1 SPECIFICATION

1.1 Technical specifications

Steering controller for DC Permanent Magnet motors
Digital Control using Two Microprocessors
Can-Bus interface
Both microprocessors Can Bus connected
Encoder Interface
Stepper Motor or Twin Pot Interface or second Encoder interface
Analog Feedback pot interface (1024 steps resolution)
Analog KTY84-130 thermal sensor input
Analog input with 1024 steps resolution (one input)
Analog input with 4096 steps resolution (one input)
Two digital inputs
Double Safety Relay inside
Operating frequency:..8 kHz with center aligned PWM
External temperature range:..-30 ℃ ÷ 40 ℃
Maximum inverter temperature:..80 °C
Environment protection: IP54

1.2 Block diagram

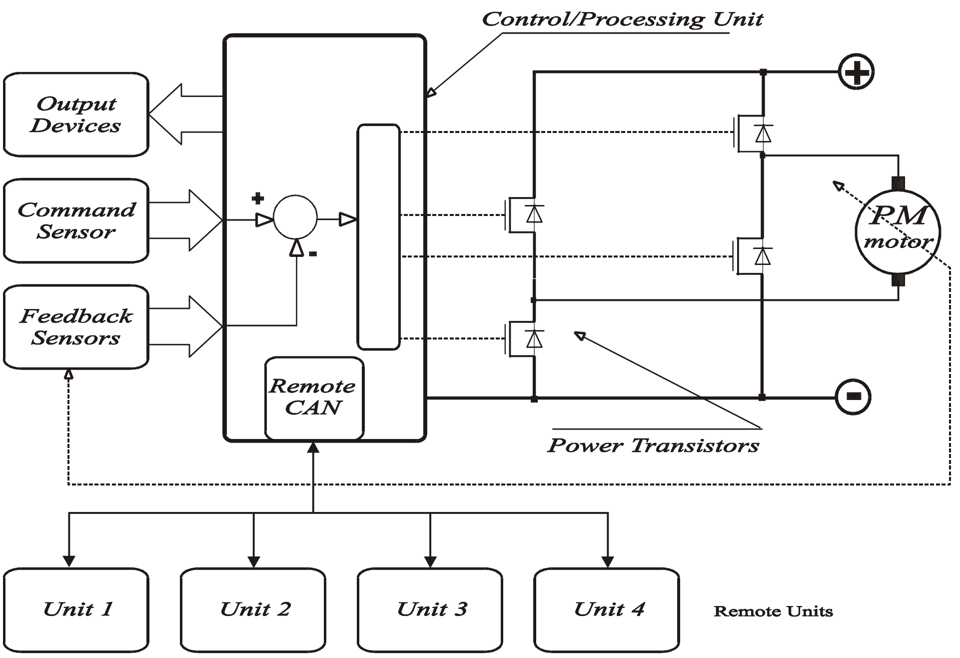


Figure 2-1

1.3 Electrical specifications

Battery Voltage:..Two releases
F70142...24 V-36V
Forthcoming...36V-48V
Maximum current (24 V-36 V): ....50 Adc for 2'
Maximum current (36V-48V) ....45Adc for 2'
Logic Supply current:...max 200 mA @ 24 V
Minimum Input (key) Supply Voltage after start-up: .... 12 V

1.4 Mechanical specifications

1.4.1 Basic release

It has Molex Minifit connector with international protection IP54.

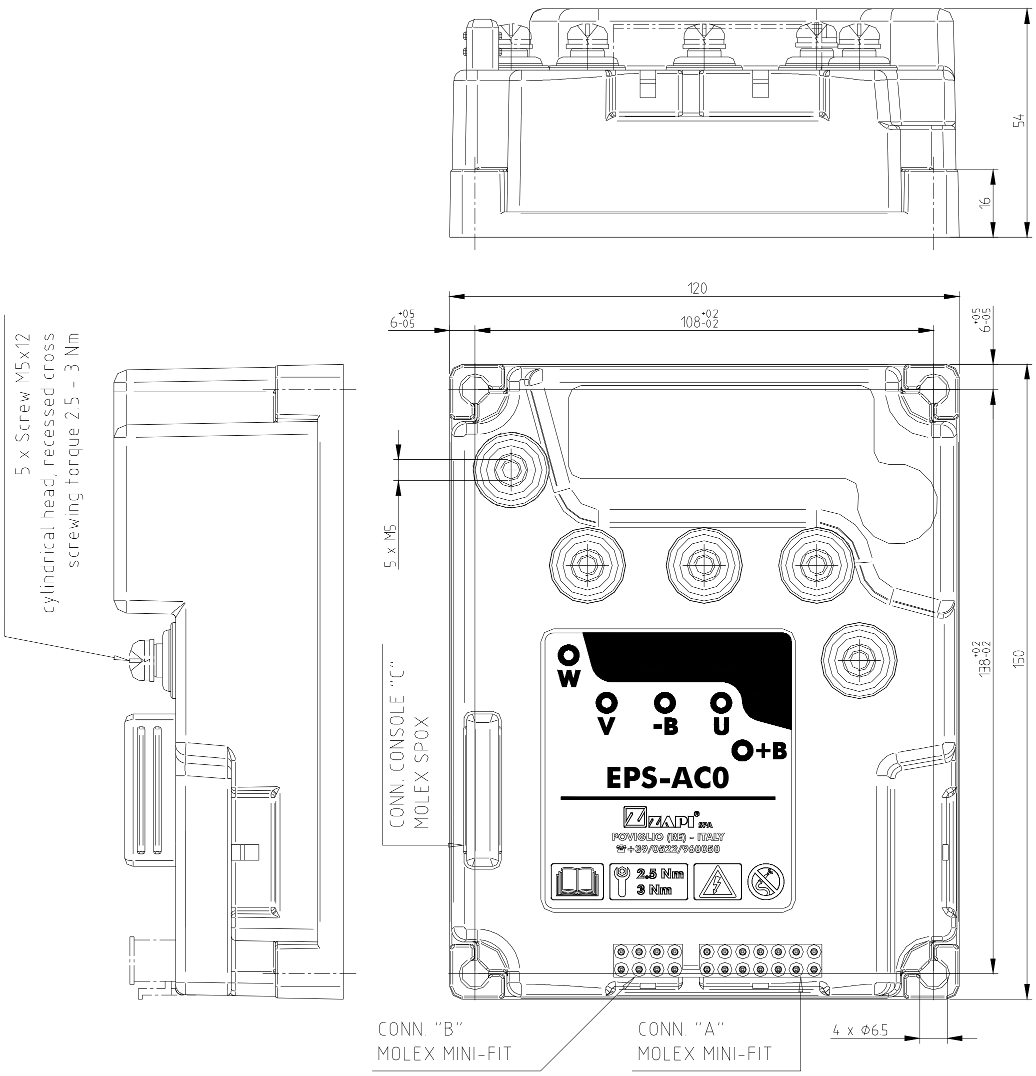


Figure 1–2

2 FUNCTIONS OF THE EPS-DC0

The eps-dc0 controls a steer by-wire system for warehouse trucks. It executes the following functions:

1) Manual mode steering
2) Automatic Centering.

2.1 Manual Mode Steering

Manual mode steering requires a command sensor in the hand wheel. The hand wheel may be of two types:

1) Multiturn steering wheel without end-strokes.
2) Handlebar, tiller or joy-stick with end-strokes to limit the angle.

With a Multiturn steering wheel, the sensor in the hand-wheel shall be a stepper motor used as a tacho-generator (see Figure 3-1). Then the control will turn the steering motor moving at a speed proportional to the stepper motor speed (Open loop Mode).

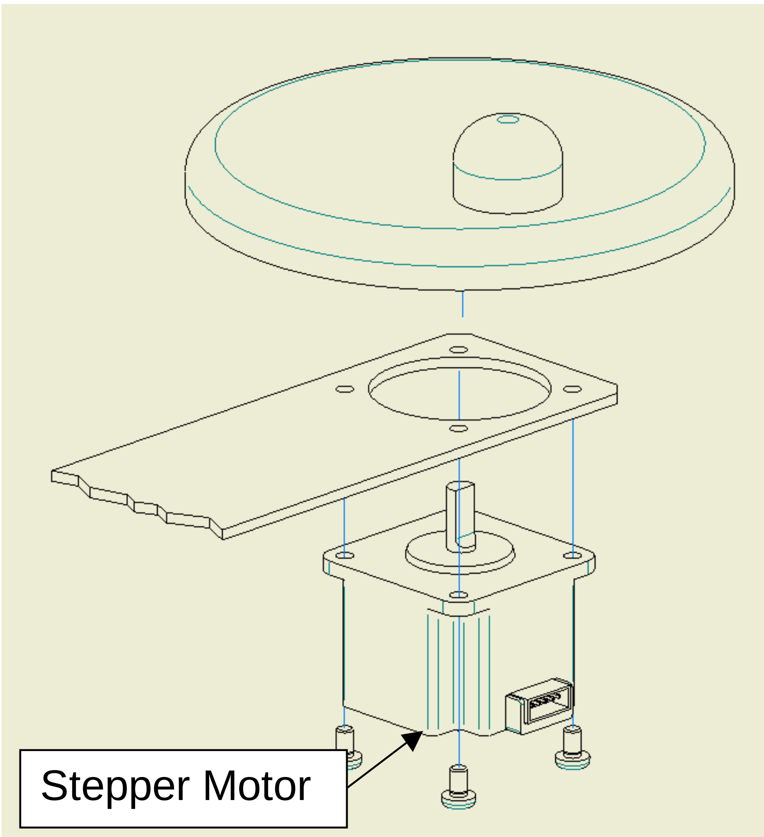


Figure 3-1

With a Handlebar (tiller or joy-stick), the sensor in the hand-wheel will be a twin pot (see Figure 3-2 below). Then the system works as a position control loop with a rigid correspondence between the angle of the handlebar and the angle of the steered wheel (Closed Loop Mode). In this case a feedback sensor on the steered wheel is mandatory.

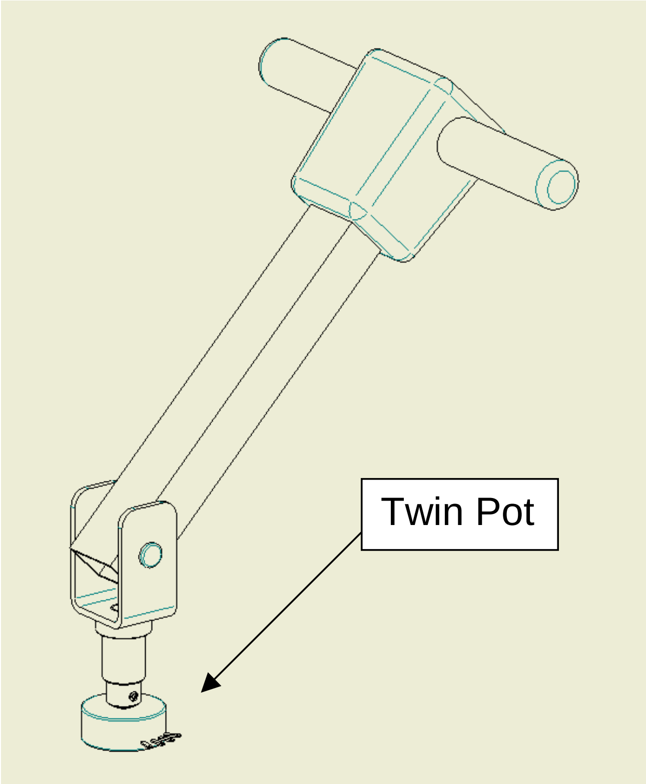


Figure 3–2

The same controller may work either with the stepper motor or the twin pot without hardware modification. It is just enough to set the SYSTEM CONFIG to the correct value (see 11.4.3.1).

2.2 Automatic Centering

Automatic Centering (AUTC) turns the steered wheel straight ahead to keep the steer aligned meanwhile travelling inside an aisle between rails (see Figure 3-3). AUTC is activated with a centering request. The centering request can be provided via CAN Bus. As alternative, it is possible to use wired requests. For example it is possible to use inputs CNA#3 and CNA#2 for the centering request (redundancy is recommended).
In case of AUTC, a special software must be developed

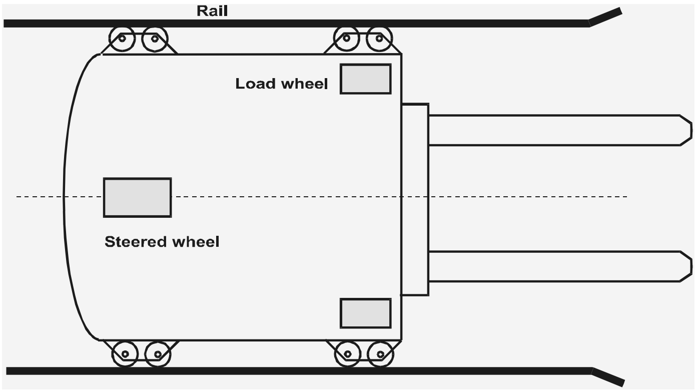


Figure 3–3

2.3 Operational features

A list of eps-ac0 operational features follows below:
1) Static sensitivity boost in open loop (steering sensitivity increases for a slow moving steering wheel).
2) Static numbness in closed loop (steering sensitivity decreases for handle steer close to the straight-ahead direction).
3) Dynamic Numbness in open loop (steering sensitivity reduces when the truck speed increases).
4) Dynamic Numbness on request in closed loop (steering sensitivity reduces when the truck speed increases).
5) Truck speed reduces when the steering angle increases.
6) Alignment at the rest position in open loop application (to avoid the drift of the steered wheel when travelling with released steering wheel).
7) Embedded PID algorithm for closed loop application (Twin Pot).
8) Embedded PID algorithm for automatic functions (AUTC).
9) Special Debugging & Troubleshooting system makes easier the fault catching.
10) Possibility to run in a stand-alone (not CAN Bus supported) configuration.
11) Motor control may be performed with or without encoder. Default choice is without encoder. The adoption of a cheap and low-resolution encoder is possible.
12) Redundant processing (two microprocessors aboard) fulfils the Category #3 requirement including the set-point comes via CAN Bus from a remote unit.
13) Redundant set point and feedback sensors fulfil the Category #3 requirement.
14) Redundant safety-contact fulfils the Category #3 requirement in a stand-alone configuration.

2.4 Feedback sensors

Feedback sensors are mandatory to close the loop in manual mode if a twin pot is mounted on the steering wheel.
Feedback sensors are strongly suggested (to improve safety) in manual mode if a stepper motor is mounted on the steering wheel (open loop).
Eps-ac0 may handle two different configurations for the feedback sensors:
1) Incremental encoder in the motor shaft together with a feedback potentiometer on the steered wheel.
2) Incremental encoder in the motor shaft together with one (or two) toggle switch(es) in the straight ahead (and 90 degrees) position of the steered wheel (SW modification required).

2.4.1 Encoder in the motor shaft and a Feedback Potentiometer

It is shown in Figure 4-4. It consists of:
1) Feedback encoder in the motor shaft.
2) Feedback potentiometer on shaft of the steering motor gear box.

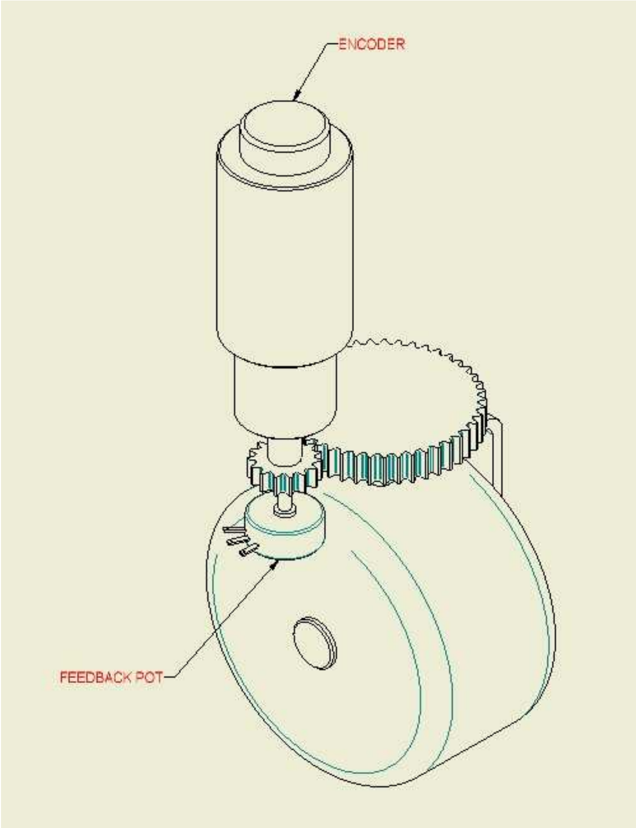


Figure 2–4

4.5.1.1 Feedback potentiometer

The feedback potentiometer is used for both, encoder initialisation and redundancy on the steered wheel angle measurement. Normally the feedback potentiometer is multiturn (5 or 10 turns) 5K hybrid technology mounted on the output shaft of the steering gearbox (see Figure 4-4).

2.4.2 Encoder in the motor shaft and one (two) toggle switches

It consists of:

1) Straight ahead toggle switch on the input CNA#3 and GND.
2) 90 degrees toggle switch on the input CNA#2 and GND.
3) Feedback encoder on the steering motor shaft

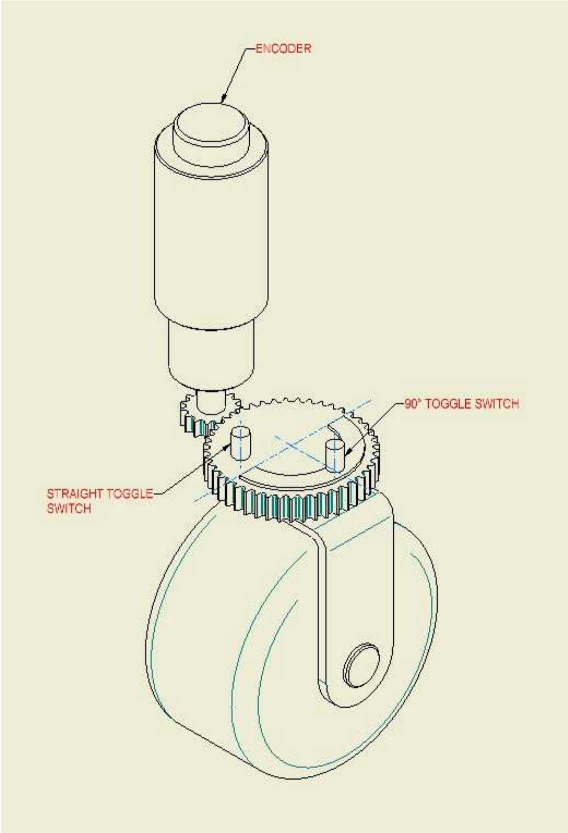


Figure 2–4

4.5.2.1 Straight ahead toggle switch

The straight ahead toggle switch must be of NPN type (i.e. it must connect a minus battery to CNA#3).
A possible arrangement for the straight-ahead switch (proximity switch) is shown in Figure 4-4- below. The proximity switch is connected to the truck frame; the Iron plate rotates together with the steered wheel.

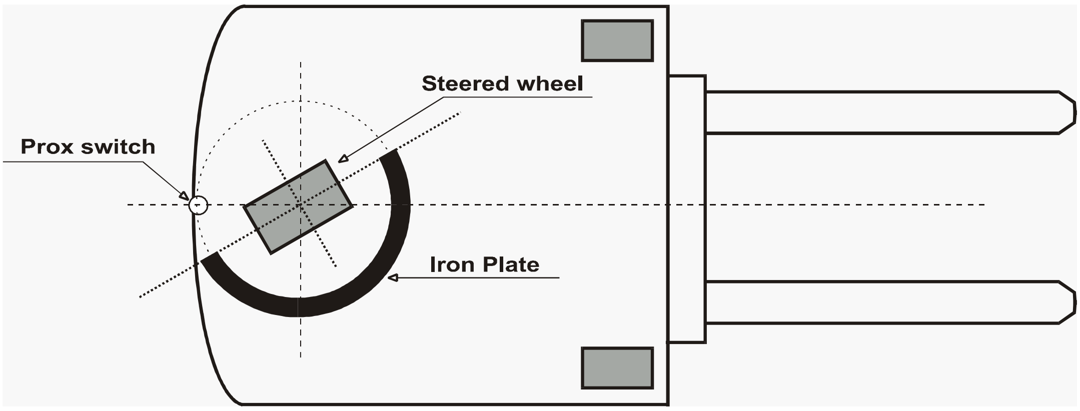


Figure 4-4

It is handled this way:

4) At key-on, the eps-ac0 turns the steering motor moving in either CW or CCW side, according to whether the output level from the straight ahead switch is high or low (in the above sketch a proximity sensor is used as a straight ahead switch).

5) When the falling edge on the prox switch is detected, the encoder counting is initialized to 0 and the steered wheel is centered.
6) Then the encoder counting is continuously updated to measure the steered wheel angle.

At key on, the Iron plate (with the shape shown in the sketch), provides the correct direction in which the eps-ac0 must turn the steering motor in order the falling edge on the proximity switch is detected.
Together with the straight-ahead switch, a second toggle switch could be adopted to detect when the steered wheel is in the 90 degrees limiting position. This second toggle switch must be connected to CNA#2 and GND (minus battery).
An hardware setting AUX FUNCTION 11 (see jjj) is used to specify the toggle switches configuration (one or two toggle switches and their succession during time).

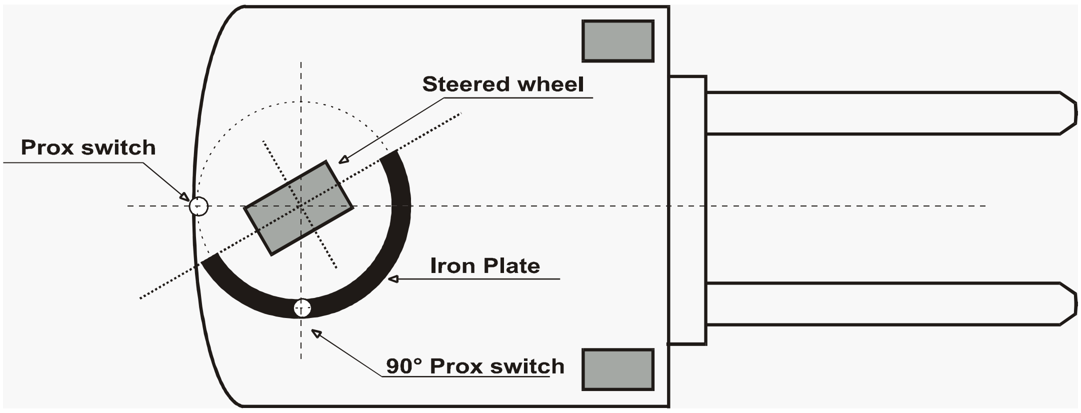
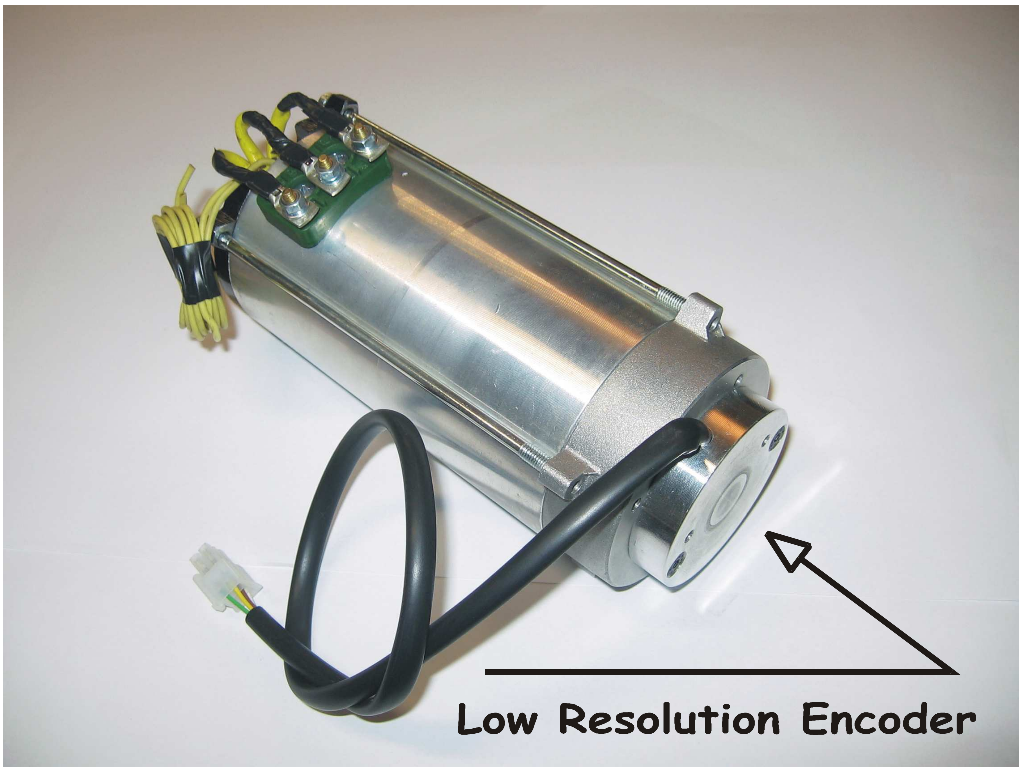


Figure 4-5

4.5.1.2 Feedback Encoder

Our competitors normally need a sensor bearing with 32 or higher pulses/rev; it is possible to work also with a cheap encoder having 4 pulses/rev. That is more than enough for the angle measurement: in fact, with a total reduction of 1:200 and a 4 pulses/revs resolution, we have 1600 events (encoder transitions) within 180° of the steered angle. So the angle measurement is determined with quanta of 180/1600=0.112 degrees.
Following this statement, we have developed, together with a Zapi's partner AC-motor-brand, a 4 pulses/rev discrete encoder. It is an external device (not integrated in the ball bearing) mounted in the backside of the motor (see Figure below showing a 300 W Motor by "Best Motor" brand). The advantages of this solution are both, money saving and effective time saving in case of encoder replacement.


Low Resolution Encoder

3 CONNECTING DIAGRAMS

Below we have a collection of suggested connecting diagrams. They correspond to the main configurations. On request it is possible to choose also customized proposals or wiring modifications.

3.1 Power Connecting Diagram

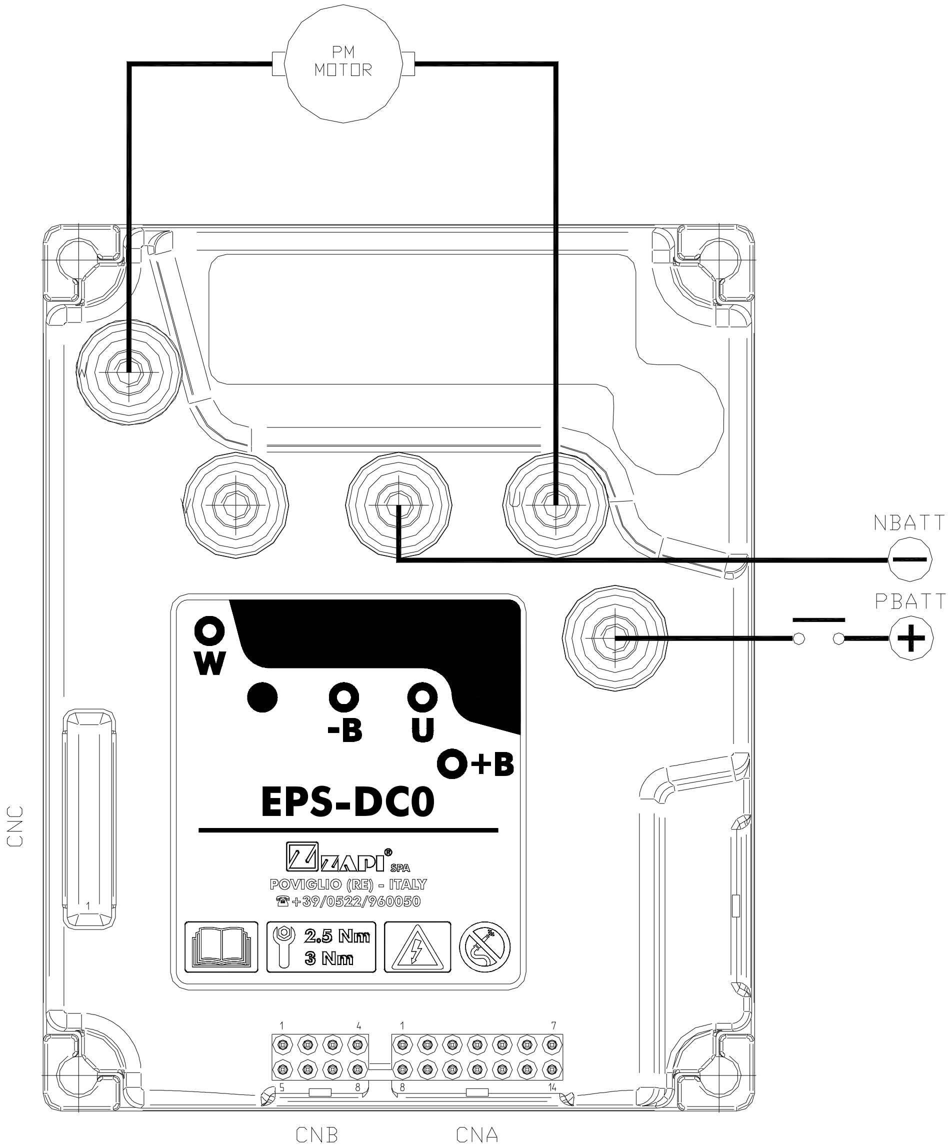


Figure 5-1

3.2 EPS-AC0 Twin pot diagram

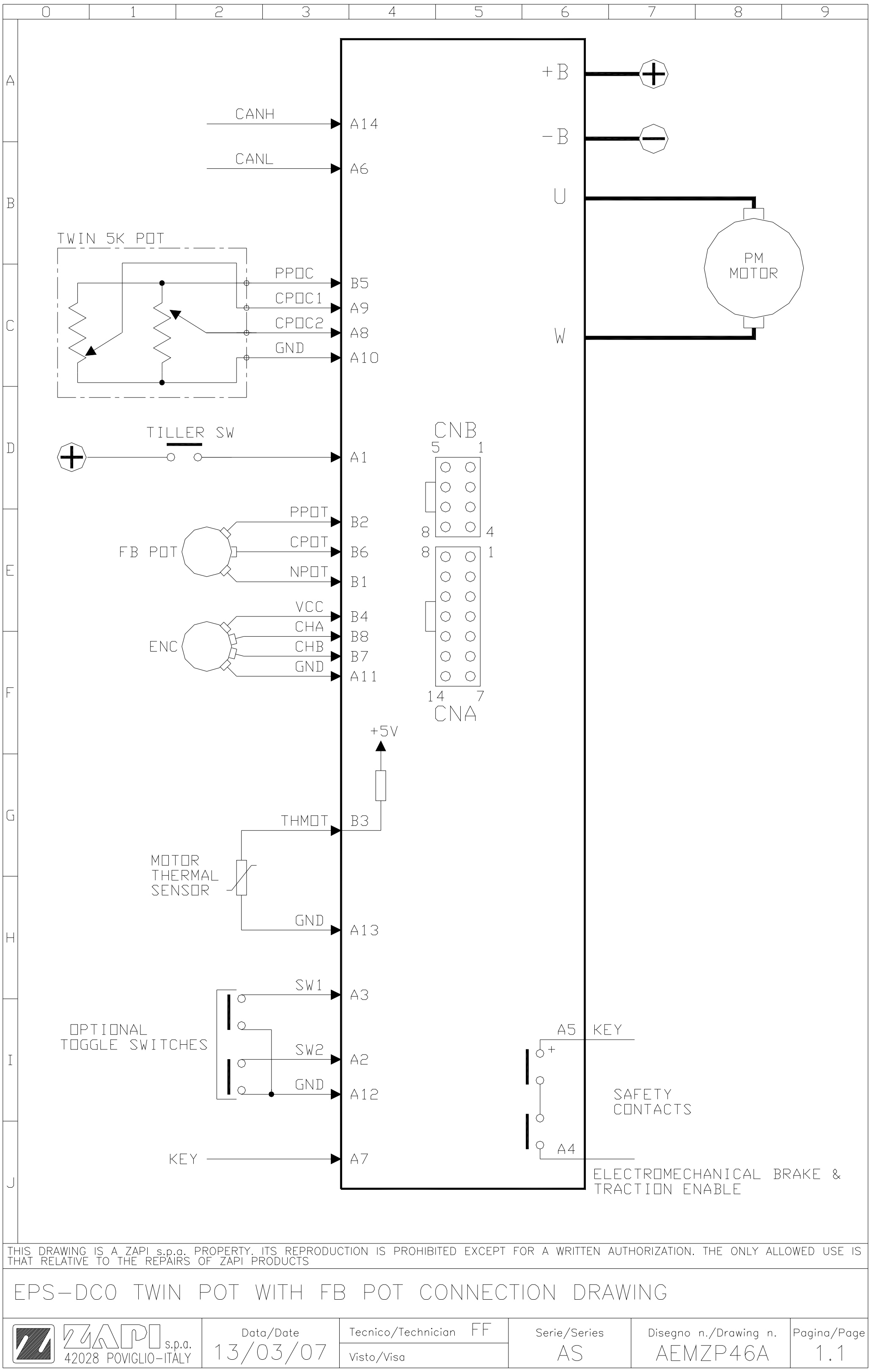


Figure 5-2

3.3 EPS-AC0 Stepper Motor diagram

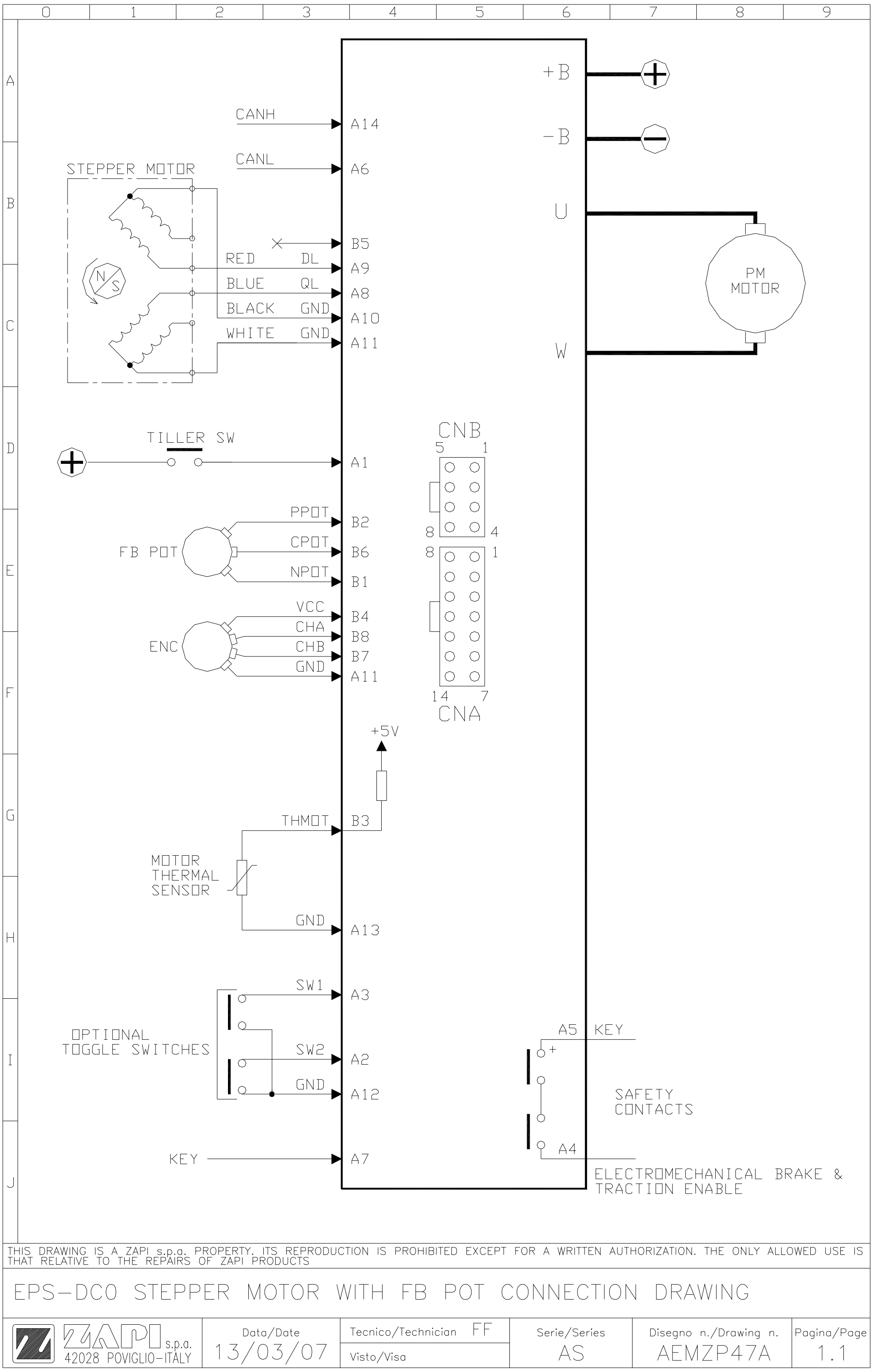


Figure 5-3

3.4 EPS-AC0 Two Command encoders diagram

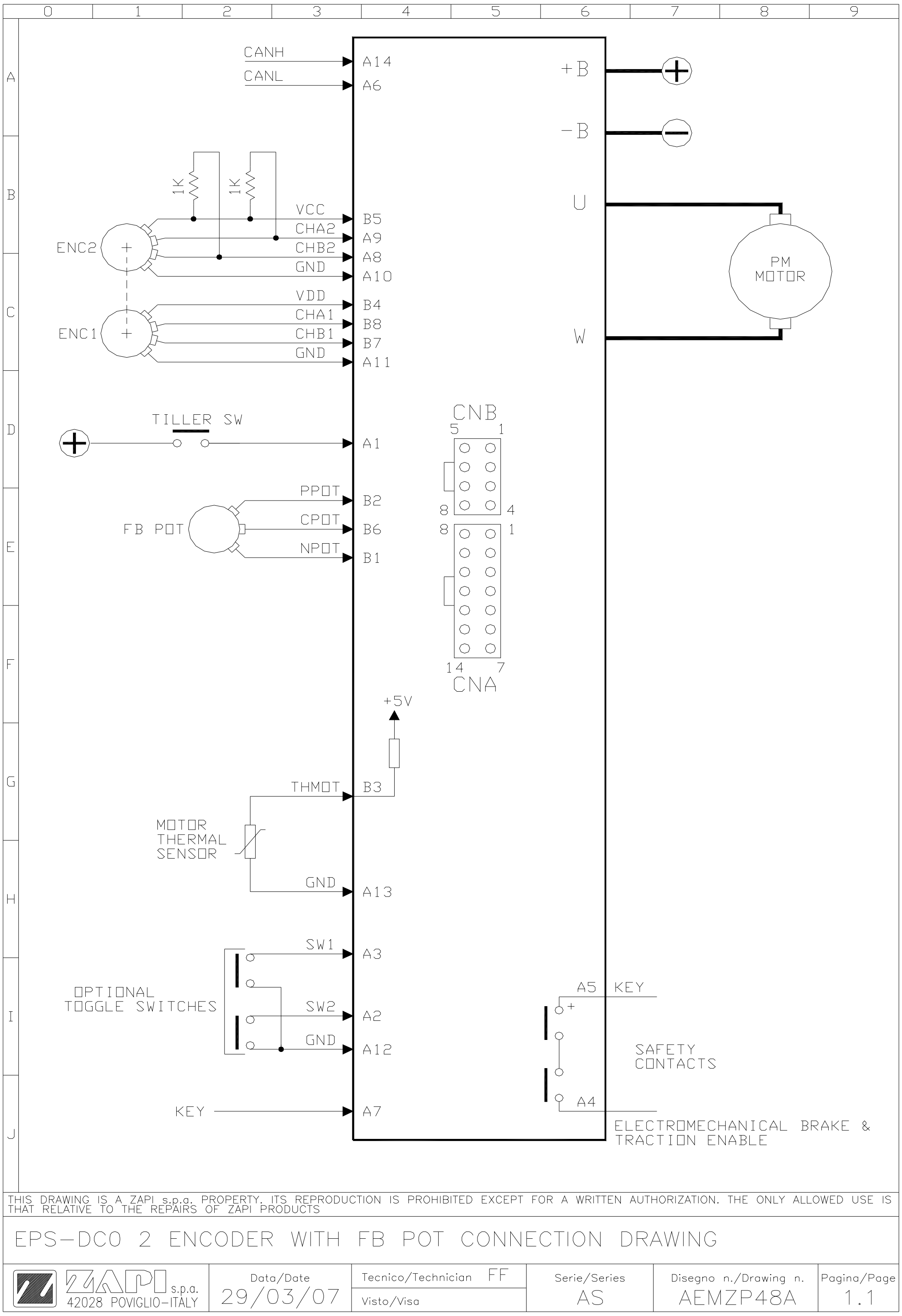


Figure 5-4