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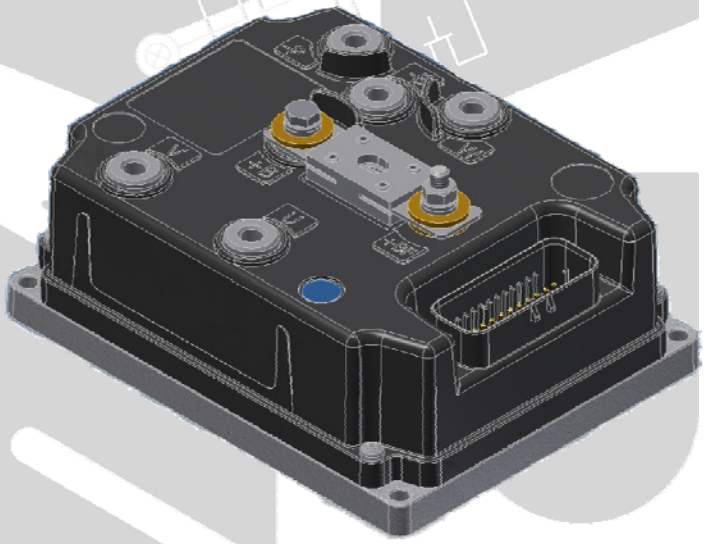
EN

User Manual

COMBIACX & ACEX 2uC



Publication N°: **AFCZP0CA**
Edition: **March 30th, 2016**

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APPROVAL SIGNS

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

1 INTRODUCTION

1.1 About this document

1.1.1 Scope of this Manual

This manual provides important information about ACEX / COMBIACX controller
It presents instructions, guidelines, diagrams related to installation and maintenance of the controller in an electrically powered vehicle.

1.1.2 Manual revision

This revision replaces all previous revisions of this document. Zapi has made every effort to ensure that this document is complete and accurate at the time of printing.
In accordance with our policy of continuous product improvement, all data in this document is subject to change or correction without prior notice.

1.1.3 Warnings and notes

Special attention must be paid to the information presented in warning and information notices when they appear in this manual. Definitions of warning and information notices are shown below:

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

These Warning boxes are used inside this publication to indicate:
- operations that can lead to a failure of the electronic device or can be dangerous or harmful for the operator;
- items which are important to guarantee system performance and safety.
Pay special attention to the annotations pointed out with this symbol.

1.2 About the Controller

1.2.1 Safety

Zapi provides this and other manuals to assist manufacturers in using the motor controller in a proper, efficient and safe manner. Manufacturers must ensure that all persons responsible for the design and use of equipment employing the motor controller have the proper professional skills and apparatus knowledge.

Before doing any operation, ensure that the battery is disconnected and, when all the installation is completed, start the machine with the drive wheels raised from the floor to ensure that any installation error do not compromise safety.
After operation, even with the Key Switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend to

disconnect the battery and to connect a resistor (between 10ohm and 100ohm) Battery Positive and Battery Negative power terminals for at least 10 seconds.

1.2.2 OEM's Responsibility

The Zapi motor controller products are intended for controlling motors in electric vehicles. These controllers are supplied to original equipment manufacturers (OEMs) for incorporation into their vehicles and vehicle control systems.
Electric vehicles are subject to national and international standards of construction and operation which must be observed. It is the responsibility of the vehicle manufacturer to identify the correct standards and ensure that their vehicle meets these standards. As a major electrical control component the role of the Zapi motor controller should be carefully considered and relevant safety precautions taken. It has several features which can be configured to help the system integrator to meet vehicle safety standards.
Zapi accepts no responsibility for incorrect application of their products.

1.2.3 Technical Support

For additional information on any topic covered in this document, or for additional information or application assistance on other Zapi vehicle systems products, contact Zapi Sales Deparment.

2 CONTROLLER SPECIFICATION

2.1 General Features

Within the ZAPIMOS family, the COMBIACX / ACEX inverter (E stands for evolution) is a controller designed to control AC induction, BLDC and PMSM motors, in the range from 600W to 2.5 kW continuous power, used in a variety of battery powered material handling trucks.
Typical applications include, but are not limited to: walkie truck and rider pallet truck, stackers, low level order pickers, small counterbalanced truck, Aerial access equipment.

Features include:

- 16 bits microcontroller for motor control and main functions, 576+ Kbytes embedded Flash memory
- 16 bits microcontroller for safety functions, 320+ Kbytes embedded Flash memory
- Controller for 600W to 2.5 kW AC motors
- Pump controller for series wounded DC motors (only for COMBIACX)
- Field-oriented motor control algorithm
- Smooth low speed control, including zero speed
- Zapi patented sensorless and sense coil control
- Driver for Line Contactor coil
- Low side and high side (short circuit protected) drivers for Electromechanical brake coil
- Drivers for PWM voltage controlled electrovalves and for two proportional valves (PWM current controlled)
- Short circuit and open load protection
- Thermal cutback, warning, and automatic shutdown provide protection to motor and controller
- ESD protected CANbus interface
- Software downloadable via Serial link (internal connectors) or CANbus (external connector)
- Diagnostic provided via CANbus using Zapi Can Pc Tool
- Rugged sealed housing and connectors meet IP65 environmental sealing standards for use in harsh environments

2.2 Technical Feauters

Motor type: ..... Induction AC, Synchronous AC, Brushless DC
Control mode:..... Speed or Torque control
Operating frequency:..... 8 kHz
Chopper Operating frequency (1): ..... 16 kHz
Ambient Operating temperature range:..... -40 °C ÷ 40 °C
Ambient Storage temperature range:..... -40 °C ÷ 85 °C
Maximum inverter temperature (at full power): .....85 °C
Connector:..... Ampseal 35 pins
Package Environmental Rating:..... IP65

Note(1): The DC chopper specifications are related to COMBIACX only.

2.3 Current Ratings

Model	Nominal DC Battery Voltage	Rated Current 2 min [Arms]	Continuous Rated Current [Arms]	DC Maximum Current [Adc]
ACEX	24V	165	80	-
	36/48V	140	70	
COMBIACX	24V	165	80	270
	36/48V	140	70	240
ACEX PW	24V	240	120	
	36/48V	210	100	-
COMBIACX PW	24V	240	120	270
	36/48V	210	100	240

Different combinations DC chopper-3 Phases inverter than reported in the previous table are available.

Internal algorithms automatically reduce maximum current limit when heatsink temperature is >85°C. Heatsink temperature is measured internally near the power MOSFETs (see paragraph 6.6).

2-minute ratings are based on an initial controller heatsink temperature of 25°C and a maximum heatsink temperature of 85°C. No additional external heatsink is used for the 2-minute rating test.

2.1 DC Supply Voltage Ratings

	24V	36/48V
Conventional working voltage range	19,2V ÷ 28,8V	28,8V ÷ 57,6V
Non-operational Overvoltage limits	35V	65V
Non-operational Undervoltage limits	10V	10V

Conventionally the controller may be set to operate without alarm in the range 80% to 120% of the nominal battery voltage. With a different DC voltage supply than specified the controller will raise an alarm condition at start-up.

The Undervoltage and Overvoltage thresholds are defined by Hardware. After start-up the controller is fully operative until the voltage supply exceed that limits.

The Undervoltage is measured on +Key line (A10) and the Overvoltage is measured on the Power Capacitor (+B)

3 I/O INTERFACE DESCRIPTION

3.1 Motor and Battery Connections

Terminal Name	Description
+B	Positive supply to the power stage
-B	Battery negative termination
U, V, W	Motor U, V, W –phase termination
-P	Series DC motor negative termination (COMBIACX only)

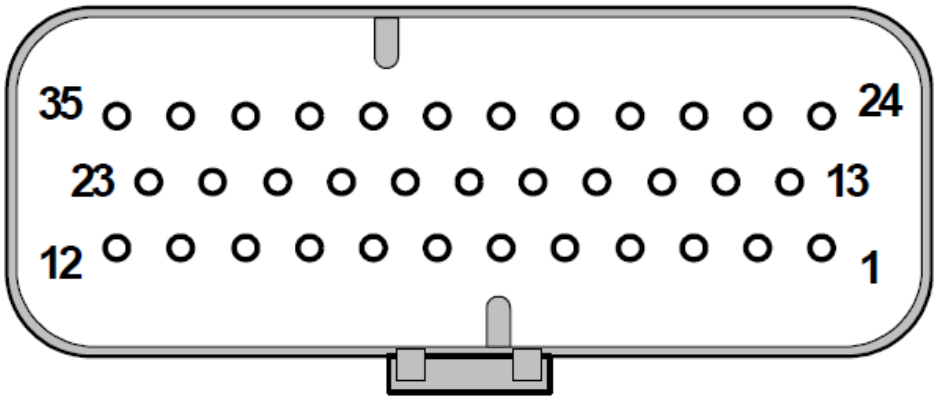
3.2 Connectors

3.2.1 External connector (Ampseal 35 poles)

The I/O Connector is referred as “CNA” later in the next.

For each I/O pin is indicated the default function using Zapi std software. The function of each pin can be changed in the customized software.

Some I/O pins can have special functionality depending by controller configuration .



Pin	Type	Name	Description
A1	Input	DI0	Input of the switch DI0. The input is activated when it is connected to +Batt. With the logic hardware properly configured it can be used to supply the EB and MC positive. The default function is the controller “TILLER” input.

Pin	Type	Name	Description
A2	Output	PEB	Positive of the electromechanical brake coil. For 24V version only it passes through an High Side Driver.
A3	Input	PEV	Positive supply for electrovalves: EV1, EV2, EV3, EV4, EV5, EVP1, EVP2, HORN and with the logic hardware properly configured it can be used to supply the EB. This input has to be supplied with positive taken after main contactor.
A4	Output	NEB	Electro mechanic brake coil driver output; PWM controlled; 2A maximum continuous current (driving to –Batt).
A5	Output	NENC	Negative supply for external device (Encoder, Potentiometers, ecc)
A6	Input	DI2	Input of the switch DI2. The input is activated when the external switch is opened. The default function is the controller "CUTBACK" input, opening the switch truck speed is reduced.
A7	Input	DI1	Input of the switch DI6. The input is activated when it is connected to +Batt. The default function is the controller "BELLY" input, closing the switch quick inversion function is activated. Active high.
A8	Output	PPOT	Positive supply for external device (+12 / +5V 150mA maximum)
A9	Output	EV 1	Output of the ON/OFF electrovalve EV1; 1A maximum continuous current (driving to –Batt).
A10	Input	KEY	Input of the key switch signal.
A11	Output	EV 2	Output of the PWM voltage controlled electrovalve EV2; 1A maximum continuous current (driving to –Batt).
A12	Output	NMC	Main contactor coil driver output; PWM voltage controlled; 1A maximum continuous current (driving to –Batt).
A13	Input	ENC B	Traction motor encoder phase B.
A14	Input	ENC A	Traction motor encoder phase A.
A15	Input	CPOT1	Analog input 1. The default function is the accelerator potentiometer wiper.
A16	Input	DI10	Inching (Backing) function, backward direction input. It must be connected to the inching backward switch.
A17	Input	DI8	Inching (Backing) function, forward direction input. It must be connected to the inching forward switch.
A18	Input	DI11 / CPOT3	Input of the switch DI11. The input is activated when the external switch is closed to -Batt. In the Sense Coil version this input is connected to the AC motor sense coil. It can be properly configured via HW as additional analog input.

Pin	Type	Name	Description
A19	Input	DI5	Input of the switch DI5. The input is activated when it is connected to +Batt. The default function is the controller “HORN” input, closing the switch the horn output is activated.
A20	Input	DI6	Input of the switch DI1. The input is activated when it is connected to +Batt. The default function is the controller “DESCENT” enable input.
A21	Input	DI12 / CPOT4	Input of the switch DI12. The input is activated when the external switch is closed to -Batt. It doesn’t have a default function. In the Sense Coil version this input is connected to the AC motor sense coil. It can be properly configured via HW as additional analog input.
A22	Input	PTH	Traction motor thermal sensor input. The internal pullup is a fixed 2mA (Max 5V) source current.
A23	Output	NAUX2	Auxiliary output. Internal 330R resistance in series to the driver (driving to –Batt). Max continuous current: 35mA. Typical function: to drive a led. (driving to –Batt).
A24	Output	EVP 1	Negative of the lower proportional PWM current controlled electrovalve driver (driving to –Batt).
A25	Output	PENC	Positive supply for external device (Encoder, potentiometers, ecc) (+12 /+5 V 150mA maximum)
A26	Output	HORN	Negative of the protected horn electrovalve driver (driving to –Batt).
A27	Output	CAN L	Low level CAN-BUS voltage I/O
A28	Output	CAN H	High level CAN-BUS voltage I/O.
A29	Input	DI9	Input of the switch DI9. The input is activated when the external switch is opened. The default function is the controller “CUTBACK2” input, opening the switch truck speed is reduced. If "H&S FUNCTION" option is PRESENT, input is activate when it is connected to +Batt and function is the controller "H&S" (Hard and Soft) request input, closing this input truck performances are modified.
A30	Input	CPOT2	Lift/Lower potentiometer wiper input. With the logic hardware properly configured it can be used as potentiometer negative reference. Using this input as NPOT the diagnosis “PEDAL WIRE KO” is implemented.
A31	Input	DI4	Input of the switch DI4. The input is activated when it is connected to +Batt. The default function is the controller “REV” request input, closing this input truck moves in backward direction.
A32	Input	DI3	Input of the switch DI3. The input is activated when it is connected to +Batt. The default function is the controller “FORWARD” request input, closing this input truck moves in forward direction.

Pin	Type	Name	Description
A33	Output	EV 3	Output of the PWM voltage controlled electrovalve EV3; 1A maximum continuous current (driving to –Batt).
A34	Output	NAUX1	Auxiliary output. Internal 330R resistance in series to the driver (driving to –Batt). Max continuous current: 35mA. Typical function: to drive a led. (driving to –Batt).
A35	Input	DI7	Input of the switch DI7. The input is activated when it is connected to +Batt. The default function is the controller "LIFT" enable input.

3.2.2 Internal connector (CNE)

Pin	Type	Name	Description
1	Output	PCLRXD	Positive serial reception (Not used: it can be disconnected).
2	Input	NCLRXD	Negative serial reception.
3	Output	PCLTXD	Positive serial transmission.
4	Output	NCLTXD	Negative serial transmission.
5	Output	GND	Negative console power supply.
6	Output	+12	Positive console power supply.
7	Input	FLASH	It must be connected to pin 8 for the Flash memory programming.
8	Input	FLASH	It must be connected to pin 7 for the Flash memory programming.

3.3 Key Input

3.3.1 Function

The KEY_INPUT supplies battery voltage to the motor controller for its internal processor and other functions. The vehicle start Key Switch generally controls power to the KEY_INPUT and charging of the filter capacitor. The KEY_INPUT voltage is monitored.

Note: For ACEX / COMBIACX, external loads connected to +B such as proximity switches will load the internal PTC resistor connected to KEY_INPUT and the pre-charge voltage will be lower than expected.

3.3.2 Protection

The KEY_INPUT is protected against reverse polarity with a diode and has approximately 22nF capacitance to B- for ESD protection and other filtering. This capacitance may give a high current spike at KEY_INPUT depending on the external circuit.

The Fuse Fu1 shown in the functional drawings (paragraph 5.2), should be sized according to the number of motor controllers connected to the fuse and to protect the cable area in the circuit (recommended fuse size max 10 A) and the current consumption of the KEY_INPUT (power input < 15 W).

The Key Switch connected to the KEY_INPUT must handle the short inrush current spike to the ESD protection capacitors. The current peak is depending on the external circuit and wire.

Cable length from the battery to the KEY_INPUT shall be as short as possible

3.4 Digital Inputs

3.4.1 Function

The digital inputs work in the voltage range [-Batt; +Batt]. Related command devices (microswitches) must be connected to +B (typically to key voltage) or to –B depending by input configuration (refer to pin description in the paragraph 3.2.1).
Pull-down or pull-up resistance are built-in.
Functional devices (like FW, BACK, PB, ecc.) are Normally Open; so related function becomes active when the microswitch closes.
Safety devices (like CUTBACK switches) are Normally Closed; so related function becomes active when the microswitches opens.

The threshold levels are:

Controller type	**24V**	**36/48V**
Logic Low Threshold	1,8V	6V
Logic High Threshold	4,5V	13,5V
Voltage Range	0V to 35V	0 to 65V

For critical functions when good diagnostic coverage is necessary it is recommended to use two digital inputs for plausibility check, for example, use of both normally open and normally closed contacts.

3.4.2 Protection

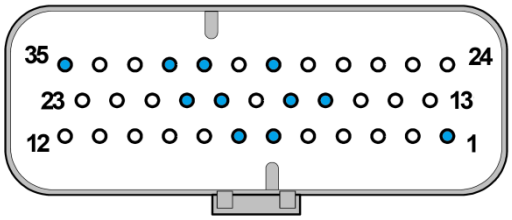
The Digital Inputs have a 22 nF capacitor (C1) to B- for ESD protection.

Total input impedance:

Controller type	24V	36/48V
Impedance	4,5kΩ	14,5kΩ

Digital inputs DI1, DI2, DI5, DI7, DI9 are normally configured to be activated when closed to +B. They can be changed by special HW configuration to be activated when closed to -B

3.4.3 Connector position



3.4.4 Microswitches

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

3.5 Analog Inputs

3.5.1 Function

The analog inputs are for application use, such as speed or brake potentiometers. Analog inputs are connected to a 10 Bit Analog to Digital Converter (ADC value range 0-1024).

Input range +0V to +10.4 V, give ADC value=0 to 1014.
Analog inputs impedance = 99 kΩ, maximum input frequency 13 Hz.

The standard connection for the potentiometer is the one in the Left side of next figure (potentiometer on one end at rest) in combination with a couple of Travel demand switches. On request it is also possible the handling in the Right side of next figure (potentiometer in the middle at rest) still in combination with a couple of Travel demand switches.

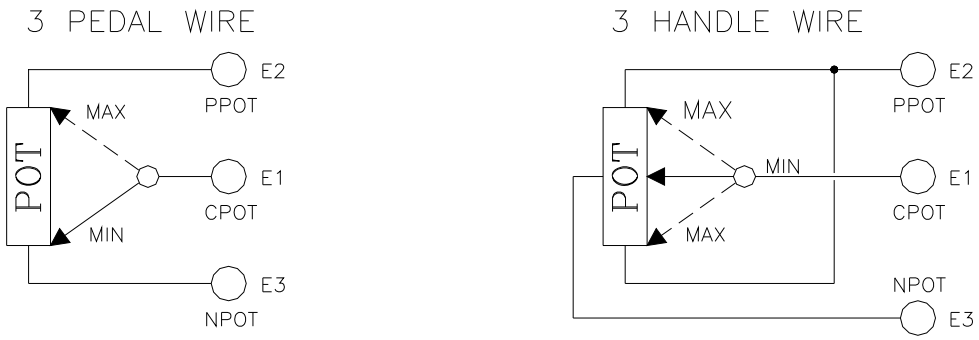


Figure 1: Potentiometer configuration

The negative supply of the potentiometer has to be taken from CNA#5 (GND). Potentiometer value should be in the 0.5 – 10 kΩ range; generally, the load should be in the 1.5 mA to 30 mA range.

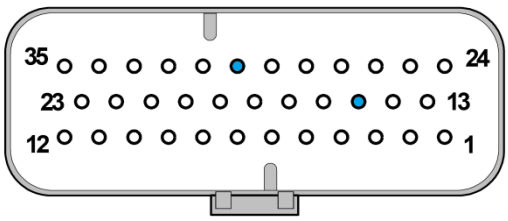
The Procedure for automatic potentiometer signal acquisition is carried out using the Console (see paragraphs 9.1, 9.2 and 9.3).

The Analog inputs may also be used as extra Digital inputs. The ADC-value shall be used as the indicator of the input status. As an example: A proximity switch supplied from B+ is connected to an analog input.

3.5.2 Protection

Analog inputs are B+ and B- protected and have a 22 nF capacitor to B- for ESD protection.

3.5.3 Connector position



If an analog input is used as a speed reference to the motor controller, a system safety strategy must be defined.

The application software must take care of analog input errors such as: Vacc out of range, Vacc not ok.

3.6 Special Inputs

3.6.1 Function

Input A18 and A21 are special inputs configured, normally, as digital inputs activated to –B.
It is possible to configure them differently in order to get two additional digital inputs activated to +B or two additional analog inputs (Electrical characteristics

compatible with the standard digital or analog inputs).

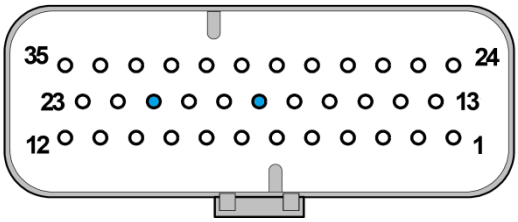
A proper Hardware configuration permits to transform A18 and A21 in a sense coil interface or in an absolute sin/cos sensor interface (PMSM) for special applications that use brushless motor.

For more details about sensor installation see also paragraphs 4.3.6, 4.3.7

3.6.2 Protection

The Digital Inputs have a 22 nF capacitor (C1) to B- for ESD protection.

3.6.3 Connector position



3.7 Encoder Input

3.7.1 Function

Digital motor feedback sensor input (for open collector sensor output) has an internal 1kΩ pull-up to SENSOR_SUPPLY
The threshold levels are:

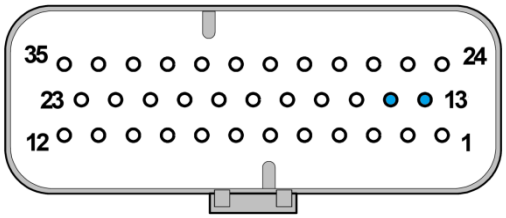
EncoderSupply Voltage	5V	12V
Logic low	1,4V	6,4V
Logic high	3,5V	4,3V

The speed sensor signals are connected to the quadrature function in the CPU.

3.7.2 Protection

Encoder inputs are B+ and B- protected and have ESD suppressor to B- for ESD protection.

3.7.3 Connector position



It is important to verify the wiring by ensuring that the Encoder signals are

not disturbed from the motor current or the electric motor brake.

For more details about encoder installation see also paragraph 4.3.5.

Note: The encoder resolution and the motor poles pair (the controller can handle), is specified in the home page display of the handset showing following headline:
A0MT2B ZP1.13

That means:
A0MT= ACE-0 traction controller (M stands for "µC Master", S for "µC Supervisor")
(A0MP= ACE-0 pump controller)
2 = motor's poles pair number
B = 64 pulses/rev encoder

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

3.8 MC Output

3.8.1 Function

Open Drain PWM voltage controlled output used normally for operating Main Contactor.
In order to utilize the built-in free-wheeling diodes, the load must be supplied from pin Key pin (A10) (see chapter 5.2).
Special hardware configuration permits to utilize a built-in free-wheeling diode connected to pin A1
In case the vehicle design does not allow usage of the built-in free-wheeling diodes, i.e. if the return path integrity cannot be guaranteed in all situations, external free-wheeling diodes must be applied over the inductive loads supplied by the open drain outputs.

Output features

- 1A continuous (hold current) and max 2.0 A peak (pull current) for a maximum of 200 ms.
- Individual hardware for driver shorted, driver open and coil open detection.
- 1kHz default PWM frequencies.
- Voltage controlled with separate pull and hold voltage software parameters.

PWM shall only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valve

PWM frequency can be changed by software. If a different PWM frequency has to be used, it is suggested to discuss it with Zapi technicians.

3.8.2 Protection

Protected against inductive discharge with internal freewheeling diodes to pin A10 and ESD protected by ESD suppressor device.

Protected against reverse polarity of the battery.

Built-in diagnostics:
- Overcurrent
- Driver shorted
- Driver open
- Coil open

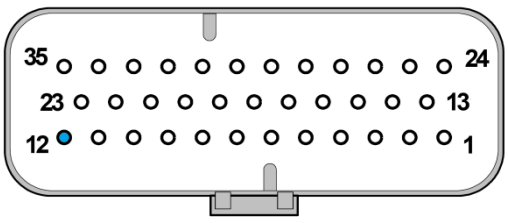
Refer to chapter 10 for more detailed description.

Overcurrent protection is applied by hardware and it is shared with EB output

*MC output can be only a "PWM voltage controlled" output. It **can't** be a used as "current controlled" output.*

When driving inductive loads on PWM Open drain outputs there must always be a path for the current to the freewheeling diodes. Do not connect any switch or fuse in series with the diode.

3.8.2 Connector position



To protect the motor controller from overvoltage at inductive load, internal free-wheeling diode is mounted to the A10 pin.

Please ensure that inductive loads are connected such that the path for the free-wheeling diode is always intact (see 3.8.1), or use an external free-wheeling diode if this is not possible.

Use of brushless fan or other loads with built-in capacitor can give high inrush current when turn ON which will give an Open Drain over current trip. The inrush current must be below the Open Drain peak current.

3.9 EB Output

3.9.1 Function

Open Drain PWM voltage controlled output used normally for operating Electro Mechanical Brake.
In order to utilize the built-in free-wheeling diodes, the load must be supplied from pin A2 (see chapter 5.2).

Only in the 24V version A2 is supplied by a Smart High Side Driver (see paragraph 3.11). for the other version it is possible to supply A2 from pin A1 or from pin A3 depending by proper hardware configuration.

In case the vehicle design does not allow usage of the built-in free-wheeling diodes, i.e. if the return path integrity cannot be guaranteed in all situations, external free-wheeling diodes must be applied over the inductive loads supplied by the open drain outputs.

Output features

- 2A continuous (hold current) and max 3.0 A peak (pull current) for a maximum of 200 ms.
- Individual hardware for driver shorted, driver open and coil open detection.
- 1kHz PWM frequencies.
- Voltage controlled with separate pull and hold voltage software parameters.

PWM shall only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valves

3.9.2 Protection

Protected against inductive discharge with internal freewheeling diodes to pin A2 and ESD protected by suppressor device.
Not protected against reverse polarity of the battery. A way to avoid that this would cause a failure is to activate the contactor only when the voltage over the DC-bus capacitors has reached the accepted pre charge level.

Built-in diagnostics:
- Overcurrent
- Driver shorted
- Driver open
- Coil open

Refer to chapter 10 for more detailed description.

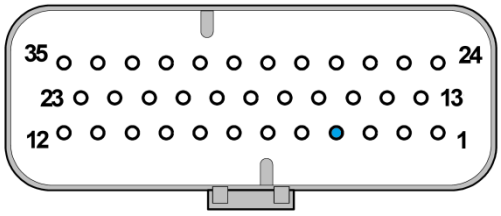
Overcurrent protection is applied by hardware and it is shared with MC output

*EB output can be only a "PWM voltage controlled" output. It **can't** be a used as "current controlled" output.*

For version different from 24V, it is suggested to discuss with Zapi technicians about supply for pin A2.

When driving inductive loads on PWM Open drain outputs there must always be a path for the current to the freewheeling diodes. Do not connect any switch or fuse in series with the diode.

3.9.3 Connector position



To protect the motor controller from overvoltage at inductive load, internal free-wheeling diode is mounted to the A2 pin.

Please ensure that inductive loads are connected such that the path for the free-wheeling diode is always intact (see 3.9.1), or use an external free-wheeling diode if this is not possible.

Use of brushless fan or other loads with built-in capacitor can give high inrush current when turn ON which will give an Open Drain over current trip. The inrush current must be below the Open Drain peak current.

3.10 Auxiliary Outputs

3.10.1 Function

Open Drain outputs can be used for operating services such as relay, hydraulic valves, horn, etc.
The Open Drain outputs may work in different modes depending by Hardware structure:

- On/Off (EV1, HORN)
- PWM Current Controlled (EVP1)

– PWM Voltage Controlled (EV2, EV3)

In order to utilize the built-in free-wheeling diodes, the load must be supplied from pin A3 (see **Errore. L'origine riferimento non è stata trovata.**).
In case the vehicle design does not allow usage of the built-in free-wheeling diodes, i.e. if the return path integrity cannot be guaranteed in all situations, external free-wheeling diodes must be applied over the inductive loads supplied by the open drain outputs.

ON/OFF Outputs features

- 1A continuous (hold current) and max 2.0 A peak (pull current) for a maximum of 200 ms.
- individual hardware for EV1 for driver shorted and driver open detection.

HORN output has not feedback hardware circuit. Any fault diagnosis is not available but an self-protected driver is used

PWM Voltage controlled Outputs features

- 1Arms continuous (hold current) and max 2.0 A peak (pull current) for a maximum of 200 ms.
- Individual hardware for driver shorted and driver open detection.
- 1kHz PWM frequencies. It is applied to all PWM outputs.
- Each PWM voltage controlled outputs can be voltage controlled with separate voltage software parameters.

PWM Current controlled Outputs features

- 1,5 A continuous (hold current) and max 1,7 A peak.
- Individual hardware for driver shorted, driver open and coil open detection
- self-protected against overload condition
- Dithering feature by giving the current a high frequency, low amplitude oscillating waveform (see paragraph 8.1.5)
  Dithering is typically used when controlling proportional valves to create microscopic movements in the valve to prevent it from “sticking”.
  Successful dithering improves the valve response for small changes.

  Dithering frequency in fixed steps:

Set value Hz	20,8	22,7	25	27,7	31,2	35,7	41,6	50	62,5	83,3

  Dithering current amplitude can be adjusted up to 13% of reference value. Actual dithering amplitude is dependent on load inductance.

3.10.2 Protection

The auxiliary outputs are protected against inductive discharge with internal freewheeling diodes to pin A3.

The Auxiliary outputs are not protected against reverse polarity of the battery. A way to avoid that this would cause a failure is to activate the contactor only when the voltage over the DC-bus capacitors has reached the accepted pre charge level. (see picture in section 5.2).

Built-in diagnostics:

- Overcurrent
- Driver shorted
- Driver open
- Coil open (only for PWM Current Controlled Outputs)

Refer to section 10 for more detailed description

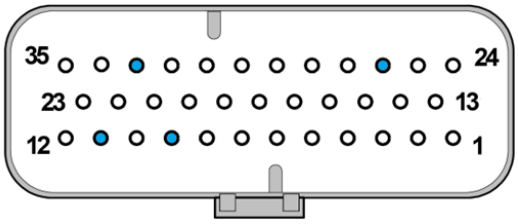
PWM shall only be used for inductive loads such as relays, contactors, motor brakes or hydraulic valves

The shunt resistor for overcurrent protection is shared between EV1, EV2, EV3, EV4 and EV5 output. The overcurrent threshold is fixed by hardware to 9A.

The maximum total continuous current for outputs EV1, EV2, EV3, EV4, EV5 is 3A. The maximum total peak current is 9A.

When driving inductive loads on PWM Open drain outputs there must always be a path for the current to the freewheeling diodes. Do not connect any switch or fuse in series with the diode.

3.10.3 Connector position



To protect the motor controller from overvoltage at inductive load, internal free-wheeling diodes are mounted to the A3 pin.

Please ensure that inductive loads are connected such that the path for the free-wheeling diode is always intact (see Function), or use an external free-wheeling diode if this is not possible.

Use of brushless fan or other loads with built-in capacitor can give high inrush current when turn ON which will give an Open Drain over current trip. The inrush current must be below the Open Drain peak current.

3.11 High Side Driver

3.11.1 Function

For 24V version is available also one High side switch for critical functions providing redundancy to turn OFF the EB.
If the open drain EB output is short circuited, it is possible to turn OFF the High side switch to disconnect load.
The High side switch has maximum output current 3A. The high side switch (Smart driver) has only ON/OFF control and it is present only on 24V version.

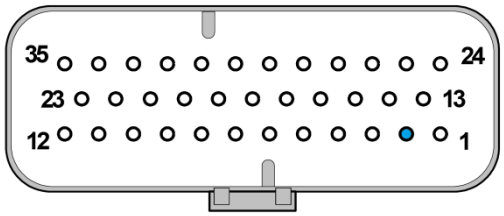
3.11.2 Protection

Internal hardware short circuit protection.

Built-in diagnostics:
- Driver shorted
- Driver open

Refer to section 10 for more detailed description.

3.11.3 Connector position



3.12 Motor Temperature Measurement Input

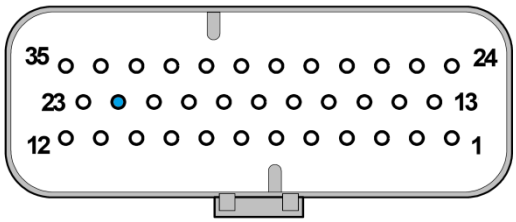
3.12.1 Function

Motor temperature sensor input for measurement of the motor winding temperature.
Support is intended for temperature sensors like KTY84 with 1000Ω @ 100°C, KTY83 with 1670Ω @ 100°C or ON/OFF sensor.

3.12.2 Protection

The input is +B protected. A 22 nF input capacitor provides ESD protection and filters disturbance noise from the motor.

3.12.3 Connector position



3.13 Sensor Supply Output

3.13.1 Function

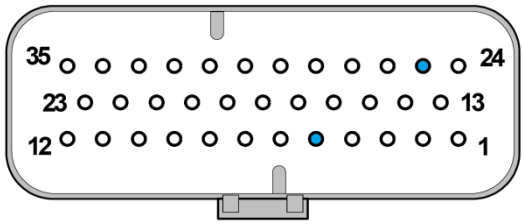
Supply for external motor speed sensors.
Output voltage is settable via hardware by internal jumper to “+12V” or “+5V” and total maximum output current is 100 mA.

Actual value for “+12V” and “+5V” are respectively 13,2V ± 0,25V and 5V ± 0,25V

3.13.2 Protection

Sensor supply output is over current protected and protected against accidental connection to B+ with a diode.

3.13.3 Connector position



3.14 Analog Supply Output

3.14.1 Function

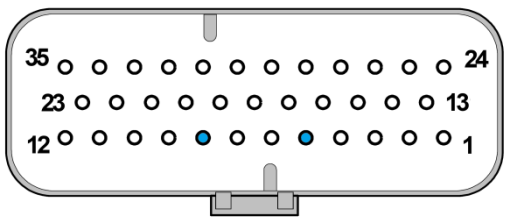
Second supply for external analog sensors and analog speed or brake potentiometers is available on pin A8 in substitution of EV5 output.
Output voltage is settable via hardware by internal jumper to “+12V” or “+5V” and maximum output current is 100 mA.

Actual value for “+12V” and “+5V” are respectively 13,2V ± 0,25V and 5V ± 0,25V

3.14.2 Protection

Analog supply output is over current protected with a thermal shut down protected against accidental connection to B+ with a diode.

3.14.3 Connector position



3.15 P- For Series DC Motor

3.15.1 Function

Only available for COMBIAC0. High current Open Drain outputs (several MOSFETS in parallel) with PWM can be used for DC hydraulic pump-motor. Motor shall be connected between B+ and P- on the motor controller. The PWM frequency is 16kHz.

3.15.2 Protection

Internal short circuit detection, voltage and current measurements. Freewheeling diode (several MOSFETs in parallel) to B+.

3.16 CAN Bus

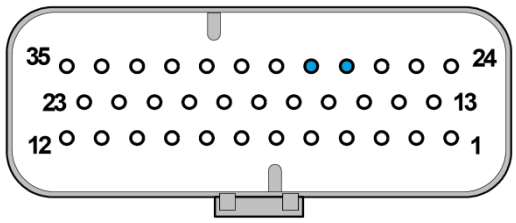
3.16.1 Function

Physical Interface according to ISO 11898-2. Data rate 125, 250 or 500 kBit/s.
The CAN driver is +5 V supplied and give maximum amplitude on the CAN_H to CAN_L signal.
An internal 120 Ω termination resistor can be installed.
Common-mode filter (resistors and capacitor) is installed.

3.16.2 Protection

Protected against accidental connection to B+ and -B.
ESD protected.

3.16.3 Connector position



CAN-cabling shall use a pair of twisted wires for CAN_H and CAN_L wires.

The CAN-cabling shall have a characteristic impedance of 120 Ω and both physical ends of the CAN Bus shall be terminated with 120 Ω between CAN_H and CAN_L for best possible noise immunity.

4 INSTALLATION HINTS

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

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

These Warning boxes are used inside this publication to indicate:
- operations that can lead to a failure of the electronic device or can be dangerous or harmful for the operator;
- items which are important to guarantee system performance and safety.
Pay special attention to the annotations pointed out with this symbol.

4.1 General

This section presents a general procedure for startup and verification of a motor controller following installation in a vehicle.
The motor controller is a software configurable device. In a CAN supervisor system, some or all aspects of the motor controller setup and operation may be managed by a vehicle master controller communicating over the CAN bus. For standalone operation (primarily the I/O version), customized software must be installed in the motor controller.
Built-in diagnostics functions monitor battery voltage, heat sink temperature, motor temperature, and other conditions. Error and warning information is available to the master controller, and all event information is stored in an event log for service access. (See chapter 10)
The event log provides additional information as well as procedures for pinpointing and eliminating causes for warning and error conditions.

Wiring errors, improper setup, or other conditions may cause the vehicle to move in the wrong direction or at the wrong speed.

Take necessary precautions to prevent injury to personnel or damage to equipment prior to applying power for the first time.

4.2 Material overview

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

4.2.1 Connection cables

For the auxiliary circuits, use cables of 0.5 mm² section.
For power connections to the motor and to the battery, use cables having proper section. The screwing torque for the controller power connection must be comprised in the range 5,6 Nm÷8,4Nm.
For the optimum inverter performance, the cables to the battery should be run side by side and be as short as possible.

4.2.2 Contactors

The main contactor must be installed. Depending on the setting two parameters in the controller (MAIN CONT VOLT [V%] and MAIN CONT V RID [%] ; see paragraphs 8.1.2 and 9.9):

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

4.2.3 Fuses

- Use a 10 A Fuse for protection of the auxiliary circuits.
- For protection of the power unit. The Fuse value shown is the maximum allowable. For special applications or requirements these values can be reduced.
- For Safety reasons, we recommend the use of protected fuses in order to prevent the spread of fused particles should the fuse blow.
- Selection of appropriate fuse ratings is a system design issue and falls under the OEMs responsibility.

Note that the fuse is not intended to protect the motor controller or motor against overloads.

4.3 Installation of the hardware

Before doing any operation, ensure that the battery is disconnected.

For traction applications, raise up or otherwise disable drives wheels to prevent the possibility of unexpected vehicle motion or motion in the wrong direction during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excess pressure build-up (in the event of a pressure relief valve malfunction).

Take necessary precautions to do not compromise safety in order to prevent injury to personnel or damage to equipment

After operation, even with the Key Switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend to

disconnect the battery and to connect a resistor (between 10ohm and 100ohm) Battery Positive and Battery Negative power terminals for at least 10 seconds.

4.3.1 Positioning and cooling of the controller

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

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

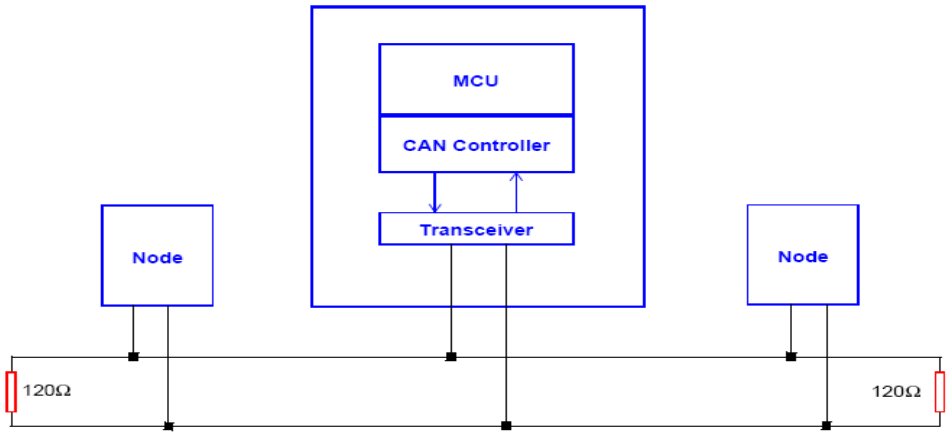
4.3.2 Wirings: power cables

- The power cables length must be as short as possible to minimize power losses.
- They must be tightened on controller power posts with a Torque of 5,6-8,4 Nm.
- The ACEX/COMBIACX module should only be connected to a traction battery. Do not use converters outputs or power supplies. For special applications please contact the nearest Zapi Service Centre.

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

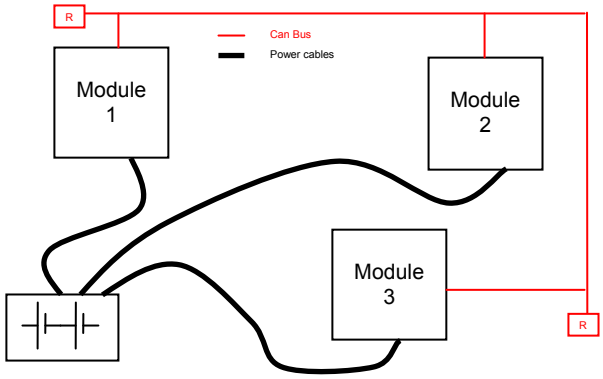
4.3.3 Wirings: CAN connections and possible interferences

CAN stands for Controller Area Network. It is a communication protocol for real time control applications. CAN operates at data rate of up to 1 Megabits per second.
It was invented by the German company Bosch to be used in the car industry to permit communication among the various electronic modules of a vehicle, connected as illustrated in this image:



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

Wrong Layout:

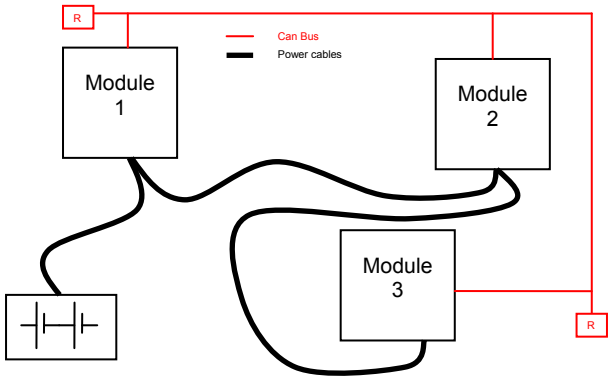


The red lines are can wires.
The black boxes are different modules, for example traction controller, pump controller and display connected by canbus.

The black lines are the power cables.

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

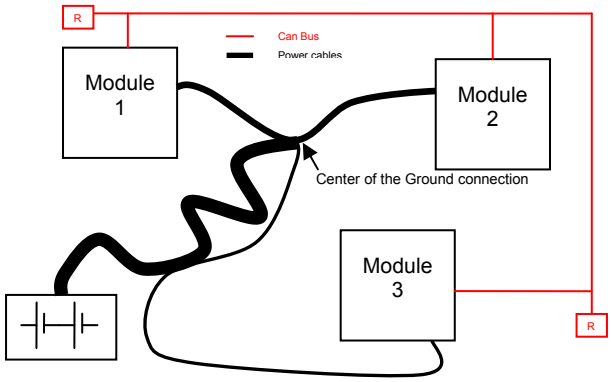
Correct Layout:



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

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

Correct Layout:



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

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

account thermal and voltage drop problems.

Can advantages:
The complexity of today systems needs more and more data, signal and information must flow from a node to another. CAN is the solution to different problems that arise from this complexity
- simplified design (readily available, multi sourced components and tools)
- lower costs (less and smaller cables)
- improved reliability (fewer connections)
- analysis of problems improved (easy connection with a pc to read the data flowing through the cable).

4.3.4 Wirings: I/O connections

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

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

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

4.3.5 Connection of standard encoder

ACEX/COMBIACX card fits for different types of encoder. To control AC motor with Zapi inverter, it is necessary to install an incremental encoder with 2 phases shifted of 90°. The encoder power supply can be +5 or +12 V. It can have different electronic output.
For special application it is possible to install incremental encoder with Zero position signal.

A25	+5V/+12V	encoder positive power supply.
A5	GND	encoder negative power supply.
A7	ENC A	phase A of encoder.
A14	ENC B	phase B of encoder.
A20	Z POS	phase B of encoder.

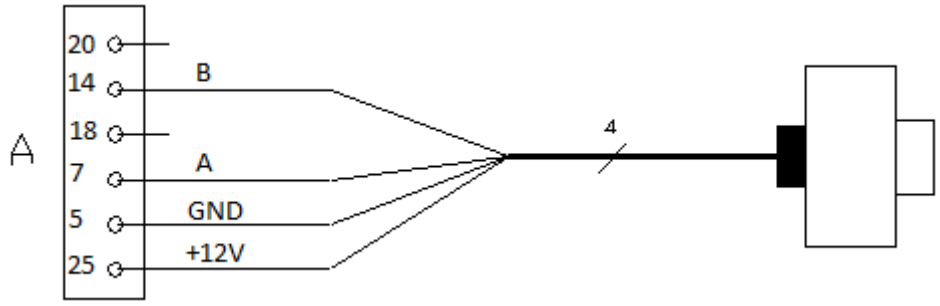


Figure 2: Standard Encoder

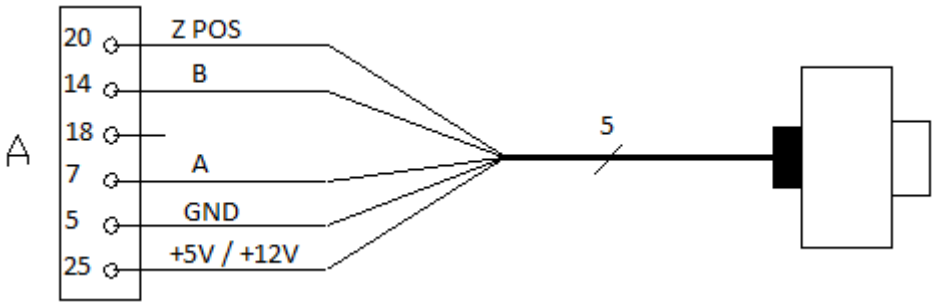


Figure 3: Encoder with Zero position signal

VERY IMPORTANT
It is necessary to specify in the order the type of encoder used, in terms of power supply, electronic output in order the logic can be properly set by Zapi.

VERY IMPORTANT
The number of pulse/rev can be properly set using the dedicated parameters (see paragraph 8.1.7).

The maximum speed detectable by standard Hardware configuration can be limited depending by number of pulse/rev. Contact Zapi technician for checking

VERY IMPORTANT
It is strongly suggested, for safety reason, to lift up the wheel from the floor and set the correct value according to the type of sensor used before to perform any operation with the truck.

4.3.6 Connection of sin/cos sensor

When the PMSM is of the BLAC type, must be controlled with sine waves shape. A PMSM is a BLAC when, by turning its shaft lightened, the electromotive force between two motor terminals is of the shape sinusoidal.
To control PMSM motor with Zapi inverter, it is necessary to install an absolute Sin/Cos sensor. The Sin/Cos sensor power supply can be +5 or +12 V.
At the first key an auto-teaching procedure it is necessary to permit to the controller to acquire the sensor signals.

A25	+5V/+12V	sensor positive power supply.
A5	GND	sensor negative power supply.
A18	SIN	sine .
A21	COS	cosine.

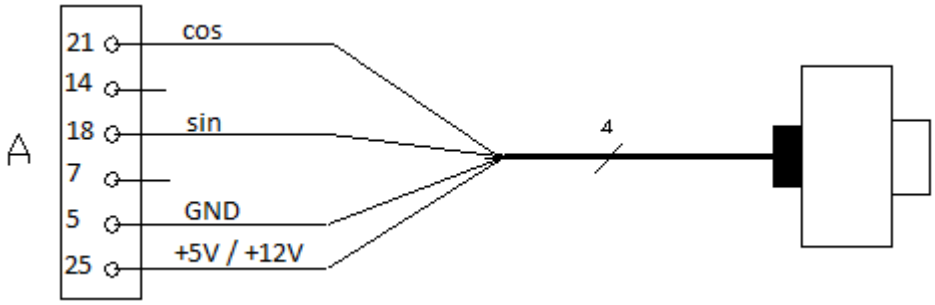


Figure 4: Sin/cos sensor connection

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

4.3.7 Connection of Hall sensors

When the PMSM is of the BLDC type, must be controlled with a six steps inverter (trapezoidal waves shape). A PMSM is a BLDC when, by turning its shaft lightened, the electromotive force between two motor terminals is of the shape trapezoidal.
To control BLDC motor with Zapi inverter, it is necessary to three Hall sensors.
Hall sensors power supply can be +5 or +12 V.

A25	+5V/+12V	sensor positive power supply.
A5	GND	sensor negative power supply.
A7	HS1	Hall sensor 1 .
A14	HS2	Hall sensor 2 .
A18	HS3	Hall sensor 3 .

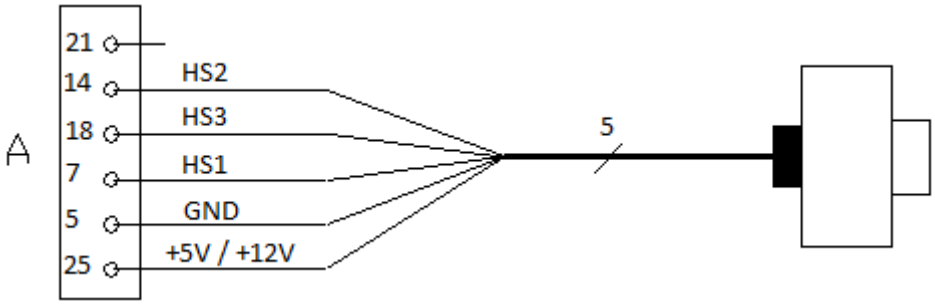


Figure 5: Hall sensors connection

VERY IMPORTANT
It is absolutely mandatory to specify in the order the type of sensor used, in terms of power supply, electronic output and n° of pulses for revolution, Hall sensor configuration in d-axes rotor orientation and the sensor sequence when the motor is turning because the logic unit and the software must be set in the correct way by Zapi.

4.3.8 Main contactor and key connection

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

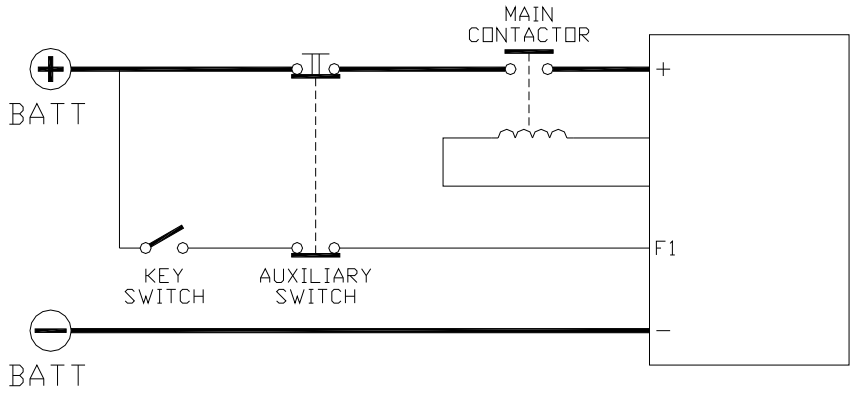


Figure 6: Main Contactor and Key connection

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

4.3.9 Insulation of truck frame

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

4.4 EMC

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

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

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

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

3) The second type of immunity, ESD, concerns the prevention of the effects of electric current due to excessive electric charge stored in an object. In fact, when a charge is created on a material and it remains there, it becomes an “electrostatic charge”; ESD happens when there is a rapid transfer from a charged object to another. This rapid transfer has, in turn, two important effects:
   - this rapid charge transfer can determine, by induction, disturbs on the signal wiring and thus create malfunctions; this effect is particularly critical in modern machines, with serial communications (canbus) which are spread everywhere on the truck and which carry critical information.
   - in the worst case and when the amount of charge is very high, the discharge process can determine failures in the electronic devices; the type of failure can vary from an intermittently malfunction to a completely failure of the electronic device.

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

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

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

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

- LAYOUT: a good layout of the cables can minimize the antenna effect; cables running nearby the truck frame or in iron channels connected to truck frames is generally a suggested not expensive solution to reduce the emission level.

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

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

   - PREVENTION: when handling ESD-sensitive electronic parts, ensure the operator is grounded; test grounding devices on a daily basis for correct functioning; this precaution is particularly important during controller handling in the storing and installation phase.
   - ISOLATION: use anti-static containers when transferring ESD-sensitive material.
   - GROUNDING: when a complete isolation cannot be achieved, a good grounding can divert the discharge current trough a “safe” path; the frame of a truck can works like a “local earth ground”, absorbing excess charge. So it is strongly suggested to connect to truck frame all the parts of the truck which can be touched by the operator, who is most of the time the source of ESD.

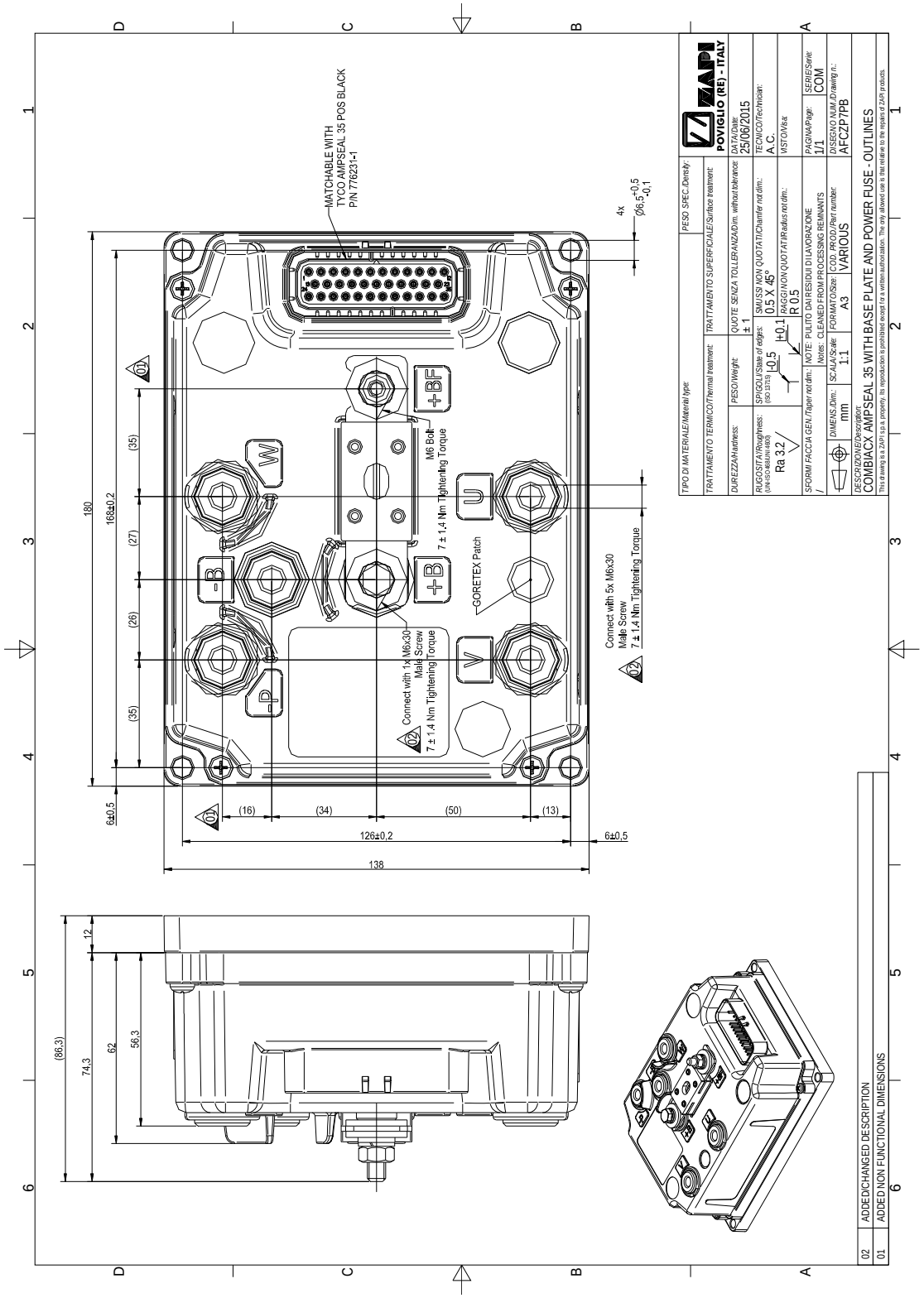
4.5 Various suggestions

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

5 DRAWINGS

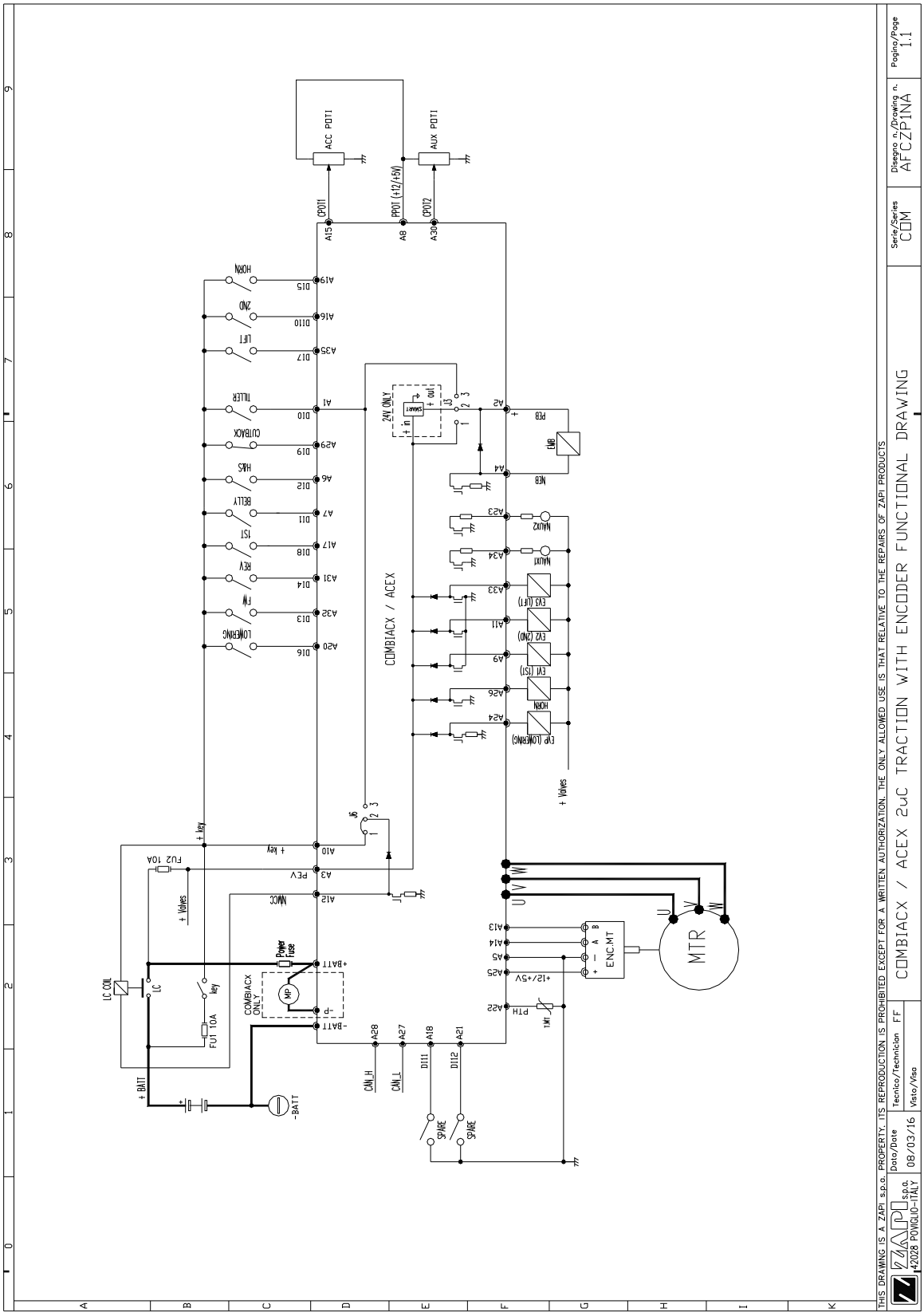
5.1 Mechanical drawings

5.1.1 Base plate version

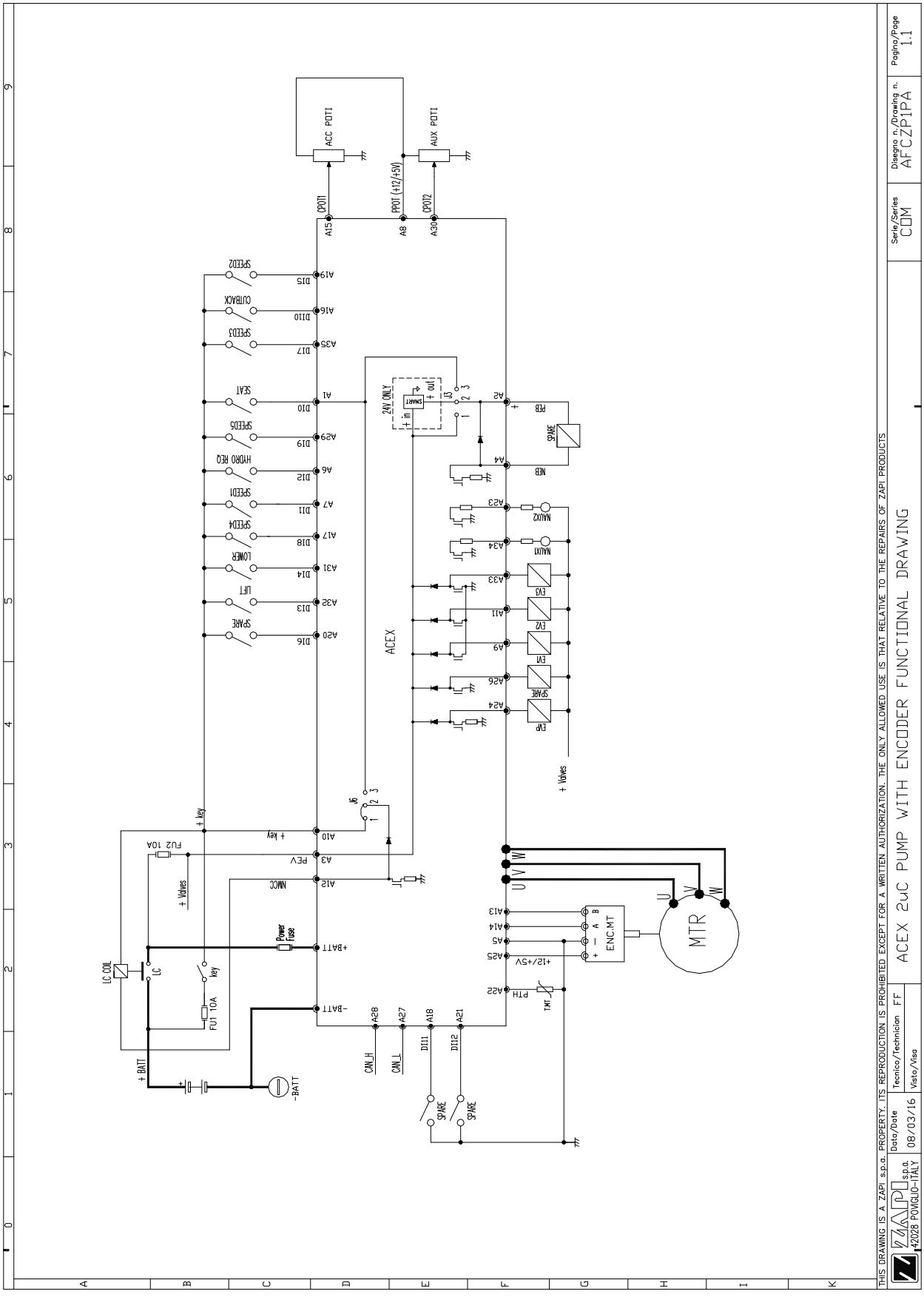


5.2 Connection drawings

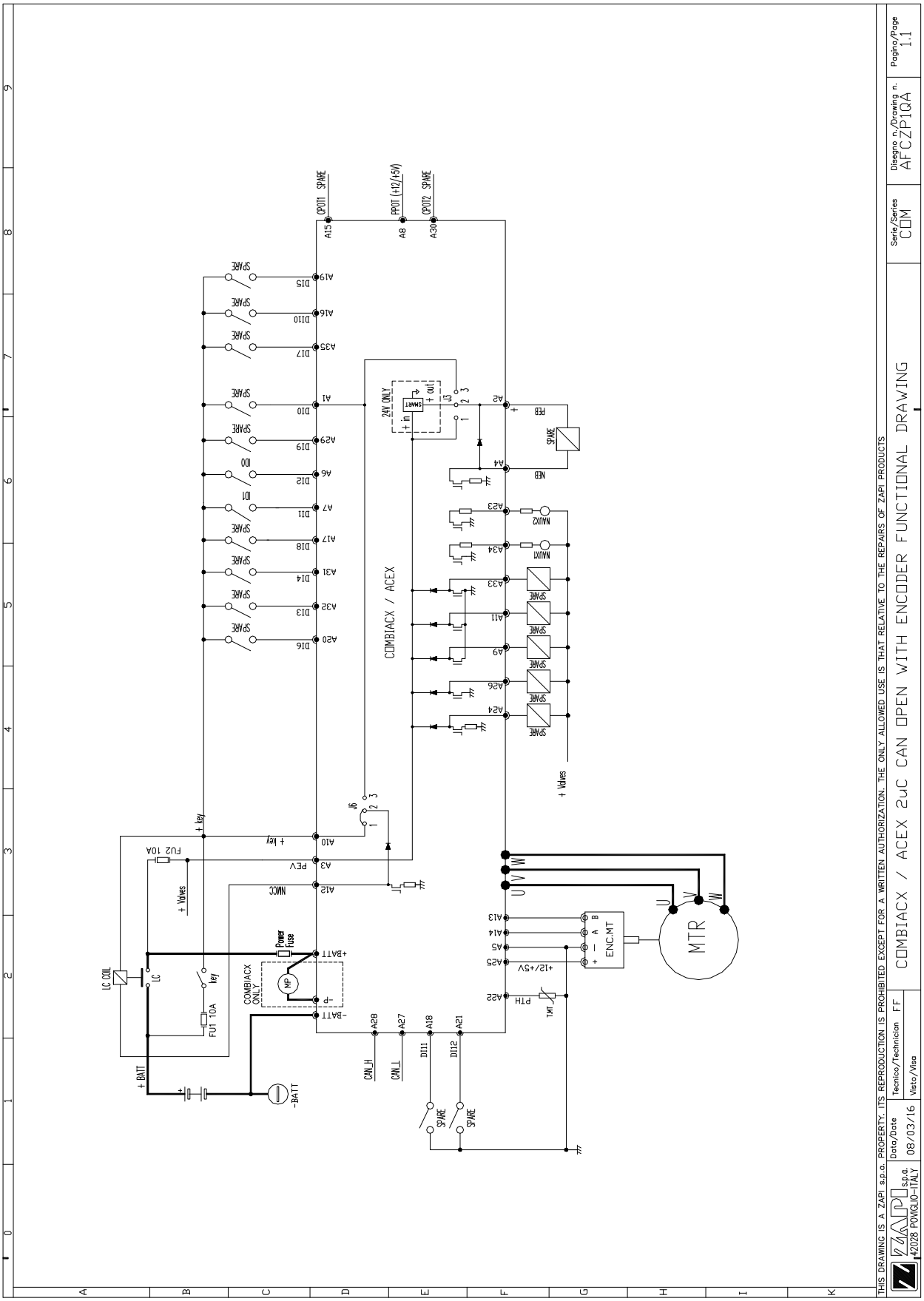
5.2.1 AC Traction configuration



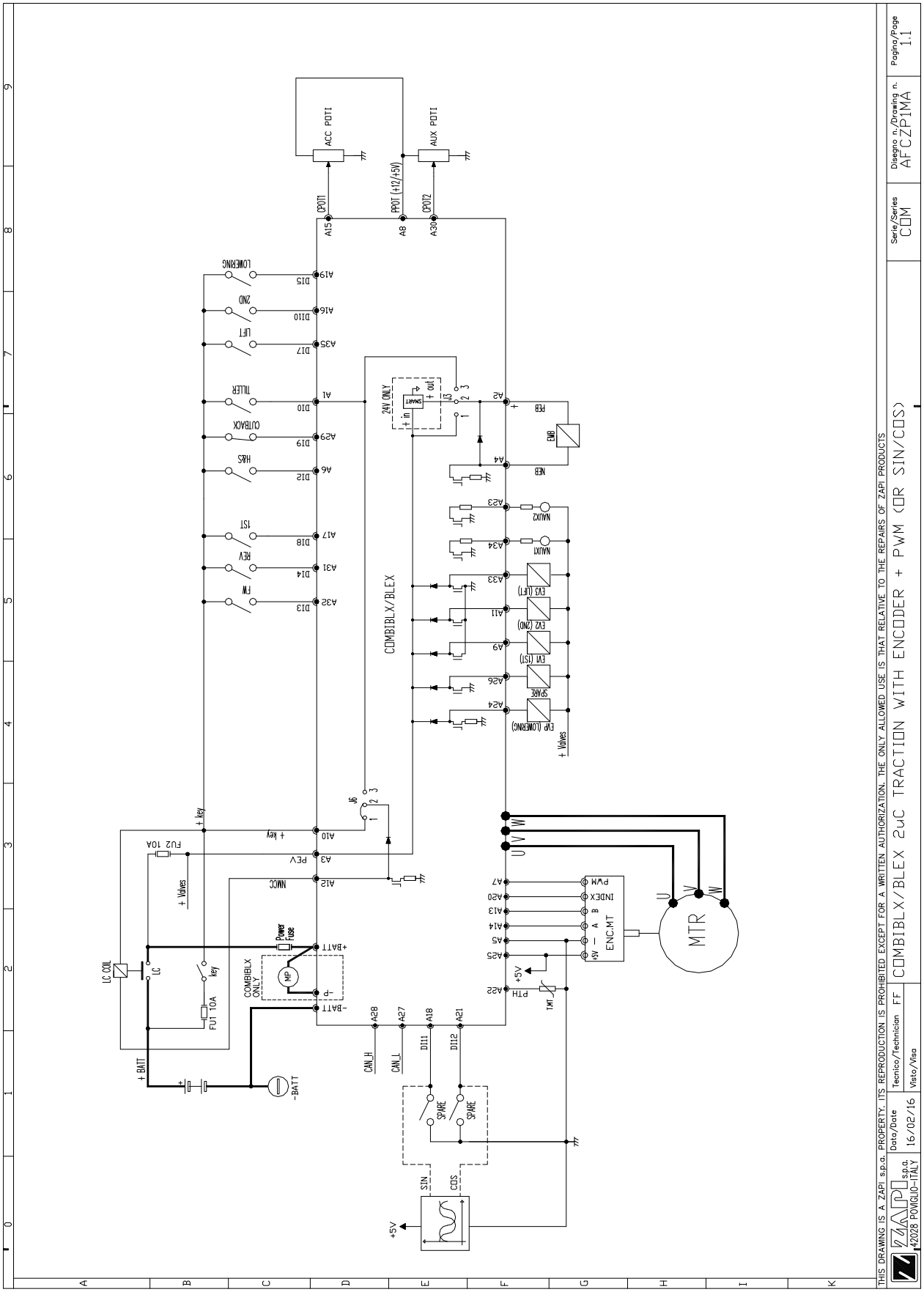
5.2.2 AC Pump configuration



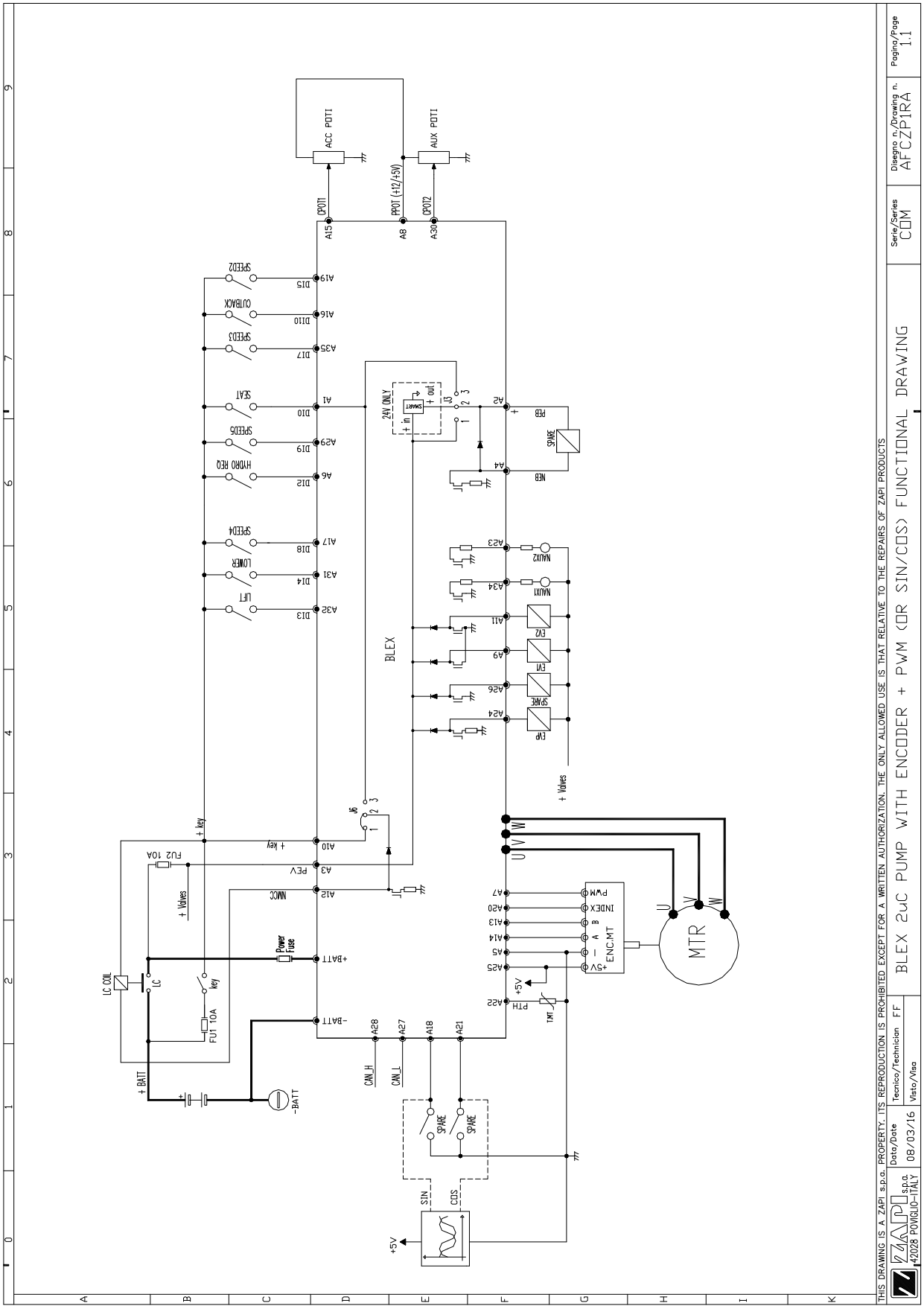
5.2.3 AC CAN Open configuration



5.2.4 PMSM Traction configuration



5.2.5 PMSM Pump configuration



6 FEATURES

6.1 Operational Features

- Speed control (three versions available: sensored, sense coil and sensorless as explained in the introduction section) .
- Optimum behaviour on a slope due to the speed feedback:
- The motor speed follows the accelerator, starting a regenerative braking if the speed overtakes the speed set-point.
- The system can perform an electrical stop on a ramp (the machine is electrically hold on a slope) for a programmable time (see also paragraph 8.1.1).
- Stable speed in every position of the accelerator.
- Regenerative release braking based upon deceleration ramps.
- Regenerative braking when the accelerator pedal is partially released (deceleration).
- Direction inversion with regenerative braking based upon deceleration ramp.
- Regenerative braking and direction inversion without contactors: only the main contactor is present.
- The release braking ramp can be modulated by an analog input, so that a proportional brake feature is obtained.
- Optimum sensitivity at low speeds.
- Voltage boost at the start and with overload to obtain more torque (with current control).
- The inverter can drive an electromechanical brake.
- Hydraulic steering function:
  - traction inverter
    - the traction inverter sends a "hydraulic steering function" request to the pump inverter on the can-bus line
    - moreover, if the pump inverter is not present (for ex: tractor application), the traction inverter can manage an "hydraulic steering function" by driving an hydraulic DC steering motor with DC section (see also paragraph 8.1.4).
  - pump inverter
    the pump inverter manage an "hydraulic steering function". That is, it drives the pump motor at the programmed speed for the programmed time.
- High efficiency of motor and battery due to high frequency commutations.
- Double microcontroller for safety functions
- Self diagnosis, the faults can be displayed through the console or Zapi's MDI/Display.
- Modification of parameters through the programming console.
- Internal hour-meter with values that can be displayed on the console.
- Memory of the last five alarms with relative hour-meter and temperature displayed on the console.
- Test function within console for checking main parameters.

6.2 Dual traction motor

In the case of dual traction motors, there is additional processing of the associated steering signal (from a potentiometer or switches) in order to generate

separate torque demands for the left and right motors of the vehicle. This allows the two motors to be operated at different speeds, which greatly assists in turning the vehicle and prevents wheel scrub. After the torque demands have been generated, the operation of each motor control system is as described in the case of a single traction motor.

6.3 Pump motor

Pump motor control is similar to traction motor control, although motion is requested using a different combination of switches.

6.4 Torque mode

In this mode the controller maintains the motor torque output at a constant value for a given throttle position.
This is similar to DC motors (in particular, series wound DC motors) and provides a driving experience like a car. To prevent excessive speed when the load torque is low, for example when driving down hill, a maximum vehicle speed can be set.

6.5 Speed mode

In this mode the controller maintains the motor at a constant speed for a given throttle position as long as sufficient torque is available. Speed mode differs from torque mode in that the torque value applied to the motor is calculated by the controller based on the operator's requested speed (determined by throttle position) and the vehicle's actual speed.

6.6 Protection and safety features

6.6.1 Protection features

The ACEX / COMBIACX is protected against some controller injuries and malfunctions:

- **Battery polarity inversion**
  It is necessary to fit a MAIN CONTACTOR to protect the inverter against reverse battery polarity and for safety reasons.
- **Connection Errors**
  All inputs are protected against connection errors.
- **Voltage monitoring**
  Protected against battery undervoltage and overvoltage
- **Thermal protection**
  If the controller temperature exceeds 85 °C, the maximum current is reduced in proportion to the thermal increase. The temperature can never exceed 105 °C.

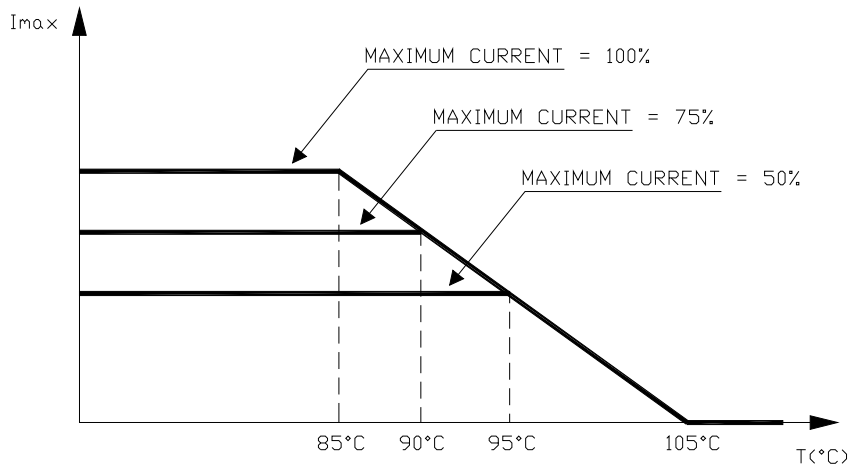


Figure 7: Thermal cutback

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

- **Protection against uncontrolled movements**
  The main contactor will not close if:
  - The Power unit is not functioning.
  - The Logic is not functioning perfectly.
  - The output voltage of the accelerator does not fall below the minimum voltage value stored, with 1 V added.
  - Running microswitch in closed position.

- **Low battery charge**
  When the battery charge is low, the maximum current is reduced to the half of the maximum current programmed.

- **Protection against accidental Start up**
  A precise sequence of operations are necessary before the machine will start.
  Operation cannot begin if these operations are not carried out correctly.
  Requests for drive, must be made after closing the key switch.

6.6.2 Safety Features

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

6.7 Diagnosis

The microcontroller continually monitors the inverter and carries out a diagnostic procedure on the main functions.
For simple visual diagnosis of system faults and to monitor system status, a red LED is provided on the body of the controller.

Figure 8: Alarm Led

It is ON at start-up and then it stays continuously OFF when there is no fault; it flashes a different number of times, in a repeated pattern, when there is a fault. The number of flashes indicates the type of fault.
The diagnosis is made in 4 points:

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

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

7 START-UP HINTS

7.1 Check prior to initial power up

For traction applications, raise up or otherwise disable drives wheels to prevent the possibility of unexpected vehicle motion or motion in the wrong direction during initial commissioning. For hydraulic applications, open the valve to prevent the possibility of excess pressure build-up (in the event of a pressure relief valve malfunction).

Take necessary precautions to do not compromise safety in order to prevent injury to personnel or damage to equipment

After operation, even with the Key Switch open, the internal capacitors may remain charged for some time. For safe operation, we recommend that the battery is disconnected, and a short circuit is made between Battery Positive and Battery Negative power terminals of the inverter using a Resistor between 10 ohm and 100 ohm.

Perform the following checks before applying power to a motor controller for the first time:

1. Verify that the proper motor controller item number for the application has been installed. Verify that the vehicle battery voltage matches the motor controllers Nominal DC Supply Voltage rating listed on the product identification label
2. Verify that the correct software for the application has been loaded into the motor controller
3. Verify that all power and signal wiring to the motor controller is correctly connected.
4. Verify that connections to battery and motor terminals are tightened with appropriate torque.
5. Verify that the control I/O plug is fully mated and latched into position with the mating connector on the motor controller.
6. Verify that the motor controller is correctly fused for the application. Refer to the vehicle manufacturer's maintenance documentation for the correct fuse size.

7.2 Verifying motor controller readiness for operation

The following procedure can be used to verify that a motor controller is functional and able to communicate over CAN bus.

1. Apply logic power to motor controller by applying battery power to KEY_INPUT and verify that the red LED indicator on the motor controller is ON for a while.
2. Verify that the red LED indicator on the motor controller is in steady OFF condition.
3. If the indicator is flashing, it indicates an error/warning or other fault condition within the motor controller. Consult the Troubleshooting chapter (section 10), for possible causes and corrective actions.

7.3 Configuring motor controller for the application

Normally, motor controllers shipped for OEM series production are programmed during manufacture with the correct parameters and do not require any further configuration.
Please refer to the OEM documentation for any further setup required during vehicle commissioning.
Setting up a prototype controller for a new vehicle, within a vehicle development program, may require extensive parameterization and possibly also re-programming of the motor controller via the CAN bus.

7.4 Sequence for Ac Inverter setting

This section of the manual describes the basic ACEX/ COMBIACX set-up procedure using console:
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 by console. Remember to re-cycle the Key Switch if you make any changes to the chopper's configuration.

- Fill your setting with the Options you need.
- Select the Battery Voltage.
- Check that all command are functional. Use the Console's TESTER function to assist.
- Perform the analog signals acquisition procedure using the Console Procedure is detailed on paragraph 9.1.
- Set the "MAXIMUM CURRENT" Current parameter.
- Set the correct motor parameters (it is suggested to discuss them with Zapi technicians).
- Set the "performance parameters" (Acceleration delay, inversion braking, ecc).
- Set the Speed Reductions as required using the dedicated parameters
- Test the truck in all the operative condition (with/without load, on flat and on the maximum ramp)
- Make the choice for the truck behaviour.

8 PROGRAMMING & ADJUSTEMENT VIA CONSOLE

To access and adjust all parameters it is necessary to use the Zapi console. Since the ACEX / COMBIACX has no external serial connector three possible solution are available:

- To use the Zapi Smart Console connected to the Canbus line (ask directly to Zapi for the dedicated User Manual)
- To use the PC CAN Console software. This tool is more powerful than the standard serial console.The following paragraphs describe the controller configuration in the case the operator is using Zapi PC CAN console.
- To connect the Smart Zapi console (or old hand console) through a remote module, like a Zapi tiller card of a Zapi display. This module has to be connected to the same Canbus line of the inverter.

The Zapi Smart Console and PC CAN Console software are tool developed to improve setup and programming of all Zapi products installed in any application. It features a clean and easy-to-use interface in order to simplify access to parameters and troubleshooting.

See Appendix A and Appendix B to have a general general overview and basic knowledge about the use these tools

The Zapi Tools permits a deep control over the parameters and behaviour of Zapi controllers. Its use is restricted to engineers and well trained technicians!

8.1 Menu Overview

PARAMETER CHANGE
ACC. TORQUE DEL.
DEC. TORQUE DEL.
ACCELER. DELAY
RELEASE BRAKING
TILLER BRAKING
INVERS. BRAKING
DECEL. BRAKING
PEDAL BRAKING
SPEED LIMIT BRK.
STEER BRAKING
MAX SPEED FORW
MAX SPEED BACK
MAX SPEED LIFT
1ST PUMP SPEED
2ND PUMP SPEED
3RD PUMP SPEED
4TH PUMP SPEED
5TH PUMP SPEED
HYD PUMP SPEED
CUTBACK SPEED 1
CUTBACK SPEED 2
H&S CUTBACK
CURVE SPEED 1
CURVE CUTBACK
FREQUENCY CREEP
TORQUE CREEP
MAXIMUM CURRENT
ACC SMOOTH
INV SMOOTH
STOP SMOOTH
BRK SMOOTH
STOP BRK SMOOTH
BACKING SPEED
BACKING TIME
AUXILIARY TIME
ROLLING DW SPEED
HYDRO TIME
MIN EVP
MAX EVP
EVP OPEN DELAY
EVP CLOSE DELAY

SET OPTION
HM DISPLAY OPT.
HM CUSTOM 1 OPT.
HM CUSTOM 2 OPT.
TILL/SEAT SWITCH
EB ON TILLER BRK
BATTERY CHECK
STOP ON RAMP
QUICK INVERSION
HARD & SOFT
MAIN POT. TYPE
AUX POT. TYPE
SET MOT. TEMPERAT
EPS TYPE
M.C. FUNCTION
EBRAKE ON APPL.
AUX OUT FUNCTION
SYNCRO
AUTO PARK BRAKE
AUTO LINE CONT.
ACCEL MODULATION
EVP TYPE
EVP2 TYPE
EV1
EV2
EV3
HIGH DYNAMIC
HORN
INVERSION MODE
STEER TABLE
DISPLAY TYPE
ABS.SENS.ACQUIRE

ADJUSTMENT
MIN LIFT DC
MAX LIFT DC
MIN LOWER
MAX LOWER
SET BATTERY
ADJUST KEY VOLT
ADJUST BATTERY
SET POSITIVE PEB
THROTTLE 0 ZONE
THROTTLE X1 MAP
THROTTLE Y1 MAP
THROTTLE X2 MAP
THROTTLE Y2 MAP
THROTTLE X3 MAP
THROTTLE Y3 MAP
BAT. MIN ADJ.
BAT. MAX ADJ.
BDI ADJ STARTUP
BDI RESET
BATT.LOW THRESHLD
STEER RIGHT VOLT
STEER LEFT VOLT
STEER ZERO VOLT
MAX ANGLE RIGHT
MAX ANGLE LEFT
STEER DEAD ANGLE
STEER ANGLE 1
STEER ANGLE 2
SPEED FACTOR
SPEED ON MDI
LOAD HM FROM MDI
CHECK UP DONE
CHECK UP TYPE
MC VOLTAGE
MC VOLTAGE RED.
EB VOLTAGE
EB VOLTAGE RED.
PWM EV2
PWM EV3
MAX MOTOR TEMP.
TEMP. MOT. STOP
A.SENS.OFFSET SE
A.SENS.OFFSET CE
MAN.OFFSET ANGLE
MAN.OFFS.ANG.DEC

SPEC ADJUSTMENT
ADJUSTMENT #01
ADJUSTMENT #02
SET CURRENT
SET TEMPERATURE
HW BATTERY RANGE
DUTY PWM CTRAP
ADJUSTMENT #03
SET CURRENT PUMP
DITHER AMPLITUDE
DITHER FREQUENCY
HIGH ADDRESS
CAN BUS SPEED
DEBUG CANMESSAGE
CONTROLLER TYPE
SAFETY LEVEL
RS232 CONSOLLE
ID CANOPEN OFST
2ND SDO ID OFST

HARDWARE SETTING
TOP MAX SPEED
CONF. POSITIVE LC
FEEDBACK SENSOR
POSITIVE E.B.
ROTATION CW ENC
ROTATION CW MOT
ROTATION CW POS
ENCODER PULSES 1
ENCODER PULSES 2
MOTOR P. PAIRS 1
MOTOR P. PAIRS 2

DC PUMP
DC PUMP
HYDRO PUMP SPEED
HYDRO COMPENS.
PUMP IMAX
PU. ACCELER. DEL
PU. DECELER. DEL
MAX SPEED LIFTDC
LIFT DC CUTBACK
1ST PU.DC SPEED
2ND PU.DC SPEED
PU.DC CREEP SPD
PU.DC COMPENSAT.
PU. HYDRO TIME
HYDRO FUNCTION

8.1 Function configuration

In the following chapters, the parameters are presented as following indicated:

Parameter	Allowable range	Description
Name of the parameter as indicated in the CAN Console tool (Availability)	Allowable range of values for the parameter	Description of the parameter and, when applicable, suggestion of how to set it.

In the “Parameter” column, the availability field (between parentheses) is the list of controller types where the parameter is available. The followings code can be indicated:

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

The parameters and the functionalities described in the following paragraphs are referred to ZAPI Standard software. They could be different in any other customized software releases depending by customer requests.

8.1.1 Menu “SET OPTIONS” functions list

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
HM DISPLAY OPT. (T, TM, P, CO)	0 ÷ 6	This parameter decides the configuration for the hour meter shown on a display (i.e. MDI). The possible settings are the same described for HM CUSTOM 1 OPT. parameter.
HM CUSTOM 1 OPT. (T, TM, P, CO)	0 ÷ 6	This parameter decides the configuration for the customer hour meter no. 1. The possible settings are: **0:** The hour meter counts since the controller is on. **1:** The hour meter counts when the 3-phase power bridge is active **2:** The hour meter counts when the DC motor power bridge is active **3:** The hour meter counts when one of the valve outputs is active **4:** The hour meter counts when the 3-phase power bridge is active or the DC motor power bridge is active **5:** The hour meter counts when the DC motor power bridge is active or one of the valve outputs is active **6:** The hour meter counts when the 3-phase power bridge is active or the DC motor power bridge is active or one of the valve outputs is active
HM CUSTOM 2 OPT. (T, TM, P, CO)	0 ÷ 6	This parameter decides the configuration for the customer hour meter no. 2. The possible settings are the same described for HM CUSTOM 1 OPT. parameter.
TILL/SEAT SWITCH (T, TM, P)	HANDLE ÷ SEAT	This option handles the input A1 . This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. **HANDLE =** A1 is managed as tiller input (no delay when released). **DEADMAN =** A1 is managed as deadman input (no delay when released) **SEAT =** A1 is managed as seat input (with a delay when released, debouncing function)
EB ON TILLER BRK (T)	OFF ÷ ON	This option defines how it is managed the Electromechanical brake dependently by the status of Tiller input: **ON =** the Electromechanical brake is engaged as soon as the tiller input goes in OFF state. The deceleration ramp defined by “tiller braking” parameter has no effect. **OFF =** when the tiller input goes in OFF state the “tiller braking” ramp is applied before to engage the Electromechanical brake.

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
BATTERY CHECK (T, TM, P, CO)	0 ÷ 3	This option specifies the handling of the low battery charge detection. There are four levels: **0 =** Nothing happens, the battery charge level is calculated but is ignored, it means no action is taken when the battery is discharged. **1 =** BATTERY LOW alarm is raised when the battery level is calculated being less than or equal to 10% of the full charge. The BATTERY LOW alarm reduces the maximum speed down to 24% of the full speed and reduces the maximum current down to 50% of the full current. **2 =** BATTERY LOW alarm is raised when the battery level is calculated being less or equal to 10% of the full charge. **3 =** BATTERY LOW alarm is raised when the battery level is calculated being less or equal to 10% of the full charge. The BATTERY LOW alarm reduces the maximum speed down to 24% of the full speed.
STOP ON RAMP (T, TM, P, CO)	OFF ÷ ON	This parameter allows to enable or disable the functionality that electrically holds the track on a slope for a defined time. **ON =** the stop on ramp feature (truck electrically hold on a ramp) is managed for a time established by "AUXILIARY TIME" parameter. After this time, the behaviour depends on the "aux out function" option programming (see also Table 1). **OFF =** the stop on ramp feature is not performed. A controlled slowdown is performed for minimum time established by "AUXILIARY TIME" parameter. After this time, the behaviour depends on the "aux out function" option programming (see also Table 1).
QUICK INVERSION (T, TM, P)	NONE ÷ BELLY	This parameters allow to enable or disable the quick inversion functionality managed by A7 input. **NONE =** The quick inversion function is not managed (no effect when A7 switches over). **BRAKE =** the motor is braked **TIMED =** The quick inversion function is timed. When the functionality is activated by switching over of input A7 the controller drives the motor in the opposite direction for a fixed time (1,5sec as default) **BELLY =** The quick inversion function is managed but not timed. When the functionality is activated by switching over of input A7 the controller drives the motor in the opposite until the input A7 switches over again (not timed).
HARD & SOFT (T, TM)	OFF ÷ ON	Enable or disable the Hard & Soft functionality. With H&S, it is possible to turn the truck moving (at reduced speed) only by activating the H&S switch (A29 input), and the accelerator, without the tiller. **ON =** H&S function is enabled **OFF =** H&S function is disabled

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
MAIN POT. TYPE (T, TM)	0 ÷ 11	This parameter decides the type of the main pot (A15). The possible settings are: **0:** V-type pot , low to high value , with direction switches, without enable switch, without enable dead band **1:** V-type pot , low to high value , with direction switches, without enable switch, with enable dead band **2:** V-type pot , high to low value , with direction switches, without enable switch, without enable dead band **3:** V-type pot , high to low value , with direction switches, without enable switch, with enable dead band **4:** Z-type pot , low to high value , with direction switches, without enable switch, without enable dead band **5:** Z-type pot , low to high value , with direction switches, without enable switch, with enable dead band **6:** Z-type pot , low to high value , without direction switches, with enable switch, with enable dead band **7:** Z-type pot , low to high value , without direction switches, without enable switch, with enable dead band **8:** Z-type pot , high to low value , with direction switches, without enable switch, without enable dead band **9:** Z-type pot , high to low value , with direction switches, without enable switch, with enable dead band **10:** Z-type pot , high to low value , without direction switches, with enable switch, with enable dead band **11:** Z-type pot , high to low value , without direction switches, without enable switch, with enable dead band

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
AUX POT. TYPE (T, TM, TS, P)	0 ÷ 12	This parameter decides the type of the auxiliary pot (A30). The possible settings are: **0:** V-type pot , low to high value , with direction switches, without enable switch, without enable dead band **1:** V-type pot , low to high value , with direction switches, without enable switch, with enable dead band **2:** V-type pot , high to low value , with direction switches, without enable switch, without enable dead band **3:** V-type pot , high to low value , with direction switches, without enable switch, with enable dead band **4:** Z-type pot , low to high value , with direction switches, without enable switch, without enable dead band **5:** Z-type pot , low to high value , with direction switches, without enable switch, with enable dead band **6:** Z-type pot , lo to hi value , without direction switches, with enable switch, with enable dead band **7:** Z-type pot , low to high value , without direction switches, without enable switch, with enable dead band **8:** Z-type pot , high to low value , with direction switches, without enable switch, without enable dead band **9:** Z-type pot , high to low value , with direction switches, without enable switch, with enable dead band **10:** Z-type pot , high to low value , without direction switches, with enable switch, with enable dead band **11:** Z-type pot , high to low value , without direction switches, without enable switch, with enable dead band **12:** No pot, with direction switches, without enable switch
SET MOT. TEMPERAT (T, TM, P, CO)	NONE ÷ OPTION#2	Sets the motor temperature sensor type. **NONE =** no motor thermal sensor switch is connected. **DIGITAL =** a digital (ON/OFF) motor thermal sensor is connected to A22. **OPTION#1 =** an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance). **OPTION#2 =** an analogue motor thermal sensor is connected to A22. The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance).

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
EPS TYPE (T, TM)	NONE ÷ OPTION#2	It allows to select which type of EPS (Electric power steering) module is connected to the controller. **NONE =** NO EPS is present on the truck, CombiACX / ACEX doesn't wait for CAN message by the EPS and it does not apply EPS and braking steer cutback. **OPTION#1 =** EPS is present and it is an EPS-AC0, ENCODER + TOGGLE SWITCHES. **OPTION#2 =** EPS is present and it is an EPS-AC0, POT + ENCODER type.
M.C. FUNCTION (T, TM, P, CO)	OFF ÷ OPTION#2	It set the configuration for output A12 NLC (Negative Line Contactor): **OFF =** Main Contactor is not present. If is set OFF the diagnosis are masked and M.C. is not closed after controller Key-on **ON =** Main Contactor in standalone configuration **OPTION#1 =** Traction + Pump only one Main Contactor for both **OPTION#2 =** Traction + Pump with double Main Contactor. Each one manages its own main contactor.
EBRAKE ON APPL. (T, TM, P, CO)	ABSENT ÷ PRESENT	The parameter enables or disables the management of the electro mechanic brake: **ABSENT =** the diagnosis are masked and E.B. is not closed after a traction request **PRESENT =** the Electro mechanic Brake is driven after a traction request if all the related diagnosis pass
AUX OUT FUNCTION (A)	NONE ÷ BRAKE	It enables the output A4 (NEB): **NONE =** the diagnosis are masked and E.B. is not closed after a traction request. **BRAKE =** the Electro mechanic Brake is driven after a traction request if all the related diagnosis pass. The behaviour on a slope depends on the "STOP ON RAMP" setting as detailed in Table 1.
SYNCRO (CO)	OFF ÷ ON	It enables or disables the syncro message **OFF =** the syncro message is not used **ON =** the Syncro message is enabled
AUTO PARK BRAKE (CO)	OFF ÷ ON	It enables or disables the autonomous management of the Brake output: **OFF =** the output is activated or deactivated according by command received by CAN Bus **ON =** the output is manged autonomously by the controller itself ignoring any activation/deactivation command received by CAN Bus

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
AUTO LINE CONT. (CO)	OFF ÷ ON	It enables or disables the autonomous management of the Line Contatctor output: **OFF =** the output is activated or deactivated according to command received by CAN Bus **ON =** the output is manged autonomously by the controller itself ignoring any activation/deactivation command received by CAN Bus
ACCEL MODULATION (T, TM, P, CO)	OFF ÷ ON	Enable or disable the accel modulation function **OFF =** the acceleration ramp is only dependent by final speed setpoint and by Accel Delay **ON =** the acceleration ramp is re-scaled by software dependently by speed setpoint and by Accel Delay See Paragraph 9.4
EVP TYPE (A)	NONE ÷ DIGITAL	It defines how it has to be managed the output A24 (EVP1): **NONE =** output not enabled, no load connected on pin A24. **ANALOG =** the related output manages a proportional valve, PWM current controlled. **DIGITAL =** the related output manages an on/off valve. See the related parameter description in the menu “Parameter change”
EV1 (A)	ABSENT ÷ OPTION#2	It enables the control of output A9 (EV1): **ABSENT =** output not enabled, no load connected to A9. **OPTION#1 =** the output manages an ON/OFF valve. As default it is activated by 1st speed command **OPTION#2 =** free for future use.
EV2 (A)	ABSENT ÷ DIGITAL	It enables the control of output A11 (EV2) : **ABSENT =** output not enabled, no load connected to A11. **DIGITAL =** the output manages a PWM voltage controlled valve. The PWM frequency is 1kHz and the duty cycle depends by “PWM EV2” parameter (menu adjustment).
EV3 (A)	ABSENT ÷ DIGITAL	It enables the control of output A33 (EV3) : **ABSENT =** output not enabled, no load connected to A33. **DIGITAL =** the output manages a PWM voltage controlled valve. The PWM frequency is 1KHz and the duty cycle depends by “PWM EV3” parameter (menu adjustment).

SET OPTIONS menu		
Parameter	**Allowable range**	**Description**
HIGH DYNAMIC (T, TM, P, CO)	OFF ÷ ON	It enables the High Dynamic function: **ON =** all the ramp set by dedicated parameters are ignored and the controller work always with maximum performance. **OFF =** standard behaviour
HORN (A)	ABSENT ÷ DIGITAL	It enables the control of output A26 (HORN) : **ABSENT =** output not enabled, no load connected to A26 **DIGITAL =** the related output manages an ON/OFF valve.
INVERSION MODE (T, TM)	OFF ÷ ON	This parameter sets the logic of the Quick Inversion input (A7): **ON =** the Quick Inversion switch is Normally Closed (function active when switch opens). **OFF =** the Quick Inversion switch is Normally Open (function active when switch closes).
STEER TABLE (TM)	OPTION#1 ÷ OPTION#3	It enables a pre-defined steer table: **OPTION#1 =** 3-Wheel steer table 1 **OPTION#2 =** 3-Wheel steer table 2 **OPTION#3=** 4-Wheel steer table 2 **The steering table depends by Truck geometry. The three options available as default could not fit the requirements of your truck.** **It is strongly recommended to consult Zapi technicians in order to establish if a default table can be used or if a proper steering table has to be created.**
DISPLAY TYPE (T, TM, P)	0 ÷ 9	This parameter decides which display is connected to the inverter. **0 =** No Display **1 =** MDI PRC connected **2 =** ECO DISPLAY connected **3 =** SMART DISPLAY connected **4 =** MDI CAN connected **5..9 =** Available for future developments
ABS.SENS.ACQUIRE (Only for BLE0 with sin/cos or PWM sens) (A)	OFF ÷ ON	This parameters activates the acquisition of motor speed sensor used for PMSM (Permanent Magnets Synchronous Motor). **Ask to Zapi Technicians for a detailed description of acquisition procedure.**

AUX OUTPUT	STOP ON RAMP	A4 OUTPUT	BEHAVIOUR ON A SLOPE
BRAKE	**ON**	It 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 really installed.**
BRAKE	**OFF**	It 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.**

Table 1: Behaviour on a slope

***IMPORTANT NOTE**: the EV5 could be not available depending by hardware configuration even if the parameter is set to PRESENT.*

8.1.2 Menu “ADJUSTMENTS” functions list

ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
MIN LIFT DC **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (step of 0.1V)	It records the minimum value of lifting potentiometer when the lift switch is closed. **See paragraph 9.2**
MAX LIFT DC **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (step of 0.1V)	It records the minimum value of lifting potentiometer when the lift switch is closed. **See paragraph 9.2**
MIN LOWER **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (step of 0.1V)	It records the minimum value of lower potentiometer when the lower switch is closed. **See paragraph 9.2**
MAX LOWER **(Read Only)** (T, TM, TS, P)	0V ÷ 25.5V (step of 0.1V)	It records the maximum value of lower potentiometer when the lower switch is closed. **See paragraph 9.2**
SET BATTERY (A)	24V ÷ 80V	This parameter must be set to the nominal battery voltage. The available options are: **24V 36V 48V**
ADJUST KEY VOLT (A)		Fine adjustment of the key voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
ADJUST BATTERY (A)		Fine adjustment of the battery voltage measured by the controller. Calibrated by Zapi production department during the end of line test.
SET POSITIVE PEB (A)	12V ÷ 80V	It permits to set the voltage supply value connected to CNA-3. The available values are: **12V 24V 36V 40V 48V**
THROTTLE 0 ZONE (T, TM, P)	0% ÷ 100% (step of 1%)	It establishes a deadband in the accelerator input curve. **See paragraph 9.8**
THROTTLE X1 MAP (T, TM, P)	0% ÷ 100% (step of 1%)	This parameter changes the characteristic of the accelerator input curve **See paragraph 9.8**
THROTTLE Y1 MAP (T, TM, P)	0% ÷ 100% (step of 1%)	This parameter changes the characteristic of the accelerator input curve. **See paragraph 9.8**
THROTTLE X2 MAP (T, TM, P)	0% ÷ 100% (step of 1%)	This parameter changes the characteristic of the accelerator input curve **See paragraph 9.8**

ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
THROTTLE Y2 MAP (T, TM, P)	0% ÷ 100% (step of 1%)	This parameter changes the characteristic of the accelerator input curve. **See paragraph 9.8**
THROTTLE X3 MAP (T, TM, P)	0% ÷ 100% (step of 1%)	This parameter changes the characteristic of the accelerator input curve. **See paragraph 9.8**
THROTTLE Y3 MAP (T, TM, P)	0% ÷ 100% (step of 1%)	This parameter changes the characteristic of the accelerator input curve. **See paragraph 9.8**
BAT. MIN ADJ. (T, TM, P, CO)	-12.8% ÷ 12.7% (step of 0.1%)	It adjusts the lower level of the battery discharge table. It is used to calibrate the discharge algorithm with the battery of the application. **See paragraph 9.10**
BAT. MAX ADJ. (T, TM, P, CO)	-12.8% ÷ 12.7% (step of 0.1%)	It adjusts the upper level of the battery discharge table. It is used to calibrate the discharge algorithm with the battery of the application. **See paragraph 9.10**
BDI ADJ STARTUP (T, TM, P, CO)	-12.8% ÷ 12.7% (step of 0.1%)	Adjusts the level of the battery charge table at startup, in order to calculate the battery charge at keyon. **See paragraph 9.10**
BDI RESET (T, TM, P, CO)	0% ÷ 100% (step of 1%)	It adjusts the minimum variation of the battery discharge table to update the battery % at the start up. It is used to calibrate the discharge algorithm with the battery of the application. **See paragraph 9.10**
BATT.LOW THRESHLD (T, TM, P, CO)	1% ÷ 50% (step of 1%)	It defines the minimum percentage of charge under that the Battery low alarms rises.
STEER RIGHT VOLT (T,TM)	0V ÷ 25.5V (step of 0.1V)	It records the maximum value of steering command in right turning **See paragraph 9.3**
STEER LEFT VOLT (T,TM)	0V ÷ 25.5V (step of 0.1V)	It records the maximum value of steering command in left turning **See paragraph 9.3**
STEER ZERO VOLT (T,TM)	0V ÷ 25.5V (step of 0.1V)	It records the maximum value of steering command in straight head position **See paragraph 9.3**
MAX ANGLE RIGHT (T,TM)	0° ÷ 90° (step of 1°)	It defines the maximum angle of steered wheel in right turning .
MAX ANGLE LEFT (T,TM)	0° ÷ 90° (step of 1°)	It defines the maximum angle of steered wheel in right turning

ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
STEER DEAD ANGLE (T, TM)	1° ÷ 50° (step of 1°)	It defines the maximum steered wheel angle up to which the traction speed permitted is 100%. **See paragraph 9.7**
STEER ANGLE 1 (T, TM)	1° ÷ 90° (step of 1°)	It defines the steered wheel angle at that the traction speed is reduced to CURVE SPEED 1. In between STEER DEAD ANGLE and STEER ANGLE 1 the traction speed is reduce linearly from 100% to CURVE SPEED 1. **See paragraph 9.7**
STEER ANGLE 2 (T, TM)	1° ÷ 90° (step of 1°)	It defines the steered wheel angle after that the traction speed is reduced to CURVE CUTBACK. In between STEER ANGLE1 and STEER ANGLE 2 the traction speed is reduce linearly from CURVE SPEED 1 to CURVE CUTBACK **See paragraph 9.7**
SPEED FACTOR (T, TM, CO)	0 ÷ 255 (step of 1)	Speed factor coefficient. It has to be set in order to have the correct speed visualization. The formula used internally by the software to transduce the speed frequency (expressed in Hz) in km/h is the following: $Km/_h = \frac{Hz \cdot 10}{Speed\ Factor}$
SPEED ON MDI (T, TM, CO)	OFF ÷ ON	It enables the speed visualization on MDI display: **ON =** MDI shows traction speed when the truck is moving. In steady-state condition the speed indication is replaced by hour meter indication. **OFF =** Standard MDI functionality.
LOAD HM FROM MDI (T, TM, P, CO)	OFF ÷ ON	Allows to enable or disable the hour meter transfer to the MDI. **OFF =** The HourMeter of the Controller is not transferred and recorded on the HourMeter of the Standard MDI **ON =** The HourMeter of the Controller is transferred and recorded on the HourMeter of the Standard MDI (connected on the Serial Link).
CHECK UP DONE (T, TM, P, CO)	OFF ÷ ON	Turn it On when the required Maintenance service has been executed to cancel the CHECK UP NEEDED warning.

ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
CHECK UP TYPE (T, TM, P, CO)	NONE ÷ OPTION#3	It specifies the handling of the CHECK UP NEEDED warning: **NONE =** No CHECK UP NEENED warning **OPTION#1 =** CHECK UP NEENED warning shown on the hand set and MDI after 300 hours **OPTION#2 =** Equal to OPTION#1 but Speed reduction after 340 hours **OPTION#3 =** Equal to OPTION#2 but the truck definitively stops after 380 hours
MC VOLTAGE (A)	0% ÷ 100% (step of 1%)	It specifies the duty cycle (t_{on}) of the PWM applied to the output A12 during the first 1 second after the activation command in order to close the main contactor.
MC VOLTAGE RED. (A)	0% ÷ 100% (step of 1%)	It specifies the percentage of MC VOLTAGE parameter and it determines the duty cycle applied after the first second to keep the contactor closed. **Example 1** MC VOLTAGE = 100% MC VOLTAGE RED = 70% The contactor will be closed applying a 100% of duty cycle to the coil and then the duty cycle will be reduced to 70%. **Example 2** MC VOLTAGE = 70% MC VOLTAGE RED. = 100% The contactor will be closed applying a 70% of duty cycle to the coil and then the voltage will be kept at the same value. **Example 3** MC VOLTAGE = 70% MC VOLTAGE RED = 70% The contactor will be closed applying a 70% of duty cycle to the coil and then the duty cycle will be reduced to 49%.
EB VOLTAGE (A)	0% ÷ 100% (step of 1%)	It specifies the duty cycle (t_{on}) of the PWM applied to the output A4 during the first 1 second after the activation command in order to release the electromechanical brake.

ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
EB VOLTAGE RED. (A)	0% ÷ 100% (step of 1%)	It specifies the percentage of EB VOLTAGE parameter, supplied to EB coil to keep the electro mechanic brake applied. **Example 1** EB VOLTAGE = 100% EB VOLTAGE RED = 70% The electromechanical brake will be released applying a 100% of duty cycle to the coil and then the duty cycle will be reduced to 70%. **Example 2** EB VOLTAGE = 70% EB VOLTAGE RED. = 100% The electromechanical brake will be released applying a 70% of duty cycle to the coil and then the voltage will be kept at the same value. **Example 3** MC VOLTAGE = 70% MC VOLTAGE RED = 70% The electromechanical brake will be released applying a 70% of duty cycle to the coil and then the duty cycle will be reduced to 49%.
PWM EV2 (A)	0% ÷ 100% (255 steps)	It defines the duty cycle of the PWM signal applied on the EV2.
PWM EV3 (A)	0% ÷ 100% (255 steps)	It defines the duty cycle of the PWM signal applied on the EV3.
MAX MOTOR TEMP. (T, TM, P, CO)	60°C ÷ 175°C (step of 1°C)	It defines the motor temperature above that it is applied a cutback of 50% to the maximum current. This cutback is valid only in motoring features; during braking the 100% of the maximum current is always available independently by the temperature.
TEMP. MOT. STOP (T, TM, P, CO)	60°C ÷ 190°C (step of 1°C)	It defines the maximum motor temperature permitted. Over this limit the controller will stop to drive the motor.
A.SENS.OFFSET SE (Only for BLE0 with sin/cos sens) (A)	Volt	It is are the values of the acquired voltage offset at the sine analog inputs during the autoteaching procedure. It can be compared with the values of the A.SENS.OFFSET SR entry
A.SENS.OFFSET CE (Only for BLE0 with sin/cos sens) (A)	Volt	It is are the values of the acquired voltage offset at the cosine analog inputs during the autoteaching procedure. It can be compared with the values of the A.SENS.OFFSET CR entry
MAN.OFFSET ANGLE (Only for BLE0) (A)	0-180 Degree (step of 1°)	This parameter , together with MAN.OFFS.ANG.DEC, gives the possibility to manually adjust the angle offset between the absolute position sensor and the PMSM rotor orientation. The unit is degrees and the max value is 180°.

ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
MAN.OFFS.ANG.DEC (Only for BLE0) (A)	0-9 tenths of Degree (step of 0.1°)	This parameter , together with MAN.OFFS.ANG.DEC, gives the possibility to manually adjust the angle offset between the absolute position sensor and the PMSM rotor orientation. The unit is tenths of degrees and the max value is 9 (0.9°).

8.1.3 Menu “PARAMETER CHANGE” functions list

PARAMETER CHANGE menu		
Parameter	**Allowable range**	**Description**
ACC. TORQUE DEL. (T, TM, P, CO)	0.1sec ÷ 10sec (step of 0.1sec)	It determines the acceleration ramp when “torque control” is set to ON. The parameter sets the time needed to increase the torque from minimum value up to the maximum.
DEC. TORQUE DEL. (T, TM, P, CO)	0.1sec ÷ 10sec (step of 0.1sec)	It determines the deceleration ramp when “torque control” is set to ON. The parameter sets the time needed to move from maximum torque down to minimum torque.
ACCELER. DELAY (T, TM, P, CO)	0.1sec ÷ 25.5sec (step of 0.1sec)	It determines the acceleration ramp. The parameter sets the time needed to speed up the traction motor from 0Hz to 100Hz. A special software features manages the acceleration ramp depending by speed set point (see explanation Graph at the end of paragraph)
RELEASE BRAKING (T, TM, P, CO)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when the travel request is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed (see explanation Graph at the end of paragraph).
TILLER BRAKING (T, TM)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when the tiller switch is released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed (see explanation Graph at the end of paragraph).
INVERS. BRAKING (T, TM, CO)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when the direction switch is inverted during travel. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed (see explanation Graph at the end of paragraph).
DECEL. BRAKING (T, TM, CO)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when the accelerator has turned down but not completely released. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed and final speed set point (see explanation Graph at the end of paragraph).
PEDAL BRAKING (T, TM, CO)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when the braking pedal position is pressed. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed (see explanation Graph at the end of paragraph).

PARAMETER CHANGE menu		
Parameter	**Allowable range**	**Description**
SPEED LIMIT BRK. (T, TM)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when a speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed and final speed set point (see explanation Graph at the end of paragraph).
STEER BRAKING (T, TM)	0.1sec ÷ 25.5sec (step of 0.1sec)	It controls the deceleration ramp when a speed reduction has been activated. The parameter sets the time needed to decelerate the traction motor from 100Hz to 0Hz. A special software features manages the deceleration ramp depending by starting speed and final speed set point (see explanation Graph at the end of paragraph).
MAX SPEED FORW (T, TM)	0% ÷ 100% (step of 1%)	It determines the maximum speed in forward direction. Percentage of the TOP MAX SPEED parameter.
MAX SPEED BACK (T, TM)	0% ÷ 100% (step of 1%)	It determines the maximum speed in backward direction. Percentage of the TOP MAX SPEED parameter.
MAX SPEED LIFT (P)	0% ÷ 100% (step of 1%)	It determines the maximum speed of the pump during a lift request. Percentage of the maximum voltage applied to the pump motor.
1ST PUMP SPEED (P)	0% ÷ 100% (step of 1%)	Defines the pump speed when the 1st speed request input is active. Percentage of the maximum pump speed.
2ND PUMP SPEED (P)	0% ÷ 100% (step of 1%)	Defines the pump speed when the 2nd speed request input is active. Percentage of the maximum pump speed.
3RD PUMP SPEED (P)	0% ÷ 100% (step of 1%)	Defines the pump speed when the 3rd speed request input is active. Percentage of the maximum pump speed.
4TH PUMP SPEED (P)	0% ÷ 100% (step of 1%)	Defines the pump speed when the 4th speed request input is active. Percentage of the maximum pump speed.
5TH PUMP SPEED (P)	0% ÷ 100% (step of 1%)	Defines the pump speed when the 5th speed request input is active. Percentage of the maximum pump speed.
HYD PUMP SPEED (P)	0% ÷ 100% (step of 1%)	Fine adjustment of the pump motor steering function speed when the parameter “HYDRO FUNCTION” is set to ON. Percentage of the maximum pump speed.
CUTBACK SPEED 1 (T, TM, P)	10% ÷ 100% (step of 1%)	Speed reduction when the cutback input 1 is active. Percentage of the TOP MAX SPEED parameter. When set to 100% the speed reduction is ineffective.
CUTBACK SPEED 2 (T, TM, P)	10% ÷ 100% (step of 1%)	Speed reduction when the cutback input 2 is active. Percentage of the TOP MAX SPEED parameter. When set to 100% the speed reduction is ineffective.

PARAMETER CHANGE menu		
Parameter	**Allowable range**	**Description**
H&S CUTBACK (T, TM)	10% ÷ 100% (step of 1%)	It determines the percentage of the TOP MAX SPEED parameter applied when the Hard & Soft function, pin A29, is active. When set to 100% the speed reduction is ineffective.
CURVE SPEED 1 (T, TM)	0% ÷ 100% (step of 1%)	It set the maximum speed when the steering angle correspond to the angle set by the parameter STEER ANGLE 1. Percentage of the TOP MAX SPEED parameter.
CURVE CUTBACK (T, TM)	1% ÷ 100% (step of 1%)	It set the maximum speed when the steering angle correspond to the angle set by the parameter STEER ANGLE 2. Percentage of the TOP MAX SPEED parameter.
FREQUENCY CREEP (T, TM, P)	0.6Hz ÷ 25Hz (step of 0.1Hz)	Minimum speed when the forward or reverse switch is closed, but the accelerator is at the a minimum value.
TORQUE CREEP (T, TM, P, CO)	0% ÷ 100% (step of 1/255)	Minimum torque when torque control is enabled and the forward or reverse switch is closed, but the accelerator is on a minimum position.
MAXIMUM CURRENT (T, TM, P, CO)	0% ÷ 100% (step of 1%)	This parameter changes the maximum current for the traction motor. Percentage of the factory calibrated maximum current.
ACC SMOOTH (T, TM, P, CO)	1 ÷ 5 (step of 0.1)	It gives a parabolic form to the acceleration ramp near to 0rpm. 1 means linear ramp, higher the value smoother the acceleration ramp.
INV SMOOTH (T, TM, CO)	1 ÷ 5 (step of 0.1)	It gives a parabolic form to the acceleration ramp near to 0rpm. 1 means linear ramp, higher the value smoother the ramp across 0 rpm.
STOP SMOOTH (T, TM, P, CO)	3Hz ÷ 100Hz (step of 1Hz)	It sets the level of frequency where the smooth effect of the acceleration parabolic form ends.
BRK SMOOTH (T, TM, CO)	1 ÷ 5 (step of 0.1)	It gives a parabolic form to the deceleration ramp. 1 means linear ramp, higher the value smoother the ramp close to 0 rpm.
STOP BRK SMOOTH (T, TM, CO)	3Hz ÷ 100Hz (step of 1Hz)	It sets the level of frequency where the smooth effect of the deceleration parabolic form ends.
BACKING SPEED (T, TM)	0% ÷ 100% (step of 1%)	This is the percentage of the TOP MAX SPEED parameter that the traction can reach when the inching function is active.
BACKING TIME (T, TM)	0sec ÷ 10sec (step of 0.1sec)	Set the duration of the inching function
AUXILIARY TIME (T, TM, P, CO)	0sec ÷ 10sec (step of 0.1sec)	For the encoder version, it determines the time duration the truck is hold on the ramp if the STOP ON RAMP option is ON.

PARAMETER CHANGE menu		
Parameter	**Allowable range**	**Description**
ROLLING DW SPEED (T, TM, P, CO)	1Hz ÷ 50Hz (step of 1Hz)	It determines the maximum speed for the rolling down function.
HYDRO TIME (P)	0sec ÷ 20sec (step of 0.1sec)	It specifies how much time the hydro guide must remain active after the traction command has been released.
MIN EVP (A)	0% ÷ 100% (step of 1/255)	This parameter determines the minimum current applied on the EVP when the position of the potentiometer is at the minimum. This parameter is not effective if the EVP is programmed like an On/Off valve.
MAX EVP (A)	0% ÷ 100% (step of 1/255)	This parameter determines the maximum current applied to the EVP when the position of the potentiometer is at the maximum. This parameter also determines the current value when the EVP is programmed like an ON/OFF valve.
EVP OPEN DELAY (A)	0sec ÷ 12.75sec (step of 0.05sec)	It determines the acceleration ramp on EVP. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE DELAY (A)	0sec ÷ 12.75sec (step of 0.05sec)	It determines the deceleration ramp on EVP. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
MIN EVP2 (A)	0% ÷ 100% (step of 1/255)	This parameter determines the minimum current applied on the EVP2 when the position of the potentiometer is at the minimum. This parameter is not effective if the EVP2 is programmed like an On/Off valve.
MAX EVP2 (A)	0% ÷ 100% (step of 1/255)	This parameter determines the maximum current applied to the EVP2 when the position of the potentiometer is at the maximum. This parameter also determines the current value when the EVP2 is programmed like an ON/OFF valve.
EVP2 OPEN DELAY (A)	0sec ÷ 12.75sec (step of 0.05sec)	It determines the acceleration ramp on EVP2. The parameter sets the time needed to increase the current to the maximum possible value.
EVP2 CLOSE DELAY (A)	0sec ÷ 12.75sec (step of 0.05sec)	It determines the deceleration ramp on EVP2. The parameter sets the time needed to decrease the current from the maximum possible value to zero.

After changing, press STORE to save data.

8.1.4 Parameters for DC PUMP control

Since the CombiACX has the possibility to drive an AC motor and a DC pump motor simultaneously, the PARAMETER CHANGE menu has these additional parameters specific for the DC pump control.

DC PUMP menu (pump parameters)		
Parameter	**Allowable range**	**Description**
DC PUMP (A)	OFF ÷ ON	It manges the DC chopper: **OFF =** only AC three phases traction controller (ACEX) **ON =** AC three phases traction controller + DC pump chopper (CombiACX)
HYDRO PUMP SPEED (A)	0% ÷ 100% (step of 1)	It sets the maximum speed of the Hydro function. Percentage of the maximum voltage applied to the pump motor.
HYDRO COMPENS. (A)	0% ÷ 100% (step of 1%)	This parameter sets the voltage compensation (ΔV) applied to the motor when the Hydro function is active. The value of this ΔV applied to the motor is a function of the motor current. Aim of this function is to keep the speed constant in different operating conditions.
PUMP IMAX (A)	0% ÷ 100% (step of 1%)	It defines the maximum current for the DC pump chopper.
PU. ACCELER. DEL (A)	0.1sec ÷ 25.5sec (step of 0.1sec)	It defines the acceleration ramp for the pump motor.
PU. DECELER. DEL (A)	0.1sec ÷ 25.5sec (step of 0.1sec)	It defines the deceleration ramp for the pump motor.
MAX SPEED LIFTDC (A)	0% ÷ 100% (step of 1%)	It limits the maximum speed of the lifting function. Percentage of the maximum voltage applied to the pump motor.
LIFT DC CUTBACK (A)	0% ÷ 100% (step of 1%)	It limits the maximum speed of the lifting cutback function. Percentage of the maximum voltage applied to the pump motor.
1ST PU.DC SPEED (A)	0% ÷ 100% (step of 1%)	It limits the maximum speed of the 1st function. Percentage of the maximum voltage applied to the pump motor.
2ND PU.DC SPEED (A)	0% ÷ 100% (step of 1%)	It limits the maximum speed of the 2nd function. Percentage of the maximum voltage applied to the pump motor.
PU.DC CREEP SPD (A)	0% ÷ 100% (step of 1%)	It sets the minimum speed for the pump motor. Percentage of the maximum voltage applied to the pump motor when the Lift SW is closed.

DC PUMP menu (pump parameters)		
Parameter	**Allowable range**	**Description**
PU.DC COMPENSAT. (A)	0% ÷ 100% (step of 1%)	This parameter sets the voltage compensation (ΔV) applied to the motor when the proportional lifting function is active. The value of this ΔV applied to the motor is a function of the motor current. Aim of this function is to reduce, as far as possible, the speed difference between the truck loaded and unloaded.
PU. HYDRO TIME (A)	0sec ÷ 20sec (step of 0.1sec)	It defines the time duration in that the pump motor is driven after the hydraulic request is released.
HYDRO FUNCTION (A)	NONE ÷ RUNNING	**NONE:** the Hydro function is never activated **KEYON:** the Hydro function is always active **RUNNING**: the Hydro function is activated only when the traction is moving

8.1.5 Menu "SPECIAL ADJUSTMENTS" functions list

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

<table>
<tr><th colspan="3">SPECIAL ADJUSTMENTS menu</th></tr>
<tr><th>Parameter</th><th>Allowable range</th><th>Description</th></tr>
<tr><td>ADJUSTMENT #01
(Read Only)
(A)</td><td>0% ÷ 255%
(step of 1%)</td><td>(Factory adjusted). This is the Gain of the first Current Sensing Amplifier of traction motor.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>ADJUSTMENT #02
(Read Only)
(A)</td><td>0% ÷ 255%
(step of 1%)</td><td>(Factory adjusted). This is the Gain of the second Current Sensing Amplifier of traction motor.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>SET CURRENT
(Read Only)
(A)</td><td>220A ÷ 350A or
180A ÷ 320A</td><td>(Factory adjusted). This is the traction motor maximum current. The available values are:
<table>
<tr><td>220Arms</td><td>320Arms</td><td>350Arms</td><td>24V controllers</td></tr>
<tr><td>180Arms</td><td>280Arms</td><td>320Arms</td><td>36V/48Vcontrollers</td></tr>
<tr><td>200Arms</td><td></td><td></td><td>80V controllers</td></tr>
</table></td></tr>
<tr><td>SET TEMPERATURE
(A)</td><td>0°C ÷ 255°C
(step of 1°C)</td><td>(Factory adjusted). Set the temperature offset to have the correct value reading. This is a fine calibration of the controller temperature sensor.</td></tr>
</table>

<table>
<tr><th colspan="3">SPECIAL ADJUSTMENTS menu</th></tr>
<tr><th>Parameter</th><th>Allowable range</th><th>Description</th></tr>
<tr><td>HW BATTERY RANGE
(Read Only)
(T, TM, P, CO)</td><td>0 ÷ 1
(step of 1)</td><td>Reserved.
NOTE: only Zapi technicians can change this value.</td></tr>
<tr><td>DUTY PWM CTRAP
(Read Only)
(A)</td><td>0% ÷ 100%</td><td>(Factory adjusted). The duty cycle for overcurrent threshold. This parameter is reserved.</td></tr>
<tr><td>ADJUSTMENT #03
(Read Only)
(A)</td><td>0% ÷ 255%</td><td>(Factory adjusted). This is the Gain of the Current Sensing Amplifier of pump motor.
NOTE: only Zapi technicians can change this value through a special procedure.</td></tr>
<tr><td>SET CURRENT PUMP
(Read Only)
(A)</td><td>270A ÷ 400A or
220A ÷ 300A</td><td>(Factory adjusted). This is the pump motor maximum current. The available values are:
<table><tr><td>270A</td><td>300A</td><td>400A</td><td>24V controllers</td></tr><tr><td>220A</td><td>300A</td><td></td><td>36V/48Vcontrollers</td></tr></table></td></tr>
<tr><td>DITHER AMPLITUDE
(A)</td><td>0% ÷ 13%</td><td>It is the dither signal amplitude. The dither signal is a square wave which is overlapped to the proportional valves set point. In this way the proportional valves response to set point variations is optimized. This parameter is a percentage of the valves maximum current. Setting the parameter to 0% means the dither isn’t used.The available values are:
0.0% 1.0% 2.5% 4.0% 5.5% 7.0% 8.5% 10% 11.5% 13.0%</td></tr>
<tr><td>DITHER FREQUENCY
(A)</td><td>20.8Hz ÷ 83.3Hz</td><td>It is the dither signal frequency. The available values are:
20.8 22.7 25 27.7 31.2 35.7 41.6 50 62.5 83.3</td></tr>
<tr><td>HIGH ADDRESS
(A)</td><td>0 ÷ 4</td><td>Reserved. Used to have access to special memory address. NOTE: only Zapi technicians can change this value.</td></tr>
<tr><td>CAN BUS SPEED
(A)</td><td>20Kbs ÷ 500Kbs</td><td>It set the CAN bus speed. The available options are the following:
20 50 125 250 500</td></tr>
<tr><td>DEBUG CANMESSAGE
(A)</td><td>OFF ÷ ON</td><td>Reserved. Used to activate special debug messages</td></tr>
<tr><td>CONTROLLER TYPE
(A)</td><td>0 ÷ 9</td><td>Reserved.
NOTE: only Zapi technicians can change this value.</td></tr>
</table>

SPECIAL ADJUSTMENTS menu		
Parameter	**Allowable range**	**Description**
SAFETY LEVEL (T, TM, P, CO)	0 ÷ 3	Defines the safety level of the controller (i.e. the functionality of the supervisor microcontroller) **0 =** the Supervisor µC does not check any signal **1 =** the Supervisor µC checks the inputs and the outputs **2 =** the Supervisor µC checks the inputs and the set-point of the motor **3 =** the Supervisor µC checks the inputs, the outputs and the set-point of the motor.
RS232 CONSOLLE (A)	OFF ÷ ON	Reserved. Used to enable parameter changing using serial interface NOTE: only Zapi technicians can change this value.
ID CANOPEN OFST (CO)	0 ÷ 56 (step of 8)	Defines the offset of the CANopen frame IDs.
2ND SDO ID OFST (A)	0 ÷ 126 (step of 2)	It decides if another SDO channel communication has to be added. Specify an ID offset different from 0 to enable channel.

8.1.6 Menu “TESTER” functions list

The TESTER functions are a real time feedback measurements of the state of the controller/motor/command devices. It is possible to know the state (active / off) of the digital I/Os, the voltage value of the analog inputs and the state of the main variables used in the motor and hydraulics control. Enter in “Function” -> “Tester”.

8.1.6.1 Tester menu for master microcontroller

The following table lists the master microcontroller data that is possible to view form the tester menu.

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
KEY VOLTAGE (A)	Volt (0.1V)	Key voltage value measured in real time (pin A10).
BATTERY VOLTAGE (A)	Volt (0.1V)	Battery voltage value measured in real time (DC bus).
MOTOR VOLTAGE (A)	% (1%)	It is the phase to phase voltage applied by the inverter to the motor expressed in percentage. 100% means maximum sine wave width; 0% means the sine wave width is null.

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
INDEX OVERMOD. **(Only for ACEX)** (A)	% (1%)	It is an indication about the correction applied to the motor voltage theoretical set point in order to over-modulate or compensate the battery voltage drop. The actual motor voltage applied is the product between “Motor Voltage” and “Index Overmod”:
FREQUENCY (A)	Hertz (0.1Hz)	This is the frequency of the sine waves the inverter is supplying.
MEASURED SPEED (A)	Hertz (0.1Hz)	This is the speed of the motor measured with the encoder and expressed in the same unit of the FREQUENCY reading.
SLIP VALUE (A)	Hertz (0.01Hz)	This is the slip between the frequency and the speed of the motor $Slip[Hz] = Frequency - Encoder$
CURRENT RMS (A)	Ampere (1A)	Root Mean Square value of the line current in the traction motor. $Current\ [Arms] = \sqrt[2]{{I_Q}^2 + {I_D}^2}$
ID FILTERED RMS (A)	Ampere (1A)	Root Mean Square value of the current in d axle.
IQ FILTERED RMS (A)	Ampere (1A)	Root Mean Square value of the current in q axle.
IQ IMAX LIMIT (A)	Ampere (1A)	Root Mean Square maximum value of the current in q axle according to parameters set.
MOT. POWER WATT (A)	Watt (1W)	Estimated power supplied to the motor.
FLUX WB/1000 (A)	milliWeber (0.1mWb)	Estimated flux into the traction motor.
MOTION TORQUE (A)	NewtonMeter (0.1Nm)	Estimated motion torque value.
STEER ANGLE (T, TM)	Degrees (1°)	Current steered wheel angle. 0° when the wheels are straight ahead.
BATTERY CHARGE (A)	% (1%)	It shows the residual charge of the battery as a percentage of the full charge level.
TEMPERATURE (A)	°C (1°C)	This is the temperature of the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm detection.

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
MOTOR TEMPERAT. (A)	°C (1°C)	This is the temperature of the motor windings picked up with an analog sensor inside the motor. Normally the sensor is a PTC Philips KTY84-130. This temperature is used only to raise a warning when the motor temperature overtakes the MOTOR OVERTEMP setting.
DC PUMP CURRENT (A)	Ampere (1A)	DC current in the pump motor.
DC PUMP VMN (A)	% (1%)	It is the voltage applied to the pump motor. It is the duty cycle of the PWM applied to the the motor and is expressed in percentage.
DI0-A1 TILLER SW (T, TM, TS)	OFF/ON	It is the status of the Digital Input on CNA-1
DI1-A7 QI/PB SW (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-7
DI2-A6 HS SW (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-6
DI3-A32 FW SW (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-32
DI3-A32 ENABLE (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-32
DI4-A31 BW SW (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-31
DI3-A32 FW-INCH (TS)	OFF/ON	It is the status of the Digital Input on CNA-32
DI4-A31 BW-INCH (TS)	OFF/ON	It is the status of the Digital Input on CNA-31
DI5-A19 HORN **(Only for ACEX)** (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-19
DI5-A19 LOWER DC **(Only for BLE0)** (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-19
DI6-A20 LOWER DC **(Only for ACEX)** (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-20

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
DI7-A35 LFT/E DC (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-35
DI7-A35 ENAB. DC (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-35
DI8-A17 SPD1 DC (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-17
DI9-A29 PURID DC (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-29
DI10-A16 SPD2 DC (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-16
DI11-A18 CUTBAC1 (Only for ACEX) (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-18
DI12-A21 CUTBAC2 (Only for ACEX) (T, TM)	OFF/ON	It is the status of the Digital Input on CNA-21
DI0-A1 SEAT SW (P)	OFF/ON	It is the status of the Digital Input on CNA-1
DI1-A7 SPD1 SW (P)	OFF/ON	It is the status of the Digital Input on CNA-7
DI2-A6 HYDRO SW (P)	OFF/ON	It is the status of the Digital Input on CNA-6
DI3-A32 LFT/E SW (P)	OFF/ON	It is the status of the Digital Input on CNA-32
DI4-A31 LOWER SW (P)	OFF/ON	It is the status of the Digital Input on CNA-31
DI5-A19 SPD2 SW (P)	OFF/ON	It is the status of the Digital Input on CNA-19
DI6-A20 FREE (Only for ACEX) (P)	OFF/ON	It is the status of the Digital Input on CNA-20
DI7-A35 SPD3 SW (P)	OFF/ON	It is the status of the Digital Input on CNA-35

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
DI8-A17 SPD4 SW (P)	OFF/ON	It is the status of the Digital Input on CNA-17
DI9-A29 SPD5 SW (P)	OFF/ON	It is the status of the Digital Input on CNA-29
DI10-A16 CUTBAC1 (P)	OFF/ON	It is the status of the Digital Input on CNA-16
DI11-A18 FREE **(Only for ACEX)** (P)	OFF/ON	It is the status of the Digital Input on CNA-18
DI12-A21 FREE **(Only for ACEX)** (P)	OFF/ON	It is the status of the Digital Input on CNA-21
NODE ID (CO)	0 ÷ 56	Node ID setting for CAN OPEN Protocol
TARGET SPEED (CO)	$Hz \cdot 10$	This values shows the speed setpoint in CAN OPEN configuration. It is expressed in tenths of Hz.
BRAKING REQUEST (CO)	0-255	This values shows the braking setpoint in CAN OPEN configuration.
CONTROL WORD (CO)	0-65535	It shows the Control Word in CAN OPEN configuration.
STATUS WORD (CO)	0-65535	It shows the Status Word in CAN OPEN configuration.
WARNING SYSTEM (CO)	0-65535	In case of warning it shows the correspondent warning code.
TARGET EVP1 (CO)	% (1%)	This value shows the setpoint of proportional electrovalve EVP1 in CAN Open configuration.
TARGET EVP2 (CO)	% (1%)	This value shows the setpoint of proportional electrovalve EVP2 in CAN Open configuration.
TARGET PUMP (CO)	% (1%)	This value shows the setpoint of DC Pump in CAN Open configuration.
TORQUE REQ. NM (CO)	Nm	This value shows the torque setpoint for AC motor in CAN Open configuration.

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
A15 POT#1 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-15
A30 POT#2 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-30
D11-A18 POT#3 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-18
D12-A21 POT#4 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-21
SIN FB. INPUT **(Only for BLE0 with sin/cos sens)** (A)	Volt (0.01V)	It is the voltage of Sin signal on A21 pin
COS FB. INPUT **(Only for BLE0 with sin/cos sens)** (A)	Volt (0.01V)	It is the voltage of Sin signal on A18 pin
A24 SET EVP (A)	% (1%)	This value shows the setpoint of proportional electrovalve EVP.
A9 OUTPUT EV1 (A)	OFF/ON	It is the status of the EV1 output on CNA-9.
A11 OUTPUT EV2 (A)	OFF/ON	It is the status of the EV2 output on CNA-11.
A33 OUTPUT EV3 (A)	OFF/ON	It is the status of the EV3 output on CNA-33.
A26 OUTPUT HORN (A)	OFF/ON	It is the status of the Horn output on CNA-26.
A12 MAIN CONT. (A)	% (1%)	This value shows the voltage applied on main contactor coil. The value the duty cycle of PWM applied and is expressed in percentage..
A4 ELEC.BRAKE (A)	% (1%)	This value shows the voltage applied on electro mechanic brake coil. The value the duty cycle of PWM applied and is expressed in percentage.
CTRAP HW (A)	\	This is a counter of the number of occurrence of hardware overcurrent detection.
CTRAP THRESOLD (A)	Volt (0.01V)	This is the voltage of the hardware overcurrent threshold

TESTER menu (Master)		
Parameter	**Unit of measure (resolution)**	**Description**
A.SENS.OFFSET SR **(Only for BLE0 with sin/cos sens)** (A)	\	This parameter shows the voltage offset of the sin signals, in digital units, acquired during the absolute sensor acquisition automatic procedure.
A.SENS.OFFSET CR **(Only for BLE0 with sin/cos sens)** (A)	\	This parameter shows the voltage offset of the cos signals, in digital units, acquired during the absolute sensor acquisition automatic procedure.
ANGLE OFFSET **(Only for BLE0 with sin/cos sens)** (A)	Degree	This is the angle offset between the orientation of the rotor and the position sensor
ANGLE OFFSET ENC **(Only for BLE0 with encoder)** (A)	Degree	This is the angle offset between the orientation of the rotor and the index signal (on an ABI encoder)
ROTOR POSITION **(Only for BLE0)** (A)	Degree	This is the runtime absolute orientation of the rotor, in degrees
CPU TIME F US (A)	\	Reserved for Zapi technicians use.
CPU TIME M US (A)	\	Reserved for Zapi technicians use.

8.1.6.2 Tester menu for supervisor microcontroller

The following table lists the master microcontroller data that is possible to view form the tester menu.

TESTER menu (Supervisor)		
Parameter	**Unit of measure (resolution)**	**Description**
MEASURED SPEED (A)	Volt (0.1V)	Key voltage value measured at the key on
DI0-A1 (A)	OFF/ON	It is the status of the Digital Input on CNA-1
DI1-A7 (A)	OFF/ON	It is the status of the Digital Input on CNA-7
DI2-A6 (A)	OFF/ON	It is the status of the Digital Input on CNA-6
DI3-A32 (A)	OFF/ON	It is the status of the Digital Input on CNA-32
DI4-A31 (A)	OFF/ON	It is the status of the Digital Input on CNA-31
DI5-A19 (A)	OFF/ON	It is the status of the Digital Input on CNA-19
DI6-A20 (A)	OFF/ON	It is the status of the Digital Input on CNA-20
DI7-A35 (A)	OFF/ON	It is the status of the Digital Input on CNA-35
DI8-A17 (A)	OFF/ON	It is the status of the Digital Input on CNA-17
DI9-A29 (A)	OFF/ON	It is the status of the Digital Input on CNA-29
DI10-A16 (A)	OFF/ON	It is the status of the Digital Input on CNA-16
DI11-A18 **(Only for ACEX)** (A)	OFF/ON	It is the status of the Digital Input on CNA-18
DI12-A21 **(Only for ACEX)** (A)	OFF/ON	It is the status of the Digital Input on CNA-21

TESTER menu (Supervisor)		
Parameter	**Unit of measure (resolution)**	**Description**
A15 POT#1 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-15
A30 POT#2 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-30
D11-A18 POT#3 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-18
D12-A21 POT#4 (A)	Volt (0.01V)	It is the voltage of the analog signal on CNA-21
WARNING SYSTEM (CO)	\	In case of warning it shows the correspondent warning code.

8.1.7 Menu “HARDWARE SETTING” functions list

The Hardware setting menu, includes the parameters for the motor control algorithm.

Only the parameters that the user can work on are described in this paragraph.

For description and teaching about missing parameters contact Zapi technician.

HARDWARE SETTING menu		
Parameter	**Allowable range**	**Description**
TOP MAX SPEED (T, TM, P, CO)	0Hz ÷ 600Hz (step of 10Hz)	Defines the maximum tractions motor speed.
CONF. POSITIVE LC (A)	0 ÷ 2 (step of 1)	Defines the positive supply configuration for Main contactor coil: **0:** the positive supply of Main Contactor coil is connected to Paux (Pin A3) **1:** the positive supply of Main Contactor coil is connected to Key (Pin A10) **2:** the positive supply of Main Contactor coil is connected to Tiller input (Pin A1)
FEEDBACK SENSOR **(Only for BLE0)** (T, TM, P, CO)	0 ÷ 4 (step of 1)	Defines the type of the feedback sensor used: **0:** Incremental encoder **1:** sin/cos sensor **2:** Incremental encoder + sin/cos sensor **3:** Incremental encoder + sin/cos sensor + index **4:** PWM absolute sensor + incremental encoder + index
POSITIVE E.B. (A)	0 ÷ 2 (step of 1)	It defines the PEB configuration (pin A2): **0:** the PEB is managed by Smart Driver (for 24V version only **1:** the PEB comes from Tiller input (pin A1) (internal jumper properly configured) **2:** the PEB comes from PAUX (pin A3) (default HW configuration for 36/48V and 80V version). Paux is connected to +B of the controller **3:** same as 2 but PAUX comes from EPS
ROTATION CW ENC (A)	OPTION#1 ÷ OPTION#2	It defines the sequence of the encoder channels expected by controller **OPTION#1:** channel A anticipates channel B **OPTION#2:** channel B anticipates channel A

HARDWARE SETTING menu		
Parameter	**Allowable range**	**Description**
ROTATION CW MOT (A)	OPTION#1 ÷ OPTION#2	It permits to change the sequence in that the motor phases are controlled. **OPTION#1:** U-V-W in forward direction. **OPTION#2:** V-U-W in forward direction.
ROTATION CW POS **(Only for BLE0)** (A)	OPTION#1 ÷ OPTION#2	It permits to change the direction of absolute position sensor. **OPTION#1** sin anticipates cos **OPTION#2** cos anticipates sin
ENCODER PULSES 1 (T, TM, P, CO)	32 ÷ 124	First copy of the number of encoder pulses per revolution. It must be set equal to ENCODER PULSES 2 or the controller will rise an alarm. The available options are: **32 48 64 80 64 128 256 512 1024 124** **NOTE: with standard HW the capability to use high number of pulses encoder could be limited depending by the speed. Ask to Zapi technician before to operate on this parameter**
ENCODER PULSES 2 (T, TM, P, CO)	32 ÷ 124	First copy of the number of encoder pulses per revolution. It must be set equal to ENCODER PULSES 2 or the controller will rise an alarm. The available options are: **32 48 64 80 64 128 256 512 1024 124** **NOTE: with standard HW the capability to use high number of pulses encoder could be limited depending by the speed. Ask to Zapi technician before to operate on this parameter**
MOTOR P. PAIRS 1 (T, TM, P, CO)	1 ÷ 30 (step of 1)	First copy of the number of traction motor pole pairs. It must be set equal to MOTOR P. PAIRS 2 or the controller will rise an alarm.
MOTOR P. PAIRS 2 (T, TM, P, CO)	1 ÷ 30 (step of 1)	Second copy of the number of traction motor pole pairs. It must be set equal to MOTOR P. PAIRS 1 or the controller will rise an alarm.

9 OTHER FEATURES & EXAMPLES

9.1 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.

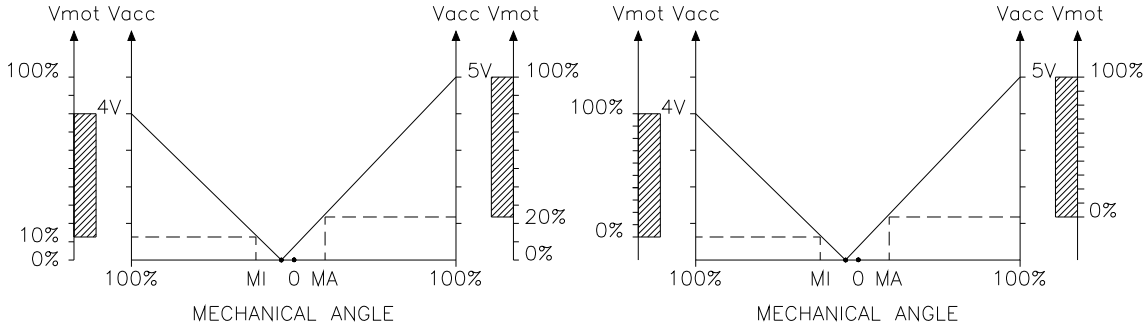


Figure 9: Program VACC

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 dissymmetry of the mechanical system between directions.
The operation is performed by operating the pedal after entering the PROGRAM VACC function.

See paragraphs 13.1.4 and 13.2.6 for procedure description

9.2 "PROGRAM LIFT / LOWER" function

This enables adjustment of the minimum and maximum useful signal level of lift and lower command. 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.

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 dissymmetry of the mechanical system between directions.

The value to acquire are in Adjustment menu:

- MIN LIFT DC

- MAX LIFT DC
- MIN LOWER
- MAX LOWER

See paragraphs 13.1.5 or 13.2.7 for acquiring procedure.

9.3 "PROGRAM STEER" function

This enables adjustment of the minimum and maximum useful signal level of steering command. This function is unique when it is necessary to compensate for asymmetry with the mechanical elements associated with the steer.

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

The value to acquire are in Adjustment menu:
- STEER RIGHT VOLT
- STEER LEFT VOLT
- STEER ZERO VOLT

See paragraphs 13.1.6 or 13.2.8 for acquiring procedure.

9.4 ACCELERATION DELAY

The Accel Delay parameter permits to define the acceleration time depending by final speed set point and by ACCEL MODULATION parameter setting:

- If ACCEL MODULATION=OFF the actual acceleration time can be obtained applying this formula:

$$Accel\ time\ [sec] = \frac{Speed\ Set\ point\ [Hz]}{100Hz} \cdot Acceler\ delay$$

- If ACCEL MODULATION = ON the actual acceleration time is manged differently by software depending by final speed set point:

Example:

Case1:
- Final speed set point = 100Hz
- Accel Delay parameter = 2,5sec

the accel time is 2,5sec as expected (black trace in the graph)

Case2:
- Final speed set point = 60Hz
- Accel Delay parameter = 2,5sec

the accel time is re-scaled by software and the time to reach the final speed is still 2,5sec (red trace in the graph)

Case3:
- Final speed set point = 150Hz

– Accel Delay parameter = 2,5sec

the accel time is:

$$Accel\ time\ [sec] = \frac{150Hz}{100Hz} \cdot Acceler\ delay = 3{,}75sec$$

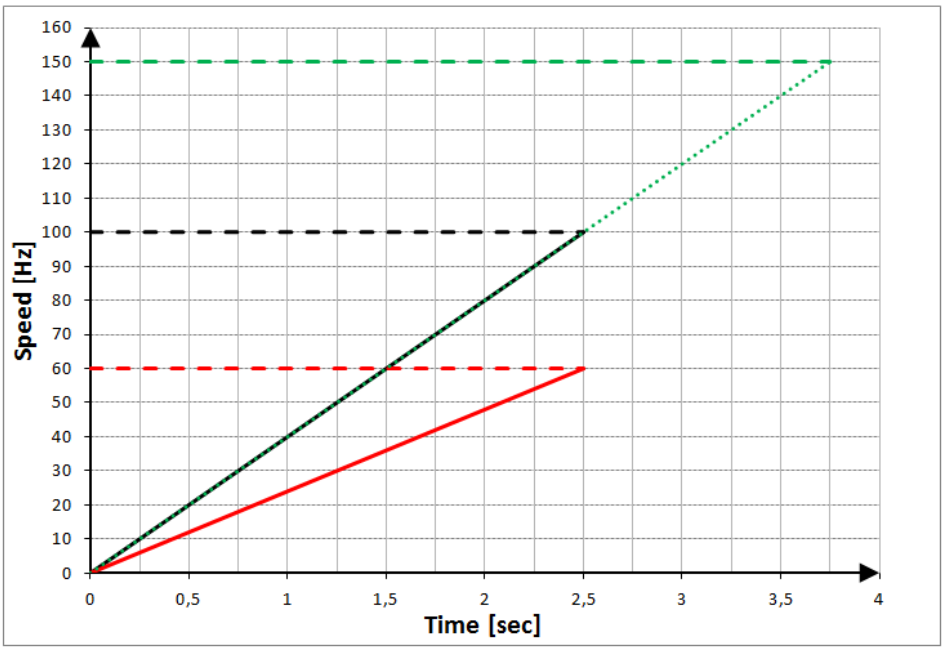


Figure 10: Accel delay

9.5 BRAKING DELAY

The “braking” parameters permit to define the deceleration time depending by final speed set point in different operating condition

Example

Case1:

- Initial speed = 110Hz
- Final speed set point = 10Hz
- Decel Braking parameter=2,5sec

the time to reach the final speed is 2,5sec (black trace in the graph)

Case2:

- Initial speed = 60Hz
- Final speed set point = 10Hz
- Decel Braking parameter=2,5sec

The ramp is re-scaled by software and the time to reach the final speed is still 2,5sec (red trace in the graph)

Case3:

- Initial speed = 150Hz
- Final speed set point = 10Hz
- Decel Braking parameter=2,5sec

the deceleration time is:

$$Decel\ time\ [sec] = \frac{150Hz}{100Hz} \cdot Decel\ Braking = 3{,}75sec$$

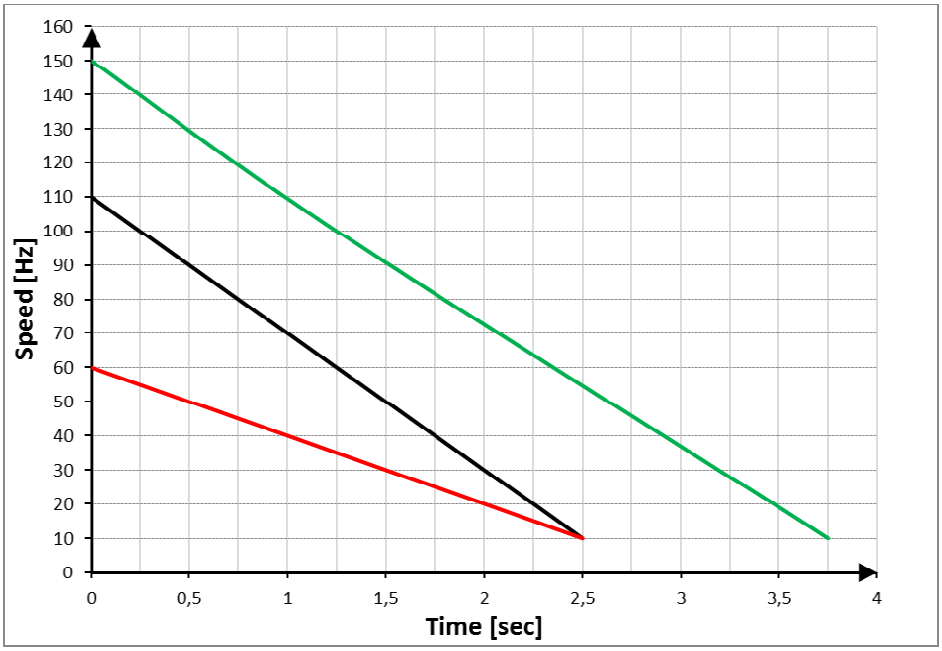


Figure 11: Braking delay

Note: This example is valid for all the "braking" parameters: Decel Braking, Inver Braking, Release Braking, Tiller Braking, Pedal Braking, Speed Limit BRK, Steer Braking

9.6 SMOOTHNESS

The "smooth" parameters give a parabolic form to the acceleration or deceleration ramp near to 0rpm. The value has not a phisycal meaning, simply 1 means linear ramp, higher the value smoother the acceleration ramp

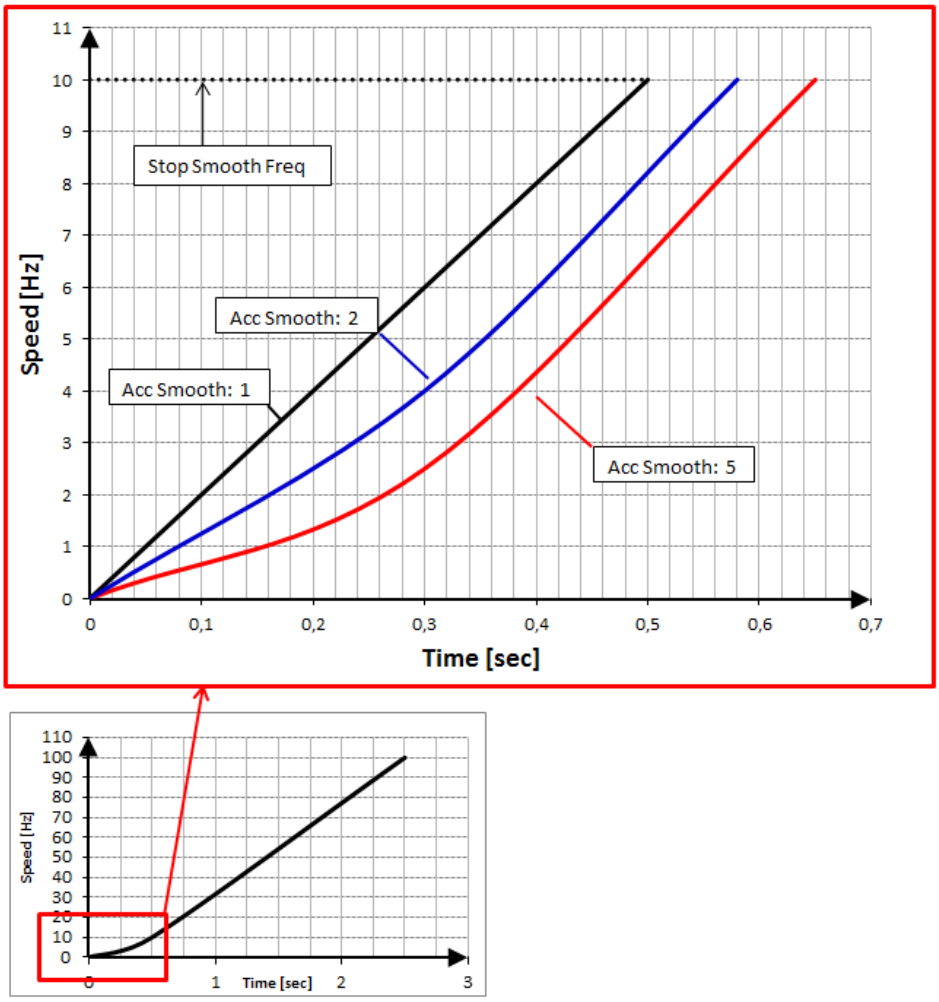


Figure 12: Smoothness

Note: This example is valid for ACC Smooth, BRK Smooth, INV Smooth

9.7 STEERING CURVE

Adjusting properly the dedicated parameters (Curve speed 1, Curve cutback, Steer dead Angle, Steer Angle 1 and Steer Angle 2), it is possible create a sort of speed profile dependent by steered wheel angle.
The profile created is valid both for positive angle values and negative angle values.

Example:

- 3 wheel CB truck
- Permitted steered wheel angle = -90°÷90°
- Curve Cutback = 30%
- Steer Dead Angle= 40°
- Steer Angle 1= 50°
- Steer Angle 2 = 80°

It will be obtained a speed profile as represented in the graph below

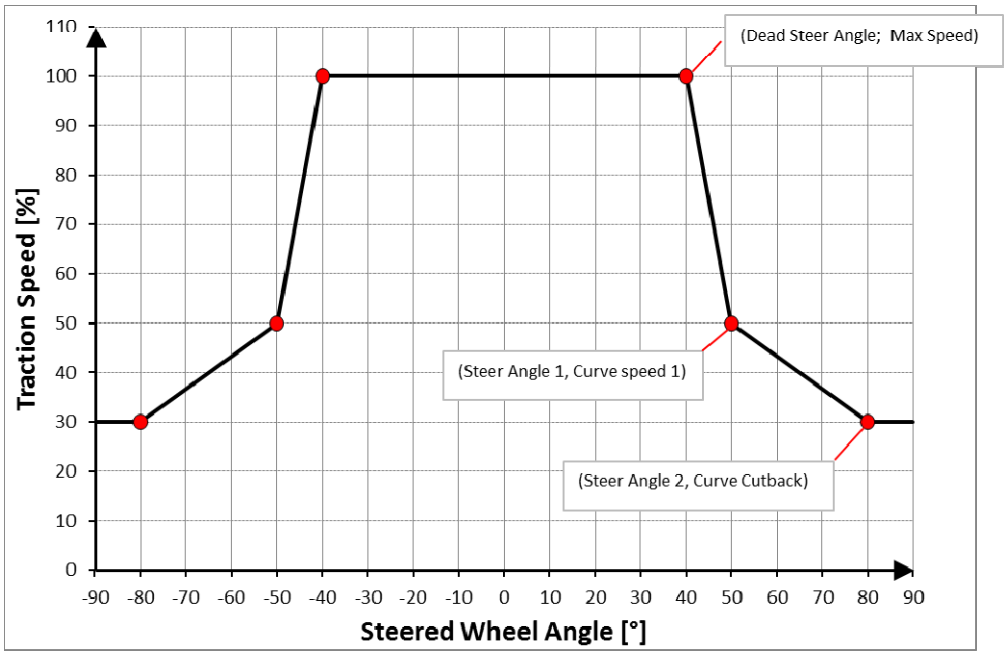


Figure 13: Steering curve

9.8 Description of the throttle regulation

This regulation applies a not linear relationship between the position of the accelerator and the speed of the truck. The main goal is to increase the resolution for the speed modulation when the truck is slowly moving.
Three adjustments are used for the throttle regulation:
1) THROTTLE 0 ZONE
2) THROTTLE X1 POINT
3) THROTTLE Y1 POINT
4) THROTTLE X2 POINT
5) THROTTLE Y2 POINT
6) THROTTLE X3 POINT
7) THROTTLE Y3 POINT

THROTTLE 0 ZONE: the speed of the truck remains at frequency creep meanwhile the voltage from the accelerator potentiometer is lower than this percentage of the MAX VACC setting. This adjustment define the width of a dead zone close to the neutral position.
THROTTLE X1 POINT & THROTTLE Y1 POINT: the speed of the truck grows up with a fixed slope (linear relationship) from the THROTTLE 0 ZONE up to THROTTLE X1 POINT. This slope is defined by the matching between the X1 point percentage of the MAX VACC setting with the Y1 point percentage of the full truck speed.
Same as for the pairs (X2;Y2) and (X3;Y3)
From the X3 point up to the MAX VACC point, the slope of the relationship between the truck speed and the accelerator position is different to match to match the full speed in the truck with the MAX VACC voltage in the accelerator position.

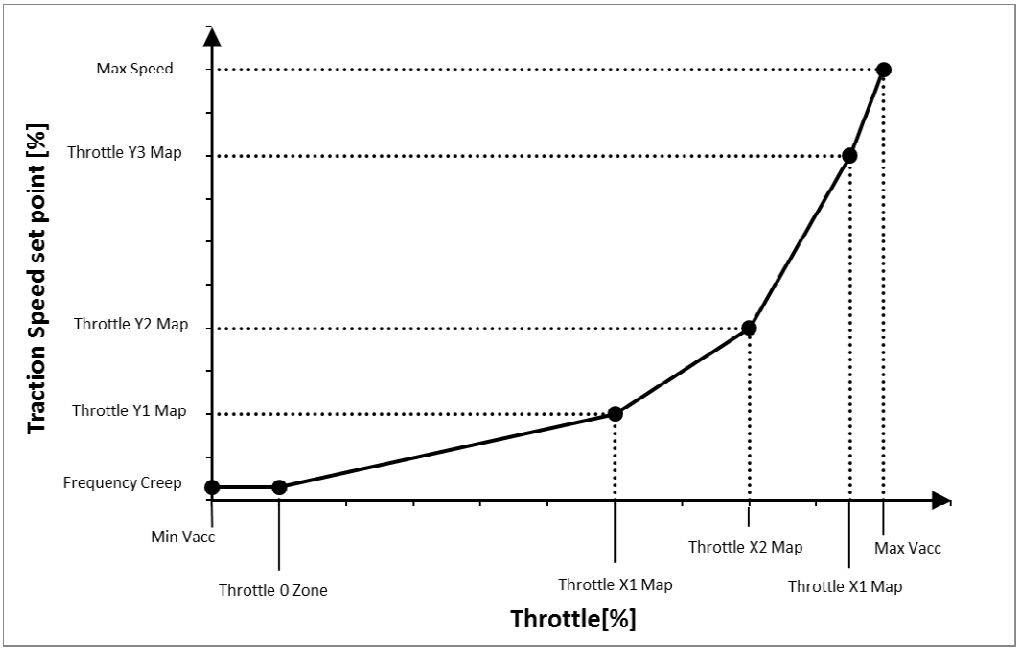


Figure 14: throttle profile

9.9 Description NMC & NEB Output management

For the NMC output (A12) (NEB output (A4)) there is the possibility to set a Pull-in voltage and define a maintenance voltage applied continuously to the coil. MC VOLTAGE (EB VOLTAGE) parameter specifies the duty cycle applied in the first second after activation and MC VOLT RED (EB VOLT RED) determines the duty cycle applied after the first second to keep the contactor closed (Brake disengaged) according to this formula:

$$Final\ Duty\ Cycle\ [\%] = MC\ VOLTAGE\ \cdot MC\ VOLT\ RED$$

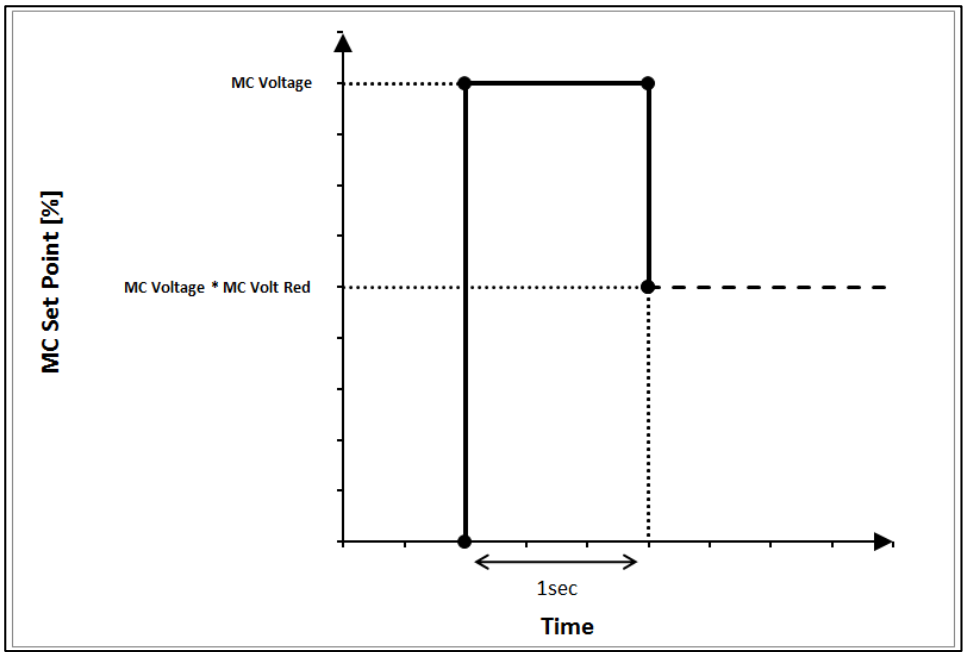


Figure 15: NMC & NEB Output management

Example 1
MC VOLTAGE = 100%
MC VOLTAGE RED = 70%
The contactor will be closed applying a 100% of duty cycle to the coil and then the duty cycle will be reduced to 70%.

Example 2
MC VOLTAGE = 70%
MC VOLTAGE RED. = 100%
The contactor will be closed applying a 70% of duty cycle to the coil and then the voltage will be kept at the same value.

Example 3
MC VOLTAGE = 70%
MC VOLTAGE RED = 70%
The contactor will be closed applying a 70% of duty cycle to the coil and then the duty cycle will be reduced to 49%.

9.10 Description of the battery charge detection setting

In operational condition the Battery Charge detection uses two setting that specify the Full Charge Voltage Level (100%) and the Discharge Voltage Level (10%). These two settings are the Bat.Max.Adj and the Bat.Min.Adj. It is possible to adapt the Battery Charge Detection to your specific battery, by changing the above two settings (e.g. if the Battery Discharged Detection occurs when the battery is not totally discharged, it is necessary to reduce the Bat.Min.Adj setting).

BDI adj Startup adjusts instead the level of the battery charge table at the start-up, in order to calculate the battery charge at keyon. The minimum variation of the battery charge that can be detecteddepends by the BDI reset parameter

The Battery Charge detection follows this algorithm:

Start up:
1) Battery voltages is read when the Battery current is zero, that is when the output power stage is not driven.
2) Vbatt is the average of the least samples measured by the microcontroller (the samples are took on key input).
3) Vbatt is compared with a threshold value (function of the actual charge percentage) in a table and with comparison is found a new charge percentage
4) Threshold value can be changed with parameters BDI Adj Startup
5) If the new charge percentage is included in the range " last percentage (last value stored in Eeprom) ± BDI reset" the percentage will not updated. Otherwise it will update to the new percentage

Operational condition:
The basic idea is following: the measure of the actual battery voltage, together with the discharge % at that time when the voltage is sampled, gives an unique information of the instantaneous battery current

1) Battery voltages is read when the Battery current is not zero, that is when the output power stage is driven.
2) Vbatt is the average of the least samples measured by the microcontroller converter (the samples are took on key input).
3) Vbatt is compared with a threshold value (function of the actual charge percentage) in a table and with comparison is found the current provided by the battery.
4) The discharge current A, obtained by said relationship, integrated in the time, gives the Ah taken from the battery
5) The charge is updated dynamically according to the Ah taken from battery.
6) Thresholds value can be changed with parameters Bat. Max. Adj. and Bat. Min.Adj. With these two settings are used to adapt the Battery Charge detection to your specific battery

9.11 EVP Setup

When the EVP is set as “ANALOG” (see paragraph 8.1.1) the output is manged as explain in the following example.
Considering the case in that the EVP is the lower valve, the “MIN EVP” parameter (see paragraph 8.1.3) determines the minimum set point current applied to the valve when the position of the potentiometer is at the minimum (MIN LOWER) (see paragraph 8.1.2).
The set point current applied to the valve is proportionally to the potentiometer value up to the maximum (MAX EVP) (see paragraph 8.1.3) when the position of the potentiometer is at the maximum (MAX LOWER) (see paragraph 8.1.2).

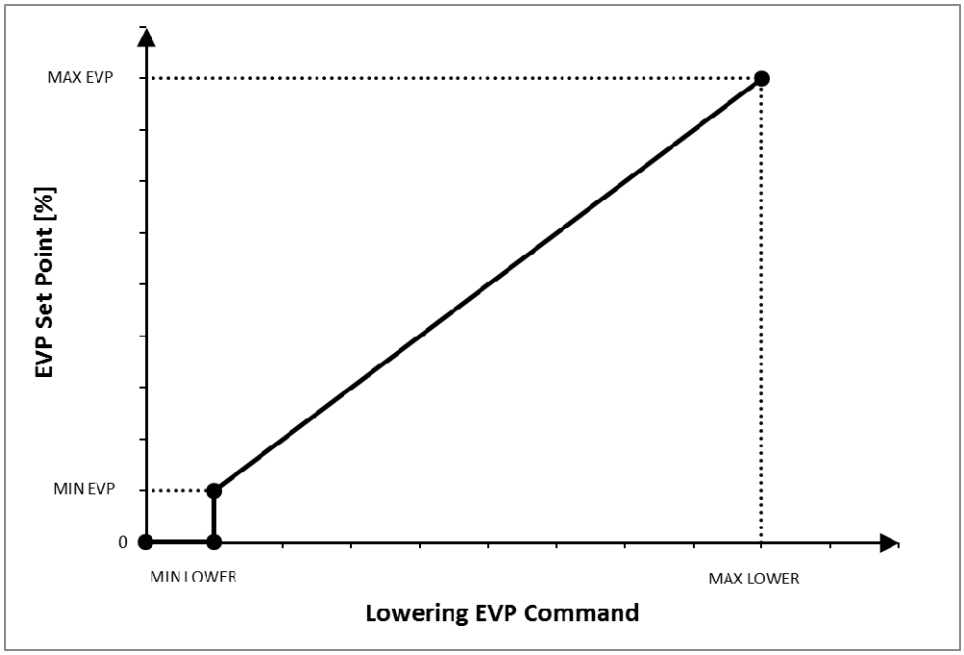


Figure 16: EVP management

If the valve is set as “ON-OFF” the MIN EVP parameters is unaffected and the set point current applied to the valve is only dependent by MAX EVP.

The dynamic delay into the applying/change the set point current, in both cases ANALOG Valve and ON/OFF Valve, is dependent by the “OPEN DELAY” and “CLOSE DELAY” parameters (see paragraph 8.1.3).
“OPEN DELAY” determines the acceleration ramp on EVP and it sets the time needed to increase the current to the maximum possible value.
“CLOSE DELAY” determines the deceleration ramp on EVP and sets the time needed to decrease the current from the maximum possible value to minimum.
.

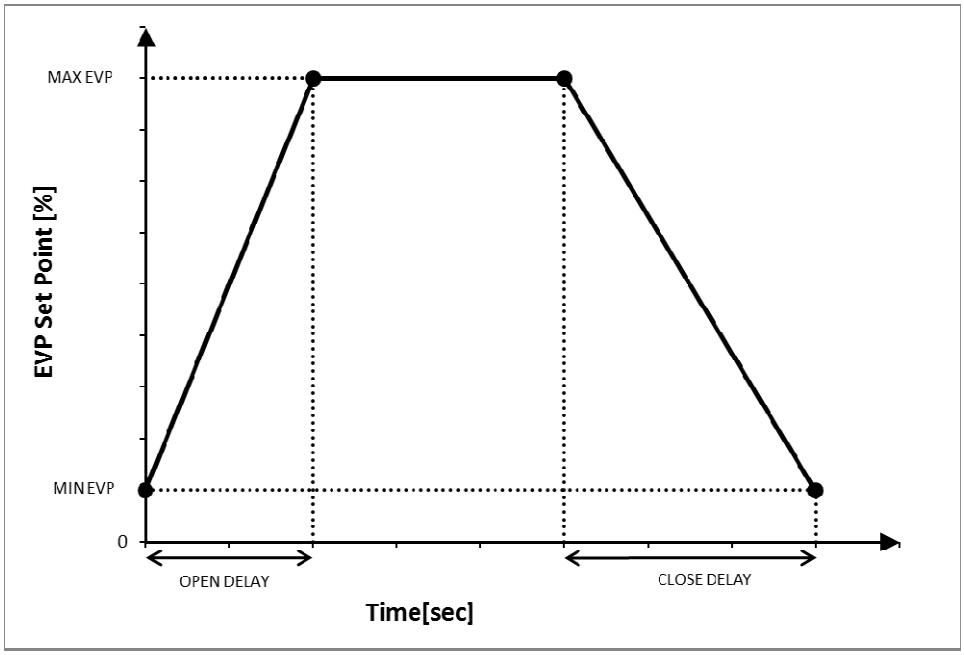


Figure 17: EVP Set point

Example 1:
The lowering output is set as “ANALOG” and the lower command is a step to “MAX EVP”.
The current is immediately set to the “MIN EVP” and then it is increased to “MAX EVP” in a time correspondent to “OPEN DELAY”
In the same way, if the actual set point applied is the maximum and the lower command is removed with a step, the current is reduced to minimum with a delay correspondent to “CLOSE DELAY” and then is set to zero.

Example 2:
The lowering output is set as “ON/OFF”.
As soon as a lowering request is applied, the current is increased from zero to “MAX EVP” in time correspondent to “OPEN DELAY”
In the same way, when the lower command is removed, the set point current is reduced to zero with a delay correspondent to “CLOSE DELAY”.

9.12 Torque Profile

Setting the proper parameter is possible define the a clamp for the max torque demand (set point) in the weakening area to match two goals:

1. Do not overtake the inner motor max torque profile.
2. To superimpose a limiting profile to the max torque to get different drive performances (Eco mode, Medium performance, High performance)

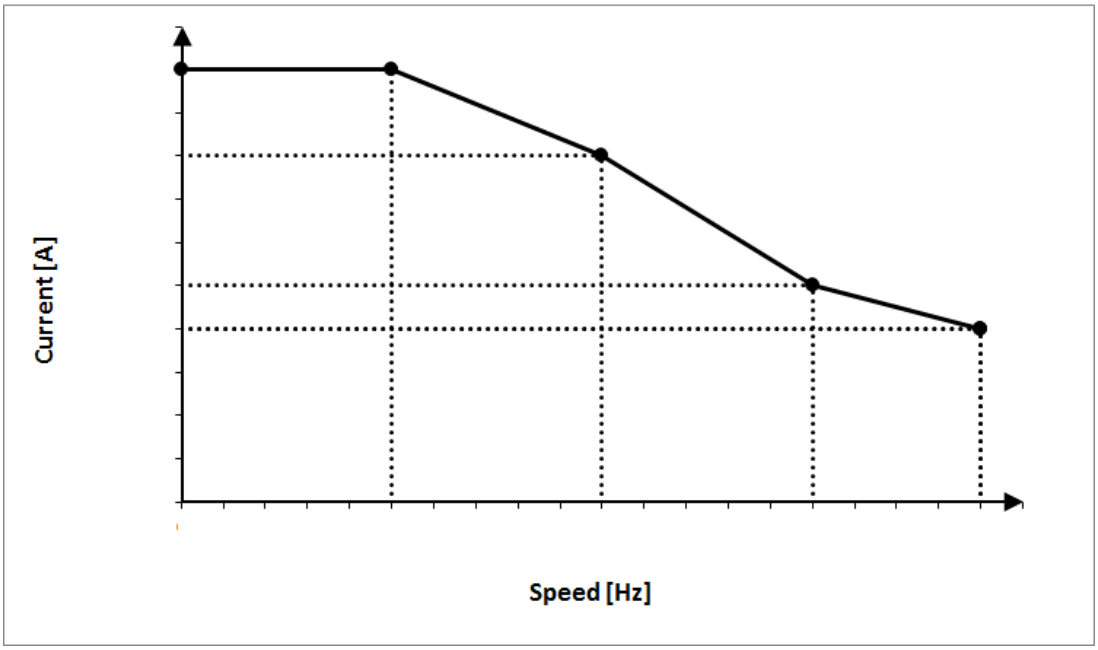


Figure 18: Torque profile

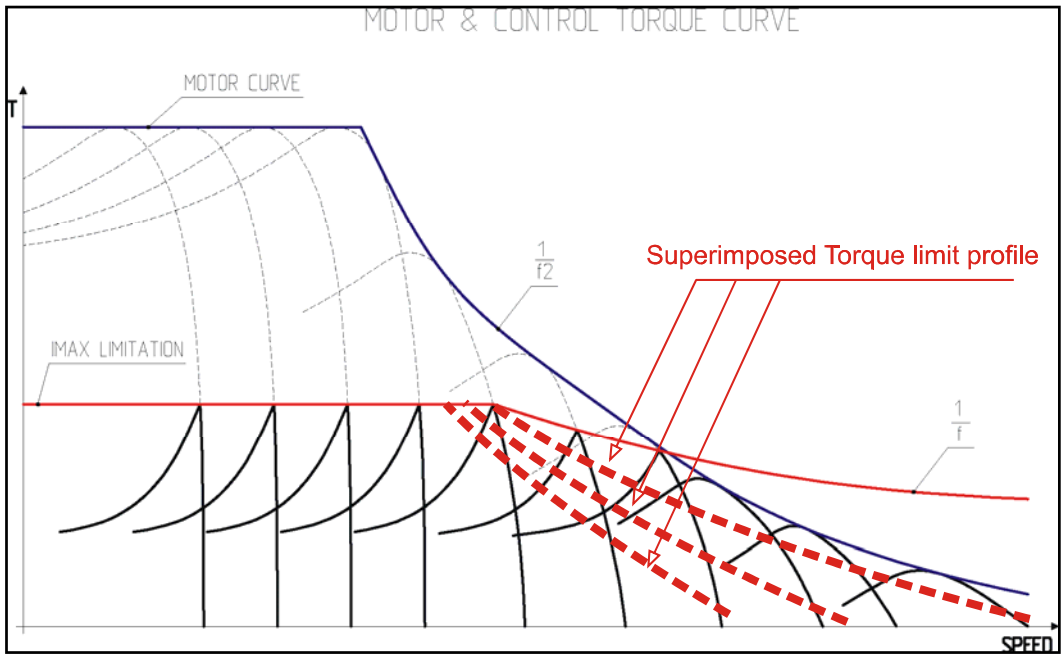


Figure 19: Torque curves

9.13 Description of “ALARMS” menu

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

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

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

For simple visual diagnosis of system faults and to monitor system status, a red LED is provided on the body of the controller. It is ON at start-up and then it stays continuously OFF when there is no fault; it flashes a different number of times, in a repeated pattern, when there is a fault.

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

10 FAULTS DIAGNOSTIC SYSTEM

The fault diagnostic system of COMBIACX /ACEX controller is divided into 2 main groups of faults:

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

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

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

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

10.1 Microcontroller Master alarms overview

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
PUMP VMN NOT OK	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump Request	0xFFBE	33	190	x0
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	77	x1
LOGIC FAILURE #1	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0X5114	54	19	x1
LOGIC FAILURE #2	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by,	Valves or Traction/Pump Request	0XFF12	55	18	x1
LOGIC FAILURE #3	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump Request	0xFF11	17	17	x1
POSITIVE LC OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	0xFFD5	35	213	x1
CTRAP THRESHOLD	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0xFFEB	99	235	x1

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
WATCHDOG	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	0x6010	96	8	x1
WRONG RAM MEM.	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	0xFFD2	71	210	x1
TILLER ERROR	Traction stopped, Eb applied	Stand-by, running	Valves or Traction/Pump Request	0xFFB9	64	185	X1
PUMP VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, Stand-by, Running	Valves or Traction/Pump Request	0xFF1C	28	28	x2
PUMP VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, Stand-by, Running	Valves or Traction/Pump Request	0xFF1D	29	29	x2
OVERLOAD	Traction is stopped	Running	Key re-cycle	0xFFB4	57	180	x2
FIELD ORIENT KO	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	0xFFFD	36	253	x2
IQ MISMATCHED	Traction is stopped	Running	Valves or Traction/Pump Request	0xFFF5	29	245	x2
EVP DRIV. SHORT.	MC is closed or opened , EB is applied, EVP stopped	EVP off	Traction/ Pump request	0x5003	94	215	x2
CAPACITOR CHARGE	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump Request	0x3130	60	60	x3
MOT.PHASE SH.36 MOT.PHASE SH.37 MOT.PHASE SH.38	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Traction/ Pump request	0xFFC4	71	196	x3
INIT VMN LOW 01 INIT VMN LOW 02 INIT VMN LOW 03	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0x3121	72	207	x3
INIT VMN HIGH 81 INIT VMN HIGH 82 INIT VMN HIGH 83	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0x3111	31	206	x3
VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump Request	0x3120	72	30	x3

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump Request	0x3110	31	61	x3
HW FAULT 11 HW FAULT 12 HW FAULT 13	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFE3	34	227	x3
HW FAULT 01 HW FAULT 02 HW FAULT 03	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFE3	34	227	x3
POWER MISMATCH	Traction is stopped EB is applied, MC is opened	Running	Traction/ Pump request	0xFFD4	36	212	x3
SMARTDRIVER KO **Only for 24V version**	MC is not closed, Traction/Pump, valves stopped	Start-up	Key re-cycle	0x3302	68	194	x3
AUX BATT. SHORT.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump Request	0x5001	27	194	x3
POS. EB. SHORTED 03	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump Request	0x3223	86	195	x4
SEAT MISMATCH	MC is not closed , EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Valves or Traction/ Pump request	0xFFDE	36	222	x4
STBY I HIGH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by	Valves or Traction/Pump Request	0x2311	53	53	x5
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	0xFFEF	12	239	x5
ENCODER ERROR	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	0xFF52	82	82	x5
SPEED FB. ERROR	MC is opened , EB is applied, EVP stopped	Running	Key re-cycle	0xFFAF	82	175	x5
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0xFF51	85	181	x6
CONTACTOR CLOSED	MC is not closed (command is not activated), EB is applied, Traction/Pump stopped	Start-up	Valves or Traction/Pump Request	0x5442	75	37	x6
CONTACTOR OPEN	MC is opened , EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0x5441	77	38	x6

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
CONTACTOR DRIVER	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0x3221	75	75	x6
LC COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0xFFE6	78	230	x6
MC-EF COIL SHOR.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up (immediately after MC closing), stand-by, running	Valves or Traction/Pump Request	0x2250	76	223	x6
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	stand-by, running	Key re-cycle	0xFFFA	96	237	x6
DRIVER SHORTED	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0x3211	74	74	x6
POWER ACQ.ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0xFFA4	4	164	x7
HOME SENSOR CORR	MC is opened , EB is applied, EVP stopped	Running	Key re-cycle	0xFFB0	3	176	x7
NO CAN MSG.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0X8130	67	67	x8
WRONG SET BAT	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	The alarms disappears as soon as the voltage come back into the correct range	0x3100	41	251	x32

10.2 Analysis and troubleshooting of alarms displayed on console (Master)

1) **PUMP VMN NOT OK**

Cause:
Before switching the LC on, the software checks the output voltage on –P connector, and expects it to be at a “steady state” value (if DC PUMP options is set to ON, see paragraph 8.1.4)
If the voltage is too low, this alarm occurs.

Troubleshooting:
Please check

- The motor connected to –P must be completely still before this alarm occurs. The software waits 30 seconds before showing this alarm. During this time it shows the “WAIT MOTOR STILL” warning (see in the warnings chapter)
- Motor internal connections
- Motor power cables connections
- Motor leakage to truck frame
- If the motor connections are ok, the problem is inside the controller it is necessary to replace the logic board.

2) **VDC LINK OVERV.**

Cause:

This fault is displayed when the controller detects an over voltage condition. Over voltage threshold is 35V for 24V controller, 65V for 36/48V controller and 116V for 80V controller.

As soon as the condition occurs the power bridge and the MC are opened.

The condition is triggered using the same HW interrupt used for undervoltage detection; the uC discerns between the two conditions evaluating the voltage on capacitors bank:

- High voltage -> Overvoltage condition
- Low/normal voltage → Undervoltage condition

Troubleshooting:

If the alarm happens during release braking, check line contactor contact, battery power cable connection.

3) **LOGIC FAILURE #1**

Cause:

This fault is displayed when the controller detects an under voltage condition on key input pin (A10).

Under voltage threshold is 11V in the 24V and 36/48V controller. In 80V controller the under voltage threshold is 30V.

Troubleshooting of fault displayed at startup or in standby:

- Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing.
- If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board.

Troubleshooting of fault displayed during motor driving:

- If the alarm happens during traction acceleration or driving hydraulic functions, check battery charge condition, power cable connection.

4) **LOGIC FAILURE #2**

Cause:

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

Troubleshooting:

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

5) **LOGIC FAILURE #3**

Cause:
Hardware problem in the logic card circuit for high current (overload) protection. An overcurrent condition is triggered even if the power bridge is not driven.

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

6) **POSITIVE LC OPEN**
Cause:
The voltage feedback of LC driver (A12) is different than expected.

Troubleshooting:
- Verify that the coil is connected correctly.
- Verify that the parameters “Positive LC” is set in accordance with the actual coil positive supply (see paragraph 8.1.7). The software, in fact, depending by specific parameter value, makes a proper diagnosis; a wrong configuration of the parameter could generate a false fault.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

7) **CTRAP THRESHOLD**
Cause:
This alarm occurs when the threshold related the overcurrent detection circuit is different than expected. The goal of this diagnosis is to detect a mismatch between set point (dependent by dedicated parameter PWM Ctrap, see paragraph 8.1.5) and the actual value.

Troubleshooting:
If the problem occurs permanently it is necessary to substitute logic board.

8) **WATCH DOG**
Cause:
This is a safety related test. It is a self-diagnosis test within the logic between Master and Supervisor microcontrollers.

Troubleshooting:
This alarm could be caused by a CANBus malfunctioning, which blinds master-supervisor communication.

9) **WRONG RAM MEM. 05**
Cause:
The algorithm implemented to check the main RAM registers finds a wrong contents: the register is “dirty”. This alarm inhibit the machine operations.

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

10) **TILLER ERROR**
Cause:
Input mismatch between Hard&Soft input (A6) and tiller input (A1): the two inputs are activated at the same time.

Troubleshooting:
- Check if there is wrong connection in the external wiring.
- Using the “Tester” menu of the controller verify that what the controller sees in input is in accordance with the actual state of the external switch inputs.
- Check if there is short circuit between A6 and A1
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

11) **PUMP VMN LOW**

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

Troubleshooting:

A) If the problem occurs at start up (the LC does not close at all), check:
- Motor internal connections
- Motor power cables connections
- If the motor connection are OK, the problem is inside the controller

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

C) If the alarm occurs during motor running, check:
- Motor internal connections
- If motor windings/cables have leakages towards truck frame
- That the LC power contact closer properly, with a good contact
- If no problem are found on the motors, the problem is inside the controller, it is necessary to replace the logic board.

12) **PUMP VMN HIGH**

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

Troubleshooting:
It is suggested to check:
- Motor internal connections
- If motor windings/cables have leakages towards truck frame
- If no problem are found on the motors, the problem is inside the controller, it is necessary to replace the logic board.

13) **OVERLOAD**

Cause:
The motor current has overcomes the limit fixed by hardware.

Troubleshooting:
Reset the alarms by Key re-cycling.
If the alarms condition occurs again ask the assistance of a Zapi technician.
The fault condition could be affected by wrong adjustment of motor parameters.

14) **FIELD ORIENT. KO**

Cause:

The error between Id set point and Id estimated is out of range.

Troubleshooting:

Ask the assistance of a Zapi technician to do the correct adjustment motor of the parameters.

15) **IQ MISMATCHED**

Cause:

The error between Id set point and Id estimated is out of range.

Troubleshooting:

Ask the assistance of a Zapi technician to do the correct adjustment motor of the parameters.

16) **EVP DRIV. SHORT.**

Cause:

- The EVP driver is shorted (output A23).
- The microcontroller detects a mismatch between the valve set-point and the driver voltage measured on the EVP output.

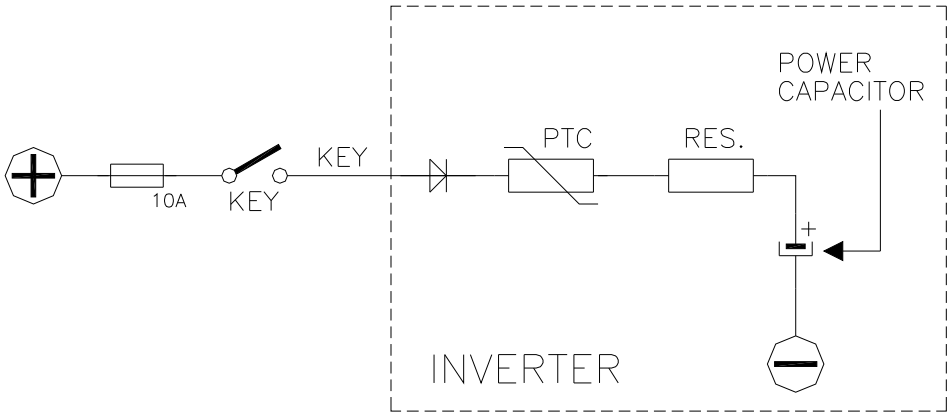
Troubleshooting:

- Check if there is a short or a low impedance between the negative of the coil and -BATT.
- Collect information about:
    - the voltage applied across the EVP coil
    - current in the coil
    - Characteristics of the coil

  Ask the assistance of a Zapi in order to verify that the software diagnosis are in accordance with the type of coil.
- If the problem is not solved it could be necessary to replace the controller.

17) **CAPACITOR CHARGE**

Follows the charging capacitor system:



Cause:

When the key is switched ON, the inverter tries to charge the power capacitors through a series of a PTC and a power resistance, and check if

the capacitor are charged within a timeout. If the capacitor voltage measured is less than 20% of the nominal battery voltage, an alarm is signaled; the main contactor is not closed.

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

18) **MOT.PHASE SH.**

Cause:
Short circuit between two of the motor phases:
- 36 → short circuit U-V
- 37 → short circuit U-W
- 38 → short circuit V-W

Troubleshooting:
- Verify the motor phases connection on motor side
- Verify the motor phases connection on inverter side
- Checks the power motor cables.
- Substitute the controller. If the alarm doesn't disappears the problem is in the motor. Replace it.

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

Cause:
Before switching the LC on, the software checks the power bridge voltage without driving it.
The software expects the voltage to be at a "steady state" value.
If it is too low, this alarm occurs.

Troubleshooting:
Please check
- Motor power cables connections
- Impedance between moto power phase columns and -B
- Motor leakage to truck frame
- If the motor connections are OK and not low impedance paths are present externally, the problem is inside the controller. Replace it

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

Cause:
Before switching the LC on, the software checks the power bridge voltage without driving it.
The software expects the voltage to be at a "steady state" value.
If it is too high, this alarm occurs.

Troubleshooting:
Please check
- Motor power cables connections
- Impedance between moto power phase columns and +B

- Motor leakage to truck frame
- If the motor connections are OK and not low impedance paths are present externally, the problem is inside the controller. Replace it.

21) **VMN LOW**

Cause 1:

Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatingly the High side Power Mosfets and expects the phases voltage to increase toward the rail capacitor value. If the phases voltage is less than 66% of the rail capacitor voltage, this alarm occurs.

Cause 2:

Motor running test. When the motor is running, power bridge is ON, the motor voltage feedback is tested; if it is lower than commanded value (a window of values are considered) fault status is entered.

Troubleshooting:

- If the problem occurs at start up (the LC does not close at all), check:
  - Motor internal connections (ohmic continuity)
  - Motor power cables connections
  - If the motor connections are OK, the problem is inside the controller, replace it.
- If the alarm occurs during motor running, check:
  - Motor connections
  - That the LC power contact closer properly, with a good contact
  - If no problem are found, the problem is inside the controller, replace it.

22) **VMN HIGH**

Cause 1:

Before switching the LC on, the software checks the power bridge: it turns on alternatingly the Low side Power Mosfets and expects the phases voltage to decrease down to -BATT. If the phases voltage is higher than 10% of nominal battery voltage, this alarm occurs.

Cause 2:

This alarm may occur also when the start-up diagnosis is overcome, and so the LC is closed. In this condition, the phases' voltages are expected to be lower than 1/2 VBATT. If it is higher than that value, fault status is entered.

Troubleshooting:

- If the problem occurs at start up (the LC does not close at all), check:
  - Motor internal connections (ohmic continuity)
  - Motor power cables connections
  - If the motor connections are OK, the problem is inside the controller, replace it.
- If the alarm occurs during motor running, check:
  - Motor connections
  - That the LC power contact closer properly, with a good contact
  - If no problem are found, the problem is inside the controller, replace it.

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

Cause:

The controller checks at each start up that the hardware circuit for enabling

and disabling of Main contactor driver (A12) by Supervisor uC works properly.

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

24) **HW FAULT 01/02/03**
Cause:
The controller checks at each start up that the hardware circuit for enabling and disabling of Power Bridge by Supervisor uC works properly.

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

25) **POWER MISMATCH**
Cause:
The error between Power set point and Power estimated is out of range.

Troubleshooting:
Ask the assistance of a Zapi technician to do the correct adjustment of the motor parameters.

26) **SMARTDRIVER KO (Only for 24V version)**
Cause:
Hardware problem in the logic card circuit for Smart driver management (pin A2). The Driver is commanded ON but the output doesn't increase.

Troubleshooting:
- Verify that the coil is connected correctly between pin A2 and pin A4. The output of Smart driver is in fact evaluated checking the voltage feedback of low side driver.
- Verify that the parameters "Positive EB" is set in accordance with the actual coil positive supply (see paragraph 8.1.7). The software, in fact, depending by specific parameter value, makes a proper diagnosis; a wrong configuration of the parameter could generate a false fault.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

27) **AUX BATT. SHORT.**
Cause:
The voltage on pin A2 is at high value even if it shouldn't.
For the version where the Smart Driver is not installed (36/48V and 80V) it is possible to decide where the positive supply for pin A2 is taken from by dedicated hardware configuration:
  - pin A3 (PAUX)
  - pin A1 (TILLER)
  - externally from other module (i.e. EPS)

The parameter "Positive EB" has to be set in accordance with hardware configuration (see paragraph 8.1.7):

Troubleshooting:
- Verify that the parameters "Positive EB" is set in accordance with the actual coil positive supply (see paragraph 8.1.7). The software, in fact,

depending by specific parameter value, makes a proper diagnosis; a wrong configuration of the parameter could generate a false fault.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

28) **POS. EB. SHORTED 03**

Cause:

The voltage on pin A2 is at high value even if the Smart Driver is commanded OFF.

Troubleshooting:

- Verify that the parameters “Positive EB” is set in accordance with the actual coil positive supply (see paragraph 8.1.6). The software, in fact, depending by specific parameter value, makes a proper diagnosis; a wrong configuration of the parameter could generate a false fault.
- Check if there is a short or a low impedance between pin A2 and of the +BATT. In case no failures/problems have been found, the problem is in the controller, which has to be replaced

29) **SEAT MISMATCH**

Cause:

This alarm can appear only in a Traction + Pump configuration.
Input mismatch between Traction controller and Pump controller: the two inputs are different.

Troubleshooting:

- Check if there is wrong connection in the external wiring.
- Using the “Tester” menu of the controller verify that what the two controller see in input is in accordance with the actual state of the external switch input.
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

30) **STBY I HIGH**

Cause:

The current sensor or the current feedback circuit is damaged in the controller. The sensor seems to detect current different than Zero

Troubleshooting:

This type of fault is not related to external components so, when it is present, it is necessary to replace the controller.

31) **CONTROLLER MISM.**

Cause:

The software is not compatible with the Hardware. Each controller produced is “signed” during the end of line test with a specific mark code saved in eeprom according to the customized Part Number.
According with this “sign”, only the customized firmware can be uploaded.

Troubleshooting:

- Upload the correct firmware
- Ask the assistance of a Zapi technician in order to verify that the firmware is correct

32) **ENCODER ERROR**

Cause:

This fault is signaled in following conditions: the frequency supplied to the motor is higher than 40 Hz and the signal feedback from the encoder has a jump higher than 40 Hz in few tens of msec. This condition is related to a malfunctioning of the encoder.

Troubleshooting:

- Check both the electric and the mechanical encoder functionality, the wires crimping.
- Check the encoder mechanical installation, if the encoder slips inside its compartment raising this alarm condition.
- Also the electromagnetic noise on the sensor bearing can be a cause for the alarm. In these cases try to replace the encoder.
- If the problem is still present after replacing the encoder, the failure is in the controller.

33) **SPEED FB. ERROR**

Cause:

This alarm appears if the absolute position sensor is used also for the speed estimation. If signaled, it means that the controller measured too high speed.

Troubleshooting:

- Check that the sensor used is compatible with the software release
- Check the sensor mechanical installation and if it works properly.
- Also the electromagnetic noise on the sensor can be a cause for the alarm.
- If no problem are found on the motors, the problem is inside the controller, it is necessary to replace the logic board.

34) **WRONG ENC SET**

Cause:

Mismatch between ENCODER PULSES 1 parameter and ENCODER PULSES 2 parameter (see paragraph 8.1.7).

Troubleshooting:

Set the correct parameters

35) **CONTACTOR CLOSED**

Cause:

Before driving the MC coil, the controller checks if the contactor is stuck. The controller drives the bridge for some tens milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does decrease by 20% of the key voltage the alarm is generated.

Troubleshooting:

It is suggested to verify the power contacts of LC; to replace the LC is necessary.

36) **CONTACTOR OPEN**

Cause:

The main contactor coil has been driven by the controller, but the power contacts seem don’t close.

In order to detect this condition the controller injects a DC current into the motor and checks the voltage on power capacitor. If the power capacitor are discharged it means that the main contactor is open.

Troubleshooting:
- It could be a problem of the contacts in the LC that are not working (does not pull-in), try replacing the LC.
- If the contactors of LC are working correctly contacts a Zapi technician.

37) **CONTACTOR DRIVER**

Cause:
The MC coil driver is not able to drive the load. The device itself or its driving circuit is damaged.
Troubleshooting:
This type of fault is not related to external components; replace the logic board.

38) **LC COIL OPEN**

Cause:
This fault appears when the no load is connected between the output NLC (A12) and the positive (for example +KEY).

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

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

Cause:
This alarm occurs when there is an overload of the MC driver (A12) and EB driver (A5). As soon as the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

Troubleshooting:
- The typical root cause is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads.
- Collect information about characteristics of the coils connected to the two driver and ask the assistance of a Zapi technician in order to verify that the limit of the hardware is not exceeded .
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

40) **ANALOG INPUT**

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

Troubleshooting:
If the problem occurs permanently it is necessary to substitute logic board.

41) **DRIVER SHORTED**

Cause:
The driver of the main contactor coil is shorted.

Troubleshooting:
- Check if there is a short or a low impedance pull-down between NLC (A12) and –BATT.
- The driver circuit is damaged in the logic board, which has to be replaced.

42) **POWER ACQ. ERROR**

Cause:
This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is Encoder ABI + PWM
The controller doesn't detect a correct information on PWM input at start up.

Troubleshooting:
- Re-cycle the key
- Check the sensor to verify that it works properly.
- Check the wiring

If the problem occurs permanently it is necessary to substitute logic board.

43) **HOME SENSOR CORR**

Cause:
The controller detected a difference between the estimated absolute orientation of the rotor, and the position of the index signal (ABI encoder). Erroneous acquisition of the angle offset between the orientation of the rotor and the index signal.

Troubleshooting:
Repeat the autoteaching procedure.

44) **NO CAN MSG. 09**

Cause:
This fault is signaled when the communication with the supervisor uC is not present.

Troubleshooting:
This type of fault is not related to external components, so, when it is permanently present it is necessary to replace the logic board.

45) **WRONG SET BAT. 05**

Cause:
At start-up, the controller checks the battery voltage (measured on Key input pin A10) and verify it is within a
window of ±20% around the nominal value.

Troubleshooting:
- Check that the controller SET BATTERY parameter value matches the battery nominal voltage.
- Check that TESTER MENU / KEY VOLTAGE parameter shows same value as the Key voltage measured with a voltmeter on pin A10. If it does not match, then do an "ADJUST BATTERY" function.
- Replace the battery.

10.3 Microcontroller Supervisor alarms overview

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
INPUT MISMATCH	MC is opened, EB is applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	0XFFD5	58	58	x0
W.SET. TG-EB	Traction/ Pump motor is stopped	Start-up, stand-by, running	Key re-cycle	0XFFD4	58	58	x0
LOGIC FAILURE #1	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Valves or Traction/Pump Request	0X5514	54	19	x1
LOGIC FAILURE #3	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Valves or Traction/Pump Request	0XFF11	17	17	x1
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0XFFCA	77	202	x1
WATCHDOG	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	0X6010	8	8	x1
WRONG RAM MEM. 05	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	0XFFD2	71	210	x1
SP MISMATCH xx	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0XFFF2	13	13	x2
OUT MISMATCH xx	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0XFFE3	13	13	x2
SP MISMATCH PUMP	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0XFFF1	13	13	x2
OUT MISMATCH PU	MC is opened, EB is applied, traction/pump stopped	Running	Key re-cycle	0XFFF0	13	13	x2
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	0XFFEF	12	239	x5
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	0XFFFA	96	96	x6
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0XFF51	85	201	x6
NO CAN MSG.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0X8130	67	248	x8

10.4 Analysis and troubleshooting of alarms displayed on console (Supervisor)

1) **INPUT MISMATCH**
Cause:
The Supervisor µC has different values of the inputs from the Master µC.

Troubleshooting:
Compare the values read by Master and Slave by tester menu of console.
Ask the assistance of a Zapi technician
If the problem is not solved it is necessary to replace the logic board

2) **W.SET. TG-EB**
Cause:
Supervisor uC has detected a Master uC wrong setpoint for TG or EB output

Troubleshooting:
- Checks the correspondence of the parameters between Master and Supervisor
- Ask the assistance of a Zapi technician.

If the problem is not solved it is necessary to replace the logic board

3) **LOGIC FAILURE #1**
Cause:
This fault is displayed when the controller detects an under voltage condition on key input pin (A10).
Under voltage threshold is 11V in the 24V and 36/48V controller. In 80V controller the under voltage threshold is 30V.

Troubleshooting of fault displayed at startup or in standby:
- Key input signal down-going pulses (below under voltage threshold) due to external loads, like DC/DC converters starting-up, relays or contactor switching, solenoids energizing / de-energizing.
- If no voltage transient is detected on the supply line and the alarm is present every time the key is switched ON, the failure is probably in the controller hardware, so it is necessary to replace the logic board.

Troubleshooting of fault displayed during motor driving:
- If the alarm happens during traction acceleration or driving hydraulic functions, check battery charge condition, power cable connection.

4) **LOGIC FAILURE #3**
Cause:
Hardware problem in the logic card circuit for high current (overload) protection. An overcurrent condition is triggered even if the power bridge is not driven.

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

5) **VDC LINK OVERV.**

Cause:

This fault is displayed when the controller detects an over voltage condition. Over voltage threshold is 35V for 24V controller, 65V for 36/48V controller and 116V for 80V controller.

As soon as the condition occurs the power bridge and the MC are opened.

The condition is triggered using the same HW interrupt used for undervoltage detection; the uC discerns between the two conditions evaluating the voltage on capacitors bank:

- High voltage -> Overvoltage condition
- Low/normal voltage → Undervoltage condition

Troubleshooting:

If the alarm happens during release braking, check line contactor contact, battery power cable connection.

6) **WATCH DOG**

Cause:

This is a safety related test. It is a self diagnosis test within the logic between Master and Supervisor microcontrollers.

Troubleshooting:

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

7) **WRONG RAM MEM. 05**

Cause:

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

Troubleshooting:

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

8) **SP MISMATCH XX**

Cause:

This is a safety related test. The Master µC has detected a Supervisor µC wrong set point.

Troubleshooting:

- Checks the correspondence of the parameters between Master and Supervisor
- Ask the assistance of a Zapi technician.
- If the problem is not solved it is necessary to replace the logic board.

9) **OUT MISMATCH XX**

Cause:

This is a safety related test. Supervisor µC has detected that the Master µC is driving traction motor in a wrong way (not correspondent to the status of operator commands).

Troubleshooting:

- Checks the correspondence of the parameters between Master and Supervisor
- Ask the assistance of a Zapi technician.

- If the problem is not solved it is necessary to replace the logic board.

10) **SP MISMATCH PUMP**

Cause:
This is a safety related test. The Master µC has detected a Supervisor µC wrong set point for DC Pump motor.

Troubleshooting:
- Checks the correspondence of the parameters between Master and Supervisor
- Ask the assistance of a Zapi technician.
- If the problem is not solved it is necessary to replace the logic board.

11) **OUT MISMATCH PU**

Cause:
This is a safety related test. Supervisor µC has detected that the Master µC is driving DC motor in a wrong way (not correspondent to the status of operator commands).

Troubleshooting:
- Checks the correspondence of the parameters between Master and Supervisor
- Ask the assistance of a Zapi technician.
- If the problem is not solved it is necessary to replace the logic board.

12) **CONTROLLER MISM.**

Cause:
The software is not compatible with the Hardware. Each controller produced is “signed” during the end of line test with a specific mark code saved in eeprom according to the customized Part Number.
According with this “sign”, only the customized firmware can be uploaded.

Troubleshooting:
- Upload the correct firmware
- Ask the assistance of a Zapi technician in order to verify that the firmware is correct

13) **ANALOG INPUT**

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

Troubleshooting:
If the problem occurs permanently it is necessary to substitute logic board.

14) **WRONG ENC SET**

Cause:
Mismatch between ENCODER PULSES 1 parameter and ENCODER PULSES 2 parameter (see paragraph 8.1.7).

Troubleshooting:
Set the correct parameters.

15) **NO CAN MSG.**

Cause:

This is a safety related test. It is a self diagnosis test within the logic between Master and Supervisor microcontrollers.

Troubleshooting:

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

10.5 Microcontroller Master warnings overview

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
WAITING FOR NODE	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle	0x0000	0	224	x0
TORQUE PROFILE	EB is applied, Traction/Pump motor is stopped	Start-up, stand-by	Valves or Traction/ Pump request	0xFFC9	98	201	x0
STEER SENS KO	EB is applied, traction/pump stopped	Continuous	Key re-cycle	0xFFB3	95	179	x0
DATA ACQUISITION	Traction is stopped	Controller calibration	Traction request	0x0000	0	247	x0
ACQUIRING A.S.		Sensor Acquiring	Key re-cycle	0xFFAB	2	171	x0
ACQUIRE END		Sensor Acquiring	Key re-cycle	0xFFAD	2	172	x0
ACQUIRE ABORT				0xFFAC	2	173	x0
SIN/COS D.ERR	Traction is stopped	running	Traction request	0xFFA8	3	168	x0
ENCODER D.ERR	Traction is stopped	running	Traction request	0xFFA9	3	169	x0
HOME SENS.ERROR	Traction is stopped	running	Traction request	0xFFAA	3	170	x0
BRAKE RUN OUT	No effect, the warning is only displayed through the console	Continuous	or Traction/Pump Request	0xFFCC	63	204	x1
Reload HM from MDI		Start-up	Key re-cycle		94	0	x1
WAIT MOT.P STILL	Valve, pump, traction stopped, LC opened, Eb applied	Start-up	None	0xFFBA	63	186	x1
CHECK UP NEEDED		Start-up, stand-by, running	Check-up done, key re-cycle	0x0000	0	249	x1
PARAM TRANSFER	MC stays closed, EB is applied, Traction/Pump, valves stopped	Continuous	Key re-cycle	0xFFC7	97	200	x2
THROTTLE PROG.	MC remain closed, EB is applied (the command is released), Traction stopped	Start-up, Stand-by,	Valves or Traction/Pump Request	0xFFF3	56	243	x2
INCORRECT START	Traction/ Pump motor is stopped	Start-up, stand-by	Traction request	0xFF4F	79	79	x2
VACC OUT OF RANGE	Traction/ Pump motor is stopped	Start-up, Stand-by, Running	Traction/ Pump request	0xFFE2	85	226	x2
PEDAL WIRE KO	Traction is stopped	Start-up, Stand-by, Running	Traction request	0xFF56	86	86	x2
FORW + BACK	Traction is stopped	Start-up, stand-by, running	Traction request	0xFF50	80	80	x2
HANDBRAKE	Traction/ Pump motor is stopped	Start-up, stand-by, running	Traction/ Pump request	0xFFDD	67	221	x2

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
EVP DRIVER OPEN	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves Request	0xFFF8	12	240	x2
EVP COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0x5002	93	214	x2
M/S PAR CHK MISM	MC stays closed, EB is applied, Traction/Pump, valves stopped	Start-up	Save again the parameter and Key re-cycle	0xFFC6	97	198	x2
PUMP INC START	Pump is stopped	Start-up, stand-by, Running	Pump request	0xFFBD	79	189	x2
TILLER OPEN	LC opens	Start-up, stand-by, running	Valves or Traction/Pump Request	0x0000	51	228	x2
PUMP I=0 EVER	Pump motor stopped	Pump function	Pump request	0x2312	52	52	x2
PUMP I NO ZERO	Pump motor stopped	start-up, stby	Pump request	0xFFBF	56	191	x2
PUMP VACC RANGE	Pump motor stopped, Evp stopped	Running	Pump request	0x3320	90	192	x2
CURRENT GAIN	Controller works, but with low maximum current	Start-up, stand-by		0x6302	92	236	x2
COIL SHOR. EVAUX	EV stopped	EV on	Valve EV request	0xFFF1	44	241	x2
LIFT + LOWER	Pump is stopped	Start-up, stand-by, Running	Pump request	0xFFBB	49	187	x2
WRONG SLAVE VER	MC opened, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	0Xffc5	97	197	x2
SENS MOT TEMP KO	The maximum current is reduced to half and speed is reduced	Start-up, stand-by, running		0x4311	68	218	x3
HW FAULT EB 01 HW FAULT EB 02 HW FAULT EB 03	MC is closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0xFFE5	34	229	x3
HW FAULT EV XX	MC is not closed , EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	0x00EE	34	238	x3
WRONG ZERO	valve, pump, traction stopped, Lc opened, Eb applied	Start-up	Valves or Traction/ Pump request	0x3210	53	252	x3
EPS RELAY OPEN	Traction/ Pump motor is stopped	Start-up, stand-by, Running	Valves or Traction/ Pump request	0xFFCD	70	205	x3
PUMP VACC NOT OK	Pump motor stopped	Start-up, stand-by, Running	Pump request	0xFFBC	49	188	x4

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
VACC NOT OK	Traction/ Pump motor is stopped	Start-up, stand-by, running	Traction/ request	0xFF4E	78	78	x4
STALL ROTOR	Traction/Pump stopped	Start-up, stand-by, running	Key-on recycle	0xFFD3	11	211	x4
PARAM RESTORE	No effect	Start-up	Traction/ Pump request	0X000	13	13	x5
EB. DRIV.SHRT.	MC remain closed, EB is applied (the command is released), Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	0x3222	40	254	x6
PEV NOT OK	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	MC is not closed, EB is applied, Traction/Pump, valves stopped	0xFFDB	73	217	x6
EB. COIL OPEN	MC remain closed, EB is applied (the command is released), Traction/Pump, valves stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	0xFFD8	42	216	x6
EB.DRIV.OPEN	MC remain closed, EB is applied (the command is released), Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	0x3224	42	246	x6
CONT DRIV EV XX	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves Request	0xFFE8	75	232	x6
DRIV SHOR EV XX	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump Request	0xFFF9	74	234	x6
EEPROM KO	Controller works using Deafult parameters	Continuous		0x3610	13	208	x6
WARNING SLAVE	It depends by Supervisor uC			0xFF01	1	244	x6
TH. PROTECTION	Traction controller reduces the max current linearly from Imax (85°C) down to 0A (105°C)	Start-up, stand-by, running		0x4210	62	62	x7
MOTOR TEMPERAT.	The maximum current is reduced to half and speed is reduced	Start-up, stand-by, running		0x4110	65	65	x7
THERMIC SENS. KO	The maximum current is reduced to half and speed is reduced	Start-up, stand-by, running		0x4211	61	250	x7
MOTOR TEMP. STOP	MC stays closed, EB is applied, Traction/Pump, valves stopped	Continuous		0xFFB2	65	179	x7
BATTERY LOW	The maximum current is reduced to half and speed is reduced (if CHECK OPTION=1)	Start-up, standby, running	Battery recharge, key re-cycle	0XFF42	0	66	x32

10.6 Analysis and troubleshooting of warnings displayed on console (Master)

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

2) **TORQUE PROFILE**
   Cause:
   There is an error on the choice of the parameters of the torque profile.

   Troubleshooting:
   Check in the hardware setting menu the value of those parameter.

3) **STEER SENS KO**
   Cause:
   The steering sensor input read by the microcontroller is not comprised in the range Steer right volt ÷ Steer left volt, programmed through the “STEER ACQUIRING” function (see paragraph 9.3).

   Troubleshooting:
   - Acquire the maximum and minimum potentiometer value through the “STEER ACQUIRING” function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer.
   - If the problem is not solved it is necessary to replace the logic board.

4) **DATA ACQUISITION**
   Cause:
   Controller in calibration state.

   Troubleshooting:
   The alarm ends when the acquisition is done.

5) **ACQUIRING A.S.**
   Cause:
   Controller is acquiring the absolute feedback sensor.

   Troubleshooting:
   The alarm ends when the acquisition is done.

6) **ACQUIRE END**
   Cause:
   Absolute feedback sensor acquired.

7) **ACQUIRE ABORT**
   Cause:
   Absolute feedback sensor acquiring aborted.

8) **SIN/COS D.ERR**
   Cause:
   This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is Sin / Cos.

The Sin/Cos signal direction is not correct.

Troubleshooting:
- Check the wiring
- If the motor direction is correct swap the sin and cos signals
- If the motor direction is not correct swap the motor phases

If the problem is not solved contact Zapi Technician.

9) **ENCODER D.ERR**

Cause:
This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is Encoder.
The A and B signals direction is not correct.

Troubleshooting:
- Check the wiring
- If the motor direction is correct swap A and Bsignals
- If the motor direction is not correct swap the motor phases

If the problem is not solved contact Zapi Technician.

10) **HOME SENS.ERR**

Cause:
This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is Encoder ABI.
The home signal is not present (diagnosis made for speed higher than 20Hz).

Troubleshooting:
- Check the wiring
- Verify if the sensor works properly

If the problem is not solved the failure is in the logic board, replace it.

11) **BRAKE RUN OUT**

Cause:
The CPOTBRAKE input read by the microcontroller is at the maximum value without the hand brake request.

Troubleshooting:
Check the mechanical calibration and the functionality of the brake potentiometer.
If the alarm is not disappeared the failure is in the logic board, replace it.

12) **RELOAD HM FROM MDI**

Cause:
The HourMeter of the Controller is transferred and recorded on the HourMeter of the Standard MDI.

13) **WAIT MOT.P STILL**

Cause:
If DC Pump option is set to ON, the software expects the voltage on –P output to be at a “steady state” value, before switching the LC on.
If the voltage is different, it could be due to the fact that the motor connected to –P is not still. For this reason, the software waits 30 seconds for the voltage to be at the “steady state” value (and for the pump motor to be still). After this time, the software assumes that the problem is not due to the fact that the pump motor is not still, and show the “PUMP VMN NOT OK” alarm

Troubleshooting:
AIf the motor connected to –P is still moving, just wait for it to be still.
If not, in 30 seconds the alarm “PUMP VMN NOT OK” will appear (See Paragraph 10.1).

14) **CHECK UP NEEDED**

Cause:
This is just a warning to call for the time programmed maintenance.

Troubleshooting:
It is just enough to turn the CHECK UP DONE option to level ON after the maintenance is executed.

15) **PARAM TRANSFER**

Cause:
Master uC is transferring parameter to Supervisor.

Troubleshooting:
Wait for the end of procedure.
I the alarms doesn’t disappear try to re-cycle the key.

16) **THROTTLE PROG.**

Cause:
A wrong profile in the Throttle map has been set.

Troubleshooting:
- Set properly the Throttle parameters (see paragraph 9.8).

17) **INCORRECT START**

Cause:
This is a warning for an incorrect starting sequence.

Troubleshooting:
The possible reasons for this alarm are (use the readings in the TESTER to facilitate the troubleshooting):
  - A travel demand active at key on
  - Presence man sensor active at key on
- Check the wirings
- Check the microswitches for failures.
- It could be also an error sequence made by the operator. A failure in the logic is possible too; so when all of the above conditions were checked and nothing was found, replace the logic board.

18) **VACC OUT RANGE**

Cause:
The CPOT input read by the microcontroller is not comprised in the range Vacc_min ÷ Vacc_max, programmed through the “PROGRAMM VACC” function (see paragraph 9.1).

Troubleshooting:
- Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer.
- If the problem is not solved it is necessary to replace the logic board.

19) **PEDAL WIRE KO**

Cause:

This alarm appears if a fault is detected in the accelerator unit wiring (only if A30 is used and properly configured as NPOT).

Troubleshooting:

- Check the pedal connection
- If the problem is not solved it is necessary to replace the logic board.

20) **FORW + BACK**

Cause:

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

Troubleshooting:

- Check the wiring of the Fwd and Rev travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting).
- Check the microswitches for failures.
- A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the logic board.

21) **HANDBRAKE**

Cause:

Input handbrake is activated (use the readings in the TESTER to facilitate the troubleshooting).

Troubleshooting:

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

22) **EVP DRIV OPEN**

Cause:

The EVP coil driver (A23) is not able to drive the load. The device itself or its driving circuit is damaged.

Troubleshooting:

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

23) **EVP COIL OPEN**

Cause:

This fault appears when the no load is connected between the output NEVP (A23) and the positive.

Troubleshooting:

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

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

Cause:

At Start-up, there is a mismatch in the parameter checksum between the Master and the Slave.

Troubleshooting:

Try to restore and save again the parameters list.

25) **PUMP INC START**

Cause:

This is a warning for a pump incorrect starting sequence.

Troubleshooting:

The possible reasons for this alarm are:

- Pump request active at keyon.
- Pump request active without man presence.

- Check the wirings.
- Check the micro-switches.
- It could also be an error sequence made by the operator.
- A failure logic is possible too.

When all of the above conditions were checked and nothing was found, replace the controller.

26) **TILLER OPEN**

Cause:

When the tiller is released, after a fixed period of time of standby (30 seconds) the main contactor open.

Troubleshooting:

At the next travel request the warning disappear.

27) **PUMP I=0 EVER**

Cause::

This test is carried out when the pump motor is running, and it verifies that the current feedback sensor is not constantly stuck to 0.

Troubleshooting:

- Check the motor connection, that there is continuity. If the motor connection is opened, the current cannot flow, so the test fails and the error code is displayed
- If everything is ok for what it concerns the motor, the problem could be in the current sensor or in the related circuit

28) **PUMP I NO ZERO**

Cause:

In standby condition (pump motor not driven), the feedback coming from the current sensor in the pump chopper gives a value out of a permitted range, because the pump current is not zero.

Troubleshooting:

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

29) **PUMP VACC RANGE**

Cause:

The voltage on A30 is outside of the parameters range.

Troubleshooting:
If the EVP TYPE parameter is set to ANALOG (See paragraph 8.1.1), please acquire again the values of MIN LOWER and MAX LOWER.

If the controller is in configuration COMBI and lifting is proportional, please acquire again also the values of MIN LIFT and MAX LIFT.

30) **CURRENT GAIN**
Cause:
The Maximum current gain parameters are at the default values, which means the maximum current adjustment procedure has not been carried out yet.
Troubleshooting:
Ask the assistance of a Zapi technician to do the correct adjustment procedure of the current gain parameters**.**

31) **COIL SHOR. EVAUX**
Cause:
This alarm occurs when there is an overload of one or more EV driver. As soon as the overload condition has been removed, the alarm exits automatically by releasing and then enabling a travel demand.

Troubleshooting:
- The typical root cause is in the harness or in the load coil. So the very first check to carry out concerns connections between controller outputs and loads.
- Collect information about characteristics of the coils connected to the two driver and ask the assistance of a Zapi technician in order to verify that the limit of the hardware is not exceeded .
- In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

32) **LIFT+LOWER**
Cause:
This alarm occurs when both the travel demands (Lift and Lower) are active at the same time.

Troubleshooting:
- Check the wiring of the Lift and Lower travel demand inputs (use the readings in the TESTER to facilitate the troubleshooting).
- Check the microswitches for failures.
- A failure in the logic is possible too. So, when you have verified the travel demand switches are fine working and the wiring is right, it is necessary to replace the logic board.

33) **WRONG SLAVE VER.**
Cause:
Wrong software version on Supervisor uC

Troubleshooting:
Upload the correct software version or ask the assistance of a Zapi technician

34) **SENS MOT TEMP KO**
Cause:

The output of the motor thermal sensor is out of range.

Troubleshooting:
- Check the sensor ohmic value and the sensor wiring.
- If the sensor is OK, then the problem is inside the logic board, replace it.

35) **HW FAULT EB 01/02/03**
Cause:
The controller checks at each start up that the hardware circuit for enabling and disabling of EB driver (A4) by Supervisor uC works properly.

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

36) **HW FAULT EV 01/02/04/08/10/20/40/80**
Cause:
The controller checks, at each start up that the hardware circuit for enabling and disabling of EV drivers by Supervisor uC works properly.
The number indicates the

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

37) **WRONG ZERO**
Cause:
The outputs of the amplifiers (used to measure the motor voltage) are cheked this alarm occurs when voltage signals >3V o <2V at the init

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

38) **EPS RELAY OPEN**
Cause:
The controller receive the information from EPS that the safety contacts have been open.

Troubleshooting:
Verify the EPS.

39) **PUMP VACC NOT OK**
Cause:
The minimum of the lift potentiometer is not correctly set.

Troubleshooting:
It is suggested to repeat the acquiring procedure.

40) **VACC NOT OK**
Cause:
The test is made at key-on and immediately after that both the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading in the TESTER menu' is 1,0V higher than PROGRAM VACC min acquisition when the accelerator is released.

Troubleshooting:
- Check the wirings
- Check the mechanical calibration and the functionality of the potentiometer
- Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function.
- If the alarm is not disappeared the failure is in the logic board, replace it.

41) **STALL ROTOR**

Cause:
The traction rotor is stuck or the encoder signal is not correctly received by the controller.

Troubleshooting:
Please check if the sign of FREQUENCY and ENCODER on the tester menu are the same and different than zero during a traction request.

42) **PARAM RESTORE**

Cause:
This warning appears when the controller restored the default values.

Troubleshooting:
If a CLEAR EEPROM has been made before the last keyon-recycle, this warning just means that the EEPROM was correctly cleared. A travel demand or a pump request cancel the alarm. If this alarm appears at keyon without any CLEAR EEPROM request by the operator, there could be a problem inside the controller

43) **EB DRIV. SHRT.**

Cause:
- The EB driver is shorted.
- The microcontroller detects a mismatch between the valve set-point and the diver voltage measured on the EB output.

Troubleshooting:
- Check if there is a short or a low impedance between the negative of the coil and -BATT.
- Check if the voltage applied is in accordance with the parameters set (see paragraph 8.1.7).
- If the problem is not solved it could be necessary to replace the controller.

44) **PEV NOT OK**

Cause:
The PEV connector (a3) is not connected to the battery or the voltage is Different than expected. This alarm occurs if one output between EVP1, EVP2, EV1, EV2, EV3, EV4, EV5 is present or AUX OUT FUNCTION is PRESENT (if POSITIVE EB= 1 or 2). In other words, one of the output load is connected to PEV.

Troubleshooting:
Check A3 connector: it must be connected to the battery voltage (after the main contactor)

45) **EB COIL OPEN**

Cause:

This fault appears when the no load is connected between the output NEB (A4) and the positive.

Troubleshooting:

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

46) **EB DRIV OPEN**

Cause:

The EB coil driver is not able to drive the load. The device itself or its driving circuit is damaged.

Troubleshooting:

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

47) **CONT DRIV EV 02/04/08**

Cause:

One or more on/off valve drivers is not able to drive the load (cannot close).

- 02 → EV1
- 04 → EV2
- 08 → EV3

If more than one output is affected by the this fault condition the codes shown will correspond to the sum of the single codes.

Troubleshooting:

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

48) **DRIV SHORT EV 02/04/08**

Cause:

One or more on/off valve driver is shorted.

- 02 → EV1
- 04 → EV2
- 08 → EV3

If more than one output is affected by the this fault condition the codes shown will correspond to the sum of the single codes.

Troubleshooting:

- Check if there is a short or a low impedance between the negative of the coil and -BATT.
- If the problem is not solved it could be necessary to replace the controller.

49) **EEPROM KO**

Cause:

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

Troubleshooting:

Try to execute a CLEAR EEPROM operation (refer to Console manual).

Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters

50) **WARNING SLAVE**

Cause:
Warning on supervisor uC

Troubleshooting:
Connect to Supervisor uC and check what alarms is shown

51) **TH. PROTECTION**

Cause:
This alarm occurs when the temperature of the base plate is higher than 85C°.
Then the maximum current decreases proportionally with the temperature increases from 85° up to 105°. At 105° the Current is limited to 0 Amps.

Troubleshooting:
It is necessary to improve the controller cooling. To realize an adequately cooling in case of finned heat sink are important factor the flux [m3/h] and temperature [°C] of cooling air. In case of thermal dissipation realized with the controller base plate installed on truck frame it is important the thickness of frame and the planarity and roughness of its surface. If the alarm is signaled when the controller is cold, the possible reasons are a thermal sensor failure or a failure in the logic card. In this case, it is necessary to replace the controller.

52) **MOTOR TEMPERAT.**

Cause:
This warning occurs when the temperature sensor is opened (if digital) or has overtaken the threshold of “MAX MOTOR TEMP” (if analogue) (see paragraph 8.1.2).

Troubleshooting:
- Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the TESTER menu).
- Check the sensor ohmic value and the sensor wiring.
- If the sensor is OK, improve the cooling of the motor.
- If the warning is present when the motor is cool, then the problem is inside the controller.

53) **THERMIC SENS. KO**

Cause:
The output of the controller thermal sensor is out of range.

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

54) **MOTOR TEMP. STOP**

Cause:
This warning occurs when the temperature sensor is has overtaken the threshold of “TEMP.MOT.STOP”. (if analogue, see paragraph 8.1.2).

Troubleshooting:

- Check the thermal sensor inside the motor (use the MOTOR TEMPERATURE reading in the TESTER menu).
- Check the sensor ohmic value and the sensor wiring.
- If the sensor is OK, improve the cooling of the motor.
- If the warning is present when the motor is cool, then the problem is inside the controller.

55) **BATTERY LOW**

Cause:

It occurs when the battery charge is calculated being less than or equal to 10% of the full charge and the BATTERY CHECK setting is other than 0 (refer to SET OPTION menu).

Troubleshooting:

- Get the battery charged
- If it doesn't work, measure with a voltmeter the battery voltage and compare it with the value in the BATTERY VOLTAGE parameter. If they are different adjust the value of the ADJUST BATTERY function connected to the right connector pin and if it is not interrupted.
- If the alarm is not disappeared the failure is in the ACE logic board, replace it.

10.7 Microcontroller Supervisor warnings overview

Error Code	Effect	Machine status When the test is done	Restart procedure	Indication			
				CAN OPEN CODE	MDI CODE	ZAPI CODE	LED BLINKS
STEER SENS KO	EB is applied, traction/pump stopped	Continuous	Key re-cycle	0xFFB3	95	179	x1
PARAM RESTORE	No effect	Start-up	Traction/ Pump request	0X000	13	13	x5
EEPROM KO	Controller works using Default parameters	Continuous		0x3610	13	208	x6

10.8 Analysis and troubleshooting of warnings displayed on console (Supervisor)

1) **STEER SENS KO**
Cause:
The steering sensor input read by the microcontroller is not comprised in the range Steer right volt ÷ Steer left volt, programmed through the “STEER ACQUIRING” function (see paragraph 9.3).

Troubleshooting:
- Acquire the maximum and minimum potentiometer value through the “STEER ACQUIRING” function. If the alarm is still present, check the mechanical calibration and the functionality of the potentiometer.
- If the problem is not solved it is necessary to replace the logic board.

2) **PARAM RESTORE**
Cause:
This warning appears when the controller restored the default values.

Troubleshooting:
If a CLEAR EEPROM has been made before the last keyon-recycle, this warning just means that the EEPROM was correctly cleared. A travel demand or a pump request cancel the alarm. If this alarm appears at keyon without any CLEAR EEPROM request by the operator, there could be a problem inside the controller

3) **EEPROM KO**
Cause:
It’s due to a HW or SW defect of the non-volatile embedded memory supporting the controller parameters. This alarm does not inhibit the machine operations, but the truck will work with the default values.

Troubleshooting:
Try to execute a CLEAR EEPROM operation (refer to Console manual). Switch the key off and on to check the result. If the alarm occurs permanently, it is necessary to replace the controller. If the alarm disappears, the previously stored parameters will have been replaced by the default parameters

11 RECOMMENDED SPARE PARTS FOR INVERTER

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

Part number	Description	Version
C16604	Protected 100A strip fuse	ACEX 36/48V
C16529	Protected 125A strip fuse	ACEX 24V
C16502	Protected 160A strip fuse	ACEX PW 24/36/48V
C16591	Protected 175A strip UL fuse	
C165504	Protected 300A strip fuse	COMBIACX 24/36/48V
C16587	Protected 300A strip UL fuse	
C16505	Protected 355A strip fuse	COMBIACX PW 24/36/48V
C16588	Protected 350A strip UL fuse	
C16520	10A 20mm control circuit fuse	All

12 PERIODIC MAINTENANCE TO BE REPEATED AT TIMES INDICATED

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

Check the Foot pedal or Tiller microswitch. Using a suitable test meter, confirm that there is no electrical resistance between the contacts by measuring the volt drop between the terminals. Switches should operate with a firm click sound. Microswitches should be checked every **3 months**.

Check the Battery cables, cables to the inverter, and cables to the motor. Ensure the insulation is sound and the connections are tight.
Cables should be checked every **3 months**.

Check the mechanical operation of the pedal or tiller. Are the return springs ok ? Do the potentiometers wind up to their full or programmed level ?
Check every **3 months**.

Check the mechanical operation of the Contactor(s). Moving contacts should be free to move without restriction.
Check every **3 months**.

Checks should be carried out by qualified personnel and any replacement parts used should be original. Beware of NON ORIGINAL PARTS.
The installation of this electronic controller should be made according to the diagrams included in this Manual. Any variations or special requirements should be made after consulting a Zapi Agent. The supplier is not responsible for any problem that arises from wiring methods that differ from information included in this Manual.

During periodic checks, if a technician finds any situation that could cause damage or compromise safety, the matter should be bought to the attention of a Zapi Agent immediately. The Agent will then take the decision regarding operational safety of the machine.

Remember that Battery Powered Machines feel no pain.

NEVER USE A VEHICLE WITH A FAULTY ELECTRONIC CONTROLLER.

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

13 APPENDICES

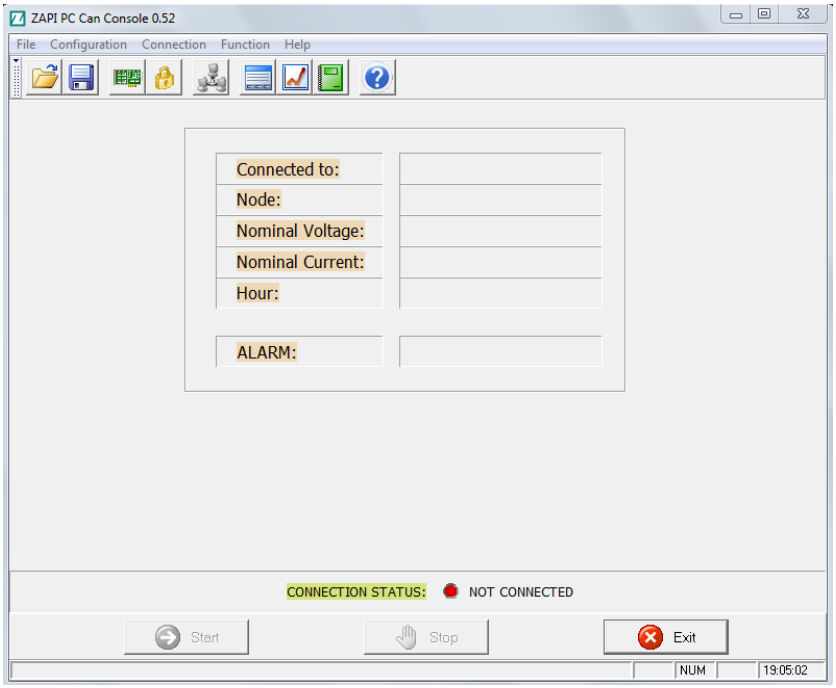
The goal of this chapter is to give to the operator a general overview relating the use of Zapi PC CAN Console and Zapi Smart Console.
The description contained in the next paragraph focuses on the basic information about the connection and change of parameters.
For additional functionalities available for both tools it is suggested to contact Zapi technicians in order to received more detailed information or dedicated documentation.

13.1 Appendix A: PC CAN Console user guide

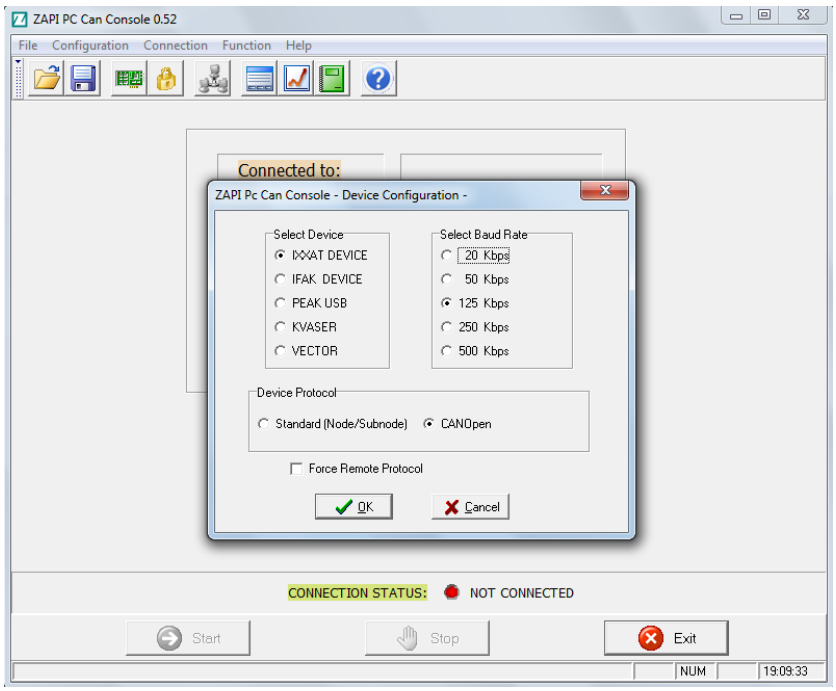
Windows PcConsole uses standard Zapi communication protocol to display chopper's information. It provides all standard Zapi Console functions with the easier handling of Windows devices. Besides, PcConsole offers another function: the possibility to save parameter configurations to a file and to restore them to the chopper.
Before running PcConsole, user must install it launching "setup.exe".

13.1.1 PC CAN Console configuration

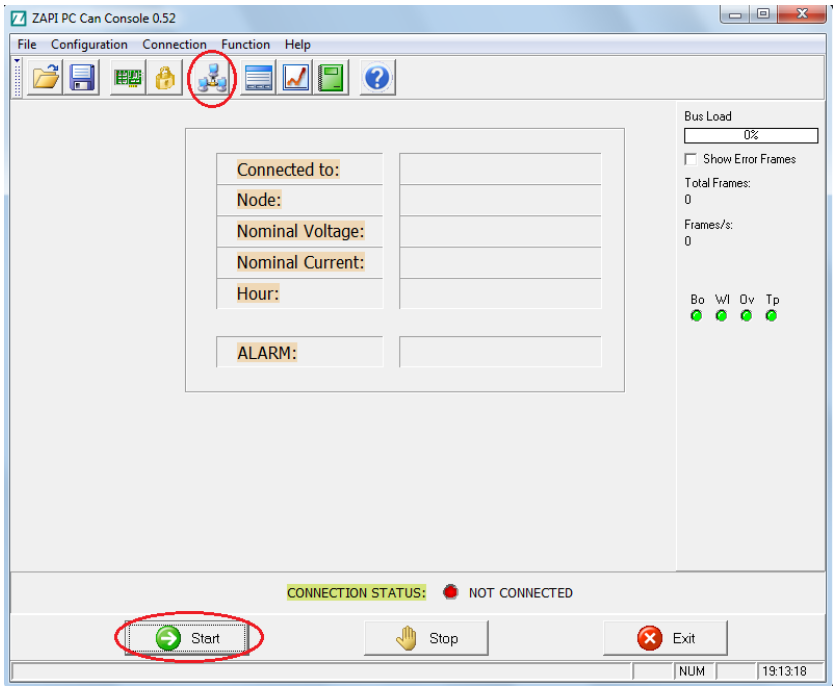
Running the PC Can Console software, the following form will appear:



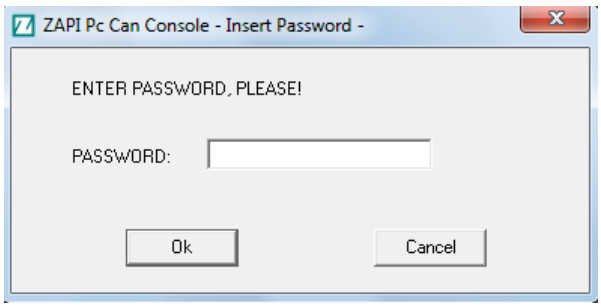
the first step to accomplish is to define the CAN device attached to the PC, so select the "Configuration" (Alt-C) -> Can Device (Ctrl-C) menu or click on Can Device icon.



From this form you can define the CAN-device used (IXXAT or IFAK or Peak) and the CAN communication speed then press the OK button.
Once you have define the CAN interface, you have to choose which CAN-device you need to connect to, then choose “Connection” -> “Set Node” menu (or push the “Set Node” icon).



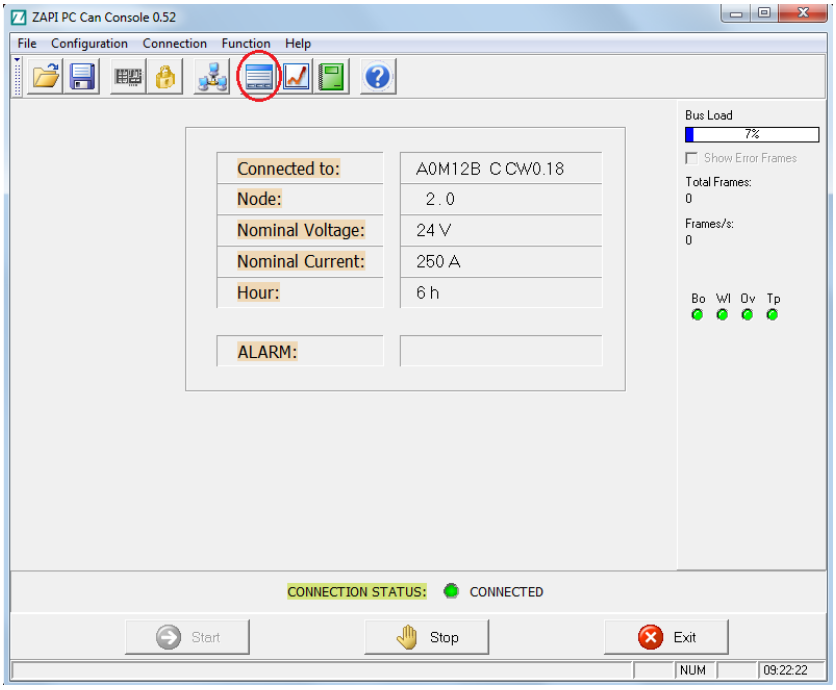
Once you have chosen the node, start the connection and insert the password in order to have the possibility to change the parameters.
Choose “Configuration” -> “Enter Password”.



Write the Password -> “ZAPI”

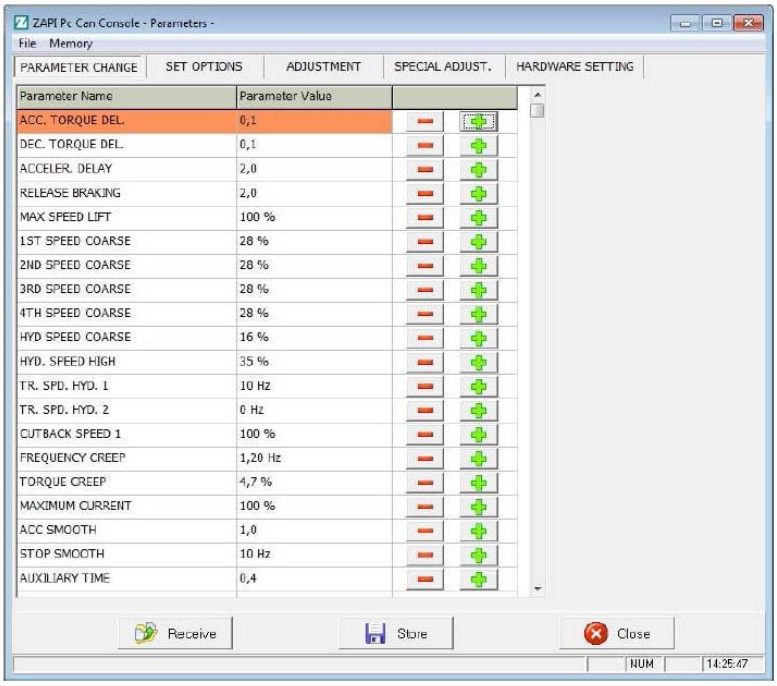
13.1.2 Parameter download

Once you are connected you need to download the parameter; choose “Function” > “Parameter” menu (or push the “Parameter” icon).



and then click on Receive button. The parameters will be downloaded automatically.
When the device as finish to send the device parameter you can change they.

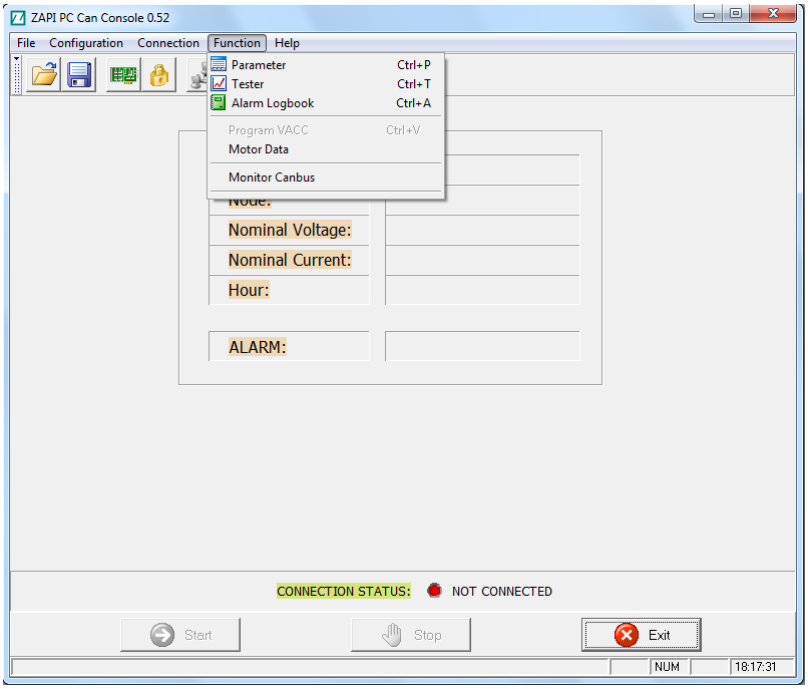
13.1.3 How to modify the parameters

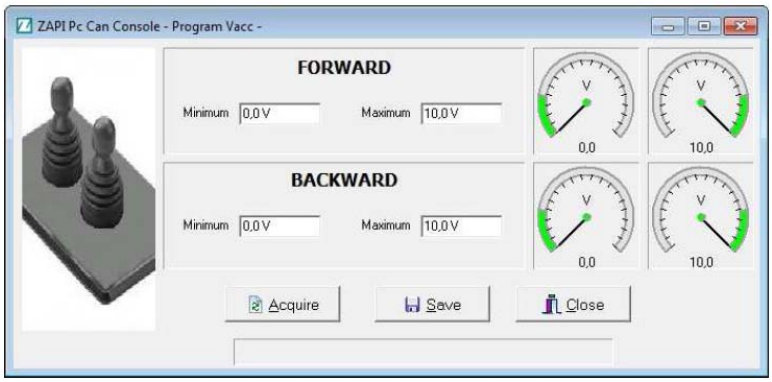


Once you are selected the menu and the parameter to change, using the “+” and “–“ button it is possible to modify the parameter value.
Click on the button “Store” to save the change on EEPROM.

13.1.4 Program Vacc

Choose “Function” > “Program VACC” menu.





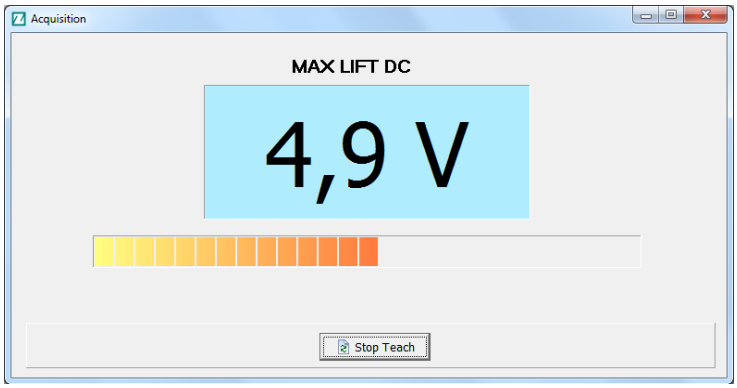
When “Acquire” is pressed PROGRAM VACC procedure will start:

- To select the Enable switch, if any
- To select the direction switch (either forward or backward)
- To press the pedal up to its maximum excursion.

Displayed values will vary accordingly to operator inputs.

13.1.5 Lift & Lower command acquiring

Once you are connected you need to download the parameter; choose “Function” > “Parameter” menu (or push the “Parameter” icon).
Choose “Adjustment” menu.
Select the value to acquire pressing “acquiring” button and the acquisition will start:



- Select the Enable switch, if any
- Select the command switch (either lift or lower)
- Move the command sensor (lift/lower potentiometer) to the correct position according to what you are acquiring
- Press “Stop Teach” command

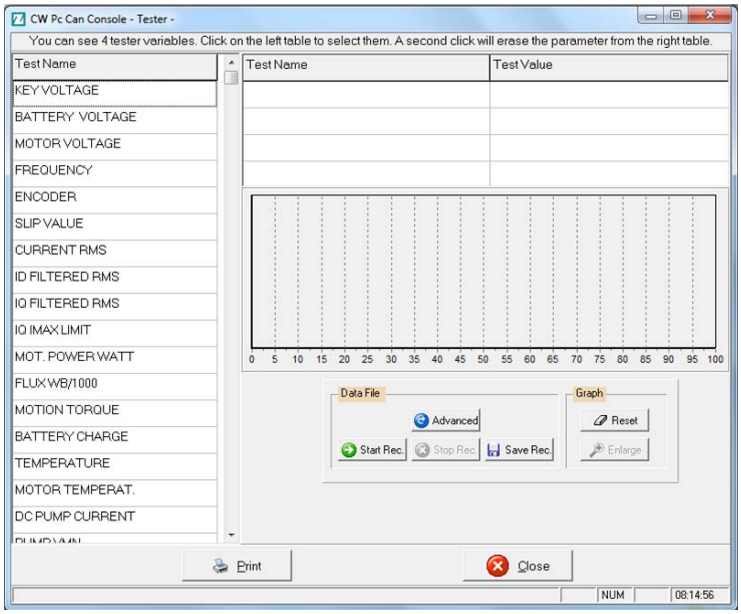
The procedure is the same for all the lift and lower command values.

13.1.6 Steer acquiring

Once you are connected you need to download the parameter; choose “Function” > “Parameter” menu (or push the “Parameter” icon).
Choose “Adjustment” menu.
Select the value to acquire pressing “acquiring” button and the acquisition will start: the procedure is the same described for Lift & Lower commands at paragraph 13.1.5

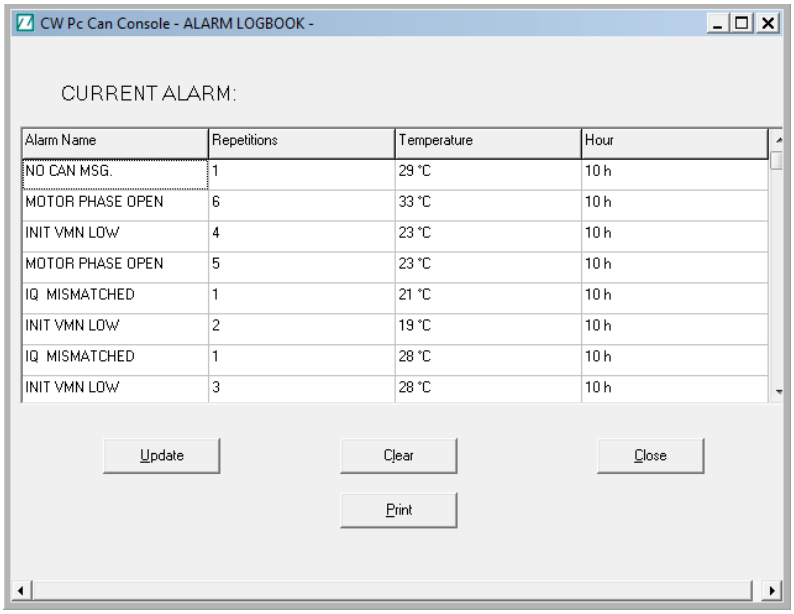
13.1.7 **Tester Functionality**

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



13.1.8 **Alarm Logbook**

This window will display the alarm stored in the controller.
For every alarm are related the working hour, motor temperature and the number of repetitions.



Four buttons are present:
Update →user can update alarm logbook,
Clear →user clear alarm logbook on chopper EEPROM,
Close →closes the window,
Print →prints alarm logbook data on the selected printer.

13.2 Appendix B: Zapi Smart Console user guide

13.2.1 Operational Modes

The Smart Console has been designed to have multiple ways of operation. Three modes can be identified:

- Serial connection powered by four standard AA size batteries placed in the battery holder of the console.
- CANBUS connection powered by four standard AA size batteries placed in the battery holder of the console.
- CANBUS connection with Smart Console supplied by an external dc source. This source may be a standard battery (lead-acid or other type) or a dc/dc converter

Current-loop serial connection

The Smart Console offers the same serial connection as the well-known Console Ultra.
Main characteristics of this operational mode:

- Current-loop serial communication
- Console is connected to a *single* controller only (even if Remote Console option is available)
- Baud-rate selectable
- Zapi can provide the serial cable compatible with Molex SPOX connector used in Console Ultra .

CANBUS connection

The Smart Console can connect to an existing CAN line and connect with any Zapi controller inside this line.
Main characteristics of this operational mode:

- It can be connected to a CAN line composed of any combination of modules, both Zapi ones and not-Zapi ones
- Supported speeds: 125, 250, 500kbps
- It sees the entire CAN line and all CAN modules.

13.2.2 The keyboard

The keyboard is used to navigate in the different menu. It features some key with special functions and a green led.

Different button functions are shown below.

UP and DOWN keys
In most cases a menu is a list of items: these items are ordered in rows. Selected item is highlighted in light blue .
Up and down keys are used to move the selection up and down: in other words they are used to “scroll”.

LEFT and RIGHT keys
Normally used to increase and decrease the value associated with the selected item inside a menu.

OK and ESC keys
OK key is used either to confirm actions or to enter a submenu.
ESC is used either to cancel an action or to exit a menu.

F1, F2, F3 keys
These buttons have a contextual use. The display will say which F button can be used and its function.

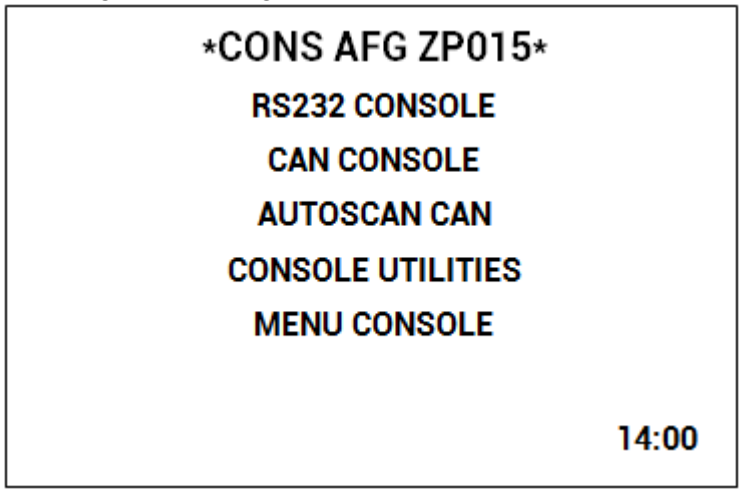
ON key
Used while operating with internal batteries.

While the Smart Console is powered from external sources on pin CNX8 the button ON is deactivated regardless of the presence of the batteries.

Green LED
When the console is powered on and running the green led is on.
Green led can blink in certain cases which will be described better in following sections.

13.2.3 Home Screen

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



From top:

- First line tells which firmware version is running inside the console, in this

case ZP 0.15

- RS232 Console: enter this menu to start a serial connection as in the Console Ultra
- CAN Console: enter this menu to start a CAN connection
- AUTOSCAN CAN: another way to start a CAN connection
- Console Utilities and Menu Console: ignore them at the moment
- The current hour is shown in the bottom right.

Moreover the green led must be turned on and still.

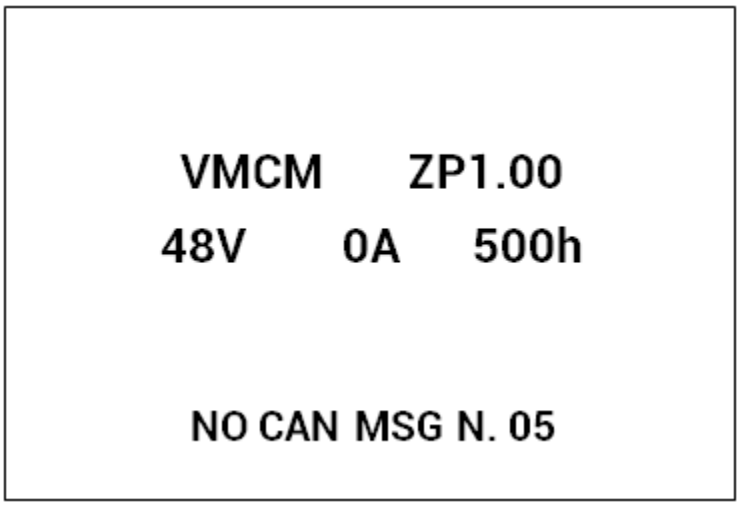
The “RS232” line is already highlighted so press OK key.
Display prompts a message to inform you that a connection attempt is ongoing.

If serial connection fails a “NO COMMUNICATION” warning will be shown after some second: press ESC key and look for what is preventing the connection.

Please notice the red dot appearing in the top right of the display every time you press a button. It indicates that the console has received the command and it is elaborating the request. If the red dot does not appear when a button is pressed, there is probably a failure inside the keyboard or the console has stalled.

13.2.4 Connected

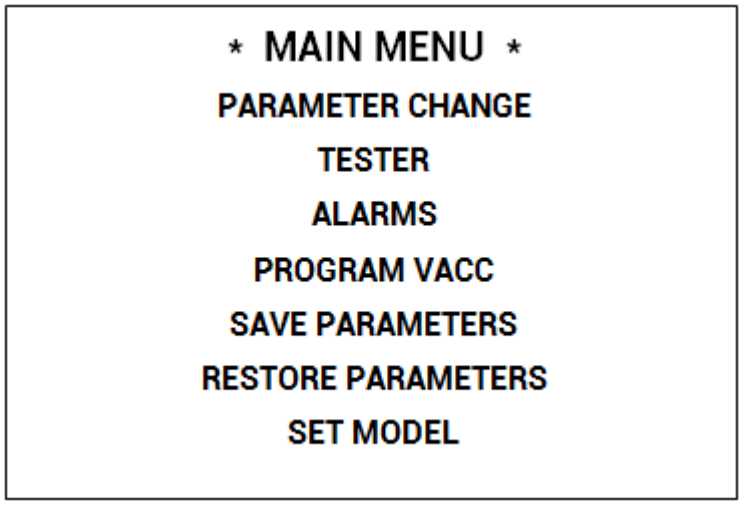
If connection is successful the display will show an image similar to the next one.



This menu shows basic information about the controller, in a way similar to console Ultra.

- First line tells the controller firmware
- Second line shows controller voltage, controller current and hourmeter
- Last line shows the current alarm code, if present

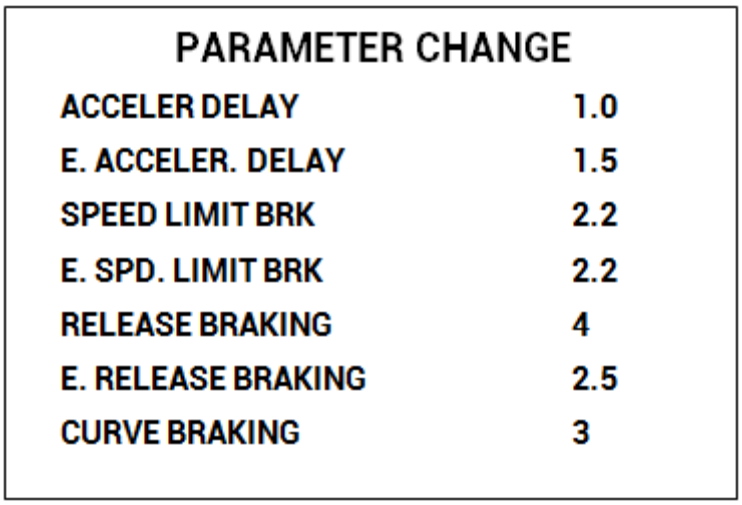
Press OK to access the MAIN MENU



MAIN MENU contains the complete list of menus available in the controller. Contrary to Console Ultra there are no “hidden” menus which must be reached by pressing many buttons at once: now all menus are visible.
Use UP and DOWN keys to navigate the list: once you find the desired menu press OK to enter it.

13.2.5 How to modify a parameter

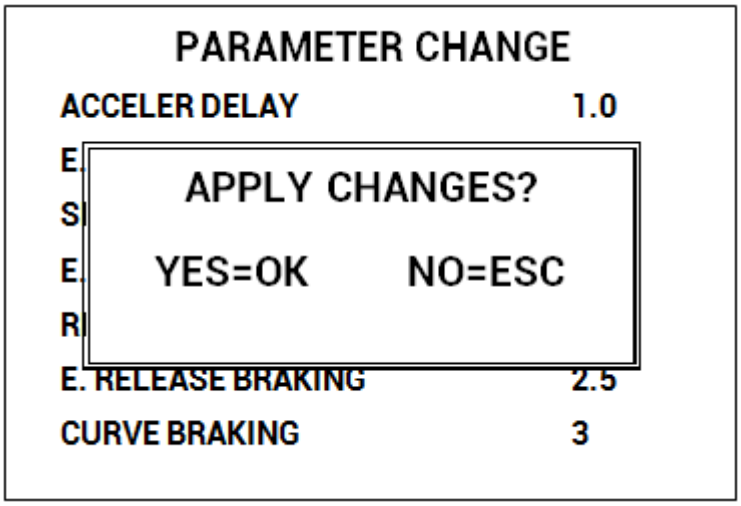
From MAIN MENU enter the PARAMETER CHANGE menu.



With UP and DOWN keys you can scroll the whole list: once you have highlighted a parameter that you want to modify, use LEFT or RIGHT keys to decrease or increase the parameter value.

Keep LEFT/RIGHT button pressed to continuously repeat the value modification (“autorepeat” function): this function will speed up the procedure in case many parameter values must be changed.

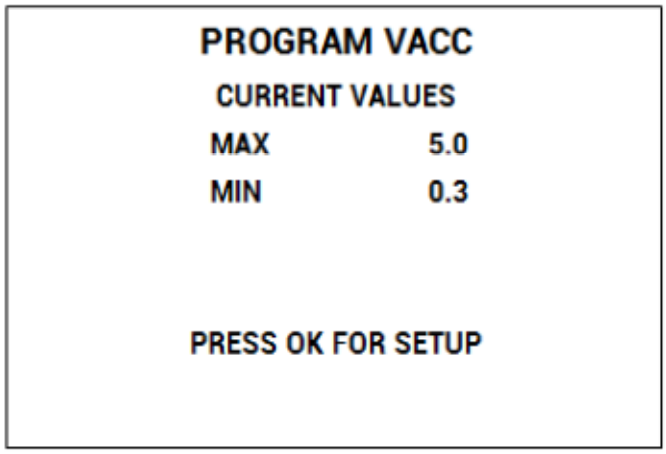
You can press ESC to exit the menu at any time. In case some parameter has been modified, the console will prompt a request to confirm/discard changes.



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

13.2.6 **Program VACC**

Program VACC menu has been slightly modified compared with old console. Upon entering this menu the console will show the current programmed values.

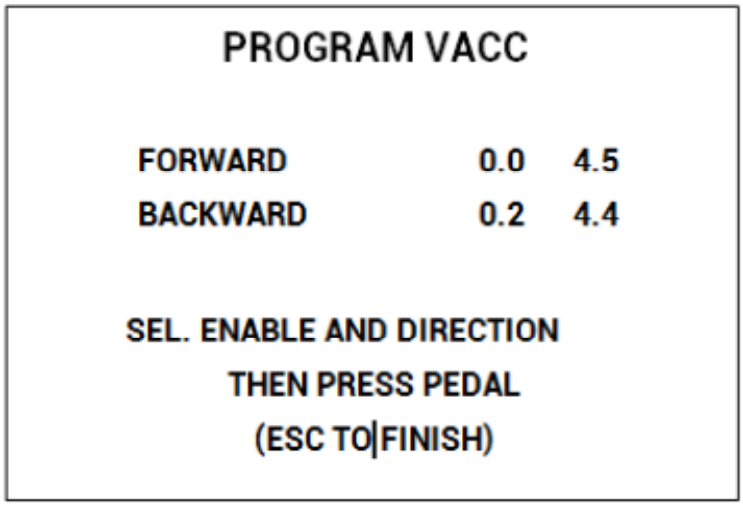


When OK is pressed PROGRAM VACC procedure will start: console will invite you:

- Select the Enable switch, if any
- Select the direction switch (either forward or backward)
- Press the pedal up to its maximum excursion.

Displayed values will vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. Anyway the logic will remain the same: before programming the min/max values, execute any tarting sequence which is necessary, then press the pedal/push the joystick.



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

13.2.7 Lift and Lower commands acquiring

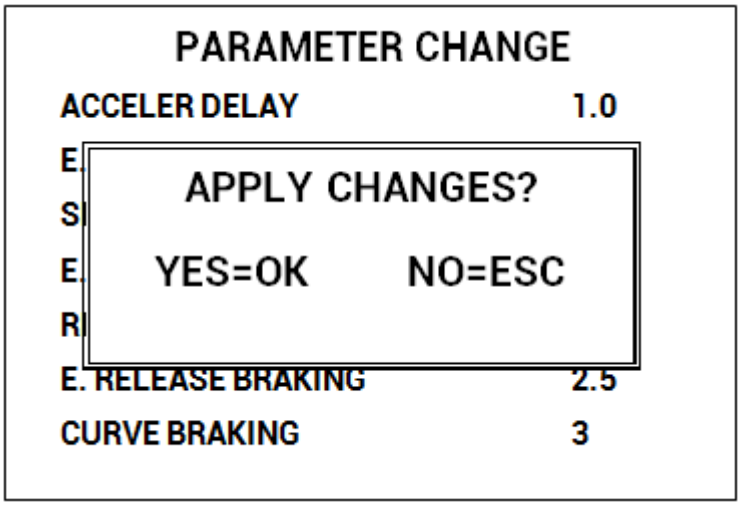
From MAIN MENU enter the Adjustment menu.
With UP and DOWN keys you can scroll the whole list: once you have highlighted a value that you want acquire press OK.
When OK is pressed the procedure will start:

- Select the Enable switch, if any
- Select the command switch if any (either lift or lower)
- Move the command sensor (lift/lower potentiometer) to the correct position according to what you are acquiring.

Displayed values will vary accordingly to operator inputs.

Sequence above can slightly vary depending on controller firmware. Anyway the logic will remain the same: before programming the min/max values, execute any tarting sequence which is necessary, then press the pedal/push the joystick.

It is possible step by step acquire all the value in only one session.
At the end you can press ESC and the console will prompt a request to confirm/discard changes.

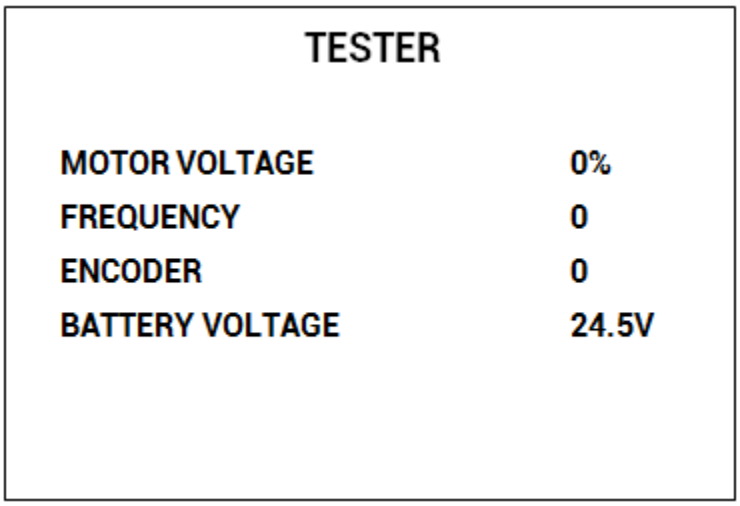


13.2.8 Steer command acquiring

From MAIN MENU enter the Adjustment menu.
The procedure to follow is the same described in paragraph 13.2.7.

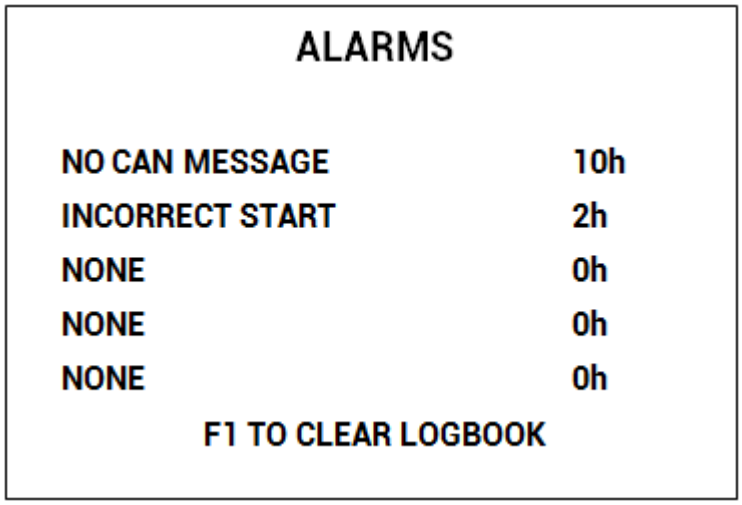
13.2.9 Tester

Compared to standard console Ultra, the TESTER menu has been modified deeply. Now it shows four variables at once: use UP/DOWN keys to scroll the list as usual.



13.2.10 Alarms

ALARMS menu has changed from Console Ultra. Display shows all controller alarms at once.



Five is the maximum number of alarm codes which is stored inside the controller.

Colours are used to separate recurrent alarm codes from rare events. In order of increasing frequency alarm names can be:

- White: up to 5 occurrences
- Yellow: up to 20,
- Orange: up to 40,
- Red: more than 40.

Use UP/DOWN to select a certain alarm in the list: if OK is pressed, additional information about that alarm will be displayed.

Press F1 to cancel the alarm logbook of the controller: once pressed, the console will ask for confirmation.