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Robotics and Electronics

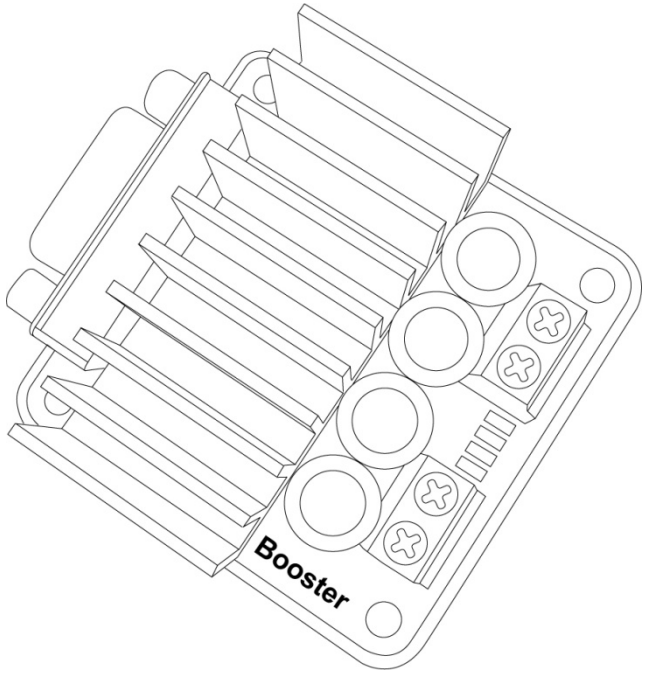
Booster – B36V2A5

Introduction

Strictly speaking, **Booster-B36V2A5** is a dual H-bridge power driver, which integrates 2*4 N-Channel MOSFETs(with low Drain-Source On-Resistance, $R_{DS(ON)}$<1.6mΩ) and various protections(reliable and flexible). It can be used for controlling the brushed DC motor, high-power LED and so on. In addition, it integrates RS485 and I2C into one connector, and they share the same user register, so it can be used via any one of the two interfaces at any time. All functions can be performed by reading or writing the user register, except for a few special operations(please refer to the corresponding communication protocols for details), which is similar to the MCU operation.

Specification

Supply Voltage	: DC 6 ~ 36V
Continuous Current	: 2 * 5A / 1 * 10A
Baudrate Range	: 1200 ~ 115200bps
I2C Speed	: 100KHz
Size	: 54.5mm * 50mm * 30.5mm (L*W*H)



Pin Definition

1. RS485-A(D+)
2. RS485-B(D-)
3. I2C-SDA
4. I2C-SCL
5. GND
6. VCC
7. VCC
8. Error
9. GND

Features

- It integrates various protections(Under-Voltage, Over-Voltage, Over-Temperature, Over-Current, Out-Of-Control and Power-Reverse). The response-time of the Over-Current protection can be flexibly set and performed by hardware(comparator), which makes the protection more timely and reliable.
- There are 18 control modes for different applications(see below).
- It integrates a stable and high-efficiency RS485, and the baud rate can be detected automatically. There is no instruction packet loss when the baud rate is not higher than 28800bps, otherwise the first instruction packet will be discarded. Furthermore, it is recommended to send the sync bytes(0xff 0xff 0xff 0xff) first when the baud rate is higher than 28800bps.
- It integrates a stable and high-efficiency I2C.

User Register Definition

Address	Name	Store	Access	Initial Value	Description
1(0x01)	ProtocolVer	ROM	R	0x__	Protocol Version (RS485 / I2C)
2(0x02)	DeviceMainClass	ROM	R	0x03	Device Main Class (0x03: Brushed DC motor controller)
3(0x03)	DeviceSubClass	ROM	R	0x01	Device Sub Class (0x01: Booster Series)
4(0x04)	HardwareVer	ROM	R	0x2_	Hardware Version (0x2_: B36V2A5)
5(0x05)	SoftwareVer	ROM	R	0x2_	Software Version (0x2_: B36V2A5)
6(0x06)	Command	RAM	W	0x00	Command Byte
7(0x07)	ID	ROM	R/W	0x01	Device Address (1~126, 0: Broadcast ID)
8(0x08)	CommandMode	ROM	R/W	0x00	Command Mode (0: Continuous 1: Discontinuous)
9(0x09)	ControlMode	ROM	R/W	0x0e	Control Mode (18 modes: Mode0 ~ Mode17, Value: 0~17)
10(0x0a)	AutoStart	ROM	R/W	0x00	Enable the Auto-Start function or not (0: Disable 1: Enable)
11(0x0b)	ProtectOC	ROM	R/W	0x01	Enable the Over-Current protection or not (0: Disable 1: Enable)

12(0x0c)	LimitedT	ROM	R/W	0x46	The threshold of the Over-Temperature protection (0~100 deg.C)
13(0x0d)	CurrentT	RAM	R	0x__	The current temperature of the MOSFETs
14(0x0e)	LimitedLV	ROM	R/W	0x1e	The threshold of the Under-Voltage protection($RegValue_{(LimitedLV)}$ / 5), this register could not be set lower than 30
15(0x0f)	LimitedHV	ROM	R/W	0xbe	The threshold of the Over-Voltage protection($RegValue_{(LimitedHV)}$ /5), this register could not be set higher than 190
16(0x10)	CurrentV	RAM	R	0x__	The power supply voltage($RegValue_{(CurrentV)}$ / 5)
17(0x11)	LimitedIA	ROM	R/W	0x32	The threshold of the Over-Current protection of A channel, which can be set to 25, 50 or 100
18(0x12)	TimeoutIA	ROM	R/W	0x32	The response-time of the Over-Current protection of A channel, which can be set from 1 to 250
19(0x13)	LimitedIB	ROM	R/W	0x32	The threshold of the Over-Current protection of B channel, which can be set to 25, 50 or 100
20(0x14)	TimeoutIB	ROM	R/W	0x32	The response-time of the Over-Current protection of B channel, which can be set from 1 to 250
21(0x15)	AccA	RAM	R/W	0x0a	The acceleration of A channel, which can be set from 1 to 250
22(0x16)	DecA	RAM	R/W	0x0a	The deceleration of A channel, which can be set from 1 to 250
23(0x17)	AccB	RAM	R/W	0x0a	The acceleration of B channel, which can be set from 1 to 250
24(0x18)	DecB	RAM	R/W	0x0a	The deceleration of B channel, which can be set from 1 to 250
25(0x19)	AmountA	RAM	R/W	0xfc	The control-amount of A channel, which can be set from 0 to 252
26(0x1a)	AmountB	RAM	R/W	0xfc	The control-amount of B channel, which can be set from 0 to 252
27(0x1b)	LimitedIAB	ROM	R/W	0x64	The threshold of the Over-Current protection of AB channel, which can be set to 25, 50 or 100
28(0x1c)	TimeoutIAB	ROM	R/W	0x32	The response-time of the Over-Current protection of AB channel, which can be set from 1 to 250
29(0x1d)	AccAB	RAM	R/W	0x0a	The acceleration of AB channel, which can be set from 1 to 250
30(0x1e)	DecAB	RAM	R/W	0x0a	The deceleration of AB channel, which can be set from 1 to 250

31(0x1f)	AmountAB	RAM	R/W	0xfc	The control-amount of AB channel, which can be set from 0 to 252

Now, some concepts must be introduced first, and then make a detail analysis of all the functions combining the user register.
Response-Time: It indicates how long does the error state to be continued before the protection performed. The protection sensitivity is performed by the time-out mechanism.
Real-Time-Register: Just as its name implies, the user register will be performed immediately once its value changed.
Non-Real-Time-Register: Even if the user register has been changed, it could not be performed unless the value updated to EEPROM and then reset the device.

- **CommandMode (Address: 0x08)**

It indicates the mode of instruction packet, there are two modes: Continuous and Discontinuous. In the Continuous mode, the device will keep the current controlled-state after an instruction packet is correctly received until it is updated by a new instruction packet. In the Discontinuous mode, the H-bridge will be cut off if there is no instruction packet correctly received within 2 seconds to achieve Out-Of-Control protection.

- **ControlMode (Address: 0x09)**

It indicates the control mode of the device, there are 18 modes that are distinguished by the type of PWM(PWM1/PWM2), the type of direction(single/dual-direction), the drive mode(separate/parallel), the type of brake and the type of current feedback. Note, this is the only Non-Real-Time-Register.
PWM: (1)The two PWM signals of Half-bridge(in one H-bridge) are fully complementary(simplified as PWM1 below), which performs a high dynamic response and the back electromotive force can be regenerated into the power source. In this modulation mode, when the switching loss of the MOSFETs is less than the regenerated energy, the total energy consumption will be reduced, but it is not suitable for controlling the pure resistive load. (2)The PWM signals are modulated in the ON-OFF-ON mode(simplified as PWM2 below), which makes the output approximately doubling the fundamental signal(the load average voltage is more stable). This modulation mode is extremely suitable for controlling the pure resistive load.
Single/Dual-Direction: The difference between the Single-Direction and the Dual-Direction is that the control-amount can be set from 0 to 250 in the Single-Direction mode while can only be set in half(0~125 or 125~250) for one direction in the Dual-Direction

mode. Obviously, the duty ratio of the PWM signal(for modulating the MOSFETs) can be set with a higher resolution in the Single-Direction mode.

Separate/Parallel: In the parallel driving mode, the loop impedance can be theoretically reduced in half, which makes the thermal losses of the MOSFETs reduced with the same ratio and dissipated uniformly. It is recommended to make the device work in the parallel driving mode when only one channel is required.

Brake: (1)Regenerative-Brake: In motor control applications, the energy stored in the coil can be fully used instead of being dissipated in the MOSFETs. (2)Dissipative-Brake: In motor control applications, the energy will be dissipated in the MOSFETs, however, the dissipation can be distributed to each MOSFET when using the PWM2 modulation. (3)No-Brake.

Current-Feedback: (1)Take the instantaneous current as the reference for Over-Current detection, which has strong real-time performance but not suitable for controlling the pure resistive load. (2)Take the average current as the reference for Over-Current detection, which is mainly designed for controlling the pure resistive load.

There are 18 control modes designed for the common applications combining the above-mentioned functions(Mode0 ~ Mode7 / Mode10 ~ Mode17: mainly used for controlling the brushed DC motor, Mode8 and Mode9: mainly used for controlling the high-power LED):

Mode0 : “PWM1” + “Dual-Direction” + “Separate-Control” + “Regenerative-Brake” + “Instantaneous-Current”
Mode1 : “PWM1” + “Dual-Direction” + “Parallel-Control” + “Regenerative-Brake” + “Instantaneous-Current”
Mode2 : “PWM1” + “Single-Direction” + “Separate-Control” + “Regenerative-Brake” + “Instantaneous-Current”
Mode3 : “PWM1” + “Single-Direction” + “Parallel-Control” + “Regenerative-Brake” + “Instantaneous-Current”
Mode4 : “PWM2” + “Dual-Direction” + “Separate-Control” + “Dissipative-Brake” + “Instantaneous-Current”
Mode5 : “PWM2” + “Dual-Direction” + “Parallel-Control” + “Dissipative-Brake” + “Instantaneous-Current”
Mode6 : “PWM2” + “Single-Direction” + “Separate-Control” + “Dissipative-Brake” + “Instantaneous-Current”
Mode7 : “PWM2” + “Single-Direction” + “Parallel-Control” + “Dissipative-Brake” + “Instantaneous-Current”
Mode8 : “PWM2” + “Single-Direction” + “Separate-Control” + “No-Brake” + “Average-Current”
Mode9 : “PWM2” + “Single-Direction” + “Parallel-Control” + “No-Brake” + “Average-Current”
Mode10 : “PWM1” + “Dual-Direction” + “Separate-Control” + “Regenerative-Brake” + “Average-Current”
Mode11 : “PWM1” + “Dual-Direction” + “Parallel-Control” + “Regenerative-Brake” + “Average-Current”
Mode12 : “PWM1” + “Single-Direction” + “Separate-Control” + “Regenerative-Brake” + “Average-Current”
Mode13 : “PWM1” + “Single-Direction” + “Parallel-Control” + “Regenerative-Brake” + “Average-Current”
Mode14 : “PWM2” + “Dual-Direction” + “Separate-Control” + “Dissipative-Brake” + “Average-Current”

Mode15 : “PWM2” + “Dual-Direction” + “Parallel-Control” + “Dissipative-Brake” + “Average-Current”
Mode16 : “PWM2” + “Single-Direction” + “Separate-Control” + “Dissipative-Brake” + “Average-Current”
Mode17 : “PWM2” + “Single-Direction” + “Parallel-Control” + “Dissipative-Brake” + “Average-Current”

- **AutoStart (Address: 0x0a)**

It indicates whether or not to enable the Auto-Start function which restores the previous settings after recovering from an error state. Firstly, the device need to avoid damage in controllable situations when error occurs. Secondly, in order to make the device work in the continuous state without any human monitoring, the previous settings must be able to be restored after recovering from an error state to return to the previous controlled-state.

- **ProtectOC (Address: 0x0b)**

It indicates whether or not to enable the Over-Current protection. The driving capability of the MOSFETs could not be fully performed due to the limitation of current carrying capability of the DB9 connector. When higher current is required in a short time, the Over-Current protection can be disabled according to the actual application(LimitedIA, TimeoutIA, LimitedIB, TimeoutIB, LimitedIAB and TimeoutIAB will be useless). Furthermore, it does not mean that the device loses the capability of self-protection, you can set an appropriate threshold for Over-Temperature protection, and the Over-Current protection will be performed indirectly(the continuous high current will be reflected on temperature by thermal effect).

- **LimitedT (Address: 0x0c)**

It indicates the threshold of the Over-Temperature protection. In fact, it is the threshold for turning on the heat-sink device(simplified as Over-Temperature-Heat below). The error-pin(PIN8) will go low and the corresponding bit(simplified as Bit-Over-Temperature-Heat below) in the error word will be set when the temperature is above $RegValue_{(LimitedT)}$. The **GDD–FANx** series is very suitable, of course, you can also use other devices(for sinking the heat) by getting the error word(for judgement). The Bit-Over-Temperature-Heat bit will be cleared when the temperature drops 10 deg.C. Note that if $RegValue_{(LimitedT)}$ is so small that the temperature could not drop to “$RegValue_{(LimitedT)}$ - 10”, which will cause the Bit-Over-Temperature-Heat bit could not be cleared automatically, you can clear it manually according to the actual application. Otherwise the temperature will continue to rise if there is no device for sinking the heat, the H-bridge will be cut off when the temperature is above “$RegValue_{(LimitedT)}$ + 5”(simplified as Over-Temperature-Protect below) or the maximum value(100 deg.C). Furthermore, because the Over-Temperature protection could not be disabled and the temperature is linear, the H-bridge will be cut off immediately when the temperature is above

Over-Temperature-Protect.

- **CurrentT (Address: 0x0d)**

It indicates the current temperature of the MOSFETs, which could not be set by instruction packets.

- **LimitedLV (Address: 0x0e)**

It indicates the threshold of the Under-Voltage protection, which could not be set lower than 30(the corresponding voltage is 6V). Furthermore, the Under-Voltage protection could not be disabled and the response-time is fixed to 1 second.

- **LimitedHV (Address: 0x0f)**

It indicates the threshold of the Over-Voltage protection, which could not be set higher than 190(the corresponding voltage is 38V). Furthermore, the Over-Voltage protection could not be disabled and the response-time is fixed to 1 second.

- **CurrentV (Address: 0x10)**

It indicates the power supply voltage, which could not be set by instruction packets. For example, $RegValue_{(CurrentV)}$=180, the corresponding voltage is 36V. Note that this value represents the actual H-bridge power supply voltage not the external power due to the reverse connection of power supply is performed by MOSFET. The actual detected voltage is lower than the external power supply(the voltage difference depends on the current).

- **LimitedIA (Address: 0x11)**

It indicates the threshold of the Over-Current protection of A channel, which can be set to 25(2.5A), 50(5A) or 100(10A).

- **TimeoutIA (Address: 0x12)**

It indicates the response-time of the Over-Current protection of A channel, which can be set from 1(0.1S) to 250(25S). However, the response-time will be fixed to 2 seconds(even if it has been set higher than 2 seconds) when the $RegValue_{(LimitedIA)}$ has been set to 25 or 50 while the current of A channel is above “2 * $RegValue_{(LimitedIA)}$ / 10”. Furthermore, the response-time will be fixed to 0.2 seconds(if the Over-Current protection has been enabled) when the current of A channel is above 15A. Therefore, it is necessary to set an appropriate acceleration to avoid the Over-Current protection during startup when the starting current is large.

- **LimitedIB (Address: 0x13)**

Refer to **LimitedIA** description.

- **TimeoutIB (Address: 0x14)**

Refer to **TimeoutIA** description.

- **AccA (Address: 0x15)**

It indicates the acceleration of A channel, which can be set from 1 to 250. The acceleration is an equivalent value because **Booster-B36V2A5** is an open loop controller.

- **DecA (Address: 0x16)**

Refer to **AccA** description.

- **AccB (Address: 0x17)**

Refer to **AccA** description.

- **DecB (Address: 0x18)**

Refer to **AccA** description.

- **AmountA (Address: 0x19)**

It indicates the control-amount of A channel, which can be set from 0 to 252. This register is available iff ControlMode is 0, 2, 4, 6, 8, 10, 12, 14 or 16(working in the separate control mode), and there are some similarities and differences between the different control modes.

Similarity :

251 : Fast Brake(Note that there is no braking operation(the H-bridge will be cut off directly) when ControlMode is 8).

252 : Coast(the H-bridge will be cut off completely to further reduce power consumption).

Difference :

When the ControlMode is 0, 4, 10 or 14(Dual-Direction mode):

125 : Stop with decelerateion.

0 ~ 125 : The resultant current is from A2 to A1.
125 ~ 250 : The resultant current is from A1 to A2.
When the ControlMode is 2, 6, 8, 12 or 16(Single-Direction mode):
0 : Stop with decelerateion.
0 ~ 250 : The resultant current is from A1 to A2.

- **AmountB (Address: 0x1a)**

It indicates the control-amount of B channel, which can be set from 0 to 252. This register is available iff ControlMode is 0, 2, 4, 6, 8, 10, 12, 14 or 16(working in the separate control mode), and there are some similarities and differences between the different control modes.

Similarity :
251 : Fast Brake(Note that there is no braking operation(the H-bridge will be cut off directly) when the ControlMode is 8).
252 : Coast(the H-bridge will be cut off completely to further reduce power consumption).

Difference :
When the ControlMode is 0, 4, 10 or 14(Dual-Direction mode):
125 : Stop with decelerateion.
0 ~ 125 : The resultant current is from B2 to B1.
125 ~ 250 : The resultant current is from B1 to B2.
When the ControlMode is 2, 6, 8, 12 or 16(Single-Direction mode):
0 : Stop with decelerateion.
0 ~ 250 : The resultant current is from B1 to B2.

- **LimitedIAB (Address: 0x1b)**

Refer to **LimitedIA** description.

- **TimeoutIAB (Address: 0x1c)**

Refer to **TimeoutIA** description.

- **AccAB (Address: 0x1d)**

Refer to **AccA** description.

- **DecAB (Address: 0x1e)**

Refer to **AccA** description.

- **AmountAB (Address: 0x1f)**

It indicates the control-amount of A and B channel controlled parallelly, which can be set from 0 to 252. This register is available iff ControlMode is 1, 3, 5, 7, 9, 11, 13, 15 or 17(working in the parallel control mode), and there are some similarities and differences between the different control modes.

Similarity :

251 : Fast Brake(Note that there is no braking operation(the H-bridge will be cut off directly) when the ControlMode is 9).

252 : Coast(the H-bridge will be cut off completely to further reduce power consumption).

Difference :

When the ControlMode is 1, 5, 11 or 15(Dual-Direction mode):

125 : Stop with decelerateion.

0 ~ 125 : The resultant current is from B1B2 to A1A2.

125 ~ 250 : The resultant current is from A1A2 to B1B2.

When the ControlMode is 3, 7, 9, 13 or 17(Single-Direction mode):

0 : Stop with decelerateion.

0 ~ 250 : The resultant current is from A1A2 to B1B2.

Error Word Definition

The error word has 16 bits, which can be returned by an instruction packet. Please refer to the corresponding communication protocols for details.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Error Sources	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Bit-Out-Of-Control	Bit-Over-Current	Bit-Over-Temperature-Protect	Bit-Over-Temperature-Heat	Bit-Over-Voltage	Bit-Under-Voltage

Restore Factory Settings

Booster-B36V2A5 can be restored to the factory settings by sending an instruction packet via RS485 or I2C at any time, in addition, a set of hardware operations(see bellow) can also complete the restore operation.

Hardware Operations:

1. Cut off the power supply completely.
2. Short circuit between the two pad holes which as shown in the picture on the right side, and please Keep the step 2 until the step 3 finished.
3. LED-Error, LED-Rx and LED-Tx will go on simultaneously after power-on.