ZAPI® S.p.A.

ELECTRONIC • OLEODYNAMIC • INDUSTRIAL EQUIPMENTS CONSTRUCTION
Via Parma, 59 – 42028 – POVIGLIO (RE) – ITALY
Tel +39 0522 960050 (r.a.) – Fax +39 0522 960259
e-mail: zapi@zapispa.it – web: www.zapispa.it

EN

User Manual

ACE3 INVERTER

Publication N°: **AFFZP0BB**
Edition: **08 May 2017**

NOTES DEFINITIONS

	This symbol is used in this publication to indicate an annotation or a suggestion you should pay attention to.
⚠	***This symbol is used inside this publication to indicate an action or a characteristic very important for security. Pay special attention to the annotations pointed out with this symbol.***

Contents

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 ACE3 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 much effort to ensure that this document is complete and accurate at the time of printing. In accordance with Zapi policy of continuous product improvement, 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 equipment knowledge.

⚠ ***Before doing any operation, ensure that the battery is disconnected and when the installation is completed start the machine with the drive 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 +Batt and -Batt terminals of the inverter.***

1.2.2 OEM’s 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

Within the ZAPIMOS family, the ACE3 inverter (E stands for evolution) is a controller designed to control AC induction, BLDC and PMAC motors, in the range from 10 kW to 20 kW 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 5 tons, HLOP (Vna), GSE, tow tractors and airport ground support vehicles, aerial-access equipment (telescopic boom and scissor lift).

The main inverter features are:

- 16 bits microcontroller for motor control and main functions (master microcontroller), 384+ Kbytes embedded Flash memory
- 16 bits microcontroller for safety functions (supervisor microcontroller), 320+ Kbytes 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
- Driver for electromechanical brake
- Drivers for PWM-modulated voltage-controlled electrovalves and for one PWM-modulated current-controlled proportional valve
- Overload, short-circuit and open-load protection
- Thermal cutback, warnings and automatic shutdown provide protection to the motor and the controller
- Optically isolated and ESD-protected CAN bus interface
- Software downloadable via serial link (internal connector) or CAN bus interface (external connector)
- Diagnostics provided via CAN bus interface using Zapi CAN Pc Tool
- Rugged sealed housing and connectors meeting IP65 environmental sealing standards for use in harsh environments

ACE3 controller can be supplied in two I/O configurations and three voltage ratings:

- **Standard Version** (24V, 36/48V, 80V): with a 23-poles Ampseal connector.
- **Premium Version** (24V, 36/48V, 80V): with an additional 23-poles Ampseal connector for enhanced I/O capabilities.

Moreover, two power-rating variants are available (see paragraphs 2.2 and 2.3):

- **ACE3**: base power ratings.
- **ACE3 Power**: increased power ratings.

2.2 Technical specifications of ACE3

Inverter for AC, BLDC and PMAC three-phase motors
Regenerative braking function
Digital control based on microcontroller
Voltage:..36, 48, 80 V
Maximum current ACE3 36-48V: .... 600 A (RMS) for 2'
Maximum current ACE3 80V: .... 450 A (RMS) for 2'
1 hour current rating ACE3 36-48V: .... 300 A (RMS)
1 hour current rating ACE3 80V:.. 225 A (RMS)
Operating frequency: ....8 kHz
External temperature range: ....-40 °C ÷ 40 °C
Maximum inverter temperature (at full power): .... 85 °C

2.3 Technical specifications of ACE3 Power

Inverter for AC, BLDC an PMAC three -phase motors
Regenerative braking functions
Digital control based upon microcontroller
Voltage:..24, 36, 48, 80 V
Maximum current ACE3 PW 24V: .... 700 A (RMS) for 2'
Maximum current ACE3 PW 36-48V: .... 650 A (RMS) for 2'
Maximum current ACE3 PW 80V: .... 550 A (RMS) for 2'
1 hour current rating ACE3 PW 24V:... 350 A (RMS)
1 hour current rating ACE3 PW 36-48V:... 325 A (RMS)
1 hour current rating ACE3 PW 80V:... 275 A (RMS)
Operating frequency: ....8 kHz
External temperature range: ....-30 °C ÷ 40 °C
Maximum inverter temperature (at full power): .... 85 °C

Internal algorithms automatically reduce maximum current limit when heat sink temperature is above 85 °C. Heat sink temperature is measured internally near the power MOSFETs (see paragraph 6.3).

Two-minutes ratings refer to the inverter equipped with a base plate. No additional external heat sink or fans are used for the two-minutes rating tests. Ratings are based on an initial base-plate temperature of 40 °C and a maximum base-plate temperature of 85 °C.

The inverter is designed to deliver the rated continuous RMS current only if it is adequately cooled. When it is equipped with its own finned heat sink, 100 m^3/h airflow is recommended. In case the controller is provided with the base plate, it is customer’s duty to design an adequate cooling system able to dissipate the heat produced by the inverter, keeping its temperature under 85 °C. Otherwise, the inverter will deliver a maximum RMS current lower than the rated one.

2.4 Functional 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 hold on a slope) for a programmable time.
- 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 an hydraulic-steering motor.

  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-diagnosis, 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.

2.5 Diagnoses

The microcontroller continually monitors the inverter and carries out a diagnostic procedure of the main functions. Diagnoses are made of 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.

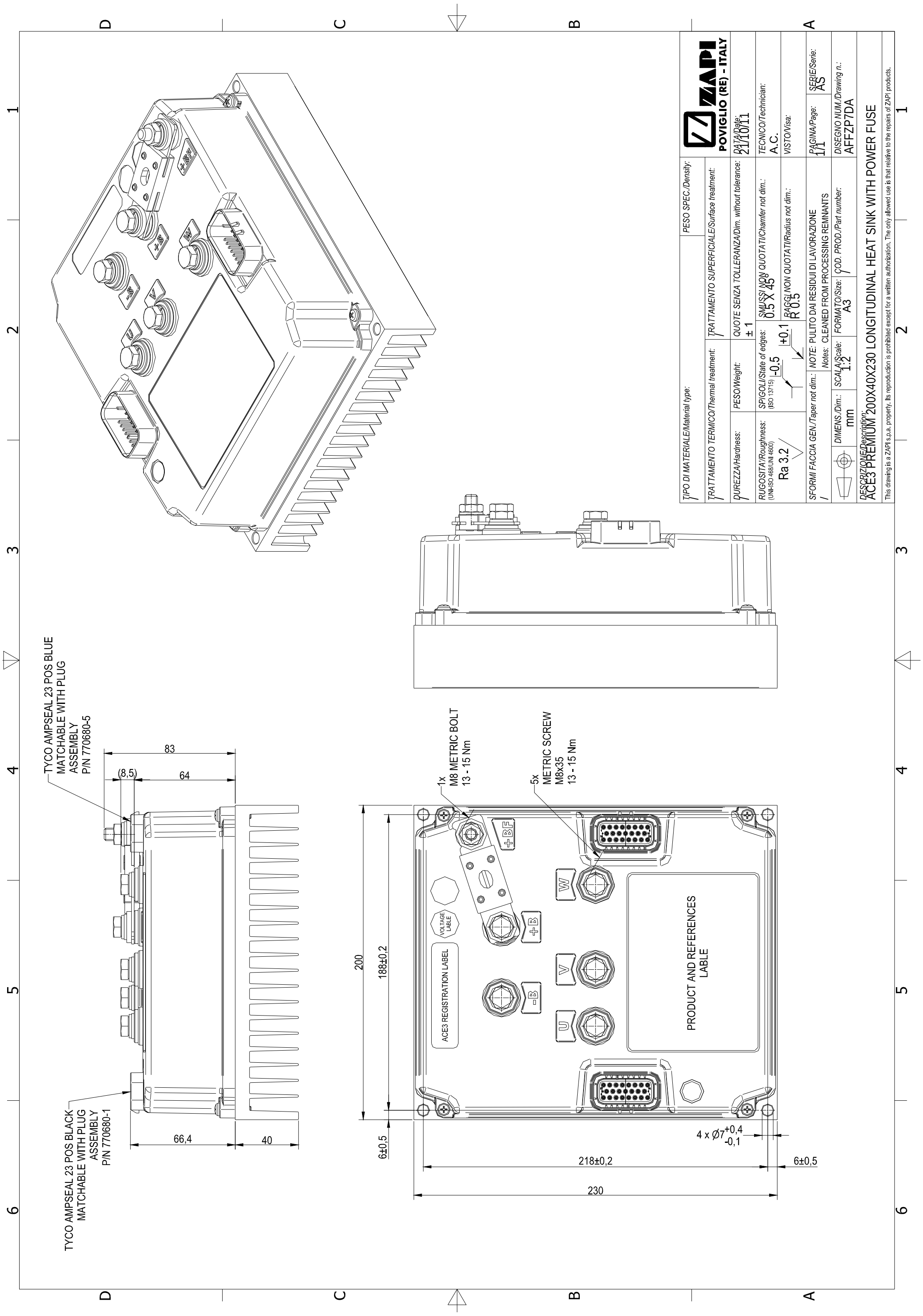
3) Diagnosis during operation that checks: watchdog circuits, contactor driver, current sensors and CAN bus interface.

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.

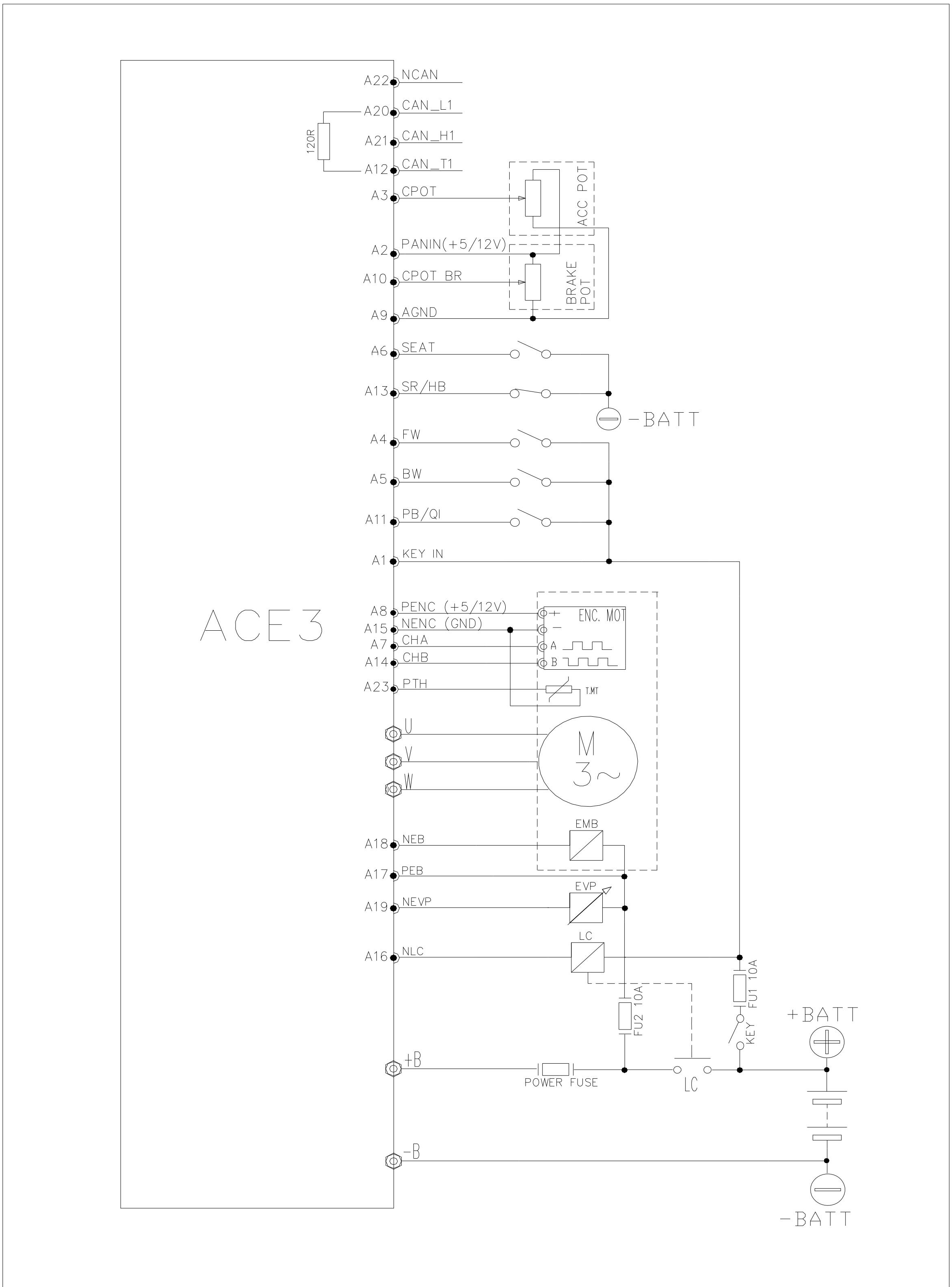
3 DRAWINGS

3.1 Mechanical drawing – ACE3 / ACE3 Power



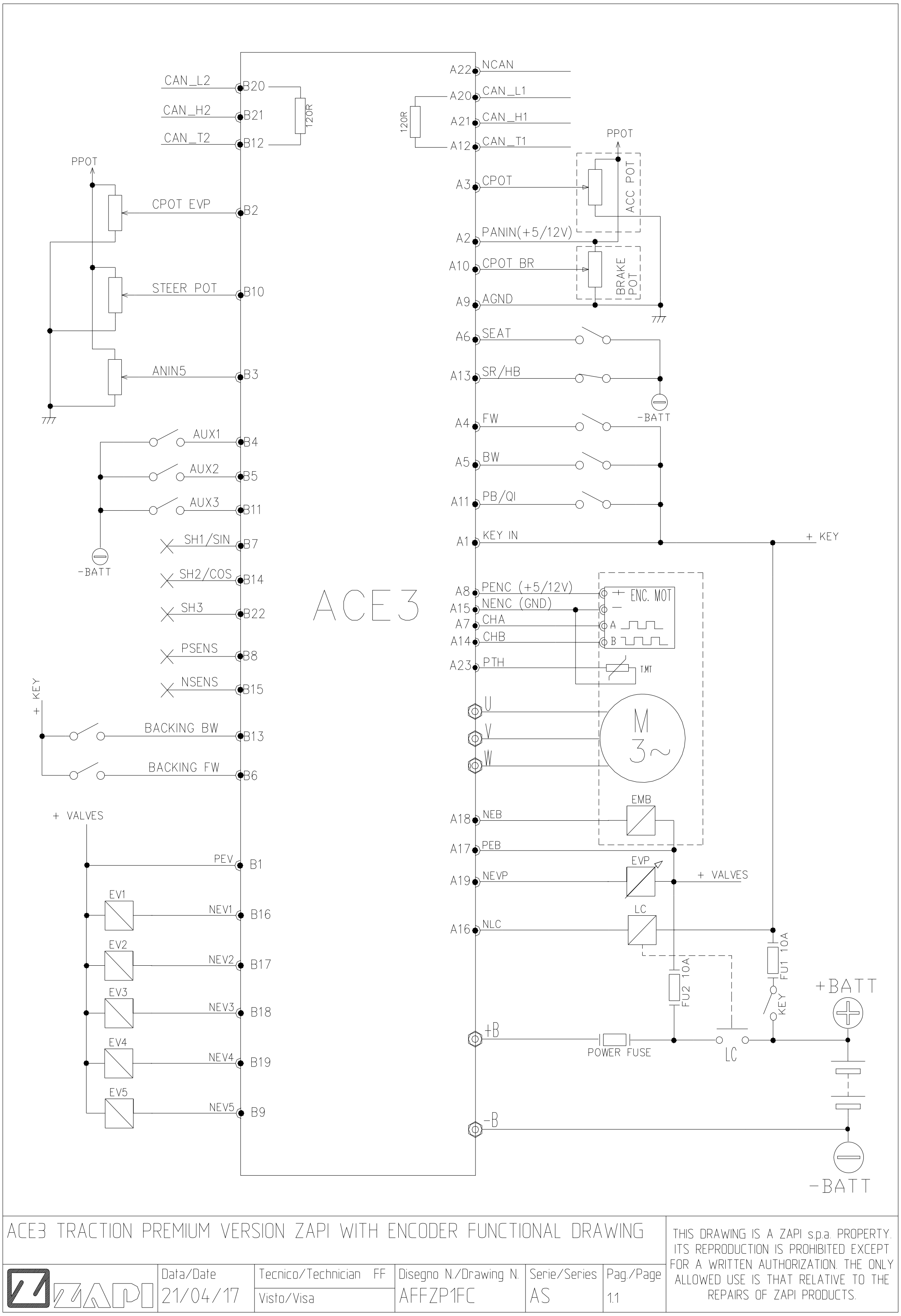
Other versions (without power fuse, with base-plate and with other heat sinks) exist.

3.2 Connection drawing – ACE3 Traction Standard

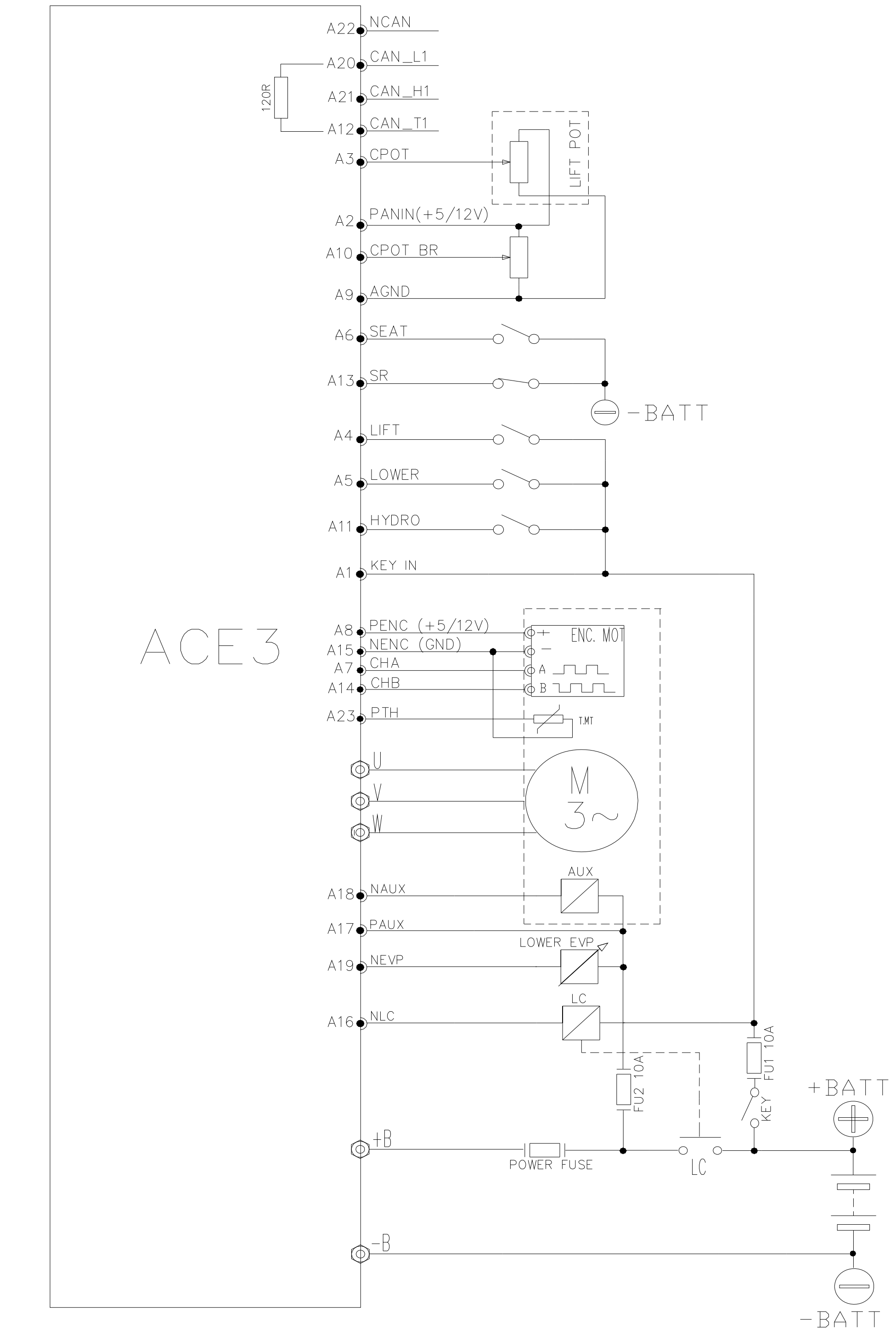


ACE3 TRACTION STANDARD VERSION ZAPI WITH ENCODER FUNCTIONAL DRAWING						THIS DRAWING IS A ZAPI s.p.a. PROPERTY. ITS REPRODUCTION IS PROHIBITED EXCEPT FOR A WRITTEN AUTHORIZATION. THE ONLY ALLOWED USE IS THAT RELATIVE TO THE REPAIRS OF ZAPI PRODUCTS.
ZAPI	Data/Date 21/04/17	Tecnico/Technician FF Visto/Visa	Disegno N./Drawing N. AFFZP1AD	Serie/Series AS	Pag./Page 1.1	

3.3 Connection drawing – ACE3 Traction Premium



3.4 Connection drawing – ACE3 Pump Standard

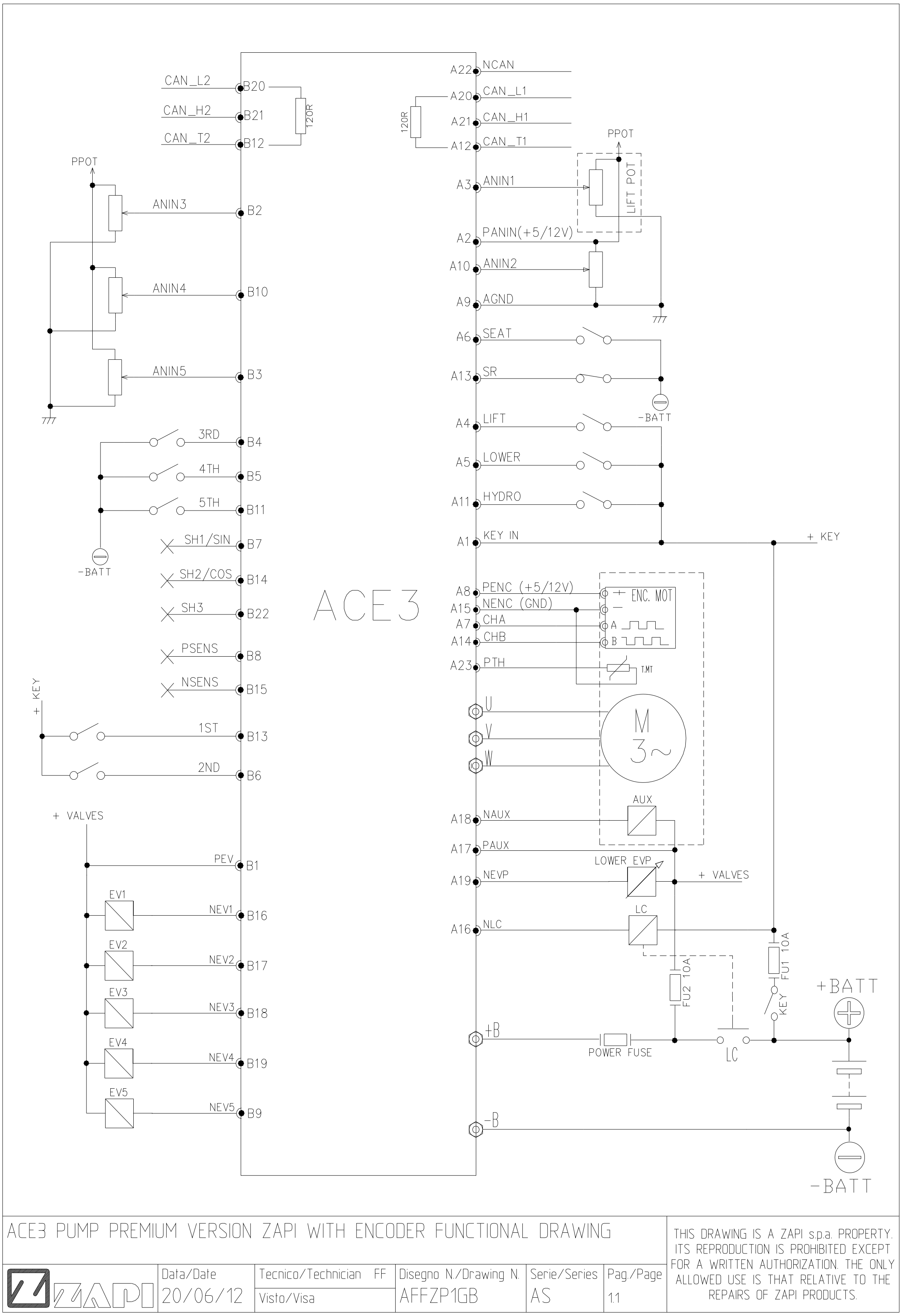


ACE3 PUMP STANDARD VERSION ZAPI WITH ENCODER FUNCTIONAL DRAWING

ZAPI	Data/Date	Tecnico/Technician FF	Disegno N./Drawing N.	Serie/Series	Pag./Page
	26/06/12	Visto/Visa	AFFZP1EB	AS	1:1

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.

3.5 Connection drawing – ACE3 Pump Premium



4 DESCRIPTION OF THE CONNECTORS

4.1 Power connectors

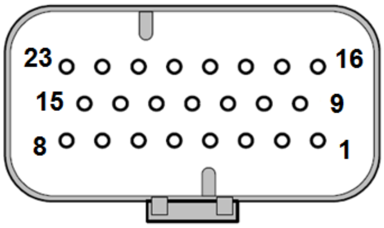
Power connections are on vertical posts where to bolt power-cables lugs. On the cover of the converter they are labeled as:

-B *	Battery negative terminal.
+B *	Battery positive terminal.
U, V, W	Motor phases. Match the sequence with that at the motor terminals.

* Throughout this manual, battery terminals are also addressed as -Batt and +Batt.

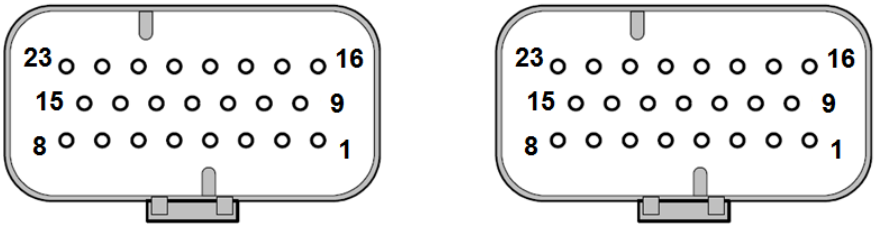
4.2 Ampseal connectors

ACE3 Standard is equipped with one 23-poles Ampseal connector like that of the following 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.



ACE3 Standard 23-poles Ampseal connector.

ACE3 Premium is equipped with two equal 23-poles Ampseal connectors. Each of the 23+23 pins is referred to as “A#” or “B#”, where “A” and “B” denote the connector name and “#” the pin number, from 1 to 23.



ACE3 Premium twin 23-poles Ampseal connectors.

The following paragraphs list the functional associations for the pins of Ampseal connectors, for Standard and Premium versions of ACE3 and for Traction and Pump configurations.

For each I/O pin, the default Zapi function is indicated. The function of each pin can be changed in the customized software. Also, some I/O pins can have special functionality depending on the HW configuration of the controller.

4.2.1 ACE3 Traction Standard

Connector A

A1	KEY	Connected to the power supply through a microswitch in series to a 10 A fuse.
A2	PANIN	Positive supply for potentiometers: 12 V / 5 V output; keep load impedance > 1 kOhm / 0.5 kOhm.
A3	CPOT	Accelerator-potentiometer input (from wiper contact).
A4	FW	Forward-request input. It must be connected to the forward-drive microswitch, active high.
A5	BW	Backward-request input. It must be connected to the backward-drive microswitch, active high.
A6	SEAT	Seat input. It must be connected to the seat microswitch, active to -Batt.
A7	CHA	Incremental-encoder phase-A input.
A8	PENC	Positive supply 12 V / 5 V for encoder.
A9	AGND	Negative supply for potentiometers.
A10	CPOT BR	Brake-potentiometer input (from wiper contact).
A11	PB/QI	Pedal-Brake/Quick-Inversion input, active high.
A12	CAN_T1	CAN termination. If it is connected with A21 (CAN_H1) it introduces the 120 Ohm termination resistance between CAN_L1 and CAN_H1.
A13	SR/HB	Speed-reduction-request or handbrake-request input. Active when the microswitch is open, inactive when it is closed to -Batt.
A14	CHB	Incremental-encoder phase-B input.
A15	NENC	Negative supply for encoder.
A16	NLC	Main-contactor output. The coil is driven to -Batt. Freewheeling diode to the positive supply is built-in.
A17	PEB	Connect the positive supply of electrovalves (EB and EVP) to this pin. Take the positive supply immediately after the main contactor.
A18	NEB	Electromechanical-brake output. The coil is driven to -Batt. Freewheeling diode to A17 is built-in.
A19	NEVP	Proportional-electrovalve output. The coil is driven to -Batt. Freewheeling diode to A17 is built-in.
A20	CAN_L1	CAN bus 1 low-level signal.
A21	CAN_H1	CAN bus 1 high-level signal.
A22	NCAN	CAN bus negative supply.
A23	PTH	Motor-temperature-sensor input. It is possible to use a digital or analog (PTC) sensor.

4.2.2 ACE3 Pump Standard

Connector A

A1	KEY	Connected to the power supply through a microswitch in series to a 10 A fuse.
A2	PANIN	Positive supply for potentiometers: 12 V / 5 V output; keep load impedance > 1 kOhm / 0.5 kOhm.
A3	CPOT	Lift-potentiometer input (from wiper contact).
A4	LIFT	Lifting-request input. It must be connected to the lifting-enable microswitch, active high.
A5	LOWER	Lowering-request input. It must be connected to the lowering-enable microswitch, active high.
A6	SEAT	Seat input. It must be connected to the seat microswitch, active to -Batt.
A7	CHA	Incremental-encoder phase-A input.
A8	PENC	Positive supply 12 V / 5 V for encoder.
A9	AGND	Negative supply for the lifting potentiometer.
A10	ANIN2	Free analog input.
A11	HYDRO	Hydraulic-steering request input, active high.
A12	CAN_T1	CAN termination. If it is connected with A21 (CAN_H1) it introduces the 120 Ohm termination resistance between CAN_L1 and CAN_H1.
A13	SR	Speed-reduction request input. Active when the switch is open. Not active when it is closed to -Batt.
A14	CHB	Incremental-encoder phase-B input.
A15	NENC	Negative supply for encoder.
A16	NLC	Main-contactor output. The coil is driven to -Batt. Freewheeling diode to the positive supply is built-in.
A17	PAUX	Connect the positive supply of electrovalves (AUX and EVP) to this pin. Take the positive supply immediately after the main contactor.
A18	NAUX	Auxiliary-coil output. The coil is driven to -Batt. Freewheeling diode to A17 is built-in.
A19	NEVP	Lowering-proportional-electrovalve output. The coil is driven to the negative reference. Freewheeling diode to A17 is built-in.
A20	CAN_L1	CAN bus 1 low-level signal.
A21	CAN_H1	CAN bus 1 high-level signal.
A22	NCAN	CAN bus negative supply.
A23	PTHERM	Motor-temperature-sensor input. It is possible to use a digital or analog (PTC) sensor.

4.2.3 ACE3 Traction Premium

Connector A

A1	KEY	Connected to the power supply through a microswitch in series to a 10 A fuse.
A2	PANIN	Positive supply for potentiometers: 12 V / 5 V output; keep load impedance > 1 kOhm / 0.5 kOhm.
A3	CPOT	Accelerator-potentiometer input (from wiper contact).
A4	FW	Forward-request input. It must be connected to the forward-drive microswitch, active high.
A5	BW	Backward-request input. It must be connected to the backward-drive microswitch, active high.
A6	SEAT	Seat input. It must be connected to the seat microswitch, active to -Batt.
A7	CHA	Incremental-encoder phase-A input.
A8	PENC	Positive supply 12 V / 5 V for encoder.
A9	AGND	Negative supply for potentiometers.
A10	CPOT BR	Brake-potentiometer input (from wiper contact).
A11	PB/QI	Pedal-Brake/Quick-Inversion input, active high.
A12	CAN_T1	CAN termination. If it is connected with A21 (CAN_H1) it introduces the 120 Ohm termination resistance between CAN_L1 and CAN_H1.
A13	SR/HB	Speed-reduction-request or handbrake-request input. Active when the microswitch is open, inactive when it is closed to -Batt.
A14	CHB	Incremental-encoder phase-B input.
A15	NENC	Negative supply for encoder.
A16	NLC	Main-contactor output. The coil is driven to -Batt. Freewheeling diode to the positive supply is built-in.
A17	PEB	Connect the positive supply of electrovalves (EB and EVP) to this pin. Take the positive supply immediately after the main contactor.
A18	NEB	Electromechanical-brake output. The coil is driven to -Batt. Freewheeling diode to A17 is built-in.
A19	NEVP	Proportional-electrovalve output. The coil is driven to -Batt. Freewheeling diode to A17 is built-in.
A20	CAN_L1	CAN bus 1 low-level signal.
A21	CAN_H1	CAN bus 1 high-level signal.
A22	NCAN	CAN bus negative supply.
A23	PTH	Motor-temperature-sensor input. It is possible to use a digital or analog (PTC) sensor.

Connector B

B1	PEV	Connect the positive supply of electrovalves (EV1, EV2, EV3, EV4, EV5) to this pin. Take the positive supply immediately after the main contactor.
B2	CPOT EVP	Proportional-valve-potentiometer input (wiper contact).
B3	ANIN5	Free analog input.
B4	AUX1	Free digital input, active when connected to -Batt
B5	AUX2	Free digital input, active when connected to -Batt.
B6	BACKING FW	Forward-inching-request input. It must be connected to the forward-inching microswitch, active high.
B7	SH1/SIN	First Hall-sensor input, active low. Using a special hardware configuration it is possible to use it for the sin signal of a sin/cos sensor.
B8	PSENS	Positive supply 12 V / 5 V for Hall sensors or sin/cos sensor.
B9	NEV5	Output for the voltage-controlled PWM-modulated EV5 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B10	STEER POT	Steering-potentiometer input (from wiper contact).
B11	AUX3	Braking-request input. It must be connected to the brake pedal microswitch, active high.
B12	CAN_T2	CAN termination. If it is connected to B21 (CAN_H2) it introduces the 120 Ohm termination resistance between CAN_L2 and CAN_H2.
B13	BACKING BW	Backward-inching-request input. It must be connected to the backward-inching microswitch, active high.
B14	SH2/COS	Second Hall-sensor input, active low. Using a special hardware configuration it is possible to use it for the cos signal of a sin/cos sensor.
B15	NSENS	Negative supply for Hall sensors (or sin/cos sensor).
B16	NEV1	Output for the voltage-controlled PWM-modulated EV1 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B17	NEV2	Output for the voltage-controlled PWM-modulated EV2 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B18	NEV3	Output for the voltage-controlled PWM-modulated EV3 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B19	NEV4	Output for the voltage-controlled PWM-modulated EV4 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B20	CAN_L2	CAN bus 2 low-level signal.
B21	CAN_H2	CAN bus 2 high-level signal.
B22	SH3	Third Hall-sensor input, active low.
B23	FREE	Free pin.

4.2.4 ACE3 Pump Premium

Connector A

A1	KEY	Connected to the power supply through a microswitch in series to a 10 A fuse.
A2	PANIN	Positive supply for potentiometers: 12 V / 5 V output; keep load impedance > 1 kOhm / 0.5 kOhm.
A3	CPOT	Lift-potentiometer input (from wiper contact).
A4	LIFT	Lifting-request input. It must be connected to the lifting-enable microswitch, active high.
A5	LOWER	Lowering-request input. It must be connected to the lowering-enable microswitch, active high.
A6	SEAT	Seat input. It must be connected to the seat microswitch, active to -Batt.
A7	CHA	Incremental-encoder phase-A input.
A8	PENC	Positive supply 12 V / 5 V for encoder.
A9	AGND	Negative supply for the lifting potentiometer.
A10	ANIN2	Free analog input.
A11	HYDRO	Hydraulic-steering request input, active high.
A12	CAN_T1	CAN termination. If it is connected with A21 (CAN_H1) it introduces the 120 Ohm termination resistance between CAN_L1 and CAN_H1.
A13	SR	Speed-reduction request input. Active when the switch is open. Not active when it is closed to -Batt.
A14	CHB	Incremental-encoder phase-B input.
A15	NENC	Negative supply for encoder.
A16	NLC	Main-contactor output. The coil is driven to -Batt. Freewheeling diode to the positive supply is built-in.
A17	PAUX	Connect the positive supply of electrovalves (AUX and EVP) to this pin. Take the positive supply immediately after the main contactor.
A18	NAUX	Auxiliary-coil output. The coil is driven to -Batt. Freewheeling diode to A17 is built-in.
A19	NEVP	Lowering-proportional-electrovalve output. The coil is driven to the negative reference. Freewheeling diode to A17 is built-in.
A20	CAN_L1	CAN bus 1 low-level signal.
A21	CAN_H1	CAN bus 1 high-level signal.
A22	NCAN	CAN bus negative supply.
A23	PTHERM	Motor-temperature-sensor input. It is possible to use a digital or analog (PTC) sensor.

Connector B

B1	PEV	Connect the positive supply of electrovalves (EV1, EV2, EV3, EV4, EV5) to this pin. Take the positive supply immediately after the main contactor.
B2	ANIN3	Free analog input.
B3	ANIN5	Free analog input.
B4	3RD	Third-speed input, to be connected to the 3rd-speed microswitch, active high.
B5	4TH	Fourth-speed input, to be connected to the 4th-speed microswitch, active high.
B6	2ND	Second-speed input, to be connected to the 2nd-speed microswitch, active high.
B7	SH1/SIN	First Hall-sensor input, active low. Using a special hardware configuration it is possible to use it for the sin signal of a sin/cos sensor.
B8	PSENS	Positive supply 12 V / 5 V for Hall sensors (or sin/cos sensor).
B9	NEV5	Output for the voltage-controlled PWM-modulated EV5 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B10	ANIN5	Free analog input.
B11	5TH	Fifth-speed input, to be connected to the 5th-speed microswitch, active high.
B12	CAN_T2	CAN termination. If it is connected to B21 (CAN_H2) it introduces the 120 Ohm termination resistance between CAN_L2 and CAN_H2.
B13	1ST	First-speed input, to be connected to the 1st-speed microswitch, active high.
B14	SH2/COS	Second Hall-sensor input, active low. Using a special hardware configuration it is possible to use it for the cos signal of a sin/cos sensor.
B15	NSENS	Negative supply for Hall sensors (or sin/cos sensor).
B16	NEV1	Output for the voltage-controlled PWM-modulated EV1 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B17	NEV2	Output for the voltage-controlled PWM-modulated EV2 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B18	NEV3	Output for the voltage-controlled PWM-modulated EV3 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B19	NEV4	Output for the voltage-controlled PWM-modulated EV4 electrovalve; 1 A maximum continuous current (driving to -Batt). Freewheeling diode to B1 is built-in.
B20	CAN_L2	CAN bus 2 low-level signal.
B21	CAN_H2	CAN bus 2 high-level signal.
B22	SH3	Third Hall-sensor input, active low.
B23	FREE	Free pin.

5 INPUT DEVICES

This chapter describes the external devices needed to complete the ACE3 installation kit.

5.1 Key Input

5.1.1 Function

Start key switch of the vehicle, generally connected to the KEY input. It supplies with the battery voltage the controller logic circuitry and it also pre-charges the DC-link capacitors at key-on. The KEY voltage is monitored.

Note: external loads connected to the +Batt 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.

5.1.2 Protection

The KEY input is protected against reverse polarity with a diode and it has got approximately a 22 nF capacitance to -Batt 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, chapter 3), should be sized according to the number of motor controllers connected to it (10 A fuse is recommended) and the current absorption of the KEY input (input power under 15 W).

5.2 Digital Inputs

Digital inputs are meant to work in the voltage range from -Batt to +Batt. Related command devices (microswitches) must be connected to +Batt (typically to the key voltage) or to -Batt, depending on the input configuration (refer to pin description in chapter 4). 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.

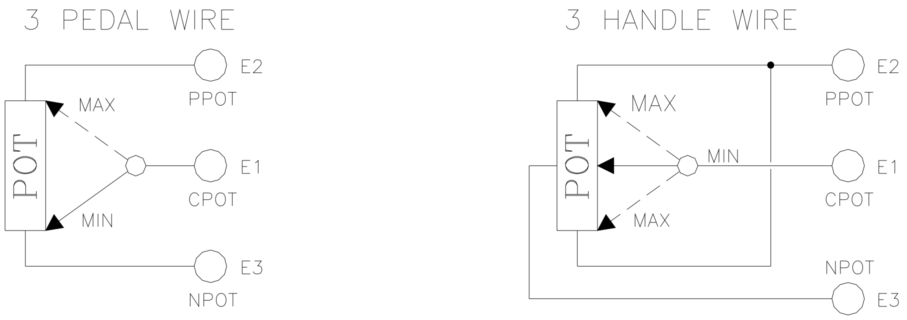
5.2.1 Microswitches

- It is suggested to adopt microswitches with 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.

5.3 Accelerator unit

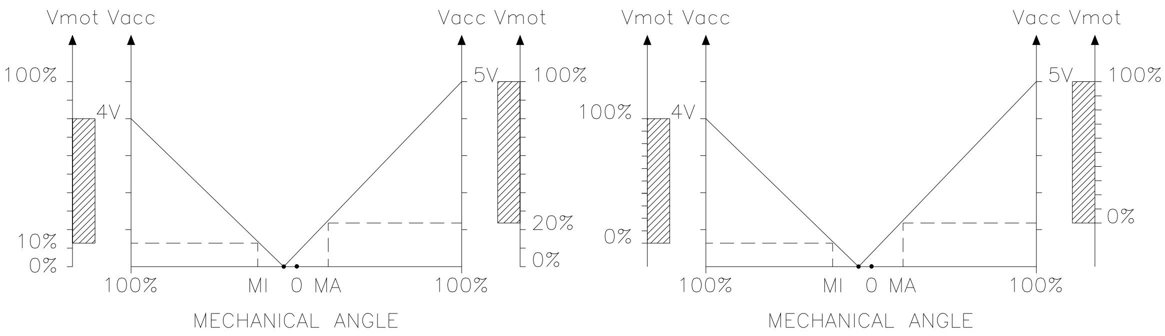
One analog input can be connected to an accelerator unit. The accelerator unit can consist of a potentiometer or a Hall-effect device. It should be in a three-wire configuration. The potentiometer is supplied through terminal A2 (positive terminal) and A9 (negative terminal). Potentiometer output signal (from the wiper contact) must drive input CPOT (A3) and voltage signal must be in the 0 – 10 V range. Potentiometer resistance should be in the 0.5 kΩ – 10 kΩ range; generally, current should be in the 1.5 – 30 mA range. Faults can occur if this limit is exceeded.

The standard connection for the potentiometer is the one on the left 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 adopt the configuration on the right (potentiometer at rest in the middle) in combination with a couple of travel-demand switches.



The procedure for automatic acquisition of the potentiometer signal is carried out using the Console, by means of the PROGRAM VACC function. This enables the adjustment of the minimum and maximum useful levels, in both direction. 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. After the adjustment procedure, Vmot percentage is mapped over the useful voltage ranges of the potentiometer, for both directions. On the other hand, before calibration it results mapped over the default 0 – 5 V range.



Before PROGRAM VACC *After PROGRAM VACC*

5.4 Other analog control unit

5.4.1 Standard version

1) Input A10 is an analog input, whose typical application is as reference for proportional braking. The driving potentiometer should be in a three-wire configuration, its resistance should be within the 0.5 – 10 kΩ range, the current within the 1.5 – 30 mA range and the voltage signal from 0 to 10 V.
2) Connections A23 (PTH) is used for a motor thermal sensor. It can be digital (on/off sensor, normally closed) or analog.

5.4.2 Premium version

Three additional analog inputs are available:

1) Input B2 is an analog input, whose typical application is as reference for the control of the proportional valve.
2) Input B10 is an analog input, whose typical application is as steering reference.
3) Input B3 is an analog input, without a predefined function.

Each driving potentiometer should be in a three-wire configuration, its resistance should be within the 0.5 – 10 kΩ range, the current within the 1.5 – 30 mA range and the voltage signal from 0 to 10 V.

5.5 Speed feedback

Motor control is based upon the motor speed feedback (sensored control). The speed transducer is an incremental encoder, with two phases shifted by 90°.

The encoder can have the following features:

- Power supply: 5 V or 12 V.
- Electric output: open collector (NPN) or push-pull.
- Standard output (channel A and channel B, 90° shifted).

For more details about encoder installation also refer to paragraph 6.2.5.

Note: encoder resolution and motor poles pair that the controller is set to handle are displayed in the home page of the PC CAN Console or of the Smart Console, as:

A3MT2B ZP1.13

Where:
A3MT = ACE3 traction controller (M stands for “Master µC”, S for “Slave µC”)
(A3MP = ACE3 pump controller)
2 = poles pair number
B = 64 pulses/rev

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

5.5.1 Sin/Cos sensor and Hall sensors

ACE3 Premium provides a special interface to connect an absolute sin/cos sensor or three Hall sensors for special applications that use brushless motor. For more details about sensors installation also refer to paragraphs 6.2.6 and 6.2.7.

6 INSTALLATION HINTS

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

6.1 Material overview

6.1.1 Connection cables

For the auxiliary circuits use cables with 0.5 mm² section.

For power connections, to the motor and from the battery, use cables with section of 50 mm² or more. Screwing torque for the power connections must be in the 13 - 15 Nm range.

For the optimum inverter performance, the cables from the battery should run side by side and be as short as possible.

6.1.2 Contactors

Main contactor must always be installed. The output driving the coil is modulated with a 1 kHz PWM basing on the setting of two 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 set by the MC VOLTAGE parameter, the PWM reduces the mean voltage down to the percentage set by the MC VOLTAGE RED. parameter. This feature is useful to decrease the power dissipation of the coil and its heating.

6.1.3 Fuses

- Use a 10 A fuse for protection of the auxiliary circuits.
- For the protection of the power unit, refer to chapter 10. 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 the fuse blows.

6.2 Hardware installation

Before doing any operation, ensure that the battery is disconnected and when the installation is completed start the machine with the drive wheels raised from the ground to ensure that any installation error do 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 the +Batt and -Batt terminals of the inverter.

6.2.1 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 thin layer of thermo-conductive grease between the two surfaces to allow better 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.
- The 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.
- The thermal energy dissipated by the power module varies with the current drawn and with the duty cycle.

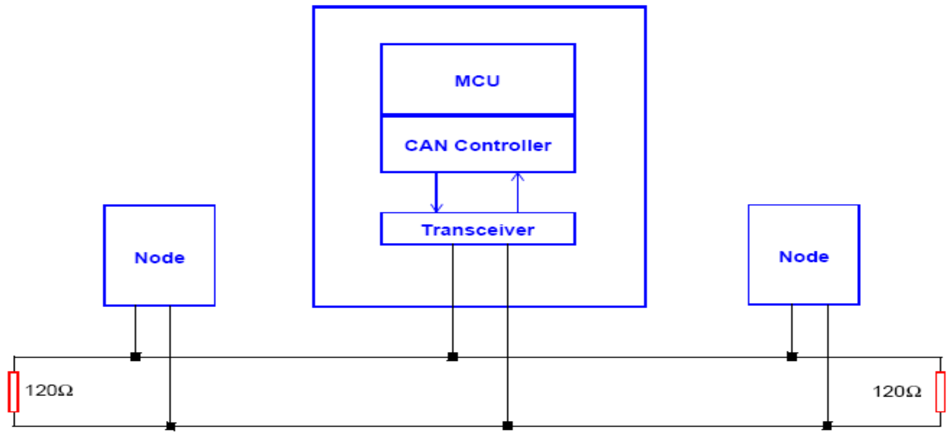
6.2.2 Wirings: power cables

- 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 – 15 Nm range.
- The ACE3 module 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.

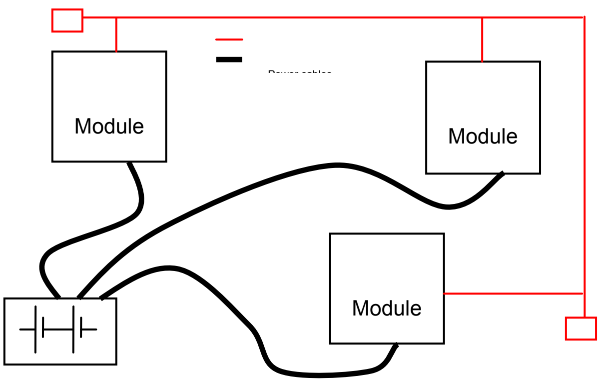
6.2.3 Wirings: CAN bus connections and possible interferences

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



- The best type of cables for CAN 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:



The red lines are CAN wires.

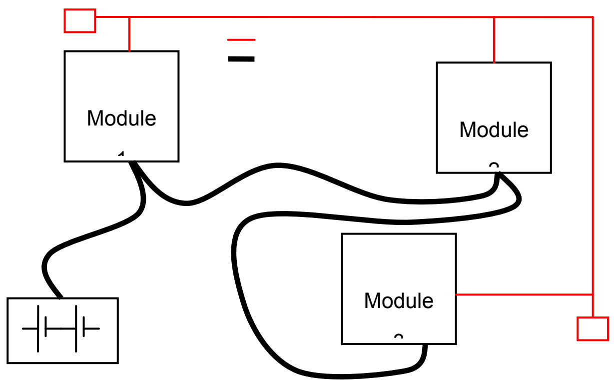
The black boxes are different modules, for example a traction controller, a pump controller and a display connected via CAN bus.

The 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.

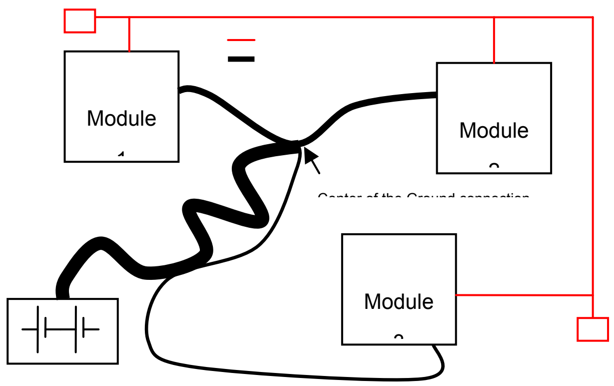
Correct Layout:



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

The chain starts from the –BATT 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 today systems needs more and more data, signal and information must flow from a node to another. CAN 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 to sniff the data being transferred onto the bus).

6.2.4 Wirings: I/O connections

- After crimping the cables, verify that all strands are entrapped in the wire barrel.
- Verify that all the crimped contacts are completely inserted in the connector cavities.

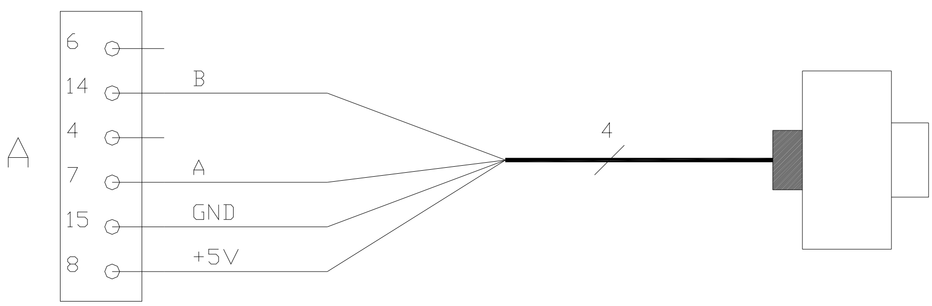
A cable connected to the wrong pin can lead to short circuits and failure; so, before turning on the truck for the first time, verify with a ohmmeter the continuity between the starting point and the end of signal wires.

- For information about the pin assignment see chapter 4.

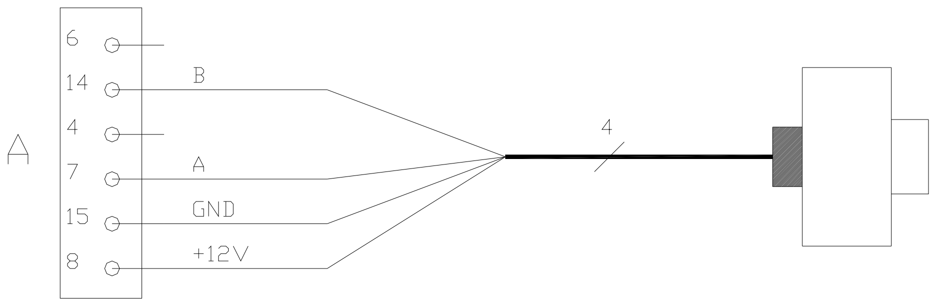
6.2.5 Connection of the encoder

ACE3 controller can handle different types of encoder. To control AC motor, it is necessary to install an incremental encoder with two phases shifted by 90°. The encoder supply can be 5 V or 12 V.

A8	+5V/+12V	positive supply.
A15	GND	negative supply.
A7	ENC A	phase A.
A14	ENC B	phase B.



Connection of encoder with +5 V supply.



Connection of encoder with +12 V supply.

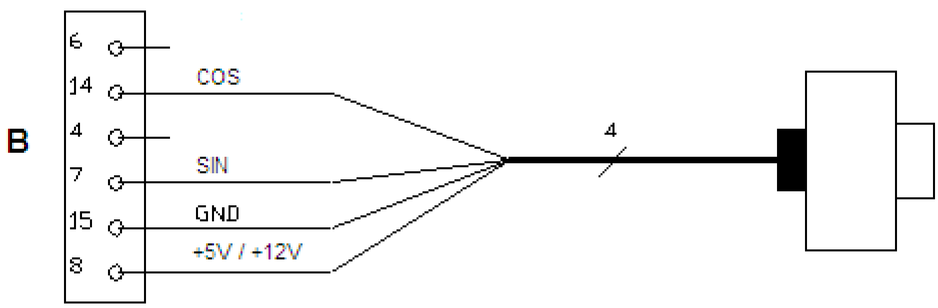
VERY IMPORTANT
It is necessary to specify in the commercial order the type of encoder used, in terms of power supply, electronic output and n° of pulses for revolution, because the logic unit must be set in the correct way by Zapi.

6.2.6 Connection of a Sin/Cos sensor

When the PMSM is of the BLAC type, must be controlled with sine waves shape. A PMSM is a BLAC when, by turning its shaft lightened, the electromotive force between two motor terminals is of the shape sinusoidal.

To control PMAC motor with Zapi inverter, it is necessary to install an absolute Sin/Cos sensor. The Sin/Cos sensor power supply can be +5 or +12 V. At the first key an auto-teaching procedure it is necessary to permit to the controller to acquire the sensor signals.

B8	+5V/+12V	positive supply.
B15	GND	negative supply.
B7	SIN	sine signal.
B14	COS	cosine signal.



Connection of sin/cos sensors.

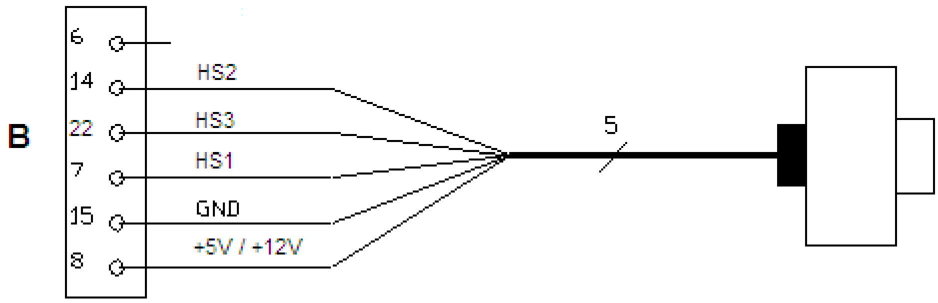
VERY IMPORTANT
It is necessary to specify in the commercial order the type of sensor used, in terms of power supply, electronic output and n° of pulses for revolution, because the logic unit and the software must be set in the correct way by Zapi lines.

6.2.7 Connection of Hall sensors

When the PMSM is of the BLDC type, must be controlled with a six steps inverter (trapezoidal wave shape). A PMSM is a BLDC when, by turning its shaft lightened, the electromotive force between two motor terminals is of the shape trapezoidal.

To control BLDC motor with Zapi inverter, it is necessary to three Hall sensors. Hall sensors power supply can be +5 or +12 V.

B8	+5V/+12V	positive supply.
B15	GND	negative supply.
B7	HS1	Hall sensor 1.
B14	HS2	Hall sensor 2.
B22	HS3	Hall sensor 3.

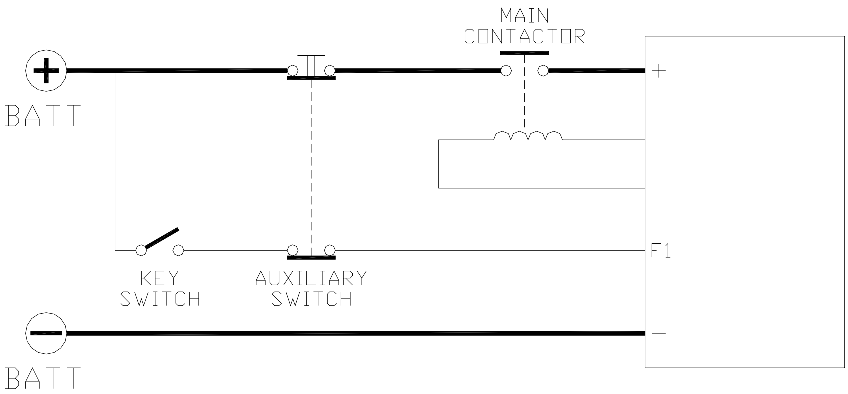


Connection of Hall sensors.

VERY IMPORTANT
It is absolutely mandatory to specify in the commercial order the type of sensor to be used, in terms of supply voltage, electronic output and number of pulses per revolution, configuration of hall sensors and the sensor sequence when the rotor is spinning because the logic unit and the software must be set in the correct way by Zapi lines.

6.2.8 Main-contactor and key connection

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



- 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.

6.2.9 Insulation of truck frame

⚠ ***As stated by EN-1175 "Safety of machinery – Industrial truck", chapter 5.7, "there shall 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.***

6.3 Protection and safety features

6.3.1 Protection features

The ACE3 inverter is protected against:

- **Battery polarity inversion**
  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.
- **Thermal protection**
  If the controller temperature exceeds 85 °C, the maximum current is reduced in proportion to the temperature excess. Also, the temperature can never exceed 105 °C.
- **External agents**
  The inverter is protected against dust and sprays with a degree of protection meeting IP65.
- **Protection against uncontrolled movements**
  The main contactor will not close if:
  - The power unit is not functioning.
  - The logic unit is not functioning.
  - The output voltage of the accelerator does not fall below the threshold given by the minimum voltage value stored during the adjustment procedure, plus 1 V.
  - One drive microswitch (forward or backward) is closed.
- **Low battery charge**
  When the battery charge is low, the maximum current is reduced to half of the maximum programmed current.
- **Protection against accidental start up**
  A precise sequence of operations are necessary for the machine to start.
  Operation does not begin if they are not correctly carried out.
  Requests for drive must be made after closing the key switch.

6.3.2 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.
The machine manufacturer holds the responsibility for the truck safety features and related approval.

6.4 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, 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).

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 level of emissions/ immunity required, 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 is 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.

6.5 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.

7 INVERTER SETTINGS

7.1 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
HYDRO TIME

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

ADJUSTMENT
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 EV1
PWM EV2
PWM EV3
PWM EV4
PWM EV5
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
HW EXTENSION
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 SETTING
TOP MAX SPEED
CONF.POSITIVE LC
FEEDBACK SENSOR
ROTATION CW ENC
ROTATION CW MOT
ENCODER PULSES 1
ENCODER PULSES 2
MOTOR P. PAIRS 1
MOTOR P. PAIRS 2
***

HYDRO SETTINGS
HYDRO TIME
HYDRO FUNCTION

7.2 Settings description

This section provides detailed information about all the inverter settings.

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 controllers (in single motor applications)
TM = Traction master controllers (in multiple motor applications)
TS = Traction supervisor controllers (in multiple motor applications)
P = AC pump controllers
CO = CANopen controllers
N = none

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 requests.

7.2.1 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, i.e. 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, i.e. 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, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint (see paragraph 8.4).
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, i.e. 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 8.4).
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, i.e. 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 8.4).
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, i.e. 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 8.4).

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
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, i.e. 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 8.5).
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, i.e. 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 8.5).
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, i.e. 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 8.5).
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, i.e. 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 8.5).
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 1st speed is requested. It represents 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 2nd speed is requested. It represents a percentage of the maximum pump speed.
3RD PUMP SPEED (P)	0% ÷ 100% (by 1% steps)	This parameter defines the speed of the pump motor when 3rd speed is requested. It represents 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. It represents 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. It represents a percentage of the maximum pump speed.

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
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. It represents 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. It represents 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. It represents 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. It represents a percentage of TOP MAX SPEED. **Note: by default H&S function is not present on ACE3.**
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- 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 and the forward- or reverse-request switch 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.
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.

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
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 is hold 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.
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.

7.2.2 SET OPTIONS

SET OPTIONS		
Parameter	**Allowable range**	**Description**
HM DISPLAY OPT. (T, TM, P, CO)	0 ÷ 6	This parameter decides the configuration for the hour meter shown on a display (i.e. MDI). The possible settings are the same of HM CUSTOM 1 OPT. parameter.
HM CUSTOM 1 OPT. (T, TM, P, CO)	0 ÷ 6	This parameter decides the configuration for the hour meter number 1 accessible to the customer. 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 ACE3**
HM CUSTOM 2 OPT. (T, TM, P, CO)	0 ÷ 6	This parameter decides the configuration for the hour meter number 2 accessible to the customer. The possible settings are the same of HM CUSTOM 1 OPT. parameter.
TILL/SEAT SWITCH (T, TM, P)	HANDLE ÷ SEAT	This option handles the input A6. This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. **HANDLE =** input A6 is managed as tiller input (no delay when released). **DEADMAN =** input A6 is managed as dead-man input (no delay when released). **SEAT =** input A6 is managed as seat input (with a delay when released and the de-bouncing function).
EB ON TILLER BRK (T)	OFF, ON	This option defines how the electromechanical brake is managed depending on the status of 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.

<table>
<tr><th colspan="3">SET OPTIONS</th></tr>
<tr><th>Parameter</th><th>Allowable range</th><th>Description</th></tr>
<tr><td>BATTERY CHECK
(T, TM, P, CO)</td><td>0 ÷ 3</td><td>This option specifies the management of the low battery charge situation. There are four levels of intervention:
0 = nothing happens; the battery charge level is evaluated but ignored, meaning that no action is taken when the battery runs out.
1 = the BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. With the BATTERY LOW alarm, the control reduces the maximum speed down to 24% of the full speed and it also reduces the maximum current down to 50% of the full current.
2 = the BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge.
3 = the BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to 10% of the full charge. With the BATTERY LOW alarm, the control reduces the maximum speed down to 24% of the full speed.</td></tr>
<tr><td>STOP ON RAMP
(T, TM, P, CO)</td><td>OFF, ON</td><td>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 (truck electrically held on a ramp) is performed for a time set in the "AUXILIARY TIME" parameter. After this interval, the behavior depends on the "AUX OUT FUNCTION" option.
OFF = the stop-on-ramp feature is not performed. A controlled slowing down is performed for a minimum duration set in the "AUXILIARY TIME" parameter. After this time, the behavior depends on the “AUX OUT FUNCTION" option.
For more details, see “Behavior on a slope” table at the end of the paragraph.</td></tr>
<tr><td>PULL IN BRAKING
(A)</td><td>OFF, ON</td><td>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 anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.</td></tr>
</table>

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 curve. 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.
QUICK INVERSION (T, TM, P)	NONE ÷ BELLY	This parameter defines the quick-inversion functionality. **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 ACE3.**

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 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 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 adopted. **NONE =** no motor thermal sensor is connected. **DIGITAL =** a digital (ON/OFF) motor thermal sensor is connected to A23. **OPTION#1 =** an analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). **OPTION#2 =** an analog motor thermal sensor is connected to A23. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance) **OPTION#3 =** an analog motor thermal sensor is connected to A23. The temperature sensor is 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; ACE3 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 ACE3 via CAN bus. **OPTION#2 =** EPS is present and it is configured with potentiometer + encoder, whose signals are acquired and related data transmitted to ACE3 via CAN bus. **ANALOG =** A hydraulic steering is adopted and ACE3 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, 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 enables or disables the management of the electromechanical brake: **ABSENT =** the diagnosis are masked and E.B. is not driven upon a traction request. **PRESENT =** E.B. is driven upon a traction request if all the related diagnosis pass.
AUX OUT FUNCTION (A)	NONE, BRAKE	This parameter enables or disables the output A18 (NEB): **NONE =** the diagnosis 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 diagnosis pass. The behavior on a slope depends on the “STOP ON RAMP” setting (see “Behavior on a slope” table at the end of the paragraph).
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 8.4.
EVP TYPE (A)	NONE ÷ DIGITAL	This parameter defines how the output A19 (EVP) operates. **NONE =** output not enabled, no load connected to A19. **ANALOG =** A19 manages a current-controlled PWM-modulated proportional valve. **DIGITAL =** A19 manages an on/off valve. See the EVP-related parameters in PARAMETER CHANGE.
EV1 (A – Premium version only)	ABSENT, OPTION#2	This parameter defines how the output B16 (NEV1) operates. **ABSENT =** output not enabled, no on B16. **OPTION#1 =** B16 manages an on/off valve. By default it is controlled by the 1st-speed command. **OPTION#2 =** free for future use.
EV2 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output B17 (NEV2) operates. **ABSENT =** output not enabled, no on B17. **DIGITAL =** B17 manages a voltage-controlled PWM-modulated valve. The PWM frequency is 1kHz and the duty cycle depends on PWM EV2 (ADJUSTMENT list).
EV3 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output B18 (NEV3) operates. **ABSENT =** output not enabled, no load on B18. **DIGITAL =** B18 manages a voltage-controlled PWM-modulated valve. The PWM frequency is 1kHz and the duty cycle depends on PWM EV3 (ADJUSTMENT list).

SET OPTIONS		
Parameter	**Allowable range**	**Description**
EV4 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output B19 (NEV4) operates. **ABSENT =** output not enabled, no on B19. **DIGITAL =** B19 manages an on/off valve.
EV5 (A – Premium version only)	ABSENT, DIGITAL	This parameter defines how the output B9 (NEV5) operates. **ABSENT =** output not enabled, no on B9. **DIGITAL =** B9 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. **ON =** the Quick-Inversion switch is normally closed (function is active when the switch is open). **OFF =** the Quick-Inversion switch 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 WHEELBASE MM, FIXED AXLE MM, STEERING AXLE and REAR POT ON LEFT parameters. **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 8.7 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 8.7.
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 8.7

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 8.7
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.**

Behavior on a slope.

AUX OUTPUT	**A4 OUTPUT**	**STOP-ON-RAMP**	**Behavior on a slope (when accelerator is released)**
BRAKE	It drives the coil of an electromagnetic brake.	**ON**	The truck is electrically held in place. After the time set in the "AUXILIARY TIME" parameter has elapsed, brake is applied and the three-phase bridge released.
		OFF	The truck is not electrically hold in place, instead it drives down very slowly; when the time set in the "AUXILIARY TIME " parameter has elapsed, brake is applied and the three-phase bridge released.

Ensure the negative brake is installed and functioning before driving the truck on any slope.

Driving the truck on a slope without the brake functioning may lead to serious accidents for the operators and surrounding people.

7.2.3 ADJUSTMENT

ADJUSTMENT		
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)	12V ÷ 80V	This parameter defines the supply-voltage value connected to CNA-3. The available values are: **12V, 24V, 36V, 40V, 48V, 72V, 80V**
SET PBRK. MIN (T, TM, TS, CO)	0V ÷ 25.5V (by steps of 0.1V)	It records the minimum value of brake potentiometer when the brake is analog.
SET PBRK. MAX (T, TM, TS, CO)	0V ÷ 25.5V (by steps of 0.1V)	It records the maximum value of brake potentiometer when the brake is analog.
MIN LIFT DC **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (by steps of 0.1V)	It records the minimum value of lifting potentiometer when the lift switch is closed. See paragraph 8.2
MAX LIFT DC **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (by steps of 0.1V)	It records the maximum value of lifting potentiometer when the lift switch is closed. See paragraph 8.2
MIN LOWER **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (by steps of 0.1V)	It records the minimum value of lower potentiometer when the lower switch is closed. See paragraph 8.2
MAX LOWER **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (by steps of 0.1V)	It records the maximum value of lower potentiometer when the lower switch is closed. See paragraph 8.2
THROTTLE 0 ZONE (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines a dead band in the accelerator input curve. See paragraph 8.8
THROTTLE X1 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 8.8
THROTTLE Y1 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 8.8

ADJUSTMENT		
Parameter	**Allowable range**	**Description**
THROTTLE X2 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 8.8
THROTTLE Y2 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 8.8
THROTTLE X3 MAP (T, TM, P)	0% ÷ 100% (by 1% steps)	This parameter defines the accelerator input curve. See paragraph 8.8
THROTTLE Y3 MAP (T, TM, P)	0% ÷ 100% (by step of 1%)	This parameter defines the accelerator input curve. See paragraph 8.8
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 8.10
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 8.10
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 8.10
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 8.10
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)	0V ÷ 25.5V (by steps of 0.1V)	This parameter records the maximum steering-control voltage while turning right. See paragraph 8.3
STEER LEFT VOLT (T,TM)	0V ÷ 25.5V (by steps of 0.1V)	This parameter records the maximum steering-control voltage while turning left. See paragraph 8.3
STEER ZERO VOLT (T,TM)	0V ÷ 25.5V (by steps of 0.1V)	This parameter records the maximum steering-control voltage when it is in the straight-ahead position See paragraph 8.3

ADJUSTMENT		
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 8.7
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 8.7
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 8.7
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.

ADJUSTMENT		
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.
PWM EV1 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV1 output (B16).
PWM EV2 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV2 output (B17).
PWM EV3 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV3 output (B18).
PWM EV4 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV4 output (B19).
PWM EV5 (A – Premium only)	0% ÷ 100% (255 steps)	This parameter defines the duty-cycle of the PWM applied to EV5 output (B9).
MC VOLTAGE (A)	0% ÷ 100% (by 1% steps)	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the main-contactor output (A16) 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 a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor. **Example 1** MC VOLTAGE = 100% MC VOLTAGE RED = 70% The contactor is closed by applying 100% PWM to the coil for one second, then duty-cycle is reduced to 70%. **Example 2** MC VOLTAGE = 70% MC VOLTAGE RED. = 100% The contactor is closed by applying 70% PWM to the coil for one second, then duty-cycle is kept at the same value. **Example 3** MC VOLTAGE = 70% MC VOLTAGE RED = 70% The contactor is closed by applying 70% PWM to the coil for one second, then duty-cycle is reduced to 49%.
EB VOLTAGE (A)	0% ÷ 100% (by 1% steps)	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the main-contactor output (A18) during the first second after the activation signal that causes the electromechanical brake to release.

ADJUSTMENT		
Parameter	**Allowable range**	**Description**
EB VOLTAGE RED. (A)	0% ÷ 100% (by 1% steps)	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released. **Example 1** EB VOLTAGE = 100% EB VOLTAGE RED = 70% The electromechanical brake is released by applying 100% PWM to the coil, then duty-cycle is reduced to 70%. **Example 2** EB VOLTAGE = 70% EB VOLTAGE RED. = 100% The electromechanical brake is closed by applying 70% PWM to the coil for one second, then duty-cycle is kept at the same value. **Example 3** MC VOLTAGE = 70% MC VOLTAGE RED = 70% The electromechanical brake is closed by applying 70% PWM to the coil for one second, then duty-cycle is reduced to 49% (70% of 70%).
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 50% cutback is applied to the maximum current. 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 maximum motor temperature permitted, above which the controller stops driving the motor.
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)	OFF, ON	When this parameter is ON, the control linearly reduces the motor torque basing on the motor temperature. Reference limits of the linear reduction are MAX MOTOR TEMP and TEMP. MOT. STOP.
VACC SETTING (A)	Volt	See the PROGRAM VACC procedure in paragraphs 0 and 12.2.6.

7.2.4 SPECIAL ADJUST.

Note: SPECIAL ADJUST. must only be accessed by skilled people. To change settings in this group of settings, a special procedure is needed. Ask for this procedure directly to a Zapi technician. In SPECIAL ADJUST. there are factory-adjusted parameters that should be changed by expert technicians only.

<table>
<tr><th colspan="3">SPECIAL ADJUST.</th></tr>
<tr><th>Parameter</th><th>Allowable range</th><th>Description</th></tr>
<tr><td>ADJUSTMENT #01
(Read Only)
(A)</td><td>0% ÷ 255%
(by 1% steps)</td><td>(Factory adjusted). Gain of the first traction-motor current-sensing amplifier.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>ADJUSTMENT #02
(Read Only)
(A)</td><td>0% ÷ 255%
(by 1% steps)</td><td>(Factory adjusted). Gain of the second traction-motor current-sensing amplifier.
NOTE: only Zapi technicians can change this value through a special procedure.</td></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}.
The available values are:
<table>
<tr><th></th><th>ACE3</th><th>ACE3 PW</th></tr>
<tr><td>24V</td><td>-</td><td>700Arms</td></tr>
<tr><td>36/48V</td><td>600Arms</td><td>650Arms</td></tr>
<tr><td>80V</td><td>450Arms</td><td>550Arms</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 for the overcurrent-detection circuit, i.e. its level of intervention. Reserved.
NOTE: only Zapi technicians can change this value.</td></tr>
</table>

SPECIAL ADJUST.		
Parameter	**Allowable range**	**Description**
HW EXTENSION (A)	ABSENT, PRESENT	This parameter defines the controller version. **ABSENT =** ACE3 standard version. **PRESENT =** ACE3 premium version.
PWM AT LOW FREQ (A)		(Factory adjusted). This parameter defines the power-bridge PWM frequency at low speed. NOTE: only Zapi technicians can change this value through a special procedure.
PWM AT HIGH FREQ (A)		(Factory adjusted). This parameter defines the power-bridge PWM frequency at high speed. NOTE: only Zapi technicians can change this value through a special procedure.
FREQ TO SWITCH (A)		(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”. NOTE: only Zapi technicians can change this value through a special procedure.
DITHER AMPLITUDE (A)	0% ÷ 13%	This parameter defines the dither signal amplitude. The dither signal is a square wave added to the proportional-valve set-point. In this way the response to set-point variations results optimized. This parameter is a percentage of the valve maximum current. Setting the parameter to 0% means the dither is not used. The available values are: **0.0%, 1.0%, 2.5%, 4.0%, 5.5%, 7.0%, 8.5%, 10%, 11.5%, 13.0%**
DITHER FREQUENCY (A)	20.8 Hz ÷ 83.3 Hz	This parameter defines the dither frequency. The 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. The available values are: **20, 50, 125, 250, 500**
EXTENDED FORMAT (A)	OFF, ON	This parameter defines the CAN bus protocol. **ON =** standard format (11 bit); **OFF =** extended format (29bit).
DEBUG CANMESSAGE (A)	OFF, ON	This parameter enables or disables special debug messages. Reserved.
CONTROLLER TYPE (A)	0 ÷ 9	This parameter defines the controller type. Reserved. NOTE: only Zapi technicians can change this value.

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.

7.2.5 HARDWARE SETTING

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

For descriptions and teaching about missing parameters contact a Zapi technician.

HARDWARE SETTING		
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) **1 =** it is connected to KEY (A1) **2 =** it is connected to SEAT input (A6)
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
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.
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.**

HARDWARE SETTING		
Parameter	**Allowable range**	**Description**
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.

7.2.6 HYDRO SETTING

HYDRO SETTING		
Parameter	**Allowable range**	**Description**
HYDRO TIME (A)	0 s ÷ 200 s (steps of 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 =** ACE3 constantly drives the pump motor from key-on. **RUNNING =** ACE3 drives the pump motor only upon an associated request (for example a lift request). **OPTION #1 =** ACE3 does not drive the pump motor, but the truck integrates hydraulics and ACE3 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.

7.3 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 controllers (in single motor applications)
TM = Traction master controllers (in multiple motor applications)
TS = Traction supervisor controllers (in multiple motor applications)
P = AC pump controllers
CO = CANopen controllers
N = none

7.3.1 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.
BATTERY VOLTAGE (A)	Volt (0.1 V)	Battery voltage measured in real time (across the DC bus).
DC BUS CURRENT (A)	Ampere (1 A)	Estimation of the DC current the inverter is drawing from the battery.
BATTERY CHARGE (A)	Percentage (1%)	Residual battery charge as percentage of the full charge.
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.

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
MEASURED SPEED (A)	Hertz (0.1 Hz)	Motor speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
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.
FLAGS LIMITATION (A)	ON, OFF	Flag for any current limitation being active, for example thermal current cutback, maximum current reached, etc. .
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)	Newton Meter (0.1 Nm)	Estimation of the motor torque.
STEER ANGLE (T, TM)	Degrees (1°)	Current steering-wheel angle. When the steering is straight ahead STEER ANGLE is zero.

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.
A6 TILLER (T, TM)	OFF/ON	Status of the TILLER/SEAT input (A6).
A11 QI/PB (T, TM)	OFF/ON	Status of the Pedal-Brake/Quick-Inversion input (A11)
B13 HS (T, TM)	OFF/ON	Status of the Hard&Soft input (B13).
A4 FW SW (T, TM, TS)	OFF/ON	Status of the forward input (A4).
A4 ENABLE (T, TM, TS)	OFF/ON	Status of the driving-demand input (A4).
A5 BW SW (T, TM)	OFF/ON	Status of the backward input (A5).
B11 AUX3 (T, TM)	OFF/ON	Status of the AUX3 input (B11) that enables EV3
B4 AUX1 (T, TM)	OFF/ON	Status of the AUX3 input (B4) that enables EV1
B5 AUX2 (T, TM)	OFF/ON	Status of the AUX3 input (B5) that enables EV2
A13 SR/HB (T, TM)	OFF/ON	Status of the Speed-Reduction/Hand-Brake input (A13).
B6 FW-INCH (TS)	OFF/ON	Status of the forward-inching input (B6).
B13 L-BW-IN (TS)	OFF/ON	Status of the backward-inching input (B13).
A6 SEAT (P)	OFF/ON	Status of the TILLER/SEAT input (A6).

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
B13 SPD1 (P)	OFF/ON	Status of the 1ST-speed input (B13).
A11 HYDRO (P)	OFF/ON	Status of the hydraulic-steering input (A11).
A4 LFT/E (P)	OFF/ON	Status of the lift input (A4).
A5 LOWER (P)	OFF/ON	Status of the lowering input (A5).
B6 SPD2 (P)	OFF/ON	Status of the 2ND-speed input (B6).
B4 SPD3 (P)	OFF/ON	Status of the 3RD-speed input (B4).
B5 SPD4 (P)	OFF/ON	Status of the 4TH-speed input (B5).
B11 SPD5 (P)	OFF/ON	Status of the 5TH-speed input (B11).
A13 CUTBAC1 (P)	OFF/ON	Status of the speed-reduction input (A13).
NODE ID (CO)	0 ÷ 56	Node ID setting for CAN OPEN Protocol
TARGET SPEED (CO)	10 Hertz (1 daHz)	This value shows the speed setpoint transmitted over CAN OPEN protocol. It is expressed in tenths of Hz.
BRAKING REQUEST (CO)	0 ÷ 255	This value shows the braking setpoint transmitted over CAN OPEN protocol.
CONTROL WORD (CO)	0 ÷ 65535	It shows the Control Word transmitted upon CAN OPEN protocol.
STATUS WORD (CO)	0 ÷ 65535	It shows the Status Word travelling upon CAN OPEN protocol.
WARNING SYSTEM (CO)	0 ÷ 65535	In case of warning it shows the related warning code.
TARGET EVP1 (CO)	Percentage (1%)	This value shows the setpoint of proportional electrovalve EVP1 in CAN Open configuration.

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
TORQUE REQ. (CO)	Newton Meter (1 Nm)	This value shows the torque setpoint for AC motor in CAN Open configuration.
TORQUE BRK REQ. (CO)	Newton Meter (1 Nm)	This value shows the torque setpoint during braking for AC motor in CAN Open configuration.
A3 POT#1 (A)	Volt (0.01V)	Voltage of the analog signal on A3.
A10 POT#2 (A)	Volt (0.01V)	Voltage of the analog signal on A10.
B2 POT#3 (A)	Volt (0.01V)	Voltage of the analog signal on B2.
B10 POT#4 (A)	Volt (0.01V)	Voltage of the analog signal on B10.
B3 POT#5 (A)	Volt (0.01V)	Voltage of the analog signal on B3.
SIN FB. INPUT (A – Only for BLE3 with sin/cos sensor)	Volt (0.01 V)	Voltage of sine input (B7).
COS FB. INPUT (A – Only for BLE3 with sin/cos sensor)	Volt (0.01 V)	Voltage of cosine input (B14).
A19 SET EVP (A)	Percentage (1%)	This value shows the setpoint of proportional electrovalve EVP.
B16 OUTPUT EV1 (A – Only Premium version)	OFF/ON	It shows the status of the EV1 output (B16).
B17 OUTPUT EV2 (A – Only Premium version)	OFF/ON	It shows the status of the EV2 output (B17).
B18 OUTPUT EV3 (A – Only Premium version)	OFF/ON	It shows the status of the EV3 output (B18).
B19 OUTPUT EV4 (A – Only Premium version)	OFF/ON	It shows the status of the EV4 output (B19).

TESTER (Master)		
Parameter	**Unit of measurement (resolution)**	**Description**
B9 OUTPUT EV5 (A – Only Premium version)	OFF/ON	It shows the status of the EV5 output (B9).
A16 MAIN CONT. (A)	Percentage (1%)	This value shows the voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.
A18 ELEC.BRAKE (A)	Percentage (1%)	This value shows the voltage applied over the electro mechanic brake coil. It corresponds to the duty cycle value of PWM applied and it is expressed in percentage.
CTRAP HW (A)	Units (1)	Number of hardware-overcurrent occurrences.
A.SENS.OFFSET SR (A – Only for BLE3 with sin/cos sensor)	Digital units	Offset of the encoder sine signal, acquired during the absolute sensor acquisition automatic procedure.
A.SENS.OFFSET CR (A – Only for BLE3 with sin/cos sensor)	Digital units	Offset of the encoder cosine signals, acquired during the absolute sensor acquisition automatic procedure.
ANGLE OFFSET (A – Only for BLE3 with sin/cos sensor)	Degrees	Angle offset between the orientation of the rotor and the position sensor.
ANGLE OFFSET ENC (A – Only for BLE3 with sin/cos sensor)	Degrees	Angle offset between the orientation of the rotor and the index signal (on an ABI encoder).
ROTOR POSITION (A – Only for BLE3 with sin/cos sensor)	Degrees	Real-time 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.

7.3.2 Supervisor microcontroller

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

TESTER (Supervisor)		
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).
A4 (A)	OFF/ON	Status of input A4.
A5 (A)	OFF/ON	Status of input A5.
A11 (A)	OFF/ON	Status of input A11.
B13 (A)	OFF/ON	Status of input B13.
B6 (A)	OFF/ON	Status of input B6.
B4 (A)	OFF/ON	Status of input B4.
B5 (A)	OFF/ON	Status of input B5.
B11 (A)	OFF/ON	Status of input B11.
A13 (A)	OFF/ON	Status of input A13.
A3 POT#1 (A)	Volt (0.01V)	Voltage of analog input A3.
A10 POT#2 (A)	Volt (0.01V)	Voltage of analog input A10.
B2 POT#3 (A)	Volt (0.01V)	Voltage of analog input B2.
B10 POT#4 (A)	Volt (0.01V)	Voltage of analog input B10.

TESTER (Supervisor)		
Parameter	**Unit of measure (resolution)**	**Description**
B3 POT#5 (A)	Volt (0.01V)	Voltage of analog input B3.
CTRAP THRESOLD (A)	Volt (0.01 V)	Threshold voltage of the hardware overcurrent.
WARNING SYSTEM (CO)	-	In case of warning it shows the correspondent warning code.

7.4 Set-up procedure for traction inverter

This section describes the basic set-up procedure for the ACE3 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 8); otherwise go down the following sequence.

- In ADJUSTMENT, set BATTERY VOLTAGE according to your set-up (see paragraph 7.2.3).
- 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 8.1).
- Set the maximum current for traction and braking in MAX. CURRENT TRA and MAX. CURRENT BRK (see paragraph 7.2.1).
- Set the motor-related parameters. It is suggested to discuss them with Zapi technicians.
- Set 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-sensored 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 “0” 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 procedure, embedded in the inverter software, must be activated only one time at commissioning, to let the inverter acquire the values.

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 direction.

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 is 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, sensor voltage range 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 ACE3 inverter in pump configuration. If you need to replicate the same set of settings on different controllers, use the SAVE and RESTORE sequence (see chapter 8); otherwise go down the following sequence.

- In ADJUSTMENT, set BATTERY VOLTAGE according to your set-up (see paragraph 7.2.3).
- 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 8.1).
- Set the maximum current for lift and lowering in MAX. CURRENT TRA and MAX. CURRENT BRK (see paragraph 7.2.1).
- Set the motor-related parameters. It is suggested to discuss them with Zapi technicians.
- Set 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.).

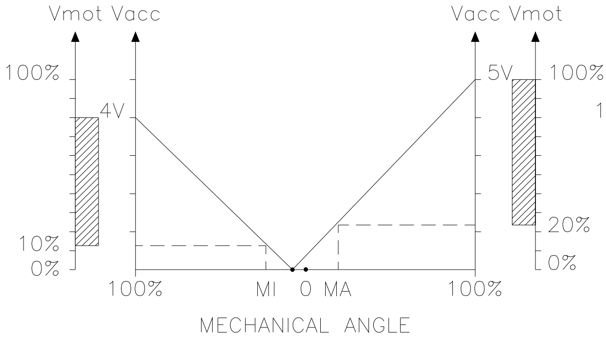
At the end of your modifications, re-cycle the key switch to make them effective.

8 OTHER FUNCTIONS

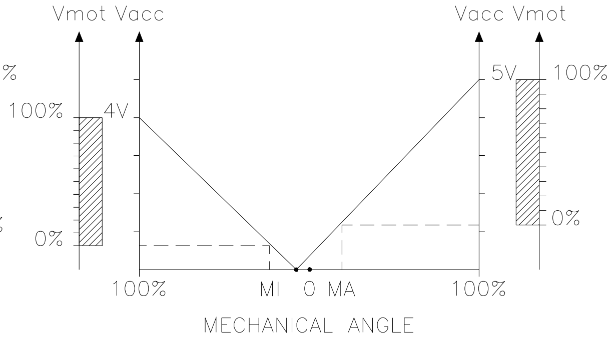
8.1 PROGRAM VACC function

This function enables the adjustment of the minimum and maximum useful levels of the accelerator voltage, in both direction. 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. After the adjustment procedure, Vmot percentage is mapped over the useful voltage ranges of the potentiometer, for both directions. On the other hand, before calibration it results mapped over the default 0 – 5 V range.



Before 'PROGRAM VACC'



After 'PROGRAM VACC'

PROGREAM 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 0 and 12.2.6.

8.2 PROGRAM LIFT / LOWER function

This function enables 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 12.1.4 or 12.2.7 for acquiring procedure.

8.3 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 steer.

This function looks for and remembers the minimum, neutral and maximum voltage over the full mechanical range of the steering. It enables compensation for dissymmetry of the mechanical system between directions.

The values to be acquired are organized in the ADJUSTEMNT group; they are:

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

See paragraphs 12.1.5 or 12.2.8 for acquiring procedure.

8.4 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 final-speed 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:

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

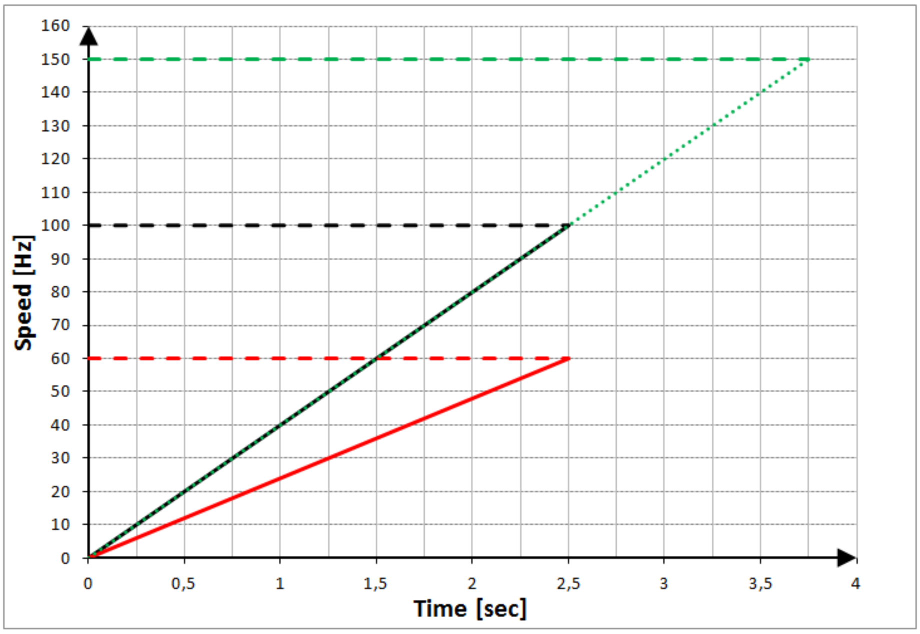


Figure 1: Acceleration time

8.5 Deceleration time

The DECEL. BRAKING parameter allows to define the deceleration rate depending on 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

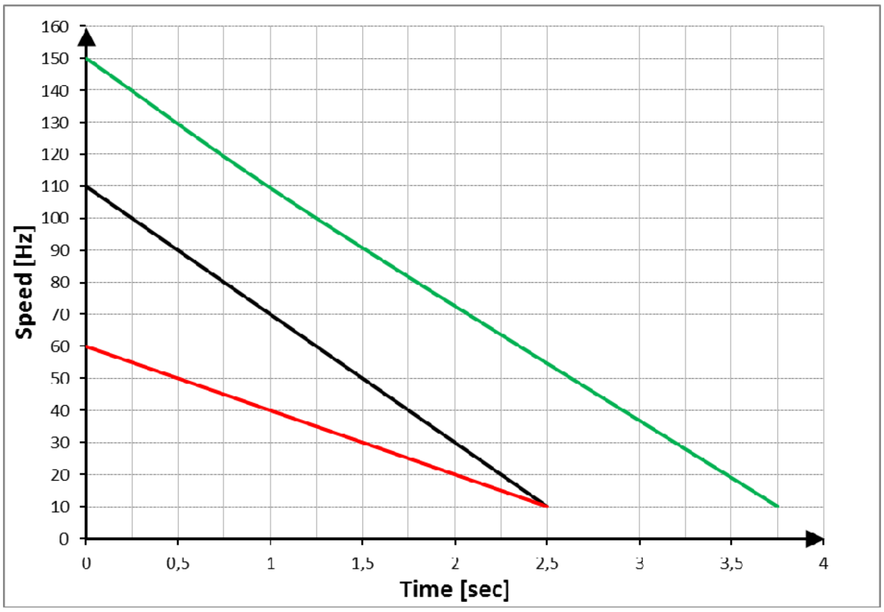
The deceleration rate is re-scaled so that the deceleration time results equal to DECEL. BRAKING, in this case 2.5 s.

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:

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



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

8.6 Acceleration smoothness

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

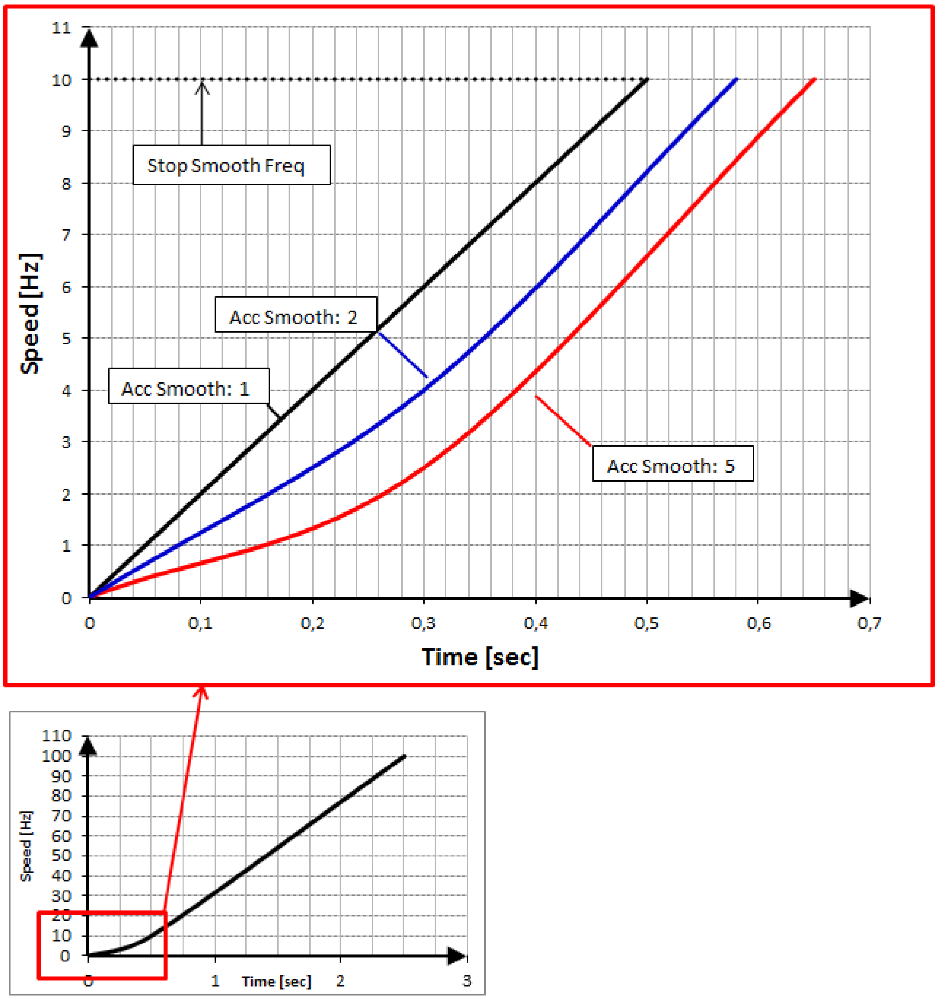


Figure 2: Smoothness

Note: This example is valid for ACC SMOOTH, BRK SMOOTH, INV SMOOTH.

8.7 Steering curve

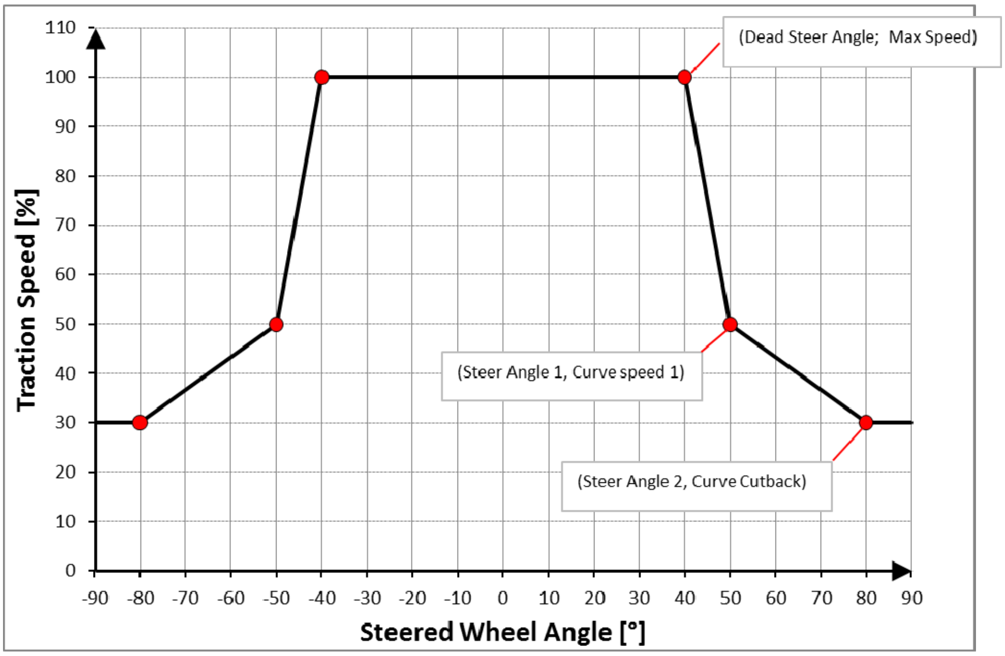
Steering-related parameters (CURVE SPEED 1, CURVE CUTBACK, STEER DEAD ANGLE, STEER ANGLE 1 and STEER ANGLE 2) define a speed-reduction profile dependent on the steering-wheel angle.

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 parameters set builds the speed profile represented in the graph below.



8.8 Throttle response

The ACE3 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:

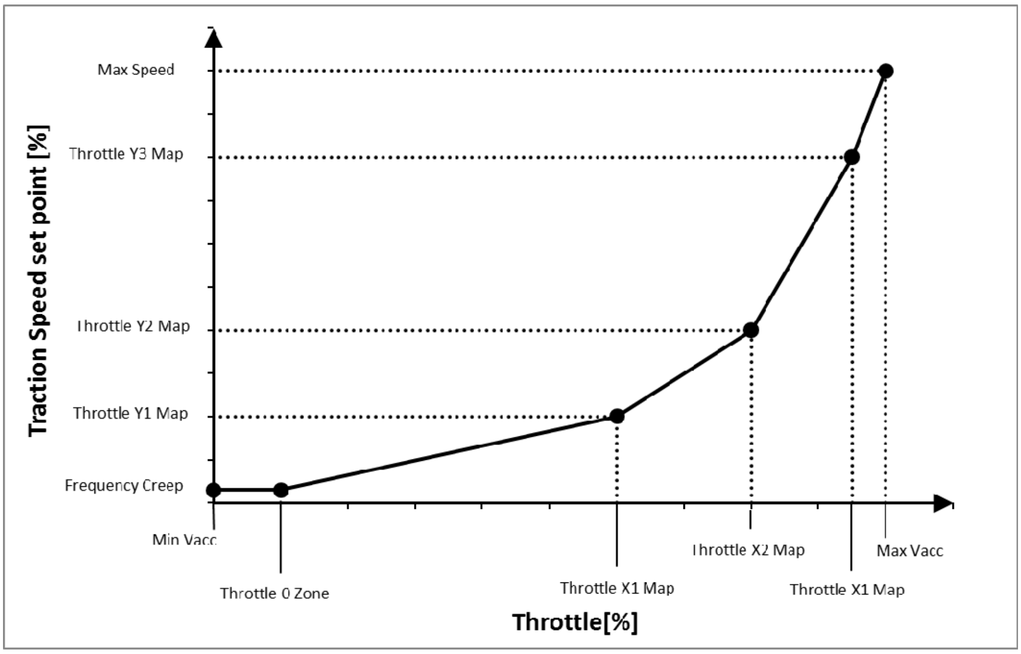
- THROTTLE 0 ZONE [% of MAX VACC]
- THROTTLE X1 POINT [% of MAX VACC]
- THROTTLE Y1 POINT [% of MAX SPEED]
- THROTTLE X2 POINT [% of MAX VACC]
- THROTTLE Y2 POINT [% of MAX SPEED]
- THROTTLE X3 POINT [% of MAX VACC]
- THROTTLE Y3 POINT [% of MAX SPEED]

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.



8.9 NLC & NEB output

For the NLC output (A16) [or NEB output (A18)] 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:

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

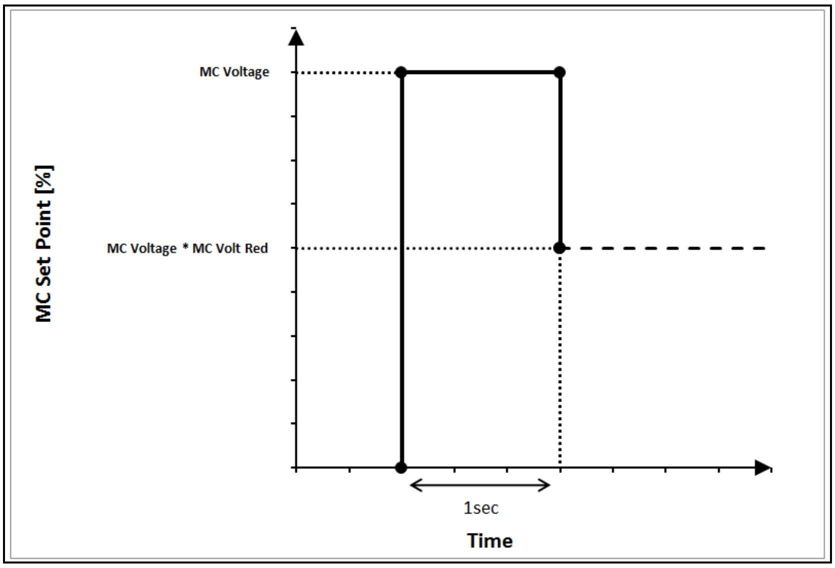


Figure 3: NMC & NEB Output management

Example 1:

MC VOLTAGE = 100%
MC VOLTAGE RED = 70%
The contactor is closed by applying 100% of duty-cycle to the coil and then then it is reduced to 70%.

Example 2:

MC VOLTAGE = 70%
MC VOLTAGE RED. = 100%
The contactor is closed by applying 70% of duty-cycle to the coil and then it is kept at the same value.

Example 3:

MC VOLTAGE = 70%
MC VOLTAGE RED = 70%
The contactor is closed by applying 70% of duty-cycle to the coil and then it is reduced to 49% (70% of 70%).

8.10 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.

Start-up

1) The battery voltage is read from key input when the battery current is zero, that 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.

Operating condition

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

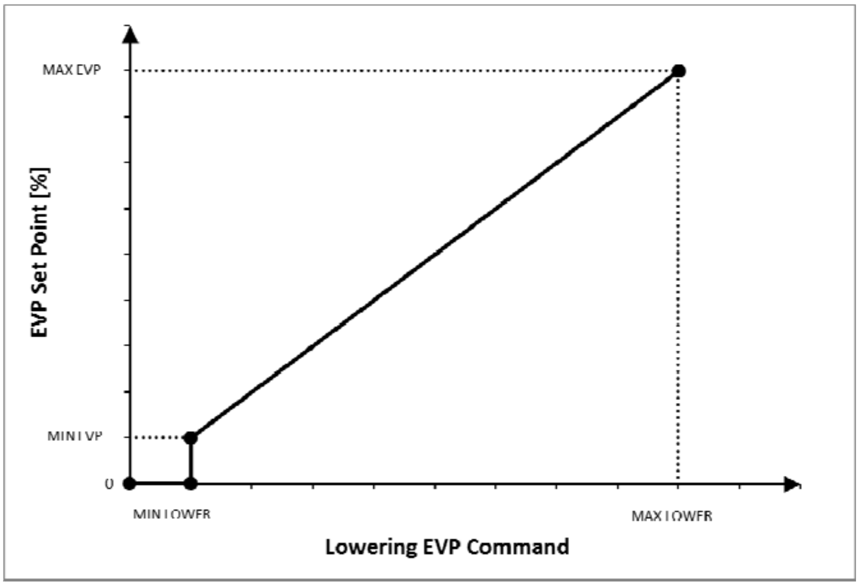
1) The battery voltage is read when the battery current is not zero, that is when the output power stage is driven. Vbatt is evaluated as the average value over a window of time.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison the 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.

8.11 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.

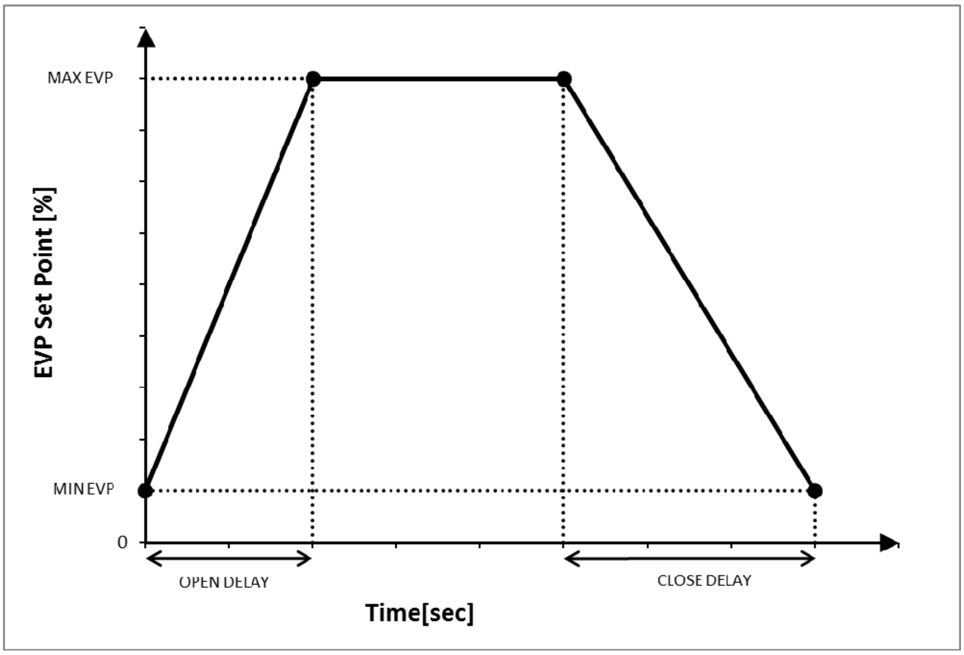


EVP analog control.

- **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 7.2.1):

  - 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.

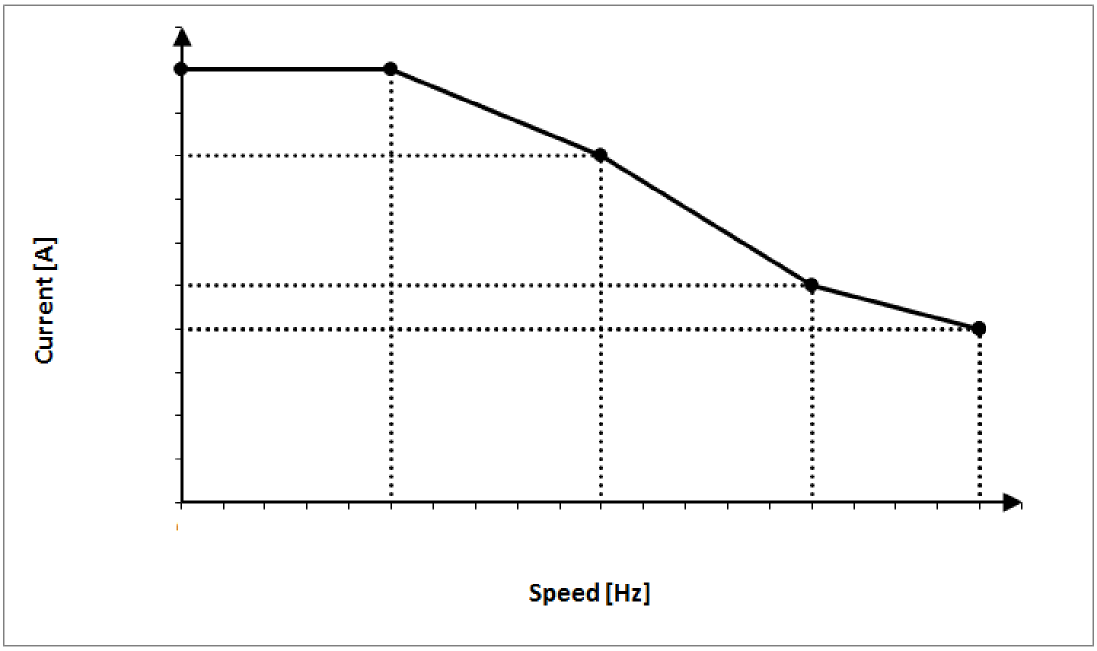
As soon as the lowering request is applied, the current is increased from zero to MAX EVP in a time equal to OPEN DELAY.

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.

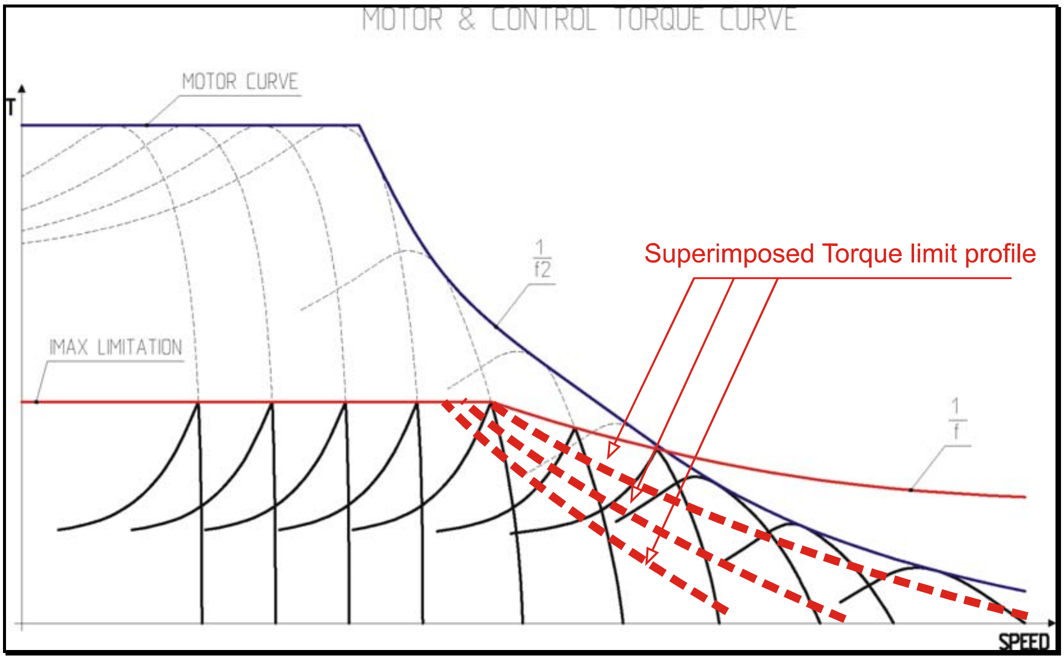
8.12 Torque profile

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

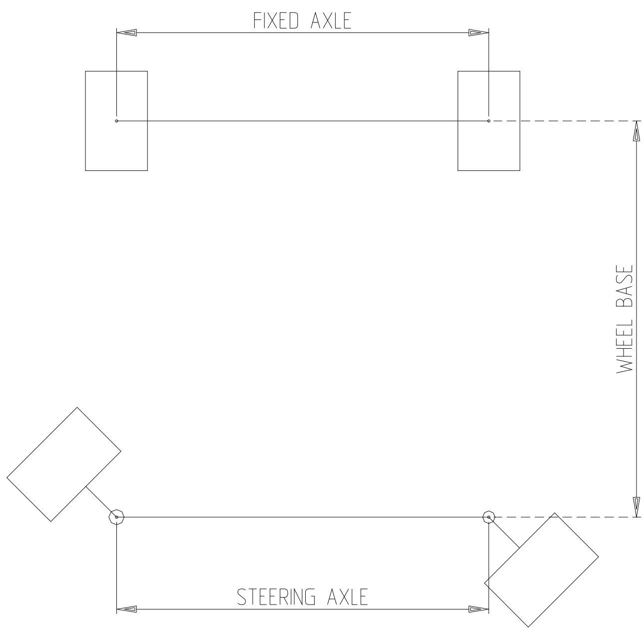
8.13 Steering table

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 FAULTS DIAGNOSTIC SYSTEM

The fault diagnostic system of ACE3 controller consists of two main groups of faults:

– **ALARMS**
  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.

  Alarms are related to:
  - Hardware failures in the motor or in the controller that forbid to run the truck.
  - Safety-related failures.

– **WARNINGS**
  Faults which do not stop the truck or stop it by mean of a controlled regenerative braking. The controller still works well, but it has detected conditions that require to stop the truck, or at least to reduce its performance, without opening the power devices.

  Warnings are related to:
  - Wrong sequences of operations by the operator.
  - Conditions that require performance reduction in order to prevent major failures (high temperature, …).

9.1 Alarms – Master uC

Error code	Effect	Condition	Restart procedure	CAN OPEN CODE	MDI CODE	ZAPI CODE	LED CODE
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	202	77
HOME SENS.ERR XX	MC is opened, EB is applied, EVP stopped	Running	Key re-cycle	0xFFB0	3	176	3
IMS ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0XFFA7	4	167	4
SHORT CIRCUIT	MC is not closed, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	0xFFA6	5	166	5
SHORT CIRCUIT KO	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Key re-cycle	0xFFA5	5	165	5
PWM ACQ.ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0xFFA4	6	164	6
WATCHDOG	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	0x6010	8	8	8
EVP DRIV. SHORT.	MC is closed or opened , EB is applied, EVP stopped	EVP off	Traction/ Pump request	0x5003	9	215	9
CONTROLLER MISM.	MC is not closed,	Start-up	Install the correct software and Key	0xFFEF	12	239	12

Error code	Effect	Condition	Restart procedure	CAN OPEN CODE	MDI CODE	ZAPI CODE	LED CODE
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	202	77
	EB is applied, Traction/Pump, valves stopped		re-cycle				
SEAT MISMATCH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Valves or Traction/ Pump request	0xFFDE	15	222	15
LOGIC FAILURE #1	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0x5114	19	19	19
LOGIC FAILURE #2	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by,	Valves or Traction/Pump Request	0XFF12	18	18	18
LOGIC FAILURE #3	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump Request	0XFF11	17	17	17
LC COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0xFFE6	22	230	22
IQ MISMATCHED	Traction is stopped	Running	Valves or Traction/Pump Request	0xFFF5	24	245	24
INIT VMN LOW 01 INIT VMN LOW 02 INIT VMN LOW 03	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0x3121	30	207	30
INIT VMN HIGH 81 INIT VMN HIGH 82 INIT VMN HIGH 83	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0x3111	31	206	31
VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump Request	0x3110	31	31	31
VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump Request	0x3120	30	30	30
HW FAULT 11 HW FAULT 12 HW FAULT 13	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFE3	32	227	32
HW FAULT 01 HW FAULT 02 HW FAULT 03	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFE3	32	227	32
POSITIVE LC OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	0xFFD5	35	213	35
FIELD ORIENT KO	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump	0xFFFD	36	253	36

Error code	Effect	Condition	Restart procedure	CAN OPEN CODE	MDI CODE	ZAPI CODE	LED CODE
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	202	77
			Request				
CONTACTOR CLOSED	MC is not closed (command is not activated), EB is applied, Traction/Pump stopped	Start-up	Valves or Traction/Pump Request	0x5442	37	37	37
CONTACTOR OPEN	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0x5441	38	38	38
POWER MISMATCH	Traction is stopped EB is applied, MC is opened	Running	Traction/ Pump request	0xFFD4	39	212	39
WRONG SET BAT	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	The alarms disappears as soon as the voltage comes back into the correct range	0x3100	41	251	41
MOT.PHASE SH.36 MOT.PHASE SH.37 MOT.PHASE SH.38	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Traction/ Pump request	0xFFC4	47	196	47
STBY I HIGH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by	Valves or Traction/Pump Request	0x2311	53	53	53
OVERLOAD	Traction is stopped	Running	Key re-cycle	0xFFB4	57	180	57
CAPACITOR CHARGE	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump Request	0x3130	60	60	60
TILLER ERROR	Traction stopped, EB applied	Stand-by, running	Valves or Traction/Pump Request	0xFFB9	64	185	64
NO CAN MSG.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0X8130	67	248	67
WRONG RAM MEM.	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	0xFFD2	71	210	71
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	0x3211	74	74	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	0x3221	75	75	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	0x2250	76	223	76
SPEED FB. ERROR	MC is opened , EB is applied, EVP stopped	Running	Key re-cycle	0xFFAF	81	175	81
ENCODER ERROR	MC is opened, EB is applied, Traction/Pump,	Running	Valves or Traction/Pump	0xFF52	82	82	82

Error code	Effect	Condition	Restart procedure	CAN OPEN CODE	MDI CODE	ZAPI CODE	LED CODE
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	202	77
	valves stopped		Request				
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0xFF51	83	181	83
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	0xFFFA	96	237	96
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	0xFFEB	99	235	99
AUX BATT. SHORT	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0x5001	27	194	27
POS. EB. SHORTED	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0x3223	84	195	84
VDC OFF SHORTED	MC is opened, EB is applied, traction/pump stopped	Start-up, stand-by, running	Key re-cycle	0xFFC8	88	200	88
VKEY OFF SHORTED	MC is opened, EB is applied, traction/pump stopped	Start-up, stand-by, running	Key re-cycle	0x5101	20	220	20
POWERMOS SHORTED	MC is opened, EB is applied, traction/pump stopped	Start-up	Key re-cycle	0xFFE9	89	233	89
BUMPER STOP	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Valves or Traction/Pump Request	0xFFA2	0	162	0
WRONG SET KEY	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	0x3101	41	170	41
WRONG SET BATTERY	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	0x3100	41	251	41

9.1.1 Troubleshooting of master-uC alarms

1) **VDC LINK OVERV.**

   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.

2) **LOGIC FAILURE #1**

   Cause

   This fault is displayed when the controller detects an undervoltage condition at the key input (A1).

   Undervoltage threshold is 11V for 36/48V controllers and 30 V for 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.

3) **LOGIC FAILURE #2**

   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.

4) **LOGIC FAILURE #3**

Cause

An 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.

5) **POSITIVE LC OPEN**

Cause

The voltage feedback of LC driver (A16) is different from expected, i.e. it is not in accordance with the driver operation.

Troubleshooting

- Verify LC coil is properly connected.
- Verify CONF. POSITIVE LC parameter is set in accordance with the actual coil positive supply (see paragraph 7.2.5). 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.

6) **CTRAP THRESHOLD**

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 7.2.4) and the feedback of the actual threshold value.

Troubleshooting

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

7) **WATCH DOG**

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.

8) **WRONG RAM MEM. 05**

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.

9) **TILLER ERROR**

Cause

Input mismatch between Hard&Soft input (A11) and tiller/seat input (A6): the two inputs are activated at the same time.

Troubleshooting

- Check if there are wrong connections in the external wiring.
- Using the TESTER function verify that inputs are in accordance with the actual state of the external switches.
- Check if there is a short circuit between A11 and A6.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

10) **OVERLOAD**

Cause

The motor current has overcome the limit fixed by hardware.

Troubleshooting

Reset the alarm by switching key off and on again.

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.

11) **FIELD ORIENT. KO**

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.

12) **IQ MISMATCHED**

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.

13) **EVP DRIV. SHORT.**

Cause

- The EVP driver is shorted (output A19).
- 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 -BATT.

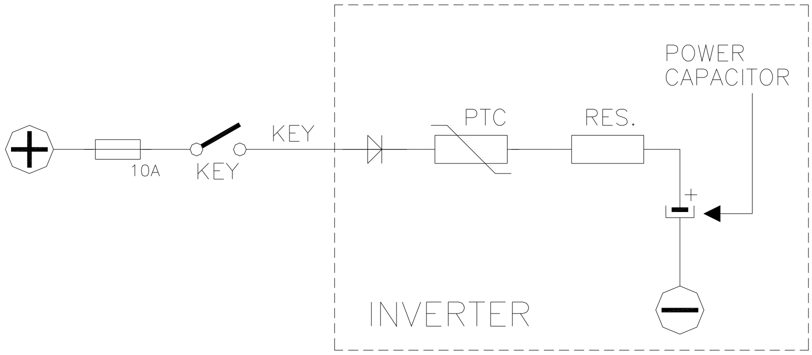
- Collect information about:
  - the voltage applied across the EVP coil,
  - the current in the coil,
  - features of the coil.

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.

14) **CAPACITOR CHARGE**

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 20% 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.

15) **MOT.PHASE SH.**

Cause

Short circuit between two motor phases. The number that follows the alarm identifies where the short circuit is located:

- 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.

16) **INIT VMN LOW 01/02/03**

Cause

Before switching the LC on, 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.

Troubleshooting

- Check the motor power cables.
- Check the impedance between U, V and W terminals and -Batt 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.

17) **INIT VMN HIGH 81/82/83**

Cause

Before switching the LC on, 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.

Troubleshooting

- Check the motor power cables;
- Check the impedance between U, V and W terminals and -Batt 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.

18) **VMN LOW**

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 below 66% 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.

19) **VMN HIGH**

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 -BATT. If the phase voltages are higher than 10% 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.

20) **HW FAULT 11/12/13**

Cause

At each start-up the supervisor microcontroller checks that the hardware circuit intended to enable and disable the LC driver (A16) works properly.

Troubleshooting

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

21) **HW FAULT 01/02/03**

Cause

At each start-up the supervisor microcontroller checks that the hardware circuit for enabling and disabling of the power bridge works properly.

Troubleshooting

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

22) **POWER MISMATCH**

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.

23) **SEAT MISMATCH**

Cause

This alarm can appear only in a Traction + Pump configuration.

There is an input mismatch between the traction controller and the pump controller relatively to the seat input (A6): 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.

24) **STBY I HIGH**

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.

25) **CONTROLLER MISM.**

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.

26) **ENCODER ERROR**

Cause

This fault occurs in the following conditions: the frequency supplied to the motor is higher than 40 Hz and the signal feedback from the encoder has a jump higher than 40 Hz 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.

27) **SPEED FB. ERROR**

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.

28) **WRONG ENC SET**

Cause

Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter (see paragraph 7.2.5).

Troubleshooting

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

29) **CONTACTOR CLOSED**

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 20% 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.

30) **CONTACTOR OPEN**

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.

31) **CONTACTOR DRIVER**

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.

32) **LC COIL OPEN**

Cause

This fault appears when no load is connected between the NLC output (A16) 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.

33) **MC-EF COIL SHOR.**

Cause

This alarm occurs when there is an overload of the MC driver (A16) and EB driver (A17). 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.

34) **ANALOG INPUT**

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.

35) **DRIVER SHORTED**

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 –BATT.
- The driver circuit is damaged; replace the logic board.

36) **POWER ACQ. ERROR**

Cause

This alarm occurs only when the controller is configured to drive a PMSM and the feedback sensor selected in the HARDWARE SETTING 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.

37) **HOME SENSOR CORR**

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.

Troubleshooting

Repeat the auto-teaching procedure.

38) **NO CAN MSG. 09**

Cause

This fault is signaled when there is no communication with the supervisor uC.

Troubleshooting

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

39) **WRONG SET BAT. 05**

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 inside the ADJUSTMENT list matches with the battery nominal voltage.
- Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A1. If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter.
- Replace the battery.

40) **IMS ERROR**

Cause

At start-up, the controller checks the presence of IMS board. If the IMS board is not well connected, this alarm appears.

Troubleshooting

- Replace the controller

41) **SHORT CIRCUIT**

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.

42) **SHORT CIRCUIT KO**

Cause

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

Troubleshooting

- Replace the controller.

43) **VDC OFF SHORTED**

Cause

The logic board measures a key voltage value 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.

44) **VKEY OFF SHORTED**

Cause

The logic board measures a key voltage that is constantly out of range, below the minimum 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.

45) **POWERMOS SHORTED**

Cause

The DC-link voltage drops to zero when a high-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.

46) **BUMPER STOP**

Cause

The two digital inputs dedicated to the bumper functionality are high at the same time.

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.

47) **WRONG SET KEY**

Cause

The measured key voltage is not the right one for the inverter.

Troubleshooting

- Check if the SET KEY VOLTAGE parameter in the ADJUSTMENT 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.

48) **WRONG SET BATTERY**

Cause

The measured battery voltage is not the right one for the inverter.

Troubleshooting

- Check if the battery voltage (measured between the +Batt and -Batt terminals of the inverter) is ok using a voltmeter, if not check the wiring;
- Record the value stored inside the HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Zapi technician.
- In case the problem is not solved, replace the logic board.

9.2 Alarms – Supervisor uC

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
WATCHDOG	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	0X6010	8	8	8
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	0XFFEF	12	239	12
SP MISMATCH xx	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0XFFF2	15	242	15
OUT MISMATCH xx	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0XFFE3	16	227	16
LOGIC FAILURE #1	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Valves or Traction/Pump Request	0X5114	19	19	19
LOGIC FAILURE #3	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Valves or Traction/Pump Request	0XFF11	17	17	17
INPUT MISMATCH	MC is opened, EB is applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	0XFFD5	58	213	58
W.SET. TG-EB	Traction/ Pump motor is stopped	Start-up, stand-by, running	Key re-cycle	0XFFD4	59	212	59
NO CAN MSG.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0X8130	67	248	67
WRONG RAM MEM. 05	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	0XFFD2	71	210	71
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	202	77
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0XFF51	85	201	85
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	0XFFFA	96	237	96

9.2.1 Troubleshooting of supervisor-uC alarms

1) **INPUT MISMATCH**

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.

2) **W.SET. TG-EB**

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.

3) **LOGIC FAILURE #1**

Cause:

This fault is displayed when the controller detects an undervoltage condition at the key input (A1).

Undervoltage threshold is 11V for 36/48V controllers and 30 V for 80V controllers.

- 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.

4) **LOGIC FAILURE #3**

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.

5) **VDC LINK OVERV.**

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.

6) **WATCH DOG**

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.

7) **WRONG RAM MEM. 05**

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.

8) **SP MISMATCH XX**

Cause:

This is a safety related test. The master µC has detected a supervisor µC wrong set point.

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.

9) **OUT MISMATCH XX**

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).

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.

10) **CONTROLLER MISM.**

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.

11) **ANALOG INPUT**

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.

12) **WRONG ENC SET**

Cause:

Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter (see paragraph 7.2.5).

Troubleshooting

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

13) **NO CAN MSG.**

Cause:

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

Troubleshooting:

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

9.3 Warnings – Master uC

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
WAITING FOR NODE	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle	0x0000	0	224	0
BATTERY LOW	The maximum current is reduced to half and speed is reduced (if CHECK OPTION=1)	Start-up, standby, running	Battery recharge, key re-cycle	0XFF42	0	66	0
DATA ACQUISITION	Traction is stopped	Controller calibration	Traction request	0x0000	0	247	0
CHECK UP NEEDED		Start-up, stand-by, running	Check-up done, key re-cycle	0x0000	0	249	0
WARNING SLAVE	It depends by Supervisor uC			0xFF01	1	244	1
ACQUIRING A.S.		Sensor Acquiring	Key re-cycle	0xFFAB	2	171	2
ACQUIRE END		Sensor Acquiring	Key re-cycle	0xFFAD	2	173	2
ACQUIRE ABORT				0xFFAC	2	172	2
SIN/COS D.ERR	Traction is stopped	running	Traction request	0xFFA8	3	168	3
ENCODER D.ERR	Traction is stopped	running	Traction request	0xFFA9	3	169	3
EVP DRIVER OPEN	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves Request	0xFFF8	9	240	9
EVP COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0x5002	9	214	9
HW FAULT EV XX	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFEE	16	238	16
STALL ROTOR	Traction/Pump stopped	Start-up, stand-by, running	Key-on recycle	0xFFD3	11	211	11
EEPROM KO	Controller works using Default parameters	Continuous		0x3610	13	208	13
PARAM RESTORE	No effect	Start-up	Traction/ Pump request	0X000	14	209	14
COIL SHOR. EVAUX	EV stopped	EV on	Valve EV request	0xFFF1	21	241	21
CONT DRIV EV XX	MC is opened (the command is released), EB is applied, Traction/Pump, valves	Start-up, stand-by, running	Valves Request	0xFFE8	21	232	21

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
	stopped						
DRV SHOR EV XX	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0xFFF9	21	234	21
PEV OPEN XX	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	MC is not closed, EB is applied, Traction/Pump, valves stopped	0xFFDB	25	217	25
HW FAULT EB 01 HW FAULT EB 02 HW FAULT EB 03	MC is closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFE5	34	229	34
EB. DRIV.SHRT.	MC remain closed, EB is applied (the command is released), Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0x3222	40	254	40
EB. DRIV.OPEN	MC remain closed, EB is applied (the command is released), Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	0x3224	42	246	42
EB. COIL OPEN	MC remain closed, EB is applied (the command is released), Traction/Pump, valves stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	0xFFD8	43	216	43
HANDBRAKE	Traction/ Pump motor is stopped	Start-up, stand-by, running	Traction/ Pump request	0xFFDD	46	221	46
THROTTLE PROG.	MC remain closed, EB is applied (the command is released), Traction stopped	Start-up, Stand-by,	Valves or Traction/Pump Request	0xFFF3	48	243	48
LIFT + LOWER	Pump is stopped	Start-up, stand-by, Running	Pump request	0xFFBB	49	187	49
TILLER OPEN	LC opens	Start-up, stand-by, running	Valves or Traction/Pump Request	0x0000	51	228	51
WRONG ZERO	Valve, pump, traction stopped, LC opened, EB applied	Start-up	Valves or Traction/ Pump request	0x3201	58	252	58
THERMIC SENS. KO	The maximum current is reduced to half and speed is reduced	Start-up, stand-by, running		0x4211	61	250	61
TH. PROTECTION	Traction controller reduces the max current linearly from Imax (85°C) down to 0A (105°C)	Start-up, stand-by, running		0x4210	62	62	62

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
BRAKE RUN OUT	No effect, the warning is only displayed through the console	Continuous	Traction/Pump Request	0xFFCC	63	204	63
Reload HM from MDI		Start-up	Key re-cycle	0x0000	94	0	94
MOTOR TEMPERAT.	The maximum current is reduced to half and speed is reduced	Start-up, stand-by, running		0x4110	65	65	65
MOTOR TEMP. STOP	MC stays closed, EB is applied, Traction/Pump, valves stopped	Continuous		0xFFB2	65	178	65
SENS MOT TEMP KO	The maximum current is reduced to half and speed is reduced	Start-up, stand-by, running		0x4311	68	218	68
EPS RELAY OPEN	Traction/ Pump motor is stopped	Start-up, stand-by, Running	Valves or Traction/ Pump request	0xFFCD	70	205	70
VACC NOT OK	Traction/ Pump motor is stopped	Start-up, stand-by, running	Traction/ request	0xFF4E	78	78	78
INCORRECT START	Traction/ Pump motor is stopped	Start-up, stand-by	Traction request	0xFF4F	79	79	79
FORW + BACK	Traction is stopped	Start-up, stand-by, running	Traction request	0xFF50	80	80	80
VACC OUT OF RANGE	Traction/ Pump motor is stopped	Start-up, Stand-by, Running	Traction/ Pump request	0xFFE2	85	226	85
PEDAL WIRE KO	Traction is stopped	Start-up, Stand-by, Running	Traction request	0xFF56	86	86	86
WRONG SLAVE VER	MC opened, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0xFFC5	91	197	91
CURRENT GAIN	Controller works, but with low maximum current	Start-up, stand-by		0x6302	92	236	92
PARAM TRANSFER	MC stays closed, EB is applied, Traction/Pump, valves stopped	Continuous	Key re-cycle	0xFFC7	93	199	93
Reload HM		Start-up	Key re-cycle	0x0000	94	0	94
STEER SENSOR KO	EB is applied, traction/pump stopped	Continuous	Key re-cycle	0xFFB3	95	179	95
M/S PAR CHK MISM	MC stays closed, EB is applied, Traction/Pump, valves	Start-up	Save again the parameter and Key re-cycle	0xFFC6	97	198	97

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
	stopped						
TORQUE PROFILE	EB is applied, Traction/Pump motor is stopped	Start-up, stand-by	Valves or Traction/ Pump request	0xFFC9	98	201	98

9.3.1 Troubleshooting of master-uC warnings

1) **WAITING FOR NODE**

   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.

2) **TORQUE PROFILE**

   Cause:

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

   Troubleshooting:

   Check in the HARDWARE SETTING menu the value of those parameters.

3) **STEER SENS KO**

   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 8.3).

   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.

4) **DATA ACQUISITION**

   Cause:

   Controller in calibration state.

   Troubleshooting:

   The alarm ends when the acquisition is done.

5) **ACQUIRING A.S.**

Cause:

Controller is acquiring data from the absolute feedback sensor.

Troubleshooting:

The alarm ends when the acquisition is done.

6) **ACQUIRE END**

Cause:

Absolute feedback sensor acquired.

7) **ACQUIRE ABORT**

Cause:

The acquiring procedure relative to the absolute feedback sensor aborted.

8) **SIN/COS D.ERR**

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.

9) **ENCODER D.ERR**

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.

10) **BRAKE RUN OUT**

Cause:

The CPOT BRAKE input read by the microcontroller is at its maximum value without the hand-brake request.

Troubleshooting:

Check the mechanical calibration and the functionality of the brake potentiometer. If the alarm is still present, replace the logic board.

11) **RELOAD HM FROM MDI**

Cause:

The hour-meter of the controller is transferred and recorded on the hour-meter of the standard MDI.

12) **CHECK UP NEEDED**

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.

13) **PARAM TRANSFER**

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.

14) **THROTTLE PROG.**

Cause:

A wrong profile has been set in the throttle profile.

Troubleshooting:

Set properly the throttle-related parameters (see paragraph 8.8).

15) **INCORRECT START**

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 state of the inputs are coherent with microswitches states.
- If the problem is not solved, replace the logic board.

16) **VACC OUT OF RANGE**

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 8.1).

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.

17) **PEDAL WIRE KO**

This is not implemented in ACE3.

Troubleshooting:

- Ask for help to a Zapi technician.

18) **FORW + BACK**

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.

19) **HANDBRAKE**

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.

20) **EVP DRIVER OPEN**

Cause:

The EVP driver (A19) 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.

21) **EVP COIL OPEN**

Cause:

No load is connected between the NEVP output (A19) and the electrovalve positive terminal.

Troubleshooting:

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

22) **M/S PAR CHK MISM**

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.

23) **TILLER OPEN**

Cause:

Tiller/seat input has been inactive for more than 30 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.

24) **CURRENT GAIN**

Cause:

The maximum current gain parameters are at the default values, which means 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.

25) **COIL SHOR. EVAUX**

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.

26) **LIFT+LOWER**

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.

27) **WRONG SLAVE VER.**

Cause:

Wrong software version on supervisor uC.

Troubleshooting:

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

28) **SENS MOT TEMP KO**

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.

29) **HW FAULT EB 01/02/03**

Cause:

At start-up, the hardware circuit dedicated to enable and disable the EB driver (A18) is found to be faulty.

Troubleshooting:

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

30) **HW FAULT EV 01/02/04/08/10/20/40/80**

Cause:

At start-up, the hardware circuit dedicate to enable and disable the EV drivers is found to be faulty.

Troubleshooting:

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

31) **WRONG ZERO**

Cause:

At start-up the amplifiers used to measure the motor voltage sense voltages above 3 V or below 2 V.

Troubleshooting:

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

32) **EPS RELAY OPEN**

Cause:

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

Troubleshooting:

Verify the EPS functionality.

33) **VACC NOT OK**

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 more than 1 V 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.

34) **STALL ROTOR**

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.

35) **PARAM RESTORE**

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 cancel the alarm.

- If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.

36) **EB. DRIV.SHRT.**

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 -BATT.
- Check if the voltage applied is in accordance with the parameters set (see paragraph 7.2.5).
- If the problem is not solved, replace the controller.

37) **PEV NOT OK**

Cause:

The PEV connector (B1, only for ACE3 Premium version) is not connected to the battery or the voltage is different from expected. This alarm occurs if one output among EVP, EV1, EV2, EV3, EV4 and EV5 is present or the AUX OUT function is active (POSITIVE EB = 1 or 2).

Troubleshooting:

Check connector B1: it must be connected to the battery voltage (after the main contactor).

38) **EB COIL OPEN**

Cause:

This fault appears when no load is connected between the NEB output (A18) and the EB positive terminal (PEB).

Troubleshooting:

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

39) **EB DRIV OPEN**

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.

40) **CONT DRIV EV 02/04/08/20**

Cause:

One or more on/off valve drivers are not able to drive the load.

- 02 → EV1
- 04 → EV2
- 08 → EV3
- 20 → EV4

If more than one output is affected by this fault condition, the code shown will correspond to the sum of the faulty-EVs codes.

Troubleshooting:

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

41) **DRIV SHORT EV 02/04/08/20**

Cause:

One or more on/off valve drivers are shorted.

- 02 → EV1
- 04 → EV2
- 08 → EV3
- 20 → EV4

If more than one output is affected by this fault condition, the code shown will correspond to the sum of the faulty-EVs codes.

Troubleshooting:

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

42) **EEPROM KO**

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.

43) **WARNING SLAVE**

Cause:

Warning on supervisor uC.

Troubleshooting:

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

44) **TH. PROTECTION**

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.

45) **MOTOR TEMPERAT.**

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 7.2.3).

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.

46) **THERMIC SENS. KO**

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.

47) **MOTOR TEMP. STOP**

Cause:

The temperature sensor has overtaken the STOP MOTOR TEMP. threshold (if analog, see paragraph 7.2.3).

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.

48) **BATTERY LOW**

Cause:

The battery charge is evaluated to be lower than 10% of the full charge and the BATTERY CHECK setting is other than 0 (refer to SET OPTION menu).

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 value in the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter with the value measured through the voltmeter.
- If the problem is not solved, replace the logic board.

9.4 Warnings overview (supervisor uC)

Error Code	Effect	Machine status when the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
STEER SENS KO	EB is applied, traction/pump stopped	Continuous	Key re-cycle	0xFFC3	95	200	95
PARAM RESTORE	No effect	Start-up	Traction/ Pump request	0X000	14	209	14
EEPROM KO	Controller works using Default parameters	Continuous		0x3610	13	208	13

9.4.1 Troubleshooting of supervisor-uC warnings

1) **STEER SENS KO**

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 8.3).

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.

2) **PARAM RESTORE**

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.

3) **EEPROM KO**

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.

10 SPARE PARTS

Recommended spare parts for ACE3 inverters are here listed.

Part number	Description	ACE3 Version
C16590	Protected 500 A strip UL Fuse.	36/48V, 650 A 36/48V, 600 A
C16589	Protected 400 A strip UL Fuse.	80V, 550 A
C16588	Protected 350 A strip UL Fuse.	80V, 450 A
C16520	10 A 20 mm Control Circuit Fuse	All
C29509	SW 200 80 V Single Pole Contactor	All
C29532	SW 200 48 V Single Pole Contactor	All
C12531	Ampseal 23 pins female connector	All
C12591	Ampseal 23 pins female connector, blue	Premium version

11 PERIODIC MAINTENANCE

Check the wear and condition of the moving and fixed contactors contacts.

Electrical contacts should be checked every **3 months**.

Check the foot pedal or tiller microswitch. Using a suitable multi-meter, confirm that there is no electrical resistance between the contacts by measuring the voltage drop across the terminals. Switches should operate with a firm click sound.

Microswitches should be checked every **3 months**.

Check the battery cables, cables to the inverter, and cables to the motor. Ensure the insulation is sound and the connections are tight.

Cables should be checked every **3 months**.

Check the mechanical operation of the pedal or tiller. Are the return springs ok? Do the potentiometers wind up to their full or programmed level?

Check every **3 months**.

Check the mechanical operation 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 NON ORIGINAL PARTS!

The installation of this electronic controller should be made according to the diagrams included in this manual. Any variations or special requirements should be made after consulting a Zapi agent. The supplier is not responsible for any problem that arises from wiring methods 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 bought to the attention of a Zapi agent immediately. The agent will then take the decision regarding 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 types of waste materials.
Zapi commits itself to update its technology in order to reduce the presence of polluting substances in its product.

---

12 APPENDICES

The goal of this chapter is to give the operator a general overview about the use of Zapi PC CAN Console and Zapi Smart Console.

The description focuses on the basic information about connection and settings.

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

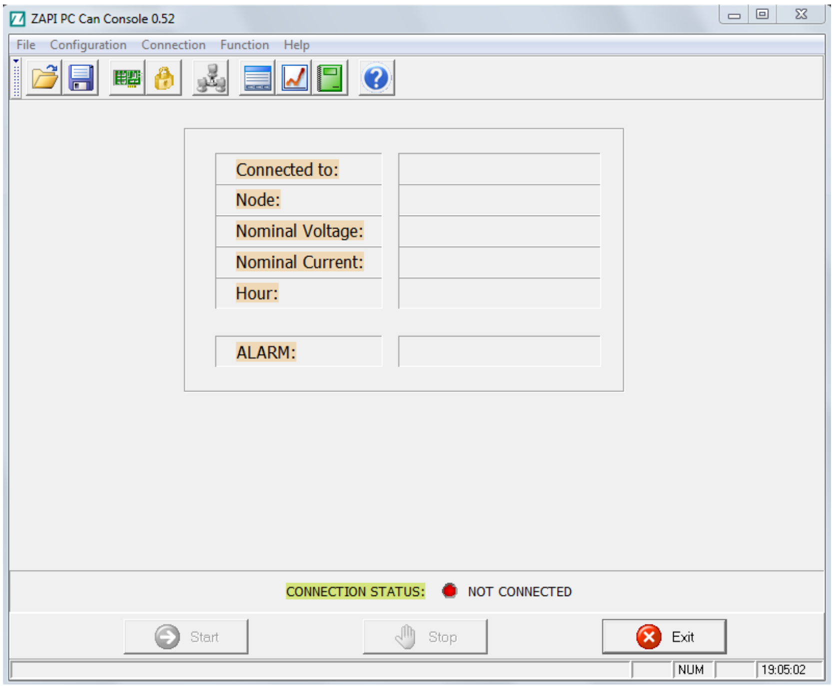
12.1 Appendix A: PC CAN Console user guide

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 to save parameter configurations into a file and to restore them onto the control afterwards.

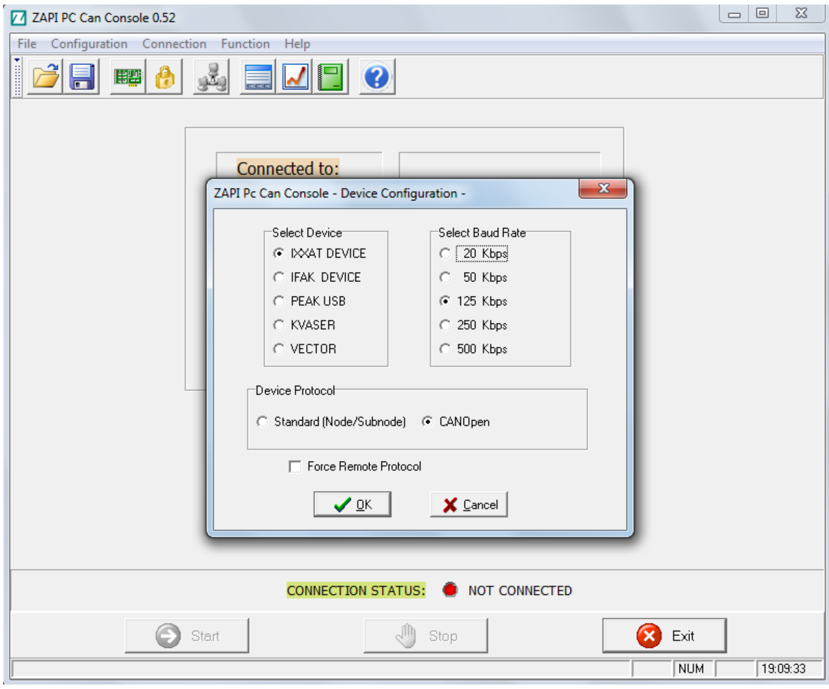
Before running Pc CAN Console, the user must install it launching "setup.exe".

12.1.1 PC CAN Console configuration

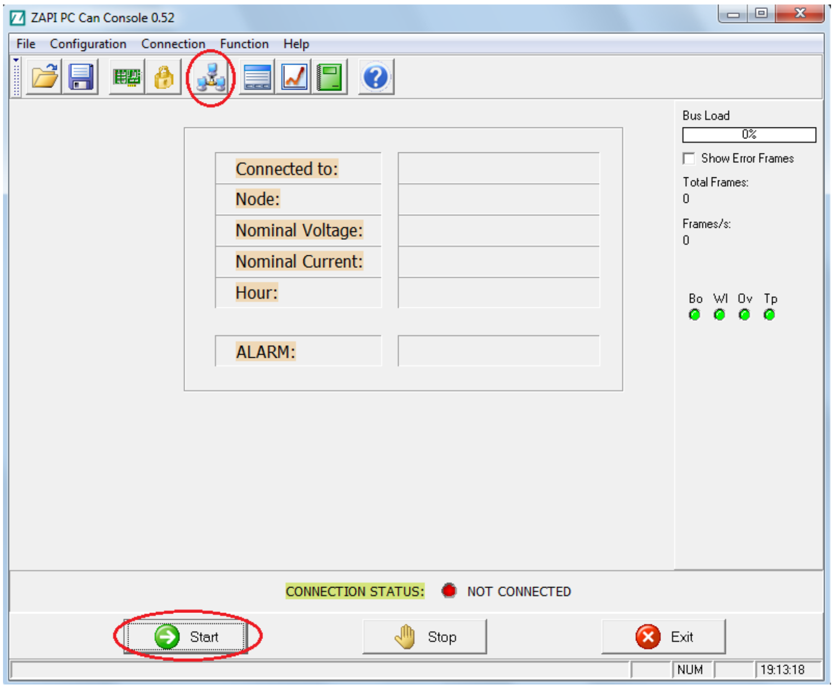
Running the PC Can Console software, the following window appears:



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



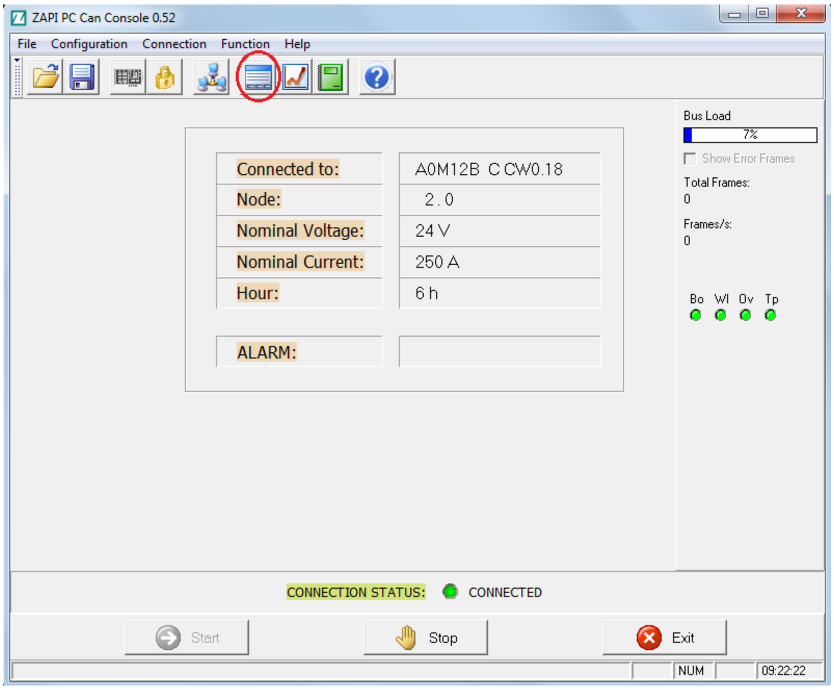
From this form you can define the CAN device in use (IXXAT, IFAK or Peak) and the CAN communication speed. Once you have defined the CAN interface, you have to choose which CAN device you want to connect to: choose “Connection” → “Set Node” (or press the “Set Node” icon).



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

12.1.2 Parameter download

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



Then click on the “Receive” button: the parameters will be downloaded automatically.

When the parameters have been all received, you can change their values.

12.1.3 How to modify 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:

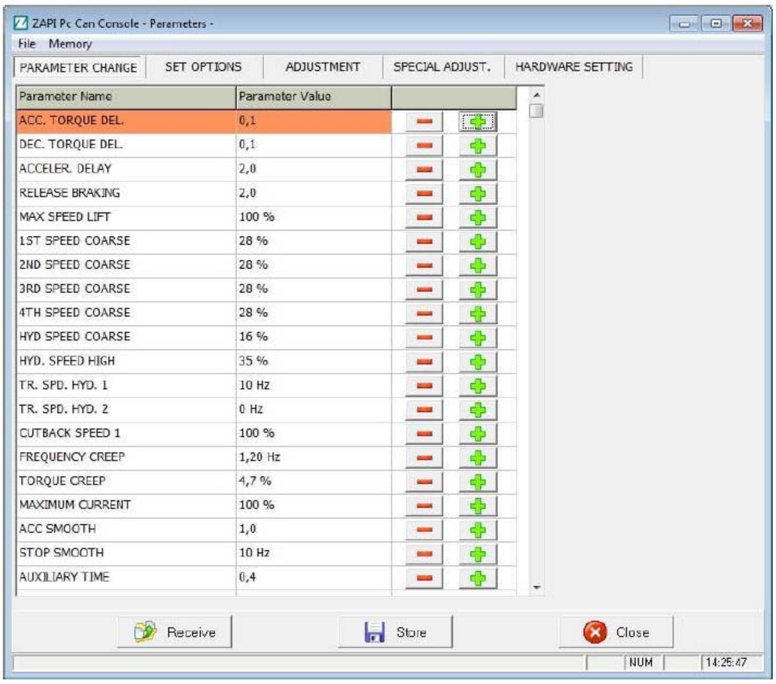
- Parameter value as it is saved within the controller (“Value” column).
- Parameter value as it is shown by console or similar tools (“Scaled Value” column).
- Name of the menu where parameter is placed (“Name menu” column).

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

This codification prevents any overwrite of previously saved files.

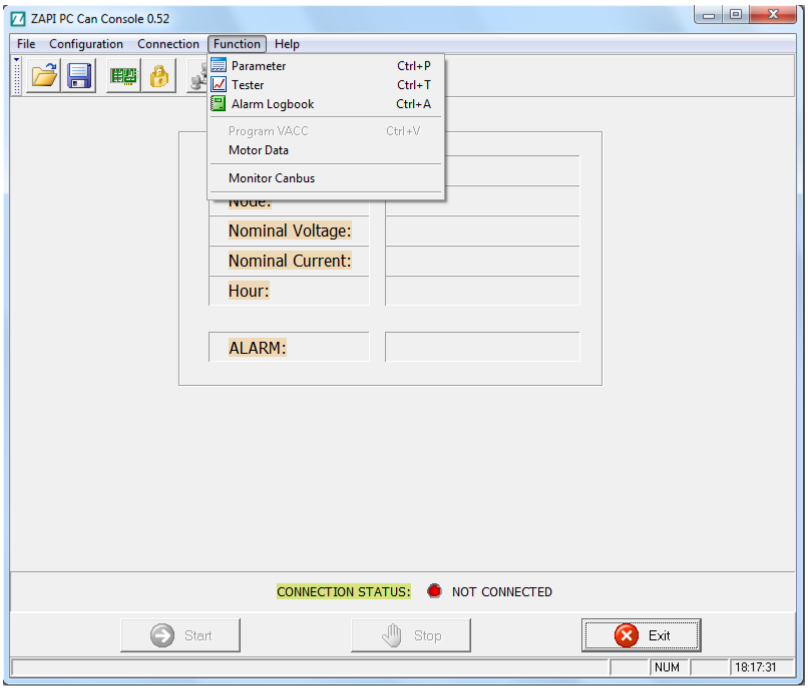
Once you have selected the menu inside that resides the parameter you want to change, it is possible to modify the value using the “+” and “–“ buttons.

Click on the “Store” button to save the changes on EEPROM.



Program Vacc

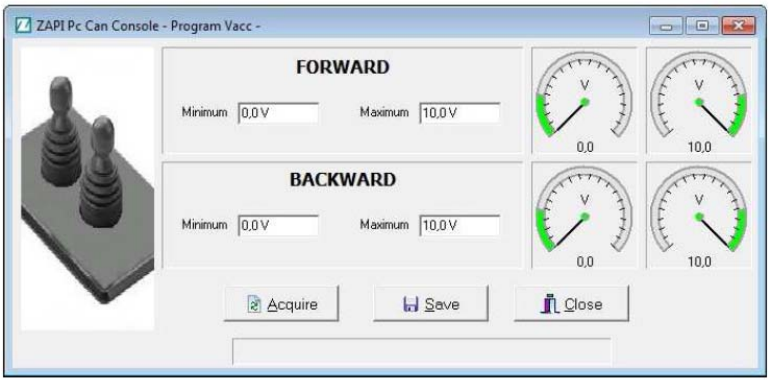
Choose "Function" → "Program Vacc" menu.



When "Acquire" is pressed, the 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 will vary accordingly to operator inputs.

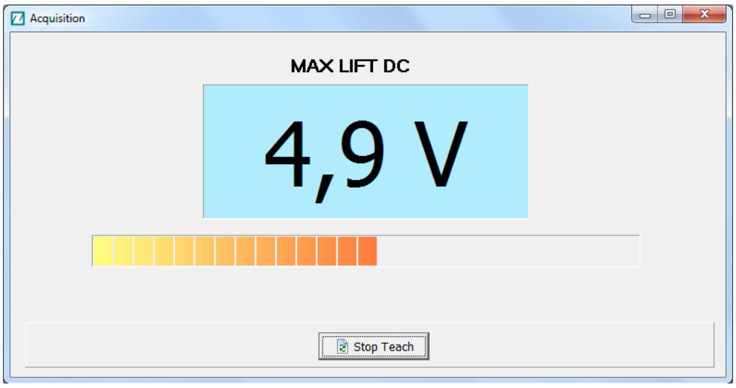


12.1.4 Lift & Lower acquisition

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 both lift and lower potentiometers.

12.1.5 Steering acquisition

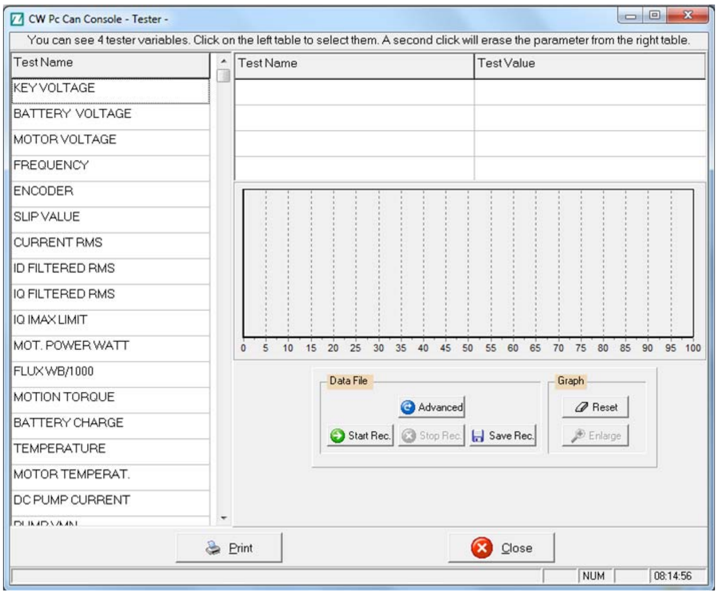
Once you have connected you need to receive the inverter parameter; choose “Function” → “Parameter” menu (or press the “Parameter” icon).

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.

12.1.6 TESTER functionality

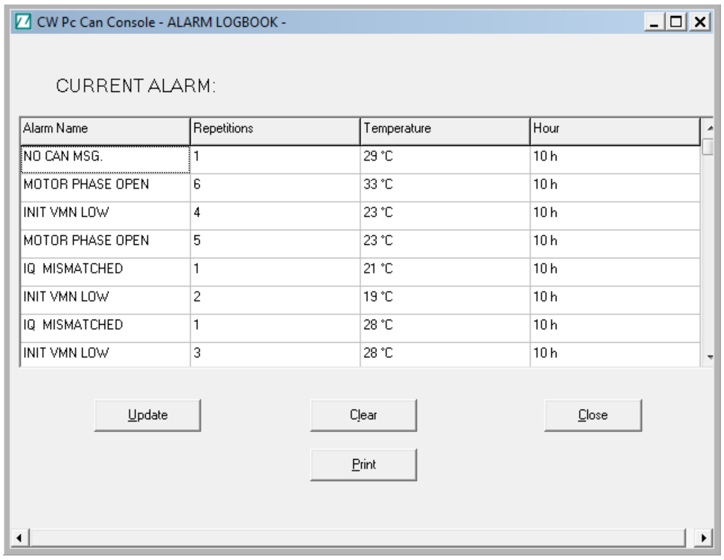
From the main page you can also access to the TESTER function from the Function menu (Alt-u)→Tester (Ctrl-T) menu where you can check some inverter information.



12.1.7 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.

12.2 Appendix B: Zapi Smart Console user guide

12.2.1 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.

12.2.2 The 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.

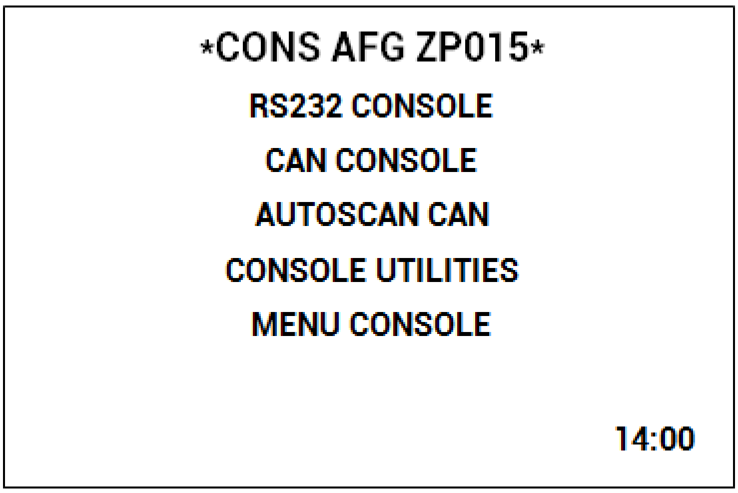
Green LED

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.

12.2.3 Home Screen

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



From top:

- First line tells which firmware version is running <u>inside the console</u>, 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.

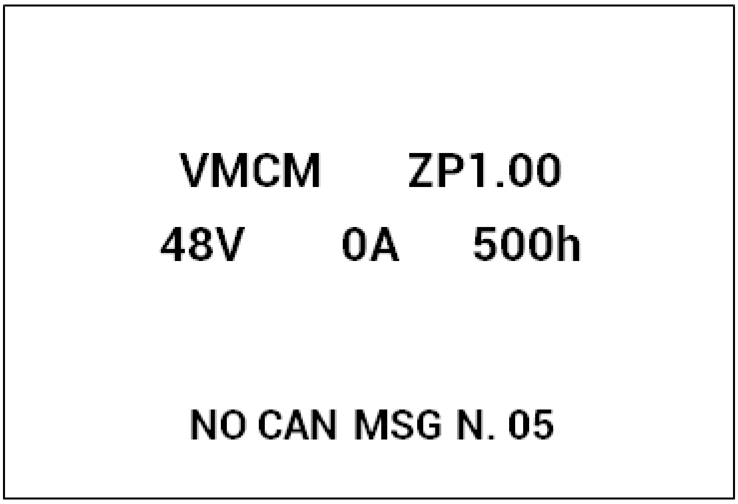
Display prompts a message to inform you that a connection attempt is ongoing.

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.

12.2.4 Connected

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.

12.2.5 How to modify parameters

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

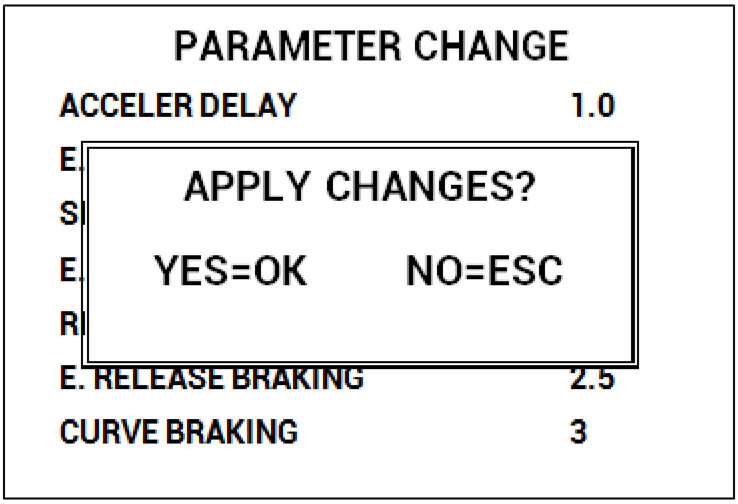
PARAMETER CHANGE

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 list: once you have highlighted the parameter you want to modify, press either 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 parameters have been modified, the console will prompt the request to confirm/discard changes.

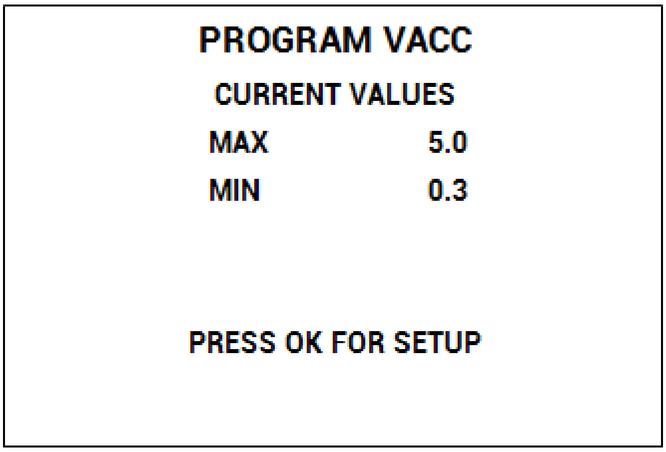


Description above is valid for every menu which contains parameters and options like SET OPTIONS, ADJUSTMENT, HARDWARE SETTING, etc.

12.2.6 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.

```
PROGRAM VACC

FORWARD      0.0   4.5
BACKWARD     0.2   4.4

SEL. ENABLE AND DIRECTION
THEN PRESS PEDAL
(ESC TO FINISH)
```

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

12.2.7 Lift and 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.

When OK is pressed, the procedure starts:

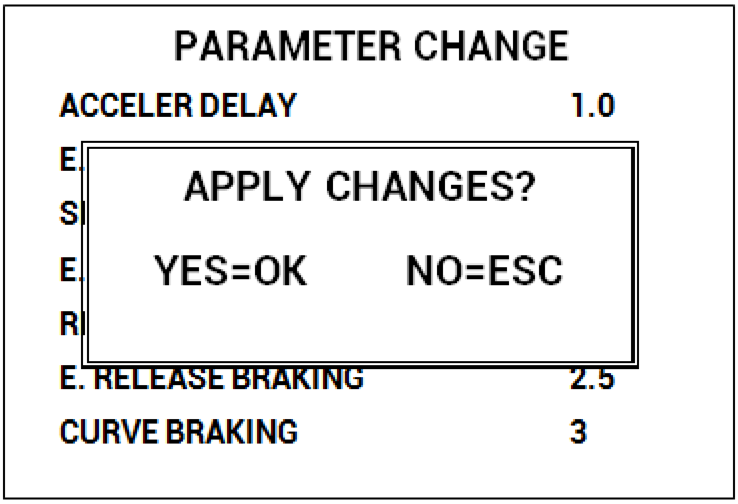
- select the Enable switch, if any;
- select the control switch if any (either lift or lower);
- move the control sensor (lift/lower potentiometer) to the correct position according to what you are acquiring.

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.



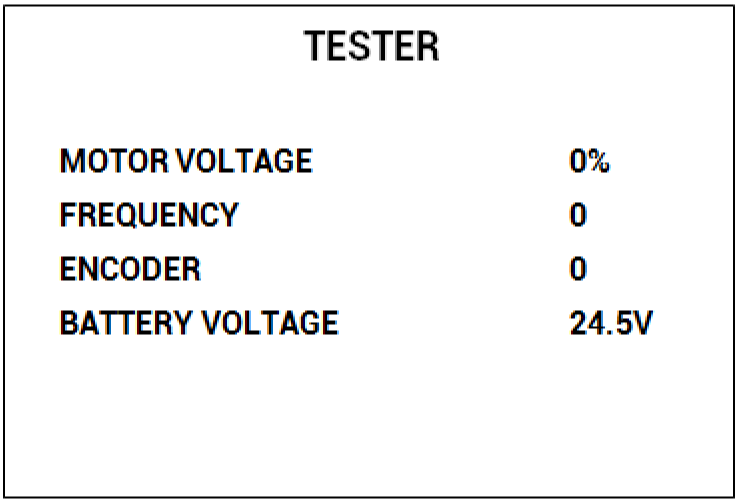
12.2.8 Steer acquisition

From MAIN MENU go into the Adjustment menu.

The procedure to follow is the same described in previous paragraph.

12.2.9 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.



12.2.10 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 are displayed.

Press F1 to clear the alarm logbook of the controller: once F1 is pressed, the console asks for confirmation.

12.2.11 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).

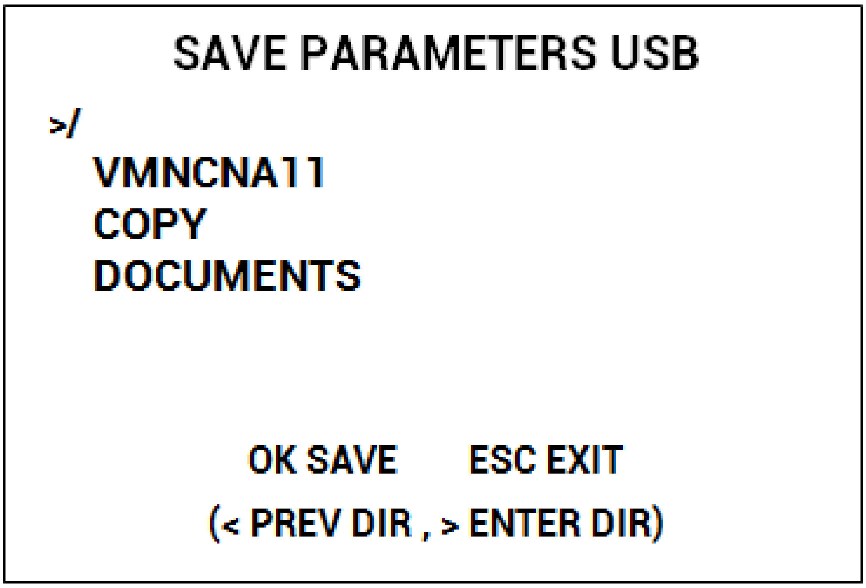
File name is generated as an hexadecimal code of the time and date of save.

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.
