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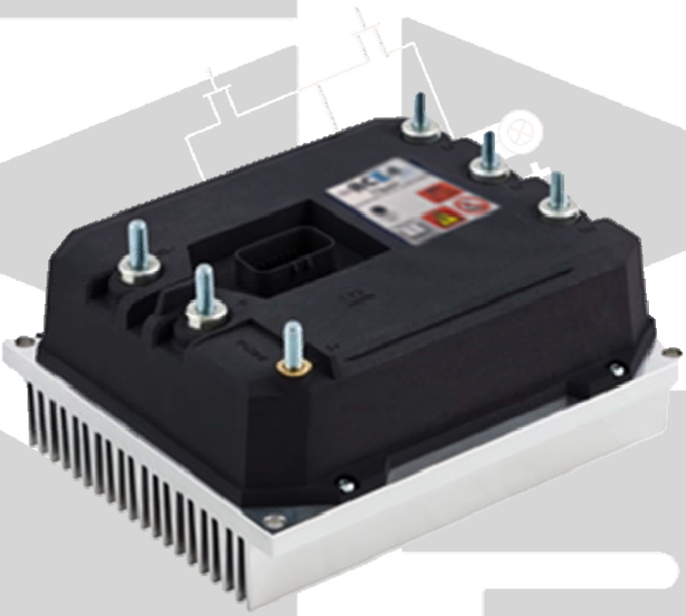
EN

User Manual

ACE4



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APPROVAL SIGNS

COMPANY FUNCTION	INITIALS	SIGN
PROJECT MANAGER		
TECHNICAL ELECTRONIC MANAGER VISA		
SALES MANAGER VISA		

1 INTRODUCTION

1.1 About this document

1.1.1 Scope of this manual

This manual provides important information about ACE4 controller: it presents instructions, guidelines and diagrams related to installation and maintenance of the controller in an electrically powered vehicle.

1.1.2 Manual revision

This revision replaces all previous revisions of this document. Zapi has put a lot of effort to ensure that this document is complete and accurate at the time of printing.
In accordance with Zapi policy of continuous improvement of products, all data in this document are subject to change or correction without prior notice.

1.1.3 Warnings and notes

In this manual special attention must be paid to information presented in warning and information notices.
Definitions of warning and information notices are the following.

This is an information box, useful for anyone is working on the installation, or for a deeper examination of the content.

This is a warning box, it can describe:
- operations that can lead to a failure of the electronic device or can be dangerous or harmful for the operator;
- items which are important to guarantee system performance and safety

This is a further warning within the box. Pay special attention to the annotations pointed out within these boxes.

1.2 About the Controller

1.2.1 Safety

Zapi provides this and other manuals to assist manufacturers in using the motor controller in a proper, efficient and safe manner. Manufacturers must ensure that all people responsible for the design and use of equipment employing the motor controller have the proper professional skills and knowledge of equipment.

Before doing any operation, ensure that the battery is disconnected and when the installation is completed start the machine with the driving wheels raised from the ground to ensure that any installation error does not compromise safety.

After the inverter turn-off, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10 – 100 Ohm between +B and -B terminals of the inverter.

1.2.2 OEM responsibility

Zapi motor controllers are intended for controlling motors in electric vehicles. These controllers are supplied to original equipment manufacturers (OEMs) for incorporation into their vehicles and vehicle control systems.
Electric vehicles are subject to national and international standards of construction and operation which must be observed. It is responsibility of the vehicle manufacturer to identify the correct standards and to ensure that the vehicle meets these standards. As a major electrical control component, the role of a Zapi motor controller should be carefully considered and relevant safety precautions taken. It has several features which can be configured to help the system integrator meeting vehicle safety standards.
Zapi does not accept responsibility for incorrect application of its products.

1.2.3 Technical support

For additional information on any topic covered in this document or application assistance on other Zapi products, contact Zapi sales department.

2 SPECIFICATIONS

2.1 General features

ACE4 inverter is a controller designed to control AC induction, BLDC and PMSM motors, in the range from 10 kW to 20 kW of continuous power, used in a variety of battery-powered material-handling trucks.
Typical applications include, but are not limited to: counterbalanced trucks with load up to 8 metric tons, HLOP (VNA), GSE, tow tractors and airport ground support vehicles, aerial-access equipment.

The main inverter features are:

- 16-bits microcontroller for motor control and main functions, 576+ kbyte embedded flash memory.
- 16-bits microcontroller for safety functions, 320+ kbyte embedded flash memory.
- Field-oriented motor-control algorithm.
- Smooth low-speed control.
- Zero-speed holding control.
- Zapi patented sensorless and sense-coil control.
- Driver for line-contactor coil.
- Low-side and high-side drivers for an electromechanical-brake coil (short circuit protected).
- Drivers for PWM-modulated voltage-controlled electrovalves and for two PWM-modulated current-controlled proportional valves.
- Short-circuit and open-load protection.
- Thermal cutback, warnings and automatic shutdown for protection of motor and controller.
- ESD-protected CAN bus interface.
- Software downloadable via serial link (internal connectors) or CAN bus (external connector).
- Diagnostics provided via CAN bus using Zapi CAN PC Tool.
- Rugged sealed housing and connectors meet IP65 environmental sealing standards for use in harsh environments.

ACE4 is available in two main functional configurations:

1) **Standard Version** (36/48V, 72/80V): with a 23 poles Ampseal connector.
2) **Premium Version** (36/48V, 72/80V): with a 35 poles Ampseal connector for enhanced I/O capabilities.

2.2 Technical specifications

Motor type: .... induction AC, synchronous AC, brushless DC
Control mode: .... speed or torque control
Operating frequency: .... 8 kHz
Inverter operating frequency: .... 16 kHz
Ambient operating temperature range: .... -40 °C ÷ 40 °C
Ambient storage temperature range: .... -40 °C ÷ 85 °C
Maximum inverter temperature at full power: .... 85 °C
Connector: .... Ampseal 23 or 35 pins
Package Environmental Rating: IP65

2.2.1 Current ratings

Nominal DC voltage	**36/48V**		**72/80V**
Maximum current [Arms]	**1000**	**800**	**700**
40 – 85 °C time at maximum current	1’ 50’’	> 2’	1’ 30’’
Two-minute rated current [Arms]	950	800	630
Continuous rated current [Arms]	480	460	355

Current ratings are based on an initial heat sink temperature of 40 °C and a maximum heat sink temperature of 85 °C. No additional external heat sink is used for the 2-minute rating test.

The inverter is designed to deliver the continuous rated RMS current only if it is adequately cooled. When it is equipped with its own finned heat sink, a proper dissipation is obtained by applying 100 m^3/h of airflow. In case it is provided with the base plate, it is customer’s duty to design an adequate cooling system that can dissipate the heat produced by the inverter, keeping it below 85 °C.

Internal algorithms automatically reduce the maximum current when heat sink temperature exceeds 85°C. Heat sink temperature is measured internally near the power MOSFETs (see paragraph 6.6).

2.2.2 Supply voltage ratings

Nominal DC voltage	**36/48V**	**72/80V**
Conventional working voltage	28,8V ÷ 57,6V	57,8V ÷ 96V
Non-operational overvoltage limit	65V	115V
Non-operational undervoltage limit	10V	30V

Conventionally, the controller can be set to operate without alarm in the range from 80% to 120% of the nominal battery voltage. With a different DC voltage than specified, the controller raises an alarm.

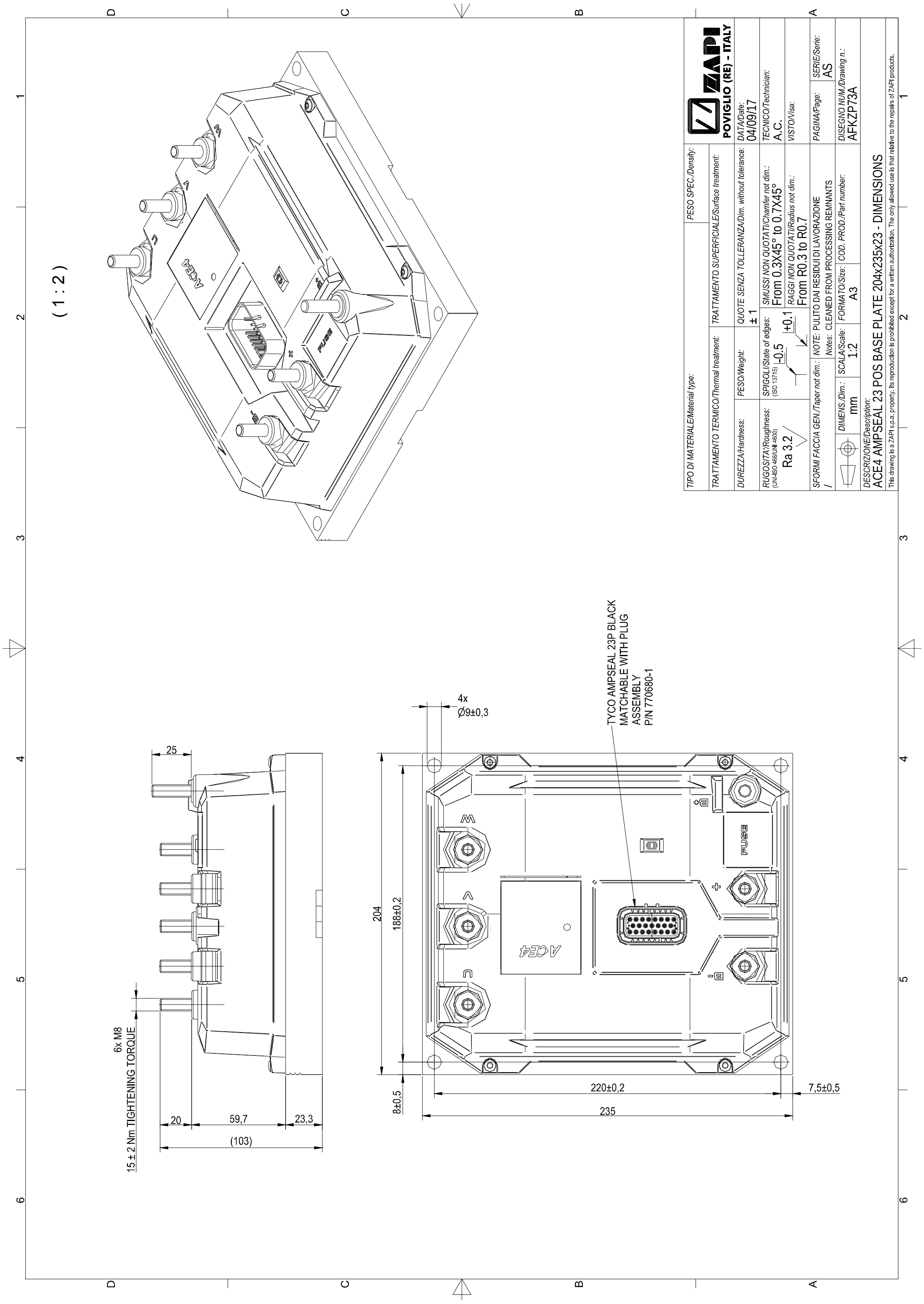
Undervoltage and overvoltage thresholds are defined by hardware. After start-up, controller is fully operative if the supply voltage stays within the limits.

Undervoltage is evaluated on the KEY input A1 (A3 for Premium ACE4); overvoltage is evaluated on the positive battery terminal +B.

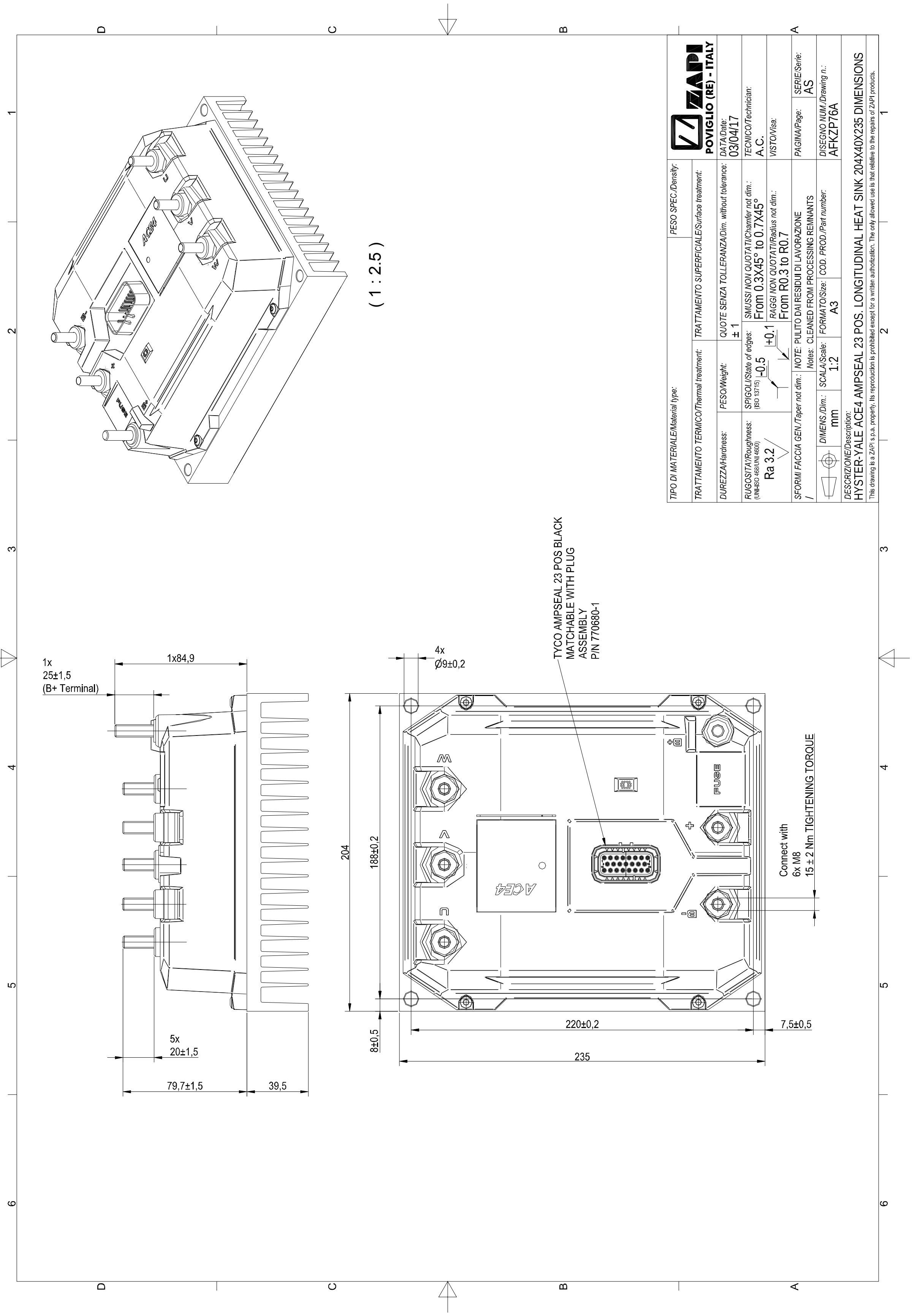
3 DRAWINGS

3.1 Mechanical drawings

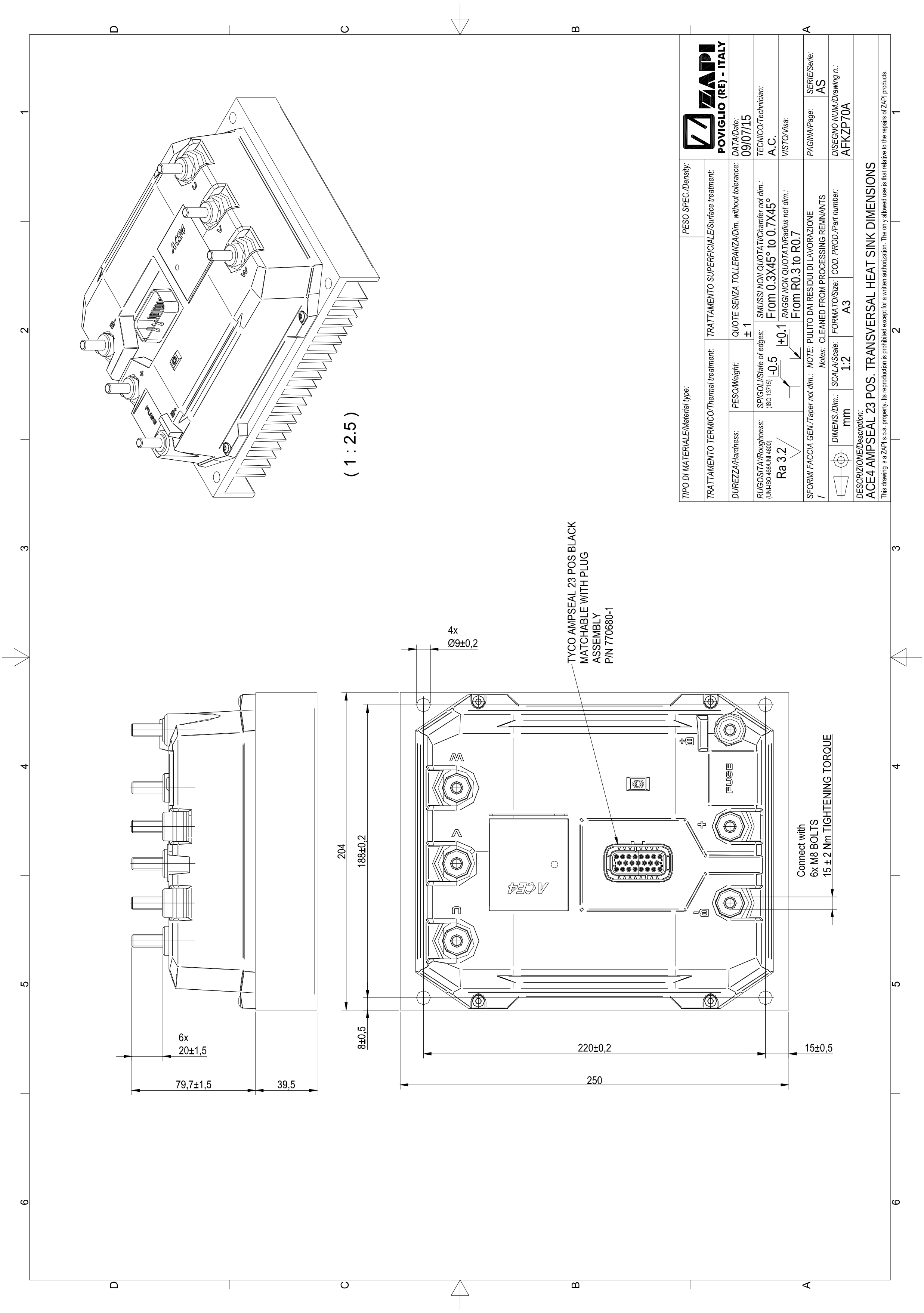
3.1.1 Base plate version



3.1.2 Longitudinal heat sink version

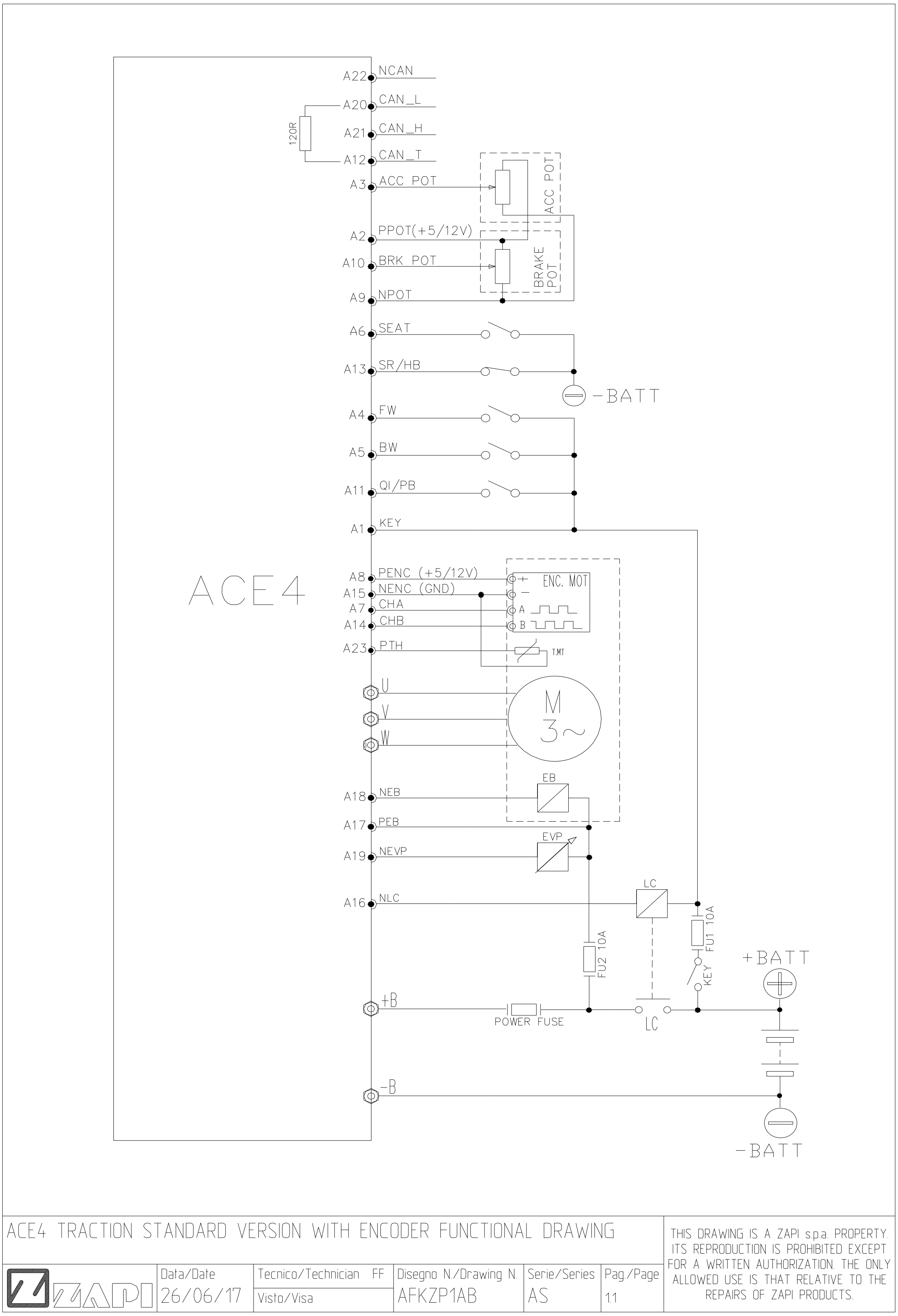


3.1.3 Transversal heat sink version

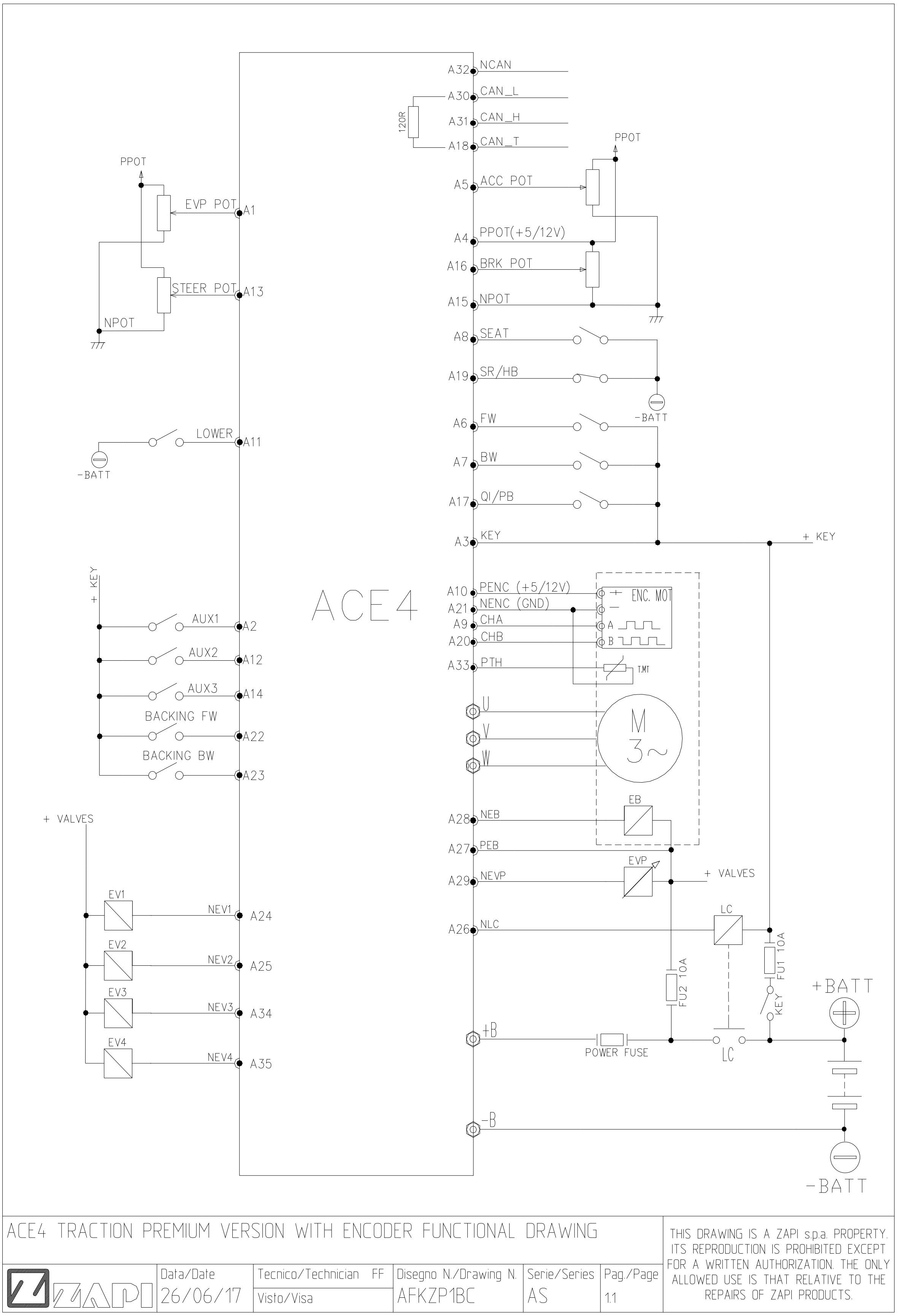


3.2 Connection drawings

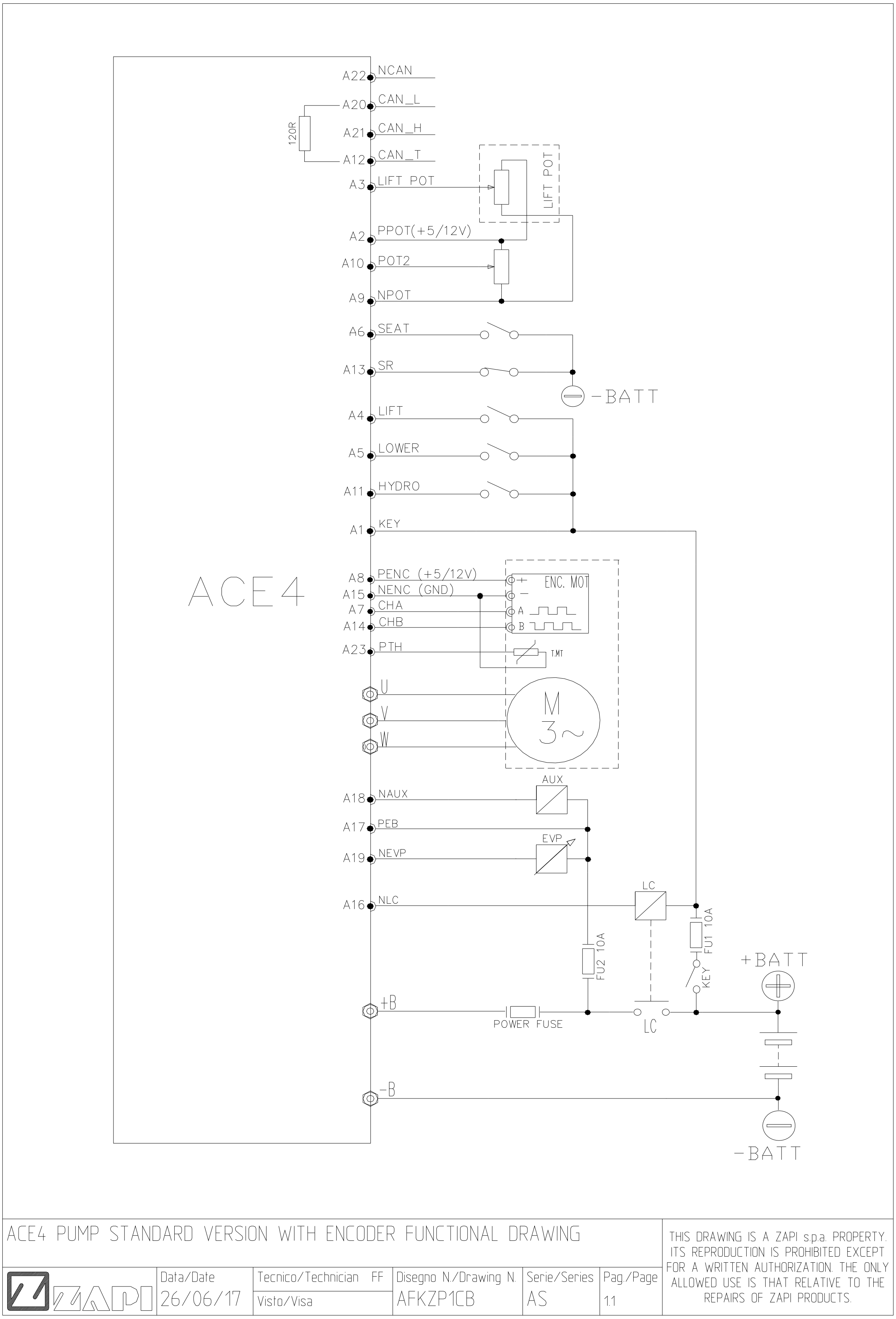
3.2.1 AC Traction configuration – Standard version



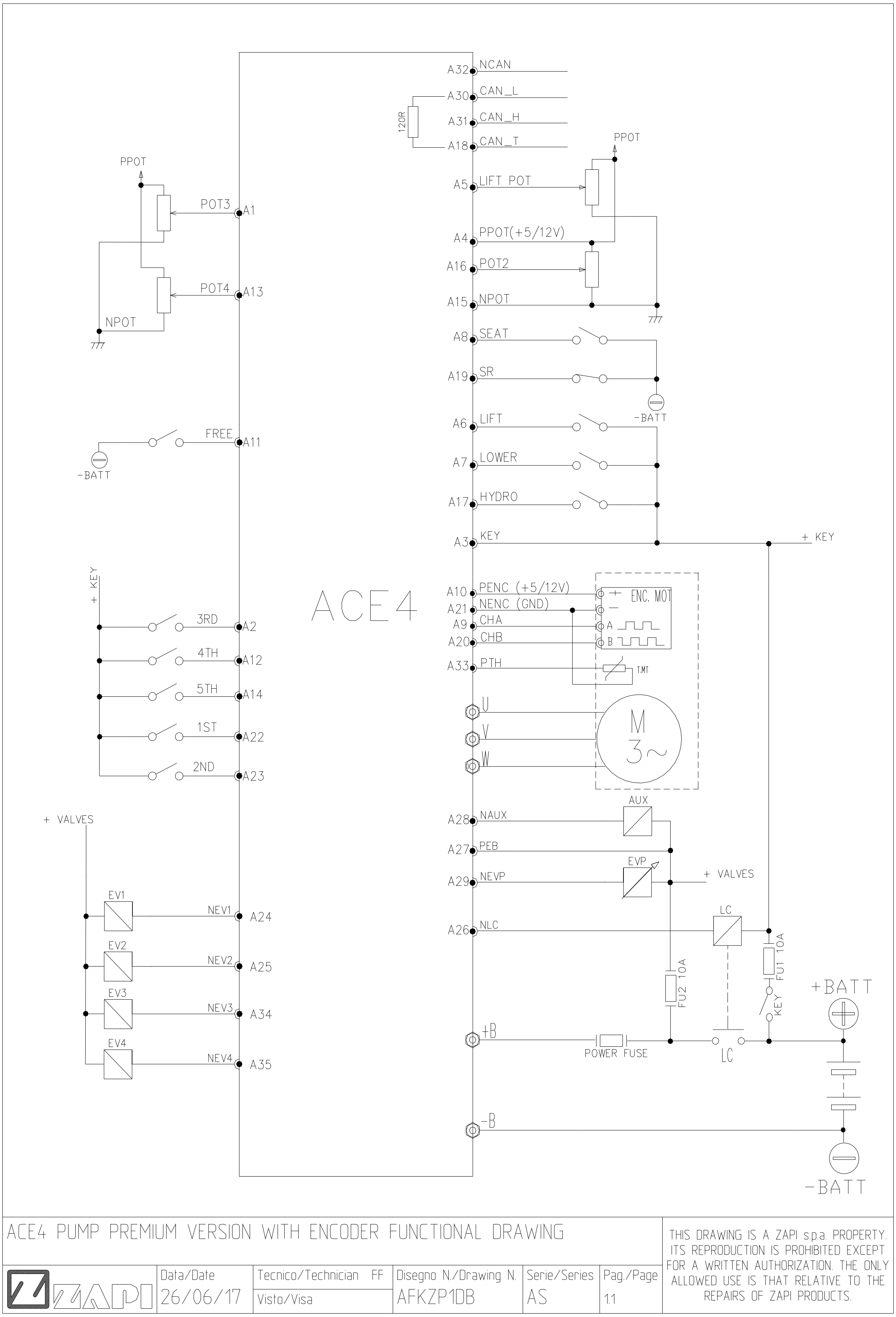
3.2.2 AC Traction configuration – Premium version



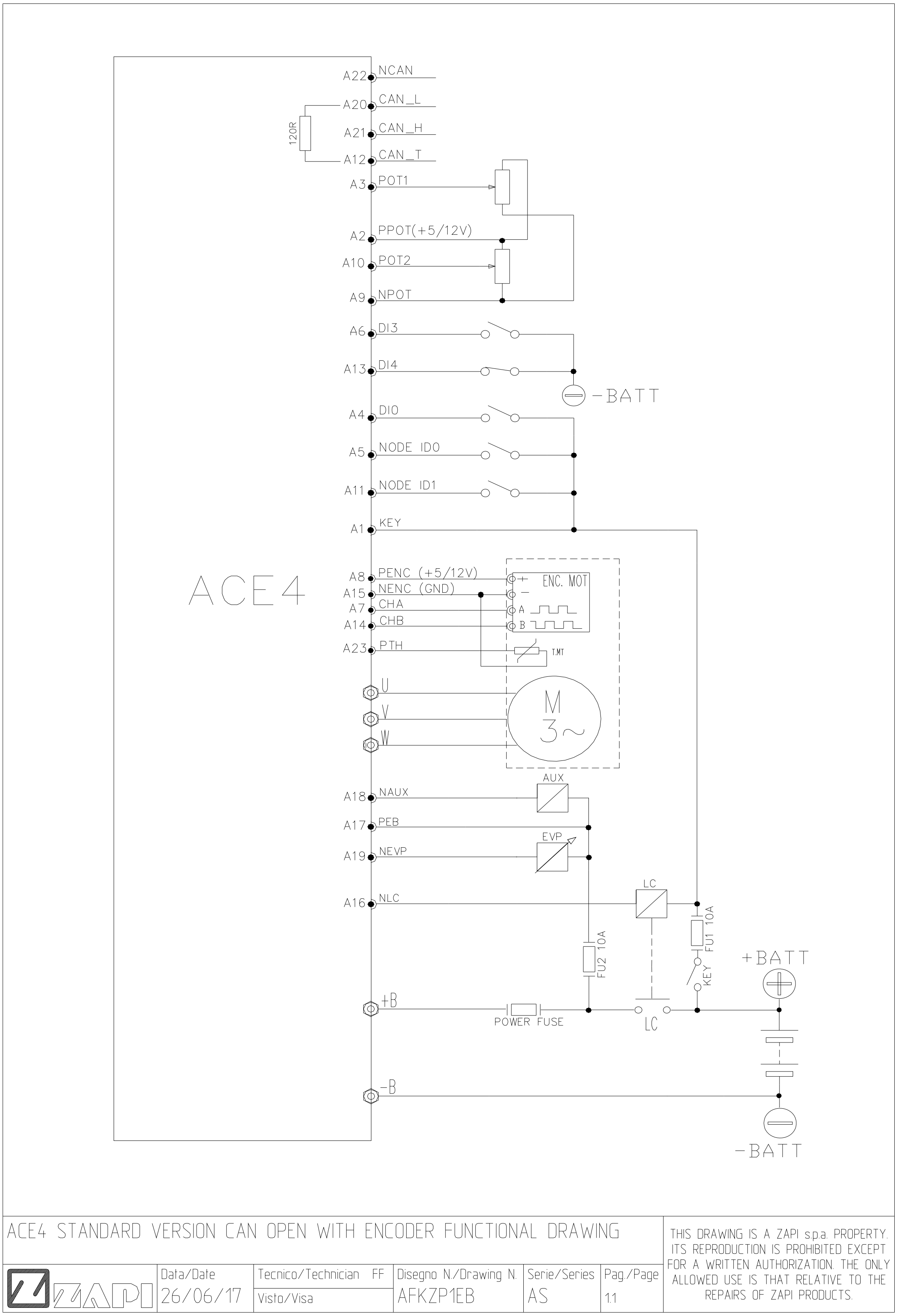
3.2.3 AC Pump configuration – Standard version



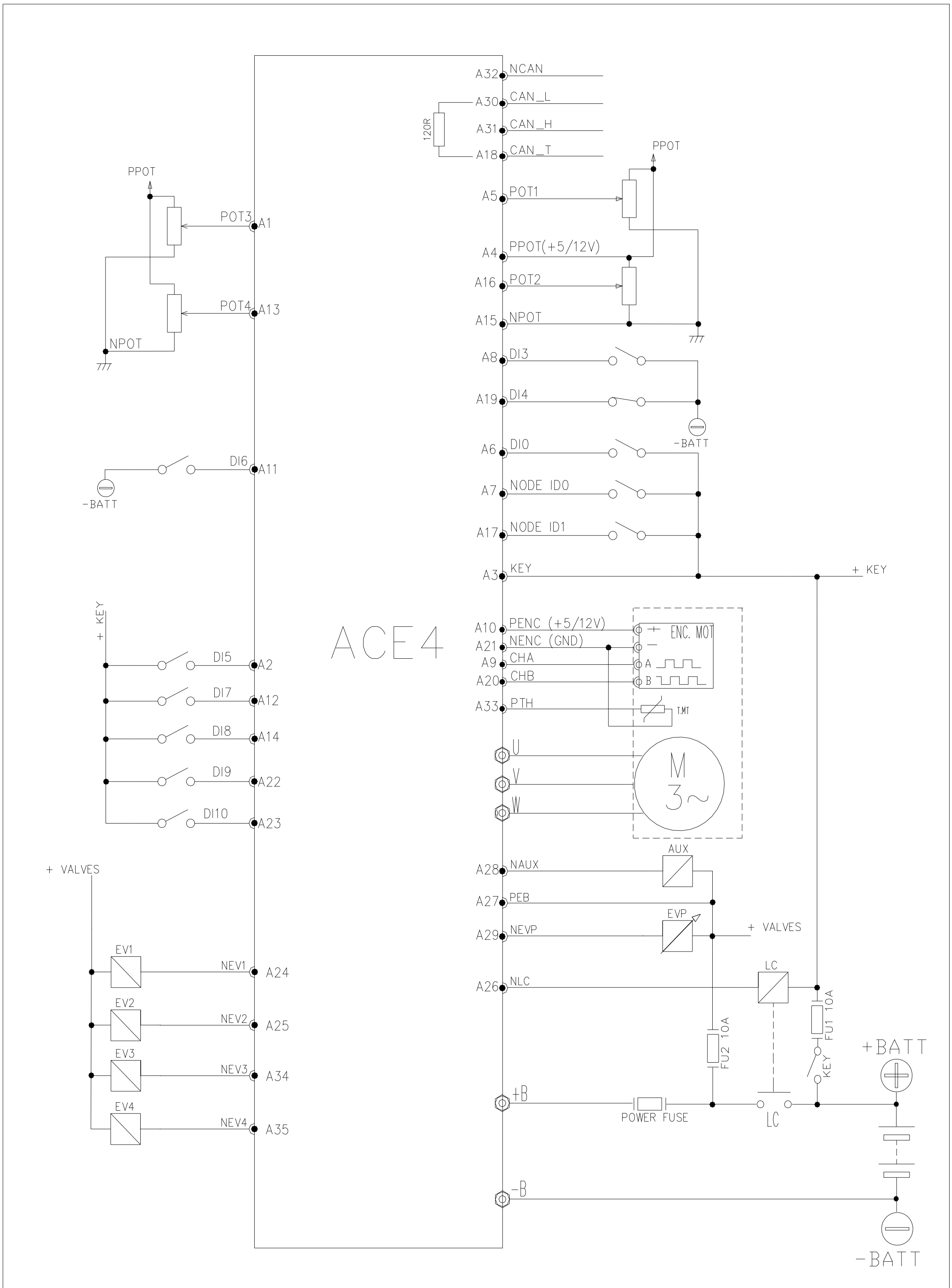
3.2.4 AC Pump configuration – Premium version



3.2.5 AC CANopen configuration – Standard version



3.2.6 AC CANopen configuration – Premium version



ACE4 PREMIUM VERSION CAN OPEN WITH ENCODER FUNCTIONAL DRAWING						THIS DRAWING IS A ZAPI s.p.a. PROPERTY. ITS REPRODUCTION IS PROHIBITED EXCEPT FOR A WRITTEN AUTHORIZATION. THE ONLY ALLOWED USE IS THAT RELATIVE TO THE REPAIRS OF ZAPI PRODUCTS.
ZAPI	Data/Date 26/06/17	Tecnico/Technician FF Visto/Visa	Disegno N./Drawing N. AFKZP1FB	Serie/Series AS	Pag./Page 11	

4 I/O INTERFACE DESCRIPTION

4.1 Power connectors

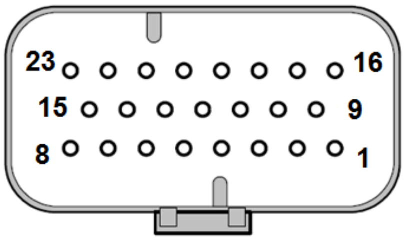
Power connections are on vertical posts that host power-cables lugs. On the cover of the converter they are labeled as in the following table.

Terminal name	Description
+B	Positive supply to the power stage.
-B	Battery negative termination.
U, V, W	Motor phase terminations.

4.2 Ampseal connector

4.2.1 Standard Version (23-poles Ampseal)

ACE4 Standard is equipped with a 23-poles Ampseal connector like that of the figure. Each of the 23 pins is referred to as “A#”, where “A” denotes the connector name and “#” the pin number, from 1 to 23.



23-poles Ampseal connector of ACE4 Standard.

For each I/O pin, the default Zapi function is indicated. The function of each pin can be changed in the customized software.

Some I/O pins can have special functionality depending on controller configuration.

The following tables list the functional associations for the pins of the 23-poles Ampseal connector, for ACE4 Standard in Traction and Pump configurations.

ACE4 Standard – Traction configuration

ACE4 Standard – Traction configuration			
Pin	**Type**	**Name**	**Description**
A1	Input	KEY	Input of the key switch signal.
A2	Output	PPOT (+5/12V)	Positive supply for potentiometers (5 or 12 V, 150 mA maximum).
A3	Input	ACC POT	Analog input 1. The default function is as accelerator reference (wiper contact of the accelerator potentiometer).
A4	Input	FW	Digital input, active when connected to +B. The default function is as FORWARD request. Closing the switch, the truck moves forward.
A5	Input	BW	Digital input, active when connected to +B. The default function is as BACKWARD request. Closing the switch, the truck moves backward.
A6	Input	SEAT	Digital input, active when connected to -B. The default function is as SEAT (or TILLER) input.
A7	Input	CHA	Channel A of an incremental encoder.
A8	Output	PENC (+5/12V)	Positive supply for encoder (5 or 12 V, 150mA maximum).
A9	Output	NPOT	Negative supply for potentiometers.
A10	Input	BRK POT	Analog input 2. The default function is as brake reference (wiper contact of the brake potentiometer).
A11	Input	QI/PB	Digital input, active when connected to +B. The default function is as BRAKING request. It must be connected to the brake pedal microswitch.
A12	Input	CAN_T	If connected to A21 (CAN_H), it introduces the 120 Ohm termination resistance between CAN_L and CAN_H.
A13	Input	SR/HB	Digital input, normally closed to -B, active when the switch is open. The default function is as SPEED REDUCTION request. Opening the switch, truck speed is reduced.
A14	Input	CHB	Channel B of an incremental encoder.

ACE4 Standard – Traction configuration			
Pin	**Type**	**Name**	**Description**
A15	Output	NENC (GND)	Negative supply for the encoder.
A16	Output	NLC	Main-contactor output; PWM voltage controlled; 1.5A maximum continuous current (driving to -B).
A17	Output	PEB	Connect this pin to the positive supply of electrovalves (EB and EVP). Take the positive supply immediately after the main contactor.
A18	Output	NEB	Electromechanical-brake output; PWM voltage controlled; 2.5A maximum continuous current (driving to -B).
A19	Output	NEVP	Lowering-proportional-electrovalve output; PWM current controlled; 1.5A maximum continuous current (driving to -B).
A20	Output	CAN_L	CAN bus low-level signal.
A21	Output	CAN_H	CAN bus high-level signal.
A22	Output	NCAN	CAN bus negative reference. To be used only in case of isolated CAN bus.
A23	Input	PTH	Motor-temperature sensor. It is possible to use a digital or analog (PTC) sensor. Internal pull-up is a fixed 2 mA current source (max 5 V).

ACE4 Standard – Pump configuration

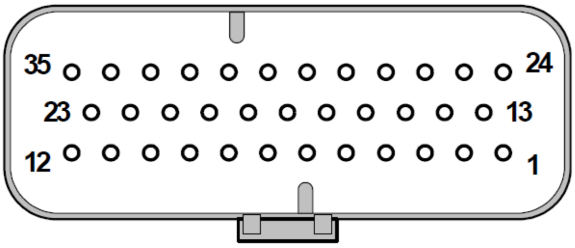
ACE4 Standard – Pump configuration			
Pin	**Type**	**Name**	**Description**
A1	Input	KEY	Input of the key switch signal.
A2	Output	PPOT (+5/12V)	Positive supply for potentiometers (5 or 12 V, 150 mA maximum).
A3	Input	LIFT POT	Analog input 1. The default function is as lift reference (wiper contact of the lift potentiometer).
A4	Input	LIFT	Digital input, active when connected to +B. The default function is as LIFT request. Closing the switch, the pump lifts the forks.

ACE4 Standard – Pump configuration			
Pin	**Type**	**Name**	**Description**
A5	Input	LOWER	Digital input, active when connected to +B. The default function is as LOWER request. Closing the switch, the pump lowers the forks.
A6	Input	SEAT	Digital input, active when connected to -B. The default function is as SEAT (or TILLER) input.
A7	Input	CHA	Channel A of an incremental encoder.
A8	Output	PENC (+5/12V)	Positive supply for encoder (5 or 12 V, 150mA maximum).
A9	Output	NPOT	Negative supply for potentiometers.
A10	Input	POT2	Analog input 2. By default it is not assigned to any function.
A11	Input	HYDRO	Digital input, active when connected to +B. The default function is as HYDRAULIC-STEERING request.
A12	Input	CAN_T	If connected to A21 (CAN_H), it introduces the 120 Ohm termination resistance between CAN_L and CAN_H.
A13	Input	SR	Digital input, active when the switch is open. The default function is as SPEED REDUCTION request. By opening the switch, pump speed is reduced.
A14	Input	CHB	Channel B of an incremental encoder.
A15	Output	NENC (GND)	Negative supply for the encoder.
A16	Output	NLC	Main-contactor output; PWM voltage controlled; 1.5A maximum continuous current (driving to -B).
A17	Output	PEB	Connect this pin to the positive supply of electrovalves (AUX and EVP). Take the positive supply immediately after the main contactor.
A18	Output	NAUX	Auxiliary-function output; PWM voltage controlled; 2.5A maximum continuous current (driving to -B).
A19	Output	NEVP	Lowering-proportional-electrovalve output; PWM current controlled; 1.5A maximum continuous current (driving to -B).

ACE4 Standard – Pump configuration			
Pin	**Type**	**Name**	**Description**
A20	Output	CAN_L	CAN bus low-level signal.
A21	Output	CAN_H	CAN bus high-level signal.
A22	Output	NCAN	CAN bus negative reference. To be used only in case of isolated CAN bus.
A23	Input	PTH	Motor-temperature sensor. It is possible to use a digital or analog (PTC) sensor. Internal pull-up is a fixed 2 mA current source (max 5 V).

4.2.2 Premium Version (35-poles Ampseal)

ACE4 Premium is equipped with a 35-poles Ampseal connector like that of the figure. Each of the 35 pins is referred to as “A#”, where “A” denotes the connector name and “#” the pin number, from 1 to 35.



35-poles Ampseal connector of ACE4 Premium.

For each I/O pin, the default Zapi function is indicated. The function of each pin can be changed in the customized software.

Some I/O pins can have special functionality depending on controller configuration.

The following tables list the functional associations for the pins of the 35-poles Ampseal connector, for ACE4 Premium in Traction and Pump configurations.

ACE4 Premium – Traction configuration

ACE4 Premium – Traction configuration			
Pin	**Type**	**Name**	**Description**
A1	Input	EVP POT	Analog input 3. The default function is as reference for the proportional electrovalve.
A2	Input	AUX1	Digital input, active when connected to +B. By default, closing the switch output NEV1 (A24) is activated.
A3	Input	KEY	Input of the key switch signal.
A4	Output	PPOT (+5/12V)	Positive supply for potentiometers (5 or 12 V, 150 mA maximum).
A5	Input	ACC POT	Analog input 1. The default function is as accelerator reference (wiper contact of the accelerator potentiometer).

ACE4 Premium – Traction configuration			
Pin	**Type**	**Name**	**Description**
A6	Input	FW	Digital input, active when connected to +B. The default function is as FORWARD request. Closing the switch, the truck moves forward.
A7	Input	BW	Digital input, active when connected to +B. The default function is as BACKWARD request. Closing the switch, the truck moves backward.
A8	Input	SEAT	Digital input, active when connected to -B. The default function is as SEAT (or TILLER) input.
A9	Input	CHA	Channel A of an incremental encoder.
A10	Output	PENC (+5/12V)	Positive supply for encoder (5 or 12 V, 150mA maximum).
A11	Input	LOWER	Digital input, active when connected to -B. The default function is as LOWERING request. Closing the switch, EVP output is activated according to the setpoint defined by EVP POT (A1).
A12	Input	AUX2	Digital input, active when connected to +B. By default, closing the switch output NEV2 (A25) is activated.
A13	Input	STEER POT	Analog input 4. The default function is as steering-potentiometer wiper.
A14	Input	AUX3	Digital input, active when connected to +B. By default, closing the switch output NEV3 (A34) is activated.
A15	Output	NPOT	Negative supply for potentiometers.
A16	Input	CPOT BR	Analog input 2. The default function is as brake reference (wiper contact of the brake potentiometer).
A17	Input	QI/PB	Digital input, active when connected to +B. The default function is as BRAKING request. It must be connected to the brake pedal microswitch.
A18	Input	CAN_T	If connected to A31 (CAN_H), it introduces the 120 Ohm termination resistance between CAN_L and CAN_H.

ACE4 Premium – Traction configuration			
Pin	**Type**	**Name**	**Description**
A19	Input	SR/HB	Digital input, normally closed to -B, active when the switch is open. The default function is as SPEED REDUCTION request. Opening the switch, truck speed is reduced.
A20	Input	CHB	Channel B of an incremental encoder.
A21	Output	NENC (GND)	Negative supply for the encoder.
A22	Input	BACKING FW	Digital input, active when connected to +B. The default function is as FORWARD BACKING (INCHING) request.
A23	Input	BACKING BW	Digital input, active when connected to +B. The default function is as BACKWARD BACKING (INCHING) request.
A24	Output	NEV1	Output for the on/off electrovalve EV1; 1 A maximum continuous current (driving to -B). By default it is associated to input AUX1 (A2).
A25	Output	NEV2	Output for the PWM-modulated voltage-controlled electrovalve EV2; 1 A maximum continuous current (driving to -B). By default it is associated to input AUX2 (A12).
A26	Output	NLC	Main-contactor output; PWM voltage controlled; 1.5A maximum continuous current (driving to -B).
A27	Output	PEB	Connect this pin to the positive supply of electrovalves (EB, EVP and EVs). Take the positive supply immediately after the main contactor.
A28	Output	NEB	Electromechanical-brake output; PWM voltage controlled; 2.5A maximum continuous current (driving to -B).
A29	Output	NEVP	Lowering-proportional-electrovalve output; PWM controlled; 1.5A maximum continuous current (driving to -B).
A30	Output	CAN_L	CAN bus low-level signal.
A31	Output	CAN_H	CAN bus high-level signal.
A32	Output	NCAN	CAN bus negative reference. To be used only in case of isolated CAN bus.

ACE4 Premium – Traction configuration			
Pin	**Type**	**Name**	**Description**
A33	Input	PTH	Motor-temperature-sensor input. It is possible to use a digital or analog (PTC) sensor. Internal pull-up is a fixed 2 mA current source (max 5 V).
A34	Output	NEV3	Output for the PWM-modulated voltage-controlled electrovalve EV3; 1 A maximum continuous current (driving to -B). By default it is associated to input AUX3 (A14).
A35	Output	NEV4	Output for the on/off electrovalve EV4; 1 A maximum continuous current (driving to -B). Default function is as backward-drive buzzer; it is activated when the truck drives backward.

ACE4 Premium – Pump configuration

ACE4 Premium – Pump configuration			
Pin	**Type**	**Name**	**Description**
A1	Input	POT3	Analog input 3. By default it is not assigned to any function.
A2	Input	3RD	Digital input, active when connected to +B. The default function is as THIRD-SPEED request.
A3	Input	KEY	Input of the key switch signal.
A4	Output	PPOT (+5/12V)	Positive supply for potentiometers (5 or 12 V, 150 mA maximum).
A5	Input	LIFT POT	Analog input 1. The default function is as lift reference (wiper contact of the lift potentiometer).
A6	Input	LIFT	Digital input, active when connected to +B. The default function is as LIFT request. Closing the switch, the pump lifts the forks.
A7	Input	LOWER	Digital input, active when connected to +B. The default function is as LOWER request. Closing the switch, the pump lowers the forks.
A8	Input	SEAT	Digital input, active when connected to -B. It function is as SEAT (or TILLER) input.

ACE4 Premium – Pump configuration			
Pin	**Type**	**Name**	**Description**
A9	Input	CHA	Channel A of an incremental encoder.
A10	Output	PENC (+5/12V)	Positive supply for encoder (5 or 12 V, 150mA maximum).
A11	Input	FREE	Digital input, active when connected to -B. By default it is not assigned to any function.
A12	Input	4TH	Digital input, active when connected to +B. The default function is as FOURTH-SPEED request.
A13	Input	POT4	Analog input 4. By default it is not assigned to any function.
A14	Input	5TH	Digital input, active when connected to +B. The default function is as FIFTH-SPEED request.
A15	Output	NPOT	Negative supply for potentiometers.
A16	Input	POT2	Analog input 2. By default it is not assigned to any function.
A17	Input	HYDRO	Digital input, active when connected to +B. The default function is as HYDRAULIC-STEERING request.
A18	Input	CAN_T	If connected to A31 (CAN_H), it introduces the 120 Ohm termination resistance between CAN_L and CAN_H.
A19	Input	SR	Digital input, active when the switch is open. The default function is as SPEED REDUCTION request. By opening the switch, pump speed is reduced.
A20	Input	CHB	Channel B of an incremental encoder.
A21	Output	NENC (GND)	Negative supply for the encoder.
A22	Input	1ST	Digital input, active when connected to +B. The default function is as FIRST-SPEED request.
A23	Input	2ND	Digital input, active when connected to +B. The default function is as SECOND-SPEED request.

ACE4 Premium – Pump configuration			
Pin	**Type**	**Name**	**Description**
A24	Output	NEV1	Output for the on/off electrovalve EV1; 1 A maximum continuous current (driving to -B).
A25	Output	NEV2	Output for the PWM-modulated voltage-controlled electrovalve EV2; 1 A maximum continuous current (driving to -B).
A26	Output	NLC	Main-contactor output; PWM voltage controlled; 1.5A maximum continuous current (driving to -B).
A27	Output	PEB	Connect this pin to the positive supply of electrovalves (EB, EVP and EVs). Take the positive supply immediately after the main contactor.
A28	Output	NEB	Electromechanical-brake output; PWM voltage controlled; 2.5A maximum continuous current (driving to -B).
A29	Output	NEVP	Lowering-proportional-electrovalve output; PWM current controlled; 1.5A maximum continuous current (driving to -B).
A30	Output	CAN_L	CAN bus low-level signal.
A31	Output	CAN_H	CAN bus high-level signal.
A32	Output	NCAN	CAN bus negative reference. To be used only in case of isolated CAN bus.
A33	Input	PTH	Motor-temperature-sensor input. It is possible to use a digital or analog (PTC) sensor. Internal pull-up is a fixed 2 mA current source (max 5 V).
A34	Output	NEV3	Output for the PWM-modulated voltage-controlled electrovalve EV3; 1 A maximum continuous current (driving to -B).
A35	Output	NEV4	Output for the on/off electrovalve EV4; 1 A maximum continuous current (driving to -B). By default it is not assigned to any function.

4.3 Internal connector

Internal connector is not available from the outside; it is accessible only removing the cover of the converter. It is intended to be used in special occasions only, such as preliminary tests of prototypes, and only by Zapi technicians through dedicated Zapi tools. It is the same for all ACE4 versions.

Pin	Type	Name	Description
1	Output	PCLRXD	Positive serial reception (not used: it can be disconnected).
2	Input	NCLRXD	Negative serial reception.
3	Output	PCLTXD	Positive serial transmission.
4	Output	NCLTXD	Negative serial transmission.
5	Output	GND	Negative console power supply.
6	Output	+12	Positive console power supply.
7	Input	FLASH	It must be connected to pin 8 for programming the flash memory.
8	Input	FLASH	It must be connected to pin 7 for programming the flash memory.

4.4 External devices

In the following paragraphs, references to connector pins are given as:

- Red colored: pin of the 23-poles Ampseal connector of ACE4 Standard.
- Blue colored: pin of the 35-poles Ampseal connector of ACE4 Premium.

Pin names, or labels, are always indicated in capital letters.
For example, the expression “it must be connected to pin PEB A17 (A27)” refers to the pin labeled as PEB, which is pin A17 in ACE4 Standard or pin A27 in ACE4 Premium.

4.4.1 Key Input

KEY input, on pin A1 (A3), is generally connected to the vehicle start key switch. It supplies battery voltage to the logic circuitry and it also pre-charges the DC-link capacitors at key-on, before main contactor closes. The KEY voltage is monitored.

Note: external loads connected to the +B power terminal, such as proximity switches, load the internal PTC resistor along the key input path, with the consequence that the pre-charge voltage may be lower than expected.

Protection

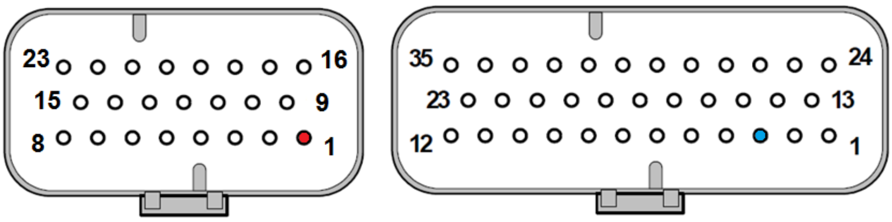
KEY input is protected against reverse polarity with a diode and it has got a capacitance of approximately 22 nF to -B for ESD protection and other filtering elements. This capacitance may give a high current spike at the KEY input depending on the external circuit.
Fuse FU1 (see functional drawings in chapter 3), should be sized according to the number of motor controllers connected to it (a 10 A fuse is recommended) and the current absorption of the KEY input (input power below 15 W).

The key switch connected to the KEY input must handle the short inrush current spike to the ESD protection capacitors. The current peak depends on the external circuit and wires.

Cables from the battery to the KEY input should be as short as possible.

Connector position

ACE4 Standard: A1.
ACE4 Premium: A3.



4.4.2 Digital inputs

Digital inputs are meant to work in the voltage range from -B to +B. Digital command devices (microswitches) must be connected to +B (typically to the key voltage) or to -B, depending on the input configuration (refer to pin description in paragraph 4.2). Pull-down or pull-up resistors are built-in. Functional devices (like FW, BW, PB, etc.) must be normally open, so that each associated function becomes active when the microswitch closes.

Safety-related devices (like CUTBACK) must be normally closed, so that each associated function becomes active when the microswitch opens.

Threshold levels are:

Nominal DC voltage	36/48V	72/80V
Voltage range	0 to 65 V	0 to 100 V
Logic low threshold	10 V	
Logic high threshold	24 V	

For critical functions, when good diagnostics coverage is necessary, it is recommended to use two digital inputs for plausibility check, for example to use both normally open and normally closed contacts.

Protection

Digital inputs have 10 nF capacitors to -B for ESD protection.

Circuit

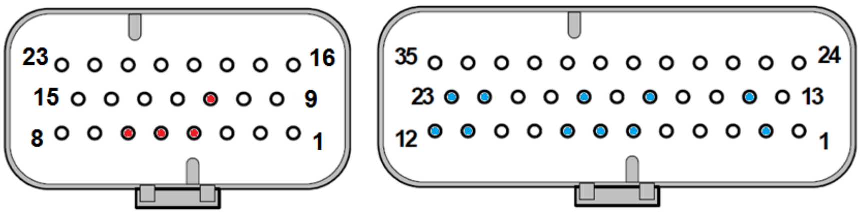
Input impedance of digital inputs is:

Nominal DC voltage	36/48V	72/80V
Impedance	14.5 kΩ	30 kΩ

Digital inputs SEAT and DI6 are normally configured to be activated when closed to -B. Their behavior can be changed by means of special HW configuration, as to be activated when closed to +B.

Connector position

ACE4 Standard: A4, A5, A6, A11.
ACE4 Premium: A2, A6, A7, A8, A11, A12, A14, A17, A19, A22, A23.

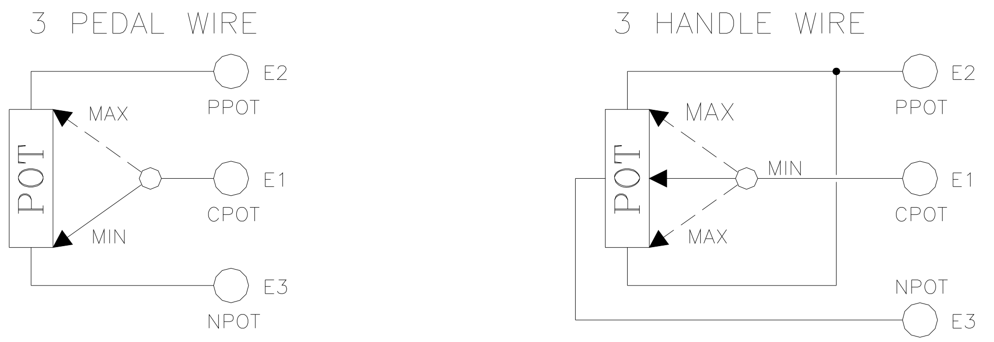


Microswitches

- It is suggested that microswitches have a contact resistance lower than 0.1 Ohm and a leakage current lower than 100 μA.
- In full-load condition, the voltage between the key-switch contacts must be lower than 0.1 V.
- If the microswitches to be adopted have different specifications, it is suggested to discuss them with Zapi technicians prior to employ them.

4.4.3 Analog inputs

Analog inputs are for application functions, such as accelerator or brake references. Analog inputs are connected to a 10-bits analog-to-digital converter (resolution is given by voltage excursion over 1024 levels).
Analog inputs are generally connected to potentiometers. The standard connection is that on the left side of next figure: potentiometer at rest on one end in combination with a couple of travel-demand switches. On request, it is also possible to have the configuration on the right side of the figure: potentiometer at rest in the middle, still in combination with a couple of travel-demand switches.



Potentiometer configuration

Negative supply of the potentiometer has to be taken from pin NPOT A9 (A15). Potentiometer resistance should be in the 500 Ω – 10 kΩ range; generally the load should be in the 1.5 mA to 30 mA range.

A procedure for automatic acquisition of potentiometers signals can be carried out using PROGRAM VACC, PROGRAM LIFT/LOWER and PROGRAM STEER functions (see paragraphs 9.1, 9.2 and 9.3).

Analog inputs may also be used as extra digital inputs. In this case ADC value should be used as the indicator of the input status. For example, a proximity switch supplied from +B could be connected to an analog input.

General features:

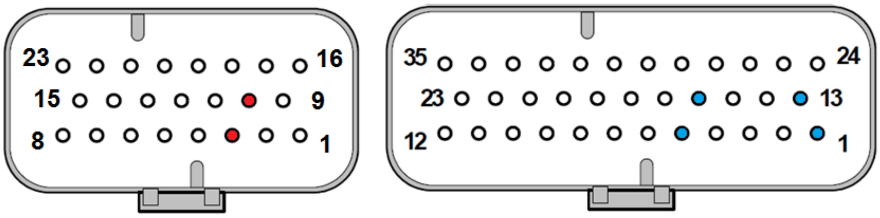
- Input impedance: 250 kΩ
- Input voltage range: 0 V ÷ 10 V
- Cut-off (-3 dB) frequency: 25.4 Hz

Protection

Analog inputs are protected against short circuits to +B and -B and they have 10 nF filtering capacitors to -B for ESD protection.

Connector position

ACE4 Standard: A3, A10.
ACE4 Premium: A1, A5, A13, A16.



If an analog input is used as speed reference, a system safety strategy must be defined. The application software must consider errors related to analog input such as: Vacc out of range, Vacc not ok.

4.4.4 Encoder input

Inputs for motor-speed feedback (encoder signals) have an internal 1 kΩ pull-up for open collector sensor output.
Threshold levels are:

Supply voltage	**5 V**	**12 V**
Logic low	1.4 V	4.3 V
Logic high	3.5 V	6.4 V

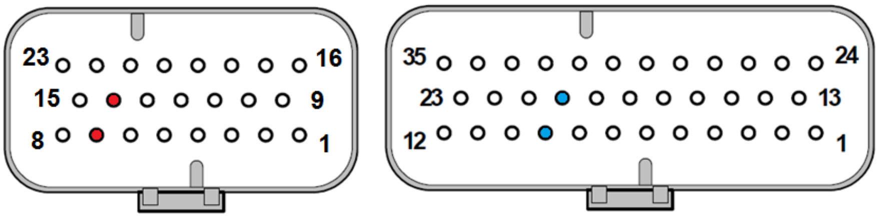
Speed-sensor signals are acquired through the quadrature peripheral of the microcontroller.

Protection

Encoder inputs are protected against short circuits to +B and -B and have ESD suppressor to -B for ESD protection.

Connector position

ACE4 Standard: A7, A14.
ACE4 Premium: A9, A20.



It is important to verify the wiring by ensuring that encoder signals are not disturbed by motor currents or by electric motor brake.

For more details about encoder installation see also paragraph 5.2.5.

Note: encoder resolution and motor pole pairs are specified in the home page, which shows a headline like the following.
A4MT2B ZP1.13

Where:
A4MT: ACE4 traction controller (M stands for "Master µC", S for "Supervisor µC")
(A4MP: ACE4 pump controller)
2: motor pole pairs number
B: 64 pulses/rev encoder

Encoder resolution is given by the last letter as:
A = 32 pulses/rev
B = 64 pulses/rev
C = 80 pulses/rev
D = 128 pulses/rev

4.4.5 Main (line) contactor

Main (or line) contactor is operated through an open-drain PWM-modulated voltage-controlled output on pin NLC A16 (A26).
In order to utilize the built-in freewheeling diode, the coil must be supplied through KEY voltage, i.e. from pin A1 (A3). A special hardware configuration allows to utilize a built-in freewheeling diode connected to pin A1 (A3).
In case the vehicle design does not allow the usage of the built-in freewheeling diode, i.e. if the integrity of return path cannot be guaranteed in all situations, an external one must be applied between the coil terminals.

Output features

- 1.5 A continuous current (holding current).
- 2 A peak current (pulling current), for a maximum of 200 ms.
- Individual hardware for detection of: shorted driver, open driver, open coil.
- 1 kHz default PWM frequency.
- Configurable output voltage, by means of separate parameters, for pulling and holding stages.

PWM should only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valves.

PWM frequency can be changed by software. If a different PWM frequency has to be used, it is suggested to discuss it with Zapi technicians.

Protection

MC output is protected against inductive discharge with internal freewheeling diode to pin A1 (A3); ESD-protected by means of ESD-suppressing device and protected against reverse polarity of the battery.

Built-in diagnoses:
- Overcurrent
- Shorted driver
- Open Driver
- Open coil

Overcurrent protection is featured by hardware, shared with EB output.

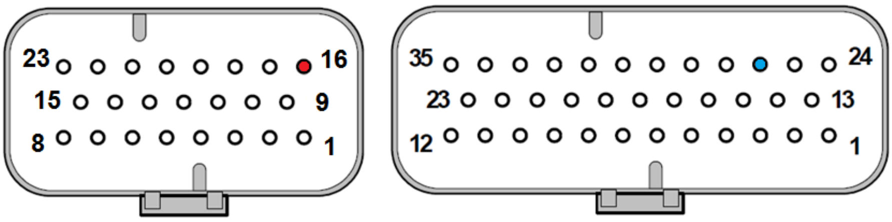
*MC output can only be a PWM-modulated voltage-controlled output. It **cannot** be used as a current-controlled output.*

To protect the controller from overvoltage caused by the inductive load, a freewheeling diode to pin KEY A1 (A3) is built-in.

Driving an inductive load on a PWM-modulated open-drain output, there must always be a path for the current through a freewheeling diode. Do not connect any switch or fuse in series with the diode.

Connector position

ACE4 Standard: A16.
ACE4 Premium: A26.



4.4.6 Electromechanical brake

Electromechanical brake is operated through an open-drain PWM-voltage-controlled output on pin NEB A18 (A28).
In order to utilize the built-in freewheeling diode, the coil must be supplied through pin PEB A17 (A27) (see paragraph 3.2).
In case the vehicle design does not allow the usage of the built-in freewheeling diode, i.e. if the integrity of return path cannot be guaranteed in all situations, an external freewheeling diode must be applied between the coil terminals.

Output features

– 2 A continuous current (holding current)
– 3 A peak (pulling current) for a maximum of 200 ms.
– Individual hardware for detection of: shorted driver, open driver, open coil.
– 1 kHz PWM frequency.
– Configurable output voltage, by means of separate parameters for pulling and holding stages.

PWM should only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valves.

Protection

EB output is protected against inductive discharge with internal freewheeling diode to pin PEB A17 (or A27) and ESD-protected by means of ESD-suppressing device.

It is not protected against reverse polarity of the battery. A way to avoid a failure caused by the polarity inversion is to activate the contactor only when the voltage over the DC-bus capacitors has reached the accepted pre-charge level.

Built-in diagnoses:
- Overcurrent
- Shorted driver
- Open driver
- Open coil

Overcurrent protection is featured by hardware, shared with MC output.

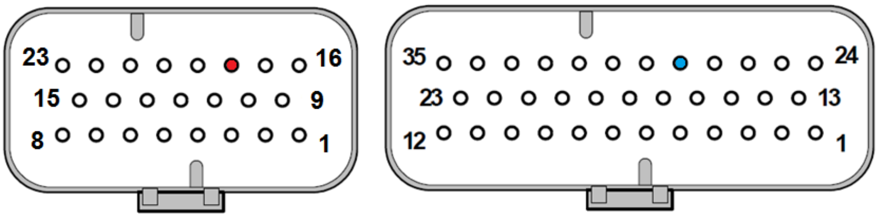
EB output can only be a PWM-modulated voltage-controlled output. It ***cannot*** *be used as current-controlled output.*

To protect the motor controller from overvoltage caused by the inductive load, a freewheeling diode to pin PEB A17 (A27) is built-in.

Driving an inductive load on a PWM-modulated open-drain output, there must always be a path for the current through a freewheeling diode. Do not connect any switch or fuse in series with the diode.

Connector position

ACE4 Standard: A18.
ACE4 Premium: A28.



4.4.7 Auxiliary outputs

Open-drain auxiliary outputs can be used for operating services such as relay, hydraulic valves, horn or others.
Drivers work in different modes, depending on the hardware structure:
- On/off (EV1, EV4).
- PWM voltage controlled (EV2, EV3).
- PWM current controlled (EVP).

In order to utilize the built-in freewheeling diodes, positive terminals of loads must be connected to pin PEB A17 (A27) (see paragraph 3.2).
In case the vehicle design does not allow the usage of the built-in freewheeling diodes, i.e. if the integrity of return paths cannot be guaranteed in all situations, external freewheeling diodes must be applied between the coil terminals of inductive loads.

Features of on/off outputs

- 1.5 A continuous current (holding current).
- 2 A peak current (pulling current) for a maximum of 200 ms.
- Individual hardware for shorted and open driver detection.
- Shared shorted-coil detection (by hardware).

Features of voltage-controlled outputs

- 1 A continuous current (holding current).
- 2 A peak current (pulling current) for a maximum of 200 ms.
- Individual hardware for detection of shorted and open driver.
- 1 kHz PWM frequency, applied to all PWM outputs.
- Each voltage-controlled output can be modified with separate parameters.

Features of current-controlled outputs

- 1.5 A continuous current (holding current)
- 1.7 A peak current (pulling current).
- Individual hardware for detection of shorted driver, open driver and open coil.
- Self-protected against overload.
- Dithering featured by means of superimposition of a high-frequency low-amplitude modulation (see paragraph 8.2.4). Dithering is typically used for controlling proportional valves in order to create microscopic movements in the valve to prevent it from “sticking”. Successful dithering improves the valve response for small changes.
  Dithering amplitude can be adjusted up to 13% of the reference value.
  Actual dithering current is dependent on load inductance.
  Dithering frequency is available in fixed values (in Hz):
  20.8; 22.7; 25; 27.7; 31.2; 35.7; 41.6; 50; 62.5; 83.3

Protection

Auxiliary outputs are protected against inductive discharge with internal freewheeling diodes on pin PEB A17 (A27).

Auxiliary outputs are not protected against battery-polarity inversion. A way to avoid a failure caused by the polarity inversion is to activate the contactor only when the voltage across the DC-link capacitors has reached the accepted pre-charge level (see picture in section 0).

Built-in diagnoses:

- Overcurrent
- Shorted driver
- Open driver
- Open coil (only for current-controlled output)

PWM should only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valves.

Shunt resistor for overcurrent detection is shared among EV1, EV2, EV3 and EV4. The overcurrent threshold is fixed by hardware at 9 A.

The maximum total continuous current for outputs EV1, EV2, EV3, EV4, is 3 A. The maximum total peak current is 9 A.

To protect the motor controller from overvoltage caused by inductive loads, internal freewheeling diodes to pin PEB A17 (A27) are built-in.

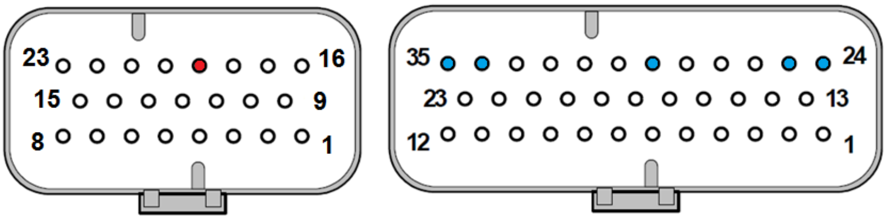
Driving an inductive load on a PWM-modulated open-drain output, there must always be a path for the current through a freewheeling diode. Do not connect any switch or fuse in series with the diode.

Always ensure that inductive loads are connected such that the paths for the freewheeling diodes are always intact, or use external freewheeling diodes if this is not possible.

Use of brushless fans or other loads with built-in capacitor can give high inrush current at turn on, which can give an open-drain over-current trip. The inrush current must be below the open-drain peak current.

Connector position

ACE4 Standard: A19.
ACE4 Premium: A24, A25, A29, A34, A35.



4.4.8 Motor-temperature measurement

Input for motor-temperature sensor, for measuring the temperature of motor windings, is available on pin PTH A23 (A33).
Compatible temperature sensors are like:

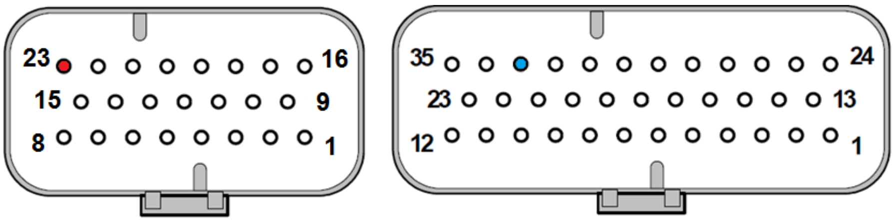
- KTY84 with 1000Ω @ 100°C
- KTY83 with 1670Ω @ 100°C
- PT1000 with 1385Ω @ 100°C
- on/off

Protection

PTH input is protected against short circuits to +B. A 22nF input capacitor provides ESD protection and filtering of noise from the motor.

Connector position

ACE4 Standard: A23.
ACE4 Premium: A33.



4.4.9 Sensor supply

Supply for an external motor-speed transducer (typically an encoder) is available on pins PENC and NENC. Output voltage is customizable through an internal jumper to 5 or 12 V. Maximum output current is 100 mA.

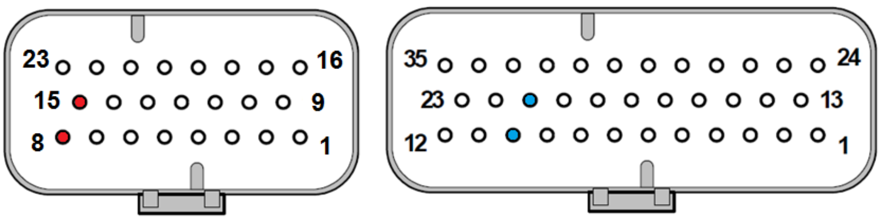
Actual values for 12 V and 5 V are respectively 12 ± 0.2 V and 5 ± 0.2 V.

Protection

Sensor-supply output is protected against overcurrent and accidental connection to +B by means of a diode.

Connector position

ACE4 Standard: A8, A15.
ACE4 Premium: A10, A21.



4.4.10 Analog supply

Supply for external analog sensors and analog potentiometers is available on pins PPOT and NPOT.
Output voltage is settable via hardware by internal jumper to 5 or 12 V and maximum output current is 100 mA.

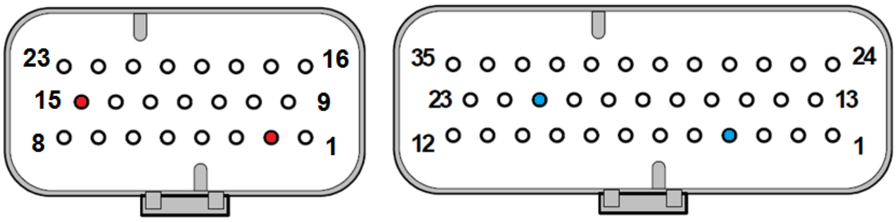
Actual value for "12 V" and "5 V" are respectively 12V ± 0.2V and 5V ± 0.2V.

Protection

Analog supply output is protected against over current with a thermal shut down and protected against accidental connection to +B with a diode.

Connector position

ACE4 Standard: A2, A15.
ACE4 Premium: A4, A21.



4.4.11 CAN bus

CAN bus interface is available for communication with the controller, featuring:

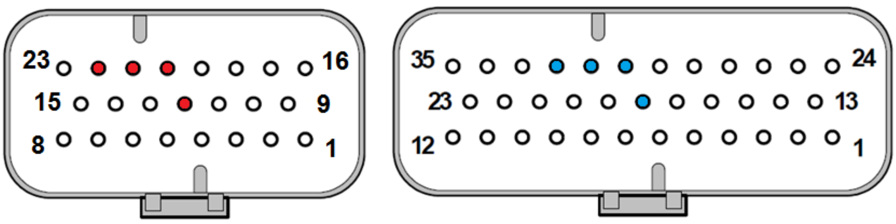
- Physical interface according to ISO 11898-2.
- Data rate can be 125, 250 or 500 kbit/s.
- CAN driver is +5 V supplied and provides a rail to rail signal on the differential output (CAN_H - CAN_L).
- A 120 Ω resistor is built-in between CAN_L and CAN_T; by externally coupling pin CAN_T A12 (A18) with pin CAN_H A21 (A31), the usual 120 Ω termination between CAN_H and CAN_L is obtained.
- Common-mode filter (resistors and capacitor) is present.
- CAN negative reference is available on pin A22 (A32) in case an isolated CAN bus is used.

Protection

CAN bus interface is protected against accidental connection to +B and -B and ESD protected.

Connector position

ACE4 Standard: A12, A20, A21, A22.
ACE4 Premium: A18, A30, A31, A32.



CAN bus should be wired through a pair of twisted wires for CAN_H and CAN_L.

CAN bus wiring should have a characteristic impedance of 120 Ω and both physical ends of the CAN bus should be terminated with 120 Ω between CAN_H and CAN_L for best possible noise immunity.

In case of isolated CAN bus line, contact Zapi technicians for the proper HW configuration of CAN bus interface.

5 INSTALLATION HINTS

This section presents a general procedure for startup and verification of ACE4 controller after installation on a vehicle.
The motor controller is a software configurable device. In a CAN supervisor system, some or all aspects of setup and operations may be managed by a vehicle master controller communicating over the CAN bus. For standalone operation (primarily the I/O version), customized software must be installed in the motor controller.
Built-in diagnostics functions monitor battery voltage, heat-sink temperature, motor temperature and other conditions. Error and warning events are available to the master controller, stored in a log for service access (see chapter 10). Events log provides additional information as well as procedures for pinpointing and eliminating causes for warnings and errors.

⚠ ***Wiring errors, improper setup or other conditions may cause the vehicle to move in the wrong direction or at the wrong speed.***

⚠ ***Take necessary precautions to prevent injury to personnel or damage to equipment before applying power for the first time.***

5.1 Material overview

Before starting the inverter, it is necessary to have the required material for a correct installation. Wrong choice of additional parts could lead to failures, misbehaviors or bad performance.

5.1.1 Connection cables

For the auxiliary circuits, use cables of 0.5 mm² section.
For power connections, to the motor and from the battery, use cables having proper section. For optimum inverter performance, cables from the battery should run side by side and be as short as possible.
Screwing torque for the power connections must be in the 13 ÷ 17 Nm range.

5.1.2 Contactor

Main contactor has always to be installed. The output driving the coil is modulated with a 1 kHz PWM basing on parameters MC VOLTAGE and MC VOLTAGE RED. . After an initial delay of about 1 second, during which the coil is driven with a percentage of VBATT defined by MC VOLTAGE, PWM reduces the mean voltage down to the percentage set in MC VOLTAGE RED. . This feature is useful to decrease the power dissipation of the coil and its heating.

5.1.3 Fuses

- Use a 10 A fuse for protection of the auxiliary circuits.
- For the protection of the power unit, refer to chapter 10.3. The fuse value shown is the maximum allowable. For special applications or requirements these values can be reduced.
- For safety reasons, we recommend the use of protected fuses in order to

prevent the spreading of particles in case a fuse blows.
- Selection of appropriate fuse ratings is a system design issue and falls under the OEMs responsibility.

⚠ ***The fuse is not intended to protect the motor controller or motor against overloads.***

5.2 Hardware installation

⚠ ***Before doing any operation, ensure that the battery is disconnected.***

⚠ ***For traction applications, raise up or otherwise disable driving wheels to prevent the possibility of unexpected vehicle motion or motion in the wrong direction during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excessive pressure (in the event of a malfunction of the pressure-relief valve).***

⚠ ***Take necessary precautions to not compromise safety in order to prevent injuries to personnel and damages to equipment.***

⚠ ***After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10 – 100 Ohm between +B and -B terminals of the inverter.***

5.2.1 Positioning and cooling of the controller

Install the inverter with the base-plate on a flat metallic surface.
- Ensure that the installation surface is clean and unpainted.
- Apply a light layer of thermo-conductive grease between the two surfaces to permit good heat dissipation.
- Ensure that cable terminals and connectors are correctly connected.
- Fit transient suppression devices to the horn, solenoids and contactors not connected to the controller.
- Ensure the compartment to be ventilated and the heat-sinking materials ample.
- Heat-sinking material and should be sized on the performance requirement of the machine. Abnormal ambient temperatures should be considered. In situations where either external ventilation is poor or heat exchange is difficult, forced ventilation should be used
- Thermal energy dissipated by the power module varies with the current drawn and with the duty cycle.

5.2.2 Wirings: power cables

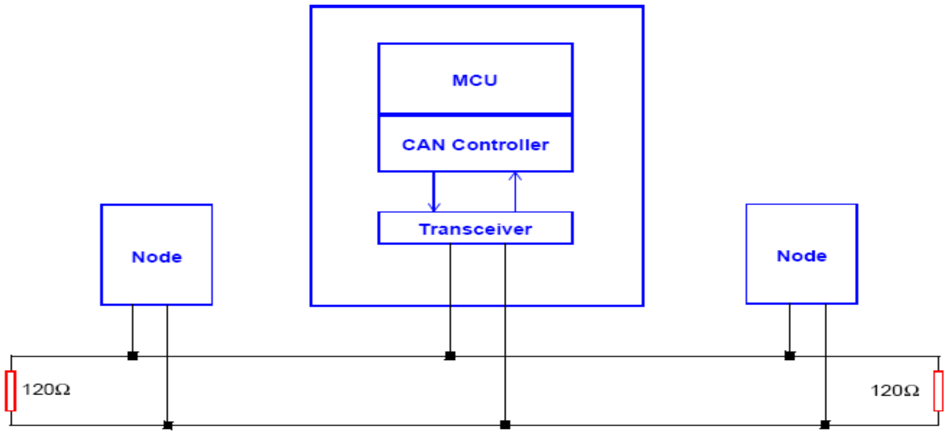
- Power cables must be as short as possible to minimize power losses.
- They must be tightened onto the controller power posts with a torque in the 13 Nm – 17 Nm range.

- ACE4 should only be connected to a traction battery. Do not use converters outputs or power supplies. For special applications please contact the nearest Zapi Service Centre.

Do not connect the controller to a battery with a nominal voltage different to the nominal value, indicated on the controller label. A higher battery voltage may cause failures in the power section. A lower voltage may not allow the controller to work.

5.2.3 Wirings: CAN bus connections and possible interferences

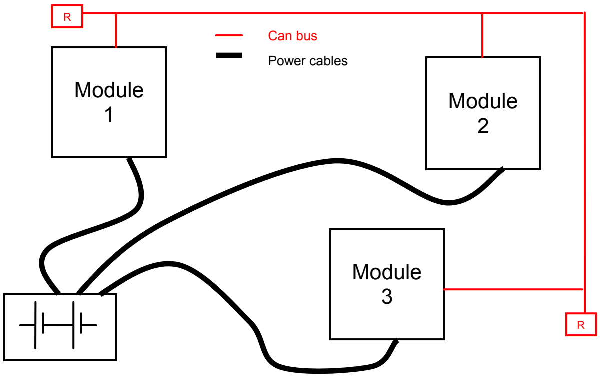
CAN stands for Controller Area Network. CAN bus is a communication protocol for real time control applications. CAN bus operates at data rate of up to 1 Mbit/s. It was invented by the German company Bosch to be used in the automotive industry to permit communication among the various electronic modules of vehicle, connected as illustrated in the following image.



- The best type of cables for CAN bus connections is the twisted pair; if it is necessary to increase the immunity of the system to disturbances, a good choice would be to use shielded cables, where the shield is connected to the frame of the truck. Sometimes it is sufficient a not shielded two-wire cable or a duplex cable.

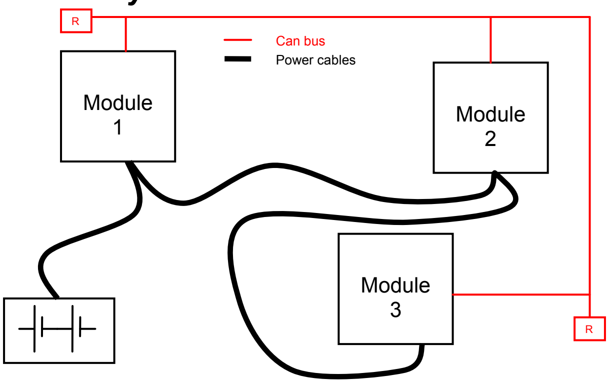
- In a system like an industrial truck, where power cables carry currents of hundreds of Ampere, voltage drops due to the impedance of the cables may be considerable, and that could cause errors on the data transmitted through the CAN wires. The following figures show an overview of wrong and right layouts for the routing of CAN connected systems.

Wrong Layout:



Red lines are CAN bus wires.
Black boxes are different modules, for example a traction controller, a pump controller and a display connected via CAN bus.
Black lines are the power cables.
This is apparently a good layout, but actually it can bring to errors onto the CAN line. The best solution depends on the type of nodes (modules) connected in the network. If the modules are very different in terms of power, then the preferable connection is the daisy chain.

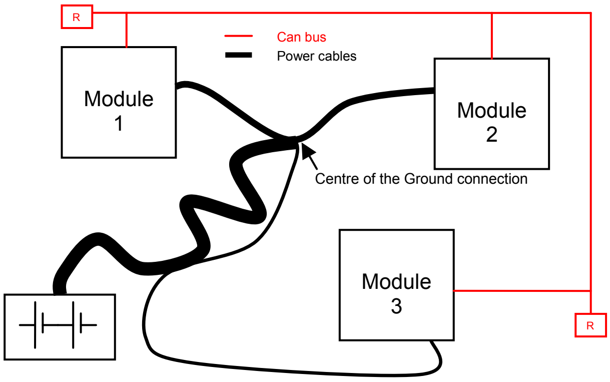
Correct Layout:



Note: Module 1 power > Module 2 power > Module 3 power

The chain starts from the -B post of the controller that deals with the highest current, while the other ones are connected in a decreasing order of power. Otherwise, if two controllers are similar in power (for example a traction and a pump motor controller) and a third module works with less current (for example a steering controller), the best way to address this configuration is creating a common ground point (star configuration), as it is in the next figure.

Correct Layout:



Note: Module 1 power ≈ Module 2 power > Module 3 power

In this case, the power cables of the two similar controllers must be as short as possible. Of course also the diameter of the cables concurs in the voltage drops described before (a greater diameter brings to a lower impedance), so in this last example the cable between negative battery terminal and the center of the ground connection (pointed by the arrow in the image) must be sized taking into account both thermal and voltage drop problems and considering the current drawn from the battery by the overall system.

The complexity of modern systems needs more and more data; signal and information must flow from a node to another. CAN bus is the solution to different problems that arise from this complexity.
- simple design (readily available, multi sourced components and tools)
- low costs (less and smaller cables)
- high reliability (fewer connections)
- ease of analysis (easy connection with a pc for sniffing the data being transferred onto the bus).

5.2.4 Wirings: I/O connections

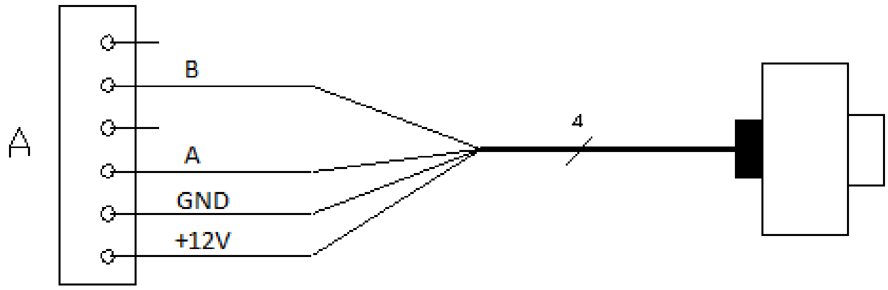
- After crimping cables, verify that all strands are entrapped in the wire barrel.
- Verify that all crimped contacts are completely inserted in the connector cavities.
- For information about pin assignment, see paragraph 4.2.

A cable connected to the wrong pin can lead to short circuits and failures; so, before turning on the truck for the first time, verify with an ohmmeter the continuity between the starting point and the end of signal wires.

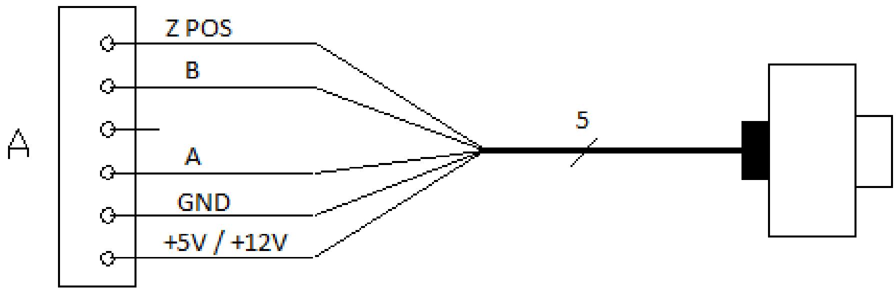
5.2.5 Connection of standard encoder

ACE4 can handle different types of encoder. To control AC motor, it is necessary to install an incremental encoder with 2 phases shifted by 90°. The encoder supply can be 5 V or 12 V. For special applications it is possible to install incremental encoder with zero-position signal.

A8 (A10)	+5V/+12V	positive supply.
A15 (A21)	GND	negative supply.
A7 (A9)	CHA	phase A.
A14 (A20)	CHB	phase B.
A13 (A19)	Z POS	Zero-position signal.



Standard Encoder



Encoder with zero-position signal

VERY IMPORTANT
It is necessary to specify in the commercial order the type of encoder used, in terms of power supply and electronic output, so that the logic can be properly set by Zapi lines.

VERY IMPORTANT
The number of pulse/rev can be properly set using the dedicated parameters (see paragraph 0).

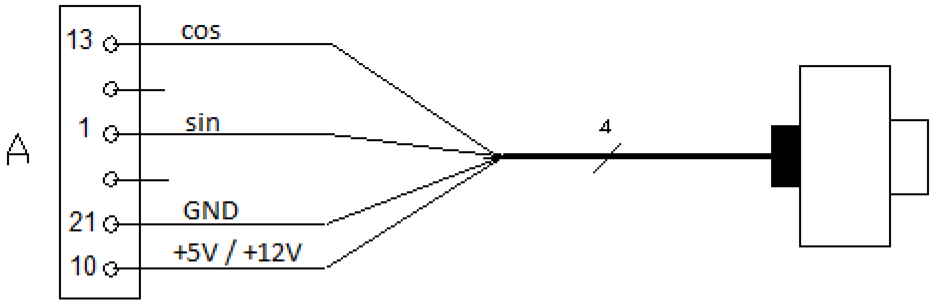
The maximum speed detectable by standard hardware configuration can be limited depending on number of pulse/rev. Contact Zapi technician for checking this aspect.

VERY IMPORTANT
It is strongly suggested, for safety reasons, to lift the wheels from the floor and set the correct value according to the type of sensor used prior to perform any operation with the truck.

5.2.6 Connection of sin/cos sensor

When the PMSM is of the BLAC type, it must be controlled with sine waves shape. A PMSM is a BLAC when turning its shaft produces sinusoidal electromotive force between two motor terminals.
To control PMSM motor, it is necessary to install an absolute sin/cos sensor. The sin/cos sensor interface is available only for Premium version of ACE4 and power supply can be +5 or +12 V.
At the first key-on, an auto-teaching procedure has to be performed to permit the controller to acquire the sensor signals.
On ACE4 Premium, sine and cosine signals from the sensor have to be connected to pins A1 and A13, thus taking the place of two analog inputs.

A10	+5V/+12V	positive supply.
A21	GND	negative supply.
A1	SIN	sine signal.
A13	COS	cosine signal.



Connections for a sin/cos sensor.

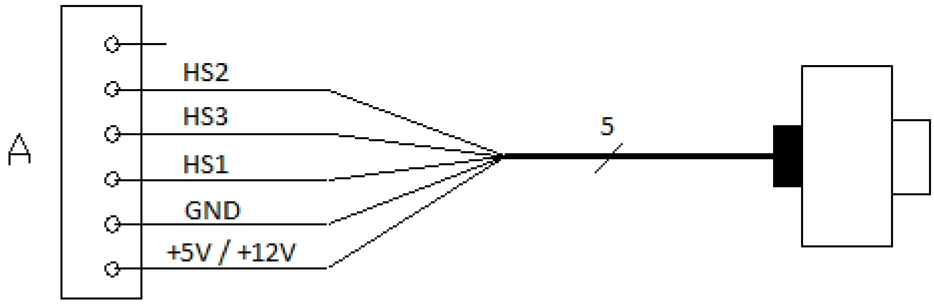
VERY IMPORTANT
It is necessary to specify the type of sensor used in terms of power supply, electronic output and number of pulses per revolution, because the logic unit and the software must be set in the correct way by Zapi.

Sin/Cos HW interface is available only for ACE4 Premium version.

5.2.7 Connection of Hall sensors

When the PMSM is of the BLDC type, it must be controlled with a six steps inverter (trapezoidal waves). A PMSM is a BLDC when, by turning its shaft lightened, the electromotive force between two motor terminals is of trapezoidal shape.
To control BLDC motor with Zapi inverter, it is necessary to three Hall sensors. Hall sensors power supply can be +5 or +12 V.

A8 (A10)	5V/+12V	Hall sensor positive supply.
A15 (A21)	GND	Hall sensor negative supply.
A7 (A9)	HS1	Hall sensor 1.
A14 (A20)	HS2	Hall sensor 2.
A13 (A19)	HS3	Hall sensor 3.

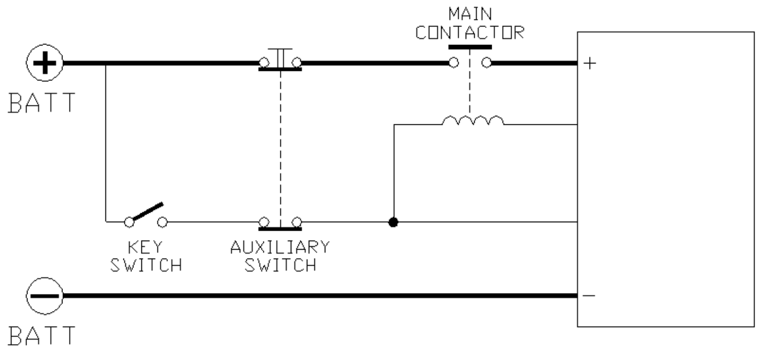


Hall sensors connection

VERY IMPORTANT
Since the logic unit and the software must be set in the correct way by Zapi lines, it is absolutely mandatory to specify in the commercial order the type of Hall sensors used (in terms of supply voltage, output voltage and number of pulses per revolution), their configuration in the d-axis rotor orientation and their sequence around one turn.

5.2.8 Main contactor and key connection

- The connection of the main contactor can be carried out as in the following figure.



Main Contactor and Key connection

- The connection of the battery line switches must be carried out following instructions from Zapi.
- If a mechanical battery line switch is installed, it is necessary that the key supply to the inverter is open together with power battery line; if not, the inverter may be damaged if the switch is opened during a regenerative braking.
- An intrinsic protection is present against battery voltages above 140% of the nominal one and against the key switching off before disconnecting the battery power line.

5.2.9 Insulation of truck frame

As stated by EN-1175 "Safety of machinery – Industrial truck", chapter 5.7, "there should be no electrical connection to the truck frame". So the truck frame has to be isolated from any electrical potential of the truck power line.

5.3 EMC

EMC and ESD performances of an electronic system are strongly influenced by the installation. Special attention must be given to lengths, paths and shielding of the electric connections. These aspects are beyond of Zapi control. Zapi can offer assistance and suggestions on EMC related problems, basing on its long experience. However, <u>ZAPI declines any responsibility for non-compliance, malfunctions and failures, if correct testing is not made. The machine manufacturer holds the responsibility to carry out machine validation, based on existing norms (EN12895 for industrial truck; EN50081-2 for other applications).</u>

EMC stands for Electromagnetic Compatibility, and it deals with the electromagnetic behavior of an electrical device, both in terms of emission and reception of electromagnetic waves that may cause electromagnetic interference with the surrounding electronics.
So the analysis works in two directions:

1) The study of the emission problems, the disturbances generated by the device and the possible countermeasures to prevent the propagation of that energy; we talk about “conduction” issues when guiding structures such as wires and cables are involved, “radiated emissions” issues when it is studied the propagation of electromagnetic energy through the open space. In our case the origin of the disturbances can be found inside the controller with the switching of the MOSFETs at high frequency which can generate RF energy. However wires have the key role to propagate disturbs because they work as antennas, so a good layout of the cables and their shielding can solve the majority of the emission problems.

2) The study of the immunity can be divided in two main branches: protection from electromagnetic fields and from electrostatic discharge. The electromagnetic immunity concerns the susceptibility of the controller with regard to electromagnetic fields and their influence on the correct work made by the electronic device. There are well defined tests which the machine has to undergo. These tests are carried out at determined levels of electromagnetic fields, simulating external undesired disturbances and verifying the response.

   The second type of immunity, to ESD, concerns the prevention of the effects of electric current due to excessive electric charge stored in an object. In fact, when a charge is created on a material and it remains there, it becomes an “electrostatic charge”; ESD happens when there is a rapid transfer from one charged object to another. This rapid transfer has, in turn, two important effects:

   - This rapid charge transfer can determine, by induction, disturbs on the signal wiring thus causing malfunctions; this effect is particularly critical in modern machines, with serial communications (CAN bus) which are spread everywhere on the truck and which may carry critical information.
   - In the worst case and when the amount of charge is very high, the discharge process can determine failures in the electronic devices; the type of failure can vary from a temporary malfunction to a definitive failure of the electronic device.

***IMPORTANT NOTE**: it is always much easier and cheaper to avoid ESD from being generated, rather than increasing the level of immunity of the electronic devices.*

There are different solutions for EMC issues, depending on the required level of emissions/ immunity, the type of controller, materials and position of the wires and electronic components.

1) EMISSIONS. Three ways can be followed to reduce the emissions:
   - SOURCE OF EMISSIONS: finding the main source of disturb and work on it.
   - SHIELDING: enclosing contactor and controller in a shielded box; using shielded cables;
   - LAYOUT: a good layout of the cables can minimize the antenna effect; cables running nearby the truck frame or in iron channels connected to truck frames are generally a suggested not expensive solution to reduce the emission level.
2) ELECTROMAGNETIC IMMUNITY. The considerations made for emissions are valid also for immunity. Additionally, further protection can be achieved with ferrite beads and bypass capacitors.
3) ELECTROSTATIC IMMUNITY. Three ways can be followed to prevent damages from ESD:
   - PREVENTION: when handling ESD-sensitive electronic parts, ensure the operator is grounded; test grounding devices on a daily basis for correct functioning; this precaution is particularly important during controller handling in the storing and installation phase.
   - ISOLATION: use anti-static containers when transferring ESD-sensitive material.
   - GROUNDING: when a complete isolation cannot be achieved, a good grounding can divert the discharge current trough a “safe” path; the frame of a truck can works like a “local earth ground”, absorbing excess charge. So it is strongly suggested to connect to truck frame all the parts of the truck which can be touched by the operator, who is most of the time the source of ESD.

5.4 Various suggestions

- Never connect SCR low frequency chopper with asynchronous inverter because the asynchronous filter capacitors alter the functioning of the SCR choppers. If it is necessary to use two or more control units (traction and lift for ex.), they must belong to the ZAPIMOS family.
- During battery charge, disconnect asynchronous from the battery.

6 FEATURES

6.1 Operational Features

- Speed control (three versions available: sensored, sense coil and sensorless, as explained in the introduction section).
- Optimum behavior on a slope due to the speed feedback: the motor speed follows the accelerator, starting a regenerative braking if the speed exceeds the setpoint.
- Electrical stop on a ramp: the machine is electrically held on a slope for a programmable time (see also paragraph 8.2.1).
- Stable speed in every position of the accelerator.
- Regenerative release braking based on deceleration ramps: regenerative braking when the accelerator pedal is partially or fully released.
- Direction inversion with regenerative braking based upon deceleration ramp.
- Regenerative braking and direction inversion without contactors: only the main contactor is present.
- Release-braking profile modulated by an analog input, as to obtain a proportional-brake feature.
- Increased resolution of the speed control at low speed.
- Voltage boost at the start and with overload to obtain more torque (with current control).
- Integrated driver for an electromechanical brake.
- Hydraulic-steering function:
  a) Traction inverter:
    - The traction inverter sends a "hydraulic-steering function" request to the pump inverter on the CAN bus line.
    - If the pump inverter is not present (for ex: tractor application), the traction inverter can manage a "hydraulic-steering function" by driving a hydro contactor which drives a hydraulic-steering motor on output A18 (A28), see also paragraph 8.2.1.
  b) Pump inverter:
    - The pump inverter manages a "hydraulic-steering function": it drives the pump motor at the programmed speed for the programmed time.
- High efficiency of motor and battery due to high frequency commutations.
- Double microcontroller for safety functions.
- Self-diagnoses, the faults can be monitored through the Console or through Zapi MDI/Display.
- Modification of parameters through the programming console.
- Internal hour-meter that can be viewed from the console.
- Memory of the last five alarms with relative hour-meter and temperature displayed on the console.
- Test function within the Console for checking the inverter parameters.

6.2 Dual traction motor

In the case of a dual-traction setup, there is the additional processing of the associated steering signal (from a potentiometer or switches) in order to generate separate torque demands for the left and right motors of the vehicle. This allows the two motors to be operated at different speeds, which greatly assists in turning the vehicle and prevents wheels scrub. After the two torque demands have been generated, operation of each motor controller is as the case of a single traction motor.

6.3 Pump motor

Pump-motor control is similar to traction-motor control, although motion is requested using a different combination of switches.

6.4 Torque mode

In this mode, the controller maintains the output torque at a constant value for a given throttle position. This is similar to DC motors (in particular, series wound DC motors) and provides a driving experience like a car. To prevent excessive speed when load torque is low, for example when driving downhill, a maximum vehicle speed can be set.

6.5 Speed mode

In this mode, the controller maintains the motor at a constant speed for a given throttle position as long as sufficient torque is available. Speed mode differs from torque mode in that the torque value applied to the motor is calculated by the controller basing on the operator's requested speed (determined by throttle position) and the vehicle actual speed.

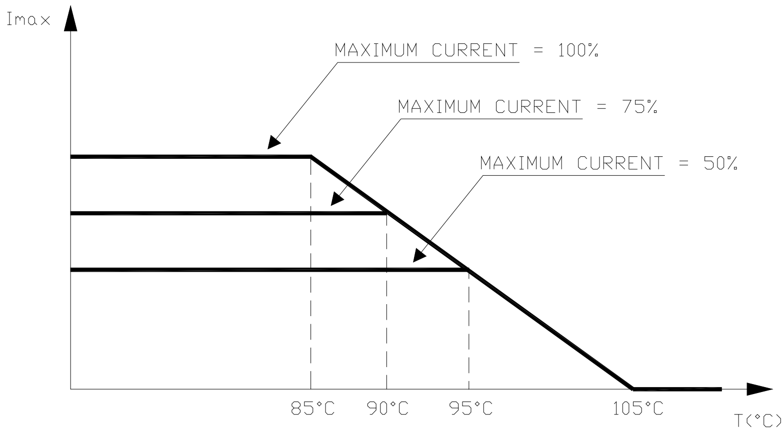
6.6 Protection and safety features

6.6.1 Protection features

ACE4 is protected against:

- **Reverse battery polarity**
  It is necessary to install a main contactor in order to protect the inverter against reverse battery polarity and for safety reasons.
- **Connection errors**
  All inputs are protected against connection errors.
- **Voltage out of range**
  Protected against battery undervoltage and overvoltage.

- **Overheating**
  If controller temperature exceeds 85 °C, maximum current is reduced in proportion to the temperature excess. Also, inverter stops when its temperature reaches 105 °C.



Thermal cutback

- **External agents**
  Inverter is protected against dust and sprays with a degree of protection meeting IP65. Nevertheless, it is suggested to carefully study controller installation and position.
- **Internal faults**
  At key-on, main contactor will not close if the power section or the logic one are not properly functioning.
- **Accidental startup**
  A precise sequence of operations is necessary to start the machine. Operation does not begin if they are not correctly carried out. Requests for drive must be made only after closing the key switch. Accelerator must not be depressed at key-on.
- **Low battery charge**
  When the battery charge is low, the maximum current is reduced to the half of the maximum current programmed.

6.6.2 Safety Features

ZAPI controllers are designed according to the prEN954-1 specifications for safety related parts of the control system and according to UNI EN1175-1 norm. The safety of the machine is strongly related to installation. Length, layout and screening of electrical connections have to be carefully designed. ZAPI is always available to cooperate with customers in order to evaluate installation and connection solutions. Furthermore, ZAPI is available to develop new SW or HW solutions to improve the safety of the machine according to customer requirements.
<u>Machine manufacturer holds the responsibility for the truck safety features and related approval.</u>

6.7 Diagnoses

The microcontroller constantly monitors the inverter and carries out a diagnostic procedure on the main functions.
For simple visual diagnoses of system faults and to monitor system status, a red LED is provided.

Alarm Led

At startup it is turned on for 2 s, then it stays continuously off if there is no fault.

In case of fault, it produces flash codes of all the active faults in a repeating cycle. Each code consists of two digits (see chapter 10) shown through the following sequence:

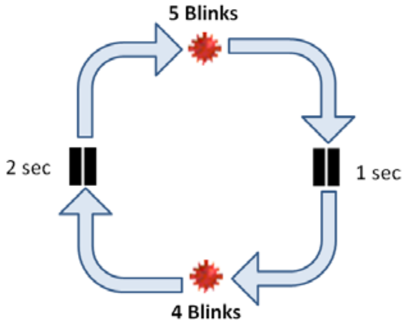
1) the LED blinks as many times as the first digit value;
2) it makes a pause of 1 s;
3) it blinks as many times as the second digit value.

The sequence is repeated after a pause of 2 s.

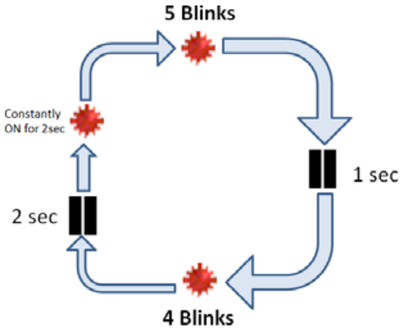
In case of fault concerning supervisor µC, the sequence is the same with the only difference that LED stays on for 2 s before starting the appropriate flash code.

Examples:

- Alarm 54 on master uC



- Alarm 54 on supervisor uC



Diagnoses are made in 4 steps:

1) Diagnosis at the key-on that checks: watchdog circuits, current sensors, charging of capacitors, phase voltages, contactor driver, CAN bus interface, if the switching sequence of microswitches is correct and if the accelerator unit is in the correct position.

2) Diagnosis during standby that checks: watchdog circuits, phase voltages, contactor driver, current sensors and CAN bus interface.

3) Diagnosis during operation that checks: watchdog circuits, contactor driver, current sensors and CAN bus interface.

4) Continuous diagnoses that check: inverter and motor temperature.

Diagnoses can be provided in two ways: the digital console can be used, which gives detailed information about failures; as an alternative the failure code is sent on the CAN bus and can be monitored by means of Zapi PC CAN Console.

7 START-UP HINTS

7.1 Checks prior to initial power up

⚠ ***For traction applications, raise up or otherwise disable driving wheels to prevent the possibility of unexpected vehicle motion during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excess pressure (in the event of a pressure-relief valve malfunction).***

⚠ ***Take necessary safety precautions in order to prevent injuries to personnel or damages to equipment.***

⚠ ***After the inverter turn-off, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10 – 100 Ohm between the +B and -B terminals of the inverter.***

Perform the following checks before applying power to a motor controller for the first time:

1. Verify that the proper motor controller for the application has been installed.
2. Verify that the battery voltage matches the motor controller nominal DC supply voltage showed on the product identification label.
3. Verify that the correct software for the application has been loaded.
4. Verify that all power and signal wires are correctly connected.
5. Verify that battery and motor terminals are tightened with appropriate torque.
6. Verify that the I/O plug (Ampseal connector) is fully mated and latched in position on the motor controller.
7. Verify that the motor controller is correctly fused for the application. Refer to the vehicle maintenance documentation for the correct fuse size.

7.2 Verifying motor controller for operation

The following procedure can be used to verify that a motor controller is functional and able to communicate over CAN bus.

1. Apply battery power to the KEY input and verify that the red LED indicator on the motor controller is on for a while.
2. Verify that the red LED indicator on the motor controller is in steady off condition.
3. If LED is flashing, it indicates an error, warning or other fault condition within the motor controller. Consult the troubleshooting in chapter 10 for possible causes and corrective actions.

7.3 Configuring motor controller for the application

Normally, motor controllers shipped for OEM series production are programmed by production lines with the correct parameters and do not require any further configuration.
Please refer to the OEM documentation for any further setup required during vehicle commissioning.
Setting up a prototype controller for a new vehicle, within a vehicle development program, may require extensive parameterization and possibly re-programming the motor controller via CAN bus.

7.4 Set-up procedure for AC inverter

This section describes the basic set-up procedure for the ACE4 inverter in traction configuration. If you need to replicate the same set of settings on different controllers, use the SAVE and RESTORE sequence (see chapter); otherwise go down the following sequence.

- In ADJUSTMENTS, set BATTERY VOLTAGE according to your set-up (see paragraph 8.2.3).
- Check the wiring and that all commands are functioning. Use the TESTER function to have real-time feedback about their state.
- Perform the accelerator acquisition using the PROGRAM VACC procedure (see paragraph 9.1).
- Set the maximum current for traction and braking in MAX. CURRENT TRA and MAX. CURRENT BRK (see paragraph 8.2.1).
- Set the motor-related parameters. It is suggested to discuss them with Zapi technicians.
- Set parameter SET MOT.TEMPERAT according to the type of the motor thermal sensor adopted.
- Set the acceleration delay (ACCEL MODULATION and ACCEL DELAY parameters). Test the behavior in both directions.
- Set the FREQUENCY CREEP starting from 0.3 Hz. The machine should just move when the drive request is active. Increase the level accordingly.
- Set SPEED REDUCTION as required by your specifications.
- Set the other performance-related parameters such as RELEASE BRAKING, INVERSION BRAKING, DECELERATION BRAKING, PEDAL BRAKING, SPEED LIMIT BRAKING, MAX SPEED FORW, MAX SPEED BACK.
- Make the choice for the truck behavior on a slope (STOP ON RAMP and AUXILIARY TIME parameters).
- Test the truck in all operative conditions (with and without load, on flat and on ramp, etc.).

At the end of your modifications, re-cycle the key switch to make them effective.

7.4.1 Sin/cos-sensor case

Sin/Cos sensors have a sinusoidal output voltage, with variable amplitude and offset, and normally sin/cos wave has an arbitrary shift with respect to magnetic-field zero position. Offset, amplitude and angle must be set before starting a PM for the first time.
Preliminary settings are the same described above. Plus, an automatic acquisition procedure, embedded in the inverter software, has to be activated only once at commissioning.

Before starting the procedure, please be sure that the motor is free to spin, with a minimum load on the shaft.

- In OPTIONS, select ABS SENS. ACQUIRE.
- Select NO at the request of saving data (otherwise the main coil will be opened).
- A message ACQUIRING ABS indicates that the acquisition procedure is ready to start.
- Use the TESTER function to monitor the motor speed for the further steps.
- Activate the TILLER and FW (or BW) microswitches. Motor starts running in open-loop mode.
- Because of the open-loop mode, it is normal if the reported speed is not perfectly stable, but value on display must be, in any case, quite fixed.
- If the motor does not spin, it vibrates or speed on display oscillates too much, stop the acquisition procedure releasing the FW or BW command (see troubleshooting at the paragraph end).
- The first phase, where motor is spinning at low speed (something like 5Hz), allows the Inverter to acquire signal offset and amplitude for both channels.
- After the previous steps are completed, rotor is aligned to the magnetic field origin, and the angle between sin/cos zero value is acquired and stored.
- The next part is a sort of verification when motor is accelerated up to 50 Hz in closed-loop mode.
- Because of the closed loop, the speed reported on display must be stable.
- If something has gone wrong (rotor is not correctly aligned because of friction on the shaft or any other problem), it is possible that rotor starts spinning at uncontrolled speed with high current absorption. The only way to stop it is by switching the inverter off using the key switch.
- When the procedure is correctly completed, the main contactor opens and display shows ACQUIRE END.
- Turn off and then on again the key switch; verify that motor can run according to the accelerator input in both directions.

Inverter goes down the procedure automatically; every phase is marked by a different message on display.

In case of problems, mainly in the first phase, please:

- Check that PM motor pole pairs are set correctly.
- In HARDWARE SETTING increase the ABS.SENS. ACQ.ID parameter (the motor current used for the open-loop phase) so to have more torque and perhaps solve some friction problems (ID RMS MAX must be set congruently).

- If increasing ABS.SENS. ACQ.ID is not enough, increase the ABS.SENS.A.KTETA parameter. It manages the speed in the open-loop phase and in some situations faster speed can help to achieve a more even rotation.

Offset angle can also be manually refined using the MAN.OFFSET ANGLE parameter. However, the voltage range of the sensor must be first acquired using the automatic procedure.

7.5 Set-up procedure for pump inverter

This section describes the basic set-up procedure for the ACE4 inverter in pump configuration. If you need to replicate the same set of settings on different controllers, use the SAVE and RESTORE sequence; otherwise go down the following sequence.

- In ADJUSTMENTS, set BATTERY VOLTAGE according to your set-up (see paragraph 8.2.3).
- Check the wiring and that all commands are functioning. Use the TESTER function to have real-time feedback about their state.
- Perform the accelerator acquisition using the PROGRAM VACC procedure (see paragraph 9.1).
- Set the maximum current for lift and lowering in MAX. CURRENT TRA and MAX. CURRENT BRK (see paragraph 8.2.1).
- Set the motor-related parameters. It is suggested to discuss them with Zapi technicians.
- Set parameter SET MOT.TEMPERAT according to the type of the motor thermal sensor adopted.
- Set the acceleration delay (ACCEL MODULATION and ACCEL DELAY parameters). Test the behavior in both directions.
- Set the FREQUENCY CREEP starting from 0.3 Hz. The pump should just run when the request is active. Increase the level accordingly.
- Set SPEED REDUCTION as required by your specifications.
- Set the other performance-related parameters such as MAX SPEED LIFT, 1ST SPEED COARSE, 2ND SPEED COARSE, 3RD SPEED COARSE.
- Set hydraulic-steering-related parameters, such as HYD SPEED FINE and HYDRO TIME.
- Test the pump in all operative conditions (with and without load, etc.).

At the end of your modifications, re-cycle the key switch to make them effective.

8 PROGRAMMING & ADJUSTEMENTS

The ACE4 software is powerful and exhaustive, but it is also complex, with a long list of parameters that grant a fine control of all functionalities the inverter can perform. After a deep reading of this section, a well-trained technician or an engineer will be able to understand and modify the parameters.
The procedure to follow in order to modify the parameters could be carried out in four steps:

- Before doing any change save a copy of the default parameters set in the inverter. This procedure is easy to do thanks to the Zapi Smart Console (see section 13.2.11) or thanks to the PC CAN Console (see section 13.1.3).
- Inside the saved copy or in a related text file, write down the reason of the changes.
- Change the parameters with full knowledge of what you are doing.
- After having saved the new parameters, check that all parameters have been changed according to your modifications by reading again the value stored inside the parameters.

To access and adjust all inverter parameters it is necessary to use the Zapi console. Since the ACE4 has no external serial connector, three possible solutions are available:

- To use the Zapi Smart Console connected to the CAN bus line (ask directly to Zapi for the dedicated User Manual)
- To use the PC CAN Console software. This tool is more powerful than the standard serial console. The following paragraphs describe the controller configuration in the case the operator is using Zapi PC CAN console.
- To connect the Zapi Smart Console (or old hand console) through a remote module, like a Zapi tiller card of a Zapi display. This module has to be connected to the same CAN bus line of the inverter.

The Zapi Smart Console and PC CAN Console software are tool developed for setup and programming all Zapi products installed in any application.

See Appendix A and Appendix B to have a general overview and basic knowledge about the use these tools

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⚠ ***Zapi tools permit a deep control over the parameters and behavior of Zapi controllers. Their use is restricted to engineers and well trained technicians!***

8.1 Settings overview

Inverter settings are defined by a wide set of parameters, organized as follows.

PARAMETER CHANGE
ACC. TORQUE DEL.
DEC. TORQUE DEL.
ACCELER. DELAY
RELEASE BRAKING
TILLER BRAKING
INVERS. BRAKING
DECEL. BRAKING
PEDAL BRAKING
SPEED LIMIT BRK.
STEER BRAKING
MAX SPEED FORW
MAX SPEED BACK
MAX SPEED LIFT
1ST PUMP SPEED
2ND PUMP SPEED
3RD PUMP SPEED
4TH PUMP SPEED
5TH PUMP SPEED
HYD PUMP SPEED
CUTBACK SPEED 1
CUTBACK SPEED 2
H&S CUTBACK
CTB. STEER ALARM
CURVE SPEED 1
CURVE CUTBACK
FREQUENCY CREEP
TORQUE CREEP
MAX. CURRENT TRA
MAX. CURRENT BRK
ACC SMOOTH
INV SMOOTH
STOP SMOOTH
BRK SMOOTH
STOP BRK SMOOTH
BACKING SPEED
BACKING TIME
EB. ENGAGE DELAY
AUXILIARY TIME
ROLLING DW SPEED
MIN EVP
MAX EVP
EVP OPEN DELAY
EVP CLOSE DELAY

SET OPTIONS
HM DISPLAY OPT.
HM CUSTOM 1 OPT.
HM CUSTOM 2 OPT.
TILL/SEAT SWITCH
EB ON TILLER BRK
BATTERY CHECK
STOP ON RAMP
PULL IN BRAKING
SOFT LANDING
QUICK INVERSION
PEDAL BRK ANALOG
HARD & SOFT
MAIN POT. TYPE
AUX POT. TYPE
SET MOT.TEMPERAT
STEERING TYPE
M.C. FUNCTION
EBRAKE ON APPL.
AUX OUT FUNCTION
SYNCRO
AUTO PARK BRAKE
AUTO LINE CONT.
ACCEL MODULATION
EVP TYPE
EV1
EV2
EV3
EV4
HIGH DYNAMIC
INVERSION MODE
STEER TABLE
WHEELBASE MM
FIXED AXLE MM
STEERING AXLE MM
REAR POT ON LEFT
DISPLAY TYPE
ABS.SENS.ACQUIRE

ADJUSTMENTS
SET BATTERY
ADJUST KEY VOLT.
ADJUST BATTERY
SET POSITIVE PEB
SET PBRK. MIN
SET PBRK. MAX
MIN LIFT DC
MAX LIFT DC
MIN LOWER
MAX LOWER
THROTTLE 0 ZONE
THROTTLE X1 MAP
THROTTLE Y1 MAP
THROTTLE X2 MAP
THROTTLE Y2 MAP
THROTTLE X3 MAP
THROTTLE Y3 MAP
BAT. MIN ADJ.
BAT. MAX ADJ.
BDI ADJ STARTUP
BDI RESET
BATT.LOW TRESHLD
BAT.ENERGY SAVER
STEER RIGHT VOLT
STEER LEFT VOLT
STEER ZERO VOLT
MAX ANGLE RIGHT
MAX ANGLE LEFT
STEER DEAD ANGLE
STEER ANGLE 1
STEER ANGLE 2
SPEED FACTOR
SPEED ON MDI
LOAD HM FROM MDI
CHECK UP DONE
CHECK UP TYPE
MC VOLTAGE
MC VOLTAGE RED.
EB VOLTAGE
EB VOLTAGE RED.
PWM EV2
PWM EV3
MAX. MOTOR TEMP.
STOP MOTOR TEMP.
A.SENS.MAX SE
A.SENS.MIN SE
A.SENS.MAX CE
A.SENS.MIN CE
MOT.T. T.CUTBACK
VACC SETTING

SPECIAL ADJUST.
ADJUSTMENT #01
ADJUSTMENT #02
CURR. SENS. COMP
DIS.CUR.FALLBACK
SET CURRENT
SET TEMPERATURE
HW BATTERY RANGE
DUTY PWM CTRAP
PWM AT LOW FREQ
PWM AT HIGH FREQ
FREQ TO SWITCH
DITHER AMPLITUDE
DITHER FREQUENCY
HIGH ADDRESS
CAN BUS SPEED
EXTENDED FORMAT
DEBUG CANMESSAGE
CONTROLLER TYPE
SAFETY LEVEL
RS232 CONSOLLE
ID CANOPEN OFST
2ND SDO ID OFST
VDC START UP LIM
VDC UP LIMIT
VDC START DW LIM
VDC DW LIMIT

HARDWARE SETTINGS
***
TOP MAX SPEED
CONF.POSITIVE LC
FEEDBACK SENSOR
TORQUE CONTROL
ROTATION CW ENC
ROTATION CW MOT
ENCODER PULSES 1
ENCODER PULSES 2
MOTOR P. PAIRS 1
MOTOR P. PAIRS 2
***

HYDRO SETTING
HYDRO TIME
HYDRO FUNCTION

8.2 Settings description

In the following paragraphs, parameters are presented as follows:

Parameter	Allowable range	Description
Name of the parameter as indicated in the PC CAN Console tool. (Availability)	Allowable range of values that can be set. (resolution)	Description of the parameter and possibly suggestions on how to set it.

In the “Parameter” column, the availability field (between parentheses) lists the controller types where the parameter is available.

Controller types are coded as:

A = All controller types
T = Traction controller (in single-motor applications)
TM = Traction master controller (in multiple-motor applications)
TS = Traction secondary controller (in multiple-motor applications)
P = AC pump controller
CO = CANopen controller
N = none

References to connector pins are coded as:

- Red colored: pin of the 23-poles Ampseal connector of ACE4 Standard.
- Blue colored: pin of the 35-poles Ampseal connector of ACE4 Premium.

The parameters and the functionalities described in the following paragraphs are referred to Zapi standard software. They could be different in any other customized software releases depending on customer’s requests.

8.2.1 PARAMETER CHANGE

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
ACC. TORQUE DEL. (T, TM, P, CO)	0.1 s ÷ 10 s (by steps of 0.1 s)	This parameter defines the acceleration ramp if TORQUE CONTROL is ON, in terms of the time needed to increase the torque from the minimum value up to the maximum one.
DEC. TORQUE DEL. (T, TM, P, CO)	0.1 s ÷ 10 s (by steps of 0.1 s)	This parameter defines the deceleration ramp if TORQUE CONTROL is ON, in terms of the time needed to decrease the torque from the maximum value down to the minimum one.
ACCELER. DELAY (T, TM, P, CO)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the acceleration ramp, in terms of the time needed to speed up the motor from 0 Hz to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint (see paragraph 9.4).
RELEASE BRAKING (T, TM, P, CO)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp performed after the running request is released, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.4).

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
TILLER BRAKING (T, TM)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp performed after the tiller/seat switch is released, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.4).
INVERS. BRAKING (T, TM, CO)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp performed when the direction switch is toggled during drive, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.4).
DECEL. BRAKING (T, TM, CO)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp performed when the accelerator is released but not completely, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.5).
PEDAL BRAKING (T, TM, CO)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp performed when the braking pedal is pressed, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.5).
SPEED LIMIT BRK. (T, TM)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp performed upon a speed-reduction request, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.5).
STEER BRAKING (T, TM)	0.1 s ÷ 25.5 s (by steps of 0.1 s)	This parameter defines the deceleration ramp related to the steering angle, in terms of the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 9.5).
MAX SPEED FORW (T, TM)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum speed in forward direction as a percentage of TOP MAX SPEED.
MAX SPEED BACK (T, TM)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum speed in backward direction as a percentage of TOP MAX SPEED.
MAX SPEED LIFT (P)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum speed of the pump motor during lift, as a percentage of the maximum voltage applied to the pump motor.
1ST PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor when 1^{st} speed is requested, as a percentage of the maximum pump speed.
2ND PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor when 2^{nd} speed is requested, as a percentage of the maximum pump speed.

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
3RD PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor when 3rd speed is requested, as a percentage of the maximum pump speed.
4TH PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor when 4th speed is requested, as a percentage of the maximum pump speed.
5TH PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor when 5th speed is requested, as a percentage of the maximum pump speed.
HYD PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor used for the steering when HYDRO FUNCTION is ON, as a percentage of the maximum pump speed.
CUTBACK SPEED 1 (T, TM, P)	10% ÷ 100% (by 1% steps)	This parameter defines the maximum speed performed when cutback input 1 is active, as a percentage of TOP MAX SPEED.
CUTBACK SPEED 2 (T, TM, P)	10% ÷ 100% (by 1% steps)	This parameter defines the maximum speed performed when cutback input 2 is active, as a percentage of TOP MAX SPEED.
H&S CUTBACK (T, TM)	10% ÷ 100% (by 1% steps)	This parameter defines the maximum speed performed when the Hard-and-Soft function is active, as a percentage of TOP MAX SPEED. **Note: by default H&S function is not present on ACE4.**
CTB. STEER ALARM (T, TM)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum traction speed when an alarm from the EPS is read by the microcontroller, if the alarm is not safety-related. The parameter represents a percentage of TOP MAX SPEED.
CURVE SPEED 1 (T, TM)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle. The parameter represents a percentage of TOP MAX SPEED.
CURVE CUTBACK (T, TM)	1% ÷ 100% (by 1% steps)	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 2 angle. The parameter represents a percentage of TOP MAX SPEED.
FREQUENCY CREEP (T, TM, P)	0.6 Hz ÷ 25 Hz (by steps of 0.1 Hz)	This parameter defines the minimum speed when the forward-request or reverse-request switch is closed, but the accelerator is at its minimum.
TORQUE CREEP (T, TM, P, CO)	0% ÷ 100% (255 steps)	This parameter defines the minimum torque applied when torque control is enabled (TORQUE CONTROL = ON) and one between the forward or reverse-request switches is closed, but the accelerator is at its minimum.
MAX. CURRENT TRA (T, TM, P, CO)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
MAX. CURRENT BRK (T, TM, P, CO)	0% ÷ 100% (by 1% steps)	This parameter defines the maximum current applied to the motor during deceleration, as a percentage of the factory-calibrated maximum current.

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
ACC SMOOTH (T, TM, P, CO)	1 ÷ 5 (by steps of 0.1)	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
INV SMOOTH (T, TM, CO)	1 ÷ 5 (by steps of 0.1)	This parameter defines the acceleration profile performed when the truck changes direction: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH (T, TM, P, CO)	3 Hz ÷ 100 Hz (by steps of 1 Hz)	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
BRK SMOOTH (T, TM, CO)	1 ÷ 5 (by steps of 0.1)	This parameter defines the deceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP BRK SMOOTH (T, TM, CO)	3 Hz ÷ 100 Hz (by steps of 1Hz)	This parameter defines the frequency at which the smoothing effect of the deceleration profile ends.
BACKING SPEED (T, TM)	0% ÷ 100% (by 1% steps)	This parameter defines maximum speed performed when the inching function is active. The parameter represents a percentage of TOP MAX SPEED.
BACKING TIME (T, TM)	0 s ÷ 10 s (by steps of 0.1 s)	This parameter defines the duration of the inching function.
EB. ENGAGE DELAY (T, TM, P, CO)	0 s ÷ 12.75 s (by steps of 0.05 s)	This parameter defines the delay introduced between the traction request and the actual activation of the traction motor. This takes into account the delay occurring between the activation of the EB output (i.e. after a traction request) and the effective EB release, so to keep the motor stationary until the electromechanical brake is actually released. The releasing delay of the brake can be measured or it can be found in the datasheet.
AUXILIARY TIME (T, TM, P, CO)	0 s ÷ 10 s (by steps of 0.1 s)	For the encoder version, this parameter defines how long the truck holds in place if the STOP ON RAMP option is ON.
ROLLING DW SPEED (T, TM, P, CO)	1 Hz ÷ 50 Hz (by steps of 1Hz)	This parameter defines the maximum speed for the rolling-down function.
MIN EVP (A)	0% ÷ 100% (255 steps)	This parameter defines the minimum current applied to EVP when the relative potentiometer is at minimum. This parameter is not effective if the EVP is programmed like an on/off valve.
MAX EVP (A)	0% ÷ 100% (255 steps)	This parameter defines the maximum current applied to EVP when the relative potentiometer is at maximum. This parameter also determines the current value when the EVP is programmed like an on/off valve.
EVP OPEN DELAY (A)	0 s ÷ 12.75 s (by steps of 0.05 s)	This parameter defines the time needed to increase the EVP current from zero up to the maximum.
EVP CLOSE DELAY (A)	0 s ÷ 12.75 s (by steps of 0.05 s)	This parameter defines the time needed to decrease the EVP current from the maximum down to zero.

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
HYDRO TIME (P)	0 s ÷ 20 s (by steps of 0.1 s)	This parameter defines how long the hydraulic steering remains active after the traction request is released.

8.2.2 SET OPTIONS

SET OPTIONS		
Parameter	**Allowable range**	**Description**
HM DISPLAY OPT. (T, TM, P, CO)	0 ÷ 6	This parameter defines the configuration for the hour meter shown on a display (i.e. MDI). The possible settings are: **0:** The hour meter counts since the controller is on. **1:** The hour meter counts when the three-phase power bridge is active **2:** The hour meter counts when the DC motor power bridge is active **3:** The hour meter counts when one of the valve outputs is active **4:** The hour meter counts when the three-phase power bridge is active or the DC motor power bridge is active **5:** The hour meter counts when the DC motor power bridge is active or one of the valve outputs is active **6:** The hour meter counts when the three-phase power bridge is active or the DC motor power bridge is active or one of the valve outputs is active **Note: options 2, 4, 5 and 6 are not effective on ACE4**
HM CUSTOM 1 OPT. (T, TM, P, CO)	0 ÷ 6	This parameter defines the configuration for the hour meter number 1 accessible to the customer. The possible settings are the same of HM DISPLAY OPT. parameter.
HM CUSTOM 2 OPT. (T, TM, P, CO)	0 ÷ 6	This parameter defines the configuration for the hour meter number 2 accessible to the customer. The possible settings are the same of HM DISPLAY OPT. parameter.
TILL/SEAT SWITCH (T, TM, P)	HANDLE ÷ SEAT	This option defines the function of input A6 (A8). This input opens when the operator leaves the truck. **HANDLE =** input A6 (A8) is managed as tiller input (no delay when released). **DEADMAN =** input A6 (A8) is managed as dead-man input (no delay when released). **SEAT =** input A6 (A8) is managed as seat input (with a delay when released and the de-bouncing function).

SET OPTIONS		
Parameter	**Allowable range**	**Description**
EB ON TILLER BRK (T)	OFF, ON	This option defines how the electromechanical brake is managed depending on the status of the TILLER/SEAT input: **ON =** the electromechanical brake is engaged as soon as the TILLER input goes into OFF state. The deceleration ramp defined by TILLER BRAKING parameter has no effect. **OFF =** when the tiller input goes into OFF state, the TILLER BRAKING ramp is applied before engaging the electromechanical brake.
BATTERY CHECK (T, TM, P, CO)	0 ÷ 3	This option specifies the management of the low battery charge situation. There are four levels of intervention: **0 =** battery charge level is evaluated but ignored, meaning that no action is taken when battery runs out. **1 =** when the alarm BATTERY LOW is present, control reduces the maximum speed down to 23% of the full speed and it also reduces the maximum current down to 50% of the full current. **2 =** when the alarm BATTERY LOW is present, lift function is disabled. **3 =** when the alarm BATTERY LOW is present, control reduces the maximum speed down to 23% of the full speed and lift function is disabled. **With settings 1, 2 or 3:** the alarm BATTERY LOW occurs when battery level is evaluated to be lower or equal to parameter BATT.LOW TRESHLD (see ADJUSTMENTS list).
STOP ON RAMP (T, TM, P, CO)	OFF, ON	This parameter enables or disables the stop-on-ramp feature (the truck is electrically held in place on a slope for a defined time). **ON =** the stop-on-ramp feature is performed for a time set in the AUXILIARY TIME parameter. **OFF =** the stop-on-ramp feature is not performed. Instead, a controlled slowdown is performed for a minimum time set in the AUXILIARY TIME parameter. After the AUXILIARY TIME interval, the three-phase bridge is released and, if present, the electromechanical brake activated (see parameter AUX OUT FUNCTION).
PULL IN BRAKING (A)	OFF, ON	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. **ON =** when the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request the inverter keeps running the pump avoiding the unwanted descent of the forks. **OFF =** when the operator releases the traction (or lift) request, the inverter does not power the motor anymore. This setting is useful especially for traction applications: when the truck is travelling on a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.

SET OPTIONS		
Parameter	**Allowable range**	**Description**
SOFT LANDING (A)	OFF, ON	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. **ON =** when the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. **OFF =** when the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor immediately.
QUICK INVERSION (T, TM, P)	NONE ÷ BELLY	This parameter defines the quick-inversion functionality managed by A11 (A17) input. **NONE =** the quick-inversion function is not managed. **BRAKE =** upon a quick-inversion request, the motor is braked. **TIMED =** the quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). **BELLY =** the quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released.
PEDAL BRK ANALOG (T, TM)	OFF, ON	This parameter defines the kind of brake pedal adopted. **ON =** brake pedal outputs an analog signal, braking is linear. **OFF =** brake pedal outputs a digital signal, braking is on/off.
HARD & SOFT (T, TM)	OFF, ON	This parameter enables or disables the Hard-and-Soft functionality. With H&S, it is possible to start the truck (at reduced speed) only by activating the H&S switch and the accelerator, without the tiller input. **ON =** H&S function is enabled **OFF =** H&S function is disabled **Note: by default this function is not present on ACE4.**

SET OPTIONS		
Parameter	**Allowable range**	**Description**
MAIN POT. TYPE (T, TM)	0 ÷ 11	This parameter defines the type of the main potentiometer connected to A3 (A5) contact. **0:** V-type pot, low to high value, with direction switches, without enable switch, without enable dead band. **1:** V-type pot, low to high value, with direction switches, without enable switch, with enable dead band. **2:** V-type pot, high to low value, with direction switches, without enable switch, without enable dead band. **3:** V-type pot, high to low value, with direction switches, without enable switch, with enable dead band. **4:** Z-type pot, low to high value, with direction switches, without enable switch, without enable dead band. **5:** Z-type pot, low to high value, with direction switches, without enable switch, with enable dead band. **6:** Z-type pot, low to high value, without direction switches, with enable switch, with enable dead band **7:** Z-type pot, low to high value, without direction switches, without enable switch, with enable dead band. **8:** Z-type pot, high to low value, with direction switches, without enable switch, without enable dead band. **9:** Z-type pot, high to low value, with direction switches, without enable switch, with enable dead band. **10:** Z-type pot, high to low value, without direction switches, with enable switch, with enable dead band. **11:** Z-type pot, high to low value, without direction switches, without enable switch, with enable dead band.
AUX POT. TYPE (T, TM, TS, P)	0 ÷ 15	This parameter defines the type of the auxiliary potentiometer connected to A10 (A16) contact. **0 ÷ 11:** Same as MAIN POT. TYPE, see prev. parameter. **12:** No pot, with direction switches, with enable switch **15:** No pot, with direction switches, without enable switch
SET MOT.TEMPERAT (T, TM, P, CO)	NONE ÷ OPTION#3	This parameter defines the type of motor temperature sensor is connected to A23 (A33). **NONE =** no motor thermal sensor is connected. **DIGITAL =** a digital (ON/OFF) motor thermal sensor. **OPTION#1 =** a KTY 84-130 PTC (positive thermal coefficient resistance). **OPTION#2 =** a KTY 83-130 PTC (positive thermal coefficient resistance) **OPTION#3 =** a PT1000 PTC (positive thermal coefficient resistance).

SET OPTIONS		
Parameter	**Allowable range**	**Description**
STEERING TYPE (T, TM)	NONE ÷ ANALOG	This parameter defines which type of steering unit is connected to the controller. **NONE =** steering module is not present on the truck; ACE4 does not wait for any CAN message from the EPS and it does not apply EPS and braking steering cutback. **OPTION#1 =** EPS is present and it is configured with encoder + toggle switches, whose signals are acquired and related data transmitted to ACE4 via CAN bus. **OPTION#2 =** EPS is present and it is configured with potentiometer + encoder, whose signals are acquired and related data transmitted to ACE4 via CAN bus. **ANALOG =** A hydraulic steering is adopted and ACE4 acquires through one of its analog inputs the signal coming from a steering potentiometer, as a feedback of the steering orientation.
M.C. FUNCTION (T, TM, P, CO)	OFF ÷ OPTION#2	This parameter defines the configuration for the main contactor or line contactor output A16 (A26), NLC: Negative Line Contactor. **OFF =** main contactor is not present. Diagnoses are masked and MC is not driven. **ON =** main contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. **OPTION#1 =** for a traction & pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. **OPTION#2 =** for a traction & pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
EBRAKE ON APPL. (T, TM, P, CO)	ABSENT, PRESENT	This parameter defines whether the application includes an electromechanical brake or not.
AUX OUT FUNCTION (A)	NONE, BRAKE	This parameter enables or disables the output NEB A18 (A28), dedicated to the electromechanical brake: **NONE =** diagnoses are masked and E.B. is not driven upon a traction request. **BRAKE =** E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the setting of the parameter STOP ON RAMP. **Do not use this setting if the electromechanical brake is not really present.** **Note:** in applications with two controllers driving two traction motors and only one E.B., this parameter has to be set on BRAKE only in the controller that drives the E.B. .
SYNCRO (CO)	OFF, ON	This parameter enables or disables the syncro message. **OFF =** the syncro message is not used. **ON =** the syncro message is enabled.

SET OPTIONS		
Parameter	**Allowable range**	**Description**
AUTO PARK BRAKE (CO)	OFF, ON	This parameter enables or disables the autonomous management of the brake. **OFF =** E.B. is activated or deactivated according to the signal received via CAN bus. **ON =** E.B. is managed by the controller itself ignoring any activation/deactivation signal received via CAN bus.
AUTO LINE CONT. (CO)	OFF, ON	This parameter enables or disables the autonomous management of the main contactor. **OFF =** main contactor is opened or closed according to the signals received by CAN bus. **ON =** main contactor is managed by the controller itself ignoring any activation/deactivation signal received via CAN bus.
ACCEL MODULATION (T, TM, P, CO)	OFF, ON	This parameter enables or disables the acceleration-modulation function. **OFF =** the acceleration rate is inversely proportional to the ACCEL DELAY parameter. **ON =** the acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY. See paragraph 9.4.
EVP TYPE (A)	NONE ÷ DIGITAL	This parameter defines how the output EVP A19 (A29) operates. **NONE =** output not enabled, no load connected to A19. **ANALOG =** A19 (A29) manages a current-controlled PWM-modulated proportional valve. **DIGITAL =** A19 (A29) manages an on/off valve. See the EVP-related parameters in PARAMETER CHANGE.
EV1 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output A24 (NEV1) operates. **ABSENT =** output not enabled, no load on A24. **DIGITAL =** A24 manages an on/off valve. By default it is controlled by input AUX1 A2.
EV2 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output A25 (NEV2) operates. **ABSENT =** output not enabled, no load on A25. **DIGITAL =** A25 manages a voltage-controlled PWM-modulated valve. By default it is controlled by input AUX2 A12. The PWM frequency is 1 kHz and the duty cycle depends on PWM EV2 (ADJUSTMENTS list).

SET OPTIONS		
Parameter	**Allowable range**	**Description**
EV3 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output A34 (NEV3) operates. **ABSENT =** output not enabled, no load on A34. **DIGITAL =** A34manages a voltage-controlled PWM-modulated valve. By default it is controlled by input AUX3 A14. The PWM frequency is 1 kHz and the duty cycle depends on PWM EV3 (ADJUSTMENTS list).
EV4 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output A35 (NEV4) operates. **ABSENT =** output not enabled, no on A35. **DIGITAL =** A35 manages an on/off valve.
HIGH DYNAMIC (T, TM, P, CO)	OFF, ON	This parameter enables or disables the High-Dynamic function. **ON =** all acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. **OFF =** standard behavior.
INVERSION MODE (T, TM)	OFF, ON	This parameter defines the behavior of the Quick-Inversion input A11 (A17). **ON =** A11 (A17) is normally closed (function is active when the switch is open). **OFF =** A11 (A17) is normally open (function is active when the switch is closed).
STEER TABLE (TM)	NONE ÷ OPTION#2	This parameter defines the steering table. **NONE =** The inverter does not follow any predefined steering table, but it creates a custom table according to parameters WHEELBASE MM, FIXED AXLE MM, STEERING AXLE MM and REAR POT ON LEFT. **OPTION#1 =** Three-wheels predefined steering table. **OPTION#2 =** Four-wheels predefined steering table. **The steering table depends on truck geometry. The two available options by default may not fit the requirements of your truck. It is advisable to store the dimensions of the truck in the parameters listed above in order to create a custom steering table.** **It is strongly recommended to consult paragraph 9.7 in order to properly understand how to fill the mentioned parameters. If the steering performance of the truck does not match your requirements even after you have entered the right truck dimensions, contact a Zapi technician in order to determine if a custom steering table has to be created.**
WHEELBASE MM (TM)	0 ÷ 32000	This parameter must be filled with the wheelbase, i.e. the distance between the two axles of the truck, expressed in millimeters. See paragraph 9.7.
FIXED AXLE MM (TM)	0 ÷ 32000	This parameter must be filled with the axle width at which the non-steering wheels are connected, expressed in millimeters. See paragraph 9.7

SET OPTIONS		
Parameter	**Allowable range**	**Description**
STEERING AXLE MM (TM)	0 ÷ 32000	This parameter must be filled with the axle length at which the steering wheels are connected. The length must be expressed in millimeters. See paragraph 9.7
REAR POT ON LEFT (TM)	OFF, ON	This parameter defines the position of the steering potentiometer. **OFF =** the steering potentiometer is not placed on the rear-left wheel. **ON =** the steering potentiometer is placed on the rear-left wheel.
DISPLAY TYPE (T, TM, P)	0 ÷ 9	This parameter defines which type of display is connected to the inverter. **0 =** none. **1 =** MDI PRC. **2 =** ECO DISPLAY. **3 =** SMART DISPLAY. **4 =** MDI CAN. **5 ÷ 9 =** available for future developments.
ABS.SENS.ACQUIRE (A – Only custom HW with sin/cos)	OFF, ON	This parameter activates the acquisition of motor speed sensor used for PMSM (Permanent-Magnets Synchronous Motor). **Contact Zapi Technicians for a detailed description of the acquisition procedure.**

8.2.3 ADJUSTMENTS

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
SET BATTERY (A)	24V ÷ 80V	This parameter defines the nominal battery voltage. The available options are: **36V, 48V, 72V, 80V**
ADJUST KEY VOLT. (A)	Volt	Fine adjustment of the key voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
ADJUST BATTERY (A)	Volt	Fine adjustment of the battery voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
SET POSITIVE PEB (A)	12 V ÷ 80 V	This parameter defines the supply-voltage value connected to PEB A17 (A27). Available values are: **12V, 24V, 36V, 40V, 48V, 72V, 80V**
SET PBRK. MIN (T, TM, TS, CO)	0 V ÷ 25.5 V (by steps of 0.1 V)	It records the minimum value of brake potentiometer when the brake is analog.
SET PBRK. MAX (T, TM, TS, CO)	0 V ÷ 25.5 V (by steps of 0.1 V)	It records the maximum value of brake potentiometer when the brake is analog.
MIN LIFT DC **(Read Only)** (T, TM, TS, P)	0 V ÷ 25.5 V (by steps of 0.1 V)	It records the minimum value of lifting potentiometer when the lift switch is closed. See paragraph 9.2.
MAX LIFT DC **(Read Only)** (T, TM, TS, P)	0 V ÷ 25.5 V (by steps of 0.1 V)	It records the maximum value of lifting potentiometer when the lift switch is closed. See paragraph 9.2.
MIN LOWER **(Read Only)** (T, TM, TS, P)	0 V ÷ 25.5 V (by steps of 0.1 V)	It records the minimum value of lower potentiometer when the lower switch is closed. See paragraph 9.2.
MAX LOWER **(Read Only)** (T, TM, TS, P)	0 V ÷ 25.5 V (by steps of 0.1 V)	It records the maximum value of lower potentiometer when the lower switch is closed. See paragraph 9.2.
THROTTLE 0 ZONE (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines a dead band in the accelerator input curve. See paragraph 9.8.
THROTTLE X1 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 9.8.
THROTTLE Y1 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 9.8.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
THROTTLE X2 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 9.8.
THROTTLE Y2 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 9.8.
THROTTLE X3 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 9.8.
THROTTLE Y3 MAP (T, TM, P)	0% ÷ 100% (by step of 1%)	This parameter defines the accelerator input curve. See paragraph 9.8.
BAT. MIN ADJ. (T, TM, P, CO)	-12.8% ÷ 12.7% (by steps of 0.1%)	This parameter defines the minimum level of the battery-discharge table. It is used to calibrate the discharge algorithm for the adopted battery. See paragraph 9.10.
BAT. MAX ADJ. (T, TM, P, CO)	-12.8% ÷ 12.7% (by steps of 0.1%)	This parameter defines the maximum level of the battery-discharge table. It is used to calibrate the discharge algorithm for the adopted battery. See paragraph 9.10.
BDI ADJ STARTUP (T, TM, P, CO)	-12.8% ÷ 12.7% (by steps of 0.1%)	This parameter defines the start-up level of the battery-charge table, in order to evaluate the battery charge at key-on. See paragraph 9.10.
BDI RESET (T, TM, P, CO)	0% ÷ 100% (by 1% steps)	This parameter defines the minimum variation of the battery-discharge table to update the battery percentage at start-up. It is used to calibrate the discharge algorithm for the adopted battery. See paragraph 9.10.
BATT.LOW TRESHLD (T, TM, P, CO)	1% ÷ 50% (by 1% steps)	This parameter defines the minimum charge percentage under which the BATTERY LOW alarm rises.
BAT.ENERGY SAVER (A)	OFF, ON	When this parameter is ON, the control saves the battery charge when it is below a certain charge threshold, through a motor-torque reduction.
STEER RIGHT VOLT (T,TM)	0 V ÷ 25.5 V (by steps of 0.1 V)	This parameter records the maximum steering-control voltage while turning right. See paragraph 9.3.
STEER LEFT VOLT (T,TM)	0 V ÷ 25.5 V (by steps of 0.1 V)	This parameter records the maximum steering-control voltage while turning left. See paragraph 9.3.
STEER ZERO VOLT (T,TM)	0 V ÷ 25.5 V (by steps of 0.1 V)	This parameter records the maximum steering-control voltage when it is in the straight-ahead position See paragraph 9.3.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
MAX ANGLE RIGHT (T,TM)	0° ÷ 90° (by steps of 1°)	This parameter defines the maximum steering-wheel angle while turning right.
MAX ANGLE LEFT (T,TM)	0° ÷ 90° (by steps of 1°)	This parameter defines the maximum steering-wheel angle while turning left.
STEER DEAD ANGLE (T, TM)	1° ÷ 50° (by steps of 1°)	This parameter defines the maximum steering-wheel angle up to which the permitted traction speed is 100%. See paragraph 9.7.
STEER ANGLE 1 (T, TM)	1° ÷ 90° (by steps of 1°)	This parameter defines the steering-wheel angle at which traction speed is reduced to the value imposed by CURVE SPEED 1. For steering-wheel angles between STEER DEAD ANGLE and STEER ANGLE 1, traction speed is reduced linearly from 100% to CURVE SPEED 1. See paragraph 9.7.
STEER ANGLE 2 (T, TM)	1° ÷ 90° (by steps of 1°)	This parameter defines the steering-wheel angle beyond which traction speed is reduced to CURVE CUTBACK. For steering-wheel angles between STEER ANGLE1 and STEER ANGLE 2 traction speed is reduced linearly from CURVE SPEED 1 to CURVE CUTBACK. See paragraph 9.7.
SPEED FACTOR (T, TM, CO)	0 ÷ 255	This parameter defines the coefficient used for evaluating the truck speed (in km/h) from the motor frequency (in Hz), according to the following formula: $Speed\ [km/h] = 10 \cdot \frac{frequency\ [Hz]}{Speed\ factor}$
SPEED ON MDI (T, TM, CO)	OFF, ON	This parameter enables or disables the speed visualization on MDI display: **ON =** MDI shows traction speed when the truck is moving. In steady-state condition the speed indication is replaced by the hour-meter indication. **OFF =** Standard MDI functionality.
LOAD HM FROM MDI (T, TM, P, CO)	OFF, ON	This parameter enables or disables the transfer of the hour-meter to a MDI unit. **OFF =** controller hour meter is not transferred and recorded on the MDI hour meter. **ON =** controller hour meter is transferred and recorded on the MDI hour meter (connected via the Serial Link).
CHECK UP DONE (T, TM, P, CO)	OFF, ON	In order to cancel the CHECK UP NEEDED warning, set this parameter ON after the required maintenance service.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
CHECK UP TYPE (T, TM, P, CO)	NONE ÷ OPTION#3	This parameter defines the CHECK UP NEEDED warning: **NONE =** no CHECK UP NEEDED warning. **OPTION#1 =** CHECK UP NEEDED warning shown on the hand-set and MDI after 300 hours. **OPTION#2 =** like OPTION#1, plus speed reduction intervenes after 340 hours. **OPTION#3 =** like OPTION#2, plus the truck definitively stops after 380 hours.
MC VOLTAGE (A)	0% ÷ 100% (by 1% steps)	This parameter defines the percentage of MC VOLTAGE applied to the main-contactor during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED. (A)	0% ÷ 100% (by 1% steps)	This parameter defines the percentage of MC VOLTAGE applied to the main-contactor after the first second of activation of the contactor. For details and examples see paragraph 9.9
EB VOLTAGE (A)	0% ÷ 100% (by 1% steps)	This parameter the percentage of EB VOLTAGE applied to the electromechanical brake during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED. (A)	0% ÷ 100% (by 1% steps)	This parameter defines the percentage of EB VOLTAGE applied to the electromechanical brake after the first second since when the electromechanical brake is released. For details and examples see paragraph 9.9**Errore. L'origine riferimento non è stata trovata.**
PWM EV2 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV2 output (A25).
PWM EV3 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV3 output (A34).
MAX. MOTOR TEMP. (T, TM, P, CO)	60 °C ÷ 175 °C (by steps of 1 °C)	This parameter defines the motor temperature above which a linear cutback is applied to the maximum current. See paragraph 9.14 for more details. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
STOP MOTOR TEMP. (T, TM, P, CO)	60 °C ÷ 190 °C (by steps of 1 °C)	This parameter defines the upper limit of the linear cutback applied for motor temperatures starting from MAX. MOTOR TEMP. It also determines the motor temperature above which a cutback equal to MOT.T. T.CUTBACK is applied to the maximum current. See paragraph 9.14 for more details. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
A.SENS.MAX SE (A – Only sin/cos customized HW)	Volt	This parameter records the maximum offset voltage at the sine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET SR entry value.
A.SENS.MIN SE (A – Only sin/cos customized HW)	Volt	This parameter records the minimum offset voltage at the sine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET SR entry value.
A.SENS.MAX CE (A – Only sin/cos customized HW)	Volt	This parameter records the maximum offset voltage at the cosine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET CR entry value.
A.SENS.MIN CE (A – Only sin/cos customized HW)	Volt	This parameter records the minimum offset voltage at the cosine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET CR entry value.
MOT.T. T.CUTBACK (A)	0% ÷ 100% (255 steps)	This parameter defines the current cutback applied when motor temperature is above STOP MOTOR TEMP or when errors THERMIC SENS KO or SENS MOT TEMP KO occur. Current cutback is expressed as a percentage of the current (torque) profile versus speed. By setting 100%, reduction has no effect; by setting 0%, reduction is total.
VACC SETTING (A)	Volt	See the PROGRAM VACC procedure in paragraphs 9.1, 13.1.4 and 13.2.6.

8.2.4 SPECIAL ADJUST.

In the SPECIAL ADJUST. list there are only factory-adjusted parameters. They are intended to be managed by skilled technicians only: if you are not, please keep your hands off. For entering this Zapi hidden menu, a special procedure is required. Ask for this procedure directly to a Zapi technician.

SPECIAL ADJUST.		
Parameter	**Allowable range**	**Description**
ADJUSTMENT #01 **(Read Only)** (A)	0% ÷ 255% (by 1% steps)	(Factory adjusted). Gain of the first traction-motor current-sensing amplifier. NOTE: only Zapi technicians can change this value through a special procedure.
ADJUSTMENT #02 **(Read Only)** (A)	0% ÷ 255% (by 1% steps)	(Factory adjusted). Gain of the second traction-motor current-sensing amplifier. NOTE: only Zapi technicians can change this value through a special procedure.

<table>
<tr><th colspan="3">SPECIAL ADJUST.</th></tr>
<tr><th>Parameter</th><th>Allowable range</th><th>Description</th></tr>
<tr><td>CURR. SENS. COMP
(A)</td><td>OFF, ON</td><td>(Factory adjusted). This parameter enables or disables the linear compensation for the current sensors.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>DIS.CUR.FALLBACK
(A)</td><td>OFF, ON</td><td>This parameter disables or enables current reduction (applied after one minute of traction).
ON = current reduction is disabled.
OFF = current reduction is enabled.</td></tr>
<tr><td>SET CURRENT
(Read Only)
(A)</td><td>450A ÷ 650A</td><td>(Factory adjusted). This parameter defines the nominal maximum current that the inverter can provide to the motor, in A_{RMS}.
Available values are:
<table>
<tr><td>36V controllers</td><td>900 A_{RMS}</td><td>1000 A_{RMS}</td></tr>
<tr><td>48V controllers</td><td>800 A_{RMS}</td><td>875 A_{RMS}</td></tr>
<tr><td>72/80V controllers</td><td>700 A_{RMS}</td><td></td></tr>
</table></td></tr>
<tr><td>SET TEMPERATURE
(A)</td><td>0 °C ÷ 255 °C
(by 1 °C steps)</td><td>(Factory adjusted).
This parameter calibrates the controller-temperature reading.</td></tr>
<tr><td>HW BATTERY RANGE
(Read Only)
(T, TM, P, CO)</td><td>0 ÷ 3</td><td>This parameter defines the battery voltage range. Reserved.
NOTE: only Zapi technicians can change this value.</td></tr>
<tr><td>DUTY PWM CTRAP
(Read Only)
(A)</td><td>0% ÷ 100%</td><td>(Factory adjusted). This parameter defines the duty-cycle of the overcurrent-detection circuit, i.e. its level of intervention. Reserved.
NOTE: only Zapi technicians can change this value.</td></tr>
<tr><td>PWM AT LOW FREQ
(A)</td><td></td><td>This parameter defines the power-bridge PWM frequency at low speed.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>PWM AT HIGH FREQ
(A)</td><td></td><td>This parameter defines the power-bridge PWM frequency at high speed.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>FREQ TO SWITCH
(A)</td><td>Volt</td><td>(Factory adjusted). This parameter defines the electrical frequency at which the switching frequency is changed from PWM AT LOW FREQ to PWM AT HIGH FREQ.</td></tr>
<tr><td>DITHER AMPLITUDE
(A)</td><td>0% ÷ 13%</td><td>This parameter defines the amplitude of the dither signal added to the proportional-valve set-point, which improves the response to variations of the set-point. This parameter is a percentage of the valve maximum current. Setting the parameter to 0% results in not applying the dither.
Available values are:
0.0%, 1.0%, 2.5%, 4.0%, 5.5%, 7.0%, 8.5%, 10%, 11.5%, 13.0%</td></tr>
</table>

SPECIAL ADJUST.		
Parameter	**Allowable range**	**Description**
DITHER FREQUENCY (A)	20.8 Hz ÷ 83.3 Hz	This parameter defines the dither frequency. Available values are: **20.8, 22.7, 25, 27.7, 31.2, 35.7, 41.6, 50, 62.5, 83.3**
HIGH ADDRESS (A)	0 ÷ 4	This parameter is used to access special memory addresses. Reserved. NOTE: only Zapi technicians can change this value.
CAN BUS SPEED (A)	20 kbps ÷ 500 kbps	This parameter defines the CAN bus data-rate in kbps. Available values are: **20, 50, 125, 250, 500**
EXTENDED FORMAT (A)	OFF, ON	This parameter defines the CAN bus protocol.
DEBUG CANMESSAGE (A)	OFF, ON	This parameter enables or disables special debug messages. Reserved.
CONTROLLER TYPE (A)	0 ÷ 15	This parameter defines the controller type: **0 =** Traction AC **1 =** Pump AC **2 =** CAN OPEN AC **3 =** Dual traction AC (master) **4 =** Dual traction AC (slave) **5 =** Traction brushless **6 =** Pump brushless **7 =** CAN OPEN brushless **8 =** Dual traction brushless (master) **9 =** Dual traction brushless (slave) **10 =** Multi-motor traction AC (slave 2) **11 =** Multi-motor traction AC (slave 3) **12 =** Multi-motor traction brushless (slave 2) **13 =** Multi-motor traction brushless (slave 3) **14 =** Gen. set AC (slave 2) **15 =** Gen. set brushless (slave 3) NOTE: a mismatch between this parameter and the hardware configuration may lead to a severe malfunctioning of the controller.

SPECIAL ADJUST.		
Parameter	**Allowable range**	**Description**
SAFETY LEVEL (T, TM, P, CO)	0 ÷ 3	This parameter defines the safety level of the controller, i.e. the functionality of the supervisor microcontroller. **0 =** supervisor µC does not check any signal. **1 =** supervisor µC checks the inputs and the outputs. **2 =** supervisor µC checks the inputs and the motor set-point. **3 =** supervisor µC checks the inputs, the outputs and the motor set-point.
RS232 CONSOLLE (A)	OFF ÷ ON	This parameter enables or disables the console to change settings. Reserved. NOTE: only Zapi technicians can change this value.
ID CANOPEN OFST (CO)	0 ÷ 56 (by steps of 8)	This parameter defines the offset of the CANopen frame IDs.
2ND SDO ID OFST (A)	0 ÷ 126 (by steps of 2)	This parameter defines if another SDO communication channel has to be added. Specify an ID offset different from 0 in order to enable the channel.
VDC START UP LIM (T, TM, P, CO)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of the nominal voltage) above which delivered power is reduced in order to avoid an overvoltage condition during braking.
VDC UP LIMIT (T, TM, P, CO)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of the nominal voltage) above which the inverter stops and gives a LOGIC FAILURE#1 alarm in order to avoid a damaging overvoltage condition.
VDC START DW LIM (T, TM, P, CO)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of nominal voltage) below which delivered power is reduced in order to avoid an undervoltage condition (typically during accelerations with low battery).
VDC DW LIMIT (T, TM, P, CO)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of nominal voltage) below which the inverter stops and gives a LOGIC FAILURE#3 alarm in order to avoid an uncontrolled shutdown due to an undervoltage condition.

8.2.5 HARDWARE SETTINGS

The HARDWARE SETTINGS parameters group includes the motor-control-related parameters. Only those parameters the user can modify are here described.

For description and teaching about missing parameters contact Zapi technicians.

HARDWARE SETTINGS		
Parameter	**Allowable range**	**Description**
TOP MAX SPEED (T, TM, P, CO)	0 Hz ÷ 600 Hz (by steps of 10 Hz)	This parameter defines the maximum motor speed.
CONF.POSITIVE LC (A)	0 ÷ 2	This parameter defines the positive supply configuration for the main-contactor coil. **0 =** it is connected to PEB A17 (A27). **1 =** it is connected to KEY A1 (A3). **2 =** it is connected to SEAT input A6 (A8).
FEEDBACK SENSOR (A)	0 ÷ 4	This parameter defines the type of the adopted speed sensor. **0 =** incremental encoder **1 =** sin/cos sensor **2 =** incremental encoder + sin/cos sensor **3 =** incremental encoder + sin/cos sensor + index **4 =** PWM absolute sensor + incremental encoder + index **5 =** resolver
TORQUE CONTROL (A)	OFF, ON	This parameter defines the type of control algorithm performed by the inverter. **OFF =** speed control is performed; accelerator input is interpreted as the speed reference. **ON =** torque control is performed; accelerator input is interpreted as the torque reference. See paragraphs 6.4 and 6.5.
ROTATION CW ENC (A)	OPTION#1, OPTION#2	This parameter defines the configuration of the encoder. **OPTION#1 =** channel A anticipates channel B **OPTION#2 =** channel B anticipates channel A
ROTATION CW MOT (A)	OPTION#1, OPTION#2	This parameter defines the sequence of the motor phases. **OPTION#1 =** U-V-W corresponds to forward direction. **OPTION#2 =** V-U-W corresponds to forward direction.

HARDWARE SETTINGS		
Parameter	**Allowable range**	**Description**
ENCODER PULSES 1 (T, TM, P, CO)	32 ÷ 1024	This parameter defines the number of encoder pulses per revolution. It must be set equal to ENCODER PULSES 2; otherwise the controller raises an alarm. The available options are: **32, 48, 64, 80, 64, 128, 256, 512, 1024** **NOTE: with standard HW the capability to use encoders with high number of pulses could be limited depending on the speed. Ask to Zapi technicians before changing this parameter.**
ENCODER PULSES 2 (T, TM, P, CO)	32 ÷ 1024	This parameter defines the number of encoder pulses per revolution. It must be set equal to ENCODER PULSES 1; otherwise the controller raises an alarm. The available options are: **32, 48, 64, 80, 64, 128, 256, 512, 1024** **NOTE: with standard HW the capability to use encoders with high number of pulses could be limited depending on the speed. Ask to Zapi technicians before changing this parameter.**
MOTOR P. PAIRS 1 (T, TM, P, CO)	1 ÷ 30	This parameter defines the number of pole pairs of the traction motor. It must be set equal to MOTOR P. PAIRS 2; otherwise the controller raises an alarm.
MOTOR P. PAIRS 2 (T, TM, P, CO)	1 ÷ 30	This parameter defines the number of pole pairs of the traction motor. It must be set equal to MOTOR P. PAIRS 1; otherwise the controller raises an alarm.

8.2.6 HYDRO SETTING

HYDRO SETTING		
Parameter	**Allowable range**	**Description**
HYDRO TIME (A)	0 s ÷ 20 s (steps of 0.1 s)	This parameter defines the delay time between the release of the hydraulic-function request and the actual stop/release of the associated output, according to the HYDRO FUNCTION setting and the HW configuration.
HYDRO FUNCTION (A)	NONE ÷ OPTION #2	This parameter defines how the pump feeding hydraulics is managed. **NONE =** no hydraulic functions are present; **KEYON =** ACE4 constantly drives the pump motor from key-on. **RUNNING =** ACE4 drives the pump motor only upon an associated request (for example a lift request). **OPTION #1 =** ACE4 does not drive the pump motor, but the truck integrates hydraulics and ACE4 acts as master controller managing a valve. The output that drives the hydraulic valve (for example EVP) is activated at key-on. **OPTION #2 =** like OPTION#1, except the valve is driven only upon request.

8.3 TESTER function

The TESTER function gives real-time feedbacks about the state of controller, motor and command devices. It is possible to know the state (active/inactive) of the digital I/Os, the voltage value of the analog inputs and the state of the main variables used for the motor and hydraulics control.
In the following tables, “Parameter” columns also report between brackets lists of the controller types where each parameter is available.
Controller types are coded as:

A = All controller types
T = Traction controller (in single-motor applications)
TM = Traction master controller (in multiple-motor applications)
TS = Traction secondary controller (in multiple-motor applications)
P = AC pump controller
CO = CANopen controller
N = none

References to connector pins are coded as:

- Red colored: pin of the 23-poles Ampseal connector of ACE4 Standard.
- Blue colored: pin of the 35-poles Ampseal connector of ACE4 Premium.

8.3.1 Master microcontroller

The following table lists the master microcontroller data that can be monitored through the TESTER function.

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
KEY VOLTAGE (A)	Volt (0.1 V)	Key voltage measured in real time on pin A1 (A3).
BATTERY VOLTAGE (A)	Volt (0.1 V)	Battery voltage measured in real time (across the DC bus).
MOTOR VOLTAGE (A)	Percentage (1%)	Theoretical phase-to-phase voltage to be applied at the motor terminals, as a percentage of the supply voltage. The actual applied voltage is changed by INDEX OVERMOD. (see next item).
INDEX OVERMOD. (A)	Percentage (1%)	Correction applied to the motor-voltage set-point in order to compensate for the actual battery voltage. The actual motor voltage delivered is the product of MOTOR VOLTAGE and INDEX OVEMOD. .
FREQUENCY (A)	Hertz (0.1 Hz)	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED (A)	Hertz (0.1 Hz)	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
SLIP VALUE (A)	Hertz (0.01 Hz)	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS (A)	Ampere (1 A)	Root-mean-square value of the line current supplied to the motor. $Current\ [Arms] = \sqrt{{I_Q}^2 + {I_D}^2}$
IMAX LIM. TRA **(A)**	Ampere (1 A)	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc…).
IMAX LIM. BRK (A)	Ampere (1 A)	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc…).
ID FILTERED RMS (A)	Ampere (1 A)	Projection of the current vector on the d-axis, expressed in root-mean-square Ampere.
IQ FILTERED RMS (A)	Ampere (1 A)	Projection of the current vector on the q-axis, expressed in root-mean-square Ampere.
IQIMAX LIM. TRA (A)	Ampere (1 A)	Maximum value of the q-axis current component, according to traction-related settings, expressed in root-mean-square Ampere.
IQIMAX LIM. BRK (A)	Ampere (1 A)	Maximum value of the q-axis current component, according to braking-related settings, expressed in root-mean-square Ampere.
MOT. POWER WATT (A)	Watt (1 W)	Estimation of the power supplied to the motor.
STATOR FLUX MWB (A)	10^{-3} Weber (0.1 mWb)	Estimation of the motor magnetic flux.
MOTION TORQUE NM (A)	Nm (0.1 Nm)	Estimation of the motor torque.
DC BUS CURRENT (A)	Ampere (1 A)	Estimation of the DC current the inverter is drawing from the battery.
STEER ANGLE (T, TM)	Degrees (1°)	Current steering-wheel angle. When the steering is straight ahead STEER ANGLE is zero.
BATTERY CHARGE (A)	Percentage (1%)	Residual battery charge as percentage of the full charge.

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
TEMPERATURE (A)	Celsius degrees (1 °C)	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT. (A)	Celsius degrees (1 °C)	Motor-windings temperature. Normally the sensor is a PTC Philips KTY84-130. This temperature is used for the MOTOR OVERTEMP alarm.
DI3 TILLER SW **(T, TM)**	OFF/ON	Status of the TILLER/SEAT input A6 (A8).
DI2 QI/PB SW **(T, TM)**	OFF/ON	Status of the Pedal-Brake/Quick-Inversion input A11 (A17)
DI0 FW SW **(T, TM, TS)**	OFF/ON	Status of the forward-request input A4 (A6).
DI1 BW SW **(T, TM)**	OFF/ON	Status of the backward-request input A5 (A7).
DI6 LOWER **(T, TM)**	OFF/ON	Status of the lowering-request input (A11).
DI8 AUX3 **(T, TM)**	OFF/ON	Status of the AUX3 input (A14) that enables EV3.
DI5 AUX1 **(T, TM)**	OFF/ON	Status of the AUX1 input (A2) that enables EV1.
DI7 AUX2 **(T, TM)**	OFF/ON	Status of the AUX2 input (A12) that enables EV2.
DI4 SR/HB **(T, TM)**	OFF/ON	Status of the Speed-Reduction/Hand-Brake input A13 (A19).
DI9 FW-INCH **(TS)**	OFF/ON	Status of the forward-inching input (A22).
DI10 BW-INCH **(TS)**	OFF/ON	Status of the backward-inching input (A23).
DI0 SEAT SW **(P)**	OFF/ON	Status of the TILLER/SEAT input A6 (A8).
DI9 SPD1 SW **(P)**	OFF/ON	Status of the 1ST-speed input (A22).
DI2 HYDRO SW **(P)**	OFF/ON	Status of the hydraulic-steering input A11 (A17).

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
DI0 LFT/E SW (P)	OFF/ON	Status of the lift-request input A4 (A6).
DI1 LOWER SW (P)	OFF/ON	Status of the lowering-request input A5 (A7).
DI10 SPD2 SW (P)	OFF/ON	Status of the 2ND-speed input (A23).
DI6 FREE (P)	OFF/ON	Status of the free input (A11).
DI5 SPD3 SW (P)	OFF/ON	Status of the 3RD-speed input (A2).
DI7 SPD4 SW (P)	OFF/ON	Status of the 4TH-speed input (A12).
DI8 SPD5 SW (P)	OFF/ON	Status of the 5TH speed input (A14).
DI4 CUTBAC1 (P)	OFF/ON	Status of the speed-reduction input A13 (A19).
NODE ID (CO)	0 ÷ 56	Node ID setting for CANopen Protocol
TARGET SPEED (CO)	10 Hertz (1 daHz)	Speed setpoint transmitted over CANopen protocol in tens of Hz.
BRAKING REQUEST (CO)	0 – 255	Braking setpoint transmitted over CANopen protocol.
CONTROL WORD (CO)	0 – 65535	Control Word transmitted upon CANopen protocol.
STATUS WORD (CO)	0 – 65535	Status Word travelling upon CANopen protocol.
WARNING SYSTEM (CO)	0 – 65535	In case of warning it shows the related warning code.
TARGET EVP1 (CO)	% (1%)	Setpoint of proportional electrovalve EVP1 in CANopen configuration.
TARGET PUMP (CO)	% (1%)	Setpoint of DC Pump in CANopen configuration.

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
TORQUE REQ. NM **(CO)**	Nm (1 Nm)	Torque setpoint for AC motor in CANopen configuration.
POT#1 **(A)**	Volt (0.01 V)	Voltage of the analog signal on A3 (A5).
POT#2 **(A)**	Volt (0.01 V)	Voltage of the analog signal on A10 (A16).
POT#3 **(A)**	Volt (0.01 V)	Voltage of the analog signal on (A1).
POT#4 **(A)**	Volt (0.01 V)	Voltage of the analog signal on (A13).
SIN FB. INPUT **(Only for BLE4 with sin/cos sensor)** **(A)**	Volt (0.01 V)	Voltage of Sine signal on (A1).
COS FB. INPUT **(Only for BLE4 with sin/cos sensor)** **(A)**	Volt (0. Volt (0.01 V))	Voltage of Cosine signal on (A13).
SET EVP **(A)**	Percentage (1%)	Setpoint of proportional electrovalve EVP.
OUTPUT EV1 **(A)**	OFF/ON	Status of the EV1 output (A24).
OUTPUT EV2 **(A)**	OFF/ON	Status of the EV2 output (A25).
OUTPUT EV3 **(A)**	OFF/ON	Status of the EV3 output (A34).
OUTPUT EV4 **(A)**	OFF/ON	Status of the EV4 output (A35).
MAIN CONT. **(A)**	Percentage (1%)	Voltage applied to the main-contactor output in terms of applied PWM duty cycle.
ELEC.BRAKE **(A)**	Percentage (1%)	Voltage applied to the electromechanical-brake output in terms of applied PWM duty cycle.
CTRAP HW **(A)**	Units (1)	Number of occurrences of hardware overcurrent detection.

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
CTRAP THRESOLD **(A)**	Volt (0.01 V)	Hardware overcurrent threshold voltage.
A.SENS.OFFSET SR **(Only for BLE4 with sin/cos sensor)** **(A)**	Digital units	Offset of the encoder sine signal, acquired during the absolute sensor acquisition automatic procedure.
A.SENS.OFFSET CR **(Only for BLE4 with sin/cos sensor)** **(A)**	Digital units	Offset of the encoder cosine signals, acquired during the absolute sensor acquisition automatic procedure.
ANGLE OFFSET **(Only for BLE4 with sin/cos sensor)** **(A)**	Degrees (1°)	Angle offset between the orientation of the rotor and the position sensor.
ANGLE OFFSET ENC **(Only for BLE4 with encoder)** **(A)**	Degrees (1°)	Angle offset between the orientation of the rotor and the index signal (on an ABI encoder).
ROTOR POSITION **(Only for BLE4)** **(A)**	Degrees (1°)	Absolute orientation of the rotor.
TRUCK SPEED (T, TM, CO)	km/h (0.1 km/h)	Speed of the truck (it requires custom software embedding gear ratio and wheels radius).
ODOMETER KM (T, TM, CO)	km (1km)	Odometer: overall distance traveled by the truck.
CPU TIME F US **(A)**	\	Reserved for Zapi technicians use.
CPU TIME M US **(A)**	\	Reserved for Zapi technicians use.

8.3.2 Supervisor microcontroller

The following table lists the supervisor microcontroller data that can be monitored through the TESTER function.

TESTER menu		
Parameter	**Unit of measure (resolution)**	**Description**
MEASURED SPEED (A)	Hertz (0.1 Hz)	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
DI0 (A)	OFF/ON	Status of the digital input on pin A4 (A6).
DI1 (A)	OFF/ON	Status of the digital input on pin A5 (A7).
DI2 (A)	OFF/ON	Status of the digital input on pin A11 (A17).
DI3 (A)	OFF/ON	Status of the digital input on pin A6 (A8).
DI4 (A)	OFF/ON	Status of the digital input on pin A13 (A19).
DI5 (A)	OFF/ON	Status of the digital input on pin (A2).
DI6 (A)	OFF/ON	Status of the digital input on pin (A11).
DI7 (A)	OFF/ON	Status of the digital input on pin (A12).
DI8 (A)	OFF/ON	Status of the digital input on pin (A14).
DI9 (A)	OFF/ON	Status of the digital input on pin (A22).
DI10 (A)	OFF/ON	Status of the digital input on pin (A23).
POT#1 (A)	Volt (0.01V)	Voltage of the analog signal on pin A3 (A5).
POT#2 (A)	Volt (0.01V)	Voltage of the analog signal on pin A10 (A16).
POT#3 (A)	Volt (0.01V)	Voltage of the analog signal on pin (A1).

8.4 ALARMS logbook

The ALARMS logbook in the MAIN MENU records the alarms occurred on the controller. It has a FIFO (First Input First Output) structure which means that the oldest alarm is lost when the database is full and a new alarm occurs. The logbook is composed of locations where is possible to stack different types of alarms with:

1) The alarm code
2) The number of times that each alarm occurs consecutively
3) The hour-meter value when the last event of every alarm occurred
4) The inverter temperature at the first occurrence of every alarm.

This function permits a deeper diagnosis of problems as the recent history can be revised.

For simple visual diagnoses of system faults and to monitor system status, a red LED is provided on the body of the controller. It is ON at the start-up and then it stays continuously OFF when there is no fault; when there is a fault it flashes several times, with a repeated pattern that identifies a specific alarm (see paragraph 6.7).

Alarms and warnings are fully described in chapter 10.

NOTE: if the same alarm is continuously happens, the controller does not use new memory of the logbook, but only updates the last memory cell increasing the related counter (point 2 of previous list). Nevertheless, the hour-meter value of this record refers to the first time the alarm occurred. In this way, comparing this hour-meter value with that at the present time, it is possible to determine:

- *when this alarm occurred the first time;*
- *how many hours are elapsed from the first occurrence to now;*
- *how many times it has occurred in this period.*

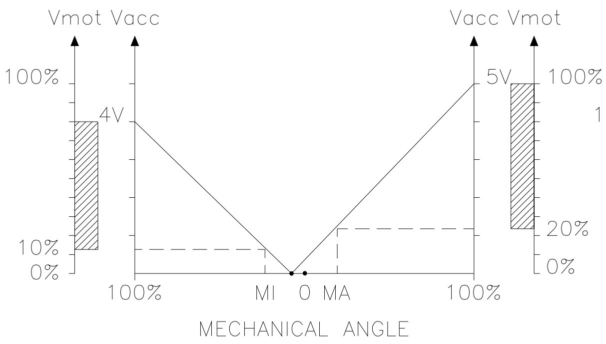
---

9 OTHER FUNCTIONS

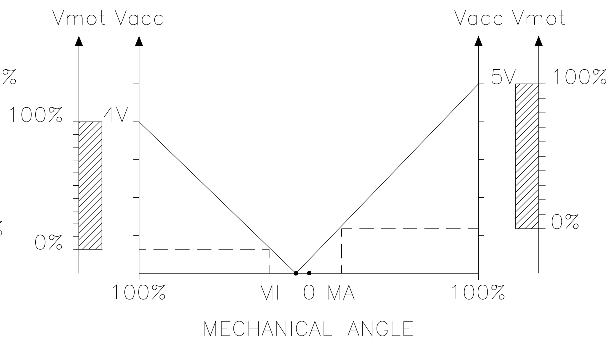
9.1 PROGRAM VACC function

This function enables the adjustment of the minimum and maximum useful levels of the voltage from the accelerator potentiometer, in both directions. This function is particularly useful when it is necessary to compensate for asymmetry of mechanical elements associated with the potentiometer, especially relating to the minimum level.

The following two graphs show the output voltage of a potentiometer versus the mechanical angle of the control lever. Angles MI and MA indicate the points where the direction switches close, while 0 represents the mechanical zero of the lever, i.e. its rest position. Also, the relationship between motor voltage (Vmot) and potentiometer voltage (Vacc) is shown. Before calibration, Vmot percentage is mapped over the default 0 – 5 V range; instead, after the adjustment procedure it results mapped over the useful voltage ranges of the potentiometer, for both directions.



Before 'PROGRAM VACC'



After 'PROGRAM VACC'

PROGRAM VACC can be carried out through Zapi PC CAN Console or through Zapi Smart Console. For the step-by-step procedures of the two cases, refer to paragraphs 13.1.4 and 13.2.6.

9.2 PROGRAM LIFT / LOWER function

This function allows to adjust the minimum and maximum useful signal levels of lift and lowering request. This function is useful when it is necessary to compensate for asymmetry of the mechanical elements associated with the potentiometer, especially relating to the minimum level.

This function looks for and records the minimum and maximum potentiometer wiper voltage over the full mechanical range of the lever.

The values to be acquired are organized in the ADJUSTEMNT list, they are:

- MIN LIFT DC
- MAX LIFT DC
- MIN LOWER
- MAX LOWER

See paragraphs 13.1.5 or 13.2.7 for acquiring procedure.

9.3 PROGRAM STEER function

This enables the adjustment of the minimum and maximum useful signal levels of the steering control. This function is useful when it is necessary to compensate for asymmetry with the mechanical elements associated with the steering.

This function looks for and records the minimum, neutral and maximum voltage over the full mechanical range of the steering. It allows to compensate for dissymmetry of the mechanical system in both directions.

The values to be acquired are organized in the ADJUSTEMNT list, they are:

- STEER RIGHT VOLT
- STEER LEFT VOLT
- STEER ZERO VOLT

See paragraphs 13.1.6 or 13.2.8 for acquiring procedure.

9.4 Acceleration time

The ACCEL DELAY parameter allows to define the acceleration rate depending on the final-speed setpoint and on ACCEL MODULATION.

- **ACCEL MODULATION = OFF**
  Acceleration time can be obtained applying this formula:

$$Accel\ time\ [s] = \frac{Speed\ setpoint\ [Hz]}{100\ Hz} \cdot Acceler\ delay\ [s]$$

- **ACCEL MODULATION = ON**
  Acceleration time is evaluated differently by software for setpoint values above or below 100 Hz.

  Case 1 (black trace in the graph):
  - Final-speed setpoint = 100 Hz
  - ACCEL DELAY = 2,5 s

  Acceleration time results 2.5 s.

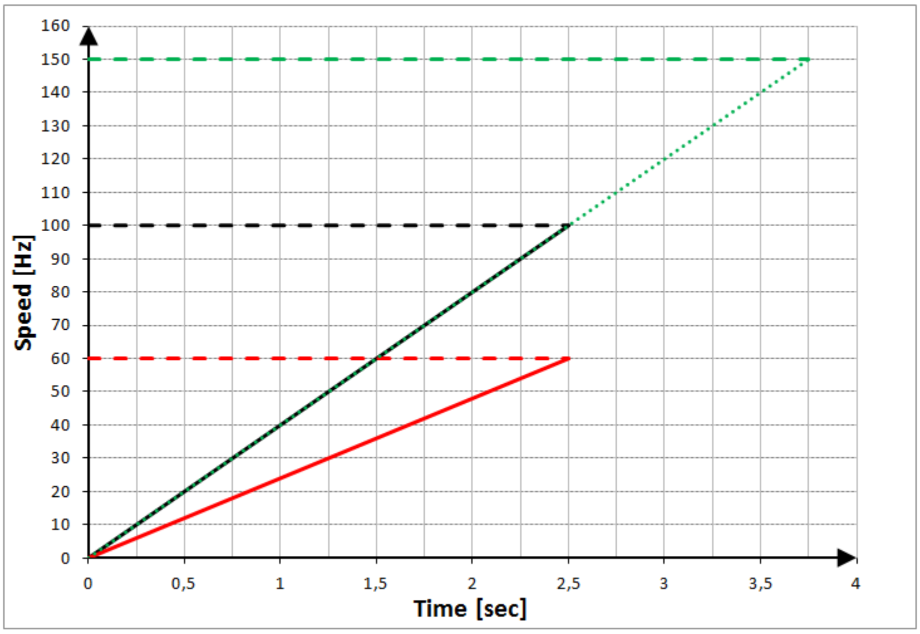
  Case 2 (red trace in the graph):
  - Final-speed setpoint = 60 Hz
  - ACCEL DELAY = 2,5 s

  Acceleration rate is re-scaled so that acceleration time results equal to ACCEL DELAY, in this case 2.5 s.

  Case 3 (green trace in the graph):
  - Final-speed setpoint = 150 Hz
  - ACCEL DELAY = 2,5 s

  Acceleration time results:

$$Accel\ time = \frac{150\ Hz}{100\ Hz} \cdot 2.5\ s = 3{,}75\ s$$



Acceleration time

9.5 Deceleration time

The DECEL. BRAKING parameter allows to define the deceleration rate depending on the final-speed setpoint. Deceleration time is evaluated differently by software for speed steps greater or smaller than 100 Hz.

Case 1 (black trace in the graph):

- Initial speed = 110 Hz
- Final-speed setpoint = 10 Hz
- DECEL. BRAKING = 2,5 s

The deceleration time results 2.5 s.

Case 2 (red trace in the graph):

- Initial speed = 60 Hz
- Final-speed setpoint = 10 Hz
- DECEL. BRAKING = 2,5 s

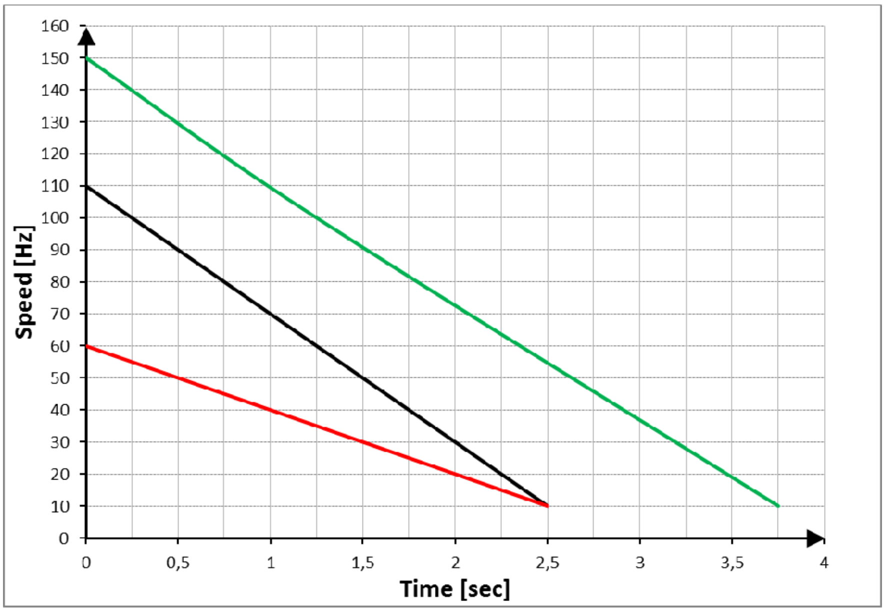
The deceleration rate is re-scaled so that the deceleration time results equal to DECEL. BRAKING, in this case 2.5 s.

Case 3 (green trace in the graph):

- Initial speed = 150 Hz
- Final-speed setpoint = 10 Hz
- DECEL. BRAKING = 2,5 s

The deceleration time results:

$$Decel\ time = \frac{150\ Hz}{100\ Hz} \cdot 2.5\ s = 3{,}75\ s$$

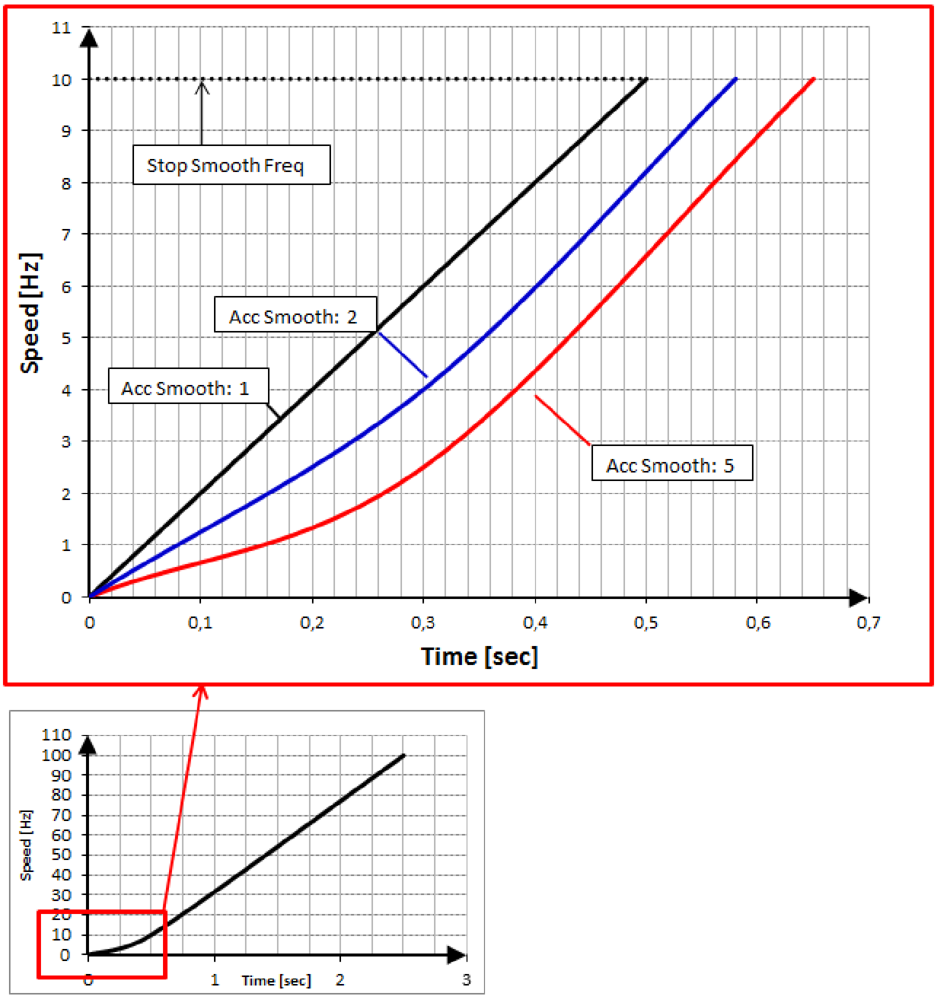


Braking delay

Note: this is valid for all the braking-related parameters: DECEL. BRAKING, INVER. BRAKING, RELEASE BRAKING, TILLER BRAKING, PEDAL BRAKING, SPEED LIMIT BRK, STEER BRAKING.

9.6 Acceleration smoothness

Smoothing-related parameters define a parabolic profile for the acceleration or deceleration ramps close to 0 rpm. Values have not a phisycal meaning: 1 means linear ramp, higher values (up to 5) result in smoother accelerations.



Smoothness

Note: this is valid for ACC SMOOTH, BRK SMOOTH and INV SMOOTH.

9.7 Steering curve

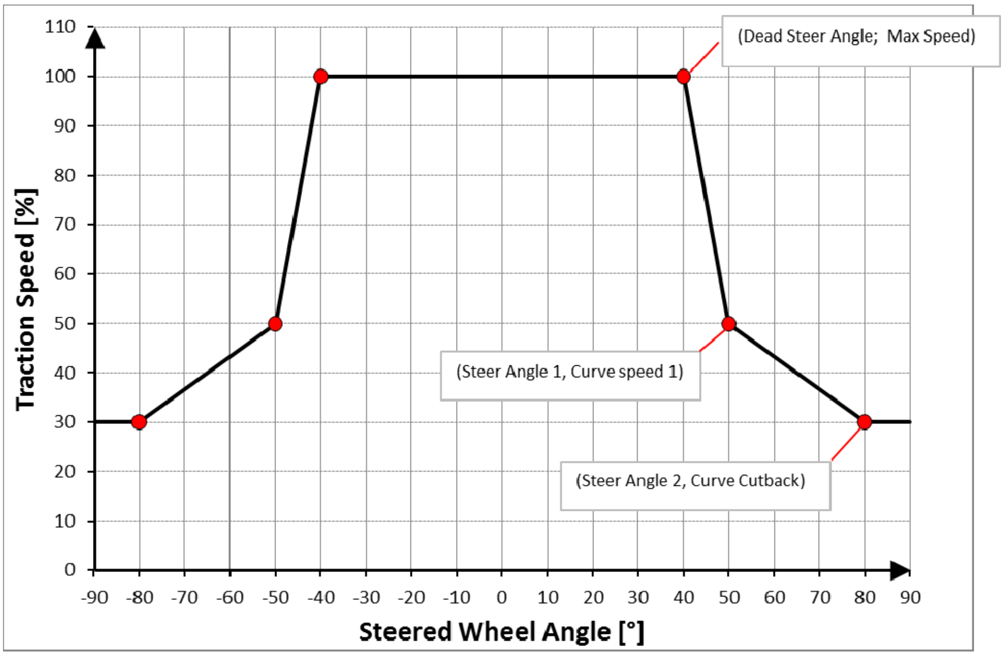
Steering-related parameters (CURVE SPEED 1, CURVE CUTBACK, STEER DEAD ANGLE, STEER ANGLE 1 and STEER ANGLE 2) define a speed-reduction profile dependent on the steering-wheel angle.

The profile is valid both for positive and negative angle values.

Example:

- Three-wheel CB truck
- Permitted steering-wheel angles = -90° ÷ 90°
- CURVE SPEED 1 = 50%
- CURVE CUTBACK = 30%
- STEER DEAD ANGLE = 40°
- STEER ANGLE 1 = 50°
- STEER ANGLE 2 = 80°

This set of parameters define the speed profile depicted in the graph below.



Steering curve

9.8 Throttle response

ACE4 controls the truck speed by means of a not linear function of the accelerator position, as to provide a better resolution of the speed control when the truck is moving slowly.

For the definition of such response, the following parameters are used:

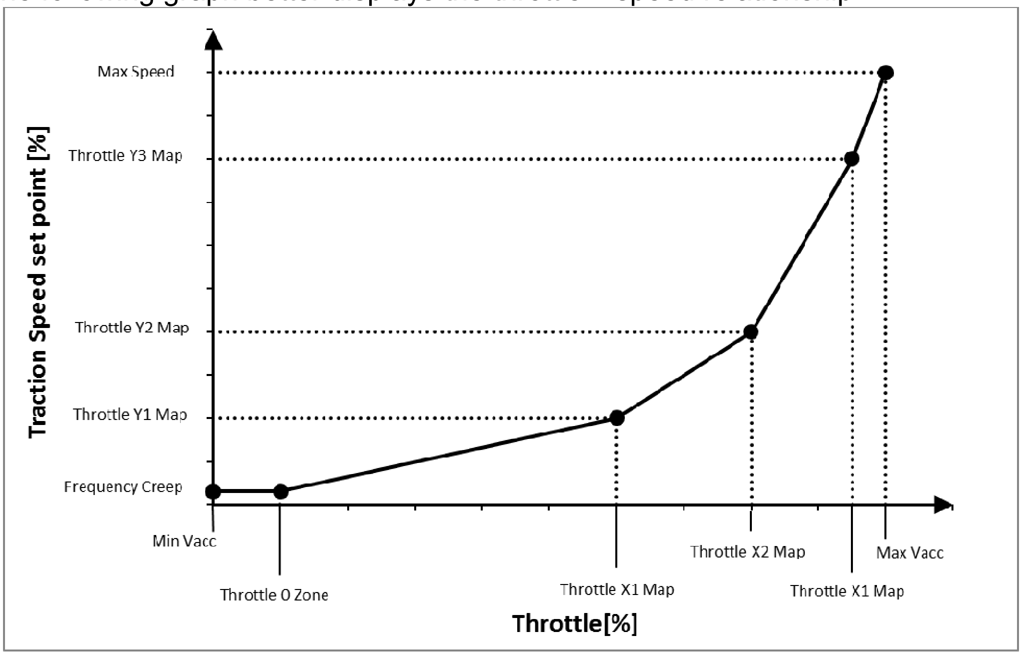
- THROTTLE 0 ZONE [% of MAX VACC]
- THROTTLE X1 POINT [% of MAX VACC]
- THROTTLE Y1 POINT [% of MAX SPEED]
- THROTTLE X2 POINT [% of MAX VACC]
- THROTTLE Y2 POINT [% of MAX SPEED]
- THROTTLE X3 POINT [% of MAX VACC]
- THROTTLE Y3 POINT [% of MAX SPEED]

The speed remains at the FREQUENCY CREEP value as long as the voltage from the accelerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position.

For higher potentiometer voltages, the speed setpoint grows up as a polygonal chain defined by the following table of points.

Throttle signal [% of MAX VACC]	Speed setpoint [% of MAX VACC]
0	FREQUENCY CREEP
THROTTLE 0 ZONE	FREQUENCY CREEP
THROTTLE X1 POINT	THROTTLE Y1 POINT
THROTTLE X2 POINT	THROTTLE Y2 POINT
THROTTLE X3 POINT	THROTTLE Y3 POINT
MAX VACC	MAX SPEED

The following graph better displays the throttle – speed relationship.

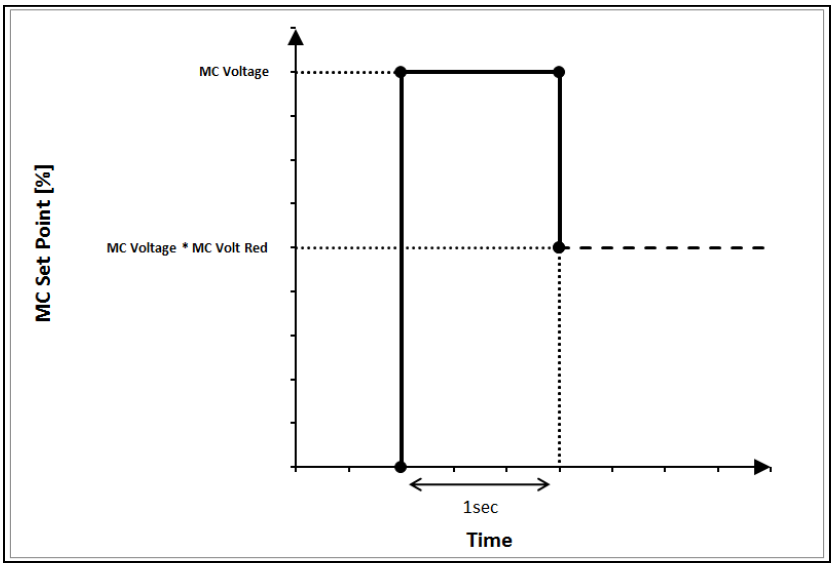


9.9 NLC & NEB output

For the NLC output [or NEB output] there is the possibility to set a pull-in voltage and to define a retention voltage continuously applied to the coil.

MC VOLTAGE [or EB VOLTAGE] parameter specifies the duty cycle applied in the first second after key-on and MC VOLT RED [or EB VOLT RED] determines the duty-cycle applied after that, necessary to keep the contactor closed [or brake disengaged] according to this formula:

$$Final\ duty\ cycle\ [\%] = MC\ VOLTAGE\ \cdot MC\ VOLT\ RED$$



NMC & NEB Output management

<u>Example 1:</u>
MC VOLTAGE = 100%
MC VOLTAGE RED = 70%
Contactor is closed by applying 100% of duty-cycle to the coil and then then it is reduced to 70%.

<u>Example 2:</u>
MC VOLTAGE = 70%
MC VOLTAGE RED. = 100%
Contactor is closed by applying 70% of duty-cycle to the coil and then it is kept at the same value.

<u>Example 3:</u>
MC VOLTAGE = 70%
MC VOLTAGE RED = 70%
Contactor is closed by applying 70% of duty-cycle to the coil and then it is reduced to 49% (70% of 70%).

9.10 Battery-charge detection

During operating condition, the battery-charge detection makes use of two parameters that specify the full-charge voltage (100%) and the discharged-battery voltage (10%): BAT.MAX.ADJ and BAT.MIN.ADJ.

It is possible to adapt the battery-charge detection to your specific battery by changing the above two settings (e.g. if the battery-discharge detection occurs when the battery is not totally discharged, it is necessary to reduce BAT.MIN.ADJ).

Moreover, BDI ADJ STARTUP adjusts the level of the battery charge table at the start-up, in order to evaluate the battery charge at key-on. The minimum variation of the battery charge that can be detected depends on the BDI RESET parameter.

The battery-charge detection works as the following procedure.

<u>Start-up</u>

1) The battery voltage is read from key input when the battery current is zero, which is when the output power stage is not driven. It is evaluated as the average value over a window of time, hereafter addressed as Vbatt.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison a new charge percentage is obtained.
3) The threshold value can be changed with the BDI ADJ STARTUP parameter.
4) If the new charge percentage is within the range “last percentage (last value stored in EEPROM) ± BDI RESET” it is discarded; otherwise charge percentage is updated with the new value.

<u>Operating condition</u>

Measure of the battery voltage, together with the charge percentage at the time of the voltage sampling, give information about the instantaneous battery current.

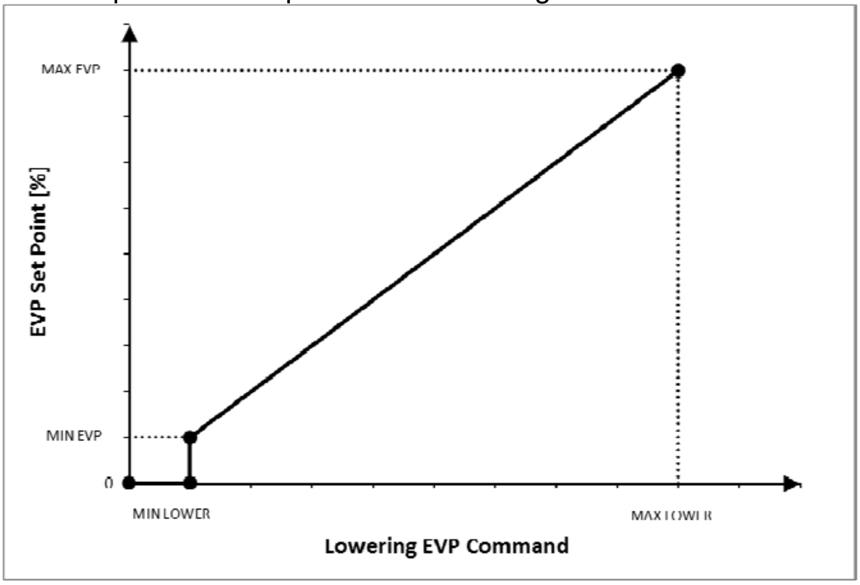
1) The battery voltage is read when the battery current is not zero, which is when the output power stage is driven. Vbatt is evaluated as the average value over a window of time.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison the current provided by the battery is obtained.
3) Current obtained at step 2 integrated over time returns the energy drawn from the battery, in Ah.
4) Charge percentage is dynamically updated basing on the energy from step 3.

Threshold values for the battery charge can be modified by means of BAT.MAX.ADJ. and BAT.MIN.ADJ. as to adapt the battery-charge detection to the specific battery in use.

9.11 EVP control

EVP can be controlled as an analog current-controlled valve or as an on/off valve.

– **EVP TYPE = ANALOG**
  The analog control of the EVP coil is made by means of a linear relationship between the lowering-potentiometer voltage and the set-point for the current applied to the valve. Considering the case when the EVP request refers to the lowering valve, the upper and lower limits of the linear profile are given by MIN LOWER – MIN EVP and MAX LOWER – MAX EVP. Instead, EVP current is kept at zero for potentiometer voltages below MIN LOWER.

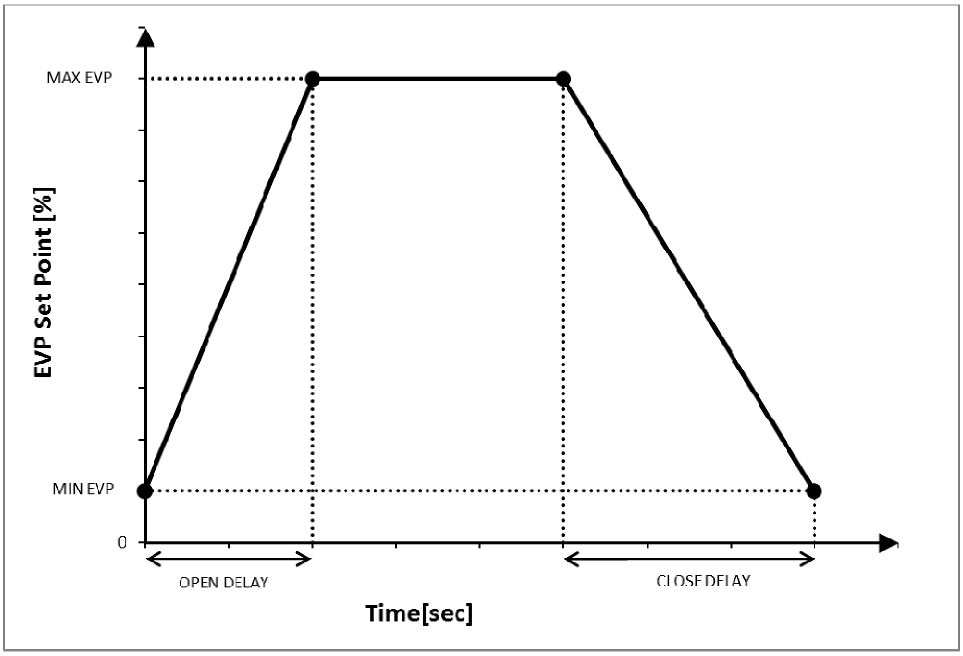


EVP analog control.

– **EVP TYPE = DIGITAL**
  If EVP is set to work as an on/off valve, the MIN EVP parameter is disabled and the current set point applied to the valve is only dependent on MAX EVP.

The dynamic delay of the current set-point variations, for both ANALOG and DIGITAL cases, depends on the EVP OPEN DELAY and EVP CLOSE DELAY parameters (see paragraph 8.2.1):

– OPEN DELAY determines the current increase rate, i.e. it defines the time needed to increase the EVP current from zero up to the maximum.
– CLOSE DELAY determines the current decrease rate, i.e. it defines the time needed to decrease the EVP current from the maximum down to zero



EVP control: evolution over time.

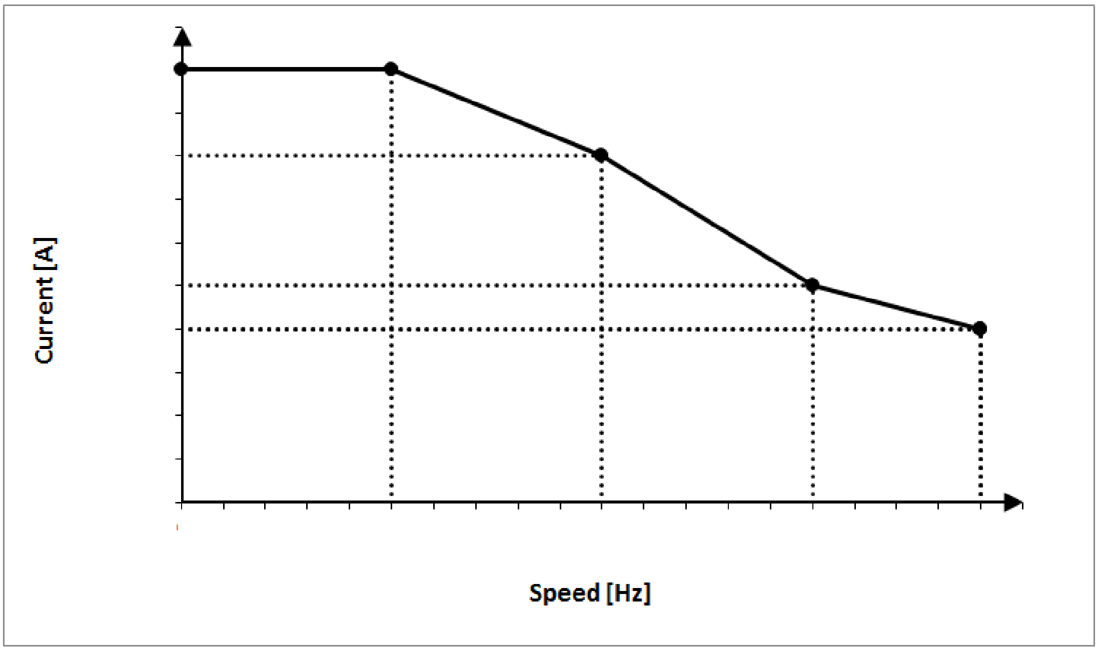
Example 1:
Lowering output is set to be analog and the lowering request consists of a step whose amplitude corresponds to MAX EVP.
The current is first set to the MIN EVP and then it is linearly increased up to MAX EVP for the time set by the OPEN DELAY parameter.
In the same way, when the lowering request is released while the set-point is at the maximum, the current is linearly reduced down to the minimum in a time equal to CLOSE DELAY and, after that transition is completed, it is set to zero.

Example 2:
Lowering output is set to be digital.
As soon as the lowering request is applied, the current is increased from zero to MAX EVP in a time equal to OPEN DELAY.
In the same way, when the lowering request is released, the current set-point is linearly reduced down to zero in a time equal to CLOSE DELAY.

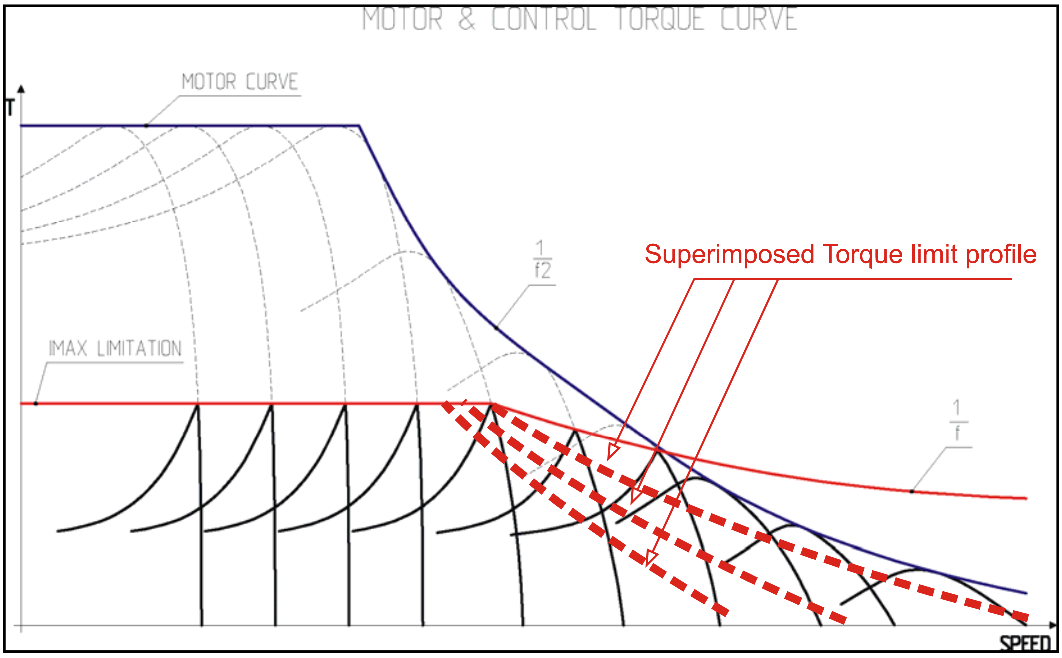
9.12 Torque profile

By setting the proper parameter, it is possible to define a limit for the maximum torque demand (through set points) in the weakening area, for matching two goals:

1. Not overtaking the maximum torque profile of the motor.
2. Superimposing a limiting profile to the maximum torque as to get different drive performances (Eco mode, Medium performance, High performance).



Torque profile



Torque curves

9.13 Steering table

Steering table allows to automatically calibrate the rotation applied to the steering wheels so to obtain the desired steering angle of the truck.

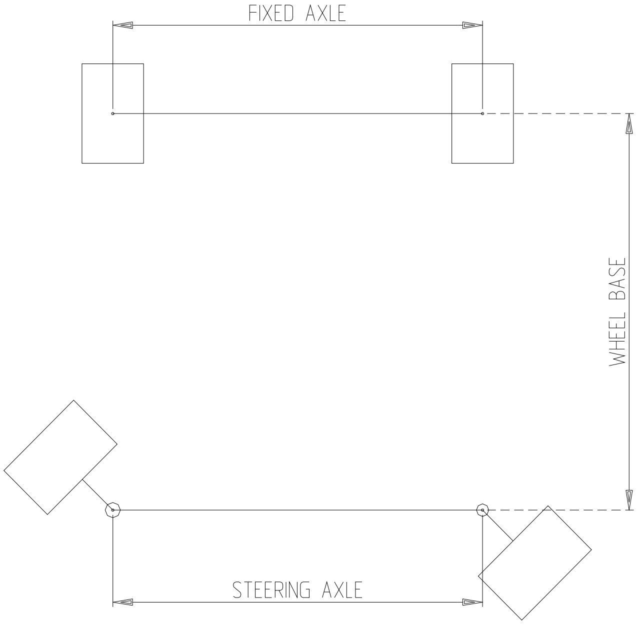
The STEER TABLE parameter defines whether to adopt a custom or predefined steering table:

- **NONE** = custom steering table, according to the following parameters:
  - WHEELBASE MM: distance between the front axle and the rear axle of the truck.
  - FIXED AXLE MM: axle width of the axle where the fixed wheels are.
  - STEERING AXLE MM: axle width of the axle where the steering wheels are.

  All three previous parameters must be expressed in millimeters.

- **OPTION#1** = three-wheels predefined steering table.

- **OPTION#2** = four-wheels predefined steering table



Geometrical steering-related parameters.

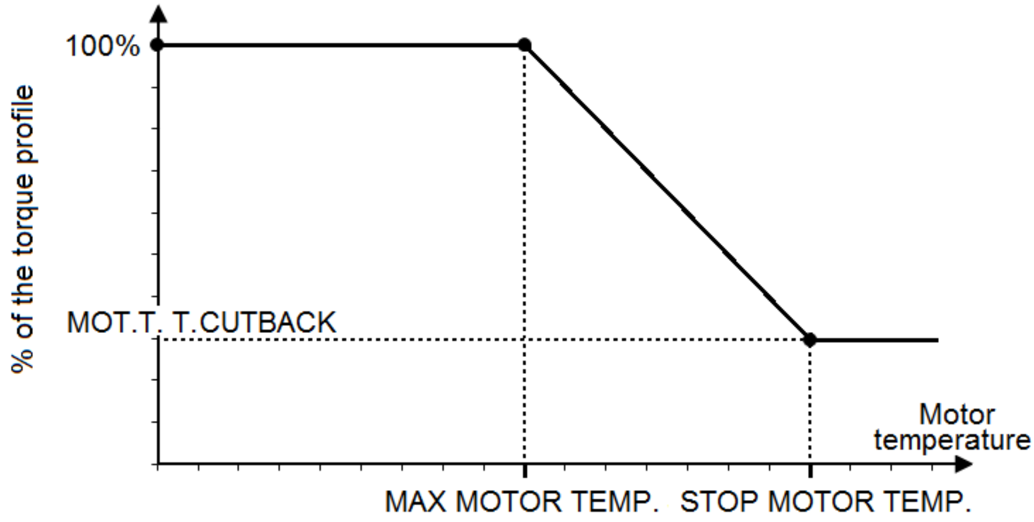
9.14 Motor thermal protection

The controller performs a thermal protection of the driven motor by monitoring its temperature and applying a linear cutback to the maximum current when it becomes excessive.

Thermal protection can be tuned setting parameters MAX. MOTOR TEMP., STOP MOTOR TEMP. and MOT.T. T.CUTBACK in the ADJUSTMENTS list.

A linear reduction is performed for temperatures between MAX. MOTOR TEMP. and STOP MOTOR TEMP. . It acts scaling down the torque profile (see paragraph 9.12) by a percentage from 100% to MOT.T. T.CUTBACK.

When motor temperature reaches STOP MOTOR TEMP., current cutback is fixed to the percentage set in parameter MOT.T. T.CUTBACK.



Cutback is valid only during motoring, instead during braking the 100% of the maximum current is always available regardless the motor temperature.

If the signal from the motor thermal sensor is out of range (for example due to a problem related to the wiring), a cutback equal to parameter MOT.T. T.CUTBACK is applied.

10 FAULTS DIAGNOSTIC SYSTEM

The diagnostic system of ACE4 provides the operator with information about a wide set of faults or problem that the controller can encounter.

- Faults which cause the power section to stop, meaning the power bridge opens and, when possible, the main contactor opens and the electromechanical brake is applied. They can be related to hardware failures that forbid to run the motor or safety-related failures.

- Problems which do not imply to stop the truck or allow to stop it by mean of a controlled regenerative braking. The controller still works, but it has detected conditions that require to stop the truck or at least to reduce its performance.

10.1 Alarms from master µC

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
WAITING FOR NODE	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle	0	0000	224
BATTERY LOW	According to parameter BATTERY CHECK (SET OPTIONS list, paragraph 8.2.3).	Start-up, standby, running	Battery recharge, key re-cycle	0	FF42	66
DATA ACQUISITION	Traction is stopped	Controller calibration	Traction request	0	0000	247
CHECK UP NEEDED		Start-up	Check-up done, key re-cycle	0	0000	249
RPM HIGH	MC is opened, Traction/Pump stopped	Start-up, standby, running		0	FFA1	161
BUMPER STOP	Traction is stopped	Start-up, standby, running		0	FFA2	162
WARNING SLAVE	It depends by the supervisor uC			1	FF01	244
ACQUIRING A.S.		Sensor Acquiring	Key re-cycle	2	FFAB	171
ACQUIRE END		Sensor Acquiring	Key re-cycle	2	FFAD	173
ACQUIRE ABORT		Sensor Acquiring	Key re-cycle	2	FFAC	172
SIN/COS D.ERR	MC is not closed, EB is applied, Traction/Pump, valves stopped	running	Key re-cycle	3	FFA8	168
ENCODER D.ERR	Traction is stopped	running	Key re-cycle	3	FFA9	169
HOME SENS.ERR XX	MC is opened , EB is applied, EVP stopped	Running	Key re-cycle	3	FFB0	176
IMS ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	4	FFA7	167
SHORT CIRCUIT	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	5	FFA6	166
SHORT CIRCUIT KO	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	5	FFA5	165
PWM ACQ.ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	6	FFA4	164

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
ED SLIP MISMATCH	MC is opened, EB is applied, Traction/Pump stopped	Running	Valves or Traction/Pump request	7	FFA3	163
WATCHDOG	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	8	6010	8
EVP DRIVER OPEN	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves request	9	FFF8	240
EVP COIL OPEN	Valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	9	5002	214
EVP DRIV. SHORT.	MC is opened , EB is applied, EVP stopped	Start-up, stand-by, running	Traction/Pump request	9	5003	215
STALL ROTOR	Traction/Pump stopped	Start-up, stand-by, running	Valves or Traction/Pump request	11	FFD3	211
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	12	FFEF	239
EEPROM KO	Controller works using default parameters	Start-up, stand-by, running		13	3610	208
PARAM RESTORE	No effect	Start-up	Traction/Pump request	14	0000	209
SEAT MISMATCH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Valves or Traction/Pump request	15	FFDE	222
HW FAULT EV XX	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	16	FFEE	238
LOGIC FAILURE #3	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump request	17	FF11	17
LOGIC FAILURE #2	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by,	Valves or Traction/Pump request	18	FF12	18
LOGIC FAILURE #1	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	19	5114	19
VKEY OFF SHORTED	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	20	5101	220
COIL SHOR. EVAUX	Valves stopped	EV on	Valve EV request	21	FFF1	241
CONT. DRV. EV XX	Valves stopped	Start-up, stand-by, running	Valves request	21	FFE8	232
DRV. SHOR. EV XX	Valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	21	FFF9	234
LC COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	22	FFE6	230
IQ MISMATCHED	Traction is stopped	Running	Valves or Traction/Pump request	24	FFF5	245
PEV NOT OK	Pump motor stopped, valves stopped	Start-up, stand-by, running	Valves request	25	FFDB	217
IQ MISMATCHED	Traction is stopped	Running	Valves or Traction/Pump request	24	FFF5	245
INIT VMN LOW XX	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	30	3121	207
VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	30	3120	30
INIT VMN HIGH XX	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	31	3111	206

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump request	31	3110	31
HW FAULT XX	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	32	FFE3	227
HW FAULT EB XX	MC is opened, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	34	FFE5	229
POSITIVE LC OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	35	FFD5	213
FIELD ORIENT. KO	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	36	FFFD	253
CONTACTOR CLOSED	MC is not closed (command is not activated), EB is applied, Traction/Pump stopped	Start-up	Valves or Traction/Pump request	37	5442	37
CONTACTOR OPEN	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	38	5441	38
POWER MISMATCH	Traction is stopped, EB is applied, MC is opened	Running	Traction/Pump request	39	FFD4	212
EB. DRIV.SHRT.	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	40	3222	254
WRONG SET BAT	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up		41	3100	251
WRONG KEY VOLT.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up		41	3101	170
EB.DRIV.OPEN	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	42	3224	246
EB. COIL OPEN	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	43	FFD8	216
WAIT MOTOR STILL	MC is not closed, EB is applied, Traction/Pump stopped	Start-up		45	FF9B	155
HANDBRAKE	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/Pump request	46	FFDD	221
MOT.PHASE SH. XX	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Traction/Pump request	47	FFC4	196
THROTTLE PROG.	MC remains closed, EB is applied (the command is released), Traction stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	48	FFF3	243
LIFT + LOWER	Pump is stopped	Start-up, stand-by, running	Pump request	49	FFBB	187
TILLER OPEN	LC opens	Start-up, stand-by, running	Valves or Traction/Pump Request	51	0000	228
STBY I HIGH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by	Valves or Traction/Pump request	53	2311	53
OVERLOAD	MC is not closed, EB is applied, Traction/Pump stopped	Running	Valves or Traction/Pump request	57	FFB4	180
CAPACITOR CHARGE	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	60	3130	60
THERMIC SENS. KO	Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.	Start-up, stand-by, running		61	4211	250
TH. PROTECTION	Traction controller reduces the max current linearly from Imax (85°C) down to 0 A (105°C)	Start-up, stand-by, running		62	4210	62

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
BRAKE RUN OUT	Traction is stopped	Start-up, stand-by, running	or Traction/Pump Request	63	FFCC	204
MOTOR TEMPERAT.	Maximum current is linearly reduced (see paragraph 9.14) and speed is reduced to a fixed value.	Start-up, stand-by, running		65	4110	65
MOTOR TEMP. STOP	EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running		65	FFB2	178
NO CAN WR MSG. XX	No effect	Start-up, stand-by, running		67	8131	229
NO CAN MSG. XX	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	67	8130	248
SENS MOT TEMP KO	Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.	Start-up, stand-by, running		68	4311	218
EPS RELAY OPEN	Traction/Pump motor is stopped	Start-up, stand-by, Running	Valves or Traction/Pump request	70	FFCD	205
WRONG RAM MEM.	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	71	FFD2	210
DRIVER SHORTED	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	74	3211	74
CONTACTOR DRIVER	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	75	3221	75
MC-EF COIL SHOR.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up (immediately after MC closing), stand-by, running	Valves or Traction/Pump request	76	2250	223
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	77	FFCA	202
VACC NOT OK	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/ request	78	FF4E	78
INCORRECT START	Traction/Pump motor is stopped	Start-up, stand-by	Traction request	79	FF4F	79
PUMP INC START	Pump motor is stopped	Start-up, stand-by, running	Pump request	79	FFDB	189
FORW + BACK	Traction is stopped	Start-up, stand-by, running	Traction request	80	FF50	80
SPEED FB. ERROR	MC is opened , EB is applied, EVP stopped	Running	Valves or Traction/Pump request	81	FFAF	175
ENCODER ERROR	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	82	FF52	82
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	83	FF51	181
VACC OUT OF RANGE	Traction/Pump motor is stopped	Start-up, Stand-by, Running	Traction/Pump request	85	FFE2	226
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	88	FFC8	200
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	89	FFE9	233
WRONG SLAVE VER.	MC opened, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	91	FFC5	197
CURRENT GAIN	Controller works, but with low maximum current	Start-up, stand-by		92	6302	236
PARAM TRANSFER	MC stays closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	93	FFC7	199

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
STEER SENS KO	Speed is reduced according to parameter CTB. STEER ALARM (PARAMETER CHANGE list, paragraph 8.2.1)	Start-up, stand-by, running	Return into correct range	95	FFB3	179
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	96	FFFA	237
M/S PAR CHK MISM	MC stays closed, EB is applied, Traction/Pump, valves stopped	Start-up	Save again the parameter and Key re-cycle	97	FFC6	198
TORQUE PROFILE	EB is applied, Traction/Pump motor is stopped	Start-up, stand-by	Valves or Traction/Pump request	98	FFC9	201
CTRAP THRESHOLD	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	99	FFEB	235

10.1.1 Troubleshooting of alarms from master µC

ACQUIRE ABORT *(MDI/LED code = 2)*

Cause:

The acquiring procedure relative to the absolute feedback sensor aborted.

ACQUIRE END *(MDI/LED code = 2)*

Cause:

Absolute feedback sensor acquired.

ACQUIRING A.S. *(MDI/LED code = 2)*

Cause:

Controller is acquiring data from the absolute feedback sensor.

Troubleshooting:

The alarm ends when the acquisition is done.

ANALOG INPUT *(MDI/LED code = 96)*

Cause

This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion.

Troubleshooting

If the problem occurs permanently it is necessary to replace the logic board.

BATTERY LOW *(MDI/LED code = 0)*

Cause:

Parameter BATTERY CHECK is other than 0 (SET OPTION list, paragraph 8.2.2) and battery charge is evaluated to be lower than BATT.LOW TRESHLD (ADJUSTMENTS list, paragraph 8.2.3).

Troubleshooting:

- Check the battery charge and charge it if necessary.
- If the battery is actually charged, measure the battery voltage through a voltmeter and compare it with the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter (ADJUSTMENTS list, paragraph 8.2.3) with the value measured through the voltmeter.

- If the problem is not solved, replace the logic board.

BRAKE RUN OUT *(MDI/LED code = 63)*

Cause:

The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX (ADJUSTMENTS list, paragraph 8.2.3).

Troubleshooting:

- Check the mechanical calibration and the functionality of the brake potentiometer.
- Acquire the minimum and maximum potentiometer values.
- If the alarm is still present, replace the logic board.

BUMPER STOP *(MDI/LED code = 0)*

Cause

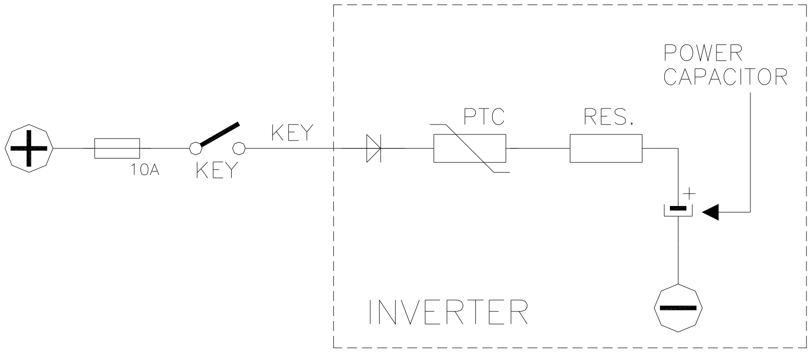
The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if ACE4 is in CAN OPEN configuration (see parameter CONTROLLER TYPE in SPECIAL ADJUST. list, paragraph 8.2.4).

Troubleshooting

- Turn off one or both inputs dedicated to the bumper functionality.
- If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck.
- In case the problem is not solved, replace the logic board.

CAPACITOR CHARGE *(MDI/LED code = 60)*

It is related to the capacitor-charging system:



Cause

When the key is switched on, the inverter tries to charge the power capacitors through the series of a PTC and a power resistance, checking if the capacitors are charged within a certain timeout. If the capacitor voltage results less than a certain percentage of the nominal battery voltage, the alarm is raised and the main contactor is not closed.

Troubleshooting

- Check if an external load in parallel to the capacitor bank, which sinks current from the capacitors-charging circuit, thus preventing the caps from charging well. Check if a lamp or a dc/dc converter or an auxiliary load is placed in parallel to the capacitor bank.
- The charging resistance or PTC may be broken. Insert a power

resistance across line-contactor power terminals; if the alarm disappears, it means that the charging resistance is damaged.
- The charging circuit has a failure or there is a problem in the power section. Replace the controller.

CHECK UP NEEDED *(MDI/LED code = 0)*

Cause:
This is a warning to point out that it is time for the programmed maintenance.

Troubleshooting:
Turn on the CHECK UP DONE option after that the maintenance service.

COIL SHOR. EVAUX *(MDI/LED code = 21)*

Cause:
This alarm occurs when there is an overload of one or more EV driver. As soon as the overload condition has been removed, the alarm disappears by releasing and then enabling a travel demand.

Troubleshooting:
- Check the EVs conditions.
- Check the wiring.
- Collect information about characteristics of EV coils and ask assistance to a Zapi technician.
- If the problem is not solved, replace the logic board.

CONT. DRV. EV XX *(MDI/LED code = 21)*

Cause:
One or more on/off valve drivers are not able to drive the load. For the meaning of code "XX", refer to paragraph 10.3 – Info code for electrovalves.

Troubleshooting:
The device or its driving circuit is damaged. Replace the controller.

CONTACTOR CLOSED *(MDI/LED code = 37)*

Cause
Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the power bridge for several dozens of milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does not decrease by more than a certain percentage of the key voltage, the alarm is raised.

Troubleshooting
It is suggested to verify the power contacts of LC; if they are stuck, is necessary to replace the LC.

CONTACTOR DRIVER *(MDI/LED code = 75)*

Cause
The LC coil driver is not able to drive the load. The device itself or its driver circuit is damaged.

Troubleshooting
This type of fault is not related to external components; replace the logic board.

CONTACTOR OPEN *(MDI/LED code = 38)*

Cause

The LC coil is driven by the controller, but it seems that the power contacts do not close. In order to detect this condition the controller injects a DC current into the motor and checks the voltage on power capacitor. If the power capacitors get discharged it means that the main contactor is open.

Troubleshooting

- LC contacts are not working. Replace the LC.
- If LC contacts are working correctly, contact a Zapi technician.

CONTROLLER MISM. *(MDI/LED code = 12)*

Cause

The software is not compatible with the hardware. Each controller produced is “signed” at the end of line test with a specific code mark saved in EEPROM according to the customized Part Number.
According with this “sign”, only the customized firmware can be uploaded.

Troubleshooting

- Upload the correct firmware.
- Ask for assistance to a Zapi technician in order to verify that the firmware is correct.

CTRAP THRESHOLD *(MDI/LED code = 99)*

Cause

This alarm occurs when a mismatch is detected between the setpoint for the overcurrent detection circuit (dependent on parameter DUTY PWM CTRAP, see paragraph 8.2.4) and the feedback of the actual threshold value.

Troubleshooting

The failure lies in the controller hardware. Replace the logic board.

CURRENT GAIN *(MDI/LED code = 92)*

Cause:

The maximum current gain parameters are at the default values, which means that the maximum current adjustment procedure has not been carried out yet.

Troubleshooting:

Ask for assistance to a Zapi technician in order to do the adjustment procedure of the current gain parameters.

DATA ACQUISITION *(MDI/LED code = 0)*

Cause:

Controller in calibration state.

Troubleshooting:

The alarm ends when the acquisition is done.

DRIVER SHORTED *(MDI/LED code = 74)*

Cause

The driver of the LC coil is shorted.

Troubleshooting
- Check if there is a short or a low impedance pull-down between NLC (A16 (A26)) and -B.
- The driver circuit is damaged; replace the logic board.

DRV. SHOR. EV XX *(MDI/LED code = 21)*

Cause:

One or more on/off valve drivers are shorted. For the meaning of code “XX”, refer to paragraph 10.3 – Info code for electrovalves.

Troubleshooting:
- Check if there is a short circuit or a low impedance path between the negative terminal of the coils and -B.
- If the problem is not solved, replace the logic board.

EB. COIL OPEN *(MDI/LED code = 43)*

Cause:

This fault appears when no load is connected between the output NEB and the EB positive terminal PEB.

Troubleshooting:
- Check the EB coil.
- Check the wiring.
- If the problem is not solved, replace the logic board.

EB. DRIV.OPEN *(MDI/LED code = 42)*

Cause:

The EB coil driver is not able to drive the load. The device itself or its driving circuit is damaged.

Troubleshooting:

This type of fault is not related to external components. Replace the logic board.

EB. DRIV.SHRT. *(MDI/LED code = 40)*

Cause:
- The EB driver is shorted.
- The microcontroller detects a mismatch between the valve setpoint and the feedback at the EB output.

Troubleshooting:
- Check if there is a short or a low impedance path between the negative coil terminal and -B.
- Check if the voltage applied is in accordance with the parameters set (see paragraph 0).
- If the problem is not solved, replace the controller.

ED SPLIP MISMATCH *(MDI/LED code = 7)*

Cause

The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.

EEPROM KO *(MDI/LED code = 13)*

Cause:

A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values.

Troubleshooting:

Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.

ENCODER D.ERR *(MDI/LED code = 3)*

Cause:

This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is the encoder. The A and B pulse sequence is not correct.

Troubleshooting:

- Check the wirings.
- If the motor direction is correct, swap A and B signals.
- If the motor direction is not correct, swap two of the motor cables.
- If the problem is not solved, contact a Zapi technician.

ENCODER ERROR *(MDI/LED code = 82)*

Cause

This fault occurs when the frequency supplied to the motor is higher than 30 Hz and the signal feedback from the encoder has a too high jump in few tens of milliseconds. This condition is related to an encoder failure.

Troubleshooting

- Check the electrical and the mechanical functionality of the encoder and the wires crimping.
- Check the mechanical installation of the encoder, if the encoder slips inside its housing it will raise this alarm.
- Also the electromagnetic noise on the sensor can be the cause for the alarm. In these cases try to replace the encoder.
- If the problem is still present after replacing the encoder, the failure is in the controller.

EPS RELAY OPEN *(MDI/LED code = 70)*

Cause:

The controller receives from EPS information about the safety contacts being open.

Troubleshooting:

Verify the EPS functionality.

EVP COIL OPEN *(MDI/LED code = 9)*

Cause:

No load is connected between the output NEVP and the electrovalve positive terminal.

Troubleshooting:

- Check the EVP condition.

- Check the EVP wiring.
- If the problem is not solved, replace the logic board.

EVP DRIV. SHORT. *(MDI/LED code = 9)*

Cause
- The EVP driver (NEVP output) is shorted.
- The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output.

Troubleshooting
- Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B.
- Collect information about:
    - the voltage applied across the EVP coil,
    - the current in the coil,
    - features of the coil.

Ask for assistance to Zapi in order to verify that the software diagnoses are in accordance with the type of coil employed.
- If the problem is not solved, it could be necessary to replace the controller.

EVP DRIVER OPEN *(MDI/LED code = 9)*

Cause:

The EVP driver (output NEVP) is not able to drive the EVP coil. The device itself or its driving circuit is damaged.

Troubleshooting:

This fault is not related to external components. Replace the logic board.

FIELD ORIENT. KO *(MDI/LED code = 36)*

Cause

The error between the Id (d-axis current) setpoint and the estimated Id is out of range.

Troubleshooting

Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.

FORW + BACK *(MDI/LED code = 80)*

Cause:

This alarm occurs when both the travel requests (FW and BW) are active at the same time.

Troubleshooting:
- Check that travel requests are not active at the same time.
- Check the FW and BW input states through the TESTER function.
- Check the wirings relative to the FW and BW inputs.
- Check if there are failures in the microswitches.
- If the problem is not solved, replace the logic board.

HANDBRAKE *(MDI/LED code = 46)*

Cause:

Handbrake input is active.

Troubleshooting:
- Check that handbrake is not active by mistake.
- Check the SR/HB input state through the TESTER function.
- Check the wirings.
- Check if there are failures in the microswitches.
- If the problem is not solved, replace the logic board.

HOME SENS.ERR XX *(MDI/LED code = 3)*

Cause

The controller detected a difference between the estimated absolute orientation of the rotor and the position of the index signal (ABI encoder). It is caused by a wrong acquisition of the angle offset between the orientation of the rotor and the index signal. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.

Troubleshooting

Repeat the auto-teaching procedure.

HW FAULT EB. XX *(MDI/LED code = 34)*

Cause:

At start-up, the hardware circuit dedicated to enable and disable the EB driver (output NEB) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.

Troubleshooting:

This type of fault is not related to external components. Replace the logic board.

HW FAULT EV. XX *(MDI/LED code = 16)*

Cause:

At start-up, the hardware circuit dedicated to enable and disable the EV drivers is found to be faulty. For the meaning of code "XX", refer to paragraph 10.3 – Info code for electrovalves.

Troubleshooting:

This type of fault is not related to external components. Replace the logic board.

HW FAULT XX *(MDI/LED code = 32)*

Cause

At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver (NLC output) is found to be faulty. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.

Troubleshooting

This type of fault is related to internal components. Replace the logic board.

IMS ERROR *(MDI/LED code = 4)*

Cause

At start-up, the controller checks the presence of IMS board. If the IMS board is not well connected, this alarm appears. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.

Troubleshooting
- Replace the controller

INCORRECT START *(MDI/LED code = 79)*

Cause:

Incorrect starting sequence. Possible reasons for this alarm are:

- A travel demand active at key-on.
- Man-presence sensor active at key on.

Troubleshooting:

- Check wirings.
- Check microswitches for failures.
- Through the TESTER function, check the states of the inputs are coherent with microswitches states.
- If the problem is not solved, replace the logic board.

INIT VMN HIGH XX *(MDI/LED code = 31)*

Cause

Before closing the LC, the software checks the power-bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too high, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase:

81: phase U
82: phase V
83: phase W

Troubleshooting

- Check the motor power cables.
- Check the impedance between U, V and W terminals and -B terminal of the controller.
- Check the motor leakage to truck frame.
- If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.

INIT VMN LOW XX *(MDI/LED code = 30)*

Cause

Before closing the LC, the software checks the power-bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too low, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase:

01: phase U
02: phase V
03: phase W

Troubleshooting

- Check the motor power cables.
- Check the impedance between U, V and W terminals and -B terminal of the controller.
- Check the motor leakage to truck frame.
- If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.

IQ MISMATCHED *(MDI/LED code = 24)*

Cause

The error between the Iq (q-axis current) setpoint and the estimated Iq is out of range.

Troubleshooting
Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.

LC COIL OPEN *(MDI/LED code = 22)*

Cause
This fault appears when no load is connected between the NLC output and the positive voltage (for example +KEY).

Troubleshooting
- Check the wiring, in order to verify if LC coil is connected to the right connector pin and if it is not interrupted.
- If the alarm is still present, than the problem is inside the logic board; replace it.

LIFT+LOWER *(MDI/LED code = 49)*

Cause:
Both the pump requests (LIFT and LOWER) are active at the same time.

Troubleshooting:
- Check that LIFT and LOWER requests are not active at the same time.
- Check the LIFT and LOWER input states through the TESTER function.
- Check the wirings.
- Check if there are failures in the microswitches.
- If the problem is not solved, replace the logic board.

LOGIC FAILURE #1 *(MDI/LED code = 19)*

Cause
This fault is displayed when the controller detects an undervoltage condition at the KEY input. Undervoltage threshold is 11V for 36/48V controllers and 30 V for 72/80V controllers.

Troubleshooting (fault at startup or in standby)
- Fault can be caused by a key input signal characterized by pulses below the undervoltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads.
- If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board.

Troubleshooting (fault displayed during motor driving)
- If the alarm occurs during motor acceleration or when there is a hydraulic-related request, check the battery charge, the battery health and power-cable connections.

LOGIC FAILURE #2 *(MDI/LED code = 18)*

Cause
Fault in the hardware section of the logic board which deals with voltage feedbacks of motor phases.

Troubleshooting
The failure lies in the controller hardware. Replace the controller.

LOGIC FAILURE #3 *(MDI/LED code = 17)*

Cause

A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven.

Troubleshooting

The failure lies in the controller hardware. Replace the controller.

M/S PAR CHK MISM *(MDI/LED code = 97)*

Cause:

At start-up there is a mismatch in the parameter checksum between the master and the supervisor microcontrollers.

Troubleshooting:

Restore and save again the parameters list.

MC-EF COIL SHOR. *(MDI/LED code = 76)*

Cause

This alarm occurs when there is an overload of the MC driver (NLC output) and EB driver (NEB output). As soon as the overload condition disappears, the alarm will be removed automatically by releasing and then enabling a travel demand.

Troubleshooting

- Check the connections between the controller outputs and the loads.
- Collect information about characteristics of the coils connected to the two drivers and ask for assistance to a Zapi technician in order to verify that the maximum current that can be supplied by the hardware is not exceeded.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

MOT.PHASE SH. XX *(MDI/LED code = 47)*

Cause

Short circuit between two motor phases. The hexadecimal value “XX” identifies the shorted phases:

36: U – V short circuit
37: U – W short circuit
38: V – W short circuit

Troubleshooting

- Verify the motor phases connection on the motor side.
- Verify the motor phases connection on the inverter side.
- Check the motor power cables.
- Replace the controller.
- If the alarm does not disappear, the problem is in the motor. Replace it.

MOTOR TEMP. STOP *(MDI/LED code = 65)*

Cause:

The temperature sensor has overtaken the threshold defined by STOP MOTOR TEMP. (if analog, see paragraph 8.2.3).

Troubleshooting:

- Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function.

- Check the sensor ohmic value and the sensor wiring.
- If the sensor is OK, improve the cooling of the motor.
- If the warning is present when the motor is cool, replace the controller.

MOTOR TEMPERAT. *(MDI/LED code = 65)*

Cause:

This warning occurs when the temperature sensor is open (if digital) or if it has overtaken the MAX. MOTOR TEMP. threshold (if analog) (see paragraph 8.2.3).

Troubleshooting:

- Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function.
- Check the sensor ohmic value and the sensor wiring.
- If the sensor is OK, improve the cooling of the motor.
- If the warning is present when the motor is cool, replace the controller.

NO CAN MSG. XX *(MDI/LED code = 67)*

Cause

CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node.

Troubleshooting

- Verify the CANbus network (external issue).
- Replace the logic board (internal issue).

NO CAN WR MSG. XX *(MDI/LED code = 67)*

Cause

CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node.

Troubleshooting

- Verify the CANbus network (external issue).
- Replace the logic board (internal issue).

OVERLOAD *(MDI/LED code = 57)*

Cause

The motor current has overcome the limit fixed by hardware.

Troubleshooting

If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjustments of motor parameters.

PARAM RESTORE *(MDI/LED code = 14)*

Cause:

The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that EEPROM was correctly cleared.

Troubleshooting:

- A travel demand or a pump request does cancel the alarm.
- If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.

PARAM TRANSFER *(MDI/LED code = 93)*

Cause:

Master uC is transferring parameters to the supervisor.

Troubleshooting:

Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.

PEV NOT OK *(MDI/LED code = 25)*

Cause:

Terminal PEB is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB (see the ADJUSTMENTS list, paragraph 8.2.3).
This alarm can occur if one output among EVP, EV1, EV2, EV3 and EV4 is present (and the related setting is active) or the AUX OUT function is active.

Troubleshooting:

- Check PEB terminal: it must be connected to the battery voltage (after the main contactor).
- Set the nominal PEB voltage in parameter SET POSITIVE PEB in ADJUSTMENTS list (see paragraph 8.2.3).

POSITIVE LC OPEN *(MDI/LED code = 35)*

Cause

The positive voltage of LC is different from expected.

Troubleshooting

- Verify LC coil is properly connected.
- Verify CONF. POSITIVE LC parameter is set in accordance with the actual coil positive supply (see paragraph 0). Software, depending on the parameter value, makes a proper diagnosis; a mismatch between the hardware and the parameter configuration could generate a false fault.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

POWER MISMATCH *(MDI/LED code = 39)*

Cause

The error between the power setpoint and the estimated power is out of range.

Troubleshooting

Ask for assistance to a Zapi technician about the correct adjustment of the motor parameters.

POWERMOS SHORTED *(MDI/LED code = 89)*

Cause

The DC-link voltage drops to zero when a high-side or low-side MOSFET is turned on.

Troubleshooting

- Check that motor phases are correctly connected.
- Check that there is no dispersion to ground for every motor phases.
- In case the problem is not solved, replace the controller.

PWM ACQ. ERROR *(MDI/LED code = 6)*

Cause

This alarm occurs only when the controller is configured to drive a PMSM and the feedback sensor selected in the HARDWARE SETTINGS list is ENCODER ABI + PWM.

The controller does not detect correct information on PWM input at start-up.

Troubleshooting

- Re-cycle the key.
- Check the sensor in order to verify that it works properly.
- Check the wiring.
- If the problem occurs permanently it is necessary to substitute logic board.

PUMP INC START *(MDI/LED code = 79)*

Cause:

Man-presence switch is not enabled at pump request.

Troubleshooting:

- Check wirings.
- Check microswitches for failures.
- Through the TESTER function, check the states of the inputs are coherent with microswitches states.
- If the problem is not solved, replace the logic board.

RPM HIGH *(MDI/LED code = 0)*

Cause:

This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.

SEAT MISMATCH *(MDI/LED code = 15)*

Cause

This alarm can appear only in a Traction + Pump configuration or in a multi-motor one.

There is an input mismatch between the traction controller and the pump controller relatively to the TILLER/SEAT input: the two values recorded by the two controllers are different.

Troubleshooting

- Check if there are wrong connections in the external wiring.
- Using the TESTER function, verify that the seat inputs are in accordance with the actual state of the external switch.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

SENS MOT TEMP KO *(MDI/LED code = 68)*

Cause:

The output of the motor thermal sensor is out of range.

Troubleshooting:

- Check if the resistance of the sensor is what expected measuring its resistance.
- Check the wiring.
- If the problem is not solved, replace the logic board.

SHORT CIRCUIT *(MDI/LED code = 5)*

Cause

The controller continuously checks that the three-phase bridge works properly and that a short-circuit between motor phases is not present.

Troubleshooting

- Check that motor phases are correctly connected.
- Verify that motor phases are not shot-circuited.
- Replace the controller.
- In case the problem is not solved, replace the motor.

SHORT CIRCUIT KO *(MDI/LED code = 5)*

Cause

The HW dedicated to detect faults on power bridge does not work properly.

Troubleshooting

- Replace the controller.

SIN/COS D.ERR *(MDI/LED code = 3)*

Cause:

This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is sin/cos.
The signal coming from sin/cos sensor has a wrong direction.

Troubleshooting:

- Check the wirings.
- If the motor direction is correct, swap the sin and cos signals.
- If the motor direction is not correct, swap two of the motor cables.
- If the problem is not solved, contact a Zapi technician.

SPEED FB. ERROR *(MDI/LED code = 81)*

Cause

This alarm occurs if the absolute position sensor is used also for speed estimation. If signaled, it means that the controller measured that the engine was moving too quick.

Troubleshooting

- Check that the sensor used is compatible with the software release.
- Check the sensor mechanical installation and if it works properly.
- Also the electromagnetic noise on the sensor can be a cause for the alarm.
- If no problem is found on the motor or on the speed sensor, the problem is inside the controller, it is necessary to replace the logic board.

STALL ROTOR *(MDI/LED code = 11)*

Cause:

The traction rotor is stuck or the encoder signal is not correctly received by the controller.

Troubleshooting:

- Check the encoder condition.
- Check the wiring.
- Through the TESTER function, check if the sign of FREQUENCY and ENCODER are the same and if they are different from zero during a traction request.

- If the problem is not solved, replace the logic board.

STBY I HIGH *(MDI/LED code = 53)*

Cause

In standby, the sensor detects a current value different from zero.

Troubleshooting

The current sensor or the current feedback circuit is damaged. Replace the controller.

STEER SENS KO *(MDI/LED code = 95)*

Cause:

The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function (see paragraph 9.3).

Troubleshooting:

- Acquire the maximum and minimum values coming from the steering potentiometer through the STEER ACQUIRING function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer.
- If the problem is not solved, replace the logic board.

TH. PROTECTION *(MDI/LED code = 62)*

Cause:

The temperature of the controller base plate is above 85 °C.
The maximum current is proportionally decreased with the temperature excess from 85 °C up to 105 °C. At 105 °C the current is limited to 0 A.

Troubleshooting:

It is necessary to improve the controller cooling. To realize an adequate cooling in case of finned heat sink important factors are the air flux and the cooling-air temperature. If the thermal dissipation is realized by applying the controller base plate onto the truck frame, the important factors are the thickness of the frame and the planarity and roughness of its surface.
If the alarm occurs when the controller is cold, the possible reasons are a thermal-sensor failure or a failure in the logic board. In the last case, it is necessary to replace the controller.

THERMIC SENS. KO *(MDI/LED code = 61)*

Cause:

The output of the controller thermal sensor is out of range.

Troubleshooting:

This kind of fault is not related to external components. Replace the controller.

THROTTLE PROG. *(MDI/LED code = 48)*

Cause:

A wrong profile has been set in the throttle profile.

Troubleshooting:

Set properly the throttle-related parameters (see paragraph 9.8).

TILLER OPEN *(MDI/LED code = 51)*

Cause:

Tiller/seat input has been inactive for more than 120 seconds.

Troubleshooting:

- Activate the tiller/seat input.
- Check the tiller/seat input state through the TESTER function.
- Check the wirings.
- Check if there are failures in the microswitches.
- If the problem is not solved, replace the logic board.

TORQUE PROFILE *(MDI/LED code = 98)*

Cause:

There is an error in the choice of the torque profile parameters.

Troubleshooting:

Check in the HARDWARE SETTINGS list the value of those parameters.

VACC NOT OK *(MDI/LED code = 78)*

Cause:

At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure.

Troubleshooting:

- Check the wirings.
- Check the mechanical calibration and the functionality of the accelerator potentiometer.
- Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function.
- If the problem is not solved, replace the logic board.

VACC OUT OF RANGE *(MDI/LED code = 85)*

Cause:

- The CPOT input read by the microcontroller is not within the MIN VACC ÷ MAX VACC range, programmed through the PROGRAMM VACC function (see paragraph 9.1).
- The acquired values MIN VACC and MAX VACC are inconsistent.

Troubleshooting:

- Acquire the maximum and minimum potentiometer values through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the accelerator potentiometer.
- If the problem is not solved, replace the logic board.

VDC LINK OVERV. *(MDI/LED code = 77)*

Cause

This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold is 65 V for 36/48V controllers and 115 V for 72/80V controllers.

As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for undervoltage detection, uC discerns between the two evaluating the voltage present across DC-link capacitors:

- High voltage → Overvoltage condition
- Low/normal voltage → Undervoltage condition

Troubleshooting

If the alarm happens during the brake release, check the line contactor contact and the battery power-cable connection.

VDC OFF SHORTED *(MDI/LED code = 88)*

Cause

The logic board measures a voltage value across the DC-link that is constantly out of range, above the maximum allowed value.

Troubleshooting

- Check that the battery has the same nominal voltage of the inverter.
- Check the battery voltage, if it is out of range replace the battery.
- In case the problem is not solved, replace the logic board.

VKEY OFF SHORTED *(MDI/LED code = 20)*

Cause

The logic board measures a voltage value of the KEY input that is constantly out of range, above the maximum allowed value.

Troubleshooting

- Check that the battery has the same nominal voltage of the inverter.
- Check the battery voltage, if it is out of range replace the battery.
- In case the problem is not solved, replace the logic board.

VMN HIGH *(MDI/LED code = 31)*

Cause 1

Before switching the LC on, the software checks the power bridge: it turns on alternatively the low-side power MOSFETs and expects the phase voltages decrease down to -B. If the phase voltages are higher than a certain percentage of the nominal battery voltage, this alarm occurs.

Cause 2

This alarm may also occur when the start-up diagnosis has succeeded and so the LC has been closed. In this condition, the phase voltages are expected to be lower than half the battery voltage. If one of them is higher than that value, this alarm occurs.

Troubleshooting

- If the problem occurs at start-up (the LC does not close), check:
  - motor internal connections (ohmic continuity);
  - motor power cables connections;
  - if the motor connections are OK, the problem is inside the controller. Replace it.
- If the alarm occurs while the motor is running, check:

- motor connections;
- that the LC power contact closes properly, with a good contact;
- if no problem is found, the problem is inside the controller. Replace it.

VMN LOW *(MDI/LED code = 30)*

Cause 1

Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatively the high-side power MOSFETs and expects the phase voltages increase toward the positive rail value. If one phase voltage is lower than a certain percentage of the rail voltage, this alarm occurs.

Cause 2

Motor running test. When the motor is running, the power bridge is on and the motor voltage feedback tested; if it is lower than expected value (a range of values is considered), the controller enters in fault state.

Troubleshooting

- If the problem occurs at start up (the LC does not close at all), check:
  - motor internal connections (ohmic continuity);
  - motor power-cables connections;
  - if the motor connections are OK, the problem is inside the controller; replace it.
- If the alarm occurs while the motor is running, check:
  - motor connections;
  - that the LC power contact closes properly, with a good contact;
  - if no problem is found, the problem is inside the controller. Replace it.

WAIT MOTOR STILL *(MDI/LED code = 45)*

Cause:

The controller is waiting for the motor to stop rotating. This warning can only appear in ACE4 for brushless motors.

WAITING FOR NODE *(MDI/LED code = 0)*

Cause:

The controller receives from the CAN bus the message that another controller in the net is in fault condition; as a consequence the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status.

Troubleshooting:

Check if any other device on the CAN bus is in fault condition.

WARNING SLAVE *(MDI/LED code = 1)*

Cause:

Warning on supervisor uC.

Troubleshooting:

Connect the Console to the supervisor uC and check which alarm is present.

WATCHDOG *(MDI/LED code = 8)*

Cause

This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers.

Troubleshooting
This alarm could be caused by a CAN bus malfunctioning, which blinds master-supervisor communication.

WRONG ENC SET *(MDI/LED code = 83)*
Cause
Mismatch between "ENCODER PULSES 1" parameter and "ENCODER PULSES 2" parameter (see paragraph 0).

Troubleshooting
Set the two parameters with the same value, according to the adopted encoder.

WRONG KEY VOLT. *(MDI/LED code = 41)*
Cause
The measured key voltage is not the right one for the inverter.

Troubleshooting
- Check if the SET KEY VOLTAGE parameter in the ADJUSTMENTS list is set in accordance with the key voltage.
- Check if the key voltage is ok using a voltmeter, if not check the wiring.
- In case the problem is not solved, replace the logic board.

WRONG RAM MEM. *(MDI/LED code = 71)*
Cause
The algorithm implemented to check the main RAM registers finds wrong contents: the register is "dirty". This alarm inhibits the machine operations.

Troubleshooting
Try to switch the key off and then on again, if the alarm is still present replace the logic board.

WRONG SET BAT. *(MDI/LED code = 41)*
Cause
At start-up, the controller checks the battery voltage (measured at key input) and it verifies that it is within a range of ±20% around the nominal value.

Troubleshooting
- Check that the SET BATTERY parameter in the ADJUSTMENTS list is set in accordance with the battery nominal voltage.
- If the nominal voltage value is not available among the possibilities of the SET BATTERY parameter, take note of the value stored as HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Zapi technician.
- Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on the KEY input. If it does not match, modify the ADJUST BATTERY parameter according to the value read on the voltmeter.
- Replace the battery

10.2 Alarms from supervisor µC

Error Code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
BUMPER STOP	Traction sopped	Start-up, stand-by, running		0	FFC7	199
WATCHDOG	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	8	6010	8
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	12	FFEF	239
EEPROM KO	Controller works using default parameters	Start-up, stand-by, running		13	3610	208
PARAM RESTORE	No effect	Start-up	Traction/Pump request	14	3611	209
SP MISMATCH xx	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	15	FFF2	242
OUT MISMATCH xx	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	16	FFE3	227
LOGIC FAILURE #3	MC is opened, EB is applied, traction/pump stopped	Stand-by	Valves or Traction/Pump request	17	FF11	17
LOGIC FAILURE #1	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Valves or Traction/Pump request	19	5514	19
INPUT MISMATCH	MC is opened, EB is applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	58	FFD5	213
W.SET. TG-EB	Traction/Pump motor is stopped	Start-up, stand-by, running	Key re-cycle	59	FFD4	212
NO CAN MSG. XX	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	67	8130	248
WRONG RAM MEM. 05	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	71	FFD2	210
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	77	FFCA	202
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	85	FF51	201
STEER SENSOR KO	EB is applied, traction/pump stopped	Start-up, stand-by, running	Key re-cycle	95	FFC3	200
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	96	FFFA	237
CTRAP THRESHOLD	MC is opened, EB is applied, traction/pump stopped	Startup, stand-by, running	Valves or Traction/Pump request	99	FFEB	235

10.2.1 Troubleshooting of alarms from supervisor µC

ANALOG INPUT *(MDI/LED code = 96)*

Cause:

This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion.

Troubleshooting

If the problem occurs permanently it is necessary to replace the logic board.

BUMPER STOP *(MDI/LED code = 0)*

Cause

The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if ACE4 is in CAN OPEN configuration (see parameter CONTROLLER TYPE in SPECIAL ADJUST. list, paragraph 8.2.4).

Troubleshooting

- Turn off one or both inputs dedicated to the bumper functionality.
- If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck.
- In case the problem is not solved, replace the logic board.

CONTROLLER MISM. *(MDI/LED code = 12)*

Cause:

The software is not compatible with the hardware. Each controller produced is “signed” at the end of line test with a specific code mark saved in EEPROM according to the customized Part Number.
According with this “sign”, only the customized firmware can be uploaded.

Troubleshooting

- Upload the correct firmware.
- Ask for assistance to a Zapi technician in order to verify that the firmware is correct.

CTRAP THRESHOLD *(MDI/LED code = 99)*

Cause

This alarm occurs when a mismatch is detected between the setpoint for the overcurrent detection circuit (dependent on parameter DUTY PWM CTRAP, see paragraph 8.2.4) and the feedback of the actual threshold value.

Troubleshooting

The failure lies in the controller hardware. Replace the logic board.

EEPROM KO *(MDI/LED code = 13)*

Cause:

A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values.

Troubleshooting:

Execute a CLEAR EEPROM procedure (refer to the Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will be replaced by the default parameters.

INPUT MISMATCH *(MDI/LED code = 58)*

Cause:

The supervisor microcontroller records different input values with respect to the master microcontroller.

Troubleshooting:

- Compare the values read by master and slave through the TESTER function.
- Ask for the assistance to a Zapi technician.

- If the problem is not solved, replace the logic board.

LOGIC FAILURE #1 *(MDI/LED code = 19)*

Cause

This fault is displayed when the controller detects an undervoltage condition at the KEY input. Undervoltage threshold is 11V for 36/48V controllers and 30 V for 72/80V controllers.

Troubleshooting (fault at startup or in standby)

- Fault can be caused by a key input signal characterized by pulses below the undervoltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads.
- If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board.

Troubleshooting (fault displayed during motor driving)

- If the alarm occurs during motor acceleration or when there is a hydraulic-related request, check the battery charge, the battery health and power-cable connections.

LOGIC FAILURE #3 *(MDI/LED code = 17)*

Cause

A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven.

Troubleshooting

The failure lies in the controller hardware. Replace the controller.

NO CAN MSG. XX *(MDI/LED code = 67)*

Cause

CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node.

Troubleshooting

- Verify the CANbus network (external issue).
- Replace the logic board (internal issue).

OUT MISMATCH XX *(MDI/LED code = 16)*

Cause:

This is a safety related test. Supervisor µC has detected that master µC is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting:

- Checks the matching of the parameters between Master and Supervisor.
- Ask for assistance to a Zapi technician.
- If the problem is not solved, replace the logic board.

PARAM RESTORE *(MDI/LED code = 14)*

Cause:

The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that

EEPROM was correctly cleared.

Troubleshooting:
- A travel demand or a pump request cancels the alarm.
- If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.

SP MISMATCH XX *(MDI/LED code = 15)*

Cause:
This is a safety related test. The master μC has detected a supervisor μC wrong set point. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting:
- Check the matching of the parameters between master and supervisor.
- Ask for assistance to a Zapi technician.
- If the problem is not solved, replace the logic board.

STEER SENSOR KO *(MDI/LED code = 95)*

Cause:
The voltage read by the microcontroller at the steering-sensor input is not within the range from STEER RIGHT VOLT to STEER LEFT VOLT, programmed through the STEER ACQUIRING function (see paragraph 9.3).

Troubleshooting:
- Acquire the maximum and minimum values from the steering potentiometer through the STEER ACQUIRING function.
- Check the mechanical calibration and the functionality of the potentiometer.
- If the problem is not solved, replace the logic board.

VDC LINK OVERV. *(MDI/LED code = 77)*

Cause
This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold is 65 V for 36/48V controllers and 116 V for 80V controllers.
As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for undervoltage detection, uC discerns between the two evaluating the voltage present across DC-link capacitors:
- High voltage → Overvoltage condition
- Low/normal voltage → Undervoltage condition

Troubleshooting
If the alarm happens during the brake release, check the line contactor contact and the battery power-cable connection.

W.SET. TG-EB *(MDI/LED code = 59)*

Cause:
Supervisor microcontroller has detected that the master microcontroller has imposed a wrong setpoint for TG or EB output.

Troubleshooting:
- Check the matching of the parameters between master and supervisor.
- Ask for the assistance of a Zapi technician.

- If the problem is not solved, replace the logic board.

WATCHDOG *(MDI/LED code = 8)*

Cause:

This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers.

Troubleshooting

This alarm could be caused by a CAN bus malfunctioning, which blinds master - supervisor communication.

WRONG ENC SET *(MDI/LED code = 85)*

Cause:

Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter (see paragraph 0).

Troubleshooting

Set the two parameters with the same value, according to the adopted encoder.

WRONG RAM MEM. *(MDI/LED code = 71)*

Cause:

The algorithm implemented to check the main RAM registers finds wrong contents: the register is “dirty”. This alarm inhibits the machine operations.

Troubleshooting

Try to switch the key off and then on again, if the alarm is still present replace the logic board.

WRONG SLAVE VER. *(MDI/LED code = 91)*

Cause:

Wrong software version on supervisor uC.

Troubleshooting:

Upload the correct software version or ask for assistance to a Zapi technician.

10.3 Info code for electrovalves

Errors related to HW circuits driving electrovalves (CONT DRV. EV, DRV. SHOR. EV and HW FAULT EV.) are followed by an info code which helps to detect which EV circuit is affected by the problem.

EVs are coded with a hexadecimal number:
- **02:** EV1
- **04:** EV2
- **08:** EV3
- **20**: EV4

If more than one EV circuit is found to be faulty, the code shown corresponds to the sum of the single info codes. This results in the following table of possibilities, where faulty EVs are marked with an "F".

Info code	EV1	EV2	EV3	EV4
02	F			
04		F		
06	F	F		
08			F	
0A	F		F	
0C		F	F	
0E	F	F	F	
20				F
22	F			F
24		F		F
26	F	F		F
28			F	F
2A	F		F	F
2C		F	F	F
2E	F	F	F	F

11 RECOMMENDED SPARE PARTS

Recommended spare parts for ACE4 inverters are here listed.

Part number	Description	ACE4 version
C16590	Protected 500 A strip UL Fuse.	36/48V, 800 A 72/80V, 700 A
C16520	10 A 20 mm Control Circuit Fuse	All
C29532	SW 200 48 V Single Pole Contactor	36/48V
C29509	SW 200 80 V Single Pole Contactor	72/80V
C12531	Ampseal 23 pins female connector	Standard version
C12532	Ampseal 35 pins female connector	Premium version

12 PERIODIC MAINTENANCE TO BE REPEATED AT TIMES INDICATED

Check the wear and the condition of the contactors' moving and fixed contacts. Electrical contacts should be checked every **3 months**.

Check the Foot pedal or Tiller microswitch. Using a suitable test meter, confirm that there is no electrical resistance between the contacts by measuring the voltage drop between the terminals. Switches should operate with a clear click sound.
Microswitches should be checked every **3 months**.

Check the Battery cables, cables connected to the inverter, and cables connected to the motor. Ensure that the insulation is sound and that the connections are tight.
Cables should be checked every **3 months**.

Check the mechanical functionality of the pedals or tiller. Control that the return springs are ok and that the potentiometers excursion matches their full or programmed level.
Check every **3 months**.

Check the mechanical functionality of the Contactor(s). Moving contacts should be free to move without restriction.
Check every **3 months**.

Checks should be carried out by qualified personnel and any replacement parts used should be original. Beware of NON ORIGINAL PARTS.
The installation of this electronic controller should be made according to the diagrams included in this Manual. Any variations or special modifications should be evaluated with a Zapi Agent. The supplier is not responsible for any problem that arises from connections that differ from information included in this Manual.

During periodic checks, if a technician finds any situation that could cause damage or compromise safety, the matter should be brought to the attention of a Zapi Agent immediately. The Agent will then take the decision regarding the operational safety of the machine.

Remember that Battery Powered Machines feel no pain.

NEVER USE A VEHICLE WITH A FAULTY ELECTRONIC CONTROLLER.

IMPORTANT NOTE ABOUT WASTE MANAGEMENT:
This controller has both mechanical parts and high-density electronic parts (printed circuit boards and integrated circuits). If not properly handled during waste processing, this material may become a relevant source of pollution. The disposal and recycling of this controller has to follow the local laws for these kinds of waste materials.
Zapi commits itself to update its technology in order to reduce the presence of polluting substances in its products.

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13 APPENDICES

This chapter reports how to use the main Zapi tools for setting and monitoring Zapi controllers: Zapi PC CAN Console and Zapi Smart Console.

Next paragraphs focus on the basic information about configuration and change of parameters.

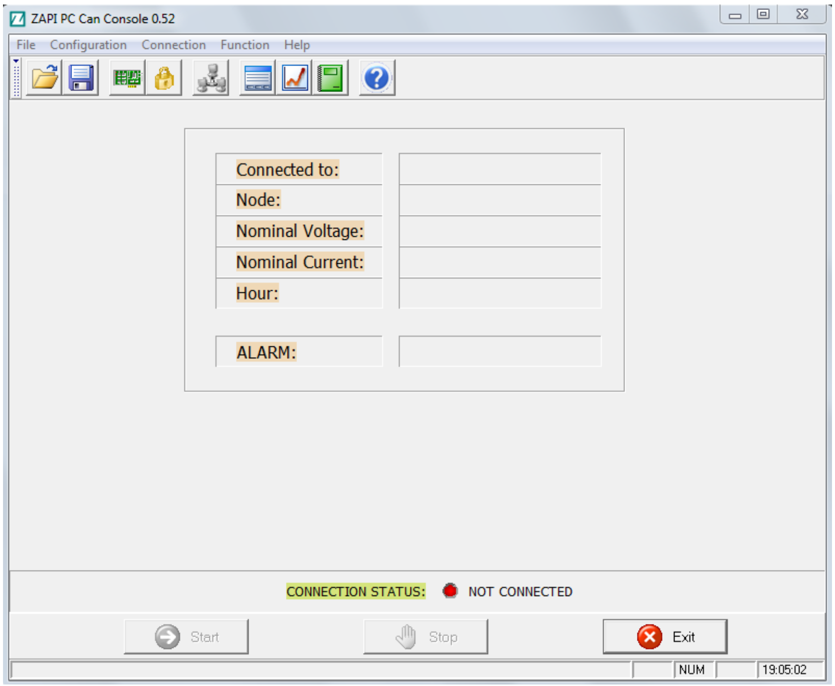
For additional functionalities available for both tools it is suggested to contact Zapi technicians in order to receive more detailed information or dedicated documentation.

13.1 Appendix A: PC CAN Console user guide

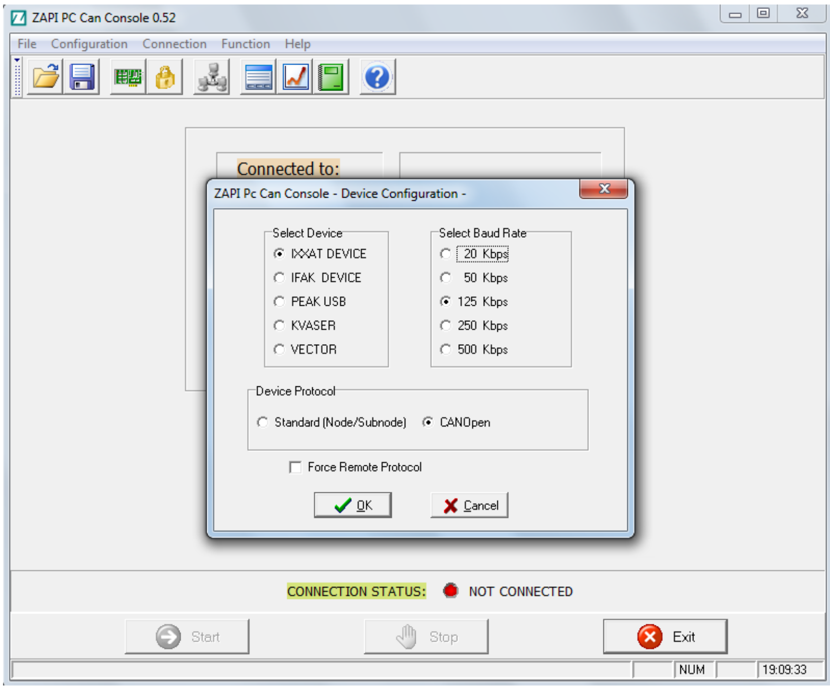
Windows Pc CAN Console uses standard Zapi communication protocol to display inverter information. It provides all standard Zapi Console functions with the easier handling of Windows environment. Besides, Pc CAN Console offers the possibility of saving parameter configurations into a file and restoring them onto the control afterwards.
Before running Pc CAN Console, the user must install it launching "setup.exe".

13.1.1 PC CAN Console configuration

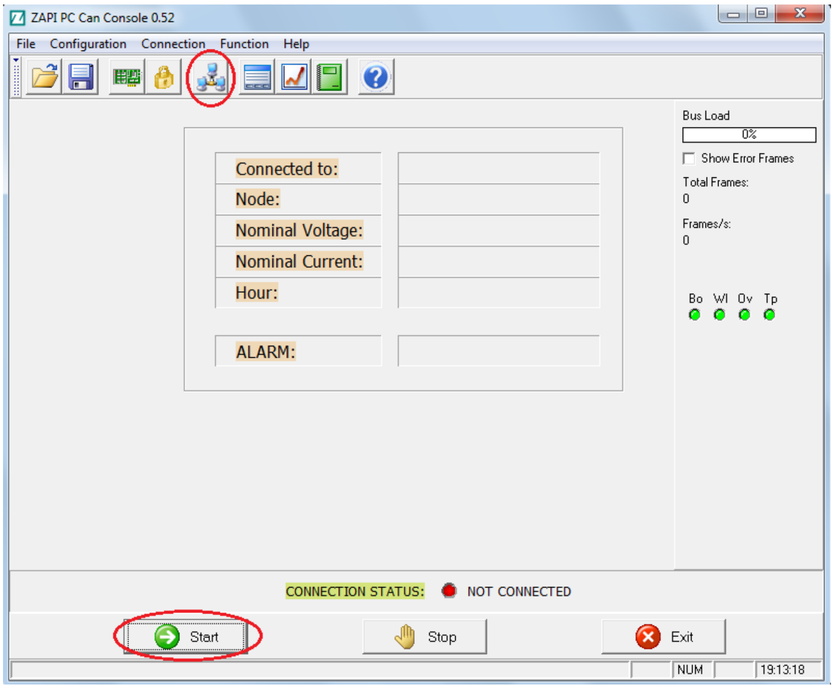
Running the PC Can Console software, the following window appears:



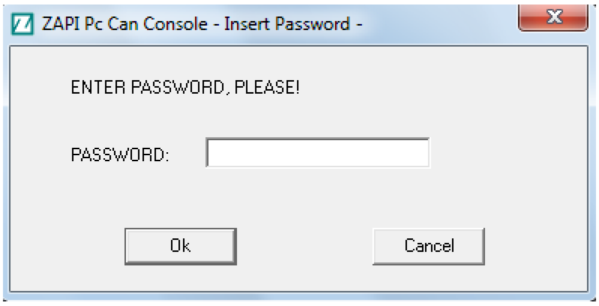
The first step to accomplish is to define the CAN device linked to the PC, so select “Configuration” (Alt-C) → “Can Device” (Ctrl-C) or click on the “Can Device” icon.



From this form you can define the CAN device in use (IXXAT, IFAK or Peak) and the communication speed. Once you have defined the CAN interface, you have to choose which CAN device you want to connect to: choose “Connection” → “Set Node” or press the “Set Node” icon.



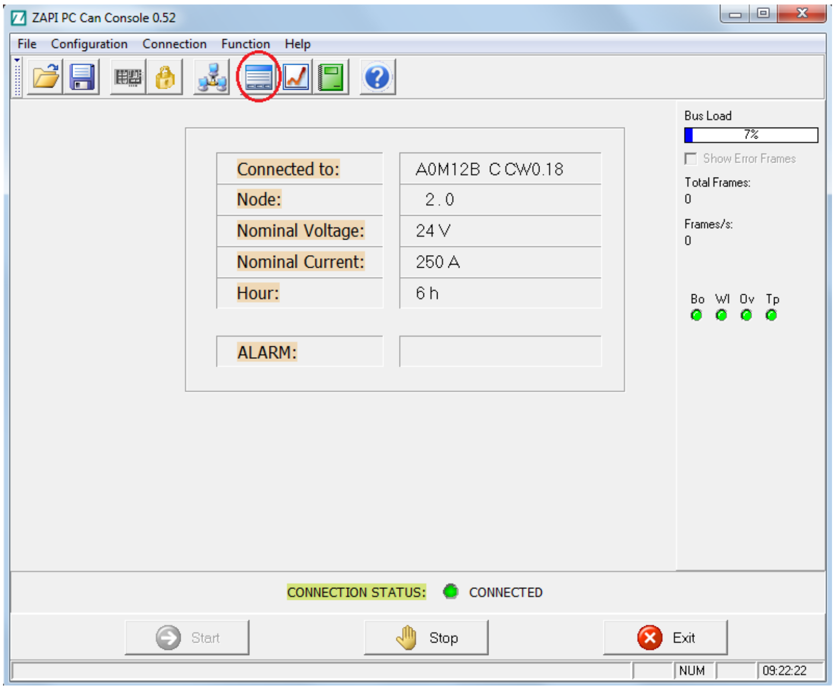
Once you have chosen the node you want to connect to, start the connection and insert the password in order to have the possibility to change the parameters: choose “Configuration” → “Enter Password”.



Type the password: “ZAPI”

13.1.2 Parameter download

Once you are connected to the selected node, you need to download the inverter parameters: choose “Function” → “Parameter” or press the “Parameter” icon.



Then click on the “Receive” button: parameters will be downloaded automatically. When parameters have been all received, you can change their values.

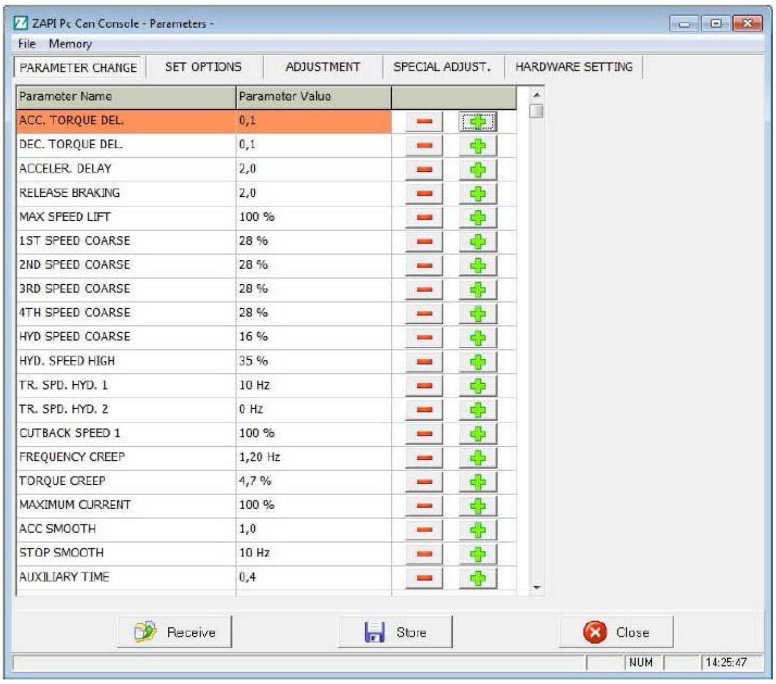
13.1.3 How to modify the parameters

Before doing any change, save the old parameters set by clicking “File” → “Save” (give the file an understandable name for ease of future use).
The complete list of parameters will be saved as a csv file in order to be opened with Microsoft Excel® or any other spreadsheet tool.
The file contains the whole list of parameter and for each one various data are available, in particular:

- Parameter value as it is saved within the controller (“Value” column).
- Parameter value as it is shown by console or similar tools (“Scaled Value” column).
- Name of the menu where parameter is placed (“Name menu” column).

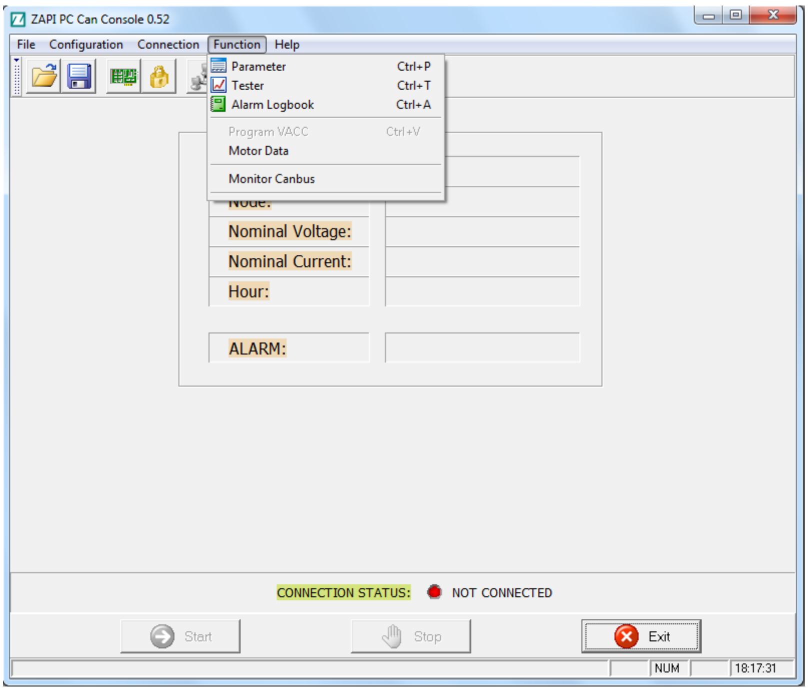
File name is generated as a hexadecimal code of the time and date of saving.

This codification prevents any overwrite of previously saved files.
Once you have selected the menu inside that resides the parameter you want to change, it is possible to modify the value using the “+” and “–“ buttons.
Click on the “Store” button to save the changes on EEPROM.



13.1.4 Program VACC

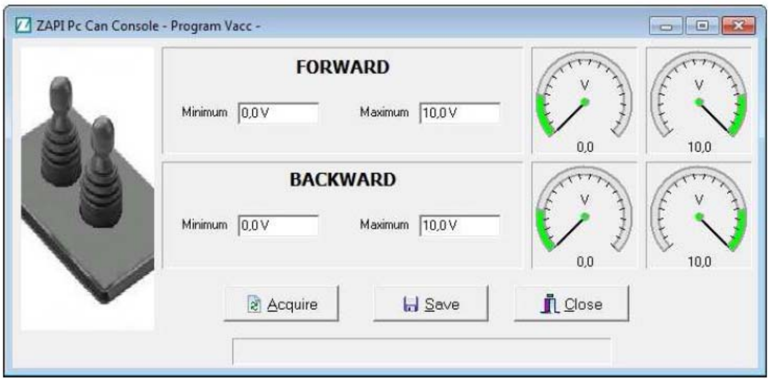
Choose “Function” → “Program VACC”.



By pressing “Acquire”, “Program VACC” procedure starts:

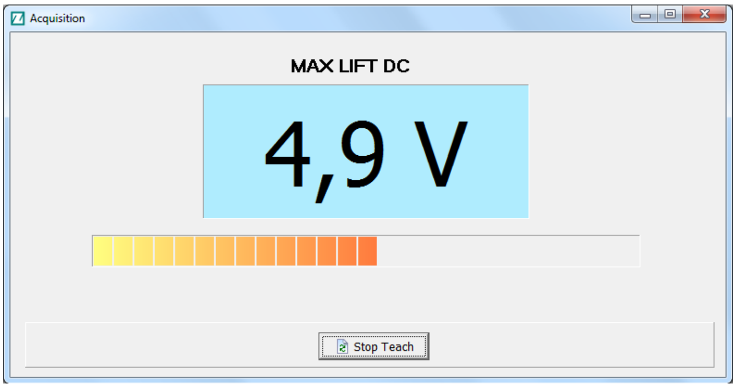
- select the Enable switch, if any;
- select the direction switch (either forward or backward);
- depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.



13.1.5 Lift & Lower acquisition

Once you have connected to the inverter, you need to download the parameters; choose “Function” → “Parameter” menu (or press the “Parameter” icon).
Choose “Adjustment” menu.
Select the value you want to acquire by pressing the “acquiring” button, the acquisition will start:



- Select the Enable switch, if any;
- Select the control switch (either lift or lower);
- Move the control sensor (lift/lower potentiometer) to the correct position according to what you are acquiring;
- Press “Stop Teach” button.

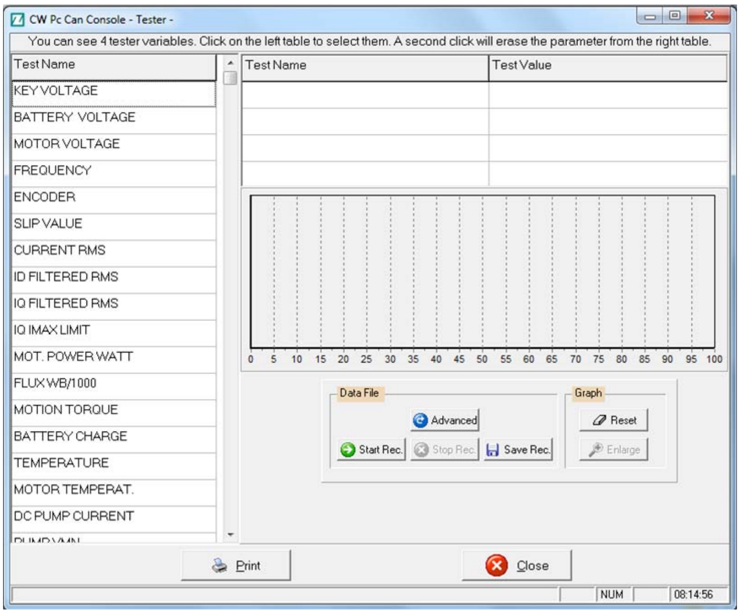
The procedure is the same for all the lift and lower potentiometers.

13.1.6 Steering acquiring

Once you have connected you need to receive the inverter parameter; choose “Function” → “Parameter” menu (or press the “Parameter” icon).
Choose “Adjustment” menu.
Select the value to acquire by pressing “acquiring” button, the acquisition will start: the procedure is the same described for Lift & Lower acquisition in the previous paragraph.

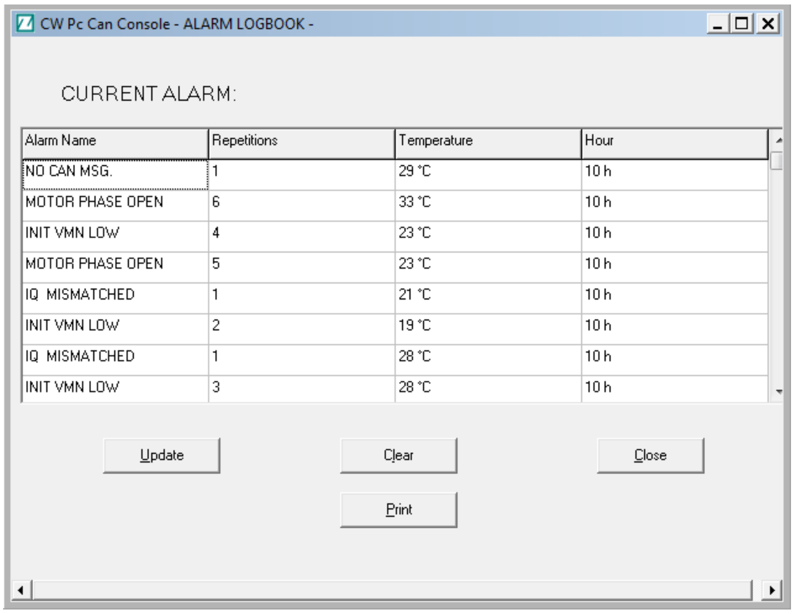
13.1.7 Tester Functionality

From the main page you can also access to the TESTER function from the Function menu (Alt-u) → Tester (Ctrl-T) menu where you can check some inverter information.



13.1.8 Alarm logbook

This window will display the alarms stored in the controller.
For every alarm will be shown the working hour at which it's occurred, the motor temperature and the number of repetitions.



Four buttons are present:
Update → user can update alarm logbook;
Clear → user can clear alarm logbook on inverter EEPROM;
Close → closes the window;
Print → prints alarm logbook data on the selected printer.

13.2 Appendix B: Zapi Smart Console user guide

13.2.1 Operational Modes

Smart Console has been designed to have multiple ways of operation. Three modes can be identified:

- Serial connection powered by four standard AA size batteries placed in the battery holder of the console.
- CAN bus connection powered by four standard AA size batteries placed in the battery holder of the console.
- CAN bus connection with Smart Console supplied by an external dc source. This source may be a standard battery (lead-acid or other type) or a dc/dc converter

Current-loop serial connection

Smart Console offers the same serial connection as the well-known Console Ultra.
Main features of this operational mode are:

- Current-loop serial communication.
- Console is connected to a *single* controller only (even if Remote Console option is available).
- Selectable baud-rate.
- Zapi can provide the serial cable compatible with Molex SPOX connector used in Console Ultra.

CAN bus connection

The Smart Console can connect to an existing CAN line and connect with any Zapi controller inside this line.
Main features of this operational mode:

- It can be connected to a CAN line composed of any combination of modules, both Zapi ones and non-Zapi ones;
- Supported speeds: 125, 250, 500 kbps;
- It sees the entire CAN line and all CAN modules.

13.2.2 Keyboard

The keyboard is used to navigate through the menus. It features some keys with special functions and a green led. Different button functions are shown below.

UP and DOWN keys

In most cases a menu is a list of items: these items are ordered in rows. The selected item is highlighted in light blue.
Up and down keys are used to move the selection up and down: in other words they are used to roll or scroll the menu.

LEFT and RIGHT keys

Normally used to increase and decrease the value associated with the selected item.

OK and ESC keys

OK key is used either to confirm actions or to enter a submenu.
ESC is used either to cancel an action or to exit a menu.

F1, F2, F3 keys

These buttons have a contextual use. The display will show which F button can be used and its function.

ON key

Used while operating with internal batteries.

While the Smart Console is powered from external sources on pin CNX8 the ON button is deactivated regardless the presence of the batteries.

Green LED

When the console is powered running the green LED is on.
Green LED can blink in certain cases which will be described better in the following sections.

13.2.3 Home Screen

After showing the Zapi logo, the HOME SCREEN will appear on the display:

```
*CONS AFG ZP015*
RS232 CONSOLE
CAN CONSOLE
AUTOSCAN CAN
CONSOLE UTILITIES
MENU CONSOLE

14:00
```

From top:

- First line tells which firmware version is running inside the console, in this case ZP 0.15.
- RS232 Console: enter this menu to start a serial connection as in the Console Ultra.
- CAN Console: enter this menu to establish a CAN connection.
- AUTOSCAN CAN: another way to establish a CAN connection.
- Console Utilities and Menu Console: ignore them at the moment.

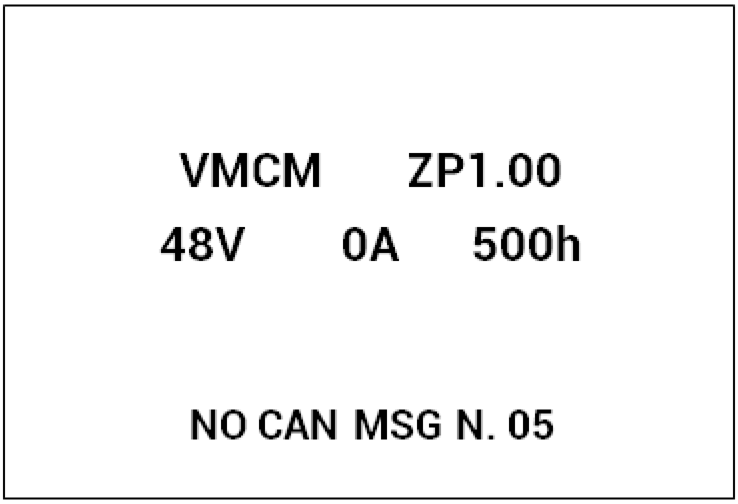
- The current hour is shown at the bottom right.

Moreover, the green LED is on and still.
The “RS232” line is already highlighted at the start-up. Press OK key to start a serial connection.
Display prompts a message to inform you that a connection attempt is ongoing.
If serial connection fails a “NO COMMUNICATION” warning will be shown after some seconds: press ESC key and look for what is preventing the connection.

Please notice the red dot appearing on the top right of the display every time you press a button. It indicates that the console has received the command and it is elaborating the request. If the red dot does not appear when a button is pressed, there is probably a failure inside the keyboard or the console has stalled.

13.2.4 Main menu

If connection is successful, the display will show a page similar to the next one.



This menu shows basic information about the controller, in a similar way to the console Ultra.

- First line displays the controller firmware.
- Second line shows controller voltage, controller current and hour meter.
- Last line shows the current alarm code, if present.

Press OK to access the MAIN MENU.

*** MAIN MENU ***

PARAMETER CHANGE
TESTER
ALARMS
PROGRAM VACC
SAVE PARAMETERS
RESTORE PARAMETERS
SET MODEL

MAIN MENU contains the complete list of menus available in the controller. Contrary to Console Ultra there are no “hidden” menus which must be reached by some combinations of buttons: here all menus are visible.
Use UP and DOWN keys to navigate the list: once you find the desired menu press OK to enter it.

13.2.5 How to modify a parameter

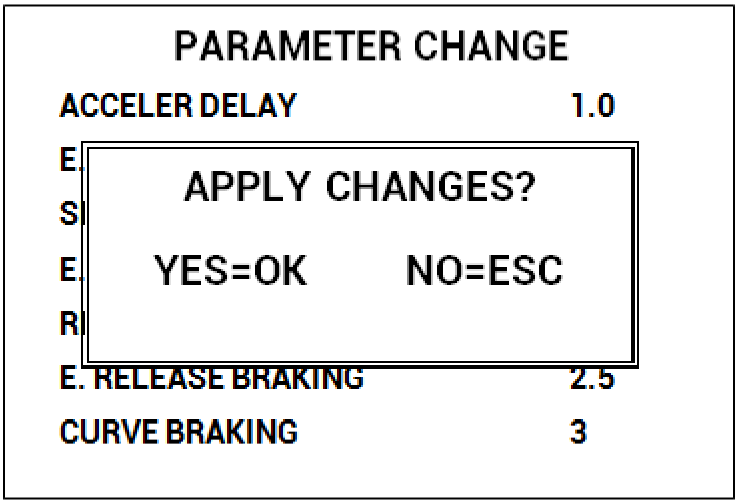
From MAIN MENU enter the desired menu (for example the PARAMETER CHANGE menu).

PARAMETER CHANGE	
ACCELER DELAY	1.0
E. ACCELER. DELAY	1.5
SPEED LIMIT BRK	2.2
E. SPD. LIMIT BRK	2.2
RELEASE BRAKING	4
E. RELEASE BRAKING	2.5
CURVE BRAKING	3

With UP and DOWN keys you can scroll the whole list: once you have highlighted the parameter that you want to modify, use LEFT or RIGHT keys to decrease or increase the parameter value.

Keep LEFT/RIGHT button pressed to continuously repeat the value modification (“auto-repeat” function): this function will speed up the procedure in case many parameter values must be changed.

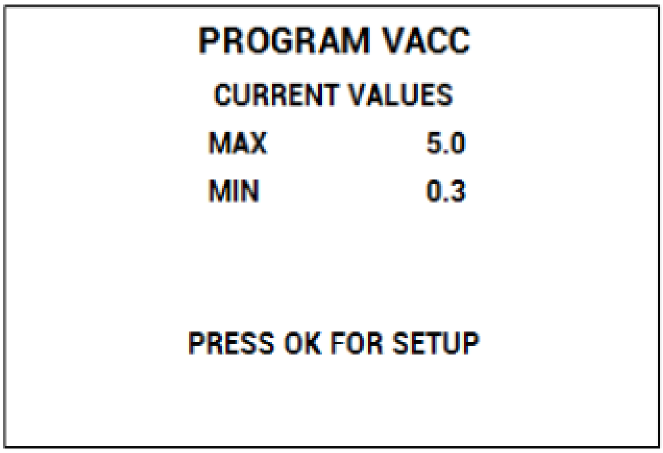
You can press ESC to exit the menu at any time. In case some parameter has been modified, the console will prompt a request to confirm/discard changes.



Description above is valid for every menu which contains parameters and options like SET OPTIONS, ADJUSTMENTS, HARDWARE SETTINGS, etc.

13.2.6 PROGRAM VACC

PROGRAM VACC menu has been slightly modified from old consoles.
Upon entering this menu the console shows the current programmed values.

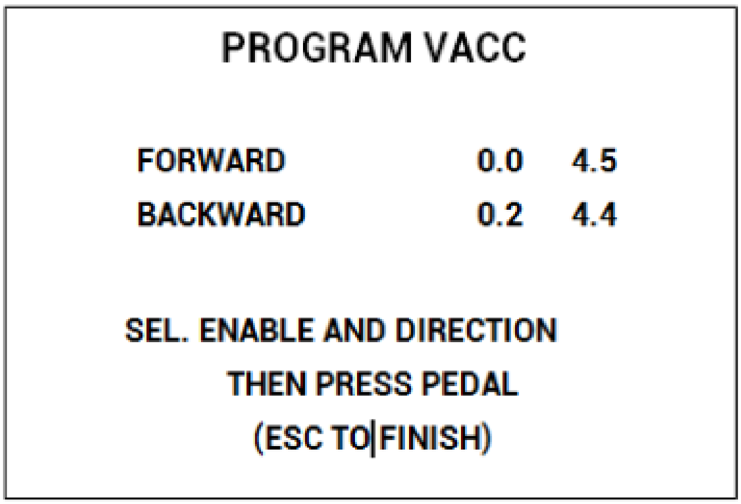


When OK is pressed, PROGRAM VACC procedure starts. Console invites you:

- to select the enable switch, if any;
- to select the direction switch (either forward or backward);
- to depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. Anyway the logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.



When ESC is pressed, console asks if programmed values must be saved or discarded.

13.2.7 Lift & Lower acquisition

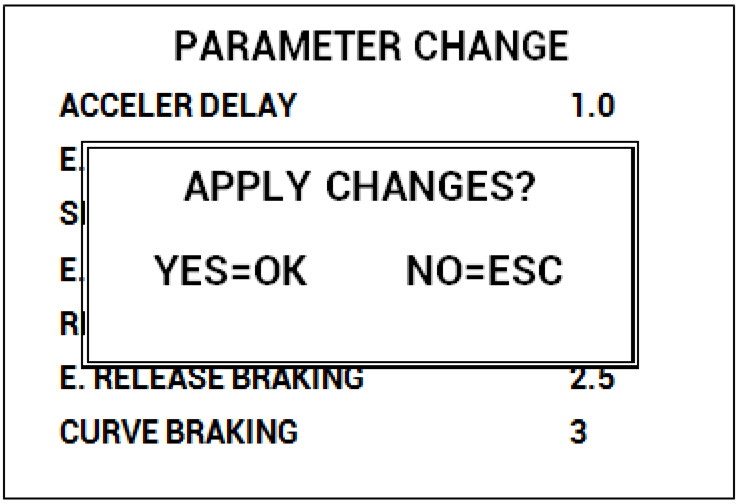
From MAIN MENU go into the Adjustment menu.
With UP and DOWN keys you can scroll the list: once you have highlighted a value you want acquire, press OK.
By pressing OK, the procedure starts:

- select the Enable switch, if any;
- select the control switch, if any (either lift or lower);
- move the control sensor (lift/lower potentiometer) to the correct position according to what you are acquiring.

Displayed values vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. Anyway the logic remains the same: before programming the min/max values, execute any starting sequence which is necessary, then press the pedal or push the joystick.

It is possible to acquire all the values in only one session.
At the end you can press ESC and the console will prompt a request to confirm/discard changes.

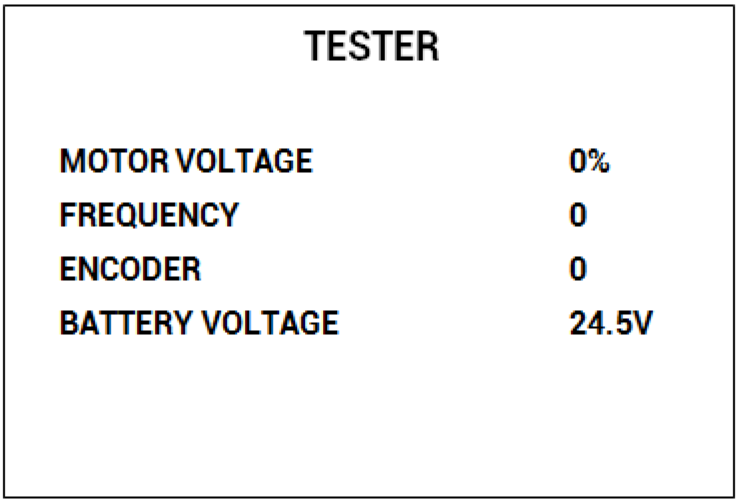


13.2.8 Steer command acquiring

From MAIN MENU go into the ADJUSTMENT menu.
The procedure to follow is the same described in previous paragraph.

13.2.9 Tester

Compared to standard console Ultra, the TESTER menu has been deeply modified. Now it shows four variables at once: use UP/DOWN keys to scroll the list.



13.2.10 Alarms

ALARMS menu has changed from Console Ultra. Display shows all controller alarms at once.

ALARMS

NO CAN MESSAGE	10h
INCORRECT START	2h
NONE	0h
NONE	0h
NONE	0h

F1 TO CLEAR LOGBOOK

Five is the maximum number of alarm codes which is stored inside the controller.

Colors are used to separate recurrent alarm codes from rare events. In order of increasing frequency, alarm names can be:

- White: up to 5 occurrences
- Yellow: up to 20,
- Orange: up to 40,
- Red: more than 40.

Use UP/DOWN to select a certain alarm in the list: if OK is pressed, additional information about that alarm will be displayed.

Press F1 to cancel the alarm logbook of the controller: once pressed, the console will ask for confirmation.

13.2.11 Download parameter list into a USB stick

When Smart Console is connected to a controller, it has the possibility to download all parameters into a USB stick.
To use this function, go into the menu SAVE PARAMETER USB in the MAIN MENU.

File format

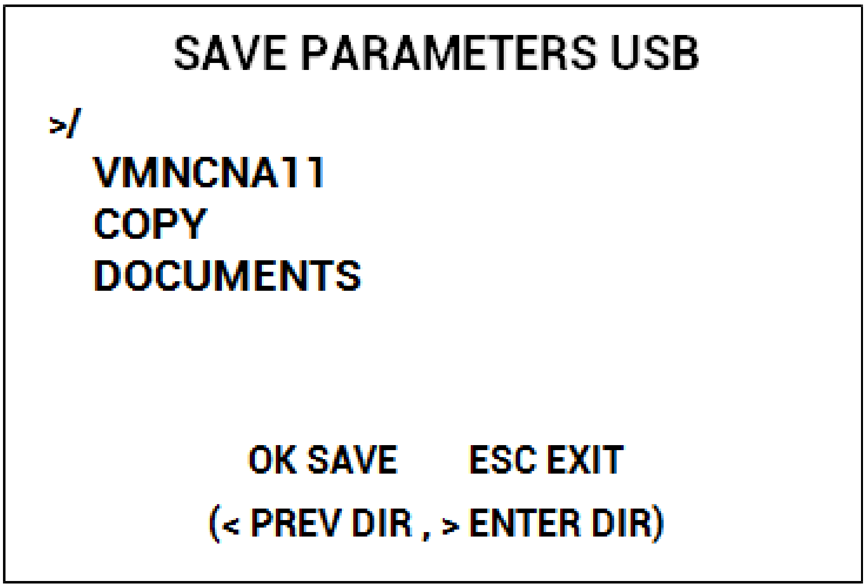
The complete list of parameters is saved as a csv file in order to be opened with Microsoft Excel® or any other spreadsheet tool.
The file is formatted in the same way as if it has been created with the PC CAN Console. Thus it contains the whole list of parameter and, for each one, various data are available, in particular:

- Parameter value as it is saved within controller ("Value" column).
- Parameter value as it is shown by console or similar tools ("Scaled Value" column).
- Name of the menu where parameter is placed tools ("Name menu" column).

File name is generated as a hexadecimal code of the time and date of save. This codification prevents any overwrite of previously saved files.

Download procedure

After entering SAVE PARAMETER TO USB, the Smart Console checks the presence of a USB stick. If the stick is not connected, it asks the operator to connect one.
When the stick is present, the display shows the content, starting from the root directory (/) of the filesystem. Display looks like the following picture.



Notice that only directories are shown, not single files.
While exploring the content, the navigation buttons work in the following way:

- Up/down keys scroll the list.
- Right key explore the highlighted directory: its content (directories only) will be shown immediately.
- Left key returns one level back in the directory tree: it does not work in the root directory.
- Esc returns to HOME SCREEN.
- OK starts download.

When saving files, the console creates a subdirectory whose name has eight digits:

- First four digits are controller type.
- Fifth and sixth digits are the customer identification code.
- Seventh and eight digits are the code of the software installed inside the controller.

An example of this code is the first directory name (VMNCNA11) shown in the previous figure.
If parameters are downloaded multiple times from the same controller, or from another controller whose eight digit code is the same, all parameter files are saved in the same location.
If the directory does not exist, it is created when download is carried out for the first time.

To download parameters, proceed as follows:

1. Navigate the directory list and go into the directory where you want to save the parameters.

2. If this directory already contains the subdirectory with the correct 8 digits go to step 3. If it is not present, a new subdirectory will be created automatically. Do not enter the subdirectory manually.
3. Press OK to start parameter download. A progression bar shows the ongoing process.
4. When finished, press ESC so to return to MAIN MENU. USB stick can be removed safely.

Connect the USB stick to a PC and enter the directory of point 1). A subdirectory with the correct name and, inside this one, a csv file are present.

During download the led blinks slowly to indicate the console is running.

When download has finished USB stick can be unplugged safely.

Do not remove USB stick during download or the file will result empty or corrupted.