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EN

User Manual

COMBIAC0 & ACE0

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NOTES LEGEND

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

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APPROVAL SIGNS

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

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1 INTRODUCTION

The COMBI AC0 / ACE0 inverter has been developed to perform all the electric functions that are usually presents in walkie and rider pallet trucks, stackers, low level order pickers.
The controller can perform the following functions:

- Controller for Ac 700W to 2,5 Kw AC motors;
- Pump controller for series wounded DC motors up to 5 KW (only for Combi AC0).
- Drivers for ON/OFF electrovalves and for two proportional valves (electro-distributor)
- Can bus interface
- Interface for canbus tiller
- Zapi patented sensorless and sense coil control
- 128 Kbytes Flash memory embedded.
- Software downloadable via Serial link or JTAG (internal connectors) or Canbus (external connector)
- ESD protection on CAN BUS inputs CANL and CANH

2 SPECIFICATION

2.1 Technical specifications Combi AC0 / ACE0

Inverter for traction AC asynchronous 3-phase motors plus chopper for DC series pump motors.
Regenerative braking functions.
Digital control based upon microcontroller

Voltage:	24, 36, 48V
Inverter maximum current (24V, 36V):	220A (RMS) for 2'
Inverter maximum current (36V, 48V):	180A (RMS) for 2'
Continuous output current (24V, 36V):	105A (RMS) continuous
Continuous output current (36V, 48V):	90A (RMS) continuous
Inverter operating frequency:	8kHz
Dc chopper Maximum current (24V,36V)(1):	270A for 2'
Dc chopper Maximum current (36V, 48V)(1):	220A for 2'
Chopper Operating frequency(1):	16kHz
External temperature working range:	-40°C ÷ 40°C
Maximum heatsink temperature (start of the thermal cutback)	85°C

Note(1): The DC chopper specifications are related to Combi AC0

2.2 Technical specifications Combi AC0 Power / ACE0 Power

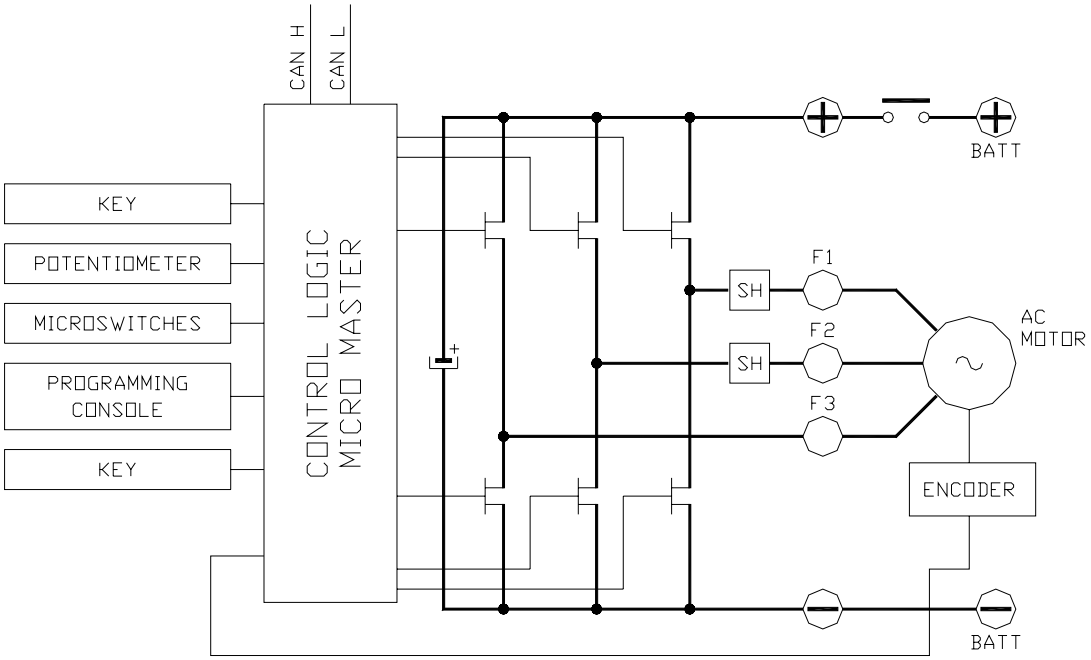
Inverter for traction AC asynchronous 3-phase motors plus chopper for DC series pump motors.
Regenerative braking functions.
Digital control based upon microcontroller

Voltage:	24, 36, 48V
Inverter maximum current (24V, 36V):	320A (RMS) for 2'
Inverter maximum current (36V, 48V):	280A (RMS) for 2'
Continuous output current (24V, 36V):	130A (RMS) continuous
Continuous output current (36V, 48V):	110A (RMS) continuous
Inverter operating frequency:	8kHz
Dc chopper Maximum current (24V,36V)(1):	270A for 2'
Dc chopper Maximum current (36V, 48V)(1):	220A for 2'
Chopper Operating frequency(1):	16kHz
External temperature working range:	-40°C ÷ 40°C
Maximum heatsink temperature (start of the thermal cutback)	85°C

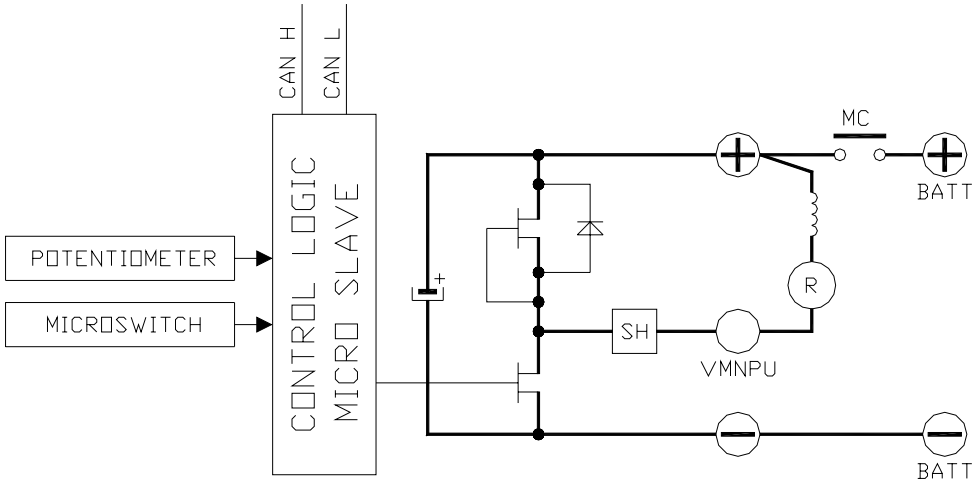
Note(1): The DC chopper specifications are related to Combi AC0

2.3 Block diagrams

2.3.1 Traction control



2.3.2 Pump control



3 SPECIFICATION FOR THE INPUT DEVICES FILLING UP THE INSTALLATION KIT

3.1 Digital inputs

COMBI AC0 / ACE0 digital inputs work in the voltage range [-Batt; +Batt].
Related command devices (microswitches) must be connected to +B (typically to key voltage).
Pull-down resistance to –Batt is built-in.
Functional devices (like FW, BACK, LIFT, DESCENT, HORN, H&S, TILLER, BELLY switches) are Normally Open; so related function becomes active when the microswitch closes.
Safety devices (like CUTBACK switches) are Normally Closed; so related function becomes active when the microswitches opens.
The DI11 and DI12, which are not available in the Sense Coil version, are activated closing the external microswitch to –Batt.

3.1.1 DI0 ÷ DI10 technical details – 24 V system

- Switching threshold: 4V [±0,5V]
- Input impedance: 4,5kOhm [±0,5kOhm]

3.1.2 DI0 ÷ DI10 technical details – 48 V system

- Switching threshold: 4,3V [±0,5V]
- Input impedance: 13,5kOhm [±1kOhm]

3.1.3 Microswitches

- It is suggested that microswitches have a contact resistance lower than 0,1Ohm and a leakage current lower than 100µA.
- When full load connected, the voltage between the key switch contacts must be lower than 0.1V.
- If the microswitch to be used has different characteristic, it is suggested to discuss them and their application with Zapi technicians.

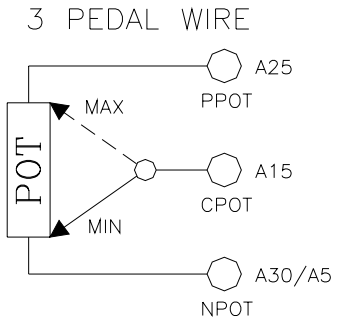
3.2 Analogue unit

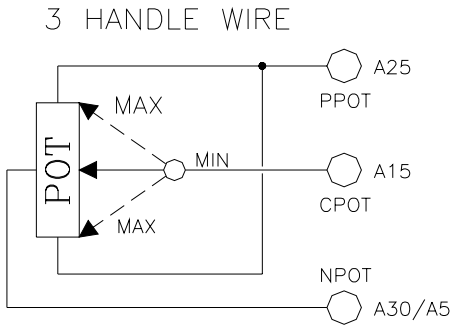
The analog input can be connected to an accelerator unit if the Zapi can or serial tiller is not used.
The accelerator unit can consist of a potentiometer or an Hall effect device.
It should be in a 3-wire configuration. The potentiometer is supplied through CNA#25.
Potentiometer output signal must be input to CPOT1 (CNA#15) signal range is from 0 to 10V.
If the pedal wire disconnection diagnosis is implemented (“PEDAL WIRE KO” warning) the negative supply of the potentiometer has to be taken from NPOT (CNA#30), otherwise has to be taken from CNA#5 (GND).

Potentiometer value should be in the 0.5 - 10 KOhm range; generally, the load should be in the 1.5mA to 30mA 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 Hand Set. This enables adjustment of the minimum and maximum useful signal level, in either direction.

3.3 Other analogue control unit

If the Zapi can tiller is not used, input CNA#30 can be used as analogue input (the “PEDAL WIRE KO” warning is lost), whose typical application is a proportional command to enable a lifting/lowering function. It is possible to use this input for an alternative function like a proportional braking.
It should be in a 3 wire configuration. Potentiometer value should be in the 0.5-10Kohm range. Generally, the load should be in the 1.5mA to 30 mA range.
The CPOTL (CNA#30) signal range is from 0 to 10V.
Use CNA#25 (positive) and CNA#5 (negative) to supply it.

3.4 Analogue motor thermal sensor input

Input CNA#22 is an analogue input to receive an analogue thermal sensor signal to measure the Traction Motor Winding Temperature. The analogue device installed in the motor has to be specified, in order to insert the correct look-up table in the software. A digital device can also be used.

3.5 Speed feedback

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

- power supply: +12V / +5V
- electric output: open collector (NPN), push-pull.

COMBI AC0 / ACE0 could also be used without encoder, sensorless control.
This solution has to be discussed with Zapi technicians.

Note (1): 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:
CA0Z2A ZP1.00

That means:
CA0Z= COMBIAC0 Zapi controller
2 = motor's poles pair number
A = 32 pulses/rev encoder

The encoder resolution is given by the second-last letter in the following list:
A = 32 pulses/rev
K = 48 pulses/rev
B = 64 pulses/rev
C = 80 pulses/rev

---

4 INSTALLATION HINTS

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

*These are **informations** 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 0.5mm² section at least.
For power connections to the motor and to the battery, use cables having a minimum section of 15 mm².
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

IT IS STRONGLY RECCOMENDED TO USE A MAIN CONTACTOR to connect and cut off the battery to the controller. Depending on the setting of a parameter in the controller:

- the output which drives the main contactor coil is on/off (the coil is driven with the full battery voltage).
- the output which drives the main contactor coil is switched at high frequency (1 KHz) with a programmable duty cycle; this feature is useful to decrease the power dissipation of the contactor coil.

The EN1175 states the main Contactor is not mandatory (under proper conditions); anyway it is recommended to protect the inverter against reverse battery polarity and to cut off the battery from the power mosfets when a failure in the three phase bridge occurs.

4.1.3 Fuses

- Use a 6.3-10A Fuse for protection of the auxiliary circuits.
- For protection of the power unit, use a 350A fuse in the Battery Positive connection. 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 chopper using a Resistor between 10 Ohm and 100 Ohm. Minimum 5 Watts.

4.2.1 Positioning and cooling of the controller

CONTROLLER WITH BASE PLATE: Install the controller with the base-plate on a flat metallic surface that is clean and unpainted; suggested characteristics are: planarity 0.05 mm and rugosity 1.6 µm

- Apply a light layer of thermo-conductive grease between the two surfaces to permit better heat dissipation.
- 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.

CONTROLLER WITH FINNED HEATSINK: Sometimes the base plate installation cannot be adopted. Due to positioning problems or to the lack of a thick enough truck frame, it is necessary to adopt a finned dissipation combined with one or more fans.

- The air flux should hit the fins directly, to maximize the cooling effect.
- In addition to fans, also air ducting systems can be used to maintain low the temperature of the controller.
- It is necessary to ensure that cold air is taken from outside the controller compartment and hot air is easily pushed away from the controller compartment.
- It is mandatory to avoid that the cooling air is recirculated inside the controller compartment.

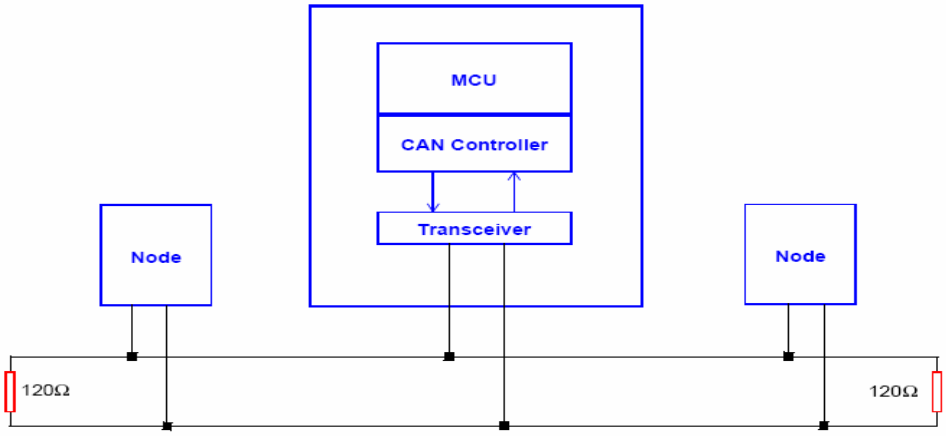
4.2.2 Wirings: power cables

- 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 7 ± 1.4 Nm
- The COMBIAC0 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 MOS failure. A lower voltage may prevent the logic operating.

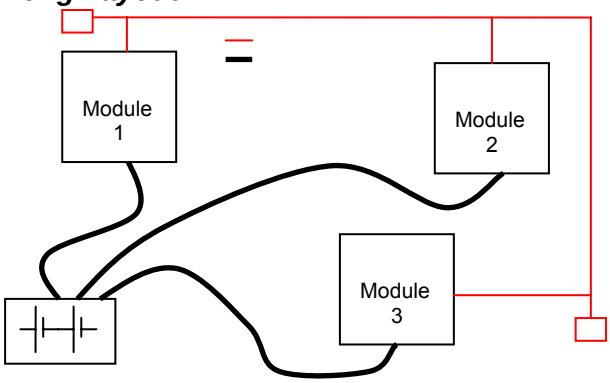
4.2.3 Wirings: CAN connections and possible interferences

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.

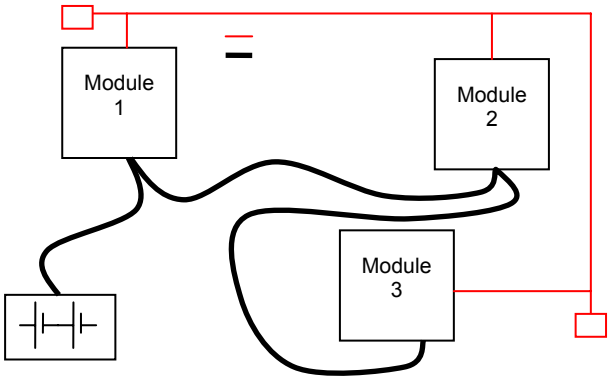
Wrong Layout:



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:

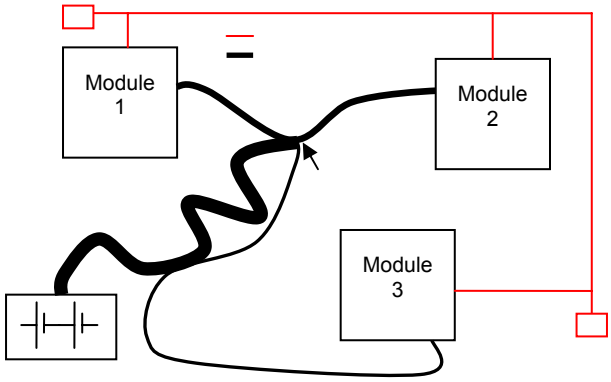


Note: Module 1 power > Module 2 power > Module 3 power

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 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”

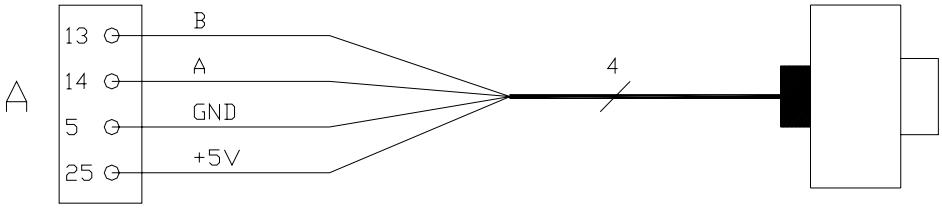
4.2.5 Connection of the encoder

1) COMBI AC0/ ACE0 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 +12V. It can have different electronic output.

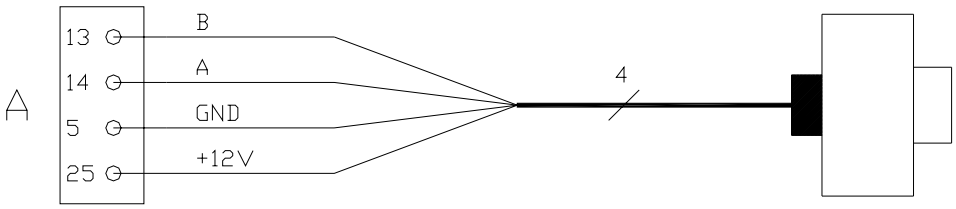
AMPSEAL CONNECTOR

A25	+5V/+12V	positive of encoder power supply.
A5	GND	negative of encoder power supply.
A14	A	phase A of encoder.
A13	B	phase B of encoder.

2) Connection of encoder with open collector output; +5V power supply.



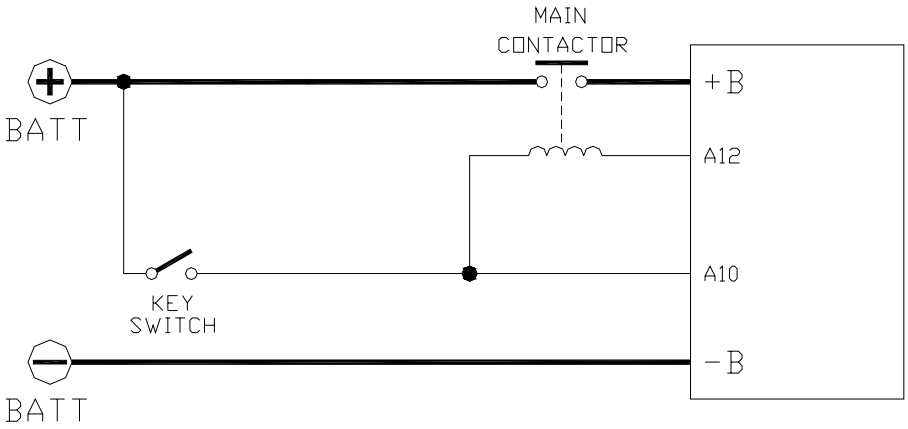
Connection of encoder with open collector output: +12V power supply.



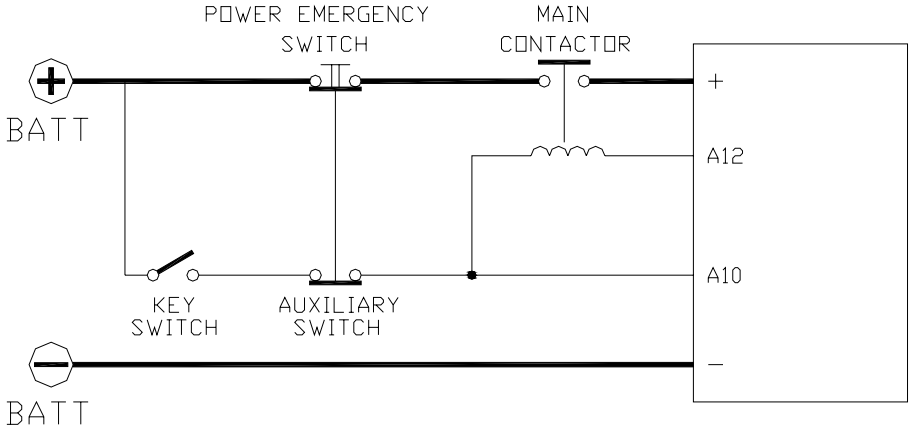
VERY IMPORTANT
It is necessary to specify in the order the type of encoder used, in terms of power supply, electronic output and n° of pulses for revolution, because the logic unit must be set in the correct way by Zapi.
The n° of pulses revolution the controller can handle is given by the second-last letter in the software release name (see 3.5).

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 strongly recommended that the key supply to the inverter is open together with power battery line (see picture below); 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 COMBI AC0/ ACE0 is protected against some controller injuries and malfunctions:

- **Battery polarity inversion**

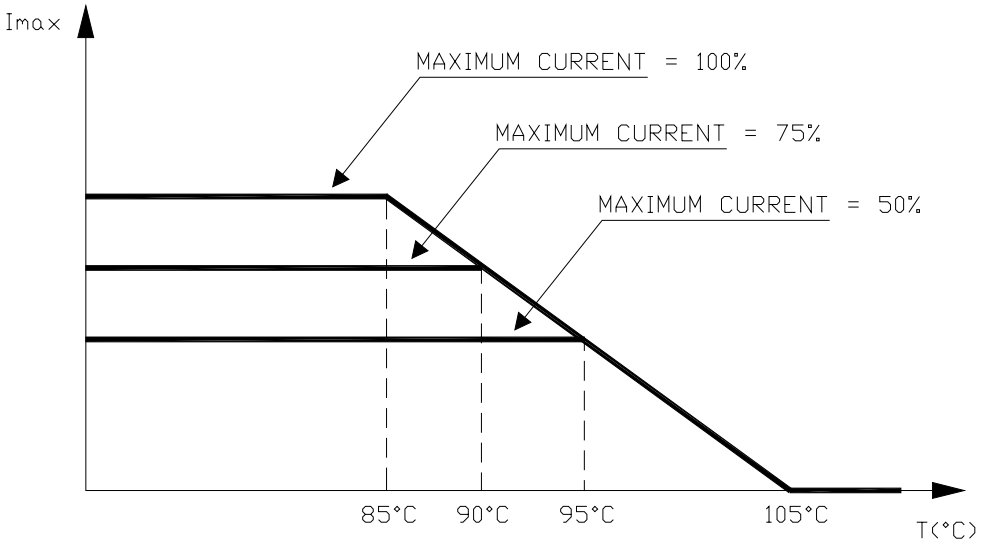
It is necessary to fit a LINE CONTACTOR to protect the controller against reverse battery polarity and for safety reasons.

- **Connection Errors**

All inputs are protected against connection errors.

- **Thermal protection**

If the controller temperature exceeds 85°C, the maximum current is reduced in proportion to the thermal increase. The temperature can never exceeds 105°C.



- **External agents**

The inverter is protected against dust and the spray of liquid to a degree of protection meeting IP65. Nevertheless, it is suggested to carefully study controller installation and position. With few simple shrewdness, the degree of controller protection can be strongly increased.

- **Protection against uncontrolled movements**

The main contactor will not close if:

- The Power unit is not functioning.
- The Logic or CANBUS interface is not functioning perfectly.
- The Can Tiller is not operating correctly.
- Running microswitches are in open position.

- **Low battery charge**

when the battery charge is low, the maximum current is reduced to the half of the maximum current programmed; additionally an alarm message is displayed.

- **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.

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 responsability 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 electromagnetical 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 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 happen 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 informations.
   - 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.

4) **EMISSIONS**. Three ways can be followed to reduce the emissions:

   A) SOURCE OF EMISSIONS: finding the main source of disturb and work on it.
   B) SHIELDING: enclosing contactor and controller in a shielded box; using shielded cables;
   C) 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.

5) **ELECTROMAGNETIC IMMUNITY**. The considerations made for emissions are valid also for immunity. Additionally, further protection can be achieved with ferrite beads and bypass capacitors.

6) **ELECTROSTATIC IMMUNITY**. Three ways can be followed to prevent damages from ESD:

   A) 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.
   B) ISOLATION: use anti-static containers when transferring ESD-sensitive material.
   C) 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 combine SCR low frequency choppers with COMBI AC0/ ACE0 modules. The filter capacitors contained in the COMBI AC0/ ACE0 module would change the SCR chopper operation and subject to excessive workload. If it is necessary to use two or more control units, like the chopper should be of the Zapimos family.

During battery recharge, the COMBI AC0/ ACE0 must be completely disconnected from the battery. Beside changing the charging current seen by the battery charger, the module can be damaged by higher than normal voltages supplied via the charger.

5 OPERATIONAL FEATURES

- Speed control.
- Optimum behaviour on a slope if the speed feedback is used:
  a) The motor speed follows the accelerator, starting a regenerative braking if the speed overtakes the speed set-point
  b) The system can perform an electrical stop on a ramp (the machine is electrically hold on a slope) for a programmable time (if encoder is used)
- 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 analogue 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.
- High efficiency of motor and battery due to high frequency commutations.
- 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.
- Direct communication between traction AC inverter and pump DC chopper.
- Backing forward and reverse options are available, with the tune and the speed of the function programmable with Zapi handset.

5.1 Diagnosis

The microcontrollers continually monitor the inverter and the chopper and carry out diagnostic procedures on the main functions.
The diagnosis is made in 4 points:

1) Diagnosis at start-up that checks: watch-dog, Current Sensors, Capacitor charging, phase's voltages, pump motor output, contactor drivers, can-bus interface, presence of a start requirement, connection with the Can Tiller.
2) Standby Diagnosis that checks: watch-dog, phase's voltages, pump motor output, Contactor Drivers, Current Sensors, can-bus interface.
3) Driving diagnosis that checks: Watchdog, Current sensors, Contactor(s), can-bus interface.
4) Continuos Diagnosis that checks: power stage temperature, motor temperature, Battery Voltage.

Error codes are 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

6.1.1 CNA external connector

The connector used is an AMPSEAL plug 35 pins

A1	DI0	Input of the switch DI0. The input is activated when it is connected to +Batt. With the logic hardware properly configured it can be used to supply the EB and MC positive. The default function is the controller “TILLER” input.
A2	PEB	Positive of the electromechanical brake coil.
A3	PAUX	Positive supply for electrovalves: EV1, EV2, EV3, EV4, EV5, LOWER EVP1, EVP2, HORN OUT and with the logic hardware properly configured it can be used to supply the EB. This input has to be supplied with positive taken after main contactor.
A4	NEB	Electro mechanic brake coil driver output; PWM controlled; 2,5A maximum continuous current (driving to –Batt).
A5	NENC	Negative of the Encoder
A6	DI2	Input of the switch DI2. The input is activated when the external switch is opened. The default function is the controller “CUTBACK” input, opening the switch truck speed is reduced.
A7	DI6	Input of the switch DI6. The input is activated when it is connected to +Batt. The default function is the controller “BELLY” input, closing the switch quick inversion function is activated.
A8	EV5	Output of the ON/OFF electrovalve EV5; 1,5 A maximum continuous current (driving to –Batt).
A9	EV1	Output of the ON/OFF electrovalve EV1; 1,5 A maximum continuous current (driving to –Batt).
A10	+KEY	Input of the key switch signal.
A11	EV2	Output of the ON/OFF electrovalve EV2; 1,5 A maximum continuous current (driving to –Batt).
A12	NMC	Main contactor coil driver output; PWM controlled; 2,5A maximum continuous current (driving to –Batt).
A13	ENC B	Traction motor encoder phase B.
A14	ENC A	Traction motor encoder phase A.
A15	CPOTTR	Accelerator potentiometer wiper.
A16	BACKING REV	Inching (Backing) function, backward direction input. It must be connected to the inching backward switch. Active high.
A17	BACKING FOR	Inching (Backing) function, forward direction input. It must be connected to the inching forward switch. Active high.

A18	DI11	Input of the switch DI11. The input is activated when the external switch is closed to -Batt. In the Sense Coil version this input is connected to the AC motor sense coil.
A19	DI5	Input of the switch DI5. The input is activated when it is connected to +Batt. The default function is the controller “HORN” input, closing the switch the horn output is activated.
A20	DI1	Input of the switch DI1. The input is activated when it is connected to +Batt. The default function is the controller “DESCENT” enable input.
A21	DI12	Input of the switch DI12. The input is activated when the external switch is closed to -Batt. It doesn’t have a default function. In the Sense Coil version this input is connected to the AC motor sense coil.
A22	THMOT	Traction motor thermal sensor input. The internal pull-up is a fixed 2mA (Max 5V) source current.
A23	EVP2	Output of the second proportional electrovalve driver (driving to –Batt).
A24	LOWER EVP1	Negative of the lower proportional electrovalve driver (driving to –Batt).
A25	PENC	Encoder Positive Supply (+12/+5 Vdc)
A26	HORN OUT	Negative of the protected horn electrovalve driver (driving to –Batt).
A27	CANL	Low level CAN-BUS voltage I/O.
A28	CANH	High level CAN-BUS voltage I/O.
A29	DI9	Input of the switch DI9. The input is activated when the external switch is opened. The default function is the controller “CUTBACK2” input, opening the switch truck speed is reduced. If "H&S FUNCTION" option is PRESENT, input is activate when it is connected to +Batt and function is the controller "H&S" (Hard and Soft) request input, closing this input truck performances are modified. Depending of wiring and internal jumper configuration, it may be necessary an external connection, through a diode, between H&S input and TILLER input.
A30	CPOTL/NPOT	Lift/Lower potentiometer wiper input. With the logic hardware properly configured it can be used as potentiometer negative reference. Using this input as NPOT the diagnosis “PEDAL WIRE KO” is implemented.
A31	DI4	Input of the switch DI4. The input is activated when it is connected to +Batt. The default function is the controller “REV” request input, closing this input truck moves in backward direction.
A32	DI3	Input of the switch DI3. The input is activated when it is connected to +Batt. The default function is the controller “FORWARD” request input, closing this input truck moves in forward direction.
A33	EV3	Output of the ON/OFF electrovalve EV3; 1,5 A

		maximum continuous current (driving to –Batt).
A34	EV4	Output of the ON/OFF electrovalve EV4; 1,5 A maximum continuous current (driving to –Batt).
A35	DI7	Input of the switch DI7. The input is activated when it is connected to +Batt. The default function is the controller “LIFT” enable input.

6.1.2 CND internal connector

The connector used is a 8 Vie STRIP

D1	Not used	Internally disconnected
D2	NCLRXD	Negative serial reception pin.
D3	PCLTXD	Positive serial transmission pin.
D4	NCLTXD	Negative serial transmission pin.
D5	GND	Serial communication negative reference.
D6	+12	+12V serial communication supply.
D7	FLASH BOOT	To connect this pin to GND (D8) for software download via serial communication.
D8	GND	Serial communication negative reference.

This internal connector is used for software download with Zapi Flasher or for the communication with Zapi Handset, or with lap-top, for controller setting an diagnosis.

6.1.3 CNE internal connector

The connector used is a 16 Vie STRIP

E1	TMS	JTAG interface, test mode selection microcontroller input.
E2	+5	+5V JTAG interface supply.
E3	TD0	JTAG data output, microcontroller output.
E4	GND	JTAG interface negative reference.
E5	CPUCLOCK	CPU clock signal for JTAG interface.
E6	GND	JTAG interface negative reference.
E7	TDI	JTAG data input, microcontroller input.
E8	RESET*	Logic reset signal.
E9	TRST*	Test-System reset, microcontroller input.
E10	BRK-OUT	Debug System: Break Out, microcontroller output.
E11	TCLK	Debug System: JTAG clock, microcontroller input.
E12	GND	JTAG interface negative reference.
E13	BRK-IN	Debug System: Break In, microcontroller input.
E14	Not used	Internally disconnected
E15	Not used	Internally disconnected
E16	Not used	Internally disconnected

This internal connector is used for software download via JTAG interface. The connector is also used by Zapi technicians to realize the software debug.

7 DESCRIPTION OF POWER CONNECTIONS

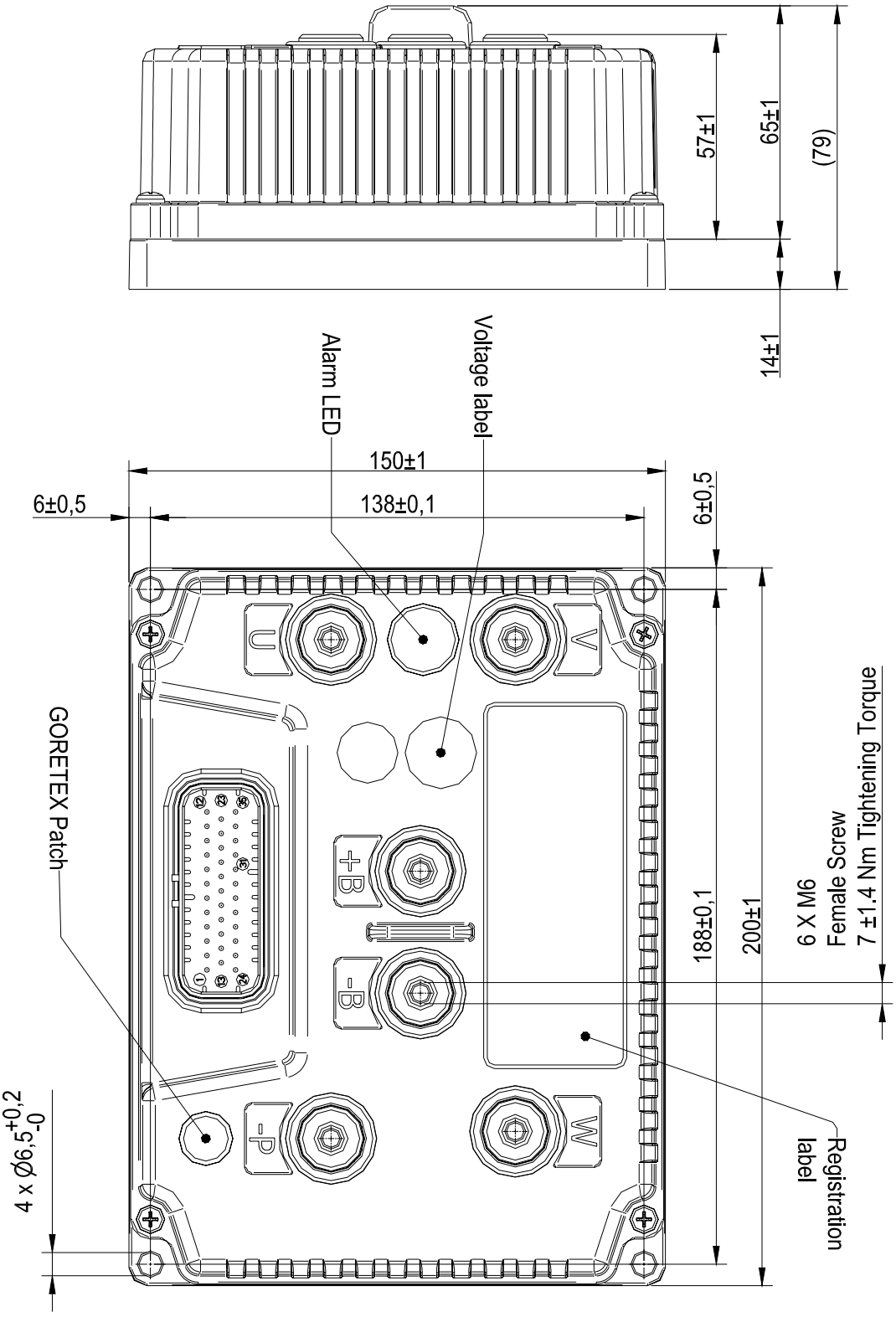
View of the power bars:

-B	Negative of the battery.
+B	Positive of the battery.
- P	Output of the Pump Motor.

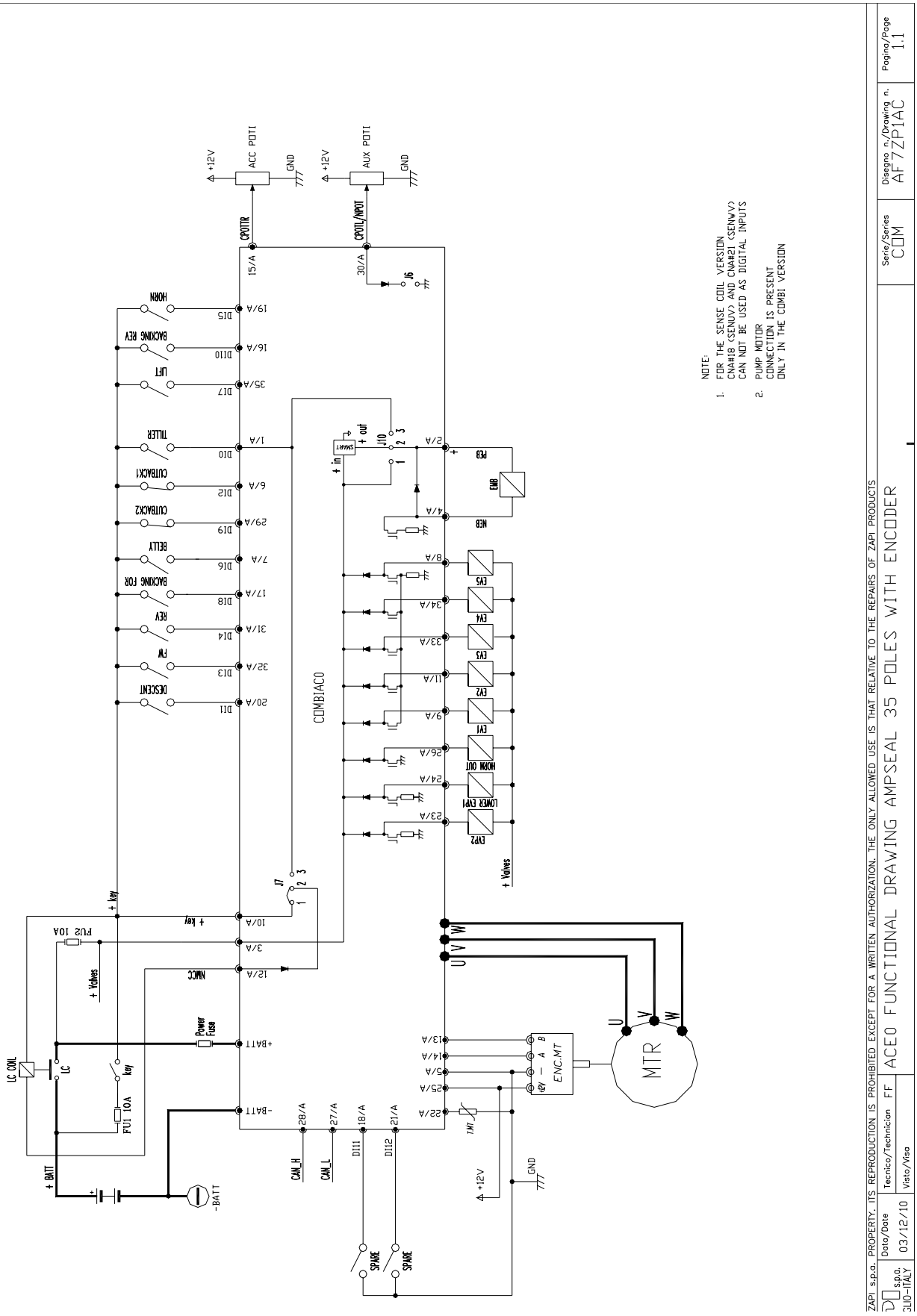
U; V; W Connection bars of the three motor phases; follow this sequence and the indication on the motor.

8 DRAWINGS

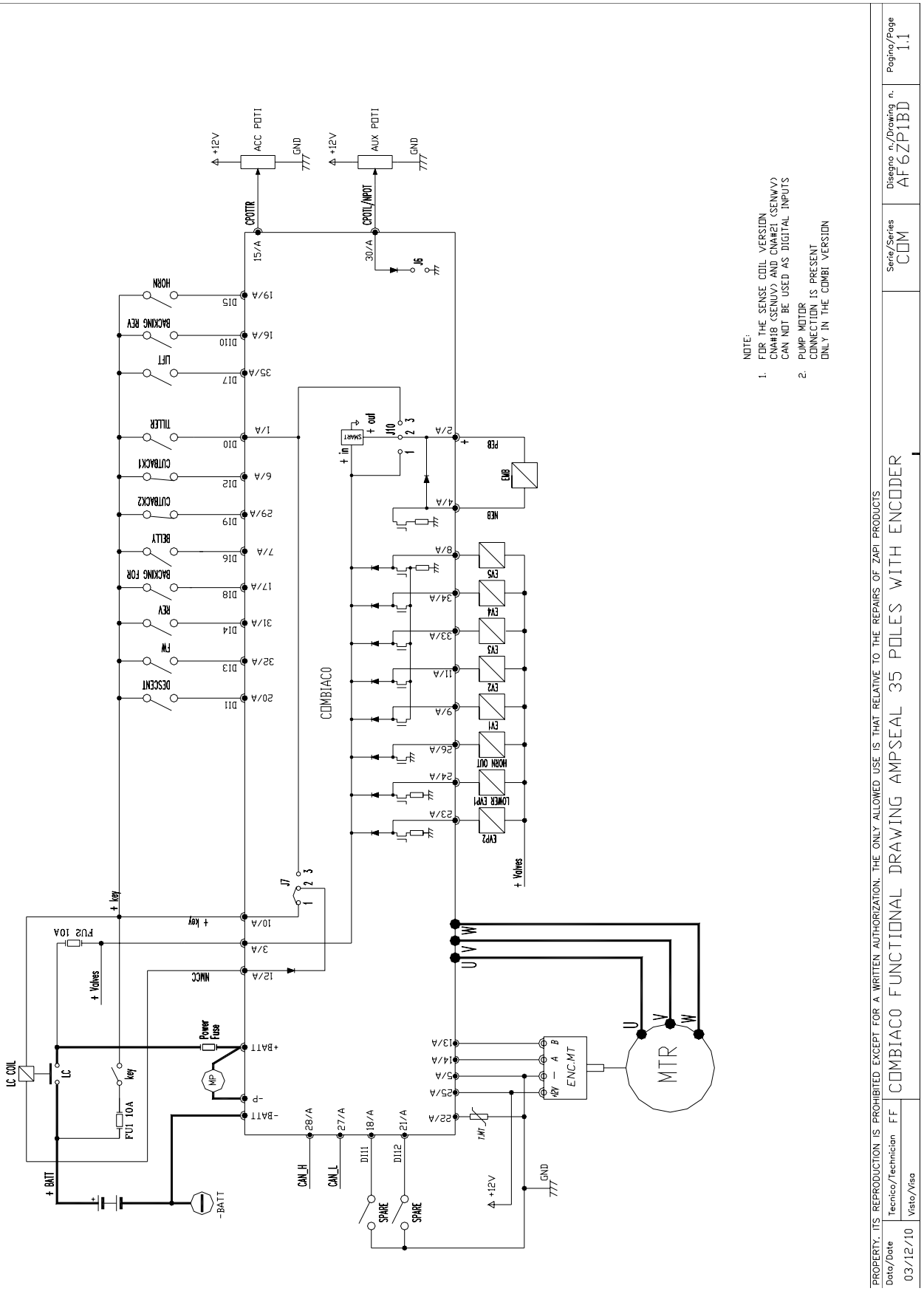
8.1 Mechanical drawing



8.2 Connection drawing ACE0



8.3 Connection drawing CombiAC0



9 ONE SHOT INSTALLATION PROCEDURE

This section of the manual describes the basic connection procedure.
To move, the truck needs a minimum I/O outfit that it is mandatory: this minimum outfit is listed in the Steps from 1 to 8 below.

Step1 Connect a potentiometer in the range 0.5 to 10Kohms, to modify the wished speed between +12 (CNA#25) and GND (CNA#5). The potentiometer wiper is connected to CPOTTR (CAN#15).

Step2 Connect two travel demand switches. The FWD travel demand must be connected between a battery (key) voltage and CNA#32. The REV travel demand must be connected between a battery (key) voltage and CNA#31. Only one of them can be active at the same time. They become active when connected to a key.

Step3 Connect a tiller (or seat) switch enabling/disabling the truck motion between CNA#1 and a key voltage. It becomes active, enabling the motion, when closed to a key voltage.

Step4 Connect the encoder in the motor shaft between CNA#25=VDD, CNA#5=GND, CNA#14=CHA, CNA#13=CHB. The VDD voltage may be 12V or 5V depending on a jumper inside the controller.

Step5 Connect the plus battery voltage through a key switch at the KEY input CNA#10. This is the input for the controller supply.

Step6 Connect the Main Contactor Coil to CNA#10 and CNA#12. The contactor must connect the battery positive to the +BATT power terminal of the ACE0/ COMBI AC0.

Step7 Connect the motors and the minus battery to the corresponding power terminals of the ACE0/ COMBI AC0.

Step8 Connect the Electromechanical Brake coil between CNA#2 and CNA#4; when the tiller switch opens, the electromechanical brake gets de-energized braking the truck.

The Steps from 1 to 8 describe the installation operations that is mandatory to do in order your truck moves. Obviously the ACE0/ COMBI AC0 may execute a wider set of optional services as:

1) to handle some speed reductions requests.
2) to handle an analogue sensor inside the motor.
3) to handle a proportional braking.
4) to handle a proportional forks lowering valve.
5) to handle a pump motor by a chopper.
6) to handle a belly switch, for truck quick inversion.
7) to handle a proportional input for the forks lifting/lowering.
8) to handle a second proportional electrovalve.
9) to handle a number of on/off E-valves.
10) to handle an Horn, driving a protected driver.

You must fill your I/O outfit with your optional functions. The optional functions are shown in the connecting drawing and described in detail inside this manual. The index may help you.

9.1 Sequence for Ac Inverter traction setting

This section of the manual describes the basic ACE0/ COMBI AC0 set-up procedure using the hand-set:
When the "Key Switch" is closed, if no alarms or errors are present, the Console Display will be showing the Standard Zapi Opening Display (Home Display).
For the setting of your truck, use the procedure below.
If you need to reply the same setting on different controller, use the Save and Restore sequence as described in the 13.1 and 13.2 paragraphs. Remember to re-cycle the Key Switch if you make any changes to the chopper's configuration.

Step1	Fill your setting with the Options you need.
Step2	Select the Battery Voltage.
Step3	Check the correct installation of all wires. Use the Console's TESTER function to assist.
Step4	Perform the accelerator signal acquisition procedure using the Console "PROGRAM VACC". Procedure is detailed on paragraph 13.3.
Step5	Set the "MAXIMUM CURRENT" Current parameter.
Step6	Set the ACCELERATION DELAY requirements for the machine. Test the parameters in both directions.
Step7	Set the FREQUENCY CREEP level starting from 0.6 Hz. The machine should just move when the accelerator microswitch is closed. Increase the Level accordingly.
Step8	Set the Speed Reductions as required. Use the parameters of the "cutback speed" family in the PARAMETER CHANGE menu to specify the reduced maximum truck speed as a percentage of the MAX SPEED FWD and MAX SPEED REV.
Step9	RELEASE BRAKING. Operate the machine at full speed. Release the accelerator. Adjust the level to your requirement. If the machine is a forklift, check the performance with and without load.
Step10	INVERSION BRAKING. Operate the machine at 25% full speed. While travelling invert the Direction Switch. Set the suited 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.
Step11	Set the parameter MAX SPEED FORW.
Step12	Set the parameter MAX SPEED BACK (Reverse).
Step13	Test the truck on the maximum ramp specification at full load.
Step14	Make the choice for the truck behaviour on a slope. If the "Stop on ramp" option is ON, set the desired value of "auxiliary time" parameter.

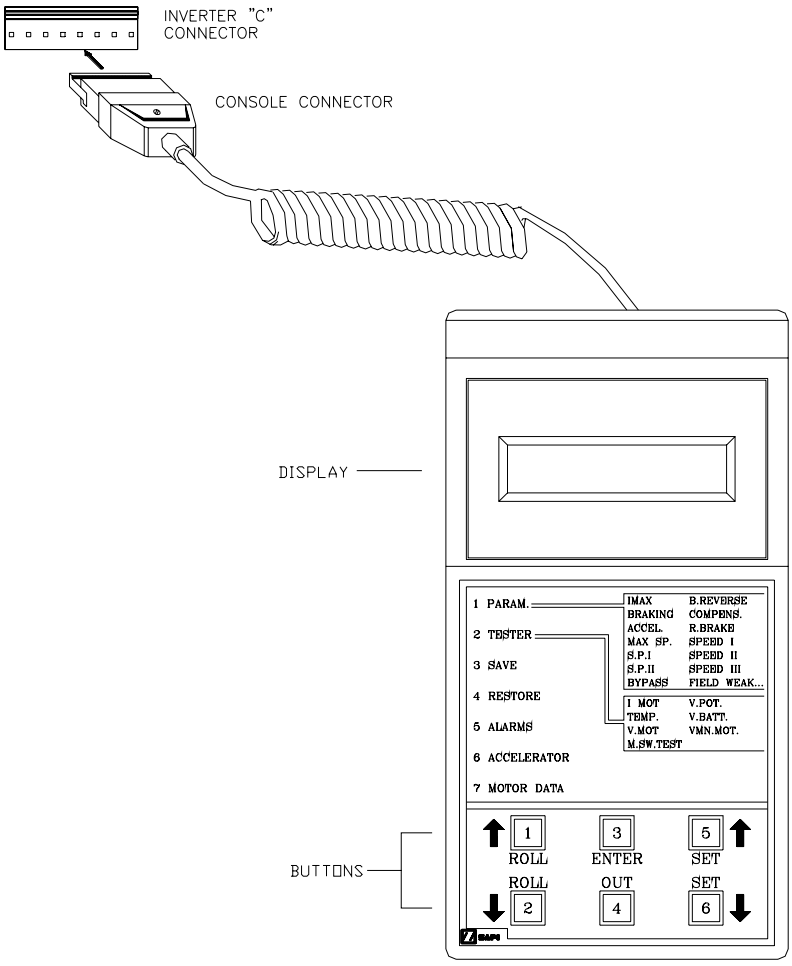
10 PROGRAMMING & ADJUSTMENTS USING DIGITAL CONSOLE

10.1 Adjustments via console

To access and adjust all parameters it is necessary to use the Zapi console. Since the COMBIAC0/ACE0 has no external serial connector, the Zapi console has to be connected through a remote module, like a Zapi tiller card of a Zapi display. This module has to be connected to the same Canbus line of the inverter.
Otherwise it is possible to connect a pc to the Canbus line and use the PC CAN Console software. This tool is more powerful than the standard serial console.

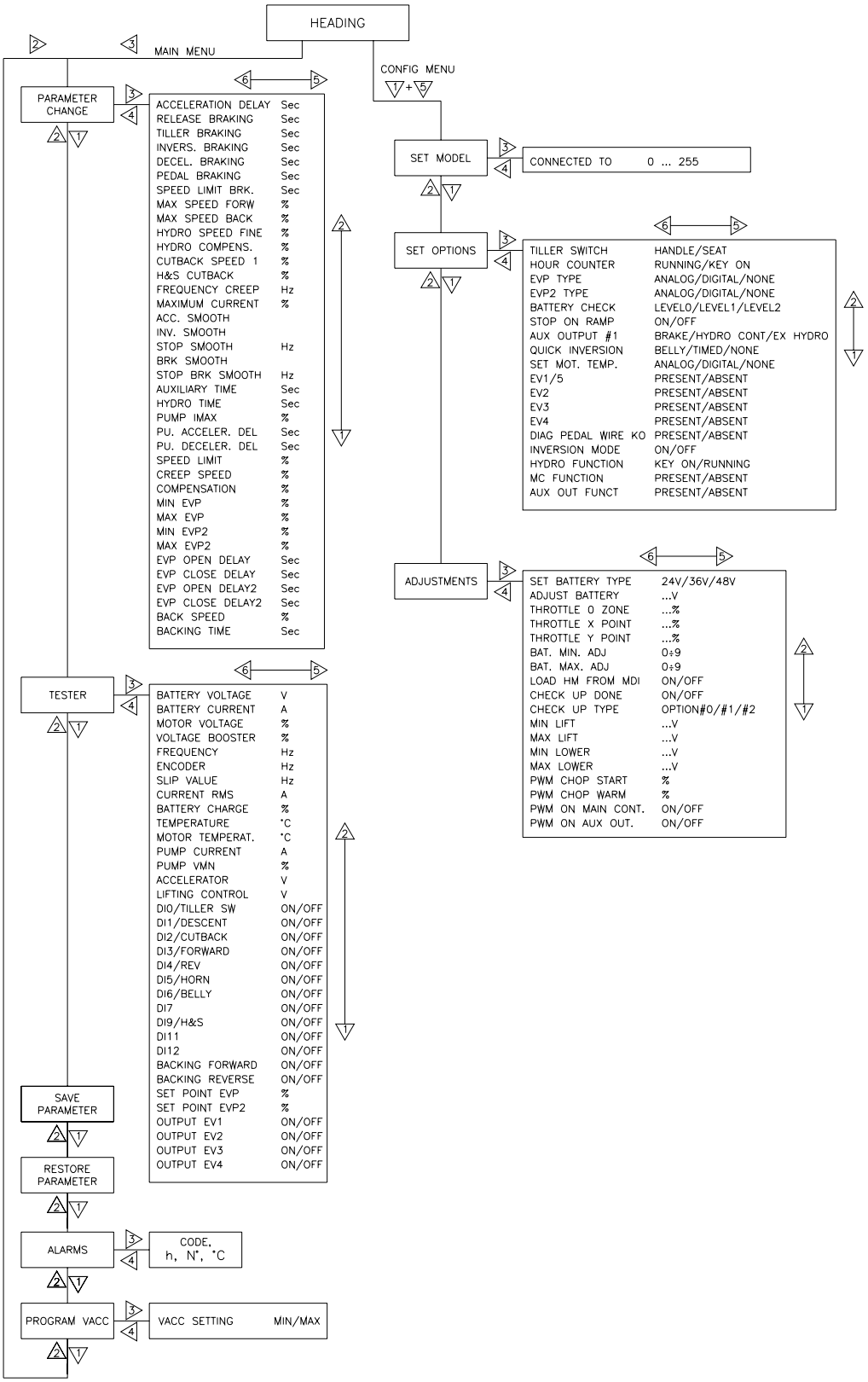
The following paragraphs describe the controller configuration in the case the operator is using the Zapi console.

10.2 Description of console (hand set) & connection



10.3 Description of the console menu

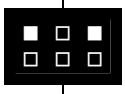
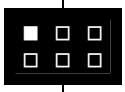
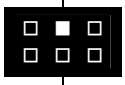
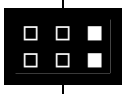
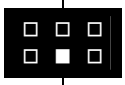
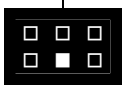
10.3.1 ACE0/ COMBIAC0 Menu



10.4 Function configuration

10.4.1 Config menu “SET OPTIONS” functions list

To enter the CONFIG MENU’ it is necessary to push in the same time the right side top and left side top buttons. Then roll until the SET OPTION item appears on the hand set display. Push the ENTER button.

Opening Zapi Display	
Push ROLL UP + SET UP simultaneously to enter CONFIG MENU	
The Display will show : SET MODEL	
Press ROLL UP or ROLL DOWN button until SET OPTIONS menu appear.	
The Display will show : SET OPTIONS	
Press ENTER to go in the SET OPTIONS MENU	
The Display will show the first OPTION	
Press SET UP or SET DOWN button in order to modify the OPTION	
The Display will show the new option	
Press OUT to exit the menu	
The Display will ask “ARE YOU SURE”.	
Press ENTER for YES, or OUT for No	
The Display will show : SET OPTIONS	
Press OUT again. Display now will show the opening Zapi menu.	

1) TILLER SWITCH

This option handles the input CNA#1. This input opens when the operator leaves the truck (tiller released). It is connected to a key voltage when the operator is present. There are two levels:

- HANDLE: CNA#1 is managed as tiller input (no delay when released).
- SEAT: CNA#1 is managed as seat input (with a delay when released → debouncing function).

2) HOUR COUNTER

This option specifies the hour counter mode. It can be set one of two:

- RUNNING: The counter registers travel time only
- KEY ON: The counter registers when the "key" switch is closed (controller supplied)

3) EVP TYPE

Analog/digital: defines the type of the EVP1 electrovalve, current controlled:
Analog: the related output manages a proportional valve, current controlled
Digital: the related output manages an on/off valve

4) EVP2 TYPE

Analog/digital: defines the type of the EVP2 electrovalve, current controlled:
Analog: the related output manages a proportional valve, current controlled
Digital: the related output manages an on/off valve

5) BATTERY CHECK

This option specifies the handling of the low battery charge detection.
There are tree levels:

- Level 0: Nothing happens, the battery charge level is calculated but is ignored, it means no action is taken when the battery is discharged.
- Level 1: BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm inhibits the Lifting function.
- Level 2: BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm reduces the maximum truck speed down to 24% of the full truck speed and it inhibits the Lifting function.

6) STOP ON RAMP

Only when the encoder is present, it is possible to electrically hold the truck on a slope when the accelerator is released but the tiller is not released.

- ON: The stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by AUXILIARY TIME parameter.
- OFF: The stop on ramp feature is not performed. That means the truck comes down slowly during the AUXILIARY TIME.

After this “auxiliary time”, the electromechanical brake is applied and the 3-phase bridge is released; if the electromechanical brake is not present the truck comes down very slowly (see the AUX OUTPUT #1 option programming and see also 13.4).

7) AUX OUTPUT #1

This option handles the digital output CNA#4. It can be used one of four:

- BRAKE: it drives an electromechanical Brake.
- HYDROCONT: it drives the contactor for a hydraulic steering function when the direction input or a movement of the truck is detected.

- EX.HYDRO: it drives the contactor for a hydraulic steering function when the exclusive hydro input is active
- FREE: it is not used.

8) QUICK INVERSION

It can be set:

- NONE: The quick inversion function is not managed (no effect when CNA#7 switches over).
- TIMED: The quick inversion function is timed.
- BELLY: The quick inversion function is managed but not timed.

9) SET MOTOR TEMPERATURE

It can be set:

- ANALOG: An analogue sensor for the control of the motor temperature is connected to CNA#22. Typically the temperature sensor is a PTC (positive thermal coefficient resistance), providing the sensor characteristic to Zapi the correct table can be loaded in the controller software.
- DIGITAL: A digital (on/off) sensor for the motor temperature monitoring is connected to CNA#22 input.
- NONE: No temperature sensor is connected.

10) EV1 / 5

PRESENT/ABSENT: If set = PRESENT the diagnosis “EV1 / 5 DRIVER SHORTED” relative to the load connected to CNA#9 or CNA#8 is activated. When set = ABSENT the diagnosis is not implemented.

11) EV2

PRESENT/ABSENT: If set = PRESENT the diagnosis “EV2 DRIVER SHORTED” relative to the load connected to CNA#11 is activated. When set = ABSENT the diagnosis is not implemented.

12) EV3

PRESENT/ABSENT: If set = PRESENT the diagnosis “EV3 DRIVER SHORTED” relative to the load connected to CNA#33 is activated. When set = ABSENT the diagnosis is not implemented.

13) EV4

PRESENT/ABSENT: If set = PRESENT the diagnosis “EV4 DRIVER SHORTED” relative to the load connected to CNA#34 is activated. When set = ABSENT the diagnosis is not implemented.

14) DIAG. PEDAL WIRE KO

PRESENT/ABSENT: If set = PRESENT the diagnosis “PEDAL WIRE KO”, relative to the connection of the two supply ends (+12V, CNA#25; NPOT, CNA#30) of the potentiometer in the accelerator , is activated. When set = ABSENT the diagnosis is not implemented.

15) INVERSION MODE

ON/OFF: This parameter sets the logic of the Quick Inversion input. If set = ON, the Quick Inversion switch is Normally Closed (function active when switch opens). If set = OFF, the Quick Inversion switch is Normally Open (function active when switch closes).

16) HYDRO FUNCTION

KEY ON/RUNNING/NONE: Defines the activation of hydraulic steering fuction.

- KEY ON: the function is activated at key-on.
- RNNING: the function is activated during a traction or braking request.
- NONE: the function is never activated.

17) M.C. FUNCTION

PRESENT/ABSENT: When is set PRESENT the Main Contactor is closed after the controller key-on if the initial diagnosis pass. If is set ABSENT the diagnosis are masked and M.C. is not closed after controller Key-on.

18) AUX OUT FUNCTION

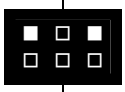
PRESENT/ABSENT: When is set PRESENT the Electro mechanic Brake is driven after a traction request if all the related diagnosis pass. If is set ABSENT the diagnosis are masked and E.B. is not closed after a traction request.

10.4.2 Config menu “ADJUSTMENTS” functions list

To enter the CONFIG MENU it is necessary to push in the same time the right side top and left side top buttons. Then roll until the ADJUSTMENTS item appears on the hand set display. Push the ENTER button.

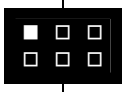
1) Opening Zapi Menu

2) Press Top Left & Right Buttons to enter CONFIG MENU



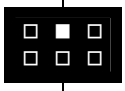
3) The Display will show: SET MODEL

4) Press ROLL UP button until ADJUSTMENTS MENU appears



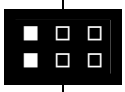
5) ADJUSTMENTS appears on the display

6) Press ENTER to go into the ADJUSTMENTS MENU



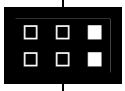
7) The display will show: SET BATTERY TYPE

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

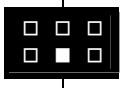


9) The desired parameter appears

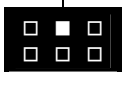
10) Press SET UP or SET DOWN button to modify the adjustment



11) Press OUT



12) Press ENTER to confirm



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

1) SET BATTERY TYPE
Selects the nominal battery voltage.

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

3) THROTTLE 0 ZONE
Establishes a deadband in the accelerator input curve.

4) THROTTLE X POINT
This parameter, together with the THROTTLE Y POINT, changes the characteristic of the accelerator input curve : when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck 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 slopes.

5) THROTTLE Y POINT
This parameter, together with the THROTTLE X POINT, changes the characteristic of the accelerator input curve (see also paragraph 13.5): when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck 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.

6) BAT. MIN ADJ.
Adjust the lower level of the battery charge table (Level 0 to 9).

7) BAT. MAX ADJ.
Adjust the upper level of the battery charge table (Level 0 to 9).

8) LOAD HM FROM MDI
When set On, the HourMeter of the Controller is transferred and recorded on the HourMeter of the MDI CAN, connected to CAN BUS network.

9) CHECK UP DONE
It can be ON/OFF. If it is ON it is possible to reset the last maintenance hour-counter and the “CHECK UP NEEDED” warning.

10) 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/DISPLAY 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

11)) MIN LIFT
This parameter stores the minimum voltage of lifting potentiometer output connected to CNA#30. The min value acquisition is done closing the Lift SW and bringing the potentiometer in its min output position.

12) MAX LIFT
This parameter stores the maximum voltage of lifting potentiometer output connected to CNA#30. The max value acquisition is done closing the Lift SW and bringing the potentiometer in its max output position.

13) MIN LOWER
%. This parameter stores the minimum voltage of lowering potentiometer output connected to CNA#30. The min value acquisition is done closing the DESCENT SW (DI1) and bringing the potentiometer in its min output

position.

14) MAX LOWER

%. This parameter stores the maximum voltage of lifting potentiometer output connected to CNA#30. The min value acquisition is done closing the DESCENT SW (DI1) and bringing the potentiometer in its min output position.

15) PWM CHOP. START

%. This parameter stores the PWM value applied to MC coil and AUX COIL for the first second of the output activation. It is expressed in percentage of battery voltage.

16) PWM CHOP. WORK

%. This parameter stores the PWM value applied to MC coil and AUX COIL after the first second of the output activation. It is expressed in percentage of battery voltage.

17) PWM ON MAIN CONT

- OFF: the inverter applies the battery voltage to the loads on the main contactor coil connected to CNA#12.
- ON: the PWM reduces the voltage on the main contactor coil down to the value programmed with “PWM CHOP. START” and “PWM CHOP. WORK” parameters.

18) PWM ON AUX OUT

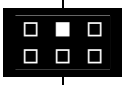
- OFF: the inverter applies the battery voltage to the loads on the auxiliary output coil connected to CAN#4.
- ON: the PWM reduces the voltage on the main contactor coil down to the value programmed with “PWM CHOP. START” and “PWM CHOP. WORK” parameters.

10.4.3 Main menu “PARAMETER CHANGE” functions list

To enter the MAIN MENU’ it is just necessary to push the ENTER button from the home display in the hand set.

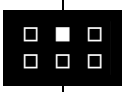
1) Opening Zapi Menu

2) Press ENTER to go into the General Menu



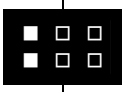
3) The Display will show: PARAMETER CHANGE

4) Press ENTER to go into the Parameter Change menu



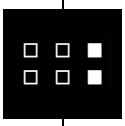
5) The Display will show the first parameter

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



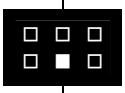
7) The names of the Parameters appear on the Display

8) When the desired Parameter appears, it’s possible to change the Level by pressing either SET UP or SET DOWN buttons.

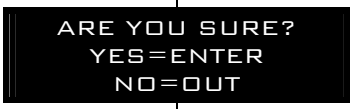


9) The Display will show the new level.

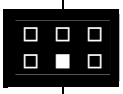
10) When you are satisfied with the result of the changes you have made, press OUT.



11) The Display asks: “ARE YOU SURE?”



12) Press ENTER to accept the changes, or press OUT to discard them.



13) The Display will show

1) ACCELER. DELAY
Seconds. It determines the acceleration ramp. The parameter sets the time needed to speed up the traction motor from 0Hz to 100Hz.

2) 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.

3) **TILLER BRAKING**
Seconds. It controls the deceleration ramp when the tiller is in braking position (released). The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz

4) **INVERS. 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.

5) **DECEL. 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.

6) **PEDAL BRAKING**
Seconds. This parameter determines the deceleration ramp when the travel request is released and the brake pedal switch is closed. It sets the time needed to decelerate the traction motor from 100Hz to 0Hz.

7) **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.

8) **MAX SPEED FWD**
Percentage. It determines the maximum speed in forward direction.

9) **MAX SPEED BWD**
Percentage. It determines the maximum speed in backward direction.

10) **HYD SPEED FINE**
Percentage. Fine adjustment of the pump motor steering function speed.

11) **HYDRO COMPENSATION**
Percentage. Adjustment of the compensation function when the pump motor steering function is active.

12) **CUTBACK SPEED 1**
Typically from 10% to 100%. It determines the percentage of the max speed applied when the cutback switch 1, CNA#6 connector, is active. When set to 100% the speed reduction is ineffective.

13) **H&S CUTBACK / CB2**
Typically from 10% to 100%. It determines the percentage of the max speed applied when the Hard & Soft function (or cutback 2 function if "H&S FUNCTION" is ABSENT), CNA#29 connector, is active. When set to 100% the speed reduction is ineffective.

14) **FREQUENCY CREEP**
Hz value. This is the minimum speed applied when the forward or reverse switch is closed, but the accelerator is at its minimum.

15) **MAXIMUM CURRENT**
Maximum level of the current (percentage of the maximum current of the

controller).

16) ACCELERATION SMOOTH
It gives a parabolic form to the acceleration ramp.

17) INVERSION SMOOTH
It gives a parabolic form to the acceleration ramp after a direction inversion.

18) STOP SMOOTH
Hz. It sets the level of frequency where the smooth effect of the acceleration parabolic form ends.

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

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

21) 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.

22) HYDRO TIME
Sec. It determines the time duration the pump motor is driven after the hydraulic request is released.

23) PUMP IMAX
Level 0 to 9. Set the maximum current for the pump motor.

24) PUMP ACCELERATION DELAY
In seconds. Set the acceleration ramp for the pump motor.

25) PUMP DECELERATION DELAY
In seconds. Set the deceleration ramp for the pump motor.

26) SPEED LIMIT
Percentage. It limits the maximum speed of the lifting function. Percentage of the maximum voltage applied to the pump motor.

27) CREEP SPEED
Percentage. It sets the minimum speed (percentage of voltage applied) for the pump motor. Percentage of the maximum voltage applied to the pump motor when the Lift SW is closed.

28) COMPENSATION
From 0% to 100% This parameter sets the voltage compensation (ΔV) applied to the motor when the proportional lifting function is active. The value of this ΔV applied to the motor is a function of the motor current. Aim of this function is to reduce, as for as possible, the speed difference between the truck loaded and unloaded.

29) MIN EVP
0 to 100. This parameter determines the minimum voltage applied on the EVP1 when the position of the potentiometer is at the minimum. This

parameter is not effective if the EVP1 is programmed like a On/Off valve.

30) MAX EVP

0 to 100. This parameter determines the maximum voltage applied on the EVP1 when the position of the potentiometer is at the maximum. If the EVP1 is programmed like a On/Off valve this parameter determines the fixed voltage applied on the electrovalve coil.

31) MIN EVP2

0 to 100. This parameter determines the minimum voltage applied on the EVP2 when the position of the potentiometer is at the minimum. This parameter is not effective if the EVP2 is programmed like a On/Off valve.

32) MAX EVP2

0 to 100. This parameter determines the maximum voltage applied on the EVP2 when the position of the potentiometer is at the maximum. If the EVP2 is programmed like a On/Off valve this parameter determines the fixed voltage applied on the electrovalve coil.

33) EVP OPEN DELAY

In seconds. It defines the opening ramp of the EVP1 electrovalve when related output is set as Analog (refer to Set Option menu).

34) EVP CLOSE DELAY

In seconds. It defines the closing ramp of the EVP1 electrovalve when related output is set as Analog (refer to Set Option menu).

35) EVP OPEN DELAY2

In seconds. It defines the opening ramp of the EVP2 electrovalve, when related output is set as Analog (refer to Set Option menu).

36) EVP CLOSE DELAY2

In seconds. It defines the closing ramp of the EVP2 electrovalve, when related output is set as Analog (refer to Set Option menu).

37) BACK SPEED

This is the percentage of the max speed that the traction can reach when the inching function is active. The inching function can be used only if the option TILLER SWITCH is set to SEAT.

38) BACKING TIME

This is the time duration of the inching function.

PARAMETER	UNIT	PROGRAMMED LEVEL									
		0	1	2	3	4	5	6	7	8	9
ACCELERATION DELAY	Sec.	From 0 to 10 sec., resolution of 0.1									
RELEASE BRAKING	Sec.	From 0 to 10 sec., resolution of 0.1									
TILLER BRAKING	Sec.	From 0 to 10 sec., resolution of 0.1									
INVERSION BRAKING	Sec.	From 0 to 10 sec., resolution of 0.1									
DECEL. BRAKING	Sec.	From 0 to 10 sec., resolution of 0.1									
PEDAL BRAKING	Sec.	From 0 to 10 sec., resolution of 0.1									
SPEED LIMIT BRAKING	Sec.	From 0 to 10 sec., resolution of 0.1									
MAX SPEED FW	%	From 0% to 100%, resolution of 1%									
MAX SPEED BW	%	From 0% to 100%, resolution of 1%									
CUTBACK SPEED 1	%Max Sp	From 0% to 100%, resolution of 1%									
H&S CUTBACK / CB2	%Max Sp	From 0% to 100%, resolution of 1%									
FREQUENCY CREEP	Hz	From 0.6 to 4.0 Hz, resolution of 0.1 Hz									
MAXIMUM CURRENT	%IMAX	From 0% to 100%, resolution of 1%									
ACC SMOOTH	Num.	From 1 to 5, resolution 0,1									
INV SMOOTH	Num.	From 1 to 5, resolution 0,1									
STOP SMOOTH	Hz	From 3 to 20 Hz, resolution of 1Hz									
BRK SMOOTH	Num.	From 1 to 5, resolution 0,1									
STOP BRAKE SMOOTH	Hz	From 3 to 20 Hz, resolution of 1Hz									
AUXILIARY TIME	Sec.	From 0 to 10 sec., resolution of 0.1									
HYDRO TIME	Sec.	From 0 to 10 sec., resolution of 0.1									
PUMP IMAX	%	From 50% to 100% of IMAX, resolution of 5%									
PUMP ACC. DELAY	Sec.	From 0 to 10 sec., resolution of 0.1									
PUMP DEC. DELAY	Sec.	From 0 to 10 sec., resolution of 0.1									
SPEED LIMIT	%	From 0% to 100%, resolution of 1%									
CREEP SPEED	%	From 0% to 100%, resolution of 1%									
COMPENSATION	%	From 0% to 100%, resolution of 1%									
HYD SPEED FINE	%	From 0% to 100%, resolution of 1%									
HYDRO COMPENSATION	%	From 0% to 100%, resolution of 1%									
MIN EVP	%	From 0% to 100%, resolution of 0.1%									
MAX EVP	%	From 0% to 100%, resolution of 0.1%									
MIN EVP2	%	From 0% to 100%, resolution of 0.1%									
MAX EVP2	%	From 0% to 100%, resolution of 0.1%									
EVP OPEN DELAY	Sec.	From 0 to 25.5 sec., resolution of 0.1									
EVP CLOSE DELAY	Sec.	From 0 to 25.5 sec., resolution of 0.1									
EVP OPEN DELAY2	Sec.	From 0 to 25.5 sec., resolution of 0.1									
EVP CLOSE DELAY2	Sec.	From 0 to 25.5 sec., resolution of 0.1									
BACK SPEED	%	From 0% to 100%, resolution of 1%									
BACKING TIME	Sec.	From 0 to 10 sec., resolution of 1									

10.4.4 Zapi menu “SPECIAL ADJUSTMENTS” functions list

Note: the below set-up description is for skilled persons only: if you aren’t, please keep your hands off. To enter this Zapi hidden menu a special procedure is required. Ask for this procedure, directly to a Zapi technician.
In the SPECIAL ADJUSTMENTS functions list, there are factory adjusted parameters only.

1) **ADJUSTMENT #01**
(Factory adjusted). % value. This is the Gain of the first Current Sensing Amplifier of traction motor.
NOTE: only Zapi technicians should change this value

2) **ADJUSTMENT#02**
(Factory adjusted). % value. This is the Gain of the second Current Sensing Amplifier of traction motor.
NOTE: only Zapi technicians should change this value

3) **SET CURRENT**
(Factory adjusted). This is the traction motor maximum current.

4) **SET TEMPERATURE**
Set the temperature offset to have the correct value reading. This is a fine calibration of the controller temperature sensor.

5) **ADJUSTMENT#03**
(Factory adjusted). % value. This is the gain of the Current Sensing Amplifier of pump motor.

6) **SET CURRENT PUMP**
(Factory adjusted). This is the pump motor maximum current.

7) **HIGH ADDRESS**
To be used to have access to special memory address.
NOTE: only Zapi technicians should change this value

8) **DITHER AMPLITUDE**
It is the dither signal amplitude. The dither signal is a square wave which is overlapped to the proportional valves set point. In this way the proportional valves response to set point variations is optimized. This parameter is a percentage of the valves maximum current. It can be adjusted in the 0% to 20.3% by nine levels. Setting the parameter to 0% means the dither isn’t used.

9) **DITHER FREQUENCY**
It is the dither signal frequency. It can be used one of three:
- 0: the dither signal frequency is 62.5 Hz
- 1: the dither signal frequency is 83 Hz
- 2: the dither signal frequency is 125 Hz.

10.4.5 Main menu “TESTER” functions list

The TESTER functions are a real time feedback measurements of the state of the controller/motor/command devices. It is possible to know the state (active / off) of the digital I/Os, the voltage value of the analog inputs and the state of the main variables used in the motor and hydraulics control. Enter the home page in the hand-set display and roll for the TESTER item.

1) **BATTERY VOLTAGE**
   Voltage value with 1 decimal digit. Battery voltage value measured at the key on.

2) **BATTERY CURRENT**
   Battery current in Ampere. This value is not directly measured by the controller but is software computed through the instantaneous values of battery voltage and percentage of charge.

3) **MOTOR VOLTAGE**
   Percentage value. It is the voltage generated by the inverter expressed in percent of the actual battery voltage. 100% means the sine wave width is close to the actual battery voltage; 0% means the sine wave width is null.

4) **VOLTAGE BOOSTER**
   Percentage value. It is the booster contribute to the voltage really supplied to the motor expressed in per cent of the actual battery voltage. (Note: when DC_LINK COMPENSATION is set ON, the VOLTAGE BOOSTER reading will not match perfectly the booster setting because this latest one is calculated respect to the nominal battery voltage; VOLTAGE BOOSTER is expressed respect to the actual battery voltage).

5) **FREQUENCY**
   Hz value. This is the frequency of the sine waves the inverter is supplying.

6) **ENCODER**
   Hz value. This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.

7) **SLIP VALUE**
   Hz value. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).

8) **CURRENT RMS**
   Ampere value. Root Mean Square value of the line current in the motor.

9) **BATTERY CHARGE**
   Percentage value. It supplies the residual charge of the battery as a percentage of the full charge level.

10) **TEMPERATURE**
    °C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.

11) **MOTOR TEMPERATURE**
    °C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning in the hand set

when the motor temperature overtakes the MOTOR OVERTEMP setting.

12) PUMP CURRENT
Ampere. It is the continuous current in the pump motor.

13) PUMP VMN
It is the voltage applied to the pump motor. Expressed in percentage of the maximum voltage.

14) ACCELERATOR
From 0.0V to 5.0V. The voltage on the wiper of the accelerator (CPOT on CNA#15) is halved inside the controller and then recorded on this reading. That means the actual wiper voltage is in the range 0 to 10V meanwhile the corresponding ACCELERATOR reading is in the range 0.0 to 5.0Vdc.

15) LIFTING CONTROL
From 0.0 to 5.0V. The voltage on the wiper of the accelerator (CPOTLIFT on CNA#30) is halved inside the controller and then recorded on this reading.That means the actual wiper voltage is in the range 0 to 10V meanwhile the corresponding ACCELERATOR reading is in the range 0.0 to 5.0Vdc

16) DI0/TILLER SWITCH
ON/OFF. This is the level of the digital input CNA#1 for the Tiller input.
- ON +VB = When it is closed to a battery (key) voltage, the Tiller input is Active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the Tiller input is not active.

17) DI1/DESCENT SWITCH
ON/OFF. This is the level of the digital input CNA#20 for the Lowering request:
- ON +VB = When it is closed to a battery (key) voltage, the Lowering request is Active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the Lowering request is not active.

18) DI2/CUTBACK SWITCH
ON/OFF. This is the level of the digital input CNA#6:
- ON GND = When it is not closed to a battery (key) voltage (or connected to GND) the CUTBACK request is active.
- OFF +VB = When it is closed to a battery (key) voltage the CUTBACK request is not active.

19) DI3/FORWARD SWITCH
ON/OFF. This is the level of the digital input CNA#32 for the forward travel demand:
- ON +VB = When it is closed to a battery (key) voltage, the Forward Travel demand is Active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the Forward Travel demand is not active.

20) DI4/REV SWITCH
ON/OFF. This is the level of the digital input CNA#31 for the backward travel demand:

- ON +VB = When it is closed to a battery (key) voltage, the Backward Travel demand is Active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the Backward Travel demand is not active.

21) DI5/HORN SWITCH

ON/OFF. This is the level of the digital CNA#19:

- ON +VB = When it is closed to a battery (key) voltage the HORN request is active.
- OFF GND = When it is not closed to a battery (key) voltage (or connected to GND) the HORN request is not active.

22) DI6/BELLY SWITCH

ON/OFF. This is the level of the digital input CNA#7 (belly button):

- ON +VB = When it is closed to a battery (key) voltage, the request of the Belly (to stop the movement) is active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the Belly request is not active.

23) DI7/LIFT SWITCH

ON/OFF. This is the level of the digital input CNA#35:

- ON +VB = When it is closed to a battery (key) voltage the voltage the LIFTING request is active.
- OFF GND = When it is not closed to a battery (key) voltage (or connected to GND) the voltage the LIFTING request is not active.

24) DI8 / BACKING FOR

ON/OFF. This is the level of the digital input CNA#17 for the inching forward request:

- ON +VB = When it is closed to a battery (key) voltage the forward inching demand is active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND) the forward inching demand is not active.

25) DI9/ H&S SWITCH [H&S FUNCTION option PRESENT]

ON/OFF. This is the level of the digital input CNA#29 for the Hard & Soft request. With the H&S service is possible to turn the truck moving (at reduced speed) only by acting the H&S switch, and the accelerator, without to let down the tiller :

- ON +VB = When it is closed to a battery (key) voltage, the H&S request is Active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the H&S request is not active.

26) DI9/CUTBACK SWITCH 2 [H&S FUNCTION option ABSENT]

ON/OFF. This is the level of the digital input CNA#29:

- ON GND = When it is not closed to a battery (key) voltage (or connected to GND) the CUTBACK2 request is active.
- OFF +VB = When it is closed to a battery (key) voltage the CUTBACK2 request is not active

27) DI10 / BACKING REV

ON/OFF. This is the level of the digital input CNA#16 for the inching reverse request:

- ON +VB = When it is closed to a battery (key) voltage, the reverse

inching demand is active.
- OFF GND = When it is not connected to a battery (key) voltage (or it is connected to GND), the reverse demand is not active.

28) DI11 SWITCH

ON/OFF. This is the level of the CNA#18 digital input:
- ON GND = When CNA#18 is not closed to a battery (key) voltage (or connected to GND) the digital input#11 is active.
- OFF +VB = When CNA#18 is closed to a battery (key) voltage the digital input#11 is not active.

29) DI12 SWITCH

ON/OFF. This is the level of the digital input CNA#21:
- ON +VB = When it is closed to a battery (key) voltage the digital input#12 is active.
- OFF GND = When it is not closed to a battery (key) voltage (or it is connected to GND) the digital input#12 is not active.

30) SET POINT EVP

This parameter shows the setpoint of EVP valve.

31) SET POINT EVP2

Show the percentage of voltage applied to EVP2 valve.

32) OUTPUT EV1

On/Off: determines if the valve EV1 or EV5 are open or closed.

33) OUTPUT EV2

On/off: determines if the valve EV2 is open or closed.

34) OUTPUT EV3

On/off: determines if the valve EV3 is open or closed.

35) OUTPUT EV4

On/off: determines if the valve EV4 is open or closed.

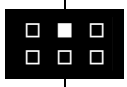
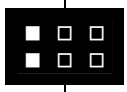
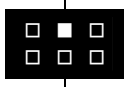
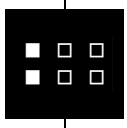
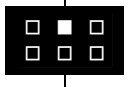
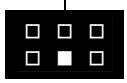
11 OTHER FUNCTIONS

11.1 Description of console “SAVE” function

The SAVE function allows the operator to transmit the Parameter values and Configuration data of the controller 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 controller using the RESTORE function.
The data that is available via the SAVE function are listed here below:

- 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.

Opening Zapi Display	
Press ENTER to go into the General menu	
The Display will show :	
Press ROLL UP or ROLL DOWN button until SAVE PARAM. appears on the display	
The Display will show :	
Press ENTER to go into the SAVE function	
If this feature has been used before, the type of controller data stored appears on the top Main with a 2 digit reference	
Keep pressing either ROLL UP or ROLL DOWN keys until the second Main indicates a FREE storage facility	
Press ENTER to commence SAVE routine	
You can see the items that are being stored whilst the SAVE routine is happening	
When finished, the Console shows :	
Press OUT to return to the Opening Zapi Display	

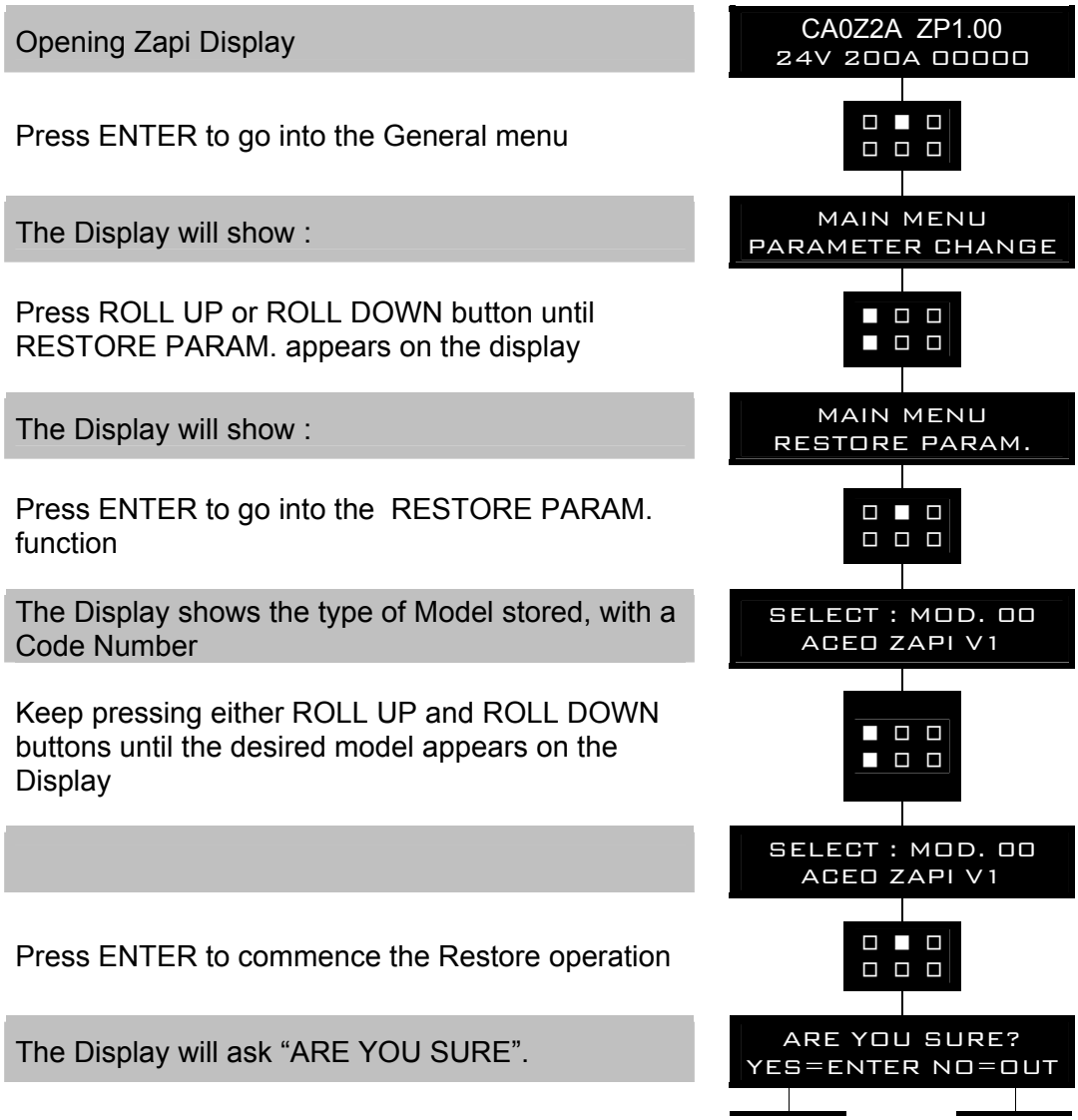
NOTE: in reality the SAVE and RESTORE function requires the Windows PC-Console.

11.2 Description of console “RESTORE” function

The RESTORE PARAM function allows transfer of the Console’s stored data into the memory of the controller. This is achieved in a fast and easy way using the method previously used with the SAVE PARAM. function.
The data that is available on the RESTORE PARAM. Function are listed here below:

- 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 controller memory will be written over and replaced with data being restored.
Flow Chart showing how to use the RESTORE function of the Digital Console.

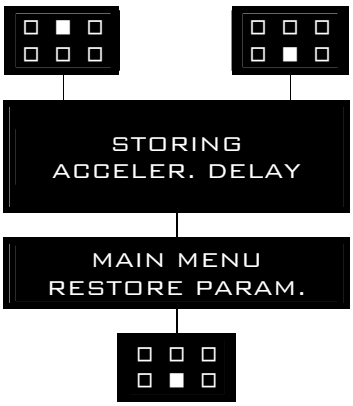


Press ENTER for YES, or OUT for No

You can see the items that are being stored in the chopper memory whilst the RESTORE routine is happening

When finished, the Console shows :

Press OUT to return to the Opening Zapi Display

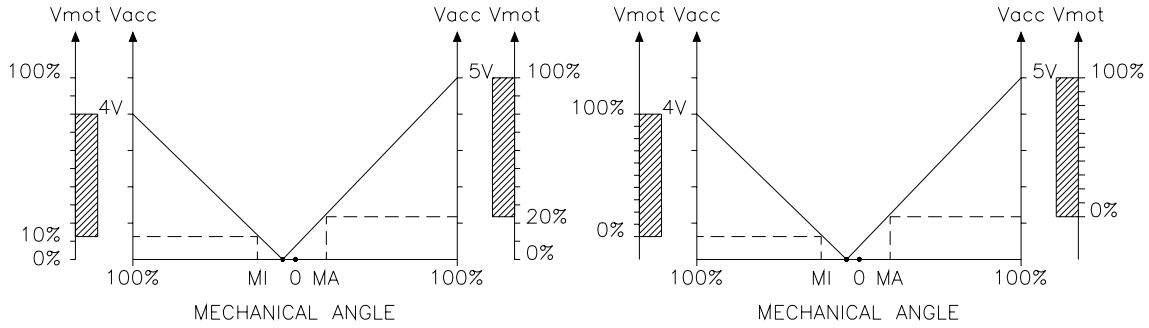


NOTE: in reality the SAVE and RESTORE function requires the Windows PC-Console.

11.3 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.

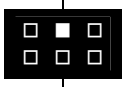


This function looks for and remembers the minimum and maximum potentiometer wiper voltage over the full mechanical range of the pedal. It enables compensation for non symmetry of the mechanical system between directions. The operation is performed by operating the pedal after entering the PROGRAM VACC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

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

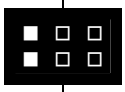
Opening Zapi Display

Press ENTER to go into the General menu



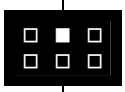
The Display will show :

Press ROLL UP or ROLL DOWN button until PROGRAM VACC the display



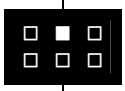
The Display will show :

Press ENTER to go into the PROGRAM VACC function



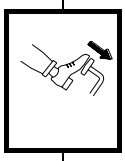
The Display will show the minimum and maximum values of potentiometer wiper output.
Both directions can be shown

Press ENTER to clear these values.
Display will show 0.0



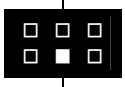
Select Forward Direction, close any interlock switches that may be in the system

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.



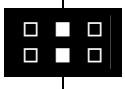
Select the Reverse Direction and repeat Item 10

When finished , press OUT



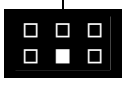
The Display will ask : ARE YOU SURE ?

Press ENTER for yes, or OUT for NO



When finished, the Console shows :

Press OUT to return to the Opening Zapi Display



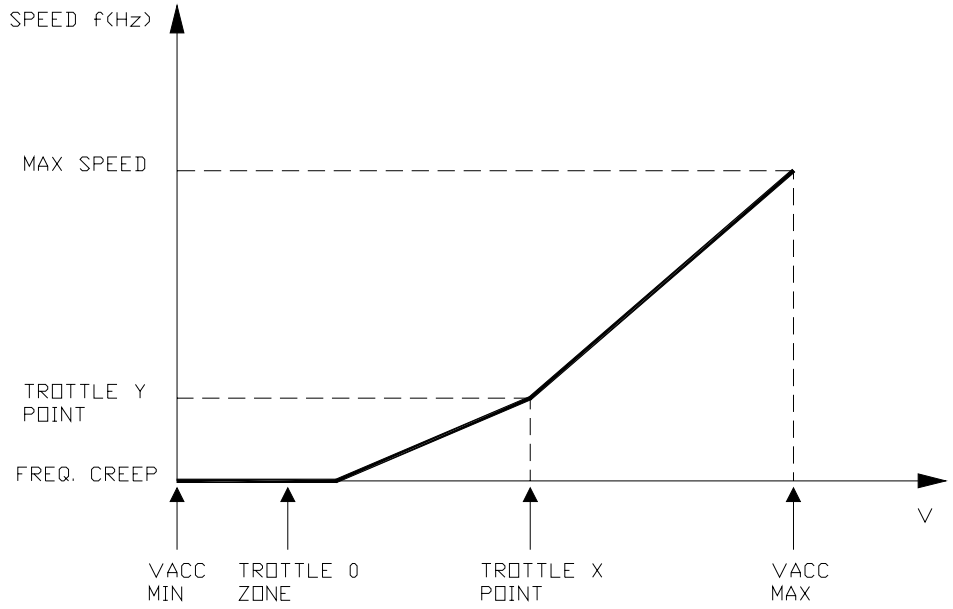
11.4 Description of the throttle regulation

This regulation applies a not linear relationship between the position of the accelerator and the speed of the truck. The main goal is to increase the resolution for the speed modulation when the truck is slowly moving.
Three adjustments are used for the throttle regulation:

1) THROTTLE 0 ZONE
2) THROTTLE X POINT
3) THROTTLE Y POINT

THROTTLE 0 ZONE: the speed of the truck remains at frequency creep meanwhile the voltage from the accelerator potentiometer is lower than this percentage of the MAX VACC setting. This adjustment define the width of a dead zone close to the neutral position.

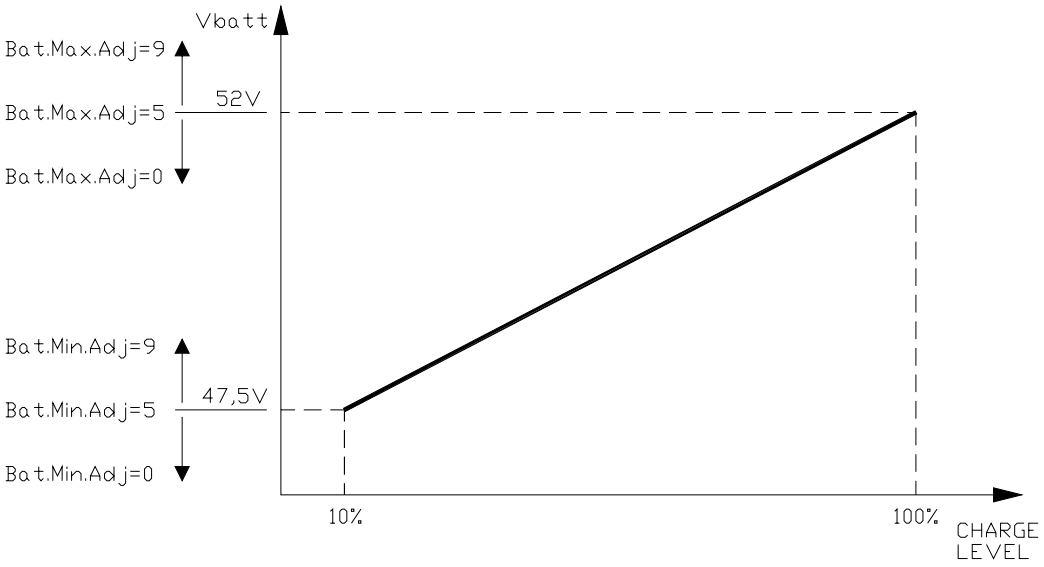
THROTTLE X POINT & THROTTLE Y POINT: the speed of the truck grows up with a fixed slope (linear relationship) from the THROTTLE 0 ZONE up to THROTTLE X POINT. This slope is defined by the matching between the X point percentage of the MAX VACC setting with the Y point percentage of the full truck speed.
From the X point up to the MAX VACC point, the slope of the relationship between the truck speed and the accelerator position is different (see figure below) to match the full speed in the truck with the MAX VACC voltage in the accelerator position.



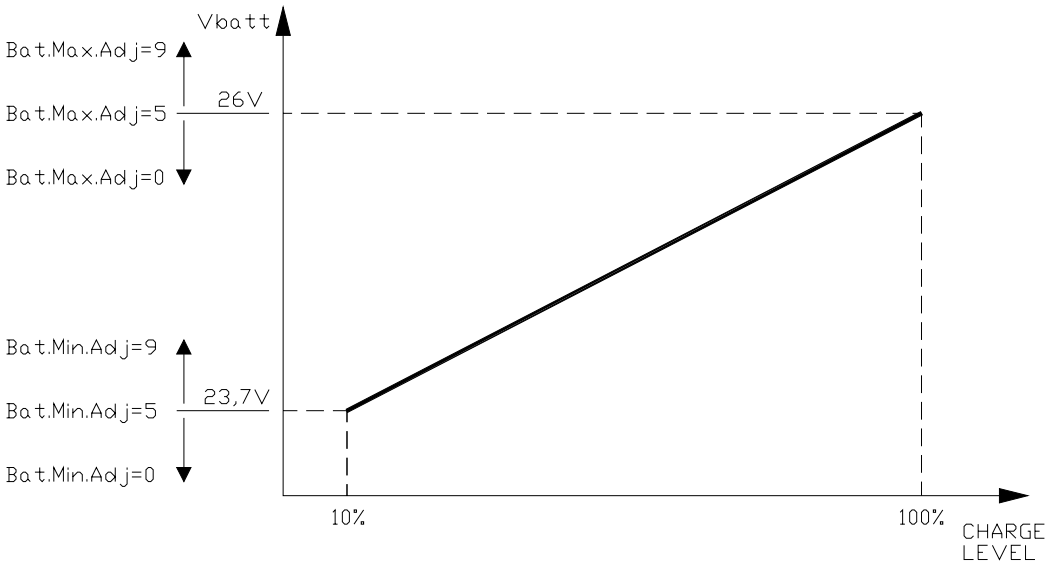
11.5 Description of the battery charge detection setting

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



The Battery Charge detection follows this algorithm:

1) Battery voltages is read when the Battery current is zero, that is when the output power stage is not driven.
2) Vbatt is the mean of the least samples measured by the microcontroller converter (the samples are took on key input).
3) Vbatt is compared with a threshold value (function of the actual charge percentage) in a table and with comparison is found a new charge percentage.
4) Thresholds value can be changed with parameters Bat. Max. Adj. and Bat. Min. Adj.
5) After key on battery charge can be only increased if the battery charge computed after key on is greater than the last value stored in Eeprom the battery charge value is updated otherwise the Battery charge is not updated.

12 ACE0 / COMBI AC0 ALARMS LIST

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.

12.1 Faults diagnostic system

The fault diagnostic system of ACE0/ COMBI AC0 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 regen 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, ….)

12.2 Alarms overview

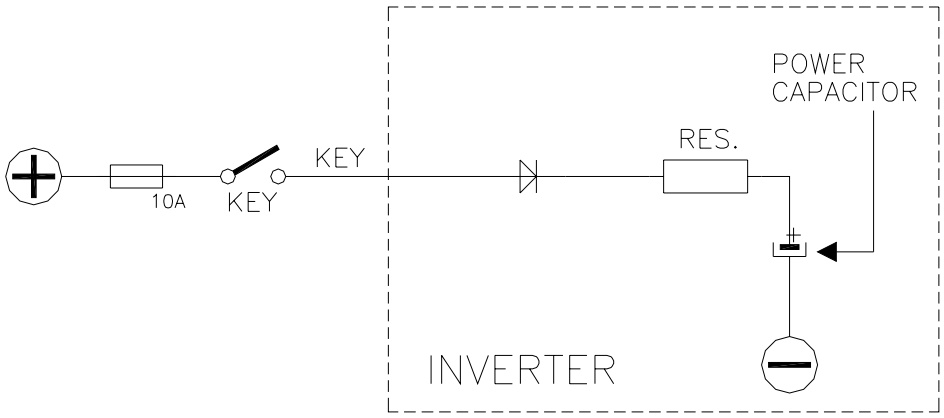
Error Code	Description	Effect	Machine status when the test is done	Restart procedure
Capacitor charge - MDI CAN 60	Power capacitors voltage does not increase	Valve, pump, traction stopped, Lc opened, Eb applied	start-up	Valve or pump or traction request
Vmn low - MDI CAN 72	Motor output voltage lower than expected	Valve, pump, traction stopped, Lc opened, Eb applied	start-up, traction	Valve or pump or traction request
Vmn high - MDI CAN 31	Motor output voltage higher than expected	Valve, pump, traction stopped, Lc opened, Eb applied	start-up, traction	Valve or pump or traction request
Power mos shorted - MDI CAN 89	Short circuit on the power mosfets	Valve, pump, traction stopped, Lc opened, Eb applied	start-up	Valve or pump or traction request
Coil shorted - MDI CAN 76	Shortcircuit on LC or EB coil	Valve, pump, traction stopped, Lc opened, Eb applied	stby, traction	Valve or pump or traction request
Driver shorted - MDI CAN 74	Driver of LC coil is shorted, so it is not able to open the LC, or LC coil is disconnected	Valve, pump, traction stopped, Lc opened, Eb applied	start-up	Valve or pump or traction request
Contactor Driver - MDI CAN 75	Driver of LC coil is damaged (not able to close)	Valve, pump, traction stopped, Lc opened, Eb applied	stby, traction	Valve or pump or traction request
Contactor Open - MDI CAN 77	The LC coil has been driven but LC does not close	Valve, pump, traction stopped, Lc opened, Eb applied	stby, traction	Valve or pump or traction request
Contactor closed - MDI CAN 75	LC contact is stuck	Valve, pump, traction stopped, Lc opened, Eb applied	start-up	Valve or pump or traction request
Aux driv. Shrt. - MDI CAN 40	When the mos of EB is shorted	Valve, pump, traction stopped, Lc opened, Eb applied	start-up,stby,marcia	Valve or pump or traction request
Aux driver open - MDI CAN 42	Driver of EB coil is damaged (not able to close)	Valve, pump, traction stopped, Lc opened, Eb applied	stby, traction	Valve or pump or traction request
Pos. EB shorted - MDI CAN 86	Output of built in Smart Driver, which supplies Eb coil positive, is high (= +batt) when the tiller switch is opened.	Valve, pump, traction stopped, Lc opened, Eb applied	start-up	Valve or pump or traction request
Logic Fail. #1 - MDI CAN 54	Overvoltage/Undervoltage condition has been detected	Valve, pump, traction stopped, Lc opened, Eb applied	start-up	Valve or pump or traction request
Logic Fail. #2 - MDI CAN 55	Motor voltage feedback circuits are damaged	Valve, pump, traction stopped, Lc opened, Eb applied	stby, immediately after Lc closing	Valve or pump or traction request
Logic fail. #3 - MDI CAN 17	Failure in the high current HW protection circuit	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby	Valve or pump or traction request
Stby i high - MDI CAN 53	In stby condition (no current applied to the traction motor) the current feedbacks are aout of permitted stby range	Valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby	Valve or pump or traction request
Wrong Set Battery - MDI CAN 41	The battery voltage is too low or too high (< 0,8 Vbatt OR > 1,2 Vbatt)	Valve, pump, traction stopped, Lc opened, Eb applied	start-up, stand-by (only immediately after Lc closing)	Valve or pump or traction request
Analog input - MDI CAN 96	Problem on the A/D conversion of uC	Valve, pump, traction stopped, Lc opened, Eb applied	traction	Valve or pump or traction request
Encoder Error - MDI CAN 82	Problem on the encoder	Valve, pump, traction stopped, Lc opened, Eb applied	traction	Valve or pump or traction request
Tiller error - MDI CAN 77	Input mismatch between hard&soft switch input and tiller input	Valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby, traction	Valve or pump or traction request
Watchdog - MDI CAN 08	One of two (or both) Watchdog circuit outputs becomes high due to an HW or SW problem	Valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby, traction	Key re-cycle

Error code	Description	Effect	Machine status when the test is done	Restart procedure
Smart driver KO - MDI CAN 68	Smart driver is open, not able to provide EB positive	valve, pump, traction stopped, Lc opened	start-up	Key re-cycle
Key-off shorted - MDI CAN 76	Key-off signal is low at Key-on	valve, pump, traction stopped, Lc opened	start-up	Key re-cycle
Evp1 not ok - MDI CAN 48	Evp driver is failed shorted (always ON) mismatch between the valve set-point and its feedback	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby	valve or pump or traction request
Evp2 not ok - MDI CAN 47	Evp2 driver is failed shorted (always ON) mismatch between the valve set-point and its feedback	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby	valve or pump or traction request
Pump Vmn Low - MDI CAN 28	Pump motor output is too low, with respect to pwm applied	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby, during pump function	valve or pump or traction request
Pump Vmn High - MDI CAN 29	Pump motor output is too high, with respect to pwm applied	valve, pump, traction stopped, Lc opened, Eb applied	during pump function	valve or pump or traction request
Wrong Zero - MDI CAN code alarm 53	The outputs of the amplifiers (used to measure the motor voltage) are cheked this alarm occurs when voltage signals >3V or <2V at the init	valve, pump, traction stopped, Lc opened, Eb applied	init	valve or pump or traction request
Evp1 coil open - MDI CAN 50	The Evp1 coil is not connected between Paux and NEVP1 output, and the parameter EVP TYPE in the set-option menu is set Analog or Digital	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby, traction	valve or pump or traction request
Evp2 coil open - MDI CAN 51	The Evp2 coil is not connected between Paux and NEVP2 output, and the parameter EVP TYPE in the set-option menu is set Analog or Digital	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby, traction	valve or pump or traction request
Aux Batt. Short - MDI CAN code alarm 74	When the positive of the AUX OUTPUT is driven by the tiller, the positive is high and the tiller is released.	valve, pump, traction stopped, Lc opened, Eb applied	start-up, stby	
Emergency - MDI CAN code alarm 80	The PAUX connector (A3) is not connected to the battery or the voltage is different.	valve, pump, traction stopped, Lc opened, Eb applied	continuous	
Flash Checksum - MDI CAN 08	The software is corrupted or the flash on the inverter is damaged.	valve, pump, traction stopped, Lc opened, Eb applied	continuous	
Current Sens. KO - MDI CAN 26	The current sensor is damaged.	valve, pump, traction stopped, Lc opened, Eb applied	continuous	
Phase KO - MDI CAN 27	One of the motor phases is open	valve, pump, traction stopped, Lc opened, Eb applied	continuous	

12.3 Analysis and troubleshooting of microcontroller alarms

To Enter the MAIN MENU' push the Enter button at the Home Page of the hand set display and Roll for the ALARMS item. Here is the ALARMS list:

1) "CAPACITOR CHARGE"
   Follows the charging capacitor system:



When the key is switched ON, the inverter tries to charge the power capacitors through a power resistance, and check if the capacitor are charged within a timeout. If they do not charge, an alarm is signalled; the main contactor is not closed.

Troubleshooting:

A) There is an external load in parallel to capacitor bank, which sinks current from the controller capacitors precharging circuit, thus preventing the caps from charging. Check if a lamp or a dc/dc converter or a auxiliary load is placed in // to capacitor bank.
B) The charging resistance is opened; insert a power resistance across line contactor power terminals; if the alarm disappears, it means the controller internal charging resistance is damaged.
C) The charging circuit has a failure, inside the controller.
D) There is a problem in the controller power section.

2) "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 does not increase, 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, fault status is entered.

Troubleshooting:

A) 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

B) 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.

3) “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 do not decrease, 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:

A) 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

B) 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

4) “POWER MOS SHORTED”

Cause: Before switching the LC 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 comands, this alarm occurs.

Troubleshooting:

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

5) “COIL SHORTED”

Cause:

This alarm occurs when there is a short circuit of one of the coils connected to outputs of the Combiac0 (LC coil or EB coil). After the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

Troubleshooting:

A) 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.

B) In case no failures/problems have been found externally, the problem is in the controller, which has to be replaced.

6) “DRIVER SHORTED”

Cause:

The driver of the main contactor coil is shorted or the coil is disconnected.

Troubleshooting:

A) Check if there is a short or a low impedance pull-down between NMCC

CNA#12 and –BATT.
B) The driver circuit is damaged in the controller, which has to be replaced.
C) The wires to the LC coil are interrupted or not connected, so check the coil related harness.

7) “CONTACTOR DRIVER”
Cause:
The LC 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 controller.

8) “CONTACTOR OPEN”
Cause:
The main contactor coil has been driven by the controller, but the contactor does not close.
Troubleshooting:
It could be also a problem of the contact in the LC that is not working (does not pull-in), try replacing the LC.

9) “CONTACTOR CLOSED”
Cause:
Before driving the LC 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 they don’t discharge the fault condition is entered.
Troubleshooting:
It is suggested to verify the power contacts of LC; to replace the LC is necessary.

10) “AUX DRIVER SHORTED”
Cause:
The driver of the electromechanical brake coil is shorted.
Troubleshooting:
A) Check if there is a short or a low impedance pull-down between NEB CNA#4 and –BATT.
B) The driver circuit is damaged in the controller, which has to be replaced.

11) “AUX DRIVER OPEN”
Cause:
The driver of the electromechanical brake coil is not able to drive the load.
Troubleshooting:
Replace the controller.

12) “POS EB SHORTED”
Cause:
The output of the built in Smart Driver, which supplies the positive to the Electromechanical brake coil is high when the Tiller and the H&S switch are open.
Troubleshooting:
A) It is suggested to check the harness, in order to verify if a positive is connected to the Smart driver output CNA#2.
B) If, even disconnecting the wire from the connector pin, the output stays at high value, the problem is inside the controller and the Smart Driver is probably shorted.

13) “LOGIC FAILURE #1”

This fault is displayed when the controller detects an overvoltage or undervoltage condition. Overvoltage threshold is 35V, undervoltage threshold is 9,5V in the 24V controller. In 48V controller overvoltage threshold is 65V, undervoltage threshold is 9,5V.

Troubleshooting of fault displayed at startup or in standby; in these cases it is very likely the fault is due to an undervoltage, so it is suggested to check:

A) Key input signal down-going pulses (below undervoltage threshold) due to external loads, like DC/DC converters starting-up, relais or contactor switching, solenoids energizing / deenergizing.
B) 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 controller.

Troubleshooting of fault displayed during motor driving; in this case it can be an undervoltage or a overvoltage condition.

A) If the alarm happens during traction acceleration or driving hydraulic functions, it is very likely it is an undervoltage condition; check battery charge condition, power cable connection.
B) If the alarm happens during release braking, it is very likely it is due to overvoltage condition; check line contactor contact, battery power cable connection.

14) “LOGIC FAILURE #2”

Cause:

Fault 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 Controller.

15) “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 controller.

16) “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.

17) “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:

A) Check that the controller SET BATTERY parameter value matches the battery nominal voltage.
B) Check that the TESTER MENU / BATTERY VOLTAGE parameter shows

same value as the battery voltage measured with a voltmeter. If it is does not match, then do a “ADJUST BATTERY” function.

C) Replace the battery.

18) “ANALOG INPUT”

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 the controller.

19) “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:

A) Check both the electric and the mechanical encoder functionality, the wires crimping.

B) Check the encoder mechanical installation, if the encoder slips inside its compartment raising this alarm condition.

C) Also the electromagnetic noise on the sensor bearing can be a cause for the alarm. In these cases try to replace the encoder.

D) If the problem is still present after replacing the encoder, the failure is in the controller.

20) “TILLER ERROR”

Cause:

Mismatch between the H&S input and the tiller input.

Troubleshooting:

Check the harness related to CAN#1 and CAN#29 with a voltmeter. If the state of these inputs is right, then it could be a problem inside the controller, which has to be changed.

21) “WATCHDOG”

Cause:

This is a safety related test. It is a self diagnosis test within the logic. The watch dog circuit is composed by two monostable multivibrators so there is a double check of software execution.

Troubleshooting:

This alarm could be caused by an hardware failure in one of two (or both) multivibrator or due to a software execution problem. For both cases it is an internal fault of the controller which must be replaced.

22) “SMART DRIVER KO”

Cause:

The built in smart driver is open, not able to provide the electro mechanic brake positive.

Troubleshooting:

A) It is suggested to check the harness, in order to verify if the Smart driver output CNA#2 is shorted to –Batt.

B) If, even disconnecting the wire from the connector pin, the output stays at

low value, the problem is inside the controller and the Smart Driver is probably damaged.

23) “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:

A) 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.
B) 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 5,6Nm÷8,4Nm.
C) 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.

24) “EVP1 NOT OK”

Cause:

A) The EVP driver is shorted.
B) The microcontroller detects a mismatch between the valve set-point and the diver voltage measured on the LOWER EVP1 output.

Troubleshooting:

Check if there is a short or a low impedance between the negative of the coil and -BATT. Otherwise the driver circuit is damaged and the controller must be replaced.

25) “EVP2 NOT OK”

Cause:

A) The EVP2 driver is shorted.
B) The microcontroller detects a mismatch between the valve set-point and the diver voltage measured on the EVP2 output.

Troubleshooting:

Check if there is a short or a low impedance between the negative of the coil and –BATT. Otherwise the driver circuit is damaged and the controller must be replaced.

26) “PUMP VMN LOW”

Cause:

The pump motor output is lower than expected, considering the pwm applied.

Troubleshooting:

A) 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
B) If the problem occurs after closing the LC (the LC closed and then opens back again), check:
   - Motor connections
   - If motor windings/cables have leakages towards truck frame
   - If no problem are found on the motors, the problem is inside the controller
C) If the alarm occurs during motor running, check:

- Motor connections
- If motor 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.

27) “PUMP VMN HIGH”

Cause:

This test is carried out when the pump motor is turning (pwm applied). The pump motor output is higher than expected, considering the pwm applied.

Troubleshooting:

It is suggested to check:

A) Motor connections
B) If motor windings/cables have leakages towards truck frame
C) If no problem are found on the motors, the problem is inside the controller

28) “WRONG ZERO”

Cause:

The outputs of the amplifiers (used to measure the traction motor voltage) are checked to be included into a range . This alarm occurs when the voltage signals >3V or <2V at the init.

Troubleshooting:

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

29) ”EVP1 COIL OPEN”

Cause:

This fault appears when the LOWER EVP1 output is used (parameter “EVP TYPE” in “SET OPTION” menu is set ANALOG or DIGITAL) but no load is connected between the output and PAUX positive.

Troubleshooting:

A) It is suggested to check the harness, in order to verify if EVP1 coil is connected to the right connector pin and if it is not interrupted.
B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.

30) ”EVP2 COIL OPEN”

Cause:

This fault appears when the EVP2 output is used (parameter “EVP2 TYPE” in “SET OPTION” menu is set ANALOG or DIGITAL) but no load is connected between the output and PAUX positive.

Troubleshooting:

A) It is suggested to check the harness, in order to verify if EVP2 coil is connected to the right connector pin and if it is not interrupted.
B) If, even connecting the coil to the right pin or replacing it, the alarm is still present than the problem is inside the controller logic board, replace it.

31) “AUX BATT. SHORT”

Cause:

A) The coil on the aux output is not correctly connected.
B) The smartdriver inside the controller is damaged.

Troubleshooting:

- It is suggested to check that the coil is correctly connected between A2 and A4.
- If no problem is found on the coil, the problem is inside the controller.

32) “EMERGENCY”

Cause:

The voltage on A3 is different than +Vbatt.

Troubleshooting:

- If A3 is correctly connected to +Vbatt.
- If the fuse on A3 is not damaged.

33) “FLASH CHECKSUM”

Cause:

The software was not correctly written into the flash memory or the flash memory is damaged.

Troubleshooting:

This type of fault is not related to external components, replace the controller.

34) “CURRENT SENS. KO”

Cause:

One of the current sensor, used to measure the value of the current on the motor phases, is damaged.

Troubleshooting:

This type of fault is not related to external components, replace the controller.

12.4 Warnings overview

Error code	Description	Effect	Machine status when the test is done	Restart procedure
Slip profile - MDI CAN 99	Error on the parameters of the slip profile setting.	Traction is stopped	start-up, stand-by, traction	Traction request
Forward+backward - MDI CAN 80	The travel or inching demands are active in both directions at the same time	Traction is stopped	start-up, stand-by, traction	Traction request
Incorrect start - MDI CAN 79	Incorrect starting sequence	Traction is stopped	start-up, stand-by, traction	Traction request
Vacc not ok - MDI CAN 78	The acceleretor value is higher than the minimum value recorded, and the direction/enable switches are opened.	Traction is stopped	start-up, stand-by, traction	Traction request
Th. Protection MDI CAN 62	The controller has reached the thermal cutback temperature 85°C	Traction controller reduces the maximum current linearly from Imax (85°C) down to 0A (105°C)	continuous	
Battery low - MDI CAN 65	Battery is <= 10% when the parameter BATTERY CHECK is set >0	The maximum current is reduced to half and speed is reduced (if CHECK OPTION = 1)	continuous	
Eeprom ko - MDI CAN 71	Error is detected in eeprom or in eeprom management	Controller works using Deafult parameters	continuous	
Motor temperature - MDI CAN 65	Traction motor temperature sensor is opened (if digital) or has overtaken the threshold of 150°C (if analog)	The maximum current is reduced to half and speed is reduced	continuous	
Thermic sens ko - MDI CAN 61	The output of the controller thermal sensor is out of range.	The maximum current is reduced to half and speed is reduced	continuous	
Check up needed	Maintenance time is reached			
Data acquisition	Maximum current adjustment procedure is in progress (NOTE: this procedure has to be done only by Zapi test department)	Traction is stopped	stand-by	Traction request
Pedal wire ko MDI CAN 86	Accelerator poti negative (Npot) voltage is out of range (less than 0,3V or >2V)	Traction is stopped	start-up, stand-by, traction	Traction request
Tiller open - MDI CAN 51	The truck is in stby with tiller switch opened for more than 30s	LC opens	standby	Valve or pump or traction request
Current gain - MDI CAN 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, stanby	
Waiting for node - MDI CAN 68	A Canbus network node is in alarm condition. uC is waiting for it to resolve its error condition.		continuous	
Deadman absent - MDI CAN 98	With the parameter "Positive EB" at level 2 in the "HW setting" menu and "Deadman" input open the alarm appears	LC opens	standby	Valve or pump or traction request

Error code	Description	Effect	Machine status when the test is done	Restart procedure
Coil shor. Ev. - MDI CAN 76	Shortcircuit on On/off valves coil	On/off valves stopped	start-up, stby, during valve function	valve on/off request
EV1/5 driver shorted - 74	EV1 or EV2 on/off valve drivers shorted (always ON)	On/off valves stopped	start-up, stby	valve on/off request
EV2 driver shorted - MDI CAN 74	EV2 on/off valve driver shorted (always ON)	On/off valves stopped	start-up, stby	valve on/off request
EV3 driver shorted - MDI CAN 74	EV3 on/off valve driver shorted (always ON)	On/off valves stopped	start-up, stby	valve on/off request
EV4 driver shorted - MDI CAN 74	EV4 on/off valve driver shorted (always ON)	On/off valves stopped	start-up, stby	valve on/off request
Evp1 not ok - MDI CAN 48	Evp driver open (not able to close, so not able to drive the valve)	Evp stopped	during Evp function	valve evp request
Evp2 not ok - MDI CAN 47	Evp2 driver open (not able to close, so not able to drive the valve)	Evp stopped	during Evp function	valve evp request
Pump I NO zero - MDI CAN 56	Pump chopper current sensor feedback is out of permitted stby range	Pump motor stopped	start-up, stby	pump request
Pump I=0 ever - MDI CAN 52	Pump current feedback is always 0A even when pump motor is running	Pump motor stopped	pump function	pump request
lift+lower - 49	lift+lower request	Pump motor stopped	continuous	hydraulic request
Cont. Drv. Ev1 - MDI CAN 75	Driver of Ev1 is open, not able to close	Ev1 stopped	during Ev1 function	valve Ev1 request
Cont. Drv. Ev2 - MDI CAN 75	Driver of Ev2 is open, not able to close	Ev2 stopped	during Ev2 function	valve Ev2 request
Cont. Drv. Ev3 - MDI CAN 75	Driver of Ev3 is open, not able to close	Ev3 stopped	during Ev3 function	valve Ev3 request
Cont. Drv. Ev4 - MDI CAN 75	Driver of Ev4 is open, not able to close	Ev4 stopped	during Ev4 function	valve Ev4 request
Cont. Drv. Ev5 - MDI CAN 75	Driver of Ev5 is open, not able to close	Ev5 stopped	during Ev5 function	valve Ev5 request
Pump Vacc not OK - MDI CAN 89	The pump accelerator value is higher than the minimum value recorded, and the lift/lower switches are open	Pump stopped	Continuous	Pump request
Sens. Mot. Temp. KO - MDI CAN 67	The motor temperature sensor is damaged	Performance highly reduced	Continuous	Key-on recycle
BACKING INPUT - MDI CAN 78	An inching request is performed and the tiller input is active, or FW or REV input is active	Traction is stopped	start-up, stand-by, traction	traction request

12.5 Analysis and troubleshooting of warnings

1) “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 parameters.

2) “FORW+BACK”
   Cause:
   This alarm occurs when both the travel demands (Fwd and Bwd) or BACKING FOR and BACKING REV are active at the same time.
   Troubleshooting:
   Check the wiring of the Fwd and Rev travel demand inputs and BACKING FOR and BACKING REV 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 and Backing switches are fine working and the wiring is right, it is necessary to replace the controller.

3) “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) A travel demand active at key on
   B) 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 controller.

4) “VACC NOT OK”
   Cause:
   The test is made at key-on and after 20sec 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:
   Check the mechanical calibration and the functionality of the potentiometer.

5) “HIGH 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:
   Improve the air cooling of the controller. 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.

6) “BATTERY LOW”
Cause:
It occurs when the battery charge is calculated being less than or equal to 10% of the full charge and the BATTERY CHECK setting is other than 0 (refer to SET OPTION menu).
Troubleshooting:
Get the battery charged. If it doesn’t work, measure with a voltmeter the battery voltage and compare it with the value in the BATTERY VOLTAGE parameter. If they are different adjust the value of the ADJUST BATTERY function.

7) “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.

8) “MOTOR TEMPERATURE”
Cause:
This warning occurs when the temperature sensor is opened (if digital) or has overtaken the threshold of 150°C (if analog).
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 air cooling of the motor. If the warning is present when the motor is cool, then the problem is inside the controller.

9) “THERMIC SENSOR 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.

10) “CHECK UP NEEDED”
Cause:
This is just a warning to call for the time programmed maintenance.
Troubleshooting:
It is just enough to turn the CHECK UP DONE option to level ON after the maintenance is executed.

11) “DATA ACQUISITION”
Cause:
Acquisition of the current gains.
Troubleshooting:
The alarm ends when the acquisition is done.

12) “PEDAL WIRE KO”
Cause:

The SW continuously checks for the connection of the two supply ends of the potentiometer in the accelerator. The test consists of reading the voltage drop on a sense diode, connected between NPOT (CNA#30) and GND and cascaded with the potentiometer: if the potentiometer gets disconnected on PPOT (CNA#25) or NPOT, no current flows in this sense diode and the voltage on the NPOT connection collapses down.
When the NPOT voltage is less than 0.3V this alarm occurs. This alarm occurs also when the NPOT voltage is higher than 2Vdc (to detect also the condition of a broken sense diode).
Troubleshooting:
Check the voltage on NPOT and the potentiometer connections.

13) “TILLER OPEN”
Cause:
Warning: when the tiller is released, after a fixed period of time of standby (30 seconds) the main contactor open.
Troubleshooting:
At the next travel request the warning disappear.

14) “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.

15) “WAITING FOR NODE”
Cause:
The controller receives from the CAN the message that another controller in the net is in fault condition; as a consequence the ACE0/ COMBIAC0 controller itself cannot enter an operative status, but has to WAIT for the other controller coming out from the fault status.

16) “DEAD MAN ABSENT”
Cause:
This warning (presents only in trucks with “Dead Man” switch) appears when the “Dead Man” switch is open.
Troubleshooting:
At the next travel request with dead man switch close the warning disappears.

17) “CURRENT SENSOR LOW”
Cause:
The pump chopper current sensor feedback is too low (below 0.5V).
Troubleshooting:
This type of fault is not related to external components; replace the controller.

18) “VALVE COIL SHORTED”
Cause:
This alarm occurs when there is a short circuit on an on/off valve coil.
Troubleshooting:
A) If the fault is present at start up, it is very likely that the hw overcurrent protection circuit is damaged, it is necessary to replace the controller.

B) If the fault is present when the controller drives the outputs, the problem is located in the harness and in the coils.

19) “EV1/5 DRIVER SHORTED”
Cause:
Electrovalve EV1 or EV2 driver is shorted.
Troubleshooting:
Check if there is a short or a low impedence between the negative of one of those coils and –BATT. Otherwise the driver circuit is damaged and the controller must be replaced.

20) “EV2 DRIVER SHORTED”
Cause:
Electrovalve EV2 driver is shorted.
Troubleshooting:
Check if there is a short or a low impedance between the negative of this coil and –BATT. This warning occurs also if the external load is not present and the parameter EV2 in the “Set Options” menu is set “PRESENT”, in this case the warning disappears setting the EV2 parameter “ABSENT”. Otherwise the driver circuit is damaged and the controller must be replaced.

21) “EV3 DRIVER SHORTED”
Cause:
Electrovalve EV3 driver is shorted.
Troubleshooting:
Check if there is a short or a low impedance between the negative of this coil and –BATT. This warning occurs also if the external load is not present and the parameter EV3 in the “Set Options” menu is set “PRESENT”, in this case the warning disappears setting the EV3 parameter “ABSENT”. Otherwise the driver circuit is damaged and the controller must be replaced.

22) “EV4 DRIVER SHORTED”
Cause:
Electrovalve EV4 driver is shorted.
Troubleshooting:
Check if there is a short or a low impedance between the negative of this coil and –BATT. This warning occurs also if the external load is not present and the parameter EV4 in the “Set Options” menu is set “PRESENT”, in this case the warning disappears setting the EV4 parameter “ABSENT”. Otherwise the driver circuit is damaged and the controller must be replaced.

23) “VALVE CONT DRIVER”
Cause:
One or more on/off valve drivers is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

24) “EVP DRIVER KO”
Cause:
The EVP valve driver is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

25) “EVP2 DRIVER KO”
Cause:

The EVP2 valve driver is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

26) “PUMP I NO ZERO”
Cause:
In standby condition (pump motor not driven), the feedback coming from the current sensor in the pump chopper gives a value out of a permitted range, because the pump current is not zero.
Troubleshooting:
This type of fault is not related to external components; replace the controller.

27) “PUMP I=0 EVER”
Cause:
This test is carried out when the pump motor is running, and it verifies that the current feedback sensor is not constantly stuck to 0.
Troubleshooting:
A) Check the motor connection, that there is continuity. If the motor connection is opened, the current cannot flow, so the test fails and the error code is displayed.
B) If everything is ok for what it concerns the motor, the problem could be in the current sensor or in the related circuit.

28) “RAM WARNING”
Cause:
Checksum of the ram failed.
Troubleshooting:
This fault is not related to external components.

29) “EEP WARNING”
Cause:
Eeprom checksum failed
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.

30) “LIFT + LOWER”
Cause:
This alarm occurs when both forks movement requests(Lift + Lower) are active at the same time.
Troubleshooting:
Check the wiring of the Lift and lower 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 controller.

31) “CONT. DRV. EV1”
Cause:
The EV1 valve driver is not able to drive the load (cannot close).
Troubleshooting:

The device or its driving circuit is damaged, replace the controller.

32) "CONT. DRV. EV2"
Cause:
The EV2 valve driver is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

33) "CONT. DRV. EV3"
Cause:
The EV3 valve driver is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

34) "CONT. DRV. EV4"
Cause:
The EV4 valve driver is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

35) "CONT. DRV. EV5"
Cause:
The EV5 valve driver is not able to drive the load (cannot close).
Troubleshooting:
The device or its driving circuit is damaged, replace the controller.

36) "TH. PROTECTION"
Cause:
The controller detected a high temperature, and the performance of the motor is limited.
Troubleshooting:
It is suggested to check the cause of the high temperature. Usually the controller is not correctly installed or the fan doesn't work.

37) "PUMP VACC NOT OK"
Cause:
The minimum of the lift potentiometer is not correctly set.
Troubleshooting:
It is suggested to repeat a "PROGRAM VACC" procedure.

38) "SENS. MOT. TEMP."
Cause:
A) The motor temperature sensor is not correctly connected to A22.
B) The motor temperature sensor is damaged.
Troubleshooting:
- Check the correct connection of the motor temperature sensor.
- If the current sensor is correctly connected, replace it.
- If the problem persist, it is due to the controller.

39) "BACKING INPUT"
Cause:
A) An inching request is performed and the tiller input is active.
B) An inching request is performed and FW or REV input is active.
Troubleshooting:
Check the movement sequences that involve FW, REV, Tiller, BACKING

FOR and BACKING REV inputs.
Check the wiring of the BACKING FOR and BACKING REV 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, if you have verified through the tester that the BACKING FOR or/and BACKING REV doesn’t change when you depress / release the correspondant switches, replace the controller.

13 RECOMMENDED SPARE PARTS

Part number	Description
C12532	AMPSEAL CONNECTOR 35 pins Female
C29508	SW 180 24V Single Pole Contactor
C29522	SW 180 48V Single Pole Contactor

14 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.

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