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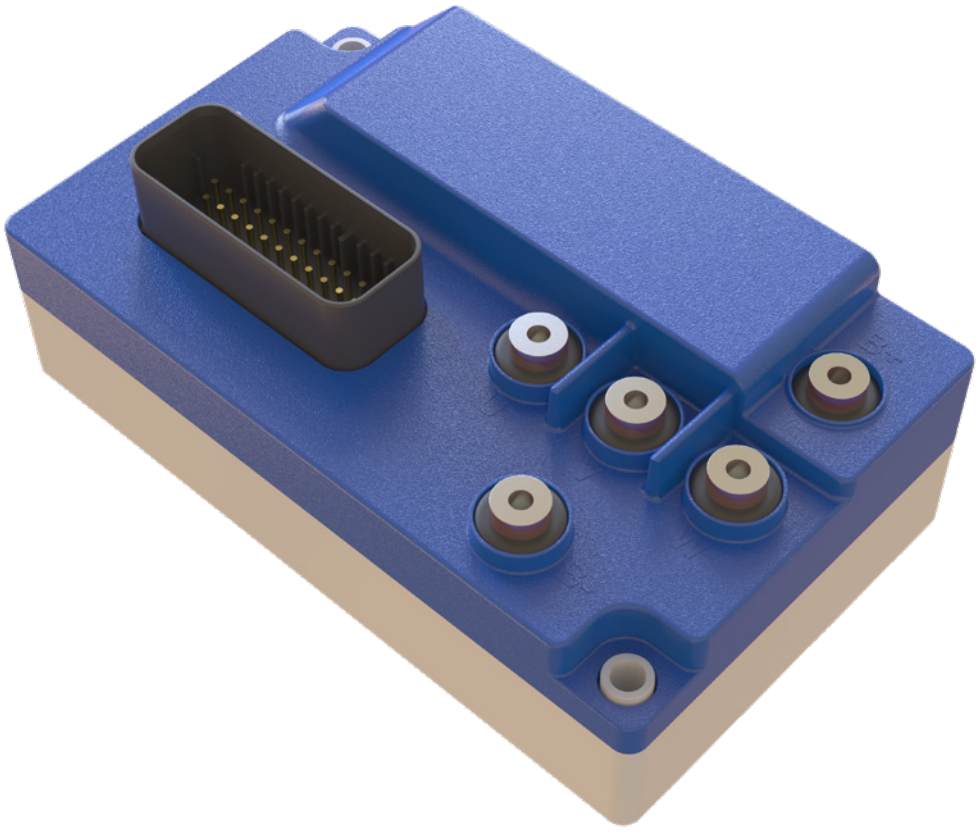
SERVICE MANUAL | rev 1 - 02/2021

7BL00100
MICROPROCESSOR CONTROLLER FOR BRUSHLESS MOTORS



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1. SAFETY INSTRUCTIONS

The controls described in this manual are to be considered and are sold as finished products to be installed only by qualified personnel. Installation must be done in accordance with all safety regulations for the prevention of risks and accidents applicable in the country of use.

Notes before energizing:
The controls for electric motors are able to produce high forces and rapid movements, therefore a high degree of attention is required in their use, especially in the installation and application development phases.
The controls must be installed in a closed electrical panel so that none of its parts can be reached in the presence of voltage.

Working on electric vehicles is potentially dangerous. Take all available precautions against burns, direct contact or inhalation of acids, etc. (wear safety glasses, gloves, etc.).
Always follow the recommendations provided by the manufacturer of the batteries as they can deliver high currents in the event of short circuits: completely disconnect the batteries before any intervention on the system (wiring operations, checks on connections and various operations).

Controls for moving electric vehicles could cause you to lose control and create dangerous situations.
Disconnect the traction motor or lift the vehicle (also make other motors that could cause damage to persons or property in appropriate safety) before starting any work on the circuits / connections.

The controls are protected against moisture by surface painting and direct circuit contacts with a partially open cover.
Place the controls in a dry, clean and ventilated position; avoid contact, in any form, with liquids such as water, detergents, acids, oxides, etc.
The controls are high-powered devices and include various safety management of the electric vehicle.

The complete safety of the application cannot be left to control alone but must be integrated with the risk analysis of the entire system by the manufacturer of the final machine.

Provide suitable fuses, battery disconnect switches (power switches, contactors, etc.), safety electro-brakes or mechanical brakes and any other external component to safeguard the system and increase the safety level of the electric vehicle.
In the event of a breakdown or serious alarm, assess in relation to the application whether the action of disconnecting power from the motors is the best solution in terms of vehicle safety.

Avoid excessive length connections between controls, power source and motors.

The controls use the high-frequency PWM technology which may produce electromagnetic disturbances, partially already filtered inside the circuits but which may not be sufficient in the final system due to the complexity or execution of the system itself. It is advisable to build the system with cables of reduced length and to appropriately separate the power cables from the signal ones. If necessary, use shielded cables or external filters to reduce electromagnetic disturbances.

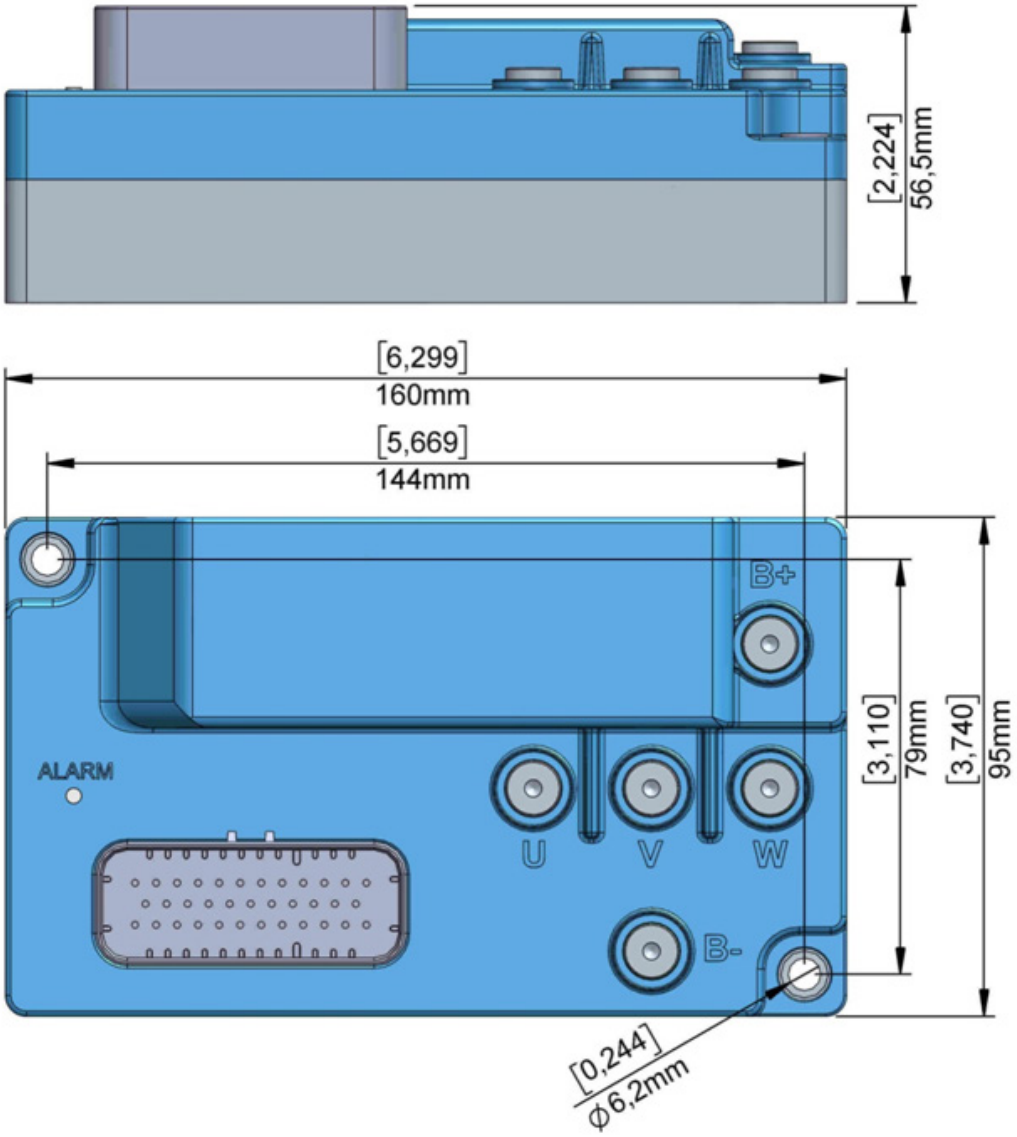
2. INTRODUCTION

The 7BL00100 is a controller for brushless PM motors for 24V - 48V battery powered industrial-trucks.
The controller is equipped with two powerful microcontrollers: main microcontroller for digital control, alarms management, parameters settings; second microcontroller for safety monitoring functions.
The controller is designed in accordance with the EC standards involved in the application.

2a. Features

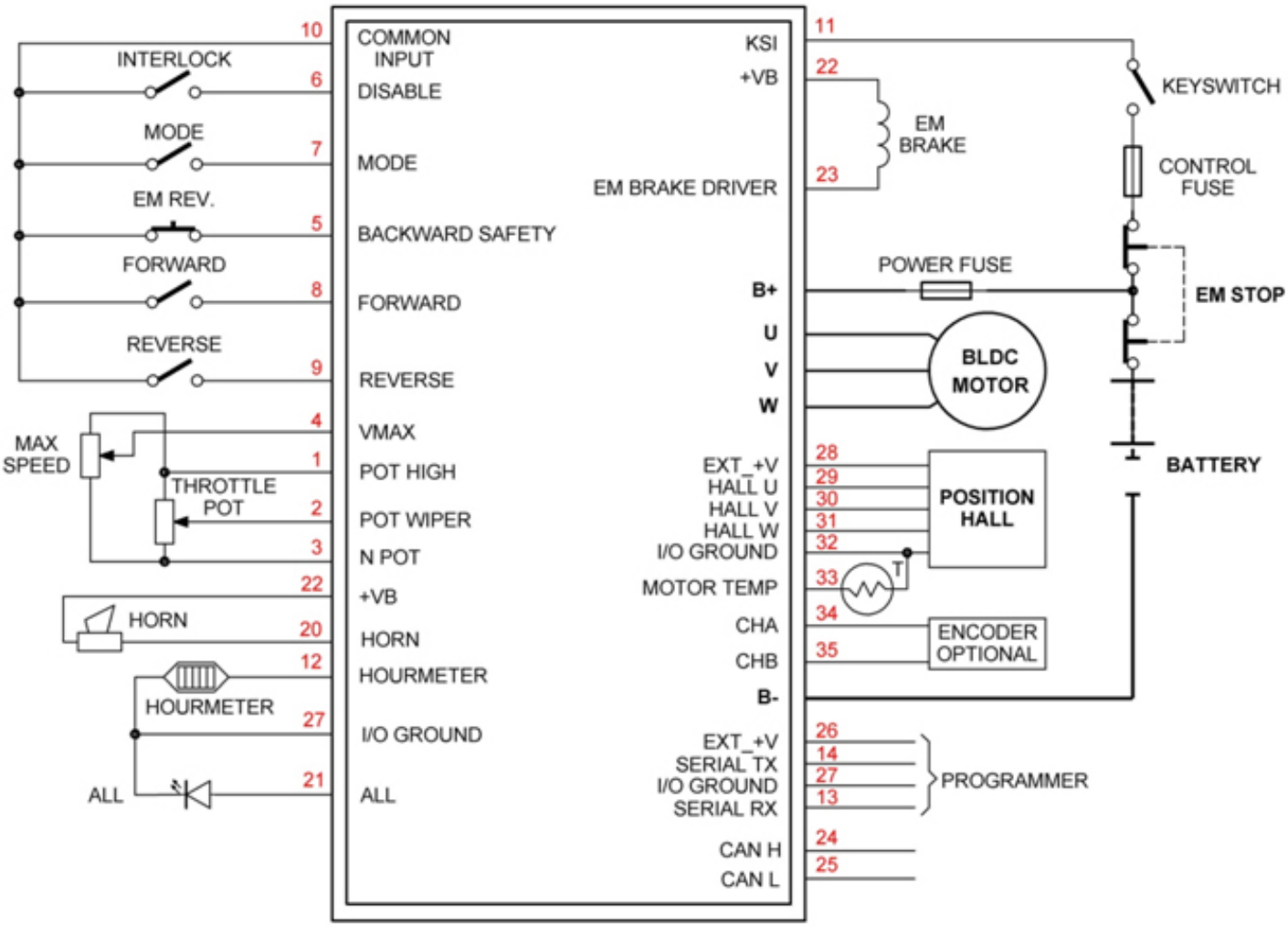
Supply (battery)	24V	36/48V
Rated current (60min)	45Arms	35Arms
Max current (1min) (@25°c)	110Arms	90Arms
Frequency	16kHz	
Max heatsink temperature	90°C	
Operating temperature	-20°C / 50°C	
Speed reference	Voltage (0-5VDC/10VDC) / Potentiometer 1-10KΩ	
Regenerative breaking	Only for battery applications	
On board main relay	24V-70A (rated) / 140A (overload 1')	
Protection	IP65	
Communication	CANBUS	
Functional safety	Designed in compliance to EN 1175-1	
Emc	EN61000-6-3; EN61000-6-2	
UI	Designed in compliance to UL583 (pending)	
Safety	Reverse battery protection	
	Output short circuit protection	
	Mosfet short circuit protection	
	Thermal protection	
	Low voltage and overvoltage protection	
	Overcurrent protection (function of temperature)	
	Potenziometer and wiring fault	
	Emergency reverse input	
	Motor hall sensors / encoder failure	
	Motor temperature sensor (optional)	
	Electro-brake management	

2b. Mechanical drawing



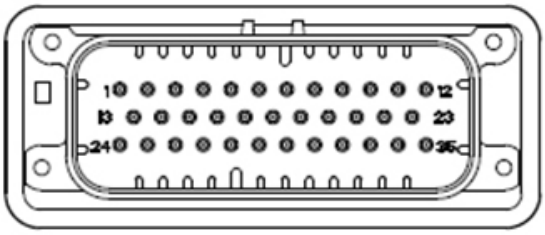
Fix the controller with all the screws on a metal surface (aluminum if possible) to reduce the heat and so for longer working time.

2c. Wiring diagram



3. CONNECTIONS

3a. J1-35 AMPSEAL connector (p/n.776231-1)



Pin 1:	Positive potentiometer supply (output from the board).
Pin 2:	Potentiometer cursor (input to the board).
Pin 3:	Negative potentiometer supply (output from the board).
Pin 4:	Analog input (Vmax).
Pin 5:	Digital input (Backward safety switch).
Pin 6:	Digital input (Disable).
Pin 7:	Digital input (Mode).
Pin 8:	Digital input (Forward switch).
Pin 9:	Digital input (Backward switch).
Pin 10:	Inputs common (output from the board; around 15Vdc).
Pin 11:	Key input (usually +Battery, used to turn on the board).
Pin 12:	Hour meter output (active at around 15Vdc when the motor is driven).
Pin 13:	Programmer RXD.
Pin 14:	Programmer TXD.
Pin 15:	Not used.
Pin 16:	Not used.
Pin 17:	Encoder serial I/O.
Pin 18:	Encoder clock.
Pin 19:	Encoder chip select.
Pin 20:	Horn output (when active is connected to –Battery).
Pin 21:	Alarm led output (positive output for external led).
Pin 22:	+VB positive common for electro-brake/horn
Pin 23:	Electro-Brake output (when active is connected to –Battery).
Pin 24:	CAN-H interface.
Pin 25:	CAN-L interface.
Pin 26:	Positive supply output for Can, Programmer, etc. (+5Vdc).
Pin 27:	Negative supply for Can, Programmer etc. (-Battery).
Pin 28:	Hall sensors positive supply (around +15Vdc).
Pin 29:	Hall A or Enc Z input.
Pin 30:	Hall B or Enc SIN-P input.
Pin 31:	Hall C or Enc COS-P input.
Pin 32:	Negative supply (-Battery).
Pin 33:	Motor temperature probe analog input.
Pin 34:	Enc CHA or SIN-N input.
Pin 35:	Enc CHB or COS-N input.

3b. Power connections

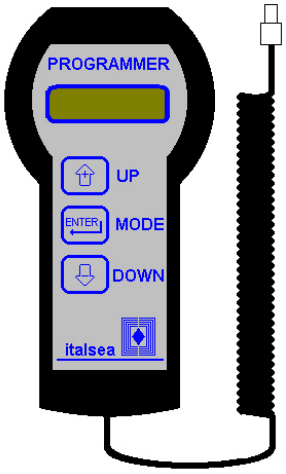
Power connections (+Battery, -Battery, Motor U, V, W), are made with screws:

M5 X 12mm (max 3.5Nm)

4. CONTROLLER SETTING

Controller parameters can be modified through an external programmer (7PROGLCD handheld programmer or Programmer key and mobile app). We will describe the handheld programmer, the interface is exactly the same if using the mobile app.

4a. 7PROGLCD handheld programmer



LCD 16X2	Displays parameters, alarms and measures
UP Key	Rolls up parameters and increases values
MODE Key	Confirms a selection and the change of value
UP Key	Rolls down parameters and decreases values

At power-on, handheld programmer displays the “Tester Mode” pages. In these pages, you’ll find speed reference input, actual speed, output current, battery voltage, overload status, internal aluminum heat-sink temperature, digital inputs and hall/encoder status, motor temperature, hour-meter and software release. Pushing the buttons “UP” and/or “DOWN”, you can move cyclically from one visualization to the other.
To start the programming function push the button “MODE”, and the first parameter will appear; pushing the “UP” button the number of the parameter will be increased and with the “DOWN” button the number will be decreased. To select a parameter, push the button “MODE”: you will enter in the change menu; change the parameter value with the buttons “UP” and “DOWN”, then confirm the value with the button “MODE”; at this point you can again move through the parameters.
To return to the tester menu push together the buttons “MODE” and “UP”. Modified parameters values are saved when you come back to tester menu.
In case of alarm, the programmer displays the alarm number.

5. TESTER MODE

The quantities visualized in the programmer are the following:

SPEED REFERENCE ##.#V ####rpm	Speed reference in Volt (potentiometer) and in rpm.
CURRENT ###Arms SPEED #####rpm	Actual motor current (Arms) and speed (rpm).
BATTERY VOLTAGE ##.#Volt	Battery voltage (Volt).
OVERLOAD LEVEL ##% (at ##Arms)	Overload level (%), actual current level (Arms).
HEATSINK TEMP. ##°C ###°F	Heat-sink temperature (in °C and °F).
J1: #,#,.. ENC: #,#,#,#,#	Main connector active inputs (connector pin number); Hall and encoder status (uppercase, lowercase).
HOURMETER #####hrs, ##min	Working hours and minutes.
MOTOR TEMP. ##°C ###°F	Motor temperature (in °C and °F).
SOFTWARE RELEASE 7BL00100_0.0	Software release.

6. ALARMS

Handheld programmer displays failures or alarms: in the following table there is the list, the meaning of these alarms, and, if possible, how to solve the problem.

Number	Description	What to do
01	Forward or backward switch closed at power on	Open the switch
02	Not used	-
03	Potentiometer fault	Check wirings
04	Reference out of neutral at power on	Move to neutral position or calibrate potentiometer
05	Over-temperature	Wait to cool the controller
06	Power stage	Change the controller
07	Over-current	Control motor connections; eventually change the controller
08	Power fuse, relay	Check power connections, fuse and relay; eventually change the controller
09	Under-voltage	Check battery charge status
10	Over-voltage	Check the battery
11	Overload protection	Check motor parameters: rated current and overload time
12	Disable switch on	Check the switch
13	Key off sequence detected	Check key connection
14	E^2 prom fail	Check parameters; if the alarm is repeated, change the controller
15	Over-speed	Speed too high
16	Hall/Encoder fail	Check the hall sensors or the encoder and their connections

7. PARAMETERS

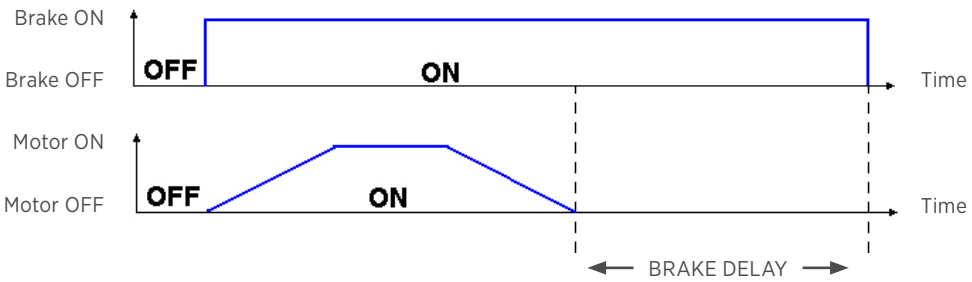
N	Min	Def	Max	Description
0	0	0	1	Default parameter setting (see note 0)
1	0.5	0.5	10.0	Acceleration time from zero to max speed [sec]
2	0.5	0.5	10.0	Deceleration time to reverse from max speed to zero [sec]
3	0.5	1.0	10.0	Deceleration time to stop from max speed to zero [sec]
4	10	200	1000	Minimum speed [rpm]
5	100	3000	10000	Maximum speed with no load [rpm]
6	10	100	100	Forward maximum speed [% of max speed]
7	10	100	100	Backward maximum speed [% of max speed]
8	24	48	48	Nominal battery voltage [Volt]
9	50	75	100	Low battery limit [% of nominal battery voltage]
10	10	40	50	Nominal current [Arms]
11	20	90	95	Maximum current [Arms]
12	100	110	120	Boost current [% of maximum current]
13	10	30	120	Overload protection time [s]
14	0	10	15	Boost time [s]
15	SE	SE	F-B	Reference type (see note 1)
16	30	100	500	Potentiometer dead band [mV]
17	24	24	48	Electro-brake voltage [V]
18	0.0	1.0	30.0	Electro-brake delay [s]
19	10	70	100	Mode 1 current limit [% of current limit]
20	10	50	100	Mode 1 maximum speed [% of max speed]
21	0	3.0	5.0	Backward safety time [s]
22	3	30	50	Backward safety speed [% of max speed]
23	90	120	150	Motor maximum temperature [°C]
24	CW	CW	CCW	Motor direction (see note 2)
25	NO	NO	NC	Disable input configuration (see note 3)
26	NO	NC	NC	Backward safety input configuration (see note 3)
27	NO	NO	NC	Multi-mode input configuration (see note 3)
28	PD	PD	PU	Disable input pull-up/down (see note 4)
29	PD	PD	PU	Backward safety input pull-up/down (see note 4)
30	PD	PD	PU	Multi-mode input pull-up/down (see note 4)
31	PD	PD	PU	Forward direction input pull-up/down (see note 4)
32	PD	PD	PU	Backward direction input pull-up/down (see note 4)
33	ENA	ENA	DIS	Enable alarm 01 (see note 5)
34	ENA	ENA	DIS	Enable alarm 03 (see note 5)
35	ENA	ENA	DIS	Enable alarm 04 (see note 5)
36	ENA	ENA	DIS	Enable alarm 12 (see note 5)
37	0	0	30000	Password to access reserved parameters (see note 6)

N	Min	Def	Max	Description
38	1	60	30000	Current loop proportional gain
39	1	15	30000	Current loop integral gain
40	1	100	30000	Speed loop proportional gain
41	1	20	30000	Speed loop integral gain
42	10	300	500	Speed filter time constant
43	0	80	30000	Flux weakening integral gain
44	1	95	100	Anti-windup for small movements gain
45	1	4	32	Motor number of polar couples
46	0	30	30000	Motor stator resistance [Ohm/1000]
47	0	20	30000	Motor synchronous inductance [Hen/100000]
48	0	180	30000	Motor permanent magnets flux [Web/10000]
49	0	0	30000	Not used
50	NOR	NOR	REV	Hall sensors active status (see note 7)
51	DIS	DIS	E+R	Encoder enable (see note 8)
52	16	32	256	Encoder pulses per revolution per channel
53	10	30	1000	Speed dead-band [% of minimum hardware speed]
54	0	0	30000	Not used
55	800	1000	1200	Bus voltage reading adjustment [1/1000]
56	800	1000	1200	Motor current reading adjustment [1/1000]
57	NOR	NOR	REV	Reference direction (in wig-wag) (see note 7)
58	0	0	4095	Max potentiometer backward [bit]
59	0	320	4095	Stop potentiometer [bit]
60	0	3520	4095	Max potentiometer forward [bit]
61	0	0	3599	Hour-meter: seconds [s]
62	0	0	60000	Hour-meter: hours [h]
63	0	0	60000	Number of switches off

Note 0:	To reset all parameters to their default value, write 1 in par. 0; at reset the default parameters values will be loaded.
Note 1:	Single Ended (SE): potentiometer with two direction switches;
	0-Vmax (0-VM): analogical voltage signal with two direction switches;
	Wig-Wag 1 (WW1): potentiometer with central stop position and enable switch;
	Wig-Wag 2 (WW2): potentiometer with central stop position, without enable switch;
	Forward/Backward (F-B): fixed speed (given by parameters 5 and 6) selected with two direction switches.
Note 2:	Clockwise (CW), Counter-clockwise (CCW).
Note 3:	Normally Open (NO), Normally Closed (NC).
Note 4:	Pull Down (PD), Pull Up (PU).
Note 5:	Enable(ENA), Disable (DIS).
Note 6:	Password value (ask to your Italsea reference).
Note 7:	Normal (NOR), Reversed (REV).
Note 8:	Disabled (DIS), Enabled (ENA), Enabled + Reversed (E+R).

8. ELECTROBRAKE DELAY MEANING

Controller supplies the electro-brake coil when the motor is running: the coil is powered-off with delay when the speed reference and direction switches are in stop position. The value of the delay is regulated by parameter 15.



9. SPEED REFERENCE CALIBRATION

When changing the speed reference selection parameter (par. 13), a special mode is entered to tune the input channel; depending on the choice, you have different possibilities:

9a. Single ended calibration

CALIBRATION STOP POS = ##.#V	Put the potentiometer in the zero position; Press the MODE key to confirm.
CALIBRATION MAX POS = ##.#V	Put the potentiometer in the max position; Press the MODE key to confirm.

9b. Voltage 0-Max calibration

CALIBRATION STOP POS = ##.#V	Set the voltage reference at its stop value; Press the MODE key to confirm.
CALIBRATION MAX POS = ##.#V	Set the voltage reference at its max value; Press the MODE key to confirm.

9c. Wig-wag 1 and 2 calibration

CALIBRATION STOP POS = ##.#V	Put the potentiometer in the zero position; Press the MODE key to confirm.
CALIBRATION MAXBW POS= ##.#V	Put the potentiometer in the max backward position; Press the MODE key to confirm.
CALIBRATION MAXFW POS= ##.#V	Put the potentiometer in the max forward position; Press the MODE key to confirm.

10. BACKWARD SAFETY

This function operates in backward direction as a safety function for the operator. It is realized by mean of a contact which activates the function when switched: the machine will immediately decelerate (at 4 times the selected inversion rate), will reverse the direction at a programmed speed for the programmed time (if the time is not zero), then it will stop. The normal operation is re-activated resetting the reference input and the switch. The parameter to regulate this function are par. 18 (backward safety time) and par. 19 (backward safety speed).

11. OVERLOAD PROTECTION

This protection is always active and is based on the three parameters: nominal current (par. 10, I_{NOM}; the current which can be sustained indefinitely by the control) current limit (par. 11, I_{MAX}; the maximum admitted current) and overload time (par. 12, T_P; the protection base time). The protection works in this way: first, a value is calculated as:

$$MAX = T_P\,(I_{MAX}-I_{NOM})^2$$

then in runtime a value is constantly calculated:

$$VAL(t) = \int_0^t (I_{RMS}\,(x) - I_{NOM})^2\,dx$$

where $I_{RMS}(t)$ is the actual current rms value. VAL(t) is clamped at zero if it becomes negative. When VAL(t) becomes greater than MAX, the overload alarm is generated. The overload status is, in every moment, the following:

$$100\left(\frac{VAL\,(t)}{MAX}\right)\%$$

Temperature influences the formula, reducing the integration time; if temperature TEMP(t) is higher than 50°C then the following modification is applied to the formula:

$$VAL(t) = \int_0^t (1.0 + 0.1(TEMP(x) - 50))\,(I_{RMS}\,(x) - I_{NOM})^2\,dx$$

For example is temperature is 80°C, the time to alarm is reduced 4 times.

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