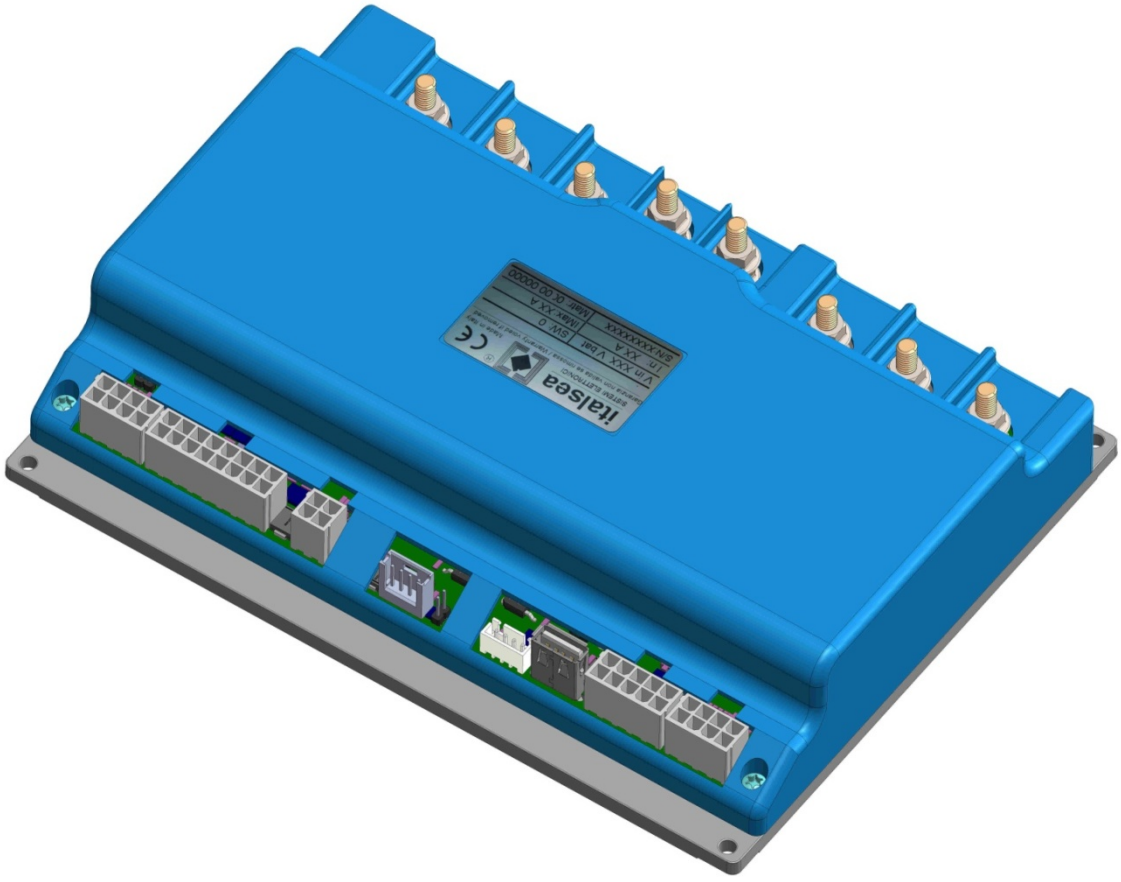
7CH2D090

MICROPROCESSOR CONTROLLER FOR 2 BRUSHLESS MOTORS



USER'S GUIDE

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- CONTENTS -

- INTRODUCTION -

The 7CH2D090 is a controller for 2 brushless PM motors for 24V-36V-48V battery powered industrial vehicles, capable of automatic steering.
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.

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- FEATURES -

SUPPLY (BATTERY)	24V-36V-48V
RATED CURRENT/CHANNEL(60min)	35Arms
MAX CURRENT/CHANNEL (1min) (25°C)	90Arms
FREQUENCY	16kHz
MAX HEATSINK TEMPERATURE	90°C
OPERATING TEMPERATURE	-20°C / 50°C
SPEED/STEERING REFERENCES	Voltage (0-5VDC/10VDC) / Potentiometer 1-10K Joystick, Modbus, CAN
REGENERATIVE BREAKING	ONLY FOR BATTERY APPLICATIONS
ON BOARD MAIN RELAY	24V-70A (rated) / 140A (overload 1')
PROTECTION	IP65
COMMUNICATION	CAN, Modbus, Bluetooth
PROGRAMMABLE PARAMETERS	By programmer 7PROGLCD or by mobile App
OPERATING MODE	Sinusoidal with Hall sensors or encoder or sin/cos
FUNCTIONAL SAFETY	DESIGNED IN COMPLIANCE TO EN 1175-1
EMC	EN61000-6-3; EN61000-6-2

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

APPLICATIONS:	Electrical Vehicles, AGV

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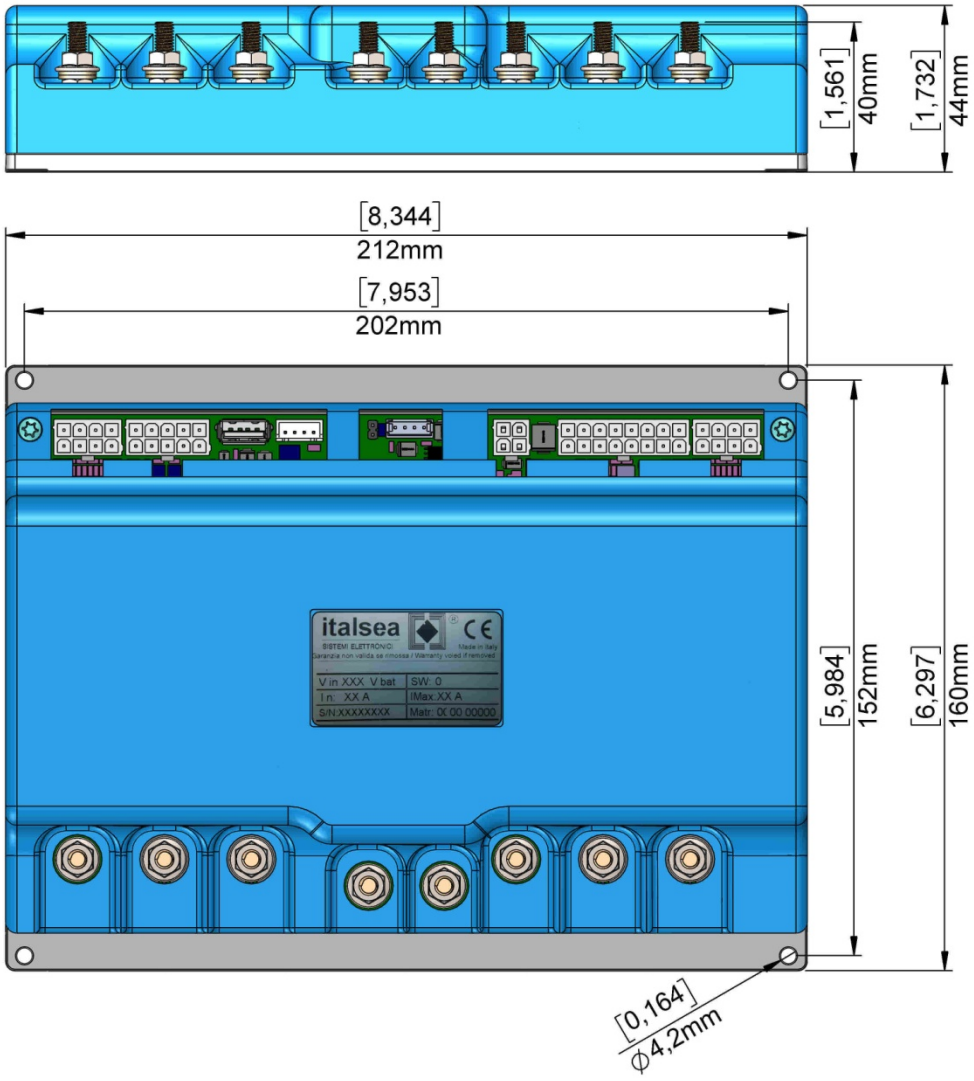
- MECHANICAL DRAWING -



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

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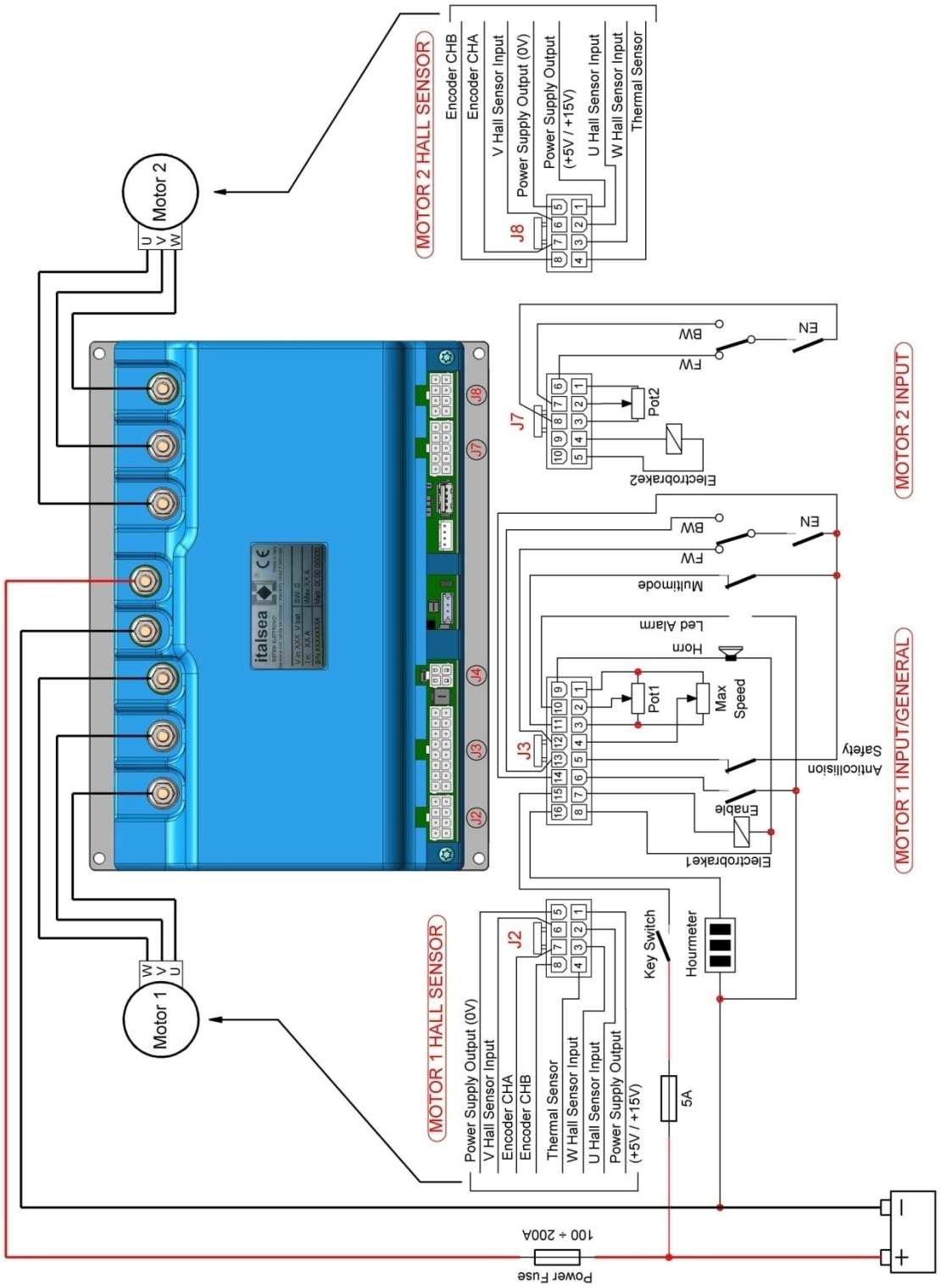
- WIRING DIAGRAM -



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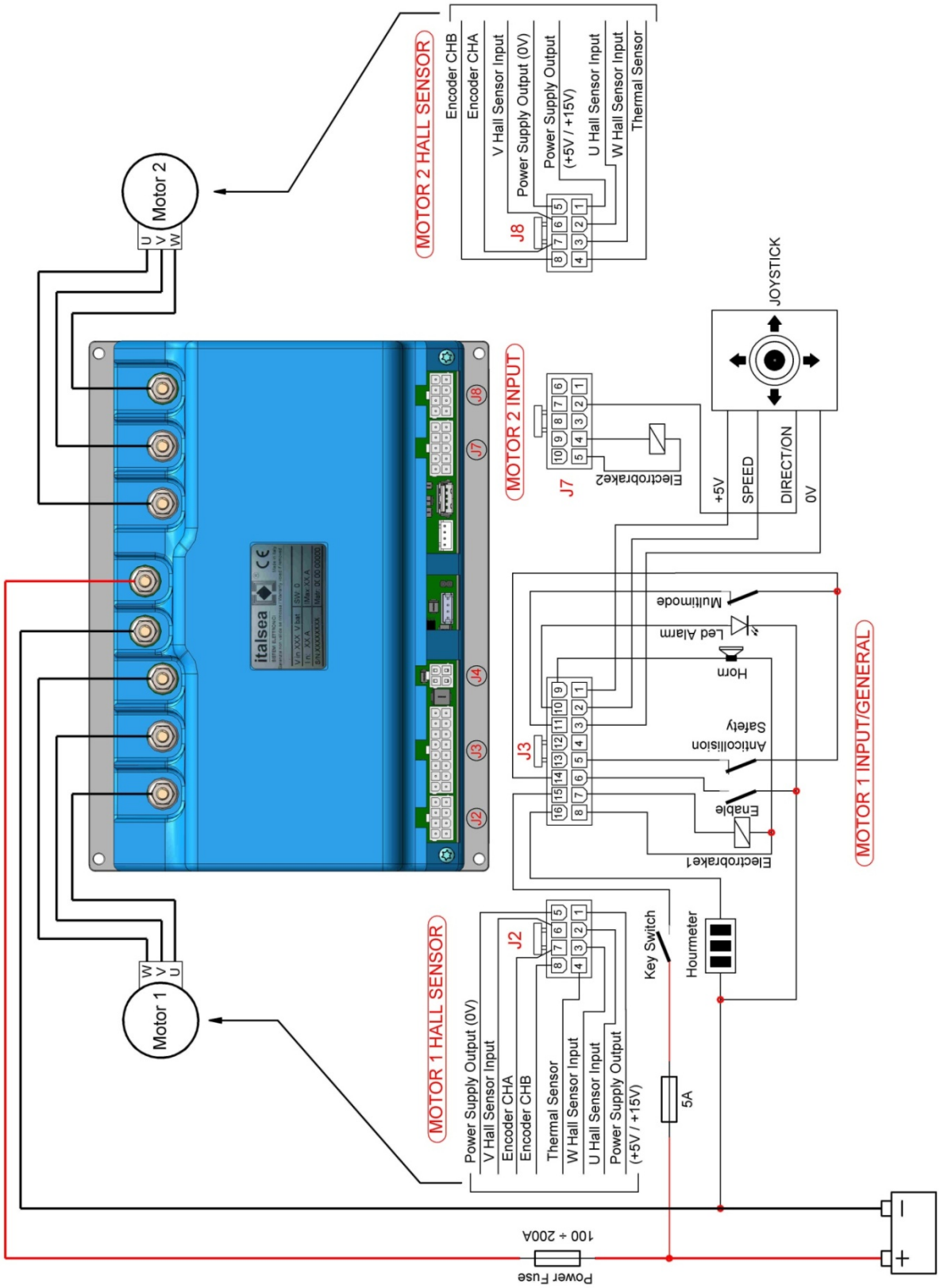

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- CONNECTIONS -

J3 MOLEX-8-8M CONNECTOR (p/n.XXX)

Pin 1:	**Positive potentiometer 1 supply (output from the board).**
Pin 2:	**Potentiometer 1 cursor (Speed ref .1 input to the board).**
Pin 3:	**Negative potentiometer 1 supply (output from the board).**
Pin 4:	**Analog input (Vmax).**
Pin 5:	**Digital input (Backward safety switch).**
Pin 6:	**Digital input (Enable).**
Pin 7:	**Electro-brake 1 output (when active is connected to –Battery).**
Pin 8:	**Positive supply for electro-brake and horn (+Battery).**
Pin 9:	**Horn output (when active is connected to –Battery).**
Pin 10:	**Alarm led output (positive output for external led).**
Pin 11:	**Digital input (Multi-mode).**
Pin 12:	**Digital input (Forward 1 switch).**
Pin 13:	**Digital input (Backward 1 switch).**
Pin 14:	**Positive supply output (for digital inputs; connected to key input).**
Pin 15:	**Key input (used to switch on the controller).**
Pin 16:	**Hour meter output (active when motors are driven).**

J7 MOLEX-5-5M CONNECTOR (p/n.XXX)

Pin 1:	**Positive potentiometer 2 supply (output from the board).**
Pin 2:	**Potentiometer 2 cursor (Speed ref .2 input to the board).**
Pin 3:	**Negative potentiometer 2 supply (output from the board).**
Pin 4:	**Digital input (Optional).**
Pin 5:	**Electro-brake 2 output (when active is connected to –Battery).**
Pin 6:	**Positive supply for electro-brake (+Battery).**
Pin 7:	**Digital input (Forward 2 switch).**
Pin 8:	**Digital input (Backward 2 switch).**
Pin 9:	**Positive supply output (for digital inputs; connected to key input).**
Pin 10:	**Not used.**

J4 MOLEX-2-2M CONNECTOR (p/n.XXX)

Pin 1:	**TX for serial communication with 7proglcd (7proglcd RX).**
Pin 2:	**RX for serial communication with 7proglcd (7proglcd TX).**
Pin 3:	**Positive supply for 7proglcd (+5V).**
Pin 4:	**Negative supply for 7proglcd (-Battery).**

J2 MOLEX-4-4M CONNECTOR (p/n.XXX)

Pin 1:	**Hall sensors / Encoder positive supply (+5Vdc).**
Pin 2:	**Hall1 U / Enc1 SIN input.**
Pin 3:	**Hall1 W / Enc1 Z.**
Pin 4:	**Motor1 thermal sensor input.**
Pin 5:	**Negative supply (-Battery).**
Pin 6:	**Hall1 V / Enc1 COS input.**
Pin 7:	**Enc1 A / Enc1 serial I/O**
Pin 8:	**Enc1 B / Enc1 serial clock.**

J8 MOLEX-4-4M CONNECTOR (p/n.XXX)

Pin 1:	**Hall sensors / Encoder positive supply (+5Vdc).**
Pin 2:	**Hall2 U / Enc2 SIN input.**
Pin 3:	**Hall2 W / Enc2 Z.**
Pin 4:	**Motor 2 thermal sensor input.**
Pin 5:	**Negative supply (-Battery).**
Pin 6:	**Hall2 V / Enc2 COS input.**
Pin 7:	**Enc2 A / Enc2 serial I/O**
Pin 8:	**Enc2 B / Enc2 serial clock.**

J5 MODU-2-4M CONNECTOR (p/n.XXX)

Pin 1:	**Negative supply (-Battery).**
Pin 2:	**CANL I/O.**
Pin 3:	**CANH I/O.**
Pin 4:	**CAN positive supply (+5V).**

J6 JST-B4B-XH-A CONNECTOR (p/n.XXX)

Pin 1: Negative supply (-Battery).
Pin 2: Board serial programming TX (programmer RX).
Pin 3: Board serial programming RX (programmer TX).
Pin 4: Programming serial communication positive supply (+5V).

JUSB 664-001K-AB-L CONNECTOR (p/n.XXX)

Pin 1: USB positive supply (+5V).
Pin 2: USB-DM.
Pin 3: Board USB-DP.
Pin 4: USB negative supply (-Battery).

POWER CONNECTIONS

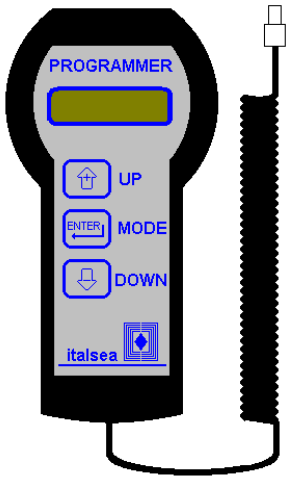
Power connections (+Battery, -Battery, U1, V1, W1, U2, V2, W2), are made with bolts and nuts:

M5

- 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.

7PROGLCD HANDHELD PROGRAMMER



LCD 16X2:
Displays parameters, alarms and measures.

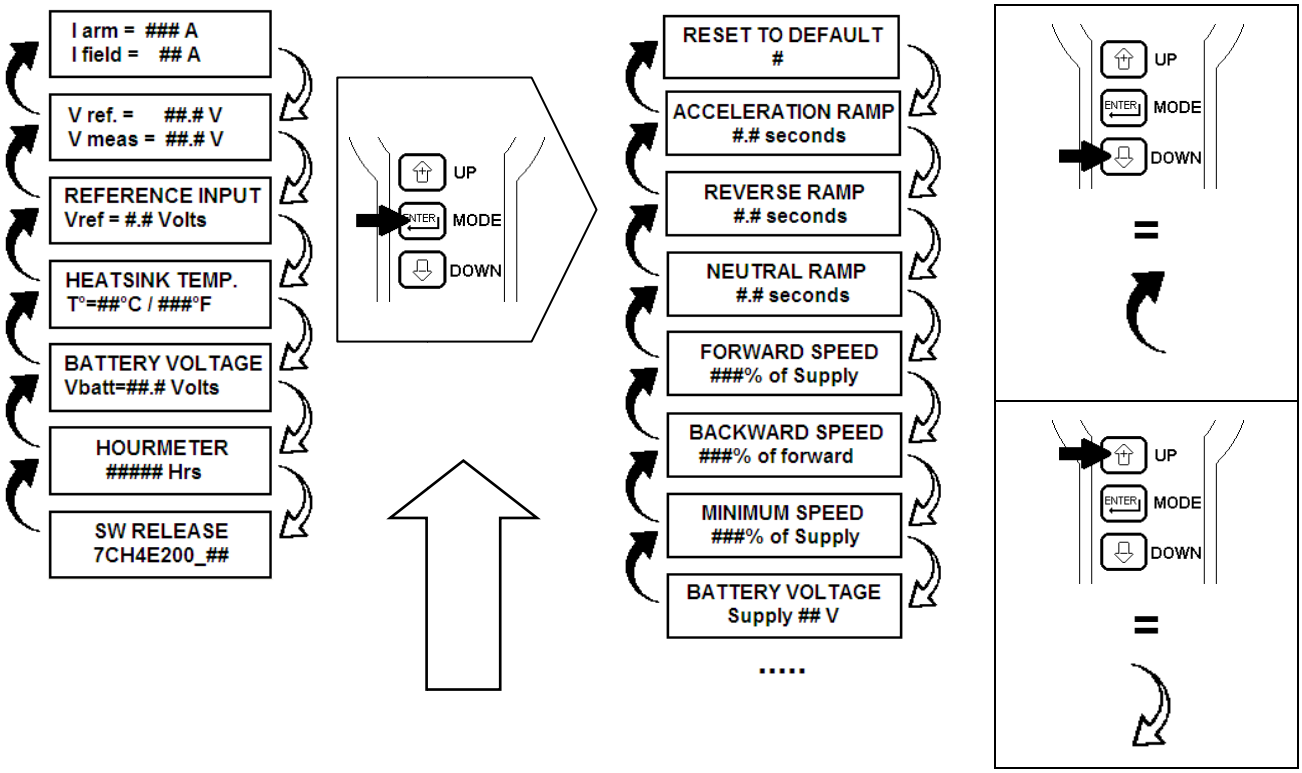
UP Key:
Rolls up parameters and increases values.

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.

Sequences example:



- TESTER MODE -

SOFTWARE RELEASE 7CH2D090_0.0	Software release.
MOTOR TEMP. 2 ##°C ###°F	Motor 2 temperature (in °C and °F).
MOTOR TEMP. 1 ##°C ###°F	Motor 1 temperature (in °C and °F).
HOURMETER #####hrs, ##min	Working hours and minutes.
HEATSINK TEMP. ##°C ###°F	Heatsink temperature (in °C and °F).
J7: #,#,.. E2: A,B,U,V,W	J7 connector active inputs (connector pin number); Hall and encoder 2 status (uppercase, lowercase).
J1: #,#,.. E1: A,B,U,V,W	J1 connector active inputs (connector pin number); Hall and encoder 1 status (uppercase, lowercase).
OVERLOAD LEV. 2 ##% (at ##Arms)	Overload level 2 (%), actual current 2 level (Arms).
OVERLOAD LEV. 1 ##% (at ##Arms)	Overload level 1 (%), actual current 1 level (Arms).

CUR 1: ##Arms CUR 2: ##Arms

Motor 1 current [Arms].
Motor 2 current [Arms].

SPE 1: ####rpm SPE 2: ####rpm

Motor 1 actual speed [rpm].
Motor 2 actual speed [rpm].

REF 1: ####rpm REF 2: ####rpm

Motor 1 speed reference [rpm].
Motor 2 speed reference [rpm].

POT 1: ##.#V POT 2: ##.#V

Potentiometer 1 voltage (speed reference).
Potentiometer 2 voltage (steering reference).

BATTERY VOLTAGE ##.#Volt

Battery voltage (Volt).

- ALARMS –

Handheld programmer displays eventual 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^2prom fail	Check parameters; if the alarm is repeated, change the controller
15	Not used	-
16	Hall/Encoder fail	Check the hall sensors or the encoder and their connections

- PARAMETERS -

N	MIN	DEF	MAX	DESCRIPTION
0	0	0	1	Default parameters setting (see note 0)
1	24	24	48	**BATTERY VOLTAGE**: nominal battery voltage [V]
2	50	75	100	**LOW BATTERY**: low battery limit [%]
3	0	0	32767	**OPTIONAL 3**
4	0	0	32767	**OPTIONAL 4**
5	0.5	5.0	10.0	**ACCELER. RAMP. 1** : acceleration time from zero to max speed [sec]
6	0.5	3.0	10.0	**NEUTRAL RAMP. 1** : deceleration time from max speed to zero [sec]
7	0.5	3.0	10.0	**REVERSE RAMP. 1**: deceleration time from max speed to zero in inversion [sec]
8	100	2200	10000	**MAXIMUM SPEED 1**: nominal speed with no load [rpm]
9	10	100	1000	**MINIMUM SPEED 1**: minimum speed [rpm]
10	10	100	100	**FW SPEED 1**: forward maximum speed [% of nominal speed]
11	10	100	100	**BW SPEED 1**: backward maximum speed [% of nominal speed]
12	0.0	1.0	10.0	**BRAKE DELAY 1:** Electro brake 1 delay [sec]
13	S-E	W-2	F-B	**SPEED REF. 1:** reference 1 type (see note 1)
14	30	100	500	**REF. DEADBAND 1**: Potentiometer 1 deadband [mV]
15	RIGHT	RIGHT	REV	**REF. DIR. 1:** reference 1 direction (in wigwag) (see note 7)
16	10	30	50	**RATED CURRENT 1:** motor 1 nominal current [Arms]
17	20	40	75	**CURRENT LIMIT 1:** motor 1 current limit [Arms]
18	1	10	120	**OVERLOAD TIME 1:** motor 1 overload protection time [sec]
19	80	120	150	**MOT. MAX TEMP. 1:** motor 1 maximum temperature [°C]
20	CW	CW	CCW	**MOT. DIR. 1 :** motor 1 direction (see note 2)
21	0	0	32767	**OPTIONAL 21**
22	0	0	32767	**OPTIONAL 22**
23	0	0	32767	**OPTIONAL 23**
24	0	0	32767	**OPTIONAL 24**
25	0.0	0.5	10.0	**STEERING ACCEL**. : Steering acceleration from zero to max [sec]
26	1	20	50	**STEERING SPEED** : Steering speed [%]
27	0	0	32767	**OPTIONAL 27**
28	0	0	32767	**OPTIONAL 28**
29	0	0	32767	**OPTIONAL 29**
30	0	0	32767	**OPTIONAL 30**
31	0	0	32767	**OPTIONAL 31**
32	0	0	32767	**OPTIONAL 32**
33	S-E	W-2	F-B	**SPEED REF. 2:** reference 2 type (see note 1)
34	30	100	500	**REF. DEADBAND 2:** potentiometer 2 deadband [mV]
35	RIGHT	RIGHT	REV	**REF. DIR. 2:** reference 2 direction (in wigwag) (see note 7)
36	10	30	50	**RATED CURRENT 2:** motor 2 nominal current [Arms]
37	20	40	75	**CURRENT LIMIT 2:** motor 2 current limit [Arms]
38	1	10	120	**OVERLOAD TIME 2:** motor 2 overload protection time [sec]
39	80	120	150	**MOT. MAX TEMP. 2:** motor 2 maximum temperature [°C]
40	CW	CCW	CCW	**MOT. DIR. 2 :** motor 2 direction (see note 2)

41	0	0	32767	**OPTIONAL 41**
42	0	0	32767	**OPTIONAL 42**
43	0	0	32767	**OPTIONAL 43**
44	0	0	32767	**OPTIONAL 44**
45	20	50	100	**MODE 1 SPEED**: % of nominal speed
46	20	50	100	**MODE 1 CURRENT**: % of lower current limit
47	0	0	32767	**OPTIONAL 47**
48	0	0	32767	**OPTIONAL 48**
49	0	0	32767	**OPTIONAL 49**
50	N.O	N.C	N.C	**BW SAF. HW CONF**: Backward safety input configuration, N.C. switch (see note 3)
51	N.O	N.C	N.C	**MMODE HW CONF.:** Multi-mode input configuration, N.C. switch(see note 3)
52	0	0	1	**PULL UP/DOWN A:** speed inputs (see note 4)
53	0	0	1	**PULL UP/DOWN B**: ausiliary inputs (see note 4)
54	EN	EN	DIS	**ENABLE ALARM 1**: enable alarm 01 (see note 5)
55	EN	DIS	DIS	**ENABLE ALARM 3:** disable alarm 03 (see note 5)
56	EN	EN	DIS	**ENABLE ALARM 4:** enable alarm 04 (see note 5)
57	EN	DIS	DIS	**ENABLE ALARM 12:** disable alarm 12 (see note 5)
58	0	0	32767	**OPTIONAL 58**
59	0	0	32767	**OPTIONAL 59**
60	0	0	30000	**Password** (see note 6)

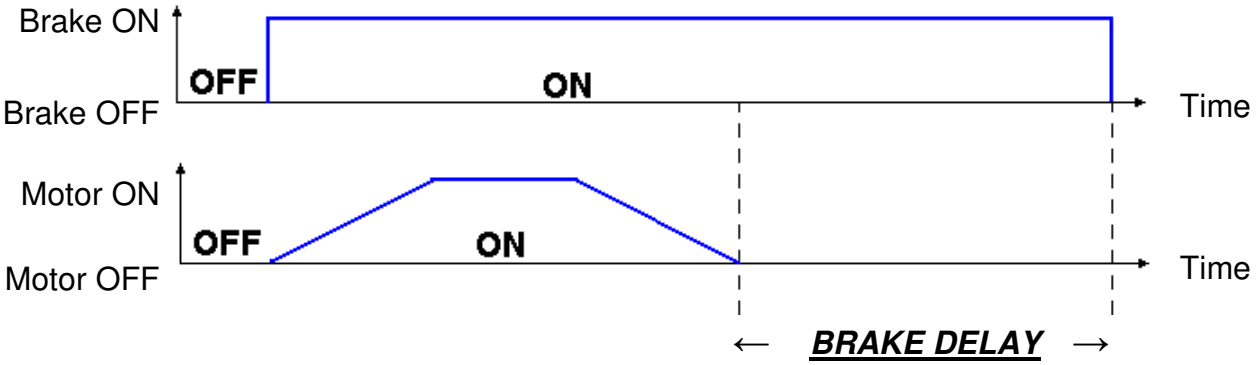
N	MIN	DEF	MAX	DESCRIPTION
61	1	4	24	Motor 1 number of polar couples
62	0	17	30000	Motor 1 stator resistance [Ohm/1000]
63	0	4	30000	Motor 1 synchronous inductance [Henry/100000]
64	0	145	30000	Motor 1 permanent magnets flux [Weber/10000]
65	0	150	30000	Motor 1 current loop proportional gain
66	0	30	30000	Motor 1 current loop integral gain
67	0	200	30000	Motor 1 speed loop proportional gain
68	0	50	30000	Motor 1 speed loop integral gain
69	10	200	1000	Motor 1 speed filter time constant
70	0	200	30000	Motor 1 flux weakening integral gain
71	0	0	32767	-
72	0	0	32767	-
73	0	0	32767	-
74	0	0	32767	-
75	NOR	NOR	REV	Motor 1 hall sensors active status (see note 7)
76	DIS	DIS	REV	Motor 1 encoder enable (see note 8)
77	8	256	4096	Motor 1 encoder pulses per revolution per channel
78	0	25	1000	Motor 1 speed deadband [% of minimum hardware speed]
79	50	95	100	Motor 1 small movements anti-windup gain
80	0	0	32767	-
81	0	0	32767	-
82	0	-	4095	Maximum potentiometer 1 backward [bit]
83	0	-	4095	Stop potentiometer 1 [bit]
84	0	-	4095	Maximum potentiometer 1 forward [bit]
85	0	0	32767	-
86	0	0	32767	-
87	0	0	32767	-
88	0	0	32767	-
89	0	0	32767	-
90	0	0	32767	-
91	0	4	24	Motor 2 number of polar couples
92	0	17	30000	Motor 2 stator resistance [Ohm/1000]
93	0	4	30000	Motor 2 synchronous inductance [Henry/100000]
94	0	145	30000	Motor 2 permanent magnets fux [Weber/10000]
95	0	150	30000	Motor 2 current loop proportional gain
96	0	30	30000	Motor 2 current loop integral gain
97	0	200	30000	Motor 2 speed loop proportional gain
98	0	50	30000	Motor 2 speed loop integral gain
99	10	200	1000	Motor 2 speed filter time constant
100	0	200	30000	Motor 2 flux weakening integral gain
101	0	0	32767	-
102	0	0	32767	-
103	0	0	32767	-

104	0	0	32767	-
105	NOR	NOR	REV	Motor 2 hall sensors active status 2 (see note 7)
106	DIS	DIS	REV	Motor 2 encoder enable (see note 8)
107	8	256	4096	Motor 2 encoder pulses per revolution per channel
108	0	25	1000	Motor 2 speed deadband [% of minimum hardware speed]
109	50	95	100	Motor 2 small movements anti-windup gain
110	0	0	32767	-
111	0	0	32767	-
112	0	-	4095	Maximum potentiometer 2 backward [bit]
113	0	-	4095	Stop potentiometer 2 [bit]
114	0	-	4095	Maximum potentiometer 2 forward [bit]
115	0	0	32767	-
116	0	0	32767	-
117	0	0	32767	-
118	0	0	32767	-
119	0	0	32767	-
120	0	0	32767	-
121	800	1000	1200	Bus voltage reading adjustment [1/1000]
122	800	1000	1200	Motor current reading adjustment [1/1000]
123	0	0	32767	-
124	0	0	32767	-
125	0	0	3599	Hourmeter seconds [s]
126	0	0	60000	Hourmeter hours [h]
127	0	0	60000	Number of switchs 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).

- 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 12.



- SPEED REFERENCE CALIBRATION -

When changing the speed reference selection parameter (par. 13 or 33), a special mode is entered to tune the input channel; depending on the choice, you have different possibilities:

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.

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.

WIG-WAG 1 AND 2 CALIBRATION

SPEED REF.1 – WIG-WAG 2

CALIBRATION **STOP POS = ##.#V**

Put the potentiometer in the zero position;
Press the MODE key to confirm.

CALIBRATION **MX BACK= ##.#V**

Put the potentiometer in the max backward position;
Press the MODE key to confirm.

CALIBRATION **MX FORW = ##.#V**

Put the potentiometer in the max forward position;
Press the MODE key to confirm.

SPEED REF.2 – WIG-WAG 2

CALIBRATION **STOP POS = ##.#V**

Put the potentiometer in the zero position;
Press the MODE key to confirm.

CALIBRATION **MX LEFT = ##.#V**

Put the potentiometer in the max left position;
Press the MODE key to confirm.

CALIBRATION **MX RIGHT = ##.#V**

Put the potentiometer in the max right position;
Press the MODE key to confirm.

At the end of the procedure verify the references directions: it is possible to change them with the parameters 15 (1) and 35 (2). Considering that also the motors rotating directions are selectable with parameters 20 (1) and 40 (2), all the possible combinations are covered.

- 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. 48 - optional [backward safety time-5] and par. 47- optional [backward safety speed-50]

- OVERLOAD PROTECTION -

This protection is always active and is based on the three parameters: nominal current (par. 16, 36, I_{NOM}; the current which can be sustained indefinitely by the control) current limit (par. 17, 37, I_{MAX}; the maximum admitted current) and overload time (par. 18, 38, 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.