Kelly KBL Brushless Motor Controller User's Manual

Devices Supported:

KBL24101	KBL36101
KBL24151	KBL36151
KBL24201	KBL36201
KBL24301	KBL36301
KBL48101	KBL72101
KBL48151	KBL72151
KBL48201	KBL72201
KBL48301	KBL72301
KBL48401B	KBL72401B
KBL48501B	KBL72501B
KBL12151H	KBL12251H

Rev.3.2
Aug. 2010

Contents

Chapter 1 Introduction

1.1 Overview

The manual introduces Kelly BLDC motor controllers' features, installation and maintenance. Read the manual carefully and thoroughly before using the controller. If you have any questions, please contact the support center of Kelly Controls, LLC.

Kelly's programmable motor controllers provide efficient, smooth and quite controls for golf cart, go-cart, electric motorcycle, forklift, hybrid vehicle, electrical vehicle, electric boat, as well as industry motor speed or torque control. It uses high power MOSFET, PWM to achieve efficiency 99% in most cases. Powerful microprocessor brings in comprehensive and precise control to the controllers. It also allows users to set parameters, conduct tests, and obtain diagnostic information quickly and easily.

Chapter 2 Features and Specifications

2.1 General functions

(1) Extended fault detection and protection. LED flashing for fault code indicates fault sources.
(2) Monitoring battery voltage. It will stop driving if battery voltage is too high. It will cut back then stop driving if voltage is going too low.
(3) Built-in current loop and over current protection.
(4) Motor temperature input and protection. Configurable range.
(5) Cutting back current at low temperature and high temperature to protect battery and controller. The current will ramp down quickly if controller's temperature is higher than 90℃, and shut down at 100℃. Low temperature current ramping down usually starts at 0℃.
(6) The controller keeps monitoring voltage during regen. It will cut back current then cut off regen if voltage is going too high.
(7) Configurable to limit max reverse speed to half of max forward speed.
(8) Configurable and programmable with RS-232. Software upgradeable. Windows GUI provided.
(9) Provide power supply (5V) for hall sensors and other sensors.
(10) 3 switch inputs: Default to throttle switch, brake switch and reverse switch. Closing to ground is to activate.
(11) 3 analog inputs, 0-5V: Default to throttle input, brake input and motor temperature input.
(12) PWMable reverse alarm output. Recirculation diodes provided.
(13) Main contactor driver. Cutting off the power if any fault is detected.
(14)Current meter to display both drive and regen current. Save shunt.
(15)Configurable boost switch. Output can arrive at the maximum current if the switch is enabled and turned on.
(16)Configurable turbo switch. Limiting max power to half if the switch is enabled and turned on.
(17)Configurable max reverse power to half.
(18)Enhanced regen brake function. Novel ABS technique provides powerful and smooth regen.
(19)Configurable 12V brake signal input, instead of motor temperature sensor.
(20)Optional joystick throttle. Single 0-5V signal for both forwarding and reversing
(21)Thermal overload detection and protection to safeguard the motor from over temperature, with recommended Silicon temperature sensors KTY83-122.
(22)3 hall position sensor inputs. Open collector, pull up provided.
(23)Optional CAN bus.
(24)Optional supply voltage 8-30V.

Caution! *Regeneration has braking effect, but can't replace mechanical brake. Mechanical brake is required to stop your vehicle. Regen isn't a safety feature! Controller may stop regen to protect itself (not you!).*

2.2 Features

1) Intelligence with powerful microprocessor.
2) Synchronous rectification, ultra low drop and fast PWM to achieve very high efficiency.
3) Electronic reversing.
4) Voltage monitoring on 3 motor phases, bus, and power supply.
5) Voltage monitoring on voltage source 12V and 5V.
6) Current sense on all 3 motor phases.
7) Current control loop.
8) Hardware over current protection.
9) Hardware over voltage protection.
10) Support torque mode, speed mode, and balanced mode operation.
11) Configurable limit for motor current and battery current.
12) Low EMC.
13) LED fault code.
14) Battery protection: current cutback, warning and shutdown at configurable high and low battery voltage.
15) Rugged aluminum housing for maximum heat dissipation and harsh environment.
16) Rugged high current terminals, and rugged aviation connectors for small signal.
17) Thermal protection: current cut back, warning and shutdown on high temperature.
18) Configurable 60 degree or 120 degree hall position sensors.
19) Support motors with any number of poles.
20) Up to 40,000 electric RPM standard. Optional high speed 70,000 ERPM and ultra high speed 100,000ERPM (Electric RPM = mechanical RPM * motor pole pairs).
21) Support three modes of regenerative braking: brake switch regen, release throttle regen, 0-5V analog signal variable regen.
22) Configurable high pedal protection: Disable operation if power up with high throttle.
23) Current multiplication: Take less current from battery, output more current to motor.
24) Easy installation: 3 wire potentiometer can work.
25) Remove fault code LED driver.
26) Current meter output.
27) Standard PC/Laptop computer to do programming. No special tools needed.
28) User program provided. Easy to use. No cost to customers.

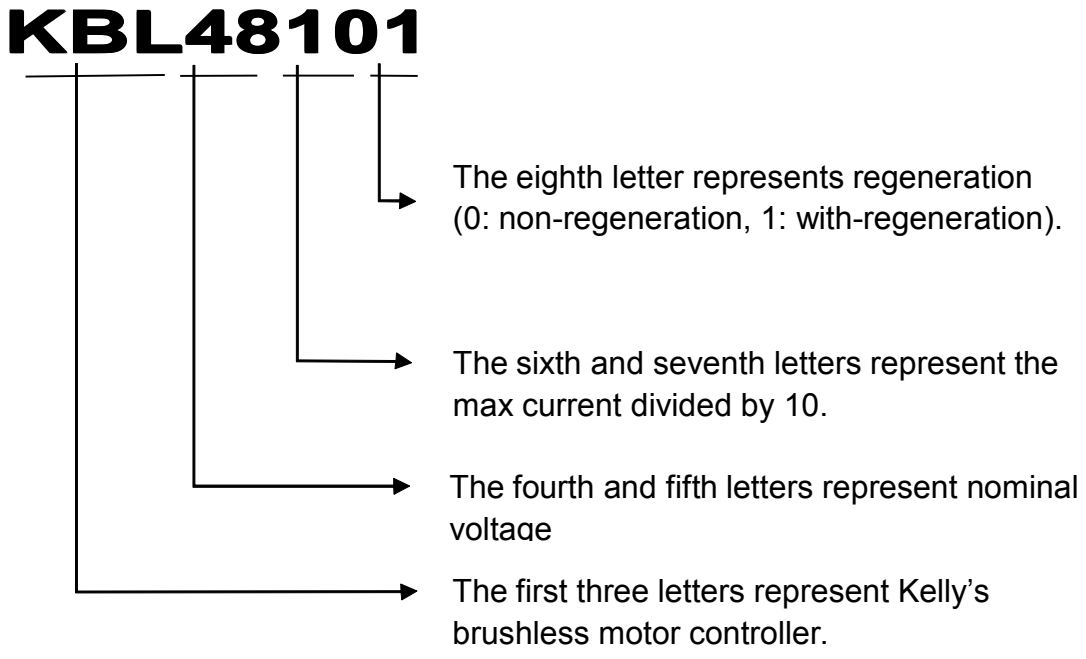
2.3 Specifications

- Frequency of Operation: 16.6kHz.
- Standby Battery Current: < 0.5mA.
- 5V Sensor Supply Current: 40mA.
- Controller supply voltage range, PWR, 8V to 30V for KBL 24V controllers. 18V to 90V for KBL controllers rated equal or lower than 72V. 18V to 136V for KBL-H 120V controllers.
- Configurable battery voltage range, B+. Max operating range: 18V to 1.25*Nominal Voltage for controller rated equal or higher than 36V. 8V to 30V for controller rated equal 24V.

•Standard Throttle Input: 0-5 Volts(3-wire resistive pot), 1-4 Volts(hall active throttle).
•Analog Brake and Throttle Input: 0-5 Volts. Producing 0-5V signal with 3-wire pot.
•Reverse Alarm, Main Contactor Coil Driver, Meter.
•Full Power Operating Temperature Range: 0℃ to 50 ℃ (controller case temperature).
•Operating Temperature Range:-30℃ to 90 ℃, 100℃ shutdown (controller case temperature).
•Motor Current Limit, 1 minute: 100-500A, depending on the model.
•Motor Current Limit, continuous: 50A-250A, depending on the model.
•Max Battery Current : Configurable.

2.4 Naming Regulations

The naming regulations of Kelly BLDC motor controllers:



Chapter 3 Wiring and Installation

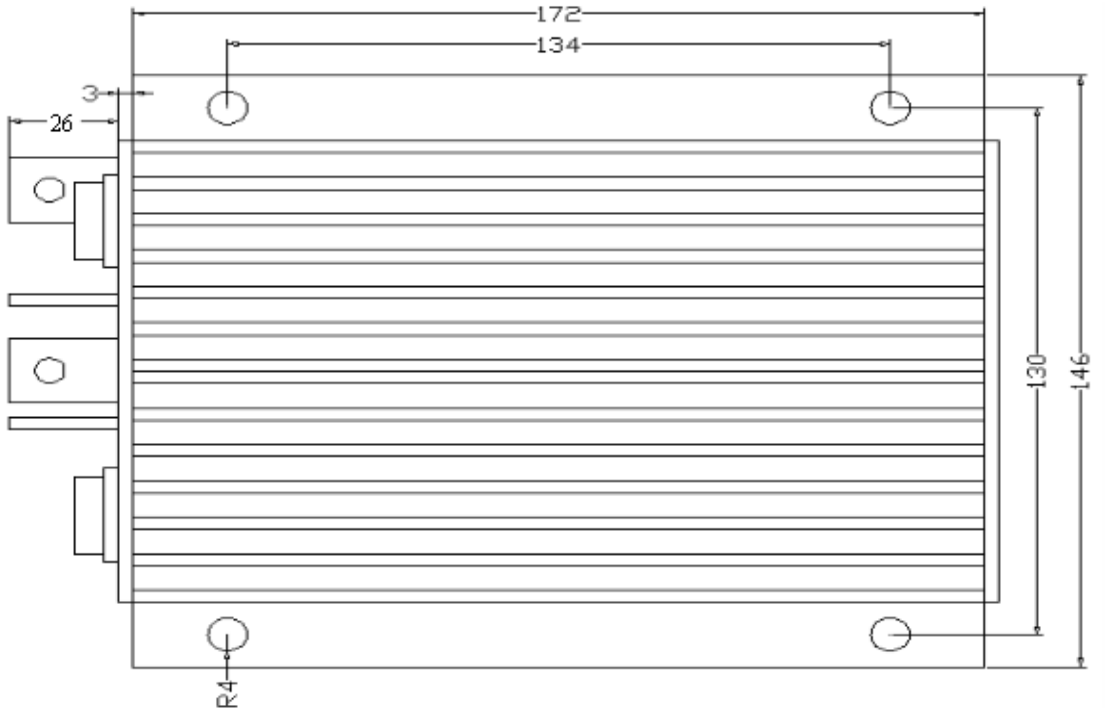
3.1 Mounting the Controller

The controller can be oriented in any position as clean and dry as possible, or shield with a cover to protect it from water and contaminants.

To ensure full rated output power, the controller should be fastened to a clean, flat metal surface with several screws. Applying silicon gel or other thermal conductive material to contact surface will enhance thermal performance.

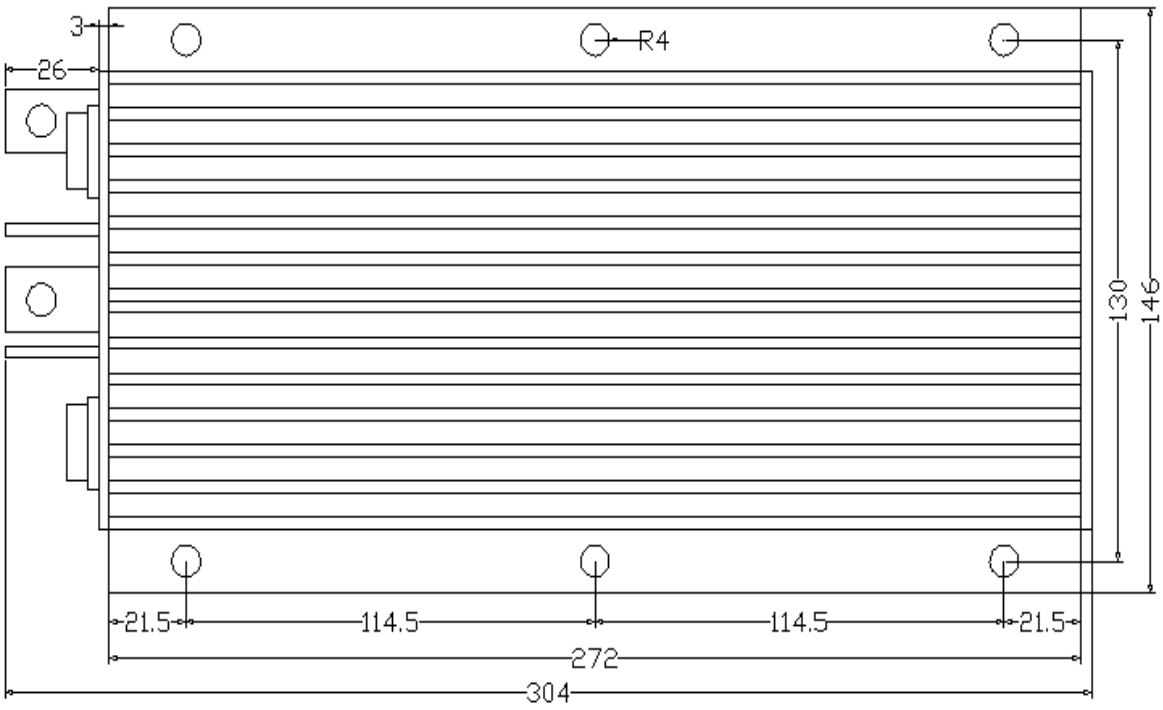
Sufficient heat sink and airflow are required for high power application.

The case outline and mounting holes' dimensions are shown in Figure 1.



Height: 62 millimeters

Figure 1: KBL/KBL-H mounting holes' dimensions (dimensions in millimeters)



Height: 62 millimeters

Figure 2: KBL-B mounting holes' dimensions (dimensions in millimeters)

3.2 Connections

3.2.1 Front Panel of BLDC Motor Controller:

Five metal bars and two plugs (J1, J2) are provided for connecting to the battery, motor and control signals in the front of the controller shown as Figure 3.

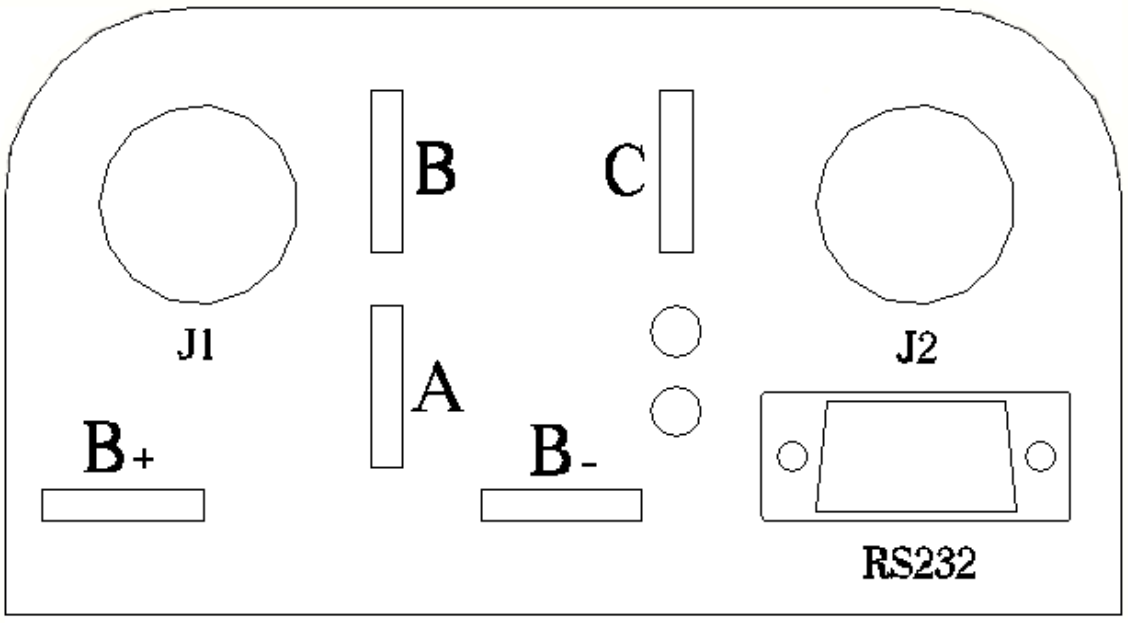


Figure 3: Front panel of BLDC motor controller

B+: battery positive
B-: battery negative
A: Output U/1/A phase
B: Output V/2/B phase
C: Output W/3/C phase

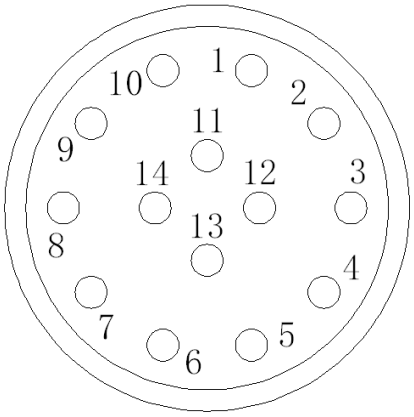


Figure 4: The connecting diagram of **J1** and **J2**

J1 Pin Definition

1- **PWR: Controller power supply (output). The pin is Red LED for S/N less :08XXXXXX.**
2- **Current meter. <200mA**
3- **Main contactor driver. <400mA**
4- **Alarm: To drive reverse beeper. <200mA**
5- **RTN: Signal return**
6- **Green LED: Running indication**
7- **RTN: Signal return**
8- **RS232 receiver**
9- **RS232 transmitter**
10- **CAN bus high**
11- **CAN bus low**
12- **Reserved**
13- **RTN: Signal return, or power supply return**
14- **Red LED: Fault code.The pin is PWR for S/N less :08XXXXXX.**

J2 Pin Definition

1- **PWR: Controller power supply (input)**
2- **RTN: Signal return, or power supply return**
3- **RTN: Signal return**
4- **Motor temperature input.**
5- **Throttle analog input, 0-5V**
6- **Brake analog input, 0-5V**
7- **5V: 5V supply output. <40mA**
8- **Micro_SW: Throttle switch input**
9- **Reverse switch input**
10- **Brake switch input**
11- **Hall phase C**
12- **Hall phase B**
13- **Hall phase A**
14- **RTN: Signal return**

Notes:

1. **All RTN pins are internally connected.**
2. **Two PWR pins, J1-1 and J2-1, are internally connected. It's recommended to use J1-1 to supply peripherals like alarm and contactor. Twist peripheral wires with PWR is the preferred for EMC. Recirculation diodes are provided in the controller to PWR for alarm and Contactor coil driver.**
3. **Kelly Ampmeter positive connect to 5V power supply of controller, negative to J1-2.**
4. **Switch to ground is active. Open switch is inactive.**

Caution: Make sure all connections are correct before applying power. Otherwise it may damage the controller! Please securely wire B- before applying power. It's preferred to place contactor or breaker on B+. Please place precharge resistor on any breaker! It can cause damage without it!!!

3.2.2 Wiring of BLDC Motor Controller

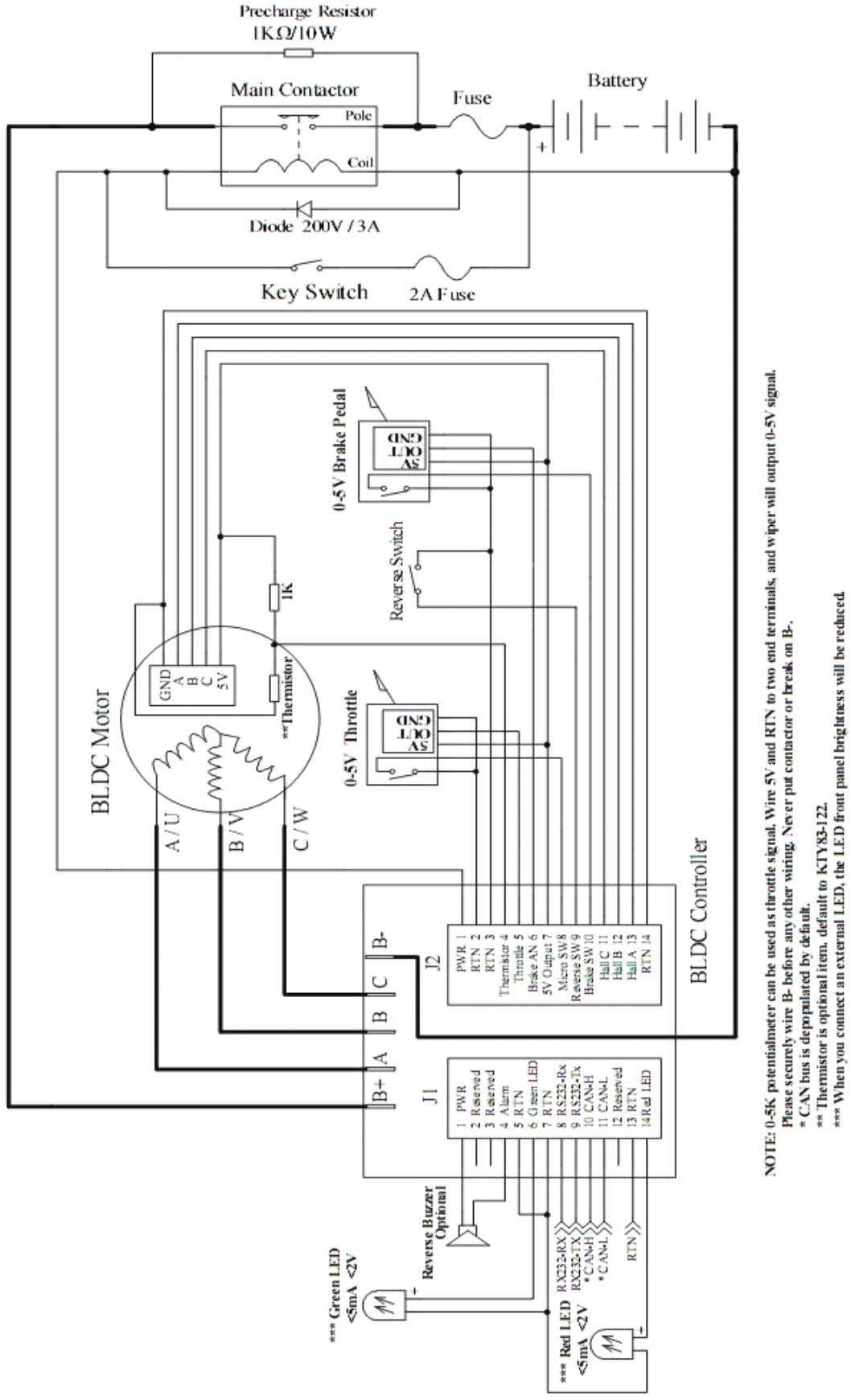


Figure 5: Standard Wiring for Controllers Rated Equal or Lower Than 120V.

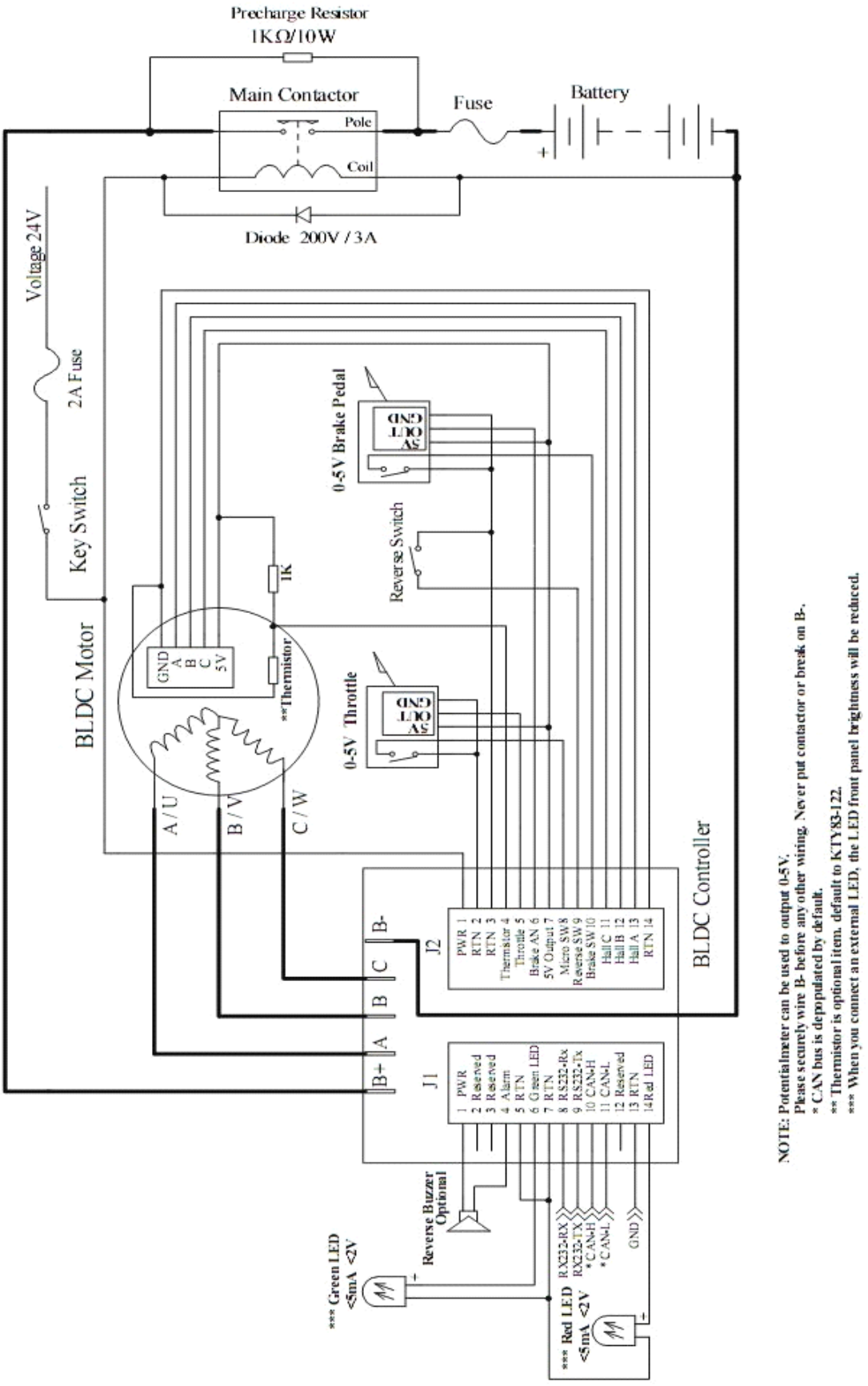


Figure 6: BLDC controller preferred wiring (24V supply is preferred)

3.2.3 Communication Port

A RS232 port is provided to communicate with host computer for calibration and configuration.

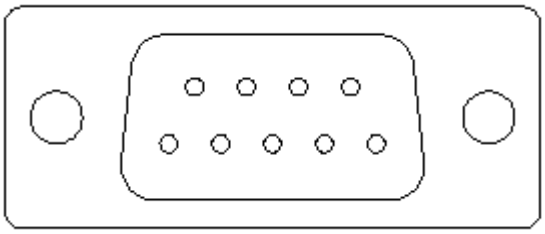


Figure 7: standard RS232 Interface

3.3 Installation Check List

Before operating the vehicle, complete the following checkout procedures. Use LED code as a reference. LED codes are listed in Table 1.

Caution:
- Put the vehicle up on blocks to get the drive wheels off the ground before beginning these tests.
- Do not allow anyone to stand directly in front of or behind the vehicle during the checkout.
- Make sure both the PWR switch and the brake are off.
- Use well-insulated tools.

- Make sure the wire is connected correctly
- Turn the PWR switch on. The LED should blink, then keep on when the controller operates normally. If this does not happen, check continuity of the PWR and return.
- The fault code will be detected automatically at restarting.
- With the brake switch open, select a direction and operate the throttle. The motor should spin in the selected direction. Please verify wiring and voltage if it doesn't operate. Also check fuse. The motor should run faster with increasing throttle. If not, refer to Table 1 LED code, and correct the fault according to the code.
- Take the vehicle off the blocks and drive it in a clear area. It should have smooth acceleration and good power.

Chapter 4 Maintenance

There are no user-serviceable parts inside the controllers. Do not attempt to open the controller, or will void warranty. However, cleaning the controller exterior periodically should be necessary.

The controller is inherently a high power device. When working with any battery powered vehicle, proper safety precautions should be taken. These include, but are not limited to, proper training, wearing eye protection, avoiding loose clothing and jewelry, and using insulated tools.

4.1 Cleaning

Although the controller requires virtually no maintenance after properly installation, the following minor maintenance is recommended in certain applications.

- Remove power by disconnecting the battery, starting with battery positive.
- Discharge the capacitors in the controller by connecting a load (such as a contactor coil, resistor or a horn) across the controller's B+ and B- terminals.
- Remove any dirt or corrosion from the bus bar area. The controller should be wiped down with a moist rag. Be sure it is dry before reconnecting the battery.
- Make sure the connections to the bus bars are tight. Use two wrenches for this task in order to avoid stressing the bus bars; the wrenches should be well insulated.

4.2 Configuration

You can configure the controller with a host computer through RS232 or USB port.

- Use straight through RS232 cable or USB converter provided by Kelly to connect the D9 connector to a host computer. Provide >18V (either J2 pin1 or J1 pin1) to PWR. Wire power supply return to any RTN pin.
- Do not connect B+, throttle and so on. The controller may display fault code, but it doesn't affect programming or configuration.

Download and setup the configuration software：

http://www.kellycontroller.com/support.php

Table 1: LED CODES

Green LED Codes

LED Code	Explanation	Solution
Green Off	No power or not operating	1. Check if all wires are correct. 2. Check fuse and power supply.
Green On	Normal operation	That's great! You got solution!
Green and Red LED Keep On		1. Software is upgrading. 2. Supply voltage too low or battery too high 3. The controller is damaged. Please contact Kelly for warrantee.

Red LED Codes

LED Code		Explanation	Solution
1,2	¤ ¤¤	Over voltage error	1. Battery voltage is higher than max operating voltage of the controller. Please check the battery voltage and configuration. 2. Over voltage at regeneration. Controller will cut back or stop regeneration. 3. Please note there could be 2% error with Overvoltage setting.
1,3	¤ ¤¤¤	Low voltage error	1. The controller will attempt to clear the fault code automatically after 5 second if battery voltage returns to normal. 2. Check the battery voltage. 3. Charge battery if necessary.
1,4	¤ ¤¤¤¤	Over temperature warning	1. The controller temperature is over 90℃. The controller will cut back current in the case. Stop or reduce output to ensure the temperature fall. 2. Improve heat sink or airflow.
2,1	¤¤ ¤	Motor fails to start	1. Motor hasn't reached 25 electrical RPM after 2 seconds from starting. Most likely the hall or phase wiring problem.
2,2	¤¤ ¤¤	Internal voltage fault	1. Check if the B+ and PWR voltage are correct, refer to B- or RTN. Could be PWR voltage low. 2. Please check load on 5V supply. Could be high load on 5V. Incorrect pot wiring can load it heavily。 3. The controller is damaged. Please contact Kelly for warrantee.
2,3	¤¤ ¤¤¤	Over temperature	1. The controller temperature is over 100℃. Controller stops driving in the case.

			2. Stop driving and wait for temperature fall. The controller will restart if temperature drops below 80℃.
2,4	¤¤ ¤¤¤¤	Throttle error at power up	1. The throttle signal is higher than configured dead zone at power-on. 2. The fault will disappear if restarts or releases throttle. 3. Configure throttle model as "Hall Active" throttle if you use that throttle model.
3,1	¤¤¤ ¤	Frequent reset	1. It can be caused by over current, bad motor, bad ground wiring or so.
3,2	¤¤¤ ¤¤	Internal reset	Reset caused by over current, high battery voltage or low supply voltage. It is normal if occurs occasionally.
3,3	¤¤¤ ¤¤¤	Throttle short or open circuit when using 1-4v hall sensor throttle	1. Check whether the throttle is short or open circuit. 2. When the throttle is normal, restart will clear the error.
3,4	¤¤¤ ¤¤¤¤	Throttle isn't zero when try to change direction	The controller won't change drive direction if throttle isn't zero. Also it won't change direction at high speed. The controller will wait throttle and speed close to zero before changing direction.
4,1	¤¤¤¤ ¤	Over voltage at startup or regeneration	The controller won't drive motor if detects overvoltage at power up. It will cut back regen current or stop regen at overvoltage. You may set max voltage threshold with GUI.
4, 2	¤¤¤¤ ¤¤	Hall sensor signal error	1. Most likely caused by incorrect hall wiring, to wrong pin or loose wire. 2. Intermittent or damaged hall sensor 3. Double check hall angle setting, 60 degree or 120 degree
4, 3	¤¤¤¤ ¤¤¤	Motor over temperature	1.The motor temperature is higher than configured max temperature. Controller will shut down and wait for motor temperature dropping. 2.Can change the temperature setting with configuration program.
4, 4	¤¤¤¤ ¤¤¤¤	Motor locked rotor	When in locked rotor condition, the max output phase current of the motor will be limited to 90% of previous current.Once the locked rotor disappear,the fault codes will disappear and the max output phase current will return to normal.
The Red LED flashes once at power on, then keeps off for normal operation. "1, 2" means it flashed once, then flashes twice after 1 second. The time between two flashes is 0.5 second. The pause time between one error code and another error code is 2 second.			

Table 2: KBL Controller CAN Commands List

Version 1.1

You should specify when sending:

ID: Our default ID is 0x6B, so only the data frame with ID 107 can be received by our controller. However, it can be set by configuration program.

Frame type:data frame

Frame format:standard 11 bits ID

Length:the number of data field bytes

Data field:data[0] is the command which indicates the operation.

Controller response:

ID: The controller sends data frames with ID 115, 0x73. It also can be set by configuration program.

Frame type:data frame

Length:the number of data field bytes

Data field: The controller sends a data frame in response.

Commands definitions

Command **CCP_FLASH_READ**
Length 3
data[0] 0xF2
data[1] INFO_MODULE_NAME
data[2] 8
Controller response
Length 8
data[0]~data[7] Controller's model in ASCII format, 8 bytes.

Description: Getting controller's model no. E.g. 0x4B,0x42,0x4C is 'K' , 'B', 'L', 0x30 is '0' . INFO_MODULE_NAME constant is defined as 64.

Command **CCP_FLASH_READ**
Length 3
data[0] 0xF2
data[1] INFO_SOFTWARE_VER
data[2] 2
Controller response
Length 2
data[0]~data[1] software version in BCD alike format, two bytes.

Description: Getting controller's software version, it also define as the controller's version, BCD alike format storage. E.g. 0x0A,0x01 should be parsed to ASCII characters '0' 'A' '0' '1' as the software version. INFO_SOFTWARE_VER constant is defined as 83.

Command **CCP_FLASH_READ**
Length 3
data[0] 0xF2
data[1] CAL_TPS_DEAD_ZONE_LOW
data[2] 1
Controller response
Length 1
data[0] TPS_Dead_Zone_Low

Desccription: Getting controller's Throttle low-end dead zone. CAL_TPS_DEAD_ZONE_LOW constant is defined as 4. The maximum value of Throttle is 200. If the value of Throttle Low-end Dead Zone is 40, indicating 20% low-end dead zone. (40/200 is 20%.)

Command **CCP_FLASH_READ**
Length 3
data[0] 0xF2
data[1] CAL_TPS_DEAD_ZONE_HIGH
data[2] 1
Controller response
Length 1
data[0] TPS_Dead_Zone_High
Desccription: Getting controller's Throttle high-end dead zone. CAL_TPS_DEAD_ZONE_HIGH constant is defined as 5. The maximum value of Throttle is 200. If the value of Throttle High-end Dead Zone is 160, indicating 80% high-end dead zone. (160/200 is 80%.)

Command **CCP_FLASH_READ**
Length 3
data[0] 0xF2
data[1] CAL_BRAKE_DEAD_ZONE_LOW
data[2] 1
Controller response
Length 1
data[0] Brake_Dead_Zone_Low
Desccription: Getting controller's Brake low-end dead zone. CAL_BRAKE_DEAD_ZONE_LOW constant is defined as 38. The maximum value of Brake is 100. If the value of Brake Low-end Dead Zone is 20, indicating 20% low-end dead zone. (20/100 is 20%.)

Command **CCP_FLASH_READ**
Length 3
data[0] 0xF2
data[1] CAL_BRAKE_DEAD_ZONE_HIGH
data[2] 1
Controller response
Length 1
data[0] Brake_Dead_Zone_High
Desccription: Getting controller's Brake high-end dead zone. CAL_BRAKE_DEAD_ZONE_HIGH constant is defined as 39. The maximum value of Brake is 100. If the value of Brake High-end Dead Zone is 80, indicating 80% high-end dead zone. (80/100 is 80%.)

Command **CCP_A2D_BATCH_READ1**
Length 1
data[0] 0x1b
Controller response
Length 5
data[0] Brake A/D
data[1] TPS A/D
data[2] Control power A/D
data[3] Vs A/D
data[4] B+ A/D
Description: Data batch reading.

1) For control power, B+, A/D value and voltage mapping relation is:
   V = Vad / 4.06. (For 24V,36V,48V controller);
   V = Vad / 2.71. (For 72V controller);
   V = Vad / 1.84. (For 120V controller).
2) Vs is defined as the 5V power supply for Hall sensor, control panel,ect. A/D value and voltage mapping relation is:120 ~ 134 mapping to 4.75 ~ 5.25V.
3) Brake and TPS are defined as the Brake and the Throttle analog input. A/D value and voltage mapping relation is: 0 ~ 255 mapping to 0 ~ 5V.

Command **CCP_A2D_BATCH_READ2**

Length 1
data[0] 0x1a
Controller response
Length 6
data[0] Ia A/D
data[1] Ib A/D
data[2] Ic A/D
data[3] Va A/D
data[4] Vb A/D
data[5] Vc A/D
Description: Data batch reading.

1) For Va, Vb, Vc, A/D value and voltage mapping relation is:
   V = Vad / 4.06. (For 24V,36V,48V controller);
   V = Vad / 2.71. (For 72V controller);
   V = Vad / 1.84. (For 120V controller).
2) Ia, Ib and Ic are defined as the three phase current.

Command **CCP_MONITOR1**
Length 1
data[0] 0x33
Controller response
Length 6
data[0] PWM
data[1] enable motor rotation
data[2] motor temperature
data[3] Controller's temperature
data[4] temperature of high side FETMOS heat sink
data[5] temperature of low side FETMOS heat sink
Description: Data batch reading.

1) PWM is output duty cycle, from 0 to 100.
2) data[1] indicates enabling motor rotation or disabling. 1 - enable, 0 - disable.
3) data[2] is defined as the temperature of motor in Celsius temperature. If the temperature sensor is not connected, the controller returns 0xFF.
4) data[3]-data[5] are defined as controller inside temperature in Celsius temperature. The value of data[4] and data[5] are inaccurate below 30℃.

Command **CCP_MONITOR2**
Length 1
data[0] 0x37
Controller response
Length 3
data[0] MSB of mechanical speed in RPM
data[1] LSB of mechanical speed in RPM
data[2] present current accounts for percent of the rated current of controller
Description: Data batch reading.

1) Mechanical speed calculation: (MSB << 8) | LSB. If the speed out data is not match the real speed value, please configure the motor poles calibration data of the controller based on the driven motor.

Command **COM_ANA_TPS**
Length 2
data[0] 0x40
data[1] COM_READING
Controller response
Length 1
data[0] TPSx
Description: Reading current TPS A/D value (valid value). TPSx - valid throttle A/D value, from 0 to

200.COM_READING constant is defined as 0.

Command **COM_ANA_TPS**
Length 3
data[0] 0x40
data[1] COM_WRITING
data[2] TPSx
Controller response
Length 1
data[0] 0 or 0xFF
Description: Setting TPS A/D value (valid value). TPSx - valid throttle A/D value. This command is disabled if the TPS physical switch is active. COM_WRITING constant is defined as 1. TPSx - from 0 to 200. data[0]-0 indicates writing successfully, data[0]-0xFF indicates that this command is disabled.

Command **COM_ANA_BRK**
Length 2
data[0] 0x41
data[1] COM_READING
Controller response
Length 1
data[0] BRAKEx
Description: Reading current Brake A/D value (valid value). BRAKEx – valid Brake A/D value, from 0 to 100. COM_READING constant is defined as 0.

Command **COM_ANA_BRK**
Length 3
data[0] 0x41
data[1] COM_WRITING
data[2] BRAKEx
Controller response
Length 1
data[0] 0 or 0xFF
Description: Setting BRAKEx A/D value (valid value). BRAKEx – valid Brake A/D value. This command is disabled if the BRAKE physical switch is active. COM_WRITING constant is defined as 1. BRAKEx - from 0 to 100. data[0]-0 indicates writing successfully, data[0]-0xFF indicates that this command is disabled.

Command **COM_SW_ACC**
Length 2
data[0] 0x42
data[0] COM_READING
Controller response
Length 1
data[0] Current throttle switch status
Description: Getting Throttle switch status, 1 – active, 0 – inactive. COM_READING constant is defined as 0.

Command **COM_SW_BRK**
Length 2
data[0] 0x43
data[0] COM_READING
Controller response
Length 1
data[0] Current Brake switch status
Description: Getting Brake swith status, 1 – active, 0 – inactive. COM_READING constant is defined as 0.

Command **COM_SW_REV**
Length 2
data[0] 0x44
data[0] COM_READING
Controller response
Length 1
data[0] Current Reverse switch status
Description: Getting Reverse swith status, 1 – active, 0 – inactive. COM_READING constant is defined as 0.

NOTICE:

1.CAN bus rate should be configured to 1Mbit/s.

2.If the command is out of above commands
Controller response
Length 1
data[0] CCP_INVALID_COMMAND
Description: CCP_INVALID_COMMAND constant is defined as 0xe3.

Contact Us:

Kelly Controls, LLC

Home Page:
http://www.KellyController.com

E-mail:
Support@KellyController.com

Phone:
(01) 224 637 5092