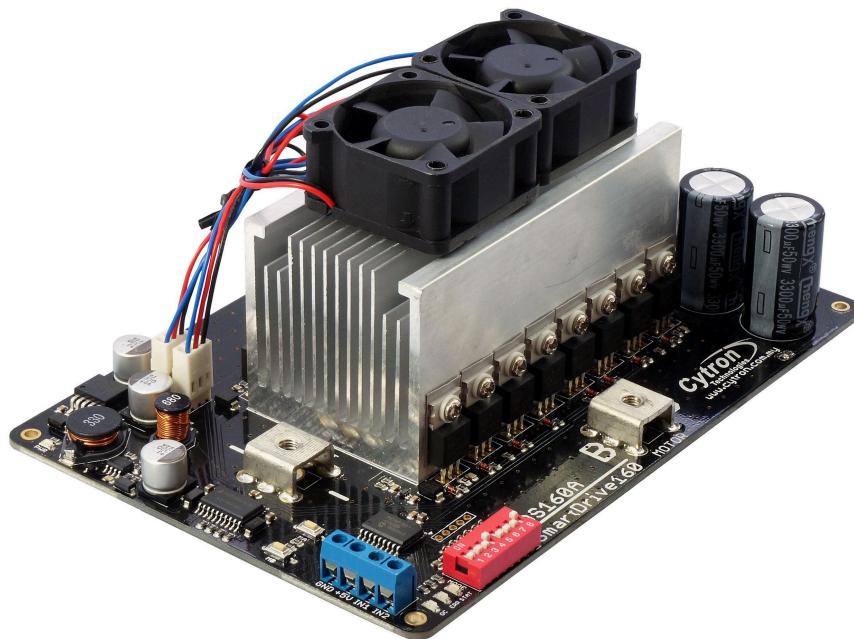




## MDS160A SmartDrive160



## User's Manual

V1.0

Aug 2014

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## 1.0 INTRODUCTION AND OVERVIEW

[SmartDrive160](#) is one of the latest smart series motor drivers designed to drive high power brushed DC motor with current capacity up to 160A continuously. MOSFETs are switched at 16 KHz to ensure quiet operation and no annoying whining sound. Besides, it also equipped with a microcontroller unit to provide smart features such as multiple input mode, current limiting and thermal protection.

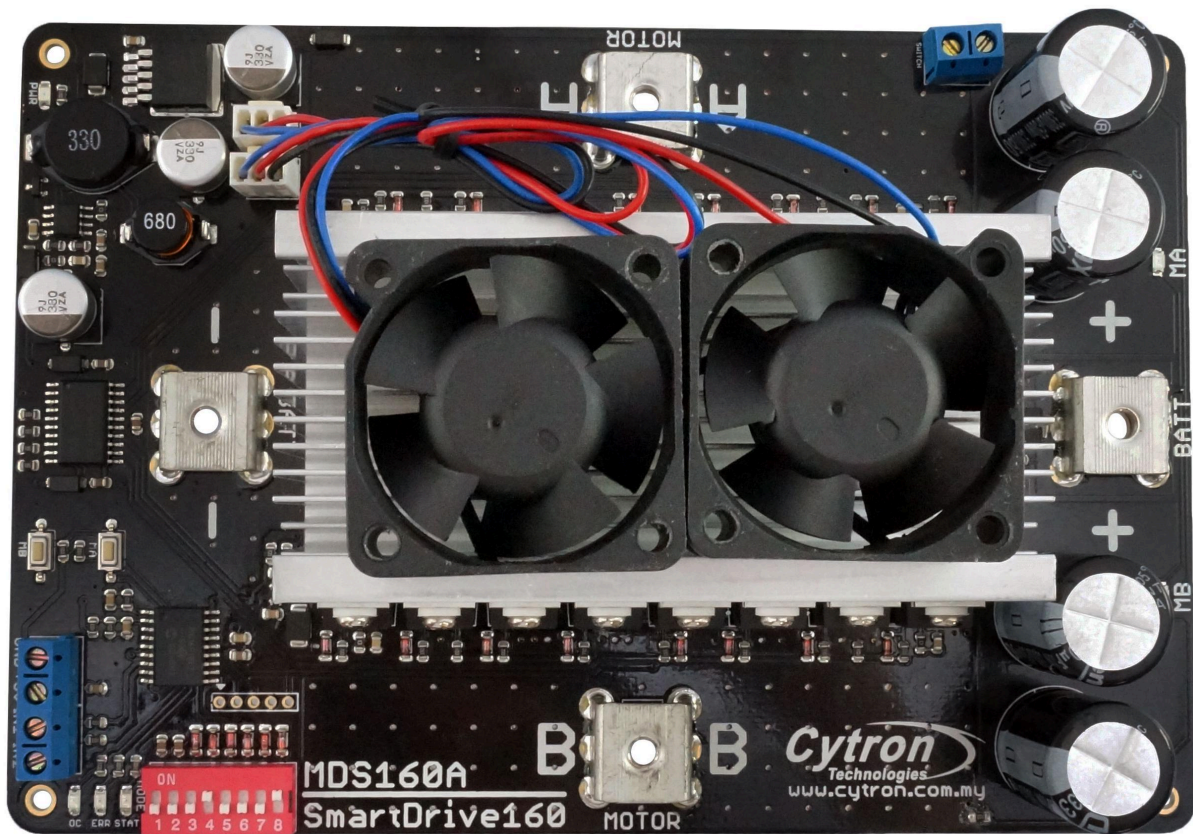
SmartDrive160 can also be hooked up with another similar unit and operates in pair. This make driving a robot with differential drive a truly plug and play experience.

Some of the features for SmartDrive160 are summarized as below:

- Bi-directional control for a single brushed DC motor.
- Support input voltage from 8V to 28V.
- Maximum current up to 190A peak (1 minute), 175A (2 minutes) or 160A (continuously).
- 16 KHz switching frequency for quiet operation.
- LiPo battery low voltage warning.
- Thermal protection.
- Current limiting base on temperature.
  - Below 60°C : 194A
  - 60°C to 70°C : 175A
  - 70°C to 80°C : 163A
  - 80°C to 90°C : 144A
  - 90°C to 100°C : 125A
  - 100°C to 110°C : 100A
  - Above 110°C : 50A
- Multiple input modes: RC, Analog, PWM, Simplified Serial and Packetized Serial.
- On board push buttons for fast test and manual operation.

## 2.0 PACKING LIST

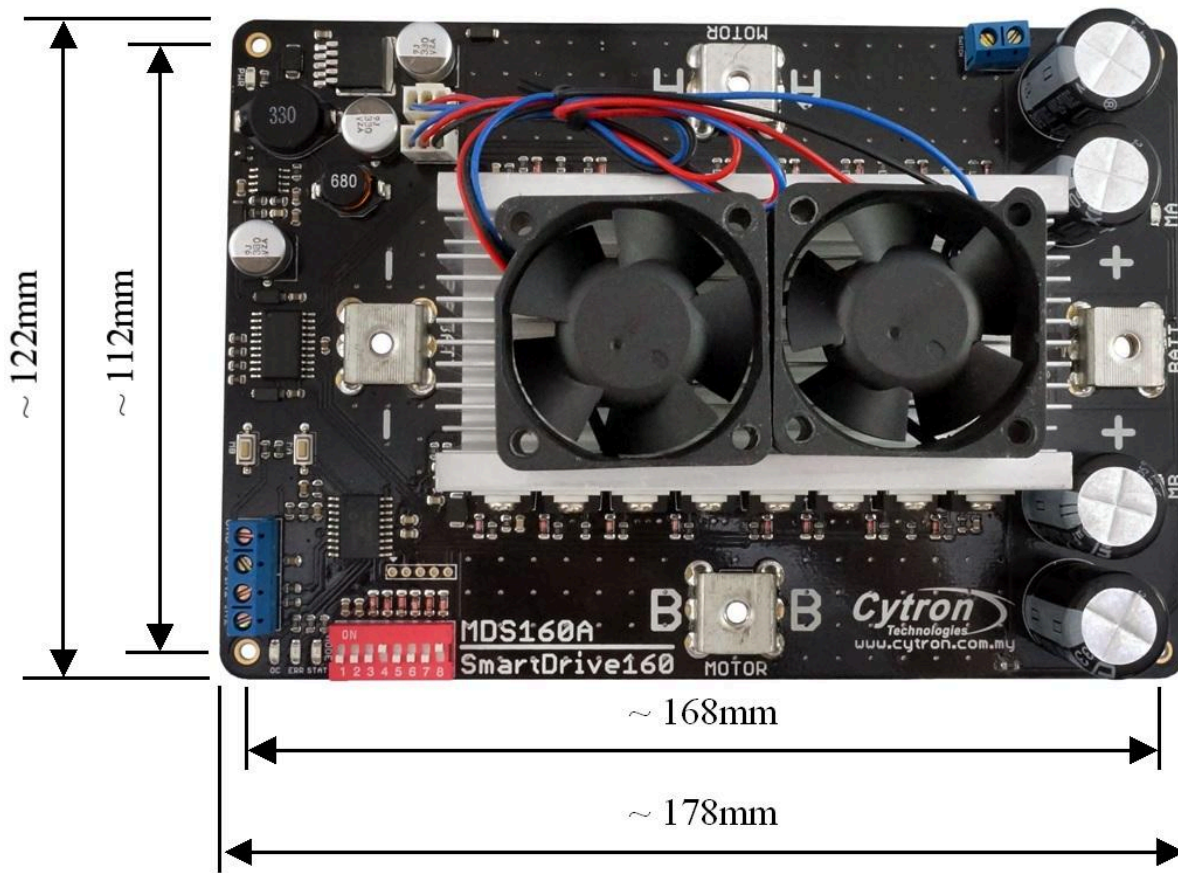
Please check the parts and components according to the packing lists. If there are any parts missing, please contact us at [sales@cytron.com.my](mailto:sales@cytron.com.my) immediately.



1. 1 x [MDS160A](#) SmartDrive160
2. User's Manual can be downloaded from <http://www.cytron.com.my>



### 3.0 PRODUCT SPECIFICATIONS



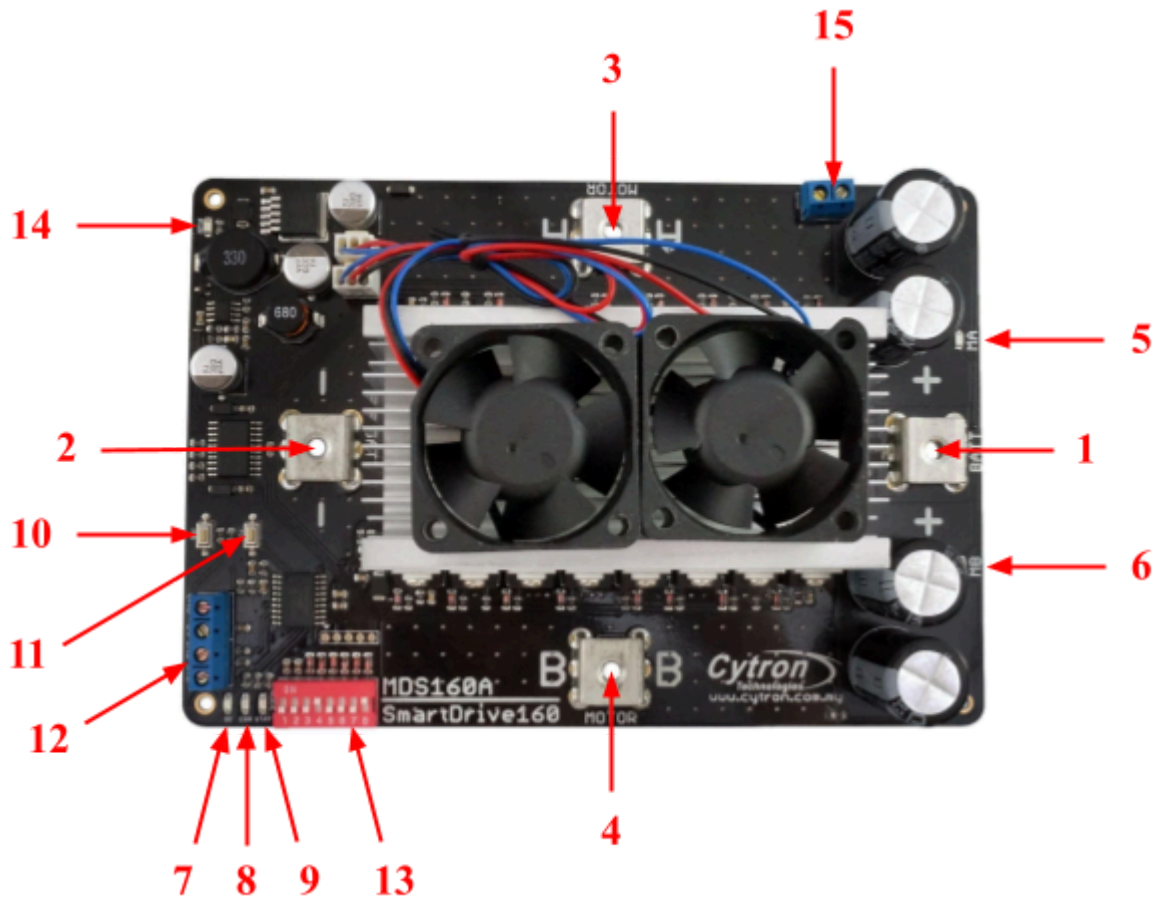
- The height is 75mm including the cooling fan.

No	Parameters	Min	Typical	Max	Unit
1	Input Voltage (Motor Supply Voltage)	8	-	28	V
2	$I_{MAX}$ (Maximum Continuous Motor Current)*	-	-	160	A
3	$I_{PEAK}$ – (Peak Motor Current) *	-	-	190	A
4	$V_{IOH}$ (Logic Input – High Level) **	3	-	5.5	V
5	$V_{IOL}$ (Logic Input – Low Level) **	0	0	0.5	V
6	5V Output Current	-	-	1	A

\* Depends on the room temperature.

\*\* Not applicable for PWM signal as PWM signal will be converted to analog voltage via low pass filter before processed by the processor.

## 4.0 BOARD LAYOUT



Components on MDS160A and their functions:

1. Positive Supply Terminal - Connect to the power source (positive).
2. Negative Supply Terminal - Connect to the power source (negative).
3. Motor Terminal A - Connect to the moto. Swap with Motor Terminal B if the direction is incorrect.
4. Motor Terminal B - Connect to the moto. Swap with Motor Terminal A if the direction is incorrect.
5. LED A – Turns on when the Motor Terminal A is high and Motor Terminal B is low. Indicates the current flows from Motor Terminal A to B.
6. LED B – Turns on when the Motor Terminal A is low and Motor Terminal B is high. Indicates the current flows from Motor Terminal B to A.
7. LED OC – Overcurrent LED. Turn on when the overcurrent is detected and the current is limited by the motor driver.

8. LED ERR – Error LED. The number of blinks is corresponding to the error.

Number of Blinks	Error	Description
Off	No Error	No error has been detected.
2	Input Error	Invalid or no input detected.
3	Lipo Undervoltage	The LiPo battery voltage is too low.
4	Over Voltage	Overvoltage is detected. The power source cannot absorb the current generated by the motor.
5	Over Temperature	The board temperature is too high.

9. LED STAT – Status LED. Turn on when the motor is running.

10. Test Button B – When this button is pressed, current flows from Motor Terminal B to A and motor will turn CCW (or CW depending on the connection).

11. Test Button A – When this button is pressed, current flows from Motor Terminal A to B and motor will turn CW (or CCW depending on the connection).

12. Input

Pin No.	Pin Name	Description
1	IN2	Input channel 2.
2	IN1	Input channel 1.
3	+5V	+5V output. Do not connect to another 5V source.
4	Gnd	Ground.

**Warning:** The +5V output is designed to power the RC receiver, mini servo motor and other circuit up to 1A only.

13. Mode Selection DIP Switch – Used to select the input mode.

14. LED PWR – Power LED. Should be on when the board is powered.

15. On/Off Switch - An alternative way to turn off the motor power without disconnecting the power cable.

## 5.0 POWER SUPPLY

SmartDrive160 supports input voltage ranges from 8V to 28V. The recommended power sources are:

- 7 – 18 cells NiMH or NiCd battery.
- 3 – 6 cells LiPo or Li-Ion battery.
- 12V – 24V sealed lead acid battery.
- 8V – 28V power supply (**Must be in parallel with a battery with same voltage**).

### **NOTE:**

1. If a power supply that cannot sink current is being used (bench top and AC to DC switching power supply), the input voltage will rise when the driver is regenerating (motor is slowing down). Thus, it is important to connect a battery with same voltage in parallel with the power supply to absorb the current generated by the motor. Else, the input voltage might rise to a level where SmartDrive160 will be destroyed permanently.

### **NOTE:**

If the board is off when power is supplied to the board, you need to shorted together the SWITCH terminal block (No. 15) by a solder bridge at the bottom layer of the PCB.

## 5.1 Connecting External On/Off Switch

SmartDrive160 includes a terminal block for external on/off switch. This allows the motor power to be turned off without unplugging the power cable.

Follow these steps to connect an external switch to the SmartDrive160:

1. By default, the pins of the terminal block are shorted together by a solder bridge at the bottom layer of the PCB. Desolder the bridge with a soldering iron.
2. Connect the external switch to the terminal block.



## 6.0 SAFETY FEATURES

SmartDrive160 incorporates some safety features which make it a robust and reliable motor driver. Below are the detailed descriptions for each feature.

a. **LiPo Under Voltage Warning (Error LED blinks 3 times)**

Upon power on, SmartDrive160 will automatically detect the number of cells for the LiPo battery. If the input voltage falls below 3.3V per cell during operation, the error LED will blink to warn the user. However, the power to the motor will be maintained and will not be cut out. Thus, it is the user's responsibility to stop the motor and replace the battery to avoid further damage to the battery.

If the other type of battery is used to power the board, the LiPo under voltage warning will still be shown. In this case, user may ignore the warning and he/she needs to estimate when to replace the battery by him/herself.

b. **Overvoltage Protection (Error LED blinks 4 times)**

When the motor is slowing down, current will be generated and flow back to charge the battery. However, if the power source cannot absorb the current generated by the motor, the voltage will rise. If the motor driver detects the rise in voltage, it will slow down the deceleration of the motor. If the voltage rises to a dangerous level, the motor will be braked immediately by shorting the 2 motor terminal to prevent any damage to the motor driver.

c. **Overcurrent Protection (OC LED turns on)**

When overcurrent occurs, the current will be limited by each PWM cycle. The actual overcurrent threshold is depending on the temperature of the board.

d. **Over Temperature Protection (Error LED blinks 5 times)**

SmartDrive160 is equipped with a temperature sensor to monitor its operating temperature. It will gradually lower down the current limiting threshold base on the temperature.

Temperature Range (°C)	Over Current Threshold (A)
< 60	194
60 - 70	175
70 - 80	163
80 - 90	144
90 - 100	125
100 - 110	100
> 110	50

## 7.0 INPUT MODE

When the [SmartDrive160](#) is powered up, the input mode will be read from the DIP switch and retained as long as the driver is powered. If you wish to change the input mode, you will need to change the setting on the DIP switch and power cycle the driver (Turn it off and turn it on again).

In RC or Analog/PWM Input mode, two units of SmartDrive160 may be used together to control two motors in mixed mode. This is useful to control the robot with differential drive system where one input controls the speed and forward/backward direction of the robot, while another input controls the left/right direction of the robot.

SmartDrive160 supports four different types of input mode. The DIP switch settings for each mode and the function for input pin are summarized as below:

Input Mode	DIP Switch (SW1 - SW4)	DIP Switch (SW5 - SW8)	Description	Input 1	Input 2
RC	0000XXXX	SW5:6  SW7  SW8	Single/Mix Mode 0X - Single 10 - Mix (Left)* 11 - Mix (Right)*  Exponential Mode  MCU Mode	Speed	Steering (Mix Mode)
Analog / PWM	XX01XXXX	SW1:2  SW5:6  SW7  SW8	Analog/PWM Mode 00 - Analog 11 - PWM  Single/Mix Mode 0X - Single 10 - Mix (Left)* 11 - Mix (Right)*  Exponential Mode  Sign-Magnitude Mode (Single Mode only). SW5 must be 0.	Speed	Steering (Mix Mode)  Direction (Sign-Magnitude)
Simplified Serial	0010XXXX	SW5  SW6:8	N/A  UART Baud Rate 000 - 1200 001 - 2400 010 - 4800 011 - 9600 100 - 19200 101 - 38400 110 - 57600 111 - 115200	UART Rx	Slave Select
Packetized Serial	0011XXXX	SW5:8	UART Slave Address (0x00 – 0x0f)	UART Rx	N/A

0 – OFF      1 – ON      X – Don't Care

\* Left/Right is just for reference. Actual side of the motor may depends on the RC transmitter or analog/PWM input.

## 7.1 RC INPUT MODE

In RC input mode, the speed and direction of the motor is controlled by the signal from the standard hobby radio control transmitter and receiver, or a microcontroller generating the similar signal.

**NOTE:** The RC transmitter must be turn on before power up the SmartDrive160.





RC Input mode is selected by setting all the **SW1 – SW4** to **0 (Down)**. SW5 – SW8 can be configured depending on the requirement of the user.

Input Mode	SW1:SW4 0000	RC Input Mode
Single/Mix Mode	SW5:SW6 0X	<b>Single Channel Mode</b> – The motor speed and direction are controlled by a single RC channel connected to Input 1. Motor stops when the input signal is at the center point. Input 2 is not used in this mode.
	10	<b>Left Mix Mode*</b> – This mode should be selected for the left motor of the robot differential drive system. Input 1 controls the overall speed as well as forward/backward movement of the robot. Input 2 controls the left/right or pivot movement of the robot. In left mix mode, the motor will be slowed down when the robot is commanded to turn left and vice versa.
	11	<b>Right Mix Mode*</b> – This mode should be selected for the right motor of the robot differential drive system. Input 1 controls the overall speed as well as forward/backward movement of the robot. Input 2 controls the left/right or pivot movement of the robot. In right mix mode, the motor will be slowed down when the robot is commanded to turn right and vice versa.
Exponential Mode	SW7 0	<b>Off</b> – The speed is linear with the input signal. This is for low to medium speed motor.
	1	<b>On</b> –The response to input is exponential and this soften the control around the center zero speed point. This is suitable for high speed and very sensitive motor.
MCU Mode	SW8 0	<b>Off</b> – The center point will be calibrated upon power up. Timeout occurs after lost of signal for 100ms and the motor will be stopped for safety purpose.
	1	<b>On</b> – The center point is fixed at 1.5ms and the timeout feature is disabled. Motor will continue to run with previous speed if new signal is not detected. This is useful when a microcontroller is used to control the motor. The microcontroller does not need to send the pulse continuously to the SmartDrive160. Instead, it only needs to send a single pulse when the speed or direction of the motor needs to be changed.

0 – OFF      1 – ON      X – Don't Care

\* Left/Right is just for reference only. Actual side of the motor may depends on the RC transmitter.

Table below shows the commonly used DIP switch settings for RC mode.

DIP Switch	Mode
 <p>(00000000)</p>	<ul style="list-style-type: none"> <li>• RC Mode</li> <li>• Single Channel Mode</li> <li>• Exponential Off</li> <li>• MCU Mode Off</li> </ul>
 <p>(00000010)</p>	<ul style="list-style-type: none"> <li>• RC Mode</li> <li>• Single Channel Mode</li> <li>• Exponential On</li> <li>• MCU Mode Off</li> </ul>
 <p>(00001000)</p>	<ul style="list-style-type: none"> <li>• RC Mode</li> <li>• Left Mix Mode</li> <li>• Exponential Off</li> <li>• MCU Mode Off</li> </ul>
 <p>(00001100)</p>	<ul style="list-style-type: none"> <li>• RC Mode</li> <li>• Right Mix Mode</li> <li>• Exponential Off</li> <li>• MCU Mode Off</li> </ul>

## 7.2 ANALOG/PWM INPUT MODE

In Analog/PWM input mode, the speed and direction of the motor is controlled by the analog voltage or PWM signal. The valid input range is 0 – 5V and it's very easy to control by using a potentiometer. For example, the motor can be controlled by a joystick or foot pedal with potentiometer.

**NOTE:** The Analog/PWM signal to stop the motor (2.5V if Sign-Magnitude mode is off, 0V otherwise) must be available when the SmartDrive160 is turned on. Else, the driver will show Input Error until the correct signal is available.

Analog/PWM input mode is selected by setting **SW3 to 0 (Down) and SW4 to 1 (Up)**. SW1 – SW2 and SW5 – SW8 can be configured depending on the requirement of the user.

PWM Mode	<b>SW1:SW2</b> 00	<b>Off</b> - The input is analog signal. The filter capacitor is not connected and the input signal is not filtered. SW1 is for Input 1 while SW2 is for Input 2.
	11	<b>On</b> - The input is PWM signal. The filter capacitor is connected and the input signal is low pass filtered to be an analog signal. SW1 is for Input 1 while SW2 is for Input 2. SW2 must be set to 0 if Sign-Magnitude mode is turned on.
Input Mode	<b>SW3:SW4</b> 01	Analog/PWM Input Mode.
Single/Mix Mode	<b>SW5:SW6</b> 0X	<b>Single Channel Mode**</b> - The motor speed and direction are controlled by a single channel connected to Input 1. Motor stops when the input signal is at the center point. Input 2 is not used in this mode.
	10	<b>Left Mix Mode*</b> - This mode should be selected for the left motor of the robot differential drive system. Input 1 controls the overall speed as well as forward/backward movement of the robot. Input 2 controls the left/right or pivot movement of the robot. In left mix mode, the motor will be slowed down when the robot is commanded to turn left and vice versa. SW8 must be set to 0.
	11	<b>Right Mix Mode*</b> - This mode should be selected for the right motor of the robot differential drive system. Input 1 controls the overall speed as well as forward/backward movement of the robot. Input 2 controls the left/right or pivot movement of the robot. In right mix mode, the motor will be slowed down when the robot is commanded to turn right and vice versa. SW8 must be set to 0.
Exponential Mode	<b>SW7</b> 0	<b>Off</b> – The speed is linear with the input signal. This is for low to medium speed motor.
	1	<b>On</b> –The response to input is exponential and this soften the control around the center zero speed point. This is suitable for high speed and very sensitive motor.





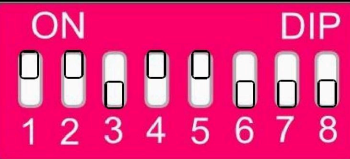
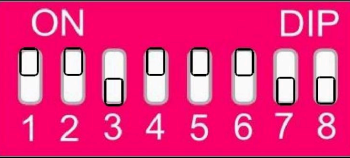
Sign-Magnitude Mode	SW8 0	<b>Off</b> – Motor stops when the input signal is 2.5V. Motor moves in one direction when the input is < 2.5V and in another direction when the input is > 2.5V.
	1	<b>On</b> – Input 1 controls the speed of the motor. Motor stops when the input is 0V and runs at full speed when the input is 5V. Input 2 is digital input and it controls the direction of the motor. SW2 must be set to 0.

0 - OFF      1 - ON      X - Don't Care

\* Left/Right is just for reference only. Actual side of the motor may depend on the Input signal.

\*\* For Watanabe revision, the center value is 3V and motor stops if < 0.8V. Input 2 must be low to enable the driver.

Table below shows the commonly used DIP switch settings for Analog/PWM mode.

DIP Switch	Mode
 <p>(00010000)</p>	<ul style="list-style-type: none"> <li>• Analog Mode</li> <li>• Single Channel Mode</li> <li>• Exponential Off</li> <li>• Sign-Magnitude Mode Off</li> </ul>
 <p>(10010001)</p>	<ul style="list-style-type: none"> <li>• PWM Mode</li> <li>• Single Channel Mode</li> <li>• Exponential Off</li> <li>• Sign-Magnitude Mode On</li> </ul>
 <p>(11011000)</p>	<ul style="list-style-type: none"> <li>• PWM Mode</li> <li>• Left Mix Mode</li> <li>• Exponential Off</li> <li>• Sign-Magnitude Mode Off</li> </ul>
 <p>(11011100)</p>	<ul style="list-style-type: none"> <li>• PWM Mode</li> <li>• Right Mix Mode</li> <li>• Exponential Off</li> <li>• Sign-Magnitude Mode Off</li> </ul>

### 7.3 SIMPLIFIED SERIAL MODE

In Simplified Serial mode, [SmartDrive160](#) is controlled by using the UART interface. Input 1 is the UART Rx pin and Input 2 is the Slave Select pin.

The Slave Select must be HIGH in order for the driver to receive the UART command. If the Slave Select pin is set to LOW, all the UART data will be ignored. This feature allows multiple SmartDrive160 to be connected together to a single microcontroller UART port. The Slave Select pin is internally pulled high and it may be left unconnected if not used.

A single byte of data is all you need to control the speed and direction of the motor. Sending byte 127 stops the motor, 0 is full reverse and 255 is full forward.

Simplified Serial mode is selected by setting **SW1, SW2 and SW4 to 0 (Down) and SW3 to 1 (Up)**. SW5 is not used in this mode and SW6 – SW8 are used to select the UART baud rate.

Input Mode	SW1 - SW4 0010	Simplified Serial Mode
UART Baud Rate	<b>SW6 - SW8</b>	<b>Baud Rate</b>
	000	1200
	001	2400
	010	4800
	011	9600
	100	19200
	101	38400
	110	57600
	111	115200

0 - OFF      1 - ON      X - Don't Care

## 7.4 PACKETIZED SERIAL MODE

In Packetized Serial mode, [SmartDrive160](#) is controlled by using the UART interface. Input 1 is the UART Rx pin and Input 2 is not used in this mode. To control the motor, data sent to the driver must be in 4 bytes packet format which includes a header, address, command and checksum. Up to 16 units of SmartDrive160 can be connected together to a single microcontroller UART port.

Besides that, the SmartDrive160 also incorporates an Auto-Baud feature in Packetized Serial mode. When the driver is first powered up, the host microcontroller must send a header byte (Decimal 85) to the driver. The driver will then calculate the baud rate automatically based on this character. After that, SmartDrive160 is ready for command and the baud rate cannot be changed without power off and on again.

**NOTE:**

1. When the driver is powered up and waiting for the header byte, the error LED will blink and indicate that there is input error.
2. SmartDrive160 may take up to 500ms to start up after power is applied. Sending the header byte for auto baud during this time period may cause undesirable results. Please allow a one-second delay between applying power and sending the header byte.

Packetized Serial mode is selected by setting **SW1, SW2 to 0 (Down) and SW3, SW4 to 1 (Up)**. SW5 – SW8 are used to select the address.

Input Mode	<b>SW1 - SW4</b> 0011	<b>Packetized Serial Mode</b>
UART Address	<b>SW5 - SW8</b> 0000 - 1111	<b>0 - 15</b>

0 - OFF            1 - ON            X - Don't Care

A packet consists of 4 bytes and the format is shown in the following table.

Byte	Name	Value (Decimal)	Description
1	Header	85	To indicate the start of packet.
2	Address	0 - 15	Used to identify the driver when multiple units are connected together. The address byte must match the address configured with the DIP switch.
3	Command	0 – 255	Value 127 stops the motor, 0 is full reverse and 255 is full forward.
4	Checksum	0 – 255	The value for checksum must be the result of Header + Address + Command

## 8.0 WARRANTY

- Product warranty is valid for 12 months.
- Warranty only applies to manufacturing defect.
- Damaged caused by miss-use is not covered under warranty
- Warranty does not cover freight cost for both ways.

*Prepared by:*

***Cytron Technologies Sdn. Bhd.***

No. 1, Lorong Industri Impian 1,  
Taman Industri Impian,  
14000 Bukit Mertajam,  
Penang, Malaysia.

*Tel:* +604-548 0668

*Fax:* +604-548 0669

*URL:* [www.cytron.com.my](http://www.cytron.com.my)

*Email:* [support@cytron.com.my](mailto:support@cytron.com.my)

[sales@cytron.com.my](mailto:sales@cytron.com.my)