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EN

User Manual

AC-X

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

The AC-X inverter has been developed for applications such as small transpallet and walkie trucks with asynchronous (AC) traction motors up to 800W (Vbatt=24V) and 1200W (Vbatt=36V).
The same AC-X can be configured in two modes:
1) Sensored version using an Encoder (Sensor Bearing) in the Motor axle
2) Sensorless version that don't need the Encoder to drive the motor.

The AC-X sensored version adopts an Encoder integrated in the Ball bearing (sensor bearing).
The Encoder fills up the truck performance, with lower minimum speed, the "stop on the ramp" service, higher torque and a smoother inversion; on the other hand the reliability gets penalized by the fragile mechanics and inaccessible position of the Sensor Bearing.
The Sensorless version uses only the thermal sensor in the motor for the flux estimation and gets the electromechanical brake mandatory to stop the truck when the speed and the frequency are not matched in between.
The AC-X can be supplied in two different type:

- **AC-X Base version**
- **AC-X Premium version**

The Base version is the more simple solution with standard functions. The Premium version has in addition the possibility to manage a Canbus comunication system, some proportional electrovalves, additional inputs, and a MDI PRC.
The correct part number for the 24V AC-X is FZ2016 for the 100Amps base version and FZ2024 for the 100Amps Premium version.
AC-X Base and Premium both have a serial link embedded.
The AC-X Premium has also the CAN Bus communication peripheral: the SW for the communication via CAN Bus between the AC-X Premium and the MDI-PRC has been already developed in a standard handling here descripted.
MDI-PRC is a Zapi module to be mounted on the dashboard of the truck to inform with a display about the state of the truck and provided with a Leds battery charge indicator. Besides, the MDI-PRC can drive four electrovalves (two proportional and two On/Off type) for an advanced hydraulics handling. MDI-PRC is the natural choice to fill the AC-X's services with those extra functions asked only on the high level trucks.
AC-X has an additional analogue input (CNA #7) suited to receive a motor thermal sensor (KTY84-130).
The reference SW release for this manual is ACXT_ _ _ _ ZP 0.14

2 SPECIFICATION

2.1 Technical specifications

Inverter for AC asynchronous 3-phase motors
Regenerative braking
Can-bus interface (only AC-X Premium)
Digital control using a microcontroller
Encoder Interface
Voltage: ..... 24 - 36V
Maximum current (24V,36V): ..... 100A (RMS) (smaller version 50A) for 2'
Booster: ..... 120A (RMS) for 10 seconds
Operating frequency: ..... 8kHz with center aligned PWM
External temperature range: ..... -30°C ÷ 40°C
Maximum inverter temperature (at full power): ..... 78°C

2.2 Block diagram

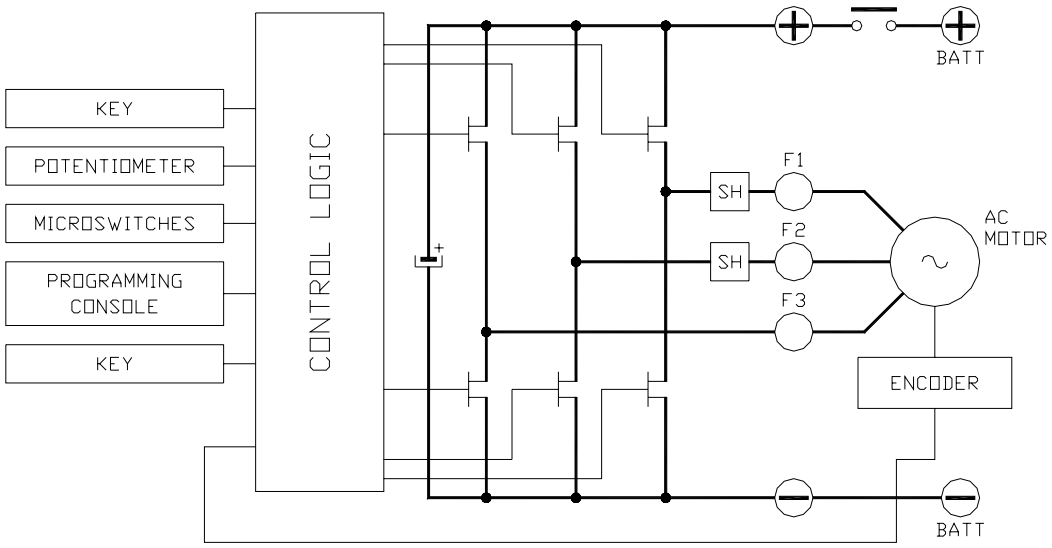

Figure 2–1

3 SPECIFICATION FOR THE INPUT DEVICES FILLING UP THE INSTALLATION KIT

The AC-X controller needs some external parts in order to work. The following devices complete the kit for the AC-X installation.

3.1 Microswitches

- The microswitches must have a contact resistance lower than 0.1Ω and a leakage current lower than 100µA.
- When full load connected, the voltage between the key switch contacts must be lower than 0.1V.
- The microswitches (if not otherwise noted) must connect or break a battery voltage to the inputs pins.

3.2 Accelerator unit

The accelerator unit can consist of a potentiometer or an Hall effect device.
It should be in a 3-wire configuration. The potentiometer is supplied through CNA#13 with about 12Vdc.
CPOT (CNA#11) signal ranges is from 0 to 10V.
Potentiometer value should be in the 0.5 - 10 KΩ range; generally, the load should be in the 1.5mA to 30mA range. Faults can occur if it is outside this range.

The standard connection for the potentiometer is the one in the Left side of Figure 3–1 (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 Figure 3–1 (potentiometer in the middle at rest) in combination with at least one Travel Demand switch. We strongly advice against the adoption of the Right side configuration without travel demand switch at all, because of a safety issue.

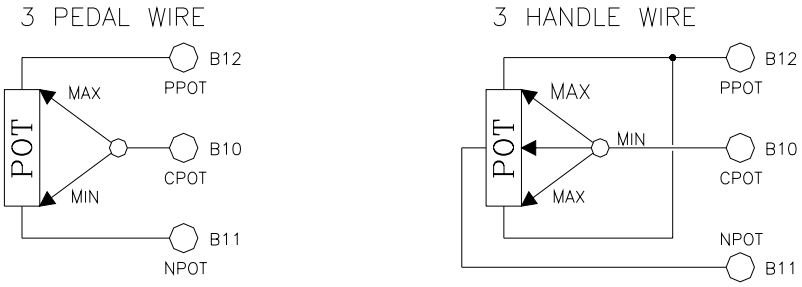

Figure 3–1

The Procedure for automatic potentiometer signal acquisition is carried out using the Hand Set. This enables adjustment of the minimum and maximum useful signal level (see paragraph 13.3 PROGRAM VACC function), in either direction.

3.3 Other analog control unit

Input CND#15 (only in Premium version) is an analog input, whose typical application is a proportional command to enable a lifting and a lowering proportional Valves. It is possible to use this input for an alternative function is a proportional braking. It should be in a 3 wire configuration. Potentiometer value should be in the 0.5-10KΩ range. Generally, the load should be in the 1.5mA to 30 mA range.
The CPOTB (CND#15) signal range is from 0 to 5V.

3.4 Analog motor thermal sensor input

Input CNA#7 is an analog input to receive an analog Thermal Sensor Model Philips KTY84-130 to measure the Motor Winding Temperature. This is a PTC polarized two terminals device: connect the positive end to CNA#7 and a the negative end to a minus battery voltage (e.g. CNA#4).
The analog thermal sensor is mandatory in the Sensorless version.

3.5 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: +5V
- electric output: open collector (NPN or PNP), push-pull.

The wished resolution must be specified when ordering the controller. The suggested resolution is from 32pulses/rev up to 64pulses/rev.
For more details about encoder installation see also chapter 8.4.

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

ACXT2AE4 ZP1.04

That means:
ACXT = AC-X traction controller
2= poles pair number
A= 32 pulses/rev encoder
E= premium version
4= KTY84 motor thermal sensor

The encoder resolution is given by the letter after the poles pair number in the following list:
A= 32 pulses/rev
K= 48 pulses/rev
B= 64 pulses/rev

C= 80 pulses/rev
S= sensorless

The AC-X premium version is specified by the letter E after the encoder resolution.
The final number specifies the thermal sensor.

3= KTY83 – 122
4= KTY84 - 130

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4 PROTECTION FEATURES

The AC-X is protected against some controller injuries and mulfunctions. These are:

1) **Battery polarity inversion**
   It is necessary to fit a MAIN CONTACTOR to cut off the Battery Positive connection to protect the inverter against reverse battery polarity.
2) **Connection Errors**
   All inputs are protected against connection errors.
3) **Thermal protection**
   If the chopper temperature exceeds 78°C, the maximum current is reduced in proportion to the thermal increase. The cut off temperature is 103°C.
4) **External agents**
   The inverter is protected against dust and the spray of liquid to a degree of protection meeting IP54.
5) **Low battery charge**
   In the encoder release, when the battery charge is low, performances are reduced according to BATTERY CHECK parameter (see 12.4.1.7).
6) **Protection against accidental Start up**
   A precise sequence of operations are necessary before the machine will start.
   The truck does not move if these operations are not carried out correctly.
   Requests for drive, must be made after closing the key switch.
7) **Protection against uncontrolled movements**
   If the main contactor is opened, it never closes if:
   - The Power unit is not functioning.
   - The Logic is not functioning perfectly.
   - The output voltage of the accelerator does not fall below a threshold is 1V higher than the minimum voltage value stored with the PROGRAM VACC operation.
   - A microswitch for a moving request in closed position.

   An important improvement against the uncontrolled movements is given by the Passive Emergency Cell (see paragraph 5.1 below).

5 ⚠ SAFETY AND PROTECTION

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.
AC-X inverter electronic implements an hardware safety circuit, which is able to switch off the three phase Power Bridge stopping the machine via HARDWARE, that is bypassing the software control.
This safety Circuit is actuated releasing the Tiller Switch and the handling is descripted in detail in the next Paragraph (see paragraph 5.1 PASSIVE EMERGENCY CELL).
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.

5.1 Passive emergency cell

The Tiller Switch input is processed by two separated devices: the uC and a PLD (GAL). When the Tiller Switch turns open, both, the uC and the PLD device switch off the power mosfets distinctly one from the other. The PLD does that with a delay of 800msec. So, this PLD is a separate device (distinct from the uC) that automatically prevent operation of the travel circuit when the operator leaves the truck.

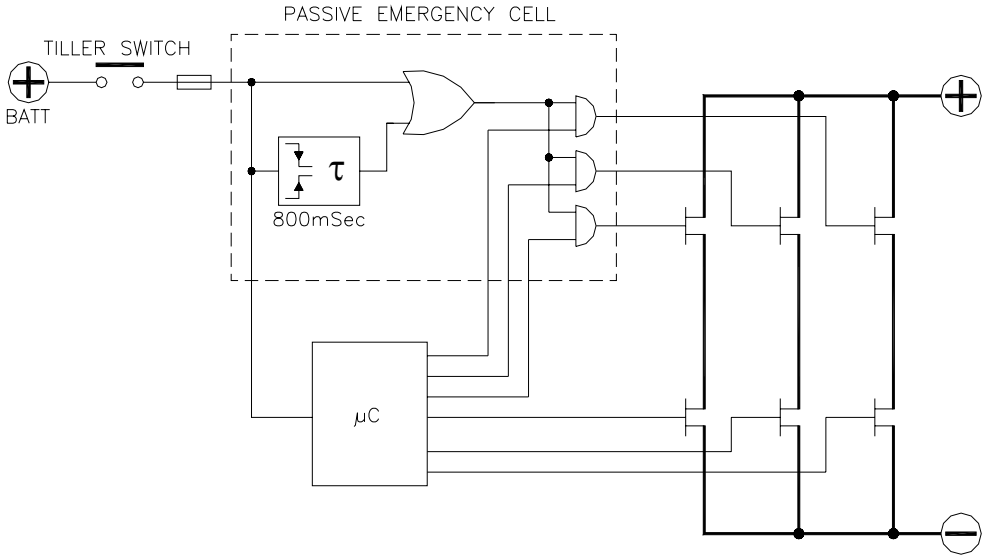


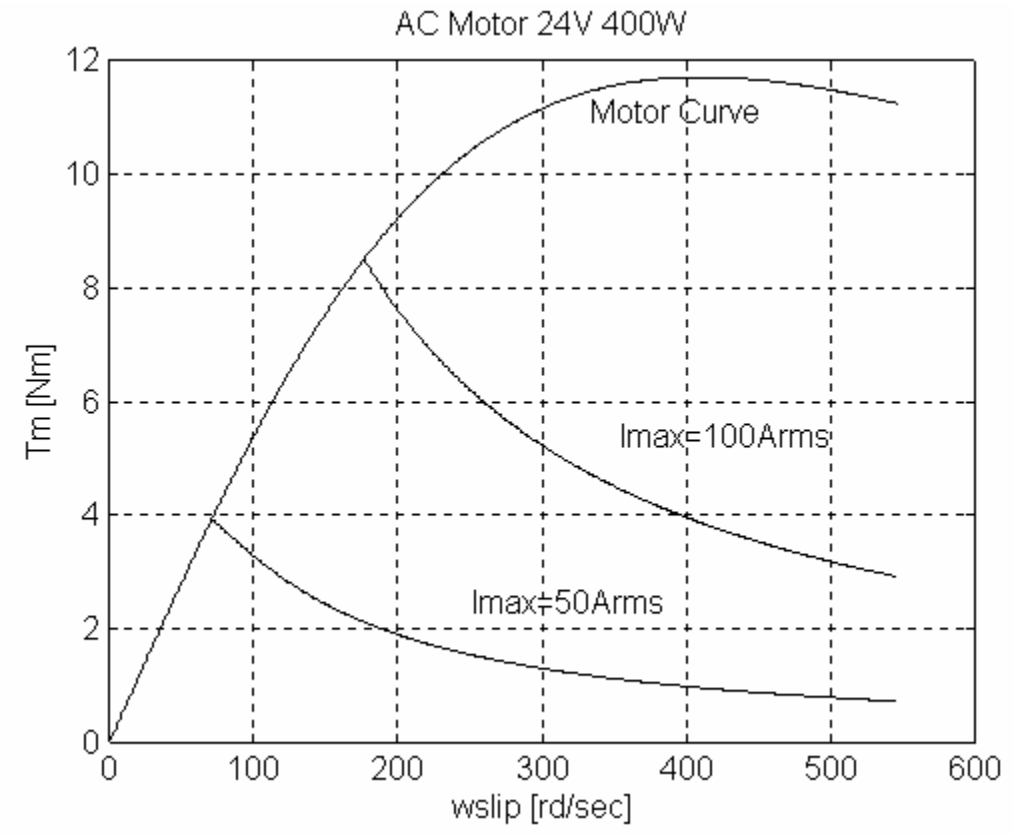
Figure 5–1

One of the reason for the adoption of this Passive Emergency cell is to comply with the EN1175-5.9.5: “A separate device indipendent of the speed control device (accelerator) shall automatically prevent operation of the travel circuit when the operator leaves the truck, e.g. seat switch, pedestrian tiller switch”. To be sure this separate device really prevent operation of the travel circuit, it is necessary a redundant device (togheter with the Elaboration Unit) reads this

separate device and stops the truck distinctly from the Elaboration Unit. This is exactly what the Passive Emergency Cell does.
In a system with a single microprocessor technology, the weak point is that just one unit (uC) processes the Inputs and decides alone to keep the motor moving or not. If this elaboration unit (uC) fails it is possible it keeps the motor moving against of the state of the commands. To avoid this risk, the Passive Emergency cell provides a further step of safety that is a redundancy in processing the motion request (Tiller or Seat Switch). In our controller the truck will be stopped, releasing the tiller, disregarding if the main Elaboration Unit (uC) is right working or not.

5.2 Control warning in the Sensorless version

The Asynchronous Motor theory states that, the torque collapses when the frequency and the speed in the motor are not mached in between. This condition may occur for example when the controller starts from a null frequency and the motor is already moving. The matching between frequency and speed is easy to satisfy when the Encoder is present; in the Sensorless version it is necessary to apply a continuous monitoring of the matching between the frequency and speed to act the Elctromechanical Brake in case of mismatching (i.e. the Electromechanical Brake is mandatory). This continuous monitoring consists of a real time calculation of the Motion Torque and requires about 500msec to detect the mismatching condition. Then the Electromechanical brake is de-energized to turn the Motor at rest .
The real time calculation of the Motor Torque is supported by the thermal sensor inside the motor getting possible the flux calculation through the estimation of the Counter Electromotive Force (EMF). Unfortunately the tolerance of the motor temperature measurement, gets the flux calculation unprecise at low frequency, resulting in a degradation of the Max Torque the AC-X may supply.
For this reason the AC-X Sensorless can be used only when the Controller is oversized respect to the rated output Power of the specific application.
Then the surplus of Current compensates for the Torque degradation due to the tolerance in the flux estimation (see the degradation of the torque when the maximum current is 50Arms vs. 100 Arms in the Figure below). To avoid this drawback, the Sense Coils solution (with EMF sense windings in the motor) may be adopted (Zapi technicians may support you for more details).



For every installed truck, it is mandatory to do an Acquisition of the Motor Resistance (see the topic 11.1 “Sequence. for AC-X traction setting”).
This operation must be executed at the end of the installation and every time the power connections or the motor connections are screwed, with the definitive motor and thermal sensor plugged in.

6 OPERATIONAL FEATURES

- 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 (this service is possible in the premium version but the SW is not developed yet).
- Optimum sensitivity at low speed (with encoder).
- The inverter drives an electromechanical brake
- High efficiency of motor and battery due to high frequency commutations.
- Self diagnosis.
- 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.
- Speed control.
- Optimum behaviour an a slope due to the speed feedback (with encoder):
  - 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 13.4 and 12.4.1.9 option STOP ON RAMP).

6.1 Diagnosis

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

- 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.
- Standby diagnosis at rest that checks: phase's voltages, contactor driver, current sensor, can-bus interface.
- Diagnosis during operation that checks: contactor driver, current sensors, encoder, can-bus interface.
- 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.

7 INSTALLATION SUGGESTIONS AND PRECAUTIONS

Read and respect the following suggestions to avoid problem during installation and in the definitive releasing.

7.1 Thermal consideration

- 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.

7.2 General suggestion

- Never connect SCR low frequency chopper with AC Motor Inverter because the Rail 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.
- Do not connect the inverter to a battery with a nominal value different from the value indicated on the chopper plate. If the battery value is greater, the MOS may fail; if it is lower, the control unit does not "power up".
- During battery charge, disconnect the controller from the battery.
- Supply the controller only with battery for traction; do not use a power supply.
- When the inverter is installed, make tests with the wheels raised from the ground, in order to avoid dangerous situations due to connection errors.
- After the controller is switched off (key off), the Rail capacitor remains charged for some minutes; if you need to work on the inverter, discharge them using a 10Ω ÷ 100Ω resistance connected from the +Batt to the –Batt terminals in the controller side.
- Fit transient suppression devices to the horn, solenoid valves, and contactors not connected to the chopper such as those for activating the pump motor or steering motor.

7.3 Susceptibility and electromagnetic emission

Electromagnetic susceptibility and emission 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. Therefore ZAPI declines any responsibility for non-compliance if correct testing is not made (the irradiated emission directive is EN50081-2).

7.4 Main contactor and key connection

- The connection of the main contactor can be carried out following the drawing in Figure 7–1.
- An intrinsic protection is present inside the logic when the voltage on the battery power connection overtakes the battery nominal voltage more than a certain percentage. Thank to this protection, it is allowed that the Main Contactor (or an emergency switch) breaks the Battery positive in every moment regardless of the state of the key (without this protection, if the Main Contactor breaks when a regenerative braking is in progress, the rail capacitor voltage increases and the overvoltage could damage the Power Mosfets).

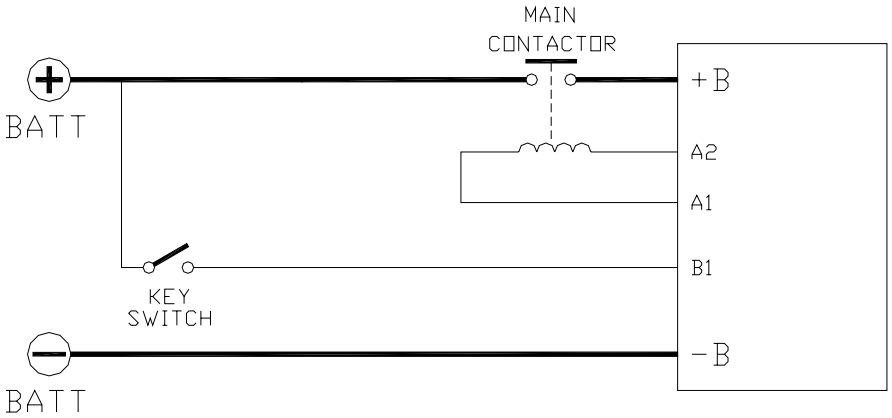


Figure 7–1

8 INSTALLATION

Install the controller 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.

8.1 Connection cables

For the auxiliary circuits, use cables at least 0.5mm² section.
For power connections to the motor and to the battery, the suggested cable section is 6 mmq @ Imax= 50Arms
or 10mmq @ Imax= 100Arms.
For the optimum inverter performance, the cables to the battery should be run side by side and be as short as possible.

8.2 Contactors

Usually a main contactor is adopted to connect and cut off the battery to the controller. Depending on the setting of a parameter (see paragraph 12.4.1.10 option AUX VOLTAGE #1):

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

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

8.3 Fuses

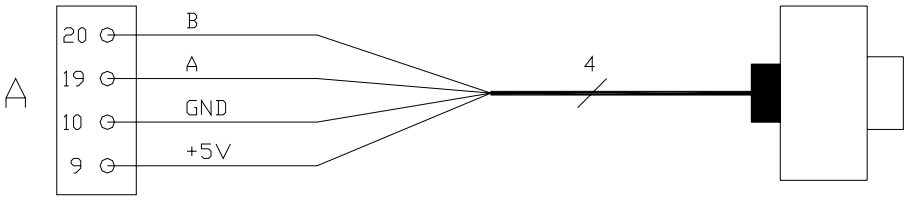
- Use a 6.3-10A Fuse for protection of the auxiliary circuits.
- For protection of the power unit, use a 80-100A fuse in the Battery Positive connection. For special applications or requirements these values can be reduced.
- For Safety reasons, we recommend the use of protected fuses in order to prevent the spread of fused particles should the fuse blow.

8.4 Encoder installation

1) AC-X 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 is +5V. It can have different electronic output.

B2	+5V	positive of encoder power supply.
B6	GND	negative of encoder power supply.
B1	A	phase A of encoder.
B5	B	phase B of encoder.

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



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

9 DESCRIPTION OF THE CONNECTORS

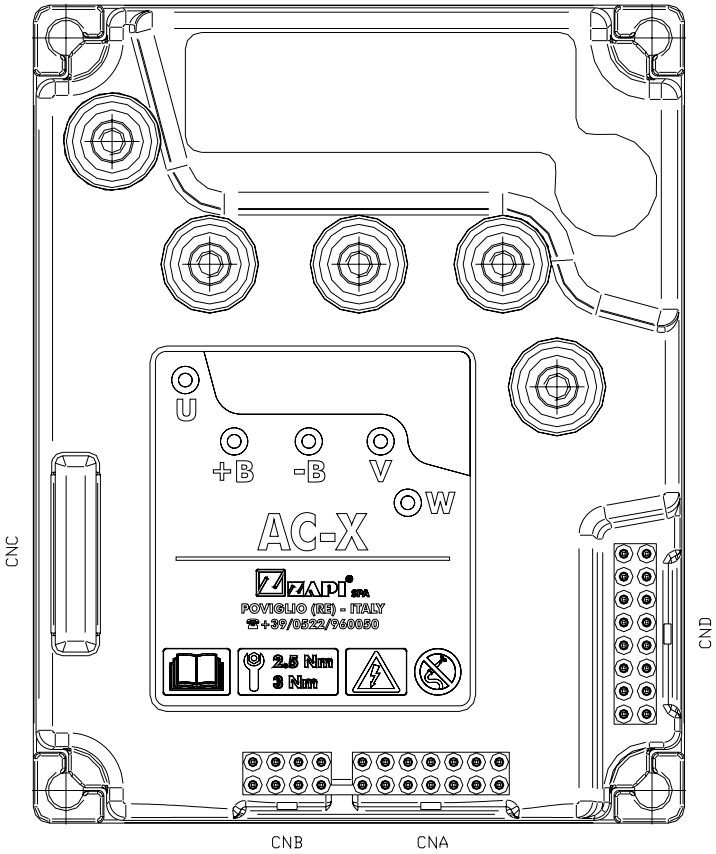


Figure 9–1

9.1 Connectors of the logic – Base version

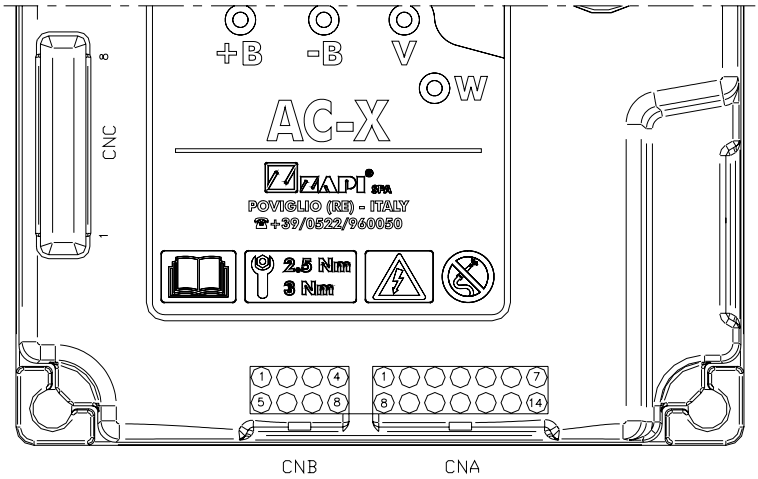


Figure 9–2

9.1.1 CNA connector

A1	KEY	Connected to the power supply through a microswitch (KEY) with a 6.3-10A fuse in series (this could be mounted on the AC-X cover).
A2	CM	Common of FW / BW / TILLER / BELLY / H&S / microswitches. This connection supplies a key voltage level.
A3	TILLER	Tiller request input. Must be connected to the tiller microswitch, active high.
A4	-BATT	-Batt.
A5	BACKWARD	Backward direction request input. Must be connected to the backward direction microswitch, active high.
A6	FORWARD	Forward direction request input. Must be connected to the forward direction microswitch, active high.
A7	MOT TH	Motor thermal sensor input. The internal pull-up is a fixed 2mA (Max 5V) source current.
A8	BELLY	Quick inversion function input; must be connected to the Belly microswitch; it is active high.
A9	PMC	Positive of main contactor coil
A10	NBRAKE	Output for driving the electromechanical brake coil; drives the load to -Batt. Maximum current : 3A.
A11	CPOT	Accelerator potentiometer wiper.
A12	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
A13	PPOT	Potentiometer positive: 10V output; keep load > 1KΩ.
A14	NMC	Negative of main contactor coil.

9.1.2 CNB connector

B1	CH A	Encoder Channel A.
B2	PENC	Encoder Positive Supply (+5V).
B3	H&S	Hard & Soft request input. Must be connected to the Hard & Soft microswitch, active high.
B4	+12V	This output provides a +12V signal for the MDI PRC, if present (only in AC-X Premium version); 100mA maximum current.
B5	CHB	Encoder Channel B.
B6	GND	Encoder Negative Supply (GND to minus battery).
B7	SEN W	not used.
B8	SEN U	not used.

9.1.3 CNC connector

C1	PCLRXD	Positive serial reception.
C2	NCLRXD	Negative serial reception.
C3	PCLTXD	Positive serial transmission.
C4	NCLTXD	Negative serial transmission.

C5	GND	Negative console power supply.
C6	+12	Positive console power supply.
C7	PGM	Must be connected to C8 for the flash memory programming.
C8	-BATT	Must be connected to C7 for the flash memory programming.

9.2 Connectors of the logic – Premium version with MDI PRC

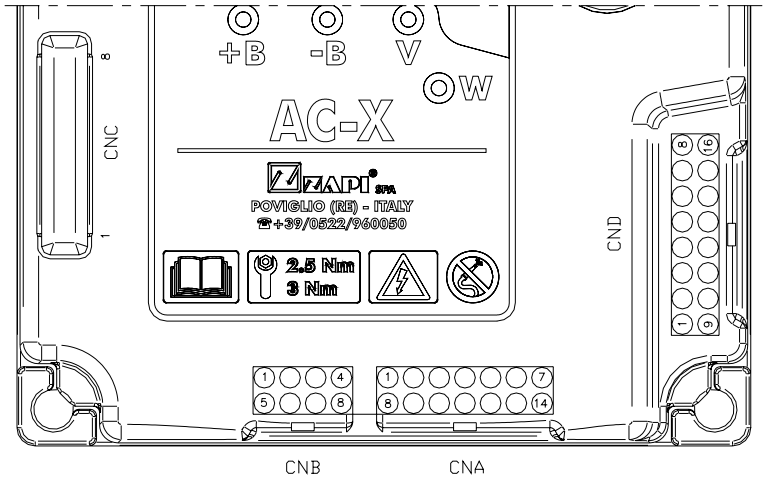


Figure 9–3

9.2.1 CNA connector

A1	KEY	Connected to the power supply through a microswitch (KEY) with a 6.3-10A fuse in series (this could be mounted on the AC-X cover).
A2	CM	Common of FW / BW / TILLER / BELLY / H&S / microswitches. This connection supplies a key voltage level.
A3	TILLER	Tiller request input. Must be connected to the tiller microswitch, active high.
A4	-BATT	-Batt.
A5	BACKWARD	Backward direction request input. Must be connected to the backward direction microswitch, active high.
A6	FORWARD	Forward direction request input. Must be connected to the forward direction microswitch, active high.
A7	MOT TH	Motor thermal sensor input. The internal pull-up is a fixed 2mA (Max 5V) source current.
A8	BELLY	Quick inversion function input; must be connected to the Belly microswitch; it is active high.
A9	PMC	Positive of main contactor coil
A10	NBRAKE	Output for driving the electromechanical brake coil; drives the load to -Batt. Maximum current : 3A.
A11	CPOT	Accelerator potentiometer wiper.

A12	NPOT	Negative of accelerator unit, tested for wire disconnection diagnosis.
A13	PPOT	Potentiometer positive: 10V output; keep load > 1KΩ.
A14	NMC	Negative of main contactor coil.

9.2.2 CNB connector

B1	CHA	Encoder Channel A.
B2	PENC	Encoder Positive Supply (+5V).
B3	H&S	Hard & Soft request input. Must be connected to the Hard & Soft microswitch, active high.
B4	+12V	This output provides a +12V signal for the MDI PRC, if present; 100mA maximum current.
B5	CHB	Encoder Channel B.
B6	GND	Encoder Negative Supply (GND to minus battery)
B7	SEN W	not used.
B8	SEN U	not used.

9.2.3 CNC connector

C1	PCLRXD	Positive serial reception.
C2	NCLRXD	Negative serial reception.
C3	PCLTXD	Positive serial transmission.
C4	NCLTXD	Negative serial transmission.
C5	GND	Negative console power supply.
C6	+12	Positive console power supply.
C7	PGM	Must be connected to C8 for the flash memory programming.
C8	-BATT	Must be connected to C7 for the flash memory programming.

9.2.4 CND connector

D1	KEY	Connected to the power supply through the key switch (see the electrical drawing 10.3).
D2	NPC	Negative of pump contactor coil.
D3	AUX OUT	Negative of the auxiliary output.
D4	NEVP	Supply a negative for a single proportional electrovalve driven by the positive CND#7.
D5	GND	-Batt. Could be used to provide a –Batt connection to the MDI-PRC.
D6	KEY OUT	Common of LIFT / LOW / LIFT AUX / LOW AUX microswitches. This connection supplies a key voltage level that could be used also to provide positive to pump contactor coil and aux output coil (when used).
D7	PEV	This output provides an interruptable +Batt for the electrovalves coils connected to the MDI PRC; 3A maximum current.

D8	NPOC	-Batt. Used as negative for the potentiometer with wiper on CND#15.
D9	LIFT AUX	Auxiliary lifting request input, active high. (Could be used also as a “cutback speed 2” request input).
D10	LIFT	Lifting request input, active high.
D11	LOW	Lowering request input, active high.
D12	LOW AUX	Auxiliary lowering request input, active high. (Could be used also as a “cutback speed 3” request input).
D13	CANHIGH	High level CAN-BUS voltage I/O.
D14	CANLOW	Low level CAN-BUS voltage I/O.
D15	CPOTB	Proportional electrovalves potentiometer wiper.
D16	PPOC	Potentiometer positive: 5V output; keep load > 1KΩ.

9.3 Description of power connections

View of the power bars:

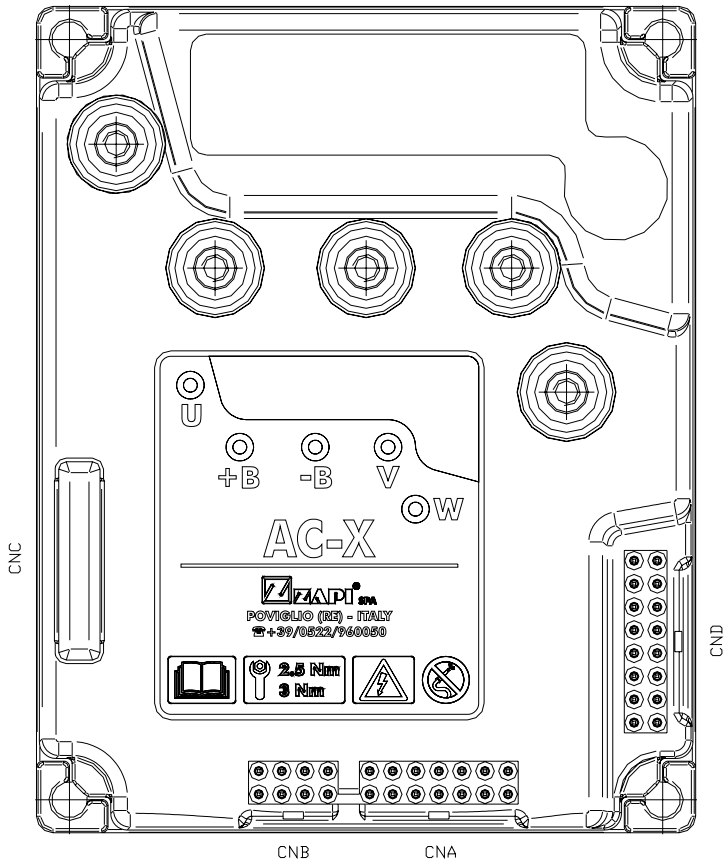


Figure 9–4

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

10 DRAWINGS

The Base version (connection drawing 10.2) has only the essential functions to drive a truck. The Premium version exists in two configuration:

1) MDI_PRC configuration: that communicates with the MDI-PRC (see connection drawing 10.4).
2) SPECIAL configuration: (see connection drawing 10.3) that controls a couple of mutuoexclusive current controlled proportional (or On/Off) valves directly connected to the AC-X. This latest handling is not implemented yet but can be considered to save money.

10.1 Mechanical drawing

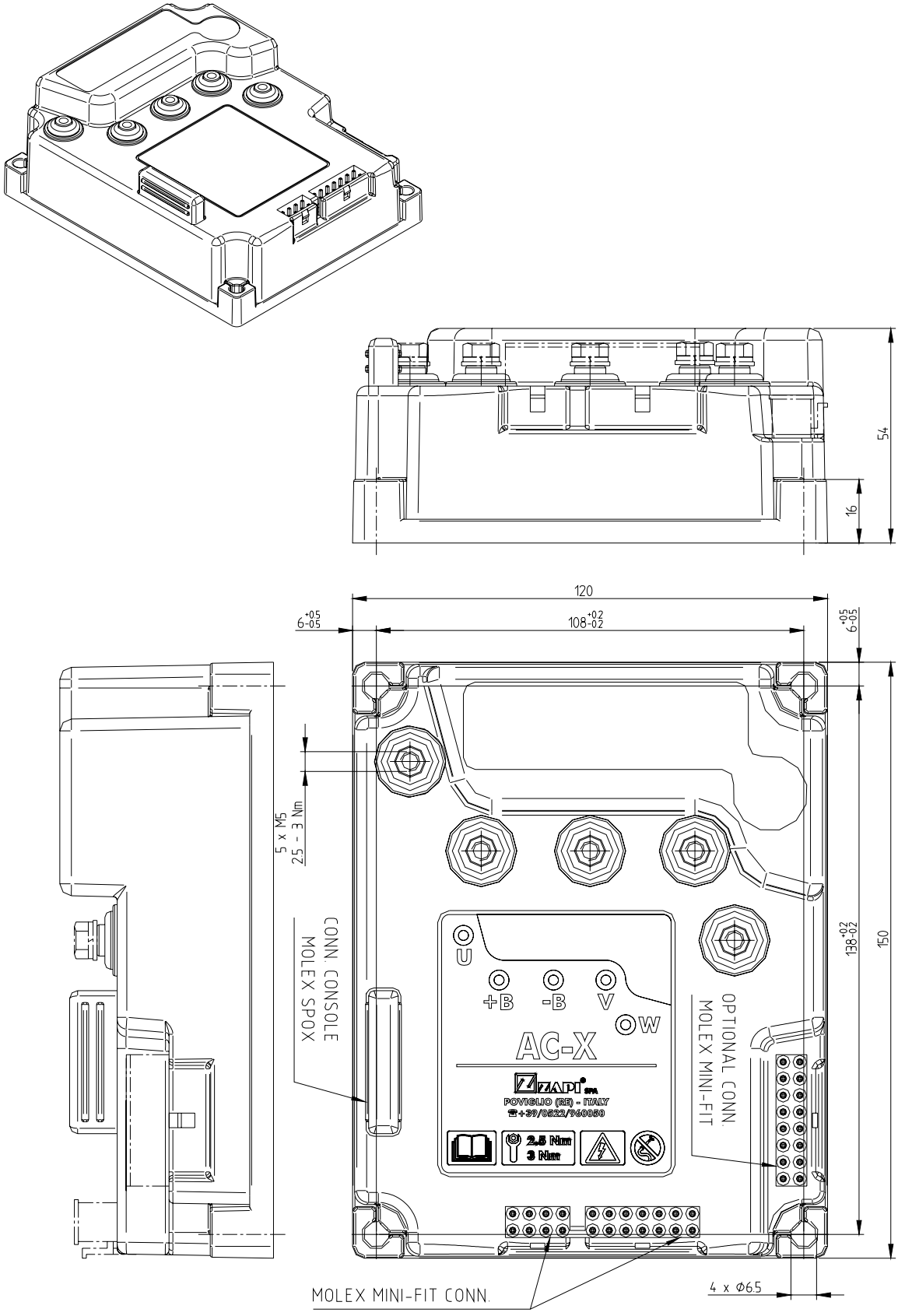


Figure 10–1

10.2 Connection drawing - Base version with Encoder

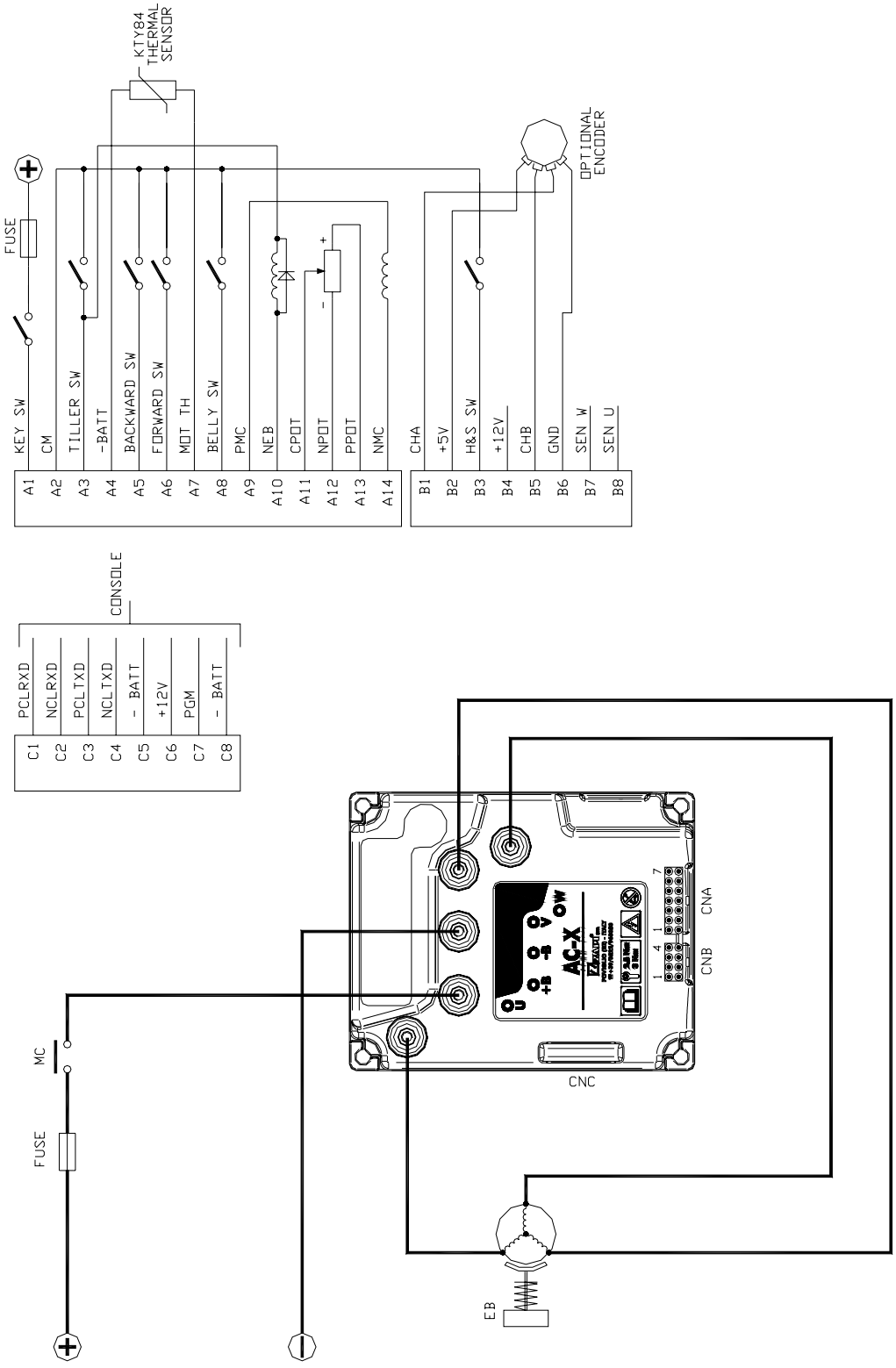


Figure 10–2

10.3 Connection drawing - Special Premium Version with Encoder

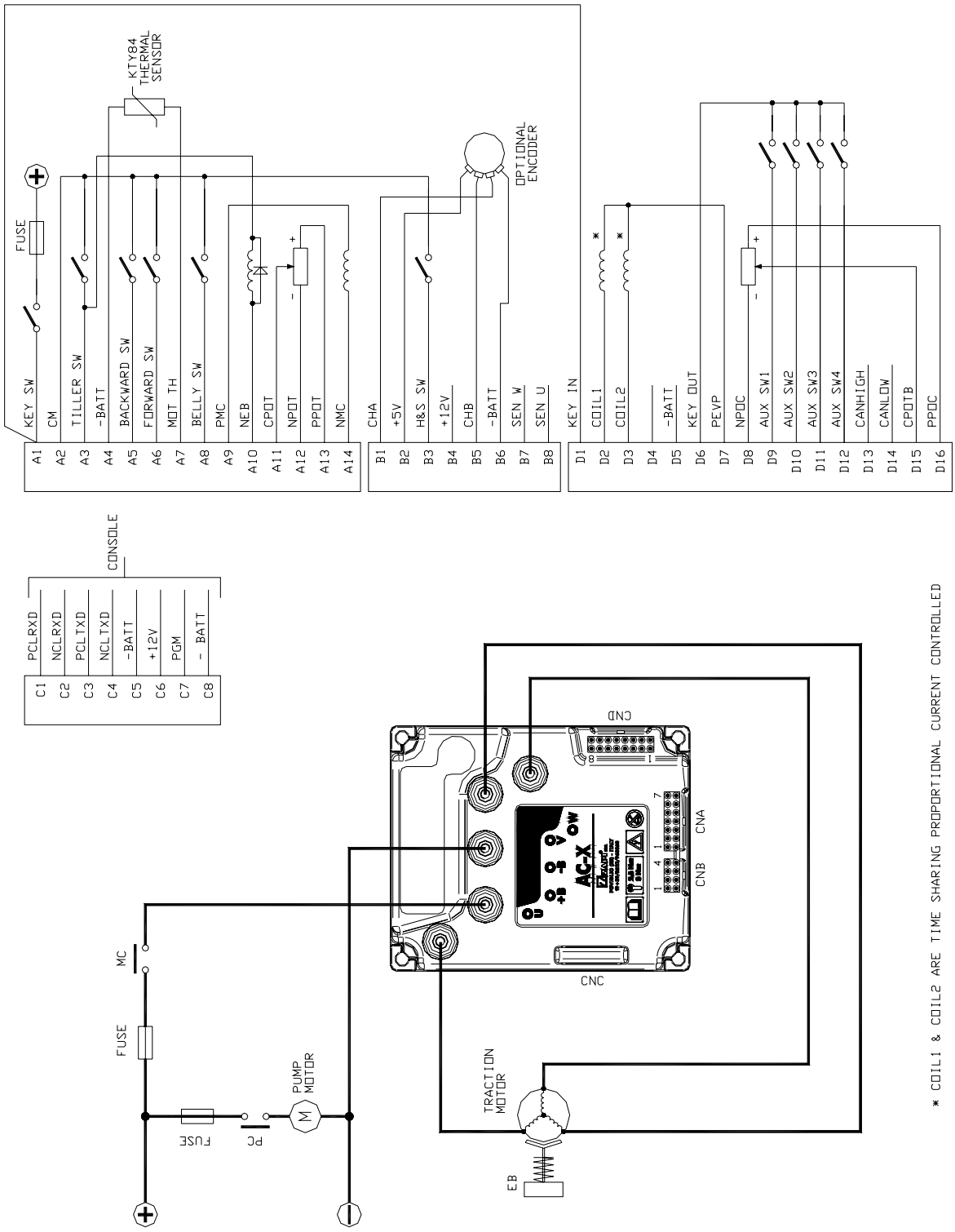


Figure 10–3

10.4 Connection drawing - Premium Version with MDI PRC and Encoder

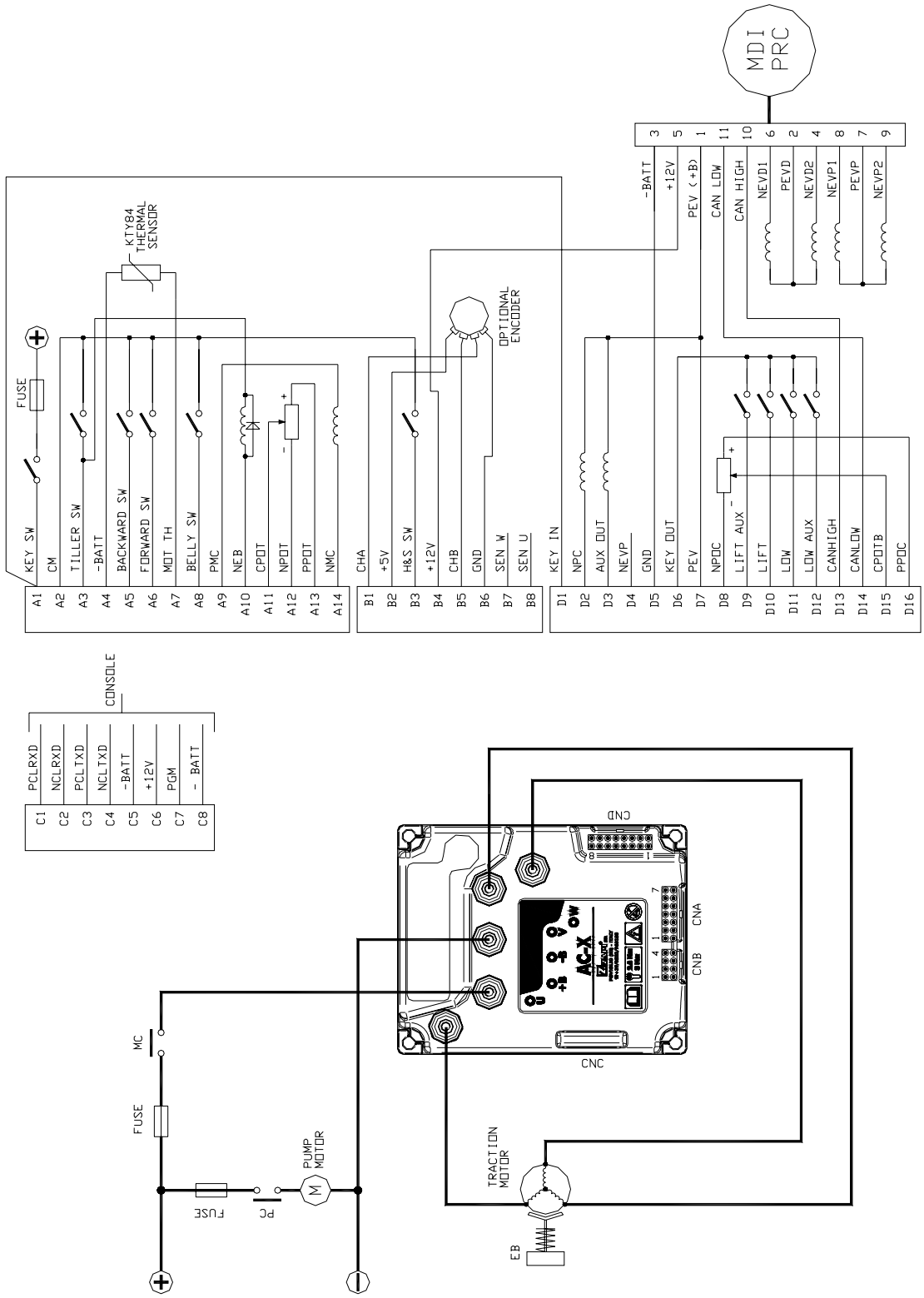


Figure 10–4

11 ONE SHOT INSTALLATION PROCEDURE

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

Step1 Connect a potentiometer in the range 0.5K to 10Kohms, to modify the wished speed, between CNA#11, CNA#12, CNA#13.

Step2 Connect two travel demand switches. The FWD travel demand must be connected between a battery (key) voltage and CNA#6. The REV travel demand must be connected between a battery (key) voltage and CNA#5. Only one of them can be active at the same time. They become active when connected to a key voltage (the key voltage is supplied on the CNA#2 connection).

Step3 Connect a tiller (or seat) switch enabling/disabling the truck motion between CNA#3 and a key voltage. It becomes active, enabling the motion, when closed to a key voltage (the key voltage is supplied on the CNA#2 connection).

Step4 Connect the encoder, when used, in the motor shaft between CNB#2=VDD, CNB#6=GND, CNB#1=CHA, CNB#5=CHB. The VDD voltage is 5V (see also 8.4).

Step5 Connect the plus battery voltage through a key switch at the KEY input CNA#1 (this is the input for the logic supply).

Step6 Connect the Main Contactor Coil to CNA#9 and CNA#14. The contactor must make and take the plus battery power cable to the +BATT power terminal of the AC-X.

Step7 Connect the motor and the minus battery to the corresponding power terminals of the AC.

Step8 Connect the Electromechanical Brake between CNA#10 and the tiller switch (when the tiller switch opens, the electromechanical brake gets de-energized braking the truck). A 3Ampere freeweeling diode (arc soppressor) with the anode to CNA#3 must be connected in parallel with the Electromechanical Brake Coil.

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

1) to handle some speed reductions requests (only Premium version)
2) to handle a analog sensor inside the motor
3) to handle a proportional braking (only Premium version)
4) to handle an On/Off forks lowering valve (only Premium version)
5) to handle a pump contactor (only Premium version)
6) to handle a belly switch
7) to handle the communication via CAN Bus with our MDI-PRC (only Premium version)
8) to handle a proportional input for the forks lifting/lowering (only Premium version)

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

11.1 Sequence for AC-X Inverter traction setting

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

Step1 Fill your setting with the Options you need (see paragraph 12.4.1).

Step2 Select the Battery Voltage. See paragraph 12.4.2.7 SET BATTERY TYPE.

Step3 Check the correct installation of all wires. Use the Console's TESTER function to assist.

Step4 Perform the accelerator signal acquisition procedure using the Console "PROGRAM VACC". Procedure is detailed on paragraph 13.3.

Step5 Only in the encoder configuration, set the "MAXIMUM CURRENT" Current, using the table on Chapter 12.4.3.31 (setting table of the "PARAMETER CHANGE" functions). In the Sensorless configuration MAXIMUM CURRENT must be 100%.

Step6 **VERY IMPORTANT**: For the Sensorless configuration only, it is mandatory to do an acquisition of the motor resistance before to turn the truck moving. To do that, roll down to zero the MOTOR RESIST Hardware Setting or do a CLEAR EEPROM operation.

Step7 Set the ACCELERATION DELAY requirements for the machine. Test the parameters in both directions.

Step8 Set the FREQUENCY CREEP level starting from 0.6 Hz or 6 Hz depending on the encoder is present or not. The machine should just move when the accelerator microswitch is closed. Increase the Level accordingly.

Step9 Set the Speed Reductions as required. Use the parameters of the "cutback speed" family in the PARAMETER CHANGE menu to specify the reduced maximum truck speed as a percentage of the MAX SPEED FWD and MAX SPEED REV (see 12.4.3.9-10-11-12) .

Step10 RELEASE BRAKING. Operate the machine at full speed. Release the accelerator pedal. Adjust the level to your requirement. If the machine is a forklift, check the performance with and without load.

Step11 INVERSION BRAKING. Operate the machine at 25% full speed. While traveling invert the Direction Switch. Set the suited Level of Inversion Braking. When satisfactory, operate the machine at Full Speed and repeat. If the machine is a Forklift, repeat the tests and make adjustments with and without load. The unladen full speed condition should be the most representative condition.

Step12 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.

Step13 Set the parameter MAX SPEED FORW.

Step14 Set the parameter MAX SPEED BACK (Reverse).

Step15 Test the truck on the maximum ramp specification at full load.

Step16 Make the choice for the truck behaviour on a slope (see chapter 13.4). If the "Stop on ramp" option is ON, set the desired value of "auxiliary time" parameter.

Can see also the Figure 12–8 for details on the settings.

12 PROGRAMMING & ADJUSTMENTS USING DIGITAL CONSOLE

12.1 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 CNC connector of the inverter.

12.2 Description of console (hand set) & connection

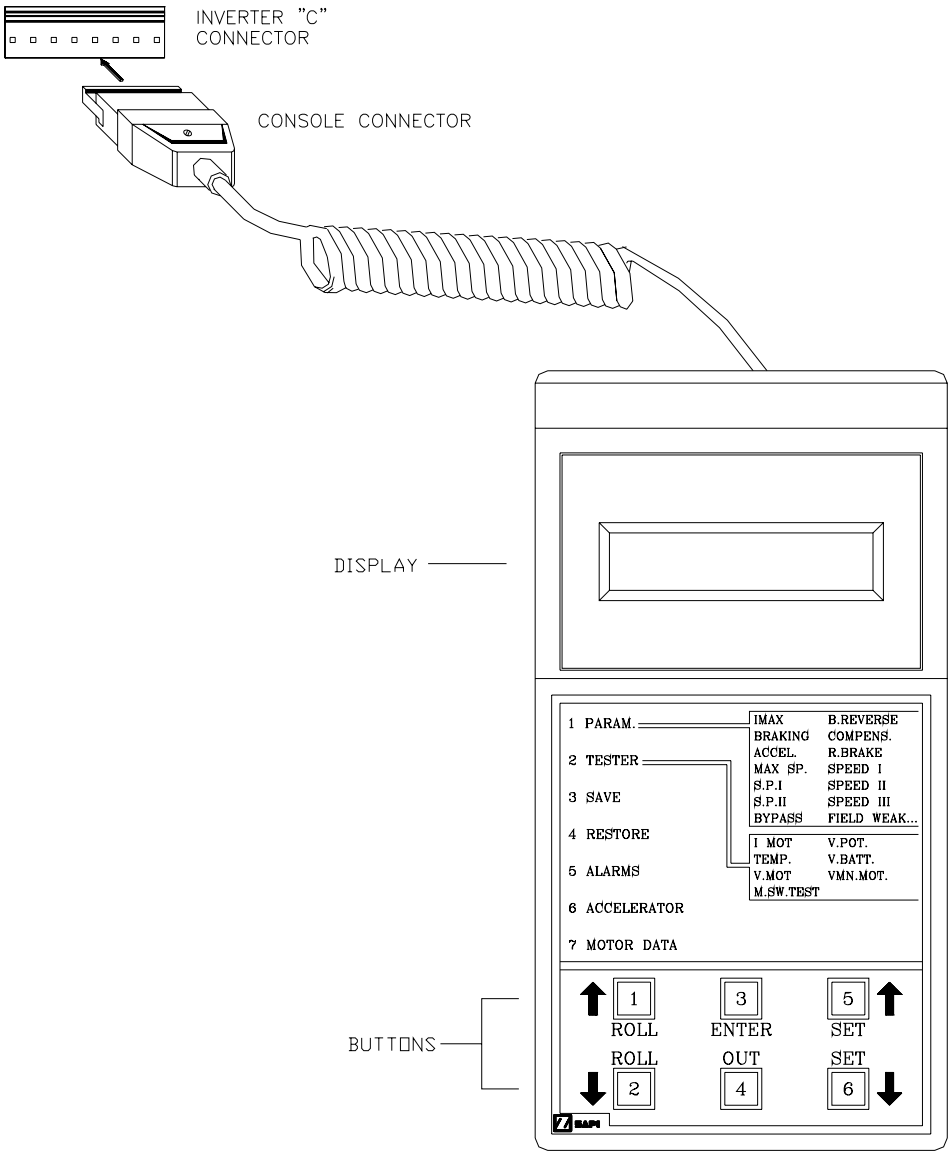


Figure 12–1

Digital consoles used to communicate with AC inverter controllers must be fitted with EPROM CK ULTRA, minimum "Release Number 3.02".
The section describes the Zapi hand set functions. Numbers inside the triangles correspond to the same number on the hand set keybord buttons shown in the Figure 12–1. The orientation of the triangle indicates the way to the next function.

12.3 Description of standard console menu

12.3.1 Base version

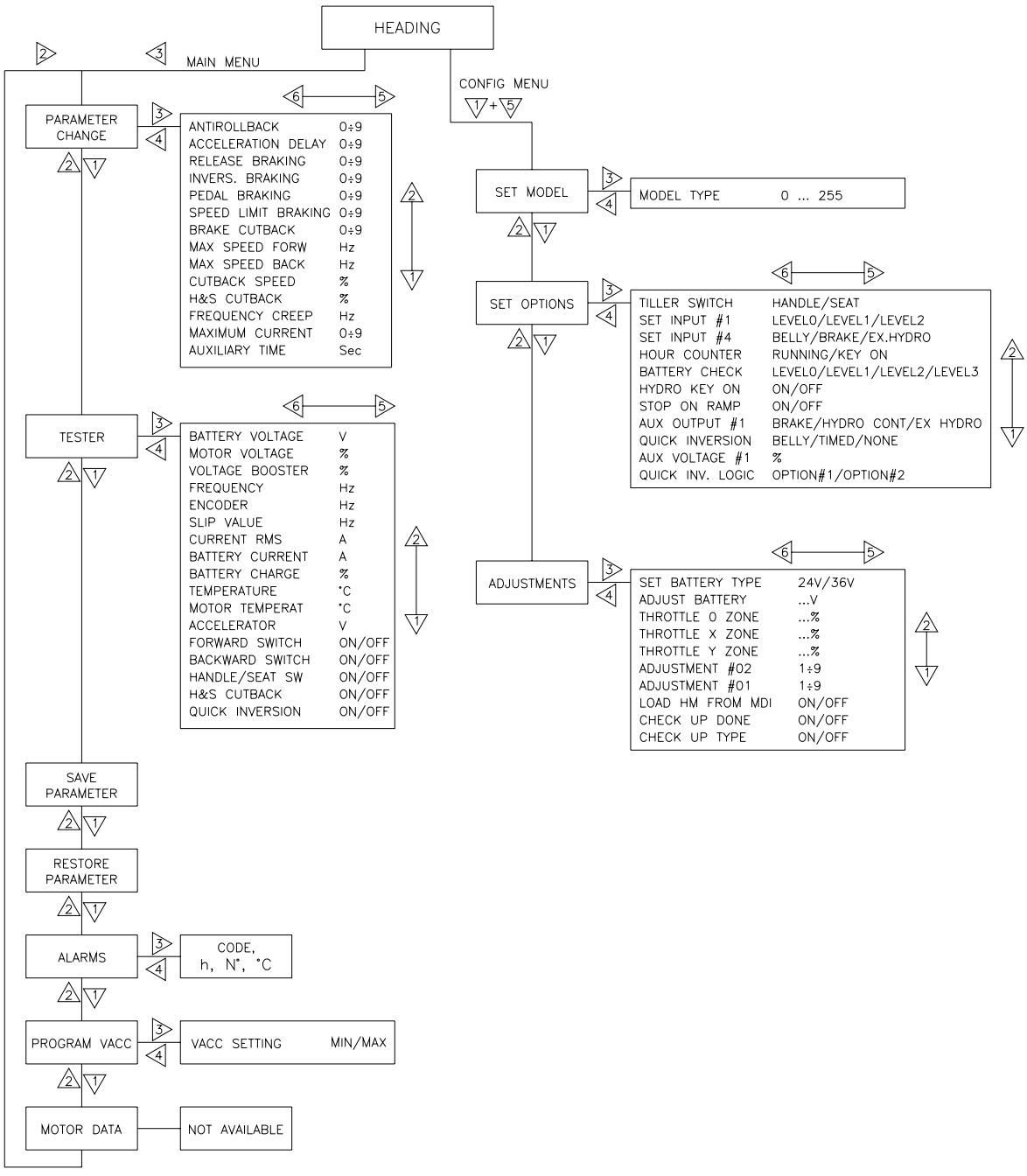


Figure 12–2

12.3.2 Premium Version

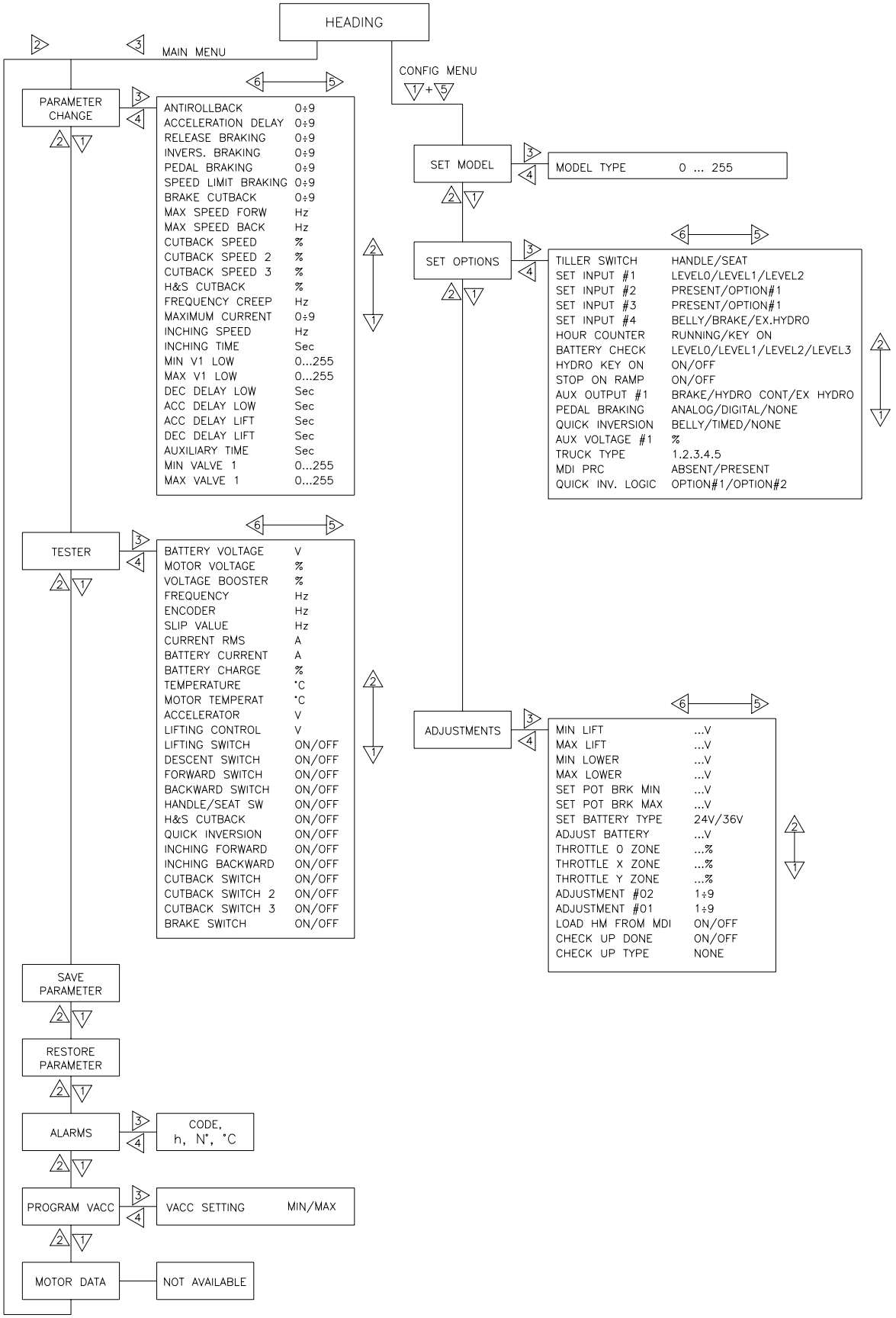


Figure 12–3

12.3.3 Premium with MDI PRC Version

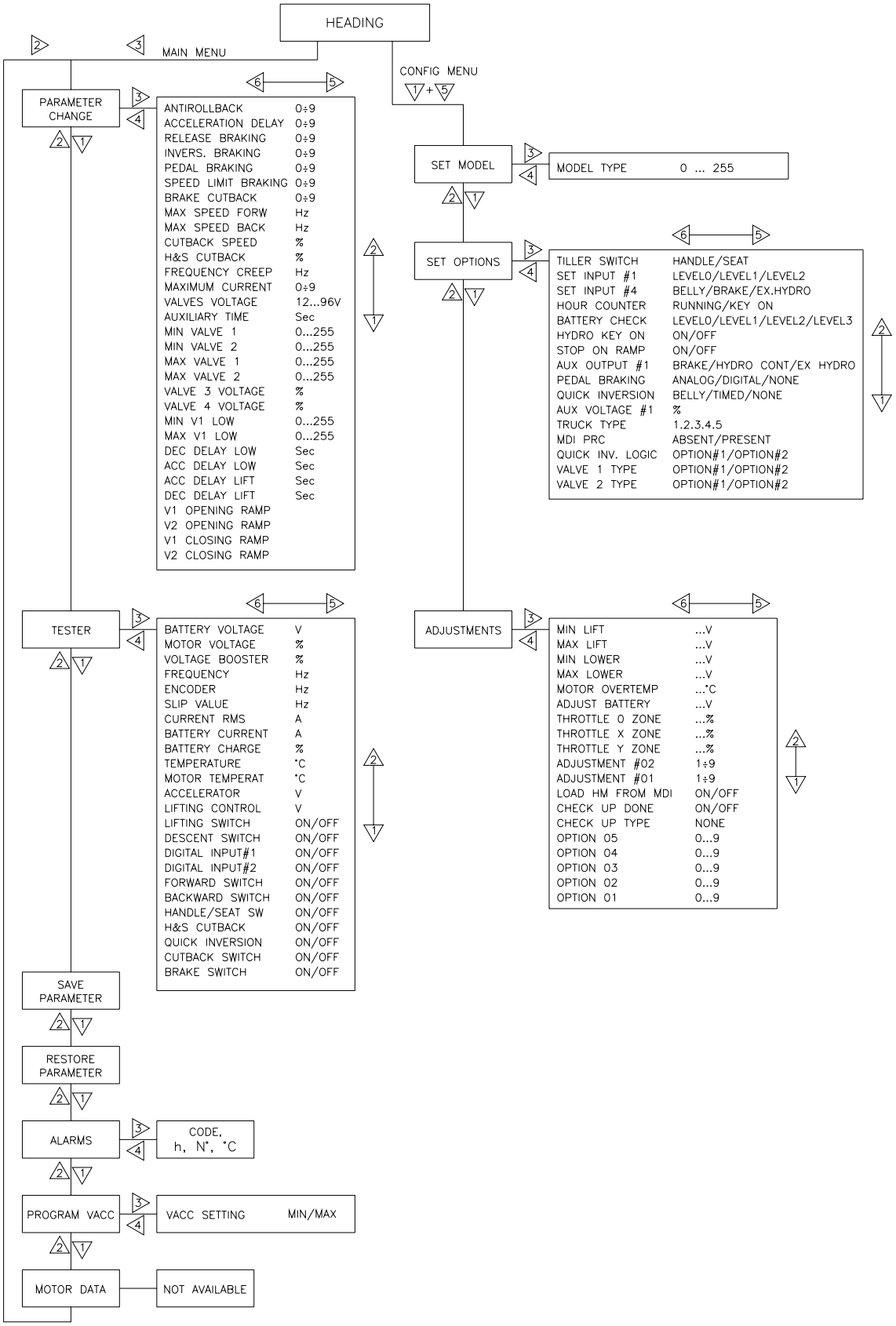


Figure 12–4

12.4 Function configuration

We will describe more configurations depending on the version (Base or premium) and depending on the MDI-PRC setting (see 12.4.1.17):
If MDI PRC is present the drive control communicates with MDI-PRC through the CAN BUS.

The configurations have different list of settings (the Base version has a reduced settings list). In the next we refer to a complete settings that is the sum of the settings list of the configurations. When the setting refers to only one configuration, it will be specified in the description.

12.4.1 Config menu “SET OPTIONS” functions list

To enter the CONFIG MENU’ it is necessary to push in the same time the right side top and left side top buttons. Then roll until the SET OPTION item appears on the hand set display. Push the ENTER button (see Figure 12–5).

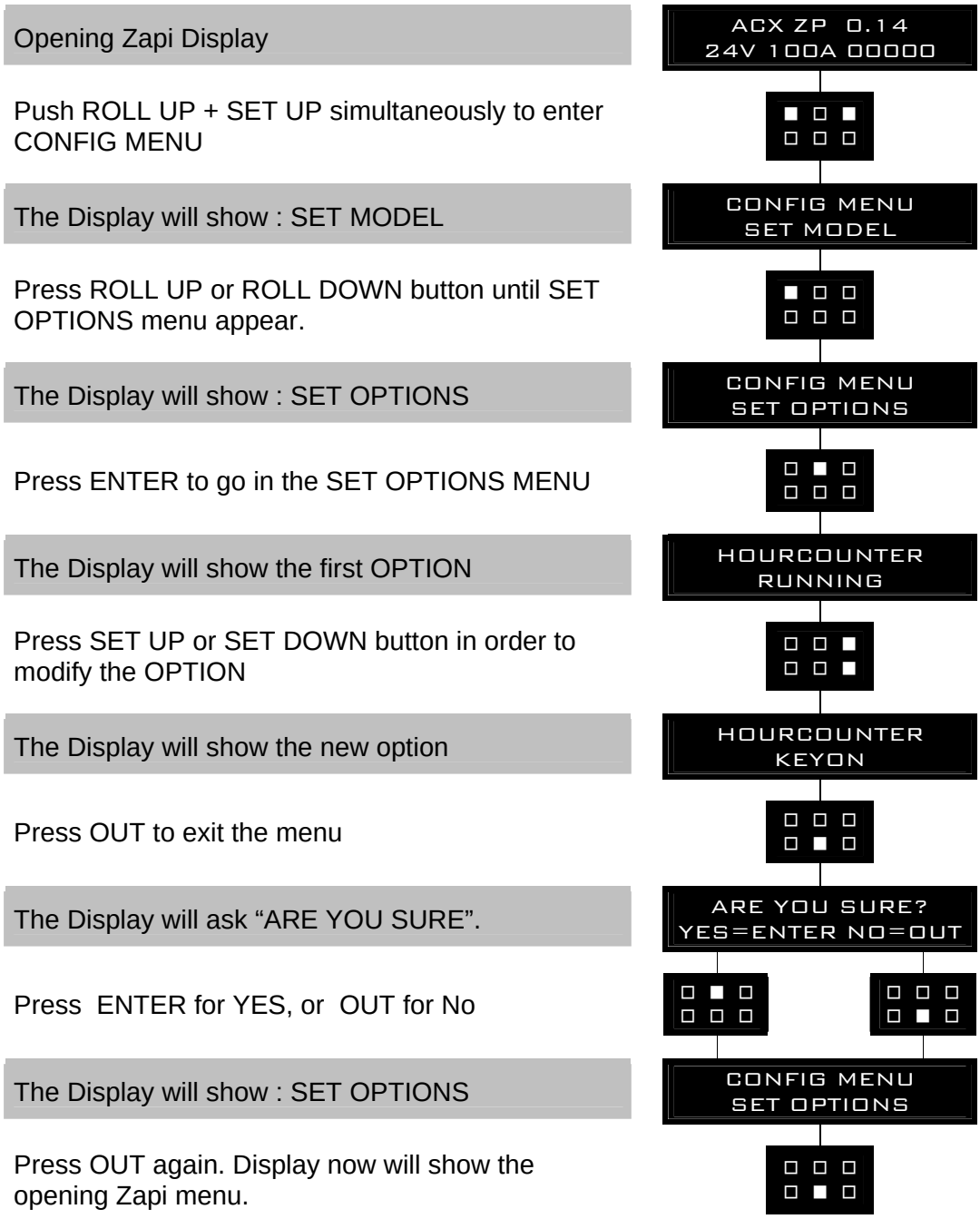


Figure 12–5

1) TILLER SWITCH

This option handles the input CNA#3. This input opens when the operator leaves the truck (released). It is connected to a key voltage when the operator is present. There are two levels:

- HANDLE: CNA#3 is managed as tiller input (no delay when released).
- SEAT: CNA#3 is managed as seat input (with a delay when released).

2) SET INPUT #1

(Only for the encoder versions, because the sensorless need the motor thermal sensor connected)
This setting handles the analog input CNA#7. It can be used one of two:

- OPTION#1: CNA#7 is managed as input for an analog motor thermal sensor KTY84-130.
- PRESENT: CNA#7 is managed as a digital cutback speed input (SR#1).

This input must be connected to a -Batt voltage in order the selected function is not active; it must be opened to turn the selected function active.

3) SET INPUT #2

(Only Premium version without MDI PRC).
This option handles the digital input CND#9. It can be used one of two:

- PRESENT: CND#9 is managed as a cutback speed input (SR#2)
- OPTION #1: CND#9 is managed as an inching forward input

The input CND#9 can only be used as Aux Lifting request when the MDI-PRC is PRESENT.
This input must be connected to a Key voltage.
The SR#2 becomes active when CND#9 is opened.
The inching forward becomes active when the CND#9 is closed to a key voltage.

4) SET INPUT #3

(Only Premium version without MDI PRC).
This option handles the digital input CND#12. It can be used one of two:

- PRESENT: CND#12 is managed as a cutback speed input (SR#3)
- OPTION #1: CND#12 is managed as an inching backward input

The input CND#12 can only be used as Aux Lowering request when MDI PRC is present.
This input must be connected to a Key voltage.
The SR#3 becomes active when CND#12 is opened.
The inching forward becomes active when the CND#12 is closed to a key voltage.

5) SET INPUT #4

This option handles the digital input CNA#8. It can be used one of three:

- BELLY: CNA#8 is managed as a Belly Switch input.
- BRAKE: CNA#8 is managed as service brake input. This information can be used also to recognise when the operator is driving with a pressed pedal braking.
- EX.HYDRO: CNA#8 is managed as Exclusive Hydro (actually not implemented).

This input must be connected to a Key voltage.
The Belly switch active level is specified on the QUICK INV LOGIC below.
The service brake or the exclusive hydro becomes active when CNA#8 is opened.

6) HOUR COUNTER

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

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

7) BATTERY CHECK

This option specifies the handling of the low battery charge detection. It can be set one of three:

- Level 0: Nothing happens, the battery charge level is ignored.
- Level 1: A BATTERY LOW alarm is raised when the battery level is calculated being less than 10% of the full charge. A BATTERY LOW alarm inhibits the Lifting function.
- Level 2: A BATTERY LOW alarm is raised when the battery level is calculated being less than 10% of the full charge. A BATTERY LOW alarm reduces the maximum truck speed down to 24% of the full truck speed then, if the MDI-PRC is absent, inhibit the Lifting function.
- Level 3: Equivalent to Level 1: a BATTERY LOW alarm is raised when the battery level is calculated being less than 10% of the full charge. A BATTERY LOW alarm inhibits the Lifting function.

8) HYDRO KEY ON

- ON/OFF: (function not implemented yet) 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).

9) STOP ON RAMP

(Only for the encoder versions).

It is possible to keep the truck on a ramp with a released travel demand.

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

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

10) AUX OUTPUT #1

(Only for the encoder versions).

This option handles the digital output CNA#10. It can be used one of four:

- BRAKE: CNA#10 drives an electromechanical Brake.
- HYDROCONT: CNA#10 drives the contactor for a hydraulic steering function when the direction input or brake pedal input are active or a movement of the truck is detected.
- EX.HYDRO: CNA#10 drives the contactor for a hydraulic steering function when the exclusive hydro input is active (see 12.4.1.5 SET INPUT #4).
- FREE: CNA#3 is not used.

The current this output can sink is up to 3Adc.

11) PEDAL BRAKING

(Only Premium version without MDI PRC).

The analog input CND#15 has one of two function:

- Pedal Braking Input
- Command input for lifting/lowering proportional valves in MDI-PRC version or with a TRUCK TYPE to LEVEL#5.

To turn from the first to the second function is just enough to set PEDAL BRAKING to NONE.

This option handles the analog input CND#15 when used as pedal braking input:

- ANALOG: With this setting is possible to modulate the strength of the braking when the accelerator is released. The strength of the braking is proportional to the brake pedal potentiometer connected to this input.
  When the pedal potentiometer voltage is equal less than the SET POT BRK MIN (see 12.4.2.5) the minimum release braking strength is applied (following the RELEASE BRAKING setting).
  When the pedal potentiometer voltage is equal higher than the SET POT BRK MAX (see 12.4.2.6) the maximum release braking strength is applied (following the PEDAL BRAKING setting).
  In the intermediate position, the electrical braking strength is a linear function between the minimum (RELEASE BRAKING) and maximum (PEDAL BRAKING) intensity.
  When there is also a switch connected to the pedal braking (i.e. SET INPUT #4 to level BRAKE), it must be closed, otherwise the release braking is stuck to the minimum strength disregarding the pedal potentiometer position.
- DIGITAL: No pedal potentiometer is expected. Only when both the SET INPUT #4 is Level BRAKE and the brake switch connected to CNA#8 is closed, the release electrical braking follows the PEDAL BRAKING setting (maximum strength); in all of the other conditions the release electrical braking follows the RELEASE BRAKING setting (minimum strength).
- NONE: The analog input CND#15 is not used for the release braking modulation.

12) QUICK INVERSION

This option specifies the quick inversion mode when the SET INPUT #4 is set BELLY. It can be set one of three:

- NONE: The quick inversion function is not managed (no effect when CNA#8 switches over).
- TIMED: The quick inversion function is timed.
- BELLY: The quick inversion function is managed but not timed.

13) AUX VOLTAGE #1

This option specifies the percentage of the key voltage to be applied to the loads on CNA#14 (main contactor coil) and CNA#10 (electromechanical brake). The voltage modulation is got with a PWM at 1KHZ frequency. After an initial delay of about 1 sec in which the entire key voltage is applied to the loads, the PWM reduces the voltage at the loads down to the specified percentage.

14) TRUCK TYPE

(Only Premium version).

This option specifies the hydraulics handling:

- 1: Present only if MDI PRC is absent (see related option).
  In this configuration, without MDI PRC, lifting request come from input CND#10. This enable the pump contactor for lifting connected to CND#2.
  Lowering request comes from input CND#11 and handle an on/off valve connected to CND#3.

- 2: Present only if MDI PRC is present (see related option).
  Both the Main Lifting/Lowering pair (CND#10 and CND#11) and the Aux Lifting/Lowering pair (CND#9 and CND#12) are used to activate two Lifting/Lowering distinct circuits (double forks truck).
  Main Lifting enables both, the pump contactor on CND#2 and a valve to re-direct the oil in the main hydraulics circuit connected to the pin #4 of the MDI-PRC.
  Main Lowering enables both, an On/Off descent valve on CND#3 and a valve to re-direct the oil in the main hydraulics circuit connected to the pin#4 of the MDI-PRC.
  Aux Lifting enables both, the pump contactor on CND#2 and a valve to re-direct the oil in the aux hydraulics circuit connected to the pin #6 of the MDI-PRC.
  Aux Lowering enables both, an On/Off descent valve on CND#3 and a valve to re-direct the oil in the aux hydraulics circuit connected to the pin#6 of the MDI-PRC.
  The valves are all On/Off type; no proportionality at all.

- 3: Present only if MDI PRC is present (see related option).
  Only the Main Lifting/Lowering pair (CND#10 and CND#11) is used to handle a fully Proportional function (there is one proportional valve connected to the pin#8 of the MDI-PRC used for both proportional Lifting and proportional Lowering).
  The CND#10 input is the Lifting request to enable the pump contactor on CND#2.
  The CND#11 input is the Lowering request to enable the descent valve on CND#3.
  The CND#15 potentiometer modulates the current in the proportional valve connected to the pin#8 of the MDI-PRC. This proportional valve is normally closed (oil does not pass-through when de-energized) and directly connected between the pump and the tank: to do a Lifting function the voltage into the Proportional Valve is turned fully On, to direct the oil into the tank before the pump contactor closes. Then the current in the Proportional Valve reduces (meanwhile the CND#15 potentiometer increases) to accelerate the Lifting.To do a Lowering function, the current in the proportional valve progressively increases (meanwhile the CND#15 potentiometer increases) to accelerate the Lowering.

- 4: Present only if MDI PRC is present (see related option).
  Only the Main Lifting/Lowering pair (CND#10 and CND#11) is used to handle an On/Off Lifting and a proportional Lowering. (There is only one proportional valve connected to the pin#8 of the MDI-PRC to modulate the Lowering).
  The CND#10 input is the Lifting request enabling the pump

contactor on CND#2.
The CND#11 input is the Lowering request to enable the On/Off descent valve connected on CND#3.
The CND#15 potentiometer modulates the current in the lowering proportional valve (pin#8 MDI-PRC) when the Lowering request is active. To do a Lowering function, the current in the proportional valve progressively increases (meanwhile the CND#15 potentiometer increases) to accelerate the Lowering.

- 5: Present only if MDI PRC is absent (see related option).
Only the Main Lifting/Lowering pair (CND#10 and CND#11) is used to handle a fully Proportional function (there is one proportional valve connected to the pin CND#2 used for both proportional Lifting and proportional Lowering).
The CND#10 input is the Lifting request that enable the pump contactor connected external from AC-X.
The Lowering request for the descent valve is external from AC-X.
The CND#15 potentiometer modulates the current in the proportional valve connected between CND#7 and CND#2 of the AC-X. This proportional valve is normally closed (oil does not pass-through when de-energized) and directly connected between the pump and the tank: to do a Lifting function the voltage into the Proportional Valve is turned fully On, to direct the oil into the tank before the pump contactor closes. Then the current in the Proportional Valve reduces (meanwhile the CND#15 potentiometer increases) to accelerate the Lifting.To do a Lowering function, the current in the proportional valve progressively increases (meanwhile the CND#15 potentiometer increases) to accelerate the Lowering.

15) VALVE 1 TYPE

(MDI-PRC version only). This option specifies the EVP1 type. The EVP1 is connected on the pin 8 of the MDI-PRC.

- OPTION#1: EVP1 is an On/Off valve.
- OPTION#2: EVP1 is a proportional valve.

16) VALVE 2 TYPE

(MDI-PRC version only). This option specifies the Electrovalove #2 type. The EVP2 is connected on the pin 9 of the MDI-PRC.

- OPTION#1: EVP2 is an On/Off valve.
- OPTION#2: EVP2 is a proportional valve

17) MDI-PRC

(Premium version only). This option specifies:

- PRESENT: The MDI-PRC is connected to the AC-X via the CAN Bus: the handling of the Hydraulics is specified on the TRUCK TYPE setting below.
- ABSENT: The MDI-PRC is not connected to the AC-X: some options disappear from the function list.

18) QUICK INV LOGIC

This option specifies the active level for the Belly switch input (CNB#7)

- OPTION#1: The quick inversion is executed when CNB#7 is opened from a KEY voltage.
- OPTION#2: The quick inversion is executed when CNB#7 is closed to a KEY voltage.

12.4.2 Config menu “ADJUSTMENTS” functions list

To enter the CONFIG MENU it is necessary to push in the same time the right side top and left side top buttons. Then roll until the ADJUSTMENTS item appears on the hand set display. Push the ENTER button (see the Figure 12–6 below).

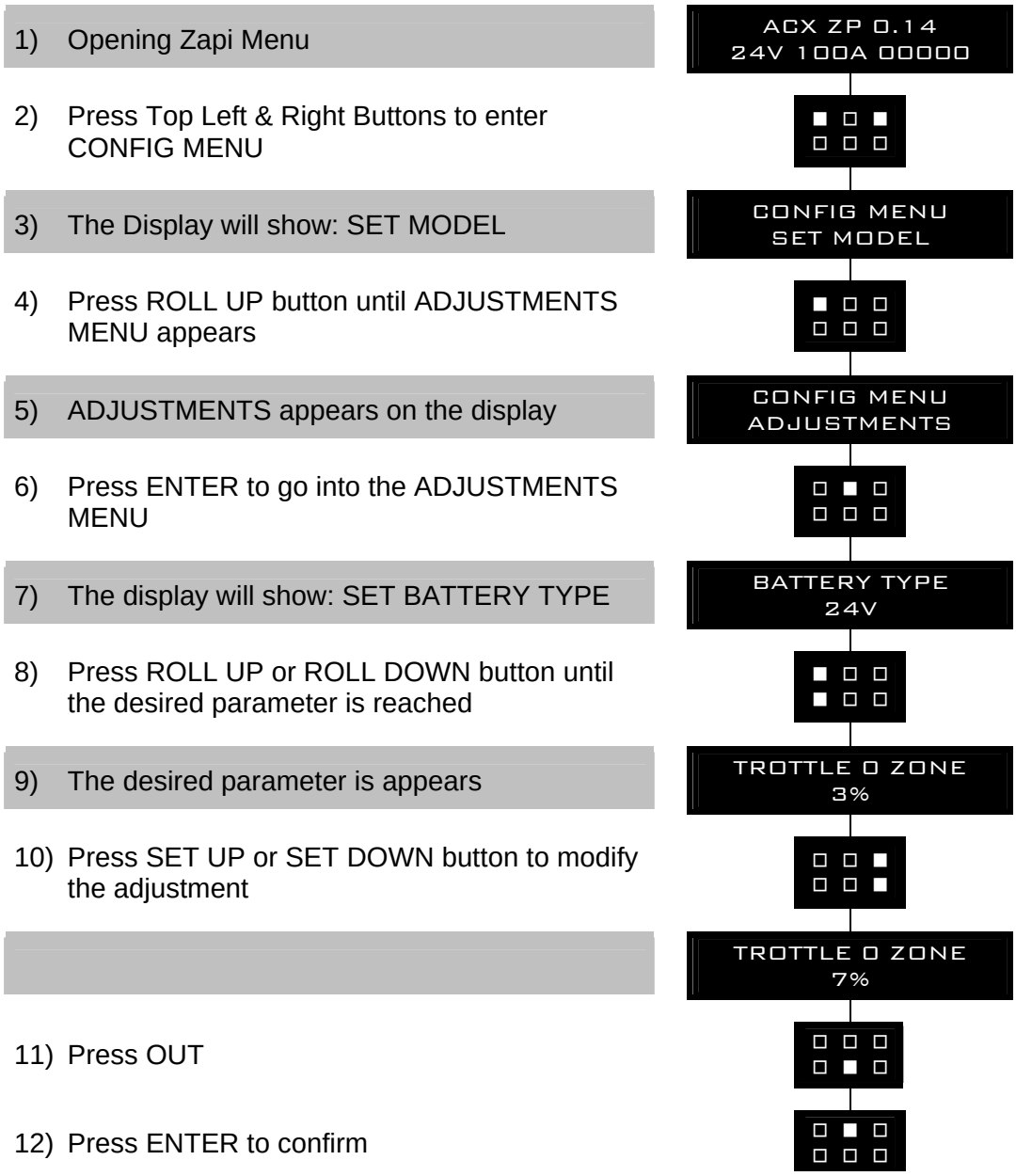


Figure 12–6

1) MIN LIFT
(Only with MDI-PRC or in premium version when CND#15 is used for lifting). By entering this setting, the SW records the actual value of the CND#15 potentiometer. The MIN LIFT setting must be Entered with the potentiometer in a position is a little bit ahead the main Lifting switch (CND#10) turns closed.

2) MAX LIFT
(Only with MDI-PRC or in premium version when CND#15 is used for lifting). By entering this setting, the SW records the actual value of the CND#15 potentiometer. The MAX LIFT setting must be Entered after the Lifting control Lever is pushed against the maximum limiting position.

3) MIN LOWER
(Only with MDI-PRC or in premium version when CND#15 is used for lifting). By entering this setting, the SW records the actual value of the potentiometer on CND#15. The MIN LOWER setting must be Entered with the CND#15 potentiometer in a position is a little bit ahead the Main Lowering switch (CND#11) turns closed.

4) MAX LOWER
(Only with MDI-PRC or in premium version when CND#15 is used for lifting). By entering this setting, the SW records the actual value of the potentiometer on CND#15. The MAX LOWER setting must be Entered after the Lowering control Lever moving the CND#15 potentiometer is pushed against the maximum limiting position.

5) SET POT BRK MIN
(Premium version without MDI PRC only). This setting 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 paragraph 13.3). This procedure must be carried out only if the PEDAL BRAKING option is programmed as ANALOG.

6) SET POT BRK MAX
(Premium version without MDI PRC only). This setting 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 paragraph 13.3). This procedure must be carried out only if the PEDAL BRAKING option is programmed as ANALOG.

7) SET BATTERY TYPE
Selects the nominal battery voltage.

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

9) THROTTLE 0 ZONE
Establishes a deadband in the accelerator input curve (see also paragraph 13.5).

10) THROTTLE X POINT
These parameter, together with the THROTTLE Y POINT, changes the characteristic of the accelerator input curve (see also paragraph 13.5): when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope (see also Figure 13–2).

11) THROTTLE Y POINT

These parameter, togheter with the THROTTLE X POINT, changes the characteristic of the accelerator input curve (see also paragraph 13.5): when the accelerator is de-pressed to X point per cent, the corresponding truck speed is Y point per cent of the Maximum truck speed. The relationship between the accelerator position and the truck speed is linear between the THROTTLE 0 ZONE and the X point and also between the X point and the maximum accelerator position but with two different slope (see also Figure 13–2).

12) ADJUSTMENT #01

Adjust the upper level of the battery charge table (Level 0 to 9). See paragraph 13.6 .

13) ADJUSTMENT #02

Adjust the lower level of the battery charge table (Level 0 to 9). See paragraph 13.6 .

14) LOAD HM FROM MDI

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

15) CHECK UP DONE

Turn it On when the asked Maintenance service has been executed to cancel the CHECK UP NEEDED warning.

16) CHECK UP TYPE

It specifies the handling of the CHECK UP NEEDED warning:

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

17) OPTION 05

(MDI-PRC version only). This setting, together with the four settings below, specifies an offset for the MDI-PRC HourMeter. The MDI-PRC HourMeter will be the sum of the Controller HourMeter plus this offset. This offset value is 5 Digits with:

- OPTION 05 is the MSDigit
- OPTION 01 is the LSDigit

It is possible to change this offset only when the controller HourMeter is less than 10 Hours. (It is used when the controller is replaced with a new one to keep updated the Total Hours measurement of the truck. It is just enough to set the OPTION 01 to OPTION 05 with the Final HourMeters of the replaced Controller).

18) OPTION 04

(MDI-PRC version only). See OPTION 05.

19) OPTION 03

(MDI-PRC version only). See OPTION 05.

20) OPTION 02
(MDI-PRC version only). See OPTION 05.

21) OPTION 01
(MDI-PRC version only). See OPTION 05.

12.4.3 Main menu “PARAMETER CHANGE” functions list

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

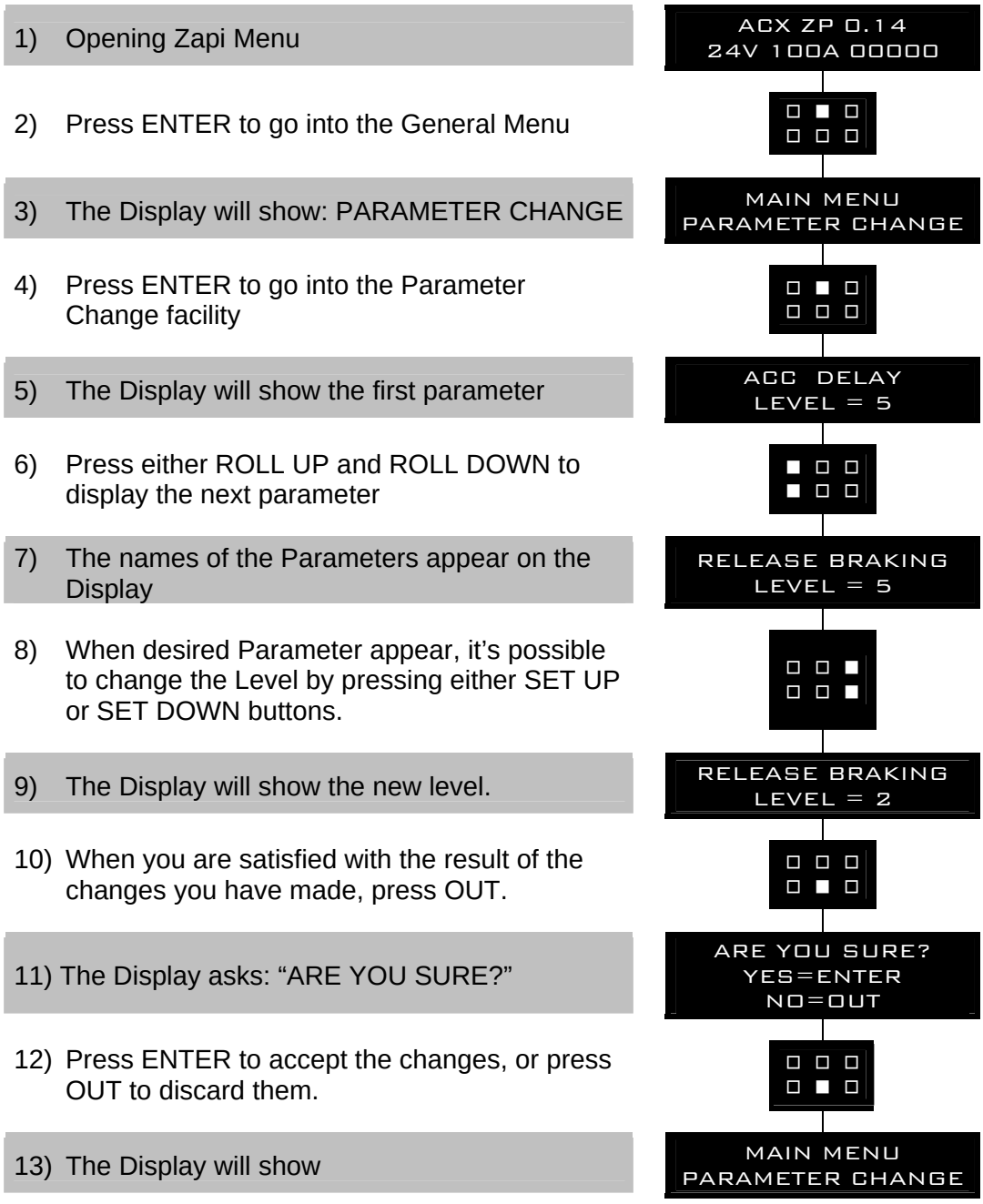


Figure 12–7

1) **ACCELER. DELAY**
Level 0 to 9. It determines the acceleration ramp. At Level 9 the truck takes long time to accelerate.

2) **RELEASE BRAKING**
Level 0 to 9. It controls the deceleration ramp when the travel request is released. At Level 9 the truck brakes abruptly.

3) **INVERS. BRAKING**
Level 0 to 9. It controls the deceleration ramp when the direction switch is inverted during travel. At Level 9 the truck brakes abruptly.

4) **PEDAL BRAKING**
Level 0 to 9. It controls the deceleration ramp when the travel request is released and the brake pedal switch is pressed to its maximum. At Level 9 the truck brakes abruptly.

5) **SPEED LIMIT BRK**
Level 0 to 9. It controls the deceleration ramp when the accelerator has turned down but not completely released. At Level 9 the truck decelerate abruptly.

6) **BRAKE CUTBACK**
Level 0 to 9. It controls the deceleration ramp when a speed reduction input becomes active and the motor slows down. At Level 9 the truck decelerate abruptly.

7) **MAX SPEED FWD**
Typically from 90Hz to 290Hz or something. It determines the maximum speed in forward direction.

8) **MAX SPEED BWD**
Typically from 90Hz to 290Hz or something. It determines the maximum speed in backward direction.

9) **CUTBACK SPEED**
(Only if used with encoder, because this cutback speed input is used for the thermal sensor in the sensorless version)
Typically from 10% to 100%. It determines the percentage of the max speed applied when the cutback switch 1 (SR#1 on CNA#7) is active. When set to 100% the speed reduction is ineffective.

10) **CUTBACK SPEED 2**
(Premium version without MDI PRC). Typically from 10% to 100%. It determines the percentage of the max speed applied when the cutback switch 2 (SR#2 on CND#9) is active. When set to 100% the speed reduction is ineffective.

11) **CUTBACK SPEED 3**
(Premium version without MDI PRC). Typically from 10% to 100%. It determines the percentage of the max speed applied when the cutback switch 3 (SR#3 on CND#12) is active. When set to 100% the speed reduction is ineffective.

12) HS CUTBACK

Tipically from 10% to 100%. It determines the percentage of the max speed applied when the Hard & Soft function (H&S switch on CNB#3) is active. When set to 100% the speed reduction is ineffective.

13) FREQUENCY CREEP

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

14) RPM CREEP

(Sensorless version only). A percentage value. Set to 100% and not used.

15) MAXIMUM CURRENT

Level 0 to 9. This changes the maximum current of the inverter. At level 9 the nominal maximum current is supplied; at level 0 the current is almost 10% of its nominal value (see 12.4.3.31).

16) INCHING SPEED

(Premium version without MDI PRC only, because the inching switches are used for the Lifting and Lowering switches in the MDI-PRC version). Hz value. It determines the speed when the "Inching function" is active (see 12.4.1.3-4 SET INPUT#2, SET INPUT#3).

17) INCHING TIME

(Premium version without MDI PRC only, because the inching switches are used for the Lifting and Lowering switches in the MDI-PRC version). Level 0 to 9. It determines the during time when the "Inching function" is active.

18) VALVES VOLTAGE

(Premium version with MDI-PRC only). A nominal Battery voltage from 12V to 120V. This parameter specifies the nominal voltage of the On/Off valves coil (EVD1 and EVD2 connected to pin #6 and pin#4 of the MDI-PRC). The MDI-PRC, supported by the AC-X, is able to control Electrovalves at a nominal voltage lower than the Battery voltage. For example Battery to 24V and Valves to 12V: then it is necessary that the MDI-PRC generates an output voltage with a PWM technique never overtaking the 50% Duty Cycle to get the Valve’s voltage less equal than 12V. Through this setting it is possible to take care the voltage on the EVD1 and EVD2 never overcomes the nominal voltage of the valves.

19) MIN VALVE 1

(Only with a TRUCK TYPE option set to #2, #3, #4 or #5). 0 to 255 digit. This parameter determines the minimum voltage applied on the EVP1 (MDI PRC version) when the position of the potentiometer on CND#15 is at the minimum. This parameter is not effective if the EVP1 is programmed like a On/Off valve (see 12.4.1.15 – VALVE 1 TYPE). The EVP1 is connected on the pin 8 of the MDI-PRC (see TRUCK TYPE – 12.4.1.14 – for the handling). If TRUCK TYPE = #5 (or #3) is set, this parameter change minimum voltage applied to the proportional valve on CND#2 (or #8 of MDI PRC) only during lifting operation.

20) MIN VALVE 2

(Only with MDI PRC and a TRUCK TYPE option set to #2 or #4). 0 to 255 digit. This parameter determines the minimum voltage applied on the EVP2 when the position of the potentiometer on CND#15 is at the minimum. This parameter is not effective if the EVP2 is programmed like a On/Off valve (see

12.4.1.16 – VALVE 2 TYPE). The EVP2 is connected on the pin 9 of the MDI-PRC (see TRUCK TYPE – 12.4.1.14 – for the handling).

21) MAX VALVE 1

(Only with a TRUCK TYPE option set to #2, #3, #4 or #5). 0 to 255 digit. This parameter determines the maximum voltage applied on the EVP1 (MDI PRC version) when the position of the potentiometer on CND#15 is at the maximum. If the EVP1 is programmed like a On/Off valve (see 12.4.1.15 – VALVE 1 TYPE), this parameter determines the fixed voltage applied on the electrovalve coil . The EVP1 is connected on the pin 8 of the MDI-PRC (see TRUCK TYPE – 12.4.1.14 – for the handling).
If TRUCK TYPE = #5 (or #3) is set, this parameter change maximum voltage applied to the proportional valve on CND#2 (or #8 of MDI PRC) only during lifting operation.

22) MAX VALVE 2

(Only with MDI PRC and a TRUCK TYPE option set to #2 or #4). 0 to 255 digit. This parameter determines the maximum voltage applied on the EVP2 when the position of the potentiometer on CND#15 is at the maximum. If the EVP2 is programmed like a On/Off valve (see 12.4.1.16 – VALVE 2 TYPE), this parameter determines the fixed voltage applied on the electrovalve coil. The EVP2 is connected on the pin 9 of the MDI-PRC (see TRUCK TYPE – 12.4.1.14 – for the handling).

23) VALVE 3 VOLTAGE

(Only with MDI PRC and a TRUCK TYPE option set to #2 or #4). A percentage from 0% to 100%. This parameter determines the voltage applied to the EVD1 (this is connected on the pin #6 of the MDI-PRC) in percentage of the above VALVES VOLTAGE setting. The voltage applied to this electrovalve is a PWM technique generated by the MDI-PRC: the Duty Cycle is modulated in order that, the voltage applied to these On/Off valve, is the wished percentage of the VALVES VOLTAGE (e.g. Vbatt=48V, VALVES VOLTAGE=24V, VALVE 3 VOLTAGE=100% means the MDI-PRC generates a PWM with a 50% duty on the EVD1).

24) VALVE 4 VOLTAGE

(Only with MDI PRC and a TRUCK TYPE option set to #2 or #4). A percentage from 0% to 100%. This parameter determines the voltage applied to the EVD2 (this is connected on the pin #4 of the MDI-PRC) in percentage of the above VALVES VOLTAGE setting. The voltage applied to this electrovalve is a PWM technique generated by the MDI-PRC: the Duty Cycle is modulated in order that, the voltage applied to these On/Off valve, is the wished percentage of the VALVES VOLTAGE (e.g. Vbatt=48V, VALVES VOLTAGE=24V, VALVE 4 VOLTAGE=100% means the MDI-PRC generates a PWM with a 50% duty on the EVD2).

25) MIN V1 LOW

(Only Premium version and a TRUCK TYPE option set to #3 or #5). 0 to 255 digit. This parameter determines the minimum voltage applied on the EVP1 (truck type #3 MDI PRC version) or the EVP on CND#2 (truck type #5 without MDI PRC) when the position of the potentiometer on CND#15 is at the minimum. This parameter have effect only during lowering operation.

26) MAX V1 LOW

(Only Premium version and a TRUCK TYPE option set to #3 or #5). 0 to 255 digit. This parameter determines the maximum voltage applied on the EVP1

(truck type #3 MDI PRC version) or the EVP on CND#2 (truck type #5, without MDI PRC) when the position of the potentiometer on CND#15 is at the maximum. This parameter have effect only during lowering operation.

27) DEC DELAY LOW

(Only Premium version and a TRUCK TYPE option set to #3 or #5).
Time units value. This parameter determines the ramp voltage applied on the EVP1 of the MDI PRC (if truck type is #3) or on the EVP on CND#2 (if truck type is #5) in the closing transition during lowering operation.

28) ACC DELAY LOW

(Only Premium version and a TRUCK TYPE option set to #3 or #5).
Time units value. This parameter determines the ramp voltage applied on the EVP1 of the MDI PRC (if truck type is #3) or on the EVP on CND#2 (if truck type is #5) in the opening transition during lowering operation.

29) ACC DELAY LIFT

(Only Premium version and a TRUCK TYPE option set to #3 or #5).
Time units value. This parameter determines the ramp voltage applied on the EVP1 of the MDI PRC (if truck type is #3) or on the EVP on CND#2 (if truck type is #5) in the closing transition during lifting operation.

30) DEC DELAY LIFT

(Only Premium version and a TRUCK TYPE option set to #3 or #5).
Time units value. This parameter determines the ramp voltage applied on the EVP1 of the MDI PRC (if truck type is #3) or on the EVP on CND#2 (if truck type is #5) in the opening transition during lifting operation.

31) V1 OPENING RAMP

(Only Premium version with MDI PRC and a TRUCK TYPE option set to #2 or #4). A time units value (from 0.0 to 2.0 seconds). This parameter determines the ramp of voltage applied on the EVP1 (pin #8 MDI-PRC) in the opening transition (if proportional); this is the time necessary to go from the minimum to the maximum voltage. If the electrovalve is programmed like an On/Off valve this parameter is not effective.

32) V2 OPENING RAMP

(Only Premium version with MDI PRC and a TRUCK TYPE option set to #2 or #4). A time units value (from 0.0 to 2.0 seconds). This parameter determines the ramp of voltage applied on the EVP2 (pin #9 MDI-PRC) in the opening transition (if proportional); this is the time necessary to go from the minimum to the maximum voltage. If the electrovalve is programmed like an On/Off valve this parameter is not effective.

33) V1 CLOSING RAMP

(Only Premium version with MDI PRC and a TRUCK TYPE option set to #2 or #4). A time units value (from 0.0 to 2.0 seconds). This parameter determines the ramp of voltage applied on the EVP1 (pin #8 MDI-PRC) in the closing transition (if proportional); this is the time necessary to go from the maximum to the minimum voltage. If the electrovalve is programmed like an On/Off valve this parameter is not effective.

34) V2 CLOSING RAMP

(Only Premium version with MDI PRC and a TRUCK TYPE option set to #2 or #4). A time units value (from 0.0 to 2.0 seconds). This parameter determines the ramp of voltage applied on the EVP2 (pin #9 MDI-PRC) in the

closing transition (if proportional); this is the time necessary to go from the maximum to the minimum voltage. If the electrovalve is programmed like an On/Off valve this parameter is not effective.

35) AUXILIARY TIME

Time units value (seconds in the sensorless configuration, 1/10 seconds in the encoder configuration). For the encoder configuration, it determines the time duration the truck is kept on the ramp if the STOP ON RAMP option is ON.

For the sensorless configuration it is the delay before the standing current goes to zero after releasing the travel demand.

36) ANTI ROLLBACK

(Sensorless configuration only: Factory adjusted). A Percentage of the Maximum Current. This setting increases the phase current when low frequency during starting operation. It is used to push up in feedforward way the torque when it is not possible to control the flux in feedback way because of the low frequency.

12.4.3.31 Setting table of the “PARAMETER CHANGE” functions

The following table shows the different values at which the parameters can be set (encoder version).

PARAMETER	UNIT	PROGRAMMED LEVEL									
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
ACCELERATION DELAY (*)	Sec.	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50
RELEASE BRAKING (**)	Sec.	5.50	5.00	4.50	4.00	3.50	3.00	2.50	2.00	1.50	1.00
INVERS BRAKING (**)	Sec.	5.50	4.90	4.50	3.90	3.40	2.80	2.30	1.70	1.10	0.50
PEDAL BRAKING (**)	Sec.	5.50	5.00	4.50	4.00	3.50	3.00	2.50	2.00	1.50	1.00
SPEED LIMIT BRAKING (**)	Sec.	8.90	8.30	7.70	7.10	6.60	6.00	5.50	4.90	4.40	3.80
BRAKE CUTBACK (**)	Sec.	5.50	5.00	4.50	4.00	3.50	3.00	2.50	2.00	1.50	1.00
MAX SPEED FW	Hz	90	100	110	120	130	140	170	180	260	290
MAX SPEED BW	Hz	90	100	110	120	130	140	170	180	260	290
CUTBACK SPEED	%Max Sp	10	20	30	40	50	60	70	80	90	100
CUTBACK SPEED 2	%Max Sp	10	15	20	25	37	50	62	75	87	100
CUTBACK SPEED 3	%Max Sp	10	15	20	25	37	50	62	75	87	100
H&S CUTBACK	%Max Sp	10	15	20	25	37	50	62	75	87	100
FREQUENCY CREEP	Hz	0.3	0.6	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0
RPM CREEP											
MAXIMUM CURRENT	%IMAX	10	20	30	40	50	60	70	80	96	100
INCHING SPEED	Hz	0	2	4	6	8	10	12	14	16	18
INCHING TIME	Sec.	0.30	1.00	2.00	2.80	3.6	4.50	5.40	6.20	7.10	8.00
VALVES VOLTAGE	V	12	24	36	48	60	72	80	96	120	120
MIN VALVE 1	This parameter can be adjusted from 1 to 255 with regulation of 1digit										
MIN VALVE 2	This parameter can be adjusted from 1 to 255 with regulation of 1digit										
MAX VALVE 1	This parameter can be adjusted from 1 to 255 with regulation of 1digit										
MAX VALVE 2	This parameter can be adjusted from 1 to 255 with regulation of 1digit										
VALVE 3 VOLTAGE	%V	12	20	25	40	50	60	70	80	90	100
VALVE 4 VOLTAGE	%V	12	20	25	40	50	60	70	80	90	100
MIN V1 LOW	This parameter can be adjusted from 1 to 255 with regulation of 1digit										
MAX V1 LOW	This parameter can be adjusted from 1 to 255 with regulation of 1digit										
DEC DELAY LOW		0.2	0.8	1.0	1.5	2.5	3.5	4.5	5.5	6.5	7.5
ACC DELAY LOW		0.2	0.8	1.0	1.5	2.5	3.5	4.5	5.5	6.5	7.5
ACC DELAY LIFT		1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5
DEC DELAY LIFT		1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.0	11.3	12.5
V1 OPENING RAMP	Sec.	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
V2 OPENING RAMP	Sec.	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
V1 CLOSING RAMP	Sec.	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
V2 CLOSING RAMP	Sec.	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
AUXILIARY TIME	Sec.	0.0	0.2	0.4	0.8	1.0	1.5	2.0	3.0	4.0	5.0
ANTIROLLBACK	%IMAX	76	79	81	84	87	90	92	95	98	100

Figure 12–8

(*) 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.

12.4.4 Zapi menu “HARDWARE SETTINGS” functions list

Note: the below set-up description is for skilled persons only: if you aren’t please keep your hands off. To enter this Zapi hidden menu a special procedure is required. Ask, this procedure, directly to a Zapi technician.
The settings below regulate the parameters for the motor control.
In the following, we distinguish the HARDWARE SETTING list between encoder and sensorless application.
It is possible to switch between one and the other by rolling the ENCODER setting and recycling the key.

12.4.4.1 Encoder “HARDWARE SETTINGS” list

In encoder configuration, the control law consists of applying a phase voltage increasing from a minimum (when the slip is null), to the maximum (when the slip reachs its maximum). Two conditions may occur:

1) If the current in the motor, for the wished phase voltage, reaches its maximum before the maximum slip is reached, the SW clamps the voltage width (under the wished value), to keep the current limited. In this condition, the SW allows the slip gets increased, standing at the maximum current, until the maximum slip is got. If the load asks higher torque than the max-slip-at-max-current can supply, the slip aims to increase, then the SW freezes the slip at its maximum by modulating the frequency to match continuously the condition max-slip-at-max-current.
2) If the current in the motor, for the wished phase voltage, stays limited under its maximum, the SW allows the slip increasing until its maximum. When the maximum slip is got with the wished phase voltage, the SW modulate the frequency in such a way the slip gets limited at its maximum. (Obviously this condition in which the slip is at its maximum but the current is not at its maximum must be avoided because generates a degraded torque strength. To avoid the problem it is just enough to increase the wished phase voltage).

It results clear the parameters needed to be specified in every working conditions are:

1) minimum phase voltage when the slip is null (minimum voltage settings).
2) maximum phase voltage when the slip is at its maximum (booster settings).
3) the absolute maximum slip (maximum slip settings).

Below is the list of all the settings used to specify the above three parameters. Are also listed the settings for the sensorless function.

1) ENCODER
ON/OFF. It choose the type of the motor control used. It’s possible to choose between encoder version (set ON) and sensorless version (set OFF). After any change of this parameter, is necessary to recycle the key. At new key on AC-X provides a CLEAR EEPROM and the controller restarts with default parameters of the configuration required.

2) CONTACTOR CLOSED
ON/OFF. This parameter enables the CONTACTOR CLOSED diagnosis.

3) MONITOR
Not used in the encoder version.

4) **COMPENSATION**
On/Off. This must be set On in order the three waves shape are perfectly sinusoidal.

5) **SLIP CONTROL**
On/Off. Set it On to enable the control law with the encoder getting the slip limited under its maximum (see the control law description at the beginning of this topic). When it is set Off the slip is not more limited and the frequency is only proportional to the accelerator position. Used, when set Off, for troubleshooting.

6) **DC LINK COMPENSATION**
On/Off. When it is set On the SW calculates the voltage quantities for the booster and minimum voltage settings as a function of the nominal battery voltage (e.g. BOOST AT LO FREQ=20% and nominal batt=24Vdc, means 20%*nominal batt=4.8V). When it is set Off the SW calculates the voltage quantities for the booster and minimum voltage settings as a function of the actual battery voltage (e.g. BOOST AT LO FREQ=20% means 20%*actual battery voltage).

7) **SAT FREQUENCY** (minimum voltage setting)
Hz value. SAT FREQUENCY sets the minimum phase voltage width when the slip is less than MAXSLIP RESET (lightened motor) and the motor is accelerating. This minimum phase voltage is calculated as:

phase voltage=(Vbatt-MINIMUM VOLTAGE)/SAT FREQUENCY*(actual applied frequency)+MINIMUM VOLTAGE.

8) **BRAKING MODUL** (minimum voltage setting)
Hz value. BRAKING MODULATION sets the minimum phase voltage width when the slip is less than MAXSLIP RESET (lightened motor) and the motor is braking. This minimum phase voltage is calculated as:

phase voltage=(Vbatt-MINIMUM VOLTAGE)/BRAKING MODUL*(actual applied frequency)+MINIMUM VOLTAGE.

9) **MINIMUM VOLTAGE** (minimum voltage setting)
% value. The MINIMUM VOLTAGE sets the phase voltage, as percentage of the battery, applied when the frequency is null and the slip is less than MAXSLIP RESET. In fact, when the frequency is null the above formulas for the phase voltage becomes.

phase voltage = MINIMUM VOLTAGE

10) **MAXSLIP RESET** (maximum slip setting)
Hz value. When the slip is from 0 to ± MAX SLIP RESET, only the minimum phase voltage (see SAT FREQUENCY and BRAKING MODULATION) is applied.

11) **BOOST AT LO FREQ** (booster setting)
% value. BOOST AT LO FREQ set the maximum phase voltage when the slip is at maximum and the frequency is null. It is the percentage of the battery voltage is to be applied over the minimum (see SAT FREQUENCY, BRAKING MODUL and MINIMUM VOLTAGE) when the slip is at its maximum (see MAX SLIP LOW FREQ, MAXSLIP INC, MAXSLIP FREQ) and the frequency is null. For example, BOOST AT LO FREQ=20% means the

phase voltage must be 20%*Vbatt + MINIMUM VOLTAGE when the frequency is null and the slip is at its maximum. When the frequency is null and the slip is not at its maximum, the voltage booster (that mean from 0% to 20% of Vbatt) is proportional to the difference max slip-MAXSLIP RESET.

12) **BOOST CORNER FREQ** (booster setting)
Hz value. BOOST CORNER FREQ specifies at which frequency the booster to be applied when the slip is at its maximum is the BOOST AT HI FREQ.

13) **BOOST AT HI FREQ** (booster setting)
% value. BOOST AT HI FREQ set the maximum phase voltage when the slip is at maximum and the frequency is at BOOST CORNER FREQ. It is the percentage of the battery voltage that must be applied over the minimum (see SAT FREQUENCY, BRAKING MODUL and MINIMUM VOLTAGE) when the slip is at its maximum (see MAX SLIP LOW FREQ, MAXSLIP INC, MAXSLIP FREQ) and the frequency is at BOOST CORNER FREQ. For example, BOOST AT HI FREQ=45% means the phase voltage must be 45%*Vbatt + minimum voltage when the frequency is at BOOST CORNER FREQ and the slip is at its maximum. When the frequency is at BOOST CORNER FREQ and the slip is not at its maximum, the voltage booster (that mean from 0% to 45%) is proportional to the difference max slip-MAXSLIP RESET.
When the frequency is inside the range from 0Hz to BOOST CORNER FREQ the booster setting change linearly between the BOOST AT LO FREQ to BOOST AT HI FREQ.

14) **BRAKING BOOSTER** (booster setting)
% value. When the truck is braking, the maximum booster to be applied is a percentage of the booster calculated with BOOST AT HI FREQ, BOOST AT LO FREQ and BOOST CORNER FREQ. This percentage is given by BRAKING BOOSTER. If it is set to 0% there is no booster when braking.

15) **MAX SLIP LOW FREQ** (maximum slip setting)
Hz value. When the frequency is from 0Hz to MAXSLIP FREQ, the maximum slip is given by MAX SLIP LOW FREQ (i.e. in the specified frequency range the slip never overtakes this MAX SLIP LOW FREQ setting).

16) **MAXSLIP FREQ** (maximum slip setting)
Hz value. When the frequency is from 0Hz to MAXSLIP FREQ, the maximum slip is given by MAX SLIP LOW FREQ.

17) **MAXSLIP INC** (maximum slip setting)
Hz value. When the frequency is higher than MAXSLIP FREQ+MAXSLIP FREQ INC, the maximum slip is given by the sum MAX SLIP LOW FREQ+MAXSLIP INC.

18) **MAXSLIP FREQ INC** (maximum slip setting)
Hz value. When the frequency is higher than MAXSLIP FREQ+MAXSLIP FREQ INC, the maximum slip is given by the sum MAX SLIP LOW FREQ+MAXSLIP INC.
When the frequency is from MAXSLIP FREQ up to MAXSLIP FREQ +MAXSLIP FREQ INC, the maximum slip setting increases proportionally between MAX SLIP LOW FREQ to MAXSLIP LOW FREQ+MAXSLIP INC.

19) **MOTOR RESISTANCE** (booster setting)
(Factory adjusted). Level 0 to 9. Normally set to Level=0. It increases the

booster setting of a quantity is proportional at the current in the motor multiplied for a constant value depending of this setting. When Level=0 this constant value is null. This is a coarse compensation of the drop on the motor resistance.

20) SLIP COEFFICIENT (booster setting)
(Factory adjusted). Level 0 to 9. Normally set to Level=0. It increases the booster setting of a quantity is proportional to the slip. Differently from the previous booster settings, the SLIP COEFFICIENT booster is applied without ramp delay or filtering. When it is set to Level=0 it is ineffective.

21) OPTION 06
(Factory adjusted). Level 0 to 9. This parameters (togheter with the OPTION 07 and OPTION 08) handles the ramp on the phase voltage to pursuit the booster setting or the maximum current limitation (what occurs first). In particular OPTION 06 defines the phase voltage ramp when the current is higher than 1.2*Imax. By increasing this setting, the voltage ramp gets faster.

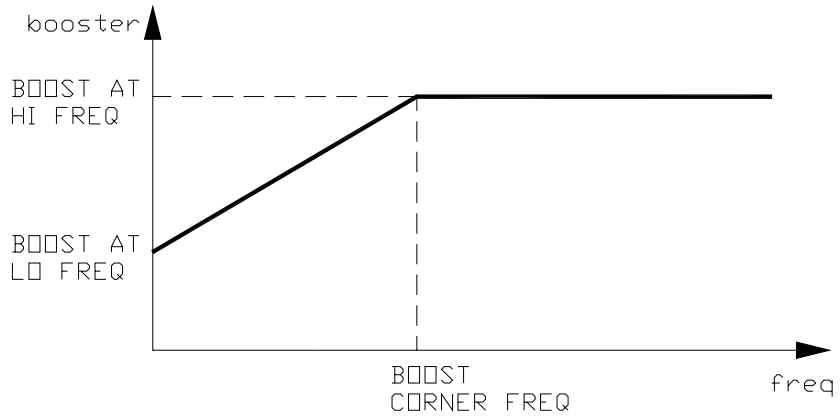
22) OPTION 07
(Factory adjusted). Level 0 to 9. This parameters (togheter with the OPTION 06 and OPTION 08) handles the ramp on the phase voltage to pursuit the booster setting or the maximum current limitation (what occurs first). In particular OPTION 07 defines the phase voltage ramp when the current is inside the range Imax to 1.2*Imax. By increasing this setting, the voltage ramp gets faster.

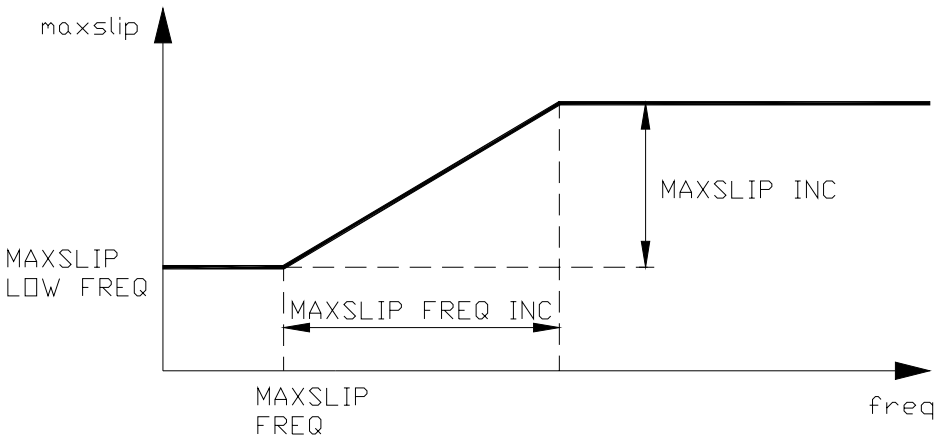
23) OPTION 08
(Factory adjusted). Level 0 to 9. This parameters (togheter with the OPTION 06 and OPTION 07) handles the ramp on the phase voltage to pursuit the booster setting or the maximum current limitation (what occurs first). In particular OPTION 08 defines the phase voltage ramp when the current is less than Imax. By increasing this setting, the voltage ramp gets faster.

OPTION 06, OPTION 07, OPTION 08 are useful in two cases:

1) When the current in the motor has a distorced wave shape (especially when at maximum current in a locked motor). Then to reduce the above settings may help.

2) When the current modulation is too slow and the Hardware current control operates frequently: then to increase the above setting may help.





12.4.4.2 Sensorless “HARDWARE SETTINGS” list

In the HARDWARE SETTINGS and in the SPECIAL ADJUSTMENTS functions list, there are the parameters for the motor control in the Sensorless configuration.
The Sensorless control works by using an estimation of the electromotive force in the motor (EMF) to calculate the actual magnetic flux. Then, the control law consists of modulating the voltage width in order the actual magnetic flux matches the wished one. As a thumb rule the control mode replays the SEM control law consisting of a distinct modulation of the flux and of the armature current.
When the frequency is close to zero, the EMFs approach to zero and it is not more possible to calculate the flux: then the control law works by increasing the current to push up the flux and the torque in a feedforward way.
It results clear the parameters required in every working conditions are:

1) Maximum Flux in the motor at the saturation knee (MAX FLUX).
2) The Magnetization Current (IOM) substaining that MAX FLUX (in order to separate the magnetization current from the armature current in the calculation).
3) The Current to be injected in the motor when low frequency at starting and stopping (ANTIROLLBACK).
4) The Current to be injected in the motor when low frequency during inversion (MINIMUM VOLTAGE).

1) ENCODER
ON/OFF. It choose the type of the motor control used. It’s possible to choose between encoder version (set ON) and sensorless version (set OFF). After any change of this parameter, is necessary to recycle the key. At new key on AC-X provides a CLEAR EEPROM and the controller restarts with default parameters of the configuration required.

2) CONTACTOR CLOSED
ON/OFF. This parameter enables the CONTACTOR CLOSED diagnosis.

3) COMPENSATION
On/Off. This must be set On in order the three waves shape are perfectly sinusoidal.

4) MINIMUM VOLTAGE
(Factory adjusted). A Percentage of the Battery Voltage. This setting increases the phase voltage (and current) when low frequency during

inversion operation. It is used to push up in feedforward way the torque when it is not possible to control the flux in feedback way because of the low frequency.

5) **MONITOR**
(On/Off). This is a predisposition to enable a monitoring function of the motor speed when either the frequency is low (control blind area) or an untuning condition is detected between frequency and speed. The aim is to get the control tuned (frequency and speed matched) togheter with the de-enegization of the Electromechanical Brake. It is not handled yet.

6) **MAXSLIP LOW FREQ**
(Factory adjusted). Hz value. This is factory adjusted and it is used to get the magnetic flux pursuiting faster or slower.

12.4.5 Zapi menu “SPECIAL ADJUSTMENTS” functions list

Note: the below set-up description is for skilled persons only: if you aren’t please keep your hands off. To enter this Zapi hidden menu a special procedure is required. Ask, this procedure, directly to a Zapi technician.
In the SPECIAL ADJUSTMENTS menu there are three parameters (IOM, MAX FLUX, MOTOR RESIST) used only in the Sensorless configuration.

1) **ADJUSTMENT #01**
(Factory adjusted). % value. This is the Gain of the first Current Sensing Amplifier.
NOTE: keep your hand off this setting.

2) **ADJUSTMENT#02**
(Factory adjusted). % value. This is the Gain of the second Current Sensing Amplifier.
NOTE: keep your hand off this setting.

3) **MOTOR RESIST**
(Sensorless configuration only). The Sensorless control estimates the electromotive force in the motor (EMF) by knowing the drop in the motor resistances. For this reason it is necessary to know the delta wound motor resistance. This setting is the autoacquired value in milliohms of the delta wound resistance. To autoacquire this value, roll this setting down to zero or do a CLEAR EEPROM operation (see also the set-up procedure 11.1).

4) **IOM**
(Sensorless configuration only, Factory adjusted). Ampere value. This is the magnetization current supporting the MAX FLUX in a lightened motor.

5) **MAX FLUX**
(Sensorless configuration only, Factory adjusted). Units value. This is the maximum flux at the knee of the saturation curve of the motor. It is expressed in mWb.

6) **SET TEMPERATURE**
(Factory adjusted) Set the temperature offset to have the correct value read.
NOTE: keep your hand off this setting.

7) **AUX FUNCTION #1**
Management of debug test point.

8) **AUX FUNCTION #2**
Management of debug test point.

9) **HIGH ADDRESS**
Used to have access to special memory address.
NOTE: keep your hand off this setting.

12.4.6 Main menu “TESTER” functions list

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

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

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

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

4) **FLUX MILLIWB**
(Sensorless only). Units value. It is the estimated flux in the motor.

5) **MOT. POWER WATT**
(Sensorless only). Units value. It is the measurement of the actual electrical power passing through the air-gap of the Motor. It is expressed in Watt. It turns negative when the Motor is braking.

6) **FREQUENCY**
Hz value with two decimal digit. This is the frequency of the sine waves the inverter is supplying.

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

8) **SLIP VALUE**
Hz value with two decimal digit. This is the slip between the frequency and the speed of the motor (SLIP VALUE = FREQUENCY-ENCODER).

9) CURRENT RMS

Ampere value. Root Mean Square value of the line current in the motor.

10) BATTERY CHARGE

Percentage value. It supplies the residual charge of the battery as a percentage of the full charge level.

11) TEMPERATURE

°C value. This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection (see 14.1.7.1).

12) MOTOR TEMPERATURE

°C value. This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally this sensor is a PTC Philips KTY84-130 or a KTY83-150. In the encoder configuration, this temperature is used only to raise a warning in the hand set when the motor temperature overtakes the MOTOR OVERTEMP setting. In the Sensorless, the drivecuts-off when the MOTOR TEMPERATURE is higher than 150°.

13) ACCELERATOR

From 0.0V to 5.0V. The voltage on the wiper of the accelerator (CPOT on CNA#11) is halved inside the controller and then recorded on this reading. That means the actual wiper voltage is in the range 0 to 10V meanwhile the corresponding ACCELERATOR reading is in the range 0.0 to 5.0Vdc.

14) BRAKE PEDAL POT

(Premium Version only and without MDI PRC). From 0.0V to 5.0V. When the MDI-PRC is absent, the potentiometer connected to CPOTB on CND#15 is used for a brake pedal sensor. The voltage on the wiper of this brake pedal potentiometer (CND#15) is recorded on this reading.

15) LIFTING CONTROL

(Only Premium with MDI-PRC or with Truck type =#5). From 0.0V to 5.0V. When the MDI-PRC is present, the potentiometer connected to CPOTB on CND#15 is used for a proportional control of the hydraulics. The voltage on the wiper of this potentiometer (CND#15) is recorded on this reading.

16) LIFTING SWITCH

(Premium Version only)

ON/OFF. This is the level of the CND#10 digital input (Lifting request):

- ON +VB = When CND#10 is closed to a battery (key) voltage, the Lifting request is Active.
- OFF GND= When CND#10 is not connected to a battery (key) voltage (or it is connected to GND), the Lifting request is not active.

17) DESCENT SWITCH

(Premium Version only)

ON/OFF. This is the level of the CND#11 digital input (Lowering request):

- ON +VB = When CND#11 is closed to a battery (key) voltage, the Lowering request is Active.
- OFF GND= When CND#11 is not connected to a battery (key) voltage (or it is connected to GND), the Lowering request is not active.

18) DIGITAL INPUT #1

(MDI-PRC version only). ON/OFF. This is the level of the CND#9 digital input (when the MDI-PRC is present this input is an Auxiliary (2nd) Lifting request):

- ON +VB = When CND#9 is closed to a battery (key) voltage the Aux Lifting request is active.
- OFF GND = When CND#9 is not closed to a battery (key) voltage (or it is connected to GND) the Aux Lifting request is not active.

19) DIGITAL INPUT #2

(MDI-PRC version only). ON/OFF. This is the level of the CND#12 digital input (when the MDI-PRC is present this input is an Auxiliary (2nd) Lowering request):

- ON +VB = When CND#12 is closed to a battery (key) voltage the Aux Lowering request is active.
- OFF GND = When CND#12 is not closed to a battery (key) voltage (or it is connected to GND) the Aux Lowering request is not active.

20) FORWARD SWITCH

ON/OFF. This is the level of the CNA#6 digital input (Forward Travel demand):

- ON +VB = When CNA#6 is closed to a battery (key) voltage, the Forward Travel demand is Active.
- OFF GND= When CNA#6 is not connected to a battery (key) voltage (or it is connected to GND), the Forward Travel demand is not active.

21) BACKWARD SWITCH

ON/OFF. This is the level of the CNA#5 digital input (Backward Travel demand):

- ON +VB = When CNA#5 is closed to a battery (key) voltage, the Backward Travel demand is Active.
- OFF GND= When CNA#5 is not connected to a battery (key) voltage (or it is connected to GND), the Backward Travel demand is not active.

22) HANDLE/SEAT SW.

ON/OFF. This is the level of the CNA#3 digital input (Tiller or seat swit.):

- ON +VB = When CNA#3 is closed to a battery (key) voltage the driver has activated the tiller (motion enabled).
- OFF GND= When CNA#3 is not connected to a battery (key) voltage (or it is connected to GND), the driver has released the tiller (motion disabled).

23) H&S CUTBACK

ON/OFF. This is the level of the CNB#3 digital input (Hard & Soft request). With the H&S service is possible to turn the truck moving (at reduced speed) only by acting the H&S switch, and the accelerator, without to let down the tiller :

- ON +VB = When CNB#3 is closed to a battery (key) voltage, the H&S request is Active.
- OFF GND= When CNB#3 is not connected to a battery (key) voltage (or it is connected to GND), the H&S request is not active.

24) QUICK INVERSION

(Only if with SET INPUT #4 CNA#8 is configured as BELLY switch)
ON/OFF. This is the level of the CNA#8 digital input:

- ON GND= This reading means the Quick Inversion request is active.
- OFF +VB = This reading means the Quick Inversion request is not active

When QUICK INV LOGIC is set to OPTION#2 the quick inversion request is active when CNA#8 is connected to a battery (key) voltage.
When QUICK INV LOGIC is set to OPTION#1 the quick inversion request is active when CNA#8 is not connected to a battery (key) voltage.
This input CNA#8 has alternative functions depending on the setting of SET INPUT #4.

25) INCHING FORWARD

(Only premium version without MDI PRC and with CND#9 set as inching)
When CND#9 is set as inching function (SET INPUT #2).
ON/OFF. This is the level of the CND#9 digital input:

- OFF +VB = This reading means the inching forward request is active.
- ON GND= This reading means the inching forward request is not active.

26) INCHING BACKWARD

(Only premium version without MDI PRC and with CND#12 set as inching)
When CND#12 is set as inching function (SET INPUT #3).
ON/OFF. This is the level of the CND#12 digital input:

- ON +VB= This reading means the inching backward request is active.
- OFF GND= This reading means the inching backward request is not active.

27) CUTBACK SWITCH

(Only with encoder and with SET INPUT #1 set as PRESENT)
ON/OFF. This is the level of the CNA#7 digital input:

- ON GND = When CNA#7 is not closed to a battery (key) voltage (or connected to GND) the SR request is active.
- OFF +VB = When CNA#7 is closed to a battery (key) voltage the SR request is not active.

28) CUTBACK SWITCH 2

(Premium version only). ON/OFF. This is the level of the CND#9 digital input (When the MDI-PRC is not present, and SET INPUT #2 is set PRESENT, this is the Speed Reduction #2 request):

- ON GND = When CND#9 is not closed to a battery (key) voltage (or connected to GND) the SR#2 request is active.
- OFF +VB = When CND#9 is closed to a battery (key) voltage the SR#2 request is not active.

29) CUTBACK SWITCH 3

(Premium version only). ON/OFF. This is the level of the CND#12 digital input (When the MDI-PRC is not present, and the SET INPUT #3 is set PRESENT, this is the Speed Reduction #3 request):

- ON GND = When CND#12 is not closed to a battery (key) voltage (or connected to GND) the SR#3 request is active.
- OFF +VB = When CND#12 is closed to a battery (key) voltage the SR#3 request is not active.

30) BRAKE SWITCH

(Only if with SET INPUT #4 CNA#8 is configured as BRAKE switch)
ON/OFF. This is the level of the CNA#8 digital input:

- ON +VB= This reading means the Pedal brake request is active.
- OFF GND = This reading means the Pedal brake request is not active

This input CNA#8 has alternative functions depending on the setting of SET INPUT #4.

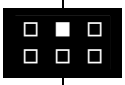
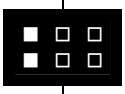
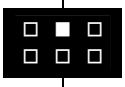
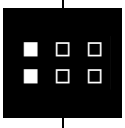
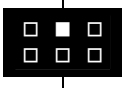
13 OTHER FUNCTIONS

13.1 Description of console “SAVE” function

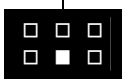
The SAVE function allows the operator to transmit the Parameter values and Configuration data of the chopper into the Console memory. It is possible to load 64 different programmes.
The information saved in the Console memory can then be reloaded into another chopper using the RESTORE function.
The data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

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

Press OUT to return to the Opening Zapi Display



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

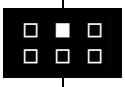
13.2 Description of console “RESTORE” function

The RESTORE PARAM function allows transfer of the Console’s stored data into the memory of the chopper. 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 chopper memory will be written over and replace with data being restored.
Flow Chart showing how to use the RESTORE function of the Digital Console.

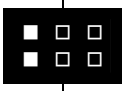
Opening Zapi Display

Press ENTER to go into the General menu



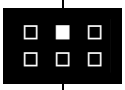
The Display will show :

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



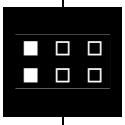
The Display will show :

Press ENTER to go into the RESTORE PARAM. function

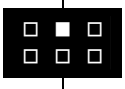


The Display shows the type of Model stored, with a Code Number

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



Press ENTER to commence the Restore operation

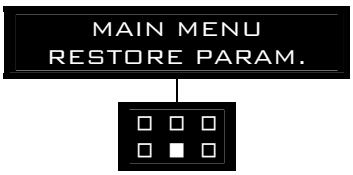


The Display will ask “ARE YOU SURE”.

Press ENTER for YES, or OUT for No

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

When finished, the Console shows :



Press OUT to return to the Opening Zapi Display

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

13.3 Description of console “PROGRAM VACC” function

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

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

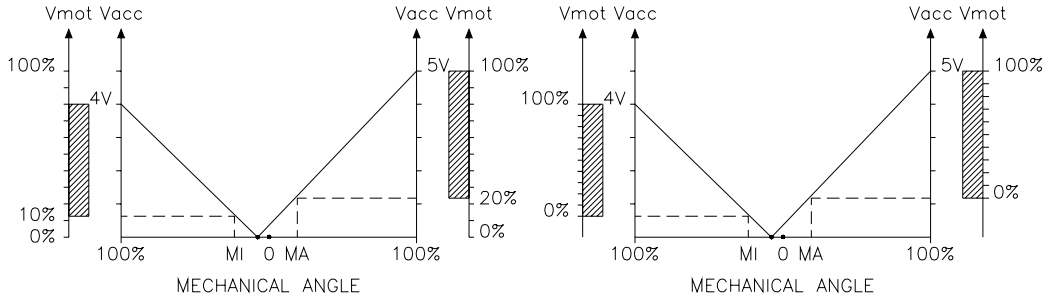


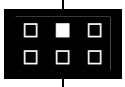
Figure 13–1

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

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

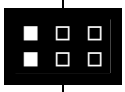
Opening Zapi Display

Press ENTER to go into the General menu



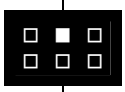
The Display will show :

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



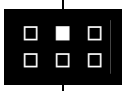
The Display will show :

Press ENTER to go into the PROGRAM VACC function



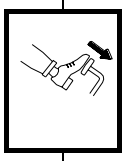
The Display will show the minimum and maximum values of potentiometer wiper output.
Both directions can be shown

Press ENTER to clear these values.
Display will show 0.0



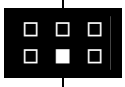
Select Forward Direction, close any interlock switches that may be in the system

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



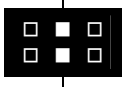
Select the Reverse Direction and repeat Item 10

When finished , press OUT



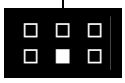
The Display will ask : ARE YOU SURE ?

Press ENTER for yes, or OUT for NO



When finished, the Console shows :

Press OUT to return to the Opening Zapi Display



13.4 Shortform table of the aux output #1 setting

The AUX OUTPUT #1 setting specifies the handling of the CNA#10 output and the STOP ON RAMP service (when the encoder is used). This handling is summarized in the table below.

AUX OUTPUT	STOP ON RAMP	A10 OUTPUT	BEHAVIOUR ON A SLOPE
BRAKE	ON	-Drives the coil of a electromagnetic brake.	"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	-Drives the coil of a electromagnetic brake.	"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	-Drives the coil of a hydraulic steering contactor.	"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	-Drives the coil of a hydraulic steering contactor.	The truck is not electrically hold on a slope, but comes down very slowly till the flat is reached.
EXCL. HYDRO	ON	-Drives the coil of a hydraulic steering contactor.	"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	-Drives the coil of a hydraulic steering contactor.	The truck is not electrically hold on a slope, but comes down very slowly till the flat is reached.

13.5 Description of the throttle regulation

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

1) THROTTLE 0 ZONE

2) THROTTLE X POINT

3) THROTTLE Y POINT

THROTTLE 0 ZONE: the speed of the truck remains at frequency creep meanwhile the voltage from the accelerator potentiometer is lower than this percentage of the MAX VACC setting. This adjustment define the width of a dead zone close to the rest position (see Figure 13–2 below).

THROTTLE X POINT & THROTTLE Y POINT: the speed of the truck grows up with a fixed slope (linear relationship) from the THROTTLE 0 ZONE up to THROTTLE X POINT. This slope is defined by the matching between the X point percentage of the MAX VACC setting with the Y point percentage of the full truck speed.
From the X point up to the MAX VACC point, the slope of the relationship between the truck speed and the accelerator position is different (see Figure 13–2 below) to match the full speed in the truck with the MAX VACC voltage in the accelerator position.

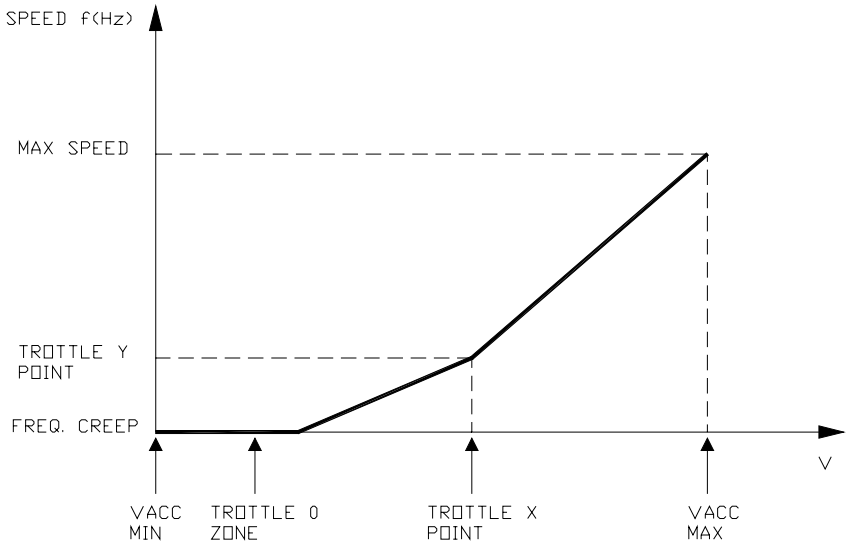


Figure 13–2

13.6 Description of the battery charge detection setting

The Battery Charge detection uses two setting that specify the Full Charge Voltage Level (100%) and the Discharge Voltage Level (10%). These two settings are the ADJUSTMENT#01 and the ADJUSTMENT#02 (see 12.4.2.12 and 12.4.2.14). It is possible to adapt the Battery Charge Detection to your specific battery, by changing the above two settings (e.g. if the Battery Discharged Detection occurs when the battery is not totally discarghed, it is necessary to reduce the ADJUSTMENT #02 setting as indicated in the Figure 13–3 below).

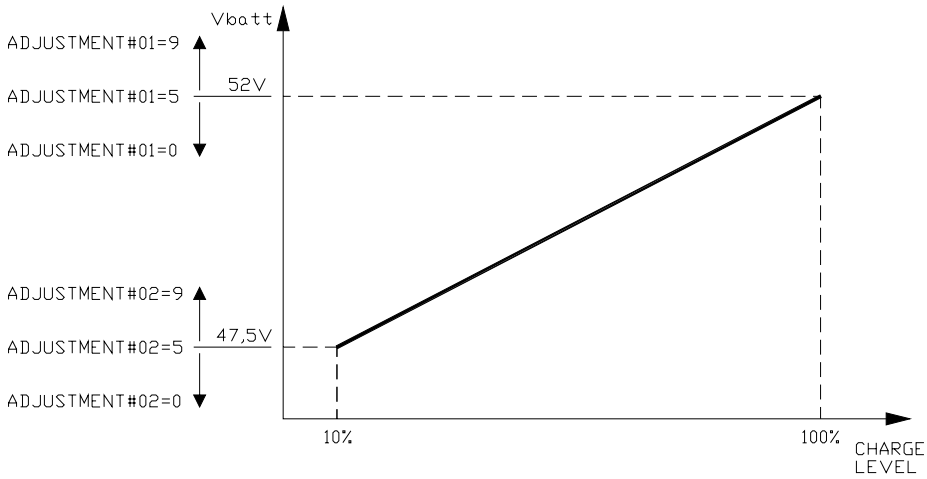


Figure 13–3

14 AC-X ALARMS LIST

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

1) The alarm code

2) The times that each alarm occurs consecutively

3) The Hour Meter value when the latest event of every alarm occured

4) And the inverter temperature when the latest event of every alarm occured.

This function permits a deeper diagnosis of problems as the recent history can be revisited.
The MDI-PRC code is the corresponding number with which the alarm is signalled on the MDI-PRC display.

14.1 Main menu "ALARMS" list

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

14.1.1 One Blink Alarms

1) WATCH DOG

MDI-PRC Code = 8

- Cause: It occurs when the embedded WATCH DOG protection is not able either to cut off the power stage when not triggered or it is not able to activate the power stage when triggered.
- Remedy: Verify the motor is connected and the continuity of the three motor phases. If the alarm occurs permanently, it is necessary to substituite the controller.

2) EEPROM KO

MDI-PRC Code = 13

- Cause: It occurs due to a HW or SW defect of the non-volatile embedded memory supporting the controller regulations.
- Remedy: Try to execute a CLEAR EEPROM operation. This consists of Entering the ALARMS item in the MAIN MENU'. Push at the same time the two right side buttons to enter the hidden ZAPI MENU'. Roll up and Down until the CLEAR EEPROM appears on the hand set display. Push Twice the Enter Button. Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to substituite the controller.

3) LOGIC FAILURE #1

MDI-PRC Code = 19

- Cause: It occurs when the battery voltage overtakes 45V (when the battery is 24V) or 47.5V (when the battery is 36V). It also occurs when the supply voltage inside the logic falls less than 11Vdc.

- Remedy: Normally the overvoltage occurs due to the regenerative braking energy increasing the battery voltage; the undervoltage of the logic supply, can be due to a depletion in the key voltage (e.g. when the pump inrush current makes the battery temporary collapsed).
  So first of all check for your failure mode then contact the Zapi technician to look for a countermeasure.
  As a matter of fact this alarm may occurs also for a HW failure and, in this case, it is necessary to substituite the Controller.

4) LOGIC FAILURE #2

MDI-PRC Code = 18

- Cause: It occurs when the circuit, to compensate for the dead times of the sine waves, is failed.
- Remedy: It is necessary to substituite the Controller.

5) LOGIC FAILURE #3

MDI-PRC Code = 17

- Cause: It occurs when the circuit to limitate via HW the current peak in the controller is active.
- Remedy: It is probably a power failure or a logic failure. If it occurs permanently it is necessary to substituite the Controller.

6) CHECK UP NEEDED

MDI-PRC Code = 99

- Cause: This is just a warning to call for the time programmed maintanance.
- Remedy: It is just enough to turn the CHECK UP DONE option to level ON (see 12.4.2.15) after the maintanance is executed.

14.1.2 Two Blinks Alarms

1) INCORRECT START

MDI-PRC Code = 79

- Cause: This is just a warning for an incorrect starting sequence.
- Remedy: The possble reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting):
  a) A travel demand active at key on
  b) The tiller switch active at key-on
  c) The H&S input active at key-on
  d) The Quick inversion active at key-on
  A failure in the logic is possible too. When all of the above conditions were checked and nothing was found, substituite the controller.

2) FORW+BACK

MDI-PRC Code = 80

- Cause: This alarm occurs when both the travel demands (Fwd and Bwd) are active at the same time.
- Remedy: Check the wiring of the Fwd and Bwd travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting).
  A failure in the logic is possible too. When you have verified the travel demand switches are fine working and the wiring is right, it is necessary to substituite the controller.

3) LIFT+LOWER

MDI-PRC Code = 90

- Cause: This alarm occurs when both a Lifting request and a Lowering request are active at the same time.
- Remedy: If the MDI-PRC is absent, check only the wiring of the main Lifting/Lowering pair (CND#11 and CND#10); if the MDI-PRC is present check also the wiring of the Aux Lifting/Lowering pair (CND#9 and CND#12). (Use the readings in the TESTER to facilitate the troubleshooting).
  A failure in the logic is possible too. When you have verified the Lifting/Lowering switches are fine working and the wiring is right, it is necessary to substituite the controller.

4) CURRENT GAIN

MDI-PRC Code = 94

- Cause: This alarm occurs the first time the controller is switched on when the not volatile memory (EEPROM) with the set-up parameters is not initialized yet. Then it is necessary to acquire the gains of the current sensing circuit.
- Remedy: The current sensing set-up must be factory adjusted and so this alarm never should happen when the controller is on the field. So ask for the assistance of a Zapi technicians when this alarm occurs.

5) MOS SHORTED

MDI-PRC Code = 89

- Cause: This alarm can detect a short circuit on power mosfet at startup. Before to switch on the main contactor, the sw turns on sequencely the Bottom and the Top side power mosfets, to check the phase voltage.
  Normally without driven mosfet the phase voltage is to Vbatt/2. If the software checks that it remains fixed to +Vbatt or to GND it means that there are mosfet shorted, and this alarm occurs.
- Remedy: Two possible reason:
  - An external shortcircuit exist between +BATT and phase voltage. Check harness and motor.
  - A power or logic failure occurred on the controller.

6) LIFT LOW ACTIVE

MDI-PRC Code = 91

- Cause: This is just a warning when a Lifting/Lowering request is active at key-on.
- Remedy: The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting):
  - When MDI_PRC is absent: at least one between LIFTING SWITCH (CND#10) or DESCENT SWITCH (CND#11) active at key on.
  - When TRUCK TYPE is Level=1: at least one between LIFTING SWITCH (CND#10), DESCENT SWITCH (CND#11), DIGITAL INPUT#1 (CND#9) or DIGITAL INPUT#2 (CND#12) active at key-on.
  - When TRUCK TYPE is Level=2: at least one between LIFTING SWITCH (CND#10) or DESCENT SWITCH (CND#11) active at key-on.
  - When TRUCK TYPE is Level=3: at least one between LIFTING SWITCH (CND#10) or DESCENT SWITCH (CND#11)

active at key-on.
A failure in the logic is possible too. When all of the above conditions were checked and nothing was found, substituite the controller.

14.1.3 Three Blinks Alarms

1) CAPACITOR CHARGE

MDI-PRC Code = 60

- Cause: In working condition, a resistance connected between the key and the Rail Capacitors, keeps the Rail Capacitors charged before the Main Contactor closes.When the voltage on the Rail Capacitors (measured on the phase V) is low and does not increase when the main contactor is opened this alarm occurs.
- Remedy: Three possibilities:
  - Another device, connected in parallel with the Rail Capacitors, has a failure
  - At least a motor phase is not connected to the controller or broken.
  - A Power failure or a Logic Failure occured in the controller. In this case it is necessary to substituite the controller.

2) WRONG ACQUISITION

MDI-PRC Code =31

- Cause: (Sensorless configuration only). It occurs when the automatic acquisition of the Motor Resistance fails. See 11.
- Remedy: Check the Motor connections, the Motor Phases continuity and the Power Battery Positive arrives to +B of the ACx

3) VMN HIGH

MDI-PRC Code = 31

- Cause: Before to switch the main contactor on, the SW turns on sequencely the Bottom side Power Mosfets and expects the phase V voltage falls to GND value. If the phase V remains high level this alarm occurs.
- Remedy: Two possibilities:
  - At least a motor phase is not connected to the controller or broken.
  - A Power Failure (e.g. a Bottom side Power Mosfet opened) or a Logic Failure occured in the controller. In this case it is necessary to substituite the controller

4) VMN LOW

MDI-PRC Code = 30

- Cause: Before to switch the main contactor on, the SW turns on sequencely the Top side Power Mosfets and expects the phase V voltage increases toward the rail capacitor value. If the phase V does not increases this alarm occurs.
  This alarm may occur also when the initial diagnosis is overcome, and so the Main Contactor is expected to be closed.Then, when the operator asks the truck moving but the +Batt terminal of the controller is lower voltage than the Battery voltage, this alarm occurs (Main Contactor has lost the contactation although it is closed).

- Remedy: If the problem occurs before the Main Contactor closes, probably a Power failure (e.g. a Bottom side Power Mosfet short circuited or a Top side Power Mosfet broken) or a Logic Failure occured in the controller. If the problem occurs when the operator turns the truck moving the problem is the Battery positive is not connected to the +Batt terminal of the controller (check the continuity of the main contactor).
  If the problem occurs permanently it is necessary to substituite the controller.

14.1.4 Four Blinks Alarms

1) VACC NOT OK

MDI-PRC Code = 78

- Cause: The test is made at key-on and after 20sec that both the travel demands have turned disactive. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is higher than 1.0V (it means the wiper of the potentiometer is higher than 2Vdc) when the accelerator is released.
- Remedy: Check the mechanical calibration and the functionality of the potentiometer.

2) PEDAL WIRE KO

MDI-PRC Code = 86

- Cause: The SW continuously checks for the connection of the two supply ends of the potentiometer in the accelerator. The test consists of reading the voltage drop on a sense diode, connected between NPOT (CNA#12) and GND and cascaded with the potentiometer: if the potentiometer gets disconnected on PPOT or NPOT, no current flow in this sense diode and the voltage on the NPOT connection collapses down.
  When the NPOT voltage is less than 0.3V this alarm occurs. This alarm occurs also when the NPOT voltage is higher than 2Vdc (to detect also the condition of a broken sense diode).
- Remedy: Check the voltage on NPOT (CNA#12) and the potentiometer connections.

3) INPUT ERROR #1

MDI-PRC Code = 91

- Cause: This alarm occurs when the PLD device has a failure. The PLD device is used for both, the Passive Emergency Cell (see 5.1) and a Multiplexer on the Main Lifting/Lowering requests. This Multiplexer exits the Lifting and the Not Lifting level on two distinct addresses. When the Lifting and the Not Lifting outputs have the same Logic Level the PLD device has failed and this alarm occurs.
- Remedy: It is necessary to substituite the controller.

4) WRONG ZERO

MDI-PRC Code = 92

- Cause: (Sensorless configuration only). This diagnosis is executed every time the controller turns from resting to move. Then, before to turn the truck moving, the outputs of the amplifiers (used to measure the Motor Currents and Voltages) are checked to be near null. This alarm occurs when the Current

signals at rest are not in the range 2.15 to 2.85V or when the Voltage signals at rest are not in the range 2 to 3V.

- Remedy: Probably the controller is failed or a the SW is corrupted

5) MISMATCHED RM

MDI-PRC Code = 70

- - Cause: (Sensorless configuration only). Each time the travel demands are at rest longer than 5sec, the SW compares the Actual Motor Resistance with the Value was acquired at the installation (see 11.1 Step6) by iniecting a DC current in the motor. If the Actual Value and the Acquired Value are different more than 20% this alarm occurs.
- - Remedy: Check the Motor connections are tightened, the thermal sensor in the motor is right working, the Motor Phases continuity.
  It is mandatory to do a new Motor Resistance acquisition after the cause of the problem was fixed.

6) OVERLOAD

MDI-PRC Code = 97

- Cause: This is just a warning occuring when the circuit to limit the current via HW (under a limiting value is about 20% higher than the nominal Current Limitation), operates several times in a short interval. The OVERLOAD condition de-energizes the Electromechanical Brake. The controller exits by itself from this condition when the circuit to limit the Current via Hardware stops to operate.
- Remedy: Normally this is a temporary warning due to a sudden application of too much load or gradient in the truck.

7) EVP NOT OK

MDI-PRC Code = 88

- Cause: The voltage of the CND#7 that provide positive for proportional valves is checked by the software.
  If this voltage is not correct this alarm is signalled.
- Remedy: Two possible reason:
  - Check if there is the positive on CND#7 and if something in the harness is not correct.
  - The problem could be on the power Mosfet or on the logic board of the AC-X.

8) PROGRAM LIFT LEVER

MDI-PRC Code = 55

- Cause: The SW continuously matches the potentiometer connected to CND#15 with the Main Lifting/Lowering pair request (CND#10 and CND#11).
  When the TRUCK TYPE is set 2, the alarms occurs in the following conditions:
  - If both the Main Lifting and Main Lowering request are disactive and the potentiometer voltage is higher than 60mV over either the MIN LIFT or the MIN LOWER (see 12.4.2.1 and 12.4.2.3) setting.
  - If the Main Lifting request is active and the potentiometer voltage is higher than 200mV over the MAX LIFT setting (see 12.4.2.2).

- If the Main Lowering request is active and the potentiometer voltage is higher than 200mV over the MAX LOWER setting (see 12.4.2.4).
- If the MIN LIFT setting is higher than the MAX LIFT setting.
- If the MIN LOWER setting is higher than the MAX LOWER setting.

  When the TRUCK TYPE is set 3, the alarms occurs in the following conditions:
- If the Main Lowering request is disactive and the potentiometer voltage is higher than the MIN LOWER (see 12.4.2.3) setting.
- If the MIN LOWER setting is higher than the MAX LOWER setting.

- Remedy: Check the Main Lifting/Lowering pair (CND#11 and CND#10) and the voltage on the potentiometer connected to CND#15. (Use the readings LIFTING SWITCH, DESCENT SWITCH and LIFTING CONTROL in the TESTER to facilitate the troubleshooting).

14.1.5 Five Blinks Alarms

1) ENCODER ERROR

MDI-PRC Code = 70

- Cause: (Encoder version only). Two consecutive readings of the encoder speed are too much different in between: because of the inertiality of the system it is not possible the encoder changes its speed a lot in a short period. Probably an encoder failure has occured (e.g. one or two channels of the encoder are corrupted or disconnected).
- Remedy: Check both the electric and the mechanical encoder functionality. Frequently we experienced one of the two Sensor bearing's ring, slips inside its seat raising this alarm condition. Also the electromagnetic noise on the sensor bearing can be a cause for the alarm.

2) STBY I HIGH

MDI-PRC Code = 53

- Cause: This diagnosis is executed only when the main contactor is opened and asked to be closed (e.g. at key on or when the main contactor is opened and a new motion request turns active). Then the outputs of the Current amplifiers must be in a narrow window close to 2.5Vdc (from 2.26V to 2.74V). Otherwise this STBY I HIGH alarm occurs.
- Remedy: If the alarm occurs permanently, it is necessary to substituite the controller.

14.1.6 Six Blinks Alarms

1) COIL SHORTED

MDI-PRC Code = 76

- Cause: This alarm occurs when there is an overload on one of the following connections: CNA#14, CNA#10, CND#2 and CND#3. Typically the problem is due to a short circuit of one of the coils conneted to these outputs. After the overload has removed, the

alarm exits automatically by releasing and then enabling a travel demand.

- Remedy: Check the coils of the main contactor (CNA#14), of the electromechanical brake (CNA#10), of the pump contactor (CND#2), of the Aux valve (CND#3).

2) CONTACTOR OPEN

MDI-PRC Code = 38

- Cause: The main contactor coil has been driven by the logic board, but the contactor doesn't close.
- Remedy: Check the coils wires of the Main Contactor. They could be interrupted. The contact of the contactor does not work properly (doesn't pull in).

3) CONTACTOR CLOSED

MDI-PRC Code = 37

- Cause: Before driving the LC coil, the controller checks if the LC contact is stuck. The controller drives the bridge for a while, trying to discharge the capacitor bank. If they don't discharge, the fault condition is entered.
- Remedy: Check if contact is really stuck.

4) AUX OUTPUT KO

MDI-PRC Code = 16

- Cause: This alarm occurs when the feedforward PWM generated by the controller to supply the Electromechanical Brake and the actual feedback voltage on the Electromechanical Brake are not matched in between. The diagnosis is made only when the Tiller Switch is active.
  Then:
  a) When the feedforward PWM is less than 10% of the battery voltage, the Actual voltage on the Electromechanical Brake is expected low. If it is higher than 14V it means the Electromechanical Brake never Brakes the truck (probably the Driver of the Elecromechanical Brake is short circuited) and this alarm occurs.
  b) When the feedforward PWM is higher than 70% of the battery voltage, the Actual voltage on the Electromechanical Brake is expected high. If it is lower than 14V it means the Electromechanical Brake always gets the truck Braked (probably the Driver of the Elecromechanical Brake is opened) and this alarm occurs.
- Remedy: Probably it is necessary to substituite the controller because the driver of the Electromechanical Brake has a failure.

5) MDI VALVE2 SHORT

MDI-PRC Code = 70

- Cause: This alarm occurs on the MDI-PRC and the information is transferred via CAN Bus to the AC-X.
- Remedy: See 14.2 and the manual of the MDI-PRC.

6) MDI NEVP1 NOT OK

MDI-PRC Code = 90

- Cause: This alarm occurs on the MDI-PRC and the information is transferred via CAN Bus to the AC-X.
- Remedy: See 14.2 and the manual of the MDI-PRC.

7) MDI PEV NOT OK

MDI-PRC Code = 89

- Cause: This alarm occurs on the MDI-PRC and the information is transferred via CAN Bus to the AC-X.
- Remedy: See 14.2 and the manual of the MDI-PRC.

8) MDI DRV 2 OPEN

MDI-PRC Code = 75

- Cause: This alarm occurs on the MDI-PRC and the information is transferred via CAN Bus to the AC-X.
- Remedy: See 14.2 and the manual of the MDI-PRC.

9) MDI DRV 2 SHORT

MDI-PRC Code = 74

- Cause: This alarm occurs on the MDI-PRC and the information is transferred via CAN Bus to the AC-X.
- Remedy: See 14.2 and the manual of the MDI-PRC.

10) ERROR IV

MDI-PRC Code = 93

- Cause: This alarm occurs when the current in the phase V has not a null medium voltage when the frequency is higher than 20Hz: a sine wave must always has a null medium voltage.
- Remedy: If the problem occurs permanently it is necessary to substituite the controller.

11) ERROR IW

MDI-PRC Code = 93

- Cause: This alarm occurs when the current in the phase W has not a null medium voltage when the frequency is higher than 20Hz: a sine wave must always has a null medium voltage.
- Remedy: If the problem occurs permanently it is necessary to substituite the controller.

12) ERROR LUV

MDI-PRC Code = 93

- Cause: This alarm occurs when the circuit to process, with low resolution, the linked voltage Between phase U and V, has not a null medium voltage when the frequency is higher than 20Hz: a sine wave must always has a null medium voltage.
- Remedy: If the problem occurs permanently it is necessary to substituite the controller.

13) ERROR LVW

MDI-PRC Code = 93

- Cause: This alarm occurs when the circuit to process, with low resolution, the linked voltage Between phase V and W, has not a null medium voltage when the frequency is higher than 20Hz: a sine wave must always has a null medium voltage.
- Remedy: If the problem occurs permanently it is necessary to substituite the controller.

14) ERROR HUV

MDI-PRC Code = 93

- Cause: This alarm occurs when the circuit to process, with high resolution, the linked voltage Between phase U and V, has not a null medium voltage when the frequency is higher than 20Hz: a sine wave must always has a null medium voltage.
- Remedy: If the problem occurs permanently it is necessary to substituite the controller.

15) ERROR HVW

MDI-PRC Code = 93

- Cause: This alarm occurs when the circuit to process, with high resolution with high resolution, the linked voltage Between phase V and W, has not a null medium voltage when the frequency is higher than 20Hz: a sine wave must always has a null medium voltage.
- Remedy: If the problem occurs permanently it is necessary to substituite the controller.

16) ANALOG INPUT

MDI-PRC Code = 96

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

14.1.7 Seven Blinks Alarms

1) HIGH TEMPERATURE

MDI-PRC Code = 61

- Cause: This alarm occurs when the temperature of the base plate is higher than 78°. Then the maximum current decreases proportionally with the temperature increases from 78° up to 103°. In the encoder version, the current is limited to 0 Amps when the temperature is higher than 103°. In the sensorless version the current is cut to 0 Amps when the temperature is higher than 94°.
- Remedy: Improve the air cooling of the controller.

2) MOTOR TEMPERAT

MDI-PRC Code = 65

- Cause: In the encoder version, this is just a warning with no effect on the truck performance. It occurs when the temperature of the motor winding overtakes the MOTOR OVERTEMP setting.
  In the sensorless version this alarm occurs when the MOTOR TEMPERATURE overtakes 150°.
- Remedy: Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the TESTER menu). If the sensor is OK, improve the air cooling of the motor.

3) **THERMIC SENS KO**

MDI-PRC Code = 73

- Cause: When the output of the thermal sensor on the base plate is higher than 4.95V or lower than 2.23V , the sensor is assumed failed and this alarm occurs.
- Remedy: It is necessary to substituite the controller.

14.1.8 Eigth Blinks Alarms

1) **CAN BUS KO**

MDI-PRC Code = 67

- Cause: It occurs if the controller does not receive any message from the CAN Bus line.
- Remedy: First of all, check the wiring. If it is OK , try to disconnect one to one the module connected to the CAN Bus and check if this alarm disappears. When you are quite sure the problem is in the present module, it is necessary to substituite the controller.

14.1.9 No Blink Alarms

1) **STOP TOP**

MDI-PRC Code = Null

- Cause: This is just a warning to inform the Passive Emergency Cell (see 5.1) operates. The Passive Emergency Cell operates when the controller takes longer than 800msec, after the tiller was released, to reduce the frequency in the motor, close to zero. The Passive Emergency Cell siwtches off the Top Side Power Mosfets (this is the reason for the name) of the three phase bridge.
- Remedy: The controller exits automatically this warning when the operator turns the truck moving.

2) **DATA ACQUISITION**

MDI-PRC Code = Null

- Cause: This is just a warning of the Sensorless configuration when the check between the actual motor resistance end the autoacquired value is in progress. This check is performed 5 Sec. after the travel demands are released.
- Remedy: No remedy required.

14.1.10 Thirty Two Blinks Alarms

1) **BATTERY LOW**

MDI-PRC Code = Local

- Cause: It occurs when the battery charge is calculated being less than 10% of the full charge and the BATTERY CHECK setting is other than 0.
- Remedy: Get the battery charged.

14.2 MDI-PRC “ALARMS” List

When the Controller communicates with the MDI-PRC, the alarm condition is represented on the MDI-PRC in a Numeric form is:
Source Device Code and Alarm Code.
The Source Device Code we are interesting in are:

16: This is a local MDI-PRC alarm

02: This is a Traction Controller (AC-X) alarm

The Alarm Code List Sourced by the Controller (Source Device Code 02) is the following:

1: WRONG CONFIG
8: WATCH DOG
13: EEPROM KO
16: AUX OUTPUT KO
17: LOGIC FAILURE #3
18: LOGIC FAILURE #2
19: LOGIC FAILURE #1
30: VMN LOW
31: VMN HIGH
37: CONTACTOR CLOSED
38: CONTACTOR OPEN
53: STBY I HIGH
55: PROGRAM LIFT LEVER
60: CAPACITOR CHARGE
61: HIGH TEMPERATURE
65: MOTOR TEMPERAT
67: CAN BUS KO
70: ENCODER ERROR OR MISMATCHED RM
71: HANDBRAKE
73: THERMIC SENS KO
76: COIL SHORTED
78: VACC NOT OK
79: INCORRECT START
80: FORW+BACK
86: PEDAL WIRE KO
88: EVP NOT OK
89: MOS SHORTED
90: LIFT+LOWER
91: LIFT LOW ACTIVE or INPUT ERROR #1
92: WRONG ZERO

93: ERROR (IV, IW, LUV, LVW, HUV, HVW)

94: CURRENT GAIN

95: WRONG ACQUISITION

96: ANALOG INPUT

97: OVERLOAD

99: CHECK UP NEEDED

The Alarm Code List Sourced by the MDI-PRC (Source Device Code 16) is the following:

67:	CAN BUS KO	The Can Bus communication is broken
70:	MDI COIL SHORT	At least one of the On/Off Valves Coil is shorted
74:	MDI DRIVER SHORT	At least one On/Off driver on pin#4 and #6 is shorted
75:	MDI VALVE DRIVER	At least one On/Off driver on pin#4 and #6 is opened
89:	MDI PEV NOT OK	The Positive Supply for the Valves is missing
90:	MDI NEVP NOT OK	At least one Proportional Valve driver on pin#8 and #9 is shorted

Example: 02A79 is an INCORRECT START alarm on the AC-X.

15 RECOMMENDED SPARE PARTS

Part number	Description
C29508	SW 180 24V Single Pole Contactor

16 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 wear and condition of the electromechanical brake. According with the ISO 6292 the electromechanical brake must be able to lock the truck in the worst case in terms of admitted gradient and load. The truck manufacturer has to take care the ISO 6292 is fullfilled with a suited maintenance scheduling.

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 chopper, 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