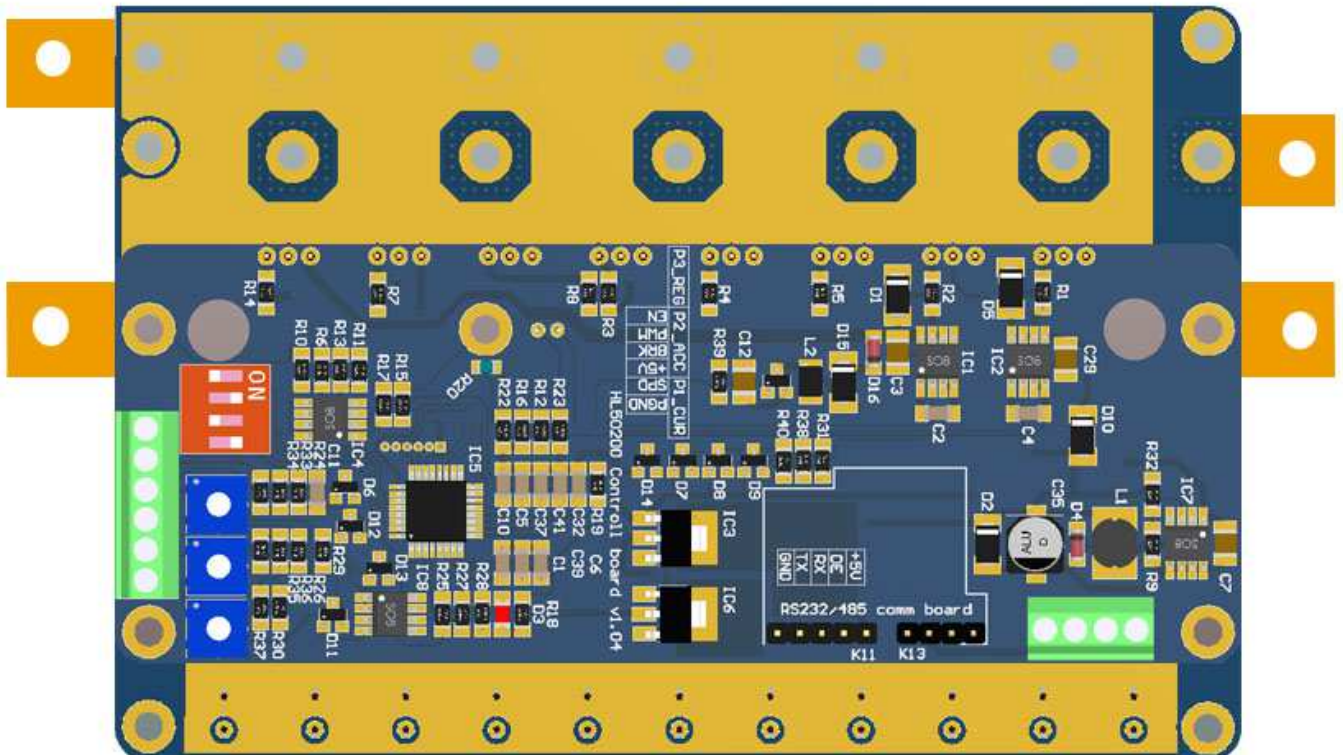


200A DC brushed motor PWM speed controller

DATASHEET FOR: Motor PWM HL50200 v1.04

TECHNICAL SPECIFICATIONS:

Supply voltage:	10-50V
Output current:	300A peak 200A continuous at 25°C additional heatsink may needed!
Minimal duty cycle:	0%
Maximal duty cycle:	min 96%
Protections:	Over current protection, Output short protection with minimal load inductance
Switching frequency:	20kHz
Power connection:	M6 on 10x3mm copper trails



PIN DESCRIPTION:

Motor+: The motor negative connection.

Motor-: The motor positive connection.

Supply+: The positive power supply connection 10-50V maximal voltage.

Supply-: The negative supply connection.

Speed GND: Ground for the speed potentiometer. Keep it isolated from the Supply GND.

Speed:

Speed potentiometer input. Use 1-10 kOhm linear potentiometer or 0-5V controll voltage.

- Potentiometer mode: 0V = 0% duty cycle
4,95V = 97% duty cycle
- Throttle mode: 0,8V = 0% duty cycle
4,2V = 97% duty cycle
- *USART mode: Analoge input.

+5V: +5V reference voltage for the speed potentiometer and for small external circuits. Max load current 50mA.

Brake input:

Brake potentiometer or switch input. Use 1-10 kOhm linear potentiometer or 0-5V controll voltage.

Activating the brake function the minimal voltage on the brake input is 0,15V. Max braking force with 3,3V

PWM input: (using PWM mode set the Mode switch in one of the PWM mode)

- PWM mode1: 0-100% PWM: You can use your own PWM controll signal from your PLC or microprocessor. The minimum controll PWM frequency is 100Hz. The step resolution 1us. The acceptable voltage level: 3,3-10V.
- PWM mode2: RC wireles receiver input 1,5msec pulse for the 0% duty cycle and 2,5msec pulse for the 97% duty cycle.
- PWM, logical and pulse counter input in USART mode

Enable input:

Enable input is open or high level: Controller output is disabled

Enable input connected to the Speed GND: Controller output is enabled.

Mode switch:

1OFF-2OFF: Hall throttle mode

1OFF-2ON: Potentiometer mode

1ON-2OFF: PWM input mode

1ON-2ON: RC-receiver PWM mode

3OFF: Peak current OFF 3ON: Peak current ON

4ON: RS232 UART simple command mode communication

4OFF: RS232 USART advanced mode

Controll potentiometers:

P1: Current limit potentiometer 0-200A (if the current limit is zero the motor won't start)

P2: Acceleration limit potentiometer 0-41sec

P3: Regenerative current limit potentiometer setting the maximum brakeing current when you use brake input

LED light on when:

- At start the controller blink 2 times
- Current limit is active.
- Enable input is open.
- Under and over voltage protection, over temperature protection
- while USART communication.

Serial communication:

The standard serial inputs are not isolated! It accepts 3.3V or 5V TTL level. Use the optional TTL or RS232 isolator board if galvanic isolation is needed. For serial command and more details used the Serial communication chapter in the datasheet.

Istructions for the heatsink:

For the maximum power the controller needs an additional heatsink or aluminium case to cool the power transistors and the aluminium base. The dimensions of the heatsink can change depending on the supply voltage and the output current and of course the ambient temperature and the air convection. Under 100A no additional heatink is needed maybe a small fan. Up to 200A use the 150x 80x40mm heatsink atouched to the aluminium base. Use the 25mm spacers to hold the heatsink on the bottom side of the board.

Keep clean the power transistors legs any small metal , copper or aluminium sliver as a foreign material can cause short between the power transistor legs damaging the controller.

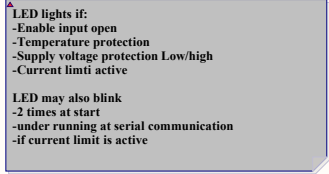
Precharge resitor:

At start limiting the turn up current avoiding any spark on the contactors use a precharge resistor. The value can change depending on the supply voltage:

Supply voltage	Resistor Ohm	Resistor power
12V	150 Ohm	2W
24V	330 Ohm	5W
36V	470 Ohm	10W

Instructions for the heatsink: For the maximum power you need to add extra heatsink to the aluminium bases. The size is depending on the ambient temperature and the air ventilation. For details check the datasheet.

Dust: It is important to keep the controller in a dust free place. Use aluminium enclosure or you can cover the controller with plastic enclosure when you placed the heatsink to the aluminium bases.



10FF-20FF: Hall throttle mode
10FF-20N: Potentiometer mode
10N-20FF: PWM input mode (0-100% duty)
10N-20N: RC-receiver PWM mode (standard 1,5msec)
30FF: Peak current OFF 3 0N: Peak current ON
40N: RS232, UART simple command mode communication
40FF: RS232, USART advanced mode

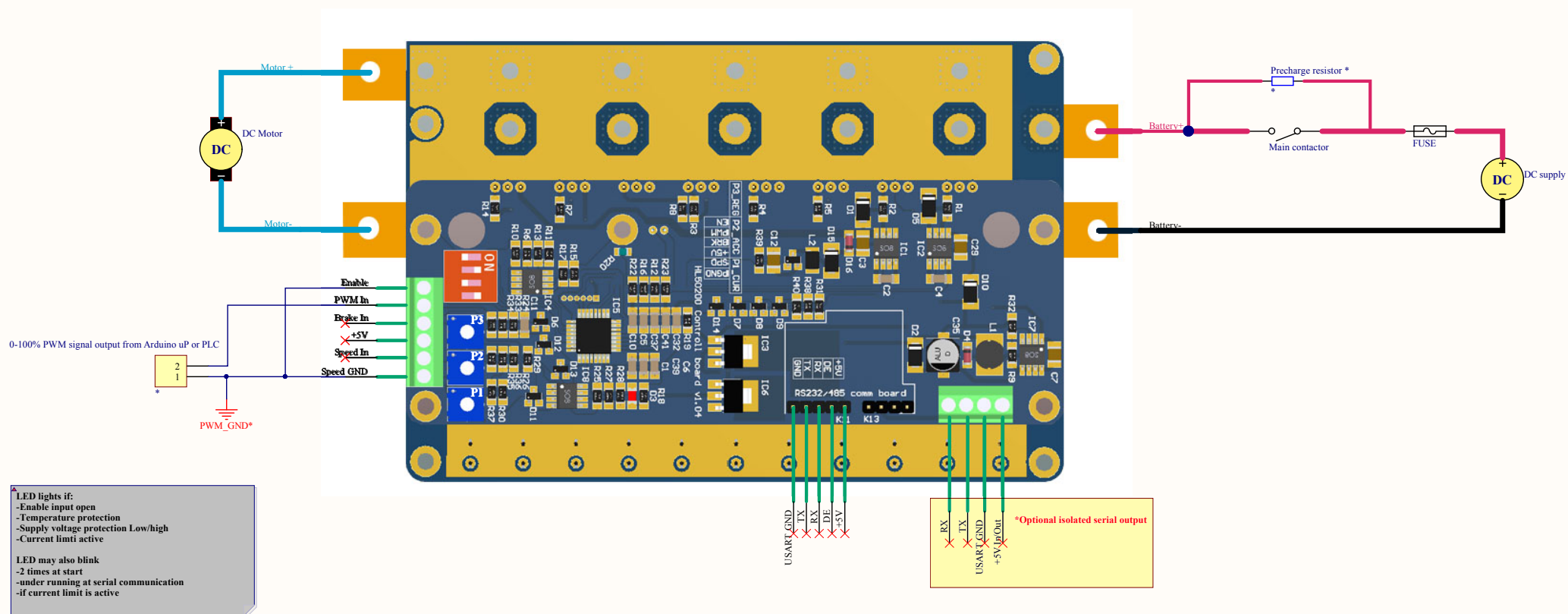
P1 current limit: CCW 0A ; CC 200A
P2 ramp (acceleration limit) CCW 0 sec ; CC 40 sec
P3 maximal brake force: CCW 0A ; CC 200A

Title Standard potentiometer or throttle + brake pot			
Size A3	Number HL50200 v1.04	Revision Rev1	
Date: File:	2019-06-07 E:\Projectek\1_Wir1_SchDoc	Sheet of	
		Drawn By:	

Instructions for the heatsink: For the maximum power you need to add extra heatsink to the aluminium bases. The size is depending on the ambient temperature and the air ventilation. For details check the datasheet.

Dust: It is important to keep the controller in a dust free place. Use aluminium enclosure or you can cover the controller with plastic enclosure when you placed the heatsink to the aluminium bases.

***WARNING!** Never connect the SPEED GND to the Supply GND. Try to isolate it or if you have common GND than dont use the Speed-GND input



RED MODE switch:

1OFF-2OFF: Hall throttle mode
 1OFF-2ON: Potentiometer mode
 1ON-2OFF: PWM input mode (0-100% duty)
 1ON-2ON: RC-receiver PWM mode (standard 1.5msec)
 3OFF: Peak current OFF 3 ON: Peak current ON
 4ON: RS232, UART simple command mode communication
 4OFF: RS232, USART advanced mode

P1 current limit: CCW 0A ; CC 200A
P2 ramp (acceleration limit) CCW 0 sec ; CC 40 sec
P3 maximal brake force: CCW 0A ; CC 200A

Title		
Size	Number	Revision
A3		
Date:	2019.06.07.	Sheet of
File:	E:\Projektek\W3\SchDoc	Drawn By:

Control register map for simple UART communication:

UART Data transmission:

revision: 1. *UART firmware v1.0*

Supported default baud rate: 9600 baud/sec

Supported bit rate: 1 start 8 data bit 1 stop and no parity bit.

Writing register you need to send first the comand byte than the second the data byte which contains the value of the wrtiten register. Reading a register send the request command and wait for the data from the controller.

Sent bytes

Command	Data	Write registers:	remark:
0x80	0x00-7F	speed motor 1	
0x82	0x00-7F	current limit	1,95A/lb
0x83	0x00-7F	regen limit	1,95A/lb
0x84	0x00-7F	accel limit	0,32ms/lb
0x85	0x00-7F	decel limit	0,32ms/lb
0x86	0x00-7F	turn off low	0,59V/lb
0x87	0x00-7F	turn on low	0,59V/lb
0x88	0x00-7F	turn on high	0,59V/lb
0x89	0x00-7F	turn off high	0,59V/lb
0x8A	0x00-03	motor deirection	0x00: stop, 0x01 forward, 0x03 regen
0xE0	-	USART command mode	Autostop after 3 sec without speed update
0xE1	-	USART command mode	No Autostop
0xE2	-	cancel USART mode	Controll with onboard potentiometers
0xA0	0x00-7F	saving_bits L	for saving use advanced mode
0xA1	0x00-7F	saving_bits H	for saving use advanced mode

Command	Read registers:	
0xC0	00-7F	read motor 1 speed
0xC2	00-7F	read current limit
0xC3	00-7F	read regen limit
0xC4	00-7F	read accel limit
0xC5	00-7F	read decel limit
0xC6	00-7F	read turn off low
0xC7	00-7F	read turn on low
0xC8	00-7F	read turn on high
0xC9	00-7F	read turn off high
0xCA	00-7F	motor 1 current
0xCC	00-7F	suppyl voltage
0xCD	00-7F	speed input
0xCE		heatsink_temp
0xCF		mainboard_temp
0xD0		status bits L

0xD1	status bits H
0xD2	configurations_bits_1 L
0xD3	configurations_bits_1 H
0xD4	configurations_bits_2 L
0xD5	configurations_bits_2 H
0xDE	software version
0xDF	hardware version

If you need more details about what the status register and confoguration_bits are doing please check the advanced communication.

Examples:

1, Start the controller in uart control mode:

Send 0xE0 or 0xE1 (with E0 you need to send a new speed data in every 3 sec otherwise the controller will stop the motor)

2, Select direction forward:

Send 0x8A 0x01

3, Speed up the motor slowly:

Acceleration set: **Send 0x84 0x0F**

Speed set: **Send 0x80 0x1F**

4, Set lower 50% speed:

Send 0x80 0x3F

5, Read motor current:

Send 0xCA

6, Read supply voltage:

Send 0xCC

UART Data transmission:

revision: 1. UART firmware v1.0

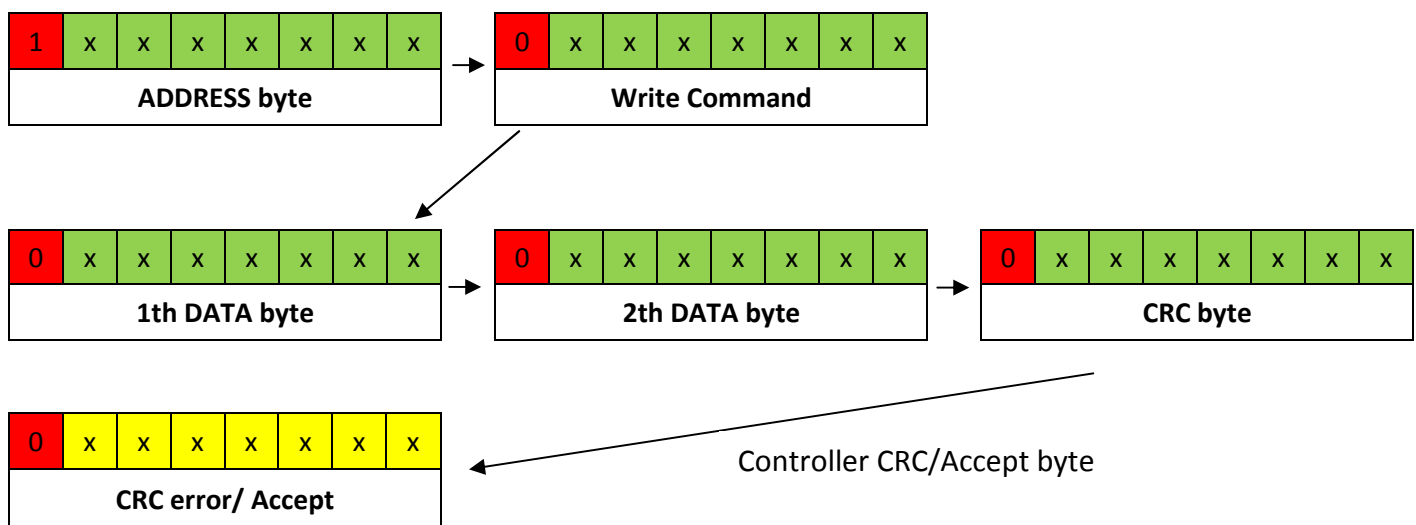
Supported default baud rate: 19200 baud/sec

Supported bit rate: 1 start 8 data bit 1 stop and no parity bit.

Sending data:

The controllers are working in SLAVE mode UART communication. It means that every commands are addressable and only the controller which has the same address will accept the command otherwise it goes into standby mode. When an address match occurs the the controller wakes up and accept the data. As long as the controller does not get other address which is not its own address remains in active mode.

Sending data from master device must be 5 bytes:



Every ADDRESS byte MSB bit must be "1" any other which is not an ADDRESS byte must be "0".

For robust and errorless communication CRC byte can be used to check the data transmission errors.

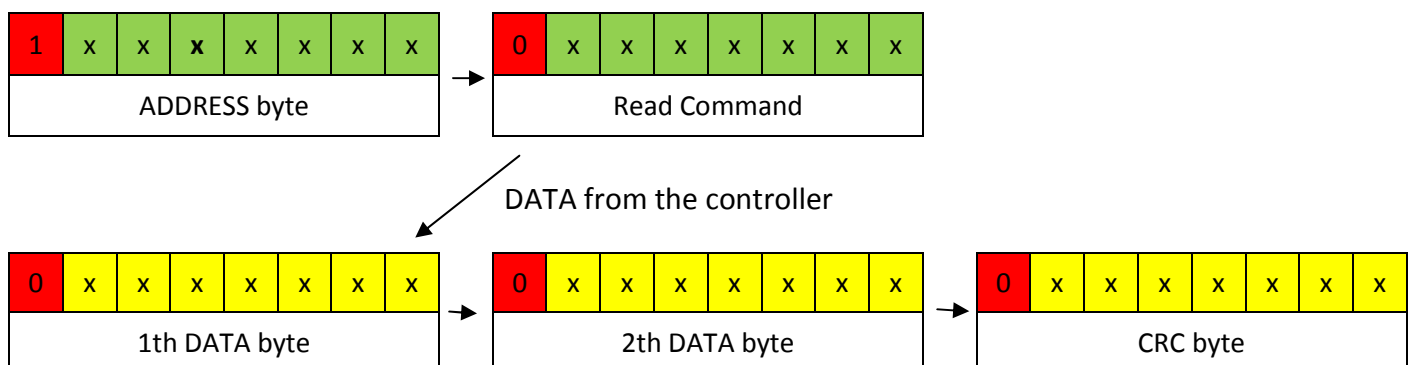
CRC check byte calculated: $((\text{Write command byte} + \text{1th DATA byte} + \text{2th DATA byte}) \& 0x7F)$

Receiving successfully the write command and the DATA bytes the controller send a confirmation byte with his UART address (0x00 | address) or CRC error message with his address (0x80 | address). You can use this byte to know when to send the next data.

Reading data:

Requesting data from master device must be 2 bytes when the controller received the 2th byte it will send the answer 3 bytes (1th DATA byte ; 2th DATA byte ; CRC)

CRC check byte calculated: $((\text{Read command byte} + \text{1th DATA byte} + \text{2th DATA byte}) \& 0x7F)$



Control register map for advanced USART communication:

Model: HL50200 v1.02

Register name	Command		Min Val.	Max val.	Value Range	Resolution	Remark
	Read	Write					
speed motor 1	0x00	0x40	0x0000	0x0FFF	97% duty		Other factors may change the output duty
current limit	0x02	0x42	0x0000	0x0FFF	250A	61.0mA	This value is internally limited at 200A.
regen limit	0x03	0x43	0x0000	0x0FFF	250A	61.0mA	This value is internally limited at 200A.
accel limit	0x04	0x44	0x0000	0x0FFF	41 sec	10msec	
decel limit	0x05	0x45	0x0000	0x0FFF	41 sec	10msec	
turn off low	0x06	0x46	0x0000	0x0FFF	75.9V	18.51mV	
turn on low	0x07	0x47	0x0000	0x0FFF	75.9V	18.51mV	
turn on high	0x08	0x48	0x0000	0x0FFF	75.9V	18.51mV	Default value: 2600
turn off high	0x09	0x49	0x0000	0x0FFF	75.9V	18.51mV	Internally limited on 2701 (49,9V)
Heatsink Temperature	0x0A		0x000A	0x0050	80°C	1°C	Shut down at 75°C
Mainboard Temperature	0x0B		0x000A	0x0050	80°C	1°C	
	0x0F						
Supply Voltage	0x10				75.9V	18.51mV	
Speed ADC Input	0x11				4.85V	1.18mV	
Load Current 1	0x12				500A	244.2mA	0A=0x07FF
Input Frequency Period Register	0x14						
Input Pulse Width	0x15						
	0x19						
I*R compensation gain	0x20	0x60	0x0000	0x0FFF			
top speed	0x21	0x61	0x0000	0x0FFF	75.9V	18.51mV	
potentiometer min	0x22	0x62	0x0000	0x0FFF	4.85V	1.18mV	
potentiometer max	0x23	0x63	0x0001	0x0FFF	4.85V	1.18mV	
	0x24						
Status Register	0x30						
Lock_level_2 Variables	0x31	0x71					
Save bites 1	0x32	0x72					
save bites 2	0x33	0x73					
Configuration bits 1	0x34	0x74					
Configuration bits 2	0x35	0x75					
UART Address		0x7C	0x0000	0x007F			Default address 0x00
Current measurement calibration		0x7D	0x0000			244.2mA	
software version	0x3E						
hardware version	0x3F						

Speed Register:

Type: Write / Read

Write command: 0x40

Read command: 0x00

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Speed register gives the base value of the output voltage (duty cycle). The final value depending some other factors. The final duty cycle depending on several other factors (current limits, regen modes..)

With default settings the speed register equal to the controller speed input ADC value modified by the acceleration/deceleration settings. Writing into this register this will be the new base value of the output voltage as long as the Speed input ADC has the same value as it was before the overwrite. When the Speed input voltage changes (turning up/down the speed potentiometer) the controller going to overwrite the register with the value of the potentiometer.

It is possible to lock the register value (speed potentiometer can't overwrite the speed register) for this feature use the **Lock Variable Register**.

The register set and cleared by UART write or Speed potentiometer input and loses it's value after restarting the controller. Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **SPEED [11:0]**: Speed register value

Max value is 4095 it is the 97% duty cycle.

Min value is 0 it is the 0% duty cycle.

Note: final duty cycle may change depending on other factors.

Current Limit Register:

Type: Write / Read

Write command: 0x42

Read command: 0x02

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Current Limit Register sets the value of the current limitation. With default settings the current limit register is equal to the controller's current limit potentiometer setting. Writing into this register overwrites the value of the potentiometer and holds the value as long as the potentiometer has the same value as it was before the overwrite. When the potentiometer changes (turning up/down the potentiometer) the controller going to overwrite the register with the value of the potentiometer.

It is possible to lock the register value (potentiometer can't overwrite the register) for this feature use the **Lock Variable Register**.

The register set and cleared by UART write or the current limit potentiometer and loses it's value after restarting the controller. Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **CURRENT_LIMIT [11:0]**: Current limit register value

Max value is 4095

Min value is 0

*Note: for the corresponding current value check the **Register Value Range** table.*

Regenerative Current Limit Register:

Type: Write / Read

Write command: 0x43

Read command: 0x03

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Regenerative Current Limit Register sets the value of the current limitation. With default settings the current limit register is equal to the controller's potentiometer setting. Writing into this register overwrites the value of the potentiometer and holds the value as long as the potentiometer has the same value as it was before the overwrite. When the potentiometer changes (turning up/down the potentiometer) the controller going to overwrite the register with the value of the potentiometer.

It is possible to lock the register value (potentiometer can't overwrite the register) for this feature use the **Lock Variable Register**.

The register set and cleared by UART write or the potentiometer and loses its value after restarting the controller. Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **CURRENT_LIMIT [11:0]**: Regenerative current limit register value

Max value is 4095

Min value is 0

*Note: for the corresponding current value check the **Register Value Range** table.*

Acceleration Limit Register:

Type: Write / Read

Write command: 0x44

Read command: 0x04

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Acceleration Limit Register sets the time how fast the output follows the speed register's value under raising condition. With default settings it is equal to the controller's acceleration (RAMP) potentiometer's setting. Writing into this register overwrites the value of the potentiometer and holds the value as long as the potentiometer has the same value as it was before the overwrite. When the potentiometer changes (turning up/down the potentiometer) the controller going to overwrite the register with the value of the potentiometer.

It is possible to lock the register value (potentiometer can't overwrite the register) for this feature use the **Lock Variable Register**.

The register set and cleared by UART write or the potentiometer and loses its value after restarting the controller. Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **CURRENT_LIMIT [11:0]**: Acceleration limit register value

Max value is 4095

Min value is 0

*Note: for the corresponding time value check the **Register Value Range** table.*

Deceleration limit register:

Type: Write / Read

Write command: 0x45

Read command: 0x05

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Deceleration Limit Register sets the time how fast the output follows the speed register's value under falling condition. With default settings it is disabled in the controller.

Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **DECELERATION_LIMIT [11:0]**: Deceleration limit register value

Max value is 4095

Min value is 0

*Note: for the corresponding time value check the **Register Value Range** table. The minimum value is 1.*

Turning off minimum voltage register:

Type: Write / Read

Write command: 0x46

Read command: 0x06

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Turning Off Minimum voltage register sets the voltage level where the controller will shut down if the supply voltage is lower than the register value. With default settings it is disabled in the controller. Writing and locking this register activates the function. When the controller shutting down because of the low supply voltage level the corresponding status register gets an update about the low supply voltage.

Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **TURN_OFF_MIN [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding voltage level check the **Register Value Range** table.*

Turning on minimum voltage register:

Type: Write / Read

Write command: 0x47

Read command: 0x07

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Turning On Minimum voltage register sets the voltage level where the controller will turn back from low supply status if the supply voltage is higher than the register value. With default settings it is disabled in the controller. Writing and locking this register activates the function.

Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **TURN_ON_MIN [11:0]:***Max value is 4095**Min value is 0*

*Note: for the corresponding voltage level check the **Register Value Range** table.*

Turning on maximum voltage register:

Type: Write / Read

Write command: 0x48

Read command: 0x08

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Turning On maximum voltage register sets the voltage level where the controller will turn back from high supply voltage status if the supply voltage is lower than the register value. With default settings it is disabled in the controller. Writing and locking this register activates the function.

Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **TURN_ON_MAX** [11:0]:*Max value is 4095**Min value is 0*

*Note: for the corresponding voltage level check the **Register Value Range** table.*

Turning off maximum voltage register:

Type: Write / Read

Write command: 0x49

Read command: 0x09

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Turning Off Maximum voltage register sets the voltage level where the controller will shut down if the supply voltage is higher than the register value. With default settings it is disabled in the controller. The internal maximum voltage settings may rewrite this register. Writing and locking this register activates the function. When the controller shutting down because of the high supply voltage level the corresponding status register gets an update about the high supply voltage.

Saving the value into the FLASH use the **Save Register**.

Bit 11:0 **TURN_OFF_MAX [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding voltage level check the **Register Value Range** table.*

Heatsink Temperature Register:

Type: Read

Read Command: 0x0A

1th DATA byte							
0	-	-	-	-	-	-	-

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

This register holds the actual heatsink temperature value in °C.

Bit 11:0 **HEATSINK TEMPERATURE [11:0]:**

Max value is 80

Min value is 10

*Note: for the corresponding temperature value check the **Register Value Range** table.*

Mainboard Temperature Register:

Type: Read

Read Command: 0x0B

1th DATA byte							
0	-	-	-	-	-	-	-

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

This register holds the actual mainboard temperature value in °C.

Bit 11:0 **MAINBOARD TEMPERATURE [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding temperature value check the **Register Value Range** table.*

Supply Voltage Register:

Type: Read

Read Command: 0x10

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

This register holds the actual supply voltage value.

Bit 11:0 **SUPPLY VOLTAGE [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding voltage value check the **Register Value Range** table.*

Speed ADC Input Register:

Type: Read

Read Command: 0x11

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Controlling and locking the controller with UART Speed commands the Speed ADC input can serve other task like measuring a sensor or anything else.

Using the Speed ADC input for other task and not for the speed control function the Speed Register Lock bit must be enabled.

Bit 11:0 **SPEED ADC INPUT [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding voltage value check the **Register Value Range** table.*

Load Current Register:

Type: Read

Read Command: 0x12

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

This register holds the actual output load current.

Bit 11:0 **LOAD CURRENT [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding current value check the **Register Value Range** table.*

Input Frequency Period Register:

Type: Read

Read Command: 0x14

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

The controller PWM/brake input can be used for measuring pulses and other purposes. Like hall sensors encoders etc. Input Frequency Register holds the period's of the measured signal.

Bit 13:0 **INPUT FREQUENCY PERIOD REGISTER [13:0]:***Max value is 16383**Min value is 0*

*Note: for the corresponding value check the **Register Value Range** table.*

Input Pulse Width Register:

Type: Read

Read Command: 0x15

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

The controller PWM/brake input can be used for measuring pulses and other purposes. Like hall sensors encoders etc. Input Pulse Width Register holds the width of the captured pulse of the measured signal.

Bit 13:0 **INPUT PULSE WIDTH REGISTER [13:0]:***Max value is 16383**Min value is 0*

*Note: for the corresponding time value check the **Register Value Range** table.*

I x R compensation register:

Type: Write / Read

Write Command: 0x60

Read Command: 0x20

1th DATA byte						
0	-	-	11. bit	10. bit	9. bit	8. bit
			7. bit			

2th DATA byte						
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit
						0. bit

I x R compensation value can be used for gain the output voltage when the motor internal resistance causing voltage drop and RPM drop. This value will be multiplied with the load current and added to the output voltage.

Using the I X R compensation constant from the Register Value Range table you can calculate the needed value.

The [%/A] tell how much compensation is needed for running the motor at the same RPM under load.

Bit 13:0 I x R COMPENSATION REGISTER [13:0]:

Max value is 16383

Min value is 0

*Note: for the corresponding value check the **Register Value Range** table.*

Top Speed register:

Type: Write / Read

Write Command: 0x61

Read Command: 0x21

1th DATA byte						
0	-	-	11. bit	10. bit	9. bit	8. bit
			7. bit			

2th DATA byte						
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit
						0. bit

Top Speed value can be used for making a reference voltage for the speed input or speed register. This can make a supply compensation when the supply voltage is changes or you can limit the maximum output output voltage / motor RPM and does not matter if the speed potentiometer would set higher output voltage the Top Speed will overwrite this value.

For the calculation use the given top speed constant from the **Register Value Range** table.

Giving and example: If the constant for the given controller is 18,51mV than if you need a maximum output voltage of 20V than calculate like this: $Top\ Speed = 20V / 0.01805V = 1080$.

So writing the 1080 in the top speed register you can set maximum 20V output voltage with the potentiometer. If your supply voltag changes between higher ranges for example 25-50V your output voltage remains the same 20V or less depending on your speed potentiometer's setting.

With TOP Speed settings you can have supply compensation fixing the speed variation with different supply voltages.

Turning on the supply compesation you need to turn on the **Top Speed /Supply compensation** bit in the **Configuration_bits_2** register.

Giving 0 or near 0 value of this register can cause 0V output voltage.

Bit 13:0 **TOP SPEED REGISTER [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding value check the **Register Value Range** table.*

Potentiometer min. register:

Type: Write / Read

Write Command: 0x62

Read Command: 0x22

1th DATA byte							
0	-	-	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

With Potentiometer min and max you can define your voltage levels on the speed input what you need for the given 0% output voltage and the given 100% output voltage.

For the calculation use the given potentiometermin/max constant from the **Register Value Range** table.

Giving and example: If the constant for the given controller is 1,184mV than if you need the 0% output starting from the speed input=1V

$$\text{Potentiometer min register} = 1V / 1,184mV = \underline{844}$$

Using this function you need to save the potentiometer min/max registers in the flash memory using the **Save register** and restart the controller with SW mode setting: 1:OFF 2:OFF.

Bit 13:0 **Potentiometer Min register [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding value check the **Register Value Range** table.*

Potentiometer max. register:

Type: Write / Read

Write Command: 0x63

Read Command: 0x23

1th DATA byte							
0	-	-	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

With Potentiometer min and max you can define your voltage levels on the speed input what you need for the given 0% output voltage and the given 100% output voltage.

For the calculation use the given potentiometermin/max constant from the **Register Value Range** table.

Giving and example: If the constant for the given controller is 1,184mV than if you need the 100% output ending at the speed input=3,5V

$$\text{Potentiometer maxregister} = 3,5V / 1,184mV = \underline{2956}$$

Using this function you need to save the potentiometer min/max registers in the flash memory using the **Save register** and restart the controller with SW mode setting: 1:OFF 2:OFF.

Bit 13:0 **Potentiometer Max register [11:0]:**

Max value is 4095

Min value is 0

*Note: for the corresponding value check the **Register Value Range** table.*

Status Register:

Type: Read

Read Command: 0x30

1th DATA byte							
0	-	-	-	-	FM	-	-

2th DATA byte							
0	BR pin	EN_in	DT	-	OT	OV	UV

Bit 9 **FM:** Forward mode:

0: Stop

1: Controller in forward mode.

Bit 6 **BR Pin:** Brake input pin state bit.

0: Brake pin is "Low"

1: Brake pin is "High"

*Note: reading this you need to be not in PWM mode.*Bit 5 **EN_in:** Enable input pin state bit:0: Enable pin is "High $V_{en} > 2V$ "1: Enable pin is "Low $V_{en} < 1V$ "Bit 4 **DT:** Drive status bit:

0: Drive mode

1: Brake mode

Bit 2 **OT:** Over temperature status bit.

0:

1: Supply voltage is lower than the Turn on minimum register value.

Bit 1 **OV:** Over voltage status bit.

0:

1: Supply voltage is higher than the Turn off maximum register value.

Bit 0 **UV:** Under voltage status bit.

0:

1: Supply voltage is lower than the Turn on minimum register value.

Lock Variables Register:

Type: Write / Read

Write Command: 0x71

Read Command: 0x31

1th DATA byte							
0	-	-	-	-	-	-	-

2th DATA byte							
0	-	-	-	ACC	REG	CUR	SPD

Locking any register means only USART update can overwrite its value. The on board potentiometers will be disabled as long as the associated bit is "1".

This is good if you want to deny the possibility to change the value of the registers on board. Other advantage if you want to use the Speed input for other purposes than you need to lock the SPD register otherwise the value of the speed input will be used for setting the output voltage.

Bit 3 **ACC:** Writing "1" locks the Speed Register.

Bit 2 **REG** Writing "1" locks the Current Limit Register.

Bit 1 **CUR:** Writing "1" locks the Regeneration Limit Register.

Bit 0 **SPD:** Writing "1" locks the Acceleration Limit Register.

Note: This register going to lose its content after restarting the controller.

Save bits 1 register:

Type: Write / Read

Write Command: 0x72

Read Command: 0x32

1th DATA byte							
0	CONF2	CONF1	ADDR	-	OFF_H	ON_H	ON_L

2th DATA byte							
0	OFF_L	DEC	ACC	REG	CUR	-	SPD

These bits are set all the registers you want to save into the flash memory. Writing into this register only designates the register to be saved. The actual saving command will be done only with writing the **Save_bits_2** register. When a memory saving occurs the data will be reloaded from the memory after every restart. Saving a register data automatically locks the particular register and only USART update can rewrite it.

- Bit 13 **CONF2:** Configuration 2 Register.
0: no saving
1: Save the given register into flash memory.
- Bit 12 **CONF1:** Configuration 1 Register.
Refer to the Bit 13 CONF2 description.
- Bit 11 **ADDR:** Configuration 2 Register.
Refer to the Bit 13 CONF2 description.
- Bit 9 **OFF_H:** Save turning off maximum value.
Refer to the Bit 13 CONF2 description.
- Bit 8 **ON_H:** Save turning on maximum value.
Refer to the Bit 13 CONF2 description.
- Bit 7 **ON_L:** Save turning off minimum value.
Refer to the Bit 13 CONF2 description.
- Bit 6 **OFF_L:** Save turning off low value.
Refer to the Bit 13 CONF2 description.
- Bit 5 **DEC:** Save deceleration value.
Refer to the Bit 13 CONF2 description.
- Bit 4 **ACC:** Save acceleration value.
Refer to the Bit 13 CONF2 description.
- Bit 3 **REG:** Save regenerative current limit value.
Refer to the Bit 13 CONF2 description.
- Bit 2 **CUR:** Save current limit value.
Refer to the Bit 13 CONF2 description.
- Bit 0 **SPD:** Save speed value.
Refer to the Bit 13 CONF2 description.

Save bits 2 register:

Type: Write / Read

Write Command: 0x72

Read Command: 0x33

1th DATA byte							
0	-	-	-	-	-	-	-

2th DATA byte							
0	-	-	P_MAX	P_MIN	TOP_S	IR_COM	C_CAL

These bits are set all the registers you want to save into the flash memory. Writing into this register designates the register to be saved and initiates the saving command. When a memory saving occurs the data will be reloaded from the memory after every restart. Saving a register data automatically locks the particular register and only USART update can rewrite it.

IMPORTANT: Writing into this register as a repeated operation is not recommended. **The FLASH memory rewritable life cycle is limited about 10.000 saving operation! Under the save operation the PWM controller stops and no other operation can be used!**

- Bit 4 **P_MAX:** Potentiometer Maximum
0: no saving
1: Save the given register into flash memory.
- Bit 3 **P_MIN:** Potentiometer Minimum
Refer to the Bit 8 OFH description.
- Bit 2 **TOP_S:** Top Speed/Supply compensation
Refer to the Bit 8 OFH description.
- Bit 1 **IR_COM:** I x R compensation
Refer to the Bit 8 OFH description.
- Bit 0 **C_CAL:** Current calibration
Refer to the Bit 8 OFH description.

Configuration bits 1 register:

Type: Write / Read

Write Command: 0x74

Read Command: 0x34

1th DATA byte							
0	-	-	-	-	FD	-	-

2th DATA byte							
0	-	DO	DM	BM	SRC_2	SRC_1	UC

Bit 9 **FD:** Forward Direrection:

0: Stop

1: Set forward direction.

Bit 4 **DO:** Disable Output*This bit has a priority over the Enable Input pin if **EN_OFF** bit in **Configuration_bits_2** register is "1".*

0: PWM output enabled.

1: PWM output disabled (both high and low side mosfets are disabled).

Bit 4 **DM:** Selecting operation mode*This bit set and cleared by UART write and cleared by hardware after restart.*

0: Drive mode.

1: Brake mode or free running mode depending on **BM** bit.Bit 3 **BM:** Braking mode*This bit set and cleared by UART write and cleared by hardware after restart.*

0: Manual brake (free running mode)

1: Auto brake (automatic regeneration)

Note: Manual brake let the motor spinning free after turning down the speed or sending 0 speed command. Auto brake start automatic current regeneration into the supply when the motor internal voltage is higher than the speed.

Bit 2:1 **SRC[1:0]:** Speed reset controll*This bit set and cleared by UART write and cleared by hardware after restart.*

00: No speed reset after no UART speed update.

01: Speed reset after 50msec without new UART speed update.

10: Speed reset after 500msec without new UART speed update.

11: Speed reset after 2800msec without new UART speed update.

Bit 0 **UC:** UART controll bit*This bit set and cleared by UART write and cleared by hardware after restart.*

0: Disable the configuration bits

1: Enable the configuration bits

Configuration bits 2 register:

Type: Write / Read

Write Command: 0x75

Read Command: 0x35

1th DATA byte								2th DATA byte							
0	-	-	-	-	EN_OFF	TOP_S	P_OFF	0	PMES	-	-	-	USP_2	USP_1	-

Note: writing 1 clears the given bit writing 0 makes no changes.

Bit 8 **EN_OFF**: Enable input pin OFF.

*This bit used to turn off the Enable input pin function. PWM output enabled/disabled with the **DO** bit in the **Configuration_bits_1** register*

0: Enable input pin is active.

1: Enable input pin has turned off.

Bit 8 **TOP_S**: Top Speed/Supply compensation enable bit.

0: Disable

1: Enable

Bit 7 **P_OFF**: Pin terminals OFF .

This bit is used to disable the Brake function of the PWM/Brake input and using as a logical input.

0: Enable

1: Disable

Bit 6 **BMC**: Pulse Measurement resolution

Resolution on the PWM/brake input

0:

1:

Bit 2:1 **USP [1:0]**: USART communication speed.

Default speed is 19200 Baud/sec

These bits set the UART baud/sec rate.

00: 19200 Baud/sec

01:

10:

11:

USART Address Register:

Type: Write

Write command: 0x7C

1th DATA byte							
0	-	-	-	-	-	-	-

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

USART Address bits is a unique 7bit address which marks the given controller. It allows to connect several controllers or even other USART devices to connect to the same RX TX channel. The default USART address is 0x00. If you want to control two or more controllers through the USART you have to change the address first one by one. After this it is possible to connect more devices to the same USART channel. USART Address will be saved into the FLASH memory and reloaded from the memory after every restart.

The controllers send out their unique USART address right after the system start. This helps to recover and recognise a forgotten address.

Bit 6:0 **USART ADDRESS [6:0]:**

Max value is 0x7F

Default value: 0x00

Current measurement calibration register:

Type: Write

Write command: 0x7D

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Motor controller boards may have current measurement error 1-15% depending on the model. Calibrating and saving the current measurement register solve the error problem and will use the value for the measurement correction.

For the calibration you need follow the steps:

1. Set maximum speed potentiometer input
2. Turn down the current limit
3. Place a pure inductive load to the output. You can use large inductors or a stalled DC- motor.
4. Place a current meter or digital clamp meter measuring the motor current.
5. Turn on the supply
6. Slowly turn up the current limit potentiometer
7. Regarding the controller and your load current capabilities turn up the current to a high enough level. For example with a 100A motor controller 30A is enough.
8. When you read the exact current on your own current meter you need to send the equivalent value into the **Current Measurement Calibration** register. Calculating the value use the constant in the **Register Value Range** table.
9. Save the register with the **Saving bits** register.

Note: If the deviation between the sent value and the internal current measurement is larger than +/-20% than the controller will ignore the command.

Example: If you Set 30A load current and your constant is 0,244A then the register value will be: $30A/0,244A = 123$

Software version register:

Type: Read

Read command: 0x3E

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Hardware version register:

Type: Read

Read command: 0x3F

1th DATA byte							
0	13. bit	12. bit	11. bit	10. bit	9. bit	8. bit	7. bit

2th DATA byte							
0	6. bit	5. bit	4. bit	3. bit	2. bit	1. bit	0. bit

Examples:

Example 1: Calling 0x00 address device and writing DATA_to send: 0x05C5 value into the Speed register:

Sent bytes:

0x80	0x40	0x0B	0x45	0x10
------	------	------	------	------

C conversion code before sending out the bytes:

```
ADDRESS=UNIT_ADDRESS | 0x80;
COMMAND= for this check the write commands in the register table
DATA_1th= (DATA_to_send>>7) & 0x7F;
DATA_2th=DATA_to_send & 0x7F;
CRC=( COMMAND + DATA_1th + DATA_2th) & 0x7F;
```

Example 2: Calling 0x02 address device and locking Speed variable:

Sent bytes:

0x82	0x71	0x00	0x01	0x72
------	------	------	------	------

C conversion code before sending out the bytes:

Refer to the Example 1.

Example 3: Calling 0x02 address device to change the regenerative braking mode to "auto regen" from "free running mode" and initiating regenerative braking with 0x062C current:

For this you need to execute 2 write commands. The first set the regenerative current limit.

Sent bytes:

0x82	0x43	0x0C	0x2C	0x7B
------	------	------	------	------

C conversion code before sending out the bytes:

Refer to the Example 1.

Second to set the Configuration bit:

Sent bytes:

0x82	0x74	0x00	0x19	0x0D
------	------	------	------	------

C conversion code before sending out the bytes:

Refer to the Example 1. and **Set Configuration bits register.**

Example 4: Calling 0x00 address device to read the load_current_register:

Sent bytes:

0x80	0x12
------	------

 (read command)

Received bytes from the controller:

0x13	0x36	0x0D
------	------	------

C conversion code for the received bytes:

CRC check:

```
if(((received_byte_1th + received_byte_2th + Read_command) & 0x7F) == received_byte_3th)
{
    load_current_register = (received_byte_1th << 7) | (received_byte_2th & 0x7F);
}
```