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EN

User Manual

ACE2 350-450 INVERTER

NOTES LEGEND

The symbol aboard is used inside this publication to indicate an annotation or a suggestion you should pay attention.

The symbol aboard is used inside this publication to indicate an action or a characteristic very important as for security. Pay special attention to the annotations pointed out with this symbol.

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1 INTRODUCTION

Within the ZAPIMOS family, the ACE-2 inverter (E stands for evolution) is the model suitable for control of 4.0 kW to 9.0 kW motors. It has been expressly designed for battery electric traction.
It is fit for electric truck, material handling: order pickers, reach truck, CB 2,0 tons, tractors, boom lift and scissors lift.

The ACE-2 can be supplied in three versions:

1) Sensored version: using an Encoder (Sensor Bearing) in the Motor axle is realised an extremely precise and reliable motor speed and torque control

2) SenseCoils version: using special auxiliary windings inside the motor instead of an encoder is realised the motor speed and torque control.

3) Sensorless version: using only the phase voltage feedback is implemented the motor speed and torque control with the Zapi patented sensor-less control software.

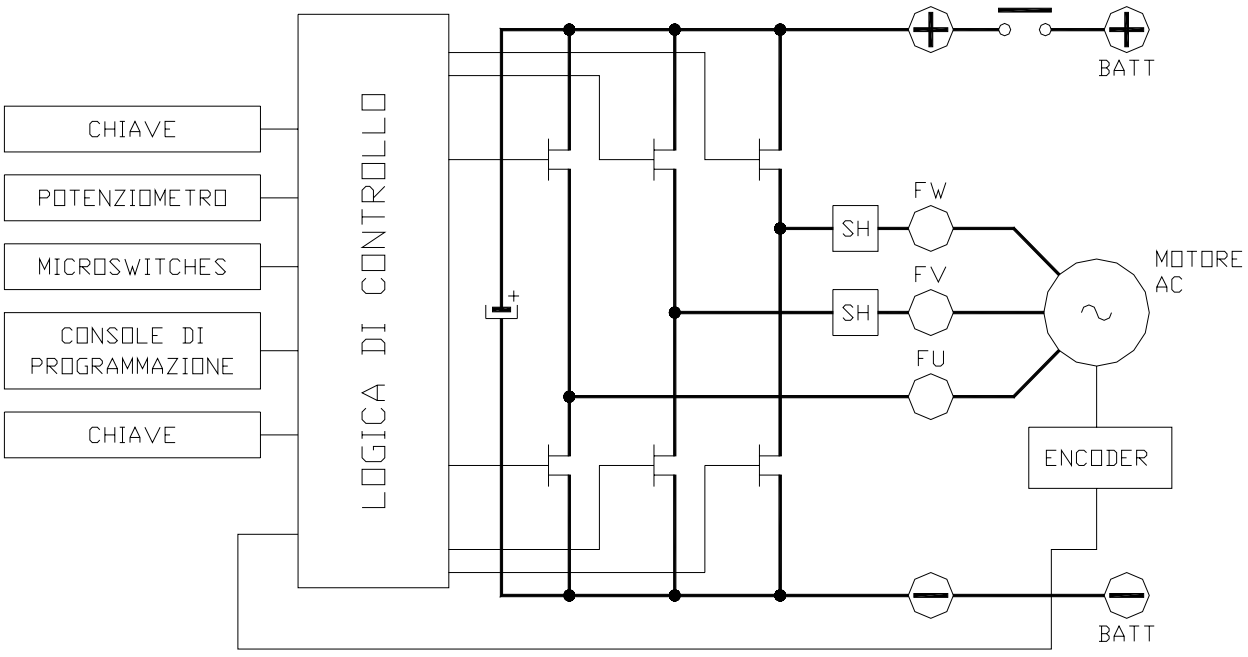
Here the Sensored Version is descripted: it adopts an Encoder integrated in the Ball Bearing (Sensor Bearing). The Encoder fills up the truck performance, respect to the Sensorless and Sense Coils versions, with lower minimum speed, the “stop on the ramp” service and a smoother inversion; on the other hand the reliability gets penalized by the fragile mechanics and inaccessible position of the Sensor Bearing.

2 SPECIFICATION

2.1 Technical specifications

Inverter for AC asynchronous 3-phase motors
Regenerative braking functions
Can-bus interface
Flash memory (128 Kbytes On-Chip Program Memory)
Digital control based upon a microcontroller
Voltage:..... 24 - 36 - 48 V
Maximum current ACE2 24V/400: ..... 400 A (RMS) for 3'
Maximum current ACE2 36-48V/350: ..... 350 A (RMS) for 3'
Maximum current ACE2 24V/500: ..... 500 A (RMS) for 3'
Maximum current ACE2 36-48V/450: ..... 450 A (RMS) for 3'
1 hour current rating ACE 24V/400:..... 200 A (RMS)
1 hour current rating ACE 36-48V/350: ..... 170 A (RMS)
1 hour current rating ACE 24V/500:..... 250 A (RMS)
1 hour current rating ACE 36-48V/450: ..... 225 A (RMS)
Operating frequency: .....8 kHz
External temperature range: .....-30 °C ÷ 40 °C
Maximum inverter temperature (at full power): .....85 °C

2.2 Block diagram



3 SPECIFICATION FOR THE INPUT DEVICES FILLING UP THE INSTALLATION KIT

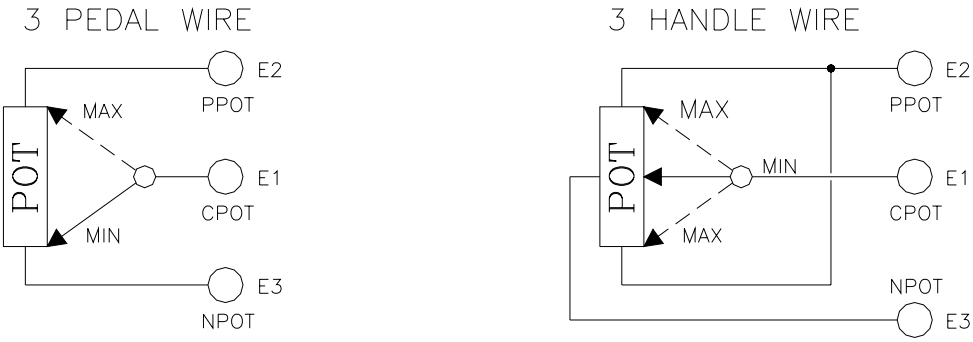
The ACE2 inverter needs some external parts in order to work. The following devices complete the kit for the ACE2 installation.

3.1 Microswitches

- The microswitches must have a contact resistance lower than 0.1 Ω and a leakage current lower than 100 µA.
- When full load connected, the voltage drop between the key switch contacts must be lower than 0.1 V.
- The microswitches send a voltage signal to the microprocessor when a function request (for ex.: running request) is made.

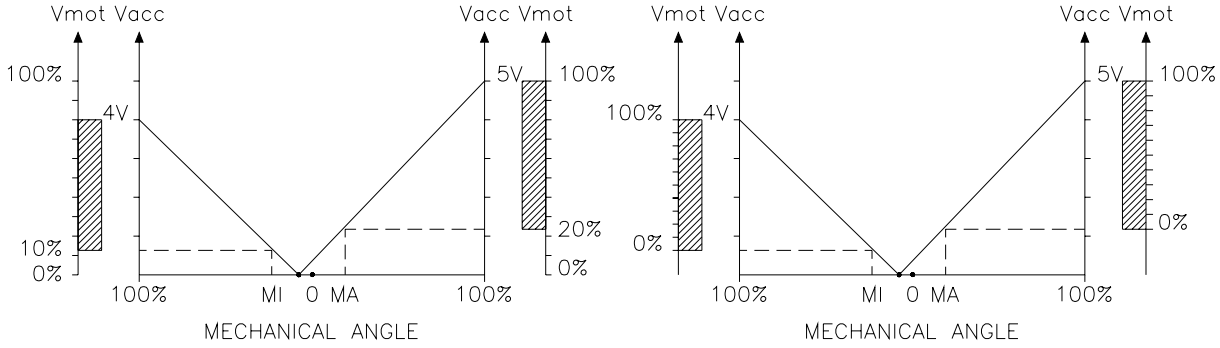
3.2 Accelerator unit

The accelerator unit can consist of a potentiometer or an Hall effect device.
It should be in a 3-wire configuration. The potentiometer is supplied through CNA#2.
Potentiometer output signal must be input to CPOT (CNA#3), signal range is from 0 to 10 V.
The negative supply of the potentiometer has to be taken from CNA#9 (GND), or from CNA-5 (REV/ 1ST SPEED) if the diagnosis PEDAL WIRE KO is done. In this case the hardware must be configured closing a jumper on the logic card.
Potentiometer value should be in the 0.5 – 10 kΩ range; generally, the load should be in the 1.5 mA to 30 mA range. Faults can occur if it is outside this range.
The standard connection for the potentiometer is the one in the Left side of next figure (potentiometer on one end at rest) in combination with a couple of Travel demand switches. On request it is also possible the handling in the Right side of next figure (potentiometer in the middle at rest) still in combination with a couple of Travel demand switches.



The Procedure for automatic potentiometer signal acquisition is carried out using the Console. This enables adjustment of the minimum and maximum useful

signal level (PROGRAM VACC function), in either direction. This function is unique when it is necessary to compensate for asymmetry with the mechanical elements associated with the potentiometer, especially relating to the minimum level.
The sequence of procedure is described in the programming console manual.



The two graphs show the output voltage from a non-calibrated potentiometer with respect to the mechanical “zero” of the control lever. MI and MA indicate the point where the direction switches close. 0 represents the mechanical zero of the rotation.
The Left Hand graph shows the relationship of the motor voltage without signal acquisition being made. The Right Hand Graph shows the same relationship after signal acquisition of the potentiometer.

3.3 Other analog control unit

1) Input A10 is an analog input, whose typical application is for proportional braking. It should be in a 3 wire configuration. Potentiometer value should be in the 0.5-10 kΩ range. Generally, the load should be in the 1.5 mA to 30 mA range. The CPOTB (A10) signal range is from 0 to 10 V.

2) Connections A22 (PTHERM) and A23 (NTHERM) are used for a motor thermal sensor. It can be digital (on/off sensor, normally closed) or analog. See also chapter 8.4 for more explanation.

3.4 Speed feedback

The motor control is based upon the motor speed feedback. The speed transducer is an incremental encoder, with two phases shifted at 90°. The encoder can be of different types:

- power supply: +5 V or +12 V.
- electric output: open collector (NPN), push-pull
- standard (A and B) output.

For more details about encoder installation see also chapter 4.2.5.

Note: The encoder resolution and the motor poles pair (the controller can handle), is specified in the home page display of the handset showing following headline:
AE2T2B ZP1.13

That means:
AE2T= ACE-2 traction controller
(AE2P= ACE-2 pump controller)
2 = motor's poles pair number
B = 64 pulses/rev encoder

The encoder resolution is given by the last letter in the following list:
A = 32 pulses/rev
B = 64 pulses/rev
C = 80 pulses/rev
D = 128 pulses/rev

4 INSTALLATION HINTS

In the description of these installation suggestions you will find some boxes of different colors, they mean:

These are information useful for anyone is working on the installation, or a deeper examination of the content

These are Warning boxes, they 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

4.1 Material overview

Before to start it is necessary to have the required material for a correct installation. Otherwise a wrong choice of cables or other parts could lead to failures/ misbehaviour/ bad performances.

4.1.1 Connection cables

For the auxiliary circuits, use cables of 0.5 mm² section.
For power connections to the motor and to the battery, use cables having section of at least 50 mm². The screwing torque for the controller power connection must be comprised in the range 13 Nm÷15Nm.
For the optimum inverter performance, the cables to the battery should be run side by side and be as short as possible.

4.1.2 Contactors

The main contactor must be installed. Depending on the setting two parameters in the controller (MAIN CONT VOLT [V%] and MAIN CONT V RID [%] ; see chapter 8.4.1, 8.4.2):

- the output which drives the main contactor coil is modulated with a PWM at high frequency (1 kHz). After an initial delay of about 1 sec in which the coil is driven with a percentage of Vbatt set by MAIN CONT. VOLT. parameter, the PWM reduces the voltage down to a percentage which is set by the MAIN CONT V RID parameter. This feature is useful to decrease the power dissipation of the contactor coil.

4.1.3 Fuses

- Use a 10 A Fuse for protection of the auxiliary circuits.
- For protection of the power unit, refer to chapter 9 (Recommended spare parts for inverter). 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 spread of fused particles should the fuse blow.

4.2 Installation of the hardware

Before doing any operation, ensure that the battery is disconnected and when all the installation is completed start the machine with the drive wheels raised from the floor to ensure that any installation error do not compromise safety.
After operation, even with the Key Switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend that the battery is disconnected, and a short circuit is made between Battery Positive and Battery Negative power terminals of the inverter using a Resistor between 10 ohm and 100 ohm.

4.2.1 Positioning and cooling of the controller

Install the inverter with the base-plate on a flat metallic surface that is clean and unpainted.

- Apply a light layer of thermo-conductive grease between the two surfaces to permit better heat dissipation.
- Ensure that the wiring of the cable terminals and connectors is carried out correctly.
- Fit transient suppression devices to the horn, solenoid valves, and contactors not connected to the controller.
- The heat generated by the power block must be dissipated. For this to be possible, the compartment must be ventilated and the heat sink materials ample.
- The heat sink material and system should be sized on the performance requirement of the machine. Abnormal ambient air temperatures should be considered. In situations where either ventilation is poor, or heat exchange is difficult, forced air ventilation should be used.
- The thermal energy dissipated by the power block module varies and is dependent on the current drawn and the duty cycle.

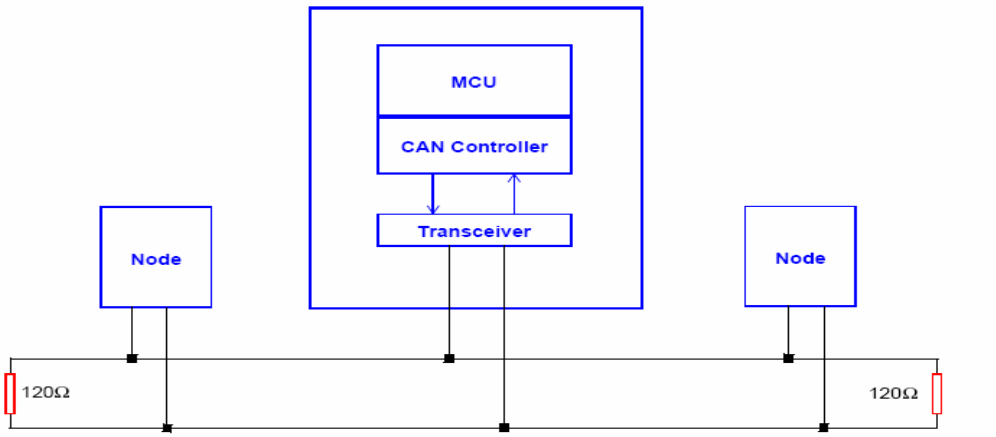
4.2.2 Wirings: power cables

- The power cables length must be as short as possible to minimize power losses.
- They must be tightened on controller power posts with a Torque of 13-15 Nm.
- The ACE2 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 than the value indicated on the controller label. A higher battery voltage may cause power section failure. A lower voltage may prevent the logic operating.

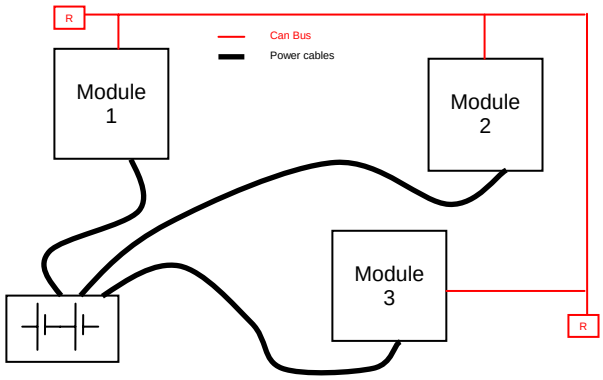
4.2.3 Wirings: CAN connections and possible interferences

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 Megabits per second.
It was invented by the German company Bosch to be used in the car industry to permit communication among the various electronic modules of a vehicle, connected as illustrated in this image:



- The best cable 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 a cable with a shield connected to the frame of the truck. Sometimes it is sufficient a simple double wire cable or a duplex cable not shielded.
- In a system like an industrial truck, where power cables carry hundreds of Ampere, there are voltage drops due to the impedance of the cables, and that could cause errors on the data transmitted through the can wires. In the following figures there is an overview of wrong and right layouts of the cables routing.

Wrong Layout:

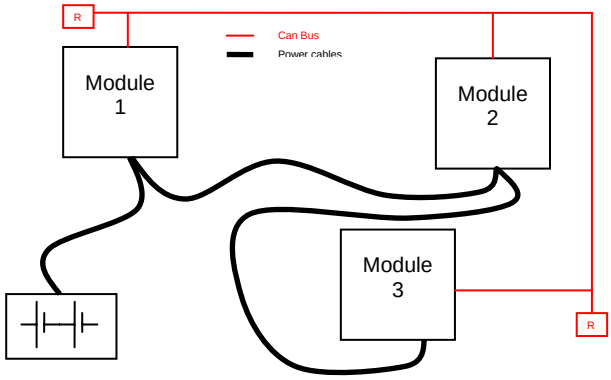


The red lines are can wires.
The black boxes are different modules, for example traction controller, pump controller and display connected by canbus.

The black lines are the power cables.

This is apparently a good layout, but can bring to errors in 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.

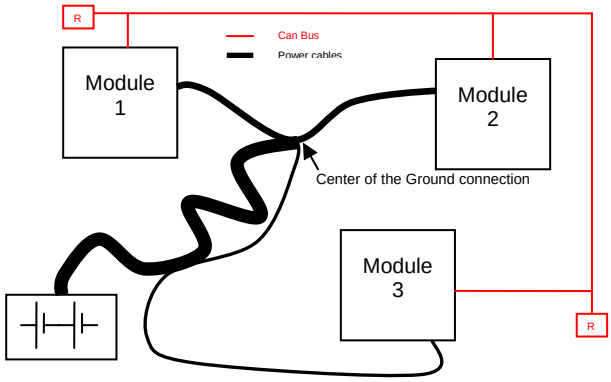
Correct Layout:



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

The chain starts from the –BATT post of the controller that works with the highest current, and the others 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, the best way to deal this configuration is to create a common ground point (star configuration).

Correct Layout:



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

In this case the power cables starting from the two similar controllers must be as short as possible. Of course also the diameter of the cable concurs in the voltage drops described before (higher diameter means lower impedance), so in this last example the cable between the minus of the Battery and the common ground point (pointed by the arrow in the image) must be dimensioned taking into

account thermal and voltage drop problems.

Can advantages:
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
- simplified design (readily available, multi sourced components and tools)
- lower costs (less and smaller cables)
- improved reliability (fewer connections)
- analysis of problems improved (easy connection with a pc to read the data flowing through the cable).

4.2.4 Wirings: I/O connections

- After crimping the cable, verify that all strands are entrapped in the wire barrel.
- Verify that all the crimped contacts are completely inserted on 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 multimeter the continuity between the starting point and the end of a signal wire.

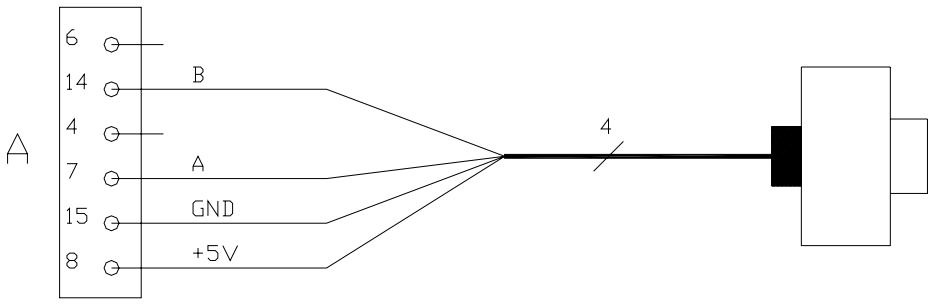
- For information about the mating connector pin assignment see the paragraph “description of the connectors”.

4.2.5 Connection of the encoder

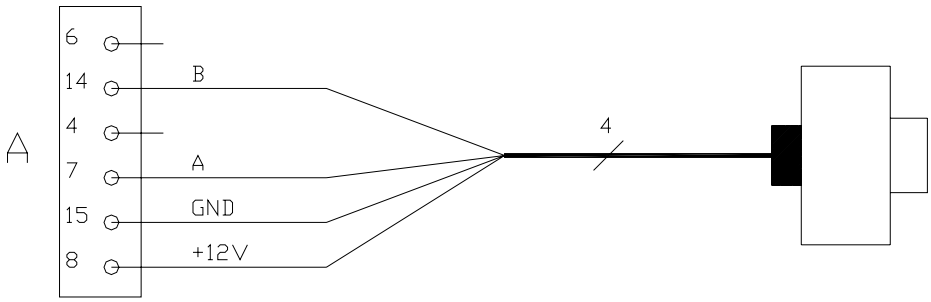
1) ACE2 card is fit for different types of encoder. To control AC motor with Zapi inverter, it is necessary to install an incremental encoder with 2 phases shifted of 90°. The encoder power supply can be +5 or +12 V. It can have different electronic output.

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

2) Connection of encoder with +5 V power supply.



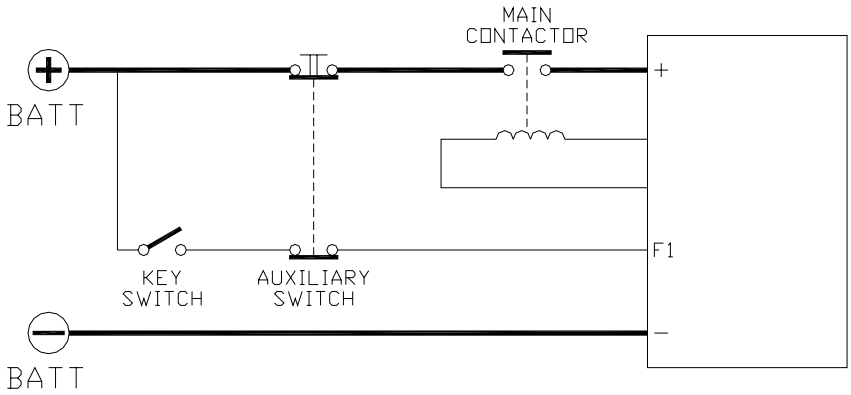
Connection of encoder with +12 V power supply.



VERY IMPORTANT
It is necessary to specify in the 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.

4.2.6 Main contactor and key connection

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



- The connection of the battery line switches must be carried out following ZAPI instructions.
- 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 inside the logic when the voltage on the battery power connection overtakes 40% more than the battery nominal voltage or if the key is switched off before the battery power line is disconnected.

4.2.7 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.

4.3 Protection and safety features

4.3.1 Protection features

The ACE-2 is protected against some controller injuries and malfunctions:

- **Battery polarity inversion**
  It is necessary to fit a MAIN CONTACTOR 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 75 °C, the maximum current is reduced in proportion to the thermal increase. The temperature can never exceed 100 °C.
- **External agents**
  The inverter is protected against dust and the spray of liquid to 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 is not functioning perfectly.
  - The output voltage of the accelerator does not fall below the minimum voltage value stored, with 1 V added.
  - Running microswitch in closed position.
- **Low battery charge**
  When the battery charge is low, the maximum current is reduced to the half of the maximum current programmed.
- **Protection against accidental Start up**
  A precise sequence of operations are necessary before the machine will start.
  Operation cannot begin if these operations are not carried out correctly.
  Requests for drive, must be made after closing the key switch.

4.3.2 Safety Features

ZAPI controllers are designed according to the prEN954-1 specifications for safety related parts of control system and 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 the customer 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.
Machine manufacturer holds the responsibility for the truck safety features and related approval.

ACE-2 inverter electronic implements an hardware safety circuit, which is able to open the Line Contactor (LC) and the Electric Brake (EB) - and therefore to cut the power line stopping the machine via HARDWARE, that is bypassing the software control of the LC and EB. This safety circuit is driven by "SAFETY" input. If safety input is connected to -BATT, the "SAFETY" circuit is inactive; if the input is open, the "SAFETY" circuit becomes active and, within a timeout, it is able to open the drivers of LC coil and EB coil. The safety circuit is also periodically checked by the ACE-2 microcontroller; if the microcontroller detects a

failure in the "SAFETY" circuit, the microcontroller itself will bring the machine in a safe status.
Suggested connection of "SAFETY" circuit:

- STANDALONE CONFIGURATION: it is suggested to connect safety input to the "SEAT" microswitch or to the "DEADMAN" microswitch (it depends on the application); in this way the machine will be brought to a safe status as soon as the operator leaves the machine.
- COMBI CONFIGURATION: in this case the pump controller acts as supervisor, checking the traction controller functionality by the CANBUS. So it is suggested to connect the "SAFETY" input of traction controller to a dedicated output of pump controller "SAFETY OUT", so that the pump controller can drive the traction safety input and open the power line in case of malfunctioning of traction controller.

4.4 EMC

EMC and ESD performances of an electronic system are strongly influenced by the installation. Special attention must be given to the lengths and the paths of the electric connections and the shields. This situation is beyond ZAPI's control. Zapi can offer assistance and suggestions, based on its years experience, on EMC related items. 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 represents the studies and the tests on the electromagnetic energy generated or received by an electrical device.
So the analysis works in two directions:

1) The study of the emission problems, the disturbances generated by the device and the possible countermeasure 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 which are working at high frequency and generate RF energy, but wires and cables have the key role to propagate the disturbs because they works 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 concern 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 be exposed to.
These tests are carried out at determined levels of electromagnetic fields, to

simulate external undesired disturbances and verify the electronic devices response.

3) The second type of immunity, 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 a 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 and thus create malfunctions; this effect is particularly critical in modern machines, with serial communications (canbus) which are spread everywhere on the truck and which 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 an intermittently malfunction to a completely failure of the electronic device.

IMPORTANT NOTE*: it is always much easier and cheaper to avoid ESD from being generated, than to increase 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.

4.5 Various suggestions

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

5 OPERATIONAL FEATURES

- Speed control (three versions available: sensored, sense coil and sensorless as explained in the introduction section) .
- Optimum behaviour on a slope due to the speed feedback:
- the motor speed follows the accelerator, starting a regenerative braking if the speed overtakes the speed set-point.
- the system can perform an electrical stop on a ramp (the machine is electrically hold on a slope) for a programmable time (see also chapter 8.4).
- Stable speed in every position of the accelerator.
- Regenerative release braking based upon deceleration ramps.
- Regenerative braking when the accelerator pedal is partially released (deceleration).
- Direction inversion with regenerative braking based upon deceleration ramp.
- Regenerative braking and direction inversion without contactors: only the main contactor is present.
- The release braking ramp can be modulated by an analog input, so that a proportional brake feature is obtained.
- Optimum sensitivity at low speeds.
- Voltage boost at the start and with overload to obtain more torque (with current control).
- The inverter can drive an electromechanical brake.
- Hydraulic steering function:
  - traction inverter
    - the traction inverter sends a "hydraulic steering function" request to the pump inverter on the can-bus line (see also OPTIONS chapter 8.4).
    - moreover, if the pump inverter is not present (for ex: tractor application), the traction inverter can manage an "hydraulic steering function" by driving a hydro contactor which drive an hydraulic steering motor (output A18), see also OPTIONS chapter.
  - pump inverter
    the pump inverter manage an "hydraulic steering function". That is, it drives the pump motor at the programmed speed for the programmed time.
- High efficiency of motor and battery due to high frequency commutations.
- Self diagnosis, the faults can be displayed through the console or Zapi's MDI/Display.
- Modification of parameters through the programming console.
- Internal hour-meter with values that can be displayed on the console.
- Memory of the last five alarms with relative hour-meter and temperature displayed on the console.
- Test function within console for checking main parameters.

5.1 Diagnosis

The microcontroller continually monitors the inverter and carries out a diagnostic procedure on the main functions. The diagnosis is made in 4 points:

1) Diagnosis on key switch closing that checks: watchdog circuit, current sensor, capacitor charging, phase's voltages, contactor drives, can-bus interface, if the switch sequence for operation is correct and if the output of accelerator unit is correct.
2) Standby diagnosis in standby that checks: watchdog circuit, phase's voltages, contactor driver, current sensor, can-bus interface.
3) Diagnosis during operation that checks: watchdog circuits, contactor driver, current sensors, can-bus interface.
4) Continuous diagnosis that check: temperature of the inverter, motor temperature.

Diagnosis is provided in two ways. The digital console can be used, which gives a detailed information about the failure; the failure code is also sent on the Can-Bus.

6 DESCRIPTION OF THE CONNECTORS

6.1 Connectors of the logic - Traction configuration

A1	KEY	Connected to the power supply through a microswitch (CH) with a 10 A fuse in series.
A2	PPOT	Potentiometer positive: 12 V / 5 V output; keep load > 1 kohm / 0.5 kohm.
A3	CPOT	Accelerator potentiometer wiper.
A4	FORW	Forward direction request input. It must be connected to the forward direction microswitch, active high.
A5	REV	Backward direction request input. It must be connected to the backward direction microswitch, active high. It can also be used as NPOT (potentiometer negative reference) with the PEDAL WIRE KO diagnosis implemented.
A6	SEAT	SEAT input; it must be connected to the SEAT microswitch; it is active when connected to -BATT.
A7	ENCA	Incremental encoder phase A input.
A8	PENC	Incremental encoder positive supply 12 V / 5 V
A9	-BATT	Negative power supply. It is used as NPOT, without PEDAL WIRE KO diagnosis, for acceleration potentiometer and brake potentiometer
A10	CPOTBR	Brake potentiometer wiper.
A11	SAFETY IN	If not connected to -Batt the MC and EB coil power output will be disabled. In the COMBI configuration it is connected to SAFETY OUT (CNA#19) of pump controller. This input can also be used as a general purpose digital input.
A12	CAN-T	If it is connected with A21 (CAN H) it introduces the 120 Ohm termination resistance between CAN-L and CAN-H.
A13	SR/HB	Speed reduction (handbrake) input. Active with switch opened. Not active with switch closed to -Batt.
A14	ENCB	Incremental encoder phase B input.
A15	ENC GND	Encoder negative power supply.
A16	NLC	Main contactor coil output. The coil is driven to negative reference.
A17	PLC/PB	Positive of the main contactor and electromechanical brake coil.
A18	NEB	Electro mechanic brake coil output. The coil is driven to negative reference.
A19	SAFETY OUT	It drives the external load to negative reference when the REV input is active. It can be used for a flashing light or acoustic indicator. The maximum current load is 1 A. In case of inductive load it is suggested to use a free-wheeling diode across the load (with cathode

		connected to +Batt)
A20	CAN-L	Low level CAN-BUS voltage I/O.
A21	CAN-H	High level CAN-BUS voltage I/O.
A22	PTHERM	Input for motor temperature sensor. It is possible to use a digital or analogue (PTC) sensor.
A23	NTHERM	-Batt.
B1	PCLRXD	Positive serial reception (Not used: it can be disconnected).
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to B8 for the Flash memory programming.
B8	FLASH	It must be connected to B7 for the Flash memory programming.

6.2 Connectors of the logic - Pump configuration

A1	KEY	Connected to the power supply through a microswitch (CH) with a 10 A fuse in series.
A2	PPOT	Potentiometer positive: 12 V / 5 V output; keep load > 1 kohm / 0.5 kohm.
A3	CPOT	Lifting potentiometer wiper.
A4	LIFT ENABLE	Input for potentiometer lifting enable input; it is active HIGH.
A5	SPEED1	Input for first speed request; it is active HIGH. It can also be used as NPOT (potentiometer negative reference) with the PEDAL WIRE KO diagnosis implemented.
A6	SEAT	SEAT input; it must be connected to the SEAT microswitch; it is active when connected to -BATT.
A7	ENCA	Incremental encoder phase A input.
A8	PENC	Incremental encoder positive supply 12 V / 5 V
A9	-BATT	Negative power supply. It is used as NPOT, without PEDAL WIRE KO diagnosis, for lifting potentiometer
A10	SPEED2	Input for second speed request; it is active HIGH.
A11	SAFETY IN	If not connected to -Batt the AUX1 and AUX2 coil power output will be disabled. It can also be used as a general purpose digital input.
A12	CAN-T	If it is connected with A21 (CAN H) it introduces the 120 Ohm termination resistance between CAN-L and CAN-H.
A13	SPEED3	Input for third speed request; it is active when

		connected to -Batt.
A14	ENCB	Incremental encoder phase B input.
A15	ENC GND	Encoder negative power supply.
A16	NLC	Main contactor coil output. The coil is driven to negative reference.
A17	PLC/PAUX	Positive of the LC and Auxiliary coil.
A18	NAUX	Auxiliary coil output. The coil is driven to negative reference.
A19	SAFETY OUT	In the COMBI configuration it is connected to SAFETY IN (CNA#11) of traction controller. It can also be used to drive an external load to negative reference when the pump motor is driven. The maximum current load is 1 A. In case of inductive load it is suggested to use a free-wheeling diode across the load (with cathode connected to +Batt)
A20	CAN-L	Low level CAN-BUS voltage I/O.
A21	CAN-H	High level CAN-BUS voltage I/O.
A22	PTHERM	Input for motor temperature sensor. It is possible to use a digital or analogue (PTC) sensor.
A23	NTHERM	-Batt.
B1	PCLRXD	Positive serial reception (Not used: it can be disconnected).
B2	NCLRXD	Negative serial reception.
B3	PCLTXD	Positive serial transmission.
B4	NCLTXD	Negative serial transmission.
B5	GND	Negative console power supply.
B6	+12	Positive console power supply.
B7	FLASH	It must be connected to B8 for the Flash memory programming.
B8	FLASH	It must be connected to B7 for the Flash memory programming.

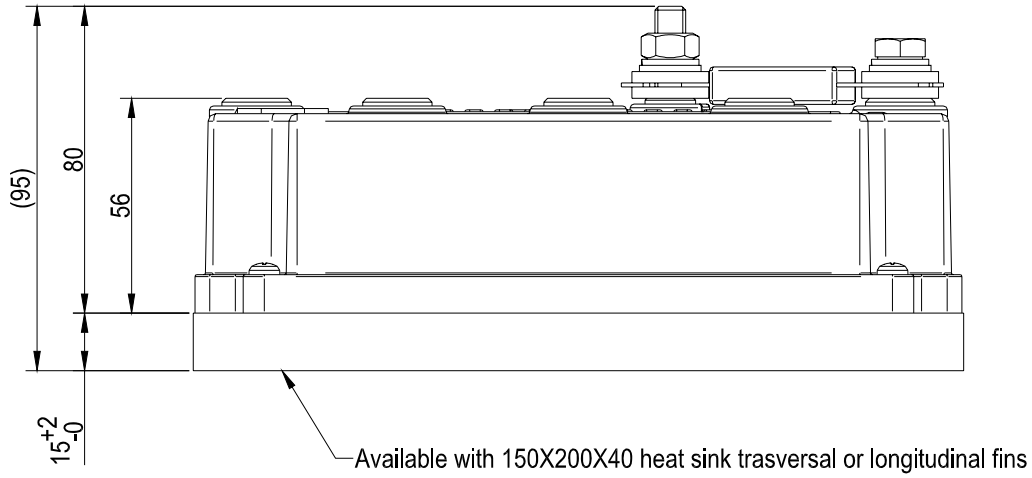
6.3 Description of power connections

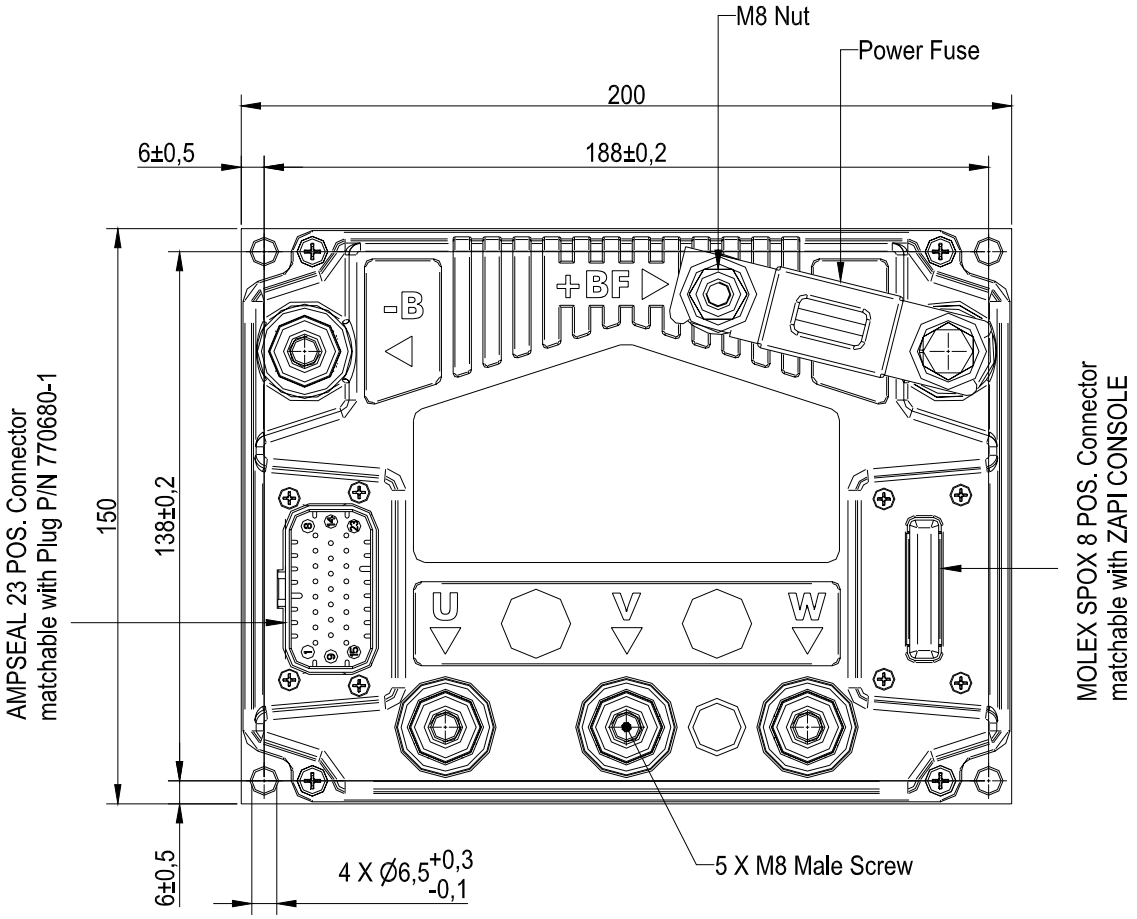
View of the power bars:

-BATT	Negative of the battery.
+BATT	Positive of the battery.
U; V; W	Connection bars of the three motor phases; follow this sequence and the indication on the motor.

7 DRAWING

7.1 Mechanical drawing

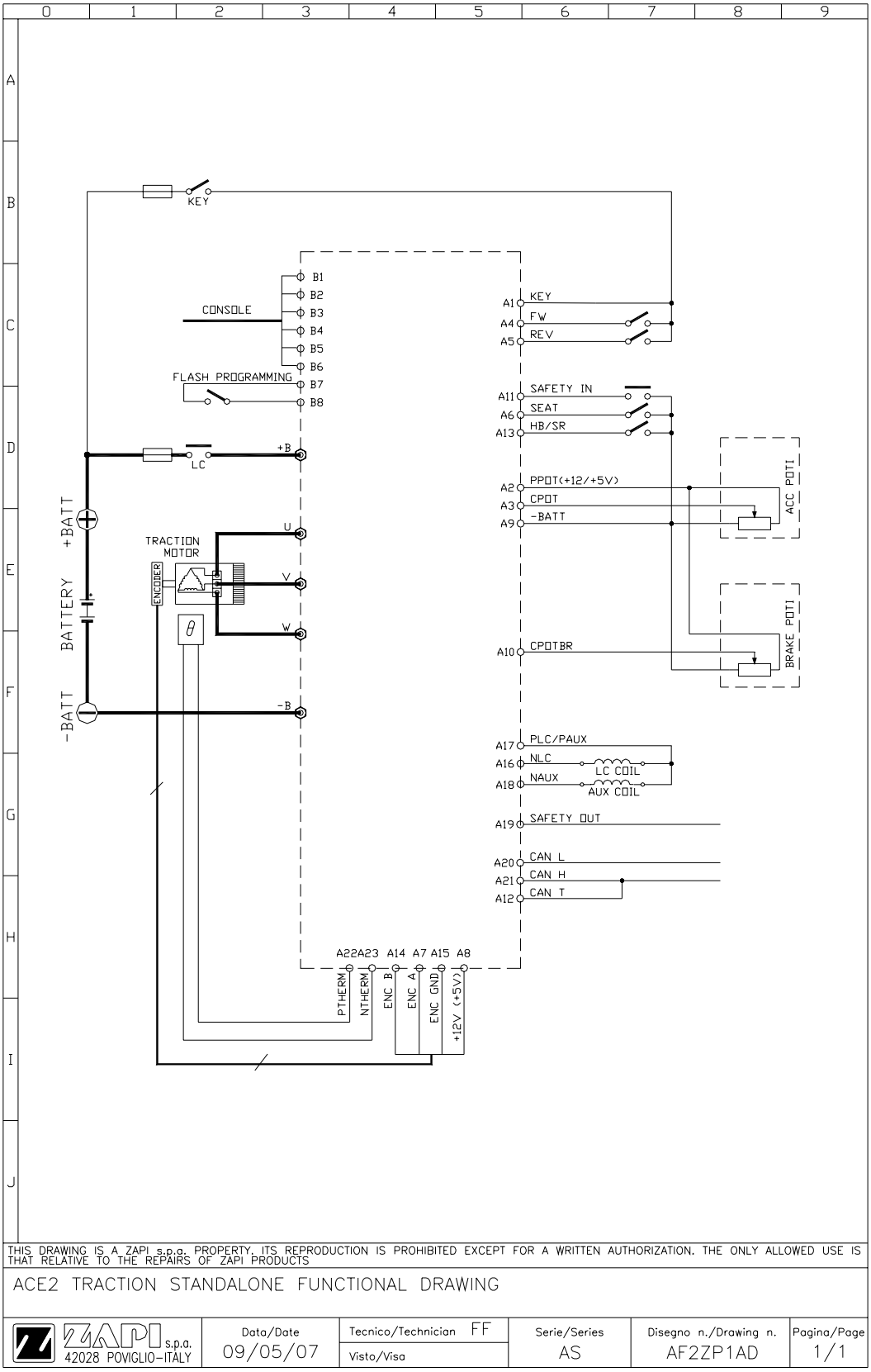




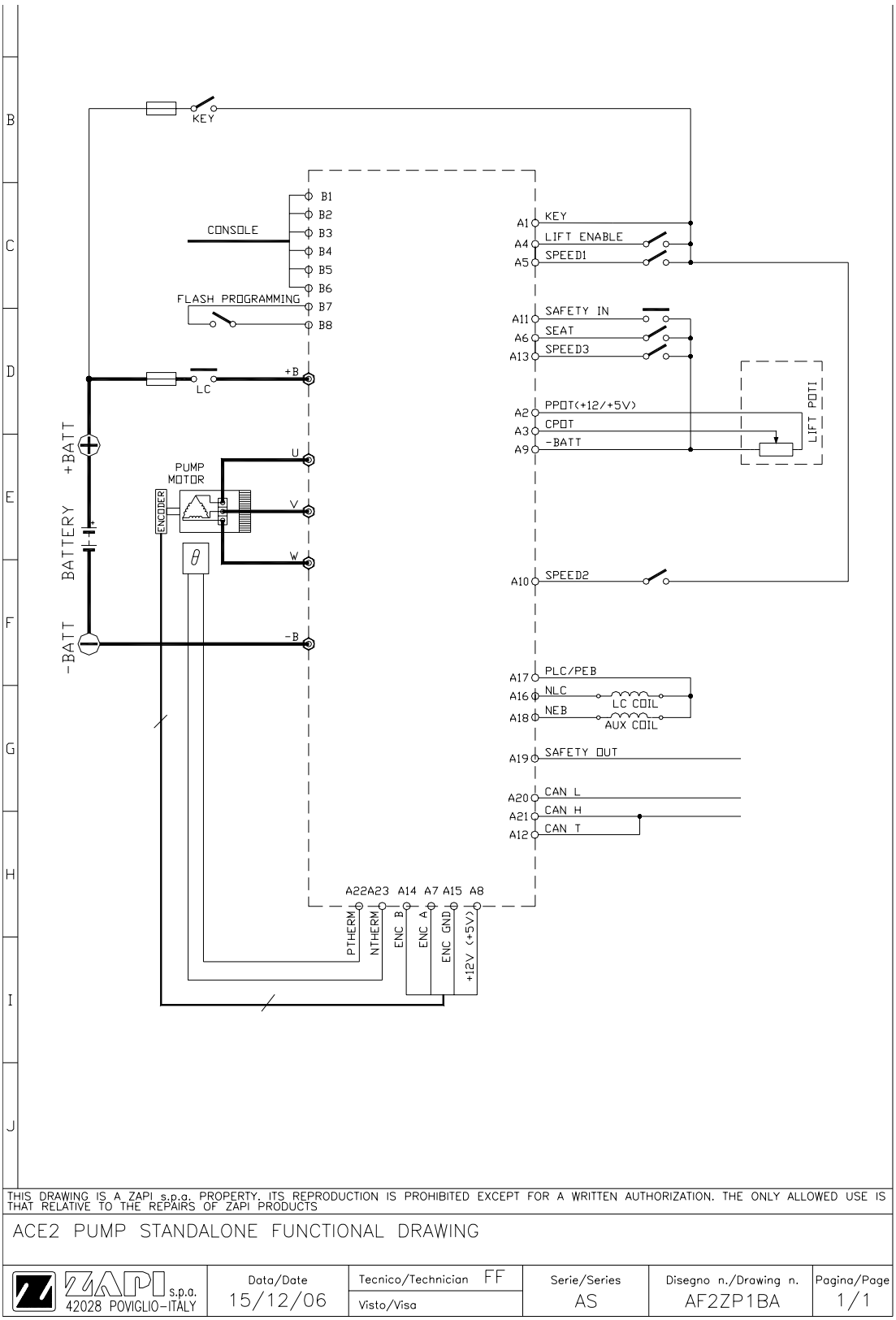
Existing others versions (with or without power fuse):

- With heat sink 200x40x150mm
- With heat sink 200x40x200mm

7.2 Connection drawing - Traction configuration



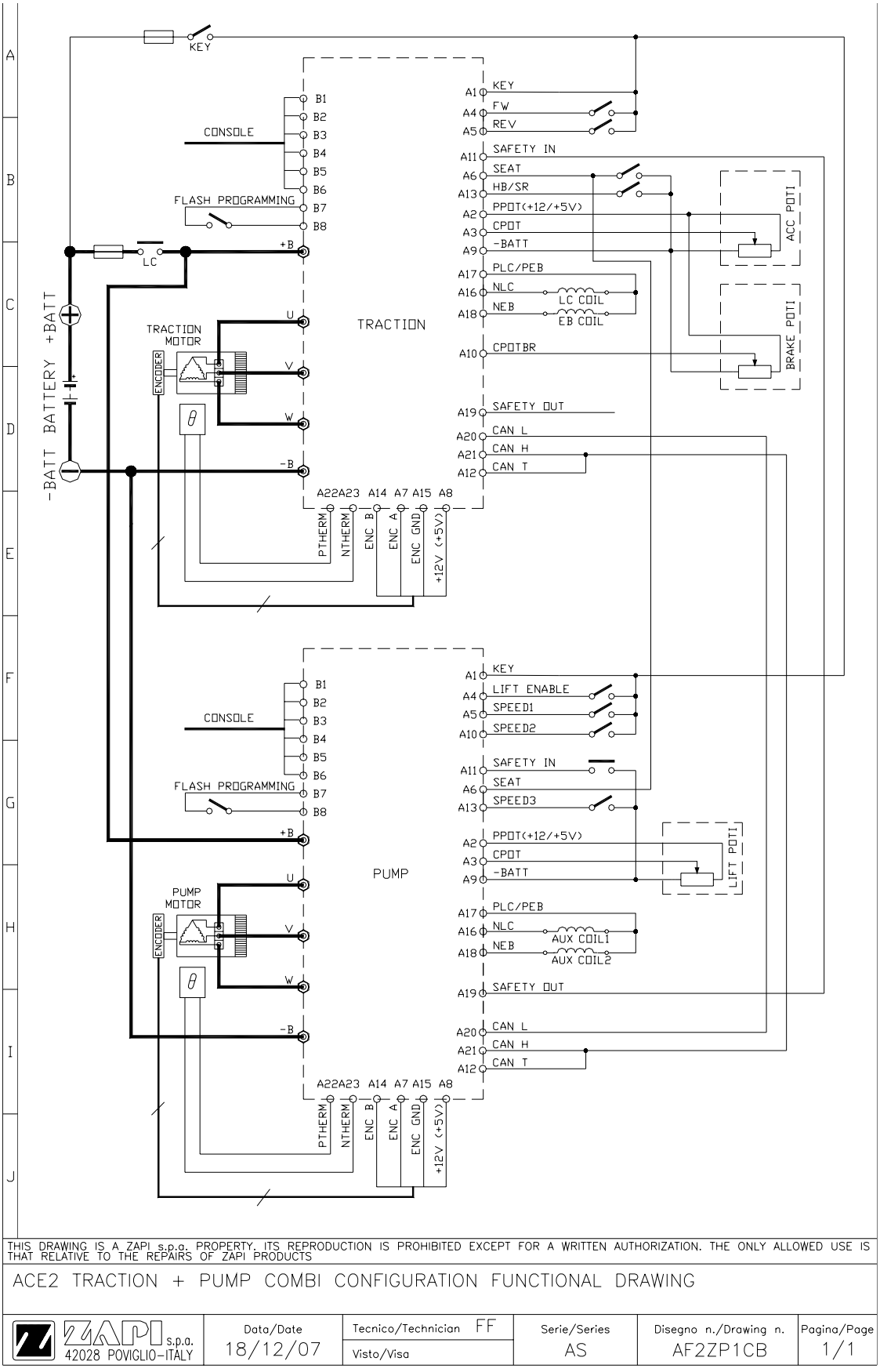
7.3 Connection drawing - Pump configuration



ACE2 PUMP STANDALONE FUNCTIONAL DRAWING

ZAPI s.p.a. 42028 POVIGLIO-ITALY	Data/Date	Tecnico/Technician FF	Serie/Series	Disegno n./Drawing n.	Pagina/Page
	15/12/06	Visto/Visa	AS	AF2ZP1BA	1/1

7.4 Connection drawing - Combi configuration



ACE2 TRACTION + PUMP COMBI CONFIGURATION FUNCTIONAL DRAWING

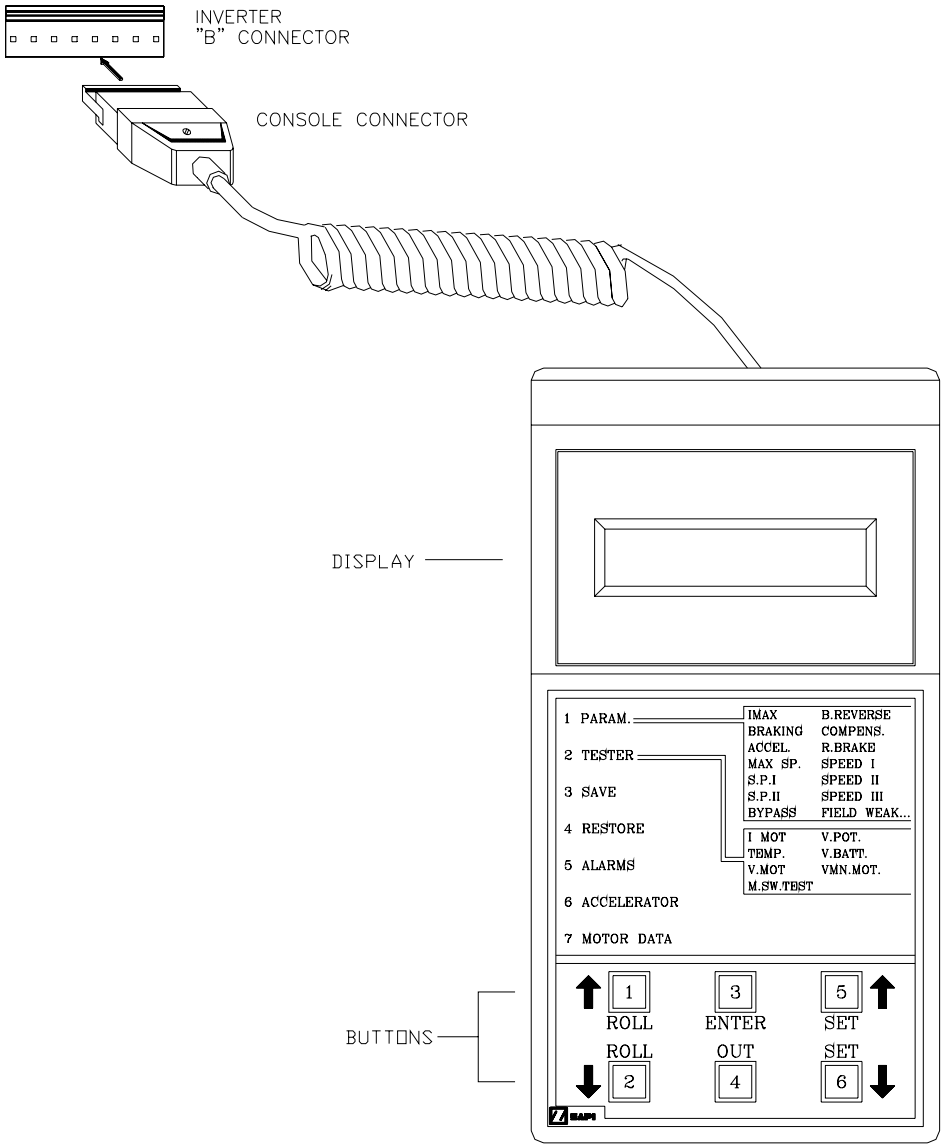
ZAPI s.p.a. 42028 POVIGLIO-ITALY	Data/Date	Tecnico/Technician	Serie/Series	Disegno n./Drawing n.	Pagina/Page
	18/12/07	FF Visto/Visa	AS	AF2ZP1CB	1/1

8 PROGRAMMING & ADJUSTMENTS USING DIGITAL CONSOLE

8.1 Adjustments via Console

Adjustment of Parameters and changes to the inverter's configuration are made using the Digital Console. The Console is connected to the "B" connector of the inverter.

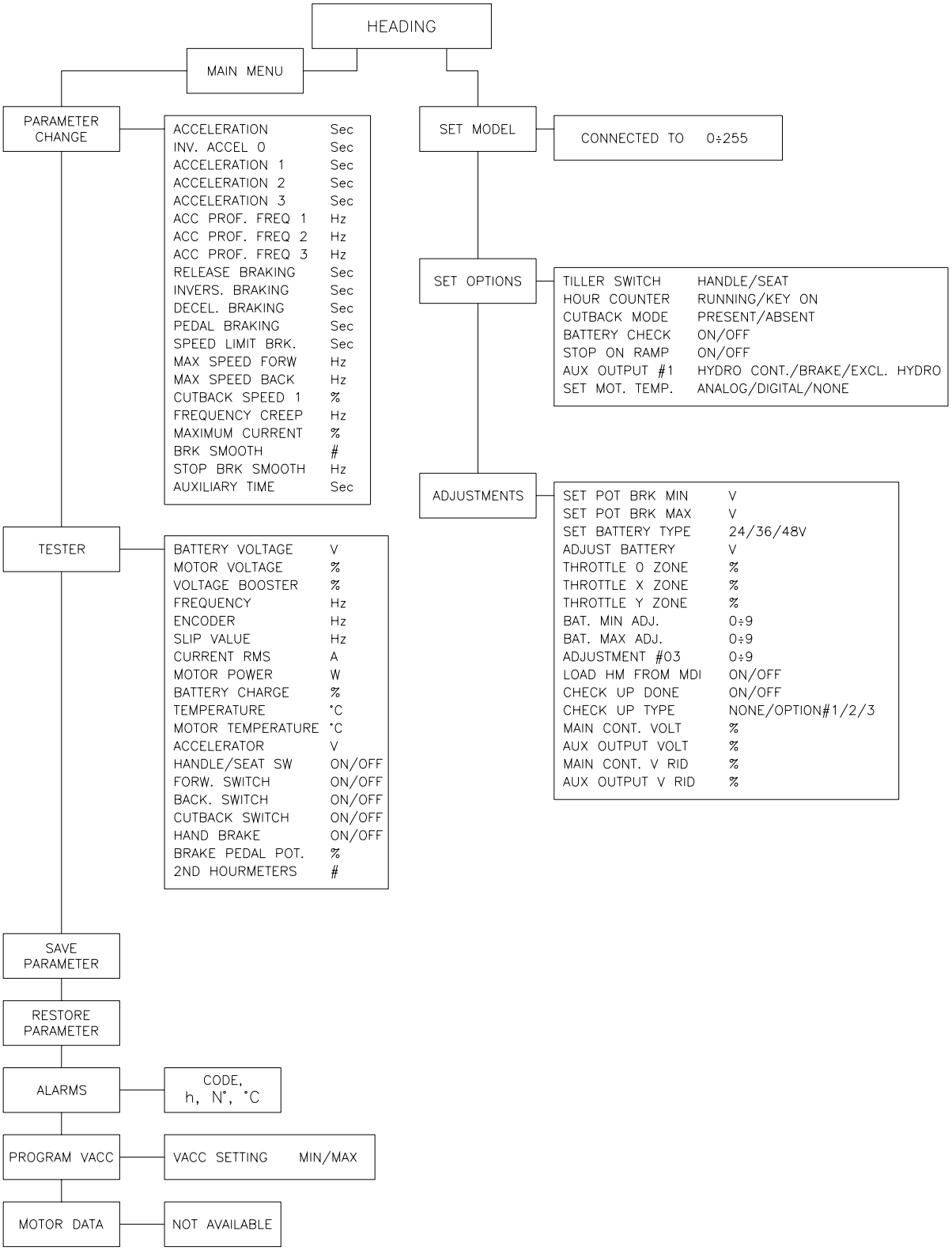
8.2 Description of Console & Connection



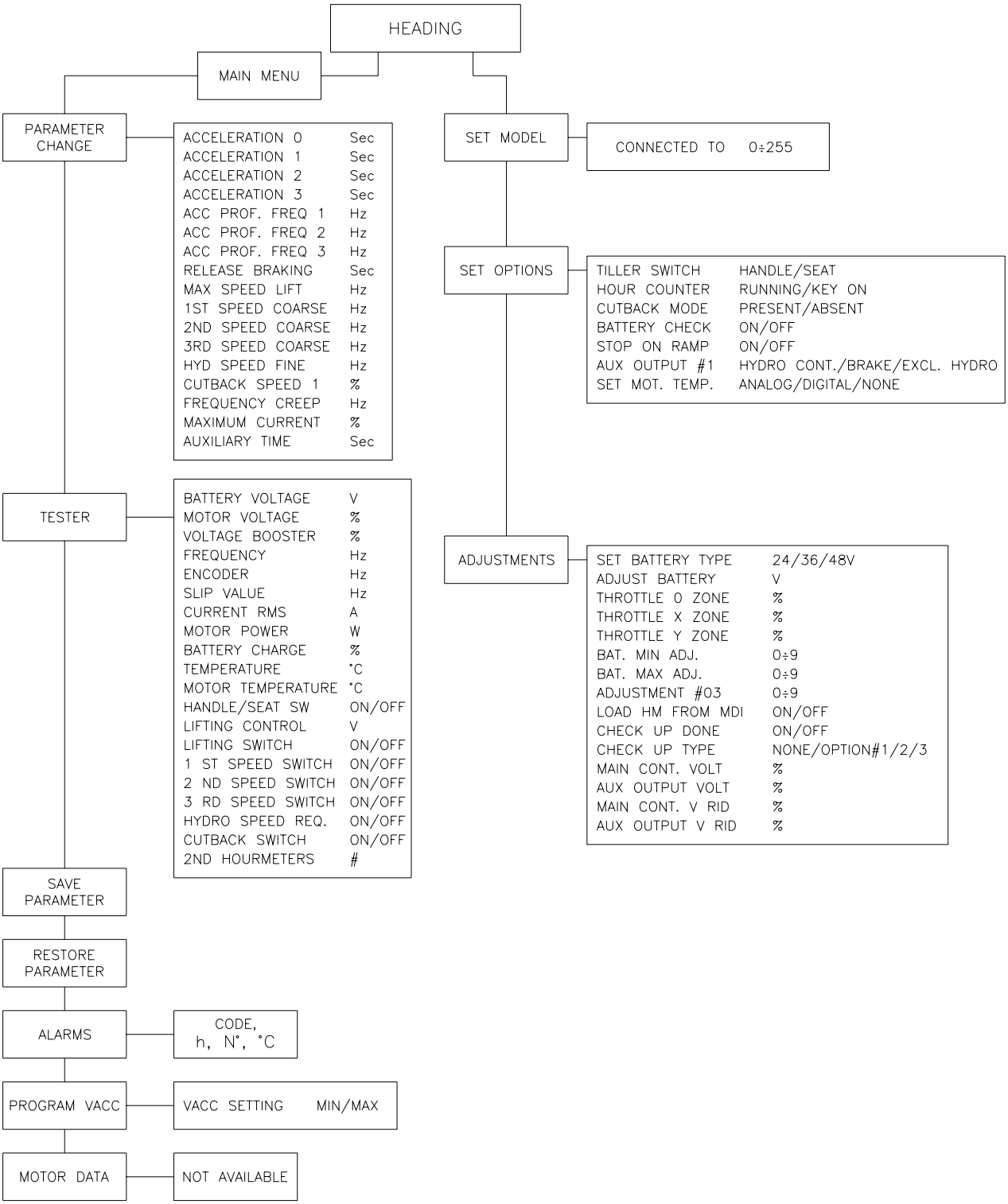
Digital consoles used to communicate with AC inverter controllers must be fitted with EPROM CK ULTRA, minimum "Release Number 3.02".

8.3 Description of Standard Console Menu

8.3.1 Traction configuration



8.3.2 Pump configuration



8.4 Function configuration

8.4.1 Traction

Using the CONFIG MENU of the programming console, the user can configure the following functions (see "OPERATIONAL FEATURE" chapter for an explanation of "hydraulic steering function"):

SUBMENU "SET OPTIONS"

1) DISPLAY TYPE
   This parameter decides wich display is connected to the inverter.
   0: No Display
   1: MDI PRC connected
   2: ECO DISPLAY connected
   3: SMART DISPLAY connected
   4: MDI CAN connected

2) TILLER SWITCH
   This option handles the input CNA#6 . This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. There are two levels:
   - HANDLE: CNA#6 is managed as tiller input (no delay when released).
   - SEAT: CNA#6 is managed as seat input (with a delay when released - debouncing function)

3) HOUR COUNTER
   - RUNNING: the counter registers travel time only.
   - KEY ON: the counter registers when the "key" switch is closed.

4) CUTBACK MODE
   OPTION#1, PRESENT or OPTION#2.
   - If option 2.5 POT is ON:
     OPTION#1: A13 is a handbrake.
     PRESENT: A13 is a speed reduction request.
     OPTION#2: no function for A13.
   - If option 2.5 POT is OFF:
     OPTION#1: A13 is a handbrake.
     PRESENT: A13 is a speed reduction request.
     OPTION#2: A13 is enable input.

5) BATTERY CHECK
   - ON: the battery discharge level check is carried out; when the battery level reaches 10%, an alarm is signalled and the maximum current is reduced to the half of the programmed value.
   - OFF: the battery discharge level check is carried out but no alarm is signalled.

6) STOP ON RAMP
   - ON: the stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by "auxiliary time" parameter. After this time, the behaviour depends on the "aux output #1" option programming (see also the following table).

- OFF: the stop on ramp feature is not performed.

7) AUX OUTPUT #1
   - HYDRO CONT.: the inverter manages an hydraulic steering function when the direction input or brake pedal input are active or a movement of the truck is detected.
   - EXCLUSIVE HYDRO: the inverter manages an hydraulic steering function when the exclusive hydro input is active.
   - BRAKE: output A18 drives an electromagnetic brake coil which is activated every time the traction motor is driven.

8) SET MOT. TEMPERATURE
   - DIGITAL: a digital (ON/OFF) motor thermal sensor is connected between A22 and A23 inputs.
   - ANALOG: an analogue motor thermal sensor is connected between A22 and A23 (the curve can be customized on a customer request).
   - NONE: no motor thermal sensor switch is connected.

9) AUX INPUT#1
   This parameter decide if input A10 is used for brake or for quick inversion.
   BRAKE: A10 is used like brake pedal.
   BELLY: A10 is used like quick inversion input. There's inversion until A10 is closed.
   TIMED: A10 is used for quick inversion request and inversion is timed.

10) 2.5 POT
    ON: when the potentiometer is under the half range level, is backward. When is over is forward. Forward and backward microswitches are not present. Enable is A4.

<u>SUBMENU "ADJUSTMENTS"</u>

1) SET POT BRK MIN
   It records the minimum value of braking pedal potentiometer when the braking switch is closed; the procedure is similar to the "Program Vacc" function (see chapter 9.4). This procedure must be carried out only if the "Pedal braking" option is programmed as "Analog".

2) SET POT BRK MAX
   It records the maximum value of braking pedal potentiometer when the braking pedal is fully pressed; the procedure is similar to the "Program Vacc" function (see chapter 9.4). This procedure must be carried out only if the "Pedal braking" option is programmed as "Analog".

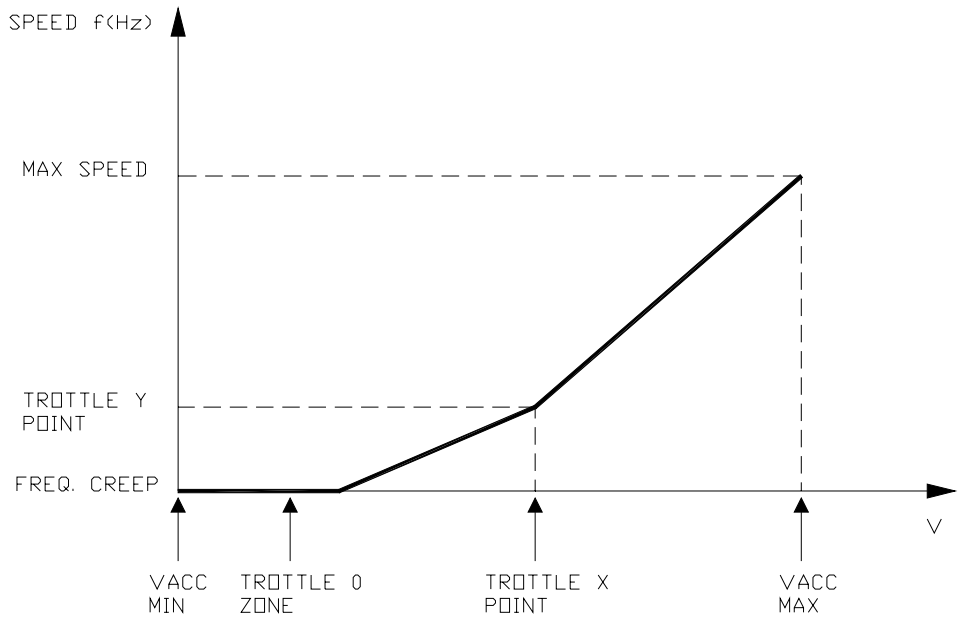
3) SET BATTERY TYPE
   It selects the nominal battery voltage.

4) ADJUST BATTERY
   Fine adjustment of the battery voltage measured by the controller.

5) THROTTLE 0 ZONE
   It establishes a deadband in the accelerator input curve (see also curve below).

6) THROTTLE X POINT
   This parameter changes the characteristic of the accelerator input curve.

7) THROTTLE Y POINT
This parameter changes the characteristic of the accelerator input curve.



VACC MIN and VACC MAX are values programmable by the "Program Vacc" function.

8) BATT. MIN. ADJ.
It adjusts the lower level of the battery discharge table. It is used to calibrate the discharge algorithm with the battery of the application. See chapter 9.5 for more information.

9) BATT. MAX. ADJ.
It adjusts the upper level of the battery discharge table. It is used to calibrate the discharge algorithm with the battery of the application. See chapter 9.5 for more information.

10) ADJUSTMENT #03
This parameter adjusts the updating of battery charge after Key-On. Decreasing this parameter the difference between the battery voltage measured after Key-On and the last stored value necessary to update the charge with the new value measured decrease. It is used to calibrate the discharge algorithm with the battery of the application. See chapter 9.5 for more information.

11) LOAD HM FROM MDI
When set On, the HourMeter of the Controller is transferred and recorded on the HourMeter of the Standard MDI (connected on the Serial Link).

12) CHECK UP DONE
Turn it On when the required Maintenance service has been executed to cancel the CHECK UP NEEDED warning.

13) CHECK UP TYPE
It specifies the handling of the CHECK UP NEEDED warning:

- NONE: No CHECK UP NEENED warning
- OPTION#1: CHECK UP NEENED warning shown on the hand set and
- MDI after 300 hours
- OPTION#2: Equal to OPTION#1 but Speed reduction after 340 hours
- OPTION#3: Equal to OPTION#2 but the truck definitively stops after 380 hours

14) MAIN CONT VOLT
It specifies the percentage of battery voltage supplied to MC coil to close the contactor.

15) AUX OUT VOLT
It specifies the percentage of battery voltage supplied to EB coil to apply the electro mechanic brake.

16) MAIN CONT. V RID
It specifies the percentage of MAIN CONT VOLT parameter, supplied to MC coil to keep the contactor closed.
Example 1
MAIN CONT VOLTAGE = 100%
MAIN CONT V RID = 70%
The contactor will be closed with full battery voltage applied to the coil and then the voltage will be reduced to 70% of battery voltage.
Example 2
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 100%
The contactor will be closed with 70% of battery voltage applied to the coil and then the voltage will be kept at the same value.
Example 3
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 70%
The contactor will be closed with 70% of battery voltage applied to the coil and then the voltage will be reduced to 49% of battery voltage.

17) AUX OUTPUT V RID
It specifies the percentage of AUX OUT VOLT parameter, supplied to EB coil to keep the electro mechanic brake applied.
Example 1
MAIN CONT VOLTAGE = 100%
MAIN CONT V RID = 70%
The Ebrake will be closed with full battery voltage applied to the coil and then the voltage will be reduced to 70% of battery voltage.
Example 2
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 100%
The Ebrake will be closed with 70% of battery voltage applied to the coil and then the voltage will be kept at the same value.
Example 3
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 70%
The Ebrake will be closed with 70% of battery voltage applied to the coil and then the voltage will be reduced to 49% of battery voltage.

AUX OUTPUT	STOP ON RAMP	A18 OUTPUT	BEHAVIOUR ON A SLOPE
BRAKE	**ON**	-It drives the coil of a electromagnetic brake. -The hydraulic steering function request is sent to the pump inverter by the can-bus link.	The truck is electrically hold on a slope; when the time set by "auxiliary time" parameter is elapsed the brake is applied and the 3-phase bridge is released. **Do not use this combination if the negative brake is not installed.**
BRAKE	**OFF**	-It drives the coil of a electromagnetic brake. -The hydraulic steering function request is sent to the pump inverter by the can-bus link.	The truck is not electrically hold on a slope, but comes down very slowly; when the time set by "auxiliary time" parameter is elapsed, the brake is applied and the 3-phase bridge is opened. **Do not use this combination if the negative brake is not installed.**
HYDRO CONT.	**ON**	-It drives the coil of a hydraulic steering contactor when the direction input or brake pedal input are active or a movement of the truck is detected.-The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is electrically hold on a slope; when the time set by "auxiliary time" parameter is elapsed, the truck comes down very slowly, till the flat is reached.
HYDRO CONT.	**OFF**	-It drives the coil of a hydraulic steering contactor when the direction input or brake pedal input are active or a movement of the truck is detected. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is not electrically hold on a slope, but comes down very slowly till the flat is reached.
EXCL. HYDRO	**ON**	-It drives the coil of a hydraulic steering contactor when the exclusive hydro input is active. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is electrically hold on a slope; when the time set by "auxiliary time" parameter is elapsed, the truck comes down very slowly, till the flat is reached.
EXCL. HYDRO	**OFF**	-It drives the coil of a hydraulic steering contactor when the exclusive hydro input is active. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is not electrically hold on a slope, but comes down very slowly till the flat is reached.

SUBMENU "SPECIAL ADJUST"

1) ADJUSTMENT#01
   Reserved.

2) ADJUSTMENT#02
   Reserved.

3) SET CURRENT
   It adjusts the regolation of maximum current. It shouldn’t be changed.

4) HIGH ADRESS
   Reserved.

5) DEBUG MODE
   Reserved.

6) INVERTER TYPE
   It decides what kind of inverter is used.
   0 and 1: traction.
   2 and 3: pump.
   The change of this parameter changes the other parameters at the next keyoff.

7) SAFETY IN
   0: input allways closed (bridged)
   1: safety_in_drived: safety came from a different controller, need a can handshake.
   2: general purpose input (not jet defined. Need hardware change)

8) SAFETY OUT
   0: none : fa comunque la diag all'init per verificare il funzionamento.
   1: driver: is for drive a safety in.
   2: general purpose: standard function: reverse direction indicator.

9) MAIN CONTACTOR

OFF	No main contactor (directly connect to +Battery)
ON	Main contactor in stand alone config
OPTION#1	Traction +pump 1 only MC
OPTION#2	Traction +pump 2 MC

10) AUX OUT FUNCTION
    ON/OFF. If OFF, A18 is not drived and there is no diagnosis on it.

8.4.2 Pump

Using the config menu of the programming console, the user can configure the following functions.

SUBMENU "SET OPTIONS"

1) DISPLAY TYPE
   This parameter decides wich display is connected to the inverter.
   0: No Display
   1: MDI PRC connected
   2: ECO DISPLAY connected
   3: SMART DISPLAY connected

4: MDI CAN connected

2) TILLER SWITCH
This option handles the input CNA#6 . This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. There are two levels:
- HANDLE: CNA#6 is managed as tiller input (no delay when released).
- SEAT: CNA#6 is managed as seat input (with a delay when released - debouncing function)

3) HOUR COUNTER
- RUNNING: the counter registers travel time only.
- KEY ON: the counter registers when the "key" switch is closed.

4) CUTBACK MODE
OPTION#1: A13 is third speed request
PRESENT: A13 is speed reduction request
OPTION#2: A13 has no function.

5) BATTERY CHECK
- ON: the battery discharge level check is carried out; when the battery level reaches 10%, an alarm is signalled and the maximum current is reduced to the half of the programmed value.
- OFF: the battery discharge level check is carried out but no alarm is signalled.

Very important:
In the combi system (pump + traction), the battery discharge calculation for the complete system is carried out by the traction inverter; the information about the pump inverter consumption is sent on the can-bus line from the pump inverter to the traction inverter. So the correct programming for the "Battery check" option is:
traction inverter: ON
pump inverter: OFF.

6) STOP ON RAMP
- ON: the stop on ramp feature (truck pump electrically hold on with load) is managed for a time established by "auxiliary time" parameter.
- OFF: the stop on ramp feature is not performed.

7) AUX OUTPUT #1
Not used.

8) SET MOT TEMPERATURE
- ANALOG: an analogue motor thermal sensor is connected between A22 and A23 inputs (the curve can be customized on a customer request).
- DIGITAL: a digital (ON/OFF) motor thermal sensor is connected between A22 and A23 inputs.
- NONE: no motor thermal sensor switch is connected.

SUBMENU "ADJUSTMENTS"

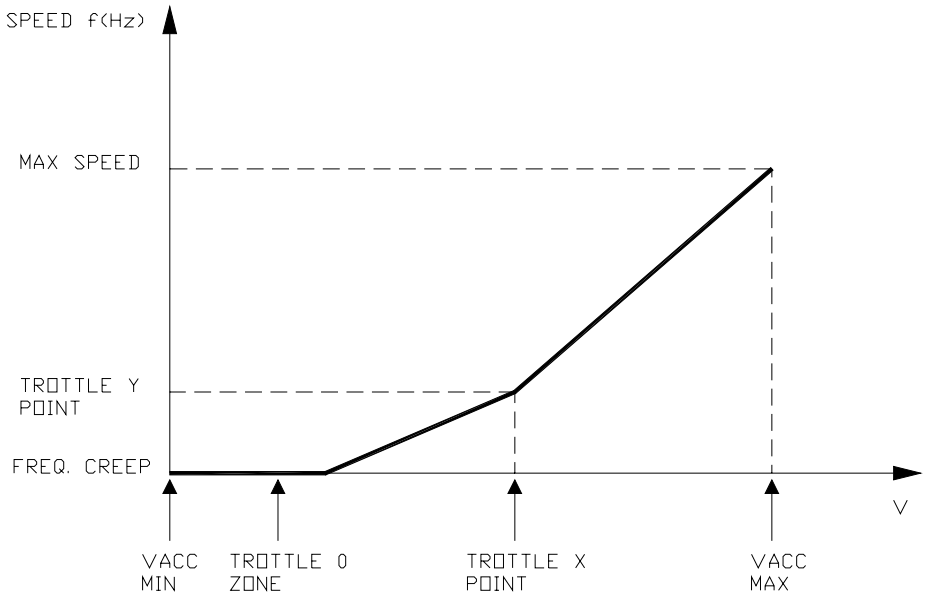
1) SET BATTERY TYPE
It selects the nominal battery voltage.

2) ADJUST BATTERY
Fine adjustment of the battery voltage measured by the controller.

3) THROTTLE 0 ZONE
It establishes a dead band in the lift potentiometer input curve (see also curve below).

4) THROTTLE X POINT
This parameter, together with the THROTTLE Y POINT, changes the characteristic of the lift potentiometer input curve : when the potentiometer is depressed to X point per cent, the corresponding pump speed is Y point per cent of the Maximum pump speed. The relationship between the lift potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum potentiometer position but with two different slopes.

5) THROTTLE Y POINT
This parameter, together with the THROTTLE X POINT, changes the characteristic of the lift potentiometer input curve (see also paragraph 13.5): when the potentiometer is de-pressed to X point per cent, the corresponding pump speed is Y point per cent of the Maximum pump speed. The relationship between the potentiometer position and the pump speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope. VACC MIN and VACC MAX are values programmable by the "Program Vacc" function.



6) BATT. MIN. ADJ.
It adjusts the lower level of the battery discharge table. It is used to calibrate the discharge algorithm with the battery of the application. See chapter 9.5 for more information.

7) BATT. MAX. ADJ.
It adjusts the upper level of the battery discharge table. It is used to calibrate the discharge algorithm with the battery of the application. See chapter 9.5 for more information.

8) ADJUSTMENT #03
This parameter adjusts the updating of battery charge after Key-On. Decreasing this parameter the minimum difference between the battery voltage measured after Key-On and the last stored value, necessary to update the charge with the new value measured, decrease. It is used to calibrate the discharge algorithm with the battery of the application. See chapter 9.5 for more information.

9) LOAD HM FROM MDI
When set On, the HourMeter of the Controller is transferred and recorded on the HourMeter of the Standard MDI (connected on the Serial Link).

10) CHECK UP DONE
Turn it On when the required Maintenance service has been executed to cancel the CHECK UP NEEDED warning.

11) CHECK UP TYPE
It specifies the handling of the CHECK UP NEEDED warning:
- NONE: No CHECK UP NEENED warning
- OPTION#1: CHECK UP NEENED warning shown on the hand set and MDI after 300 hours
- OPTION#2: Equal to OPTION#1 but Speed reduction after 340 hours
- OPTION#3: Equal to OPTION#2 but the truck definitively stops after 380 hours

12) MAIN CONT VOLT
It specifies the percentage of battery voltage supplied to MC coil to close the contactor.

13) AUX OUT VOLT
It specifies the percentage of battery voltage supplied to AUX coil to close the AUXILIARY electro valve.

14) MAIN CONT. V RID
It specifies the percentage of MAIN CONT VOLT parameter, supplied to MC coil to keep the contactor closed.
Example 1
MAIN CONT VOLTAGE = 100%
MAIN CONT V RID = 70%
The contactor will be closed with full battery voltage applied to the coil and then the voltage will be reduced to 70% of battery voltage.
Example 2
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 100%
The contactor will be closed with 70% of battery voltage applied to the coil and then the voltage will be kept at the same value.
Example 3
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 70%
The contactor will be closed with 70% of battery voltage applied to the coil

and then the voltage will be reduced to 49% of battery voltage.

15) AUX OUTPUT V RID
It specifies the percentage of AUX OUT VOLT parameter, supplied to EB coil to keep the electro mechanic brake applied.
Example 1
MAIN CONT VOLTAGE = 100%
MAIN CONT V RID = 70%
The load will be closed with full battery voltage applied to the coil and then the voltage will be reduced to 70% of battery voltage.
Example 2
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 100%
The load will be closed with 70% of battery voltage applied to the coil and then the voltage will be kept at the same value.
Example 3
MAIN CONT VOLTAGE = 70%
MAIN CONT V RID = 70%
The load will be closed with 70% of battery voltage applied to the coil and then the voltage will be reduced to 49% of battery voltage.

SUBMENU "SPECIAL ADJUST"

1) ADJUSTMENT#01
   Reserved.

2) ADJUSTMENT#02
   Reserved.

3) SET CURRENT
   It adjust the regolation of maximum current. It shouldn’t be changed.

4) HIGH ADRESS
   Reserved.

5) DEBUG MODE
   Reserved.

6) INVERTER TYPE
   It decides what kind of inverter is used.
   0 and 1: traction.
   2 and 3: pump.
   The change of this parameter changes the other parameters at the next keyoff.

7) SAFETY IN
   0: input allways closed (bridged)
   1: safety_in_drived: safety came from a different controller, need a can handshake.
   2: general purpose input (not jet defined. Need hardware change).

8) SAFETY OUT
   0: none : fa comunque la diag all'init per verificare il funzionamento.
   1: driver: is for drive a safety in.
   2: general purpose: standard function: reverse direction indicator.

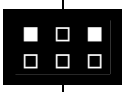
9) MAIN CONTACTOR
   OFF No main contactor (directly connect to +Battery)
   ON Main contactor in stand alone config
   OPTION#1 Traction +pump 1 only MC
   OPTION#2 Traction +pump 2 MC

10) AUX OUT FUNCTION
   ON/OFF. If OFF, A18 is not drived and without diagnosis.

Flow chart showing how to make changes to OPTION Menu.

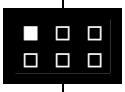
1) Opening Zapi Menu.

2) Press Top Left & Right Buttons to enter SET Menu.



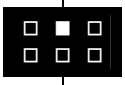
3) The Display will show: SET MODEL.

4) Press ROLL UP or ROLL DOWN button until SET MODEL Menu appears.



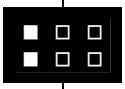
5) SET OPTIONS appears on the display.

6) Press ENTER to go into the SET MODEL Menu.



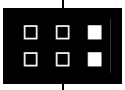
7) The display will shows the first OPTION.

8) Press ROLL UP or ROLL DOWN button until desired OPTION appears.



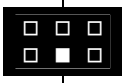
9) Desired OPTION appears.

10) Press SET UP or SET DOWN button in order to modify the changes.



11) New OPTION appears.

12) Press OUT to exit the Menu.

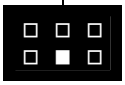


13) Confirmation request appears.

14) Press ENTER to accept the changes, or press OUT if you do not accept the changes.

15) SET OPTIONS Menu appears.

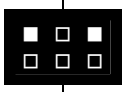
16) Press OUT again. Display now show the Opening Zapi Menu.



Flow chart showing how to make changes to ADJUSTMENTS Menu.

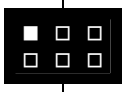
1) Opening Zapi Menu.

2) Press Top Left & Right Buttons to enter CONFIG Menu.



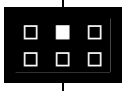
3) The display will show: SET MODEL.

4) Press ROLL UP or ROLL DOWN button until ADJUSTMENTS Menu appears.



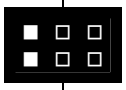
5) ADJUSTMENTS appears on the display.

6) Press ENTER to go into the ADJUSTMENTS Menu.



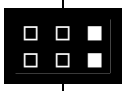
7) The display will shows SET BATTERY TYPE.

8) Press ROLL UP or ROLL DOWN button until the desired parameter is reached.

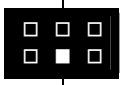


9) The desired parameter appears.

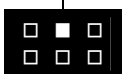
10) Press SET UP or SET DOWN button to modify the adjustment.



11) Press OUT.



12) Press ENTER to confirm.

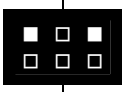


13) Repeat the same from 5 to 12 points for the other adjustments.

Flow chart showing how to use the SET BATTERY TYPE adjustment.

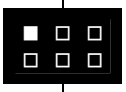
1) Opening Zapi Menu.

2) Press Top Left & Right Buttons to enter CONFIG Menu.



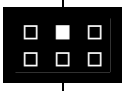
3) The Display will show: SET MODEL.

4) Press ROLL UP button until ADJUSTMENTS Menu appears.



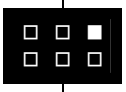
5) ADJUSTMENTS appears on the display.

6) Press ENTER to go into the ADJUSTMENTS Menu.

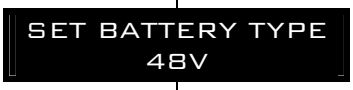


7) The display will show: SET BATTERY TYPE.

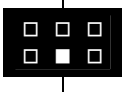
8) Press SET UP to choose nominal value of the battery.



9) New battery value appears.

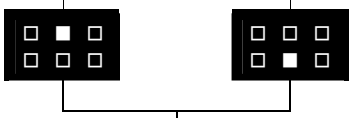


10) Press OUT.

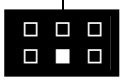


11) Confirmation request appears.

12) Press ENTER to accept the changes, or press OUT if you do not accept the changes.



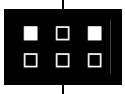
13) Press OUT. Display now shows the Opening Zapi Menu.



Flow chart showing how to carry out ADJUSTMENT BATTERY operation by console.

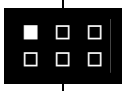
1) Opening Zapi Menu.

2) Press Top Left & Right Buttons to enter CONFIG Menu.



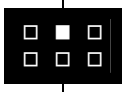
3) The Display will show: SET MODEL.

4) Press ROLL UP button until ADJUSTMENTS Menu appears.

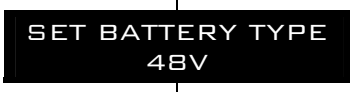


5) ADJUSTMENTS appears on the display.

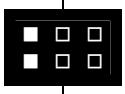
6) Press ENTER to go into the ADJUSTMENTS Menu.



7) The display will show the first OPTION.

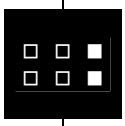


8) Press ROLL UP or ROLL DOWN button until desired OPTION appears.



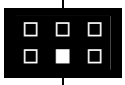
9) ADJUST BATTERY appears.

10) Press SET UP or SET DOWN button in order to increase or decrease respectively. Set the value read by an external meter.



11) Battery value appears on the display.

12) Press OUT to exit the Menu.

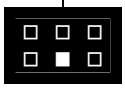


13) Confirmation request appears.

14) Press ENTER to accept the changes, or press OUT if you do not accept the changes.

15) ADJUSTMENTS Menu appears.

16) Press OUT. Display now show the Opening Zapi Menu.



8.5 Parameter regulation

In addition to the input configuration, parameter modification is made directly by ZAPI on customer specifications, or by the customer, making the adjustments using the programming console.

8.5.1 Traction

The following parameters can be modified:

1) ACCELERATION 0
It specifies the motor acceleration at 0 Hz. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

2) INV. ACCEL 0
It specifies the motor acceleration at 0 Hz after an inversion of direction. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

3) ACCELERATION 1
It specifies the motor acceleration at ACC PROF. FREQ 1 [Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

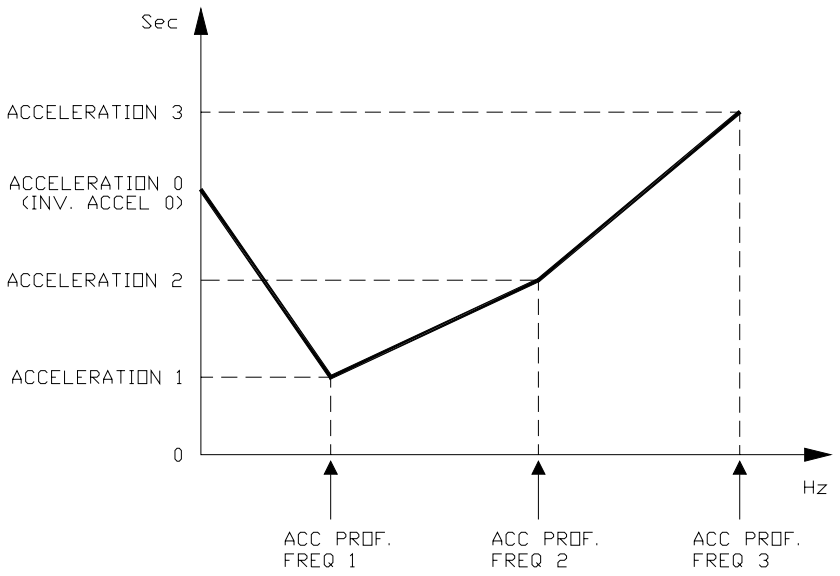
4) ACCELERATION 2
It specifies the motor acceleration at ACC PROF. FREQ 2 [Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

5) ACCELERATION 3
It specifies the motor acceleration at ACC PROF. FREQ 3 [Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

6) ACC PROF. FREQ 1
In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 1 parameter.

7) ACC PROF. FREQ 2
In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 2 parameter.

8) ACC PROF. FREQ 3
In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 3 parameter.



9) RELEASE BRAKING
Seconds. It controls the deceleration ramp when the travel request is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

10) INVERSION BRAKING
Seconds. It controls the deceleration ramp when the direction switch is inverted during travel. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

11) DECELERATION BRAKING
Seconds. It controls the deceleration ramp when the accelerator has turned down but not completely released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

12) PEDAL BRAKING
Seconds. It controls the deceleration ramp when the pedal position is changed but not completely released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

13) SPEED LIMIT BRK
Seconds. It controls the deceleration ramp when a speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

14) TIL. REL. BRAKING
Seconds. It controls the deceleration ramp when the tiller is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

15) MAX SPEED FORW
It determines the maximum speed in forward direction.

16) MAX SPEED BACK
It determines the maximum speed in backward direction.

17) CUTBACK SPEED 1

Speed reduction when the cutback input is active.

18) FREQUENCY CREEP
Minimum speed when the forward or reverse switch is closed, but the accelerator is on a minimum position.

19) MAXIMUM CURRENT
This parameter changes the maximum current of the inverter.

20) BRK SMOOTH
It gives a parabolic form to the deceleration ramp.

21) STOP BRK SMOOTH
Hz. It sets the level of frequency where the smooth effect of the deceleration parabolic form ends.

22) AUXILIARY TIME
Time units value (seconds). For the encoder version, it determines the time duration the truck is hold on the ramp if the STOP ON RAMP option is ON.
The following table shows the minimum / maximum programmable value for each parameter. In the table is also present the parameters resolution.

PARAMETER	UNIT	MIN VALUE	MAX VALUE	RESOLUTION
ACCELERATION 0 (*)	Sec.	0,3	10	0,1
INV. ACCEL 0 (*)	Sec.	0,3	10	0,1
ACCELERATION 1 (*)	Sec.	0,3	10	0,1
ACCELERATION 2 (*)	Sec.	0,3	10	0,1
ACCELERATION 3 (*)	Sec.	0,3	10	0,1
ACC PROF. FREQ 1	Hz	0	200	1
ACC PROF. FREQ 2	Hz	0	200	1
ACC PROF. FREQ 3	Hz	0	200	1
RELEASE BRAKING (**)	Sec.	0,3	10	0,1
INVERS BRAKING (**)	Sec.	0,3	10	0,1
DECELERATION BRAKING (**)	Sec.	0,3	10	0,1
PEDAL BRAKING (**)	Sec.	0,3	10	0,1
SPEED LIMIT BRAKING (**)	Sec.	0,3	10	0,1
MAX SPEED FW	Hz	5	200	1
MAX SPEED BW	Hz	5	200	1
CUTBACK SPEED 1	%Max Sp	10	100	1
FREQUENCY CREEP	Hz	0,6	4	0,1
MAXIMUM CURRENT	% IMAX	0	100	1
BRK SMOOTH	Num	1	5	0,1
STOP BRK SMOOTH	Hz.	3	20	1
AUXILIARY TIME	Sec.	0	10	0,1

(*) The acceleration time shown is the time from 0 Hz to 100 Hz. This is the ideal ramp calculated by the software; the real ramp could change as a function of motor control parameter setting and, obviously, as a function of the load.

(**) The braking feature is based upon deceleration ramps. The value shown in the table is the time to decrease the speed from 100 Hz to 0 Hz. This is the ideal ramps calculated by the software; the real ramp could change as a function of motor control parameter setting and, obviously, as a function of the load.

After changing a parameter, press ENTER to confirm data when requested by the message on the console. Parameters modified and optimized on one unit can be stored by the console (SAVE) and then released (RESTORE) on another inverter, thus allowing fast and standardized settings (see console manual for details).

8.5.2 Pump

The following parameters can be modified:

1) ACCELERATION 0
   It specifies the motor acceleration at 0 Hz. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

2) ACCELERATION 1
   It specifies the motor acceleration at ACC PROF. FREQ 1 [Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

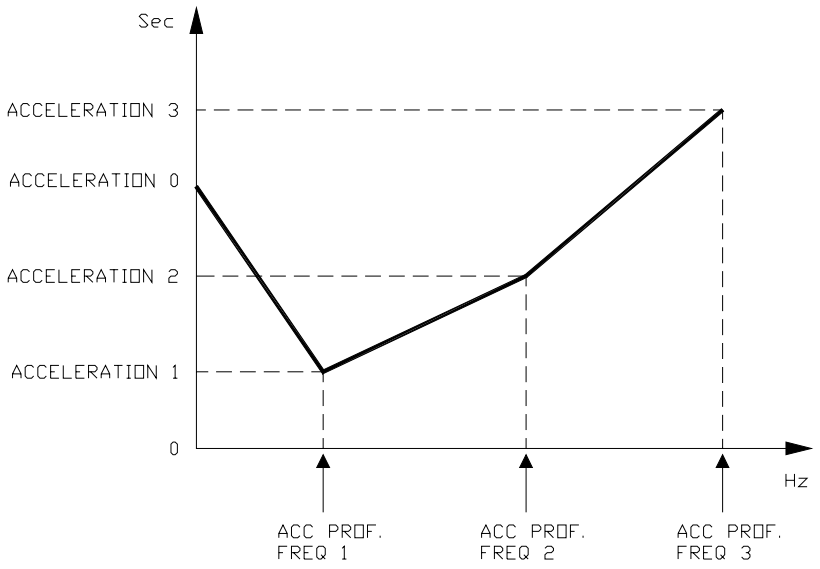
3) ACCELERATION 2
   It specifies the motor acceleration at ACC PROF. FREQ 2 [Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

4) ACCELERATION 3
   It specifies the motor acceleration at ACC PROF. FREQ 3 [Hz]. At level 0 the acceleration is maximum. Increasing the parameter's level the acceleration decreases.

5) ACC PROF. FREQ 1
   In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 1 parameter.

6) ACC PROF. FREQ 2
   In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 2 parameter.

7) ACC PROF. FREQ 3
   In correspondence to this frequency in [Hz] the acceleration is defined by the ACCELERATION 3 parameter.



8) RELEASE BRAKING
Seconds. It controls the deceleration ramp when the pump request is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

9) MAX SPEED LIFT
It determines the pump maximum speed when LIFT ENABLE switch is closed .

10) 1ST SPEED COARSE
It determines the pump maximum speed when SPEED1 switch is closed .

11) 2ND SPEED COARSE
It determines the pump maximum speed when SPEED2 switch is closed .

12) 3RD SPEED COARSE
It determines the pump maximum speed when SPEED3 switch is closed.

13) HYD SPEED FINE
It determines the pump maximum speed when an hydraulic steering function request is received via CAN BUS.

14) CUTBACK SPEED 1
Speed reduction when the cutback input is active.

15) FREQUENCY CREEP
Minimum speed when the LIFT ENABLE switch is closed, but the accelerator is on a minimum position.

16) MAXIMUM CURRENT
This parameter changes the maximum current of the inverter.

17) AUXILIARY TIME
Time units value (seconds). For the encoder version, is the delay when an hydraulic steering function request is switched off.

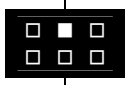
The following table shows the minimum / maximum programmable value for each parameter. In the table is also present the parameters resolution.

PARAMETER	UNIT	MIN VALUE	MAX VALUE	RESOLUTION
ACCELERATION 0 (*)	Sec.	0,3	10	0,1
ACCELERATION 1 (*)	Sec.	0,3	10	0,1
ACCELERATION 2 (*)	Sec.	0,3	10	0,1
ACCELERATION 3 (*)	Sec.	0,3	10	0,1
ACC PROF. FREQ 1	Hz	0	200	1
ACC PROF. FREQ 2	Hz	0	200	1
ACC PROF. FREQ 3	Hz	0	200	1
RELEASE BRAKING (**)	Sec.	0,3	10	0,1
MAX SPEED LIFT	Hz	5	200	1
1^{ST} SPEED COARSE	Hz	5	200	1
2^{ND} SPEED COARSE	Hz	5	200	1
3^{RD} SPEED COARSE	Hz	5	200	1
HYD SPEED FINE	Hz	5	200	1
CUTBACK SPEED 1	%Max Sp	10	100	1
FREQUENCY CREEP	Hz	0,3	2	0,1
MAXIMUM CURRENT	% IMAX	0	100	1
AUXILIARY TIME	Sec.	0	10	1

Flow Chart showing how to make Programme changes using Digital Console fitted with Eprom CK ULTRA.

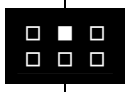
1) Opening Zapi Display.

2) Press ENTER to go into the General Menu.



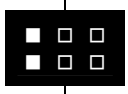
3) The Display will show:

4) Press ENTER to go into the Parameter Change facility.



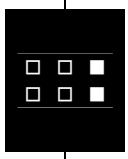
5) The Display will show the first parameter.

6) Press either ROLL UP and ROLL DOWN to display the next parameter.



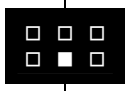
7) The names of the Parameters appear on the Display.

8) When the desired Parameter appears, the Display will show the parameter value. Press either SET UP (Top Right) or SET DOWN (Bottom Right) buttons to increase/decrease the value.



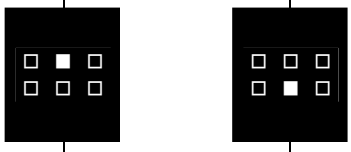
9) The Display will show the New Level.

10) When you are satisfied with the results of the changes you have made, Press OUT.



11) The Display asks " ARE YOU SURE?".

12) Press ENTER to accept the changes, or press OUT if you do not wish to accept the changes and wish to make further modifications to the parameters.



13) The Display will show:

8.6 Programming console functions

- Functional configuration (see 8.1, 8.2, 8.3, 8.4).
- Parameter programming (see 8.5.1, 8.5.2).
- Tester: the user can verify the state of the following parameters:

TRACTION	PUMP
battery voltage (V)	battery voltage (V)
motor voltage (%)	motor voltage (%)
voltage booster (%)	voltage booster (%)
frequency (Hz)	frequency (Hz)
encoder (Hz)	encoder (Hz)
slip value (Hz)	slip value (Hz)
current rms (A)	current rms (A)
motor power (W)	motor power (W)
battery charge (%)	battery charge (%)
temperature (°C)	temperature (°C)
motor temperat. (°C)	motor temperature (°C)
accelerator (V)	handle/seat switch (ON/OFF)
handle/seat switch (ON/OFF)	lifting control (V)
forward switch (ON/OFF)	lifting enable (ON/OFF)
backward switch (ON/OFF)	1st speed switch (ON/OFF)
cutback switch (ON/OFF)	2nd speed switch (ON/OFF)
hand brake (ON/OFF)	3rd speed switch (ON/OFF)
Brakepedal pot. (%)	hydro speed req. (ON/OFF)
2ND hourmeters	2nd hourmeters

- Save function (for storing data).
- Restore function (for loading parameters on another inverter).
- Display of the last 5 alarms including hour-meter value and temperature at the moment of the alarm.
- Accelerator range programming: records the minimum and maximum useful accelerator stroke values for both direction of running.
- See the console manual for a detailed description of function and parameters.

8.7 Sequence for Ac Inverter Traction setting

When the "Key Switch" is closed, if no alarms or errors are present, the Console Display will be showing the Standard Zapi Opening Display.
If the controller is not configured to your requirements, follow the sequence detailed on Chapter 9.2. Remember to re-cycle the Key Switch if you make any changes to the controller's configuration. Otherwise follow the sequence detailed below:

1) Select the Options required. See Chapter 8.4.1.
2) Select and set the Battery Voltage. See Chapter 8.4.1.
3) Confirm correct installation of all wires. Use the Console's TESTER function to assist.
4) Perform the accelerator signal acquisition procedure using the Console "PROGRAM VACC". Procedure is detailed on Chapter 9.4.
5) Set the "MAXIMUM CURRENT" Current, using the table on Chapter 8.5.1.
6) Set the Acceleration Delay requirements for the machine. Test the parameters in both directions.
7) Set the FREQUENCY CREEP level starting from level 0.3 Hz. The machine should just move when the accelerator microswitch is closed. Increase the Level accordingly.
8) Set the Speed Reductions as required. Make adjustments to "CUTBACK SPEED" Check the performance with the accelerator pedal totally depressed. If the machine is a forklift, check the performance with and without load.
9) RELEASE BRAKING. Operate the machine at full speed. Release the accelerator pedal. Adjust the level to your requirements. If the machine is a forklift, check the performance with and without load.
10) INVERSION BRAKING. Operate the machine at 25% full speed. Whilst travelling INVERT the Direction Switch. Set a soft Level of Inversion Braking. When satisfactory, operate the machine at Full Speed and repeat. If the machine is a Forklift, repeat the tests and make adjustments with and without load. The unloaded full speed condition should be the most representative condition.
11) DECELERATION BRAKING. Operate the machine at full speed. Release the accelerator pedal until 50% of its range is reached. Adjust the level to your requirements. If the machine is a forklift, check the performance with and without load.
12) PEDAL BRAKING (If used). Operate the machine at full Speed. Release the accelerator pedal and press the Pedal Brake. Set braking level to your requirements. If the machine is a forklift, check the performance with and without load.
13) SPEED LIMIT BRAKING (If used). Operate the machine at full Speed. Close the speed reduction switch. Set braking level to your requirements. If the machine is a forklift, check the performance with and without load.
14) Set "MAX SPEED FORW".
15) Set "MAX SPEED BACK" (Reverse).
16) Make the choice for the truck behaviour on a slope (see chapter 8.4). If the "Stop on ramp" option is ON, set the desired value of "auxiliary time" parameter.
17) Set "SET TEMPERATURE", setting the motor thermal sensor type used.

8.8 Sequence for Ac Inverter Pump setting

When the "Key Switch" is closed, if no alarms or errors are present, the Console Display will be showing the Standard Zapi Opening Display.
If the controller is not configured to your requirements, follow the sequence detailed on Chapter 9.2. Remember to re-cycle the Key Switch if you make any changes to the controller's configuration. Otherwise follow the sequence detailed below:

1) Select the Options required. See Chapter 8.4.2.
2) Select and set the Battery Voltage. See Chapter 8.4.2.
3) Confirm correct installation of all wires. Use the Console's TESTER function to assist.
4) Perform the lift signal acquisition procedure using the Console "PROGRAM VACC". Procedure is detailed on Chapter 9.4.
5) Set the "MAXIMUM CURRENT" Current, using the table on Chapter 8.5.2.
6) Set the Acceleration and Deceleration Delay requirements for the pump.
7) Set the "FREQUENCY CREEP" level starting from 0 Hz. The pump should just turn when the request microswitch is closed. Increase the level accordingly.
8) Set the Speed Reductions as required. Make adjustments to "CUTBACK SPEED 1". Check the performance with the full request. Check the performance with and without load.
9) Set "MAX SPEED LIFT" , max speed of pump motor when Lift enable switch is closed.
10) Set "1ST SPEED COARSE", speed of pump motor when SPEED1 switch is closed.
11) Set "2ND SPEED COARSE", speed of pump motor when SPEED2 switch is closed.
12) Set "3RD SPEED COARSE", speed of pump motor when SPEED3 switch is closed.
13) Set "HYD SPEED FINE" to adjust the hydraulic steering speed (pump motor speed when HYDRO function is requested).
14) Set "AUXILIARY TIME" (time delay before pump stops when an hydraulic steering function request is switched off).
15) Set "SET TEMPERATURE", setting the motor thermal sensor type used.

8.9 Tester: description of the function

The most important input or output signals can be measured in real time using the TESTER function of the console. The Console acts as a multimeter able to read voltage, current and temperature. The following definition listing shows the relative measurements.

8.9.1 Traction

1) BATTERY VOLTAGE
   Level of battery voltage measured at the input to the key switch.
2) MOTOR VOLTAGE
   This is the RMS voltage supplied to the motor by the inverter; it is expressed as a percentage of the full voltage (which depends of the battery voltage).
3) VOLTAGE BOOSTER
   This is the booster of the voltage supplied to the motor in load condition; it is expressed in a percentage of the full voltage.
4) FREQUENCY
   This is the frequency of the voltage and current supplied to the motor.
5) ENCODER
   This is the speed of the motor, expressed in the same unit of the frequency; this information comes from the speed sensor.
6) SLIP VALUE
   This is the difference of speed between the rotating field and the shaft of the motor, expressed in the same unit of the frequency.
7) CURRENT RMS
   Root Mean Square value of the motor current.
8) MOTOR POWER
   It is the power provided to the motor.
9) BATTERY CHARGE
   The percentage Charge level of the battery.
10) TEMPERATURE
    The temperature measured on the aluminium heat sink holding the MOSFET devices.
11) MOTOR TEMPERAT.
    This is the temperature of the motor; if the option is programmed "None" (see chapter 8.4.1) it shows 0°.
12) ACCELERATOR
    The voltage of the accelerator potentiometer's wiper (CPOT). The voltage level is shown on the Left Hand Side of the Console Display and the value in percentage is shown on the Right Hand Side.
13) HANDLE/SEAT switch
    The level of the Handle/Seat digital entry
    - ON / GND = active entry of closed switch.
    - OFF / GND = non active entry of open switch.
14) FORWARD SWITCH
    The level of the Forward direction digital entry FW.
    - ON / +VB = active entry of closed switch.
    - OFF / GND = non active entry of open switch.
15) BACKWARD SWITCH
    The level of the Reverse direction digital entry BW.
    - ON / +VB = active entry of closed switch.
    - OFF / GND = non active entry of open switch.
16) CUTBACK SWITCH

The level of the Speed Reduction Microswitch.
- ON / GND = active entry of speed reduction microswitch.
- OFF / +VB = non active entry of microswitch.

17) HAND BRAKE
The level of the Hand Brake Microswitch.
- ON / GND = active entry of Brake pedal Microswitch.
- OFF / +VB = non active entry of microswitch.

18) BRAKEPEDAL POT.
The percentage of the pressure on the brake pedal (100% if the pedal is totally pressed, 0% if the pedal is released).

19) 2ND HOURMETERS
This parameter displays the working hour of traction controller.

8.9.2 Pump

1) BATTERY VOLTAGE
Level of battery voltage measured at the input to the key switch.

2) MOTOR VOLTAGE
This is the voltage supplied to the motor by the inverter; it is expressed as a percentage of the full voltage (which depends of the battery voltage).

3) VOLTAGE BOOSTER
This is the booster of the voltage supplied to the motor in load condition; it is expressed in a percentage of the full voltage.

4) FREQUENCY
This is the frequency of the voltage and current supplied to the motor.

5) ENCODER
This is the speed of the motor, expressed in the same unit of the frequency; this information comes from the speed sensor.

6) SLIP VALUE
This is the difference of speed between the rotating field and the shaft of the motor, expressed in the same unit of the frequency.

7) CURRENT RMS
Root Mean Square value of the motor current.

8) MOTOR POWER
It is the power provided to the motor.

9) BATTERY CHARGE
The percentage Charge level of the battery.

10) TEMPERATURE
The temperature measured on the aluminium heat sink holding the MOSFET devices.

11) MOTOR TEMPERATURE
This is the temperature of the motor; if the option is programmed "None" (see chapter 8.4.2) it shows 0°.

12) HANDLE/SEAT switch
The level of the Handle/Seat digital entry
- ON / GND = active entry of closed switch.
- OFF / +VB = non active entry of open switch.

13) LIFTING CONTROL
The voltage of the lift potentiometer's wiper (CPOT). The voltage level is shown on the Left Hand Side of the Console Display and the value in percentage is shown on the Right Hand Side.

14) LIFT ENABLE
Status of the lifting switch.
- ON / +VB = active entry of closed switch.
- OFF / GND = non active entry of open switch.

15) 1ST SPEED SWITCH
Status of the first speed switch of the pump.

- ON / +VB = active entry of closed switch.
- OFF / GND = non active entry of open switch.

16) 2ND SPEED SWITCH
Status of the second speed switch of the pump.
- ON / +VB = active entry of closed switch.
- OFF / GND = non active entry of open switch.

17) 3RD SPEED SWITCH
Status of the third speed switch of the pump.
- ON / GND = active entry of closed switch.
- OFF / +VB = non active entry of open switch.

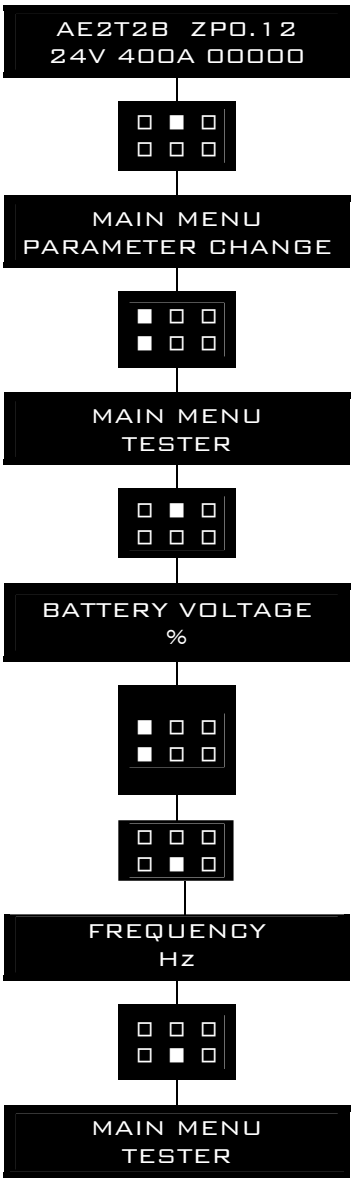
18) HYDRO SPEED REQ.
Status of the hydro speed request of the pump.
- ON = an hydro speed request is received via Can Bus.
- OFF = no hydro speed request active.

19) CUTBACK SWITCH
The level of the Speed Reduction Microswitch.
- ON / GND = active entry of speed reduction microswitch.
- OFF / +VB = non active entry of microswitch.

20) 2ND HOURMETERS
This parameter displays the working hour of pump controller.

Flow Chart showing how to use the TESTER function of the Digital Console.

1) Opening Zapi Display.



2) Press ENTER to go into the General menu.

3) The Display will show:

4) Press ROLL UP or ROLL DOWN button until TESTER MENU appear on the display.

5) The Display shows:

6) Press ENTER to go into the TESTER function.

7) The first variable to be tested is shown on the Display.

8) Press either ROLL UP or ROLL DOWN buttons until your desired variable for measurement appears on the Display.

9) When you have finished, Press OUT.

10) The Display shows:

11) Press OUT again and return to Opening Zapi Display.

Remember it is not possible to make any changes using TESTER. All you can do is measure as if you were using a pre-connected multimeter.

21) Other functions

8.10 Description of the Console “SAVE” function

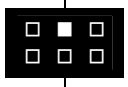
The SAVE function allows the operator to transmit the Parameter values and Configuration data of the inverter into the Console memory. It is possible to load 64 different programmes.
The information saved in the Console memory can then be reloaded into another inverter using the RESTORE function.
The data that is available via the SAVE function is as follows:

- All Parameter Values (PARAMETER CHANGE).
- Options (SET. OPTIONS).
- The Level of the Battery (ADJUST BATTERY).

Flow Chart showing how to use the SAVE function of the Digital Console.

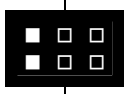
1) Opening Zapi Display.

2) Press ENTER to go into the General menu.



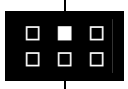
3) The Display will show:

4) Press ROLL UP or ROLL DOWN button until SAVE PARAM. appears on the display.



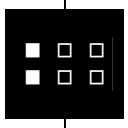
5) The Display will show:

6) Press ENTER to go into the SAVE function.

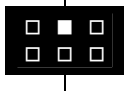


7) If this facility has been used before the type of inverter data stored appears on the top Main with a 2 digit reference.

8) Keep pressing either ROLL UP or ROLL DOWN keys until the second Main indicates a FREE storage facility.



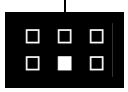
9) Press ENTER to commence SAVE routine.



10) You can see the items that are being stored whilst the SAVE routine is happening.

11) When finished, the Console shows:

12) Press OUT to return to the Opening Zapi Display.



8.11 Description of Console “RESTORE” function

The RESTORE PARAM function allows transfer of the Console’s stored data into the memory of the inverter. This is achieved in a fast and easy way using the method previously used with the SAVE PARAM. function.
The data that is available via the RESTORE PARAM. function is as follows:

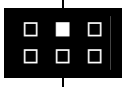
- All Parameter Values (PARAMETER CHANGE).
- Options (SET OPTIONS).
- The level of the Battery (ADJUST BATTERY).

ATTENTION: When the RESTORE operation is made, all data in the inverter memory will be written over and replace with data being restored.

Flow Chart showing how to use the RESTORE function of the Digital Console.

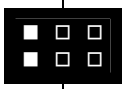
1) Opening Zapi Display.

2) Press ENTER to go into the General menu.



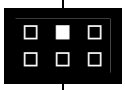
3) The Display will show:

4) Press ROLL UP or ROLL DOWN button until RESTORE PARAM. appears on the Display.



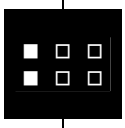
5) The Display will show:

6) Press ENTER to go into the RESTORE PARAM. Function.

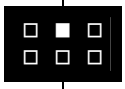


7) The Display shows the type of Model stored, with a Code Number.

8) Keep pressing either ROLL UP and ROLL DOWN buttons until the desired model appears on the Display.



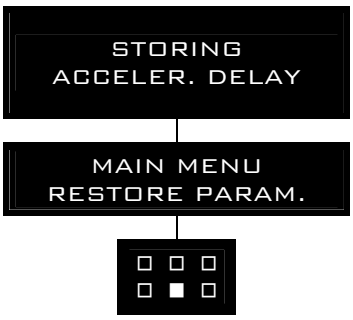
9) Press ENTER to commence the Restore operation.



10) The Display will ask “ARE YOU SURE?”.

11) Press ENTER for YES, or OUT for No.

12) You can see the items that are being stored in the inverter memory whilst the RESTORE routine is happening.



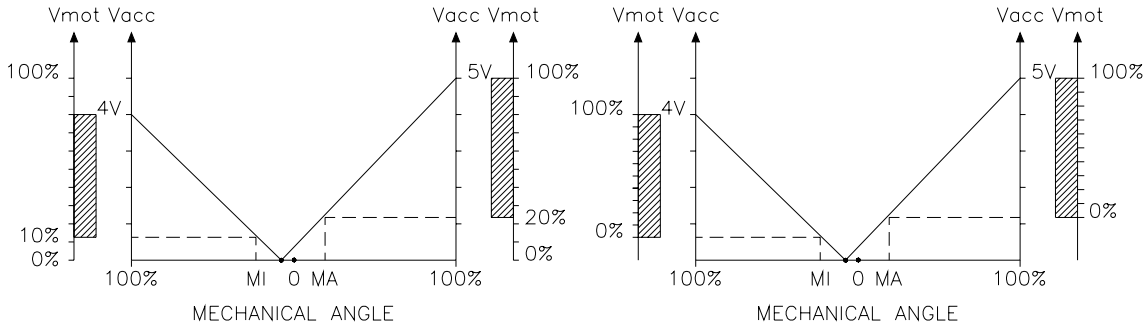
13) When finished the Console displays:

14) Press OUT to return to the Opening Zapi Display.

8.12 Description of Console “PROGRAM VACC” function

This enables adjustment of the minimum and maximum useful signal level, in either direction. This function is unique when it is necessary to compensate for asymmetry with the mechanical elements associated with the potentiometer, especially relating to the minimum level.

The two graphs show the output voltage from a non-calibrated potentiometer with respect to the mechanical “zero” of the control lever. MI and MA indicate the point where the direction switches close. 0 represents the mechanical zero of the rotation.
The Left Hand graph shows the relationship of the motor voltage without signal acquisition being made. The Right Hand Graph shows the same relationship after signal acquisition of the potentiometer.

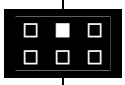


This function looks for and remembers the minimum and maximum potentiometer wiper voltage over the full mechanical range of the pedal. It enables compensation for non symmetry of the mechanical system between directions. The operation is performed by operating the pedal after entering the PROGRAM VACC function.

Flow Chart showing how to use the PROGRAM VACC function of the Digital Console.

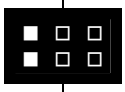
1) Opening Zapi Display.

2) Press ENTER to go into the General Menu.



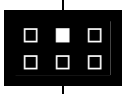
3) The Display will show:

4) Press ROLL UP or ROLL DOWN button until PROGRAM VACC appears on the display.



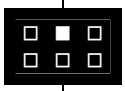
5) The Display will show:

6) Press ENTER to go into the PROGRAM VACC routine.



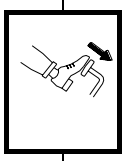
7) The Display will show the minimum and maximum values of potentiometer wiper output. Both directions can be shown.

8) Press ENTER to clear these values. Display will show 0.0.



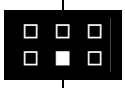
9) Select Forward Direction, close any interlock switches that may be in the system.

10) Slowly depress the accelerator pedal (or tiller butterfly) to its maximum value. The new minimum and maximum voltages will be displayed on the Console plus an arrow indicating the direction.



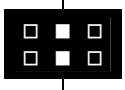
11) Select the Reverse Direction and repeat Item 10.

12) When finished, press OUT.



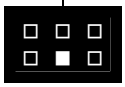
13) The Display will ask: “ARE YOU SURE?”.

14) Press ENTER for yes, or OUT for NO.



15) When finished, the Console shows:

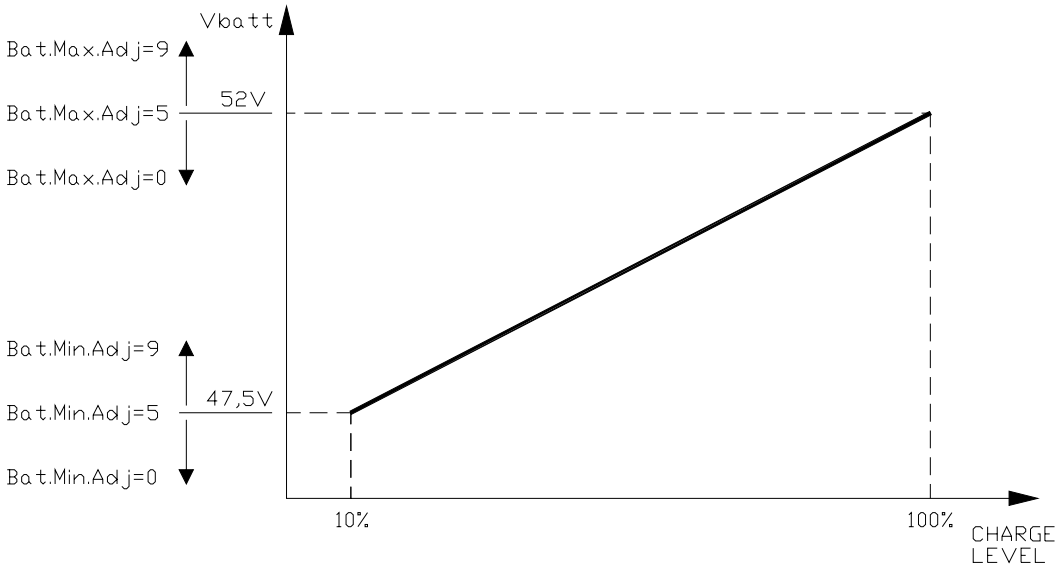
16) Press OUT again to return to the Opening Zapi Menu.



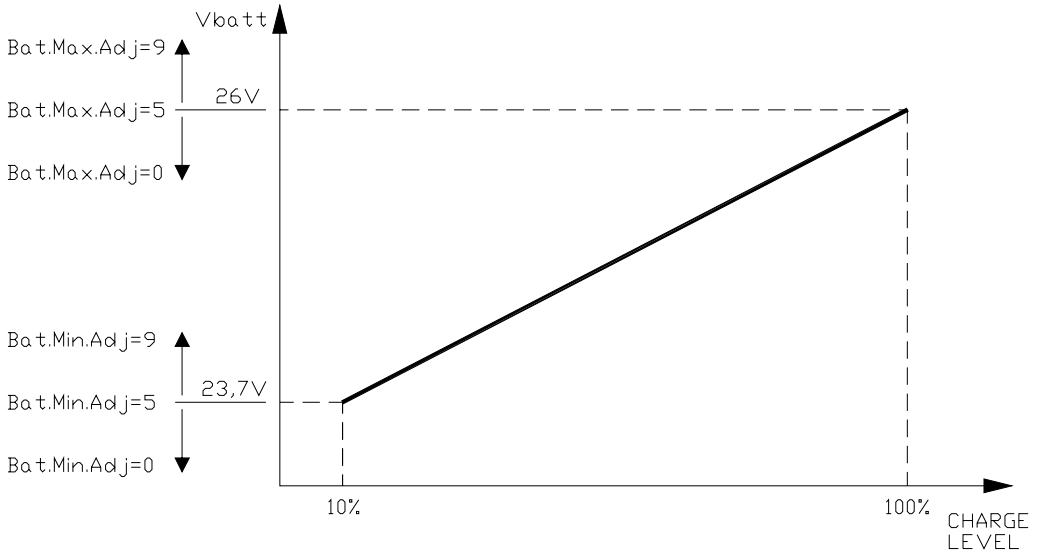
8.13 Description of the battery charge detection setting

The Battery Charge detection uses two setting that specify the Full Charge Voltage Level (100%) and the Discharge Voltage Level (10%). These two settings are the Bat.Max.Adj and the 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 Discharged Detection occurs when the battery is not totally discharged, it is necessary to reduce the Bat.Min.Adj setting as indicated in the figure below).

48V NOMINAL BATTERY VOLTAGE



24V NOMINAL BATTERY VOLTAGE



8.14 Description of “ALARMS” menu

The ALARMS logbook in the MAIN MENU’ records the alarms of the controller. It has a FIFO (First Input First Output) structure that means the oldest alarm is lost when the database is full and a new alarm occurs. The logbook is composed of five locations getting possible to stack five different type of alarms with the following information:

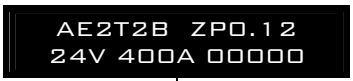
1) The alarm code
2) The times that each alarm occurs consecutively
3) The Hour Meter value when the first event of every alarm occurred
4) And the inverter temperature when the first event of every alarm occurred.

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

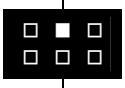
NOTE: if the same alarm is continuously happening, the controller does not use new memory of the logbook, but only updates the last memory cell increasing the related counter (point 2) of previous list). Nevertheless, the hourmeter indicated in this memory refers to the first time the alarm occurred. In this way, comparing this hourmeter with the controller hourmeter, it is possible to determine:
- When this alarm occurred the first time.
- How many hours are elapsed from the first occurrence to now.
- How many times it has occurred in said period.

Flow Chart showing how to use the ALARMS function via the Digital Console.

1) Opening Zapi Display.

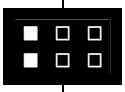


2) Press ENTER to go into the General menu.



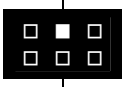
3) The Display will show:

4) Press ROLL UP or ROLL DOWN button until PARAMETER CHANGE appears on the display.



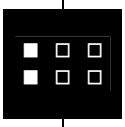
5) The Display will show:

6) Press ENTER to go into the ALARMS function.



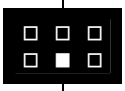
7) The Display will show the most recent Alarm.

8) Each press of the ROLL UP button brings up following Alarms. Pressing ROLL DOWN returns to the most recent.



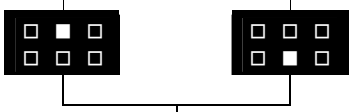
9) If an Alarm has not occurred, the Display will show: ALARM NULL.

10) When you have finished looking at the Alarms, press OUT to exit the ALARMS menu.

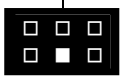


11) The Display will ask “CLEAR LOGBOOK?”.

12) Press ENTER for yes, or OUT for NO.



13) Press OUT to return to the Opening Zapi Display.



8.15 Faults diagnostic system

The fault diagnostic system of ACE-2 controller is divided into 2 main groups of faults:

ALARMS: these are the faults which open the power section, which means the power bridge is opened and, when possible, the LC is opened and EB is applied. These are faults related to:

- failures in the motor/controller that the power system is not anymore able to drive the truck
- safety related failures

WARNINGS: these are faults which do not stop the truck or stop it by a controlled regenerative braking. In other words, the controller is working well, but it has detected conditions to reduce the performances or to stop the truck without opening the power devices. These warnings are related to:

- wrong operator sequences
- conditions which require performance reduction (like high temperatures, ….)

8.16 Microcontroller alarms overview

Error Code	Description	Effect	Machine status When the test is done	Restart procedure
Flash checksum MDI code allarm **71**	The program verify is not OK	MC is not closed, EB is applied, traction/pump stopped	Start-up	Key re-cycle
Analog MDI code allarm **96**	The analogue channel Reading is not updated	MC is opened, EB is applied, traction/pump stopped	Start-up, running	Traction/Pump request
Wrong set battery	The absolute difference between the Key voltage and the nominal battery voltage is greater than 20% of Vbatt nom.	MC is not closed, EB is applied, traction/pump stopped	Start-up	Traction/Pump Request
Capacitor charge MDI code allarm **60**	Power capacitors voltage does not increase	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump request
Coil shorted hw ko MDI code allarm **76**	The harware to check a MC or EB/AUX coil shorted is damaged	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump Request
Driver shorted MDI code allarm **74**	The MC driver is shorted so it is not able to open the contactor	MC is opened (the command is released), EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Traction/Pump Request
Aux driver shorted	The EB/AUX driver is shorted so it is not able to open the contactor	MC is opened (the command is released), EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Traction/Pump Request
Safety in MDI code allarm **86**	The safety input is open (it is not connected to –Batt)	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle

Safety out	The Safety-out driver is damaged (shorted or open)	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump request
Watchdog#1 MDI code allarm **8**	The watchdog signal #1 is not in the correct status	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle
Watchdog#2 MDI code allarm **8**	The watchdog signal #2 is not in the correct status	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle
Keyoff shorted MDI code allarm **76**	At Start-up the Key-off logic signal is low	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle
Logic Failure#1 MDI code allarm **54**	An undervoltage / overvoltage condition has been detected	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Traction/Pump request
Logic failure #3 MDI code allarm **17**	High current HW protection circuit is damaged	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump request
Power mos shorted MDI code allarm **89**	Short circuit on the power Mosfets	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump request
Vmn high	Motor output voltage higher than expected	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, Stand-by	Traction/Pump request
Vmn low MDI code allarm **72**	Motor output voltage lower than expected	MC is opened, EB is applied, Traction/Pump stopped	Start-up, running	Traction/Pump request
Stby I high MDI code allarm **53**	In stby condition (no current applied to the motor) the current feedbacks are out of permitted stby range	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump request
Wrong 0 voltage MDI code allarm **53**	The motor phases voltage feedback are out of permitted range	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Traction/Pump Request
Contactor closed MDI code allarm **75**	LC contact is stuck	MC is not closed (command is not activated), EB is applied, Traction/Pump stopped	Start-up	Traction/Pump Request

Hardware fault 20	The Mosfets driver are not switched off with Watch-dog signal in alarm status	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle
Hardware fault 21	The EB/AUX driver is not switched off with Watch-dog signal in alarm status	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle
Hardware fault A1	The MC driver is not switched off with Watch-dog signal in alarm status	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle
Coil shorted MC MDI code allarm **76**	Shortcircuit on MC coil	MC is opened, EB is applied, Traction/Pump stopped	Start-up (immediately after MC closing), stand-by, running	Traction/Pump Request
Coil shorted EF MDI code allarm **68**	Shortcircuit on EB/AUX coil	MC is opened, EB is applied, Traction/Pump stopped	Start-up (immediately after MC closing), stand-by, running	Traction/Pump Request
Contactor open MDI code allarm **77**	The MC coil has been driven but MC does not close	MC is opened , EB is applied, Traction/Pump stopped	Start-up (immediately after MC closing), Stand-by, running	Traction/Pump Request
Logic failure #2 MDI code allarm **55**	Motor phases voltage feedback circuits are damaged	MC is opened , EB is applied, Traction/Pump stopped	Start-up (immediately after MC closing)	Traction/Pump Request
Contactor driver MDI code allarm **75**	Driver of MC coil is damaged (not able to close)	MC is opened (the command is released), EB is applied, Traction/Pump stopped	Stand-by, running	Traction/Pump Request
Aux Driver Open	Driver of EB/AUX coil is damaged (not able to apply the brake)	MC is opened, EB is applied, Traction/Pump stopped	Stand-by, running	Traction/Pump Request
Encoder Error MDI code allarm **82**	Problem on the encoder reading	MC is opened, EB is applied, Traction/Pump stopped	Running	Traction/Pump Request
Wrong Ram Memory MDI code allarm **71**	The program checks the contents of main RAM registers and find a “dirty value”	MC is opened, EB is applied, Traction/Pump stopped	Continuous	Key re-cycle

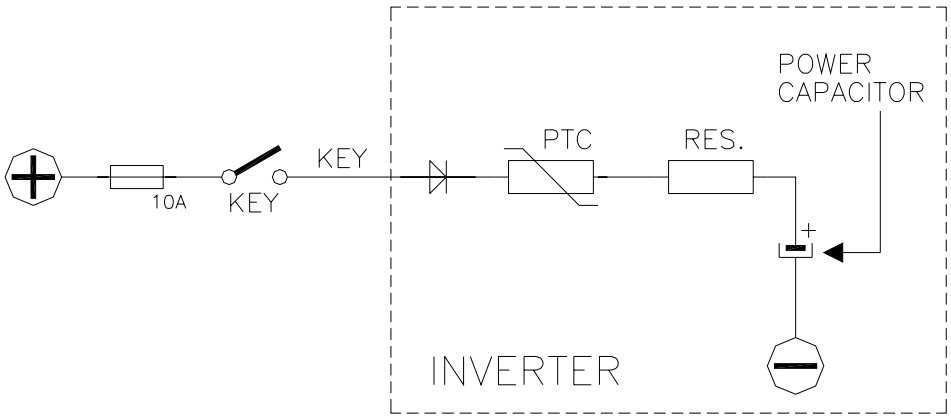
8.17 Analysis and troubleshooting of alarms displayed on console

1) FLASH CHECKSUM
   Cause:
   After Key-on the software verifies the integrity of program stored in the flash memory, if the verify has a negative result this alarm is generated.
   Troubleshooting:
   The problem is in the microcontroller flash memory, which could be damaged, or in the program stored inside, which could be corrupted.
   Try to program the logic again, if the alarms is still signalled the problem is in the microcontroller. Replace the ACE logic board.

2) ANALOG
   Cause:
   This alarm occurs when the A/D conversion of the analog inputs gives frozen value, on all of the converted signals, for more than 400msec. The goal of this diagnosis is to detect a failure of the A/D converter or a problem in the code flow that omits the refreshing of the analog signal conversion.
   Troubleshooting:
   If the problem occurs permanently it is necessary to substitute ACE logic board.

3) WRONG SET BATTERY
   Cause:
   At start-up, the controller checks the battery voltage and verify it is within a window around the nominal value.
   Troubleshooting:
   - Check that the controller SET BATTERY parameter value matches the battery nominal voltage.
   - Check that TESTER MENU / BATTERY VOLTAGE parameter shows same value as the battery voltage measured with a voltmeter. If it does not match, then do an “ADJUST BATTERY” function.
   - Replace the battery.

4) CAPACITOR CHARGE
   Follows the charging capacitor system:



Cause:
When the key is switched ON, the inverter tries to charge the power capacitors through a series of a PTC and a power resistance, and check if the capacitor are charged within a timeout. If the capacitor voltage measured is less than 20% of the nominal battery voltage, an alarm is signalled; the main contactor is not closed.
Troubleshooting:
- There is an external load in parallel to capacitor bank, which sinks current from the controller capacitors pre-charging circuit, thus preventing the caps from charging. Check if a lamp or a dc/dc converter or an auxiliary load is placed in parallel to capacitor bank.
- The charging resistance or PTC is opened; insert a power resistance across line contactor power terminals; if the alarm disappears, it means the controller internal charging resistance is damaged.
- The charging circuit has a failure, inside the controller.
- There is a problem in the controller power section.

5) COIL SHORT HW KO
Cause:
The hardware circuits which manages short circuits protection of LC and EB/AUX coils has a problem.
Troubleshooting:
This type of fault is not related to external components; replace the ACE logic board.

6) DRIVER SHORTED
Cause:
The driver of the main contactor coil is shorted.
Troubleshooting:
- Check if there is a short or a low impedance pull-down between NMC (CNA#16) and –BATT.
- The driver circuit is damaged in the logic board, which has to be replaced.

7) AUX DRIVER SHORTED
Cause:
The driver of the electro mechanic brake/ auxiliary electro valve coil is shorted.
Troubleshooting:
- Check if there is a short or a low impedance pull-down between NEB/NAUX (CNA#18) and –BATT.
- The driver circuit is damaged in the logic board, which has to be replaced.

8) SAFETY IN
Cause:
The safety input is opened and accordingly the MC is opened an EB/AUX OUT coil is driven.
Troubleshooting:
Check the CAN#11 input, if it is connected to –Batt and the alarm is generated then there is a fault in the SAFETY IN hardware circuit. Replace the logic board.

9) SAFETY OUT
Cause:
The safety out driver is shorted.

Troubleshooting:

- Check if there is a short or a low impedance pull-down between SAFETY OUT (CAN#19) and –BATT.
- The driver circuit is damaged in the logic board, which has to be replaced.

10) WATCHDOG#1

Cause:

At start-up the watch dog signal is already active before the software has generated it. At stby or running condition the watch dog signal is not active (in alarm status).

Troubleshooting:

The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.

11) WATCHDOG#2

Cause:

At start-up the watch dog signal is already active before the software has generated it. At stby or running condition the watch dog signal is not active (in alarm status).

Troubleshooting:

The WD hardware circuit or microcontroller output port are damaged. In both cases no external component are involved. Replace the logic board.

12) KEYOFF SHORTED

Cause:

This fault is displayed when the controller detects a low logic level of Key-Off signal during Start-Up diagnosis.

Troubleshooting:

It is very likely the fault is due to an under voltage, so it is suggested to check:

- Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing.
- Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and –Batt, which must be screwed with a torque comprised in the range 13Nm÷15Nm.
- If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board.

13) LOGIC FAILURE#1

Cause:

This fault is displayed when the controller detects an over voltage or under voltage condition. Over voltage threshold is 45V, under voltage threshold is 9V in the 24V controller. In 48V controller over voltage threshold is 65V, under voltage threshold is 11V.

Troubleshooting:

Troubleshooting of fault displayed at start-up or in standby; in these cases it is very likely the fault is due to an under voltage, so it is suggested to check:

- Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing.
- Check the connection of power cables to the battery terminal, positive and negative, to MC and to controller +Batt and –Batt, which must be screwed with a torque comprised in the range 13Nm÷15Nm.

- If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board. Troubleshooting of fault displayed during motor driving; in this case it can be an under voltage or an over voltage condition.
- If the alarm happens during traction acceleration or driving hydraulic functions, it is very likely it is an under voltage condition; check battery charge condition, power cable connection.
- If the alarm happens during release braking, it is very likely it is due to over voltage condition; check line contactor contact, battery power cable connection.

14) LOGIC FAILURE #3
Cause:
Hardware problem in the logic card circuit for high current (overload) protection.
Troubleshooting:
This type of fault is not related to external components, so, when it is present it is necessary to replace the ACE logic board.

15) POWER MOS SHORTED
Cause:
Before switching the MC on, the software checks the power bridge: it turns on alternatingly the Low side and High side Power Mosfets and expects the phases voltage to decrease down to –BATT (increase up to +Batt). If the phases voltage do not follow the commands, this alarm occurs.
Troubleshooting:
This type of fault is not related to external components; replace the controller.

16) VMN HIGH
Cause 1:
Before switching the LC on, the software checks the power bridge: it turns on alternatingly the Low side Power Mosfets and expects the phases voltage to decrease down to -BATT. If the phases voltage is higher than 10% of nominal battery voltage, this alarm occurs.
Cause 2:
This alarm may occur also when the start up diagnosis is overcome, and so the LC is closed. In this condition, the phases' voltages are expected to be lower than 1/2 Vbatt. If it is higher than that value, fault status is entered.
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 connection are OK, the problem is inside the controller, replace it.
- If the problem occurs after closing the LC (the LC closed and then opens back again), check:
  - Motor connections
  - If motor phases windings/cables have leakages towards truck frame
  - If no problem are found on the motors, the problem is inside the controller, replace it.

17) VMN LOW
Cause 1:
Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatingly the High side Power Mosfets and expects the

phases voltage to increase toward the rail capacitor value. If the phases voltage is less than 66% of the rail capacitor voltage, this alarm occurs.
Cause 2:
Motor running test. When the motor is running, power bridge is ON, the motor voltage feedback is tested; if it is lower than commanded value (a window of values are considered) fault status is entered.
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
  - Motor leakage to truck frame
  - If the motor connections are OK, the problem is inside the controller, replace it.
- If the alarm occurs during motor running, check:
  - Motor connections
  - If motor phases windings/cables have leakages towards truck frame
  - That the LC power contact closer properly, with a good contact
  - If no problem are found on the motors, the problem is inside the controller, replace it.

18) STBY I HIGH
Cause:
The current transducer or the current feedback circuit is damaged in the controller.
Troubleshooting:
This type of fault is not related to external components so, when it is present, it is necessary to replace the controller.

19) WRONG 0 VOLTAGE
Cause:
At start-up the high resolution VMN feedback is not comprised in a permitted window of values centred around 2,5V. The circuit is damaged in the controller.
Troubleshooting:
It is suggested to check:
- Motor internal connections (ohmic continuity)
- Motor power cables connections
- Motor leakage to truck frame
- If the motor connections are OK, the problem is inside the controller, replace the logic board

20) CONTACTOR CLOSED
Cause:
Before driving the MC coil, the controller checks if the contactor is stuck. The controller drives the bridge for some tens milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does decrease by 20% of the key voltage the alarm is generated.
Troubleshooting:
It is suggested to verify the power contacts of LC; to replace the LC is necessary.

21) HARDWARE FAULT 20
Cause:
Before driving the MC coil, the controller checks if the Mosfets drivers are turned of by a not active (alarm status) Watch-dog signal. If they are not turned of then the alarm is generated.

Troubleshooting:
The problem is inside the controller, no external component are involved, replace the logic board.

22) HARDWARE FAULT 21
Cause:
Before driving the MC coil, the controller checks if the EB/AUX driver is turned of by a not active (alarm status) Watch-dog signal. If it is not turned of then the alarm is generated.
Troubleshooting:
The problem is inside the controller, no external component are involved, replace the logic board.

23) HARDWARE FAULT A1
Cause:
Before driving the MC coil, the controller checks if the MC/AUX driver is turned of by a not active (alarm status) Watch-dog signal. If it is not turned of then the alarm is generated.
Troubleshooting:
The problem is inside the controller, no external component are involved, replace the logic board.

24) COIL SHORTED MC
Cause:
This alarm occurs when there is a short circuit of the MC coils connected to CNA#16 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.
Troubleshooting:
- The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads.
- In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.

25) COIL SHORTED EF
Cause:
This alarm occurs when there is a short circuit of the EB/AUX coils connected to CNA#18 output. After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.
Troubleshooting:
- The typical root cause for this error code to be displayed is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads.
- In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.

26) CONTACTOR OPEN
Cause:
The main contactor coil has been driven by the controller, but the contactor does not close.
Troubleshooting:
- It could be a problem of the contacts in the MC that are not working (does not pull-in), try replacing the MC.
- If the contactors of MC are working correctly than the problem is in the controller, replace it.

27) LOGIC FAILURE #2

Cause:

Fault is in the hardware section of the logic board which manages the phase's voltage feedback.

Troubleshooting:

This type of fault is not related to external components, so when it happens it is necessary to replace the ACE2 logic board.

28) CONTACTOR DRIVER

Cause:

The MC 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 ACE2 logic board.

29) AUX DRIVER OPEN

Cause:

The EB/AUX 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 ACE2 logic board.

30) ENCODER ERROR

Cause:

This fault is signalled in 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 mSec. This condition is related to a malfunctioning of the encoder.

Troubleshooting:

- Check both the electric and the mechanical encoder functionality, the wires crimping.
- Check the encoder mechanical installation, if the encoder slips inside its compartment raising this alarm condition.
- Also the electromagnetic noise on the sensor bearing can be a 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.

31) WRONG RAM MEMORY

Cause:

The algorithm implemented to check the main RAM registers finds a wrong contents: the register is "dirty". This alarm inhibit the machine operations.

Troubleshooting:

Try to switch the key off and then on, if the alarm is still present replace the ACE2 logic board.

8.18 Microcontroller warning overview

Error code	Description	Effect	Machine status when the test is done	Restart procedure
Vacc not OK MDI code allarm **78**	The accelerator/ lift potentiometer value is higher than the minimum value recorded, and the direction/enable switches are opened.	Traction/ Pump motor is stopped	Start-up, stand-by, running	Traction/Pump request
Incorrect start MDI code allarm **79**	Incorrect starting sequences	Traction/ Pump motor is stopped	Start-up, stand-by	Traction/Pump request
Vacc out of range MDI code allarm **85**	The accelerator input is out of the range Vacc_min ÷ Vacc_max, which has been acquired with “PROGRAMM VACC” function.	Traction/ Pump motor is stopped	Start-up, stand-by, running	Traction/Pump request
Temperature MDI code allarm **62**	The controller has reached the thermal cutback temperature of 85°C when the current is I_{MAX}	Traction controller reduces the max current linearly from Imax (85°C) down to 0A (105°C)	Continuous	
Motor temperature MDI code allarm **65**	Motor temperature sensor is opened (if digital) or has overtaken the threshold of 150°C (if analogue)	The maximum current is reduced to half and speed is reduced	Continuous	
Brake run out	The Brake potentiometer input is at the maximum value without the HB request	No effect, the warning is only displayed through the console	Continuous	Traction/Pump request
Handbrake	A traction request is done with the Handbrake input active	Traction motor is stopped	Stand-by, running	Traction/ Pump request
Current Gain MDI code allarm **92**	The Maximum current gain parameters are the default values, which means the maximum current adjustment procedure has not been carried out yet	Controller works, but with low maximum current	Start-up, stand-by	
Sens mot temp Ko MDI code allarm **65**	The output of the motor thermal sensor is out of range.	The maximum current is reduced to half and speed is reduced	Continuous	
Thermic sens Ko MDI code allarm **61**	The output of the controller thermal sensor is out of range.	The maximum current is reduced to half and speed is reduced	Continuous	
Slip profile MDI code allarm **99**	Error on the parameters of the slip profile setting.	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/ Pump request
EEPROM KO MDI code allarm **71**	Error is detected in Eeprom or in Eeprom management	Controller works using default parameters	continuous	
Forward + Backward MDI code allarm **80**	The travel demands are active in both directions at the same time	Traction is stopped	Start-up, stand-by, running	Traction request

8.19 Analysis and troubleshooting of warnings displayed on console

1) VACC NOT OK
   Cause:
   The test is made at key-on and immediately after that both the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is 1,0V higher than PROGRAM VACC min acquisition when the accelerator is released.
   Troubleshooting:
   Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.

2) INCORRECT START
   Cause:
   This is a warning for an incorrect starting sequence.
   Troubleshooting:
   The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting):
   - A travel demand active at key on
   - Presence man sensor active at key on

   Check the wirings. Check the micro switches. It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the ACE logic board.

3) VACC OUT OF RANGE
   Cause:
   The CPOT input red by the microcontroller is not comprised in the range Vacc_min ÷ Vacc_max, programmed through the "PROGRAMM VACC" function.
   Troubleshooting:
   Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.

4) TEMPERATURE
   Cause:
   This alarm occurs when the temperature of the base plate is higher than 85°. Then the maximum current decreases proportionally with the temperature increases from 85° up to 105°. At 105° the Current is limited to 0 Amps.
   Troubleshooting:
   It is necessary to improve the controller cooling. For realise an adequately cooling in case of finned heat sink are important factor the flux [m3/h] and temperature [°C] of cooling air. In case of thermal dissipation realised with the controller base plate installed on truck frame it is important the thickness of frame and the planarity and roughness of its surface. If the alarm is signalled when the controller is cold, the possible reasons are a thermal sensor failure or a failure in the logic card. In this case, it is necessary to replace the controller.

5) MOTOR TEMPERATURE
Cause:
This warning occurs when the temperature sensor is opened (if digital) or has overtaken the threshold of 150° (if analogue).
Troubleshooting:
Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the TESTER menu); 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, then the problem is inside the controller.

6) BRAKE RUN OUT
Cause:
The CPOTBRAKE input red by the microcontroller is at the maximum value without the hand brake request.
Troubleshooting:
Check the mechanical calibration and the functionality of the brake potentiometer. If the alarm is not disappeared the failure is in the ACE logic board, replace it.

7) HAND BRAKE
Cause:
The hand brake input is active when a traction request is done.
Troubleshooting:
The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting):
- The HB switch is damaged so it does not close the input CNA#13 to – Batt. Replace it.
- The HB switch work correctly but in the tester menu the HB input is always ON. In this case the failure is in the logic board, replace it.

8) 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 the assistance of a Zapi technician to do the correct adjustment procedure of the current gain parameters

9) SENS MOT TEMP KO
Cause:
The output of the motor thermal sensor is out of range.
Troubleshooting:
Check the sensor ohmic value and the sensor wiring. If the sensor is OK, then the problem is inside the ACE logic board, replace it.

10) THERMIC SENS KO
Cause:
The output of the controller thermal sensor is out of range.
Troubleshooting:
This type of fault is not related to external components; replace the controller.

11) SLIP PROFILE

Cause:

There is an error on the choice of the parameters of the slip profile.

Troubleshooting:

Check in the hardware setting menu the value of those parameter

12) EEPROM KO

Cause:

It's due to a HW or SW defect of the non-volatile embedded memory supporting the controller parameters. This alarm does not inhibit the machine operations, but the truck will work with the default values.

Troubleshooting:

Try to execute a CLEAR EEPROM operation (refer to 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 have been replaced by the default parameters.

13) FORW+BACK

Cause:

This alarm occurs when both the travel demands (Fwd and Bwd) are active at the same time.

Troubleshooting:

Check the wiring of the Fwd and Rev travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting). Check the microswitches for failures.

A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the ACE-2 logic board.

9 RECOMMENDED SPARE PARTS FOR INVERTER

Part number	Description	ACE Version
C16588	Protected 350 A strip UL Fuse.	24V/400 & 36-48V/450
C16588	Protected 350 A strip UL Fuse.	24V/500
C16586	Protected 250 A strip UL Fuse.	36-48V/350
C16520	10 A 20 mm Control Circuit Fuse	All
C29522	SW 180 48 V Single Pole Contactor	All
C29508	SW 180 24 V Single Pole Contactor	All
C12531	Connector Ampseal 23 pins Female	All
C12372	Connector Molex 8 pins Female	All

10 PERIODIC MAINTENANCE TO BE REPEATED AT TIMES INDICATED

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

Check the Foot pedal or Tiller microswitch. Using a suitable test meter, confirm that there is no electrical resistance between the contacts by measuring the volt drop between 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 of NON ORIGINAL PARTS.
The installation of this electronic controller should be made according to the diagrams included in this Manual. Any variations or special 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.