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EN

User Manual

AC-2 FLASH INVERTER

NOTES LEGEND

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

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

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1 INTRODUCTION

Within the ZAPIMOS family, the AC-2 FLASH inverter is the model suitable for control of 3.0 kW to 8.0 kW motors. It has been expressly designed for battery electric traction.
It is fit for electric truck, golf cars, utility cars.

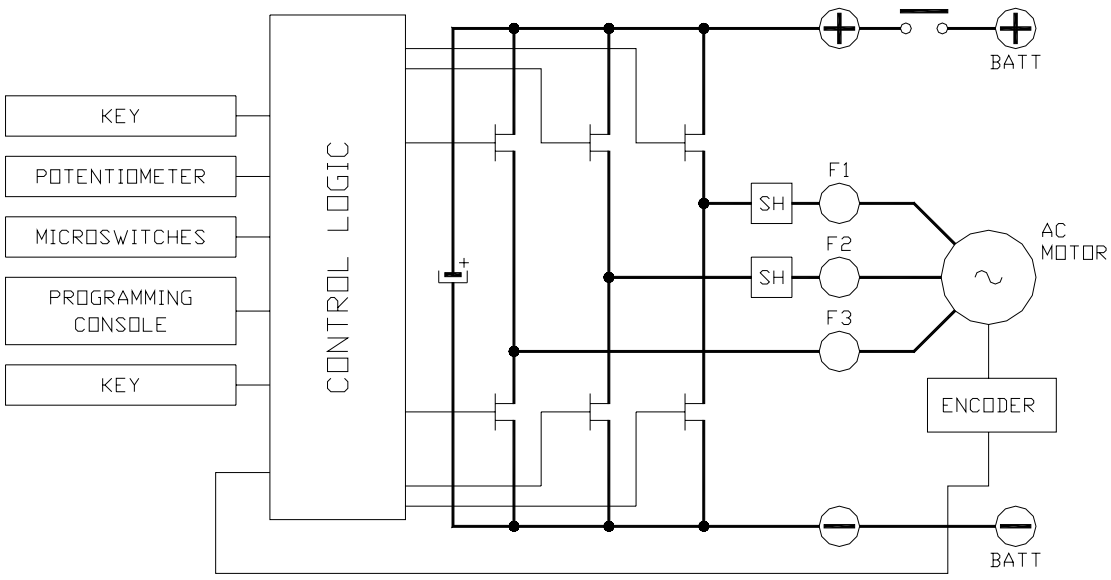
2 SPECIFICATION

2.1 Technical specifications

Inverter for AC asynchronous 3-phase motors
Regenerative braking functions
Can-bus interface
Flash memory (256 Kbytes On-Chip Program Memory)
Digital control based upon a microcontroller
Voltage:.....24 - 36 - 48 - 72 – 80 – 96 V
Maximum current (24 V, 36 V):..... 500 A (RMS) for 3'
Maximum current (36 V, 48 V):..... 450 A (RMS) for 3'
Maximum current (72 V, 80 V): (*)..... 275/400 A (RMS) for 3'
Maximum current (96 V): ..... 250 A (RMS) for 3'
Booster (all version).....10% of maximum current for some seconds;
Operating frequency: .....8 kHz
External temperature range: .....-30 °C ÷ 40 °C
Maximum inverter temperature (at full power): .....75 °C

Note (*) For the 72/80 V voltage battery two versions are available: with maximum current provided of 275 A and of 400 A.

2.2 Block diagram



3 SPECIFICATION FOR THE INPUT DEVICES FILLING UP THE INSTALLATION KIT

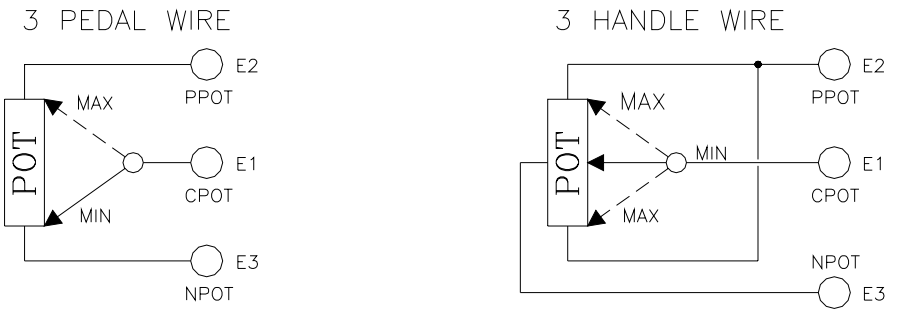
The AC-2 FLASH inverter needs some external parts in order to work. The following devices complete the kit for the AC-2 FLASH installation.

3.1 Microswitches

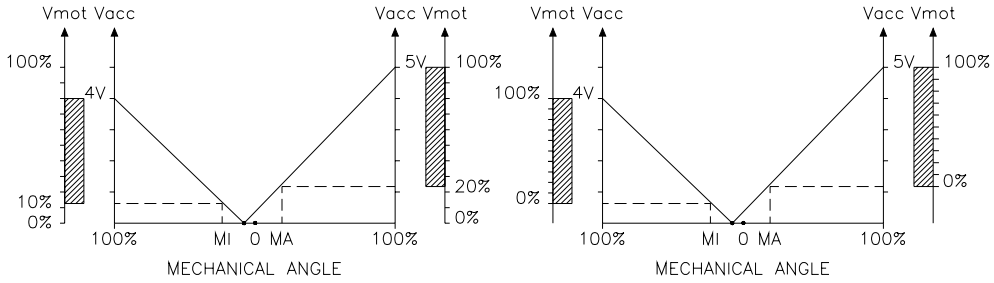
- The microswitches must have a contact resistance lower than 0.1 Ω and a leakage current lower than 100 µA.
- When full load connected, the voltage drop between the key switch contacts must be lower than 0.1 V.
- The microswitches send a voltage signal to the microprocessor when a function request (for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

3.2 Accelerator unit

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



The Procedure for automatic potentiometer signal acquisition is carried out using the Console. This enables adjustment of the minimum and maximum useful signal level (PROGRAM VACC function), in either direction. This function is unique when it is necessary to compensate for asymmetry with the mechanical elements associated with the potentiometer, especially relating to the minimum level.
The sequence of procedure is described in the programming console manual.



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

3.3 Other analog control unit

1) Input E8 is an analog input, whose typical application is for proportional braking. It should be in a 3 wire configuration. Potentiometer value should be in the 0.5-10 kΩ range. Generally, the load should be in the 1.5 mA to 30 mA range.
The CPOTB (E8) signal range is from 0 to 10 V.

2) Connections F6 (PTHERM) and F12 (NTHERM) are used for a motor thermal sensor. It can be digital (on/off sensor, normally closed) or analog. See also chapter 8.4 for more explanation.

3.4 Speed feedback

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

- power supply: +5 V or +12 V.
- electric output: open collector (NPN or PNP), push-pull, line driver
- standard (A and B) or differential $(A, \overline{A}, B, \overline{B})$ output.

For more details about encoder installation see also chapter 4.2.5.

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

AC2T2D F ZP1.13

That means:
AC2T= AC-2 traction controller
(AC2P= AC-2 pump controller)
2 = motor’s poles pair number
D = 128 pulses/rev encoder

F = flash

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

4 INSTALLATION HINTS

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

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

These are Warning boxes, they describe:
- operations that can lead to a failure of the electronic device or can be dangerous or harmful for the operator;
- items which are important to guarantee system performance and safety

4.1 Material overview

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

4.1.1 Connection cables

For the auxiliary circuits, use cables of 0.5 mm² section.
For power connections to the motor and to the battery, use cables having section of at least 50 mm².
For the optimum inverter performance, the cables to the battery should be run side by side and be as short as possible.

4.1.2 Contactors

The main contactor must be installed. Depending on the setting of a parameter in the controller (PWM ON MAIN CONT; see chapter 8.4.1, 8.4.2):

- 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 modulated with a PWM at high frequency (1 kHz). After an initial delay of about 1 sec in which the coil is driven with the full battery voltage, the PWM reduces the voltage down to 62%.This feature is useful to decrease the power dissipation of the contactor coil.

4.1.3 Fuses

- Use a 10 A Fuse for protection of the auxiliary circuits.
- For protection of the power unit, refer to diagrams. The Fuse value shown is the maximum allowable. For special applications or requirements these values can be reduced.
- For Safety reasons, we recommend the use of protected fuses in order to prevent the spread of fused particles should the fuse blow.

4.2 Installation of the hardware

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

4.2.1 Positioning and cooling of the controller

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

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

4.2.2 Wirings: power cables

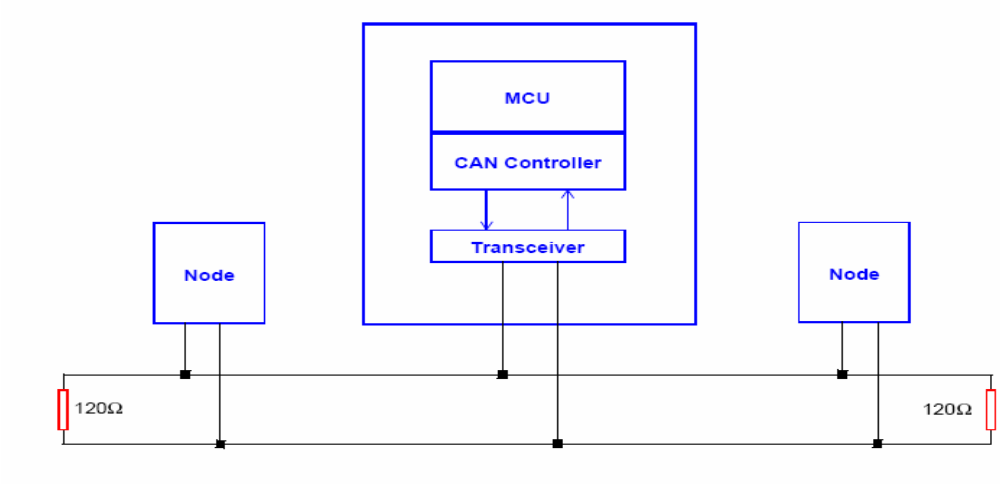
- The power cables length must be as short as possible to minimize power losses.
- They must be tightened on controller power posts with a Torque of 13-15 Nm.
- The AC-2 FLASH module should only be connected to a traction battery. Do not use converters outputs or power supplies. For special applications please contact the nearest Zapi Service Centre.

Do not connect the controller to a battery with a nominal voltage different than the value indicated on the controller label. A higher battery voltage may cause power section failure. A lower voltage may prevent the logic operating.

4.2.3 Wirings: CAN connections and possible interferences

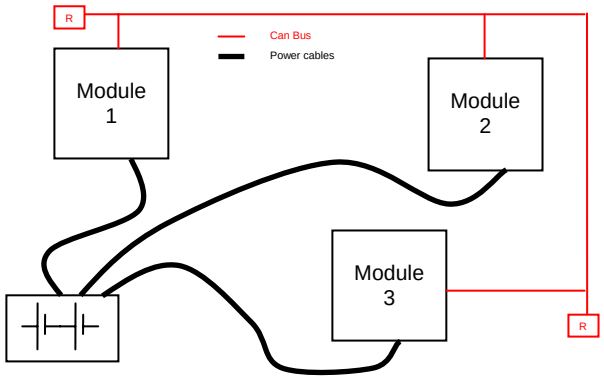
CAN stands for Controller Area Network. It is a communication protocol for real time control applications. CAN operates at data rate of up to 1 Megabits per second.

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



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

Wrong Layout:

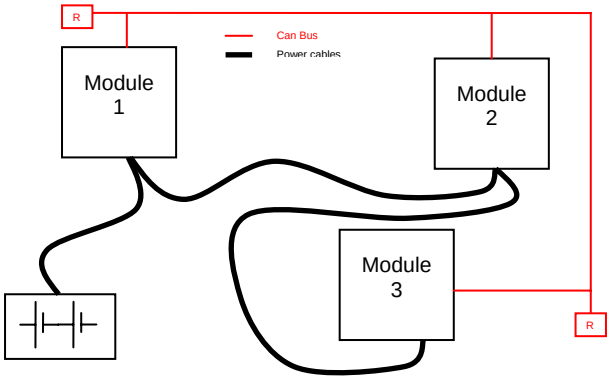


The red lines are can wires.
The black boxes are different modules, for example traction controller, pump controller and display connected by canbus.
The black lines are the power cables.

This is apparently a good layout, but can bring to errors in the can line.
The best solution depends on the type of nodes (modules) connected in the network.
If the modules are very different in terms of power, then the preferable

connection is the daisy chain.

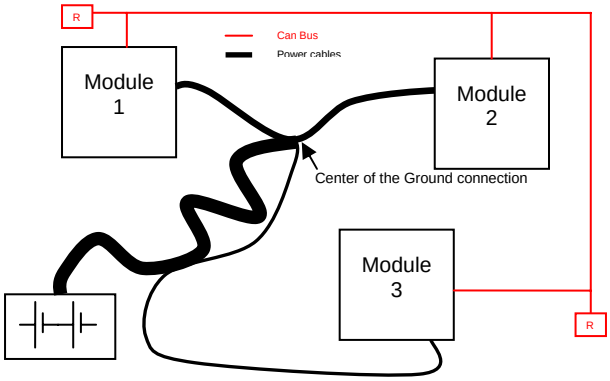
Correct Layout:



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

The chain starts from the –BATT post of the controller that works with the highest current, and the others are connected in a decreasing order of power. Otherwise, if two controllers are similar in power (for example a traction and a pump motor controller) and a third module works with less current, the best way to deal this configuration is to create a common ground point (star configuration).

Correct Layout:



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

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

Can advantages

The complexity of today systems needs more and more data, signal and information must flow from a node to another. CAN is the solution to different

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

4.2.4 Wirings: I/O connections

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

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

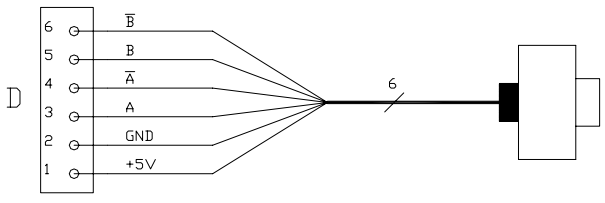
- For information about the mating connector pin assignment see the paragraph “description of the connectors”.

4.2.5 Connection of the encoder

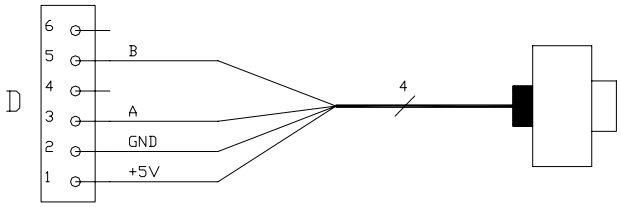
1) AC-2 FLASH card is fit for different types of encoder. To control AC motor with Zapi inverter, it is necessary to install an incremental encoder with 2 phases shifted of 90°. The encoder power supply can be +5 or +12 V. It can have different electronic output.

D1	+5V/+12V	positive of encoder power supply.
D2	GND	negative of encoder power supply.
D3	A	phase A of encoder.
D4	$\overline{A}$	phase A inverted (encoder with differential output).
D5	B	phase B of encoder.
D6	$\overline{B}$	phase B inverted (encoder with differential output).

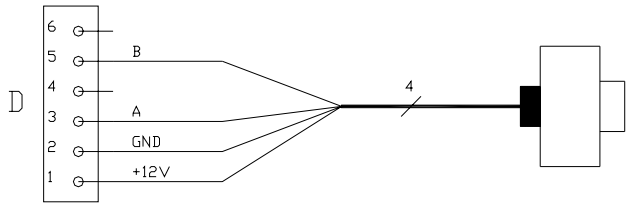
2) Connection of encoder with differential outputs; +5 V power supply.



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



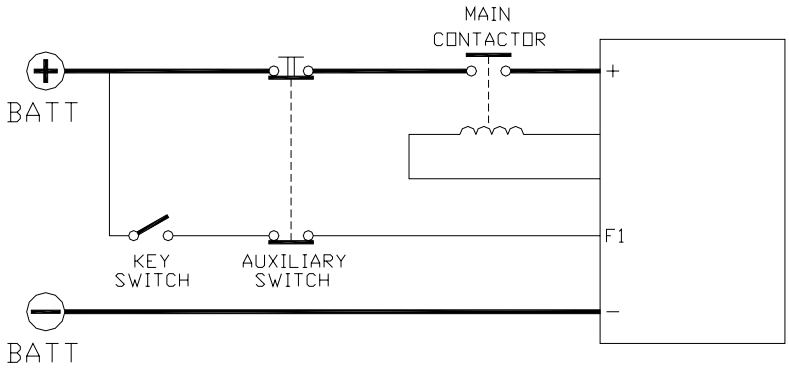
4) Connection of encoder with open collector output: +12 V power supply.



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

4.2.6 Main contactor and key connection

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



- The connection of the battery line switches must be carried out following ZAPI instructions.
- If a mechanical battery line switch is installed, it is necessary that the key supply to the inverter is open together with power battery line; if not, the inverter may be damaged if the switch is opened during a regenerative braking.
- An intrinsic protection is present inside the logic when the voltage on the battery power connection overtakes 40% more than the battery nominal voltage or if the key is switched off before the battery power line is disconnected.

4.2.7 Insulation of truck frame

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

4.3 Protection and safety features

4.3.1 Protection features

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

- **Battery polarity inversion**
  It is necessary to fit a MAIN CONTACTOR to protect the inverter against reverse battery polarity and for safety reasons.
- **Connection Errors:**
  All inputs are protected against connection errors.
- **Thermal protection**
  If the controller temperature exceeds 75 °C, the maximum current is reduced in proportion to the thermal increase. The temperature can never exceed 100 °C.
- **External agents:**
  The inverter is protected against dust and the spray of liquid to a degree of protection meeting IP54.
- **Protection against uncontrolled movements:**
  The main contactor will not close if:
  - The Power unit is not functioning.
  - The Logic is not functioning perfectly.
  - The output voltage of the accelerator does not fall below the minimum voltage value stored, with 1 V added.
  - Running microswitch in closed position.
- **Low battery charge:**
  When the battery charge is low, the maximum current is reduced to the half of the maximum current programmed.
- **Protection against accidental Start up**
  A precise sequence of operations are necessary before the machine will start.
  Operation cannot begin if these operations are not carried out correctly.
  Requests for drive, must be made after closing the key switch.

4.3.2 Safety Features

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

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

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

4.4 EMC

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

EMC stands for Electromagnetic Compatibility, and it represents the studies and the tests on the electromagnetic energy generated or received by an electrical device.
So the analysis works in two directions:

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

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

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

A) this rapid charge transfer can determine, by induction, disturbs on the signal wiring and thus create malfunctions; **this effect is particularly critical in modern machines, with serial communications (canbus) which are spread everywhere on the truck and which carry critical information.**

B) in the worst case and when the amount of charge is very high, the discharge process can determine failures in the electronic devices; the type of failure can vary from an intermittently malfunction to a completely failure of the electronic device.

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

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

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

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.

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

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

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 connect SCR low frequency chopper with ASYNCHRONOUS INVERTER because the ASYNCHRONOUS filter capacitors alter the SCR choppers' work. If it is necessary to use two or more control units (traction + lift. for ex.), they must belong to the ZAPIMOS family.
- During battery charge, disconnect ASYNCHRONOUS from the battery.

5 OPERATIONAL FEATURES

- Speed control.
- Optimum behaviour an a slope due to the speed feedback:
  - the motor speed follows the accelerator, starting a regenerative braking if the speed overtakes the speed set-point.
  - the system can perform an electrical stop on a ramp (the machine is electrically hold on a slope) for a programmable time (see also chapter 8.4).
- Stable speed in every position of the accelerator.
- Regenerative release braking based upon deceleration ramps.
- Regenerative braking when the accelerator pedal is partially released (deceleration).
- Direction inversion with regenerative braking based upon deceleration ramp.
- Regenerative braking and direction inversion without contactors: only the main contactor is present.
- The release braking ramp can be modulated by an analog input, so that a proportional brake feature is obtained.
- Optimum sensitivity at low speeds.
- Voltage boost at the start and with overload to obtain more torque (with current control).
- The inverter can drive an electromechanical brake.
- Hydraulic steering function:
  1) traction inverter
    - the traction inverter sends a "hydraulic steering function" request to the pump inverter on the can-bus line (see also OPTIONS chapter 8.4).
    - moreover, if the pump inverter is not present (for ex: tractor application), the traction inverter can manage an "hydraulic steering function" by driving a hydro contactor which drive a hydraulic steering motor (output F9), see also OPTIONS chapter.

  2) pump inverter
    - the pump inverter manage an "hydraulic steering function". That is, it drives the pump motor at the programmed speed for the programmed time.
- High efficiency of motor and battery due to high frequency commutations.
- Self diagnosis with indication of the fault shown by a flashing led.
- Modification of parameters through the programming console.
- Internal hour-meter with values that can be displayed on the console.
- Memory of the last five alarms with relative hour-meter and temperature displayed on the console.
- Test function within console for checking main parameters.

5.1 Diagnosis

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

1) Diagnosis on key switch closing that checks: watchdog circuit, current sensor, capacitor charging, phase's voltages, contactor drives, can-bus interface, if the switch sequence for operation is correct and if the output of accelerator unit is correct.

2) Standby diagnosis in standby that checks: watchdog circuit, phase's voltages,

contactor driver, current sensor, can-bus interface.

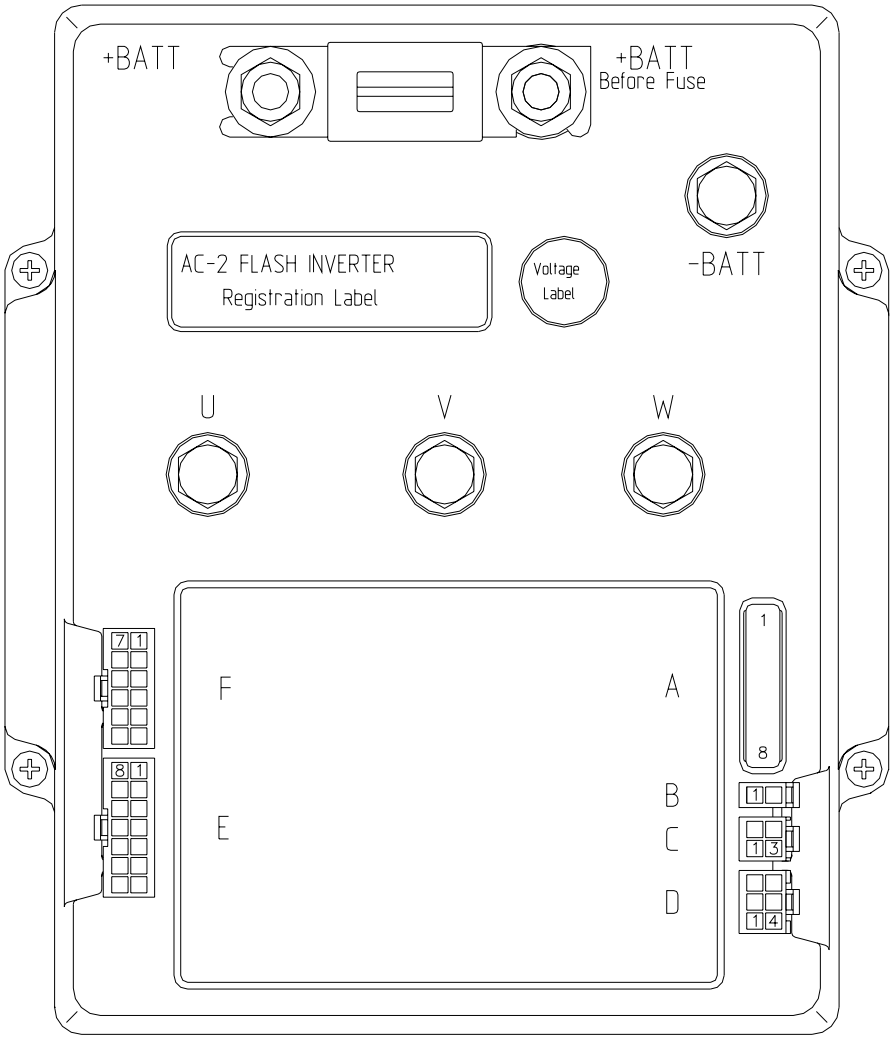
3) Diagnosis during operation that checks: watchdog circuits, contactor driver, current sensors, can-bus interface.

4) Continuous diagnosis that check: temperature of the inverter, motor temperature.

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

6 DESCRIPTION OF THE CONNECTORS

6.1 Connectors of the logic - Traction configuration

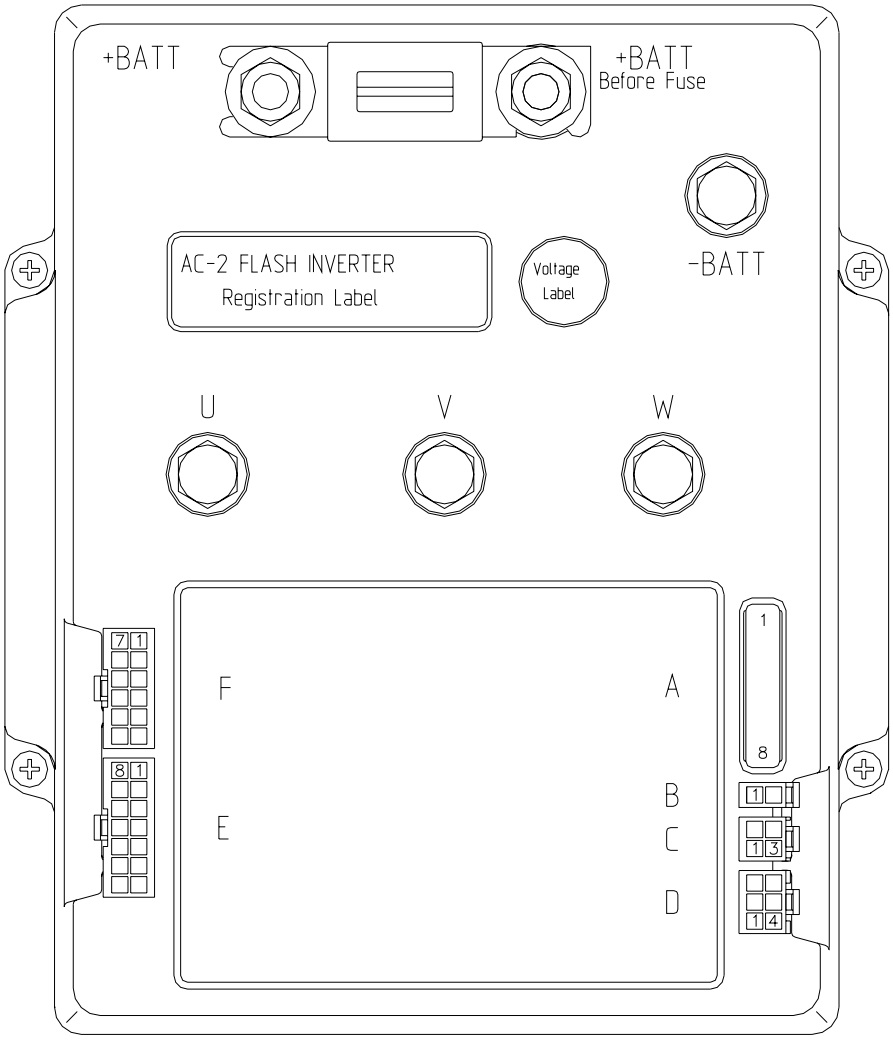


A1	PCLRXD	Positive serial reception.
A2	NCLRXD	Negative serial reception.
A3	PCLTXD	Positive serial transmission.
A4	NCLTXD	Negative serial transmission.
A5	GND	Negative console power supply.
A6	+12	Positive console power supply.
A7	FLASH	It must be connected to A8 for the Flash memory programming.
A8	FLASH	It must be connected to A7 for the Flash memory programming.
B1	-BATT	-Batt.

B2	MODE	This input allows the customer to select the software for traction or lifting application. Configuration: MODE: Open (not connected) Traction inverter MODE: Close (connected with A5) Pump inverter.
C1	CAN-L	Low level CAN-BUS voltage I/O.
C2	CAN-L-OUT	Low level CAN-BUS voltage I/O.
C3	CAN-H	High level CAN-BUS voltage I/O.
C4	CAN-H-OUT	High level CAN-BUS voltage I/O.
D1÷D6		Incremental ENCODER connector (see chapter 4.2.5).
E1	CPOT	Accelerator potentiometer wiper.
E2	PPOT	Potentiometer positive: 10 V output; keep load > 1 kΩ.
E3	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
E4	CM	Common of FW / BW / SR / PB / SEAT / BACK. FW / BACK. BW / EXCLUSIVE HYDRO / ENABLE microswitches.
E5	FORW	Forward direction request input. It must be connected to the forward direction microswitch, active high.
E6	BACK	Backward direction request input. It must be connected to the backward direction microswitch, active high.
E7	PB	Brake request input. It must be connected to the brake pedal switch, active high.
E8	CPOTB	Brake potentiometer wiper.
E9	PPOTB	Brake potentiometer positive. 10 V output; keep load >1 kΩ.
E10	NPOTB	-Batt.
E11	-BATT	-Batt.
E12	BACK. FORW	Inching function, forward direction input. It must be connected to the inching forward switch. Active high.
E13	BACK. BACK	Inching function, reverse direction input. It must be connected to the inching reverse switch. Active high.
E14	EX. HYDRO/ENABLE	Exclusive hydro or accelerator enable function input. It must be connected to the exclusive hydro microswitch or to the accelerator enable switch. Active high (see also OPTION chapter).
F1	KEY	Connected to the power supply through a microswitch (CH) with a 10 A fuse in series.
F2	PLC	Positive of main contactor coil.
F3	PBRAKE	Positive of the electromechanical brake coil.
F4	SEAT	SEAT input; it must be connected to the SEAT microswitch; it is active high.
F5	SAFETY	If not connected to -Batt the MC coil power output will

		be disabled. It can also be used as a general purpose input.
F6	PTHERM	Input for motor temperature sensor.
F7	CM	Common of FW / BW / SR / PB / SEAT / INCHING FW / INCHING BW / EXCLUSIVE HYDRO / ENABLE microswitches.
F8	NLC	Negative of main contactor coil.
F9	NBRAKE	Output for driving a brake or an hydraulic steering contactor coil; it drives the load to -Batt maximum current: 3 A.
F10	SR/HB	Speed reduction (handbrake) input. Active low (switch opened). See also OPTION chapter.
F11	GND	-Batt.
F12	NTHERM	-Batt.

6.2 Connectors of the logic - Pump configuration



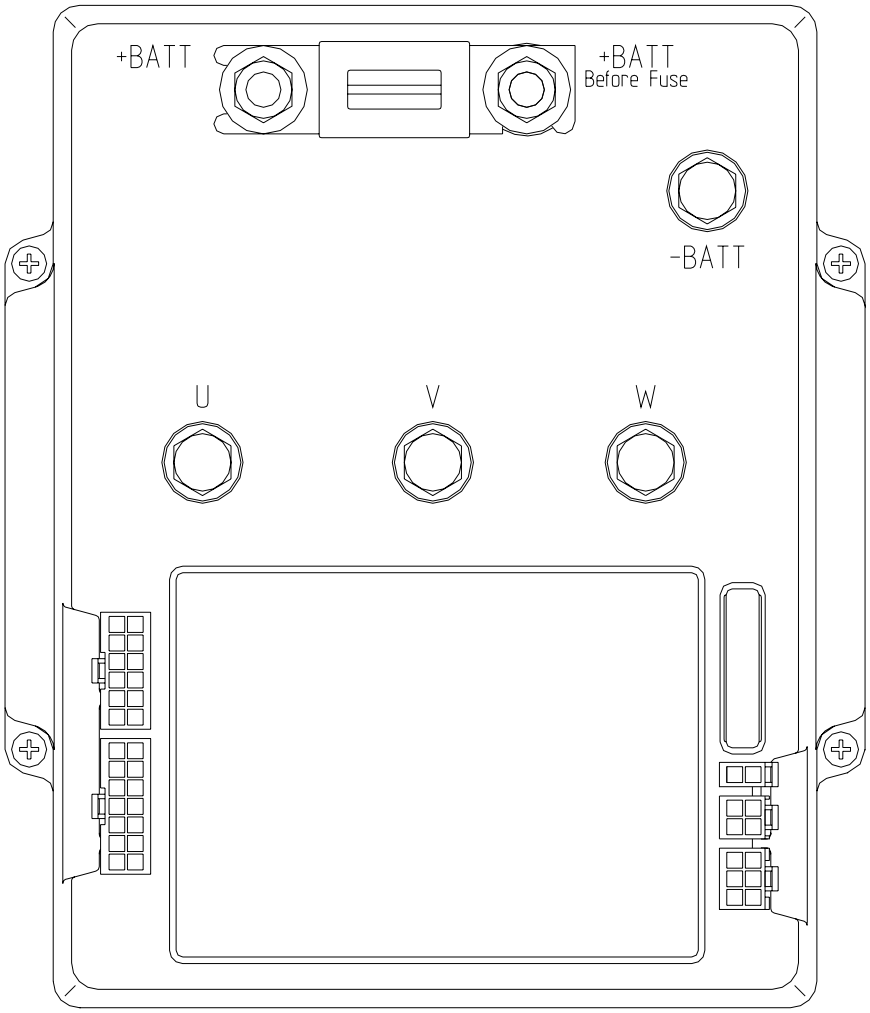
A1	PCLRXD	Positive serial reception.
A2	NCLRXD	Negative serial reception.
A3	PCLTXD	Positive serial transmission.
A4	NCLTXD	Negative serial transmission.
A5	GND	Negative console power supply.
A6	+12	Positive console power supply.
A7	FLASH	It must be connected to A8 for the Flash memory programming.
A8	FLASH	It must be connected to A7 for the Flash memory programming.
B1	-BATT	-Batt.
B2	MODE	This input allows the customer to select the software for traction or lifting application.

		Configuration: MODE: Open (not connected) Traction inverter MODE: Close (connected with B1) Pump inverter.
C1	CAN-L	Low level CAN-BUS voltage I/O.
C2	CAN-L-OUT	Low level CAN-BUS voltage I/O.
C3	CAN-H	High level CAN-BUS voltage I/O.
C4	CAN-H-OUT	High level CAN-BUS voltage I/O.
D1÷D6		Incremental ENCODER connector (see chapter 4.2.5).
E1	CPOT	Accelerator potentiometer wiper.
E2	PPOT	Potentiometer positive: 10 V output; keep load > 1 kΩ.
E3	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
E4	CM	Common of LIFT ENABLE / 1st SPEED / 2nd SPEED / 3rd SPEED / 4th SPEED / HYDRO / SR microswitches.
E5	LIFT ENABLE	Input for potentiometer lifting enable input; it is active HIGH.
E6	1st SPEED	Input for first speed request; it is active HIGH.
E7	3rd SPEED	Input for third speed request; it is active HIGH.
E8	AN. IN.	Free analog input.
E9	PPOT	Potentiometer positive: 10 V output; keep load > 1 kΩ.
E10	-BATT	-Batt.
E11	-BATT	-Batt.
E12	HYDRO REQ.	Input for hydraulic steering request. Active high.
E13	SR	Speed reduction input. Active low (switch opened).
E14	DIG. IN.	This is a digital input, free for customer request.
F1	KEY	Connected to the power supply through a microswitch (CH) with a 10 A fuse in series.
F2	PAUX	Positive of the auxiliary output.
F3	PHYDRO	Positive for the hydraulic steering contactor.
F4	4th SPEED	Input for fourth speed request; it is active HIGH.
F5	SAFETY	If not connected to -Batt the MC coil power output will be disabled. It can also be used as a general purpose input.
F6	PTHERM	Input for motor temperature sensor.
F7	CM	Common of LIFT ENABLE / 1st SPEED / 2nd SPEED / 3rd SPEED / 4th SPEED / HYDRO / SR microswitches.
F8	NAUX	This output can be used for drive the main contactor coil (single pump configuration) or to drive an auxiliary load (combi configuration).

F9	NHYDRO	Output for driving an hydraulic steering contactor; it drives the load to -Batt. Maximum current: 3 A.
F10	2nd SPEED	Input for second speed request; it is active HIGH.
F11	GND	-Batt.
F12	NTHERM	-Batt.

6.3 Description of power connections

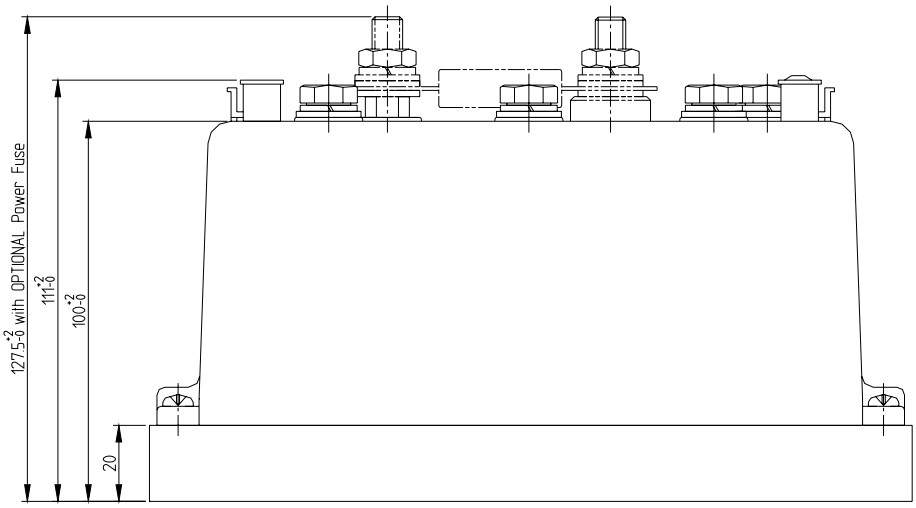
View of the power bars:

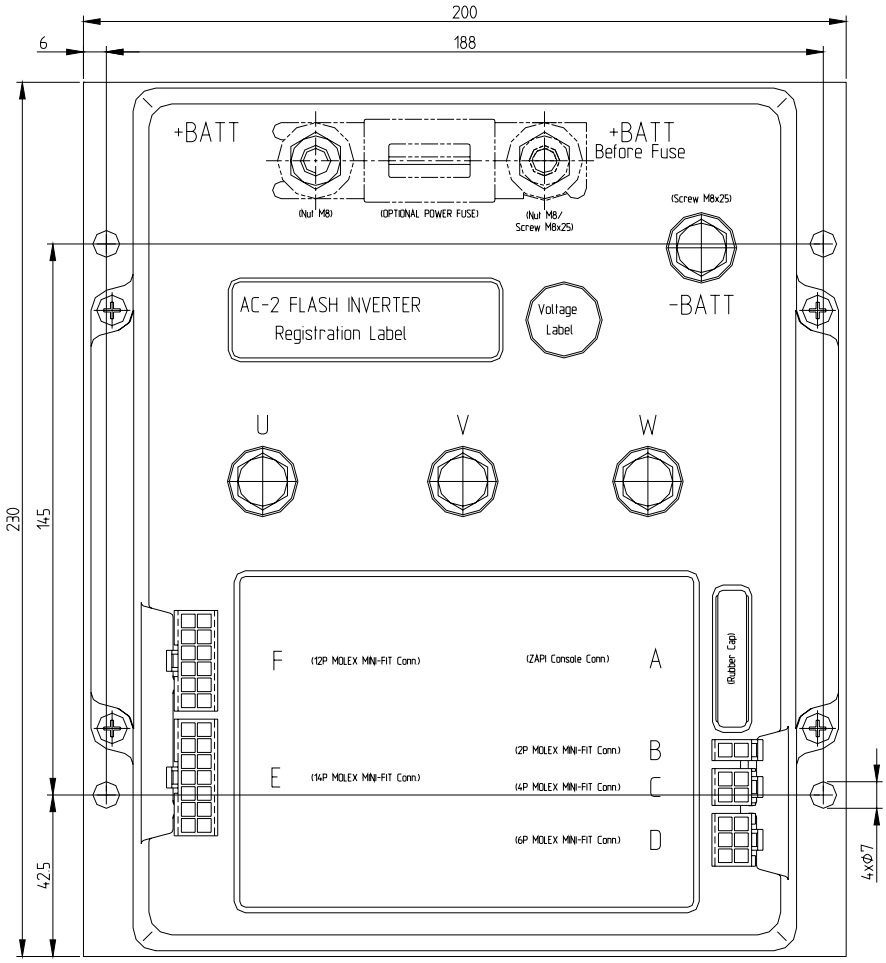


-BATT	Negative of the battery.
+BATT	Positive of the battery.
U; V; W	Connection bars of the three motor phases; follow this sequence and the indication on the motor.

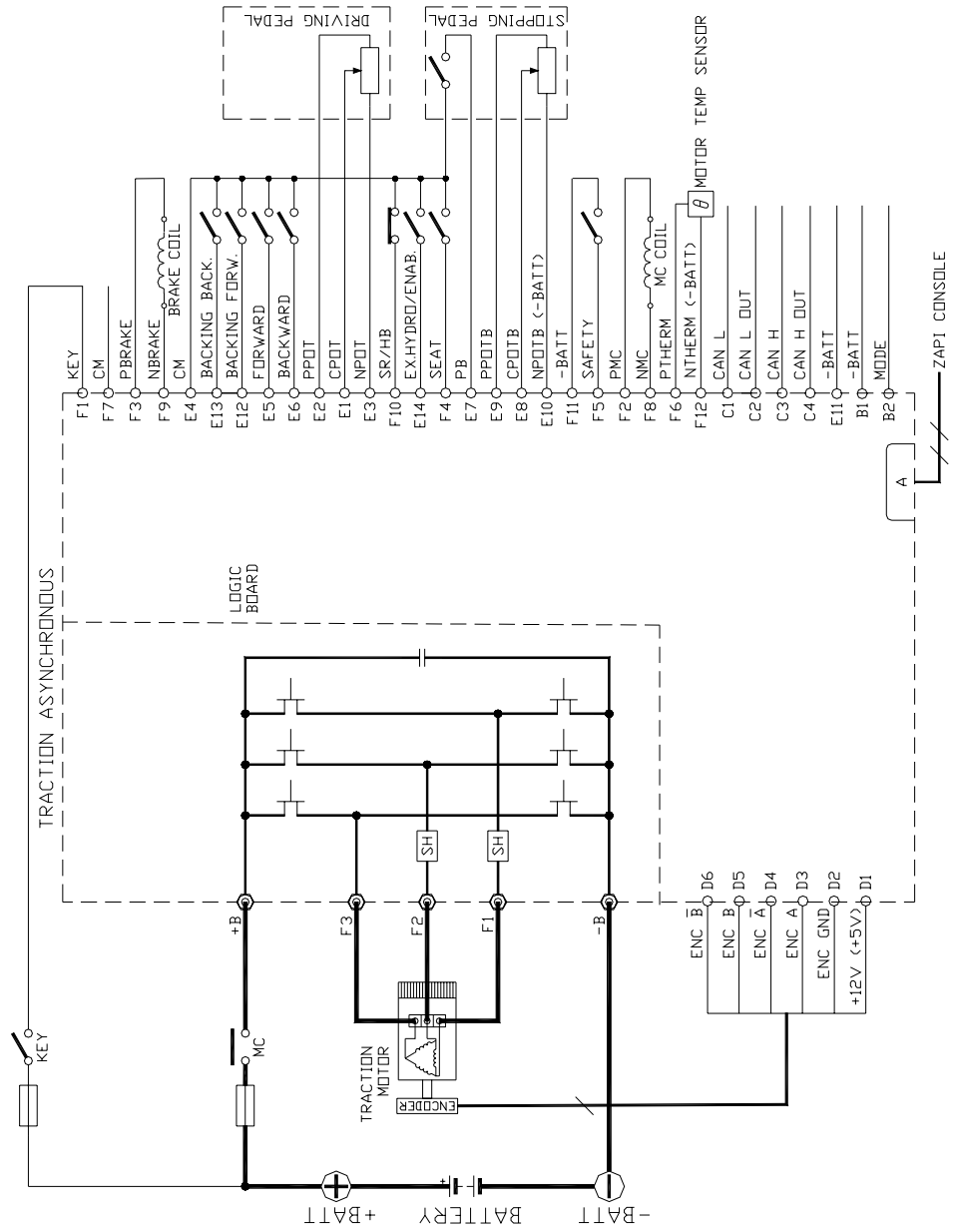
7 DRAWINGS

7.1 Mechanical drawing

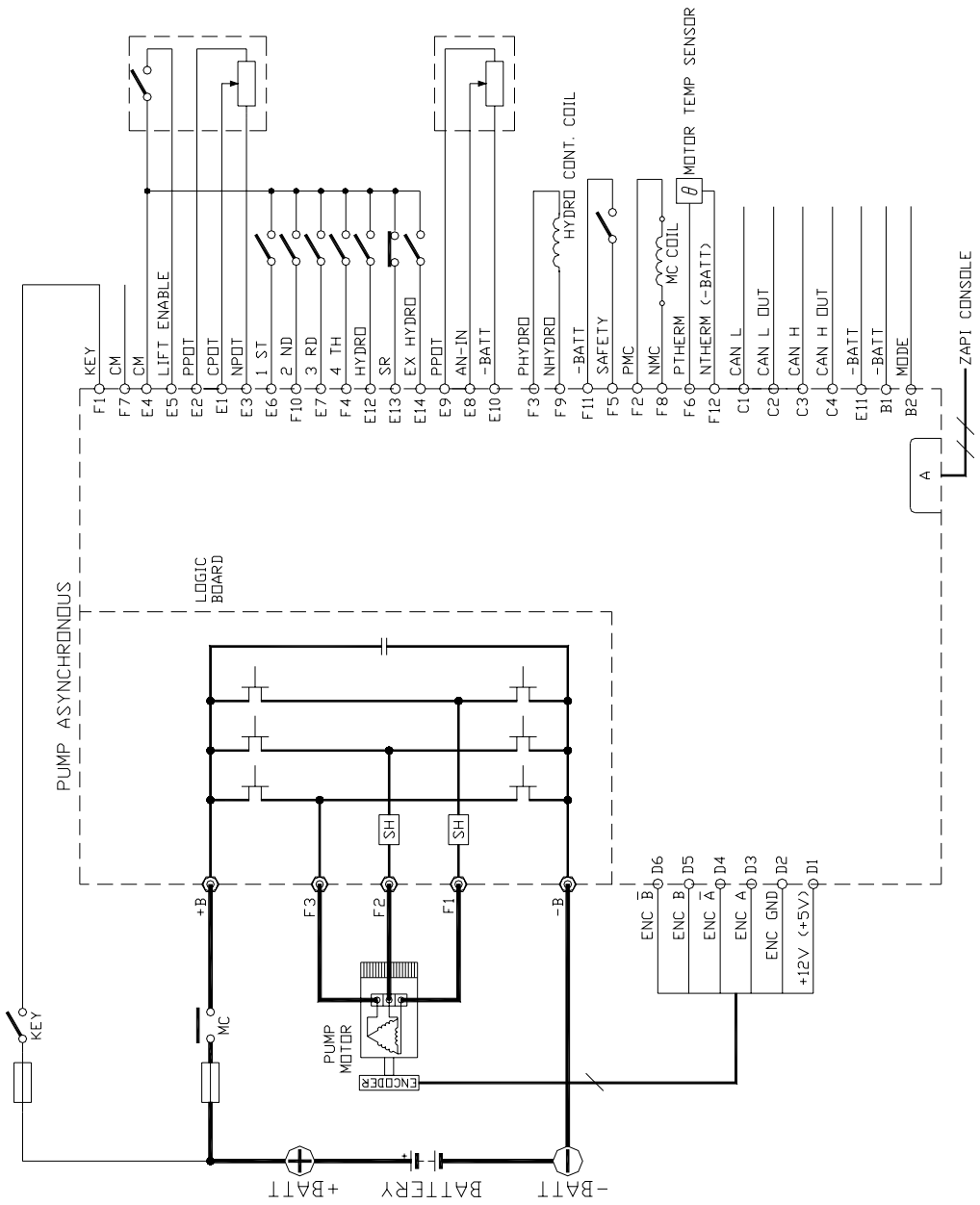




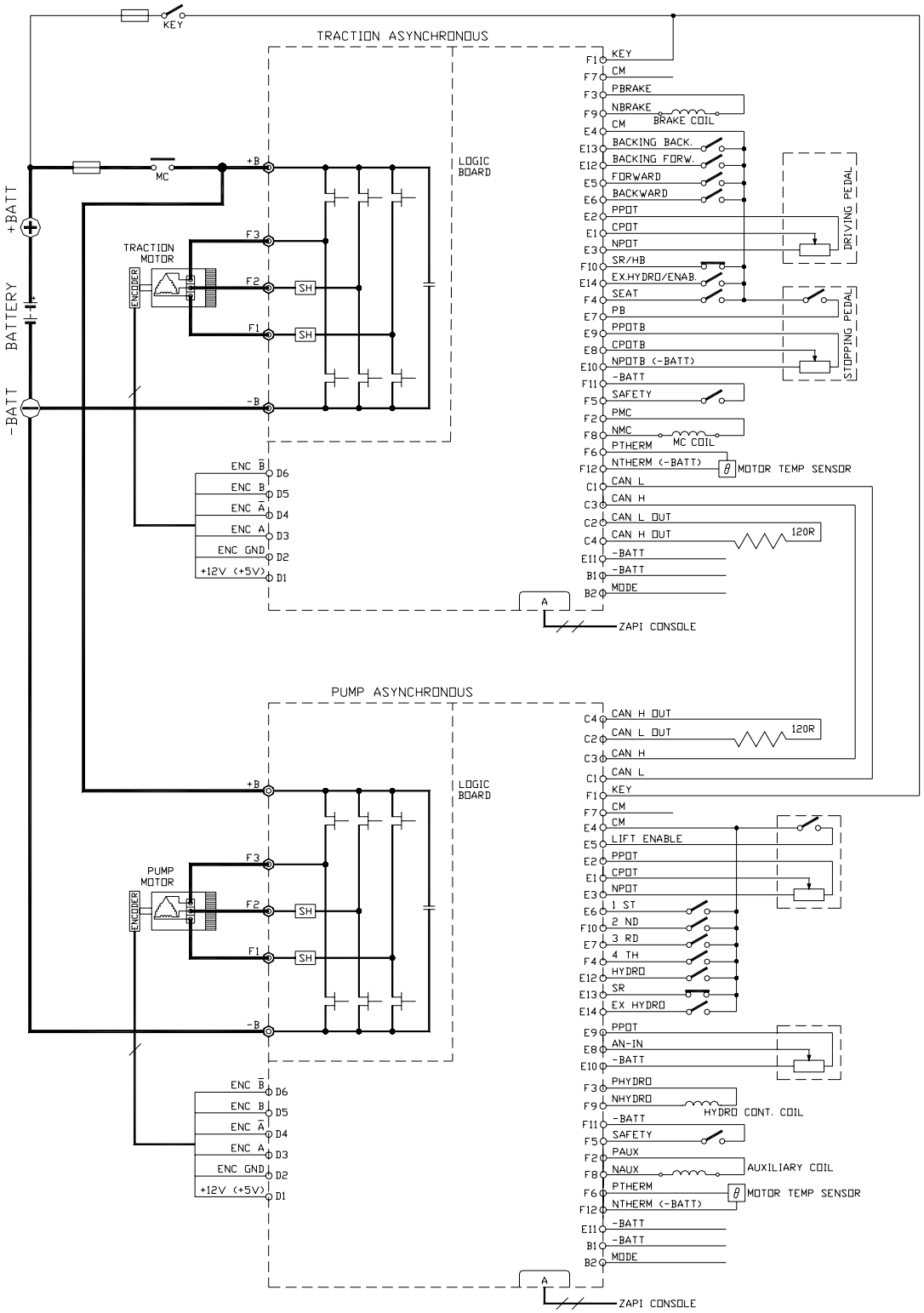
7.2 Connection drawing - Traction configuration



7.3 Connection drawing - Pump configuration



7.4 Connection drawing - Combi configuration

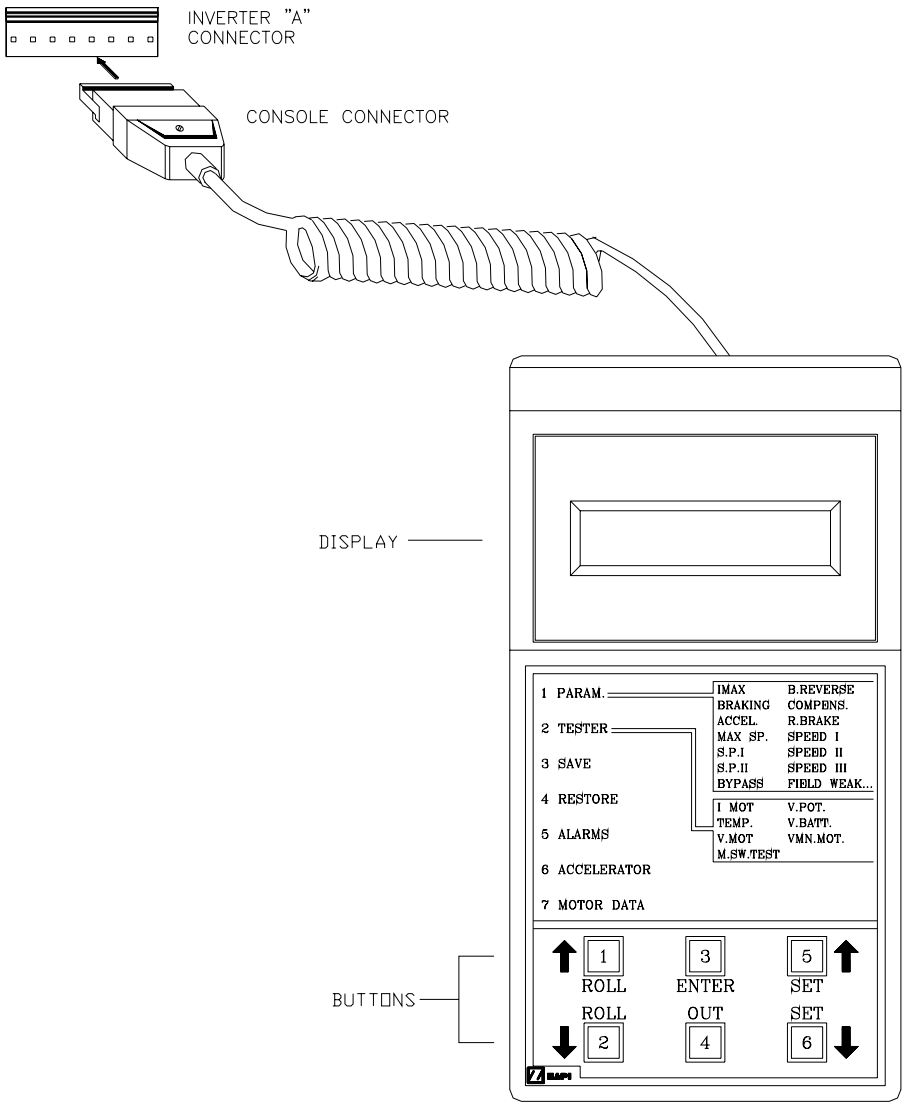


8 PROGRAMMING & ADJUSTMENTS USING DIGITAL CONSOLE

8.1 Adjustments via Console

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

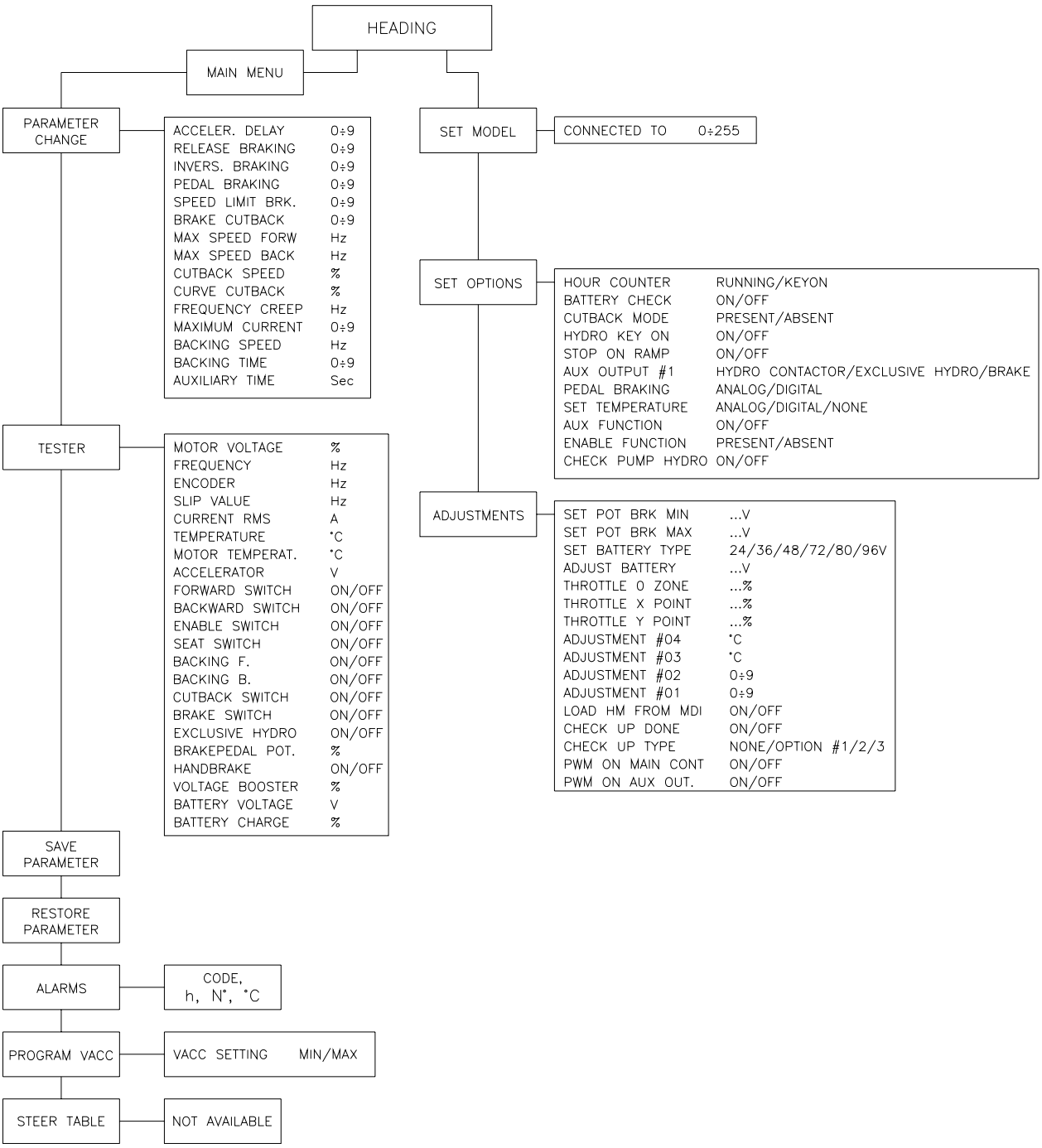
8.2 Description of Console & Connection



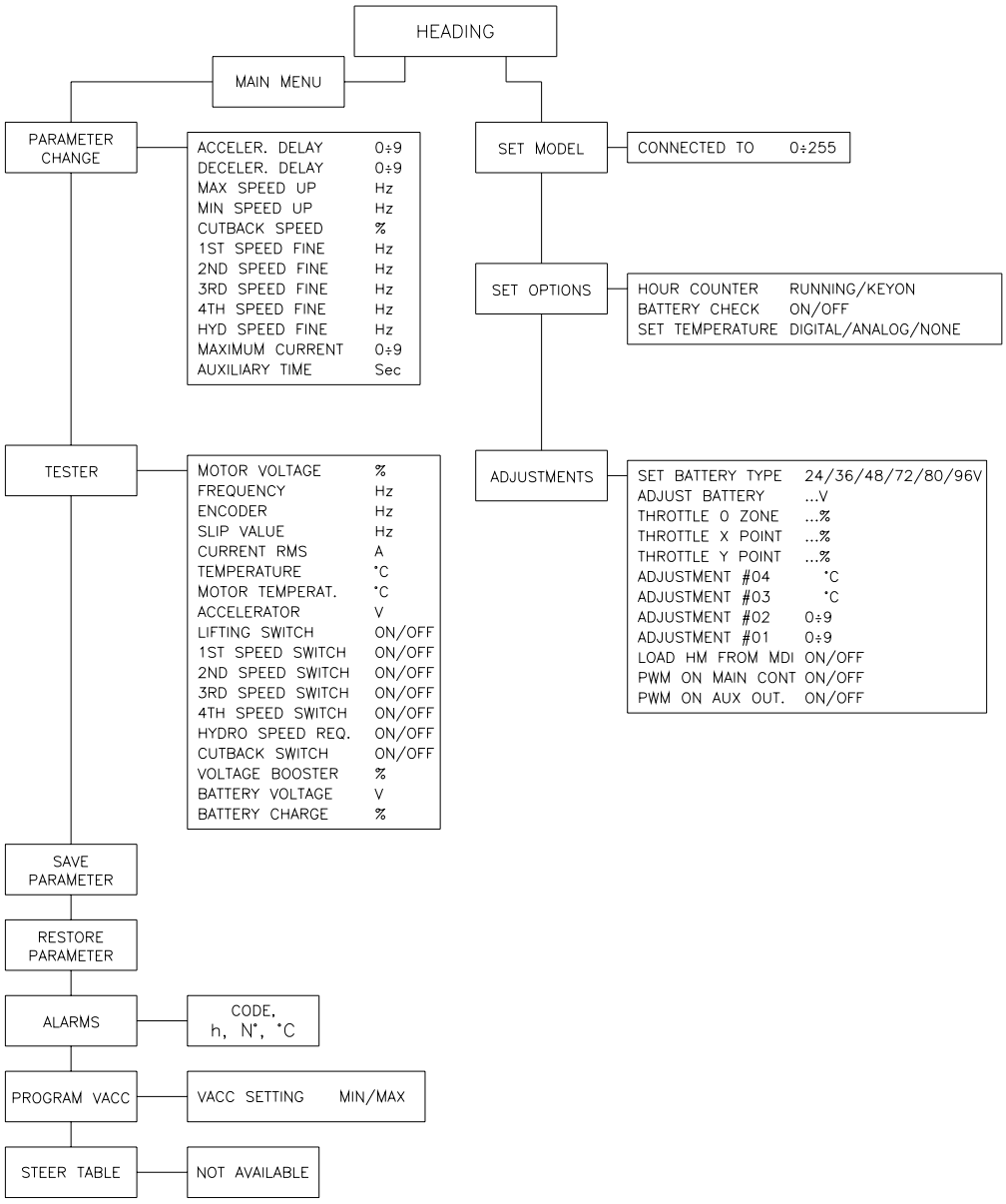
Digital consoles used to communicate with AC inverter controllers must be fitted with EPROM CK ULTRA, minimum "Release Number 3.02".

8.3 Description of Standard Console Menu

8.3.1 Traction configuration



8.3.2 Pump configuration



8.4 Function configuration

8.4.1 Traction

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

SUBMENU "SET OPTIONS"

1) HOUR COUNTER

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

2) BATTERY CHECK

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

3) CUTBACK MODE

- PRESENT: input F10 is managed as a cutback speed input.
- ABSENT: input F10 is managed as an handbrake input.

4) HYDRO KEY ON

- ON / OFF: if this option is programmed ON the traction inverter manages an hydraulic steering function when the "key" is switched ON (only if the "aux output #1" option is programmed as "hydro contactor" or as "exclusive hydro").

5) STOP ON RAMP

- ON: the stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by "auxiliary time" parameter. After this time, the behaviour depends on the "aux output #1" option programming (see also the following table).
- OFF: the stop on ramp feature is not performed.

6) AUX OUTPUT #1

- BRAKE: output F9 drives an electromagnetic brake coil (see also the table below).
- HYDRO CONT.: the inverter manages an hydraulic steering function when the direction input or brake pedal input are active or a movement of the truck is detected.
- EX. HYDRO: the inverter manages an hydraulic steering function when the exclusive hydro input is active.

7) PEDAL BRAKING

- ANALOG: the mechanical brake pedal has a switch and a potentiometer installed. When the accelerator is released and the pedal brake is pushed the inverter performs an electrical braking whose intensity is proportional to the brake pedal potentiometer. The minimum intensity is established by the "Release braking" parameter, when the brake pedal is slightly pressed (brake switch close but brake potentiometer at the minimum). The maximum intensity is established by the "Pedal braking" parameter when the brake pedal is fully pressed (brake potentiometer at the maximum). In the middle positions, the electrical braking intensity is a linear function between minimum and maximum intensity.
- DIGITAL: The truck does not have a potentiometer installed on the mechanical brake pedal, but only a microswitch; when the accelerator pedal is released and the brake pedal is pushed (brake switch closed), the inverter performs an electrical braking following "Pedal braking" parameter.

8) SET TEMPERATURE

- DIGITAL: a digital (ON/OFF) motor thermal sensor is connected to F6 input.
- ANALOG: an analog motor thermal sensor is connected between F6 and F12 (the curve can be customized on a customer request).
- NONE: no motor thermal sensor switch is connected.

9) AUX FUNCTION

- ON/OFF: if this option is programmed ON the traction inverter applies maximum braking and traction torque.

10) ENABLE FUNCTION

- PRESENT: input E14 is managed as accelerator enable input.
- ABSENT: input E14 is managed as exclusive hydro input.

11) CHECK PUMP HYDRO

- ON/OFF: if this option is programmed ON, if the traction inverter doesn't receive any messages by the pump inverter from the CAN-BUS line, the "CAN BUS KO" warning appears on the traction and the maximum speed is reduced down to 10%. The traction also checks via CAN that there aren't alarms on pump. If pump is in alarm, the maximum speed is reduced down to 10%, but in this case any alarm or warning appears.

SUBMENU "ADJUSTMENTS"

1) SET POT BRK MIN

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

2) SET POT BRK MAX

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

3) SET BATTERY TYPE

It selects the nominal battery voltage.

4) ADJUST BATTERY

Fine adjustment of the battery voltage measured by the controller.

5) THROTTLE 0 ZONE

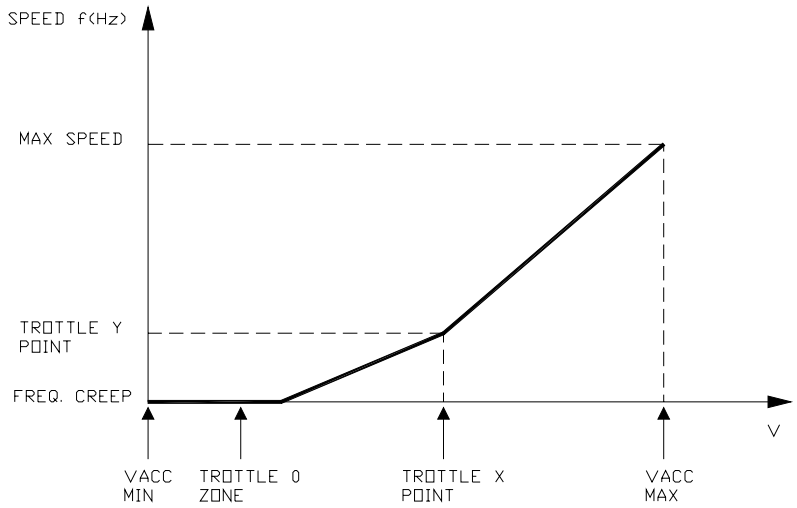
It establishes a deadband in the accelerator input curve (see also curve below).

6) THROTTLE X POINT

This parameter changes the characteristic of the accelerator input curve.

7) THROTTLE Y POINT

This parameter changes the characteristic of the accelerator input curve.



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

8) ADJUSTMENT #04

This parameter determines the motor temperature level at which the “Motor temperature” alarm is signalled. The range is from 70 °C to 160 °C with 10 °C steps. This parameter must be adjusted only if the “Set temperature” (menu “Set option”) parameter is programmed “Analog”.

9) ADJUSTMENT #03

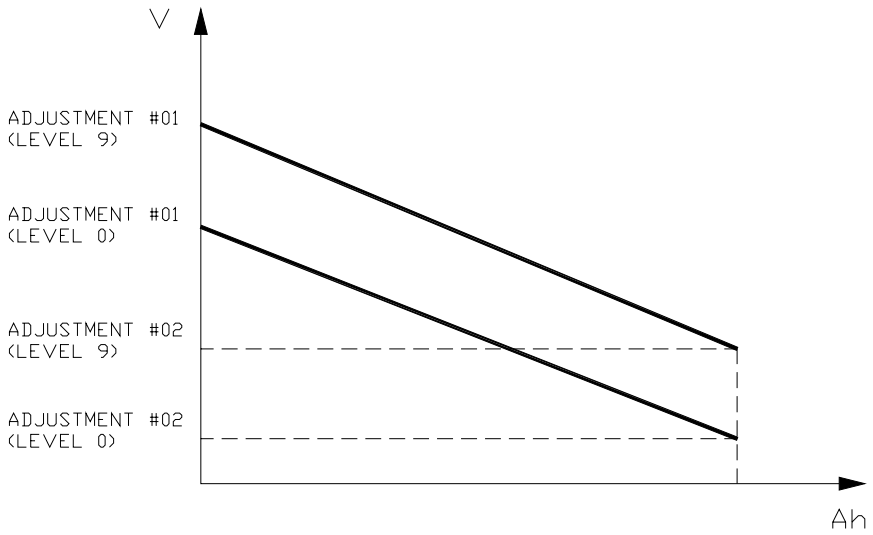
This parameter isn't used.

10) ADJUSTMENT #02

It adjust the lower level of the battery discharge table.

11) ADJUSTMENT #01

It adjusts the upper level of the battery discharge table.



12) LOAD HM FROM MDI

For an explanation of this point see the MDI instrument handbook.

13) CHECK UP DONE

For an explanation of this point see the MDI instrument handbook.

14) CHECK UP TYPE

For an explanation of this point see the MDI instrument handbook.

15) PWM ON MAIN CONT

- OFF: the inverter applies the battery voltage to the loads on the main contactor coil.
- ON: the PWM reduces the voltage at the loads on the main contactor coil down to 62% of the battery voltage.

16) PWM ON AUX OUT.

- OFF: the inverter applies the battery voltage to the loads on the auxiliary output.
- ON: the PWM reduces the voltage at the loads on the auxiliary output down to 62% of the battery voltage.

AUX OUTPUT	STOP ON RAMP	F9 OUTPUT	BEHAVIOUR ON A SLOPE
BRAKE	**ON**	-It drives the coil of a electromagnetic brake. -The hydraulic steering function request is sent to the pump inverter by the can-bus link.	The truck is electrically hold on a slope; when the time set by "auxiliary time" parameter is elapsed the brake is applied and the 3-phase bridge is released. **Do not use this combination if the negative brake is not installed.**
BRAKE	**OFF**	-It drives the coil of a electromagnetic brake. -The hydraulic steering function request is sent to the pump inverter by the can-bus link.	The truck is not electrically hold on a slope, but comes down very slowly; when the time set by "auxiliary time" parameter is elapsed, the brake is applied and the 3-phase bridge is opened. **Do not use this combination if the negative brake is not installed.**
HYDRO CONT.	**ON**	-It drives the coil of a hydraulic steering contactor. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is electrically hold on a slope; when the time set by "auxiliary time" parameter is elapsed, the truck comes down very slowly, till the flat is reached.
HYDRO CONT.	**OFF**	-It drives the coil of a hydraulic steering contactor. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is not electrically hold on a slope, but comes down very slowly till the flat is reached.
EXCL. HYDRO	**ON**	-It drives the coil of a hydraulic steering contactor. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is electrically hold on a slope; when the time set by "auxiliary time" parameter is elapsed, the truck comes down very slowly, till the flat is reached.
EXCL. HYDRO	**OFF**	-It drives the coil of a hydraulic steering contactor. -The hydraulic steering function request is also sent to the pump inverter by the can-bus link.	The truck is not electrically hold on a slope, but comes down very slowly till the flat is reached.

8.4.2 Pump

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

SUBMENU "SET OPTIONS"

1) **HOUR COUNTER**
   - RUNNING: the counter registers travel time only.
   - KEY ON: the counter registers when the "key" switch is closed.
2) **BATTERY CHECK**
   - ON: the battery discharge level check is carried out; when the battery level reaches 10%, an alarm is signalled and the maximum current is reduced to the half of the programmed value.
   - OFF: the battery discharge level check is carried out but no alarm is signalled.

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

- traction inverter: ON
- pump inverter: OFF.

3) SET TEMPERATURE

- DIGITAL: a digital (ON/OFF) motor thermal sensor is connected to F6 input.
- ANALOG: an analog motor thermal sensor is connected between F6 and F12 (the curve can be customized on a customer request).
- NONE: no motor thermal sensor switch is connected.

SUBMENU "ADJUSTMENTS"

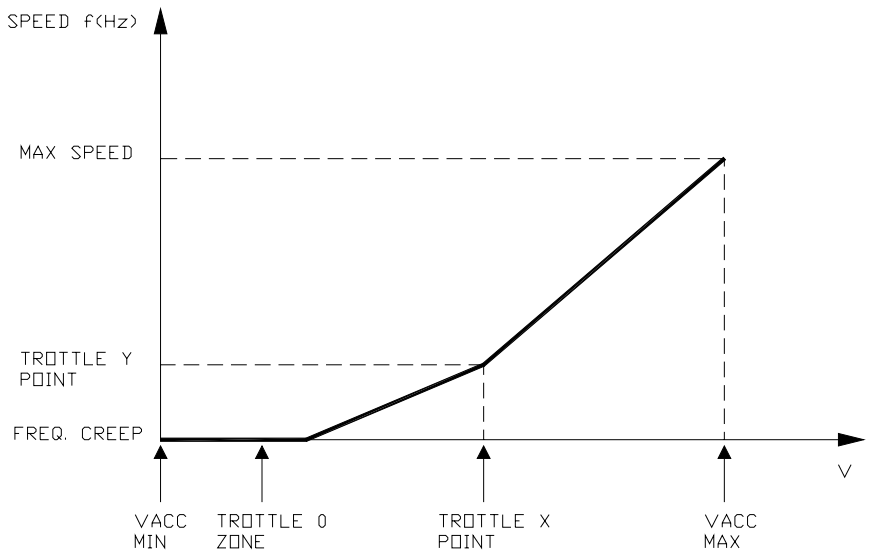
1) SET BATTERY TYPE
It selects the nominal battery voltage.

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

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

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

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



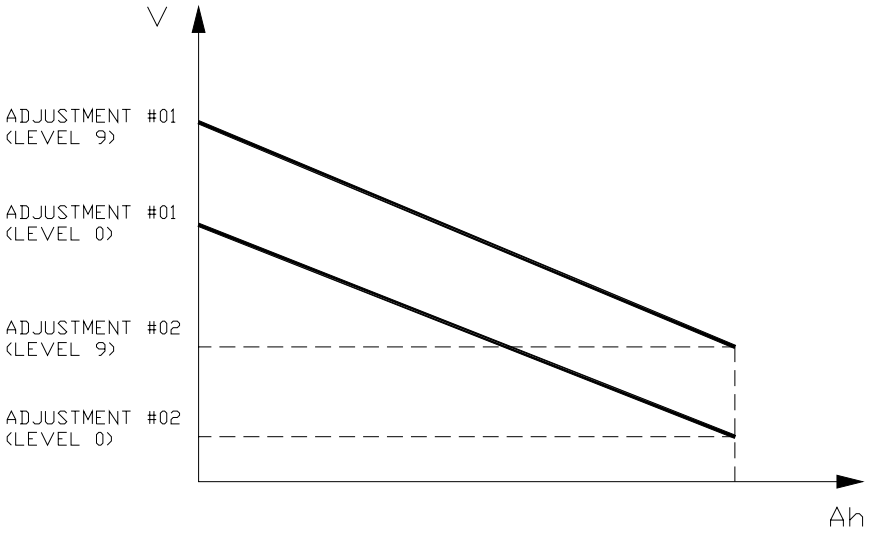
VACC MIN and VACC MAX are values programmable by the "Program Vacc" function.

6) **ADJUSTMENT #04**
This parameter determines the motor temperature level at which the “Motor temperature” alarm is signalled. The range is from 70 °C to 160 °C with 10 °C steps. This parameter must be adjusted only if the “Set temperature” (menu “Set option”) parameter is programmed “Analog”.

7) **ADJUSTMENT #03**
This parameter isn’t used.

8) **ADJUSTMENT #02**
It adjusts the lower level of the battery discharge table.

9) **ADJUSTMENT #01**
It adjusts the upper level of the battery discharge table.



10) **LOAD HM FROM MDI**
For an explanation of this point see the MDI instrument handbook.

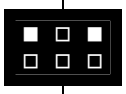
11) **PWM ON MAIN CONT**
- OFF: the inverter applies the battery voltage to the loads on the main contactor coil.
- ON: the PWM reduces the voltage at the loads on the main contactor coil down to 62% of the battery voltage.

12) **PWM ON AUX OUT.**
- OFF: the inverter applies the battery voltage to the loads on the auxiliary output.
- ON: the PWM reduces the voltage at the loads on the auxiliary output down to 62% of the battery voltage.

Flow chart showing how to make changes to OPTION Menu.

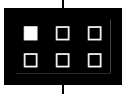
1) Opening Zapi Menu.

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



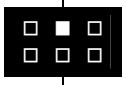
3) The Display will show: SET MODEL.

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



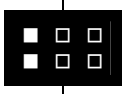
5) SET OPTIONS appears on the display.

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



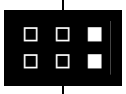
7) The display will shows the first OPTION.

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



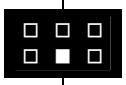
9) Desired OPTION appears.

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



11) New OPTION appears.

12) Press OUT to exit the Menu.

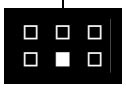


13) Confirmation request appears.

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

15) SET OPTIONS Menu appears.

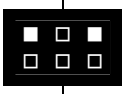
16) Press OUT again. Display now show the Opening Zapi Menu.



Flow chart showing how to make changes to ADJUSTMENTS Menu.

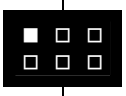
1) Opening Zapi Menu.

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



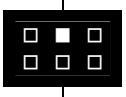
3) The display will show: SET MODEL.

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



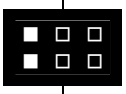
5) ADJUSTMENTS appears on the display.

6) Press ENTER to go into the ADJUSTMENTS Menu.



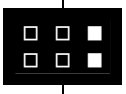
7) The display will shows SET BATTERY TYPE.

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

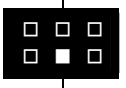


9) The desired parameter appears.

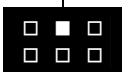
10) Press SET UP or SET DOWN button to modify the adjustment.



11) Press OUT.



12) Press ENTER to confirm.

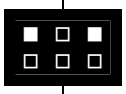


13) Repeat the same from 5 to 12 points for the other adjustments.

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

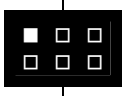
1) Opening Zapi Menu.

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



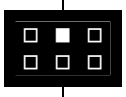
3) The Display will show: SET MODEL.

4) Press ROLL UP button until ADJUSTMENTS Menu appears.



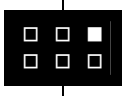
5) ADJUSTMENTS appears on the display.

6) Press ENTER to go into the ADJUSTMENTS Menu.

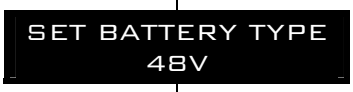


7) The display will show: SET BATTERY TYPE.

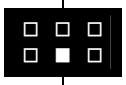
8) Press SET UP to choose nominal value of the battery.



9) New battery value appears.

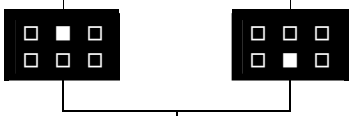


10) Press OUT.

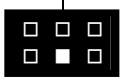


11) Confirmation request appears.

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



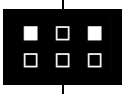
13) Press OUT. Display now shows the Opening Zapi Menu.



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

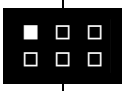
1) Opening Zapi Menu.

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



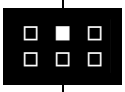
3) The Display will show: SET MODEL.

4) Press ROLL UP button until ADJUSTMENTS Menu appears.



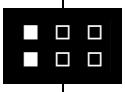
5) ADJUSTMENTS appears on the display.

6) Press ENTER to go into the ADJUSTMENTS Menu.



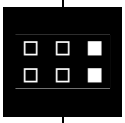
7) The display will show the first OPTION.

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



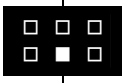
9) ADJUST BATTERY appears.

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



11) Battery value appears on the display.

12) Press OUT to exit the Menu.

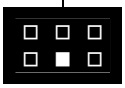


13) Confirmation request appears.

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

15) ADJUSTMENTS Menu appears.

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



8.5 Parameter regulation

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

8.5.1 Traction

The following parameters can be modified:

1) **ACC DELAY**
   It determines the acceleration ramp.
2) **RELEASE BRAKING**
   It controls the deceleration ramp when the travel request is released.
3) **INVERSION BRAKING**
   It controls the deceleration ramp when the direction switch is inverted during travel.
4) **PEDAL BRAKING**
   It determines the deceleration ramp when the travel request is released and the brake pedal switch is closed.
5) **SPEED LIMIT BRK.**
   Deceleration ramp when the pedal position is changed but not completely released.
6) **BRAKE CUTBACK**
   It determines the deceleration ramp when the speed reduction input becomes active and the motor slow down.
7) **MAX SPEED FORW**
   It determines the maximum speed in forward direction.
8) **MAX SPEED BACK**
   It determines the maximum speed in backward direction.
9) **CUTBACK SPEED**
   Speed reduction when the cutback switch is active.
10) **CURVE CUTBACK**
    It determines the speed reduction in curve (only if the eps is present).
11) **FREQUENCY CREEP**
    Minimum speed when the forward or reverse switch is closed, but the accelerator is on a minimum position.
12) **MAXIMUM CURRENT**
    This parameter changes the maximum current of the inverter.
13) **BACKING SPEED**
    It determines the speed in inching function.
14) **BACKING TIME**
    It determines the time of the inching function.
15) **AUXILIARY TIME**
    It determines the time that the truck is hold on the ramp if the "stop on ramp" option is ON.

The following table shows the different values at which the parameters can be set.

PARAMETER	UNIT	PROGRAMMED LEVEL									
		0	1	2	3	4	5	6	7	8	9
ACCELERATION DELAY (*)	Sec.	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
RELEASE BRAKING (**)	Sec.	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0
INVERS BRAKING (**)	Sec.	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0
PEDAL BRAKING (**)	Sec.	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0
SPEED LIMIT BRAKING (**)	Sec.	8.9	8.3	7.7	7.1	6.6	6.0	5.5	4.9	4.4	3.8
BRAKE CUTBACK (**)	Sec.	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0
MAX SPEED FW	Hz	65	80	95	110	125	140	155	170	185	200
MAX SPEED BW	Hz	65	80	95	110	125	140	155	170	185	200
CUTBACK SPEED	%Max Sp	10	20	30	40	50	60	70	80	90	100
CURVE CUTBACK	%Max Sp	0	10	21	33	44	55	66	78	89	100
FREQUENCY CREEP	Hz	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
MAXIMUM CURRENT	%IMAX	47	53	58	64	70	76	82	88	94	100
BACKING SPEED	Hz	0	2	4	6	8	10	12	14	16	18
BACKING TIME	Sec.	0. 2	0.5	1.0	1.4	1.8	2.3	2.7	3.1	3.6	4.0
AUXILIARY TIME	Sec.	0	1	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5

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

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

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

8.5.2 Pump

The following parameters can be modified:

1) **ACCELER. DELAY**
   Acceleration ramp.
2) **DECELER. DELAY**
   Deceleration ramp.
3) **MAX SPEED UP**
   It determines the maximum lifting speed with a potentiometer control.
4) **MIN SPEED UP**
   It determines the minimum lifting speed with a potentiometer control when the lifting enable switch is closed.
5) **CUTBACK SPEED**
   Speed reduction when the cutback switch is active.

6) **1ST SPEED FINE**
First speed, fine regulation.
7) **2ND SPEED FINE**
Second speed, fine regulation.
8) **3RD SPEED FINE**
Third speed, fine regulation.
9) **4TH SPEED FINE**
Fourth speed, fine regulation.
10) **HYD SPEED FINE**
Hydro speed, fine regulation.
11) **MAXIMUM CURRENT**
The maximum current of the inverter.
12) **AUXILIARY TIME**
Time delay when an hydraulic steering function request is switched off.

The following table shows the different values at which the parameters can be set.

PARAMETER	UNIT	PROGRAMMED LEVEL									
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
ACCEL. DELAY (*)	Sec.	0.5	0.7	1.0	1.4	1.9	2.5	3.2	4.0	4.8	5.5
DECEL. DELAY (**)	Sec.	0.5	0.7	1.0	1.4	1.9	2.5	3.2	4.0	4.8	5.5
MAX SPEED UP	Hz	65	80	95	110	125	140	155	170	185	200
MIN SPEED UP	Hz	0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5
CUTBACK SPEED	%Max Sp	10	20	30	40	50	60	70	80	90	100
SPEED FINE (ALL) (***)	Hz	-	-	-	-	-	-	-	-	-	-
MAX CURRENT	%IMAX	47	53	58	64	70	76	82	88	94	100
AUXILIARY TIME	Sec.	0	0.2	0.4	0.8	1.0	1.5	2.0	3.0	4.0	5.0

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

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

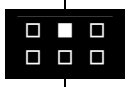
(***) Adjustable with a 1Hz resolution in the 0 to 200 Hz range.

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

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

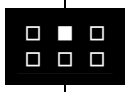
1) Opening Zapi Display.

2) Press ENTER to go into the General Menu.



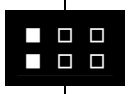
3) The Display will show:

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



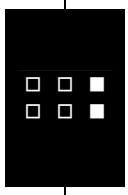
5) The Display will show the first parameter.

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



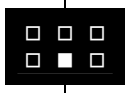
7) The names of the Parameters appear on the Display.

8) When the desired Parameter appears, the Display will show a Level Number that will be Between 0 and 9. Press either SET UP (Top Right) or SET DOWN (Bottom Right) buttons to change the Level value.



9) The Display will show the New Level.

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



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

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

13) The Display will show:

8.6 Programming console functions

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

TRACTION	PUMP
motor voltage (%)	motor voltage (%)
frequency (Hz)	frequency (Hz)

encoder (Hz)	encoder (Hz)
slip value (Hz)	slip value (Hz)
current rms (A)	current rms (A)
temperature (°C)	temperature (°C)
motor temperat. (°C)	motor temperature (°C)
accelerator (V)	accelerator (V)
forward switch (ON/OFF)	lifting switch (ON/OFF)
backward switch (ON/OFF)	1st speed switch (ON/OFF)
enable switch (ON/OFF)	2nd speed switch (ON/OFF)
seat switch (ON/OFF)	3rd speed switch (ON/OFF)
backing f. (ON/OFF)	4th speed switch (ON/OFF)
backing b. (ON/OFF)	hydro speed req. (ON/OFF)
cutback switch (ON/OFF)	cutback switch (ON/OFF)
brake switch (ON/OFF)	voltage booster (%)
exclusive hydro (ON/OFF)	battery voltage (V)
brakepedal pot. (%)	battery charge (%)
hand brake (ON/OFF)	
voltage booster (%)	
battery voltage (V)	
battery charge (%)	

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

8.7 Sequence for Ac Inverter Traction setting

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

1) Select the Options required. See Chapter 8.4.1.
2) Select and set the Battery Voltage. See Chapter 8.4.1.
3) Confirm correct installation of all wires. Use the Console's TESTER function to assist.
4) Perform the accelerator signal acquisition procedure using the Console "PROGRAM VACC". Procedure is detailed on Chapter 9.4.
5) Set the "MAXIMUM CURRENT" Current, using the table on Chapter 8.5.1.
6) Set the Acceleration Delay requirements for the machine. Test the parameters in both directions.
7) Set the FREQUENCY CREEP level starting from level 0.6 Hz. The machine should just move when the accelerator microswitch is closed. Increase the Level accordingly.
8) Set the Speed Reductions as required. Make adjustments to "CUTBACK SPEED" Check the performance with the accelerator pedal totally depressed.

If the machine is a forklift, check the performance with and without load.

9) RELEASE BRAKING. Operate the machine at full speed. Release the accelerator pedal. Adjust the level to your requirements. If the machine is a forklift, check the performance with and without load.

10) INVERSION BRAKING. Operate the machine at 25% full speed. Whilst travelling INVERT the Direction Switch. Set a soft Level of Inversion Braking. When satisfactory, operate the machine at Full Speed and repeat. If the machine is a Forklift, repeat the tests and make adjustments with and without load. The unlade full speed condition should be the most representative condition.

11) PEDAL BRAKING (If used). Operate the machine at full Speed. Release the accelerator pedal and press the Pedal Brake. Set braking level to your requirements.

12) Set “MAX SPEED FORW”.

13) Set “MAX SPEED BACK” (Reverse).

14) Make the choice for the truck behaviour on a slope (see chapter 8.4). If the "Stop on ramp" option is ON, set the desired value of "auxiliary time" parameter.

15) Set “SET TEMPERATURE”, setting the motor thermal sensor type used.

8.8 Sequence for Ac Inverter Pump setting

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

1) Select the Options required. See Chapter 8.4.2.

2) Select and set the Battery Voltage. See Chapter 8.4.2.

3) Confirm correct installation of all wires. Use the Console’s TESTER function to assist.

4) Perform the lift signal acquisition procedure using the Console “PROGRAM VACC”. Procedure is detailed on Chapter 9.4.

5) Set the "MAXIMUM CURRENT” Current, using the table on Chapter 8.5.2.

6) Set the Acceleration and Deceleration Delay requirements for the pump.

7) Set the “MIN SPEED UP” level starting from 0 Hz. The pump should just turn when the request microswitch is closed. Increase the level accordingly.

8) Set the Speed Reductions as required. Make adjustments to “CUTBACK SPEED”. Check the performance with the full request. Check the performance with and without load.

9) Set “MAX SPEED UP” (max speed of pump motor).

10) Set “HYD SPEED FINE” to adjust the hydraulic steering speed (pump motor speed when HYDRO function is requested).

11) Set “AUXILIARY TIME” (time delay before pump stops when an hydraulic steering function request is switched off).

12) Set “SET TEMPERATURE”, setting the motor thermal sensor type used.

8.9 Tester: description of the function

The most important input or output signals can be measured in real time using

the TESTER function of the console. The Console acts as a multimeter able to read voltage, current and temperature. The following definition listing shows the relative measurements.

8.9.1 Traction

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

- OFF / +VB = non active entry of microswitch.

16) **BRAKE SWITCH**
The level of the Pedal Brake Microswitch.
- ON / +VB = active entry of Brake pedal Microswitch.
- OFF / GND = non active entry of microswitch.

17) **EXCLUSIVE HYDRO**
Status of the exclusive hydro input.
- ON / +VB = active entry of closed switch.
- OFF / GND = non active entry of open switch.

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

19) **HAND BRAKE**
The level of the Handbrake Microswitch.
- ON / GND = active entry of Handbrake Switch (open switch).
- OFF/ +VB = non active entry of microswitch (closed switch).

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

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

22) **BATTERY CHARGE**
The percentage Charge level of the battery.

8.9.2 Pump

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

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

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

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

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

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

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

8) **ACCELERATOR**
The voltage of the accelerator potentiometer's wiper (CPOT). The voltage level is shown on the Left Hand Side of the Console Display and the value in percentage is shown on the Right Hand Side.

9) **LIFTING SWITCH**
Status of the lifting switch.
- ON / +VB = active entry of closed switch.
- OFF / GND = non active entry of open switch.

10) **1ST SPEED SWITCH**
Status of the first speed switch of the pump.
- ON / +VB = active entry of closed switch.

- OFF / GND = non active entry of open switch.

11) 2ND SPEED SWITCH

Status of the second speed switch of the pump.

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

12) 3RD SPEED SWITCH

Status of the third speed switch of the pump.

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

13) 4TH SPEED SWITCH

Status of the fourth speed switch of the pump.

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

14) HYDRO SPEED REQ.

Status of the hydro speed request of the pump.

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

15) CUTBACK SWITCH

The level of the Speed Reduction Microswitch.

- ON / GND = active entry of speed reduction microswitch.
- OFF / +VB = non active entry of microswitch.

16) VOLTAGE BOOSTER

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

17) BATTERY VOLTAGE

Level of battery voltage measured at the input to the key switch.

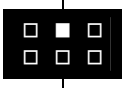
18) BATTERY CHARGE

The percentage Charge level of the battery.

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

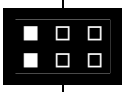
1) Opening Zapi Display.

2) Press ENTER to go into the General menu.



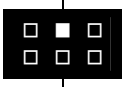
3) The Display will show:

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



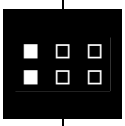
5) The Display shows:

6) Press ENTER to go into the TESTER function.

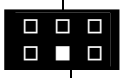


7) The first variable to be tested is shown on the Display.

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

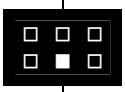


9) When you have finished, Press OUT.



10) The Display shows:

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



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

9 OTHER FUNCTIONS

9.1 Description of the Console “SAVE” function

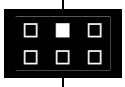
The SAVE function allows the operator to transmit the Parameter values and Configuration data of the inverter into the Console memory. It is possible to load 64 different programmes.
The information saved in the Console memory can then be reloaded into another inverter using the RESTORE function.
The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

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

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

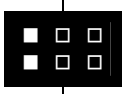
1) Opening Zapi Display.

2) Press ENTER to go into the General menu.



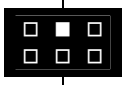
3) The Display will show:

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



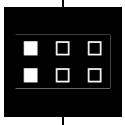
5) The Display will show:

6) Press ENTER to go into the SAVE function.

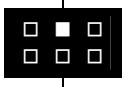


7) If this facility has been used before the type of inverter data stored appears on the top Main with a 2 digit reference.

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



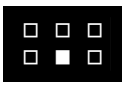
9) Press ENTER to commence SAVE routine.



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

11) When finished, the Console shows:

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



9.2 Description of Console “RESTORE” function

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

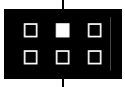
- All Parameter Values (PARAMETER CHANGE).
- Options (SET OPTIONS).
- The level of the Battery (ADJUST BATTERY).

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

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

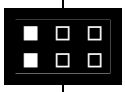
1) Opening Zapi Display.

2) Press ENTER to go into the General menu.



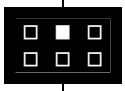
3) The Display will show:

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



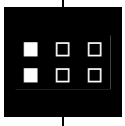
5) The Display will show:

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

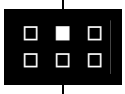


7) The Display shows the type of Model stored, with a Code Number.

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



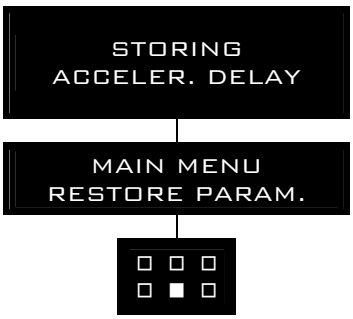
9) Press ENTER to commence the Restore operation.



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

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

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



13) When finished the Console displays:

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

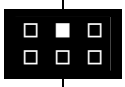
9.3 Description of “ALARMS” menu

The microprocessor in the inverter remembers the last five Alarms that have occurred. Items remembered relative to each Alarm are: the code of the alarm, the number of times the particular Alarm occurred, the Hour Meter count, and the inverter temperature.
This function permits a deeper diagnosis of problems as the recent history can now be accessed.

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

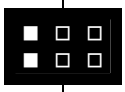
1) Opening Zapi Display.

2) Press ENTER to go into the General menu.



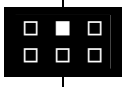
3) The Display will show:

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



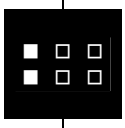
5) The Display will show:

6) Press ENTER to go into the ALARMS function.



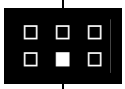
7) The Display will show the most recent Alarm.

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



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

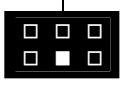
10) When you have finished looking at the Alarms, press OUT to exit the ALARMS menu.



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

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

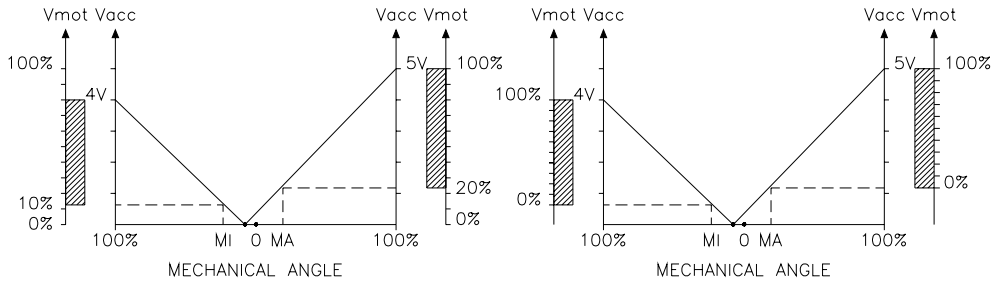
13) Press OUT to return to the Opening Zapi Display.



9.4 Description of Console “PROGRAM VACC” function

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

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

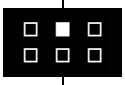


This function looks for and remembers the minimum and maximum potentiometer wiper voltage over the full mechanical range of the pedal. It enables compensation for non symmetry of the mechanical system between directions. The operation is performed by operating the pedal after entering the PROGRAM VACC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

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

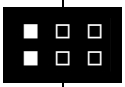
1) Opening Zapi Display.

2) Press ENTER to go into the General Menu.



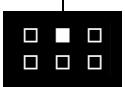
3) The Display will show:

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



5) The Display will show:

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



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

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

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

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

11) Select the Reverse Direction and repeat Item 10.

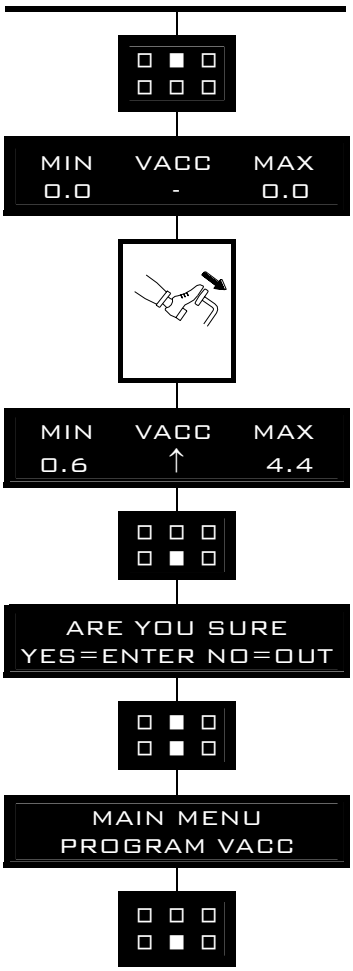
12) When finished, press OUT.

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

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

15) When finished, the Console shows:

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



10 AC-2 FLASH INVERTER DIAGNOSTIC - TRACTION CONFIGURATION

The alarms are signalled by a diagnostic LED.

1 blink:	logic failure ("WATCHDOG", "EEPROM KO", "LOGIC FAILURE #1", "LOGIC FAILURE #2", "LOGIC FAILURE #3", "CHECK UP NEEDED").
2 blinks:	running request on start-up or error in seat sequence, double direction request or encoder problem ("INCORRECT START", "HANDBRAKE", "FORW + BACK", "ENCODER ERROR").
3 blinks:	phase voltage or capacitor charge failure ("CAPACITOR CHARGE", "VMN LOW", "VMN HIGH").
4 blinks:	failure in accelerator ("VACC NOT OK", "PEDAL WIRE KO", "PEDAL FAILURE").
5 blinks:	failure of current sensor ("STBY I HIGH", "DATA ACQUISITION").
6 blinks:	failure of contactor driver ("COIL SHORTED", “DRIVER SHORTED", "CONTACTOR DRIVER", "AUX OUTPUT KO", "CONTACTOR OPEN", "CONTACTOR CLOSED").
7 blinks:	excessive temperature ("HIGH TEMPERATURE", "MOTOR TEMPERATURE", "THERMIC SENSOR KO", "MOT. TH. SENSOR KO").
8 blinks:	failure of can-bus or problem in the SAFETY circuit ("CAN-BUS KO", "SAFETY", "SAFETY KO").
long blink:	discharge battery or wrong battery voltage ("LOW BATTERY", "WRONG SET BATT.").
no blink:	problem in a remote module ("WAITING FOR NODE").

10.1 Analysis of alarms displayed on console

1) **WATCH DOG**
   The test is made in both running and standby. It is a self-diagnosing test within the logic. If an alarm should occur, replace the logic.
2) **EEPROM KO**
   Fault in the area of memory in which the adjustment parameters are stored; this alarm inhibits machine operation. If the defect persists when the key is switched OFF and ON again, replace the logic. If the alarm disappears, remember that the parameters stored previously have been cancelled and replaced by the default values.
3) **LOGIC FAILURE #1**
   This alarm signals that an undervoltage / overvoltage protection operation has occurred. Two possible reasons:
   A) A real undervoltage / overvoltage situation happened.
   B) Fault in the hardware section of the logic board which manages the overvoltage protection. Replace the logic card.

4) LOGIC FAILURE #2

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

5) LOGIC FAILURE #3

Fault in the hardware section of the logic board which manages the hardware current protection. Replace the logic board.

6) CHECK UP NEEDED

This is a warning. It is an information for the user that the programmed time for maintenance is elapsed.

7) INCORRECT START

This alarm signals an incorrect starting sequence. Possible causes:

A) running microswitch failure;
B) error in sequence made by the operator;
C) incorrect wiring;
D) if the default persists, replace the logic.

8) FORW + BACK

The test is carried out continuously. An alarm is signalled when a double running request is made simultaneously. Possible causes:

A) defective wiring;
B) running microswitch failure;
C) incorrect operation;
D) if the defect persists, replace the logic.

9) HANDBRAKE

The truck does not start because the handbrake switch is opened. Possible causes:

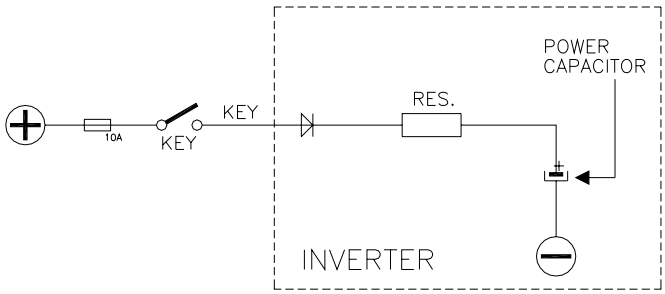
A) defective wiring;
B) failure of the microswitch;
C) incorrect operation of the operator;
D) if the defect persist, replace the logic.

10) ENCODER ERROR

Two consecutive readings of the encoder speed are too much different in between: because of the inertia of the system it is not possible the encoder changes its speed a lot in a short period. Probably an encoder failure has occurred (e.g. one or two channels of the encoder are corrupted or disconnected). Check both the electric and the mechanical encoder functionality. Also the electromagnetic noise on the sensor bearing can be a cause for the alarm.

11) CAPACITOR CHARGE

Follows the charging capacitor system:



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

Possible reasons:

A) the charging resistance is opened; if it is opened.
B) The charging circuit has a failure.
C) There is a problem on the power modules.

12) VMN LOW, VMN HIGH

The test is carried out during initial diagnosis and in standby.
Possible causes:

A) problem with the motor connections or the motor power circuit; check if the 3 phases are correctly connected; check if there's a dispersion of the motor towards ground;
B) inverter failure, replace it.

13) VACC NOT OK

The test is made in standby. This alarm indicates that the accelerator voltage is 1 V greater than the minimum value programmed by the PROGRAM VACC function.
Possible causes:

A) the potentiometer is not correctly calibrated;
B) the potentiometer is defective.

14) PEDAL WIRE KO

This alarm is signalled if a fault is detected in the accelerator unit wiring (NPOT or PPOT cable is interrupted).

15) PEDAL FAILURE

This alarm can be activated on request and it is signalled if the accelerator signal is out of the range. Possible cause: an hardware problem on the logic board or a potentiometer problem (disconnected wire, damaged cursor).

16) STBY I HIGH

Test carried out in standby. Check if the current is 0. If not verified, an alarm is signalled which inhibits machine operations. Possible causes:

A) current sensor failure;
B) logic failure: first replace the logic; if the defect persists, replace the power unit.

17) DATA ACQUISITION

This alarm is signalled in the current gain acquisition phase. Wait the end of the acquisition activity.

18) MAIN CONTACTOR ALARMS

- **COIL SHORTED**
  When the key is switched ON the µP checks the MC driver FF SR. If it does not react in a correct way to the µP stimulus, the alarm is signalled. Replace the logic board. The FF SR makes an hardware control of the current in the MC coil. If this is too high, it opens the MC and the alarm is signalled.
  Check if there are external shortcircuit and if the ohmic value of the MC is correct; otherwise replace the logic.
- **DRIVER SHORTED**
  When the key is switched ON, the µP checks that the MC coil driver is not shorted; if it is, this alarm is signalled; replace the logic board.
- **CONTACTOR DRIVER**
  When the initial diagnosis is finished, the traction logic closes the MC and checks the voltage on the Drain of the driver. If this is not low, an alarm is signalled.
  Replace the logic.
- **CONTACTOR OPEN**
  The main contactor coil has been driven by the logic board, but the contactor does not close. Two possible reasons:
  A) the wires to the coil are interrupted or not well connected.
  B) the contact of the contactor is not properly working.

- **CONTACTOR CLOSED**
  The controller checks if the LC contact is closed when the coil isn't driven, trying to discharge the capacitor bank. If they don't discharge, the fault condition is entered. It is suggested to check the contactor contact, if it is mechanically stuck or pasted.

19) AUX OUTPUT KO

The µP checks the driver of the electromechanical brake. If the status of the driver output does not correspond to the signal coming from the µP, the alarm is signalled. Replace the logic.

20) HIGH TEMPERATURE

Inverter temperature is greater than 75 °C. The maximum current is reduced proportionally to the temperature increase. The inverter stops at 100 °C.
If the alarm is signalled when the inverter is cold:

A) check the wiring of the thermal sensor;
B) thermal sensor failure;
C) logic failure.

21) MOTOR TEMPERATURE

This warning is signalled if the motor temperature switch opens (digital sensor) or if the analog signal overtakes the cut off level. If it happens when the motor is cold, check the wiring. If all is ok, replace the logic board.

22) THERMIC SENSOR KO

The range of inverter temperature sensor is always checked and a warning is signalled if it is out of range.
When this alarm is signalled, check the connection of the sensors.

23) MOT. TH. SENSOR KO

The range of motor temperature sensor is always checked and a warning is signalled if it is out of range.
When this alarm is signalled, check the connection of the sensors.

24) CAN BUS KO

The diagnosis of the CAN-BUS line is present only if the inverter uses this link (depends on the software version). It is signalled if the inverter does not receive any message from the CAN-BUS line. First of all, check the wiring. If it is ok, the problem is on the logic board, which must be replaced.

25) SAFETY

This alarm is signalled when the "SAFETY" input is open. The "SAFETY" circuit gets active and opens the drivers of LC and EB and stops the machine. Verify the "SAFETY" input connection.

26) SAFETY KO

This alarm is present in combi systems (traction + pump). If a stopping alarm is detected on the pump, the traction also stops. The failure must be looked for in the pump inverter.

27) BATTERY LOW

If the "battery check" option is ON, a battery discharge algorithm is carried out. When the charge level is 10%, this alarm is signalled and the current is reduced to the half of the programmed level.

28) WRONG SET BATT.

When the key is turned ON, the controller check the battery voltage and verifies it is within a window around the nominal value. Replace the battery with a correct battery.

29) WAITING FOR NODE

The controller receives from a remote module via CAN Bus the information that it isn't possible to close the LC (the module isn't ready locked in an alarm state). Verify the other modules to determinate in which of them there is the problem.

11 AC-2 FLASH INVERTER DIAGNOSTIC - PUMP CONFIGURATION

The alarms are signalled by a diagnostic LED.

1 blink:	logic failure ("WATCHDOG", "EEPROM KO", "LOGIC FAILURE #1", "LOGIC FAILURE #2", "LOGIC FAILURE #3").
2 blinks:	running request on start-up, error in seat sequence or encoder problem ("INCORRECT START", "ENCODER ERROR").
3 blinks:	phase voltage or capacitor charge failure ("CAPACITOR CHARGE", "VMN LOW", "VMN HIGH").
4 blinks:	failure in accelerator ("VACC NOT OK", "PEDAL WIRE KO").
5 blinks:	failure of current sensor ("STBY I HIGH", "SEAT KO", "DATA ACQUISITION").
6 blinks:	failure of contactor driver ("COIL SHORTED", "DRIVER SHORTED", "CONTACTOR DRIVER", "CONTACTOR OPEN", "AUX OUTPUT KO").
7 blinks:	excessive temperature ("HIGH TEMPERATURE", "MOTOR TEMPERATURE", "THERMIC SENSOR KO").
8 blinks:	failure of can-bus or problem in the SAFETY circuit ("CAN-BUS KO", "SAFETY").
long blink:	discharge battery o wrong battery voltage ("LOW BATTERY", "WRONG SET BATT.").
no blink:	problem in a remote module ("WAITING FOR NODE").

11.1 Analysis of alarms displayed on console

1) **WATCH DOG**
   The test is made in both running and standby. It is a self-diagnosing test within the logic. If an alarm should occur, replace the logic.
2) **EEPROM KO**
   Fault in the area of memory in which the adjustment parameters are stored; this alarm inhibits machine operation. If the defect persists when the key is switched OFF and ON again, replace the logic. If the alarm disappears, remember that the parameters stored previously have been cancelled and replaced by the default values.
3) **LOGIC FAILURE #1**
   This alarm signals that an undervoltage / overvoltage protection operation has occurred. Two possible reasons:
   A) A real undervoltage / overvoltage situation happened.
   B) Fault in the hardware section of the logic board which manages the overvoltage protection. Replace the logic card.

4) LOGIC FAILURE #2

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

5) LOGIC FAILURE #3

Fault in the hardware section of the logic board which manages the hardware current protection. Replace the logic board.

6) INCORRECT START

This alarm signals an incorrect starting sequence. Possible causes:

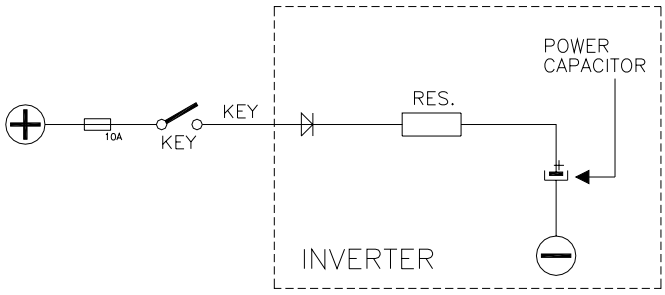
A) running microswitch failure;
B) error in sequence made by the operator;
C) incorrect wiring;
D) if the default persists, replace the logic.

7) ENCODER ERROR

Two consecutive readings of the encoder speed are too much different in between: because of the inertia of the system it is not possible the encoder changes its speed a lot in a short period. Probably an encoder failure has occurred (e.g. one or two channels of the encoder are corrupted or disconnected). Check both the electric and the mechanical encoder functionality. Also the electromagnetic noise on the sensor bearing can be a cause for the alarm.

8) CAPACITOR CHARGE

Follows the charging capacitor system:



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

Possible reasons:

A) check if the charging resistance is opened.
B) The charging circuit has a failure.
C) There is a problem on the power modules.

9) VMN LOW, VMN HIGH

The test is carried out during initial diagnosis and in standby.

Possible causes:

A) problem with the motor connections or the motor power circuit; check if the 3 phases are correctly connected; check if there's a dispersion of the motor towards ground;
B) inverter failure, replace it.

10) PEDAL WIRE KO

This alarm is signalled if a fault is detected in the accelerator wiring (NPOT or PPOT cable is interrupted).

11) VACC NOT OK

The test is made in standby. This alarm indicates that the accelerator voltage is 1 V greater than the minimum value programmed by the PROGRAM VACC function.

Possible causes:

A) the potentiometer is not correctly calibrated;
B) the potentiometer is defective.

12) STBY I HIGH

Test carried out in standby. Check if the current is 0. If not verified, an alarm is signalled which inhibits machine operations. Possible causes:

A) current sensor failure;
B) logic failure: first replace the logic; if the defect persists, replace the power unit.

13) SEAT KO

This alarm is present in combi systems (traction + pump). The pump compares the status of the seat input with the value transmitted by the traction via CAN-BUS. The alarm is signalled if the two values are different in between.

14) DATA ACQUISITION

This alarm is signalled in the current gain acquisition phase. Wait the end of the acquisition activity.

15) MAIN CONTACTOR ALARMS

In the combi system (pump + traction) the main contactor is driven by the traction inverter. So the following description concerns the pump inverter used independently from the traction inverter. In this configuration the pump inverter manages its own main contactor.

- **COIL SHORTED**
  When the key is switched ON the µP checks the MC driver FF SR. If it does not react in a correct way to the µP stimulus, the alarm is signalled. Replace the logic board. The FF SR makes an hardware control of the current in the MC coil. If this is too high, it opens the MC and the alarm is signalled.
  Check if there are external shortcircuit and if the ohmic value of the MC is correct; otherwise replace the logic.
- **DRIVER SHORTED**
  When the key is switched ON, the µP checks that the MC coil driver is not shorted; if it is, this alarm is signalled; replace the logic board.
- **CONTACTOR DRIVER**
  When the initial diagnosis is finished, the traction logic closes the MC and checks the voltage on the Drain of the driver. If this is not low, an alarm is signalled.
  Replace the logic.
- **CONTACTOR OPEN**
  The main contactor coil has been driven by the logic board, but the contactor does not close. Two possible reasons:
  A) the wires to the coil are interrupted or not well connected.
  B) the contact of the contactor is not properly working.

16) AUX OUTPUT KO

The µP checks the driver of the electromechanical brake. If the status of the driver output does not correspond to the signal coming from the µP, the alarm is signalled. Replace the logic.

17) HIGH TEMPERATURE

Inverter temperature is greater than 75 °C. The maximum current is reduced proportionally to the temperature increase. The inverter stops at 100 °C.
If the alarm is signalled when the inverter is cold:

A) check the wiring of the thermal sensor;
B) thermal sensor failure;
C) logic failure.

18) MOTOR TEMPERATURE

This warning is signalled if the motor temperature switch opens digital sensor or if the analog signal overtakes the cut-off level. If it happens when the motor is cold, check the wiring. If all is OK, replace the logic board.

19) THERMIC SENSOR KO

The range of inverter temperature sensor is always checked and a warning is signalled if it is out of range.
When this alarm is signalled, check the connection of the sensors.

20) CAN BUS KO

The diagnosis of the CAN-BUS line is present only if the inverter uses this link (depends on the software version). It is signalled if the inverter does not receive any message from the CAN-BUS line. First of all, check the wiring. If it is ok, the problem is on the logic board, which must be replaced.

21) SAFETY

This alarm is signalled when the "SAFETY" input is open. The "SAFETY" circuit gets active and opens the drivers of LC and EB and stops the machine. Verify the “SAFETY” input connection.

22) BATTERY LOW

If the "battery check" option is ON, a battery discharge algorithm is carried out. When the charge level is 10%, this alarm is signalled and the current is reduced to the half of the programmed level.

23) WRONG SET BATT.

When the key is turned ON, the controller check the battery voltage and verifies it is within a window around the nominal value. Replace the battery with a correct battery.

24) WAITING FOR NODE

The controller receives from a remote module via CAN Bus the information that it isn’t possible to close the LC (the module isn’t ready locked in an alarm state). Verify the other modules to determinate in which of them there is the problem.

12 RECOMMENDED SPARE PARTS FOR INVERTER

Part number	Description
C16507	Protected 500 A strip Fuse.
C16505	Protected 355 A strip Fuse.
C16520	10 A 20 mm Control Circuit Fuse
C29523	SW 180 80 V Single Pole Contactor
C29522	SW 180 48 V Single Pole Contactor
C29508	SW 180 24 V Single Pole Contactor
C12442	Molex Minifit Connector 2 pins Female
C12358	Molex Minifit Connector 4 pins Female
C12359	Molex Minifit Connector 6 pins Female
C12407	Molex Minifit Connector 12 pins Female
C12403	Molex Minifit Connector 14 pins Female
C12777	Female Molex Minifit pin harness side

13 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.