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EN

User Manual

DUALACE2 NEW GENERATION

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APPROVAL SIGNS

COMPANY FUNCTION	INITIALS	SIGN
PROJECT MANAGER		
TECHNICAL ELECTRONIC MANAGER VISA		
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1 INTRODUCTION

1.1 About this document

1.1.1 Scope of this manual

This manual provides important information about DUALACE2 NEW GENERATION controller. It presents instructions, guidelines and diagrams related to installation and maintenance of the controller in an electrically powered vehicle.

1.1.2 Terms and abbreviations

Application	A customer specific use of Zapi hardware and software
CAN	Controller Area Network
ESD	Electrostatic discharge
LED	Light Emitting Diode
MCU	Micro Computer Unit
OEM	Original equipment manufacturer
PTC	Positive temperature coefficient
PWM	Pulse width modulation

1.1.3 Manual revision

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

1.1.4 Warnings and notes

In this manual special attention must be paid to information presented in warning and information notices.
Definitions of warning and information notices are the following.

This is an information box, useful for anyone working on the installation, or for a deeper examination of the content.

This is a warning box, it can describe:
- operations that can lead to a failure of the electronic device or can be dangerous or harmful for the operator;
- items which are important to guarantee system performance and safety.

This is a further warning within the box. Pay special attention to the annotations pointed out within warning boxes.

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 people responsible for the design and use of equipment employing the motor controller have the proper professional skills and knowledge of equipment.

The high power levels and high torque available from a motor and motor controller combination can cause severe or fatal injury.

Before installation, always verify that the motor controller model is correct for the vehicle's battery supply voltage. The DC Supply nominal voltage is shown on the motor controller's identification label

Before doing any operation, ensure that the battery is disconnected and when the installation is completed start the machine with the driving wheels raised from the ground to ensure that any installation error does not compromise safety.

After the inverter turn-off, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10 – 100 Ohm between +B and -B terminals of the inverter for at least 10 seconds.

1.2.2 OEM's responsibility

Zapi motor controllers 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 responsibility of the vehicle manufacturer to identify the correct standards and to ensure that the vehicle meets these standards. As a major electrical control component, the role of a 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 meeting vehicle safety standards.
Zapi does not accept responsibility for incorrect application of its products.

1.2.3 Technical support

For additional information on any topic covered in this document or application assistance on other Zapi products, contact Zapi sales department.

2 SPECIFICATIONS

2.1 General features

DUALACE2 NEW GENERATION inverter is a controller designed to control a pair of AC induction, PMSM, SRM and SRPM motors, in the range from 4 kW to 12 kW continuous power, used in a variety of battery-powered material handling trucks.
Typical applications include, but are not limited to: counterbalanced trucks with load up to 3 tons, HLOP (VNA), reach truck, tow tractors, airport ground support vehicles, aerial-access equipment (telescopic boom and scissor lift), e-mobility vehicles.

The main inverter features are:

- 16-bits real time signal controller for motor control and main functions.
- 16-bits real time signal controller for safety functions.
- Field-oriented motor control.
- Compatible with several types of speed/position sensors:
    - 2 x Incremental encoder
    - 2 x sin/cos sensors
    - 2 x set of hall sensors
- Low-side driver for a line-contactor coil.
- Low-side drivers for electromechanical-brake coils
- Driver for a proportional valve (PWM current controlled).
- High-side driver for electromechanical-brake
- Thermal cutback, warnings and automatic shutdown for protection of motor and controller.
- ESD-protected.
- Software downloadable via serial link (internal connector) or CAN bus (external connector).
- Diagnostic provided via CAN bus using Zapi PC CAN Console.
- Rugged sealed housing and connectors meet IP65 environmental sealing standards for use in harsh environments.

2.2 Technical specifications

Motor type: ....ACIM, PMSM, SRM, SRPM
Control mode:..speed or torque control
Operating frequency: ....8 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:...23 or 35-pins Ampseal
Package environmental rating: IP65

2.3 Current ratings

Nominal DC voltage [V]	Maximum 2-min rated current [Arms]	Continuous rated current [Arms]
24	2 x 550	2 x 275
	2 x 500	2 x 250
	2 x 450	2 x 225
	2 x 400	2 x 200
	2 x 350	2 x 175
36 / 48	2 x 550	2 x 275
	2 x 500	2 x 250
	2 x 450	2 x 225
	2 x 400	2 x 200
	2 x 350	2 x 175
	2 x 275	2 x 135
72 / 80	2 x 400	2 x 200
	2 x 350	2 x 175
	2 x 300	2 x 150
	2 x 250	2 x 125
96	TBD	TBD

Internal algorithms automatically reduce the maximum current limit when heat sink temperature is above 85°C. Heat sink temperature is measured internally near the power MOSFETs (see paragraph 6.6.1).

Two-minute ratings are referred to an inverter equipped with a base plate. No additional external heat sink or fans are used for the 2-minute rating test. Ratings are based on an initial base plate temperature of 40°C and a maximum base plate temperature of 85°C.

The inverter can deliver the rated continuous current only if it is adequately cooled. When it is equipped with its own finned heat sink, a proper dissipation is obtained by applying a 100 m^3/h airflow. In case it is provided with the base plate, it is customer's duty to design an adequate cooling system that can dissipate the heat produced by the inverter, keeping its temperature below 85 °C. Otherwise, the inverter will deliver a continuous RMS current lower than the rated one.

Upon request controller can be configured having different current rating for the two power section

2.4 Voltage ratings

Nominal DC voltage	**24 V**	**36 V / 48 V**	**72 V / 80 V**	**96 V**
Conventional working voltage range	19.2V÷28.8V	28.8V÷57.6V	57.6V÷96V	76.8V÷115.2V
Non-operational overvoltage limits	35 V	72.5 V	115 V	130 V
Non-operational undervoltage limits	10 V	10 V	30 V	30 V

Conventionally, the controller can be set to operate without alarm in the range from 80% to 120% of the nominal battery voltage. With a different DC voltage than specified, the controller raises an alarm.

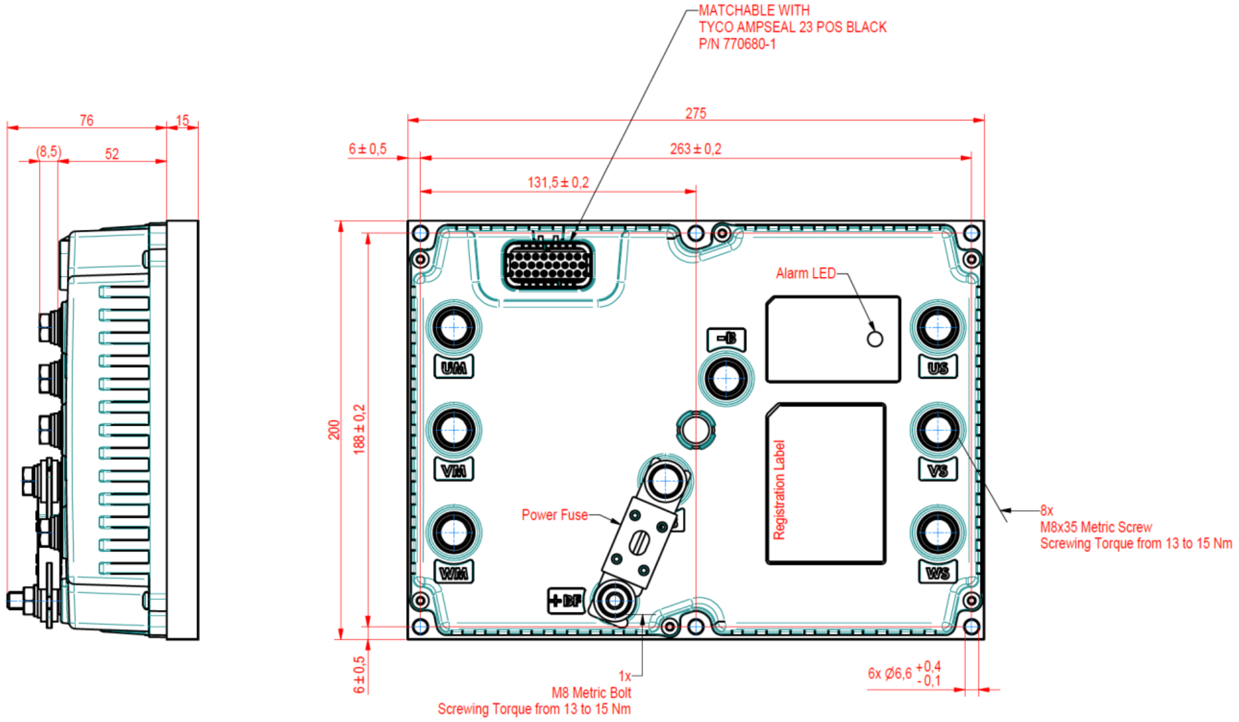
Undervoltage and overvoltage thresholds are defined by hardware. After start-up, controller is fully operative if the supply voltage stays within these limits.

Undervoltage is evaluated on the KEY input (A3); overvoltage is evaluated on the positive battery terminal +B.

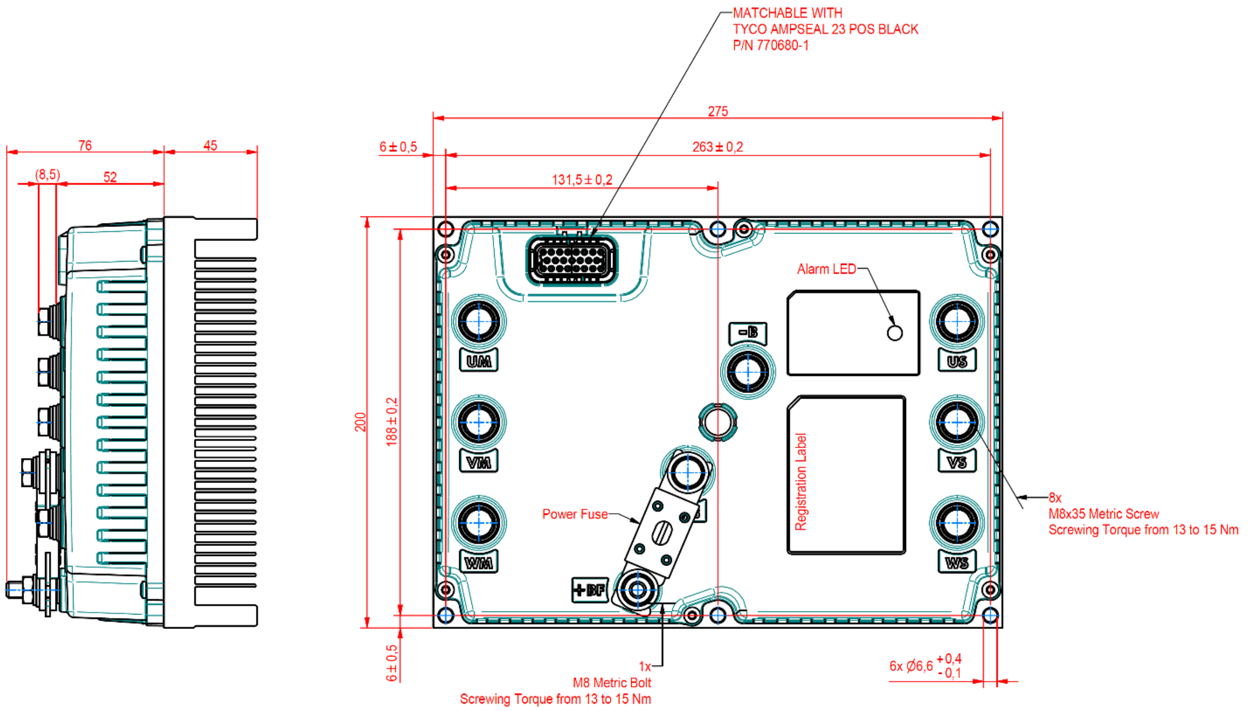
3 DRAWINGS

3.1 Mechanical drawings

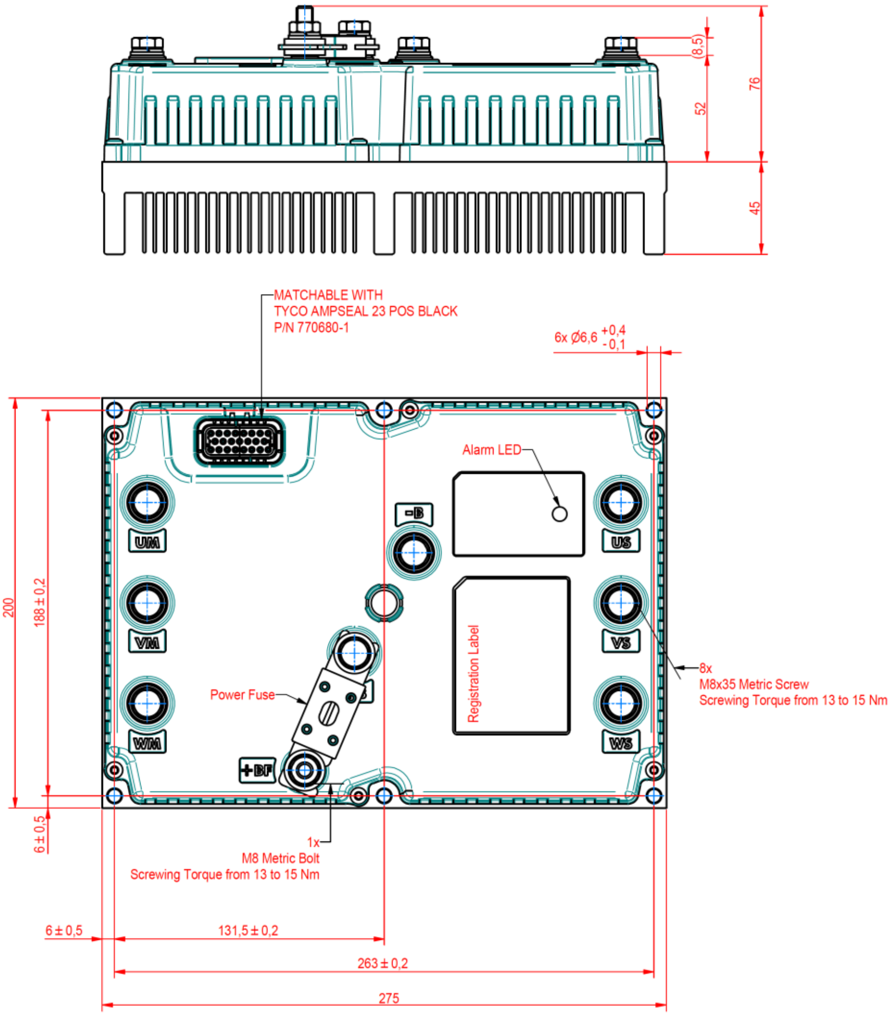
3.1.1 Standard version – Base-plate with fuse



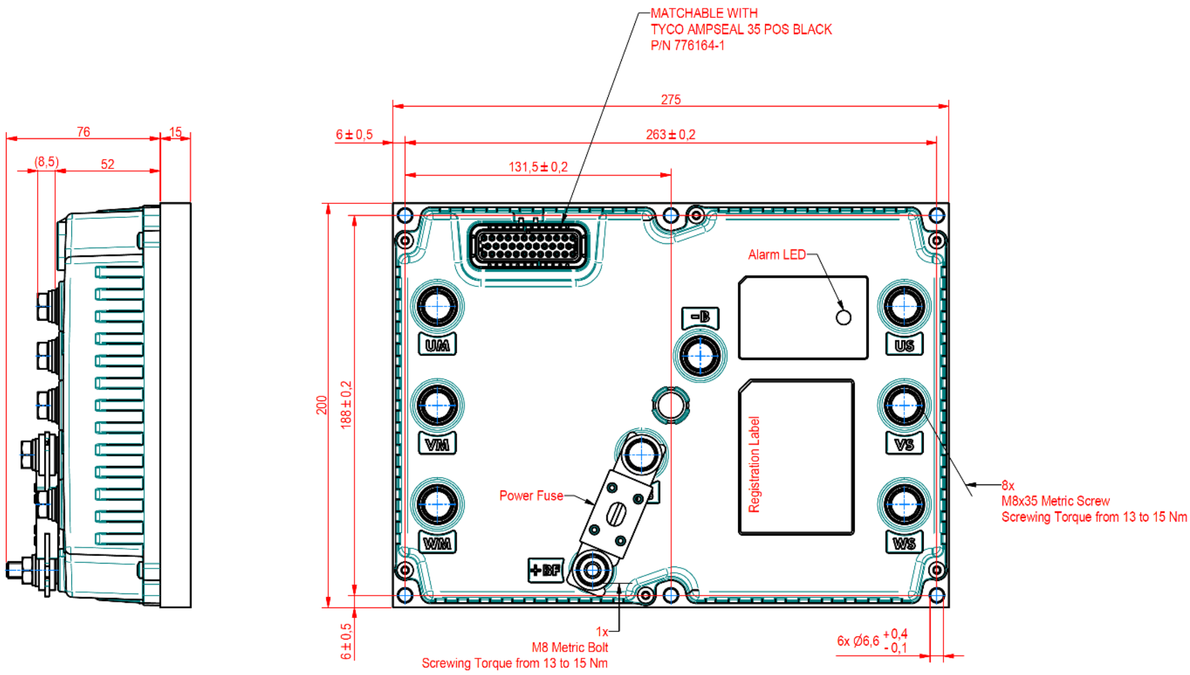
3.1.2 Standard version – Longitudinal Heatsink with fuse



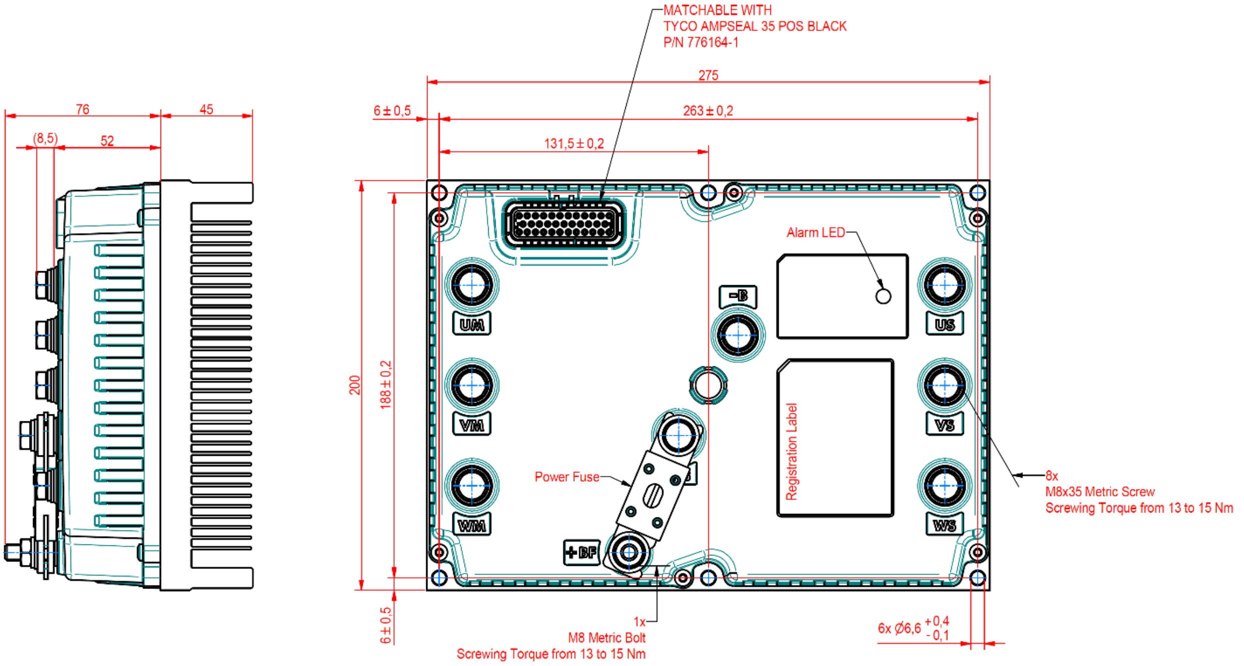
3.1.3 Standard version – Transversal Heatsink with fuse



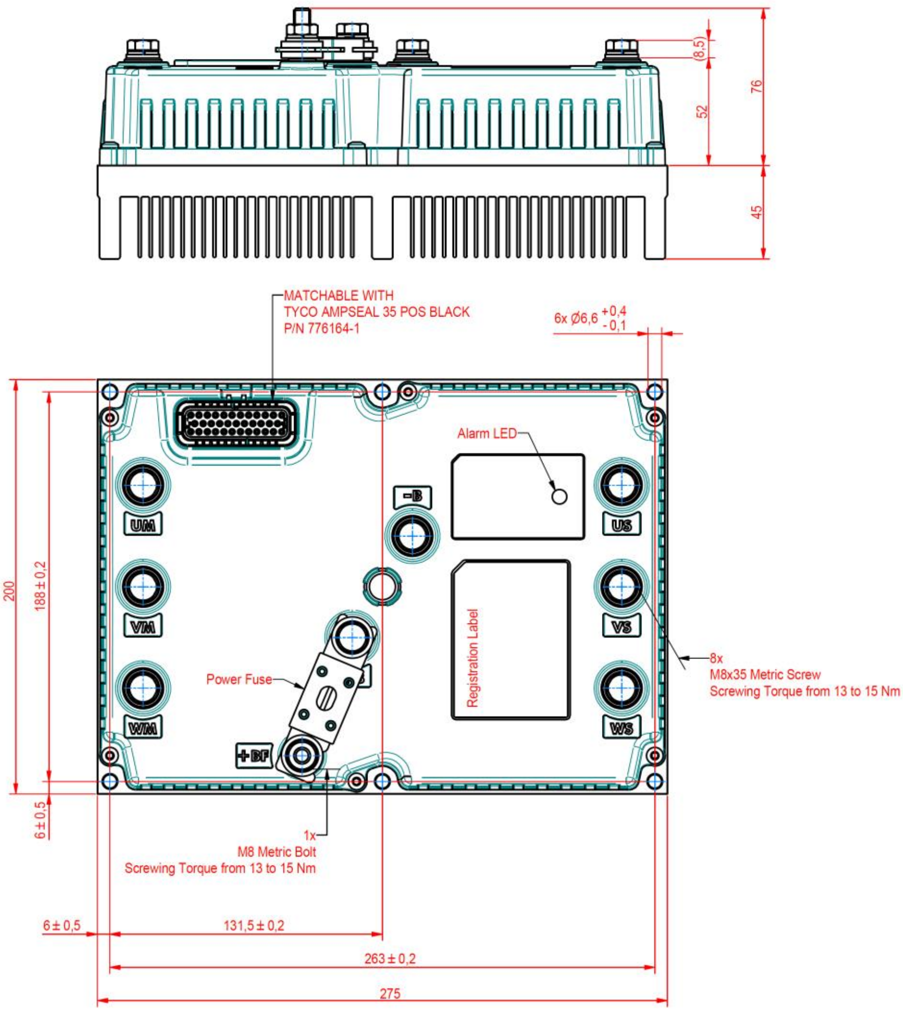
3.1.4 Premium version – Base-plate with fuse



3.1.5 Premium version – Longitudinal Heatsink with fuse

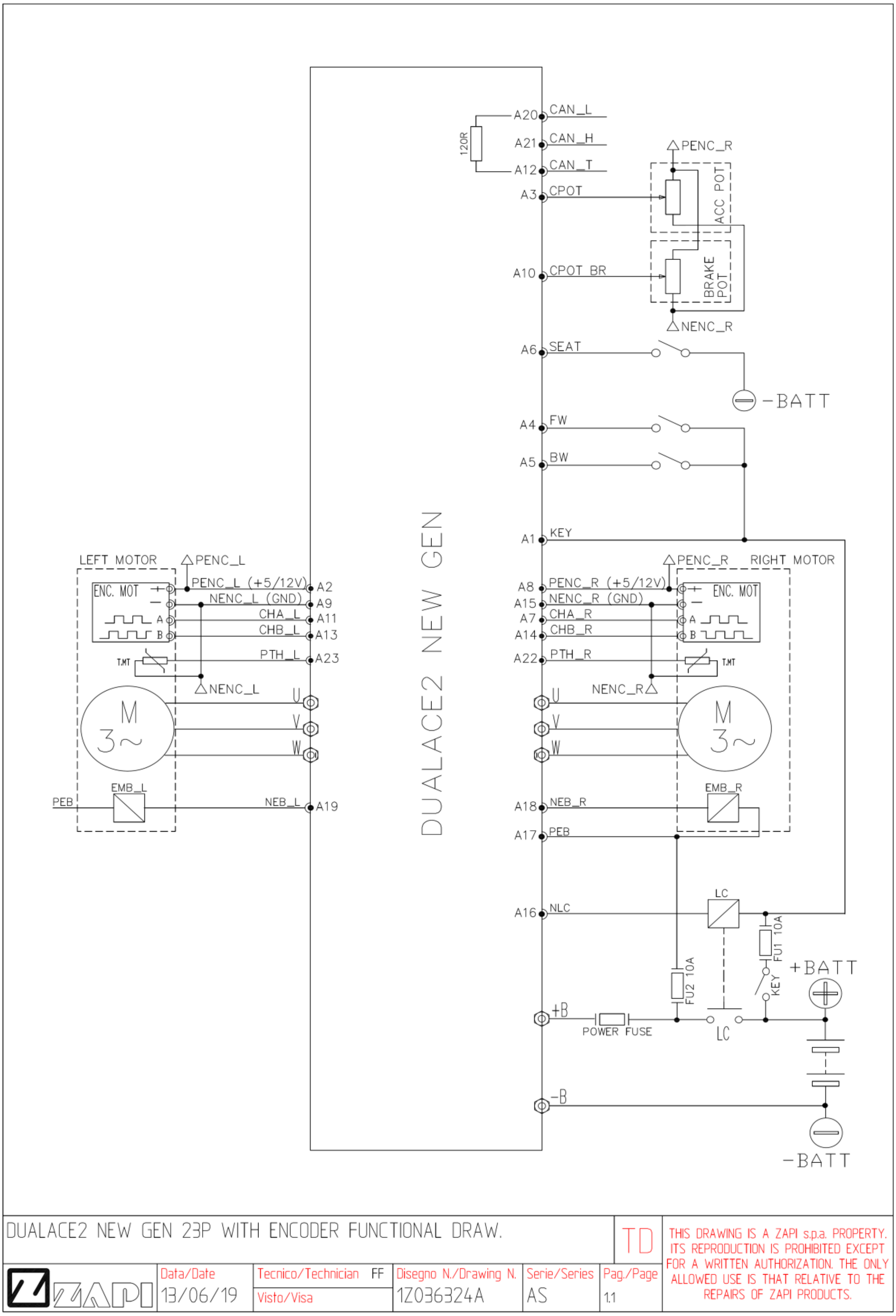


3.1.6 Premium version – Transversal Heatsink with fuse

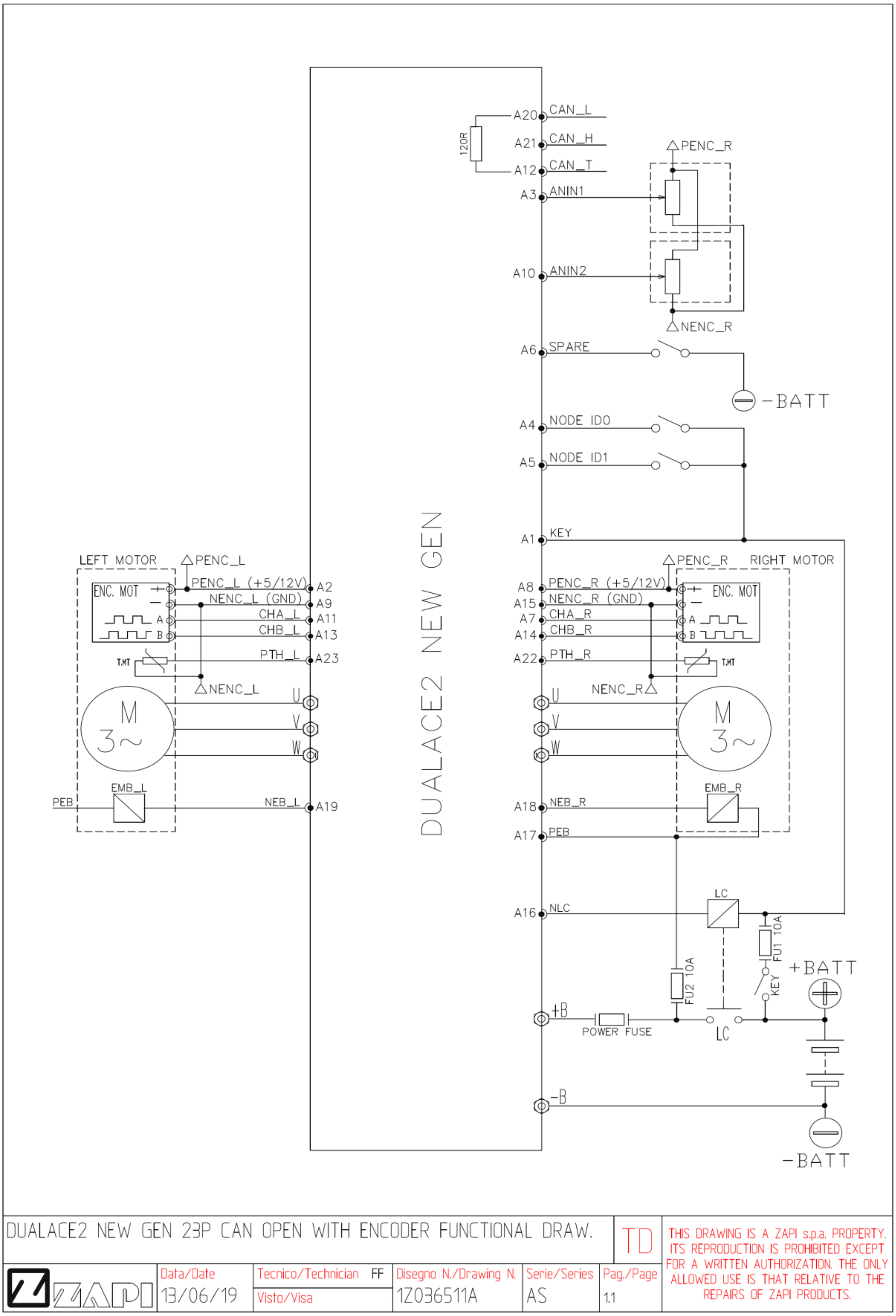


3.2 Connection drawings

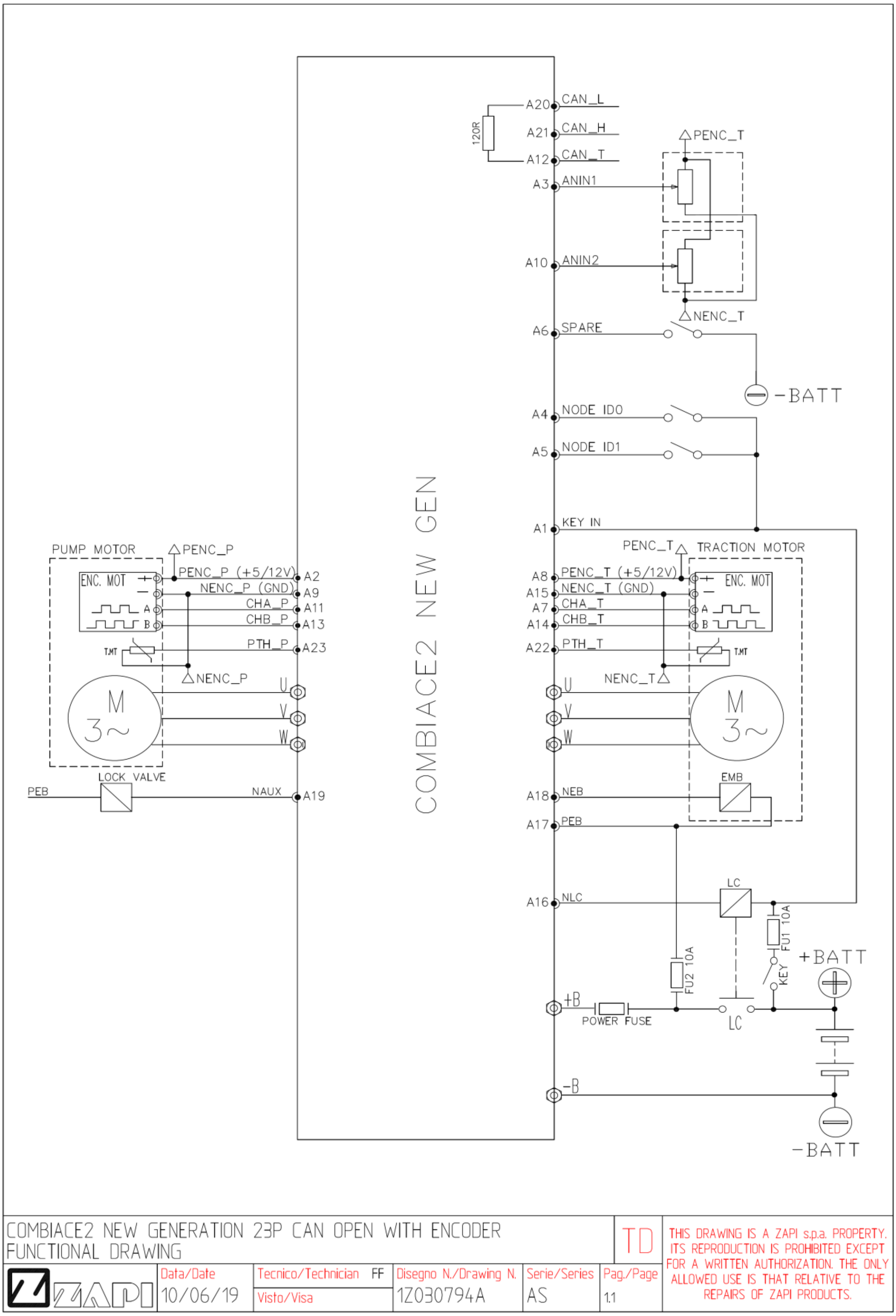
3.2.1 Standard version – Dual AC traction configuration



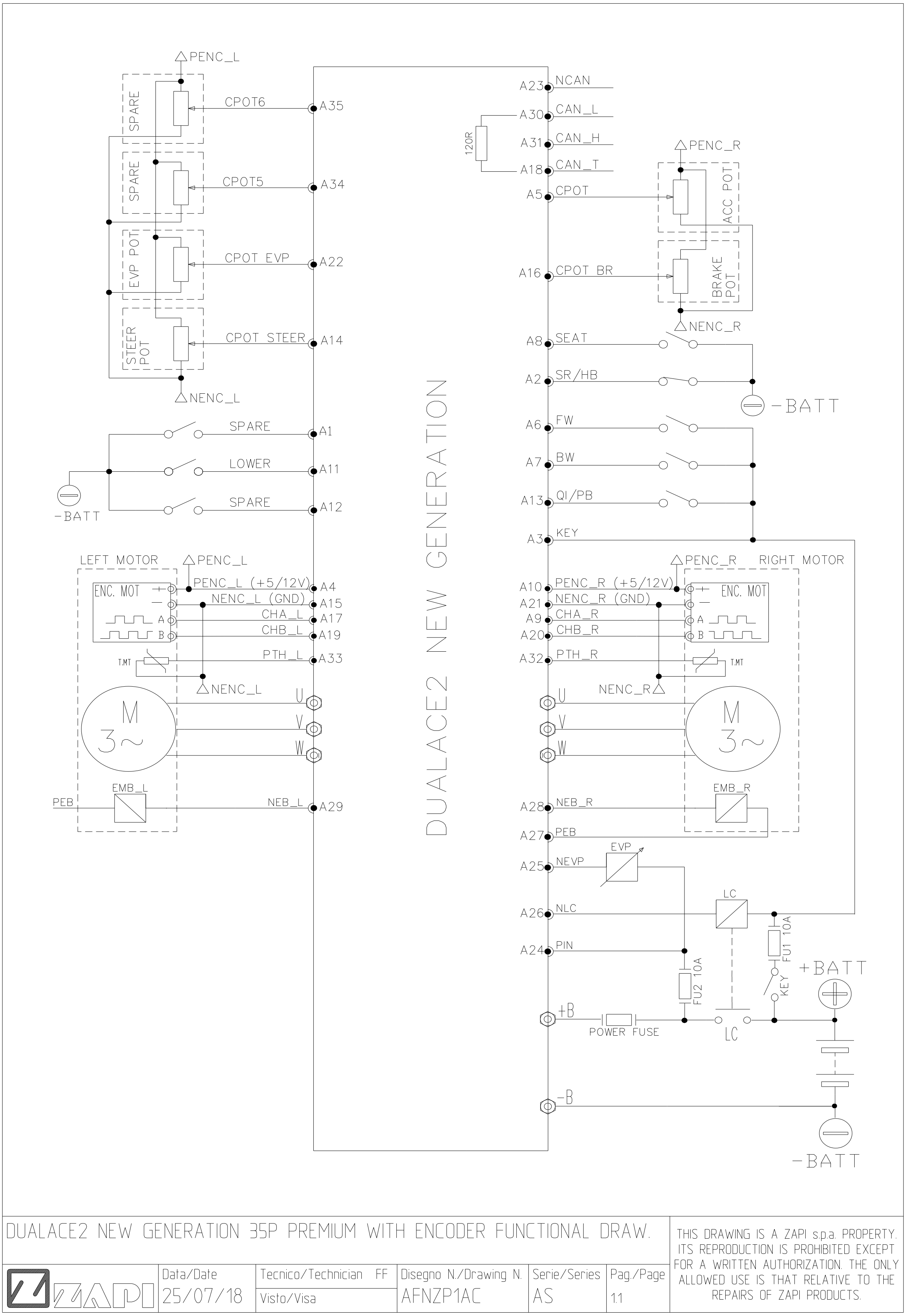
3.2.2 Standard version – CAN controlled Dual AC traction configuration



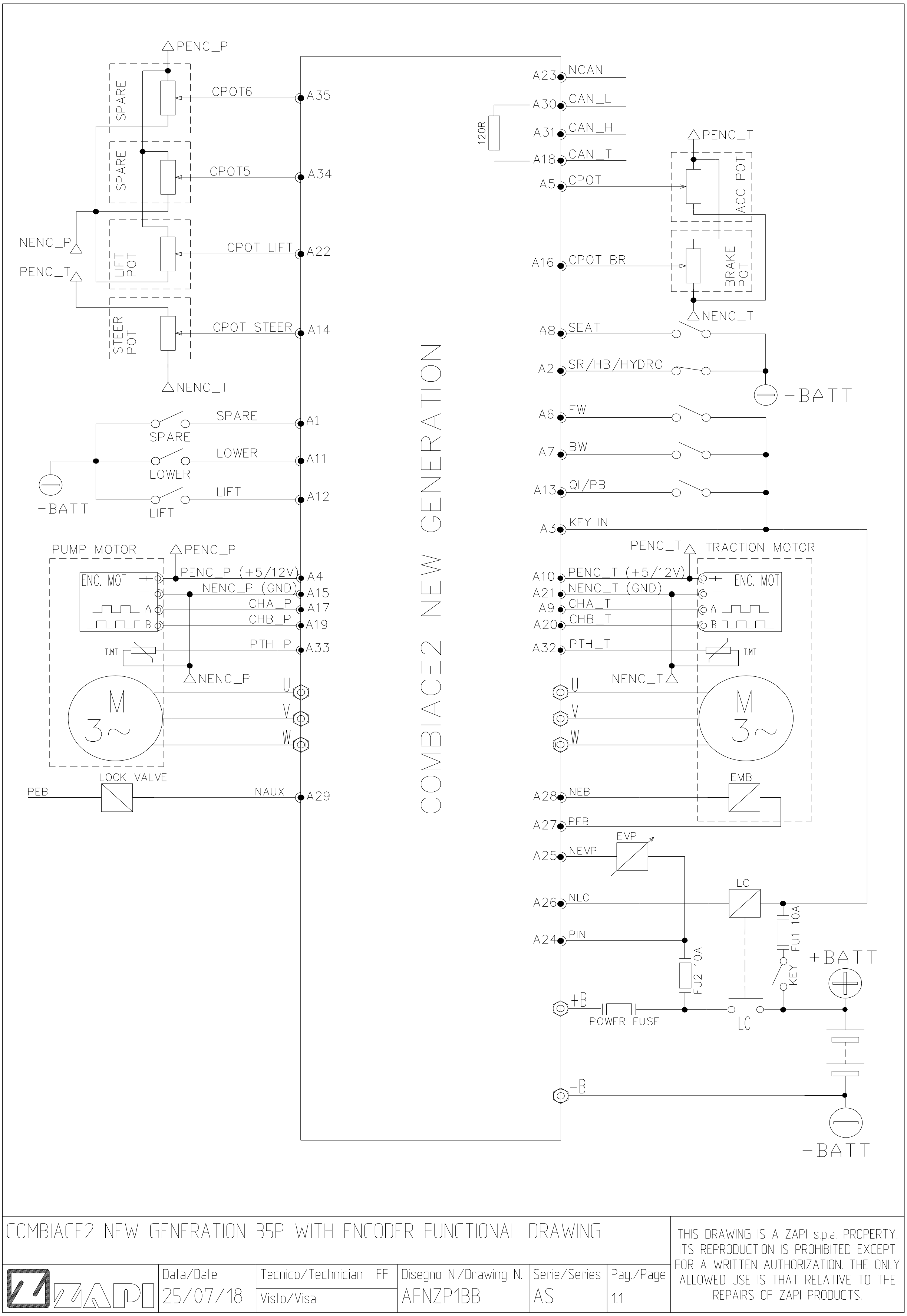
3.2.3 Standard version – CAN controlled Combi AC configuration (AC traction + AC pump)



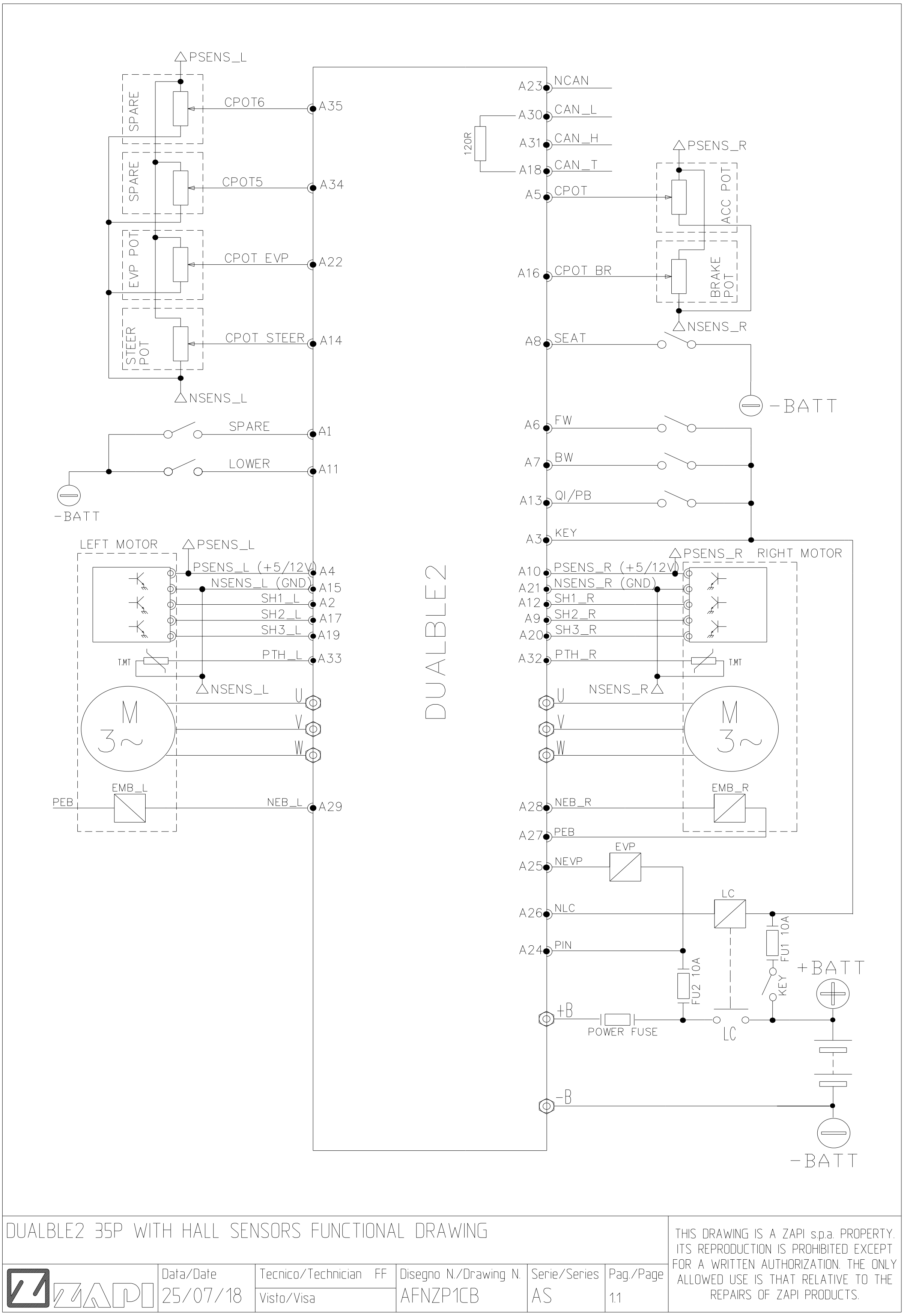
3.2.4 Premium version – Dual AC traction configuration



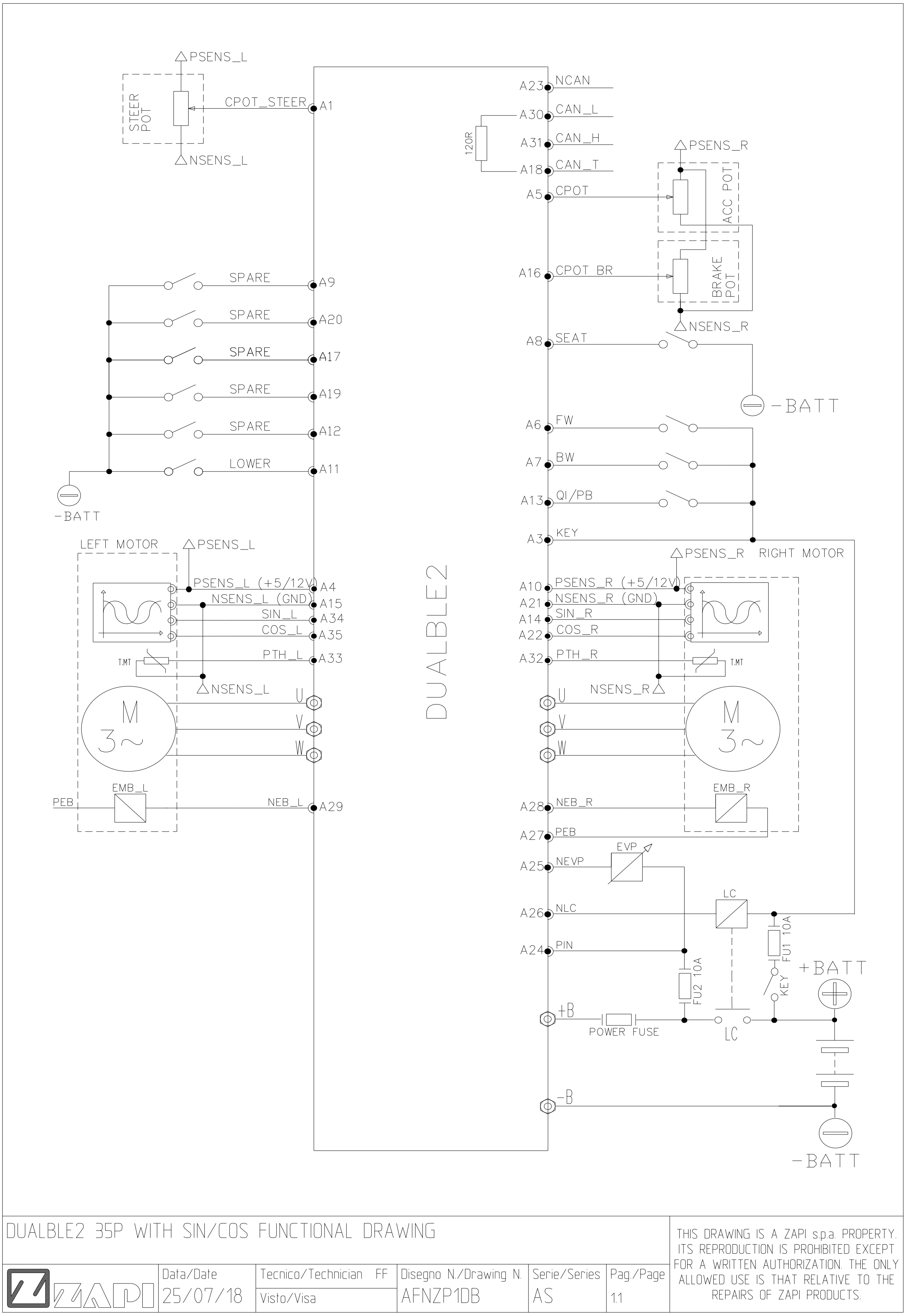
3.2.5 Premium version – Combi AC configuration (AC traction + AC pump)



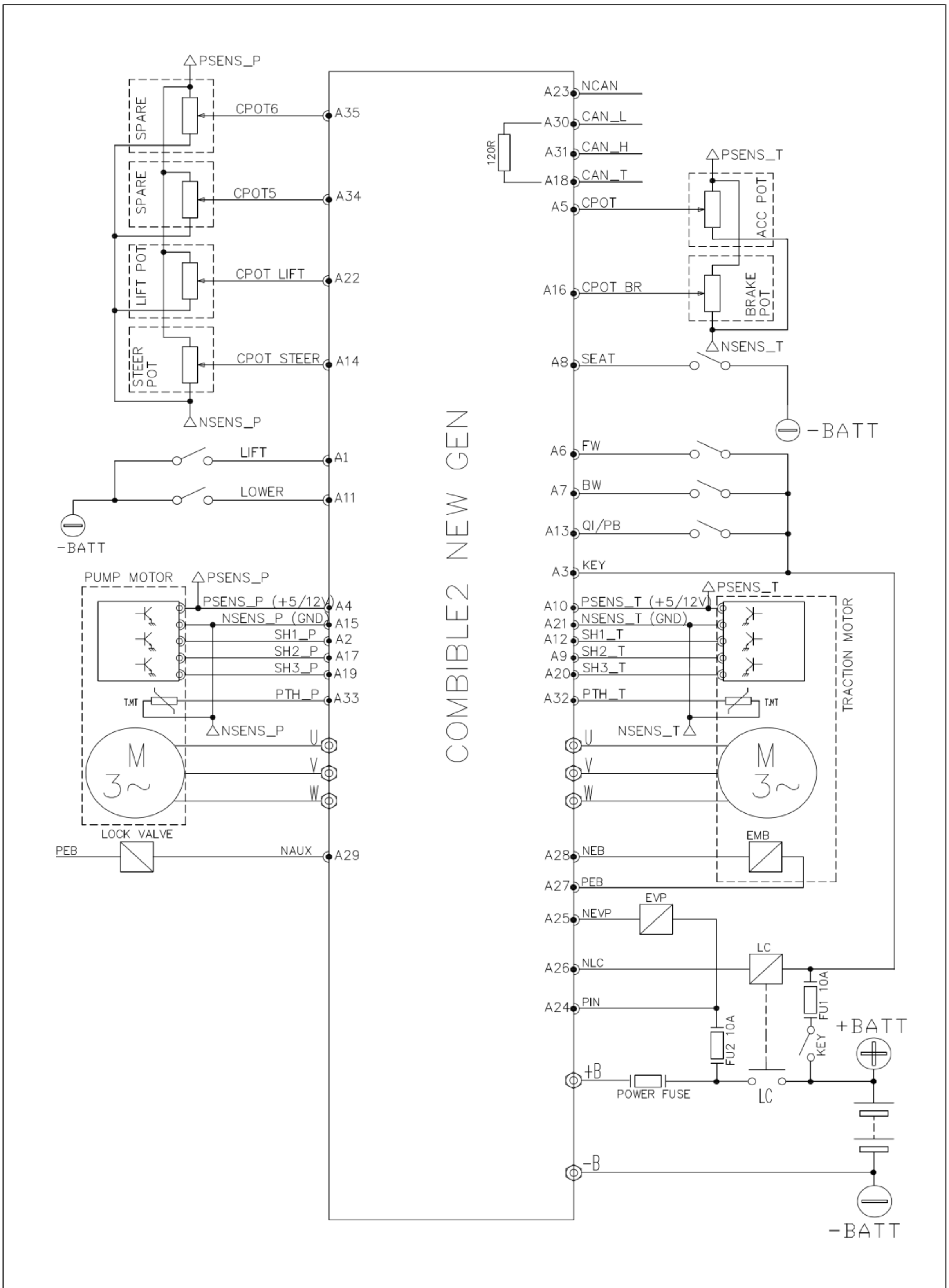
3.2.6 Premium version – Dual BL traction with Hall sensors



3.2.7 Premium version – Dual BL traction with sin/cos sensors



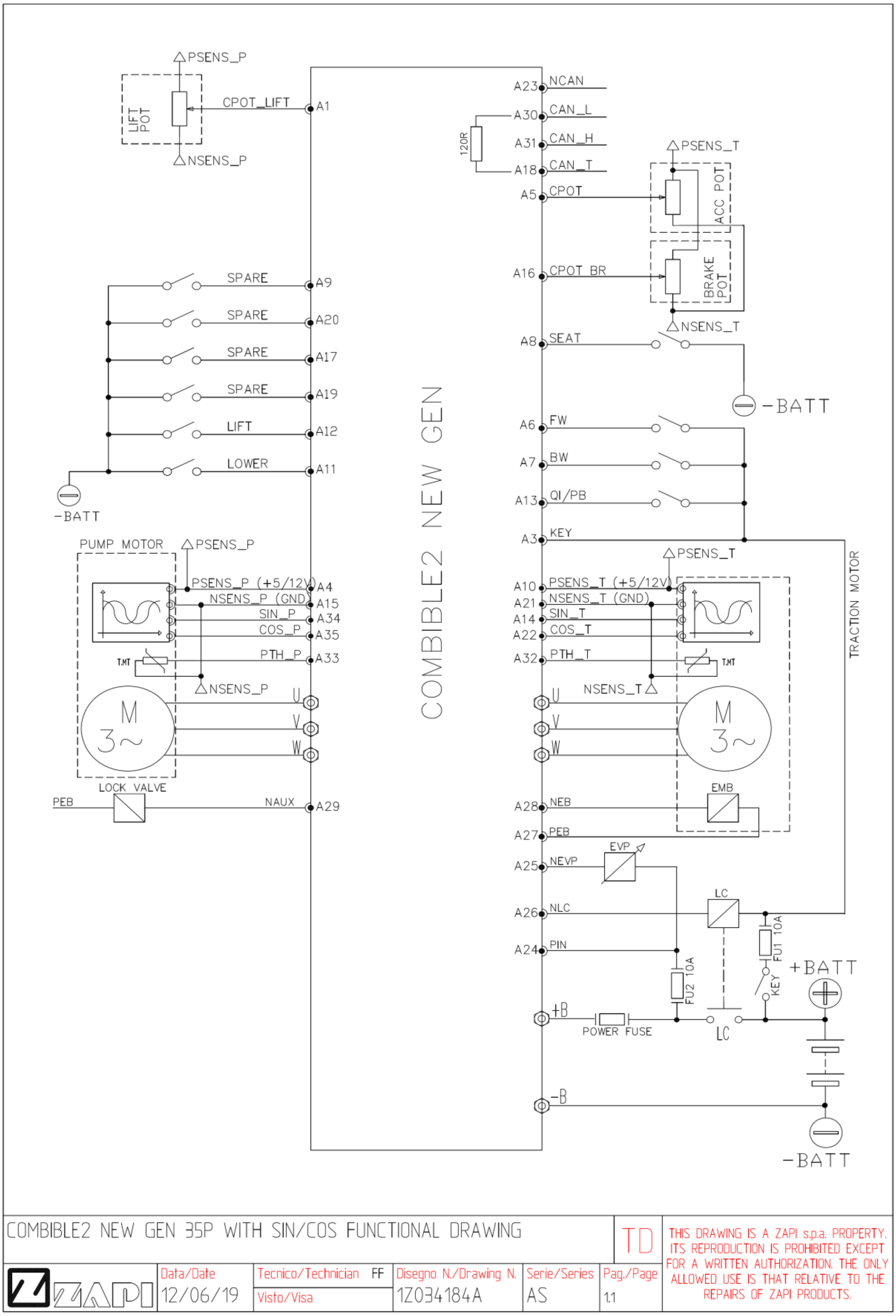
3.2.8 Premium version – Combi BL configuration (BL traction + BL pump) with Hall sensors



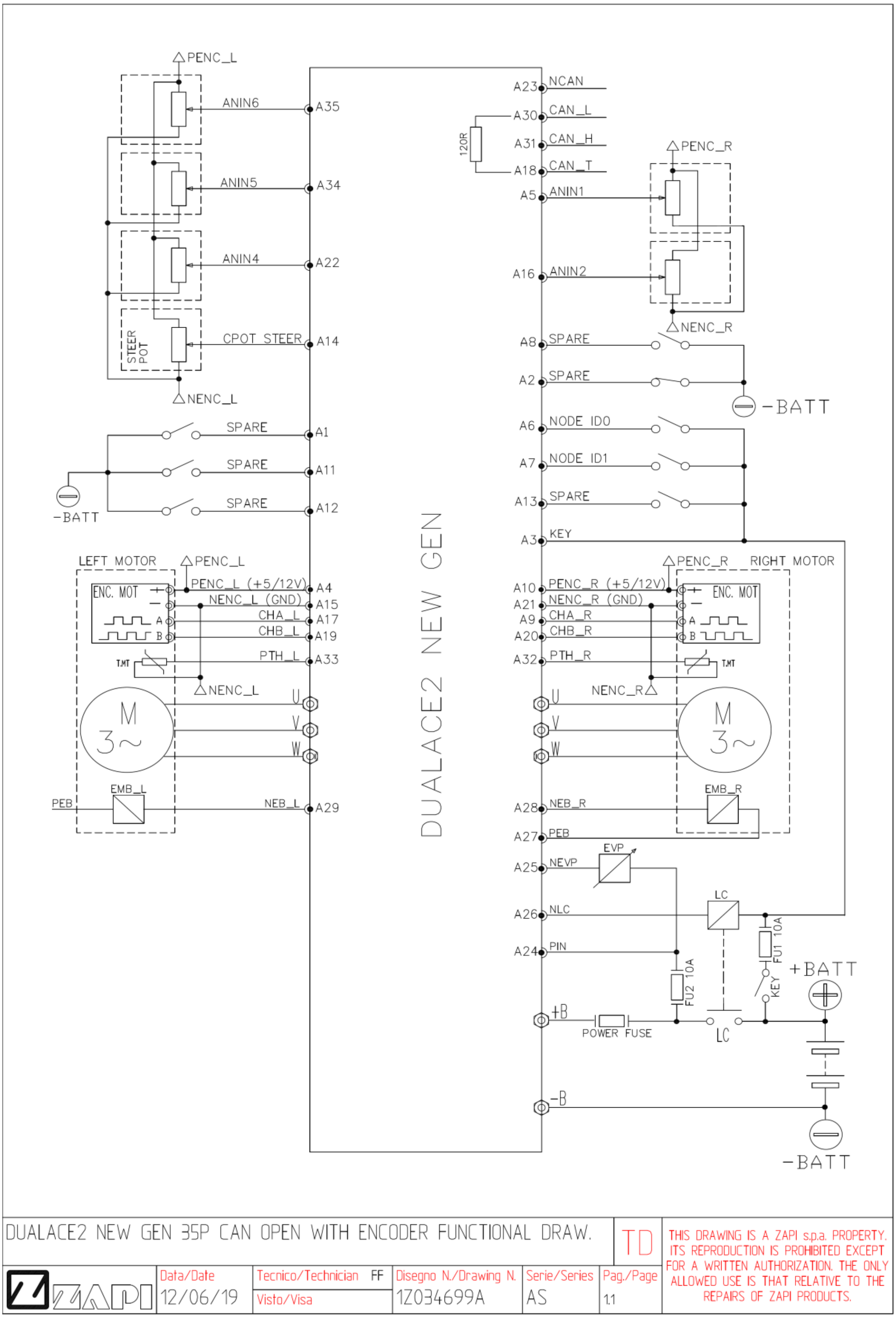
COMBIBLE2 NEW GEN 35P WITH HALL SENSORS
FUNCTIONAL DRAWING

ZAPI	Data/Date	Tecnico/Technician FF	Disegno N./Drawing N.	Serie/Series	Pag./Page	TD
	11/06/19	Visto/Visa	1Z032393A	AS	1.1	

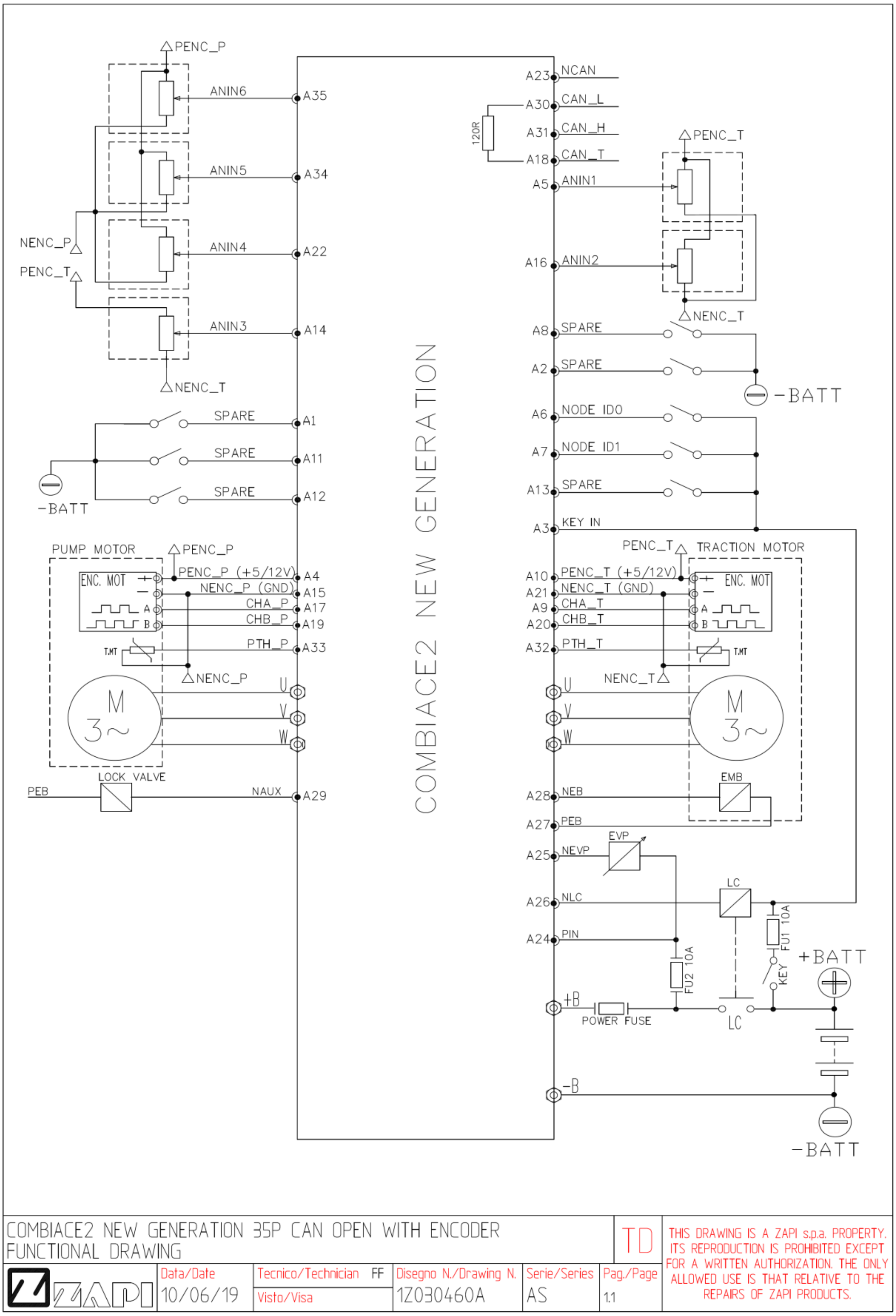
3.2.9 Premium version – Combi BL configuration (BL traction + BL pump) with sin/cos sensors



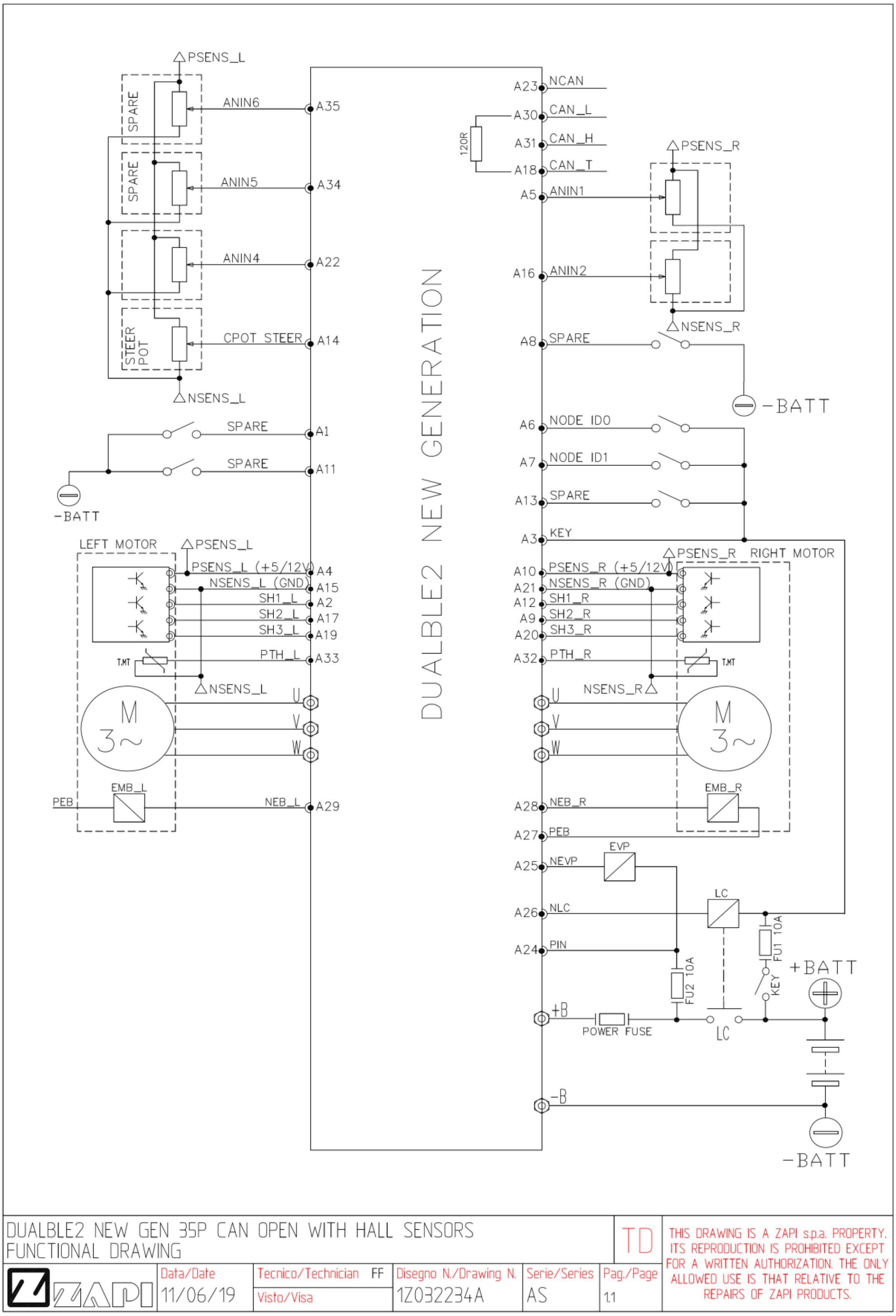
3.2.10 Premium version – CAN controlled Dual AC traction configuration



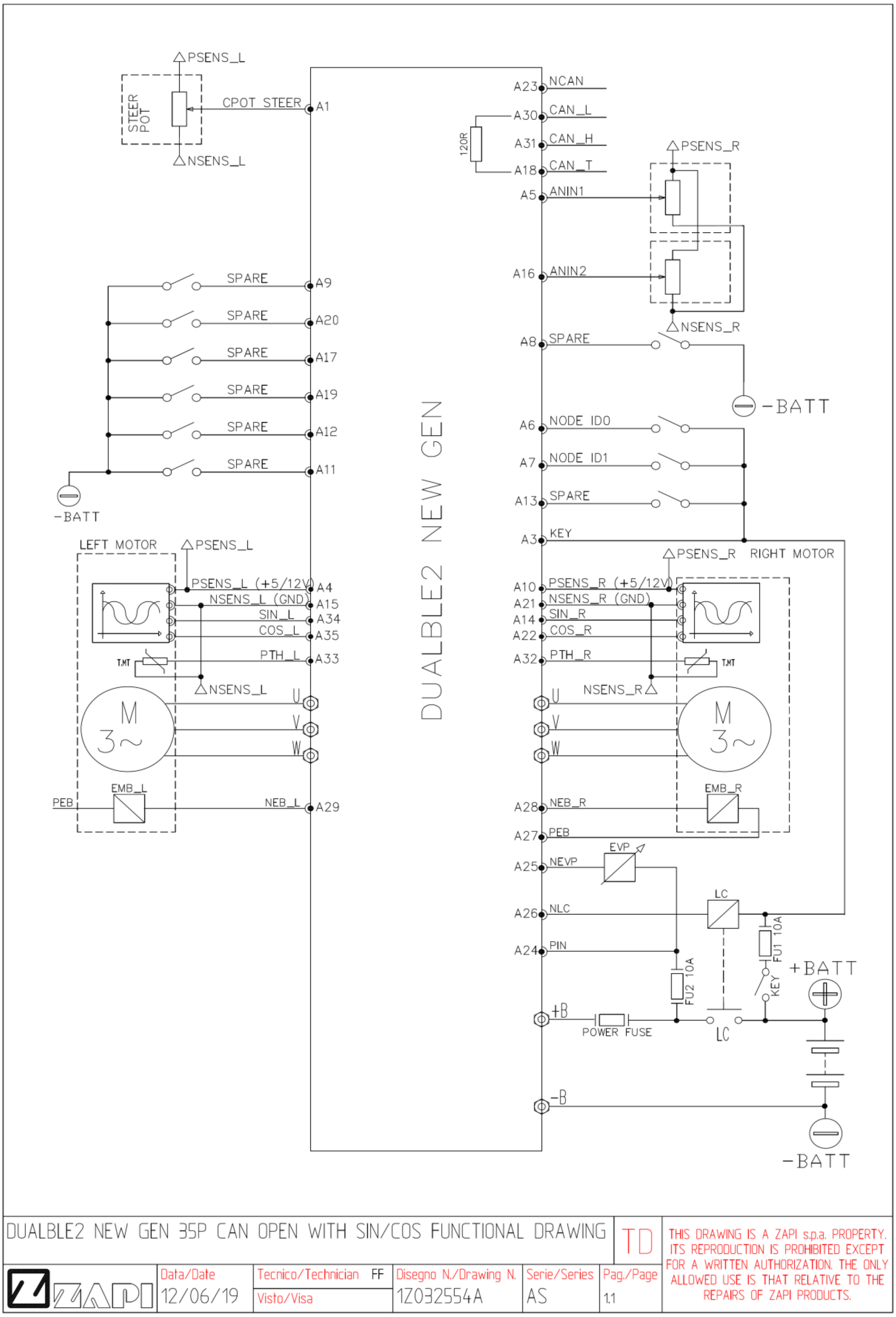
3.2.11 Premium version – CAN controlled Combi AC configuration (AC traction + AC pump)



3.2.12 Premium version – CAN controlled Dual BL traction with Hall sensors



3.2.13 Premium version – CAN controlled Dual BL traction with sin/cos sensors



4 I/O INTERFACE DESCRIPTION

4.1 Power connectors

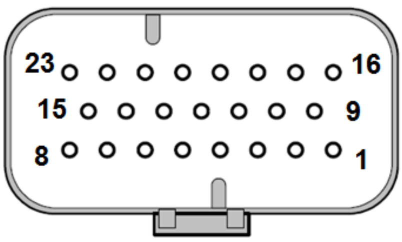
Power connections are on vertical posts where to bolt power-cables lugs. On the cover of the converter they are labeled as follows.

Terminal name	Description
+B, -B	Battery terminations
UM, VM, WM	Motor 1 phase terminations.
US, VS, WS	Motor 2 phase terminations.

4.2 Ampseal connector

4.2.1 Standard version

DUALACE2 NEW GENERATION Standard is equipped with a 23-poles Ampseal connector like that of the figure. Each of the 23 pins is referred to as "A#", where "A" denotes the connector name and "#" the pin number, from 1 to 23.



23-poles Ampseal connector of DUALACE2 NEW GENERATION Standard.

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

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

DUALACE2 NEW GENERATION Standard

Pin	Type	Name	Description
A1	Input	KEY	Input of the key switch signal.
A2	Output	PENC_L	Positive supply for the left-hand side encoder and for potentiometers (+5 V or +12 V, 200 mA maximum).

DUALACE2 NEW GENERATION Standard

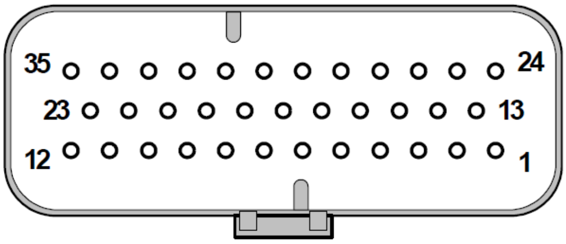
Pin	Type	Name	Description
A3	Input	CPOT	Analog input 1. The default function is as accelerator reference (wiper contact of the accelerator potentiometer).
A4	Input	FW	Digital input active when connected to +B. The default function is as forward request; closing this input the truck moves forward.
A5	Input	BW	Digital input active when connected to +B. The default function is as backward request; closing this input the truck moves backward.
A6	Input	SEAT	Digital input active when connected to -B. The default function is as seat (or tiller) input.
A7	Input	CHA_R	Channel A of the right-hand side incremental encoder.
A8	Output	PENC_R	Positive supply for the right-hand side encoder and for potentiometers (+5 V or +12 V, 200 mA maximum).
A9	Output	NENC_L	Negative supply for the left-hand side encoder, the left-hand side thermal sensor and potentiometers.
A10	Input	CPOT BR	Analog input 2. The default function is as breaking reference (wiper contact of the brake potentiometer).
A11	Input	CHA_L	Channel A of the left-hand side incremental encoder.
A12	Output	CANT	If connected to A31 (CANH), it introduces the 120 Ohm termination resistance between CANL and CANH.
A13	Input	CHB_L	Channel B of the left-hand side incremental encoder.
A14	Input	CHB_R	Channel B of the right-hand side incremental encoder.
A15	Output	NENC_R	Negative supply for the right-hand side encoder, the right-hand side thermal sensor and potentiometers.
A16	Output	NLC	Driving output for the line – or main – contactor (driving to -B); PWM controlled; 2 A maximum continuous current.
A17	Output	PEB	Connecting this pin to the positive supply of electromechanical brakes and proportional electrovalve closes the recirculating path for the built-in freewheeling diodes.
A18	Output	NEB_R	Driving output for the right-hand side electromechanical brake (driving to -B); PWM controlled; 3 A maximum continuous current.

DUALACE2 NEW GENERATION Standard

Pin	Type	Name	Description
A19	Output	NEB_L	Driving output for the left-hand side electromechanical brake (driving to -B); PWM controlled; 3 A maximum continuous current.
A20	Output	CANL	Low-level CAN bus line.
A21	Output	CANH	High-level CAN bus line.
A22	Input	PTH_R	Analog input for the thermal sensor of the right-hand side traction motor. Internal pull-up is a 2 mA current source.
A23	Input	PTH_L	Analog input for the thermal sensor of the left-hand side traction motor. Internal pull-up is a 2 mA current source.

4.2.2 Premium version

DUALACE2 NEW GENERATION Premium is equipped with a 35-poles Ampseal connector like that of the figure. Each of the 35 pins is referred to as "A#", where "A" denotes the connector name and "#" the pin number, from 1 to 35.



35-poles Ampseal connector of DUALACE2 NEW GENERATION Premium.

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

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

4.2.3 Dual AC traction configuration

DUALACE2 NEW GENERATION (dual traction)

Pin	Type	Name	Description
A1	Input	SPARE	Digital input, active when connected to -B. The default function is not defined.

DUALACE2 NEW GENERATION (dual traction)

Pin	Type	Name	Description
A2	Input	SR/HB	Digital input, inactive when connected to -B, active when the switch is open. The default function is as speed-reduction or handbrake request (see parameter HB ON / SR OFF, paragraph 8.2.3).
A3	Input	KEY	Input of the key switch signal.
A4	Output	PENC_L	Positive supply for the left-hand side encoder and for potentiometers (+5 V or +12 V, 200 mA maximum).
A5	Input	CPOT	Analog input 1. The default function is as accelerator reference (wiper contact of the accelerator potentiometer).
A6	Input	FW	Digital input active when connected to +B. The default function is as forward request; closing this input the truck moves forward.
A7	Input	BW	Digital input active when connected to +B. The default function is as backward request; closing this input the truck moves backward.
A8	Input	SEAT	Digital input active when connected to -B. The default function is as seat (or tiller) input.
A9	Input	CHA_R	Channel A of the right-hand side incremental encoder.
A10	Output	PENC_R	Positive supply for the right-hand side encoder and for potentiometers (+5 V or +12 V, 200 mA maximum).
A11	Input	LOWER	Digital input, active when connected to -B. The default function is as lowering request. Closing the switch, NEVP output (A25) is activated according to the setpoint defined by CPOT EVP (A22).
A12	Input	SPARE	Digital input, active when connected to -B. The default function is not defined.
A13	Input	QI/PB	Digital input active when connected to +B. The default function is as quick-inversion or brake-pedal input.
A14	Input	CPOT STEER	Analog input 4. The default function is as steering reference (wiper contact of the steering potentiometer).
A15	Output	NENC_L	Negative supply for the left-hand side encoder, the left-hand side thermal sensor and potentiometers.
A16	Input	CPOT BR	Analog input 2. The default function is as breaking reference (wiper contact of the brake potentiometer).

DUALACE2 NEW GENERATION (dual traction)

Pin	Type	Name	Description
A17	Input	CHA_L	Channel A of the left-hand side incremental encoder.
A18	Output	CANT	If connected to A31 (CANH), it introduces the 120 Ohm termination resistance between CANL and CANH.
A19	Input	CHB_L	Channel B of the left-hand side incremental encoder.
A20	Input	CHB_R	Channel B of the right-hand side incremental encoder.
A21	Output	NENC_R	Negative supply for the right-hand side encoder, the right-hand side thermal sensor and potentiometers.
A22	Input	CPOT EVP	Analog input 4. The default function is as reference for the proportional electrovalve.
A23	Input	NCAN	CAN bus negative reference. See paragraph 4.4.11
A24	Input	PIN	Positive supply for the high-side driver of pin PEB (A27). By default, it is to be connected after the main contactor.
A25	Output	NEVP	Driving output for the proportional electrovalve (driving to -B); PWM current-controlled; 1.7 A maximum continuous current. Default function is as LOWERING valve.
A26	Output	NLC	Driving output for the line – or main – contactor (driving to -B); PWM controlled; 2 A maximum continuous current.
A27	Output	PEB	Positive supply for the electromechanical brake and the electrovalves. It is supplied by PIN (A24) through a high-side driver.
A28	Output	NEB_R	Driving output for the right-hand side electromechanical brake (driving to -B); PWM controlled; 3 A maximum continuous current.
A29	Output	NEB_L	Driving output for the left-hand side electromechanical brake (driving to -B); PWM controlled; 3 A maximum continuous current.
A30	Output	CANL	Low-level CAN bus line.
A31	Output	CANH	High-level CAN bus line.
A32	Input	PTH_R	Analog input for the thermal sensor of the right-hand side traction motor. Internal pull-up is a 2 mA current source (max 5 V).

DUALACE2 NEW GENERATION (dual traction)

Pin	Type	Name	Description
A33	Input	PTH_L	Analog input for the thermal sensor of the left-hand side traction motor. Internal pull-up is a 2 mA current source (max 5 V).
A34	Input	CPOT5	Analog input 5. The default function is not defined.
A35	Input	CPOT6	Analog input 6. The default function is not defined.

4.2.4 Combi AC configuration (traction + pump)

When the inverter is configured as COMBIACE2 NEW GENERATION for controlling one traction motor and one pump motor, the pinout differs from that of the dual traction configuration only for the pins listed in the following table. The other ones are unchanged both in name and in function (see paragraph 4.2.3).

COMBIACE2 NEW GENERATION (traction + pump)

Pin	Type	Name	Description
A2	Input	SR/HB/ HYDRO	Digital input, inactive when connected to -B, active when the switch is open. The default function is as hydro request.
A4	Output	PENC_P	Positive supply for the pump encoder and for potentiometers (+5 V or +12 V, 200 mA maximum).
A9	Input	CHA_T	Channel A of the traction incremental encoder.
A10	Output	PENC_T	Positive supply for the traction encoder and for potentiometers (+5 V or +12 V, 200 mA maximum).
A12	Input	LIFT	Digital input, active when connected to -B. The default function is as lift request; closing this input the pump is activated.
A15	Output	NENC_P	Negative supply for the pump encoder, the pump thermal sensor and potentiometers.
A17	Input	CHA_P	Channel A of the left-hand side incremental encoder.
A19	Input	CHB_P	Channel B of the pump incremental encoder.
A20	Input	CHB_T	Channel B of the traction incremental encoder.

COMBIACE2 NEW GENERATION (traction + pump)

Pin	Type	Name	Description
A21	Output	NENC_T	Negative supply for the traction encoder, the traction side thermal sensor and potentiometers.
A22	Input	CPOT LIFT	Analog input 4. The default function is as lift reference.
A28	Output	NEB_T	Driving output for the traction electromechanical brake (driving to -B); PWM controlled; 3 A maximum continuous current.
A29	Output	NAUX	Driving output for an auxiliary electrovalve (driving to -B); PWM controlled; 3 A maximum continuous current.
A32	Input	PTH_T	Analog input for the thermal sensor of the traction motor. Internal pull-up is a 2 mA current source (max 5 V).
A33	Input	PTH_P	Analog input for the thermal sensor of the pump traction motor. Internal pull-up is a 2 mA current source (max 5 V).

4.2.5 Dual BL traction with sin/cos sensor

When the inverter is configured as DUALBLE2 NEW GENERATION for controlling two traction brushless motors equipped with sin/cos sensors as speed and position feedback, the pinout differs from that of the dual AC traction configuration only for the pins listed in the following table. The other ones are unchanged both in name and in function (see paragraph 4.2.3).

DUALBLE2 NEW GENERATION with sin/cos sensors

Pin	Type	Name	Description
A1	Input	CPOT STEER	Analog input 4. The default function is as steering reference (wiper contact of the steering potentiometer).
A4	Output	PSENS_L	Positive supply for the left-hand side sin/cos sensor and for potentiometers (+5 V or +12 V, 200 mA maximum).
A9	Input	SPARE	Digital input, active when connected to -B. The default function is not defined.
A10	Output	PSENS_R	Positive supply for the right-hand side sensor and for potentiometers (+5 V or +12 V, 200 mA maximum).
A14	Input	SIN_R	Sine signal of the right-hand side sin/cos sensor.
A15	Output	NSENS_L	Negative supply for the left-hand side sin/cos sensor, the left-hand side thermal sensor and potentiometers.
A17	Input	SPARE	Digital input, active when connected to -B. The default function is not defined.

DUALBLE2 NEW GENERATION with sin/cos sensors

Pin	Type	Name	Description
A19	Input	SPARE	Digital input, active when connected to -B. The default function is not defined.
A20	Input	SPARE	Digital input, active when connected to -B. The default function is not defined.
A21	Output	NSENS_R	Negative supply for the right-hand side sin/cos sensor, the right-hand side thermal sensor and potentiometers.
A22	Input	COS_R	Cosine signal of the right-hand side sin/cos sensor.
A34	Input	SIN_L	Sine signal of the left-hand side sin/cos sensor.
A35	Input	COS_L	Cosine signal of the left-hand side sin/cos sensor.

4.2.6 Dual BL traction with Hall sensors

When the inverter is configured as DUALBLE2 NEW GENERATION for controlling two traction brushless motors, each one equipped with a set of three Hall sensors as speed and position feedback, the pinout differs from that of the dual AC traction configuration only for the pins listed in the following table. The other ones are unchanged both in name and in function (see paragraph 4.2.3).

DUALBLE2 NEW GENERATION with Hall sensors

Pin	Type	Name	Description
A2	Input	SH1_L	First left-hand side Hall sensor.
A4	Output	PSENS_L	Positive supply for the left-hand side Hall sensors and for potentiometers (+5 V or +12 V, 200 mA maximum).
A9	Input	SH2_R	Second right-hand side Hall sensor.
A10	Output	PSENS_R	Positive supply for the right-hand side sensor and for potentiometers (+5 V or +12 V, 200 mA maximum).
A12	Input	SH1_R	First right-hand side Hall sensor.
A15	Output	NSENS_L	Negative supply for the left-hand side Hall sensors, the left-hand side thermal sensor and potentiometers.
A17	Input	SH2_L	Second left-hand side Hall sensor.

DUALBLE2 NEW GENERATION with Hall sensors

Pin	Type	Name	Description
A19	Input	SH3_L	Third left-hand side Hall sensor.
A20	Input	SH3_R	Third right-hand side Hall sensor.
A21	Output	NSENS_R	Negative supply for the right-hand side Hall sensors, the right-hand side thermal sensor and potentiometers.

4.3 Internal connector

Pin	Type	Name	Description
1	-	-	Not used: it can be unconnected.
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	+15	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.

4.4 External devices

4.4.1 Key input

KEY input A3 (A1) is generally connected to the vehicle start key switch. It supplies battery voltage to the logic circuitry and it also pre-charges the DC-link capacitors at key-on, before main contactor closes. The KEY voltage is monitored.

Note: external loads connected to the power terminal +B, such as proximity switches, load the internal PTC resistor along the key input path, with the consequence that the pre-charge voltage may be lower than expected.

Protection

The KEY input is protected against reverse polarity with a diode and it has got approximately a 2.2 nF capacitance to -B for ESD protection and other filtering elements. This capacitance may give a high current spike at the KEY input depending on the external circuit.

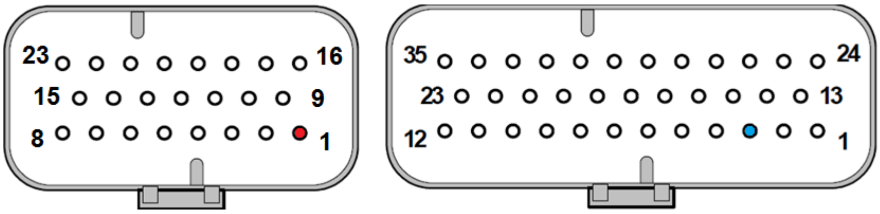
Fuse FU1 (see functional drawings, paragraph 3.2), should be sized according to the number of motor controllers connected to it (10 A fuse is recommended) and the current absorption of the KEY input (input power below 15 W).

The key switch connected to the KEY input must handle the short inrush current spike to the ESD protection capacitors. The current peak depends on the external circuit and wires.

Cables from the battery to the KEY input should be as short as possible

Connector position

Standard A1 | Premium A3



4.4.2 Digital inputs

Digital inputs are meant to work in the voltage range from -B to +B. Related command devices (microswitches) must be connected to +B (typically to the key voltage) or to -B, depending on the input configuration (refer to pin description in the paragraph 4.4.2). Pull-down or pull-up resistors are built-in.

Functional devices (like FW, BW, LOWER, etc.) are normally open, so that each associated function becomes active when the microswitch closes. Safety-related devices (by default only SR/HB) must be normally closed, so that each associated function becomes active when the microswitch opens.

Nominal voltage figures for digital inputs in standard Zapi configuration are listed below. Custom hardware may feature different voltage values.

Inverter voltage		**24 V**	**36/48 V**	**72/80 V**	**96 V**
Active high	Low threshold	3.6 V	3.6 V	8.2 V	9.8 V
	High threshold	8.5 V	8.5 V	19 V	22.9 V
Active low	Low threshold	3.6 V	3.6 V	3.8 V	3.8 V
	High threshold	8.5 V	8.5 V	8.8 V	8.8 V
Voltage range		0 ÷ 35 V	0 ÷ 72.5 V	0 ÷ 115 V	0 ÷ 130 V

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

Protection

Each digital input has a 22 nF capacitor to -B for ESD protection.

Circuit

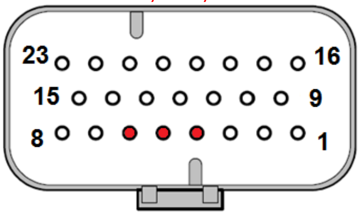
Input impedance to GND of active high digital inputs in standard Zapi configurations are listed below. Custom hardware may feature different impedance values.

Inverter voltage	**24 V**	**36/48 V**	**72/80 V**	**96 V**
Input impedance (Active high)	3.8 kΩ	9 kΩ	20 kΩ	27.6 kΩ

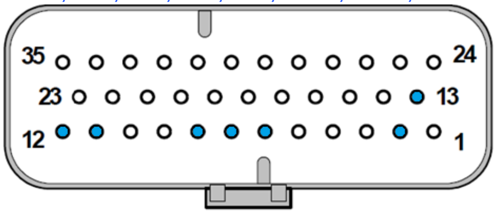
Digital inputs on A1, A2, A8 (A6), A11 and A12 are normally configured to be activated when closed to -B. Their behavior can be changed by special HW configuration, as to be activated when closed to +B.

Connector position

Standard
A4, A5, A6



Premium
A1, A2, A6, A7, A8, A11, A12, A13



Microswitches

- It is suggested that microswitches have a contact resistance lower than 0.1 Ω and a leakage current lower than 500 µA.
- In full-load condition, the voltage between the key-switch contacts must be lower than 0.1 V.
- If the microswitches to be adopted have different specifications, it is suggested to discuss them with Zapi technicians prior to employ them.

4.4.3 Analog inputs

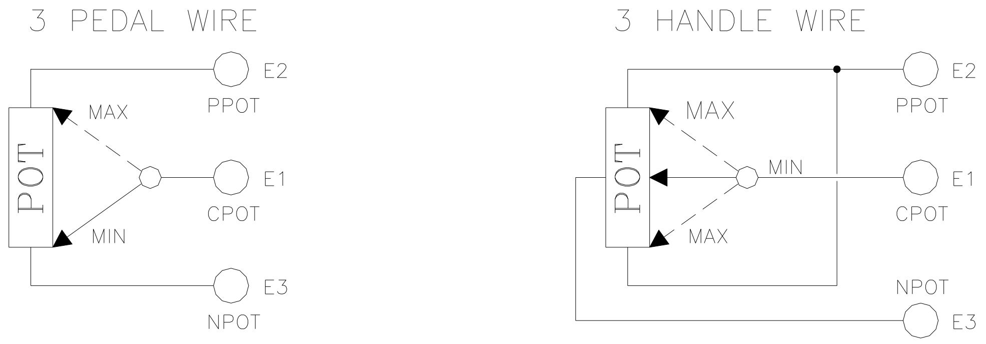
Analog inputs are for functions such as accelerator or brake references and they are acquired through a 10-bit analog-to-digital converter (resolution is given by voltage excursion over 1024 levels).

Circuit

Input impedance and maximum frequency for analog inputs in standard Zapi configurations are listed below. Custom hardware may feature different values.

Inverter voltage	**24 V**	**36/48 V**	**72/80 V**	**96 V**
Input impedance	44 kΩ	94 kΩ	240 kΩ	300 kΩ
Maximum frequency	145 Hz	68 Hz	27 Hz	21 Hz

The standard connection for the potentiometer is that on the left side of next figure: potentiometer at rest on one end, in combination with a couple of travel-demand switches. On request it is also possible to have the configuration on the right side of next figure: potentiometer at rest in the middle, still in combination with a couple of travel-demand switches.



Potentiometer configuration.

The negative supply of the potentiometer is to be taken from one of NENC pins; A21 (A15) and A15 (A9).

Potentiometer resistance value should be in the 0.5 – 10 kΩ range; generally, the load should be in the 1.5 mA to 30 mA range.

A procedure for automatic acquisition of potentiometers signals can be carried out using the console (see paragraphs 9.1, 9.2 and 9.3).

Analog inputs may also be used as extra digital inputs. In this case ADC value should be used as the indicator of the input status. For example, a proximity switch supplied from +B could be connected to an analog input.

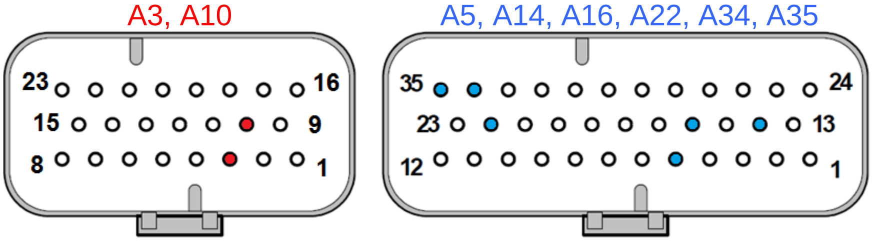
Protection

Analog inputs are protected against short circuits to +B and -B. Each one has a 10 nF capacitor to -B for ESD protection.

Connector position

Standard
A3, A10

Premium
A5, A14, A16, A22, A34, A35



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 or VACC NOT OK.

4.4.4 Encoder input

Inputs for motor-speed feedback (encoder signals) have an internal 1 kΩ pull-up for open collector sensor output. Threshold levels are listed below.

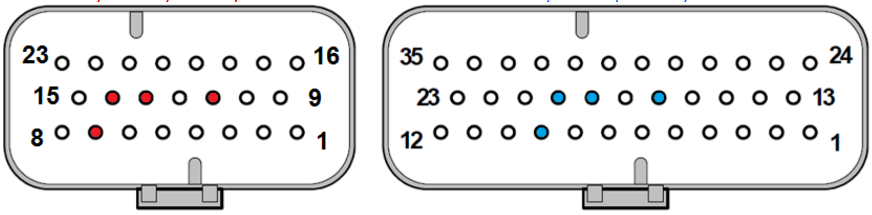
Supply Voltage	5 V	12 V
Logic low	1.5 V	3.8 V
Logic high	3.5 V	6.1 V

Speed-sensor signals are acquired through the quadrature peripheral of the microcontroller.

Protection

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

Connector position



It is important to verify the wiring by ensuring that encoder signals are not disturbed by motor currents or by electric motor brake.

For more details about encoder installation see also paragraph 5.2.6.

The encoder resolution, the motor pole pairs and other pieces of information are specified in the Zapi Console by means of an head line like the following:

A2MT2B 2 ZP1.21

Where:
A2: DUALACE2 NEW GENERATION.
M: Master µC (S: Supervisor µC).
T: Traction controller (P: pump controller).
2: Motor poles pair number.
B: 64 pulses/rev encoder.
2: Motor control generation.
ZP1.21: Firmware version.

The encoder resolution is encoded in the last letter of the first batch as:

Code:	*A*	*B*	*C*	*D*	*G*	*H*
Pulses/rev:	*32*	*64*	*80*	*128*	*256*	*512*

Code:	*I*	*K*	*X*
Pulses/rev:	*1024*	*48*	*25, 124*

Encoder resolution can be changed through the dedicated parameters. See paragraph 8.2.7.

4.4.5 MC output

Main (or line) contactor is operated through an open-drain PWM-voltage-controlled output.

In order to utilize the built-in freewheeling diode, the coil must be supplied with KEY voltage, pin A3 (A1), see chapter 3.2

A nonstandard hardware configuration permits to utilize a built-in freewheeling diode connected to pin PEB A27 (A17).

In case the vehicle design does not allow usage of the built-in freewheeling diode, i.e. if the return path integrity cannot be guaranteed in all situations, an external one must be applied between the coil terminals.

Output features

- Up to 1 Arms continuous current (holding).
- Up to 2 A peak (pulling) current for a maximum of 200 ms.
- Individual hardware for detection of: shorted driver, open driver, open coil.
- 1 kHz default PWM frequency.
- Configurable output voltage, by means of separate parameters for pulling and holding stages.

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

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.

Protection

Protected against inductive discharge with internal freewheeling diode to pin KEY A3 (A1) and ESD protected by means of ESD-suppressing device. Protected against reverse polarity of the battery.

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

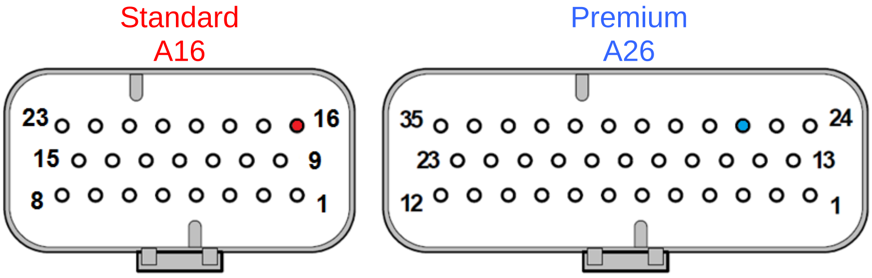
Refer to chapter 10 for more detailed description.

---

*MC output can only be a PWM-voltage-controlled output. It **cannot** be used as a current-controlled output.*

When driving an inductive load on PWM open-drain output, there must always be a path for the current through a freewheeling diode. Do not connect any switch or fuse in series with the diode.

Connector position



To protect the controller from overvoltage caused by an inductive load, freewheeling diode to pin KEY A3 (A1) is built-in.

Please ensure that inductive loads are connected so that the paths through the freewheeling diodes are always present; otherwise use external freewheeling diodes.

Use of brushless fan or other loads with built-in capacitors may lead to high inrush currents at turn-on, which may eventually bring to open-drain overcurrent trips. Inrush current must be below the peak current.

4.4.6 EB outputs

Electromechanical brakes are operated through an open-drain PWM-voltage-controlled outputs on pin NEB_R A28 (A18) and NEB_L A29 (A19). In order to utilize the built-in freewheeling diodes, the coil must be supplied by pin PEB A27 (A17) (see chapter 3.1.1), which in turn is supplied by a high-side driver (see paragraph 4.4.8).

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

Output features

- Up to 2.5 Arms continuous current (holding).
- Up to 3 A peak (pulling) current for a maximum of 200 ms.
- Individual hardware for detection of: shorted driver, open driver, open coil.
- 1 kHz PWM frequencies.
- Configurable output voltage, by means of separate parameters for pulling and holding stages.

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

Protection

Protected against inductive discharge with internal freewheeling diode to pin PEB A27 (A17) and ESD protected by suppressor device.

Not protected against reverse polarity of the battery. A way to avoid a failure caused by the polarity inversion 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

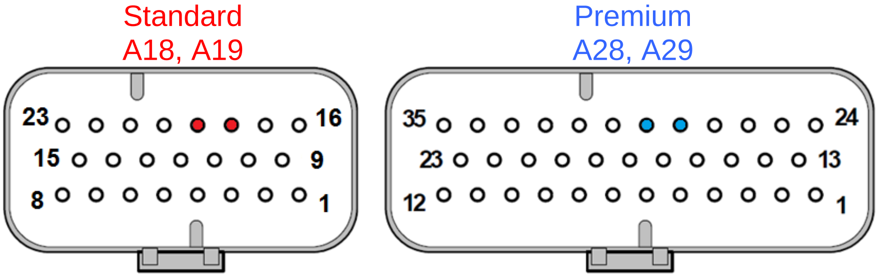
Refer to chapter 10 for more detailed description.

Overcurrent protection is applied by hardware.

*EB outputs can be only a PWM voltage-controlled output. It **cannot** be used as current-controlled output.*

Driving an inductive load on a PWM-modulated open-drain output, there is always to be a path for the current through the freewheeling diode. Do not connect any switch or fuse in series with the diode.

Connector position



To protect the motor controller from overvoltage at inductive load, internal freewheeling diode toward pin A27 (A17) is built-in.

Please ensure that the inductive load is connected such that the path for the freewheeling diode is always intact, or use an external freewheeling diode if this is not possible.

Use of brushless fans or other loads with built-in capacitor can give high inrush current at turn on, which can give an open-drain over-current trip. The inrush current must be below the open-drain peak current.

4.4.7 PWM current-controlled output

In premium version only (35-poles Ampseal) an additional Open-drain current controlled output can be used for operating services such as relays, hydraulic valves, horn, etc.

In order to utilize the built-in freewheeling diodes, the loads must be supplied from pin PIN A24, see paragraph 3.1.1.

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

- Up to 1.5 Arms continuous (hold) current and 1.7 A peak current.
- Individual hardware for detection of shorted driver, open driver and open coil.
- Self-protected against overload condition.
- Dithering feature thanks to a low amplitude current modulation at high frequency (see paragraph 8.2.6).

  Dithering is typically used when controlling proportional valves in order to create microscopic movements in the valve to prevent it from “sticking”. Successful dithering improves the valve response for small changes.

  Dithering frequency is available in fixed steps:
  20.8, **22.7**, **25.0**, **27.7**, **31.2**, **35.7**, **41.6**, **50.0**, **62.5**, **83.3**.

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

Protection

The auxiliary outputs are protected against inductive discharge with internal freewheeling diodes on pin PIN A24.

The auxiliary outputs are not protected against reverse polarity of the battery. A way to avoid a failure caused by the polarity inversion 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 3.1.1).

Built-in diagnostics:
- Overcurrent;
- Shorted driver;
- Open driver;
- Open coil (only for PWM current-controlled outputs).

Refer to chapter 10 for more details about alarms.

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

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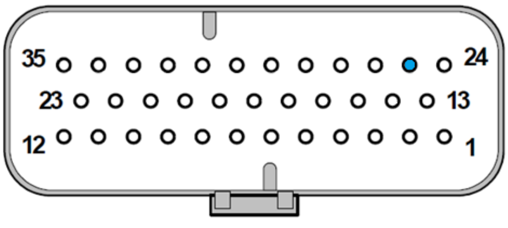
When driving inductive loads on PWM Open drain outputs there must always be a path for the current to the freewheeling diodes. Do not connect any switch or fuse in series with the diode.

Connector position

Premium
A25



To protect the motor controller from overvoltage at inductive load, internal freewheeling diodes are mounted to the A24 pin.

Please ensure that inductive loads are connected such that the path for the freewheeling diode is always intact, or use an external freewheeling 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.

4.4.8 High-side driver

In premium version only (35-poles Ampseal), a high-side switch provides redundancy in turning off the EB and the EVs. If one of the open-drain outputs is short circuited, it is possible to turn off the high-side switch so to disconnect the load on pin A27 (PEB) from the positive supply on pin A24 (PIN).
The high-side switch has a maximum output current of 5 A. The high-side switch can only be controlled as an on/off switch, it is not suited for switching operation.

The high-side switch has a maximum output current of 4 A.

The high-side switch can only be controlled as an on/off switch, it is not suited for switching operation.

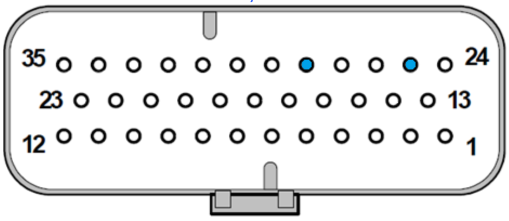
Protection

Built-in diagnostics:
- Shorted driver
- Open driver

Refer to chapter 10 for more detailed description.

Connector position

Premium
A24, A27



4.4.9 Motor-temperature measurement

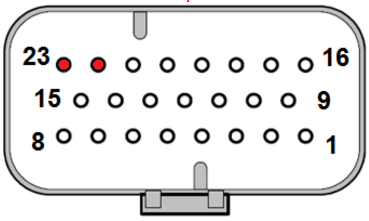
Inputs for motor-temperature sensors, for measuring the temperature of each motor windings, is available on pin PTH_R A32 (A22) and PTH_L A33 (A23).
Compatible temperature sensors are like:
- KTY84 with 1000Ω @ 100°C.
- KTY83 with 1670Ω @ 100°C.
- PT1000 with 1385Ω @ 100°C.
- On/Off.

Protection

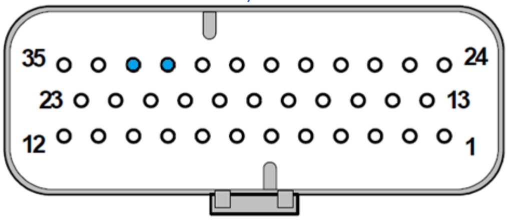
PTH input is protected against short circuits to +B and ESD protected by suppressor device. A low-pass filter attenuates the noise from the motor.

Connector position

Standard
A22, A23



Premium
A32, A33



4.4.10 Sensor supply

Supplies for external motor-speed sensors are available between pin PENC_R A10 (A8) and pin NENC_R A21 (A15) and between pin PENC_L A4 (A2) and pin NENC_R A15 (A9).
Output voltage is configurable via hardware by internal jumper to +12V or +5V; the maximum output current is 200 mA.

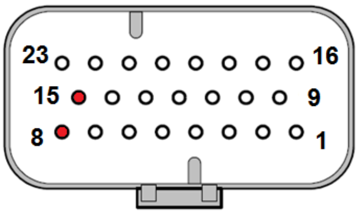
Actual values for "+12V" and "+5V" are respectively 12.1 V ± 0.5 V and 5 V ± 0.3 V.

Protection

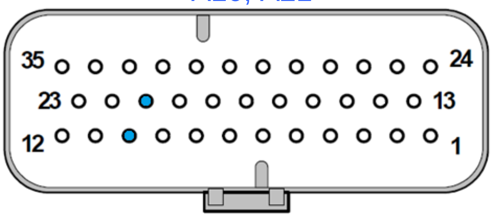
Sensor supply has a current limiter at 200 mA and it is protected against accidental connection to +B with a diode.

Connector position

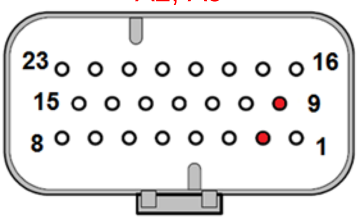
Standard
A8, A15



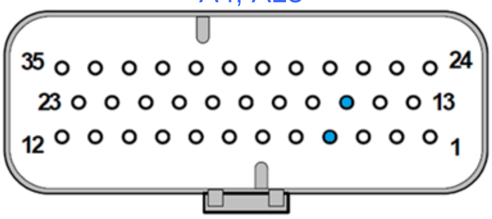
Premium
A10, A21



Standard
A2, A9



Premium
A4, A15



4.4.11 CAN bus

CAN bus interface is available for communication with the controller, featuring:

- Physical Interface according to ISO 11898-2.
- Data rate can be 125, 250 or 500 kbit/s.
- CAN driver is +5 V supplied and provides a rail to rail signal on the differential output (CANH - CANL).
- An internal 120 Ω termination resistor can be built-in.

CAN bus interface is isolated with Opto-couplers and internal +5 V supply from isolated DC/DC.
The CAN driver gives maximum amplitude on the CAN_H to CAN_L signal.

Ground reference for CAN, CAN_GND, must be routed together with CAN_H and CAN_L in the CAN-bus to avoid communication problems.
There is internal high impedance connection between CAN_GND and B- for ESD protection and EMC suppression components.

Incorrect use of isolation - risk of personnel injury. Isolation is only for increased noise immunity when running high current to the motor. The isolation must not be used for safety.
i.e. CAN_GND and B- shall be externally connected together in one point in the vehicle system.

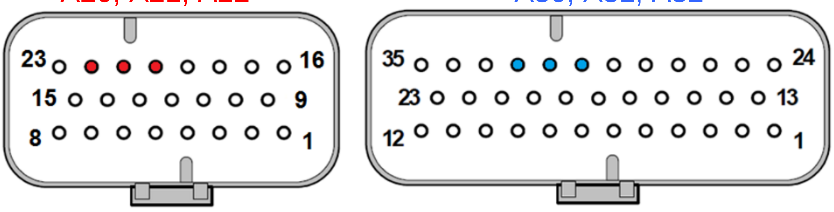
Protection

CAN bus interface is protected against accidental connection to +B and –B and ESD protected.

Connector position

Standard
A20, A21, A22

Premium
A30, A31, A32



The CAN wiring shall consist of a pair of twisted wires for CANH and CANL.

The CAN wiring shall have a characteristic impedance of 60 Ω; both physical ends of the CAN bus shall be terminated with 120 Ω between CANH and CANL for the best possible noise immunity.

5 INSTALLATION HINTS

Installation the motor controller in a specific vehicle may vary from what is presented here or include additional steps. It is the responsibility of the vehicle manufacturer to develop detailed instructions for installation and maintenance of the motor controller in the target vehicle.

The motor controller contains no user adjustable or user replaceable components beneath its protective cover. Do not remove the cover.

Do not clean the motor controller using high-pressure water.

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.

The instructions in this chapter are general-purpose procedures that do not address vehicle-specific requirements. Personnel performing maintenance should consult the vehicle manufacturer's instructions, which always supersede the instructions in this document.

5.1 Material overview

Before starting the inverter installation, it is necessary to have the required material for a correct installation. Wrong choice of additional parts could lead to failures, misbehaviors or bad performance.

5.1.1 Connection cables

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

5.1.2 Contactors

Main contactor has always to be installed. The output driving the coil is modulated with a 1 kHz PWM basing on parameters MC VOLTAGE and MC VOLTAGE RED.. After an initial delay of about 1 second, during which the coil is driven with a percentage of VBATT defined by MC VOLTAGE, PWM reduces the mean voltage down to the percentage set in MC VOLTAGE RED.. This feature is useful to decrease the power dissipation of the coil and its heating.

5.1.3 Fuses

- Use a 10 A fuse for protection of the auxiliary circuits

- Selection of appropriate fuse ratings is a system design issue and falls under the OEMs responsibility. As a rule of thumb, the fuse shall be rated based on the motor controller's power output (2 min. rating) listed in chapter 2.3.

  Calculate DC input current as follows:

  $$I_{DC_{IN}} = \frac{Power\ output\ [kVA](2\min rating)\ x\ 1000}{V_{DC}}$$

  Select a fuse with rating and time delay characteristics which will carry I_{DC_IN} indefinitely, but blow within 2 - 3 seconds for 2 x I_{DC_IN}.

- Chapter 11 shows the maximum allowable values. 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 spreading of particles in case a fuse blows.
- Selection of appropriate fuse ratings is a system design issue and falls under the OEMs responsibility.

⚠ ***The fuse is not intended to protect the motor controller or motor against overloads.***

5.2 Installation of the hardware

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

⚠ ***Take necessary precautions to not compromise safety in order to prevent injuries to personnel and damages to equipment.***

5.2.1 Positioning and cooling of the controller

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

- Ensure that the installation surface is clean and unpainted.
- Apply a light layer of thermo-conductive grease between the two surfaces to permit good heat dissipation.
- Ensure that cable terminals and connectors are correctly connected.
- Fit transient suppression devices to the horn, solenoids and contactors not connected to the controller.
- Ensure the compartment to be ventilated and the heat-sinking materials ample.
- Heat-sinking material and should be sized on the performance requirement of the machine. Abnormal ambient temperatures should be considered. In

situations where either external ventilation is poor or heat exchange is difficult, forced ventilation should be used
- Thermal energy dissipated by the power module varies with the current drawn and with the duty cycle.

Hot surfaces - risk of personnel injury. After operation of the motor controller, the heat sink may be too hot to touch. Allow it to cool before performing any maintenance.

Water sensitive equipment - risk of damage to equipment. Do not clean the motor controller using high-pressure water.

5.2.2 Dust and liquid ingress prevention

The dust/moisture protection of the motor controller is only valid when the mating I/O connector is inserted and correctly assembled with appropriate cable seals.
The motor controller cover provides a measure of protection from liquids and particles dripping, splashing or spraying onto it. The motor controller must not be subjected to liquids under high pressure.

5.2.3 Wirings: power cables

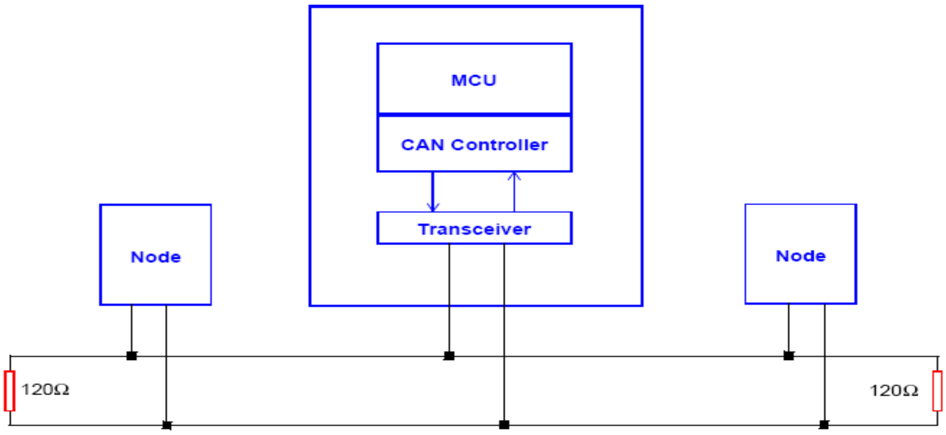
- Power cables must be as short as possible to minimize power losses. They must be tightened onto controller power posts with a torque of 13 Nm ÷ 15 Nm.
- The DUALACE2 New Gen should only be connected to a traction battery. Do not use converters outputs or power supplies. For special applications please contact the nearest Zapi Service Centre.

Do not connect the controller to a battery with a nominal voltage different to the nominal value, indicated on the controller label. A higher battery voltage may cause failures in the power section. A lower voltage may not allow the controller to work.

Ring lugs for motor and battery connections must be adequately rated to carry motor and battery currents. Otherwise cables and terminal posts may be overheated.

5.2.4 Wirings: CAN bus connections and possible interferences

CAN stands for Controller Area Network. CAN bus is a communication protocol for real time control applications. CAN bus operates at data rate of up to 1 Mbit/s. It was invented by the German company Bosch to be used in the automotive industry to permit communication among the various electronic modules of vehicle, connected as illustrated in the following image.

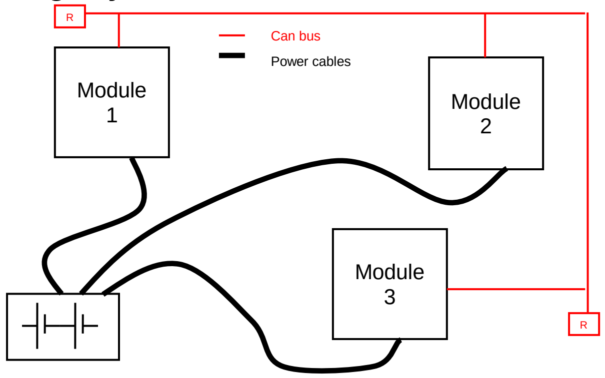


- The best type of cables for CAN bus connections is the twisted pair; if it is necessary to increase the immunity of the system to disturbances, a good choice would be to use shielded cables, where the shield is connected to the frame of the truck. Sometimes it is sufficient a not shielded two-wire cable or a duplex cable.

- In a system like an industrial truck, where power cables carry currents of hundreds of Ampere, voltage drops due to the impedance of the cables may be considerable, and that could cause errors on the data transmitted through the CAN wires. The following figures show an overview of wrong and right layouts for the routing of CAN connected systems.

⚠

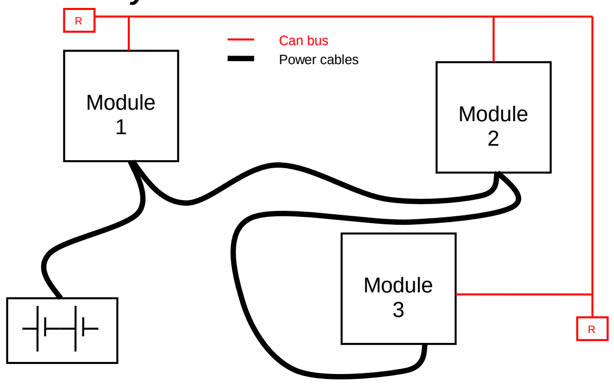
Wrong Layout:



Red lines are CAN bus wires.
Black boxes are different modules, for example a traction controller, a pump controller and a display connected via CAN bus.
Black lines are the power cables.
This is apparently a good layout, but actually it can bring to errors onto 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.

⚠

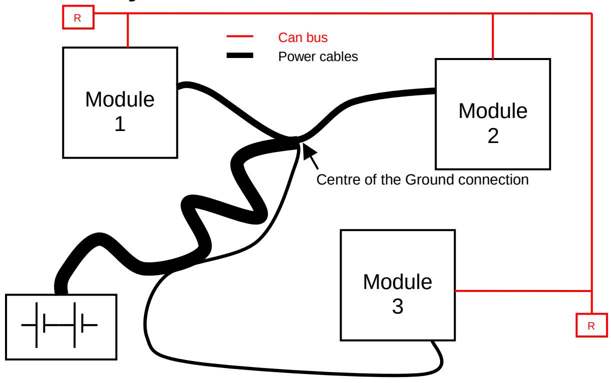
Correct Layout:



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

The chain starts from the -B post of the controller that deals with the highest current, while the other ones 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 (for example a steering controller), the best way to address this configuration is creating a common ground point (star configuration), as it is in the next figure.

Correct Layout:



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

In this case, the power cables of the two similar controllers must be as short as possible. Of course also the diameter of the cables concurs in the voltage drops described before (a greater diameter brings to a lower impedance), so in this last example the cable between negative battery terminal and the center of the ground connection (pointed by the arrow in the image) must be sized taking into account both thermal and voltage drop problems and considering the current drawn from the battery by the overall system.

The complexity of modern systems needs more and more data, signal and information must flow from a node to another. CAN bus is the solution to different problems that arise from this complexity.
- simple design (readily available, multi sourced components and tools)
- low costs (less and smaller cables)
- high reliability (fewer connections)
- ease of analysis (easy connection with a pc for sniffing the data being transferred onto the bus).

5.2.5 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.
- For information about pin assignment, see chapter 3.2.
- Very high currents may circulate between motor controller and battery. Even if cables are dimensioned correctly, this may lead to a significant voltage drop between motor controller B- terminal and negative terminal on the battery. This means that there may be voltage differences between GND references of different units in a control system. Therefore it is strongly recommended to connect all wires of sensors supplied by the motor controller directly to the intended I/O connector pins.
- Consider an alternative path for I/O cables that generates less noise (EMC).

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.

5.2.6 Motor feedback sensor

To minimize the possibility of electrical noise coupling into motor feedback sensor wires, avoid routing cables next to conductors carrying high currents or high current pulses. Noise immunity may also be improved by using twisted conductor cable for the motor feedback sensor cables from motor to the motor controller.

Wiring of feedback sensor and the relationship between feedback sensor vs. rotational direction depends upon feedback sensor installation in the motor. Contact the motor manufacturer to get the correct wiring and relationship between rotational direction and feedback sensor signals. Swapping the channels from feedback sensor will lead to improper motor operation.

The motor feedback sensor may be ESD sensitive; see ESD related system design suggestions in chapter 12.4.

Incremental encoder speed signals

The incremental encoder speed sensor provides speed and direction feedback for the motor controller. The standard speed encoder switches two open collector outputs to produce two square wave signals phase shifted 90 º ±45 º (see Figure 16), with a maximum frequency of 20 kHz. The sensor signals must have a minimum 6µs edge separation.
The motor controller can be configured to accept different pulses/revolution.

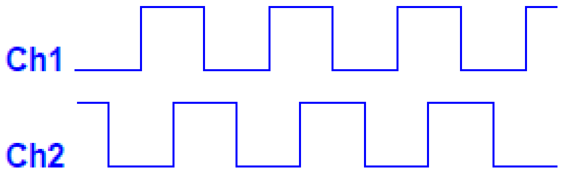


Figure 16. Incremental speed encoder signals

The speed encoder sensor signals are connected to the Encoder CHA & CHB inputs (chapter 4.4.4) and the sensor is supplied using sensor supply (see chapters 4.4.10).

Six-step (or UVW) encoder signals

The six-step encoder, for DC brushless motors, provides position, speed and direction feedback for the motor controller. The six-step encoder switches three open collector outputs to produce a three-phase square wave output for six-step commutation timing (see Figure 17), phase shifted 120 º ±15 º, max 400 Hz. The motor controller can be configured to operate DC brushless motors.

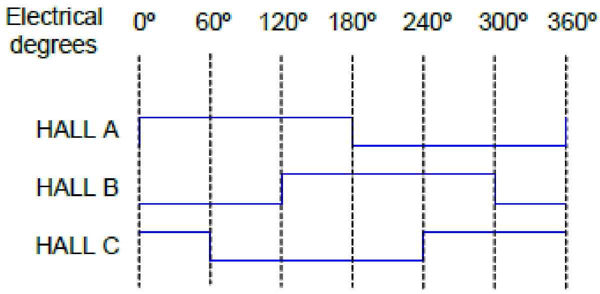


Figure 17. Six-step encoder signals

The six-step encoder sensor signals are connected to the SH1, SH2 and SH3 inputs (chapter 4.2.6) and the sensor is supplied using sensor supply (see chapters 4.4.10).

Care must be taken to ensure that the six-step hall device matches the motor controller sensor supply voltage

Sinusoidal Motor Speed Sensor Input

The sinusoidal sensor for synchronous motors provides position, speed and direction feedback for the motor controller. The sinusoidal analog sensor produces a single-ended two-phase sinusoidal wave output (see Figure 19).

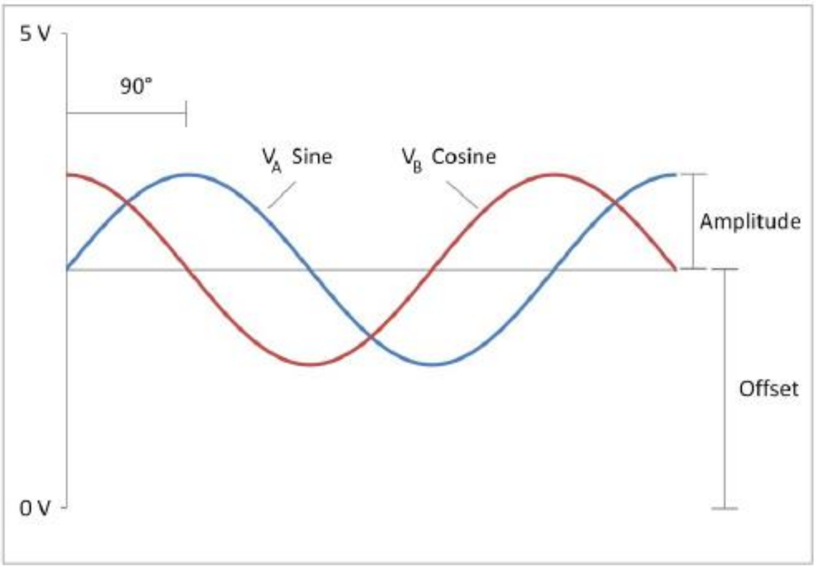


Figure 19. Sinusoidal analog sensor signal

Connect the feedback sensor according to chapter 4.2.5.
Dynamic offset and gain adjustments (individual for each channel) are done in software to compensate for minor changes in sensor characteristics.

It is suggested to share with Zapi technicians the specifications of the adopted encoder in order to be sure about its full compatibility with the Zapi controller

The number of pulses/rev can be properly set using the dedicated parameters (see paragraph 8.2.7).

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

It is strongly suggested, for safety reasons, to lift the wheels from the floor and set the correct value according to the type of sensor used prior to perform any operation with the truck.

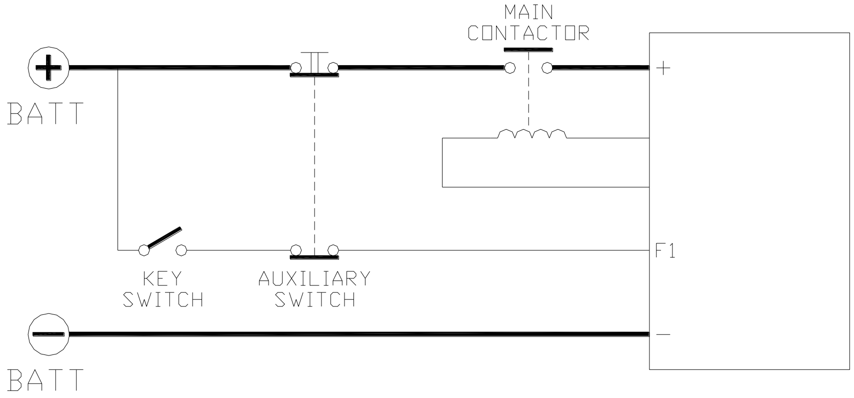
5.2.7 Connection of Motor temperature sensor

A temperature sensor with a positive temperature coefficient embedded in the motor winding provides a means for the motor controller to monitor motor temperature. Motor temperature is used in the vector control algorithms, and can also be used to protect the motor from overheating.
The motor controller can be configured to operate with different sensors such as KTY 84, PT1000 and similar.

Installation of the motor temperature sensor is done by the motor manufacturer. Contact the motor manufacturer to get the correct wiring. If the temperature sensor cables are not connected with the right polarity, the sensor readings will not be correct and overtemperature protection of the motor will not work properly.

5.2.8 Connection of main contactor and key switch

Main contactor and key switch can be connected as the following figure.



CONNECTION OF MAIN CONTACTOR AND KEY SWITCH

The connection of the battery line switches must be carried out following instructions from Zapi.

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 against battery voltages above 140% of the nominal one and against the key switching off before disconnecting the battery power line.

During start-up (after voltage has been supplied to the KEY_INPUT of the motor controller), the motor controller monitors the voltage of the capacitor bank. When the voltage over the capacitor bank has reached a pre-defined level, the motor controller will switch on the main contactor.

5.2.9 Insulation of the 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.

5.3 EMC

EMC and ESD performances of an electronic system are strongly influenced by the installation. Special attention must be given to lengths, paths and shielding of the electric connections. These aspects are beyond of Zapi control. Zapi can offer assistance and suggestions on EMC related problems, basing on its long experience. However, <u>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).</u>

EMC stands for Electromagnetic Compatibility, and it deals with the electromagnetic behavior of an electrical device, both in terms of emission and reception of electromagnetic waves that may cause electromagnetic interference with the surrounding electronics or malfunctions of the device itself.
So the analysis works in two directions:

1) The study of the emission problems, the disturbances generated by the device and the possible countermeasures 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 at high frequency which can generate RF energy. However wires have the key role to propagate disturbs because they work 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 concerns 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 undergo. These tests are carried out at determined levels of electromagnetic fields, simulating external undesired disturbances and verifying the response.

The second type of immunity, to 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 one 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 thus causing malfunctions; this effect is particularly critical in modern machines, with serial communications (CAN bus) which are spread everywhere on the truck and which may 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 a temporary malfunction to a definitive failure of the electronic device.

It is always much easier and cheaper to avoid ESD from being generated, rather than increasing the level of immunity of the electronic devices.

There are different solutions for EMC issues, depending on the required level of emissions/ immunity, 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 are 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.

6 FEATURES

6.1 Operational features

- Speed control or Torque control available
- 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 held in place) for a programmable time (see also paragraph 8.2.4).
- Regenerative release braking based upon deceleration ramps.
- Direction inversion with regenerative braking based upon deceleration ramps.
- Optimized speed control and reference sensitivity at low speeds.
- Hydraulic steering function:
  - When DUALACE2 New Gen works as dual traction inverter:
    The traction inverter sends a "hydraulic steering function" request to the pump inverter on the CAN bus line.
  - When DUALACE2 New Gen works as combi inverter:
    The pump inverter manages a 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-diagnoses with faults displayed by means of Zapi tools (Smart console, PC CAN Console) or Zapi MDI/Display.
- Inverter settings managed by means of Zapi tools (Smart console, PC CAN Console).
- Log of alarms history.
- TESTER function for monitoring the main readouts

6.2 Dual traction motor

In the case of a dual-traction setup, there is the 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

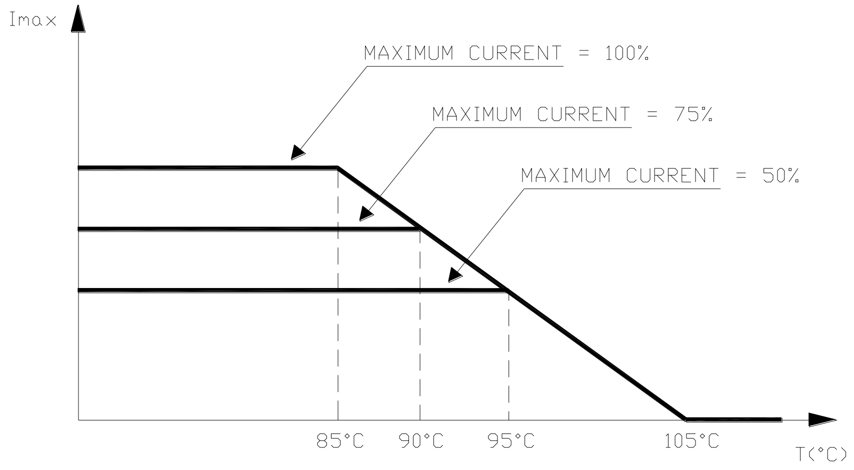
In this mode the controller maintains the motor at a constant speed for a given throttle position, as long as sufficient torque is available. Speed mode differs from torque mode in that the torque value applied to the motor is calculated by the controller based on the requested speed (determined by throttle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

6.6 Protection and safety features

6.6.1 Protection features

DUALACE2 NEW GEN is protected against:

- **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 temperature excess. The temperature can never exceed 105 °C.



Thermal cutback.

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

- **Uncontrolled movements**
  The main contactor will not close in the following conditions:
  - The power unit is not working.
  - The logic board does not work perfectly.
  - The output voltage of the accelerator is more than 1 V above the minimum value stored during the calibration procedure.
  - Travel-demand microswitches are active.

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

- **Accidental start-up**
  A precise sequence of operations is necessary for the machine to 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.

<u>Machine manufacturer holds the responsibility for the truck safety features and related approval.</u>

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7 START-UP HINTS

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.

7.1 Check prior to initial power up

⚠ ***For traction applications, raise up or otherwise disable drive 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 excessive pressure to build-up (in the event of a malfunction of the pressure-relief valve).***

⚠ ***Do not connect the controller to a battery with a nominal voltage different to the nominal value, indicated on the controller label. A higher battery voltage may cause failures in the power section. A lower voltage may not allow the controller to work***

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

⚠ ***All motor controller settings and functionality have to be verified and validated by the OEM prior to use in the field by an end user.***
The complete range of parameter values that are updated by the truck controller (or any other device) must also be verified and validated prior to use in the field by the end user.
During the process when the parameter values are established it is of major importance to take proper safety precautions when testing since incorrect parameter values may jeopardize the operation of the truck's safety critical functions.

⚠ ***It is the OEMs responsibility to ensure that the vehicle is configured and set up to conform to applicable safety regulations***

⚠ ***After operation, even with the key switch open, the internal capacitors may remain charged for some time. For safe operation onto the setup, it is***

recommended to disconnect the battery and to discharge the capacitors by means of a resistor of about 10 Ω – 100 Ω between terminals +B and -B of the inverter.

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

1. Verify that the proper motor controller for the application has been installed.
2. Verify that the battery voltage matches the motor controller nominal DC supply voltage showed on the product identification label.
3. Verify that the correct software for the application has been loaded.
4. Verify that all power and signal wires are correctly connected.
5. Verify that battery and motor terminals are tightened with appropriate torque.
6. Verify that the I/O plug (Ampseal connector) is fully mated and latched in position on the motor controller.
7. Verify that the motor controller is correctly fused for the application. Refer to the vehicle maintenance documentation for the correct fuse size.

7.2 Configuring motor controller for the application

Normally, motor controllers shipped for OEM series production are programmed by production lines 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 re-programming of the motor controller via the CAN bus.

7.2.1 Main parameters set-up

When the key switch is closed, if no alarms or errors are present, the Console display shows the standard Zapi opening line.
For the setting of your truck, use the procedure below.
If you need to reply the same settings on different controllers, use the SAVE and RESTORE sequence. Remember to re-cycle the key switch if you want to make active any change to the configuration.

- In ADJUSTMENTS, set BATTERY VOLTAGE according to the nominal battery voltage (see paragraph 8.2.5).
- Check the wiring and that all commands are functioning. Use the TESTER function to have a real-time feedback about their state.
- Perform the accelerator acquisition using the PROGRAM VACC procedure (see paragraph 9.1).
- Set the maximum current for traction and braking in MAX. CURRENT TRA and MAX. CURRENT BRK (see paragraph 8.2.1).
- Set the motor-related parameters. It is suggested to discuss them with Zapi technicians.
- Set the parameter SET MOT.TEMPERAT according to the type of motor thermal sensor adopted.
- Set the acceleration delay (parameters ACCEL MODULATION and ACCEL DELAY). Test the behavior in both directions.

- Set the FREQUENCY CREEP starting from 0.3 Hz. The machine should just move when the drive request is active. Increase the level accordingly.
- Set speed reduction as required by your specifications (see parameter HB ON / SR OFF in list SET OPTIONS).
- Set the other performance-related parameters such as RELEASE BRAKING, INVERSION BRAKING, DECELERATION BRAKING, PEDAL BRAKING, SPEED LIMIT BRAKING, MAX SPEED FORW, MAX SPEED BACK.
- Set the parameters related to the behavior on a slope (STOP ON RAMP and AUXILIARY TIME parameters).
- Test the truck in all operative conditions (with and without load, on flat and on ramp, etc.).

7.2.2 Set-up additional procedure for AC pump inverter

This section describes the additional set-up procedure for the pump section when controller is used in Combi configuration.

- MAX SPEED LIFT, 1ST SPEED COARSE, 2ND SPEED COARSE, 3RD SPEED COARSE.
- Set the parameters related to hydraulic steering, such as HYD SPEED FINE and HYDRO TIME.
- Test the pump in all operative conditions (with and without load, etc.).

At the end of your modifications, re-cycle the key switch to make them effective.

7.2.3 Position Sensor acquisition

Position sensor needs to be acquired because it has an arbitrary shift with respect to the magnetic-field zero position. Offset, amplitude and angle must be set before starting a PM for the first time.
Preliminary settings are the same as described above. Plus, an automatic acquisition procedure embedded in the inverter software is to be activated only once at commissioning.

Before starting the procedure, be sure that the motor is free to spin, with a minimum load on the shaft.

- In OPTIONS, select ABS SENS. ACQUIRE.
- Select NO at the request of saving data (otherwise the main coil will be opened).
- The message ACQUIRING ABS indicates that the acquisition procedure is ready to start.
- Use the TESTER function to monitor the motor speed for the next steps.
- Activate the TILLER and FW (or BW) microswitches. Motor starts running in open-loop mode.
- Because of the open-loop mode, it is normal if the reported speed is not perfectly stable, but value on display must be, in any case, quite fixed.
- If the motor does not spin, it vibrates or speed on display oscillates too much, stop the acquisition procedure releasing the FW or BW command (see troubleshooting at the paragraph end).
- The first phase, where motor is spinning at low speed (something like 5 Hz), allows the inverter to acquire signal offset and amplitude for both channels.
- After the previous steps are completed, rotor is aligned to the magnetic field origin, and the sin/cos angle is acquired and stored.

- The next part is a sort of verification, where the motor is accelerated up to 50 Hz in closed-loop mode.
- Because of the closed loop, the speed reported on display must be stable.
- If something has gone wrong (rotor is not correctly aligned because of friction on the shaft or any other problem), it is possible that rotor starts spinning at uncontrolled speed with high current absorption. The only way to stop it is by switching the inverter off using the key switch.
- When the procedure is correctly completed, the main contactor opens and display shows ACQUIRE END.
- Re-cycle the key switch and verify that the motor can run according to the accelerator input in both directions.

The inverter goes down the procedure automatically; every phase is marked by a different message on display.

In case of problems, mainly in the first phase, consider the following suggestions.
- Check that PM motor pole pairs are set correctly.
- Check that sensor pole pairs are set correctly.
- In HARDWARE SETTING increase the ABS.SENS. ACQ.ID parameter (the motor current used for the open-loop phase) so to have more torque and perhaps solve some friction problems (ID RMS MAX must be set congruently).

8 PROGRAMMING & ADJUSTEMENTS

The DUALACE2 New Gen software is powerful and exhaustive, but it is also complex, with a long list of parameters that grant a fine control of all the functionalities the inverter can perform. After a deep reading of this section, a well-trained technician or an engineer will be able to understand and modify the parameters.

The procedure for modifying the parameters is the following.

- Before doing any change save a copy of the parameters set. This procedure is easy to do thanks to the Zapi Smart Console (see section 13.2) or thanks to the PC CAN Console (see section 13.1).
- Inside the saved copy or in a related text file write down the reason of the changes.
- Change the parameters with full knowledge of what you are doing.
- After having saved the new parameters, check that all parameters have been changed according to your modifications by reading again the value stored inside the parameters.

To access and adjust all inverter parameters it is necessary to use the Zapi console. Since the DUALACE2 New Gen has no external serial connector, three possibilities are available:

- To use the Zapi Smart Console connected to the CAN bus (ask directly to Zapi for the dedicated user manual).
- To use the PC CAN Console software. The following paragraphs describe the controller configuration in the case the operator is using Zapi PC CAN Console.
- To connect the Zapi Smart Console (or old hand console) through a remote module, like a Zapi tiller card of a Zapi display. This module is to be connected to the same CAN bus line of the inverter.

Zapi Smart Console and PC CAN Console software are tools 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 overview and basic knowledge about the use of these tools.

Zapi tools permit a deep control over the parameters and behavior of Zapi controllers. Their use is restricted to engineers and well trained technicians.

8.1 Settings overview

Inverter settings are defined by a wide set of parameters, organized as follows.

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
CUTBACK SPEED 1
CTB. STEER ALARM
CURVE SPEED 1
CURVE SPEED 2
FREQUENCY CREEP
TORQUE CREEP
MAX. CURRENT TRA
MAX. CURRENT BRK
ACC SMOOTH
INV SMOOTH
STOP SMOOTH
BRK SMOOTH
STOP BRK SMOOTH
EB. ENGAGE DELAY
AUXILIARY TIME
ROLLING DW SPEED
REL. MIN MODUL.

SET OPTIONS
HM DISPLAY OPT.
HM CUSTOM 1 OPT.
HM CUSTOM 2 OPT.
TILL/SEAT SWITCH
EB ON TILLER BRK
BATTERY CHECK
STOP ON RAMP
PULL IN BRAKING
SOFT LANDING
QUICK INVERSION
PEDAL BRK ANALOG
HB ON / SR OFF
MAIN POT. TYPE
AUX POT. TYPE
SET MOT.TEMPERAT
STEERING TYPE
M.C. FUNCTION
M.C. OUTPUT
EBRAKE ON APPL.
AUX OUT FUNCTION
COMP.VOLT.OUTPUT
BUMPER STOP
SYNCRO
AUTO PARK BRAKE
ACCEL MODULATION
HIGH DYNAMIC
INVERSION MODE
STEER TABLE
WHEELBASE MM
FIXED AXLE MM
STEERING AXLE MM
REAR POT ON LEFT
DISPLAY TYPE
PDO2RX
ABS.SENS.ACQUIRE
RESOLVER PULSE

ADJUSTMENT
SET BATTERY
ADJUST KEY VOLT.
ADJUST BATTERY
SET POSITIVE PEB
SET PBRK. MIN
SET PBRK. MAX
MIN LIFT
MAX LIFT
MIN LOWER
MAX LOWER
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 TRESHLD
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.
MAX MOTOR TEMP.
TEMP. MOT. STOP
A.SENS.MAX SE
A.SENS.MIN SE
A.SENS.MAX CE
A.SENS.MIN CE
OFFSET ANGLE
SENSOR ANGLE D
ANGLE CORRECTION
COR ANGLE FEEDB.
DIAG.JUMP SENSOR

SPEC ADJUSTMENT
M ADJUSTMENT #01
M ADJUSTMENT #02
S ADJUSTMENT #01
S ADJUSTMENT #02
DIS.CUR.FALLBACK
SET CURRENT
M SET TEMPERAT.
S SET TEMPERAT.
HW BATTERY RANGE
DUTY PWM CTRAP
PWM AT LOW FREQ
PWM AT HIGH FREQ
FREQ TO SWITCH
HIGH ADDRESS
CAN BUS SPEED
EXTENDED FORMAT
DEBUG CANMESSAGE
CONTROLLER TYPE
MOTOR TYPE M
MOTOR TYPE S
SAFETY LEVEL
RS232 CONSOLE
2ND SDO ID OFST
VDC START UP LIM
VDC UP LIMIT
VDC START DW LIM
VDC DW LIMIT

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

PARAMETER PUMP	SLV SET OPTIONS	SLV ADJUSTMEN	VALVE OUTPUT	SLV HARDWARE SETTING
P ACCELER. DELAY	S AUX OUT FUNCT.	SLV ADJUSTMENT	EVP TYPE	S TOP MAX SPEED
P RELEASE BRK		S DIAG.JUMP SENS	EVP COIL RESIST.	S FEEDBACK SENS
P TILLER BRAKING			MIN EVP	S ROT. CW ENC
P DECEL. BRAKING			MAX EVP	S ROT CW MOT
P SPD. LIMIT BRK			EVP OPEN DELAY	S ENC PULSES 1
MIN SPEED LIFT			EVP CLOSE DELAY	S ENC PULSES 2
MAX SPEED LIFT			DITHER AMPLITUDE	S MOT. P. PAIRS 1
1ST PUMP SPEED			DITHER FREQUENCY	S MOT. P. PAIRS 2
P MAX.CURR. TRA.				S FEEDBACK SENS
P MAX.CURR. BRK.				S ROT. CW ENC
HYD PUMP SPEED				S ROT CW MOT
P AUXILIARY TIME				
P EBRAKE ON APPL				
P EB.ENGAGE DEL.				
P ROLLING DW SPD				
P ACCEL MODULAT.				
P STOP ON RAMP				
HYDRO TIME				
P THROTTLE 0				
P THROTTLE X1				
P THROTTLE Y1				
P THROTTLE X2				
P THROTTLE Y2				
P THROTTLE X3				
P THROTTLE Y3				

8.2 Settings description

In the following paragraphs, parameters are presented as follows:

Parameter	Allowable range	Description
Name of the parameter as indicated in the PC CAN Console tool. (Availability)	Allowable range of values that can be set. (resolution)	Description of the parameter and possibly suggestions on how to set it.

In the "Parameter" column, the availability field (between parentheses) lists the controller types where the parameter is available.

Controller types are coded as:

- **A =** All controller types
- **D =** Dual Traction controller
- **C =** Combi controller
- **CO =** Dual/Combi open CAN controller
- **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 on customer's requests.

8.2.1 Parameter Change

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
ACC. TORQUE DEL. (A)	0.1 s ÷ 10 s (steps of 0.1 s)	This parameter defines the acceleration ramp if TORQUE CONTROL is ON, i.e. the time needed to increase the torque from the minimum value up to the maximum one.
DEC. TORQUE DEL. (A)	0.1 s ÷ 10 s (steps of 0.1 s)	This parameter defines the deceleration ramp if TORQUE CONTROL is ON, i.e. the time needed to decrease the torque from the maximum value down to the minimum one.
ACCELER. DELAY (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint (see paragraph 9.5).
RELEASE BRAKING (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed after the running request is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
TILLER BRAKING (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed after the tiller/seat switch is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
INVERS. BRAKING (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed when the direction switch is toggled during drive, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
DECEL. BRAKING (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed when the accelerator is released but not completely, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
PEDAL BRAKING (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed when the braking pedal is pressed, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
SPEED LIMIT BRK. (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed upon a speed-reduction request, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
STEER BRAKING (A)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp related to the steering angle, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
MAX SPEED FORW (A)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum speed in forward direction as a percentage of TOP MAX SPEED.
MAX SPEED BACK (A)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum speed in backward direction as a percentage of TOP MAX SPEED.
CUTBACK SPEED 1 (A)	10% ÷ 100% (steps of 1%)	This parameter defines the maximum speed performed when cutback input 1 is active. It represents a percentage of TOP MAX SPEED.
CTB. STEER ALARM (A)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum traction speed when an alarm from the EPS is read by the microcontroller, if the alarm is not safety-related. The parameter represents a percentage of TOP MAX SPEED.
CURVE SPEED 1 (A)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 1 angle. The parameter represents a percentage of TOP MAX SPEED.
CURVE SPEED 2 (A)	1% ÷ 100% (steps of 1%)	This parameter defines the maximum traction speed when the steering angle is equal to the STEER ANGLE 2 angle. The parameter represents a percentage of TOP MAX SPEED.

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
FREQUENCY CREEP (A)	0.6Hz ÷ 25Hz (steps of 0.1 Hz)	This parameter defines the minimum speed when the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
TORQUE CREEP (A)	0% ÷ 100% (steps of 1/255)	This parameter defines the minimum torque applied when torque control is enabled and the forward- or reverse-request switch is closed, but the accelerator is at its minimum.
MAX. CURRENT TRA (A)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
MAX. CURRENT BRK (A)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum current applied to the motor during deceleration, as a percentage of the factory-calibrated maximum current.
ACC SMOOTH (A)	1 ÷ 5 (steps of 0.1)	This parameter defines the acceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
INV SMOOTH (A)	1 ÷ 5 (steps of 0.1)	This parameter defines the acceleration profile performed when the truck changes direction: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP SMOOTH (A)	3Hz ÷ 100Hz (steps of 1 Hz)	This parameter defines the frequency at which the smoothing effect of the acceleration profile ends.
BRK SMOOTH (A)	1 ÷ 5 (steps of 0.1)	This parameter defines the deceleration profile: 1 results in a linear ramp, higher values result in smoother parabolic profiles.
STOP BRK SMOOTH (A)	3Hz ÷ 100Hz (steps of 1 Hz)	This parameter defines the frequency at which the smoothing effect of the deceleration profile ends.
EB. ENGAGE DELAY (A)	0 s ÷ 12.75 s (steps of 0.05 s)	This parameter defines the delay introduced between the traction request and the actual activation of the traction motor. This takes into account the delay occurring between the activation of the EB output (i.e. after a traction request) and the effective EB release, so to keep the motor stationary until the electromechanical brake is actually released. The releasing delay of the brake can be measured or it can be found in the datasheet.
AUXILIARY TIME (A)	0 s ÷ 10 s (steps of 0.1 s)	For the encoder version, this parameter defines how long the truck holds in place if the STOP ON RAMP option is ON.
ROLLING DW SPEED (A)	1 Hz ÷ 50Hz (steps of 1 Hz)	This parameter defines the maximum speed for the rolling-down function.
REL. MIN MODUL (A)	8% ÷ 100% (steps of 1%)	This parameter defines the threshold speed for the fast response of release braking function (see paragraph 9.6)

8.2.2 Valve output

PARAMETER CHANGE		
Parameter	**Allowable range**	**Description**
EVP TYPE (A)	NONE ÷ ANALOG	This parameter defines the behavior of output EVP A25 NONE = Output A25 is not enabled. DIGITAL = Output A25 manages an on/off valve ANALOG = Output A25 manages a PWM-modulated current-controlled proportional valve.
EVP COIL RESIST. (A)	0 ÷ 255 (steps of 1/255)	This parameter defines the resistance of the coil connected to EVP output (A25). It is expressed in Ohm
MIN EVP (A)	0% ÷ 100% (steps of 1/255)	This parameter determines the minimum current applied to the EVP when the potentiometer position is at the minimum. This parameter is not effective if the EVP is programmed like an on/off valve.
MAX EVP (A)	0% ÷ 100% (steps of 1/255)	This parameter determines the maximum current applied to the EVP when the potentiometer position 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)	0 s ÷ 12.75 s (steps of 0.05 s)	It determines the current increase rate on EVP. The parameter sets the time needed to increase the current to the maximum possible value.
EVP CLOSE DELAY (A)	0 s ÷ 12.75 s (steps of 0.05 s)	It determines the current decrease rate on EVP. The parameter sets the time needed to decrease the current from the maximum possible value to zero.
DITHER AMPLITUDE (A)	0% ÷ 13%	This parameter defines the dither signal amplitude. The dither signal is a square wave added to the proportional-valve set-point. In this way the response to set-point variations results optimized. This parameter is a percentage of the valve maximum current. Setting the parameter to 0% means the dither is not used. The available values are: **0.0%, 1.0%, 2.5%, 4.0%, 5.5%, 7.0%, 8.5%, 10%, 11.5%, 13.0%**
DITHER FREQUENCY (A)	20.8 Hz ÷ 83.3 Hz	This parameter defines the dither frequency. The available values are: **20.8, 22.7, 25, 27.7, 31.2, 35.7, 41.6, 50, 62.5, 83.3**

8.2.3 Parameter Pump

All the parameters listed below refer to pump motor

PARAMETER PUMP		
Parameter	**Allowable range**	**Description**
P ACCELER. DELAY (C)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the acceleration ramp, i.e. the time needed to speed up the motor from 0 Hz up to 100 Hz. A special software feature manages the acceleration ramp depending on the speed setpoint (see paragraph 9.5).
P RELEASE BRK (C)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed after the running request is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
P TILLER BRAKING (C)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed after the tiller/seat switch is released, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
P DECEL. BRAKING (C)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed when the accelerator is released but not completely, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
P SPD. LIMIT BRK. (C)	0.1 s ÷ 25.5 s (steps of 0.1 s)	This parameter defines the deceleration ramp performed upon a speed-reduction request, i.e. the time needed to decelerate the motor from 100 Hz down to 0 Hz. A special software feature manages the deceleration ramp depending on the starting speed (see paragraph 0).
MIN SPEED LIFT (C)	0% ÷ 100% (steps of 1%)	This parameter defines the minimum speed of the pump motor during lift, as a percentage of the maximum voltage applied to the pump motor.
MAX SPEED LIFT (C)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum speed of the pump motor during lift, as a percentage of the maximum voltage applied to the pump motor.
1ST PUMP SPEED (C)	0% ÷ 100% (steps of 1%)	This parameter defines the speed of the pump motor when 1st speed is requested. It represents a percentage of the maximum pump speed.
P MAX. CURR. TRA. (C)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum current applied to the motor during acceleration, as a percentage of the factory-calibrated maximum current.
P MAX. CURR. BRK. (C)	0% ÷ 100% (steps of 1%)	This parameter defines the maximum current applied to the motor during deceleration, as a percentage of the factory-calibrated maximum current.

PARAMETER PUMP		
Parameter	**Allowable range**	**Description**
HYD PUMP SPEED (C)	0% ÷ 100% (steps of 1%)	This parameter defines the speed of the pump motor used for the hydro steering, when traction request is present. It represents a percentage of the maximum pump speed. When it is set to 0% Hydro fuction is disabled
P AUXILIARY TIME (C)	0 s ÷ 10 s (steps of 0.1 s)	This parameter defines how long the motor holds in place if the STOP ON RAMP option is ON.
P EBRAKE ON APPL. (C)	ABSENT, PRESENT	This parameter defines whether the application includes an electromechanical brake or not.
P EB. ENGAGE DELAY (C)	0 s ÷ 12.75 s (steps of 0.05 s)	This parameter defines the delay introduced between the traction request and the actual activation of the pump motor. This takes into account the delay occurring between the activation of the EB output (i.e. after a pump request) and the effective EB release, so to keep the motor stationary until the electromechanical brake is actually released. The releasing delay of the brake can be measured or it can be found in the datasheet.
P ROLLING DW SPEED (C)	1 Hz ÷ 50Hz (steps of 1 Hz)	This parameter defines the maximum speed for the rolling-down function.
P ACCEL MODULAT. (C)	OFF ÷ ON	This parameter enables or disables the acceleration-modulation function. **OFF =** The acceleration rate is inversely proportional to the ACCEL DELAY parameter. **ON =** The acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY. See paragraph 9.5.
P STOP ON RAMP (C)	OFF ÷ ON	This parameter enables or disables the stop-on-ramp feature (the motor is electrically held in place for a defined time). **ON =** The stop-on-ramp feature is performed for a time set in the P AUXILIARY TIME parameter. **OFF =** The stop-on-ramp feature is not performed. Instead, a controlled slowdown is performed for a minimum time set in the AUXILIARY TIME parameter. After the AUXILIARY TIME interval, the three-phase bridge is released and, if present, the electromechanical brake activated (see parameter SLV AUX OUT FUNCTION).
HYD TIME (C)	0 ÷ 20 (steps of 0,1)	This parameter defines the time for that the hydro function stays activated after traction request releasing.
P THROTTLE 0 ZONE (C)	0% ÷ 100% (steps of 1%)	This parameter defines a dead band in the lift potentiometer input curve. See paragraph 9.9.

PARAMETER PUMP		
Parameter	**Allowable range**	**Description**
P THROTTLE X1 MAP (C)	0% ÷ 100% (steps of 1%)	This parameter defines the lift potentiometer curve. See paragraph 9.9.
P THROTTLE Y1 MAP (C)	0% ÷ 100% (steps of 1%)	This parameter defines the lift potentiometer curve. See paragraph 9.9.
P THROTTLE X2 MAP (C)	0% ÷ 100% (steps of 1%)	This parameter defines the lift potentiometer curve. See paragraph 9.9.
P THROTTLE Y2 MAP (C)	0% ÷ 100% (steps of 1%)	This parameter defines the lift potentiometer curve. See paragraph 9.9.
P THROTTLE X3 MAP (C)	0% ÷ 100% (steps of 1%)	This parameter defines the lift potentiometer curve. See paragraph 9.9.
P THROTTLE Y3 MAP (C)	0% ÷ 100% (steps of 1%)	This parameter defines lift potentiometer curve. See paragraph 9.9.

8.2.4 Set Option

SET OPTIONS		
Parameter	**Allowable range**	**Description**
HM DISPLAY OPT. (D, C)	0 ÷ 6	This parameter defines the configuration for the hour meter shown on a display (i.e. MDI). The possible settings are the same described for parameter HM CUSTOM 1 OPT..
HM CUSTOM 1 OPT. (A)	0 ÷ 6	This parameter decides the configuration for the hour meter number 1 accessible to the customer. The possible settings are: **0:** The hour meter counts since the controller is on. **1:** The hour meter counts when the three-phase power bridge is active. **2:** Not used in ACE2 NEW GENERATION. **3:** The hour meter counts when one of the valve outputs is active. **4:** Not used in ACE2 NEW GENERATION. **5:** The hour meter counts when one of the valve outputs is active. **6:** Not used in ACE2 NEW GENERATION.
HM CUSTOM 2 OPT. (A)	0 ÷ 6	This parameter decides the configuration for the hour meter number 2 accessible to the customer. The possible settings are the same of HM CUSTOM 1 OPT. parameter.

SET OPTIONS		
Parameter	**Allowable range**	**Description**
TILL/SEAT SWITCH (D, C)	HANDLE ÷ SEAT	This option handles the input A8 (A6). This input opens when the operator leaves the truck. It is connected to a key voltage when the operator is present. **HANDLE =** A8 (A6) is managed as tiller input (no delay when released). **DEADMAN =** A8 (A6) is managed as dead-man input (no delay when released). **SEAT =** A8 (A6) is managed as seat input (with a delay when released and the de-bouncing function).
EB ON TILLER BRK (D, C)	OFF ÷ ON	This option defines how the electromechanical brake is managed depending on the status of tiller/seat input: **ON =** the electromechanical brake is engaged as soon as the tiller input goes into OFF state. The deceleration ramp defined by TILLER BRAKING parameter has no effect. **OFF =** when the tiller input goes into OFF state, the “tiller braking” ramp is applied before engaging the electromechanical brake.
BATTERY CHECK (A)	0 ÷ 3	This option specifies the management of the low battery charge situation. There are four levels of intervention: **0 =** The battery charge level is evaluated but ignored, meaning that no action is taken when the battery runs out. **1 =** The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT.LOW TRESHLD. With the BATTERY LOW alarm, the control reduces the maximum speed down to 24% of the full speed and it also reduces the maximum current down to 50% of the full current. **2 =** The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT.LOW TRESHLD. **3 =** The BATTERY LOW alarm occurs when the battery level is evaluated to be lower or equal to BATT.LOW TRESHLD. With the BATTERY LOW alarm, the control reduces the maximum speed down to 24% of the full speed. See parameter BATT.LOW TRESHLD in the ADJUSTMENTS list, paragraph 8.2.5.
STOP ON RAMP (A)	OFF ÷ ON	This parameter enables or disables the stop-on-ramp feature (the truck is electrically held in place on a slope for a defined time). **ON =** The stop-on-ramp feature is performed for a time set in the AUXILIARY TIME parameter. **OFF =** The stop-on-ramp feature is not performed. Instead, a controlled slowdown is performed for a minimum time set in the AUXILIARY TIME parameter. After the AUXILIARY TIME interval, the three-phase bridge is released and, if present, the electromechanical brake activated (see parameter AUX OUT FUNCTION).

SET OPTIONS		
Parameter	**Allowable range**	**Description**
PULL IN BRAKING (A)	OFF ÷ ON	This parameter enables or disables the functionality that continues to give torque even if the traction (or lift) request has been released. **ON =** When the operator releases the traction request, the inverter keeps running the truck, as to oppose the friction that tends to stop it. Similarly, in pump applications, when the operator releases the lift request, the inverter keeps running the pump avoiding the unwanted descent of the forks. **OFF =** When the operator releases the traction (or lift) request, the inverter does not power anymore the motor. This setting is useful especially for traction application. When the truck is travelling over a ramp and the driver wants to stop it by gravity, the motor must not be powered anymore, until the truck stops.
SOFT LANDING (A)	OFF ÷ ON	This parameter enables or disables the control of the deceleration rate of the truck when the accelerator is released. **ON =** When the accelerator is released, the inverter controls the deceleration rate of the truck through the application of a linearly decreasing torque curve. This is useful when the operator releases the accelerator while the truck is going uphill. If the rise is steep, the truck may stop fast and may also go backwards in short time, possibly leading to a dangerous situation. **OFF =** When the accelerator is released, the inverter does not control the deceleration rate of the truck, instead it stops driving the motor.
QUICK INVERSION (D, C)	NONE ÷ BELLY	This parameter defines the quick-inversion functionality. **NONE =** The quick-inversion function is not managed. **BRAKE =** Upon a quick-inversion request, the motor is braked. **TIMED =** The quick-inversion function is timed: upon a QI request the controller drives the motor in the opposite direction for a fixed time (1.5 seconds by default). **BELLY =** The quick-inversion function is managed but not timed: upon a QI request the controller drives the motor in the opposite direction until the request is released.
PEDAL BRK ANALOG (D, C)	OFF ÷ ON	This parameter defines the kind of brake pedal adopted. **ON =** Brake pedal outputs an analog signal, braking is linear. **OFF =** Brake pedal outputs a digital signal, braking is on/off.
HB ON / SR OFF (D, C)	OFF, ON	This parameter defines the function associated with input A19 (A13). **ON =** Handbrake. **OFF =** Speed reduction.

<table>
<tr><th colspan="3">SET OPTIONS</th></tr>
<tr><th>Parameter</th><th>Allowable range</th><th>Description</th></tr>
<tr><td>MAIN POT. TYPE
(D, C)</td><td>0 ÷ 11</td><td>This parameter decides the feature of the main potentiometer, connected to pin A5 (A3).
<table>
<tr><th>#</th><th>Pot. type</th><th>Low to High / High to Low</th><th>Direction switches</th><th>Enable switch</th><th>En. dead band</th></tr>
<tr><td>0</td><td>V-type</td><td>L to H</td><td>X</td><td></td><td></td></tr>
<tr><td>1</td><td>V-type</td><td>L to H</td><td>X</td><td></td><td>X</td></tr>
<tr><td>2</td><td>V-type</td><td>H to L</td><td>X</td><td></td><td></td></tr>
<tr><td>3</td><td>V-type</td><td>H to L</td><td>X</td><td></td><td>X</td></tr>
<tr><td>4</td><td>Z-type</td><td>L to H</td><td>X</td><td></td><td></td></tr>
<tr><td>5</td><td>Z-type</td><td>L to H</td><td>X</td><td></td><td>X</td></tr>
<tr><td>6</td><td>Z-type</td><td>L to H</td><td></td><td>X</td><td>X</td></tr>
<tr><td>7</td><td>Z-type</td><td>L to H</td><td></td><td></td><td>X</td></tr>
<tr><td>8</td><td>Z-type</td><td>H to L</td><td>X</td><td></td><td></td></tr>
<tr><td>9</td><td>Z-type</td><td>H to L</td><td>X</td><td></td><td>X</td></tr>
<tr><td>10</td><td>Z-type</td><td>H to L</td><td></td><td>X</td><td>X</td></tr>
<tr><td>11</td><td>Z-type</td><td>H to L</td><td></td><td></td><td>X</td></tr>
</table></td></tr>
<tr><td>AUX POT. TYPE
(D, C)</td><td>0 ÷ 12</td><td>This parameter decides the type of the auxiliary potentiometer, connected to pin A16 (A10).
<table>
<tr><th>#</th><th>Pot. type</th><th>Low to High / High to Low</th><th>Direction switches</th><th>Enable switch</th><th>En. dead band</th></tr>
<tr><td>0
÷
11</td><td colspan="5">Same as MAIN POT. TYPE,
see previous parameter.</td></tr>
<tr><td>12</td><td>No</td><td>H to L</td><td>X</td><td>X</td><td></td></tr>
<tr><td>13
÷
15</td><td colspan="5">For future uses</td></tr>
</table></td></tr>
<tr><td>SET MOT.TEMPERAT
(A)</td><td>NONE ÷ OPTION#2</td><td>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 A33 (A23).
OPTION#1 = an analogue motor thermal sensor is connected to A33 (A23). The temperature sensor is a KTY 84-130 PTC (positive thermal coefficient resistance).
OPTION#2 = an analogue motor thermal sensor is connected to A33 (A23). The temperature sensor is a KTY 83-130 PTC (positive thermal coefficient resistance)
OPTION#3 = an analog motor thermal sensor is connected to A33 (A23). The temperature sensor is a PT1000 PTC (positive thermal coefficient resistance).</td></tr>
</table>

SET OPTIONS		
Parameter	**Allowable range**	**Description**
STEERING TYPE (A)	NONE ÷ OPTION #4	It allows to select which type of steering unit is connected to the controller. **NONE =** NO steering module is present on the truck, controller does not wait for CAN message by the EPS and it does not apply braking steer cutback. **OPTION#1 =** EPS is present and it is configured with an ENCODER + TOGGLE SWITCHES. These signals are transmitted to controller over CAN bus. **OPTION#2 =** EPS is present and it is configured with a POT + ENCODER. These signals are transmitted to controller over CAN bus. **ANALOG =** A hydraulic steer is used on the truck and controller is reading through one of its analog input the signal coming from a wheel potentiometer in order to read the wheel rotation. **OPTION#4 =** EPS is present and it is configured Open CAN
M.C. FUNCTION (A)	OFF ÷ OPTION#2	This parameter defines the configuration of the NLC output A26 (A16), dedicated to the main – or line – contactor. **OFF =** Main contactor is not present. Diagnoses are masked and MC is not driven. **ON =** Main contactor is in standalone configuration. Diagnoses are performed and MC is closed after key-on only if they have passed. **OPTION#1 =** For a traction-and-pump setup, with only one main contactor for both controllers. Diagnoses are performed and MC is closed after key-on only if they have passed. **OPTION#2 =** For a traction-and-pump setup, with two main contactors. Each controller drives its own MC. Diagnoses are performed and MCs are closed after key-on only if they have passed.
M.C. OUTPUT (A)	ABSENT, PRESENT	This parameter defines whether a load coil is connected to the NLC output A26 (A16) or not. **ABSENT =** NLC output is not connected to any load coil. **PRESENT =** NLC output is connected to a load coil (by default, that of the main contactor).
EBRAKE ON APPL. (A)	ABSENT, PRESENT	This parameter defines whether the application includes an electromechanical brake or not.

SET OPTIONS		
Parameter	**Allowable range**	**Description**
AUX OUT FUNCTION (A)	NONE, BRAKE	This parameter enables or disables the NEB output A28 (A18), dedicated to the electromechanical brake. **NONE =** Diagnoses are masked and E.B. is not driven upon a traction request. **BRAKE =** E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. **Do not use this setting if the electromechanical brake is not really present.** **Note:** in applications with two controllers driving two traction motors and only one E.B., this parameter has to be set on BRAKE only in the controller that drives the E.B.
COMP.VOLT.OUTPUT (A)	0 ÷ 3	This parameter defines the voltage compensation for the MC and EB drivers in dependence of the battery voltage. **0 =** None. **1 =** MC only. **2 =** EB only. **3 =** MC and EB.
BUMPER STOP (CO)	OFF ÷ ON	This parameter enables or disables the bumper stop function. **OFF =** function disabled **ON =** function enabled according to dedicated inputs state
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 to the signal received by CAN bus **ON =** the output is managed autonomously by the controller itself ignoring any activation/deactivation signal received by CAN bus
ACCEL MODULATION (A)	OFF ÷ ON	This parameter enables or disables the acceleration-modulation function. **OFF =** The acceleration rate is inversely proportional to the ACCEL DELAY parameter. **ON =** The acceleration ramp is inversely proportional to the ACCEL DELAY parameter only if speed setpoint is greater than 100 Hz. Below 100 Hz the acceleration ramp is also proportional to the speed setpoint, so that the acceleration duration results equal to ACCEL DELAY. See paragraph 9.5.

SET OPTIONS		
Parameter	**Allowable range**	**Description**
HIGH DYNAMIC (A)	OFF ÷ ON	This parameter enables or disables the high-dynamic function. **ON =** All acceleration and deceleration profiles set by dedicated parameters are ignored and the controller works always with maximum performance. **OFF =** Standard behavior.
INVERSION MODE (A)	OFF ÷ ON	This parameter sets the behavior of the Quick-Inversion input A17 (A11): **ON =** The Quick-Inversion switch is normally closed (function is active when the switch is open). **OFF =** The Quick-Inversion switch is normally open (function is active when the switch is closed).
STEER TABLE (D, CO)	NONE ÷ OPTION#2	This parameter defines the steering table. **NONE =** The inverter does not follow any predefined steering table, but it creates a custom table according to parameters WHEELBASE MM, FIXED AXLE MM, STEERING AXLE MM and REAR POT ON LEFT. **OPTION#1 =** Three-wheels predefined steering table. **OPTION#2 =** Four-wheels predefined steering table. The steering table depends on the truck geometry. The two options available as default may not fit the requirements of your truck. It is advisable to define the geometrical dimensions of the truck in the parameters listed below in order to create a custom table. It is strongly recommended to consult paragraph 9.14 in order to properly understand how to fill the following parameters. If the steering performance of the truck do not match your requirements even if you have defined the right truck geometry, contact a Zapi technician in order to establish if a custom steering table has to be created.
WHEELBASE MM (D, CO)	0 ÷ 32000	This parameter must be filled with the wheelbase distance, i.e. the distance present between the two truck axles. The distance must be expressed in millimeters. See paragraph 9.14.
FIXED AXLE MM (D, CO)	0 ÷ 32000	This parameter must be filled with the axle length at which the non-steering wheels are connected. The length must be expressed in millimeters. See paragraph 9.14.
STEERING AXLE MM (D, CO)	0 ÷ 32000	This parameter must be filled with the axle length at which the non-steering wheels are connected. The length must be expressed in millimeters. See paragraph 9.14.

SET OPTIONS		
Parameter	**Allowable range**	**Description**
REAR POT ON LEFT (D, CO)	OFF ÷ ON	This parameter defines the position of the steering potentiometer. **OFF =** The steering potentiometer is not placed on the rear-left wheel. **ON =** The steering potentiometer is placed on the rear-left wheel.
DISPLAY TYPE (D, C)	0 ÷ 9	This parameter defines which type of display is connected to the inverter. **0 =** None. **1 =** MDI PRC. **2 =** ECO DISPLAY. **3 =** SMART DISPLAY. **4 =** MDI CAN. **5 ÷ 9 =** available for future developments.
PDO2RX **(CO)**	ABSENT ÷ PRESENT	This parameter defines whether or not the message PDORX is expected to be received. **ABSENT =** Message PDO2RX is not expected to be received. **PRESENT =** Message PDO2RX is expected to be received. If it is not received, a CAN alarm is raised.
S AUX OUT FUNCTION (D, CO)	NONE, BRAKE	This parameter enables or disables the NEB output A29 (A19), dedicated to the electromechanical brake. **NONE =** Diagnoses are masked and E.B. is not driven upon a traction request. **BRAKE =** E.B. is driven upon a traction request if all the related diagnoses pass. The behavior on a slope depends on the STOP ON RAMP setting. **Do not use this setting if the electromechanical brake is not really present.**

8.2.5 Adjustments

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
SET BATTERY (A)	24 V ÷ 80 V	This parameter must be set to the nominal battery voltage. The available options are: **24V**, **36V**, **48V**, **72V**, **80V**
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)	12 V ÷ 80 V	This parameter defines the supply-voltage value connected to PEBA27 (A17). Available values are: **12V**, **24V**, **36V**, **40V**, **48V**, **72V**, **80V**
SET PBRK. MIN (D, C)	0 V ÷ 25.5 V (steps of 0.1 V)	It records the minimum value of brake potentiometer when the brake is analog.
SET PBRK. MAX (D, C)	0 V ÷ 25.5 V (steps of 0.1V)	It records the maximum value of brake potentiometer when the brake is analog.
MIN LIFT **(Read Only)** (D, C)	0 V ÷ 25.5 V (steps of 0.1V)	It records the minimum value of lower potentiometer when the lower switch is closed. See paragraph 9.2.
MAX LIFT **(Read Only)** (D, C)	0 V ÷ 25.5 V (steps of 0.1V)	It records the maximum value of lower potentiometer when the lower switch is closed. See paragraph 9.2.
MIN LOWER **(Read Only)** (D, C)	0 V ÷ 25.5 V (steps 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)** (D, C)	0 V ÷ 25.5 V (steps of 0.1V)	It records the maximum value of lower potentiometer when the lower switch is closed. See paragraph 9.2.
THROTTLE 0 ZONE (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines a dead band in the accelerator input curve. See paragraph 9.9.
THROTTLE X1 MAP (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines the accelerator input curve. See paragraph 9.9.
THROTTLE Y1 MAP (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines the accelerator input curve. See paragraph 9.9.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
THROTTLE X2 MAP (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines the accelerator input curve. See paragraph 9.9.
THROTTLE Y2 MAP (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines the accelerator input curve. See paragraph 9.9.
THROTTLE X3 MAP (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines the accelerator input curve. See paragraph 9.9.
THROTTLE Y3 MAP (D, C)	0% ÷ 100% (steps of 1%)	This parameter defines the accelerator input curve. See paragraph 9.9.
BAT. MIN ADJ. (A)	-12.8% ÷ 12.7% (steps of 0.1%)	It adjusts the lower level of the battery discharge table. It is used to calibrate the discharge algorithm for the battery used. See paragraph 0.
BAT. MAX ADJ. (A)	-12.8% ÷ 12.7% (steps of 0.1%)	It adjusts the upper level of the battery discharge table. It is used to calibrate the discharge algorithm for the battery used. See paragraph 9.11.
BDI ADJ STARTUP (A)	-12.8% ÷ 12.7% (steps of 0.1%)	Adjusts the level of the battery charge table at start-up, in order to calculate the battery charge at key-on. See paragraph 9.11.
BDI RESET (A)	0% ÷ 100% (steps 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 for the battery used. See paragraph 9.11.
BATT.LOW TRESHLD (A)	1% ÷ 50% (steps of 1%)	This parameter defines the minimum charge percentage below which the BATTERY LOW alarm rises.
STEER RIGHT VOLT (A)	0 V ÷ 25.5 V (steps of 0.1 V)	This parameter records the maximum steering-control voltage while turning right. See paragraph 9.3.
STEER LEFT VOLT (A)	0 V ÷ 25.5 V (steps of 0.1 V)	This parameter records the maximum steering-control voltage while turning left. See paragraph 9.3.
STEER ZERO VOLT (A)	0 V ÷ 25.5 V (steps of 0.1 V)	This parameter records the maximum steering-control voltage when it is in the straight-ahead position. See paragraph 9.3.
MAX ANGLE RIGHT (A)	0° ÷ 90° (steps of 1°)	This parameter defines the maximum steering-wheel angle while turning right.
MAX ANGLE LEFT (A)	0° ÷ 90° (steps of 1°)	This parameter defines the maximum steering-wheel angle while turning left.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
STEER DEAD ANGLE (D, C)	1° ÷ 50° (steps of 1°)	This parameter defines the maximum steering-wheel angle up to which the permitted traction speed is 100%. See paragraph 9.8.
STEER ANGLE 1 (D, C)	1° ÷ 90° (steps of 1°)	This parameter defines the steering-wheel angle at which traction speed is reduced to the value imposed by CURVE SPEED 1. For steering-wheel angles between STEER DEAD ANGLE and STEER ANGLE 1, traction speed is reduced linearly from 100% to CURVE SPEED 1. See paragraph 9.8.
STEER ANGLE 2 (D, C)	1° ÷ 90° (steps of 1°)	This parameter defines the steering-wheel angle beyond which traction speed is reduced to CURVE CUTBACK. For steering-wheel angles between STEER ANGLE1 and STEER ANGLE 2 traction speed is reduced linearly from CURVE SPEED 1 to CURVE CUTBACK. See paragraph 9.8.
SPEED FACTOR (A)	0 ÷ 255 (steps of 1)	This parameter defines the coefficient used for evaluating the truck speed (in km/h) from the motor frequency (in Hz), according to the following formula: $Speed\ [km/h] = 10 \cdot \frac{frequency\ [Hz]}{Speed\ factor}$
SPEED ON MDI (D, C)	OFF ÷ ON	This parameter enables or disables 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 the hour-meter indication. **OFF =** Standard MDI functionality.
LOAD HM FROM MDI (D, C)	OFF ÷ ON	This parameter enables or disables the transfer of the hour-meter to a MDI unit. **OFF =** controller hour meter is not transferred and recorded on the MDI hour meter. **ON =** controller hour meter is transferred and recorded on the MDI hour meter (connected via the Serial Link).
CHECK UP DONE (A)	OFF ÷ ON	In order to cancel the CHECK UP NEEDED warning, set this parameter ON after the required maintenance service.
CHECK UP TYPE (A)	NONE ÷ OPTION#3	This parameter defines the CHECK UP NEEDED warning: **NONE =** no CHECK UP NEEDED warning. **OPTION#1 =** CHECK UP NEEDED warning shown on the hand-set and MDI after 300 hours. **OPTION#2 =** Like OPTION#1, plus speed reduction intervenes after 340 hours. **OPTION#3 =** Like OPTION#2, plus the truck definitively stops after 380 hours.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
MC VOLTAGE (A)	0% ÷ 100% (steps of 1%)	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the main-contactor output A26 (A16) during the first second after the activation signal that causes the main contactor to close.
MC VOLTAGE RED. (A)	0% ÷ 100% (steps of 1%)	This parameter defines a percentage of MC VOLTAGE parameter and it determines the duty-cycle applied after the first second of activation of the contactor. For details and examples see paragraph 0.
EB VOLTAGE (A)	0% ÷ 100% (steps of 1%)	This parameter specifies the duty-cycle (t_{ON}/T_{PWM}) of the PWM applied to the electromechanical brake output A28 (A18) during the first second after the activation signal that causes the electromechanical brake to release.
EB VOLTAGE RED. (A)	0% ÷ 100% (steps of 1%)	This parameter defines a percentage of EB VOLTAGE parameter and it determines the duty-cycle applied after the first second since when the electromechanical brake is released. For details and examples see paragraph 0.
MAX. MOTOR TEMP. (A)	60°C ÷ 175°C (steps of 1°C)	This parameter defines the motor temperature above which a 50% cutback is applied to the maximum current. Cutback is valid only during motoring, while during braking the 100% of the maximum current is always available independently by the temperature.
TEMP. MOT. STOP (A)	60°C ÷ 190°C (steps of 1°C)	This parameter defines the maximum motor temperature permitted, above which the controller stops driving the motor.
DIAG.JUMP SENS (A)	0-255Hz	This parameter defines the maximum jump admitted for the feedback sensor of motor 1 above which the controller stops driving the motor rising an alarm.
S DIAG.JUMP SENS (A)	0-255Hz	This parameter defines the maximum jump admitted for the feedback sensor of motor 2 above which the controller stops driving the motor rising an alarm.
A.SENS.MAX SE (Only for BLE version with sin/cos sensor) (A)	Volt	This parameter records the maximum offset voltage at the sine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET SR entry value.
A.SENS.MIN SE (Only for BL version with sin/cos sensor) (A)	Volt	This parameter records the minimum offset voltage at the sine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET SR entry value.
A.SENS.MAX CE (Only for BLE version) (A)	Volt	This parameter records the maximum offset voltage at the cosine analog input during the auto-teaching procedure. It can be compared with the A.SENS.OFFSET CR entry value.

ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
A.SENS.MIN CE **(Only for BLE version with sin/cos sensor)** (A)	Volt	This parameter records the minimum offset voltage at the cosine analog input during the auto-teaching procedure**.** It can be compared with the A.SENS.OFFSET CR entry value.
TOOTHS OFF.ANGLE **(Only for BLE version with zero-index encoder)** (A)		This parameter records the angle offset of index signal input during the auto-teaching procedure**.**
OFFSET ANGLE **(Only for BLE version with sin/cos sensor or sixstep)** (A)	0° - 180° (steps of 0.1°)	This parameter gives the possibility to manually adjust the offset angle present between the absolute position sensor and the PMSM rotor orientation. The unit is degrees and the max value is 180°.
HYST. ANGLE **(Only for BLE version with sixstep)** (A)		This parameter records the hysteresis angle present between the absolute position sensor and the PMSM rotor orientation during the auto-teaching procedure**.**

8.2.6 Special Adjustment

Note: SPECIAL ADJUST. must only be accessed by skilled people. To change settings in this group of settings, a special procedure is needed. Ask for this procedure directly to a Zapi technician. In SPECIAL ADJUST. there are factory-adjusted parameters that should be changed by expert technicians only.

SPECIAL ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
M ADJUSTMENT #01 **(Read Only)** (A)		First gain of the first traction-motor current-sensing amplifier. NOTE: only Zapi technicians can change this value through a special procedure.
M ADJUSTMENT #02 **(Read Only)** (A)		Second gain of the first traction-motor current-sensing amplifier. NOTE: only Zapi technicians can change this value through a special procedure.
S ADJUSTMENT #01 **(Read Only)** (A)		First gain of the second traction-motor current-sensing amplifier. NOTE: only Zapi technicians can change this value through a special procedure.
S ADJUSTMENT #02 **(Read Only)** (A)		Second gain of the second traction-motor current-sensing amplifier. NOTE: only Zapi technicians can change this value through a special procedure.
DIS.CUR.FALLBACK (A)	OFF ÷ ON	This parameter disables or enables current reduction (applied after one minute of traction). **ON =** Current reduction is disabled. **OFF =** Current reduction is enabled.
SET CURRENT **(Read Only)** (A)		(Factory adjusted). This is maximum current that the inverter can provide to the motor.
M SET TEMPERAT. (A)	0°C ÷ 255°C (steps of 1°C)	This parameter calibrates the master controller-temperature reading.
S SET TEMPERAT. (A)	0°C ÷ 255°C (steps of 1°C)	This parameter calibrates the slave controller-temperature reading.
HW BATTERY RANGE **(Read Only)** (A)	0 ÷ 3 (steps of 1)	This parameter defines the battery voltage range. NOTE: only Zapi technicians can change this value.

SPECIAL ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
DUTY PWM CTRAP **(Read Only)** (A)	0% ÷ 100%	This parameter defines the duty cycle for overcurrent threshold. Reserved.
PWM AT LOW FREQ (A)		This parameter defines the power-bridge PWM frequency at low speed. NOTE: only Zapi technicians can change this value through a special procedure.
PWM AT HIGH FREQ (A)		This parameter defines the power-bridge PWM frequency at high speed. NOTE: only Zapi technicians can change this value through a special procedure.
FREQ TO SWITCH (A)	Volt	(Factory adjusted). This parameter defines the electrical frequency at which the switching frequency is changed from PWM AT LOW FREQ to PWM AT HIGH FREQ.
HIGH ADDRESS (A)	0 ÷ 4	This parameter is used to access special memory addresses.
CAN BUS SPEED (A)	20 kbps ÷ 500 kbps	This parameter defines the CAN bus data-rate in kbps. **20, 50, 125, 250, 500**
EXTENDED FORMAT (A)	OFF, ON	This parameter defines the CAN bus protocol.
DEBUG CANMESSAGE (A)	OFF, ON	This parameter enables or disables special debug messages.
CONTROLLER TYPE (A)	0 ÷ 3	This parameter defines the controller type: **Dual Traction wired** **Combi wired** **Dual OPEN CAN** **Combi OPEN CAN** **NOTE:** a mismatch between this parameter and the hardware configuration may lead to a severe malfunctioning of the controller.
MOTOR TYPE M (A)	0 ÷ 1	This parameter defines the motor 1 type: **AC Motor:** AC induction motor **BL Motor:** permanent magnet synchronous motor
MOTOR TYPE S (A)	0 ÷ 1	This parameter defines the motor 1 type: **AC Motor:** AC induction motor **BL Motor:** permanent magnet synchronous motor

SPECIAL ADJUSTMENTS		
Parameter	**Allowable range**	**Description**
SAFETY LEVEL (A)	0 ÷ 3	This parameter defines the safety level of the controller, i.e. the functionality of the supervisor microcontroller. **0 =** Supervisor µC does not check any signal. **1 =** Supervisor µC checks the inputs and the outputs. **2 =** Supervisor µC checks the inputs and the motor set-point. **3 =** Supervisor µC checks the inputs, the outputs and the motor set-point.
RS232 CONSOLLE (A)	OFF ÷ ON	This parameter enables or disables the console to change settings. NOTE: only Zapi technicians can change this value.
NODE ID OFST (CO)	0 ÷ 126 (by steps of 1)	This parameter defines the offset of the CAN frame IDs.
ID CANOPEN OFST (CO)	0 ÷ 56 (by steps of 8)	This parameter defines the offset of the Open CAN frame IDs.
2ND SDO ID OFST (A)	0 ÷ 126 (by steps of 2)	This parameter defines if another SDO communication channel has to be added. Specify an ID offset different from 0 in order to enable the channel.
VDC START UP LIM (A)	by 1% steps)	This parameter defines the battery voltage (as percentage of the nominal voltage) above which delivered power is reduced in order to avoid an overvoltage condition during braking.
VDC UP LIMIT (A)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of the nominal voltage) above which the inverter stops in order to avoid a triggering of overvoltage condition.
VDC START DW LIM (A)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of nominal voltage) below which delivered power is reduced in order to avoid an undervoltage condition (typically during accelerations with low battery).
VDC DW LIMIT (A)	0% ÷ 255% (by 1% steps)	This parameter defines the battery voltage (as percentage of nominal voltage) below which the inverter stops in order to avoid an uncontrolled shutdown due to an undervoltage condition.

8.2.7 Hardware Setting

The HARDWARE SETTINGS parameters group includes the motor-control-related parameters. Only those parameters the user can modify are here described.

For descriptions and teaching about missing parameters contact a Zapi technician.

HARDWARE SETTING		
Parameter	**Allowable range**	**Description**
TOP MAX SPEED (A)	0 Hz ÷ 600 Hz (by steps of 10 Hz)	This parameter defines the maximum motor speed. Factory adjusted.
CONF.POSITIVE LC (A)	0 ÷ 2 (steps of 1)	This parameter defines the positive supply configuration for the main-contactor coil. Factory adjusted. **0:** The positive supply of Main Contactor coil is connected to PEB A27 (A17). **1:** The positive supply of Main Contactor coil is connected to KEY A3 (A1). **2:** The positive supply of Main Contactor coil is connected to SEAT A8 (A6). **NOTE:** only Zapi technicians can change this value through a special procedure.
FEEDBACK SENSOR (A)	0 ÷ 6	This parameter defines the type of the adopted speed sensor for motor 1. Factory adjusted. **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. **5 =** Resolver. **6 =** Hall effect sensor (six-step). **NOTE**: not all the sped sensor models listed above are compatible with DualACE2. sensor model should be discussed with Zapi technicians
POSITIVE E.B. (A)	0 ÷ 2	This parameter defines the hardware configuration for the positive terminal of the electromechanical brake PEB A27. **0 =** PEB is managed by an internal high-side driver, supplied by PIN A24. This is the standard configuration. **1 =** PEB is externally connected to the SEAT input A8. **2 =** PEB is externally connected after the main contactor. **NOTE**: configurations 1 and 2 are not standard and their adoption should be discussed with Zapi technicians.

HARDWARE SETTING		
Parameter	**Allowable range**	**Description**
ROTATION CW ENC (A)	OPTION#1 ÷ OPTION#2	It defines how the signal sequence coming from the encoder channels is expected by controller 1 **OPTION#1 =** Channel A anticipates channel B. **OPTION#2 =** Channel B anticipates channel A.
ROTATION CW MOT (A)	OPTION#1 ÷ OPTION#2	It permits to change the sequence in which the motor 1 phases are powered. Factory adjusted. **OPTION#1 =** U-V-W corresponds to forward direction. **OPTION#2 =** V-U-W corresponds to forward direction.
ROTATION CW POS **(Only for BLE version)** (A)	OPTION#1 ÷ OPTION#2	It permits to reverse the direction read by the absolute position sensor. **OPTION#1 =** Sin anticipates cos. **OPTION#2 =** Cos anticipates sin.
ENCODER PULSES 1 (A)	32 ÷ 1024	This parameter defines the number of encoder pulses per revolution (motor 1). It must be set equal to ENCODER PULSES 2; otherwise the controller raises an alarm. The available options are: **25** **32** **48** **64** **80** **124** **128** **256** **512** **1024** NOTE: with standard HW, the capability to use encoders with high number of pulses could be limited depending on the speed. Ask to Zapi technician before to operate on this parameter
ENCODER PULSES 2 (A)	32 ÷ 1024	This parameter defines the number of encoder pulses per revolution (motor 1). It must be set equal to ENCODER PULSES 1; otherwise the controller raises an alarm. The available options are: **25** **32** **48** **64** **80** **124** **128** **256** **512** **1024** NOTE: with standard HW, the capability to use encoders with high number of pulses could be limited depending on the speed. Ask to Zapi technician before to operate on this parameter
MOTOR P. PAIRS 1 (A)	1 ÷ 30	This parameter defines the number of pole pairs of the motor 1. It must be set equal to MOTOR P. PAIRS 2; otherwise the controller raises an alarm.
MOTOR P. PAIRS 2 (A)	1 ÷ 30	This parameter defines the number of pole pairs of the motor 1. It must be set equal to MOTOR P. PAIRS 1; otherwise the controller raises an alarm.

8.2.8 SLV HW Setting

HARDWARE SETTING		
Parameter	**Allowable range**	**Description**
S FEEDBACK SENS. (A)	0 ÷ 6	This parameter defines the type of the adopted speed sensor for motor 2. Factory adjusted. **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. **5 =** Resolver. **6 =** Hall effect sensor (six-step).
S ROT. CW ENC (A)	OPTION#1 ÷ OPTION#2	It defines how the signal sequence coming from the encoder channels is expected by controller 2 **OPTION#1 =** Channel A anticipates channel B. **OPTION#2 =** Channel B anticipates channel A.
S ROT CW MOT (A)	OPTION#1 ÷ OPTION#2	It permits to change the sequence in which the motor 2 phases are powered. Factory adjusted. **OPTION#1 =** U-V-W corresponds to forward direction. **OPTION#2 =** V-U-W corresponds to forward direction.
S ENC PULSES 1 (A)	32 ÷ 1024	This parameter defines the number of encoder pulses per revolution (motor 2). It must be set equal to ENCODER PULSES 2; otherwise the controller raises an alarm. The available options are: **25** **32** **48** **64** **80** **124** **128** **256** **512** **1024** NOTE: with standard HW, the capability to use encoders with high number of pulses could be limited depending on the speed. Ask to Zapi technician before to operate on this parameter

HARDWARE SETTING		
Parameter	**Allowable range**	**Description**
S ENC PULSES 2 (A)	32 ÷ 1024	This parameter defines the number of encoder pulses per revolution (motor 1). It must be set equal to ENCODER PULSES 1; otherwise the controller raises an alarm. The available options are: **25** **32** **48** **64** **80** **124** **128** **256** **512** **1024** NOTE: with standard HW, the capability to use encoders with high number of pulses could be limited depending on the speed. Ask to Zapi technician before to operate on this parameter
S. MOT. P. PAIRS 1 (A)	1 ÷ 30	This parameter defines the number of pole pairs of the motor 1. It must be set equal to MOTOR P. PAIRS 2; otherwise the controller raises an alarm.
S. MOT P. PAIRS 2 (A)	1 ÷ 30	This parameter defines the number of pole pairs of the motor 2. It must be set equal to MOTOR P. PAIRS 1; otherwise the controller raises an alarm.

8.3 Tester Function

The TESTER function gives real- time feedbacks about the state of the controller, the motor and command devices. It is possible to know the state (active/inactive, on/off) of the digital I/Os, the voltage value of the analog inputs and the state of the main variables used for the motor and hydraulics control.
In the following tables, “Parameter” columns also report between brackets lists of the controller types where each parameter is available.
Controller types are coded as:

- **A =** All controller types
- **D =** Dual Traction controller
- **C =** Combi controller
- **CO =** Dual/Combi open CAN controller
- **N =** none

8.3.1 Tester – Master microcontroller

The following table lists the master microcontroller data that can be monitored through the TESTER function.

TESTER (Master µC)		
Parameter	**Unit of measure (resolution)**	**Description**
KEY VOLTAGE (A)	Volt (0.1 V)	KEY voltage A3 (A1) value measured in real time.

TESTER (Master µC)		
Parameter	**Unit of measure (resolution)**	**Description**
BATTERY VOLTAGE (A)	Volt (0.1 V)	Battery voltage measured in real time across the DC-bus.
MOTOR VOLTAGE (A)	Percentage (1%)	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage. The actual applied voltage is changed by INDEX OVERMOD. (see next item).
INDEX OVERMOD. (A)	Percentage (1%)	Correction applied to the motor-voltage set-point in order to compensate for the actual battery voltage. The actual motor voltage delivered is the product of MOTOR VOLTAGE and INDEX OVEMOD.
FREQUENCY (A)	Hertz (0.1 Hz)	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED (A)	Hertz (0.1 Hz)	Motor 1 speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
MEASURED SPD SLV (A)	Hertz (0.1 Hz)	Motor 2 speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE (A)	Hertz (0.01 Hz)	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS (A)	Ampere (1 A)	Root-mean-square value of the line current supplied to the motor 1. $Current\ [Arms] = \sqrt{{I_Q}^2 + {I_D}^2}$
CURRENT RMS SLV (A)	Ampere (1 A)	Root-mean-square value of the line current supplied to the motor 2. $Current\ [Arms] = \sqrt{{I_Q}^2 + {I_D}^2}$
IMAX LIM. TRA (A)	Ampere (1 A)	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
IMAX LIM. BRK (A)	Ampere (1 A)	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
ID FILTERED RMS (A)	Ampere (1 A)	Projection of the current vector on the d-axis, expressed in root-mean-square Ampere.
IQ FILTERED RMS (A)	Ampere (1 A)	Projection of the current vector on the q-axis, expressed in root-mean-square Ampere.

TESTER (Master µC)		
Parameter	**Unit of measure (resolution)**	**Description**
IQIMAX LIM. TRA (A)	Ampere (1 A)	Maximum value of the q-axis current component, according to traction-related settings, expressed in root-mean-square Ampere
IQIMAX LIM. BRK (A)	Ampere (1 A)	Maximum value of the q-axis current component, according to braking-related settings, expressed in root-mean-square Ampere.
MOT. POWER WATT (A)	Watt (1 W)	Estimation of the power supplied to the motor.
STATOR FLUX MWB (A)	10^{-3} Weber (0.1 mWb)	Estimation of the motor magnetic flux.
MOTION TORQUE NM (A)	Nm (0.1 Nm)	Estimation of the motor torque.
STEER ANGLE (A)	Degrees (1°)	Current steering- wheel angle. When the steering is straight ahead STEER ANGLE is zero.
TEMPERATURE (A)	Celsius degrees (1 °C)	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
TEMPERATURE SLV (A)	Celsius degrees (1 °C)	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT. (A)	Celsius degrees (1 °C)	Motor-windings temperature. Normally the sensor is a PTC Philips KTY84-130. This temperature is used for the MOTOR OVERTEMP alarm.
DI2-A8 SEAT SW (D, C)	OFF/ON	Status of the TILLER/SEAT input A8 (A6).
DI3-A13 QI/PB SW (D, C)	OFF/ON	Status of the quick-inversion/pedal-brake input A17 (A11).
DI0-A6 FW SW (D, C)	OFF/ON	Status of the forward-request input A6 (A4).
DI1-A7 BW SW (D, C)	OFF/ON	Status of the backward-request input A7 (A5).
DI0-A6 ENABLE (D, C)	OFF/ON	Status of the lowering-request input A6 (A4).
DI7-A2 SR/HB (D, C)	OFF/ON	Status of the speed-reduction/hand-brake input A2.

TESTER (Master µC)		
Parameter	**Unit of measure (resolution)**	**Description**
DI6-A1 SPARE (D)	OFF/ON	Status of the spare input A1.
DI4-A11 LIFT (D, C)	OFF/ON	Status of the lift-request input A11 .
DI5-A12 LOWER (D, C)	OFF/ON	Status of the lowering-request input A12.
DI6-A1 SPD1 SW (C)	OFF/ON	Status of the speed1 input A1.
IN0 BUMPER STOP (CO)	OFF/ON	Status of the bumper stop input 0.
IN1 BUMPER STOP (CO)	OFF/ON	Status of the bumper stop input 1.
A5 POT#1 (D, CO)	Volt (0.01 V)	Voltage of the analog input 1 A5 (A3).
A16 POT#2 (D, CO)	Volt (0.01 V)	Voltage of the analog input 2 A16 (A10).
A14 POT#3 (D, CO)	Volt (0.01 V)	Voltage of the analog signal on A14.
A22 POT#4 (D, CO)	Volt (0.01 V)	Voltage of the analog signal on A22.
A34 POT#5 (D, CO)	Volt (0.01 V)	Voltage of the analog signal on A34.
A35 POT#6 (D, CO)	Volt (0.01 V)	Voltage of the analog signal on A35.
MAIN CONT. (D, CO)	% (1%)	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
ELEC.BRAKE MST (D, CO)	% (1%)	Voltage applied over the electromechanical brake coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
ELEC.BRAKE SLV (D, D.CO)	% (1%)	Voltage applied over the electromechanical brake coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
SET EVP (D, CO)	% (1%)	Setpoint of proportional electrovalve EVP.

TESTER (Master µC)		
Parameter	**Unit of measure (resolution)**	**Description**
CTRAP HW (A)	Number (1)	Counter showing the number of occurrences of hardware-overcurrent detection.
CTRAP THRESOLD (A)	Volt (0.01 V)	Threshold voltage of the overcurrent detection circuit.
TRUCK SPEED (A)	km/h (0.1 km/h)	Speed of the truck (it requires custom software embedding gear ratio and wheels radius).
ODOMETER KM (A)	km (1 km)	Odometer: overall distance traveled by the truck.
CPU TIME F US (A)	-	Reserved for Zapi technicians use.
CPU TIME M US (A)	-	Reserved for Zapi technicians use.
NODE ID (CO)	1- 126	CAN node ID used by controller
TARGET SPEED (CO)	10·Hz	Speed setpoint transmitted over CAN bus. It is expressed in tenths of Hz.
BRAKING REQUEST (CO)	0-255	Braking setpoint transmitted over CAN bus.
CONTROL WORD (CO)	0-65535	Control word transmitted over CAN bus.
CONTROL WORD 2 (CO)	0-65535	Status word 2 travelling over CAN bus.
STATUS WORD (CO)	0-65535	Status word travelling over CAN bus.
WARNING SYSTEM (CO)	0-65535	Warning code (in case of warning).
TARGET EVP1 (CO)	% (1%)	Setpoint of the proportional electrovalve EVP1 transmitted over CAN bus.
TORQUE REQ. (CO)	% (255 steps)	Torque setpoint of the motor transmitted over CAN bus, expressed as percentage of the maximum torque.
TORQUE BRK REQ. (CO)	% (255 steps)	Breaking torque setpoint of the motor transmitted over CAN bus, expressed as percentage of the maximum torque.

TESTER (Master µC)		
Parameter	**Unit of measure (resolution)**	**Description**
BYTE 4 PDO1TX (CO)	% (1%)	Status byte4 of PDO1TX travelling over CAN bus.
BYTE 5 PDO1TX (CO)	% (1%)	Status byte5 of PDO1TX travelling over CAN bus.
BYTE 6 PDO1TX (CO)	% (1%)	Status byte6 of PDO1TX travelling over CAN bus.
BYTE 7 PDO1TX (CO)	% (1%)	Status byte7 of PDO1TX travelling over CAN bus.
BYTE 2 PDO2TX (CO)	% (1%)	Status byte2 of PDO2TX travelling over CAN bus.
BYTE 5 PDO2TX (CO)	% (1%)	Status byte5 of PDO2TX travelling over CAN bus.
WORD 6 PDO2TX (CO)	% (1%)	Status word of PDO2TX travelling over CAN bus.
ROTOR POSITION **(Only for BLE version)** (A)	Degrees (0.1°)	Real-time absolute orientation of the rotor, expressed in degrees.

8.3.2 Tester – Supervisor microcontroller

The following table lists the supervisor microcontroller data that can be monitored through the TESTER function.

TESTER (Supervisor µC)		
Parameter	**Unit of measure (resolution)**	**Description**
KEY VOLTAGE (A)	Volt (0.1 V)	KEY voltage A3 (A1) value measured in real time.
BATTERY VOLTAGE (A)	Volt (0.1 V)	Battery voltage measured in real time across the DC-bus.
MOTOR VOLTAGE (A)	Percentage (1%)	Theoretical phase- to- phase voltage to be applied at the motor terminals, as a percentage of the supply voltage. The actual applied voltage is changed by INDEX OVERMOD. (see next item).
INDEX OVERMOD. (A)	Percentage (1%)	Correction applied to the motor-voltage set-point in order to compensate for the actual battery voltage. The actual motor voltage delivered is the product of MOTOR VOLTAGE and INDEX OVEMOD.

TESTER (Supervisor µC)		
Parameter	**Unit of measure (resolution)**	**Description**
FREQUENCY (A)	Hertz (0.1 Hz)	Frequency of the current sine-wave that the inverter is supplying to the motor.
MEASURED SPEED (A)	Hertz (0.1 Hz)	Motor 1 speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
MEASURED SPD SLV (A)	Hertz (0.1 Hz)	Motor 2 speed measured through the encoder and expressed in the same unit of FREQUENCY (Hz).
SLIP VALUE (A)	Hertz (0.01 Hz)	Motor slip, i.e. difference between the current frequency and the motor speed (in Hz).
CURRENT RMS (A)	Ampere (1 A)	Root-mean-square value of the line current supplied to the motor 1. $Current\ [Arms] = \sqrt{{I_Q}^2 + {I_D}^2}$
CURRENT RMS SLV (A)	Ampere (1 A)	Root-mean-square value of the line current supplied to the motor 2. $Current\ [Arms] = \sqrt{{I_Q}^2 + {I_D}^2}$
IMAX LIM. TRA (A)	Ampere (1 A)	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a traction request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
IMAX LIM. BRK (A)	Ampere (1 A)	Instantaneous value of the maximum current the inverter can apply to the motor to satisfy a braking request. The value is evaluated basing on actual conditions (inverter temperature, motor temperature, etc.).
ID FILTERED RMS (A)	Ampere (1 A)	Projection of the current vector on the d-axis, expressed in root-mean-square Ampere.
IQ FILTERED RMS (A)	Ampere (1 A)	Projection of the current vector on the q-axis, expressed in root-mean-square Ampere.
IQIMAX LIM. TRA (A)	Ampere (1 A)	Maximum value of the q-axis current component, according to traction-related settings, expressed in root-mean-square Ampere
IQIMAX LIM. BRK (A)	Ampere (1 A)	Maximum value of the q-axis current component, according to braking-related settings, expressed in root-mean-square Ampere.
MOT. POWER WATT (A)	Watt (1 W)	Estimation of the power supplied to the motor.
STATOR FLUX MWB (A)	10^{-3} Weber (0.1 mWb)	Estimation of the motor magnetic flux.

TESTER (Supervisor µC)		
Parameter	**Unit of measure (resolution)**	**Description**
MOTION TORQUE NM (A)	Nm (0.1 Nm)	Estimation of the motor torque.
STEER ANGLE (A)	Degrees (1°)	Current steering- wheel angle. When the steering is straight ahead STEER ANGLE is zero.
TEMPERATURE (A)	Celsius degrees (1 °C)	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
TEMPERATURE SLV (A)	Celsius degrees (1 °C)	Temperature measured on the inverter base plate. This temperature is used for the HIGH TEMPERATURE alarm.
MOTOR TEMPERAT. (A)	Celsius degrees (1 °C)	Motor-windings temperature. Normally the sensor is a PTC Philips KTY84-130. This temperature is used for the MOTOR OVERTEMP alarm.
DI2-A8 SEAT SW (D, C)	OFF/ON	Status of the TILLER/SEAT input A8 (A6).
DI3-A13 QI/PB SW (D, C)	OFF/ON	Status of the quick-inversion/pedal-brake input A17 (A11).
DI0-A6 FW SW (D, C)	OFF/ON	Status of the forward-request input A6 (A4).
DI1-A7 BW SW (D, C)	OFF/ON	Status of the backward-request input A7 (A5).
DI0-A6 ENABLE (D, C)	OFF/ON	Status of the lowering-request input A6 (A4).
DI7-A2 SR/HB (D, C)	OFF/ON	Status of the speed-reduction/hand-brake input A2.
DI6-A1 SPARE (D)	OFF/ON	Status of the spare input A1.
DI4-A11 LIFT (D, C)	OFF/ON	Status of the lift-request input A11 .
DI5-A12 LOWER (D, C)	OFF/ON	Status of the lowering-request input A12.
DI6-A1 SPD1 (D)	OFF/ON	Status of the speed1 input A1.

TESTER (Supervisor µC)		
Parameter	**Unit of measure (resolution)**	**Description**
IN0 BUMPER STOP (CO)	OFF/ON	Status of the bumper stop input 0.
IN1 BUMPER STOP (CO)	OFF/ON	Status of the bumper stop input 1.
A5 POT#1 (D, CO)	Volt (0.01 V)	Voltage of the analog input 1 A5 (A3).
A16 POT#2 (A)	Volt (0.01 V)	Voltage of the analog input 2 A16 (A10).
A14 POT#3 (A)	Volt (0.01 V)	Voltage of the analog signal on A14.
A22 POT#4 (A)	Volt (0.01 V)	Voltage of the analog signal on A22.
A34 POT#5 (A)	Volt (0.01 V)	Voltage of the analog signal on A34.
A35 POT#6 (D)	Volt (0.01 V)	Voltage of the analog signal on A35.
MAIN CONT. (D)	% (1%)	Voltage applied over the main contactor coil. It corresponds to the duty cycle value of PWM applied, expressed as percentage.
CTRAP HW (A)	Number (1)	Counter showing the number of occurrences of hardware-overcurrent detection.
CTRAP THRESOLD (A)	Volt (0.01 V)	Threshold voltage of the overcurrent detection circuit.
CPU TIME F US (A)	-	Reserved for Zapi technicians use.
CPU TIME M US (A)	-	Reserved for Zapi technicians use.
NODE ID (CO)	1-126	CAN node ID used by controller
TARGET SPEED (CO)	10·Hz	Speed setpoint transmitted over CAN bus. It is expressed in tenths of Hz.
BRAKING REQUEST (CO)	0-255	Braking setpoint transmitted over CAN bus.

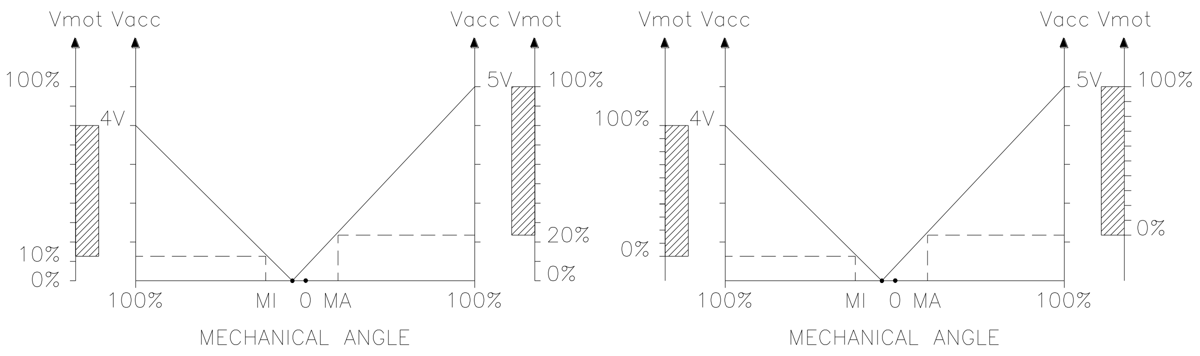
TESTER (Supervisor µC)		
Parameter	**Unit of measure (resolution)**	**Description**
CONTROL WORD (CO)	0-65535	Control word transmitted over CAN bus.
STATUS WORD (CO)	0-65535	Status word travelling over CAN bus.
WARNING SYSTEM (CO)	0-65535	Warning code (in case of warning).
TORQUE REQ. (CO)	% (255 steps)	Torque setpoint of the AC motor transmitted over CAN bus, expressed as percentage of the maximum torque.
TORQUE BRK REQ. (CO)	% (255 steps)	Breaking torque setpoint of the AC motor transmitted over CAN bus, expressed as percentage of the maximum torque.
BYTE 4 PDO1TX (CO)	% (255 steps)	Status byte4 of PDO1TX travelling over CAN bus.
BYTE 5 PDO1TX (CO)	% (255 steps)	Status byte5 of PDO1TX travelling over CAN bus.
BYTE 6 PDO1TX (CO)	% (255 steps)	Status byte6 of PDO1TX travelling over CAN bus.
BYTE 7 PDO1TX (CO)	% (255 steps)	Status byte7 of PDO1TX travelling over CAN bus.
BYTE 2 PDO2TX (CO)	% (255 steps)	Status byte2 of PDO2TX travelling over CAN bus.
BYTE 5 PDO2TX (CO)	% (255 steps)	Status byte5 of PDO2TX travelling over CAN bus.
WORD 6 PDO2TX (CO)	% (255 steps)	Status word of PDO2TX travelling over CAN bus.
ROTOR POSITION **(Only for BLE2 version)** (A)	Degrees (0.1°)	Real-time absolute orientation of the rotor, expressed in degrees.

9 OTHER FUNCTIONS

9.1 Program VACC function

This function enables the adjustment of the minimum and maximum useful levels of the voltage from the accelerator potentiometer, in both directions. This function is particularly useful when it is necessary to compensate for asymmetry of mechanical elements associated with the potentiometer, especially relating to the minimum level.

The following two graphs show the output voltage of a potentiometer versus the mechanical angle of the control lever. Angles MI and MA indicate the points where the direction switches close, while 0 represents the mechanical zero of the lever, i.e. its rest position. Also, the relationship between motor voltage (Vmot) and potentiometer voltage (Vacc) is shown. Before calibration, Vmot percentage is mapped over the default 0 – 5 V range; instead, after the adjustment procedure it results mapped over the useful voltage ranges of the potentiometer, for both directions.



Before 'PROGRAM VACC'. *After 'PROGRAM VACC'.*

PROGRAM VACC can be carried out through Zapi PC CAN Console or through Zapi Smart Console. For the step-by-step procedures of the two cases, refer to paragraphs 13.1.4 or 13.2.6.

9.2 Program LIFT / LOWER function

This function allows to adjust the minimum and maximum useful signal levels of lift and lowering request. This function is useful when it is necessary to compensate for asymmetry of the mechanical elements associated with the potentiometer, especially relating to the minimum level.

This function looks for and records the minimum and maximum potentiometer wiper voltage over the full mechanical range of the lever.

The values to be acquired are organized in the ADJUSTMENT list, they are:
- MIN LIFT
- MAX LIFT

- MIN LOWER
- MAX LOWER

See paragraphs 13.1.5 or 13.2.7 for the acquiring procedure.

9.3 Program STEER function

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

This function looks for and records the minimum, neutral and maximum voltage over the full mechanical range of the steering. It allows to compensate for dissymmetry of the mechanical system in both directions.

The values to be acquired are organized in the ADJUSTMENT list, they are:
- STEER RIGHT VOLT
- STEER LEFT VOLT
- STEER ZERO VOLT

See paragraphs 13.1.6 or 13.2.8 for acquiring procedure.

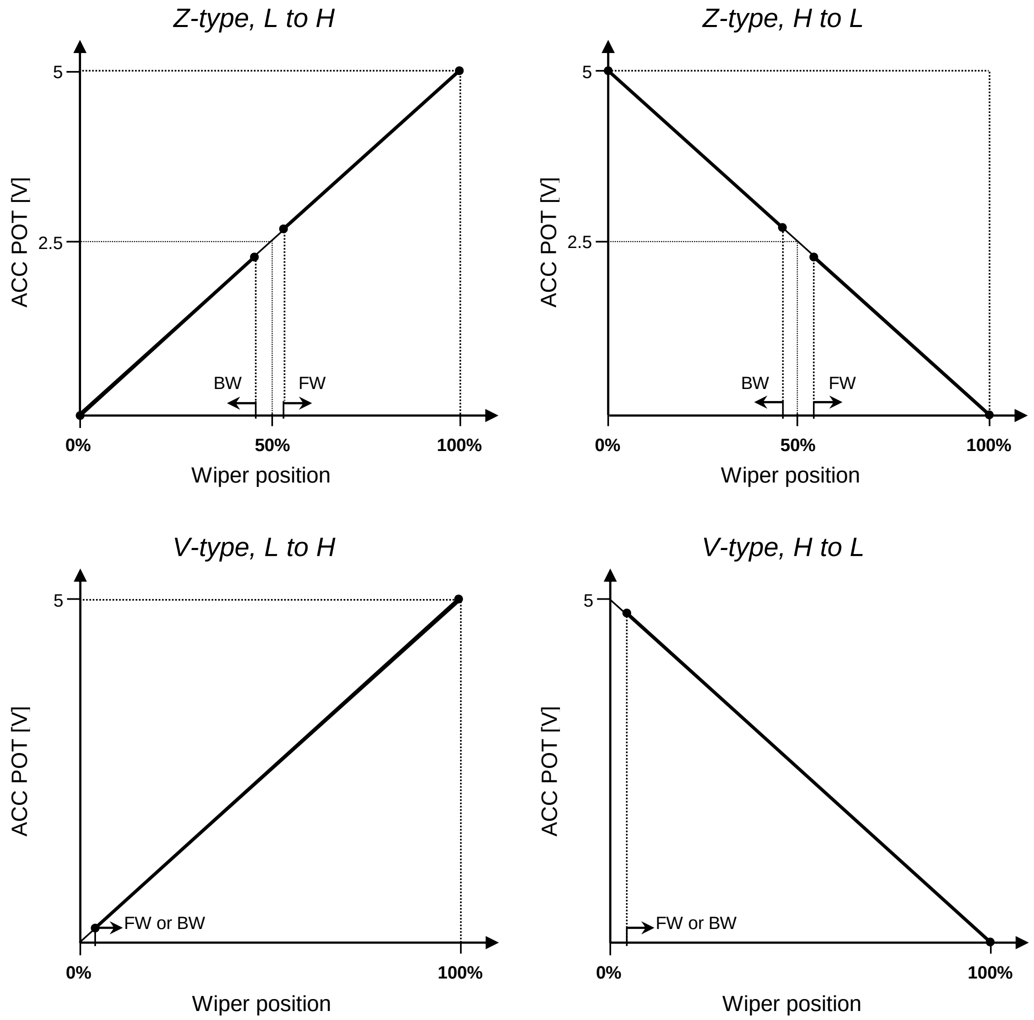
9.4 Potentiometers

The controller can handle different types of potentiometers and, if present, direction and enable switches. Parameters MAIN POT. TYPE and AUX POT. TYPE are to be set accordingly to the configuration of the machine (see paragraph 8.2.4).

The following graphs describe how the mechanical position of the potentiometer wiper and its voltage result in the forward and backward requests. Basing on the application, the voltage excursion may differ from the 0 V through 5 V here shown.

Adopting a Z-type potentiometer, both the speed set-point and the travel direction are defined; direction switches are not mandatory.

Adopting a V-type potentiometer, only the speed set-point is defined; a couple of direction switches are mandatory, except where the application only requires one direction of rotation (for example only lift in pump applications).



Potentiometer configurations.

9.5 Acceleration time

The ACCELER. DELAY parameter allows to define the acceleration rate depending on the speed set-point variation and on ACCEL MODULATION.

- **ACCEL MODULATION = OFF**

  The acceleration time results:

$$\text{ACCELER. DELAY} \cdot \frac{\text{Set-point step}}{100\ \text{Hz}}$$

- **ACCEL MODULATION = ON**
  Acceleration time is evaluated differently by software depending on the set-point variation.

Fast response:

– Set-point step < 100 Hz

The acceleration time results:

$$\text{ACCELER. DELAY} \cdot \frac{\text{Set-point step}}{100\ \text{Hz}}$$

Modulation (grey area):

– Set-point step > 8 Hz

– Set-point step <= 100 Hz

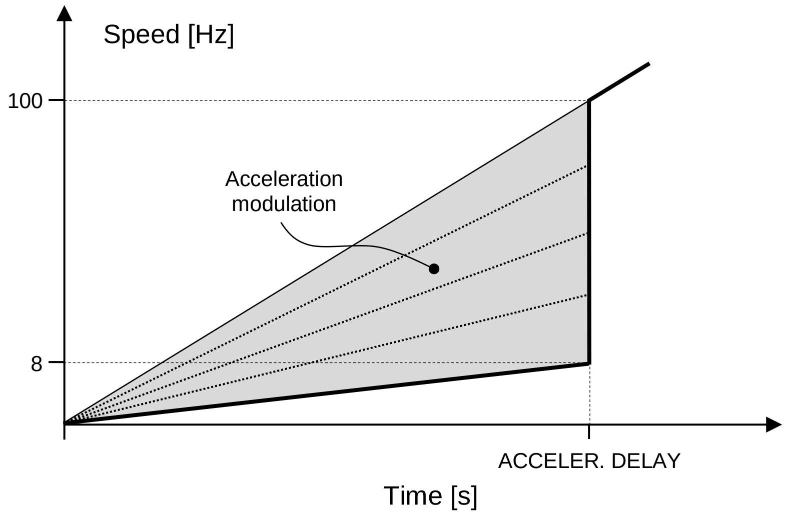
The acceleration rate is re-scaled so that the acceleration time results equal to ACCELER. DELAY.

Wide variation:

– Set-point step > 100 Hz

The acceleration time results:

$$\text{ACCELER. DELAY} \cdot \frac{\text{Set-point step}}{100\ \text{Hz}}$$



Speed evolution during acceleration.

9.6 Release modulation

Parameter RELEASE BRAKING allows to define the deceleration rate depending on the speed set-point variation upon a travel release. Deceleration time is evaluated differently by software depending on the speed variation.

Fast response:

- Set-point drop < 100 Hz · REL. MIN MODUL.

The deceleration time results:

$$\text{RELEASE BRAKING} \cdot \frac{\text{Set-point drop}}{100\ \text{Hz}}$$

Modulation (grey area):

- Set-point drop > 100 Hz · REL. MIN MODUL.
- Set-point drop <= 100 Hz

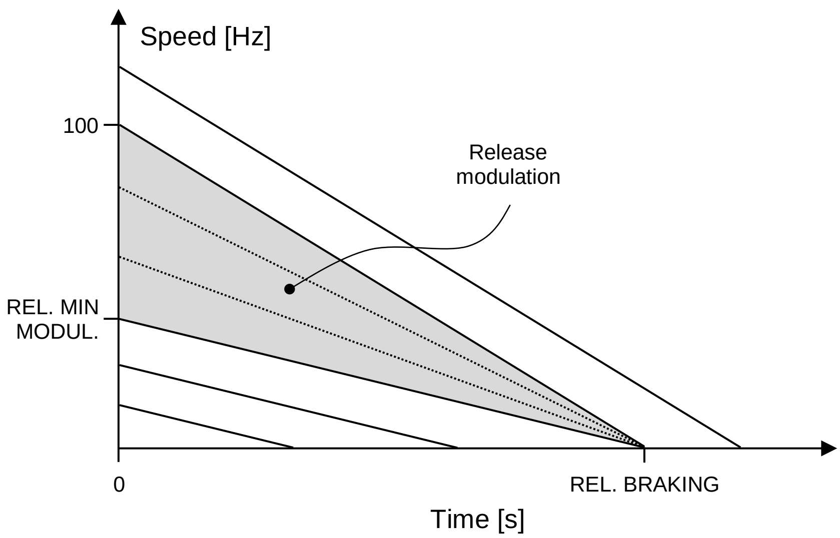
The deceleration rate is re-scaled so that the deceleration time results equal to RELEASE BRAKING.

Wide variation:

- Set-point drop > 100 Hz

The deceleration time results:

$$\text{RELEASE BRAKING} \cdot \frac{\text{Set-point drop}}{100\ \text{Hz}}$$

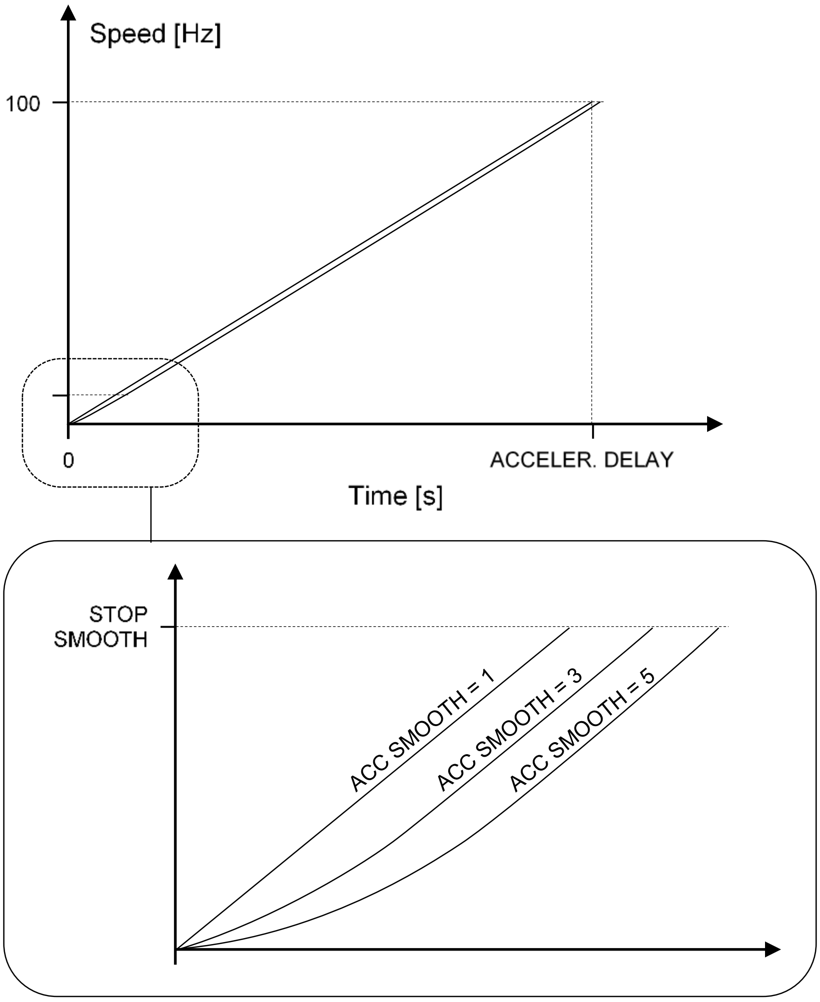


Speed evolution during release.

The deceleration modulation is valid for all the braking-related parameters: DECEL. BRAKING, INVER. BRAKING, RELEASE BRAKING, TILLER BRAKING, PEDAL BRAKING, SPEED LIMIT BRK, STEER BRAKING.

9.7 Acceleration smoothness

Smoothing-related parameters define a parabolic profile for the acceleration or deceleration ramps close to 0 Hz. Values from 1 to 5 define the smoothness effect, without a phisycal meaning: 1 results in a linear ramp, higher values result in smoother acceleration profiles.



Acceleration smoothness.

The smoothing effect is applied to acceleration, braking and inversion as per the settings of parameters ACC SMOOTH, BRK SMOOTH and INV SMOOTH.

The reference speed for the parabolic profile is given by parameters STOP SMOOTH and STOP BRK SMOOTH.

9.8 Steering curve

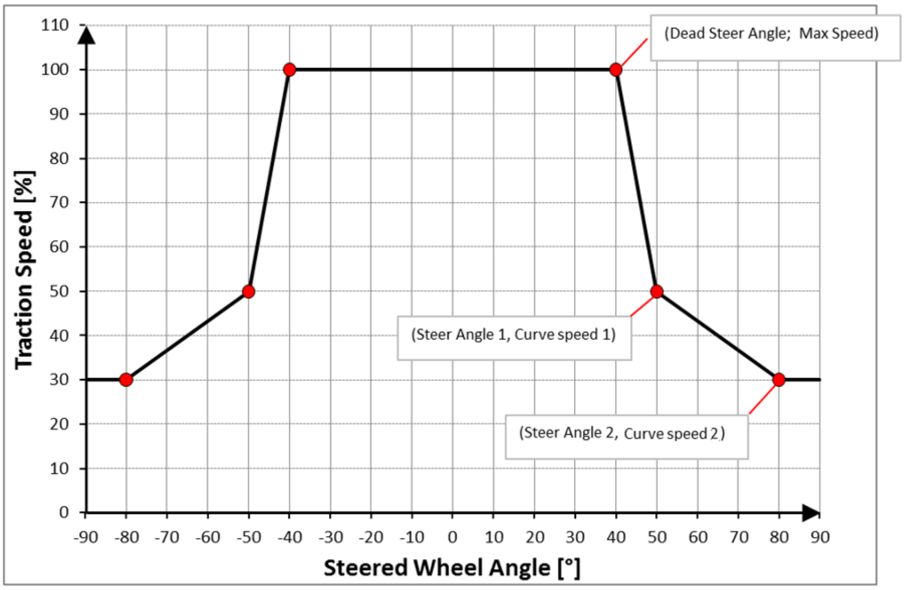
Steering-related parameters (CURVE SPEED 1, CURVE SPEED 2, STEER ANGLE 1 and STEER ANGLE 2) define a speed-reduction profile dependent on the steering-wheel angle.

The profile is valid both for positive and negative angle values.

Example:

- Three-wheel CB truck
- Permitted steering-wheel angles = -90° ÷ 90°
- CURVE SPEED 1 = 50%
- CURVE SPEED 2 = 30%
- STEER DEAD ANGLE = 40°
- STEER ANGLE 1 = 50°
- STEER ANGLE 2 = 80°

This set of parameters define the speed profile depicted in the graph below.



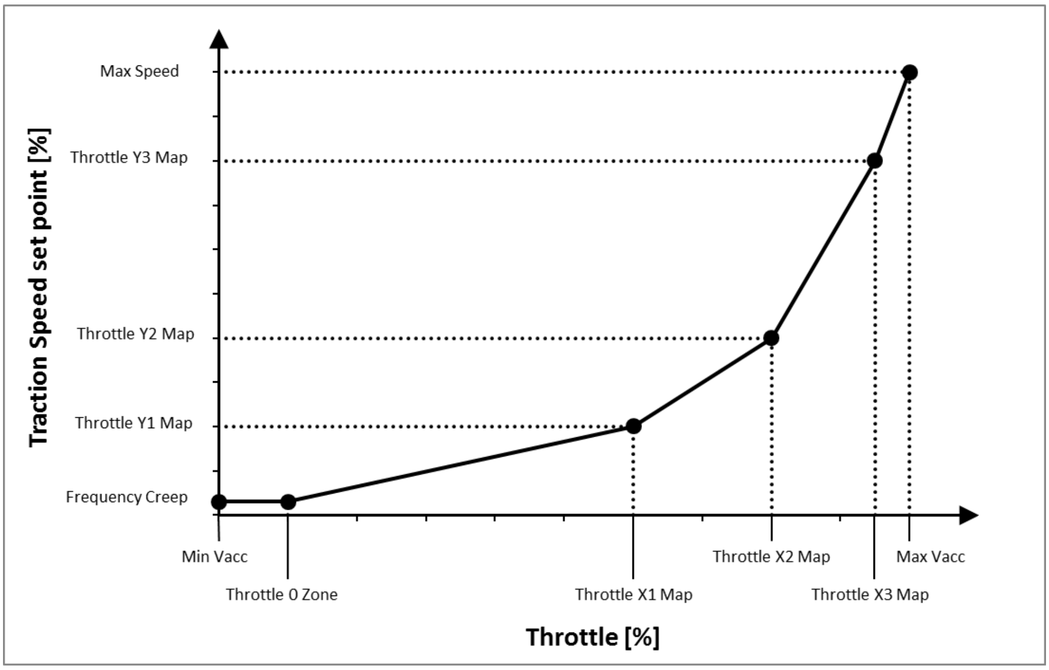
Steering curve.

9.9 Throttle profile

The controller performs the speed control along a non-linear function of the accelerator position, so to provide a better resolution of the speed set-point at low speed. The relationship between the throttle voltage and the speed set-point is defined as a polygonal chain, as per the following table of points.

Throttle signal [% of MAX VACC]	**Speed set-point** [% of MAXIMUM SPEED]
0	FREQUENCY CREEP
THROTTLE 0 ZONE	FREQUENCY CREEP
THROTTLE X1 MAP	THROTTLE Y1 MAP
THROTTLE X2 MAP	THROTTLE Y2 MAP
THROTTLE X3 MAP	THROTTLE Y3 MAP
MAX VACC	MAX SPEED

The speed remains at the FREQUENCY CREEP value as long as the voltage from the accelerator potentiometer is below THROTTLE 0 ZONE. Basically this defines a dead zone close to the neutral position. For higher potentiometer voltages, the speed set-point grows up as a polygonal chain. The following graph better displays the throttle – speed relationship.



Throttle profile.

9.10 MC and EB modulation

The outputs dedicated to drive the main contactor and the electromechanical brake are PWM-modulated in an open loop fashion (voltage controlled).

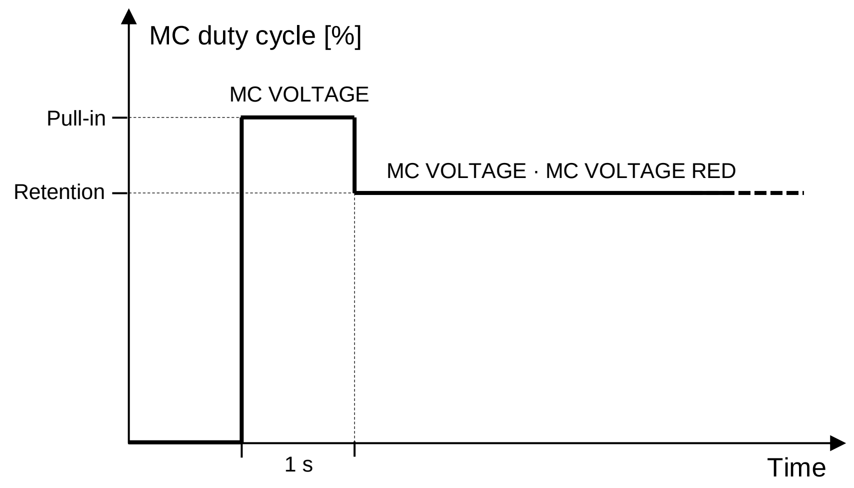
For both the outputs, dedicated parameters (under SET OPTIONS list) define the pull-in duty-cycle and the retention one, the first applied in the first second of actuation, the latter afterwards. The following table summarizes how parameters effect such duty-cycles.

	Pull-in	Retention
MC Duty-cycle [%]	MC VOLTAGE	MC VOLTAGE · MC VOLTAGE RED.
EB Duty-cycle [%]	EB VOLTAGE	EB VOLTAGE · EB VOLTAGE RED.

<u>Example 1:</u>
MC VOLTAGE = 100% ➲ Pull-in duty-cycle = 100%
MC VOLTAGE RED. = 80% ➲ Retention duty-cycle = 80% (100% x 80%).

<u>Example 2:</u>
MC VOLTAGE = 80% ➲ Pull-in duty-cycle = 80%
MC VOLTAGE RED. = 100% ➲ Retention duty-cycle = 80% (80% x 100%).

<u>Example 3:</u>
MC VOLTAGE = 80% ➲ Pull-in duty-cycle = 80%
MC VOLTAGE RED. = 80% ➲ Retention duty-cycle = 64% (80% x 80%).



Main contactor output behavior.

9.11 Battery-charge detection

During operating condition, the battery-charge detection makes use of two parameters that specify the full-charge voltage (100%) and the discharged-battery voltage (10%): BAT.MAX.ADJ and 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-discharge detection occurs when the battery is not totally discharged, it is necessary to reduce BAT.MIN.ADJ).

Moreover, BDI ADJ STARTUP adjusts the level of the battery charge table at the start-up, in order to evaluate the battery charge at key-on. The minimum variation of the battery charge that can be detected depends on the BDI RESET parameter.

The battery-charge detection works as the following procedure.

<u>Start-up</u>

1) The battery voltage is read from key input when the battery current is zero, which is when the output power stage is not driven. It is evaluated as the average value over a window of time, hereafter addressed as Vbatt.
2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison a new charge percentage is obtained.
3) The threshold value can be changed with the BDI ADJ STARTUP parameter.
4) If the new charge percentage is within the range “last percentage (last value stored in EEPROM) ± BDI RESET” it is discarded; otherwise charge percentage is updated with the new value.

<u>Operating condition</u>

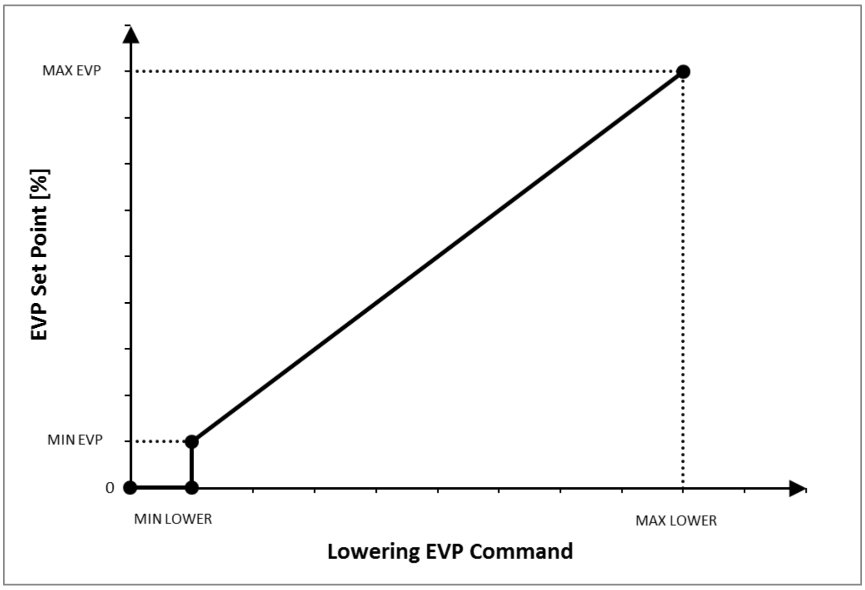
Measure of the battery voltage, together with the charge percentage at the time of the voltage sampling, give information about the instantaneous battery current.

1) The battery voltage is read when the battery current is not zero, which is when the output power stage is driven. Vbatt is evaluated as the average value over a window of time.

2) Vbatt is compared with a threshold value which comes as function of the actual charge percentage; by this comparison the current provided by the battery is obtained.
3) Current obtained at step 2 integrated over time returns the energy drawn from the battery, in Ah.
4) Charge percentage is dynamically updated basing on the energy from step 3.
5) Threshold values for the battery charge can be modified by means of BAT.MAX.ADJ. and BAT.MIN.ADJ. as to adapt the battery-charge detection to the specific battery in use.

9.12 EVP Setup

When the EVP is set as ANALOG (see paragraph 8.2.2) the output is managed as explained in the following example.
Considering the case in that the EVP request is concerning the lowering valve, the MIN EVP parameter (see paragraph 8.2.2) determines the minimum current set point applied to the valve when the position of the potentiometer is at the minimum (MIN LOWER) (see paragraph 8.2.2).
Then, the current set point applied to the valve increases proportionally with the potentiometer voltage up to the maximum (MAX EVP) (see paragraph 8.2.2), reached when the position of the potentiometer is at the maximum (MAX LOWER) (see paragraph 8.2.2).



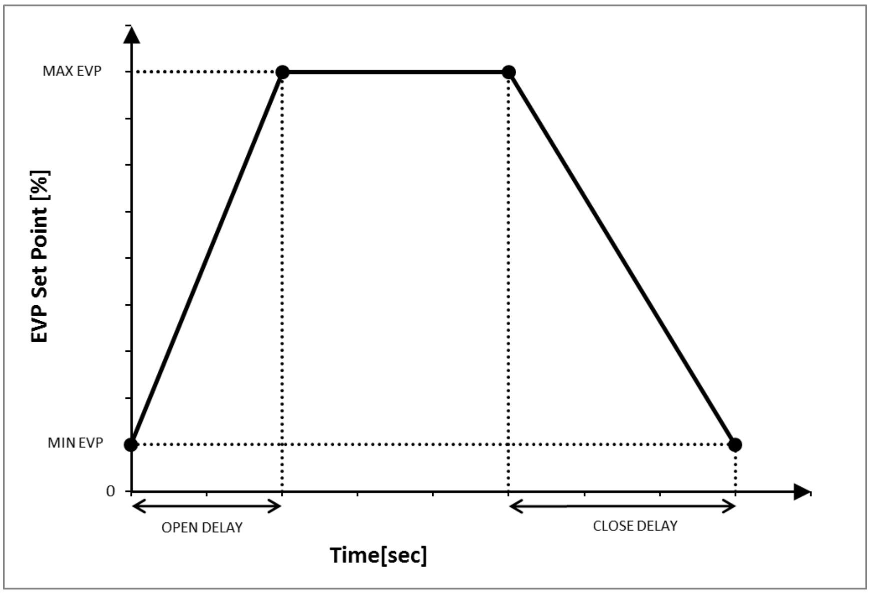
EVP management.

If the valve is set as ON-OFF the MIN EVP parameter is disabled and the current set point applied to the valve is only dependent by MAX EVP.

The dynamic delay seen during the modification of the current set point, in both cases, ANALOG Valve and ON/OFF Valve, is dependent by the OPEN DELAY and CLOSE DELAY parameters (see paragraph 8.2.2).

OPEN DELAY determines the current increase rate on EVP and it sets the time needed to increase the current to the maximum permitted value.

CLOSE DELAY determines the current decrease rate on EVP and sets the time needed to decrease the current from the maximum value to minimum.



EVP set point.

Example 1:
The lowering output is set to ANALOG and the descent request consists of a step whose width corresponds to MAX EVP.
The current is immediately set to the MIN EVP and then it is increased up to MAX EVP in the time set by the OPEN DELAY parameter.
In the same way, if the actual set point applied is the maximum and the lowering request is removed all at once, the current is reduced to minimum with a time delay equal to CLOSE DELAY and then is set to zero.

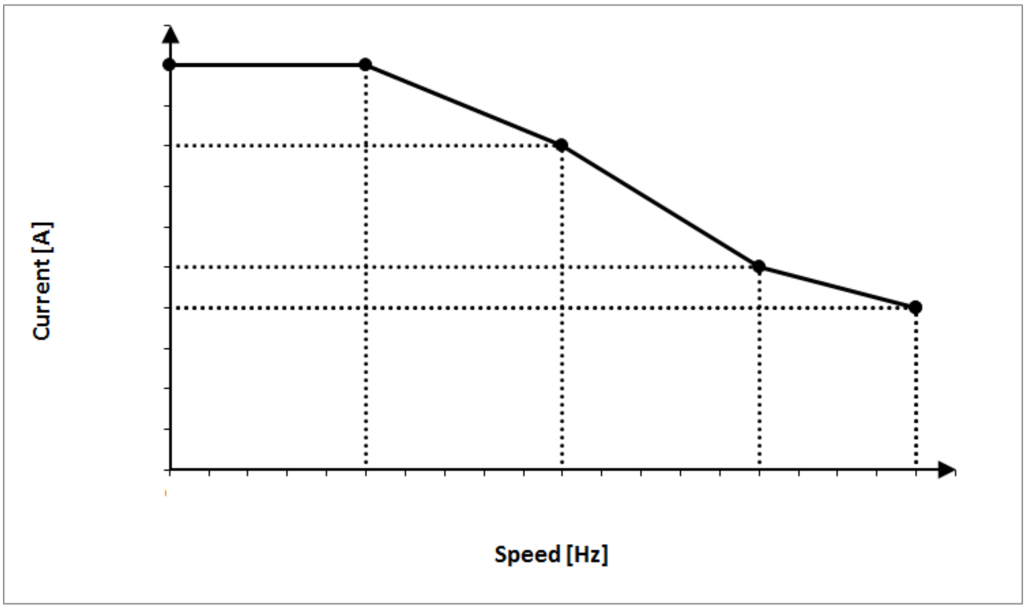
Example 2:
The lowering output is set to ON/OFF.
As soon as the lowering request is applied, the current will increase from zero to MAX EVP in the time frame correspondent to OPEN DELAY value.
In the same way, when the lowering request is removed, the set point current is reduced to zero with a time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

9.13 Torque Profile

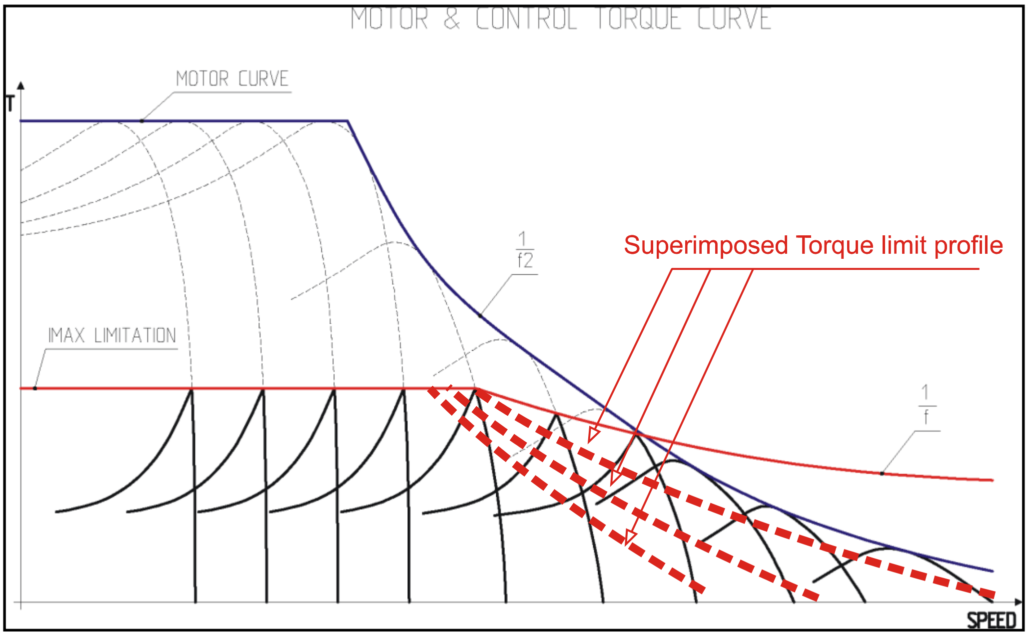
By setting the proper parameter, it is possible to define a limit for the maximum torque demand (through set points) in the weakening area, for matching two goals:

1. Not overtaking the maximum torque profile of the motor.

Superimposing a limiting profile to the maximum torque as to get different drive performances (Eco mode, Medium performance, High performance).



Torque profile.



Torque curves.

9.14 Steering table

Steering table allows to automatically calibrate the rotation applied to the steering wheels so to obtain the desired steering angle of the truck.

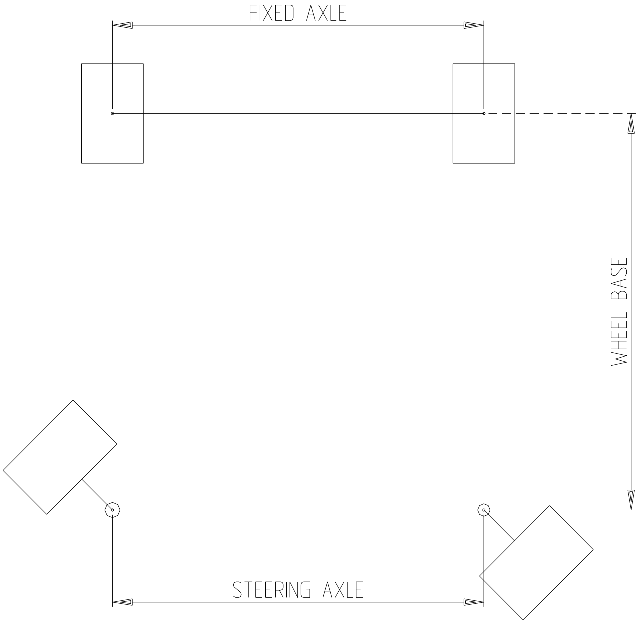
The STEER TABLE parameter defines whether to adopt a custom or predefined steering table:

- **NONE** = custom steering table, according to the following parameters:
  - WHEELBASE MM: distance between the front axle and the rear axle of the truck.
  - FIXED AXLE MM: axle width of the axle where the fixed wheels are.

- STEERING AXLE MM: axle width of the axle where the steering wheels are.

All three previous parameters must be expressed in millimeters.

- **OPTION#1** = three-wheels predefined steering table.
- **OPTION#2** = four-wheels predefined steering table



Geometrical steering-related parameters.

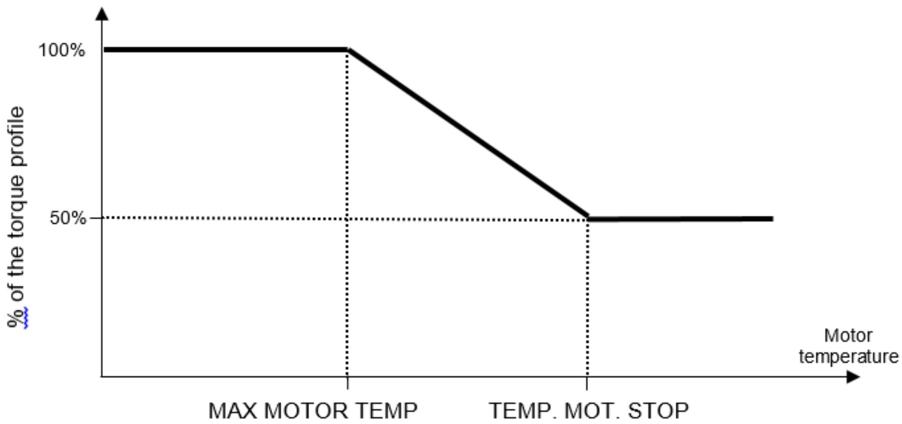
9.15 Motor thermal protection

The controller performs a thermal protection of the driven motor by monitoring its temperature and applying a linear cutback to the maximum current when it becomes excessive.

Thermal protection can be tuned setting parameters MAX. MOTOR TEMP., TEMP.MOT. STOP ADJUSTMENTS list.

A linear reduction is performed for temperatures between MAX. MOTOR TEMP. and TEMP. MOT. STOP . It acts scaling down the torque profile (see paragraph 9.15) by a percentage from 100% to 50%.

When motor temperature reaches TEMP. MOT. STOP, current cutback is fixed to 50%.



Torque reduction for motor thermal protection.

Cutback is valid only during motoring, instead during braking the 100% of the maximum current is always available regardless the motor temperature.

If the signal from the motor thermal sensor is out of range (for example due to a problem related to the wiring), a cutback equal to 50% is applied.

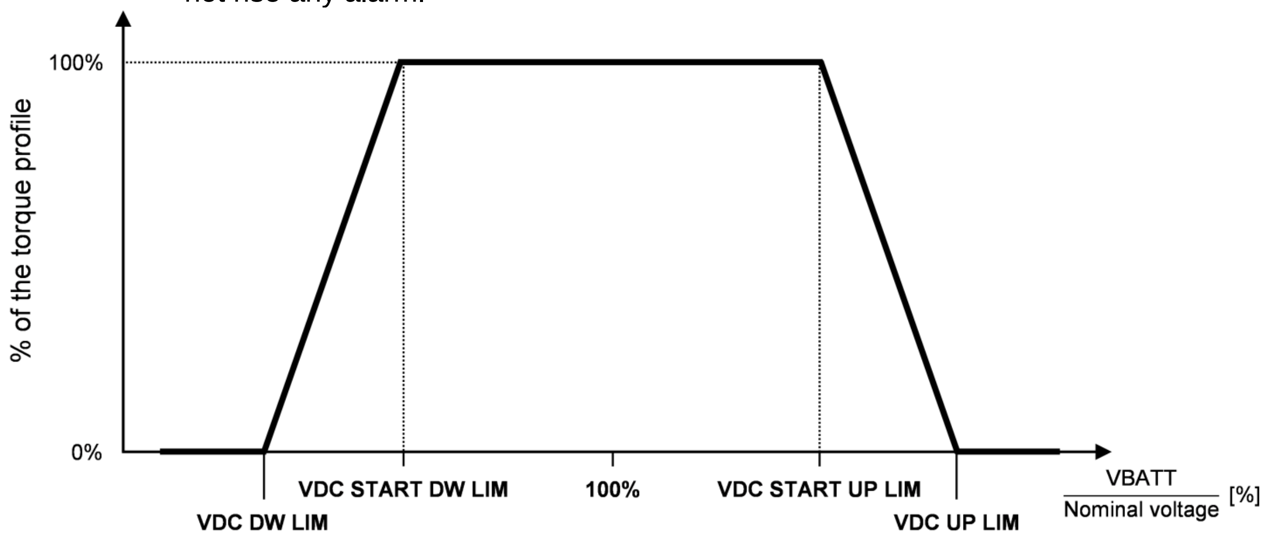
9.16 Overvoltage and undervoltage limitations

The controller performs overvoltage and undervoltage protections by monitoring the DC-link voltage and reducing the torque profile when the voltage becomes too high or too low.

Overvoltage and undervoltage limitations can be tuned by setting parameters VDC START UP LIM, VDC UP LIM, VDC START DW LIM and VDC DW LIM in the SPECIAL ADJUSTMENTS list. These parameters represent a percentage of the nominal battery voltage.

A linear reduction of the torque profile is performed scaling it down by a percentage from 100% to 0% depending on the sensed voltage, as depicted in the graph below. Outside the limits defined by VDC UP LIM and VDC DW LIM the torque profile is clamped to zero. Normal operation at full torque profile is automatically restored as soon as the voltage goes back into the range defined by VDC START DW LIM and VDC START UP LIM.

Overvoltage and undervoltage limitations are transparent to the user and they do not rise any alarm.



Reduction of the torque profile based on the battery voltage

10 DIAGNOSTIC SYSTEM

The diagnostic system of DUALACE2 New Gen provides the operator with information about a wide set of faults or problem that the controller can encounter.

Faults which cause the power section to stop, meaning the power bridge opens and, when possible, the main contactor opens and the electromechanical brake is applied. They can be related to hardware failures that forbid to run the motor or safety-related failures.
Problems which do not imply to stop the truck or allow to stop it by mean of a controlled regenerative braking. The controller still works, but it has detected conditions that require to stop the truck or at least to reduce its performance.
Detailed information about each alarm is given in paragraphs 10.2 and 10.4.

10.1 ALARMS menu

The ALARMS logbook in the records the alarms occurred on the controller. It has a FIFO (First Input First Output) structure which means that the oldest alarm is lost when the database is full and a new alarm occurs. The logbook is composed of locations where it is possible to stack different types of alarms with the following information:

1) the alarm code;
2) the number of times each alarm has consecutively occurred;
3) the hour-meter value at the last occurrence of each alarm;
4) the inverter temperature at the first occurrence of each alarm.

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

NOTE: if the same alarm is continuously happening, the controller does not use new memory of the logbook, but only updates the last memory cell increasing the related counter (point 2) of previous list). Nevertheless, the hour-meter indicated in this memory refers to the first time the alarm occurred. In this way, comparing this hour-meter with the controller hour-meter, 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 this period.

For simple visual diagnosis of system faults and for monitoring the system status, a red LED is provided on the body of the controller. It is ON at the start-up and then it stays continuously OFF when there is no fault; when there is a fault it flashes several times, with a repeated pattern that identifies a specific alarm.

10.2 Diagnoses

The microcontroller constantly 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.

Alarm LED.

At start-up it is turned ON for 2 seconds and then it stays continuously OFF when there is no fault.

In case of fault it produces flash codes displaying all the active faults in a repeating cycle.

Each code consists of two digits (see chapter 10) shown through the following sequence:

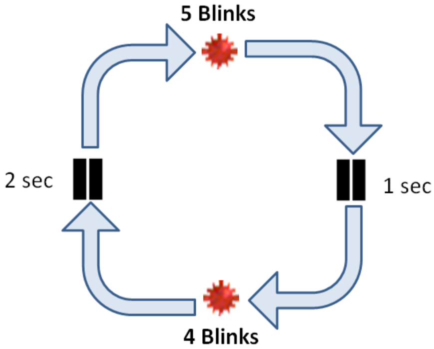
1) the LED blinks as much times as the first digit value
2) it makes a pause of 1 sec
3) it blinks as much times as the second digit value.

The sequence it is repeated after a pause of 2 seconds.

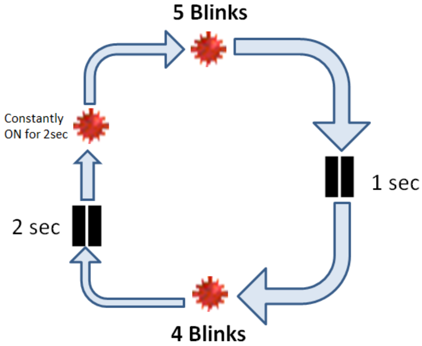
In case of fault concerning supervisor uC the sequence is the same with the only difference that LED stays ON for 2 sec before to start for flashing the appropriate code.

Examples:

- Alarm 54 on master uC



- Alarm 54 on supervisor uC



The diagnosis is made in 4 points:

1) Diagnosis on start-up 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 the accelerator unit is correct.
2) Standby diagnosis in standby that checks: watchdog circuit, phase 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, but the failure code is also sent on the CAN bus.

10.3 Alarms from master µC

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
WAITING FOR NODE	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle	0	0	224
BATTERY LOW	According to parameter BATTERY CHECK (SET OPTIONS list, paragraph 8.2.2).	Start-up, standby, running	Battery recharge, key re-cycle	0	FF42	66
DATA ACQUISITION	Traction is stopped	Controller calibration	Traction request	0	0	247
CHECK UP NEEDED		Start-up	Check-up done, key re-cycle	0	0	249
RPM HIGH	MC is opened, Traction/Pump stopped	Start-up, standby, running		0	FFA1	161
BUMPER STOP	Traction is stopped	Start-up, standby, running		0	FFA2	162
WARNING SLAVE	It depends on the supervisor uC			1	FF01	244
ACQUIRING A.S.		Sensor Acquiring	Key re-cycle	2	FFAB	171
ACQUIRE END		Sensor Acquiring	Key re-cycle	2	FFAD	173
ACQUIRE ABORT		Sensor Acquiring	Key re-cycle	2	FFAC	172
SIN/COS D.ERR XX	MC is not closed, EB is applied, Traction/Pump, valves stopped	running	Key re-cycle	3	FFA8	168
ENCODER D.ERR XX	Traction is stopped	running	Key re-cycle	3	FFA9	169
HOME SENS.ERR XX	MC is opened , EB is applied, EVP stopped	Running	Key re-cycle	3	FFB0	176
OFFSET SPD.SENS.	EB is applied, Traction/Pump, valves stopped.	Start-up	Perform ABS SENS. ACQUIRE	3	FF99	174
PWM ACQ. ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	6	FFA4	164
ED SLIP MISMATCH	MC is opened, EB is applied, Traction/Pump stopped	Running	Valves or Traction/Pump request	7	FFA3	163
WATCHDOG	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	8	6010	8
EVP DRIVER OPEN	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves request	9	FFF8	240
EVP COIL OPEN	Valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	9	5002	214
EVP DRIV. SHORT.	MC is opened , EB is applied, EVP stopped	Start-up, stand-by, running	Traction/Pump request	9	5003	215

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
STALL ROTOR	Traction/Pump stopped	Start-up, stand-by, running	Valves or Traction/Pump request	**11**	**FFD3**	**211**
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	**12**	**FFEF**	**239**
EEPROM KO	Controller works using default parameters	Start-up, stand-by, running		**13**	**3610**	**208**
PARAM RESTORE	No effect	Start-up	Traction/Pump request	**14**	**0**	**209**
HW FAULT EV.	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	**16**	**FFEE**	**238**
LOGIC FAILURE #3	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump request	**17**	**FF11**	**17**
LOGIC FAILURE #2	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by,	Valves or Traction/Pump request	**18**	**FF12**	**18**
LOGIC FAILURE #1	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	19	5114	19
VKEY OFF SHORTED	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	**20**	**5101**	**220**
CONT. DRV. EV	Valves stopped	Start-up, stand-by, running	Valves request	**21**	**FFE8**	**232**
DRV. SHOR. EV	Valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	**21**	**FFF9**	**234**
OPEN COIL EV.	MC remains closed, EB is applied, Traction/Pump, valves stopped (the command is released)	Start-up, Stand-by, running	Valves or Traction/Pump Request	**21**	**FFF2**	**242**
LC COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	**22**	**FFE6**	**230**
IQ MISMATCHED	Traction is stopped, MC is opened	Running	Valves or Traction/Pump request	**24**	**FFF5**	**245**
PEB NOT OK	Pump motor stopped, valves stopped	Start-up, stand-by, running	Valves request	**25**	**FFDB**	**217**
AUX BATT. SHORT.	None	Start-up, stand-by, running		**27**	**5001**	**194**
INIT VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	**30**	**3121**	**207**
VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	**30**	**3120**	**30**
INIT VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	**31**	**3111**	**206**
VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump request	**31**	**3110**	**31**
HW FAULT	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	**32**	**FFE3**	**227**
HW FAULT EB.	MC is opened, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	34	FFE5	229
POSITIVE LC OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	35	FFD5	213
FIELD ORIENT. KO	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	36	FFFD	253
CONTACTOR CLOSED	MC is not closed (command is not activated), EB is applied, Traction/Pump stopped	Start-up	Valves or Traction/Pump request	37	5442	37
CONTACTOR OPEN	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	38	5441	38
POWER MISMATCH	Traction is stopped, EB is applied, MC is opened	Running	Traction/Pump request	39	FFD4	212
EB. DRIV.SHRT.	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	40	3222	254
WRONG SET BAT.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up		41	3100	251
WRONG KEY VOLT.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up		41	3101	170

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
EB. DRIV.OPEN	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	42	3224	246
EB. COIL OPEN	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	43	FFD8	216
HANDBRAKE	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/Pump request	46	FFDD	221
MOT.PHASE SH.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Traction/Pump request	47	FFC4	196
THROTTLE PR,	MC remains closed, EB is applied (the command is released), Traction stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	48	FFF3	243
LIFT+LOWER	Pump is stopped	Start-up, stand-by, running	Pump request	49	FFBB	187
TILLER OPEN	LC opens	Start-up, stand-by, running	Valves or Traction/Pump Request	51	0	228
STBY I HIGH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by	Valves or Traction/Pump request	53	2311	53
OVERLOAD	MC is not closed, EB is applied, Traction/Pump stopped	Running	Valves or Traction/Pump request	57	FFB4	180
CAPACITOR CHARGE	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	60	3130	60
THERMIC SENS. KO	Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.	Start-up, stand-by, running		61	4211	250
TH. PROTECTION	Traction controller reduces the max current linearly from Imax (85°C) down to 0 A (105°C)	Start-up, stand-by, running		62	4210	62
BRAKE RUN OUT	Traction is stopped	Start-up, stand-by, running	Traction/Pump Request	63	FFCC	204
TILLER ERROR	Traction stopped, EB applied	Stand-by, running	Valves or Traction/Pump Request	64	FFB9	185
MOTOR TEMPERAT.	Maximum current is linearly reduced (see paragraph 9.15) and speed is reduced to a fixed value.	Start-up, stand-by, running		65	4110	65
MOTOR TEMP. STOP	EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running		65	FFB2	178
NO CAN MSG.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	67	8130	248
SENS MOT TEMP KO	Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.	Start-up, stand-by, running		68	4311	218
SMARTDRIVER KO	MC is not closed, Traction/Pump, valves stopped	Start-up	Key re-cycle	69	3302	193
EPS RELAY OPEN	Traction/Pump motor is stopped	Start-up, stand-by, Running	Valves or Traction/Pump request	70	FFCD	205
WRONG RAM MEM.	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	71	FFD2	210
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	74	3211	74
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	75	3221	75
COIL SHOR. MC	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up (immediately after MC closing), stand-by, running	Valves or Traction/Pump request	76	2250	223
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	77	FFCA	202
VACC NOT OK	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/ request	78	FF4E	78
INCORRECT START	Traction/Pump motor is stopped	Start-up, stand-by	Traction request	79	FF4F	79
PUMP INC START	Pump motor is stopped	Start-up, stand-by, running	Pump request	79	FFBD	189
FORW + BACK	Traction is stopped	Start-up, stand-by, running	Traction request	80	FF50	80
SPEED FB. ERROR	MC is opened , EB is applied, EVP stopped	Running	Valves or Traction/Pump request	81	FFAF	175

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
ENCODER D.ERR XX	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	3	FFA9	169
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	83	FF51	181
POS. EB. SHORTED	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	84	3223	195
VACC OUT RANGE	Traction/Pump motor is stopped	Start-up, Stand-by, Running	Traction/Pump request	85	FFE2	226
VDC OFF SHORTED	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, Stand-by, Running	Key re-cycle	88	FFC8	200
POWERMOS SHORTED	MC is opened, EB is applied, traction/pump stopped	Start-up	Key re-cycle	89	FFE9	233
PUMP VACC RANGE	DC Pump motor is stopped	Start-up, stand-by	Pump request	90	FFC0	192
WRONG SLAVE VER.	MC opened, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	91	FFC5	197
CURRENT GAIN	Controller works, but with low maximum current	Start-up, stand-by		92	6302	236
PARAM TRANSFER	MC stays closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	93	FFC7	199
STEER SENSOR KO	Speed is reduced according to parameter CTB. STEER ALARM (PARAMETER CHANGE list, paragraph 8.2.1)	Start-up, stand-by, running	Return into correct range	95	FFB3	179
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	96	FFFA	237
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	97	FFC6	198
TORQUE PROFILE	EB is applied, Traction/Pump motor is stopped	Start-up, stand-by	Valves or Traction/Pump request	98	FFC9	201
CTRAP THRESHOLD	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	99	FFEB	235
COIL SHOR. EB.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	76	FFB1	177
ENCODER ERROR XX	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	153	FF52	153
INT. CANBUSKO	MC is opened, EB applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	67	8131	188
INPUT MISMATCHXX	MC is opened, EB applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	59	FF9D	157
SP MISMATCH XX	MC is opened, EB applied, traction/pump stopped	Running	Key re-cycle	15	FF9B	155
OUT MISMATCH XX	MC is opened, EB applied, traction/pump stopped	Running	Key re-cycle	15	FF9A	154

10.3.1 Troubleshooting of alarms from master μC

ACQUIRE ABORT *(MDI/LED code = 2)*
Cause:
The acquiring procedure relative to the absolute feedback sensor aborted.

ACQUIRE END *(MDI/LED code = 2)*
Cause:
Absolute feedback sensor acquired.

ACQUIRING A.S. *(MDI/LED code = 2)*
Cause:
Controller is acquiring data from the absolute feedback sensor.

Troubleshooting:
The alarm ends when the acquisition is done.

ANALOG INPUT *(MDI/LED code = 96)*
Cause
This alarm occurs when the A/D conversion of the analog inputs returns frozen values, on all the converted signals, for more than 400 ms. The goal of this diagnosis is to detect a failure in the A/D converter or a problem in the code flow that skips the refresh of the analog signal conversion.

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

AUX BATT. SHORT. *(MDI/LED code = 27)*
Cause:
The voltage on PEB output (pin A27) is at high value even if it should not.
For the versions where the high driver is not installed, it is possible to decide where the positive supply for pin A27 comes from by choosing a dedicated hardware configuration. The parameter POSITIVE E.B. has to be set in accordance with the hardware configuration (see paragraph 8.2.7), because the software makes a proper diagnosis depending on the parameter; a wrong setting could generate a false fault. The available choices are:
0 = PEB is managed by the high side driver supplied by PIN A2. This is the standard configuration
1 = PEB comes from the SEAT input (A8).
2 = PEB is externally connected after the main contactor..

This alarm can only appear if POSITIVE E.B. is set as 1 SEAT.

Troubleshooting:
Verify that the parameter POSITIVE E.B. is set in accordance with the actual coil positive supply (see paragraph 8.2.7).
In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

BATTERY LOW *(MDI/LED code = 0)*
Cause:
Parameter BATTERY CHECK is other than 0 (SET OPTION list, paragraph 8.2.3) and battery charge is evaluated to be lower than BATT.LOW TRESHLD (ADJUSTMENTS list, paragraph 8.2.5).

Troubleshooting:
Check the battery charge and charge it if necessary.
If the battery is actually charged, measure the battery voltage through a voltmeter and compare it with the BATTERY VOLTAGE reading in the TESTER function. If they are different, adjust the ADJUST BATTERY parameter (ADJUSTMENTS list, paragraph 8.2.5) with the value measured through the voltmeter.
If the problem is not solved, replace the logic board.

BRAKE RUN OUT *(MDI/LED code = 63)*
Cause:
The CPOT BRAKE input read by the microcontroller is out of the range defined by parameters SET PBRK. MIN and SET PBRK. MAX (ADJUSTMENTS list, paragraph 8.2.5).

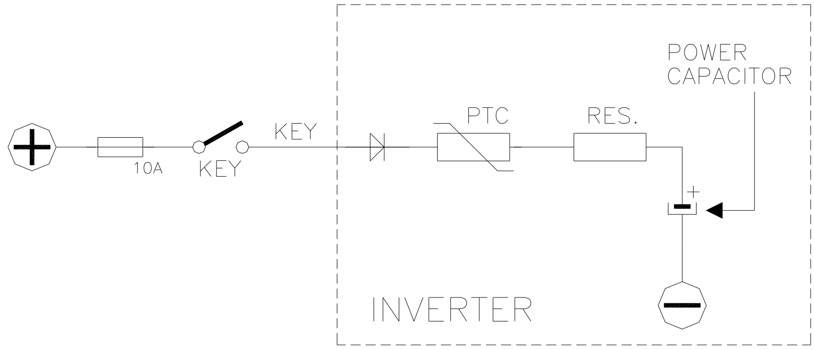
Troubleshooting:
Check the mechanical calibration and the functionality of the brake potentiometer. Acquire the minimum and maximum potentiometer values.

If the alarm is still present, replace the logic board.

BUMPER STOP *(MDI/LED code = 0)*
Cause
The two digital inputs dedicated to the bumper functionality are high at the same time. The alarm can occur only if parameter BUMPER STOP = ON and only if DUALACE2 is in OPEN CAN configuration (see parameter CONTROLLER TYPE in SPECIAL ADJUST. list, paragraph 8.2.6).

Troubleshooting
Turn off one or both inputs dedicated to the bumper functionality.
If the alarm occurs even if the inputs are in the rest position, check if the microswitches are stuck.
In case the problem is not solved, replace the logic board.

CAPACITOR CHARGE *(MDI/LED code = 60)*
It is related to the capacitor-charging system:



Cause
When the key is switched on, the inverter tries to charge the power capacitors through the series of a PTC and a power resistance, checking if the capacitors are charged within a certain timeout. If the capacitor voltage results less than a certain percentage of the nominal battery voltage, the alarm is raised and the main contactor is not closed.

Troubleshooting
Check if an external load in parallel to the capacitor bank, which sinks current from the capacitors-charging circuit, thus preventing the caps from charging well. Check if a lamp or a DC/DC converter or an auxiliary load is placed in parallel to the capacitor bank.
The charging resistance or PTC may be broken. Insert a power resistance across line-contactor power terminals; if the alarm disappears, it means that the charging resistance is damaged.
The charging circuit has a failure or there is a problem in the power section. Replace the controller.

CHECK UP NEEDED *(MDI/LED code = 0)*
Cause:
This is a warning to point out that it is time for the programmed maintenance.

Troubleshooting:
Turn on the CHECK UP DONE option after that the maintenance service.

CONT. DRV. EV XX *(MDI/LED code = 21)*

Cause:
One or more on/off valve drivers are not able to drive the load. For the meaning of code “XX”, refer to paragraph **Errore. L'origine riferimento non è stata trovata.**.
Alarm not present on DualACE2.

Troubleshooting:
The device or its driving circuit is damaged. Replace the controller.

CONTACTOR CLOSED *(MDI/LED code = 37)*
Cause
Before driving the LC coil, the controller checks if the contactor is stuck. The controller drives the power bridge for several dozens of milliseconds, trying to discharge the capacitors bank. If the capacitor voltage does not decrease by more than a certain percentage of the key voltage, the alarm is raised.

Troubleshooting
It is suggested to verify the power contacts of LC; if they are stuck, is necessary to replace the LC.

CONTACTOR DRIVER *(MDI/LED code = 75)*
Cause
The LC coil driver is not able to drive the load. The device itself or its driver circuit is damaged.

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

CONTACTOR OPEN *(MDI/LED code = 38)*
Cause
The LC coil is driven by the controller, but it seems that the power contacts do not 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 capacitors get discharged it means that the main contactor is open.

Troubleshooting
LC contacts are not working. Replace the LC.
If LC contacts are working correctly, contact a Zapi technician.

CONTROLLER MISM. *(MDI/LED code = 12)*
Cause
The software is not compatible with the hardware. Each controller produced is “signed” at the end of line test with a specific code mark 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 for assistance to a Zapi technician in order to verify that the firmware is correct.

CTRAP THRESHOLD *(MDI/LED code = 99)*
Cause

This alarm occurs when a mismatch is detected between the setpoint for the overcurrent detection circuit (dependent on parameter DUTY PWM CTRAP, see paragraph 8.2.6) and the feedback of the actual threshold value.

Troubleshooting
The failure lies in the controller hardware. Replace the logic board.

CURRENT GAIN *(MDI/LED code = 92)*
Cause:
The current gain parameters are at the default values, which means that the maximum current adjustment procedure has not been carried out yet.

Troubleshooting:
Ask for assistance to a Zapi technician in order to do the adjustment procedure of the current gain parameters**.**

DATA ACQUISITION *(MDI/LED code = 0)*
Cause:
Controller in calibration state.

Troubleshooting:
The alarm ends when the acquisition is done.

DRIVER SHORTED *(MDI/LED code = 74)*
Cause
The driver of the LC coil is shorted.

Troubleshooting
Check if there is a short or a low impedance pull-down between NLC (pin A12) and -B.
The driver circuit is damaged; replace the logic board.

DRV. SHOR. EV XX *(MDI/LED code = 21)*
Cause:
One or more on/off valve drivers are shorted. For the meaning of code “XX”, refer to paragraph **Errore. L'origine riferimento non è stata trovata.**.
Alarm not present on DualACE2.

Troubleshooting:
Check if there is a short circuit or a low impedance path between the negative terminals of the involved coils and -B.
If the problem is not solved, replace the logic board.

EB. COIL OPEN *(MDI/LED code = 43)*
Cause:
No load is connected between the NEB output (pin A28 (A18)) and the EB positive terminal PEB (pin A27).

Troubleshooting:
Check the EB coil.
Check the wiring.
If the problem is not solved, replace the logic board.

EB. DRIV.OPEN *(MDI/LED code = 42)*
Cause:

The EB driver (pin A28 (A18)) 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.

EB. DRIV.SHRT. *(MDI/LED code = 40)*
Cause:
The EB driver is shorted (pin A28 (A18)).
The microcontroller detects a mismatch between the setpoint and the feedback at the EB output.

Troubleshooting:
Check if there is a short or a low impedance path between the negative coil terminal and -B.
Check if the voltage applied is in accordance with the settings of the EB-related parameters (see paragraph 8.2.5).
If the problem is not solved, replace the controller.

EEPROM KO *(MDI/LED code = 13)*
Cause:
A HW or SW defect of the non-volatile embedded memory storing the controller parameters. This alarm does not inhibit the machine operations, but it makes the truck to work with the default values.

Troubleshooting:
Execute a CLEAR EEPROM procedure (refer to the 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 be replaced by the default parameters.

ED SPLIP MISMATCH (MDI/LED code = 7)
Cause
The control detects a mismatch between the expected slip and the evaluated one. This diagnostic occurs only if ED COMPENSATION = TRUE.

ENCODER D.ERR XX *(MDI/LED code = 3)*
Cause:
This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is the encoder. The A and B pulse sequence is not correct. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting:
Check the wirings.
If the motor direction is correct, swap A and B signals.
If the motor direction is not correct, swap two of the motor cables.
If the problem is not solved, contact a Zapi technician.

ENCODER ERROR XX
Cause:
The frequency supplied to the motor is above 40 Hz and the feedback from the feedback sensor has a jump greater than value define by parameter DIAG.JUMP SENS in few tens of millisecond (see paragraph 8.2.5)Special Adjustment. This condition is related to an encoder failure.

Troubleshooting:
Check both the electric and the mechanical functionality of the encoder.
Check the wires crimping.
Check the mechanical installation of the encoder, if the encoder slips inside its housing it may raise this alarm.
The electromagnetic noise on the sensor can be a cause for the alarm. In this case try to replace the encoder.
If the problem is still present after replacing the encoder, the failure is in the controller. Replace it.

EPS RELAY OPEN *(MDI/LED code = 70)*
Cause:
The controller receives from EPS information about the safety contacts being open.

Troubleshooting:
Verify the EPS functionality.

PUMP INC START (MDI/LED code = 79)
Cause:
Man-presence switch is not enabled at pump request.

Troubleshooting:
- Check wirings.
- Check microswitches for failures.
- Through the TESTER function, check the states of the inputs are coherent with microswitches states.
- If the problem is not solved, replace the logic board.

EVP COIL OPEN *(MDI/LED code = 9)*
Cause:
No load is connected between the NEVP output (pin A23) and the electrovalve positive terminal.

Troubleshooting:
Check the EVP condition.
Check the EVP wiring.
If the problem is not solved, replace the logic board.

EVP DRIV. SHORT. *(MDI/LED code = 9)*
Cause
The EVP driver (output NEVP, pin A23) is shorted.
The microcontroller detects a mismatch between the valve set-point and the feedback of the EVP output.

Troubleshooting
Check if there is a short circuit or a low-impedance conduction path between the negative of the coil and -B.
Collect information about:
the voltage applied across the EVP coil,
the current in the coil,
features of the coil.
Ask for assistance to Zapi in order to verify that the software diagnoses are in accordance with the type of coil employed.

If the problem is not solved, it could be necessary to replace the controller.

EVP DRIVER OPEN *(MDI/LED code = 9)*
Cause:
The EVP driver (output NEVP, pin A23) is not able to drive the EVP coil. The device itself or its driving circuit is damaged.

Troubleshooting:
This fault is not related to external components. Replace the logic board.

FIELD ORIENT. KO *(MDI/LED code = 36)*
Cause
The error between the estimated Id (d-axis current) and the relative setpoint is out of range.

Troubleshooting
Ask for assistance to a Zapi technician in order to do the correct adjustment of the motor parameters.

FORW + BACK *(MDI/LED code = 80)*
Cause:
This alarm occurs when both the travel requests (FW and BW) are active at the same time.

Troubleshooting:
Check that travel requests are not active at the same time.
Check the FW and BW input states through the TESTER function.
Check the wirings relative to the FW and BW inputs.
Check if there are failures in the microswitches.
If the problem is not solved, replace the logic board.

HANDBRAKE *(MDI/LED code = 46)*
Cause:
Handbrake input is active.

Troubleshooting:
Check that handbrake is not active by mistake.
Check the SR/HB input state through the TESTER function.
Check the wirings.
Check if there are failures in the microswitches.
If the problem is not solved, replace the logic board.

HOME SENS.ERR XX *(MDI/LED code = 3)*
Cause
The controller detects a difference between the estimated absolute orientation of the rotor and the position of the index signal (ABI encoder).
It is caused by a wrong acquisition of the angle offset between the stator and the index signal. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting
Repeat the auto-teaching procedure.

HW FAULT EB. XX *(MDI/LED code = 34)*
Cause:

At start-up, the hardware circuit dedicated to enable and disable the EB driver (output NEB, pin A28) is found to be faulty. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting:
This type of fault is not related to external components. Replace the logic board.

HW FAULT EV. XX *(MDI/LED code = 16)*
Cause:
At start-up, the hardware circuit dedicated to enable and disable the EV drivers is found to be faulty. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting:
This type of fault is not related to external components. Replace the logic board.

HW FAULT XX *(MDI/LED code = 32)*
Cause
At start-up, some hardware circuit intended to enable and disable the power bridge or the LC driver (output NLC, pin A26) is found to be faulty. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

Troubleshooting
This type of fault is related to internal components. Replace the logic board.

INCORRECT START *(MDI/LED code = 79)*
Cause:
Incorrect starting sequence. Possible reasons for this alarm are:
- A travel demand active at key-on.
- Man-presence sensor active at key on.

Troubleshooting:
Check the states of the input at key-on.
Check wirings and the microswitches for failures.
Through the TESTER function, check the states of the inputs are coherent with microswitches states.
If the problem is not solved, replace the logic board.

INIT VMN HIGH XX (MDI/LED code = 31)
Cause
Before closing the LC, the software checks the power bridge voltage without driving it. The software expects the voltage to be in a “steady state” value.
If it is too high, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase:
81: phase U
82: phase V
83: phase W

Troubleshooting
Check the motor power cables.
Check the impedance between U, V and W terminals and -B terminal of the controller.
Check the motor leakage to truck frame.
If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.

INIT VMN LOW XX (MDI/LED code = 30)

Cause

Before closing the LC, the software checks the power bridge voltage without driving it. The software expects the voltage to be in a “steady state” value. If it is too low, this alarm occurs. The hexadecimal value “XX” identifies the faulty phase:

- 01: phase U
- 02: phase V
- 03: phase W

Troubleshooting

Check the motor power cables.
Check the impedance between U, V and W terminals and -B terminal of the controller.
Check the motor leakage to truck frame.
If the motor connections are OK and there are no external low impedance paths, the problem is inside the controller. Replace it.

IQ MISMATCHED *(MDI/LED code = 24)*

Cause

The error between the estimated Iq (q-axis current) and the related set point is out of range.

Troubleshooting

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

LC COIL OPEN *(MDI/LED code = 22)*

Cause

No load is connected between the NLC output (pin A26) and the positive voltage (for example +KEY).

Troubleshooting

Check the wiring, in order to verify if LC coil is connected to the right connector pin and if it is not interrupted.
If the alarm is still present, than the problem is inside the logic board; replace it.

LIFT+LOWER *(MDI/LED code = 49)*

Cause:

Both the pump requests (LIFT and LOWER) are active at the same time.

Troubleshooting:

Check that LIFT and LOWER requests are not active at the same time.
Check the LIFT and LOWER states through the TESTER function.
Check the wirings and the microswitches.
If the problem is not solved, replace the logic board.

LOGIC FAILURE #1 *(MDI/LED code = 19)*

Cause

The controller detects an undervoltage condition at the KEY input (pin A3).
Undervoltage threshold are indicated at paragraph 2.4

Troubleshooting (fault at startup or in standby)

Fault can be caused by a key input signal characterized by pulses below the undervoltage threshold, possibly due to external loads like DC/DC converters starting-up, relays or contactors during switching periods, solenoids energizing or de-energizing. Consider to remove such loads.
If no voltage transient is detected on the supply line and the alarm is present every time the key switches on, the failure probably lies in the controller hardware. Replace the logic board.

Troubleshooting (fault displayed during motor driving)
If the alarm occurs during motor acceleration or when there is a hydraulic-related request, check the battery charge, the battery health and power-cable connections.

LOGIC FAILURE #2 *(MDI/LED code = 18)*
Cause
Fault in the hardware section of the logic board which deals with voltage feedbacks of motor phases.

Troubleshooting
The failure lies in the controller hardware. Replace the controller.

LOGIC FAILURE #3 *(MDI/LED code = 17)*
Cause
A hardware problem in the logic board due to high currents (overload). An overcurrent condition is triggered even if the power bridge is not driven.

Troubleshooting
The failure lies in the controller hardware. Replace the controller.

M/S PAR CHK MISM *(MDI/LED code = 97)*
Cause:
At start-up there is a mismatch in the parameter checksum between the master and the supervisor microcontrollers.

Troubleshooting:
Restore and save again the parameters list.

COIL SHOR. MC *(MDI/LED code = 76)*
Cause:
This alarm occurs when there is an overload of the MC driver (pin A26). As soon as the overload condition disappears, the alarm will be removed automatically by releasing and then enabling a travel demand.

Troubleshooting:
The typical root cause is in the wiring harness or in the load coil. So the very first check to carry out concerns the connections between the controller outputs and the loads.
Collect information about characteristics of the coils connected to the two drivers and ask for assistance to a Zapi technician in order to verify that the maximum current that can be supplied by the hardware is not exceeded.

COIL SHOR. EB *(MDI/LED code = 76)*
Cause:

This alarm occurs when there is an overload of the EB driver (pin A28). As soon as the overload condition disappears, the alarm will be removed automatically by releasing and then enabling a travel demand.

Troubleshooting:
The typical root cause is in the wiring harness or in the load coil. So the very first check to carry out concerns the connections between the controller outputs and the loads.
Collect information about characteristics of the coils connected to the two drivers and ask for assistance to a Zapi technician in order to verify that the maximum current that can be supplied by the hardware is not exceeded.

MOT.PHASE SH. XX *(MDI/LED code = 47)*
Cause
Short circuit between two motor phases. The hexadecimal value “XX” identifies the shorted phases:
- 36: U – V short circuit
- 37: U – W short circuit
- 38: V – W short circuit

Troubleshooting
Verify the motor phases connection on the motor side.
Verify the motor phases connection on the inverter side.
Check the motor power cables.
Replace the controller.
If the alarm does not disappear, the problem is in the motor. Replace it.

MOTOR TEMPERAT. *(MDI/LED code = 65)*
Cause:
This warning occurs when the temperature sensor has overtaken the MAX. MOTOR TEMP. threshold (if analog) (see paragraph 8.2.5).

Troubleshooting:
Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function.
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, replace the controller.

MOTOR TEMP. STOP. *(MDI/LED code = 65)*
Cause:
This warning occurs when the temperature sensor is open (if digital) or if it has overtaken the TEMP. MOT. STOP threshold (if analog) (see paragraph 8.2.5).

Troubleshooting:
Check the temperature read by the thermal sensor inside the motor through the MOTOR TEMPERATURE reading in the TESTER function.
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, replace the controller.

NO CAN MSG. XX *(MDI/LED code = 67)*
Cause

CANbus communication does not work properly. The hexadecimal value “XX” identifies the faulty node.

Troubleshooting
Verify the CANbus network (external issue).
Replace the logic board (internal issue).

INT CANBUSKO *(MDI/LED code = 67)*
Cause
Internal CANbus communication between the two uC does not work properly.

Troubleshooting
Replace the logic board (internal issue).

OFFSET SPD.SENS. *(MDI/LED code = 3)*
Cause:
It is necessary to acquire the offset angle between the stator and the speed sensor, i.e. they mutual angular misalignment. An automatic function is dedicated to this procedure.

Troubleshooting:
Perform the teaching procedure: in OPTIONS, select ABS SENS. ACQUIRE. See paragraph **Errore. L'origine riferimento non è stata trovata.** for more details.

OPEN COIL EV. XX *(MDI/LED code = 21)*
Cause:
This fault appears when no load is connected between one or more EV outputs and the positive terminal PEV (pin A24)
Alarm not present for DualACE2

Troubleshooting:
Check the coils.
Check the wiring.
If the problem is not solved, replace the logic board.

OVERLOAD *(MDI/LED code = 57)*
Cause
The motor current has overcome the limit fixed by hardware.

Troubleshooting
If the alarm condition occurs again, ask for assistance to a Zapi technician. The fault condition could be affected by wrong adjustments of motor parameters.

PARAM RESTORE *(MDI/LED code = 14)*
Cause:
The controller has restored the default settings. If a CLEAR EEPROM has been made before the last key re-cycle, this warning informs you that EEPROM was correctly cleared.

Troubleshooting:
A travel demand or a pump request does cancel the alarm.
If the alarm appears at key-on without any CLEAR EEPROM performed, replace the controller.

PARAM TRANSFER *(MDI/LED code = 93)*

Cause:
Master uC is transferring parameters to the supervisor.

Troubleshooting:
Wait until the end of the procedure. If the alarm remains longer, re-cycle the key.

PEB NOT OK *(MDI/LED code = 25)*
Cause:
PEB terminal PIN (pin A27) is supplied by Terminal PIN (pin A24). This pin is not connected to the battery or the voltage is different from that defined by parameter SET POSITIVE PEB (see the ADJUSTMENTS list, paragraph 8.2.5).
This alarm can occur if AUX OUT FUNCTION or S AUX OUT FUNTION iare active.

Troubleshooting:
Check PEV terminal (pin A27): it must be connected to the battery voltage (after the main contactor).
Set the nominal PEV voltage in parameter SET POSITIVE PEB in the ADJUSTMENTS list (see paragraph 8.2.5).

POS. EB. SHORTED *(MDI/LED code = 84)*
Cause:
The voltage on terminal PEB (pin A27) is at the high value even if the high side driver is turned OFF.

Troubleshooting:
Verify that the parameter POSITIVE EB is set in accordance with the actual coil positive supply (see paragraph 8.2.7). Since the software makes a proper diagnosis depending on the parameter, a wrong setting could generate a false fault.
Check if there is a short or a low impedance path between PEB (pin A27) and the positive battery terminal +B. In case no failures/problems can be found, the problem is in the controller, which has to be replaced.

POSITIVE LC OPEN *(MDI/LED code = 35)*
Cause:
The voltage feedback of the LC driver (output NLC, pin A26) is different than expected.

Troubleshooting:
Verify LC coil is properly connected.
Verify CONF. POSITIVE LC parameter is set in accordance with the actual coil positive supply (see paragraph 8.2.7). Software makes a proper diagnosis depending on the parameter; a wrong setting could generate a false fault.
In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

POWER MISMATCH *(MDI/LED code = 39)*
Cause
The error between the power setpoint and the estimated power is out of range.

Troubleshooting
Ask for assistance to a Zapi technician about the correct adjustment of the motor parameters..

PWM ACQ. ERROR *(MDI/LED code = 6)*
Cause
This alarm occurs only when the controller is configured to drive a PMSM and the feedback sensor selected in the HARDWARE SETTINGS list is ENCODER ABI + PWM.
The controller does not detect correct information on PWM input at start-up.

Troubleshooting
Re-cycle the key.
Check the sensor in order to verify that it works properly.
Check the wiring.
If the problem occurs permanently it is necessary to substitute logic board.

RPM HIGH *(MDI/LED code = 0)*
Cause:
This alarm occurs in Gen. Set versions when the speed exceeds the threshold speed.

SENS MOT TEMP KO *(MDI/LED code = 68)*
Cause:
The output of the motor thermal sensor is out of range.

Troubleshooting:
Check if the resistance of the sensor is what expected measuring its resistance.
Check the wiring.
If the problem is not solved, replace the logic board.

SIN/COS D.ERR XX *(MDI/LED code = 3)*
Cause:
This alarm occurs only when the controller is configured as PMSM and the feedback sensor selected is sin/cos. The signal coming from sin/cos sensor has a wrong direction. The hexadecimal value "XX" facilitates Zapi technicians debugging the problem.

XX	DESCRIPTION	Cause
20	The module of the signal sin and signal cos is not constant	Problem of the sensor. A signal is clamped. A signal is short or open
1	direction wrong	Swapped motor or sensor phases
2	direction wrong	Swapped motor or sensor phases
3	sensor not connected or without power	
4	scaling error	check motor pulses or sensor periodicity
5	Error on module	A signal short or open
6	Error on module	A signal short or open

Troubleshooting:
Check the wirings.
If the motor direction is correct, swap the sin and cos signals.
If the motor direction is not correct, swap two of the motor cables.
If the problem is not solved, contact a Zapi technician.

SMARTDRIVER KO *(MDI/LED code = 69)*
Cause:

Hardware problem in the circuit for the management of high side driver. The driver is turned ON but the output voltage does not increase.

Troubleshooting:
Verify that the coil is connected correctly between terminals PEB (pin A27) and NEB (pin A28). The output of Smart driver is in fact evaluated checking the voltage feedback of low side driver.
Verify that the parameter POSITIVE EB is set in accordance with the actual coil positive supply (see paragraph 8.2.7). The software makes a proper diagnosis depending on the parameter; a wrong setting could generate a false fault.
In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

SPEED FB. ERROR *(MDI/LED code = 81)*
Cause
This alarm occurs if the absolute position sensor is used also for speed estimation. If signaled, it means that the controller measured that the engine was moving too quick.

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 is found on the motor or on the speed sensor, the problem is inside the controller, it is necessary to replace the logic board.

STALL ROTOR *(MDI/LED code = 11)*
Cause:
The traction rotor is stuck or the encoder signal is not correctly received by the controller.

Troubleshooting:
Check the encoder condition.
Check the wiring.
Through the TESTER function, check if the sign of FREQUENCY and ENCODER are the same and if they are different from zero during a traction request.
If the problem is not solved, replace the logic board.

STBY I HIGH *(MDI/LED code = 53)*
Cause
In standby, the sensor detects a current value different from zero.
Troubleshooting
The current sensor or the current feedback circuit is damaged. Replace the controller.

STEER SENSOR KO *(MDI/LED code = 95)*
Cause:
The voltage read by the microcontroller at the steering-sensor input is not within the STEER RIGHT VOLT ÷ STEER LEFT VOLT range, programmed through the STEER ACQUIRING function (see paragraph 9.3).

Troubleshooting:
Acquire the maximum and minimum values coming from the steering potentiometer 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, replace the logic board.

TH. PROTECTION *(MDI/LED code = 62)*
Cause:
The temperature of the controller base plate is above 85 °C.
The maximum current is proportionally decreased with the temperature excess from 85 °C up to 105 °C. At 105 °C the current is limited to 0 A.

Troubleshooting:
It is necessary to improve the controller cooling. To realize an adequate cooling in case of finned heat sink important factors are the air flux and the cooling-air temperature. If the thermal dissipation is realized by applying the controller base plate onto the truck frame, the important factors are the thickness of the frame and the planarity and roughness of its surface.
If the alarm occurs when the controller is cold, the possible reasons are a thermal-sensor failure or a failure in the logic board. In the last case, it is necessary to replace the controller.

THERMIC SENS. KO *(MDI/LED code = 61)*
Cause:
The output of the controller thermal sensor is out of range.

Troubleshooting:
This kind of fault is not related to external components. Replace the controller.

THROTTLE PR. *(MDI/LED code = 48)*
Cause:
A wrong profile has been set in the throttle profile.

Troubleshooting:
Set properly the throttle-related parameters (see paragraph 9.9).

TILLER ERROR *(MDI/LED code = 64) (Not present on DualACE2)*
Cause:
Input mismatch between H&S input and TILLER/SEAT input: the two inputs are activated at the same time.

Troubleshooting:
Check if there are wrong connections in the external wiring.
Using the TESTER function of the controller verify that the input-related readings are in accordance with the actual state of the external input switches.
Check if there is a short circuit between pins
In case no failures/problems have been found, the problem is in the controller, which has to be replaced.

TILLER OPEN *(MDI/LED code = 51)*
Cause:
Tiller/seat input (A8 (A6)) has been inactive for more than 120 seconds.

Troubleshooting:
Activate the tiller/seat input.
Check the tiller/seat input state through the TESTER function.
Check the wirings.

Check if there are failures in the microswitches.
If the problem is not solved, replace the logic board.

TORQUE PROFILE *(MDI/LED code = 98)*
Cause:
There is an error in the choice of the torque profile parameters.

Troubleshooting:
Check in the HARDWARE SETTINGS list the value of those parameters.

VACC NOT OK *(MDI/LED code = 78)*
Cause:
At key-on and immediately after that, the travel demands have been turned off. This alarm occurs if the ACCELERATOR reading (in TESTER function) is above the minimum value acquired during the PROGRAM VACC procedure.

Troubleshooting:
Check the wirings.
Check the mechanical calibration and the functionality of the accelerator potentiometer.
Acquire the maximum and minimum potentiometer value through the PROGRAM VACC function.
If the problem is not solved, replace the logic board.

VACC OUT RANGE *(MDI/LED code = 85)*
Cause:
The CPOT input read by the microcontroller is not within the MIN VACC ÷ MAX VACC range, programmed through the PROGRAMM VACC function (see paragraph 9.1).
The acquired values MIN VACC and MAX VACC are inconsistent.

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

VDC LINK OVERV. *(MDI/LED code = 77)*
Cause
This fault is displayed when the controller detects an overvoltage condition. Overvoltage threshold depends on the nominal voltage of the controller (see paragraph 2.4)

As soon as the fault occurs, power bridge and MC are opened. The condition is triggered using the same HW interrupt used for undervoltage detection, uC discerns between the two evaluating the voltage present across DC-link capacitors:
High voltage → Overvoltage condition
Low/normal voltage → Undervoltage condition

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

VDC OFF SHORTED *(MDI/LED code = 88)*

Cause
The logic board measures a voltage value across the DC-link that is constantly out of range, above the maximum allowed value.

Troubleshooting
Check that the battery has the same nominal voltage of the inverter.
Check the battery voltage, if it is out of range replace the battery.
If the battery voltage is ok, replace the logic board.

VKEY OFF SHORTED *(MDI/LED code = 20)*
Cause
At key-on, the logic board measures a voltage value of the KEY input that is constantly out of range, below the minimum allowed value.

Troubleshooting
Check that the battery has the same nominal voltage of the inverter.
Check the battery voltage, if it is out of range replace the battery.
If the battery voltage is ok, replace the logic board.

VMN HIGH *(MDI/LED code = 31)*
Cause 1
Before switching the LC on, the software checks the power bridge: it turns on alternatively the low-side power MOSFETs and expects the phase voltages decrease down to -B. If the phase voltages are higher than a certain percentage of the nominal battery voltage, this alarm occurs.
Cause 2
This alarm may also occur when the start-up diagnosis has succeeded and so the LC has been closed. In this condition, the phase voltages are expected to be lower than half the battery voltage. If one of them is higher than that value, this alarm occurs.

Troubleshooting
If the problem occurs at start-up (the LC does not close), 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 while the motor is running, check:
motor connections;
that the LC power contact closes properly, with a good contact;
if no problem is found, the problem is inside the controller. Replace it.

VMN LOW *(MDI/LED code = 30)*
Cause 1
Start-up test. Before switching the LC on, the software checks the power bridge: it turns on alternatively the high-side power MOSFETs and expects the phase voltages increase toward the positive rail value. If one phase voltage is lower than a certain percentage of the rail voltage, this alarm occurs.

Cause 2
Motor running test. When the motor is running, the power bridge is on and the motor voltage feedback tested; if it is lower than expected value (a range of values is considered), the controller enters in fault state.

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 while the motor is running, check:
motor connections;
that the LC power contact closes properly, with a good contact;
if no problem is found, the problem is inside the controller. Replace it.

WAITING FOR NODE *(MDI/LED code = 0)*
Cause:
The controller receives from the CAN bus the message that another controller in the net is in fault condition; as a consequence the controller itself cannot enter into an operative status, but it has to wait until the other node comes out from the fault status.

Troubleshooting:
Check if any other device on the CAN bus is in fault condition.

WARNING SLAVE *(MDI/LED code = 1)*
Cause:
Warning on supervisor uC.

Troubleshooting:
Connect the Console to the supervisor uC and check which alarm is present.

WATCHDOG *(MDI/LED code = 8)*
Cause
This is a safety related test. It is a self-diagnosis test that involves the logic between master and supervisor microcontrollers.

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

WRONG ENC SET *(MDI/LED code = 83)*
Cause
Mismatch between “ENCODER PULSES 1” parameter and “ENCODER PULSES 2” parameter (see paragraph 8.2.7).

Troubleshooting
Set the two parameters with the same value, according to the adopted encoder.

WRONG KEY VOLT. *(MDI/LED code = 41)*
Cause
The measured key voltage is not the right one for the inverter.

Troubleshooting
Check if the SET KEY VOLTAGE parameter in the ADJUSTMENTS list is set in accordance with the key voltage.
Check if the key voltage is ok using a voltmeter, if not check the wiring.
In case the problem is not solved, replace the logic board.

WRONG RAM MEM. *(MDI/LED code = 71)*
Cause

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

<u>Troubleshooting</u>
Try to switch the key off and then on again, if the alarm is still present replace the logic board.

WRONG SET BAT. *(MDI/LED code = 41)*
<u>Cause</u>
At start-up, the controller checks the battery voltage (measured at key input) and it verifies that it is within a range of ±20% around the nominal value.

<u>Troubleshooting</u>
Check that the SET BATTERY parameter inside the ADJUSTMENTS list matches with the battery nominal voltage.
If the battery nominal voltage is not available for the SET BATTERY parameter inside the ADJUSTMENTS list, record the value stored as HARDWARE BATTERY RANGE parameter in the SPECIAL ADJUST. list and contact a Zapi technician.
Through the TESTER function, check that the KEY VOLTAGE reading shows the same value as the key voltage measured with a voltmeter on pin A3. If it does not match, then modify the ADJUST BATTERY parameter according to the value read by the voltmeter.
Replace the battery.

WRONG SLAVE VER. *(MDI/LED code = 91)*
<u>Cause:</u>
There is a mismatch in the software versions of master and supervisor microcontrollers.

<u>Troubleshooting:</u>
Upload the software to the correct version or ask for assistance to a Zapi technician.

INPUT MISMATCH *(MDI/LED code = 59)*
<u>Cause:</u>
The master microcontroller records different input values with respect to the master microcontroller.

<u>Troubleshooting:</u>
Compare the values read by master and slave through the TESTER function.
Ask for the assistance to a Zapi technician.
If the problem is not solved, replace the logic board.

SP MISMATCH XX *(MDI/LED code = 15)*
<u>Cause:</u>
This is a safety related test. The master µC has detected a mismatch in the speed setpoint with respect to the master µC. The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

<u>Troubleshooting:</u>
Check the matching of the parameters between master and supervisor.
Ask for assistance to a Zapi technician.
If the problem is not solved, replace the logic board.

OUT MISMATCH XX *(MDI/LED code = 15)*

<u>Cause:</u>

This is a safety related test. Master µC has detected that supervisor µC is driving traction motor in a wrong way (not corresponding to the operator request). The hexadecimal value “XX” facilitates Zapi technicians debugging the problem.

<u>Troubleshooting:</u>

Checks the matching of the parameters between Master and Supervisor.
Ask for assistance to a Zapi technician.
If the problem is not solved, replace the logic board.

10.4 Alarms from supervisor µC

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
WAITING FOR NODE	MC is opened, EB is applied, Traction/Pump stopped	Start-up, stand-by, running	Key re-cycle	0	0	224
BATTERY LOW	According to parameter BATTERY CHECK (SET OPTIONS list, paragraph 8.2.2).	Start-up, standby, running	Battery recharge, key re-cycle	0	FF42	66
DATA ACQUISITION	Traction is stopped	Controller calibration	Traction request	0	0	247
CHECK UP NEEDED		Start-up	Check-up done, key re-cycle	0	0	249
RPM HIGH	MC is opened, Traction/Pump stopped	Start-up, standby, running		0	FFA1	161
BUMPER STOP	Traction is stopped	Start-up, standby, running		0	FFA2	162
WARNING SLAVE	It depends on the supervisor uC			1	FF01	244
ACQUIRING A.S.		Sensor Acquiring	Key re-cycle	2	FFAB	171
ACQUIRE END		Sensor Acquiring	Key re-cycle	2	FFAD	173
ACQUIRE ABORT		Sensor Acquiring	Key re-cycle	2	FFAC	172
SIN/COS D.ERR XX	MC is not closed, EB is applied, Traction/Pump, valves stopped	running	Key re-cycle	3	FFA8	168
ENCODER D.ERR XX	Traction is stopped	running	Key re-cycle	3	FFA9	169
HOME SENS.ERR XX	MC is opened , EB is applied, EVP stopped	Running	Key re-cycle	3	FFB0	176
OFFSET SPD.SENS.	EB is applied, Traction/Pump, valves stopped.	Start-up	Perform ABS SENS. ACQUIRE	3	FF99	174
PWM ACQ. ERROR	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	6	FFA4	164
ED SLIP MISMATCH	MC is opened, EB is applied, Traction/Pump stopped	Running	Valves or Traction/Pump request	7	FFA3	163
WATCHDOG	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	8	6010	8
EVP DRIVER OPEN	MC is opened (the command is released), EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves request	9	FFF8	240
EVP COIL OPEN	Valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	9	5002	214
EVP DRIV. SHORT.	MC is opened , EB is applied, EVP stopped	Start-up, stand-by, running	Traction/Pump request	9	5003	215
STALL ROTOR	Traction/Pump stopped	Start-up, stand-by, running	Valves or Traction/Pump request	11	FFD3	211
CONTROLLER MISM.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Install the correct software and Key re-cycle	12	FFEF	239
EEPROM KO	Controller works using default parameters	Start-up, stand-by, running		13	3610	208
PARAM RESTORE	No effect	Start-up	Traction/Pump request	14	0	209
HW FAULT EV.	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	16	FFEE	238
LOGIC FAILURE #3	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump request	17	FF11	17
LOGIC FAILURE #2	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by,	Valves or Traction/Pump request	18	FF12	18
LOGIC FAILURE #1	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	19	5114	19
VKEY OFF SHORTED	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	20	5101	220
CONT. DRV. EV	Valves stopped	Start-up, stand-by, running	Valves request	21	FFE8	232
DRV. SHOR. EV	Valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	21	FFF9	234

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
OPEN COIL EV.	MC remains closed, EB is applied, Traction/Pump, valves stopped (the command is released)	Start-up, Stand-by, running	Valves or Traction/Pump Request	21	FFF2	242
LC COIL OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	22	FFE6	230
IQ MISMATCHED	Traction is stopped	Running	Valves or Traction/Pump request	24	FFF5	245
PEV NOT OK	Pump motor stopped, valves stopped	Start-up, stand-by, running	Valves request	25	FFDB	217
AUX BATT. SHORT.	None	Start-up, stand-by, running		27	5001	194
INIT VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	30	3121	207
VMN LOW	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	30	3120	30
INIT VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	31	3111	206
VMN HIGH	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by	Valves or Traction/Pump request	31	3110	31
HW FAULT	MC is not closed, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	32	FFE3	227
HW FAULT EB.	MC is opened, EB is applied, Traction/Pump stopped	Start-up	Key re-cycle	34	FFE5	229
POSITIVE LC OPEN	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	35	FFD5	213
FIELD ORIENT. KO	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	36	FFFD	253
CONTACTOR CLOSED	MC is not closed (command is not activated), EB is applied, Traction/Pump stopped	Start-up	Valves or Traction/Pump request	37	5442	37
CONTACTOR OPEN	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	38	5441	38
POWER MISMATCH	Traction is stopped, EB is applied, MC is opened	Running	Traction/Pump request	39	FFD4	212
EB. DRIV.SHRT.	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump Request	40	3222	254
WRONG SET BAT.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up		41	3100	251
WRONG KEY VOLT.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up		41	3101	170
EB. DRIV.OPEN	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Running	Valves or Traction/Pump Request	42	3224	246
EB. COIL OPEN	MC remains closed, EB is applied (the command is released), Traction/Pump, valves stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	43	FFD8	216
HANDBRAKE	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/Pump request	46	FFDD	221
MOT.PHASE SH.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Traction/Pump request	47	FFC4	196
THROTTLE PROG.	MC remains closed, EB is applied (the command is released), Traction stopped	Start-up, Stand-by, running	Valves or Traction/Pump Request	48	FFF3	243
LIFT+LOWER	Pump is stopped	Start-up, stand-by, running	Pump request	49	FFBB	187
TILLER OPEN	LC opens	Start-up, stand-by, running	Valves or Traction/Pump Request	51	0	228
STBY I HIGH	MC is not closed, EB is applied, Traction/Pump stopped	Start-up, stand-by	Valves or Traction/Pump request	53	2311	53
OVERLOAD	MC is not closed, EB is applied, Traction/Pump stopped	Running	Valves or Traction/Pump request	57	FFB4	180
CAPACITOR CHARGE	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Valves or Traction/Pump request	60	3130	60

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
THERMIC SENS. KO	Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.	Start-up, stand-by, running		61	4211	250
TH. PROTECTION	Traction controller reduces the max current linearly from Imax (85°C) down to 0 A (105°C)	Start-up, stand-by, running		62	4210	62
BRAKE RUN OUT	Traction is stopped	Start-up, stand-by, running	Traction/Pump Request	63	FFCC	204
TILLER ERROR	Traction stopped, EB applied	Stand-by, running	Valves or Traction/Pump Request	64	FFB9	185
MOTOR TEMPERAT.	Maximum current is linearly reduced (see paragraph 9.14) and speed is reduced to a fixed value.	Start-up, stand-by, running		65	4110	65
MOTOR TEMP. STOP	EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running		65	FFB2	178
NO CAN MSG.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	67	8130	248
SENS MOT TEMP KO	Maximum current is reduced according to parameter MOT.T. T.CUTBACK and speed is reduced to a fixed value.	Start-up, stand-by, running		68	4311	218
SMARTDRIVER KO	MC is not closed, Traction/Pump, valves stopped	Start-up	Key re-cycle	69	3302	193
EPS RELAY OPEN	Traction/Pump motor is stopped	Start-up, stand-by, Running	Valves or Traction/Pump request	70	FFCD	205
WRONG RAM MEM.	MC is opened, EB is applied, Traction/Pump, valves stopped	Stand-by	Key re-cycle	71	FFD2	210
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	74	3211	74
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	75	3221	75
COIL SHOR. MC	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up (immediately after MC closing), stand-by, running	Valves or Traction/Pump request	76	2250	223
VDC LINK OVERV.	MC is not closed, EB is applied, Traction/Pump, valves stopped	Stand-by, running	Valves or Traction/Pump request	77	FFCA	202
VACC NOT OK	Traction/Pump motor is stopped	Start-up, stand-by, running	Traction/ request	78	FF4E	78
INCORRECT START	Traction/Pump motor is stopped	Start-up, stand-by	Traction request	79	FF4F	79
PUMP INC START	Pump motor is stopped	Start-up, stand-by, running	Pump request	79	FFBD	189
FORW + BACK	Traction is stopped	Start-up, stand-by, running	Traction request	80	FF50	80
SPEED FB. ERROR	MC is opened , EB is applied, EVP stopped	Running	Valves or Traction/Pump request	81	FFAF	175
ENCODER ERROR XX	MC is opened, EB is applied, Traction/Pump, valves stopped	Running	Valves or Traction/Pump request	153	FF52	153
WRONG ENC SET	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	83	FF51	181
POS. EB. SHORTED	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	84	3223	195
VACC OUT RANGE	Traction/Pump motor is stopped	Start-up, Stand-by, Running	Traction/Pump request	85	FFE2	226
PEDAL WIRE KO	Traction is stopped	Start-up, Stand-by, Running	Traction request	86	FF56	86
VDC OFF SHORTED	MC is not closed, EB is applied, Traction/Pump, valves stopped	Start-up, Stand-by, Running	Key re-cycle	88	FFC8	200
POWERMOS SHORTED	MC is opened, EB is applied, traction/pump stopped	Start-up	Key re-cycle	89	FFE9	233
WRONG SLAVE VER.	MC opened, EB is applied, Traction/Pump, valves stopped	Start-up	Key re-cycle	91	FFC5	197
CURRENT GAIN	Controller works, but with low maximum current	Start-up, stand-by		92	6302	236
PARAM TRANSFER	MC stays closed, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Key re-cycle	93	FFC7	199

Error code	Effect	Condition	Restart procedure	MDI / LED CODE	CAN OPEN CODE	ZAPI CODE
STEER SENSOR KO	Speed is reduced according to parameter CTB. STEER ALARM (PARAMETER CHANGE list, paragraph 8.2.1)	Start-up, stand-by, running	Return into correct range	95	FFB3	179
ANALOG INPUT	MC is opened, EB is applied, traction/pump stopped	Stand-by, running	Key re-cycle	96	FFFA	237
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	97	FFC6	198
TORQUE PROFILE	EB is applied, Traction/Pump motor is stopped	Start-up, stand-by	Valves or Traction/Pump request	98	FFC9	201
CTRAP THRESHOLD	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	99	FFEB	235
COIL SHOR. EB.	MC is opened, EB is applied, Traction/Pump, valves stopped	Start-up, stand-by, running	Valves or Traction/Pump request	76	FFB1	177
INT. CANBUSKO	MC is opened, EB applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	67	8131	188
INPUT MISMATCHXX	MC is opened, EB applied, Traction/Pump stopped	Start-up, standby, running	Key re-cycle	59	FF9D	157
SP MISMATCH XX	MC is opened, EB applied, traction/pump stopped	Running	Key re-cycle	15	FF9B	155
OUT MISMATCH XX	MC is opened, EB applied, traction/pump stopped	Running	Key re-cycle	15	FF9A	154
PEB NOT OK	Pump motor stopped, valves stopped	Start-up, stand-by, running	Valves request	25	FFDB	217

10.4.1 Troubleshooting of alarms from supervisor μC

See paragraph 10.3.1

11 RECOMMENDED SPARE PARTS

Part number	Description	Version
C12535	AMPSEAL CONNECTOR 35 pins Female	
C16520	10A 20mm Control Circuit Fuse	

12 PERIODIC MAINTENANCE

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

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

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

Check the mechanical functionality of the pedals or tiller. Control that the return springs are ok and that the potentiometers excursion matches their full or programmed level.
Check every **3 months**.

Check the mechanical functionality 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 modifications should be evaluated with a Zapi Agent. The supplier is not responsible for any problem that arises from connections 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 brought to the attention of a Zapi Agent immediately. The Agent will then take the decision regarding the 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 kinds of waste materials.
Zapi commits itself to update its technology in order to reduce the presence of polluting substances in its products.

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13 APPENDICES

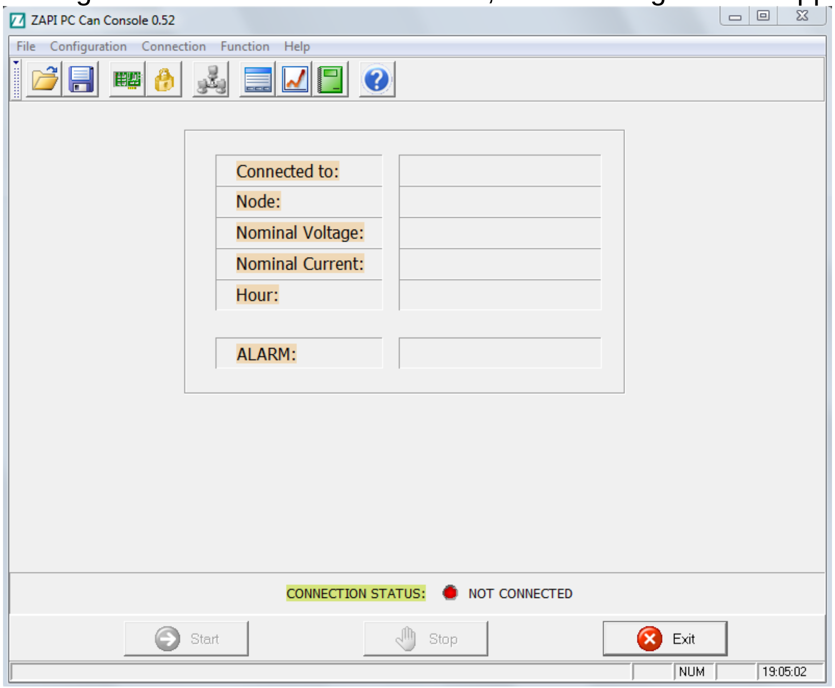
The goal of this chapter is to give the operator a general overview about the use of Zapi PC CAN Console and Zapi Smart Console.
The description focuses on the basic information about connection and settings. For additional functionalities available for both tools, it is suggested to contact Zapi technicians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

13.1 Appendix A: PC CAN Console user guide

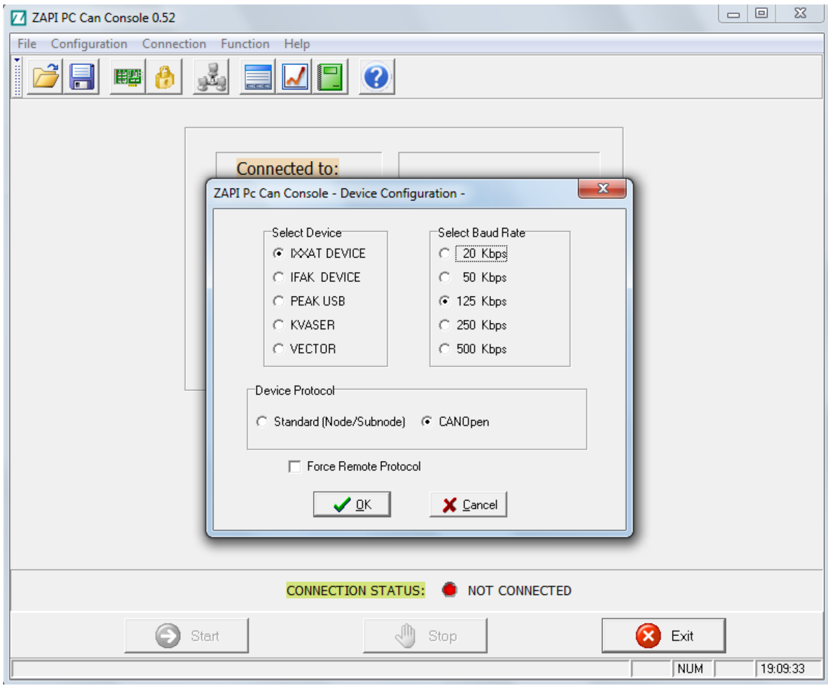
Windows Pc CAN Console uses standard Zapi communication protocol to display inverter information. It provides all standard Zapi Console functions with the easier handling of Windows environment. Besides, Pc CAN Console offers the possibility to save parameter configurations into a file and to restore them onto the control afterwards.
Before running Pc CAN Console, the user must install it launching "setup.exe".

13.1.1 PC CAN Console configuration

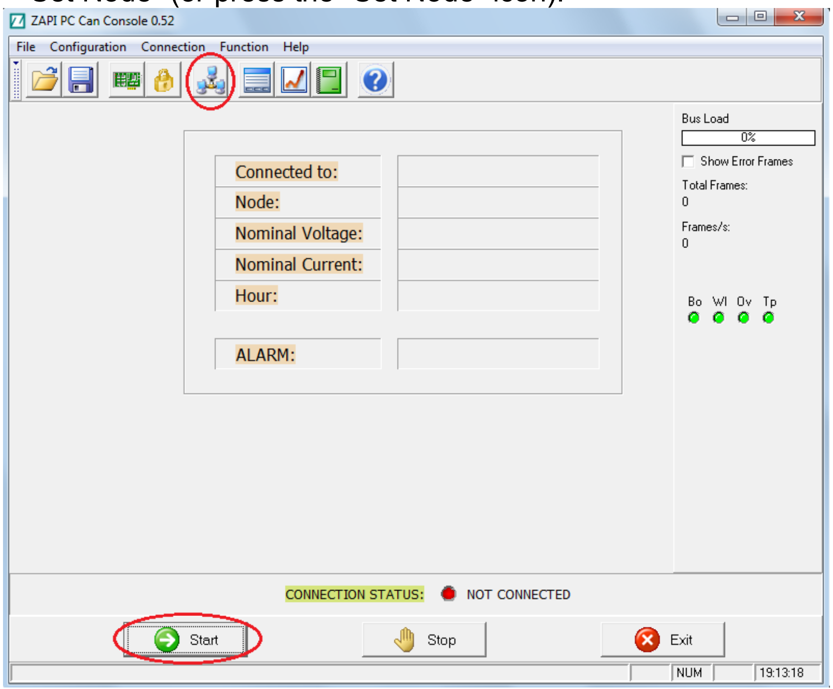
Running the PC Can Console software, the following window appears:



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.



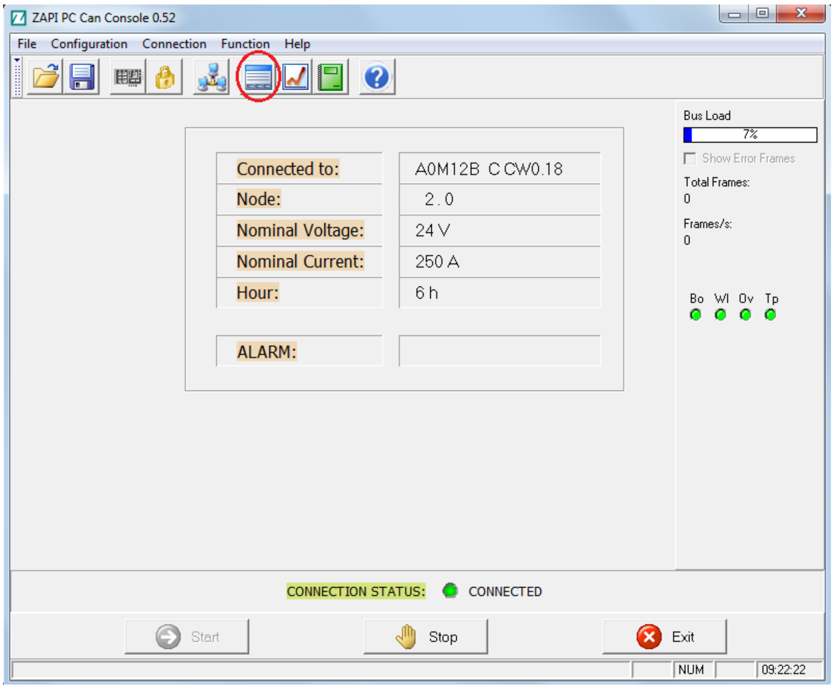
From this form you can define the CAN device in use (IXXAT, IFAK or Peak) and the CAN communication speed. Once you have defined the CAN interface, you have to choose which CAN device you want to connect to: choose “Connection” → “Set Node” (or press the “Set Node” icon).



Once you have chosen the node you want to connect to, start the connection. Insert the password in order to have the possibility to change the parameters: choose “Configuration” → “Enter Password”. Type the password: “ZAPI”

13.1.2 Parameter download

Once you are connected to the selected node, you need to download the inverter parameters: choose “Function” → “Parameter” menu (or press the “Parameter” icon).



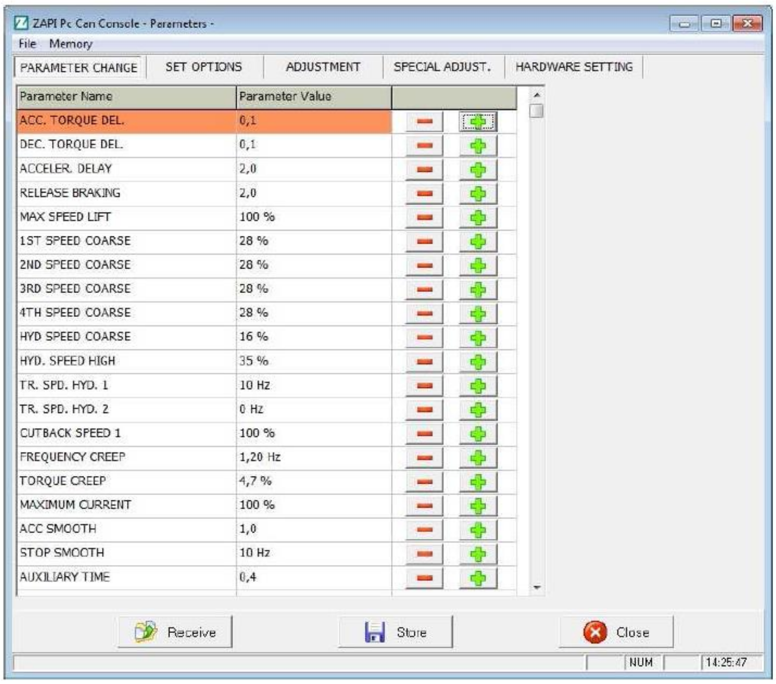
Then click on the "Receive" button: the parameters will be downloaded automatically.
When the parameters have been all received, you can change their values.

13.1.3 How to modify parameters

Before doing any change, save the old parameters set by clicking "File" → "Save" (give the file an understandable name for ease of future use).
The complete list of parameters will be saved as a csv file in order to be opened with Microsoft Excel® or any other spreadsheet tool.
The file contains the whole list of parameter and for each one various data are available, in particular:

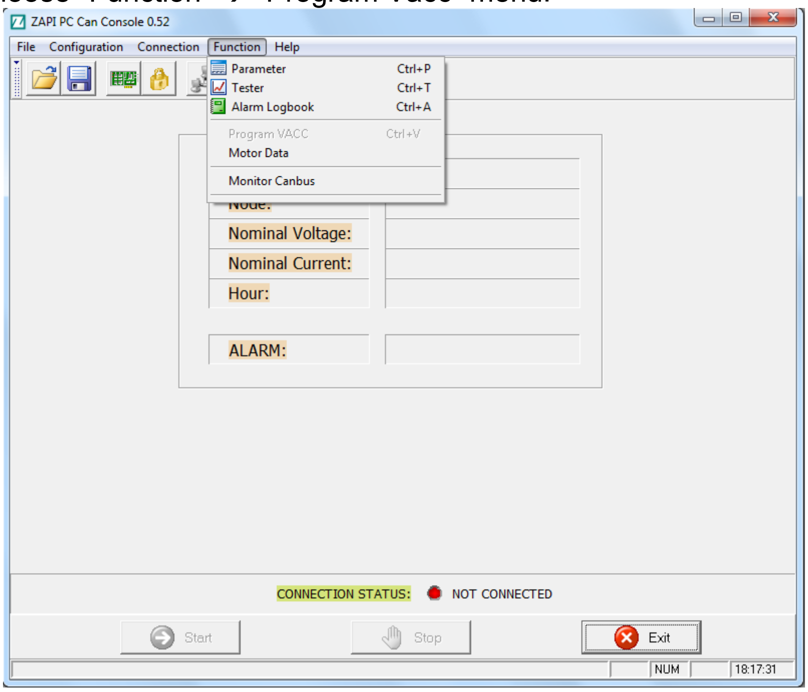
- Parameter value as it is saved within the controller ("Value" column).
- Parameter value as it is shown by console or similar tools ("Scaled Value" column).
- Name of the menu where parameter is placed ("Name menu" column).

File name is generated as a hexadecimal code of the time and date of saving. This codification prevents any overwrite of previously saved files.
Once you have selected the menu inside that resides the parameter you want to change, it is possible to modify the value using the "+" and "–" buttons.
Click on the "Store" button to save the changes on EEPROM.



13.1.4 Program Vacc

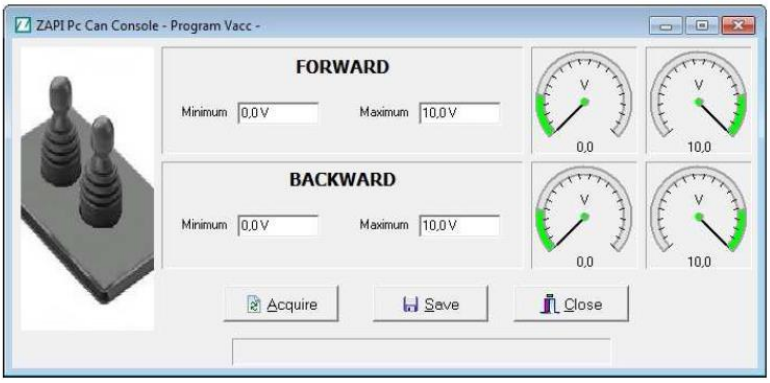
Choose “Function” → “Program Vacc” menu.



When “Acquire” is pressed, the PROGRAM VACC procedure starts:

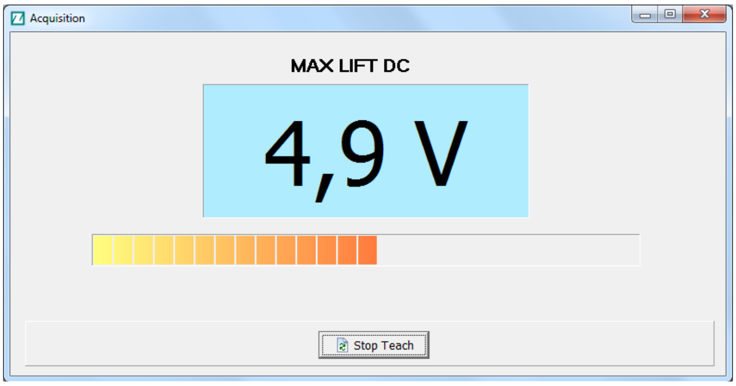
- Select the Enable switch, if any;
- Select the direction switch (either forward or backward);
- Depress the pedal to its maximum excursion.

Displayed values will vary accordingly to operator inputs.



13.1.5 Lift & Lower acquisition

Once you have connected to the inverter, you need to download the parameters; choose “Function” → “Parameter” menu (or press the “Parameter” icon).
Choose “Adjustment” menu.
Select the value you want to acquire by pressing the “acquiring” button, the acquisition will start:



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

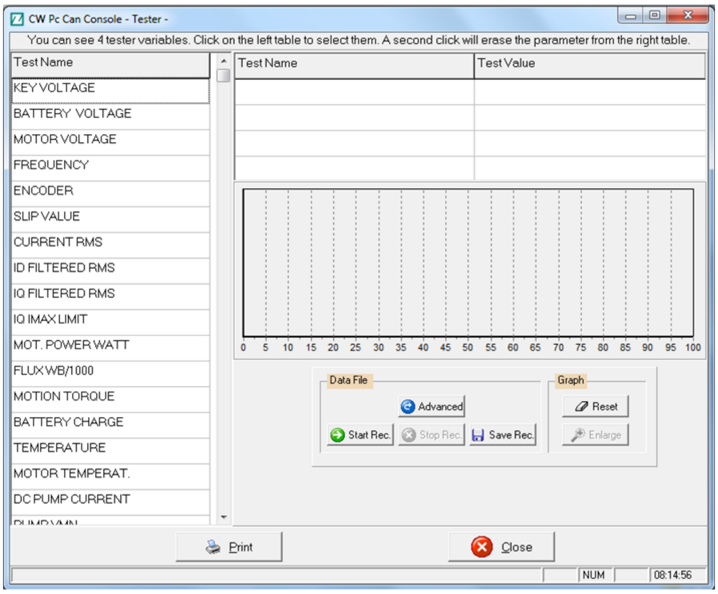
The procedure is the same for both lift and lower potentiometers.

13.1.6 Steering acquisition

Once you have connected you need to receive the inverter parameter; choose “Function” → “Parameter” menu (or press the “Parameter” icon).
Choose “Adjustment” menu.
Select the value to acquire by pressing “acquiring” button, the acquisition will start: the procedure is the same described for Lift & Lower acquisition in the previous paragraph.

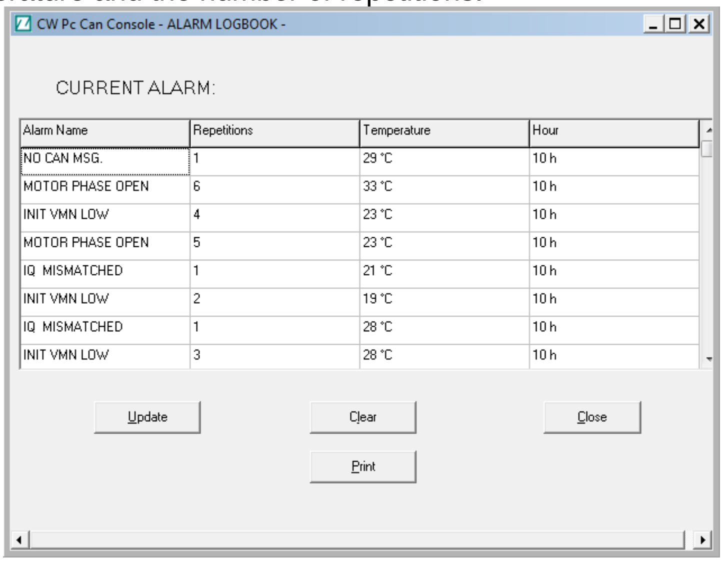
13.1.7 TESTER functionality

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



13.1.8 Alarm Logbook

This window will display the alarms stored in the controller.
For every alarm will be shown the working hour at which it's occurred, the motor temperature and the number of repetitions.



Four buttons are present:
Update → user can update alarm logbook;
Clear → user can clear alarm logbook on inverter 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

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.
- CAN bus connection powered by four standard AA size batteries placed in the battery holder of the console.
- CAN bus 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

Smart Console offers the same serial connection as the well-known Console Ultra.

Main features of this operational mode are:

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

CAN bus connection

The Smart Console can connect to an existing CAN line and connect with any Zapi controller inside this line.

Main features of this operational mode:

- It can be connected to a CAN line composed of any combination of modules, both Zapi ones and non-Zapi ones;
- Supported speeds: 125, 250, 500 kbps;
- It sees the entire CAN line and all CAN modules.

13.2.2 The keyboard

The keyboard is used to navigate through the menus. It features some keys 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. The 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 roll or scroll the menu.

LEFT and RIGHT keys

Normally used to increase and decrease the value associated with the selected item.

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 show which F button can be used and its function.

ON key

Used while operating with internal batteries.

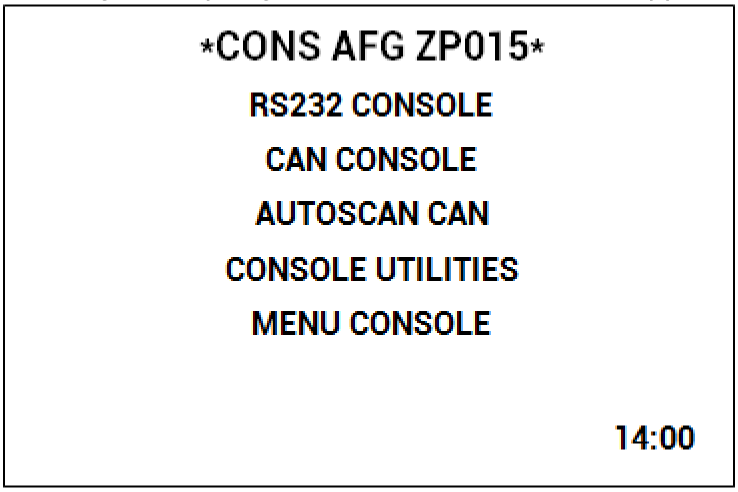
While the Smart Console is powered from external sources on pin CNX8 the ON button is deactivated regardless the presence of the batteries.

Green LED

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

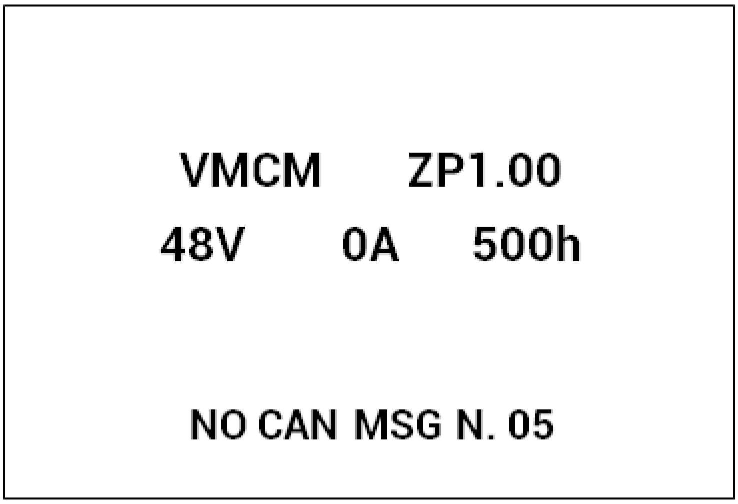
- CAN Console: enter this menu to establish a CAN connection.
- AUTOSCAN CAN: another way to establish a CAN connection.
- Console Utilities and Menu Console: ignore them at the moment.
- The current hour is shown at the bottom right.

Moreover, the green LED is on and still.
The “RS232” line is already highlighted at the start-up. Press OK key to start a serial connection.
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 seconds: press ESC key and look for what is preventing the connection.

Please notice the red dot appearing on 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 a page similar to the next one.



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

- First line displays the controller firmware.
- Second line shows controller voltage, controller current and hour meter.
- Last line shows the current alarm code, if present.

Press OK to access the MAIN MENU.

* MAIN MENU *

PARAMETER CHANGE

TESTER

ALARMS

PROGRAM VACC

SAVE PARAMETERS

RESTORE PARAMETERS

SET MODEL

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 some combinations of buttons: here 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 parameters

From MAIN MENU enter the desired menu (for example the PARAMETER CHANGE menu).

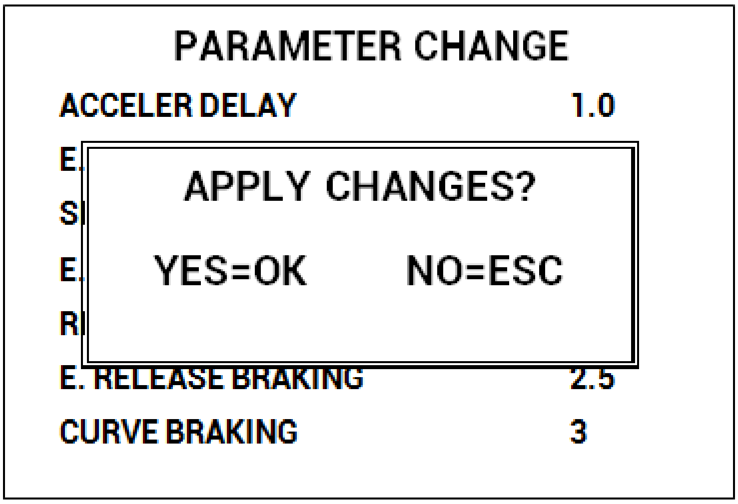
PARAMETER CHANGE

ACCELER DELAY	1.0
E. ACCELER. DELAY	1.5
SPEED LIMIT BRK	2.2
E. SPD. LIMIT BRK	2.2
RELEASE BRAKING	4
E. RELEASE BRAKING	2.5
CURVE BRAKING	3

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

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

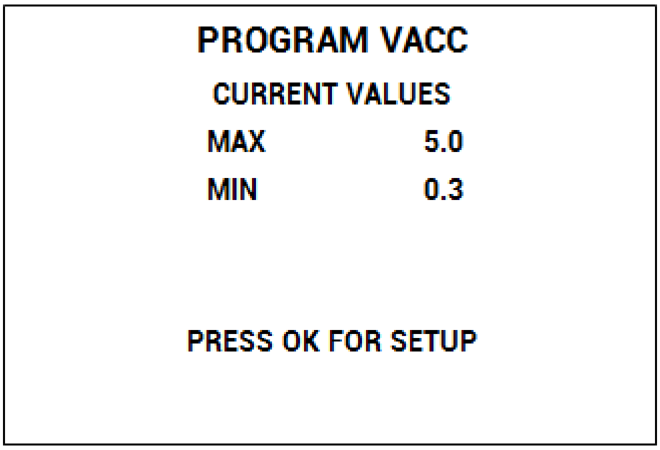
You can press ESC to exit the menu at any time. In case parameters have been modified, the console will prompt the request to confirm/discard changes.



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

13.2.6 PROGRAM VACC

PROGRAM VACC menu has been slightly modified from old consoles.
Upon entering this menu the console shows the current programmed values.



When OK is pressed, PROGRAM VACC procedure starts. Console invites you:

- to select the enable switch, if any;
- to select the direction switch (either forward or backward);
- to depress the pedal to its maximum excursion.

Displayed values vary accordingly to operator inputs.

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

PROGRAM VACC

FORWARD	0.0	4.5
BACKWARD	0.2	4.4

SEL. ENABLE AND DIRECTION
THEN PRESS PEDAL
(ESC TO FINISH)

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

13.2.7 Lift and Lower acquisition

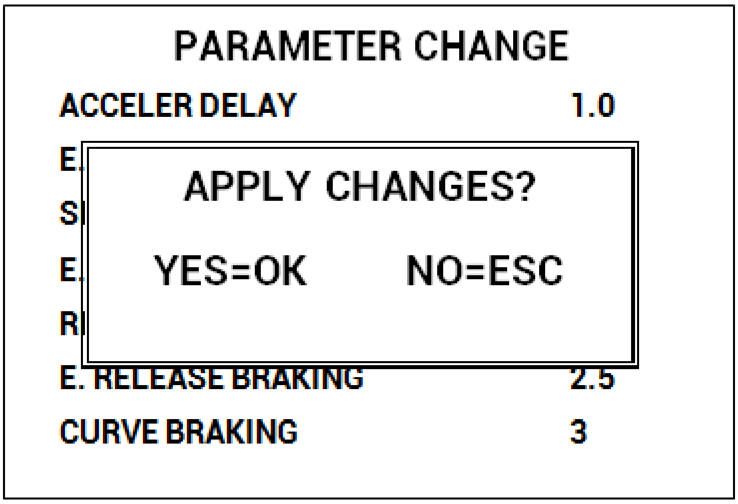
From MAIN MENU go into the Adjustment menu.
With UP and DOWN keys you can scroll the list: once you have highlighted a value you want acquire, press OK.
When OK is pressed, the procedure starts:

- select the Enable switch, if any;
- select the control switch if any (either lift or lower);
- move the control sensor (lift/lower potentiometer) to the correct position according to what you are acquiring.

Displayed values vary accordingly to operator inputs.

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

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

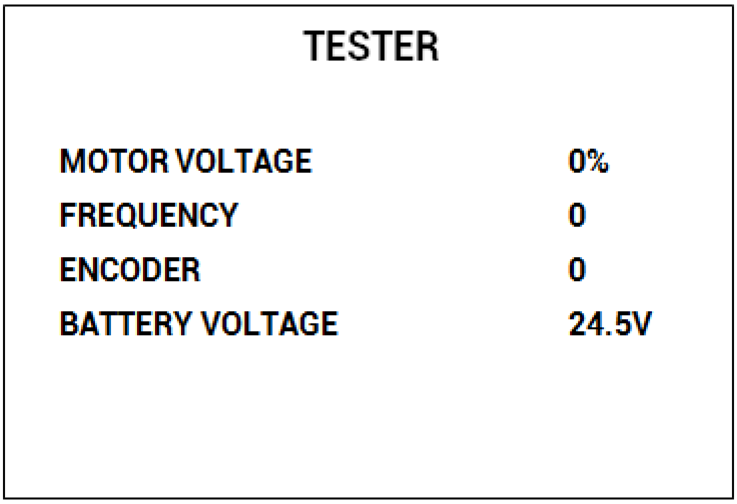


13.2.8 Steer acquisition

From MAIN MENU go into the Adjustment menu.
The procedure to follow is the same described in previous paragraph.

13.2.9 Tester

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



13.2.10 Alarms

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

ALARMS	
NO CAN MESSAGE	10h
INCORRECT START	2h
NONE	0h
NONE	0h
NONE	0h
F1 TO CLEAR LOGBOOK	

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

Colors 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 pieces of information about that alarm are displayed.
Press F1 to clear the alarm logbook of the controller: once F1 is pressed, the console asks for confirmation.

13.2.11 Download parameter list into a USB stick

When Smart Console is connected to a controller, it has the possibility to download all parameters into a USB stick.
To use this function, go into the menu SAVE PARAMETER USB in the MAIN MENU.

File format

The complete list of parameters is saved as a csv file in order to be opened with Microsoft Excel® or any other spreadsheet tool.
The file is formatted in the same way as if it has been created with the PC CAN Console. Thus it contains the whole list of parameter and, for each one, various data are available, in particular:

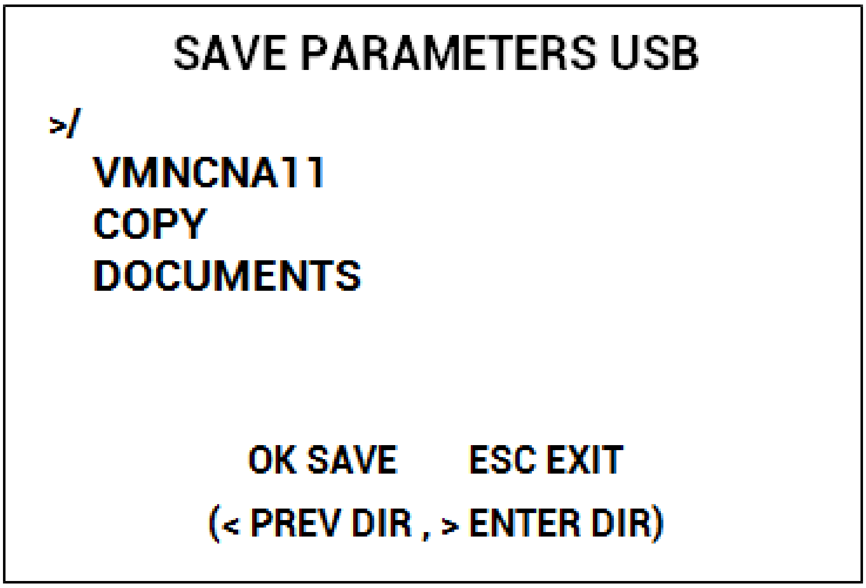
- Parameter value as it is saved within controller (“Value” column).
- Parameter value as it is shown by console or similar tools (“Scaled Value” column).
- Name of the menu where parameter is placed tools (“Name menu” column).

File name is generated as a hexadecimal code of the time and date of save. This codification prevents any overwrite of previously saved files.

Download procedure

After entering SAVE PARAMETER TO USB, the Smart Console checks the presence of a USB stick. If the stick is not connected, it asks the operator to connect one.

When the stick is present, the display shows the content, starting from the root directory (/) of the filesystem. Display looks like the following picture.



Notice that only directories are shown, not single files.
While exploring the content, the navigation buttons work in the following way:

- Up/down keys scroll the list.
- Right key explore the highlighted directory: its content (directories only) will be shown immediately.
- Left key returns one level back in the directory tree: it does not work in the root directory.
- Esc returns to HOME SCREEN.
- OK starts download.

When saving files, the console creates a subdirectory whose name has eight digits:

- First four digits are controller type.
- Fifth and sixth digits are the customer identification code.
- Seventh and eight digits are the code of the software installed inside the controller.

An example of this code is the first directory name (VMNCNA11) shown in the previous figure.
If parameters are downloaded multiple times from the same controller, or from another controller whose eight digit code is the same, all parameter files are saved in the same location.
If the directory does not exist, it is created when download is carried out for the first time.

To download parameters, proceed as follows:

1. Navigate the directory list and go into the directory where you want to save the parameters.
2. If this directory already contains the subdirectory with the correct 8 digits go to step 3. If it is not present, a new subdirectory will be created automatically. Do not enter the subdirectory manually.
3. Press OK to start parameter download. A progression bar shows the ongoing process.
4. When finished, press ESC so to return to MAIN MENU. USB stick can be removed safely.

Connect the USB stick to a PC and enter the directory of point 1). A subdirectory with the correct name and, inside this one, a csv file are present.

During download the led blinks slowly to indicate the console is running.

When download has finished USB stick can be unplugged safely.

Do not remove USB stick during download or the file will result empty or corrupted.
