$ | Input Resistance | Voltage mode (referenced to +5 V) | typ. 2,2 ±1% | | kΩ |
| | | Current mode | typ. 220 | | Ω |
| $I_I$ | Input Current measuring range | | 0 | 22,7 | mA |
| $I_E$ | Input Error | Voltage mode | | 0,18 | V |
| | | Current mode | | 0,8 | mA |
| BW | Input Low Pass Filter Bandwidth | -3 dB cut-off frequency | typ.40 | | Hz |
| $C_I$ | Input pin capacitance | | typ. 47 | | nF |
| $V_{I\text{-range}}$ | Input voltage range | Voltage mode (Note 1) | -0,5 | 33 | V |
| | | Current mode (Note 1) | -0,5 | 30 | V |

**Note 1**: Exceeding the max value might cause damage to input.

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### 4.6.2 Functional Block Diagram




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### 4.7 AI/DI_Type064_3

- These pins are analog inputs
- The pins can be configured either as a current input or as a voltage input.
- There is a control signal for selecting:
  - Voltage mode: High impedance input for signal from 0 to 5 V
  - Current mode: Low impedance input for signal from 0 to 22 mA
- The input impedance is controlled by a bit in output memory (%Q).



When configured to current mode, analog inputs can be protected against overvoltage by using *3000AnalogInputProtection* programming library. For more information, refer to *Epec Programming and Libraries Manual*.

#### 4.7.1 DI

- These pins can also be used as digital inputs by using an application library.
- The pin must be configured to voltage mode when using as digital input

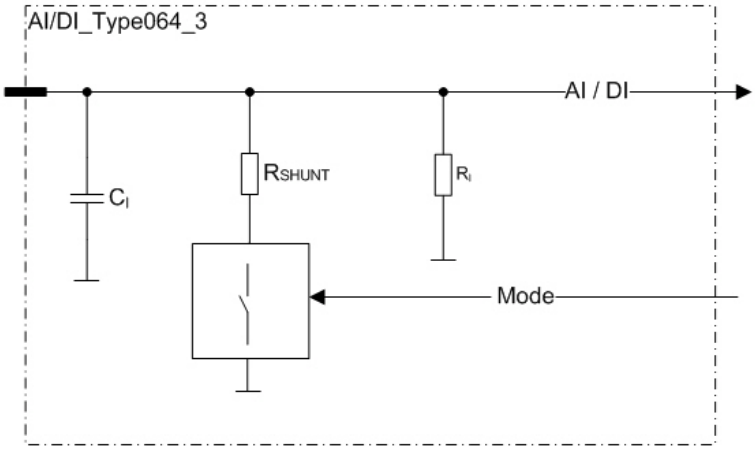
**Electrical characteristics**

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $V_I$ | Input Voltage measuring range | | 0 | 5 | V |
| $R_I$ | Input Resistance | Voltage mode (referenced to GND) | typ. 82,0 | | kΩ |
| | | Current mode | typ. 220 | | Ω |
| $I_I$ | Input Current measuring range | | 0 | 22,7 | mA |
| $I_E$ | Input Error | Voltage mode | | 0,18 | V |
| | | Current mode | | 0,8 | mA |
| BW | Input Low Pass Filter Bandwidth | -3 dB cut-off frequency | typ. 40 | | Hz |
| $C_I$ | Input pin capacitance | | typ. 47 | | nF |
| $V_{I\text{-range}}$ | Input voltage range | Voltage mode (Note 1) | -0,5 | 33 | V |
| | | Current mode (Note 1) | -0,5 | 30 | V |

**Note 1**: Exceeding the max value might cause damage to input.

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### 4.7.2 Functional Block Diagram




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### 4.8 DI/PI_Type046_1

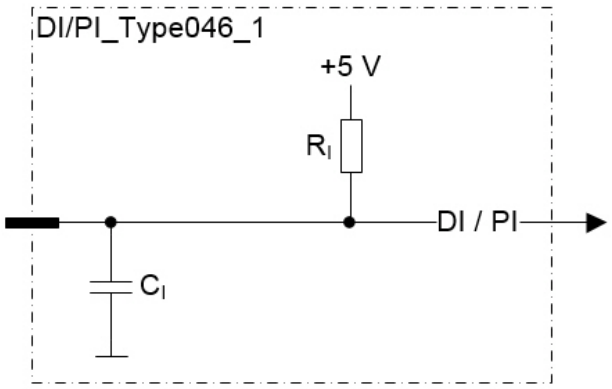
- This type of pin is a digital input (DI) including a pulse counting (PI) feature.
- This kind of pins have a pull-up resistor to +5 V
- Pulse inputs can be used as a 1 or 2 channel pulse counter and they have a possibility for reset pulse.
- Inputs of this type are also suitable for quadrature sensor position counting.

**Electrical characteristics**

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $R_I$ | Input Resistance | Referenced to +5 V | typ. 10 | | kΩ |
| $V_{IH}$ | Input High Voltage | Overload conditions (Note 1) | 4,1 | 33 | V |
| $V_{IL}$ | Input Low Voltage | | -0,5 | 3,3 | V |
| $f_I$ | Input Frequency (frequency measurement and pulse counting) | (Note 4, 5) | | 20 | kHz |
| | Input Frequency (digital inputs) | (Note 2, 3) | | $1/ 2t_C$ | kHz |
| $t_I$ | Input Pulse Width | | 1 | 10000 | ms |
| $C_I$ | Input Capacitance | | typ. 1 | | nF |

**Note 1:** Exceeding the max value might cause damage to input.
**Note 2:** $t_C$ denotes the software cycle time in milliseconds.
**Note 3:** The pulse width must be greater that the software cycle time. For example with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)
**Note 4:** The maximum value can be reached with 50 % duty cycle.
**Note 5:** The maximum frequency sum for all the pins is 40 kHz.

#### 4.8.1 Functional block diagram




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## 4.9 AUX OUT

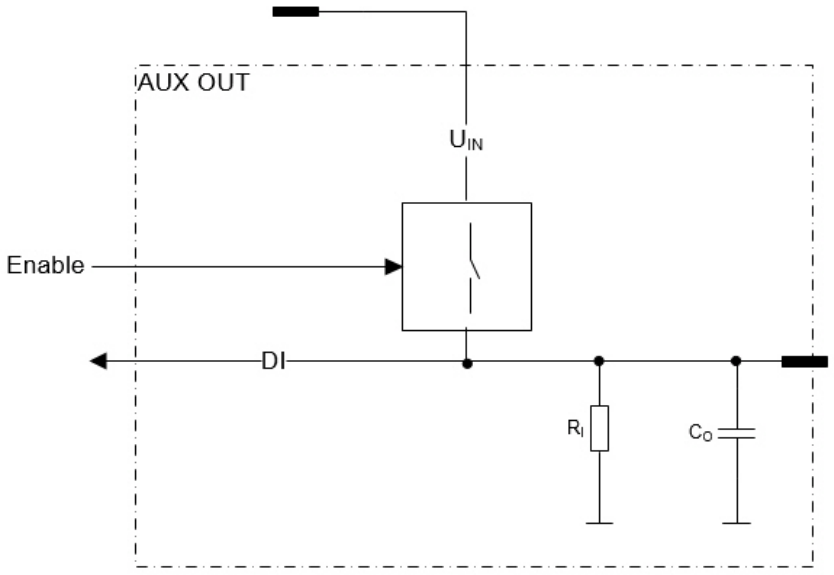
- This kind of pin is an auxiliary supply for external devices ($U_{in}$ / max 4 A)
- The output is enabled by default during power-up
- This output has integrated protection features (overload, overcurrent)
- This kind of pin is a current sourcing output
  - In other words, the pin connects the load to the positive supply voltage.
- The application program can also simultaneously monitor the actual state of the pin.
  - This feature makes it possible to detect short circuits to the ground and short circuits to the power supply.
  - Open loads can not be detected because the internal load resistor is connected to the ground.

**Electrical characteristics**

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $R_O$ | Output Resistance | Output On | | 0,1 | Ω |
| $I_O$ | Output Current | Output On | 0 | 4 | A |
| $I_{o\text{-}lim}$ | Internal current limitation | Output On (Note 1, 2) | typ. 12 | | A |
| **Digital status** | | | | | |
| $R_I$ | Input Resistance | Output Off; Referenced to GND | typ. 10 | | kΩ |
| $V_{IH}$ | Input High Voltage | Output Off (Note 3) | 3,5 | $U_{in}$ | V |
| $V_{IL}$ | Input Low Voltage | Output Off | -0,5 | 1,5 | V |
| $C_I$ | Input pin capacitance | | typ. 1 | | nF |

**Note 1:** Current limit for short circuit protection to protect cabling and to limit internal power dissipation.
N**ote 2:** When the limit is exceeded, the output voltage circuit starts to limit the current by switching off the output voltage. The switching does not effect the application software.
**Note 3:** Exceeding the max value might cause permanent damage.

### 4.9.1 Functional block diagram




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### 4.10 Loader BSL Pin

Loader BSL pin's main purpose is for factory use, but it can also be used for resetting the control unit to factory settings (application and all parameters are removed, node-IDs are reset).

In case the control unit (FW version 1.170 or newer) is not responding to CAN messages, use the BSL pin to reset the control unit:

1. Disconnect the power from the control unit.
2. Connect the BSL pin to ground.
3. Power up the unit.
4. Wait for 10 seconds.
5. Power off the unit, disconnect the BSL pin from ground and then power up the unit.
6. The unit is now restored to factory settings.

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### 4.11 +5V REF_Type041_4

- This is an internally regulated and monitored reference voltage supply for external devices.
- This reference output can be switched on/off by application.

#### 4.11.1 Protection Features

- Overcurrent
- External voltage protection
- Errors are indicated with a fault signal

#### 4.11.2 Voltage Monitoring

The level of the output voltage can be monitored by application.

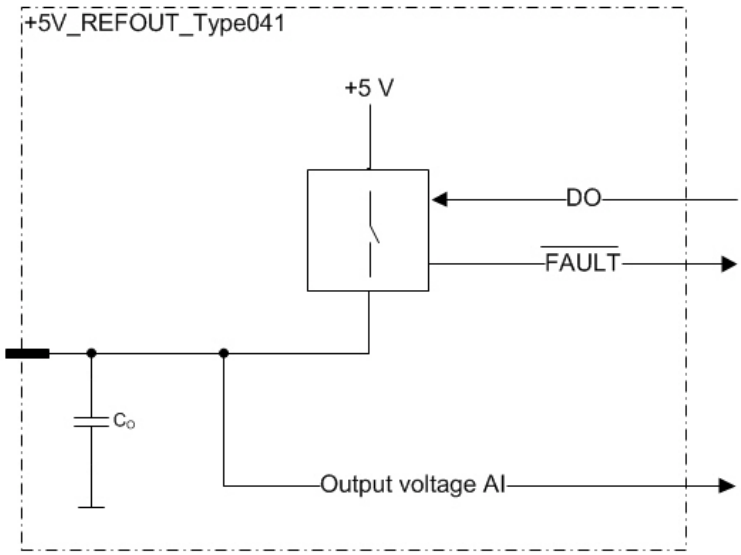
**Electrical characteristics**

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $V_{o\text{-}level}$ | Output voltage | Output On; Unconnected pins | typ. 5 | | V |
| $R_o$ | Output Resistance | Output On | | 0,46 | Ω |
| $I_o$ | Nominal Output Current | Output On; | 0 | 270 | mA |
| $I_{o\text{-}lim}$ | Internal Current Limitation | Output On (Note 2, 3) | typ. 370 | | mA |
| $I_{o\text{-}sc}$ | Short-circuit Current Limit | Output On; Overcurrent | typ. 270 | | mA |
| $C_o$ | Output Capacitance | | typ. 4,7 | | uF |
| $V_{I\text{-}max}$ | Max Input voltage | Overload conditions (Note 1) | | 33 | V |
| **Voltage monitoring** | | | | | |
| $V_{I\text{-}range}$ | Nominal Voltage measuring range | | 0 | 5 | V |
| | Fault-signal overvoltage threshold | Overvoltage | Typ. 5,2 | | V |
| | Fault-signal activation time | Overvoltage / Overload | | 10 | ms |

**Note 1:** When output voltage is under overload conditions, for example, short circuit to supply voltages. Exceeding the max value might cause damage to output.
**Note 2:** Current limit for overcurrent protection to limit internal power dissipation.
**Note 3:** When the limit is exceeded, the output current is regulated. In regulation, the output is switched into overcurrent mode.

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### 4.11.3 Functional Block Diagram




### 4.11.4 Diagnostics

The +5V reference supply has two diagnostics checks:

- analog output voltage monitoring and
- dedicated digital fault-signal

Both can be used to indicate overload and overvoltage situations. The diagnostics are independent from each other.

For fastest and most reliable error detection, it is recommended to use both output voltage monitoring and fault-flag diagnostics to detect errors.

#### 4.11.4.1 OVERLOAD

The diagnostics can detect overcurrent situation. The fault-signal is activated when excessive current is taken from the output. The output current is regulated when internal current limit is reached. The regulation current is always smaller than the limit. Current regulation causes the output voltage to drop with increasing load. This can be detected, using the output voltage monitoring feature, by setting a minimum (low) value limit for the output voltage.

With large enough loads, the output is switched temporarily off to protect the output from overheating. This is indicated by the fault-signal.
The fault-signal is deactivated, when the error source is removed by decreasing the load or when the output is turned off.

Overheat protection of the +5V REF can cause spurious errors in other analog measurements. Thus it is recommended to turn off the output when fault-signal becomes active.

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#### 4.11.4.2 OVERVOLTAGE

Overvoltage event caused by an external source can be detected by using a combination of the diagnostic features. The fault-signal is activated when pin voltage goes above the fault-signal overvoltage threshold level. If the output voltage monitoring value is 5 V (or more) and the fault-signal is active, it can be determined that an external voltage source is connected to the output pin.

The output pins are protected against external voltages, but it is not recommended to connect external voltage sources to these pins.



In case of a limit violation, the output should be disabled as soon as possible. The control unit can handle short term errors, but long term (e.g. several hours) exposures should be avoided with application/system design. Long term exposure to overvoltage or overload can cause permanent damage to the unit.

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### 4.12 Power Supply

- Nominal supply voltage 12/24 VDC
- Operating range 8,5…33 VDC
- Undervoltage reset ≤ 8 VDC

#### 4.12.1 Overvoltage Protection

- Max. 70 V (Stresses above this value may cause permanent damage to the module.)
- Control unit has a shutdown circuit which protects the unit and loads against overvoltage. The shutdown circuit cuts off the power feed for the logic and loads in case of overvoltage. The shutdown circuit is activated when voltage reaches circa 35 V. Power feed is restored when supply voltage drops to 32,5 V.

#### 4.12.2 Power Consumption

- Approx. 1,5 W (+24 VDC, no external load)
- Supply Voltage ($U_{in}$) maximum continuous current 13 A (with full external load)
- GND current sum max 13 A

**Power supply pins**

| Designation | Connector / pin number | Potential |
|---|---|---|
| Supply voltage ($U_{in}$; for logic and power) | X4.4<br>X4.5 | +12/+24 VDC (+8,5…33 VDC) |
| Ground (for supply voltage) | X4.1<br>X4.3 | GND |
| Ground | X1.12<br>X2.12<br>X3.10<br>X3.11<br>X3.12<br>X3.13 | GND<br>(3 A/pin) |
| **Supply outputs** | | |
| Auxiliary supply (for external devices) | X3.1<br>X3.9 | $U_{in}$ / max 4 A<br>(max total for all pins together) |
| Reference supply (for external devices) | X3.2 | +5 VDC / max 270 mA |



Always use an external fuse to protect the control unit. The fuse is needed for reverse voltage and overload protection.

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## Electrical characteristics

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $V_I$ | Nominal Input voltage | | 8,5 | 33 | V |
| $I_{TOT-max}$ | Max Total Current Output | | | 13 | A |
| $V_{I-Load-dump}$ | Max Input transient Voltage level | (Note 1) | | 100 | V |
| $V_{I-max}$ | Max Continuous Input Voltage Level | (Note 2) | -0,5 | 40 | V |
| $V_{I-ovp}$ | Overvoltage Protection Cut-off Level | | 33 | 36,5 | V |
| | Overvoltage Cut-off Hysteresis | | typ. 2 | | V |
| $V_{UVP}$ | Undervoltage Threshold Level | | typ. 7,7 | | V |
| **Supply voltage monitoring** | | | | | |
| $V_{I-range}$ | Nominal Input Voltage measuring range | | 0 | 46 | V |

**Note 1:** Load dump protection according to ISO7637-2: 2004 pulse 5, Us=+123 V. For more information, see *EMC Tests*
**Note 2:** If the voltage is less than 8,5 V or higher than 33 V, the control unit is in non-operational state.

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# 5 BUS CONNECTIONS

## 5.1 CAN Bus

### 5.1.1 CAN interface

- Higher layer protocol is user programmable (CAN2) communication.
- The physical interface of CAN interface is according to ISO 11898 and CAN 2.0B protocol.
- The downloading of the PLCopen application can only be done via CAN1.
- All interfaces support bit rates 50, 125, 250, 500, 800, 1000 kbit/s
- CAN1 and CAN2 are CANopen compatible and user programmable
- For example CANopen, SAE J1939 or ISOBUS are available for both CANs.
- All interfaces can be configured as listen only mode. An exception is CAN1, which is in boot up normal mode because it is used for CODESYS communication.
- 11-bit and 29-bit message receive and transmit are supported.
- Transmitting of remote frames is supported in all CAN interfaces.
- Receiving one remote frame is supported. This is received for the control unit's own node guard functionality.

### 5.1.2 CAN bus connection pins

The CAN communication pins and the power supply are connected in the control unit’s AMP8 connector as follows:

| Designation | Pin number |
|---|---|
| CAN1 interface, system interface, user programmable communication | X4.2 (CAN H)<br>X4.6 (CAN L) |
| CAN2 interface, user programmable communication | X4.7 (CAN H)<br>X4.8 (CAN L) |
| Factory use only,<br>this pin must be left open | X3.15 |

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# 6 INTERNAL DIAGNOSTICS

## 6.1 Temperature and Voltage Monitoring

This unit's internal temperature and incoming operating voltage can be read from the PLCopen addresses with the numerical values and resolutions shown in the following table.

| Type | PLCopen address | Precision | Resolution bits | Full reading |
|---|---|---|---|---|
| **Internal Diagnostics** | | | | |
| AI($T_{PCB}$) | %IW26 | ≤ ±3,5 % | 10 | |
| AI($U_{R2V5}$)* | %IW29 | ≤ ±3,5 % | 10 | 5 V |
| AI($U_{R4V3}$)* | %IW31 | ≤ ±3,5 % | 10 | 5 V |
| AI($U_{R7V3}$)* | %IW30 | ≤ ±3,5 % | 10 | 10 V |
| **External Diagnostics** | | | | |
| AI($U_{in}$) | %IW28 | ≤ ±3,5 % | 10 | 46 V |
| AI(+5 V REF) | %IW27 | ≤ ±3,5 % | 10 | 5 V |

** Internal voltage measurement is used for internal voltage level monitoring. MultiTool Creator adds these automatically to code template.*

### 6.1.1 Temperature

This control unit has one temperature sensor for monitoring PCB area temperature. The temperature information is useful for self diagnostic purposes and safety features.

| Symbol | Parameter | Conditions | Min | Max | Units |
|---|---|---|---|---|---|
| $T_{PCB}$ | Nominal PCB Temperature measuring range | | -40 | 125 | ˚C |
| $T_{PCB-err}$ | Temperature Measurement Error | -40 .. +125 ˚C | | +/- 5 | % (FS) |

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## 6.2 Error Log

The control unit's internal error log stores the firmware errors in a log.

For more information about the logs and how to read them, refer to *Epec Programming and Libraries Manual MAN000538*.

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Epec Oy

Postal address
PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland

Phone
+358-(0)20-7608 111

Internet
www.epec.fi

# 7 APPROVALS AND SAFETY

## 7.1 EMC Tests

Epec 3720 control units are certified according to EMC tests that are described in this section.

The following tables provide a summary of performed EMC tests:

Emission tests according to the test specification EN 61000-6-3 (2007), Amd. A1 (2011)

| Emission test | Test method |
|---|---|
| Radiated disturbance | EN 55016-2-3 |
| Conducted disturbance at the mains ports | EN 55016-2-1 |

Immunity tests according to the test specification EN 61000-6-2 (2005)

| Immunity test | Test method |
|---|---|
| Electrostatic discharge (ESD) | EN 61000-4-2 |
| Radiated radio-frequency electromagnetic field | EN 61000-4-3 |
| Electrical fast transients (EFT/B) | EN 61000-4-4 |
| Surges | EN 61000-4-5 |
| Conducted radio-frequency field immunity | EN 61000-4-6 |

Emission tests according to the E/ECE Regulation No. 10, Revision 4

| Emission test | Test method |
|---|---|
| Measurement of radiated interference field strength in the frequency range 30 – 1000 MHz | E/ECE Reg. No. 10, Annexes 7 and 8 |
| Measurement of conducted disturbances | E/ECE Reg. No. 10, Annex 10 |

Immunity tests according to the E/ECE Regulation No. 10, Revision 4

| Immunity test | Test method |
|---|---|
| Radiated radio-frequency electromagnetic field | E/ECE Reg. No. 10, Annex 9 |
| Immunity to transient disturbances conducted along supply lines | E/ECE Reg. No. 10, Annex 10 |

The following tables provide more detailed descriptions about the performed EMC tests:

<table>
<tr><th colspan="2">Emission tests according to the E/ECE Regulation No. 10, Revision 4</th></tr>
<tr><td>Radiated disturbance emission test</td><td>Test method E/ECE Reg. No. 10, Annexes 7 and 8, CISPR 25
<table>
<tr><th>Frequency (MHz)</th><th>Limit value (dBmV/m)</th></tr>
<tr><td>30 – 1000</td><td>62/52/63 (Broadband QP)</td></tr>
<tr><td>30 – 1000</td><td>52/42/53 (Narrowband AVE)</td></tr>
</table></td></tr>
</table>

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<table>
<tr><td>Conducted disturbances emission test</td><td>Test method E/ECE Reg. No. 10, Annex 10, ISO 7637-2: 2004/Amd.1:2008<br><table><tr><th>Port</th><th>Limit level (V)</th></tr><tr><td rowspan="2">12 V DC input</td><td>+75</td></tr><tr><td>-100</td></tr><tr><td rowspan="2">24 V DC input</td><td>+150</td></tr><tr><td>- 450</td></tr></table></td></tr>
<tr><td colspan="2">Immunity tests according to the E/ECE Regulation No. 10, Revision 4 (2012)</td></tr>
<tr><td>Immunity to transient disturbances conducted along supply lines test</td><td>Test method E/ECE Reg. No. 10, Annex 10, ISO 7637-2: 2004/Amd.1:2008<br>Performance criterion:<br><table><tr><th>Pulse</th><th>Criterion</th></tr><tr><td>1</td><td>C</td></tr><tr><td>2a</td><td>A</td></tr><tr><td>2b</td><td>C</td></tr><tr><td>3a</td><td>A</td></tr><tr><td>3b</td><td>A</td></tr><tr><td>4</td><td>C (12 V)<br>A (24 V)</td></tr><tr><td>5a</td><td>C</td></tr></table><br>12 V input, Pulse:<br><table><tr><th>Pulse</th><th>Pulse parameters</th></tr><tr><td>1</td><td>-150 V, $R_i$ 10 Ω, 3 s, 5000 pulses</td></tr><tr><td>2a</td><td>+112 V, $R_i$ 2 Ω, 200 ms, 5000 pulses</td></tr><tr><td>2b</td><td>+10 V, 500 ms, 10 pulses</td></tr><tr><td>3a</td><td>-220 V, 10/90 ms, 60min</td></tr><tr><td>3b</td><td>+150 V, 10/90 ms, 60min</td></tr><tr><td>4</td><td>$t_d$ 40 ms -7,0 V, 20 s -6 V, 10 pulses</td></tr><tr><td>5a</td><td>$t_d$ 400ms, $R_i$ 0,5 Ω, +70 V, 1 pulses<br>$t_d$ 100ms, $R_i$ 10 Ω, +123 V, 1 pulses</td></tr></table><br>24 V input, Pulse:<br><table><tr><th>Pulse</th><th>Pulse parameters</th></tr><tr><td>1</td><td>-600 V, $R_i$ 50 Ω, 3 s, 5000 pulses</td></tr><tr><td>2a</td><td>+112 V, $R_i$ 2 Ω, 200 ms, 5000 pulses</td></tr><tr><td>2b</td><td>+20 V, 500 ms, 10 pulses</td></tr><tr><td>3a</td><td>-300 V, 10/90 ms, 60min</td></tr><tr><td>3b</td><td>+300 V, 10/90 ms, 60min</td></tr><tr><td>4</td><td>$t_d$ 100 ms -12 V, 10 s -5 V, 1 pulses</td></tr><tr><td>5a</td><td>$t_d$ 350ms, $R_i$ 1 Ω, +70 V, 1 pulses<br>$t_d$ 100ms, $R_i$ 10 Ω, +123 V, 1 pulses</td></tr></table></td></tr>
</table>

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Immunity of ESAs to electromagnetic radiation

Test method E/ECE Reg. No. 10, Annex 9, ISO 11452-2:2004, ISO 11452-4:2005, Cor 1: 2009
Performance criterion: A

| Specification | Step | Dwell time | Frequency Range (MHz) | Test level |
|---|---|---|---|---|
| Modulation AM80% 1 kHz | 5% | 3 s | 20-80 | 60 mA |
| Modulation AM80% 1 kHz | 2% | 3 s | 80-800 | 30 V/m |
| PM 577/4600 µs | 1% | 3 s | 800-1000 | 30 V/m |
| PM 577/4600 µs | 1% | 3 s | 1000-2000 | 30 V/m |

Classification of functional status

*Class A:*
All functions of a device/system perform as designed during and after exposure to disturbance.

*Class B:*
All functions of a device/system perform as designed during and after exposure to disturbance. However, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain class A.

*Class C:*
One or more functions of a device/system do not perform as designed during exposure but return automatically to normal operation after exposure is removed.

*Class D:*
One or more functions of a device/system do not perform as designed during exposure and do not return to normal operation until exposure is removed and a device/system is reset by simple “operator/use” action.

*Class E:*
One or more functions of a device/system do not perform as designed during exposure and cannot be returned to operation without repairing the device/system.

***EN 61000-6-3 (2007), Amd. A1 (2011)***
**Electromagnetic compatibility-generic emission standard part 6-3: residential, commercial and light industry**

Radiated disturbance emission test

Test method EN 55016-2-3

| Frequency (MHz) | Limit value (dBmV/m) |
|---|---|
| 30 – 1000 | 30/37 (QP) |

Conducted disturbance at main ports emission test

Test method EN 55016-2-1

| Frequency (MHz) | Limit value (dBmV) |
|---|---|
| 0,15 - 30 | 66/56/60 (QP) |
| 0,15 - 30 | 56/46/50 (AVE) |

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***EN 61000-6-2 (2005)***
Electromagnetic compatibility-generic immunity standard
part6-2: industrial environment

**Conducted radio-frequency common mode immunity test**

Test method EN 61000-4-6
Performance criterion A

| Specification | Port | Test level |
|---|---|---|
| Frequency range 0,150-80 MHz, Modulation AM80% 1 kHz, Dwell time 2 s | DC input port | 10 $V_{RMS}$ |
| | Signal ports | 10 $V_{RMS}$ |

**Radiated radio-frequency electromagnetic field immunity test**

Test method EN 61000-4-3
Performance criterion A

| Specification | Range (MHz) | Test level |
|---|---|---|
| Modulation AM 80% 1 kHz, Dwell time 2 s | 80-1000 | 10 V/m |
| | 1000-2700 | 10 V/m |

**Electrical fast transient (EFT/B) immunity test**

Test method EN 61000-4-4
Performance criterion B

| Test pulse | Port | Test level |
|---|---|---|
| Repetition frequency 5 kHz, Duration 1 minute | DC input port | ± 2,0 kV |
| | Signal ports | ± 1,0 kV |

**Surge Immunity**

Test method EN 61000-4-5
Performance criterion B

| Specification | Port | Path | Test level |
|---|---|---|---|
| Pulses: 5 Repetition rate: 60 s | DC Input port | Line to Line | ± 0,5 kV |
| | | Line to Ground | ± 0,5 kV<br>± 1,0 kV |

**Electrostatic discharge (ESD) immunity test**

Test method EN61000-4-2
Performance criterion B

| Discharge mode | Test level (kVp) |
|---|---|
| Contact | ± 2, ± 4, ± 6 |
| Indirect contact | ± 2, ± 4, ± 6, ± 8 |
| Air | ± 2, ± 4, ± 8 |

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**Performance criteria for immunity tests**

*Performance criterion A:*
The EUT shall continue to operate as intended during and after the test. No degradation of performance is allowed.

*Performance criterion B:*
The EUT shall continue to operate as intended after the test. However, moderate degradation of performance is allowed. No change of actual operating state or loss of memory functions is allowed.

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Epec Oy

Postal address
PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland

Phone
+358-(0)20-7608 111

Internet
www.epec.fi

## 7.2 Environmental Tests

The following environmental tests have been performed to Epec 3720 control units:

| **Temperature** | | | |
|---|---|---|---|
| **Test** | **Temperature** | **Duration/ Exposure time** | **Remarks** |
| Cold<br>IEC 60068-2-1 (2007-03), Test Ad | -45 °C | 16 h | 1 °C/min |
| Dry heat<br>IEC 60068-2-2 (2007-07), Test Bb | 70 °C | 16 h | 1 °C/min |
| Damp heat cycling<br>IEC 60068-2-30 (2005-08), Test Db | +25 °C/+55 °C | | rel. humidity >90%<br>cycle duration 24h<br>six test cycles |
| Change of temperature IEC 60068-2-14 (2009-01), Test Na | -50 °C/+60 °C | 3 h | change time between extreme temperatures 1-2 min<br>5 test cycles |
| Change of temperature IEC 60068-2-14 (2009-01), Test Nb | -40 °C/+70 °C | 3 h | change of temperature 10 °C/min<br>2 test cycles |

| **Mechanical resistance** | | |
|---|---|---|
| **Test** | **Duration and direction** | **Remark** |
| Shock test IEC 60068-2-27 (2008-02) Test Ea | pulse duration 6 ms<br>500 impulses in six directions | half sine pulse shape<br>peak acceleration 500 $m/s^2$ |
| Shock test IEC 60068-2-27 (2008-02) Test Ea | pulse duration 4 ms<br>100 impulses in two directions | half sine pulse shape<br>peak acceleration 750 $m/s^2$ and 1000 $m/s^2$ |
| Vibration, random<br>IEC 60068-2-64 (2008-04), Test Fh | test duration 60 min in every three test direction | ASD-level 5 $m^2/s^3$, 10 … 200 Hz<br>ASD-level 1,0 $m^2/s^3$, 200 … 500 Hz<br>total spectral acceleration 3,54 grms |
| Vibration, random<br>IEC 60068-2-64 (2008-04), Test Fh | test duration 10 min in one test direction at each level | frequency range 10...500 Hz<br>ASD-level 0,1 $g^2$/Hz (10,0 $m^2/s^3$), 10...200 Hz<br>ASD-level 0,02 $g^2$/Hz (2,0 $m^2/s^3$), 200...500 Hz, 5,00 grms<br>ASD-level 0,2 $g^2$/Hz (20,0 $m^2/s^3$), 10...200 Hz<br>ASD-level 0,04 $g^2$/Hz (4,0 $m^2/s^3$), 200...500 Hz, 7,05 grms<br>ASD-level 0,4 $g^2$/Hz (40,0 $m^2/s^3$), 10...200 Hz<br>ASD-level 0,08 $g^2$/Hz (8,0 $m^2/s^3$), 200...500 Hz, 9,96 grms<br>ASD-level 0,8 $g^2$/Hz (80,0 $m^2/s^3$), 10...200 Hz<br>ASD-level 0,16 $g^2$/Hz (16,0 $m^2/s^3$), 200...500 Hz, 14,08 grms<br>ASD-level 1,45 $g^2$/Hz (145,0 $m^2/s^3$), 10...200 Hz |

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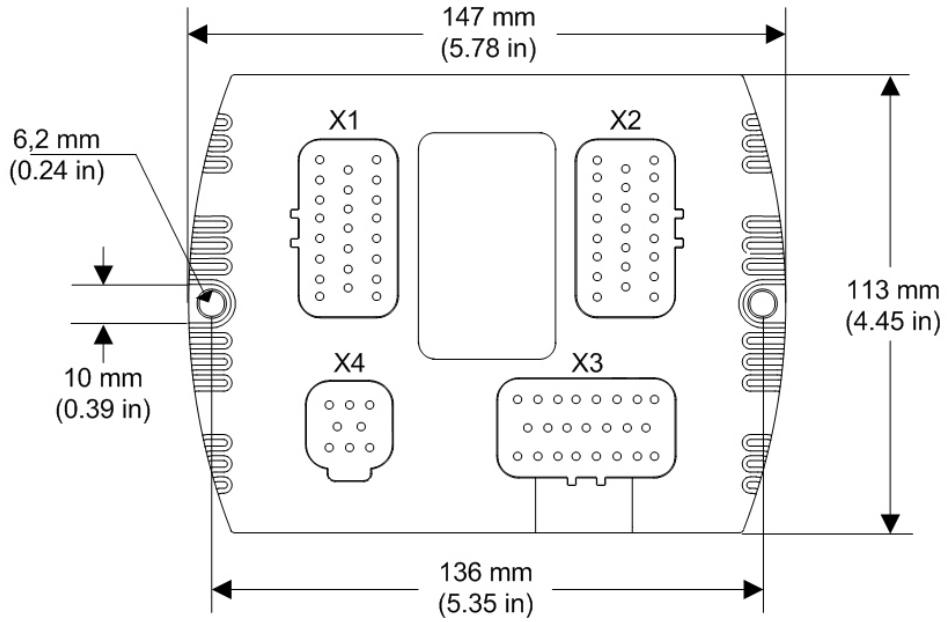
| | | | |
|---|---|---|---|
| | | ASD-level 0,29 g²/Hz (29,0 m²/s³), 200...500 Hz, 19,04 grms | |
| Free fall,<br>IEC 60068-2-31 (2008-05),<br>Test Ec | one fall / direction<br>on each surface and corner | fall height 100 cm | |
| **Corrosion** | | | |
| **Test** | **Temperature** | **Duration** | **Concentration** |
| Salt spray test<br>ISO 9227 | +35 °C | 24 h | 5 % NaCl |
| **Tightness tests for IP67** | | | |
| **Test** | **Duration and procedure** | **Remark** | |
| Dust test for IP6X according to IEC 60529 | exposed to the free settling dust for 2 hours<br>underpressure during the test 1,8 kPa<br>flow rate of the air 0,3 l/min | no deposit of dust noticed inside<br>complies with the requirements stated for the protection class IP6X | |
| Water test for IPX7 according to IEC 60529 | immersion duration 30 minutes<br>immersion depth 1000 mm<br>water temperature +20 °C | no ingress of water noticed inside<br>complies with the requirements stated for the protection class IPX7 | |

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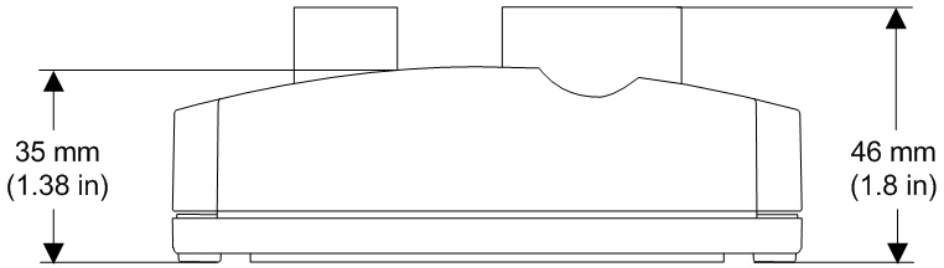
# 8 MECHANICS AND CABLING

## 8.1 Unit Dimensions

Unit dimensions from the top:




Unit dimensions from the side:




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## 8.2 Mounting and Cleaning

Control unit mounting location should be planned so that the machine's washing does not damage the unit.

A direct water jet towards the control units should be avoided, especially when using high pressure. Also, the use of any such solvent that causes damage to electronic devices should be avoided when handling the control units.

When cleaning the control unit, do not use highly alkaline / acidic substances, too hot water, or too heavy mechanical abrasion.

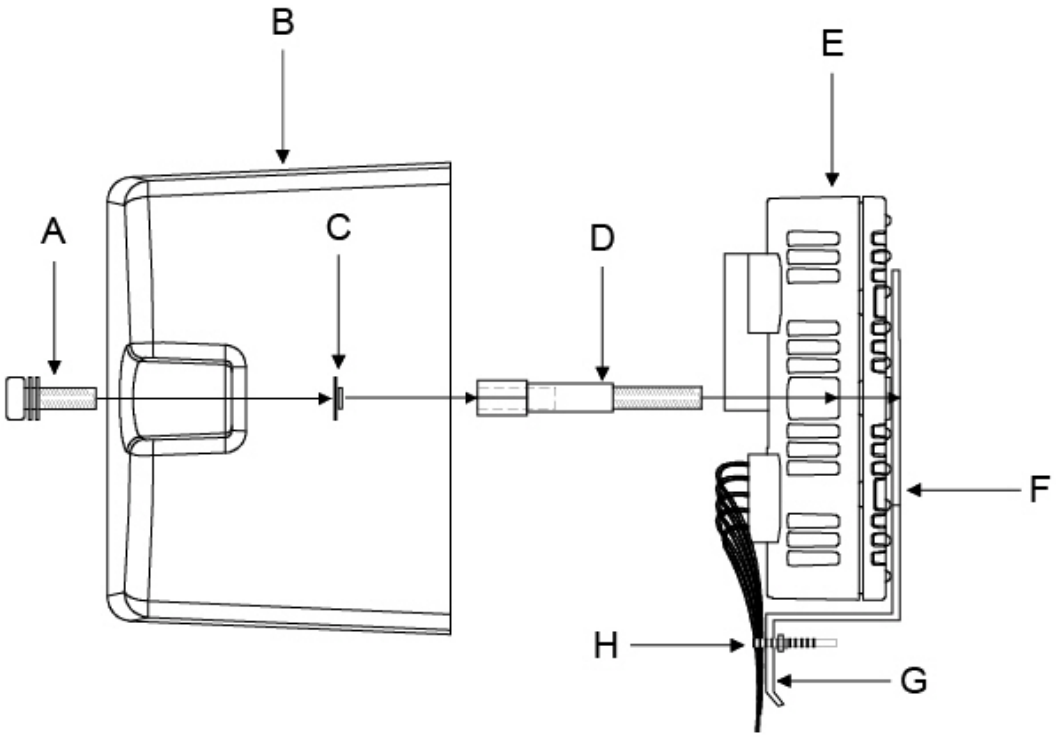
In moist conditions, the unit must be mounted and oriented so that the connectors are not filled with water.

- The mounting is done with 2 screws, for example M6 according to DIN 912
- It is possible to use a spring washer under the screw head
- Mounting must be done on to a conductive metal base. The control unit's aluminum housing must have a galvanic connection to the machine frame
- The paint must be removed from the control unit under each screw head before mounting, to ensure a galvanic connection to the control unit frame. Also, remove the paint from the machine frame, where the control unit will be attached.
- Reserve 10 cm installation space for the connector cables
- Mounting position must be horizontal or vertical to allow water, etc. flowing away from connectors, see the figures below.



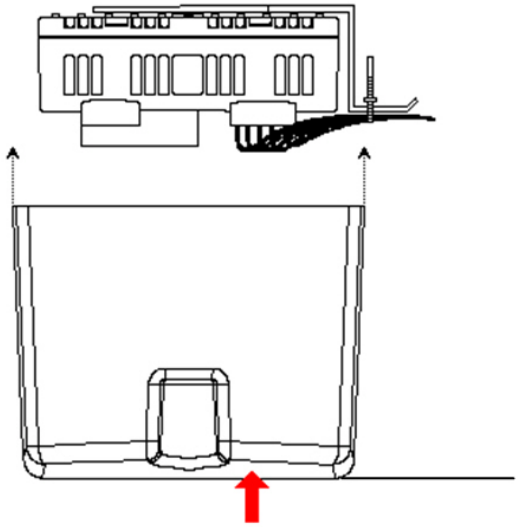

- If a separate Epec shock protection cover is mounted, it is recommended to use fastening bolts delivered by Epec.
- The following figure shows how the shock cover is mounted on top of the unit with screws (unit mounting screws have threads for unit cover screws):

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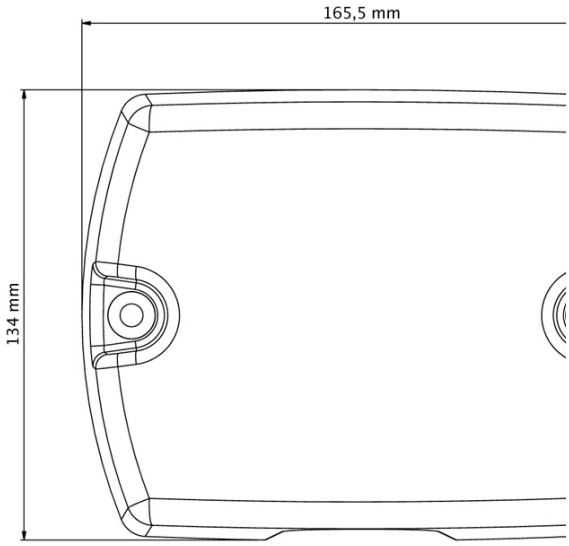

A = Shock cover mounting screw
B = Shock cover
C = Stopper washer
D = Shock cover mounting screw
E = Control unit
F = Shock cover mounting bracket
G = Shock cover base knob
H = Wires are binded to the base knob with cable ties

- If the unit is mounted upside down with a unit cover in wet conditions, it is recommended to drill a small hole on the cover to allow water flow away on the bottom of the cover. In the picture below, the red arrow points an example location of a leaking hole:

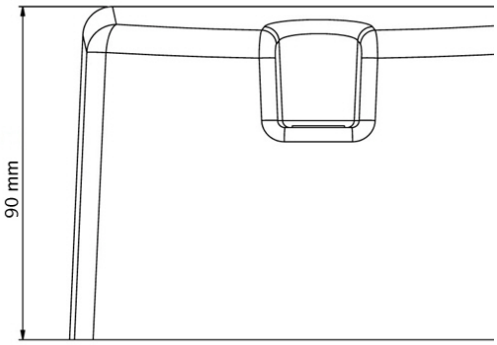


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Shock cover dimensions from above:



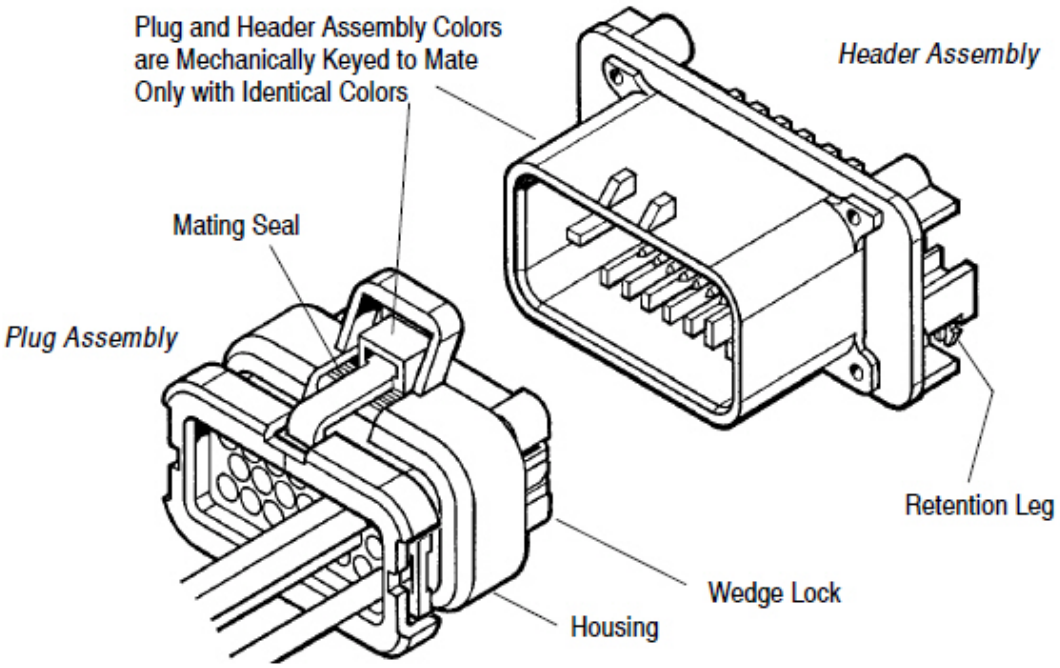

Shock cover dimensions from the side:




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## 8.3 Plugging and unplugging the connectors

Epec control units use heavy duty gold plated, locked and sealed AMPSEAL connectors. The following figure shows an example of an AMPSEAL connector:



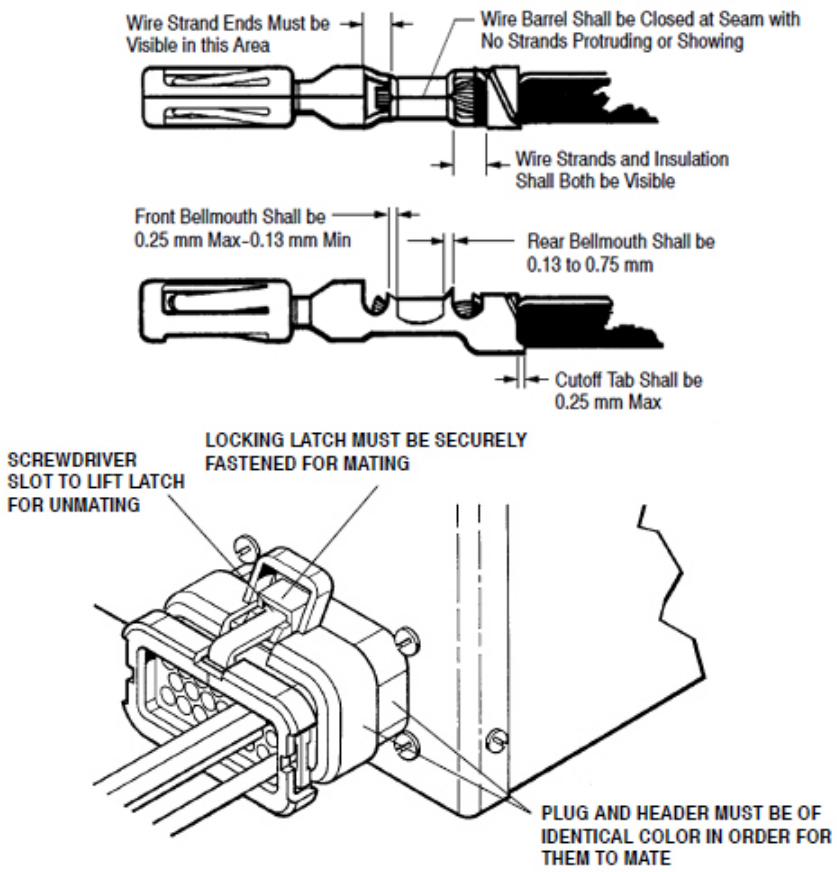

- Gold plated AMPSEAL connectors pack a current of 15 amperes per contact and tolerate operating temperature range.
- All module connectors are mechanically keyed to mate only with identical colors (blue, grey and black).

When connecting, make sure that:

- connectors are pressed down to the bottom and that they are locked
- connectors are clean (avoid moisture or dirt inside the connector)
- unused connectors are covered with empty connectors of the same color (this helps to keep the control unit connectors dry and protected)
- all cables, connectors and tools are of correct type, and sufficiently high quality, and suitable for this kind of use (protection for moisture, mechanical stability, power durability, coupling resistance among other things)
- there is a sufficient margin (slack) left in the cables to prevent the torsion of the connectors
- wires are bound to the control unit cover base knob with cable ties

The following figure describes some general instructions about the connectors.

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Refer to AMP Application Specification 114-16016 for more detailed information on connectors and cable recommendations.

Ordering codes for the AMPSEAL connectors, crimps and tools are listed in Section *Accessories and Ordering Codes*.

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## 8.4 Cabling

### 8.4.1 System Topologies

Generally, cabling should be properly designed and documented to help the initial assembly and maintenance.
It is highly recommended to mark each cable on both ends to avoid confusion and errors.

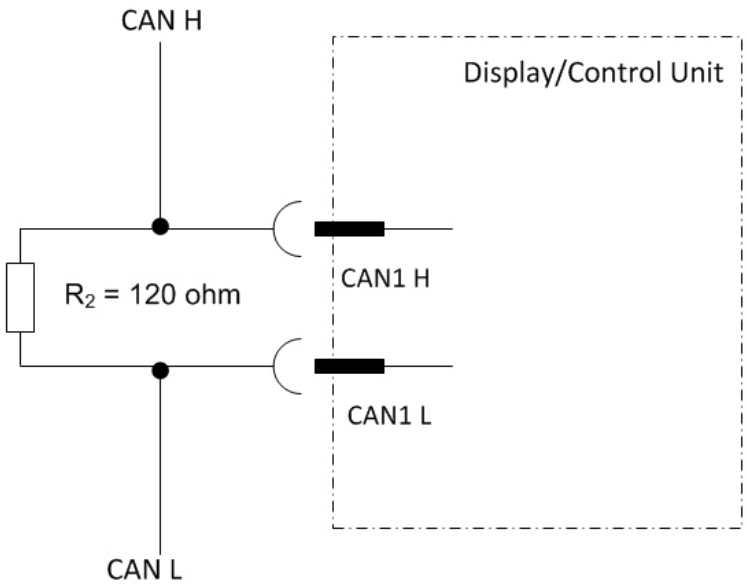
The cables must be run in a safe route along the machine frame.
When routing cables, avoid interfering objects and pay particular attention to moving parts of the machine.
It is also good to minimize the amount of the connection points of the cable harness to maximize reliability.
Also, all valid safety instructions should be observed when coupling.

- The control units are connected with each other using standardized CAN bus.
- The idea of the Epec embedded control system, is that all the control units are installed close to sensors, encoders and other equipment connected to them.
    - This way the amount of the traffic on the CAN bus is minimized and connections can be made using short wires.

**Termination resistors**

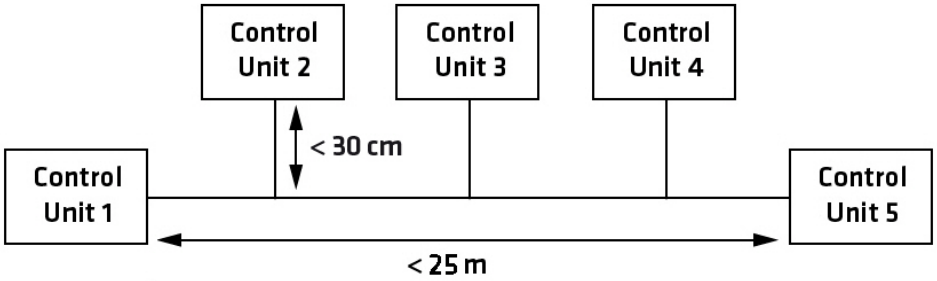
- Generally, the bus cable is terminated at both ends with termination resistors (ISO 11898:1993).
- External termination resistor (120 Ω) has to be connected at both ends between CAN H and CAN L.

The cable lengths presented here are approximates. Actual cable lengths also depend on the cable quality, the cable type and also on the machine environment (possible interference).

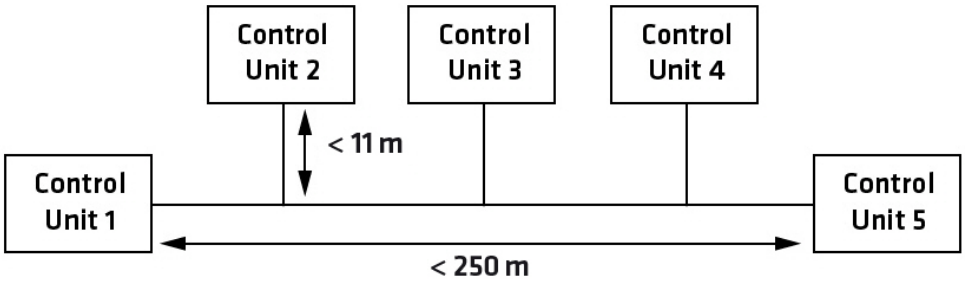



**Example1.** The figure shows a connection example of an external termination resistor in CAN1

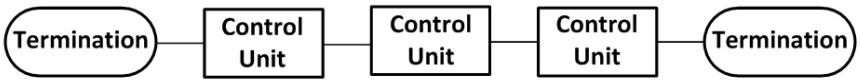
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**Example 2**. Control system topology in theory with maximum bus speed (1000 kbit/s); Control Units in traditional bus arrangement. Termination resistor must be connected at control unit 1 and control unit 5. For more information about the bus speeds, refer to CiA DS-102 standard.




**Example 3**. Control system topology in theory with 250 kbit/s bus speed; Control Units in traditional bus arrangement. Termination resistor must be connected at control unit 1 and control unit 5. For more information about the bus speeds, refer to CiA DS-102 standard.




**Example 4**. The usage of the termination resistor (TR) in a conventional bus. The maximum recommended bus length is directly dependent on the bus speed.
In theory, the maximum length with the maximum speed can be up to 25 meters. If the bus speed is lower, the length can be extended.
The maximum length of the bus depends on the bus speed. For more information about the bus speeds, see the table below / refer to CiA DS-102 standard.

The following table shows some baud rates in general purpose CAN bus networks as well as the maximum bus length for a given baud rate, that CAN in Automation (CiA) international users and manufacturers group has recommended to be used. For more information, refer to CiA DS-102 standard.

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CAN bus baud rates and bus lengths according to CiA DS-102 standard

| Baudrate | Bus length |
|---|---|
| 1 Mbits/s | 25 m |
| 800 kbits/s | 50 m |
| 500 kbits/s | 100 m |
| 250 kbits/s | 250 m |
| 125 kbits/s | 500 m |
| 50 kbits/s | 1000 m |

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Epec Oy

Postal address
PL/P.O.Box 194
FIN-60101 Seinäjoki, Finland

Phone
+358-(0)20-7608 111

Internet
www.epec.fi

### 8.4.2 CAN Bus Cabling

The CAN bus cable is the neural backbone of the whole system and should be designed and constructed with extra care.

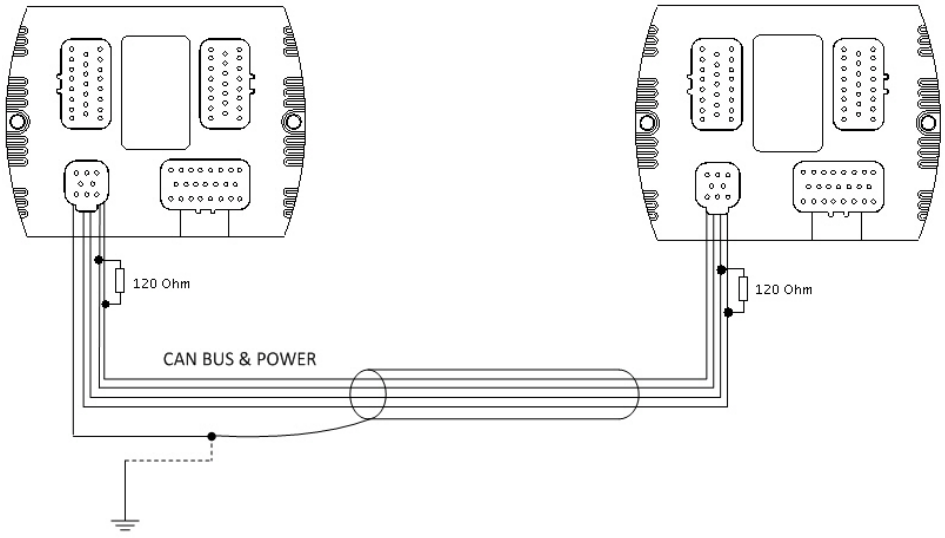
- In all Epec 3700 series control units, the bus connection can be found in black AMP 8 pin connector.
- For information about the CAN bus lengths and baud rates, refer to section *System Topologies*.

**Cable**

- It is recommended to use high quality and twisted (approx. 1 round / 1 inch) CAN bus cable.
- Normal UTP (Unshielded Twisted Pairs) cable is well suited for distances under approximately 10 meters.
- In longer distances, and especially if there is possibility for electromagnetic interference, it is highly recommended to use shielded and twisted cable for CAN bus, also for shorter distances.
- To avoid electromagnetic interference (EMI), locate the bus cable as far away from high-current carrying cables as possible. Generally, the amount of the connections and connectors should be minimized to maximize security; also all connections should be done carefully.
- The shield grounding must be done only in one end of the cable

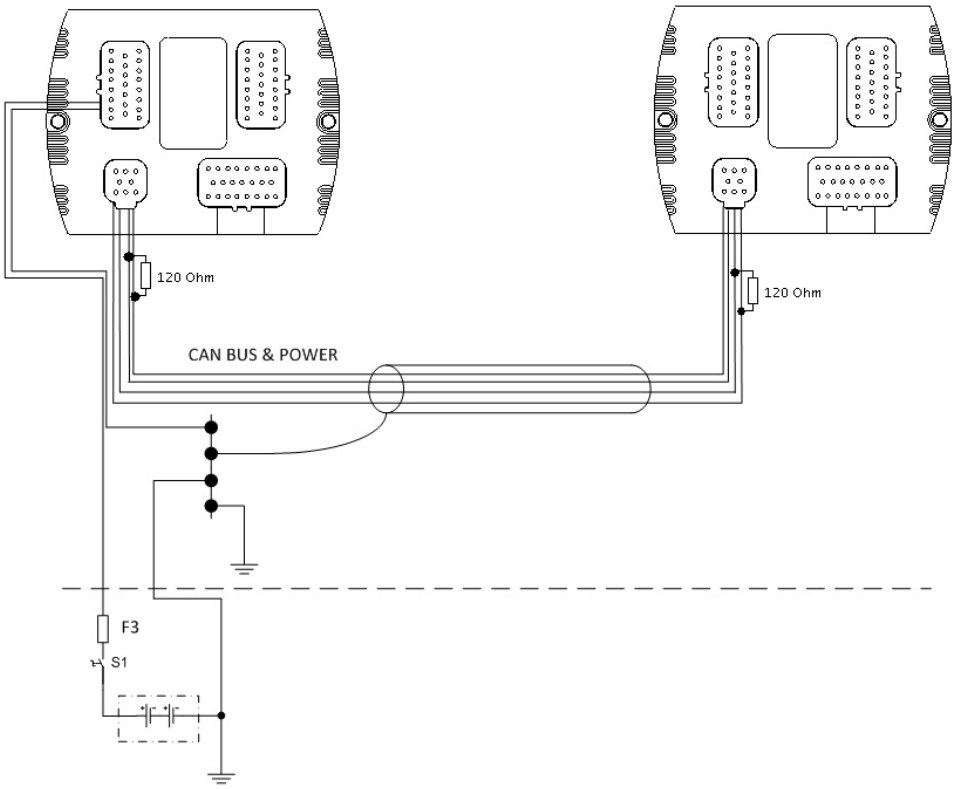
**Cable shield**

Connection example when there is a GND pin available in the control unit:




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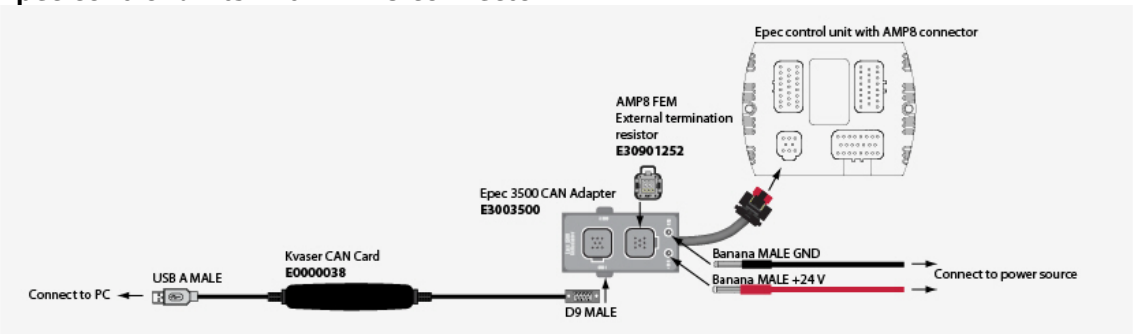
Connection example when there is not a GND pin available in the control unit:




### 8.4.2.1 CAN cabling for system developers

The following figure describes cabling for CAN communication between Epec control units and a PC.
Ordering codes for the needed hardware are included in the figure.

**Epec control units with AMP8 connector:**




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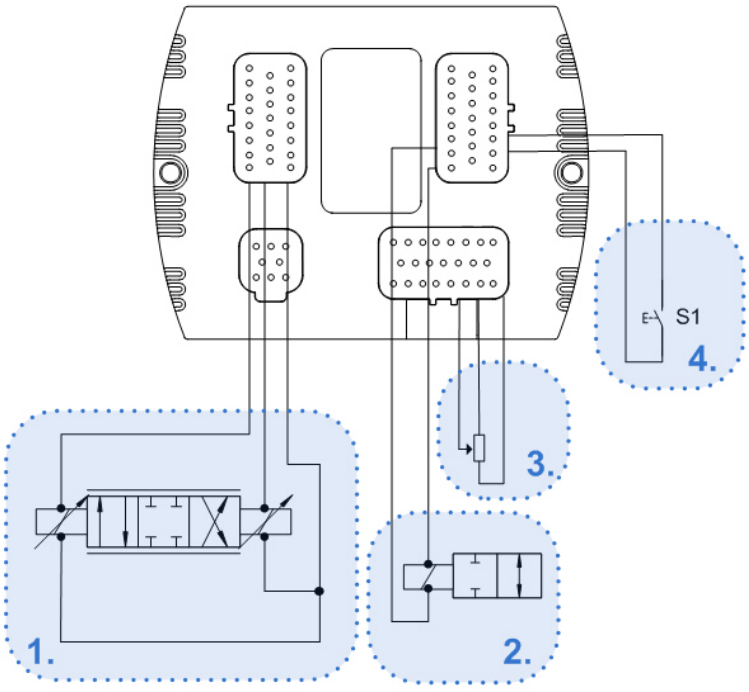
### 8.4.3 I/O Cabling

Closed circuit loops are always recommended and mandatory when you are using DO or PWM pin as an input.
Closed circuit loop means that the current from the control unit to the sensor must return to the same control unit, see the figures below.

To ensure correct measurement, reserve separate GND pin(s) for AI pin(s) and don't use it/them for any other purposes. See cabling example below.

- The cabling for encoders etc. is in many cases supplied together with them.
- In many cases, very simple basic cable may be used, e.g. automobile R2 cable (0,5 or 1,0) by NK Cables.
- Dimensions of the cable should be appropriate for AMP contacts (so that crimping is possible).
  - Refer to AMPSEAL table (in section *Accessories and Ordering Codes*) for dimensions.
  - Take extra care for protecting the cables against physical wear and damage.
- Only one wire can be connected to one AMPSEAL connector pin. However, if more than one wire has to be connected to one connector pin, it has to be connected by branch wiring.
- Some voltage inputs use relatively low voltages.
  - Consider using shielded cables for these encoders etc. especially for longer distances to increase safety
- Using shielded cable is recommended also in joystick connections.

The following figure describes four different ways to connect closed circuit loop through the control unit:

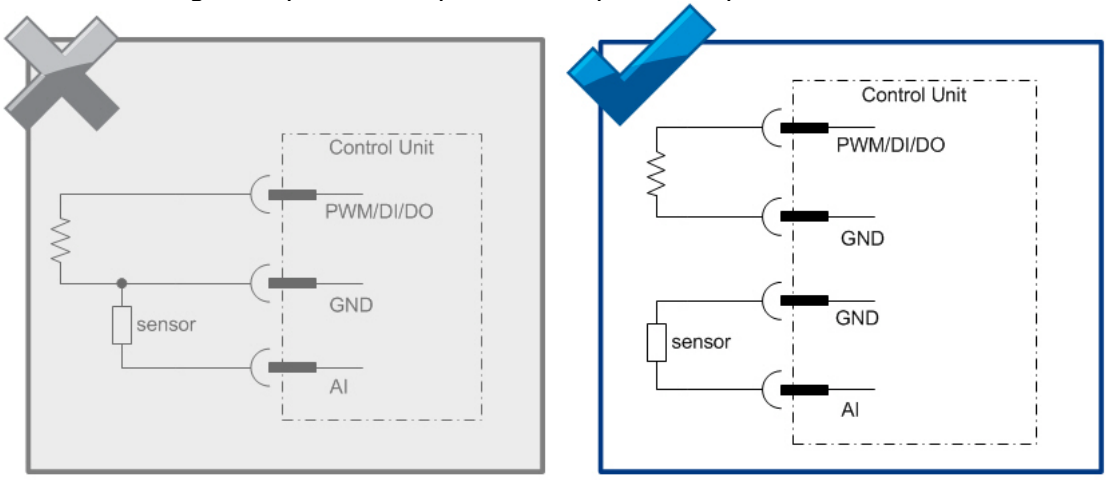



**1.** Proportional valve
**2.** ON/OFF valve

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**3.** Joystick
**4.** ON/OFF switch

AI - GND cabling examples (use separate GND pin for AI pins):




- sensors and encoders must be wired according to the closed-loop principle, i.e. the power for the sensors and encoders is supplied by the control unit they are connected to. This way, it is possible to avoid potential harmful differences, so the MOSFET driven output power switching operates properly.

When designing the sensor and encoder connections, observe single-point grounding. Each control unit connector has several GND pins which should be used.

Refer to section Power supply pins and limitations for accurate pin allocation of connectors.

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### 8.4.4 Power Supply Cabling



The maximum continuous current per pin is 10 A.



The maximum fuse that can be used per pin is 10 A.
The fuse serves as short-circuit protection.



The power for sensors, encoders and other equipment should be supplied from the very same unit that the equipment is connected to, to ensure the best performance of the system. No external power (or ground) connections are allowed.

- See section *Power Supply* for accurate pin allocation of the connectors when using Epec 3720 control unit.
- Single point grounding should be used for power supply for all control units.
- Epec recommends using doubled power cabling, though in the picture below both power cables are doubled. By using double cables one gets more area for power cables and therefore more current handling capabilities.

Generally the required area of the power cable (Cu) can be determined in following way:
Area = Max Current (A) x Nominal Resistance (Ωm) x Cable Length (m) / Max Voltage Drop (V)

Epec recommends the maximum voltage drop measured against ground potential to be at maximum 2 volts. For extra safety 1 volt should be used as a limit.

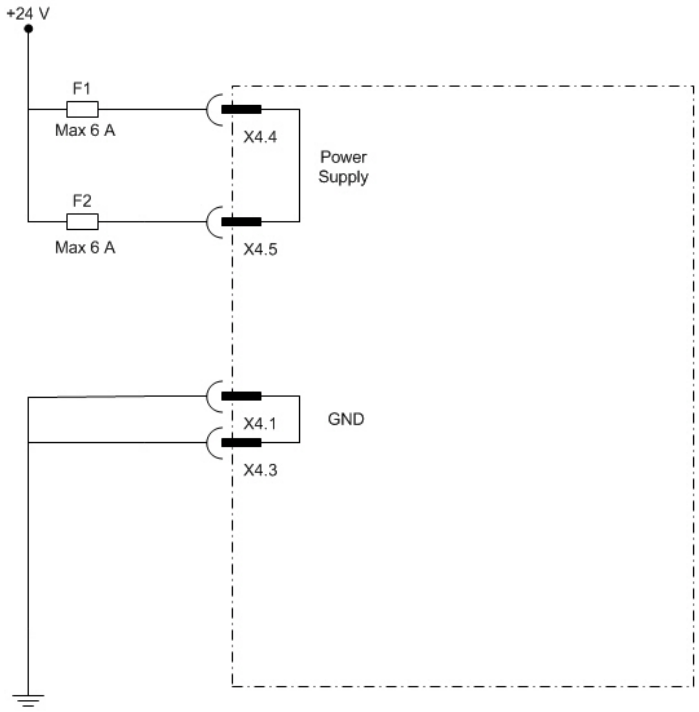
Example:
Let's assume that the machine has a 15 meters boom cable made of copper. There will be estimated 5 amps current, so the recommended cable area would be:
5 A x 0,0172*10-6 Ωm x 15 m / 2 V = 0,7 $mm^2$

Especially in those cases, where the formula above gives greater cable dimensions that can be fitted in AMPSEAL contacts, it is recommended to use doubled power cabling.

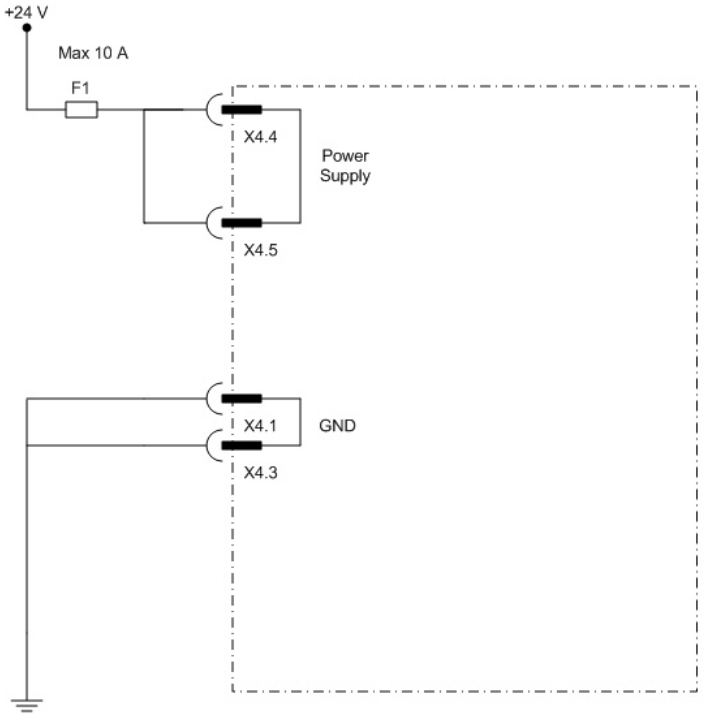
If power cables are inside the same cable with CAN bus cables, the maintenance of the system is generally easier.

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Power supply's wiring example when max 13 A is needed:

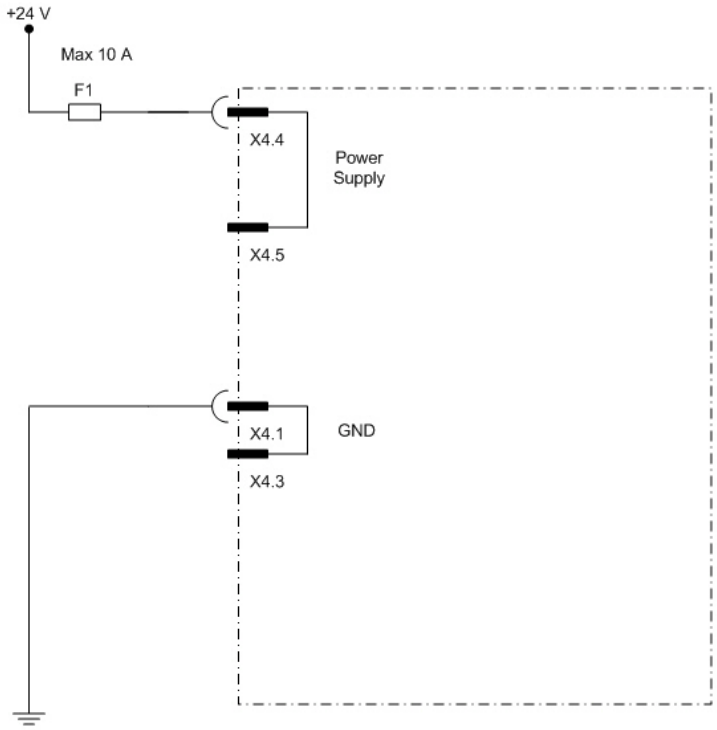



Power supply's wiring example when max 10 A is needed:

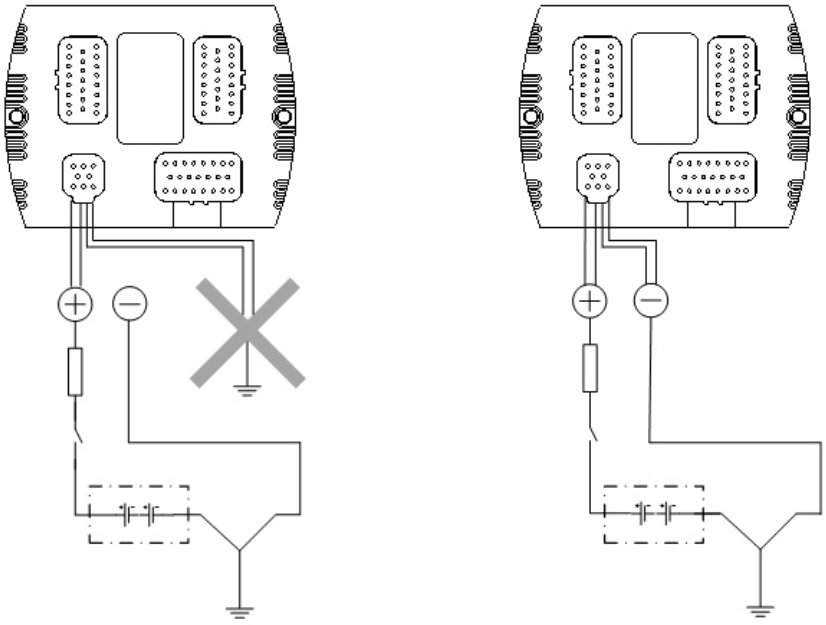



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Power supply's wiring example when max 10 A is needed:




- The power for other unit is supplied through the black AMP8 connector.
- The following figure shows a wiring example of the power supply. Single point grounding should be used for power supply for all units:




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#### 8.4.4.1 Emergency Stop



In all European Community countries, the emergency stop should be implemented in accordance with standard EN ISO 13850, which complies to the EC Machinery directive 2006/42/EC. In other countries, the emergency stop should be implemented according to local standards and/or to local legislation.

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## 8.5 Welding



Welding causes some high current flows and voltage peaks in the machine. It should be noted that the electronics of the control system may be damaged, if the welding current can get through the control unit itself. So, when welding, it should be taken care to prevent high currents from going through the control units or through the CAN bus.

Follow carefully the following instructions.



Disconnect all the connectors from the control units before welding.



Generally, even if the control system power is disconnected, welding should be done carefully and by following appropriate safety measures. Welding grounding should be connected close to the welding point to avoid long distance high current flow through machine frame.

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## 8.6 System Examples

**Loading machine**
Cabin control unit

- reads the joysticks and switches
- controls the boom and bucket
- controls the gearing
- controls the steering and brakes
- controls the lights

Rear frame control unit

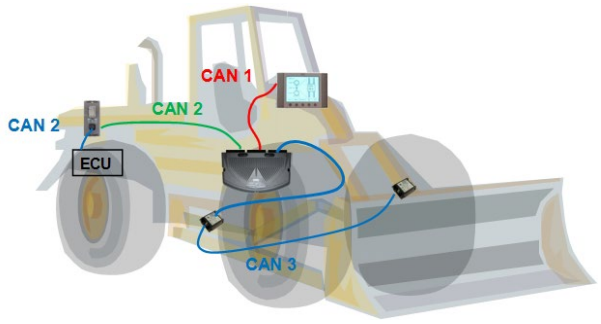
- controls the engine
- controls the hydraulic pumps
- controls the rear lights

Tilt sensors

- measures the frame position
- measures the loader position

Display

- gauge
- diagnostics
- software updating

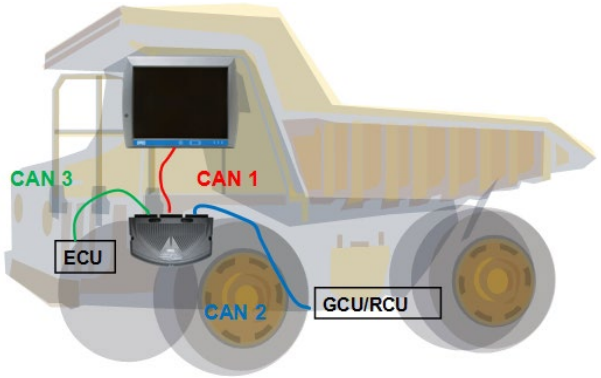



**Dumper**
Cabin control unit

- reads the joysticks and switches
- controls the engine
- controls the gearing
- controls the driveshaft brake
- controls the steering and brakes
- controls the dump box

Display

- remote connection
- positioning
- gauge
- diagnostics
- software updating



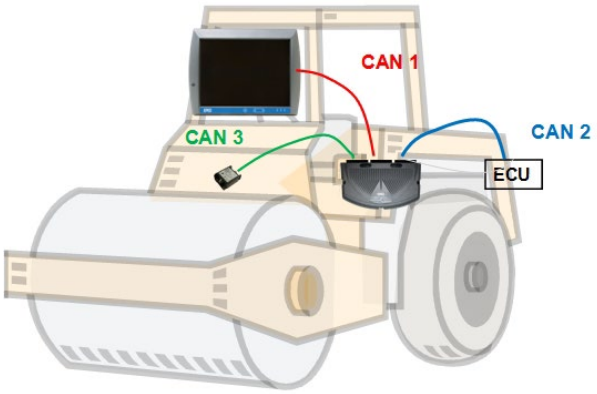

**Landfill compactor**
Cabin control unit

- reads the joysticks and switches
- controls the engine

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- controls the transmission
- controls the steering
- controls the lights

Tamping sensors
- measures the degree of concentration

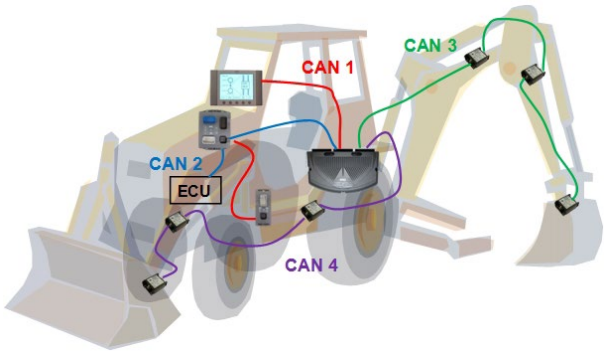



Display
- remote connection
- positioning
- gauge
- diagnostics
- software updating

**Backhoe**

Cabin control unit
- reads the joysticks and switches
- controls the excavator
- controls the roof lights
- booms' position calculation

Engine control unit
- controls the engine
- controls the front loader
- reads the fluid pressures and temperatures




Gearing control unit
- controls the gearing
- controls the suspension

Tilt sensors
- measures the frame position
- measures the excavator and front loader positions

Display
- gauge
- diagnostics
- software updating

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## 8.7 Accessories and Ordering Codes

**Related products**

| Picture | Product Name | Epec ordering code | Epec data sheet code |
|---|---|---|---|
|  | Shock Cover for Epec Control Units | E30C02192 | MAN000401 |
|  | Epec Simulator Box for Control Unit 2024 | E3003503 | MAN000411 |
|  | 3500 CAN Adapter Box | E3003500 | MAN000385 |
|  | Epec Measuring Adapter | E3002014 | MAN000387 |
| - | External termination resistor | E30901252 | - |
| - | Kvaser CAN Card | E0000038 | - |

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**AMPSEAL Connectors**

Epec uses gold plated, locked and sealed AMPSEAL heavy duty connectors for all Epec CAN Control Unit Family products to ensure endurance under extreme conditions.

- All connectors are mechanically keyed to mate only with identical colors

| AMPSEAL product | TE Connectivity ordering code | Epec ordering code |
|---|---|---|
| Contact for AMP plug assembly | 770854-3 | KX0010 |
| Crimping tool | 58529-1 | TT0018 |
| AMP 23-pin Plug Assembly, Grey | 770680-4 | KX0007 |
| AMP 23-pin Plug Assembly, Grey with 2 m leads | - | E30901310 |
| AMP 23-pin Plug Assembly, Black | 770680-1 | KX0008 |
| AMP 23-pin Plug Assembly, Black with 2 m leads | - | E30901311 |
| AMP 23-pin Plug Assembly, Blue | 770680-5 | KX0009 |
| AMP 23-pin Plug Assembly, Blue with 2 m leads | - | E30901312 |
| AMP 8-pin Plug Assembly, Black | 776286-1 | KX0187 |
| AMP 8-pin Plug Assembly, Black with 2 m leads | - | E30901313 |

**AMPSEAL cable dimensions**

<table>
<tr><th colspan="2">Size</th><th rowspan="2">Insulation diameter range</th><th>Strip length ±0,4</th></tr>
<tr><th>mm²</th><th>AWG</th><th>AWG</th></tr>
<tr><td>0,5</td><td>20</td><td rowspan="3">1,7<br>to<br>2,7</td><td rowspan="4">5,1</td></tr>
<tr><td>0,8</td><td>18</td></tr>
<tr><td>1,4</td><td>16</td></tr>
<tr><td>1,5</td><td>---</td><td>2,2<br>to<br>2,4</td></tr>
</table>

Typical hand crimping tool e.g.: AMP Procrimper 58529-1 (TE Connectivity), Epec ordering code TT0018

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