AccurET Modular 400-600 Position Controllers

Hardware Manual

Version N

ETEL

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Record of revisions:

Document revisions		
Version	**Date**	**Main modifications**
Ver A	15.05.09	First version
Ver B	19.01.10	Updated version: - Compatibility with EnDat2.2
Ver C	10.01.11	Updated version: - New UL certification laboratory (TUV) - Minor changes
Ver D	29.03.12	Updated version: - A current value modification for AccurET 600 - Minor changes
Ver E	13.09.13	Updated version: - Addition of the specific points concerning the hardware revision 2 (EA-P2M-xxx-xxxxxx-xxxx-**01**)
Ver F	08.05.14	Updated version: - Minor changes
Ver G	08.12.14	Updated version: - Dual encoder feedback connection (refer to §3.2.5) - Technical details added - AccurET 600 10/20A removed for end of life
Ver H	11.05.15	Updated version: - Minor changes (refer to §2.3.2)
Ver I	04.07.16	Updated version: - Low voltage directive 2006/95EC replaced by 2014/35/EU and EMC Directive 2004/108EC replaced by 2014/30/EU - Minor changes
Ver J	19.10.17	Updated version: - Safe Torque Off (STO) function added (refer to §3.6)
Ver K	20.11.18	Updated version: - Inductance calculation (refer to §2.2.1) - Include new product codification for EtherCAT variant (refer to §2.5.1)
Ver L	17.05.19	Updated version: - Minor modification concerning Hall effect sensor (refer to §3.3.1)
Ver M	27.11.19	Updated version: - I/O commutation times updated (refer to §3.3.1, §3.3.2, §3.3.3 & §3.3.4)
Ver N	15.09.20	Updated version: - Safety relay description updated (refer to §3.6)

Documentation concerning the AccurET Modular 400-600:

- **Hardware Manual**
- Operation & Software Manual
- Service Manual

Specifications & electrical interfaces
AccurET setup, use & programming manual
Maintenance of the fuse

Type tested
Production monitored
TÜV
PRODUCT SERVICE
NRTL
UL 508 C

The AccurET Modular 400 and 600 position controllers as well as their corresponding power supply 400 and 600 have been successfully tested and evaluated to meet the UL 508C for US market.

This standard describes the fulfillment by design of minimum requirements for electrically operated power conversion equipment which is intended to eliminate the risk of fire, electrical shock, or injury to persons being caused by such equipment.

1. Introduction

This document concerns a two axes position controller of ETEL's AccurET family: the AccurET Modular 400 (EA-P2M-400-xx/xxA) and 600 (EA-P2M-600-xx/xxA) also called 'controller' in this document as well as their corresponding power supply 400 (EA-S0M-400-xx/xxA) and 600 (EA-S0M-600-xx/xxA) also called 'power supply' in this document.
The purpose of this manual is to give details regarding the specifications, installation, interfacing and hardware items. All details for proper connections are provided herein. Detailed information concerning the programming of the controller is provided in the corresponding **'Operation & Software Manual'**.

Remark: The updates between two successive versions are highlighted with a modification stroke in the margin of the manual.

1.1 Safety

	**The user must have read and understood this documentation before carrying out any operation on an AccurET position controller. Please contact ETEL or authorized distributors in case of missing information or doubt regarding the installation procedures, safety or any other issue.**
	**ETEL S.A. disclaims all responsibility to possible industrial accidents and material damages if the procedures & safety instructions described in this manual are not followed (including the ones given in the manuals listed page 5).**

- Never use the controller and the power supply in operating conditions and for purposes other than those described in this manual.
- A competent and trained technician must install and operate the controller and the power supply, in accordance with all specific regulations of the respective country concerning both safety and EMC aspects.
- High voltage may be present on the power and motor connectors.
- The customer must provide at all time the appropriate protections against electrical hazard and moving parts of the connected system. Operating the controller will make the motor move.
- Before connecting or disconnecting a cable on one of these connectors or touching the controller, **turn off all the power supplies and wait 10 minutes** to allow the internal DC bus capacitors to discharge.
- In the controller, the **leakage current** through the protective conductor to the GND is greater than a.c. 3.5 mA.
- The safety symbols placed on the controller or written in the manuals (page 5) must be respected.
- If the controller and the power supply are integrated into a machine, the manufacturer of this machine must establish that it fulfills the 2014/30/EU directive on EMC before operating the controller.

	**Signals a danger of electrical shock to the operator. Can be fatal for a person.**
	**Signals a danger for the controller and the power supply. Can be destructive for the material. A danger for the operator can result from this.**
	**Indicates electrostatic discharges (ESD), dangerous for the controller and the power supply. The components must be handled in an ESD protected environment, only.**

Remark: The controller associated to its motor connector complies with the 2014/30/EU directive on EMC and the 2014/35/EU low voltage directive.

1.2 Presentation

1.2.1 Working principle

AccurET position controllers are proposed in a modular format dedicated to multi-axis applications where a single power supply unit is able to power many AccurET units to minimize the space required for the Electronics. Their modular cooling unit as well as their versatile design allow several configurations. These controllers include on a single board, the control circuits, the power bridge and all the necessary interfaces for the communication, the encoders and the inputs/outputs for two motors.

1.2.2 Applications

The AccurET modular 400 can drive two, single-phase, two-phase or/and three-phase motors and three-phase motors only for the AccurET modular 600. This controller can drive brushless motors, DC motors, steppers, etc. They must also be implemented with analog incremental 1 Vpp encoder, or absolute encoder (EnDat 2.1 and EnDat 2.2) or TTL encoders. Digital Hall effect sensor can also be connected to the controller. It is also possible to drive stepper motors in open loop (no need of encoder in this case).

1.2.3 General operating conditions

The AccurET controller is an open type device and must be installed in an **enclosure** providing electrical, mechanical and fire protection as well as adapted environment such as temperature, humidity, pollution degree 2,…(refer to UL 508C and EN 61800-5-1 standards for more information). Never switch ON outside of the enclosure. The AccurET modular 400 and 600 are designed to operate in a non-aggressive and clean environment, with a humidity rate ranging between 10 % and 85 %, an altitude < 2000 m (6562 ft), and a temperature ranging between +10 °C (50 °F) and +40 °C (104 °F). The controllers and their corresponding power supply must be connected to an electrical network of overvoltage category 3 (refer to EN 61800-5-1 and UL 508C standards for more information) and are suitable for use on a circuit capable of delivering not more than 5000 Arms, symmetrical amperes. The voltage is limited to 400 VDC maximum for the AccurET 400 and 600 VDC maximum for the AccurET 600. The controllers must have its control input (X100) connected to a power supply with SELV outputs (Isolated secondary output). The AccurET modular 400 and 600 are intended for use in the second environment(1). The AccurET modular 400 and 600 are not designed or intended for use in the on-line control of air traffic, aircraft navigation and communications as well as critical components in life support systems or in the design, construction, explosive atmosphere, operation and maintenance of any nuclear facility. **All control voltages or all connections (except Mains) must fulfill requirements for Limited Voltage Circuits/ Isolated Secondary Circuits.**
ETEL recommends limiting the vibration level of AccurET controllers by not mounting them on highly dynamic moving parts.

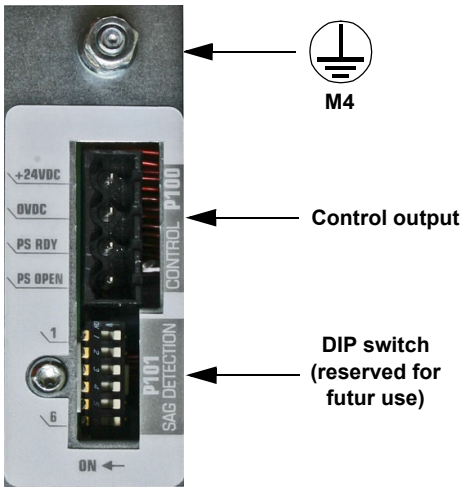
(1): Definition of Second Environment in product standard EN 61800-3 (2004): Environment that includes all establishments other than those directly connected to a low-voltage power supply network which supplies buildings used for domestic purposes (industrial areas and technical areas of any building fed from a dedicated transformer are examples of second environment locations).

1.2.4 Transport and storage conditions

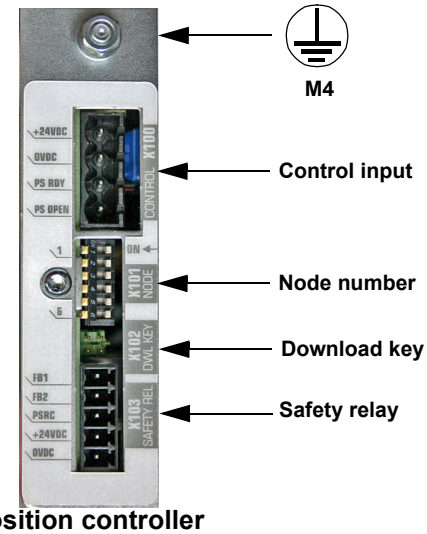
During the transport and the storage, the controller and the corresponding power supply must remain inside their original packaging which complies with the ESD standard. The transport conditions must respect the class 2K3 of the IEC 60721-3-2 standard (temperature between -25 °C (-13 °F) and +70 °C (+158 °F), and humidity < 95 % without condensation) and the storage conditions must respect the class 1K2 of the IEC 60721-3-1 standard (temperature between +5 °C (+41 °F) and +45 °C (+113 °F), and humidity between 5 and 85 % without condensation).

1.3 Connection diagram

1.3.1 Top view



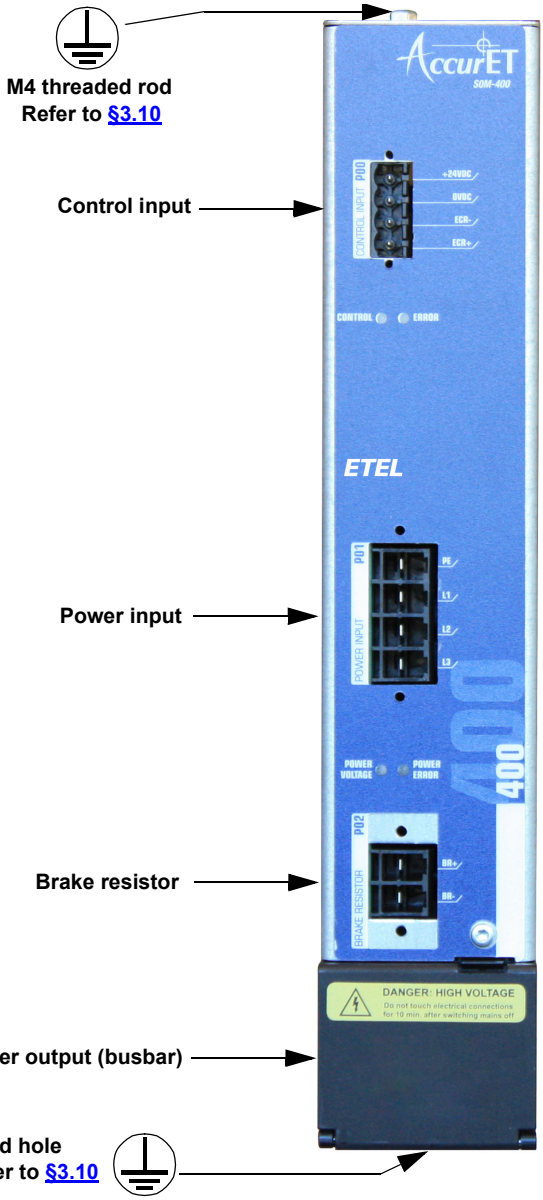
Power supply



Position controller

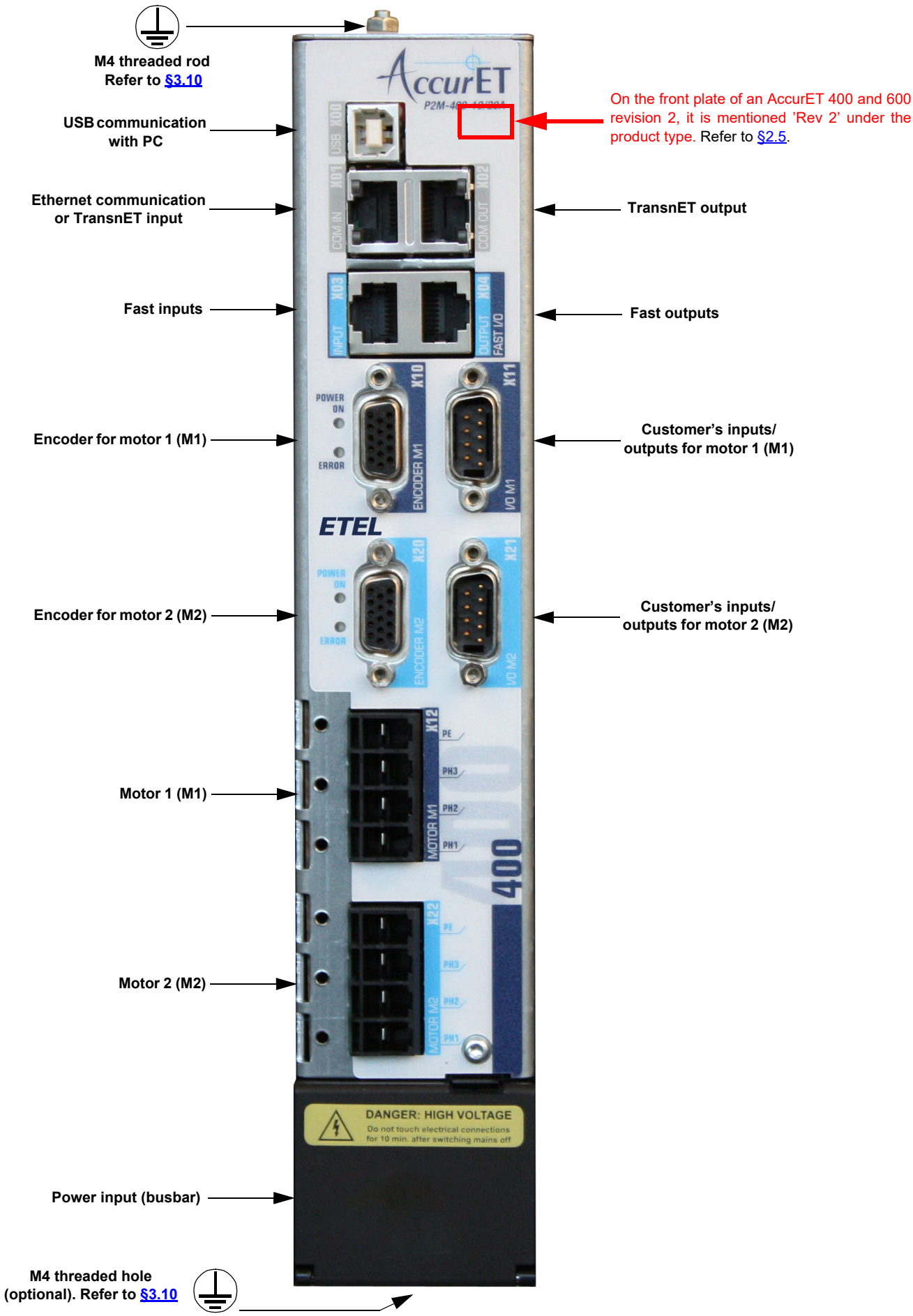
1.3.2 Front view

- **Power supply**



Remark: Refer to §3. for more information.

- **Position controller**

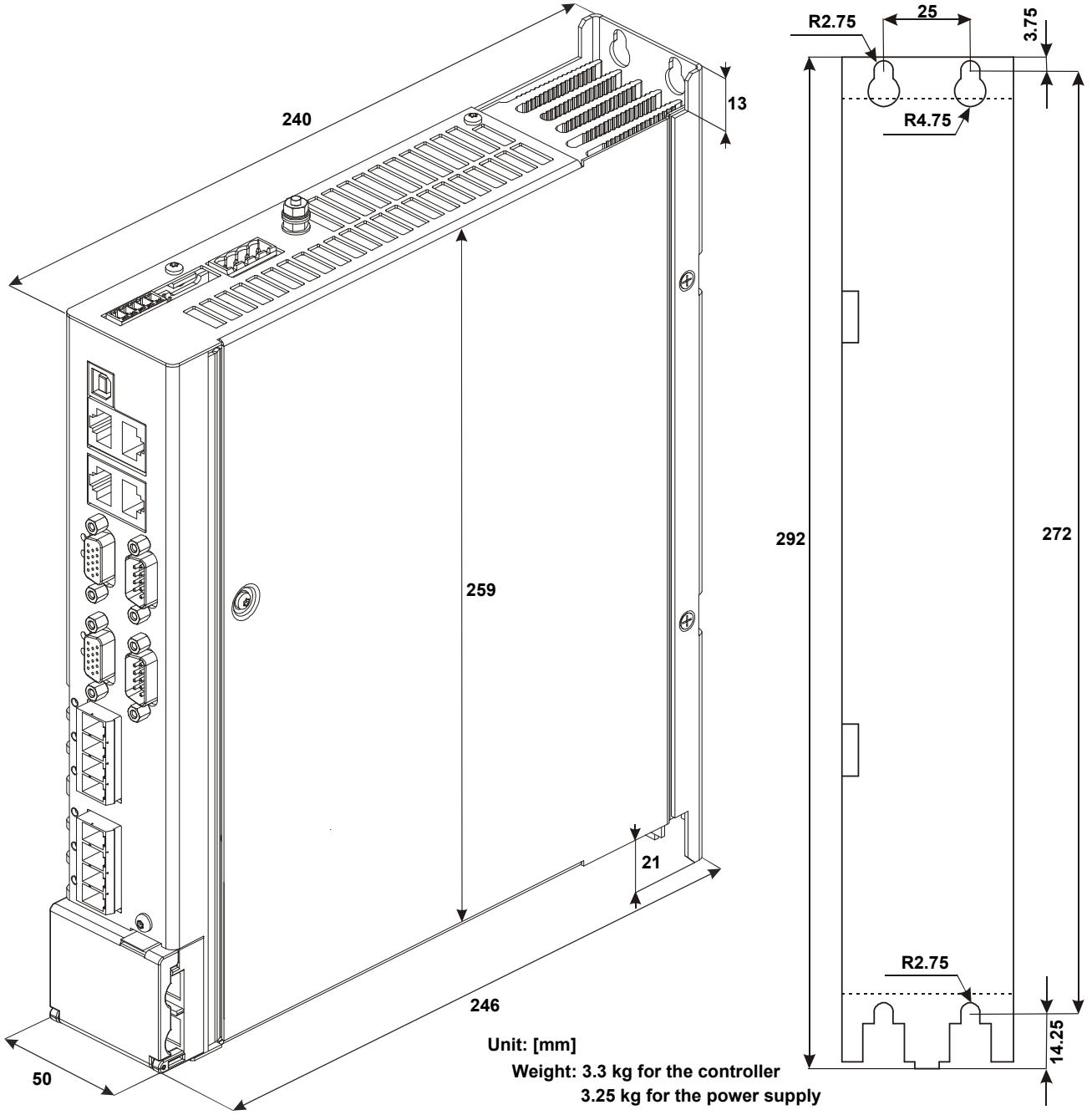


Remark: Refer to §3. for more information. A wider version also exist to include an optional board.

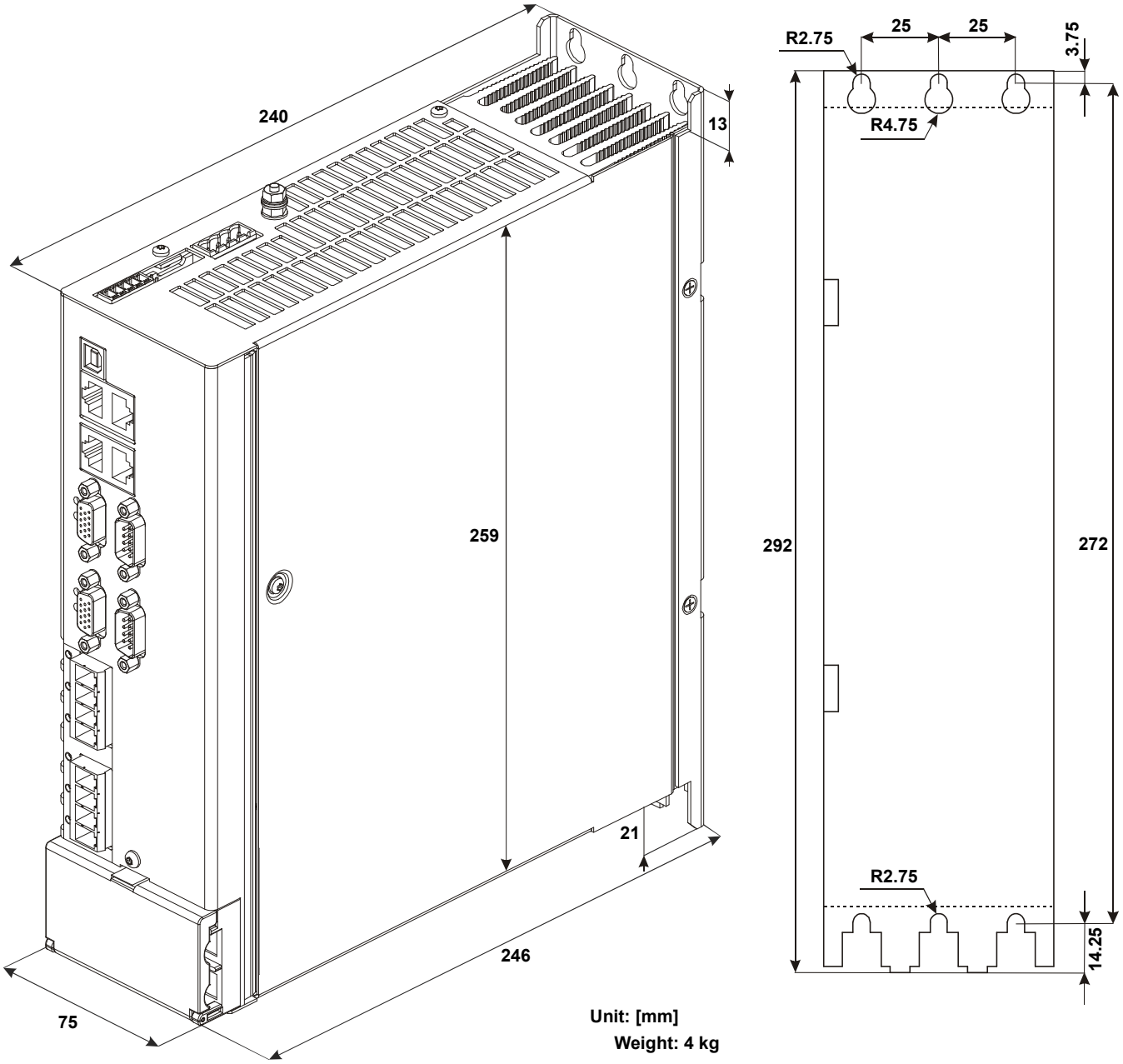
2. Models characteristics

Depending on the current output range and the possibility to have or not an optional board, there are two different widths for the controller 400 (50 mm and 75 mm) and one for the controller 600 (75 mm). The power supply 400 and 600 have the same dimensions as the 50 mm width controller.

2.1 Outline and dimensions



Remark: The 50 mm width does not exist for an AccurET 600.
If the user needs the ETEL's cooling system, the center-to-center distance between the screws at the top of the controller and the bottom screws used to fix the mounting bar is 293 mm (refer to §2.4). It is recommended to leave 100 mm above and under the controller to guarantee an air flow (the fan power depends on the user application). **Caution: some magnetic components like the fans** (not those present in ETEL's cooling unit) **may perturb the current measurement of the controller if they are too close**. If this problem occurs, use another type of fan or increase the distance between **the fan and the controller while ensuring the following minimum air flow**: 65.4 m^3/h for a 50 mm width and 76.4 m^3/h for a 75 mm width.
Caution: the surface of the heat sink at the top of the controller may be hot.
The ventilation must be activated on as soon as the control and/or power input is switched on.



Remark: If the user needs the ETEL's cooling system, the center-to-center distance between the screws at the top of the controller and the bottom screws used to fix the mounting bar is 293 mm (refer to §2.4).
It is recommended to leave 100 mm above and under the controller to guarantee an air flow (the fan power depends on the user application). **Caution: some magnetic components like the fans** (not those present in ETEL's cooling unit) **may perturb the current measurement of the controller if they are too close**. If this problem occurs, use another type of fan or increase the distance between **the fan and the controller while ensuring the following minimum air flow**: 65.4 m^3/h for a 50 mm width and 76.4 m^3/h for a 75 mm width.
Caution: the surface of the heat sink at the top of the controller may be hot.
The ventilation must be activated on as soon as the control and/or power input is switched on.

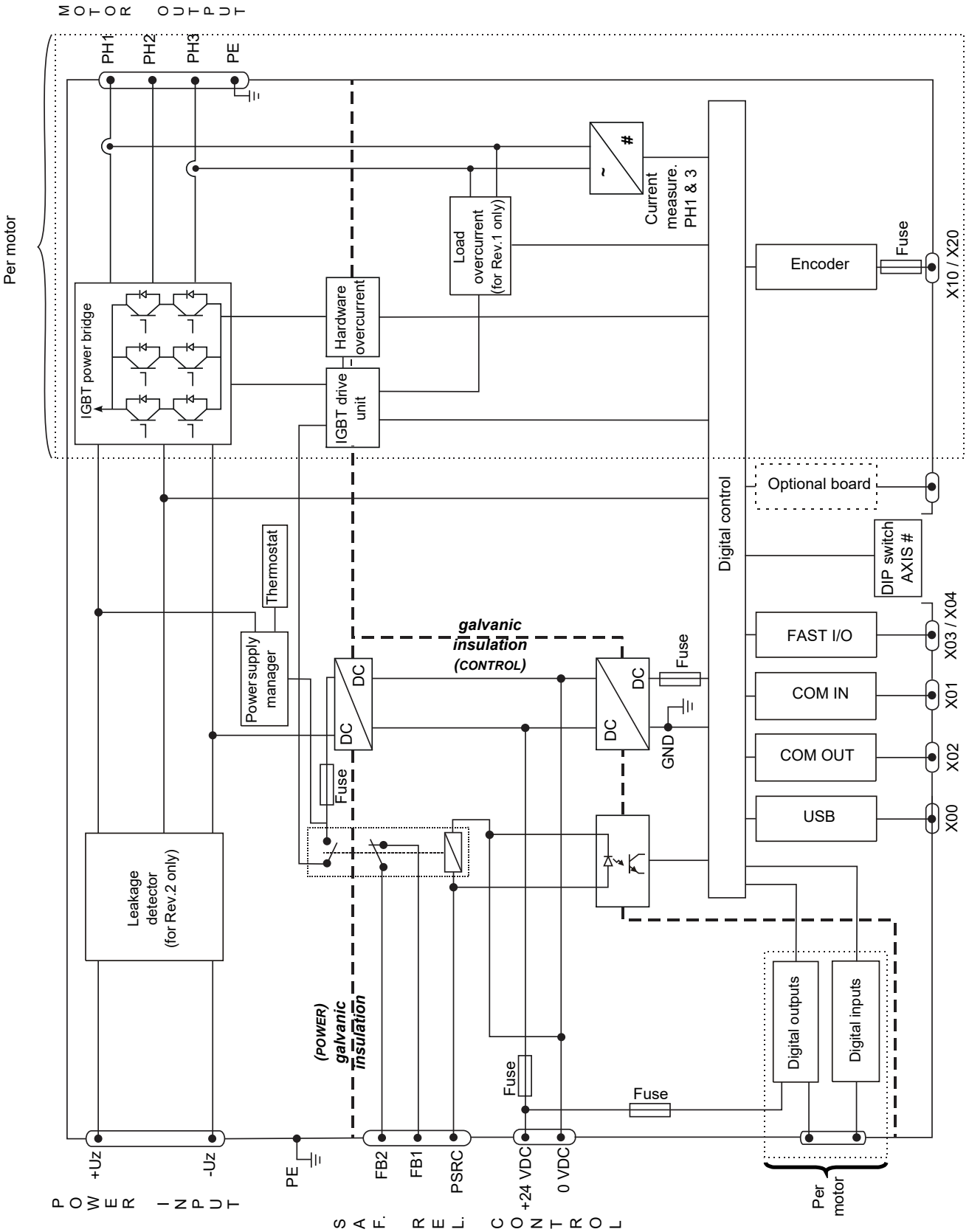
Here is the weight and the correspondence between the controller/power supply's width and the AccurET type:

	AccurET 400				AccurET 600	Power 400 / 600
Characteristics	Any current with optional board slot	05/10A without optional board slot	10/20A without optional board slot	15/40A without optional board slot	15/40A with or without optional board slot	-
Width	75 mm	50 mm	50 mm	75 mm	75 mm	50 mm
Weight	4 kg	3.3 kg	3.3 kg	4 kg	4 kg	3.25 kg ±0.1

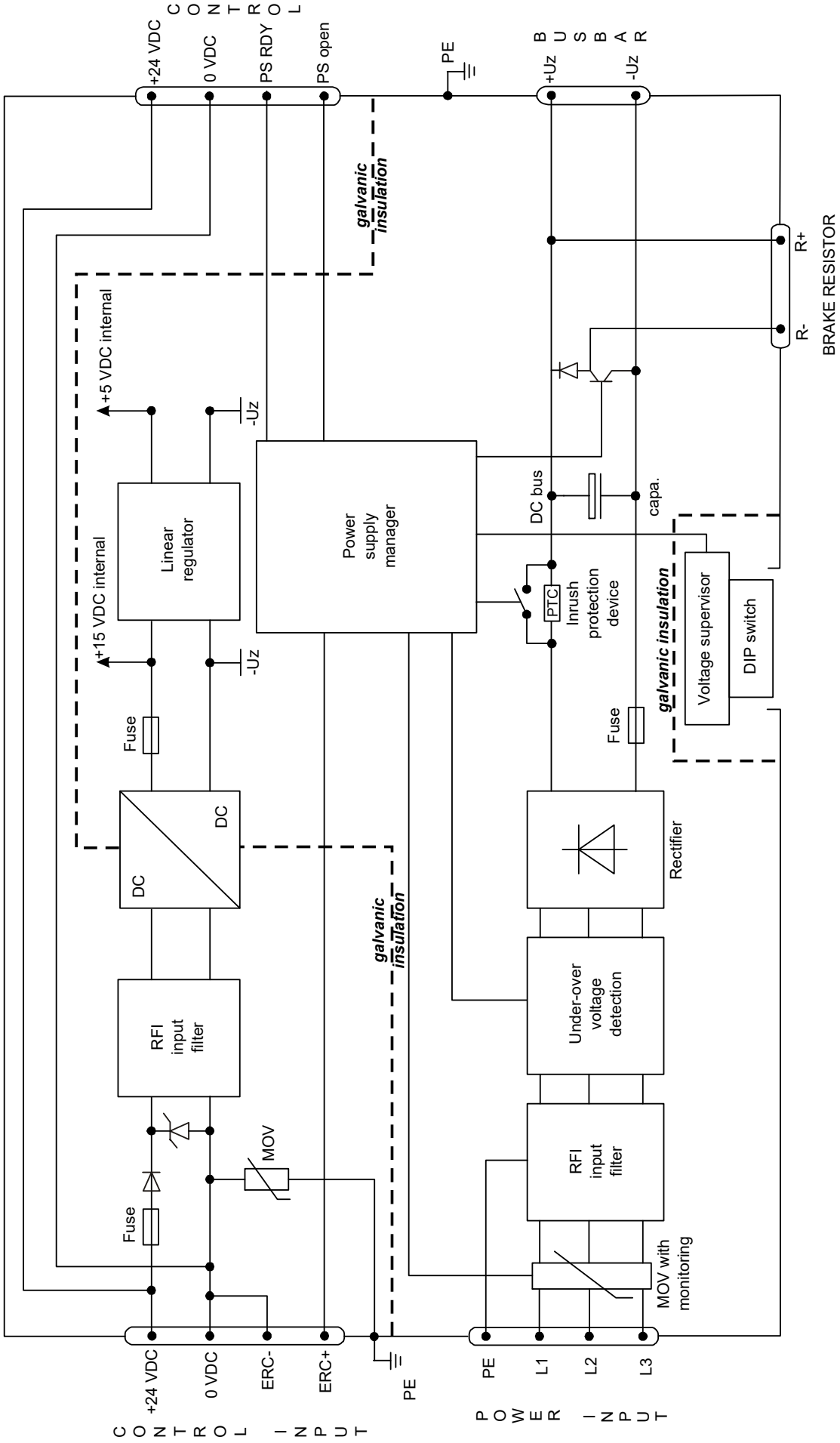
2.2 Block schematics

2.2.1 Position controller

The power part and the control part of the controller are galvanically separated. The inputs and outputs are insulated from the control part.



2.2.2 Power supply



2.3 Ratings

2.3.1 Position controllers

All the specifications are given for an ambient temperature ranging from +10 °C (50 °F) to +40 °C (104 °F) and with the ETEL bottom to top air flow cooling system (with a top to bottom air flow, the performances are 25 % lower). If this cooling system is not used, a **minimum air flow** of 65.4 m^3/h for a 50 mm width controller and 76.4 m^3/h for a 75 mm width controller is required. Contact your ETEL's representative if the ambient temperature is not included in the above-mentioned range.

Remark: The values given in the following table are valid for each motor.

- **AccurET Modular 400**

EA-P2M-400 POWER FEATURES					
Characteristics			**EA-P2M-400-05/10A**	**EA-P2M-400-10/20A**	**EA-P2M-400-15/40A**
Output to the motor (per motor)		Bus voltage	Max. 400 VDC		
		Current range on product label (refer to §2.5)	5/10 Arms	10/20 Arms	15/40 Arms
	Motor ripple at 40 kHz (PWM at 20 kHz)	**Three-phase** motor Max. full load current	7 A (5 Arms)	11.3 A (8 Arms)	16.9 A (12 Arms)
		Three-phase motor Max. overload current during 2 seconds	14.1 A (10 Arms)	28.2 A (20 Arms)	56.5 A (40 Arms)
	Motor ripple at 20 kHz (PWM at 10 kHz)	**Three-phase** motor Max. full load current	7 A (5 Arms)	14.1 A (10 Arms)	21.2 A (15 Arms)
		Three-phase motor Max. overload current during 2 seconds	14.1 A (10 Arms)	28.2 A (20 Arms)	56.5 A (40 Arms)
	Motor ripple at 40 kHz (PWM at 20 kHz)	**Two-phase** motor Max. full load current	7 A (5 Arms)	9.8 A (7 Arms)	14.1 A (10 Arms)
		Two-phase motor Max. overload current during 2 seconds	14.1 A (10 Arms)	28.2 A (20 Arms)	56.5 A (40 Arms)
	Motor ripple at 20 kHz (PWM at 10 kHz)	**Two-phase** motor Max. full load current	7 A (5 Arms)	14.1 A (10 Arms)	21.2 A (15 Arms)
		Two-phase motor Max. overload current during 2 seconds	14.1 A (10 Arms)	28.2 A (20 Arms)	56.5 A (40 Arms)
	Motor ripple at 40 kHz (PWM at 20 kHz)	**One-phase** motor Max. full load current	8.4 A (6 Arms)	15.5 A (11 Arms)	18.3 A (13 Arms)
		One-phase motor Max. overload current during 2 seconds	14.1 A (10 Arms)	28.2 A (20 Arms)	56.5 A (40 Arms)
	Motor ripple at 20 kHz (PWM at 10 kHz)	**One-phase** motor Max. full load current	11.3 A (8 Arms)	21.2 A (15 Arms)	28.2 A (20 Arms)
		One-phase motor Max. overload current during 2 seconds	14.1 A (10 Arms)	28.2 A (20 Arms)	56.5 A (40 Arms)
Power input		DC voltage	100 - 400 VDC(1)		
		Max. current	30 Arms		
Control input		DC voltage	24 VDC (0+10%)		
		Max. current at 24 VDC	Typ. 1.3 A(2) / Max. 2.5 A		
Maximum current measurable by the controller			17 A	34 A	68 A
DC bus capacitors			280 µF		

(1): The controller itself can work with a power input of 48 VDC or above.
(2): The current can change depending on the type(s) of encoder(s), the type of optional board as well as the number of inputs/outputs used. A current equal to about twice the above-mentioned typical value can be necessary to switch on the controller (because of the inrush pulse).
With two-phase motor, the current in 'motor phase 1- / 2-' is equal to (√2 x motor phase 1+) or (√2 x motor phase 2+). Be careful to use the suitable cable diameter.

Remark: The values of current in the table above are given for a two or three-phase sinusoidal current. If a DC current is requested (motor at standstill, or very low speed), these values can be divided by a factor up to √2.

- **AccurET Modular 600**

EA-P2M-600 POWER FEATURES			
Characteristics			**EA-P2M-600-15/40A**
Output to the motor (per motor)		Bus voltage	Max. 600 VDC
		Current range on product label (refer to §2.5)	15/40 Arms
	PWM at 10 kHz	**Three-phase** motor Max. full load current	11.3 A (8 Arms)
		Three-phase motor Max. overload current	56.5 A (40 Arms / 0.8s)
	PWM at 5 kHz	**Three-phase** motor Max. full load current	21.2 A (15 Arms)(*)
		Three-phase motor Max. overload current	56.5 A (40 Arms / 1.5s)
Power input		DC voltage	200 - 600 VDC(1)
		Max. current	30 Arms
Control input		DC voltage	24 VDC (0+10%)
		Max. current at 24 VDC	Typ. 1.3 A(2) / Max. 2.5 A
Maximum current measurable by the controller			68 A
DC bus capacitors			135 µF

(*): For an ambient temperature exceeding +30 °C, a derating of 1 Arms per 5 °C (up to 40 °C) must be applied on the above-mentioned current values.
(1): The controller itself can work with a power input of 48 VDC or above.
(2): The current can change depending on the type(s) of encoder(s), the type of optional board as well as the number of inputs/outputs used. A current equal to about twice the above-mentioned typical value can be necessary to switch on the controller (because of the inrush pulse).

Remark: The values of current in the table above are given for a two or three-phase sinusoidal current. If a DC current is requested (motor at standstill, or very low speed), these values can be divided by a factor up to √2.
With PWM at 20 kHz, the current ripple in the motor is at 40 kHz (20 kHz with PWM at 10 kHz).
With two-phase motor, the current in 'motor phase 1- / 2-' is equal to (√2 x motor phase 1+) or (√2 x motor phase 2+). Be careful to use the suitable cable diameter.

When the current ripple in the motor becomes too important, it could limit the performance of the control loops or even overheat the motor. To avoid this, the inductance of the motor must comply with the following formula:

$$\frac{L1 \cdot I_p \cdot \sqrt{2}}{\alpha} \geq \frac{V_{PWR}}{f_{PWM}}$$

Where:
- L1: inductance of the motor [mH] (terminal to terminal)
- I_p: peak current of the motor [Arms]
- V_{pwr}: DC bus voltage of the position controller [V]
- f_{PWM}: controller PWM frequency [kHz]
- α: constant, depending on use cases:
  - α = 2 when $f_e \leq 100$ Hz
  - α = 4 when $f_e > 100$ Hz

f_e: electrical frequency of motor phases [Hz]

For a rotary motor, it is defined as:

$$f_e = \frac{n}{60} \cdot p$$

n: speed of the rotary motor [rpm]
p: number of pair of poles (2p is the number of poles)

For a linear motor, it is defined as:

$$f_e = \frac{v}{2T_p}$$

v: speed of the motor [mm/s]
$2T_p$: magnetic period [mm]

Remark: In case the formula is not complying, the user could add external inductance on each phase of the motor.

Example using an ETEL torque motor (TMM0140-050):

p = 11 (2p=22 poles)
L1 = 14.1 mH
R = 2.5 Ω
I_p = 39.5 Arms
v = 1200 rpm
f_{PWM} = 10 kHz
V_{pwr} = 600 V

Electrical frequency:

$$f_e = \frac{1200}{60} \cdot 11 = 220Hz$$

Constant α = 4 (as f_e > 100 Hz)

Verification that the inductance of the motor is big enough:

$$\frac{14.1 \cdot 39.5 \cdot \sqrt{2}}{4} \geq \frac{600}{10} \quad => \quad 196.9 \geq 60 \quad => \quad \text{There is no risk}$$

EA-P2M-400 and EA-P2M-600 CONTROL FEATURES		
General	Motion profile and command management sampling time	400 µs
	Digital current loop sampling time	50 µs
	Position loop sampling time	50 µs
	Motion profiles	Trapezoidal / S-curve / sine / look-up table /.../ interpolated (UltimET)
	Processor	SHARC Digital Signal Processor, 40 bits floating point
	Power safety relay	Relay disabling the output power bridge
Standard interfaces	USB 2.0 (for setting only)	Full speed (12 Mbps)
	TransnET Ethernet	1 Gbps 10 / 100 MHz
Position encoders interfaces	Analog 1Vpp	Max. 500kHz in. / Up to 2'048 (x4) interpolation factor
	EnDat 2.1 and 2.2 (absolute encoder)	RS485
	Encoder limit switch (EHO/L1 & ELS/L2 signals)	TTL signal
	Digital (TTL high speed)(*)	Max. 10MHz input frequency
User's inputs / outputs	Digital input, insulated	5 per motor
	Fast digital input	4 (common to both motor)
	Digital output, insulated	2 per motor
	Fast digital output	4 (common to both motor)
	Analog input	0
	Analog output	0

EA-P2M-400 and EA-P2M-600 CONTROL FEATURES		
Software / programmability	ComET software for setting / monitoring	For software compatibility, refer to the ComET manual
	EDI (DLL files for C and C++)	For software compatibility, refer to the EDI manual
	Firmware update	USB and TransnET

(*): the period frequency (2.5 MHz) is one fourth of the counter frequency (10 MHz).

2.3.2 Power supply

All the specifications are given for an ambient temperature ranging from +10 °C (50 °F) to +40 °C (104 °F) and with the ETEL bottom to top air flow cooling system (with a top to bottom air flow, the performances are 25 % lower). If this cooling system is not used, a **minimum air flow** of 65.4 m^3/h for a 50 mm width controller and 76.4 m^3/h for a 75 mm width controller is required. Contact your ETEL's representative if the ambient temperature is not included in the above-mentioned range.

POWER FEATURES				
Characteristics			**EA-S0M-400-40/80A**	**EA-S0M-600-40/80A**
Power supply output	DC voltage		100 - 400 VDC	200 - 600 VDC
	Max. continuous current		Limited by max. AC input current 10 Arms(1)	
	Max. pulse current		80 A	
	Efficiency		Around 95%	
Auxiliary supply output	DC voltage		24 VDC ±10%	
	Max. continuous current (coming from external 24 VDC power supply)		10A(2)	
Power supply input	AC voltage(3)	Three phases	71 - 280 VAC (50 - 60 Hz)	142 - 424 VAC (50 - 60 Hz)
		Single phase (L1 + neutral)	71 - 280 VAC (50 - 60 Hz)	-
	Max. AC current		10 Arms	10 Arms
	Max. inrush current per phase(3)		15 Apeak at 280 VAC	15 Apeak at 424 VAC
	Max. continuous power with 1-phase AC input		2.8 KW	N/A
	Max. continuous power with 3-phase AC input		4.8 KW	7.3 KW
	Power factor correction		No	
Auxiliary supply input	DC voltage		24 VDC (0+10%)	
	Max. current		10 A	
External braking resistor	Internal value (voltage limitation device)		No	
	External resistor (depends on customer application)		>20 Ω (400 VDC)	>30 Ω (600 VDC)
	Max. continuous current(4)		20 A	20 A
Weight	-		3.25 kg ±0.1	3.25 kg ±0.1

(1): can be reached only with forced cooling (external fan necessary)
(2): depending on the type of encoder, the type of optional board as well as the number of inputs/outputs used, one controller can consume differently from another. On average, 5 controllers can be used with a single power supply.
(3): voltage measured between contact in the power input connector.
(4): the current is fixed by the value of the external resistor (>20 Ω for 400 VDC and >30 Ω for 600 VDC)

Remark: N/A means «Not Applicable».

DESIGN & SAFETY FEATURES		
Characteristics	**Power input**	**Control input**
Separated supply	Advantage: if the power input is turned off for safety reasons, the control input may remain on and the reading of the position is kept. **For safety reasons, do not supply power if the control input is not supplied**	
Input filters	Filter reduces EMI (Electromagnetic Interferences)	Yes
Fuse	Protects the power output against short-circuits	Yes
Inrush current limiters	Measurement, relay and limitation PTC resistor, with feedback to the controller. Inrush current < 15 A	-
DC bus capacitors	1400 µF for AccurET 400 675 µF for AccurET 600	-
Undervoltage detection	If Vin<50 VAC for the power 400 If Vin<75 VAC for the power 600 (Red LED power error is ON)	In the controller
Voltage limitation / braking	If Vpwr > 420 VDC, braking ON for the power 400 If Vpwr > 615 VDC, braking ON for the power 600 (no feedback to the controller)	N/A
Output overvoltage detection	Error if > 470 VDC for AccurET 400 Error if > 670 VDC for AccurET 600	36 V protection by zener
Input overvoltage protection	MOV with monitoring of the status	MOV

2.4 Mounting

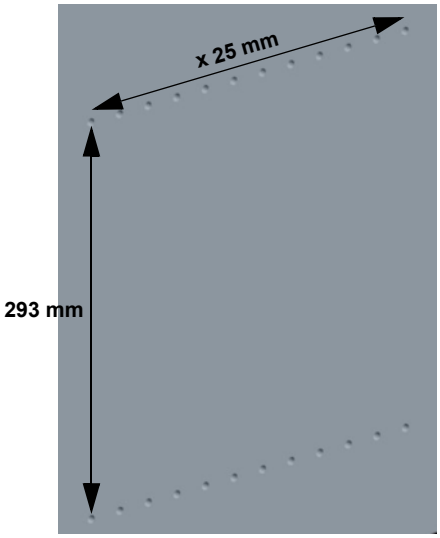
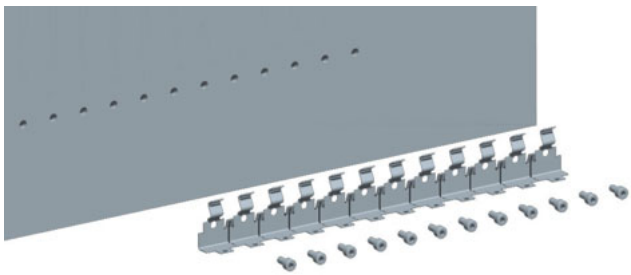
The controller and the power supply have the following electrical safety degree: IP 20 (according to EN 60529 standard).
The AccurET controller and power supply must be installed in an enclosure providing electrical, mechanical and fire protection as well as adapted environment such as temperature, humidity, pollution degree 2,…(refer to UL 508C and EN 61800-5-1 standards for more information).

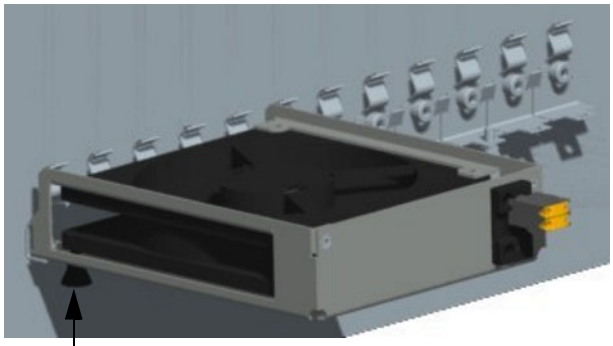
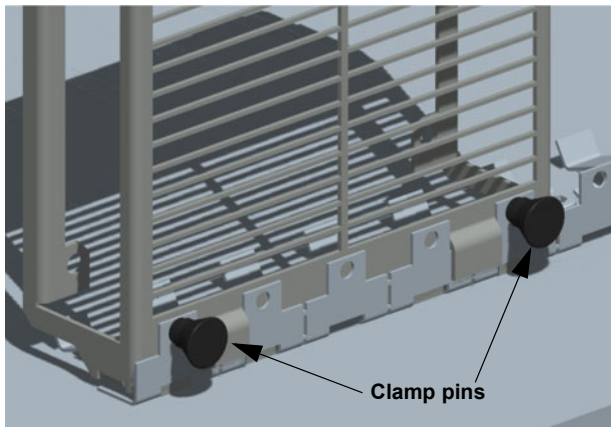
2.4.1 Hardware mounting

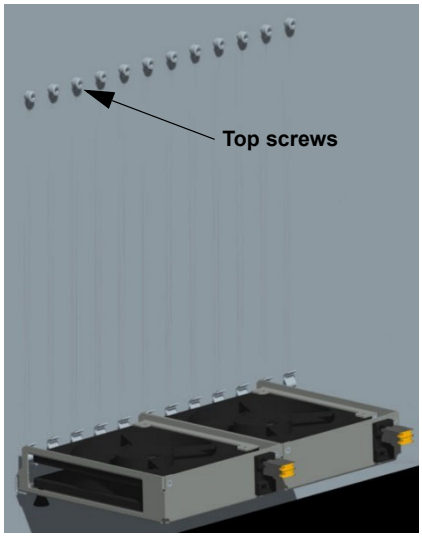
The controller and its corresponding power supply should be protected against any splashes of liquid and any contacts with smoke and dust. It must be installed inside a closed cabinet and mounted as mentioned below. The ground must be connected prior to any other connections (refer to §3.10 for more information). Fresh air is necessary to cool the controller inside the cabinet. It is recommended to leave 100 mm above and under the controller to guarantee an air flow (the fan power depends on the user application). **Caution: some magnetic components like the fans** (not those present in ETEL's cooling unit) **may perturb the current measurement of the controller if they are too close**. If this problem occurs, use another type of fan or increase the distance between **the fan and the controller while ensuring the following minimum air flow**: 65.4 m^3/h for a 50 mm width and 76.4 m^3/h for a 75 mm width.

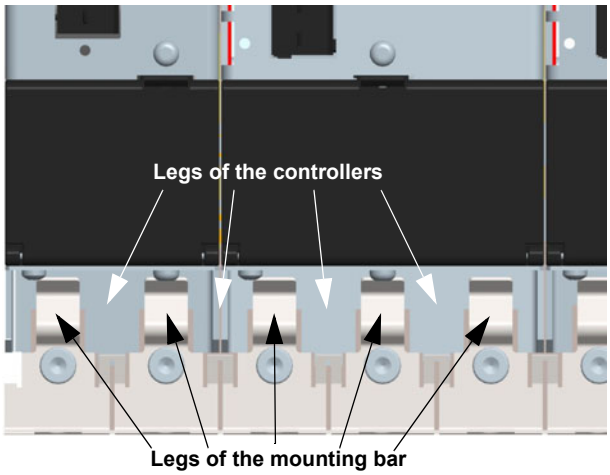
There are three different ways to fasten the controller:

- The ETEL's cooling system is required. In that case, the procedure described hereafter must be followed.
- The user does not need the ETEL's cooling system as well as the mounting bar. In that case, only 4 screws are needed to fasten it. Refer to §2.1 to have the dimensions.
- The user does not need the ETEL's cooling system but wants to use the mounting bar. In that case, the step 1 and 2 of the procedure mentioned below must be followed (refer also to §2.1 to have the dimensions).

Step 1	Step 2
	
The drilling must be realized. The center-to-center distance between the screws at the top of the controller and the bottom screws used to fix the mounting bar is 293 mm. The pitch between each screw belonging to the same row is 25 mm.	Fasten the mounting bar with M5 screws

Step 3
    Bottom view
Put the fans in position and fix them with the black clamp pins (2 per fan)

Step 4

Screw, half way, the top screws

Step 5
 
Put the power supply as mentioned above. The legs at the bottom of the power must be inserted between each leg of the mounting bar.

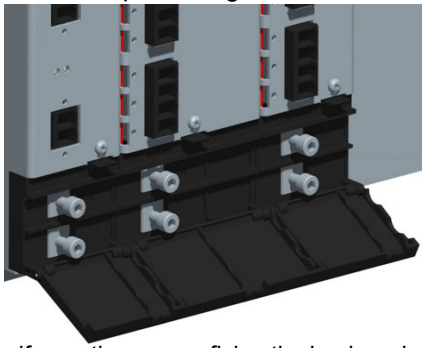
Step 6	Step 7
	
Push the power against the back panel, then against the fan and finish to screw the top screws.	Proceed as mentioned in step 5 and 6 to put the controllers.

Remark: The mounting bar and ETEL's fans are identical whatever the AccurET modular product.

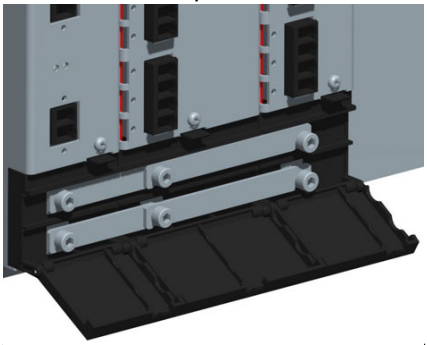
- **Busbar mounting**

	**High voltage may be present on the busbar. Before connecting or disconnecting the busbar elements, turn off all the power supplies, wait 10 minutes to allow the internal DC bus capacitors to discharge and control the voltage between the contacts. This must be respected also before opening the plastic cover. This cover must be closed before turning on the power!**

To open the cover protecting the busbar, lift the flap and swivel the mobile part round.



Screw, half way, the screws fixing the busbar elements (a screwdriver for T4 torx screw is needed)

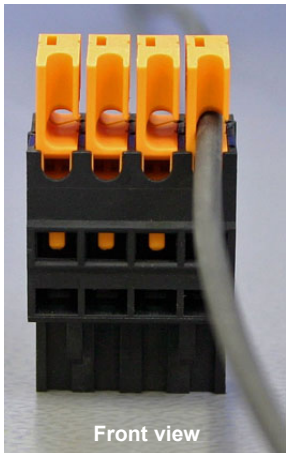
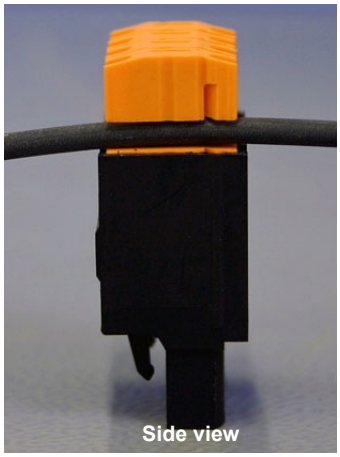
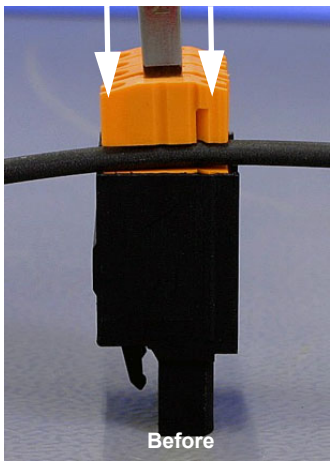
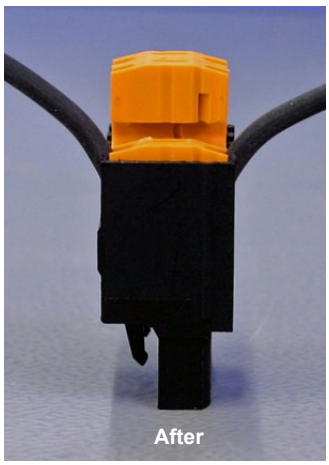
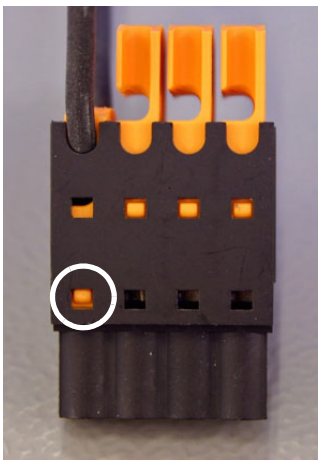


Put the busbar elements in position and finish to screw the screws fixing the busbar elements

2.4.2 Fan power and control input wiring

The power input voltage connector of the fans as well as the ones of the control input voltage of the controller (going from the top of the power supply to all connected controllers) are connected all together with the type of connector delivered by ETEL. These connectors are self-strip connectors and are delivered only if the connectors kit is ordered. The user must correctly size his power supply according to the number of controller (with or without optional board) connected together.

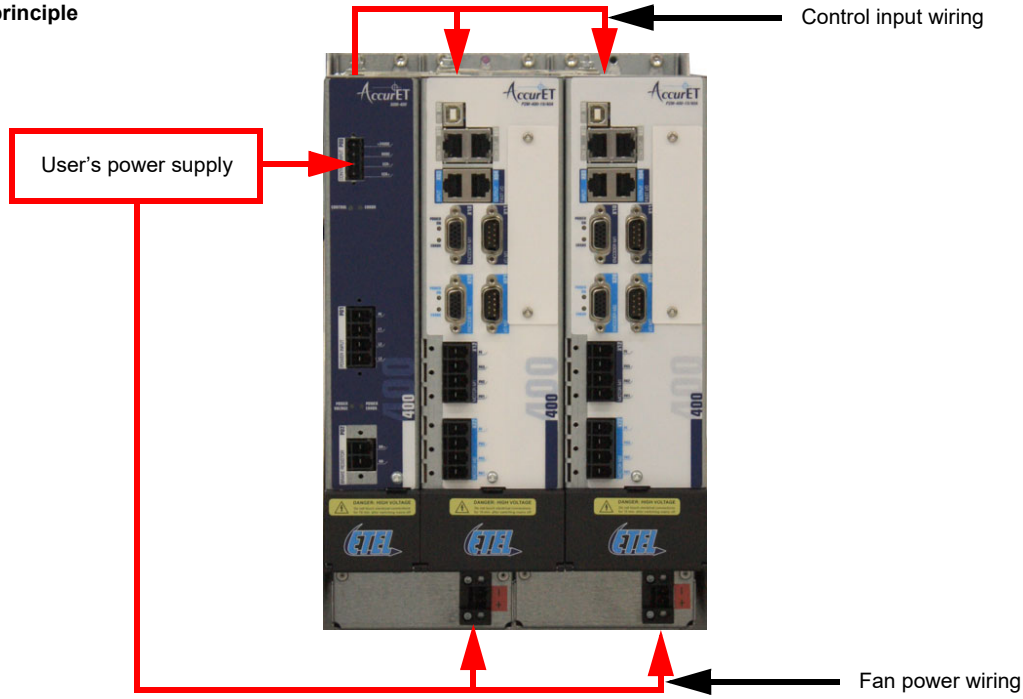
Here is the procedure to manufacture the wiring:

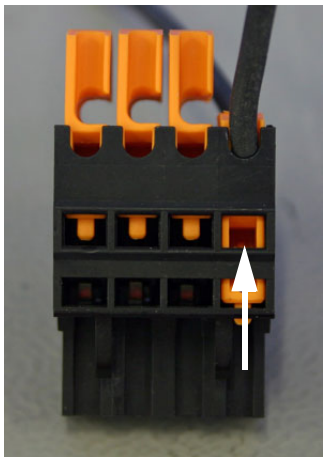
 	1) Insert the cable in the slot. **Caution: Use only wire with a section from 0.5 mm^2 (AWG 20) to 1 mm^2 (AWG 18).**
 	2) Push down the upper part (orange) with a screwdriver for example. **Caution: It is forbidden to realize this operation with the connector plug on the controller. It must be done before plugging it into the controller.** **Be careful, not to get your finger caught when pushing down.**
	3) To check if the upper part has been pushed enough, the orange pin must be visible in the black cut-out. 4) Repeat the steps 1 to 3 for the other wires. 4 wires are needed per control input connector and 2 for the fan power connector. 5) Repeat the steps 1 to 4 for the other connectors. There are as many control input connectors as controllers. The number of fan power connectors depends on the width of the fan (refer to §2.5.2). 6) The wires before the first connector and after the last connector must be cut short.

Here is an example with a power and a single controller.

Caution: the length of the wires between 2 connectors must take into account the length lost inside the connector and the fact that the distance may change depending on the controller's width.

Wiring principle





If the wire must be released, push up the orange part with a small screwdriver for example. However, it is not recommended to do it to avoid failure and security problem.

2.5 Ordering information

Here is the ordering information describing the meaning of each digit present on each product:

2.5.1 Position controller

EA	-	P	2	M	-	400	-	05/10A	-	0	0	0	0	-	0	1

Family code:
EA = Electronics AccurET

Product type / technology:
P = PWM

Axis number:
2 = Dual axis

Format:
M = Modular

Maximum operating DC voltage:
400 = 400 VDC
600 = 600 VDC

Continuous / peak current:
05/10A = 05 / 10 Arms(*)
10/20A = 10 / 20 Arms(*)
15/40A = 15 / 40 Arms

Reserved

Optional board slot:
0 = No
1 = Yes

Standard:
0 = UL 508C compliant(**)
9 = Not UL 508C compliant(***)

EtherCAT Option
(or future software option)
0 = No EtherCAT
2 = EtherCAT supported

Hardware revision:
00 = Standard product: hardware revision 1
01 = Standard product: hardware revision 2

(*): not available in the AccurET 600
(**): By default, all products are compliant
(***): May exceptionally occur during product life time. Should this happen, customer would be officially notified in case it may be unacceptable

2.5.2 Cooling unit

EA	-	CU	M	-	125	-	BT	-	0	0

Family code:
EA = Electronics AccurET

Product type / technology:
CU = Cooling Unit

Format:
M = modular

Size:
75 = 75 mm
100 = 100 mm
125 = 125 mm

Type:
BT = Bottom to Top air flow (by default)
TB = Top to Bottom air flow (performances 25 % lower compared to BT)

Reserved

Reserved

Remark: The width of the fans depends on the width of the selected controllers.
ETEL's fans are identical whatever the AccurET modular product.

2.5.3 Power supply

EA	-	S	0	M	-	400	-	40/80A	-	0	0	0	0	-	00

Family code:
EA = Electronics AccurET

Product type / technology:
S = power Supply

Reserved

Format:
M = Modular

Maximum operating DC voltage:
400 = 400 VDC
600 = 600 VDC

Peak current:
40/80A = 80 Arms peak

Reserved

Reserved

Standard:
0 = UL 508C compliant(*)
9 = Not UL 508C compliant(**)

Reserved

Hardware revision:
00 = Standard product

(*): By default, all products are compliant
(**): May exceptionally occur during product life time. Should this happen, customer would be officially notified in case it may be unacceptable

2.5.4 Mounting bar

EA	-	MB	M	-	300	-	0	0

Family code:
EA = Electronics AccurET

Product type / technology:
MB = Mounting Bar

Format:
M = modular

Size:
300 = 300 mm

Reserved

Reserved

Remark: The mounting bar is identical whatever the AccurET modular product.

2.5.5 AccurET kits

EA	-	BCK	-	P2M	-	400/600	-	00

Family code:
EA = Electronics AccurET

Product type / technology:
BCK = Black Connectors Kit
STK = Starting Kit
SHK = Shielding kit

Product type:
S0M = Modular power supply
P2M = Modular position controller 2 axes

Voltage:
400/600 = suitable for 400 and 600 VDC
controller or power supply

Reserved

3. Electrical interface

This chapter describes the pin assignment for every connector. More detailed explanations for proper connections are given in each case.

Here is the list of the groups of connectors, according to their function:

Communication connectors (refer to §3.1).

Encoders connectors (refer to §3.2).

Inputs / outputs connectors (refer to §3.3).

Motor connectors (refer to §3.4).

Power connectors (refer to §3.5).

Safety relay connector (refer to §3.6).

Download key connector (refer to §3.7).

Node number switch (refer to §3.8).

Optional board slot (refer to §3.9).

Remark: **Avoid misalignment of male and female connector as well as insertion of other connector than the one intended to receive it.**

In the next paragraphs, connectors with male pins are indicated with the '•'symbol (full), and female pins are represented with the 'o' symbol (empty).

	**High voltage may be present on the power and motor connectors.** **Before connecting or disconnecting a cable on one of these connectors or touching the controller, turn off all the power supplies and wait 10 minutes to allow the internal DC bus capacitors to discharge.** **Always connect the ground prior to any other connection.**
	**The controllers must be connected to a power supply with an isolated secondary output.** **The motor connectors must always be correctly screwed onto the controller.**
	**All the connectors must be handled in an ESD protected environment, only.**
	**This is a product of the restricted distribution class according to IEC61800-3. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.**

3.1 Communication connectors

	**Signals are not insulated from Protective Earth (PE).**
	**The communication connectors must be handled in an ESD protected environment, only.**

The communication between a host (PC) and a controller is obtained via a USB protocol (connector X00). The communication between the controllers and the master (UltimET) is obtained via a TransnET (ETEL's property) protocol. To do so, the connectors X01 and X02 are used to make a daisy chain with standard RJ-45 cables.

3.1.1 USB communication (connector X00)

The USB 2.0 (full speed) communication is used for the setting and the monitoring of the controller. The USB connector is a «Type B» connector.

3.1.2 TransnET / Ethernet input (connector X01)

This input, mentioned «COM IN» (COMmunication INput) on the front panel of the controller, is used to connect the input cable of the ETEL TransnET or the Ethernet communication. **Both communications are not possible at the same time**. The Ethernet connection is used to directly connect the PC to a single controller.

Remark: The RJ-45 cable must meet the following characteristics: 1:1 shielded cable, category 5E SFTP with 8 wires. The cumulated length of all TransnET cables must not exceed 100 m.

3.1.3 TransnET output (connector X02)

The TransnET output, mentioned «COM OUT» (COMmunication OUTput) on the front panel of the controller is used to connect the output cable of ETEL's TransnET communication. For the last controller, this connector is not used as the incoming and outgoing data run through the same cable.

Remark: The RJ-45 cable must meet the following characteristics: 1:1 shielded cable, category 5E SFTP with 8 wires. The cumulated length of all TransnET cables must not exceed 100 m.

3.2 Encoder connectors (connectors X10 and X20)

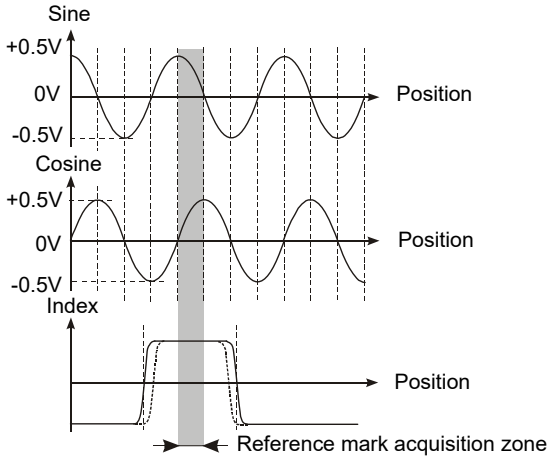
	**Signals are not insulated from Protective Earth (PE).** **Avoid proximity with noisy power cable.**
	**The encoder connectors must be handled in an ESD protected environment, only.**

Remark: The encoder cable(s) connected to the controller must be shielded (refer to §3.11.1).
The connector X10 is used to connect the encoder of motor 1 and X20 for the one of motor 2.

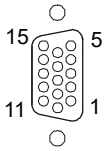
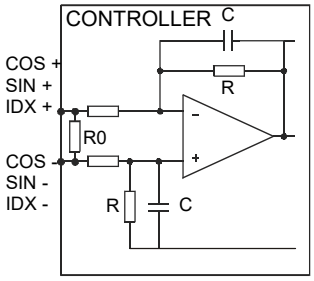
Three different types of encoder can be connected to the encoder connectors: either an incremental analog 1 Vpp encoder or an absolute encoder (EnDat 2.1 and 2.2) or a true TTL encoder.

3.2.1 Incremental analog encoder (1 Vpp)

The incremental analog encoder has 1Vpp signals with a load resistor R_0=120 Ω. It determines the motor position thanks to two sinusoidal signals with a 90° phase-shift (sine and cosine). A third signal, the index (also called reference mark) gives the absolute motor position:



D-SUB, 15 pins, high density, female

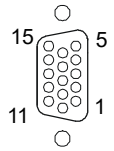
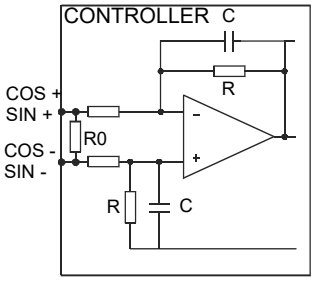
Encoder	Pin #	Signal	Function	Interface
X10 & X20 	1	Reserved	**Do not connect**	
	2	Reserved	**Do not connect**	
	3	Reserved	**Do not connect**	
	4	+5 VDC	Encoder supply output (protected by fuse F4 of 1.5 A)	
	5	GND	Encoder supply output (0 V)	
	6	COS -	Cosine - signal input	
	7	SIN -	Sine - signal input	
	8	IDX -	Index - signal input	
	9	Reserved	**Do not connect**	
	10	EHO/L1	Encoder home switch input EHO or encoder limit switch L1 (TTL signal)	
	11	ELS/L2	Encoder limit switch input ELS or encoder limit switch L2 (TTL signal)	
	12	GND	Encoder supply output (0 V)	
	13	COS +	Cosine + signal input	
	14	SIN +	Sine + signal input	
	15	IDX +	Index + signal input	

Remark: The +5 VDC encoder supply output is protected by the fuse F4 (1.5 A) on X10 and X20. On the hardware revision 2 (EA-P2M-xxx-xxxxxx-xxxx-**01**), the fuse F4 has been replaced by a resettable fuse called F5.
Refer to the corresponding 'Operation & Software Manual' for more information about the use of the EHO/L1 and ELS/L2 signals.
The connector X10 is used to connect the encoder of motor 1 and X20 for the one of motor 2.

3.2.2 Absolute encoder (EnDat 2.1)

The EnDat 2.1 is an **absolute encoder**. It has 1Vpp signals with a load resistor R_0=120 Ω. Its signals are similar to the incremental encoders (without the index), but it additionally includes a RS485 serial link (EIA standard, EnDat 2.1 interface) for the absolute position measure: EDT (serial data) and ECL (clock). The ECL (clock) signal is received from the controller. From its first falling edge (latch signal), the **absolute position will be defined within one incremental signal period** (depends on the encoder type)

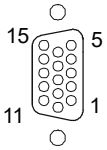
D-SUB, 15 pins, high density, female

Encoder	Pin #	Signal	Function	Interface
X10 & X20 	1	EDT +	EnDat serial data I/O + / RS485	
	2	ECL +	EnDat clock output + / RS485	
	3	ECL -	EnDat clock output - / RS485	
	4	+5 VDC	Encoder supply output (protected by fuse F4 of 1.5 A)	
	5	GND	Encoder supply output (0 V)	
	6	COS -	Cosine - signal input	
	7	SIN -	Sine - signal input	
	8	Reserved	**Do not connect**	
	9	EDT -	EnDat serial data I/O - / RS485	
	10	Reserved	**Do not connect**	
	11	Reserved	**Do not connect**	
	12	GND	Encoder supply output (0 V)	
	13	COS +	Cosine + signal input	
	14	SIN +	Sine + signal input	
	15	Reserved	**Do not connect**	

Remark: The +5 VDC encoder supply output is protected by the fuse F4 (1.5 A) on X10 and X20. On the hardware revision 2 (EA-P2M-xxx-xxxxxx-xxxx-**01**), the fuse F4 has been replaced by a resettable fuse called F5.
The cable used with an absolute encoder (EnDat 2.1) must have power wires with a minimum section to guarantee a sufficient voltage at the terminals of the encoder (refer to the data sheet of the encoder for more information).
The connector X10 is used to connect the encoder of motor 1 and X20 for the one of motor 2.

3.2.3 Absolute encoder (EnDat 2.2)

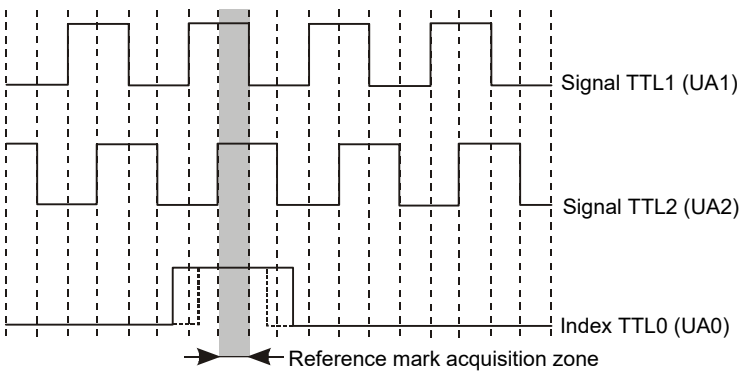
The EnDat 2.2 is an **absolute encoder**. It includes a RS485 serial link (EIA standard, EnDat 2.2 interface) for the absolute position measure: EDT (serial data) and ECL (clock). The ECL (clock) signal is received from the controller. Refer to the Heidenhain documentation for more information about the EnDat 2.2.

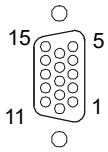
D-SUB, 15 pins, high density, female			
Encoder	**Pin #**	**Signal**	**Function**
X10 & X20  	1	EDT +	EnDat serial data I/O + / RS485
	2	ECL +	EnDat clock output + / RS485
	3	ECL -	EnDat clock output - / RS485
	4	+5 VDC	Encoder supply output (protected by fuse F4 of 1.5 A)
	5	GND	Encoder supply output (0 V)
	6	Reserved	**Do not connect**
	7	Reserved	**Do not connect**
	8	Reserved	**Do not connect**
	9	EDT -	EnDat serial data I/O - / RS485
	10	Reserved	**Do not connect**
	11	Reserved	**Do not connect**
	12	GND	Encoder supply output (0 V)
	13	Reserved	**Do not connect**
	14	Reserved	**Do not connect**
	15	Reserved	**Do not connect**

Remark: The +5VDC encoder supply output is protected by the fuse F4 (1.5 A) on X10 and X20. On the hardware revision 2 (EA-P2M-xxx-xxxxxx-xxxx-**01**), the fuse F4 has been replaced by a resettable fuse called F5.
The cable used with an absolute encoder (EnDat 2.2) must have power wires with a minimum section to guarantee a sufficient voltage at the terminals of the encoder (refer to the data sheet of the encoder for more information) and a length of maximum 40 m.
The connector X10 is used to connect the encoder of motor 1 and X20 for the one of motor 2.

3.2.4 TTL encoder

TTL encoders measure the motor position with 2 phase-shifted TTL signals. Each change of state of one of the signals corresponds to an increment of the motor position. A third signal (index) gives the motor reference position. The encoder TTL signals have to be compatible with the EIA standard RS422. These signals have the following form:

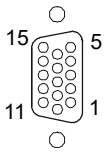


D-SUB, 15 pins, high density, female			
Encoder	**Pin #**	**Signal**	**Function**
X10 & X20 	1	UA1 +	TTL1 + signal input
	2	UA2 +	TTL2 + signal input
	3	UA2 -	TTL2 - signal input
	4	+5 VDC	Encoder supply output (protected by fuse F4 of 1.5 A)
	5	GND	Encoder supply output (0 V)
	6	Reserved	**Do not connect**
	7	Reserved	**Do not connect**
	8	Reserved	**Do not connect**
	9	UA1 -	TTL1 - signal input
	10	UA0 -	TTL0 - signal input
	11	UA0 +	TTL0 + signal input
	12	GND	Encoder supply output (0 V)
	13	Reserved	**Do not connect**
	14	Reserved	**Do not connect**
	15	Reserved	**Do not connect**

Remark: The +5VDC encoder supply output is protected by the fuse F4 (1.5 A) on X10 and X20. On the hardware revision 2 (EA-P2M-xxx-xxxxxx-xxxx-**01**), the fuse F4 has been replaced by a resettable fuse called F5.
The connector X10 is used to connect the encoder of motor 1 and X20 for the one of motor 2.
The period frequency (2.5 MHz) is one fourth of the counter frequency (10 MHz).

3.2.5 Dual encoder feedback

The dual encoder feedback is only possible with 1Vpp, TTL and absolute EnDat 2.2 encoders. Here are the 3 possible configurations:

D-SUB, 15 pins, high density, female			
		1 Vpp / TTL (K76=1)	**1 Vpp / EnDat 2.2 (K76=2) & EnDat 2.2 / 1 Vpp (K76=3)**
Encoder	**Pin #**	**Signal**	**Signal**
X10 & X20 	1	UA1 +	EDT +
	2	UA2 +	ECL +
	3	UA2 -	ECL -
	4	+5 VDC	+5 VDC
	5	GND	GND
	6	COS -	COS -
	7	SIN -	SIN -
	8	IDX -	IDX -
	9	UA1 -	EDT -
	10	EHO/L1 or UA0 -	EHO/L1
	11	ELS/L2 or UA0 +	ELS/L2
	12	GND	GND
	13	COS +	COS +
	14	SIN +	SIN +
	15	IDX +	IDX +

Remark: Refer to the corresponding encoder table to know the function of each signal.

3.3 Inputs / outputs connectors (connectors X11, X21, X03 and X04)

	**The digital inputs and outputs must be connected to a power supply with an isolated secondary output.** **The digital inputs and outputs are galvanically insulated from the Protective Earth (PE).** **The digital inputs and outputs are connected to the same 0 VDC as the +24 VDC.**
	**The inputs/outputs connectors must be handled in an ESD protected environment, only.**

Remark: The inputs/outputs cable(s) connected to the controller must be shielded (refer to §3.11.1).

The controller has:

- 5 standard digital inputs (DIN1, DIN2, DIN3, DIN9 and DIN10) per motor and 4 **fast** digital inputs (FDIN1 to FDIN4) for both motors. DIN2 and DIN3 are opto-coupled through a **high speed** opto-couplers (100 ns).
- 2 standard digital outputs (DOUT1 and DOUT2) per motor and 4 **fast** digital outputs (FDOUT1 to FDOUT4) for both motors.

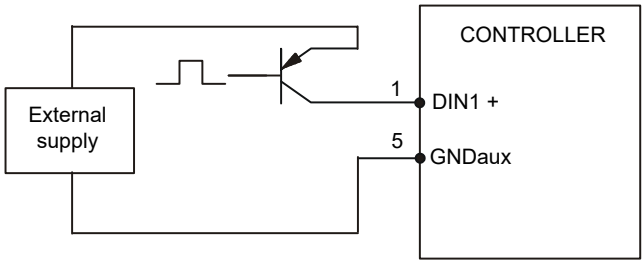
Every digital input and output is referenced to the +24 VDC (connector X100). Only inputs and outputs **interface** is considered here. Refer to the corresponding **'Operation & Software Manual'** for more information about the use of these inputs and outputs.

3.3.1 Digital inputs (connectors X11 and X21)

The digital inputs switch to '1' when a voltage ranging between +14 VDC and +28 VDC is applied between pins DIN+ of the corresponding input and GNDaux.
The digital inputs switch to '0' when a voltage ranging between 0 VDC and +2 VDC to is applied between pins DIN+ of the corresponding input and GND. Any voltage between +2 VDC and +14 VDC will give an uncertain input value.

Remark: When using an external 'positive limit switch', connect it to DIN10.
When using an external 'negative limit switch', connect it to DIN9.
When using an external 'home switch', connect it to DIN2.

The auxiliary supply can be external to the controller, as shown below:



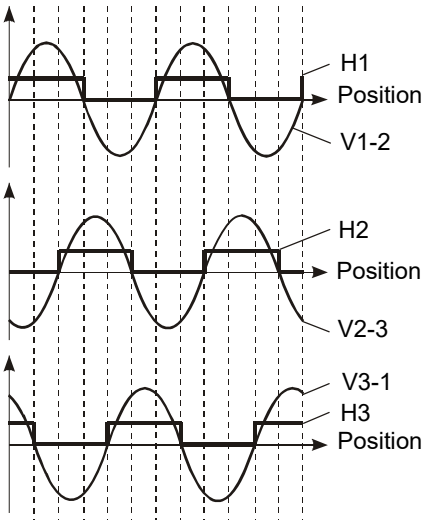
The commutation times of the above-mentioned inputs are as follows:

	Status	Maximum	Unit
DINs 2 and 3 (high speed)	0 => 1	100	ns
	1 => 0	100	ns
DINs 1, 9 and 10	0 => 1	100	µs
	1 => 0	100	µs

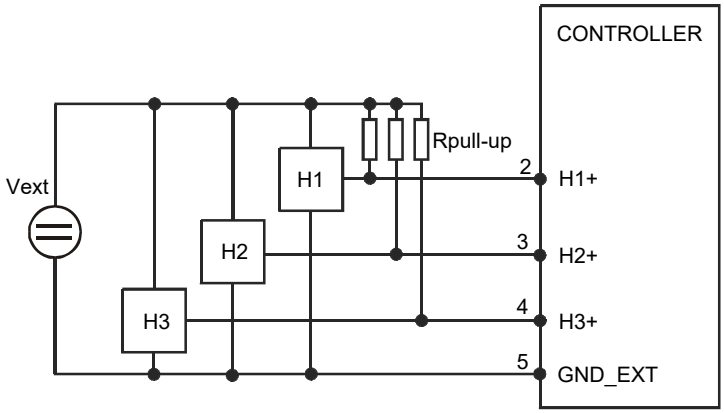
Remark: The above-mentioned times takes only the hardware into account.

Digital Hall effect sensor

3 digital inputs (H1+, H2+ and H3+) which correspond to the digital inputs 2, 9 and 10, are used to connect a digital Hall effect sensor. This sensor is used for the motor commutation thanks to three digital signals (one for each Hall effect sensor). On the following graph, the Hall signals and the sine voltages between the motor phases are displayed:



The digital Hall effect sensors (H1, H2 and H3) must be connected as shown below:

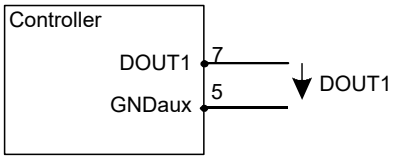


As described in §3.3.2, there is no internal pull up on H1+, H2+, H3+ inputs. External resistors must be added. With Vext equal to +24 VDC, a 2K2 pull up resistor must be connected to H1+, H2+, H3+.

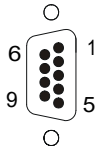
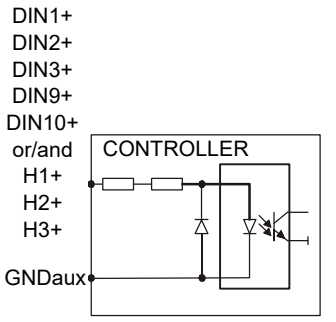
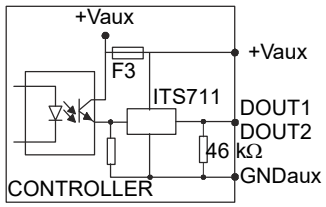
Remark: Take care that Hall sensors withstand the Vext and the current chosen.
The connector X11 is used to connect the inputs/outputs of motor 1 and X21 for the ones of motor 2.

3.3.2 Digital outputs (connectors X11 and X21)

The +Vaux voltage used to supply the digital output is the same as the one present on the control input connector (X100). **Do not supply Vaux voltage on connector X11 or X21 but only on connector X100.** The maximum total current provided per digital output is limited to 500 mA.



Remark: This diagram shows the use of DOUT1, but it is the same with DOUT2.

D-SUB, 9 pins, male				
I / O	**Pin #**	**Signal**	**Function**	**Interface**
X11 & X21 	1	DIN1 +	Digital input 1 +	
	2	DIN2 +	Digital input 2 + (High speed: 100 ns) (H1+)	
	3	DIN9 +	Digital input 9 + (H2+)	
	4	DIN10 +	Digital input 10 + (H3+)	
	5	GNDaux	External supply input (0V) for DIN and DOUT (linked to the 0VDC of the connector X100)	
	6	DIN3 +	Digital input 3 + (High speed: 100 ns)	
	7	DOUT1	Digital output 1 +	
	8	DOUT2	Digital output 2 +	
	9	+Vaux	Power supply output provided by +24 VDC on connector X100 (fuse F3)(*)	

Remark: The connector X11 is used to connect the inputs/outputs of motor 1 and X21 for the ones of motor 2.
(*): On the hardware revision 2 (EA-P2M-xxx-xxxxxx-xxxx-**01**), the fuse F3 has been replaced by a resettable fuse.

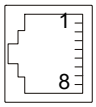
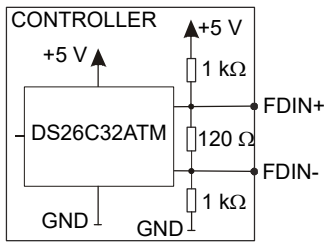
The commutation times of the above-mentioned outputs are as follows:

	Status	**Maximum**	**Unit**
DOUTs	0 => 1	500	µs
	1 => 0	500	µs

Remark: The above-mentioned times takes only the hardware into account.

3.3.3 Fast digital input (connector X03)

The fast digital inputs are common to both motors and can be used by the customer for synchronization, position capture, etc. They are RS422 signals.

RJ-45, 8 pins, female				
Fast input	**Pin #**	**Signal**	**Function**	**Interface**
X03 	1	FDIN1+	Fast digital input 1+ (data reception RS422 +)	
	2	FDIN1-	Fast digital input 1- (data reception RS422 -)	
	3	FDIN3+	Fast digital input 3+ (data reception RS422 +)	
	4	FDIN2+	Fast digital input 2+ (data reception RS422 +)	
	5	FDIN2-	Fast digital input 2- (data reception RS422 -)	
	6	FDIN3-	Fast digital input 3- (data reception RS422 -)	
	7	FDIN4+	Fast digital input 4+ (data reception RS422 +)	
	8	FDIN4-	Fast digital input 4- (data reception RS422 -)	

The commutation times of the above-mentioned inputs are as follows:

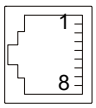
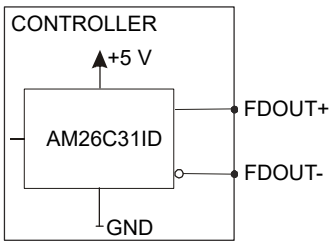
	Status	Maximum	Unit
FDINs	0 => 1	30	ns
	1 => 0	30	ns

Remark: The above-mentioned times takes only the hardware into account.
The RJ45 cable must be shielded.

3.3.4 Fast digital output (connector X04)

The fast digital outputs are common to both motors and can be used by the customer for triggers, encoder signals outputs, etc. They are RS422 signals.

RJ-45, 8 pins, female

Fast output	Pin #	Signal	Function	Interface
X04 	1	FDOUT1+	Fast digital output 1+ (data transmission RS422 +)	
	2	FDOUT1-	Fast digital output 1- (data transmission RS422 -)	
	3	FDOUT3+	Fast digital output 3+ (data transmission RS422 +)	
	4	FDOUT2+	Fast digital output 2+ (data transmission RS422 +)	
	5	FDOUT2-	Fast digital output 2- (data transmission RS422 -)	
	6	FDOUT3-	Fast digital output 3- (data transmission RS422 -)	
	7	FDOUT4+	Fast digital output 4+ (data transmission RS422 +)	
	8	FDOUT4-	Fast digital output 4- (data transmission RS422 -)	

The commutation times of the above-mentioned outputs are as follows:

	Status	Maximum	Unit
FDOUTs	0 => 1	30	ns
	1 => 0	30	ns

Remark: The above-mentioned times takes only the hardware into account.
The RJ45 cable must be shielded.

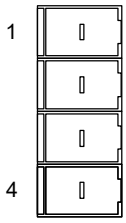
3.4 Motor connectors (connectors X12 and X22)

	**High voltage may be present on the motor connectors. Before connecting or disconnecting the motor cable or touching the controller, turn off all the power supplies and wait 10 minutes to allow the internal DC bus capacitors to discharge. Always connect the ground prior to any other connection.**
	**The motor connectors must be insulated (no contact) from the power and the mains.The motor connectors must always be correctly screwed onto the controller to respect the EMC standard.**
	**The motors connectors must be handled in an ESD protected environment, only.**

Remark: The motor cables connected to the controller must be shielded (refer to §3.11.1).

The controller can drive single-phase, two-phase and three-phase motors. Connectors X12 and X22 enable the supply of the motor phase(s).

Phoenix Contact PC 4/4-G-7,62 (plastic connector)

Motor	Pin #	Signal	Function		
			1-phase motor	2-phase motor	3-phase motor
X12 & X22 	1	PE	Protective earth	Protective earth	Protective earth
	2	PH3_M1	**Do not connect**	Motor phase 2 +	Motor phase 3
	3	PH2_M1	Motor phase -	Motor phase 1 - / 2 - (*)	Motor phase 2
	4	PH1_M1	Motor phase +	Motor phase 1 +	Motor phase 1

(*): With two-phase motor, the current in 'motor phase 1- / 2-' is equal to (√2 x motor phase 1+) or (√2 x motor phase 2+). Be careful to use the suitable cable diameter.

Remark: The connector X12 is used to connect the motor 1 and X22 for the motor 2.
It is compulsory to use the metallic cover described in §3.11.2.
The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.

3.5 Power connectors

	**High voltage may be present on the power connectors. Before connecting or disconnecting the power cables or touching the controller, turn off all the power supplies and wait 10 minutes to allow the internal DC bus capacitors to discharge. Always connect the ground prior to any other connection.**
	**The power connectors must be handled in an ESD protected environment, only.**

Remark: The power cables connected to the controller must be shielded (refer to §3.11.1).

3.5.1 At the power supply level

3.5.1.1 Control input (connector P00)

Phoenix Contact MSTB 2.5/4-G BK (plastic connector)			
Control input	**Pin #**	**Signal**	**Function**
P00 1 2 3 4	1	+24 VDC	Control input (+24 VDC (-0 +10%))
	2	0 VDC	Control input (0 VDC)
	3	ERC -	External Relay Command output (0 VDC)
	4	ERC +	External Relay Command output (+24 VDC / 0.5 A max)

For safety reasons, always connect first the protective earth (PE) to the dedicated screws!

Remark: The control input shall be supplied by an isolated power supply with SELV outputs (Isolated secondary output), rated 24 VDC (±10%). The external power supply must ensure the reinforced insulation between mains and output and provide overvoltage category II (refer to EN 61800-5-1 and UL 508C standards for more information).
The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.

The +24 VDC input of this connector is internally connected to the +24 VDC of the control output (refer to §3.5.1.5). The ERC outputs signals command the external input relay connected on the AC power line. In case of problem detected on the controllers or on the power supply side, a zero volt is applied between these 2 contacts to open this relay.

3.5.1.2 Power input (connector P01)

This is a product of the restricted distribution class according to IEC61800-3. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.

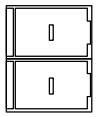
Phoenix Contact PC 4/4-G-7.62 BK (plastic connector)					
Power input	**Pin #**	**Signal**	**Function**	**three-phase mains**	**single-phase mains(*)**
P01 1 2 3 4	1	PE	Protective earth	PE	PE
	2	L1	Mains line supply input for power	Mains L1	Mains L
	3	L2	Mains line supply input for power	Mains L2	Mains N
	4	L3	Mains line supply input for power	Mains L3	**Do not connect**

For safety reasons, always connect first the ground as mentioned in §3.10!

Remark: (*): Not applicable for power supply 600.
The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.
To avoid any mis-connection (damage or hazard), be careful not to connect the power input cable of the PS600 to the power input of the PS400 (as the female connectors are identical).

3.5.1.3 Brake resistor (connector P02)

Use only resistor with thermal shutdown protection. The resistor minimal value is 20 Ω for the AccurET 400 and 30 Ω for the AccurET 600. The use of an undersized power and energy withstand capability resistor could generate an explosion.

Phoenix Contact PC4/2-G-7.62 BK (plastic connector)			
Brake resistor	**Pin #**	**Signal**	**Function**
P02 1 2 	1	BR+	Connect the + of the external brake resistor, if needed
	2	BR-	Connect the - of the external brake resistor, if needed

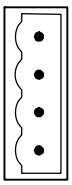
Remark: The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.

If you determine that a brake resistor is needed, select it to fit your application (refer to §4. for more information about the sizing). This resistor **must** include a thermal circuit breaker. Example of resistor used by ETEL: Frizlen GmbH (Germany), cemented, double pipe resistor, type FZZG 400x65, 39 Ω, 1200 W at 300 °C. Metallic case protection (shielding), shielded connector.

3.5.1.4 Power output

The power output of the power supply is realized with a busbar present behind the bottom black cover. The provided metallic pieces must be screwed from the power supply (on the left) up to the last controller (on the right). Refer to §2.4 for the mounting instructions.

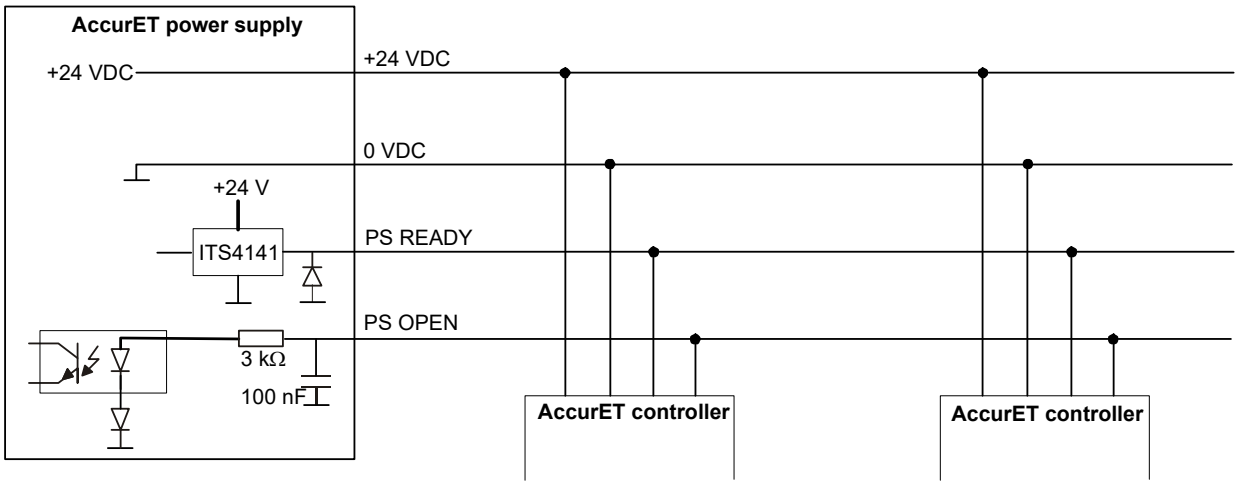
3.5.1.5 Control output (connector P100)

Phoenix Contact MSTB 2.5/4-G BK (plastic connector)			
Control output	**Pin #**	**Signal**	**Function**
P100 1 2 3 4 	1	+24 VDC	Control output (+24 VDC (±10%))
	2	0 VDC	Control output (0 VDC)
	3	PS RDY	Power supply ready (output for the power supply) A high level (24 VDC) on this output indicates everything is OK. A low level indicates an error or an inrush mode not completed. This low level disables the controllers. The inrush relay is closed for PS RDY = 1 and opened for 0.
	4	PS OPEN	Power supply open (input for the power supply) A high level (24 VDC) on this output, coming from the controller, disables the power supply. The inrush relay is opened as well as the external input relay.

For safety reasons, always connect first the ground as mentioned in §3.10!

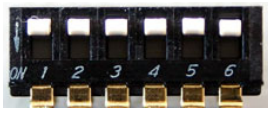
Remark: The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.

The +24 VDC output of this connector is internally connected to the +24 VDC coming from the control input (refer to §3.5.1.1). This control output connector is connected with a 1:1 cable to all the control input connectors (connector X100) of the controllers.
The 'PS RDY' (Power Supply ReaDY) signal comes from the ETEL power supply and indicates the status of the voltage present on the DC bus (0 V = DC power not ready and 24 V = power supply ready).
The 'PS OPEN' (Power Supply OPEN) signal comes from each controller asking for a power interrupt (internal relay opened) (0 V = normal condition and 24 V = PS OPEN asked).



3.5.1.6 *DIP switch*

This DIP switch is reserved for future use. However, the position of the switches must remain in the position mentioned below:



By default, all the switches are in high position.

Remark: The DIP switch is located on the top of the power supply.

3.5.2 At the position controller level

3.5.2.1 *Power input (busbar)*

High voltage is present on the power connectors.
Before connecting or disconnecting the busbar, turn off all the power supplies and wait 10 minutes to allow the internal DC bus capacitors to discharge. Always connect the ground prior to any other connection.

The power input of the controllers is realized with a busbar present behind the bottom black cover. The provided metallic pieces must be screwed from the power supply (on the left) up to the last controller (on the right). Refer to §2.4 for the mounting instructions.

3.5.2.2 *Control input (connector X100)*

Phoenix Contact MSTBA 2.5/4-G BK (plastic connector)			
Control input	**Pin #**	**Signal**	**Function**
X100 1 2 3 4	1	+24 VDC	Control supply input (24 VDC (-0+10 %) for hardware revision 1 and (±10 %) for hardware revision 2). If used with ETEL power supply, refer to §3.5.1 for power characteristics).
	2	0 VDC	Control supply input (0 VDC)
	3	PS RDY	Power supply ready input (for the controller)
	4	PS OPEN	Power supply opened output (for the controller)

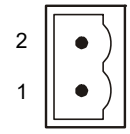
For safety reasons, always connect first the ground as mentioned in §3.10!

Remark: To ensure proper operation of the controller, it is recommended to wait for 1 second between two successive ON or OFF cycles (1sec minimum for the OFF state when ON/OFF/ON cycle and 1sec minimum for the ON state when OFF/ON/OFF).
The control input shall be supplied by an isolated power supply with SELV outputs (Isolated secondary output), rated 24 VDC (±10 %).

The control input connector is located on the top of the controller.
The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.

The control input connectors of the controllers are connected to each other and to the control input connector of the power supply (connector P100) with a 1:1 cable (refer to §2.4.2 for more information).
The 'PS RDY' (Power Supply ReaDY) signal comes from the ETEL power supply and indicates the status of the voltage present on the DC bus (0 V = DC power not ready and 24 V = power supply ready).
The 'PS OPEN' (Power Supply OPEN) signal comes from each controller asking for a power interrupt (internal relay opened) (0 V = normal condition and 24 V = PS OPEN asked).

3.5.3 At the fan level

Phoenix Contact DFK-MSTB 2.5/2-G BK (plastic connector)			
Power input	**Pin #**	**Signal**	**Function**
	2	0 VDC	Supply input (0 VDC)
	1	+24 VDC	Supply input (24VDC (-0+10 %))

The power input connectors of the fans are connected to each other with a 1:1 cable (refer to §2.4.2 for more information).

Remark: The current requirement according to the fan's width is as follows:
0.2 A for the 75 mm, 0.3 A for the 100 mm and 0.5 A for the 125 mm.

3.5.4 Connection to the mains

For safety reasons, always connect first the protective earth (PE) to the dedicated screw, before wiring any other connection!

Remark: It is strongly recommended to connect the control input **before** the power input.

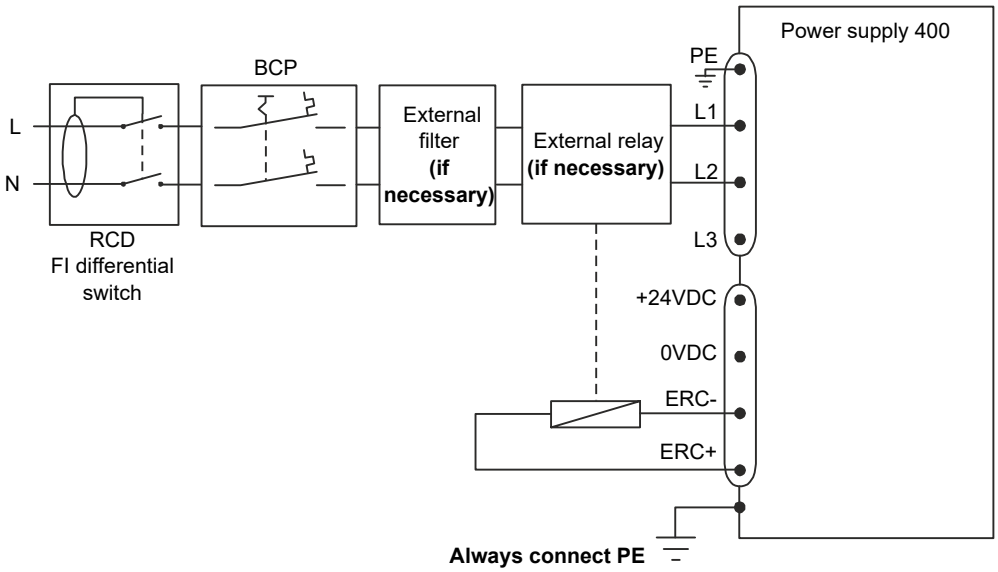
Caution: **This is a product of the restricted distribution class according to IEC61800-3. In a domestic environment, this product may cause radio interference in which case the user may be required to take adequate measures.**
Only TT and TN power systems are allowed. Any other grounding systems such as corner ground, starpoint to earth with high impedance and isolated,... are forbidden.

3.5.4.1 Single-phase line

Machinery including a power supply and controller(s) should be equipped with additional emergency stop, brake and protection devices to protect the personnel against any contact with high temperatures, moving parts and high voltage. These devices are not included in the power supply, they must be provided by the machinery manufacturer.

- **For a power supply 400**

The input filter of the power supply enables the use of a high sensitive differential switch (the use of RCD with long motor cable or highly capacitive motor has to be tested):



Remark: RCD = Residual Current Device (also called Electrical Leakage Circuit Breaker or FI)
The use of a RCD (type B) is mandatory. The RCD as well as the corresponding ΔI must be selected according to the machine as the leakage current depends on the motor type and the cables length.
BCP = Branch Circuit Protection
If the power supply is used in an UL compatible system, the manufacturer of this system must use a BCP (listed RK5 fuses rated 600 V, 30 A (max. 300 % of rated current), 200 kA or a listed circuit braker rated 277/480 V, 13 A, 14 kA) otherwise a 16A circuit breaker is suitable for non-UL system.
The AccurET already includes an in-built filter. An additional filter can be added (for example Schaffner FN2070-16-06) to reduce further electromagnetic disturbances.

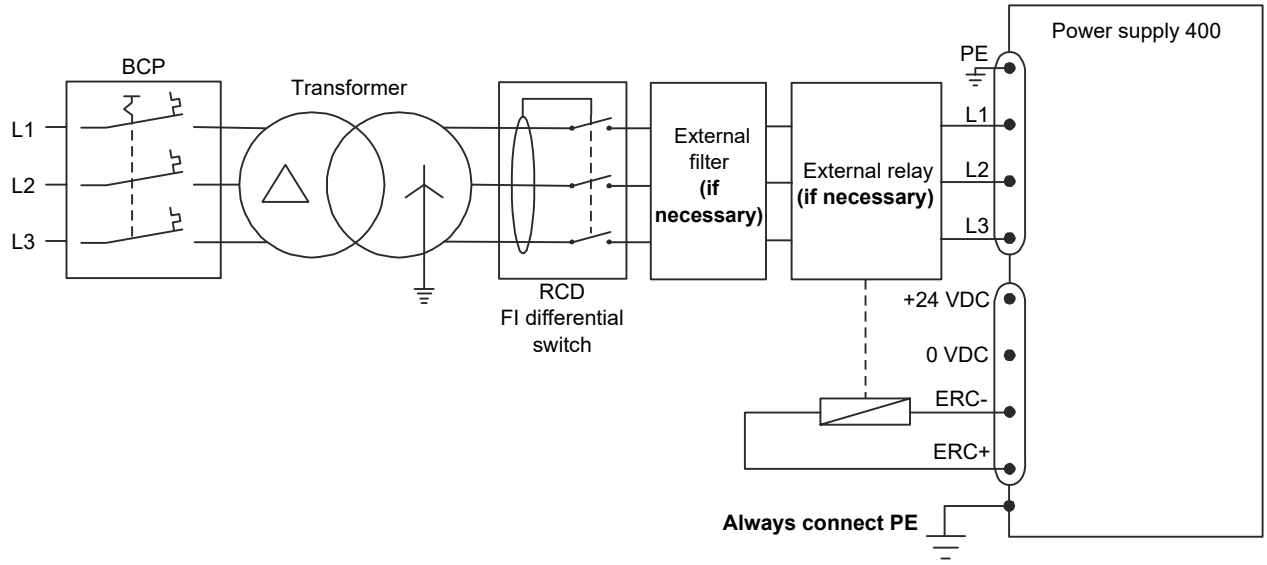
3.5.4.2 Three-phase line

	**Machinery including a power supply And controller(s) should be equipped with additional emergency stop, brake and protection devices to protect the personnel against any contact with high temperatures, moving parts and high voltage. These devices are not included in the power supply, they must be provided by the machinery manufacturer.**

- **For a power supply 400**

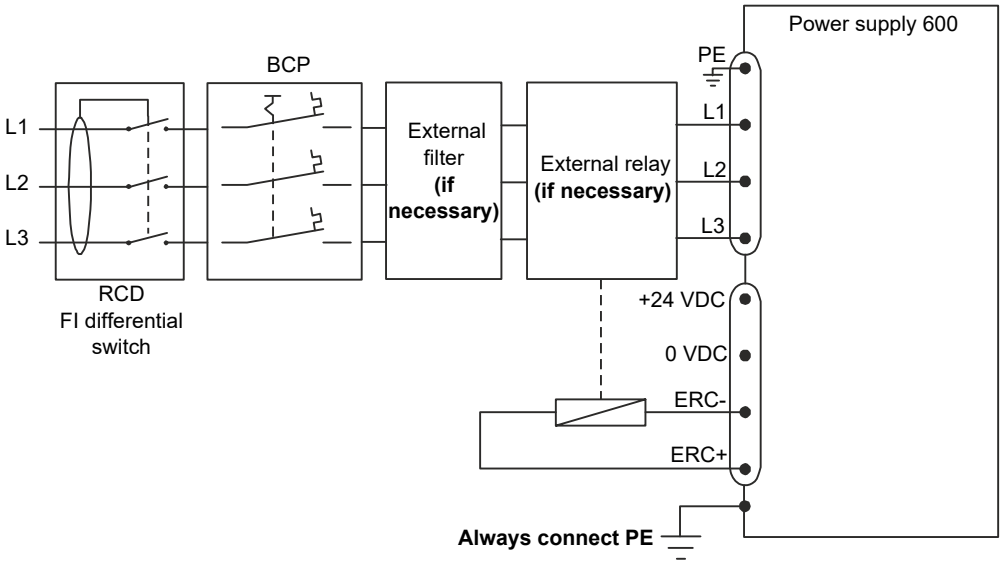
Caution: It is recommended to supply the power with an external transformer, whose characteristics depend on the user's application and on the mains supply characteristics. The transformer must meet the standard in force in the corresponding country.

- With European mains: Primary 3 x 380 V Δ - Secondary 3 x 270 V Y; the transformer adapts the mains voltage to the controller and prevents possible disturbances from invading the mains.
- With US mains: Primary 3 x 220 V Δ - Secondary 3 x 220 V Y; the insulation transformer prevents possible disturbances from invading the mains.



Remark: RCD = Residual Current Device (also called Electrical Leakage Circuit Breaker or FI)
The use of a RCD (type B) is mandatory. The RCD as well as the corresponding ΔI must be selected according to the machine as the leakage current depends on the motor type and the cables length. If a transformer is used (i.e. European mains as Primary 3 x 380 V Δ - Secondary 3 x 270 V Y), a RCD to protect against leakage current, must be used after the transformer output.
BCP = Branch Circuit Protection
If the power supply is used in an UL compatible system, the manufacturer of this system must use a BCP (listed RK5 fuses rated 600 V, 30 A (max. 300% of rated current), 200 kA or a listed circuit braker rated 277/480 V, 13 A, 14 kA) otherwise a 16 A circuit breaker is suitable for non-UL system.
The AccurET already includes an in-built filter. An additional filter can be added (for example Schaffner FN3258-42-33) to reduce further electromagnetic disturbances.

- **For a power supply 600**



Remark: RCD = Residual Current Device (also called Electrical Leakage Circuit Breaker or FI)
The use of a RCD (type B) is mandatory. The RCD as well as the corresponding ΔI must be selected according to the machine as the leakage current depends on the motor type and the cables length.
BCP = Branch Circuit Protection
If the power supply is used in an UL compatible system, the manufacturer of this system must use a BCP (listed RK5 fuses rated 600 V, 30 A (max. 300 % of rated current), 200 kA or a listed

circuit braker rated 277/480 V, 13 A, 14 kA) otherwise a 16 A circuit breaker is suitable for non-UL system.
The AccurET already includes an in-built filter. An additional filter can be added (for example Schaffner FN3258-42-33) to reduce further electromagnetic disturbances.

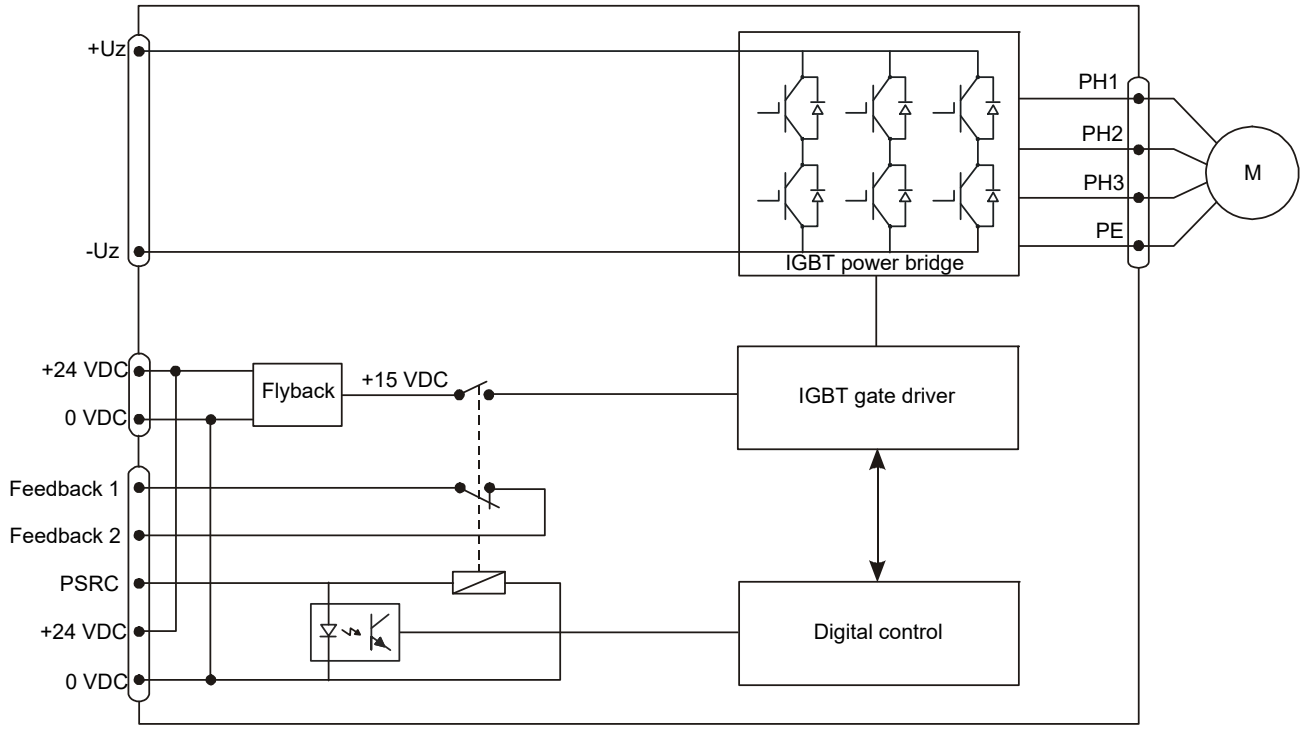
3.6 Safety relay (connector X103)

Phoenix Contact MC 1.5/5-G-3.81 BK (plastic connector)			
Safety relay	**Pin #**	**Signal**	**Function**
X103 1 2 3 4 5	1	FB1 (Feedback 1)	Feedback control 1 of the power safety relay (24 V / 0.8 A max)
	2	FB2 (Feedback 2)	Feedback control 2 of the power safety relay (24 V / 0.8 A max)
	3	PSRC (Power Safety Relay Control)	Safety relay supply input (+24 VDC ±10 %) from control input
	4	+24 V	Control supply output (+24 VDC). 40 mA max. To bypass the safety relay, connect this pin to pin 3 (PSRC), otherwise let this pin not connected
	5	0 V	Control supply (0 VDC) internally connected to GNDaux (pin 2 of X100)

Remark: The +24 V (pin 4) is internally connected to +24 V (pin 1 of X100).
Pin 4 must not be used to power something else than the power safety relay.
The associated connector can be ordered through the connector kit (refer to §2.5.5). If not, be sure to use a connector compatible with the above-mentioned one.

The **safety relay** (according to the EN 50205 standard and IEC 60947-5-1) (+24 V / 800 Ω) allows the user to cut the +15 VDC voltage supplying the IGBT gate driver, when the +24 V supply input of this relay is stopped. If the power safety relay is not powered, the IGBT gate driver is deactivated (IGBT opened) and no power is present on the motor's output. The power safety relay **must** then be powered (pin 3 to +24 V) to have power on the motor's output. A complete switch-off of the machine is not required to be sure no current is sent to the motor. There is a feedback contact allowing the user to monitor the status of the safety relay. **As long as the safety relay is not activated, the motor is switched off. This is not a 'short-circuit relay' as there is no braking action (the motor is free without position control). Anyway, the customer must provide at anytime the appropriate protections against electrical direct contact and moving parts of the connected system.**

Here is the safety relay principle:



Remark: **If the safety relay function is not wanted, a bridge between the pin 3 and 4 is needed to enable the power.**
The safety relay connector is located on the top of the controller.

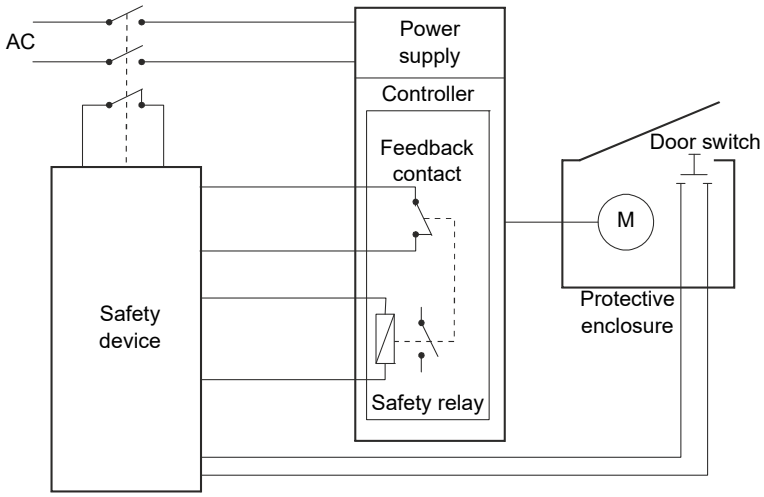
The AccurET 300 safety relay has the following specifications:

- Internal Safety Relay according to EN50205 “Forced Guided Relay”.
- B10d = 4 200 000 cycles (used to calculate MTTFd).
- Maximum operate time at 24 V and +23 °C (including bounce time): 28 ms.
- Maximum release time (including bounce time): 21 ms.

Controllers must be installed in IP54 enclosure for dust and water splash protection.

Warning: In case of motor shut-down using the Safety Relay, the moving parts are not controlled by ETEL products anymore. The machine manufacturer is responsible for the safety of the machine and must add some additional component (ex: brake) to stop the movements.
The relay disables torque/force in the motor but does not disconnect the controller power outputs from the power supply. Switch off the power and wait for the complete discharge before approaching the electrical parts.
In case of component failure (ex: IGBT), a transient torque/force can produce an uncontrolled movement on one magnetic period.

Here is an example of operation using the safety relay:



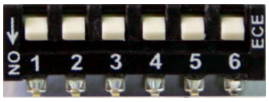
3.7 Download key (connector X102)

If the controller does not switch to 'wait for program' when the user wants to download a new firmware, there is an hardware override possibility to force this mode. To do so, plug the jumper (in any horizontal or vertical position) on the X102 connector, switch off and on the power, and the controller will switch to 'wait for program' to download a new firmware.

Remark: The download key jumper is located on the top of the controller.

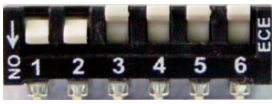
3.8 Axis number selection (connector X101)

On top of the software possibility, it is possible to assign or to change the axis number of the controller with a DIP switch. After each starting, the controller takes the axis number given by the DIP switch except when all the switches are in the down position which means set to 1 (like in the picture below). In this case the axis number is set by the AXI command or the value previously saved in the controller or by the default value always equal to 1 (this default value is used when no AXI command has been executed or no save has been done).



The value given on the DIP switch represents a binary value (64 possibilities). The axes are numbered from 0 to 62 because the node 63 is reserved. If the DIP switch is not used, all the bit must be set to 1 (low position).

Example:



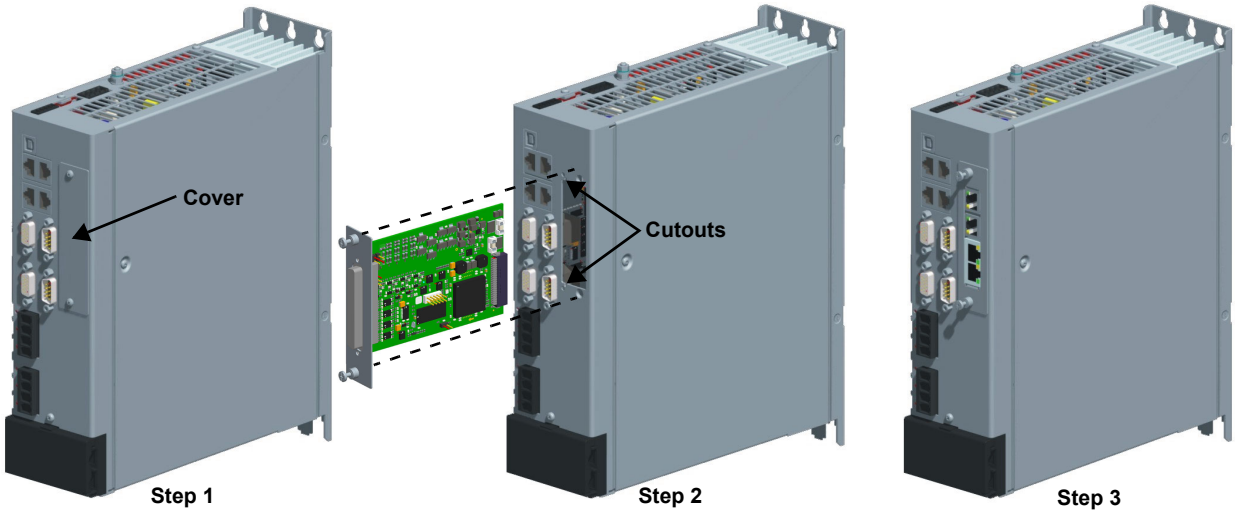
The axis number given by this DIP switch is equal to: $2^0 + 2^1 = 3$. Then, the second axis of the controller will have the number 4.

Remark: **Each axis number must be different from all the others connected to the same TransnET communication bus. It is forbidden to have twice the same axis number on the same TransnET communication bus.**
The DIP switch is located on the top of the controller.

3.9 Optional board

To install an optional board (like the UltimET light motion controller for example) inside the position controller, the user must use the following procedure:

- Work in an ESD protected environment, ground connected yourself.
- Turn off all the power supplies (main and control) and wait 10 minutes to allow the internal DC bus capacitors to discharge.
- Unplug all the cables connected to the position controller.
- Unscrew the two screws fastening the cover of the optional board area on the front panel of the controller (step 1)
- Slide carefully the optional board inside the controller by putting the PCB in the two cutouts (step 2)
- Push the board until the connection with the internal back panel connector is done
- Screw the two screws present on the front panel of the optional board (step 3)



Remark: Follow in the reverse order the opposite actions of the above-mentioned steps to remove the UltimET light from the controller.
Refer to the ordering information (§2.5) to know which controller can accept an optional board.

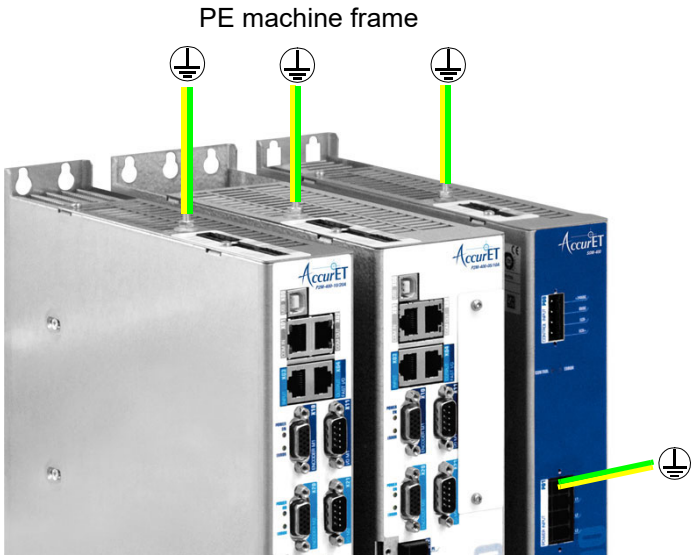
3.10 Ground connection

Always connect the ground prior to any other connection.

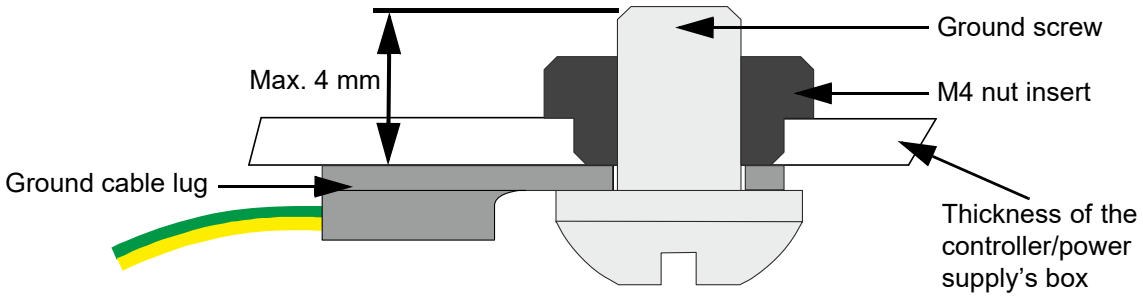
We recommend to connect the ground cables as follows:

Each controller and the power supply must be individually connected to the threaded rod (M4) present at the top of each of them. Each ground wire (green and yellow cable) must have a section at least equal to the wires L1, L2 and L3 present on the 'power input' connector (P01) of the corresponding power supply and must be connected to the machine frame (PE machine) according to the norms applicable.

On top of this ground cable, the one present on the 'power input' connector (P01) of the corresponding power supply MUST also be connected with a section at least equal to the wires L1, L2 and L3 present on the 'power input' connector (P01).



Remark: It is also possible to connect the ground cable to the M4 threaded hole present under the controller/power supply instead of the connection to the M4 threaded rod present on the top of the controller/power supply. In this case, the length of the screw (not provided) must not exceed 4mm from the external surface of the controller/power supply box.



3.11 Cables manufacturing

If you do not use the cables delivered by ETEL, follow the shield recommendations below for those cables:

- The encoder cables: X10 and X20
- The inputs/outputs cables: X11 and X21
- The motor cables: X12 and X22

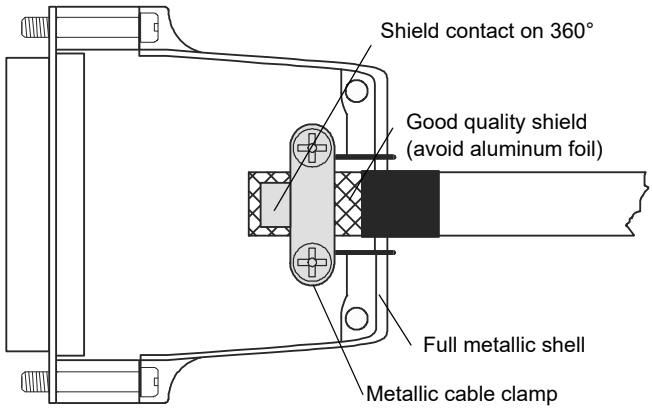
Simple shielded cable **must** be linked to the connector shells on both cable ends. Only full metallic conductive shells connector must be used. Shield with only aluminum foil (metallized plastic film) is forbidden!. Use only copper braid (85 % covering shield). The shield must entirely cover all wires. 'Pig tails' connections are forbidden! The shield contact on 360° and a metallic cable clamp is necessary.

Remark: All the cables connected to the controller must have copper conductors only and an insulation standing at least 75 °C.
A bad shielding connection can perturb the encoder signal, phasing, etc.

3.11.1 Encoder and input/output cables

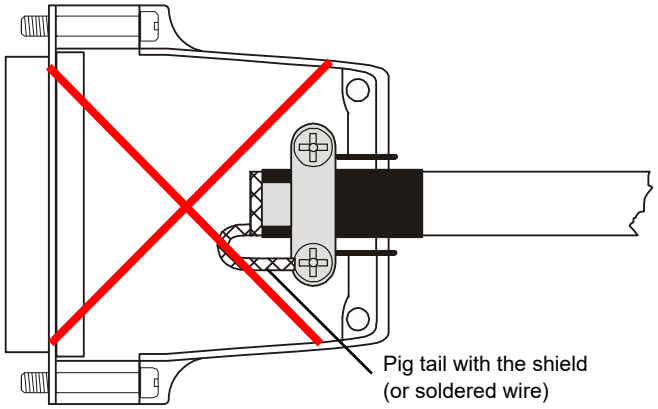
Here is an example of good shielding connection:

Good shielding connection

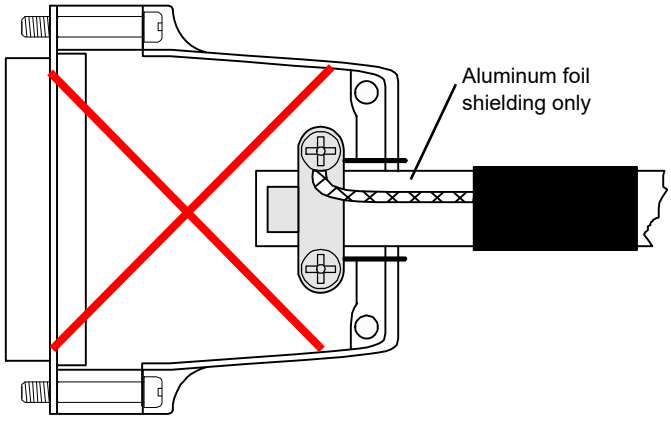


Here are two examples of bad shielding connections:

Bad shielding connection

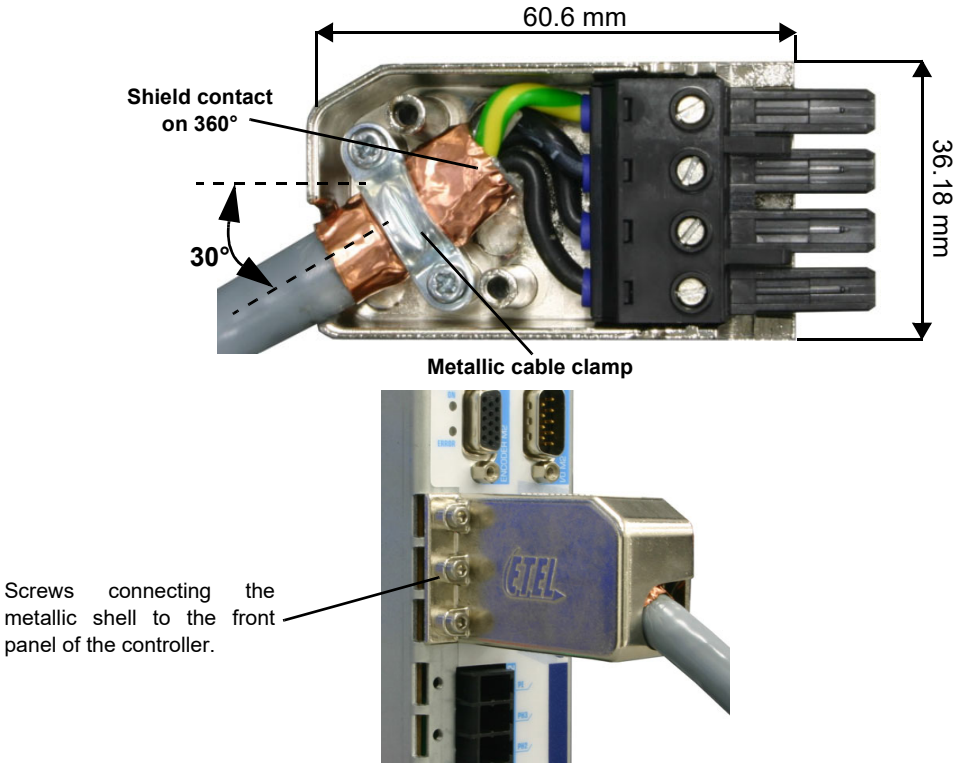


Bad shielding connection



3.11.2 Motor cable

To respect the EMC standard, the following motor connector must be used. **It is compulsory to completely screw the three screws of the metallic cover to the front panel of the controller with a tightening torque of 0.4 Nm max.**

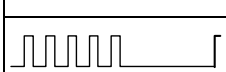
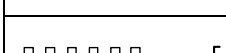
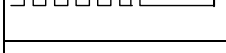
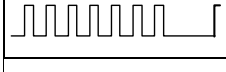
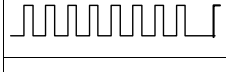
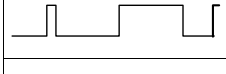


Remark: The cable's radius of curvature must be taken into account to adjust the distance between the front plate of the controller and the cabinet. If a motor cable with a small diameter is used, turn the metallic clamp over to maintain the shield continuity.
The associated connector can be ordered through the connector kit (refer to §2.5.5).

3.12 LEDs meaning

3.12.1 At the power supply level

- The **'Error'** LED (red) present on the power supply has the following meaning according to the status. The **'Control'** LED (green) **has always the same status** (running status):

Error LED status	Meaning	External relay command(*)
	Normal mode: voltages are present, no error detected and the PS RDY signal is high.	24 VDC
	Error 1: **Undervoltage** on the DC bus. The bus voltage is lower than 100 VDC for a power supply 400 and 146VDC for a power supply 600. If this error occurs, check the DC voltage level.	24 VDC
	Error 2: **Overvoltage on the DC bus**. The bus voltage is greater than 475 VDC for a power supply 400 and 670VDC for a power supply 600. If this error occurs, check the DC voltage level.	24 VDC
	Error 3: **Overtemperature**. The temperature of the heat sink is greater than 74 °C. If this error occurs, check the recommendations mentioned in §2.1.	0 VDC
	Error 4: **Overvoltage at the AC input**. The bus voltage is greater than 304 VAC for a power supply 400 and 440 VAC for a power supply 600. If this error occurs, check the input voltage level.	0 VDC
	Error 5: **Broken MOV**. A component in the overvoltage suppressor stage is broken. If this error occurs, remove the power supply and the user must contact its ETEL representative.	0 VDC
	Error 6: **Inrush** resistor **overload**. If this error occurs, look for a short-circuit on the output of the power supply. After having removed the cause of the error, it is necessary to switch off and on the power supply to reset it.	0 VDC
	Error 7: Brake resistor **gate driver faulty**. If this error occurs, check the external brake resistor.	0 VDC
	Error 8: Power supply disabled by the **'PS open'** signal sent by the controller. The red LED is never off for a long time: it blinks all the time. If this error occurs, check the wiring.	0 VDC
	Error 9: **Internal** error. If this error occurs, remove the power supply and the user must contact its ETEL representative.	0 VDC
	**Braking** mode. When the power reaches the braking threshold of 420 VDC for the power supply 400 or 650 VDC for the power supply 600.	24 VDC
Blinks at 10Hz	**Inrush** mode: while the capacitor bank is charging, the inrush relay is opened and the PS RDY signal is low.	24 VDC

(*): The voltage corresponds to the one of the ERC signal in the mode described in the 'Meaning' column.

- The **'Power voltage'** LED (green) and the **'Power error'** LED (red) present on the power supply have the following meaning when the power supply (and the controller) are switched on:

Both LEDs status	Meaning
ON and then the 'Power error' LED turns off	**Power input and control input are switched on:** both LEDs are simultaneously switched on. After about 2 seconds, you hear a «click» coming from the inrush protection device relay. At the same time, the 'Power error' LED turns off. During this time, the controller has initiated its self-test process.
OFF	**Only control input is switched on:** both LEDs are switched off but the communication with the controller(s) is possible.
ON	**Only power input is switched on:** Both LEDs are simultaneously switched on and remain on.

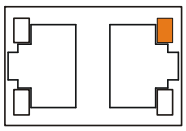
Remark: Each switch-on warm up the PTC resistors and to limit the inrush current, these resistors have to be at low temperature.

3.12.2 At the position controller level

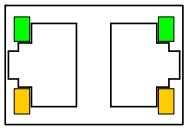
The different LEDs present on the controller have the following meaning:

3.12.2.1 Communication

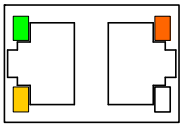
- **The position controller is switched on without connection to a communication bus**

LED regarding the communication	Meaning
COM IN X01  COM OUT X02	Orange LED is ON => The controller is switched on.

- **The position controller is switched on and connected to a TransnET communication bus**

LED regarding the communication	Meaning
COM IN X01  COM OUT X02	Green LEDs is ON => The connection (link) is detected on each connector. Yellow LEDs is ON => The TransnET data are running on each connector. The 'COM OUT' connector of the last controller on the TransnET bus is not connected, however, the green and yellow LEDs are also on to indicate that the TransnET bus loops correctly on itself.

- **The position controller is switched on and connected to an Ethernet communication bus**

LED regarding the communication	Meaning
COM IN X01  COM OUT X02	Orange LED is ON => The controller is switched on. Green LED is ON => The connection (link) is detected. Green LED is blinking => The controller is waiting for an IP address from a DHCP server Yellow LED is flashing => An activity is running on the Ethernet

3.12.2.2 Motor

LED regarding motor 1 / 2	Status	Meaning
Red LED 'ERROR'	ON	Error on motor 1 / 2 => check monitoring M64
	OFF	No error on motor 1 / 2
Green LED 'POWER ON'	ON	Motor 1 / 2 is in 'power ON'
	OFF	Motor 1 / 2 is in 'power OFF' (*)

Remark: If the red LED 'ERROR' and the green LED 'POWER ON' are ON at the same time (not blinking), then the controller is waiting for the end of a firmware download ('Wait for program' mode). Refer to the corresponding 'Operation & Software' for more information.

The red LED 'ERROR' and the green LED 'POWER ON' can be OFF together when the motor 1 / 2 is without error and in power OFF

(*): If the dynamic braking is activated due to an error (refer to the Operation & Software manual), the power bridge transistors are still switching (shortcut at the motor phases output) while the 'POWER ON' green LED is OFF.

4. Brake resistor sizing

A motor coupled with a load has a certain amount of energy. This energy is mainly kinetic when the load is moving or rotating. When the system brakes, the energy must be either stored or dissipated. It may be gravitational potential energy in addition to kinetic energy if the load movement is not horizontal (in case of a linear motor), or could be stored in a spring or in any outer system. In this case, the energy must be either stored or dissipated when the system is braking, and sometimes also when the system is at constant speed in descent direction. The AccurET and the corresponding power supply contain capacitors that are capable of storing a certain amount of energy. If the energy is too big, then a brake resistor is needed.

4.1 How big is the energy stored in my system?

In a standard direct drive application, the energy balance can be written as follows:

$$E_M = (\underbrace{E_K + E_P}_{\text{System energy}}) - (\underbrace{E_{Co} + E_F}_{\text{System losses}})$$

With:
E_M = Total energy of motor/load minus the system losses [J]
E_K= Kinetic energy of motor/load [J]
E_P = Gravitational potential energy of motor/load [J]
E_{Co} = Energy lost in the motor copper (Ohm losses) [J]
E_F = Energy lost by friction [J]

4.1.1 Torque motor case, standard configuration (E_P term equal to zero)

$$E_M = \underbrace{\frac{1}{2} \cdot (J_M + J_L) \cdot \omega_M^2}_{\text{Kinetic energy}} - \underbrace{3 \cdot I_M^2 \cdot \left(\frac{R_M}{2}\right) \cdot t_d}_{\text{Copper losses}} - \underbrace{\frac{t_d \cdot \omega_M}{2} \cdot T_F}_{\text{Friction losses}}$$

With:
J_M= Rotor inertia [kgm^2]
J_L= Load inertia [kgm^2]
ω_M= Motor speed before deceleration [rad/s]
I_M= Motor current during deceleration [A_{rms}/phase]
R_M= Motor resistance [Ω] terminal to terminal
t_d= Time to decelerate [s]
T_F= Friction torque [Nm]

Remark: A rotary axis may have in addition: gravitational potential energy (in case of non-direct drive, if the load is non horizontal), spring stored energy, etc.

4.1.2 Linear motor case with gravitational potential energy

$$E_M = \underbrace{\frac{1}{2} \cdot (m_M + m_L) \cdot v_M^2}_{\text{Kinetic energy}} + \underbrace{(m_M + m_L) \cdot g \cdot (h_{initial} - h_{final})}_{\text{Gravitational potential energy}} - \underbrace{3 \cdot I_M^2 \cdot \left(\frac{R_M}{2}\right) \cdot t_d}_{\text{Copper losses}} - \underbrace{\frac{t_d \cdot v_M}{2} \cdot F_F}_{\text{Friction losses}}$$

With:
m_M = Motor mass [kg] moving part of motor only
m_L = Load mass [kg]
v_M = Motor speed before deceleration [m/s]
g = Gravitational acceleration [m/s2]
$h_{initial}$ = Initial load altitude [m]
h_{final} = Final load altitude [m]
I_M = Motor current during deceleration [A_{rms}/phase]
R_M = Motor resistance [Ω] terminal to terminal
t_d = Time to decelerate [s]
F_F = Friction force [N]

Remark: For a constant speed system (like a long stroke conveyor for example), all the terms of the above-mentioned equation have the same meaning except for:

v_M = Motor speed (constant) during the travel [m/s]
I_M = Motor current during travel at constant speed [A_{rms}/phase]
t_d = Time to travel [s]

4.2 Is a brake resistor needed?

If the following condition is true, then a brake resistance is needed. For a n axes system plugged on the same power supply (all negative E_M terms are set to zero in order to have the worst case).

$$\sum_{j=1}^{n} E_{Mj} > \underbrace{\frac{1}{2} \cdot C \cdot (U_{MAX}^2 - U_{Nom}^2)}_{\text{Maximal energy storable in the capacitors}}$$

With: E_M = Total energy of motor/load minus the system losses [J]
C = Total capacitance seen from the bus [F] (refer to §4.5)
U_{MAX} = Maximal allowed bus voltage [V] (refer to §4.5)
U_{Nom} = Nominal bus voltage [V] (refer to §4.5)

4.3 How to determine the resistance value?

For an n axes system plugged on the same power supply:

$$R_{MAX} = \frac{U_{MAX}^2}{\sum_{j=1}^{n} U_{Bj} \cdot I_{Mj} \cdot \sqrt{3}}$$

With: R_{MAX} = Brake resistance maximal value [Ω]
U_{MAX} = Maximal allowed bus voltage [V] (see table 1)
U_B = Motor back EMF less motor losses [V] (refer to §4.3.1 and §4.3.2)
I_M = Deceleration current in motor [A_{rms}/phase]

4.3.1 Torque motor case

$$U_B = \underbrace{K_u \cdot \omega_M}_{\text{Back EMF}} - \underbrace{I_M \cdot \left(\frac{R_M}{2}\right) \cdot \sqrt{3}}_{\text{Phase voltage}}$$

With: K_u = Back EMF constant [V/(rad/s)] terminal to terminal

4.3.2 Linear motor case

$$U_B = \underbrace{K_u \cdot v_M}_{\text{Back EMF}} - \underbrace{I_M \cdot \left(\frac{R_M}{2}\right) \cdot \sqrt{3}}_{\text{Phase voltage}}$$

With: Ku = Back EMF constant [V/(m/s)] terminal to terminal

4.4 How to determine the resistance dissipated power

For an n axes system plugged on the same power supply (all negative E_M are set to zero):

$$P_{AV} = \frac{\sum_{j=1}^{n} E_{Mj} - \left(\frac{1}{2} \cdot C \cdot (U_{MAX}^2 - U_{HYS}^2)\right)}{t_{CYCLE}}$$

With: P_{AV} = Average power to be dissipated by the brake resistance [W]
U_{HYS} = Hysteresis point of power supply [V] (refer to §4.5)
t_{CYCLE} = Longest (time between two consecutive decelerations) of the n axis system [s]

When the time between two consecutive decelerations becomes very large, the average power is not a meaningful number. In this case, the peak power is the main concerned:

$$P_{PK} = \frac{V_{MAX}^2}{R_{REGEN}}$$

With: P_{PK} = Peak power dissipated by the regenerative resistance [W]
R_{REGEN} = Brake resistance value [Ω]

4.5 AccurET specifications

	C	U_{MAX}	$R_{internal}$	U_{Nom}	U_{HYS}
AccurET 400	280 µF	450 VDC	220 KΩ	120-400 VDC	420 VDC
AccurET 600	135 µF	650 VDC	220 KΩ	300-565 VDC	620 VDC
Power 400	1400 µF	475 VDC	55 KΩ	120-400 VDC	420 VDC
Power 600	675 µF	695 VDC	55 KΩ	300-565 VDC	620 VDC

Remark: In the case of one power supply and n AccurET controller, C is calculated as follows:

$$C[\mu F] = 1400 + n \cdot 280$$ for an AccurET 400

$$C[\mu F] = 675 + n \cdot 135$$ for an AccurET 600

and in that case, $R_{internal}$ is calculated as follows:

$$R_{internal}[\Omega] = \frac{1}{\left(\frac{1}{55k} + \frac{n}{220k}\right)}$$ for an AccurET 400 V and 600 V

5. Service and support

For any inquiry regarding technical, commercial and service information relating to ETEL S.A. products, please contact your ETEL S.A. representative:

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Please refer to your corresponding ETEL S.A. representative for more information about the technical documentation. ETEL S.A. organizes training courses for customers on request, including theoretical presentations of our products and practical demonstrations at our facilities.