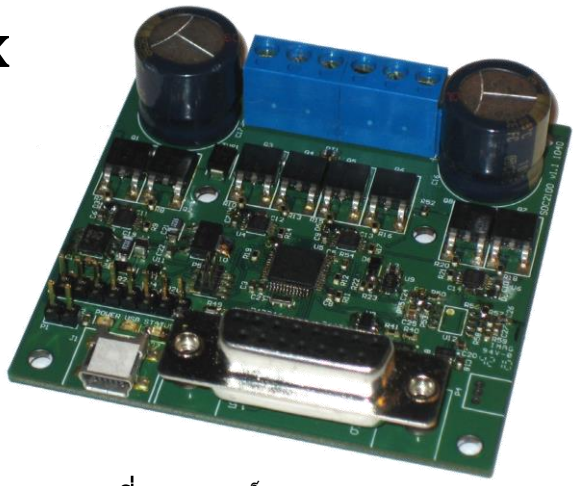
ภาคผนวก จ
คุณสมบัติบอร์ด Motion Controller และการเชื่อมต่อ

Roboteq SDC21xx

2x20A or 1x40A High Performance Dual Channel Brushed DC Motor Controller with USB and CAN Interface



ภาพที่ จ - 1 บอร์ด Motion controller

Fitting a very compact 70x70mm board, Roboteq SDC21xx controller is designed to convert commands received from an RC radio, Analog Joystick, wireless modem, PC (via RS232 or USB) or microcomputer into high voltage and high current output for driving one or two DC motors. A version with CAN bus allows up to 127 controllers to communicate at up to 1Mbit/s on a single twisted pair. The controller features a high-performance 32-bit microcomputer and quadrature encoder inputs to perform advanced motion control algorithms in Open Loop or Close Loop (Speed or Position) modes. The SDC21xx features several Analog, Pulse and Digital I/Os which can be remapped as command or feedback inputs, limit switches, or many other functions. For mobile robot applications, the controller's two motor channels can either be operated independently or mixed the set the direction and rotation of a vehicle by coordinating the motion of each motor. Numerous safety features are incorporated into the controller to ensure reliable and be safe operational. The controller's operation can be extensively automated and customized using Basic Language user programs. The controller can be reprogrammed in the field with the latest features by downloading new operating software from Roboteq.

Applications

- Industrial Automation
- Tracking, Pan & Tilt systems
- Small to mid-size Terrestrial and Underwater Robotic Vehicles
- Automatic Guided Vehicles
- Automated machines
- Telepresence Systems
- Animatronics

Features List

• USB, RS232, 0-5V Analog, or Pulse (RC radio) command modes
• Available in version with CAN bus up to 1Mbit/s
• Auto switch between USB, RS232 (12V levels or no inverted TTL levels), CAN, Analog, or Pulse based on user defined priority
• Input for direct connection to Spektrum digital RC radios
• Built-in high-power power drivers for two brushed DC motors at up to 20A output per channel
• Available in single channel version up to 40A
• Full forward & reverse control on each channel. Four quadrant operation. Supports regeneration
• Built - in programming language for automation and customization
• Operates from a single power source
• Programmable current limit for each channel up to 2x20A or 1x40A for protecting controller, motors, wiring and battery
• Up to 4 Analog Inputs for use as command and/or feedback
• Up to 5 Pulse Length, Duty Cycle or Frequency Inputs for use as command and/or feedback
• Up to 6 Digital Inputs for use as Dead man Switch, LimitSwitch, Emergency stop or user inputs
• Dual Quadrature Encoder inputs with 32-bit counters
• 2 general purpose 24V, 1A output for brake release or accessories
• Selectable min, max, center and dead band in Pulse and Analog modes
• Selectable exponentiation factors for each command inputs
• Trigger action if Analog, Pulse or Encoder capture are outside user selectable range (soft limit switches)
• Open loop or closed loop speed control operation
• Closed loop position control with analog or pulse/frequency feedback
• Precise speed and position control when Encoder feedback is used
• PID control loop with separate gains for each channel
• Optional Mixed control (sum and difference) for tank-like steering
• Configurable Data Logging of operating parameters on RS232 Output for telemetry or analysis
• Built-in Battery Voltage and Temperature sensors
• Power Control header for turning On or Off the controller from the external microcomputer or switch
• No consumption by output stage when motors stopped
• Regulated 5V output for powering Encoders, the RC radio, the RF Modem or the microcomputer
• Separate Programmable acceleration and deceleration for each motor
• Separate Programmable maximum forward and reverse power
• Support for CAN open and two simplified CAN protocols
• Direct connection to multi – channel Spektrum SPM9545 2.4 GHz RC satellite receiver
• Ultra – efficient 10 mOhm ON resistance MOSFETs Orderable as single channel version up to 40A

• Stall detection and selectable triggered action if Amps is outside user - selected range
• Overvoltage and Under voltage protection
• Programmable Watchdog for automatic motor shutdown in case of command loss
• Over temperature protection
• Diagnostic LED
• Efficient heat sinking using conduction bottom plate. Operates without a fan in most applications
• Power wiring via terminal strip wires up to AWG12
• 2.76" (70mm) L, 2.76" W (70mm), 0.78" (20mm) H
• -40o to +85o C operating environment
• 3.5oz (100g)
• Easy configuration, tuning and monitory using provided PC utility
• Field upgradeable software for installing latest features via the internet

Orderable Product References

ตารางที่ จ – 1 Orderable Product References

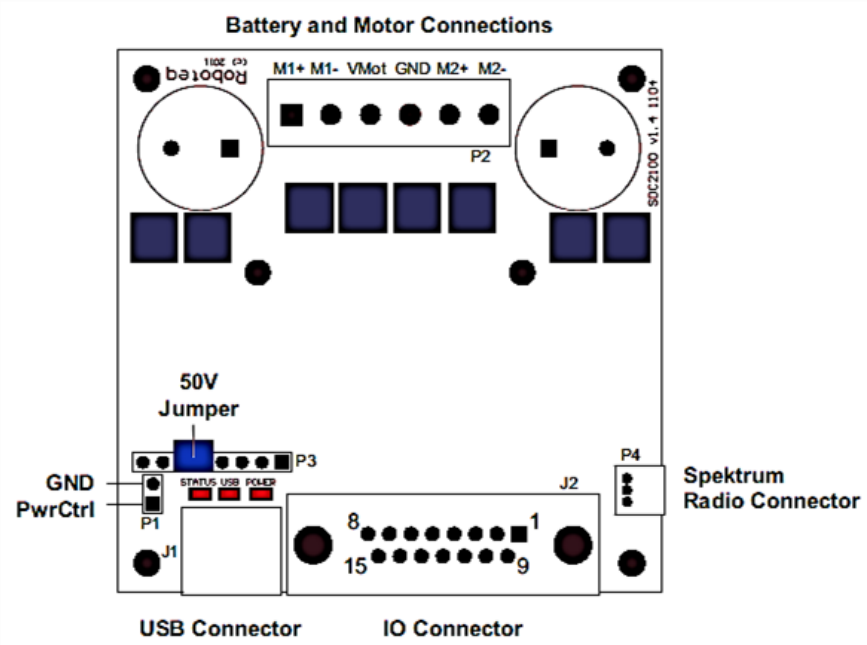
Reference	Number of Channels	Amps/Channel	Volts	CAN	USB
SDC2130	2	20	30	No	Yes
SDC2150	2	20	50	No	Yes
SDC2130S	1	40	30	No	Yes
SDC2150S	1	40	50	No	Yes
SDC2150N	2	20	50	Yes	No
SDC2150SN	1	40	50	Yes	No

Important Safety Disclaimer

Dangerous uncontrolled motor runaway condition can be occur for a number of reasons, including, but not limited to : command or feedback wiring are failure, configuration error, faulty firmware, errors in user script or user program, or controller hardware failure.

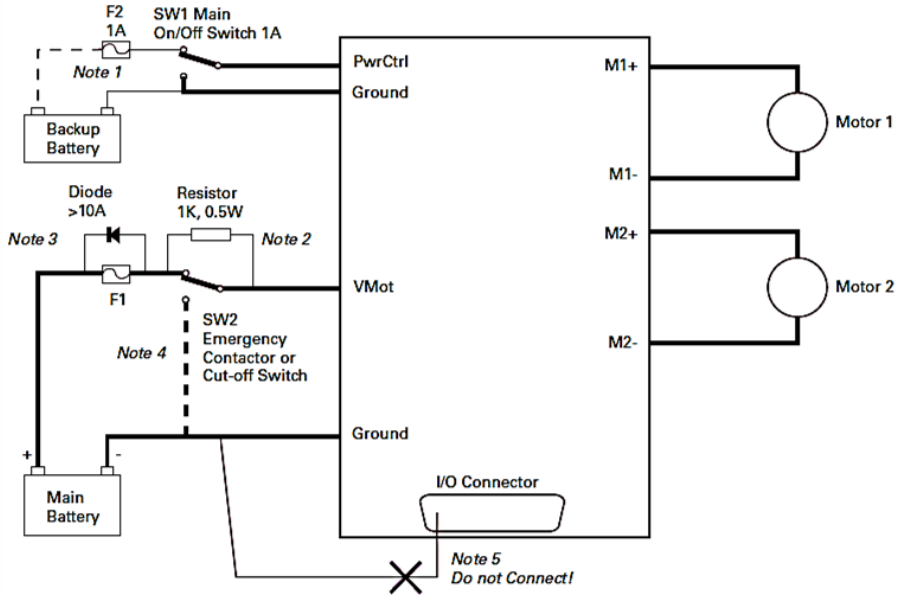
The user must assume that such failures can occur and must make his/her system safe in all conditions. Roboteq will not be liable in case of damage or injury as a result of product misuse or failure.

Power Wires Identifications and Connection



ภาพที่ จ – 2 ชื่อของขาที่ใช้ในการเชื่อมต่อ

The diagram below shows how to wire the dual-channel controller and how to turn power On and Off.



ภาพที่ จ – 3 การต่อมอเตอร์แบบสองช่อง

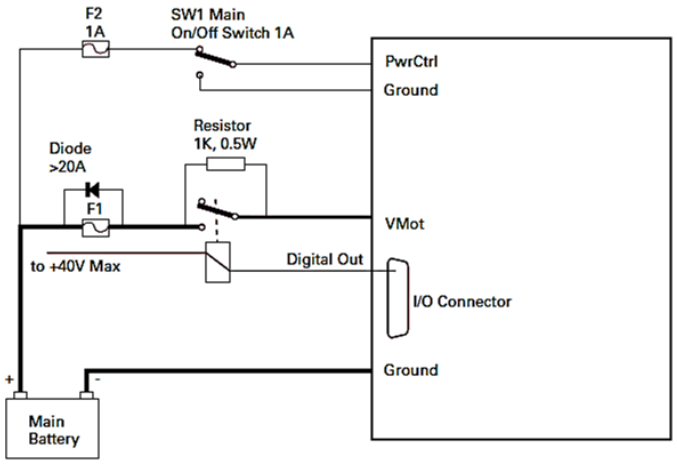
Important Warning
Carefully follow the wiring instructions provided in the Power Connection section of the User Manual. The information on this datasheet is only a summary.

Mandatory Connections
It is imperative that the controller is connected as shown in the above diagram in order to ensure a safe and trouble - free operation. All connections shown as thick black lines line are mandatory. The controller must be powered On/Off using switch SW1on the Power Control Header.

Emergency Switch or Contactor
The battery must be connected in permanence to the controller's VMot power via an input emergency switch or contactor SW2 as additional safety measure. The user must be able to deactivate the switch or contactor at any time, independently of the controller state.

Precautions and Optional Connections
Note 1: Optional backup battery to ensure motor operation with weak or discharged battery.
Note 2: Use recharge 1K Resistor to prevent switch arcing.
Note 3: Insert a high – current diode to ensure a return path to the battery during regeneration in case the fuse is blown.
Note 4: Optionally ground the VMot wires when the controller is Off if there is any concern that the motors could be made to spin and generate voltage in excess of 35V.
Note 5: Beware not to create a path from the ground pins on the I/O connector and the battery's minus terminal.

Use of Safety Contactor for Critical Applications
An external safety contactor must be used in any application where damage to property or injury to person can occur because of uncontrolled motor operation resulting from failure in the controller's power output stage.

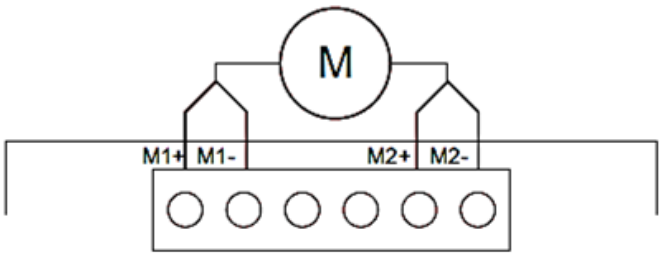


ภาพที่ จ – 4 ไดอะแกรมการเชื่อมต่อ

The contactor coil must be connected to a digital output configured to activate when “No MOSFET Failure”. The controller will automatically deactivate the coil if the output is expected to be off and battery current of 500mA or more is measured for more than 0.5s. This circuit will not protect against other sources of failure such as those described in the “Important Safety Disclaimer” on page 108.

Single Channel Wiring

The single channel version of the controller (SDC2130S and SDC2150S) require that the output be parallel and that the load be wired as shown in the diagram below.



ภาพที่ จ – 5 เชื่อมต่อมอเตอร์แบบตัวเดียว

Important Warning

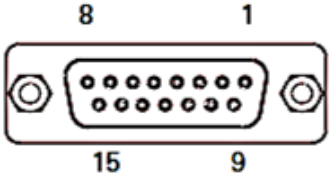
This wiring is only possible on controllers fitted with the Single Channel version of the firmware. Dual channel controllers will be damaged if wired as single channel. Verify that the PC utility identifies the controller as SDC2130S or SDC2150S before applying power to the load.

Controller Mounting

During motor operation, the controller will generate heat that must be evacuated. The published amps rating can only be fully achieved if adequate cooling is a provided. Mount the controller so that the bottom plate makes contact with a metallic surface (chassis, cabinet) to conduct the heat.

Sensor and Commands Connection

Connection to RC Radio, Microcomputer, Joystick and other low current sensors and actuators is done via the 15 connector located in front of the board. The functions of many pins vary depending on user configuration. Pin assignment is found in the table below.



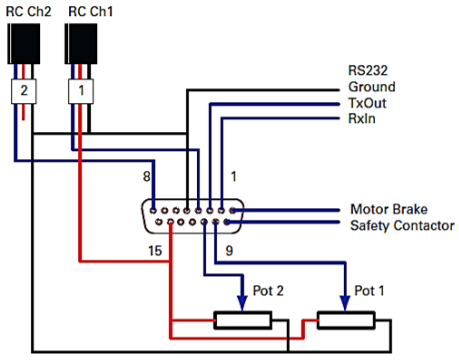
ภาพที่ จ – 6 หัวต่อแบบ DB 16

ตารางที่ จ – 2 ตำแหน่งการเชื่อมต่อ

Connector Pin	Power	Dout	Com	RC	Ana	Dinput	Enc	Default Config
1		DOUT1						Unused
9		DOUT2						Unused
2			TxOut					RS232Tx
10				RC5	ANA1	DIN5	ENC2A	AnaCmd1 (2)
3			Rx In					RS232Rx
11				RC4	ANA4	DIN4		AnaCmd2 (2)
4				RC1		DIN1	ENC1A	RCRadio1
12				RC3	ANA3	DIN3		Unused
5	GND							
13	GND							
6			TTL TxD/ CANL (1)					TTL Serial TxD/CANL
14	5VOut							
7			TTL RxD/ CANH (1)					TTL Serial RxD/CANH
15						DIN6	ENC2B	Unused
8				RC2	ANA2	DIN2	ENC1B	RCRadio2
Note 1: CANH and CANL on SDC2130N and SDC2150N versions Note 2: Analog command is disabled in factory default configuration								

Default I/O Configuration

The controller can be configured so that practically any Digital, Analog and RC pin can be used for any purpose. The controller's factory default configuration provides an assignment that is suitable for most applications. The figure below shows how to wire the controller to two analog potentiometers, an RC radio, and the RS232 port. It also shows how to connect the two outputs to motor brake solenoids. You may omit any connection that is not required in your application. The controller automatically arbitrates the command priorities depending on the presence of a valid command signal in the following order : 1 - RS232 , 2 – RC Pulse, 3- None. If needed, use the Roborun+ PC Utility to change the pin assignments and the command priority order.



ภาพที่ จ – 7 การเชื่อมต่อแบบที่มีการตั้งค่ามาจากโรงงาน

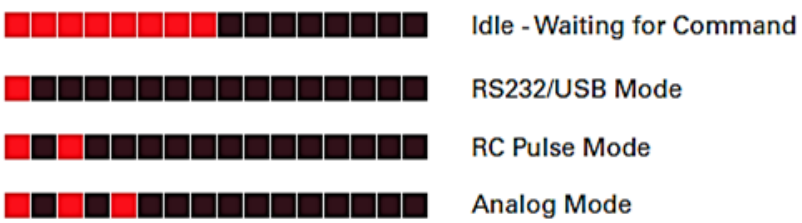
Enabling Analog Commands
For safety reasons, the Analog command mode is disabled by default. To enable the Analog mode, use the PC utility and set Analog in Command Priority 2 or 3 (leave Serial as priority 1). Note that by default the additional securities are enabled and will prevent the motor from starting unless the potentiometer is centered, or if the voltage is below 0.25V or above 4.75V. The drawing shows suggested assignment of Pot 1 to ANA 1 and Pot 2 to ANA4. Use the PC utility to enable and assign analog inputs.

CAN Bus Operation
The controller can interface to a standard CAN Bus network, using 3 possible protocols : Standard CAN Open , and two simplified proprietary schemes (Mini CAN and Raw CAN). Please refer to the User Manual for details. USB and CAN cannot operate at the same time. The controller starts up with CAN available , but CAN will be disabled as soon as the controller is plugged into the USB. To re – enable CAN, disconnect USB and restart the controller.

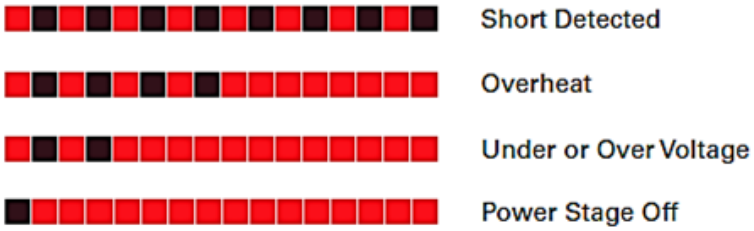
USB communication
Use USB only for configuration, monitoring and troubleshooting. USB is not a reliable communication method when used in a electrically noisy environments and communication will not always recover after it is lost without unplugging and replugging the connector, or restarting the controller . Always prefer to RS232 communication when interfacing to a computer.

Spektrum Satellite Receiver Connection
3 – pin plug is provided for direct connection to a Spektrum SP9545 miniature receiver.

Status LED Flashing Patterns
After the controller is powered on, the Power LED will turn on, indicating that the controller is On. The Status LED will be flashing at a 2 seconds interval. The flashing pattern provides operating or exception status information.



ภาพที่ จ – 8 ไฟแสดงสถานะการทำงาน



ภาพที่ จ – 9 ไฟแสดงสถานะการทำงาน(ต่อ)

Electrical Specifications
Absolute Maximum Values
The values in the table below should never be exceeded. Permanent damage to the controller may result.

ตารางที่ จ – 3 ตารางแสดงข้อจำกัดของบอร์ด

Parameter	**Measure point**	**Models**	**Min**	**Typ**	**Max**	**Units**
Battery Leads Voltage	Ground to VMot	SDC2130	10		40	Volts
		SDC2150	10		50	Volts
Reverse Voltage on Battery Leads	Ground to VMot	All	-1			Volts
Motor Leads Voltage	Ground to M1+, M1-, M2+, M2-	SDC2130			35	Volts
		SDC2150			50	Volts
Digital Output Voltage	Ground to Output pins	All			40	Volts
Analog and Digital Inputs Voltage	Ground to any signal pin on 25 & 9-pin connectors	All			15	Volts
RS232 I/O pins Voltage	External voltage applied to Rx/Tx pins	All			15	Volts
Board Temperature	Board		-40		85	oC
Humidity	Board				100 (2)	%
Note 1: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source Note 2: Non-condensing						

Power Stage Electrical Specifications (at 25oC ambient)

ตารางที่ จ – 4 ข้อมูลทางไฟฟ้าของบอร์ด

Parameter	Measure point	Models	Min	Typ	Max	Units
Battery Leads Voltage	Ground to VMot	SDC2130(S)	10 (1)		35	Volts
		SDC2150(S)	10 (1)		55	Volts
Motor Leads Voltage	Ground to M1+, M1-, M2+, M2-	SDC2130(S)	0 (1)		35(2)	Volts
		SDC2150(S)	0 (1)		55(2)	Volts
Over Voltage protection range	Ground to VMot	SDC2130(S)	5	30 (4)	35	Volts
		SDC2150(S)	5	50 (4)	55(2)	Volts
Under Voltage protection range	Ground to VMot	SDC2130(S)	0	5 (4)	35	Volts
		SDC2150(S)	0	5 (4)	55	Volts
Idle Current Consumption	VMot or Pwr Ctrl wires	All	50	75 (5)	100	mA
ON Resistance (Excluding wire resistance)	VMot to M+, plus M- to Ground at 100% power Per channel	SDC2130/50		20		mOhm
		SDC2130S/50S		10		mOhm
Max Current per channel for 30s	Ch1 or Ch2 Motor current	SDC2130/50			20	Amps
		SDC2130S/50S			40	Amps
Continuous Max Current per channel	Ch1 or Ch2 Motor current	SDC2130/50			15 (7)	Amps
		SDC2130S/50S			30 (7)	Amps
Current Limit range	Ch1 or Ch2 Motor current	SDC2130/50	1	15 (8)	20	Amps
		SDC2130S/50S	1	30 (8)	40	Amps
Stall Detection Amps range	Ch1 or Ch2 Motor current	SDC2130/50	1	15 (8)	20	Amps
		SDC2130S/50S	1	30 (8)	40	Amps
Stall Detection timeout range	Ch1 or Ch2 Motor current	All	1	500 (9)	65000	ms
Motor Acceleration/Deceleration range	Ch1 or Ch2	All	100	500 (10)	65000	ms

Note 1: Negative voltage will cause a large surge current. Protection fuse needed if battery polarity inversion is possible

Note 2: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source

Note 3: Minimum voltage must be present on VMot or Power Control wire

Note 4: Factory default value. Adjustable in 0.1V increments

Note 5: Current consumption is lower when higher voltage is applied to the controller's VMot or PwrCtrl wires

Note 6: Max value is determined by current limit setting. Duration is estimated and is dependent on ambient temperature cooling condition

Note 7: Estimate. Limited by heatsink temperature. Current may be higher with better cooling

Note 8: Factory default value. Adjustable in 0.1A increments

Note 9: Factory default value. Time in ms that Stall current must be exceeded for detection

Note 10: Factory default value. Time in ms for power to go from 0 to 100%

Command, I/O and Sensor Signals Specifications

ตารางที่ จ – 5 คุณสมบัติสัญญาณคำสั่ง และ เซ็นเซอร์

Parameter	Measure point	Min	Typ	Max	Units
Main 5V Output Voltage	Ground to 5V pins on	4.6	4.75	4.9	Volts
5V Output Current	5V pins on RJ45 and DSub15			100	mA
Digital Output Voltage	Ground to Output pins			30	Volts
Digital Output Current	Output pins, sink current			1	Amps
Output On resistance	Output pin to ground	0.75		1.5	Ohm
Output Short circuit threshold	Output pin	1.05	1.4	1.75	Amps
Input Impedances AIN/DIN	Input to Ground			53	kOhm
Digital Input 0 Level	Ground to Input pins	-1		1	Volts
Digital Input 1 Level	Ground to Input pins	3		15	Volts
Analog Input Range	Ground to Input pins	0		5.1	Volts
Analog Input Precision	Ground to Input pins		0.5		%
Analog Input Resolution	Ground to Input pins		1		mV
Pulse durations	Pulse inputs	20000		10	us
Pulse repeat rate	Pulse inputs	50		250	Hz
Pulse Capture Resolution	Pulse inputs		1		us
Frequency Capture	Pulse inputs	100		10000	Hz
Encoder count	Internal	-2.147		2.147	10^9 Counts
Encoder frequency	Encoder input pins			30000 or 1M(1)	Counts/s
Note1: Dual Channel controller max at 30Kcounts/s. Single channel version max at 1Mcounts/s					

Operating & Timing Specifications

ตารางที่ จ – 6 คุณสมบัติการควบคุม และ เวลา

Parameter	Measure Point	Min	Typ	Max	Units
Command Latency	Command to output change	1	0.5	1	ms
PWM Frequency	Ch1, Ch2 outputs	10	18 (1)	20	kHz
Closed Loop update rate	Internal		1000		Hz
USB Rate	USB pins			12	MBits/s
RS232 baud rate	Rx & Tx pins		115200 (2)		Bits/s
RS232 Watchdog timeout	Rx pin	1 (3)		65000	ms
Note 1: May be adjusted with configuration program Note 2: 115200, 8-bit, no parity, 1 stop bit, no flow control Note 3: May be disabled with value 0					

Scripting

ตารางที่ จ – 7 สคริป

Parameter	Measure Point	Min	Typ	Max	Units
Scripting Flash Memory	Internal		8192		Bytes
Max Basic Language programs	Internal	1000		1500	Lines
Integer Variables	Internal		1024		Words (1)
Boolean Variables	Internal		1024		Symbols
Execution Speed	Internal	50 000		100 000	Lines/s
Note 1: 32-bit words					

Thermal Specifications

ตารางที่ จ – 8 คุณสมบัติของเทอร์มินอล

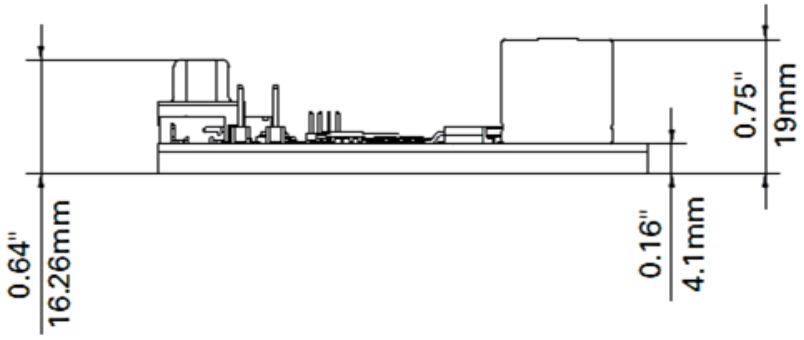
Parameter	Measure Point	Model	Min	Typ	Max	Units
Board Temperature	PCB	All	-40		85 (1)	oC
Thermal Protection range	PCB	All	70		80 (2)	oC
Thermal resistance	Power MOSFETs to heats sink	All			2	oC/W
Note 1: Thermal protection will protect the controller power Note 2: Max allowed power out starts lowering at minimum of range, down to 0 at max of range						

The SDC21xx uses a conduction plate at the bottom of the board for heat extraction. For best results, attach firmly with thermal compound paste against a metallic chassis so that heat transfers to the conduction plate to the chassis. If no metallic surface is available, mount the controller on spacers so that forced or natural air flow can go over the plate surface to remove heat.

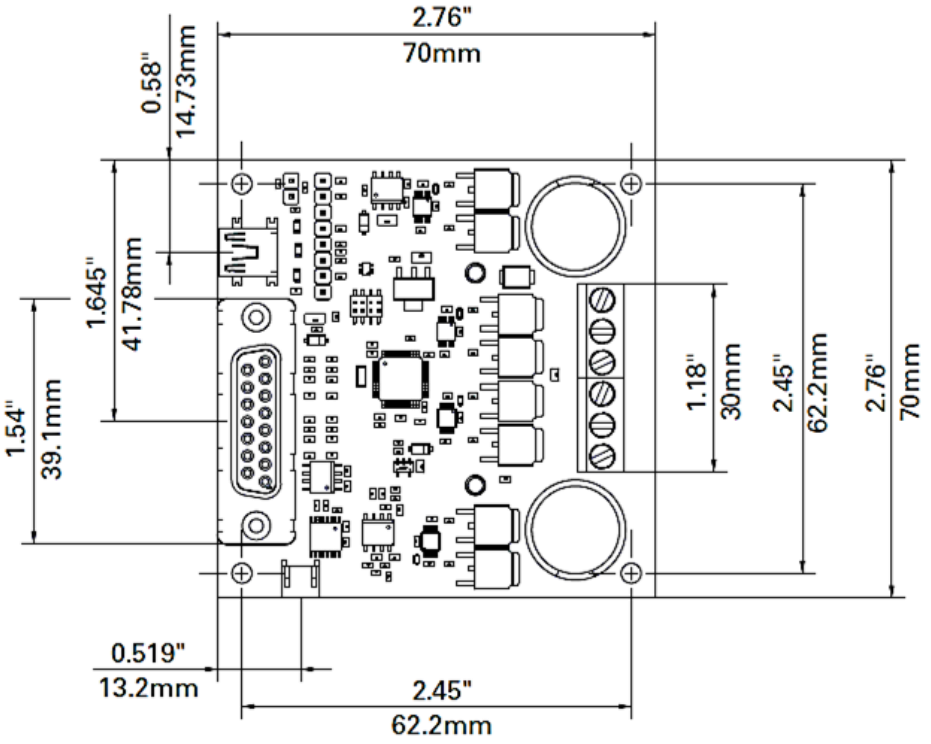
Mechanical Specifications

ตารางที่ จ – 9 คุณสมบัติทางกล

Parameter	Measure Point	Min	Typ	Max	Units
Weight	Board		100 (3.5)		g (oz.)
Power Wire Gauge	Terminal strip			12	AWG



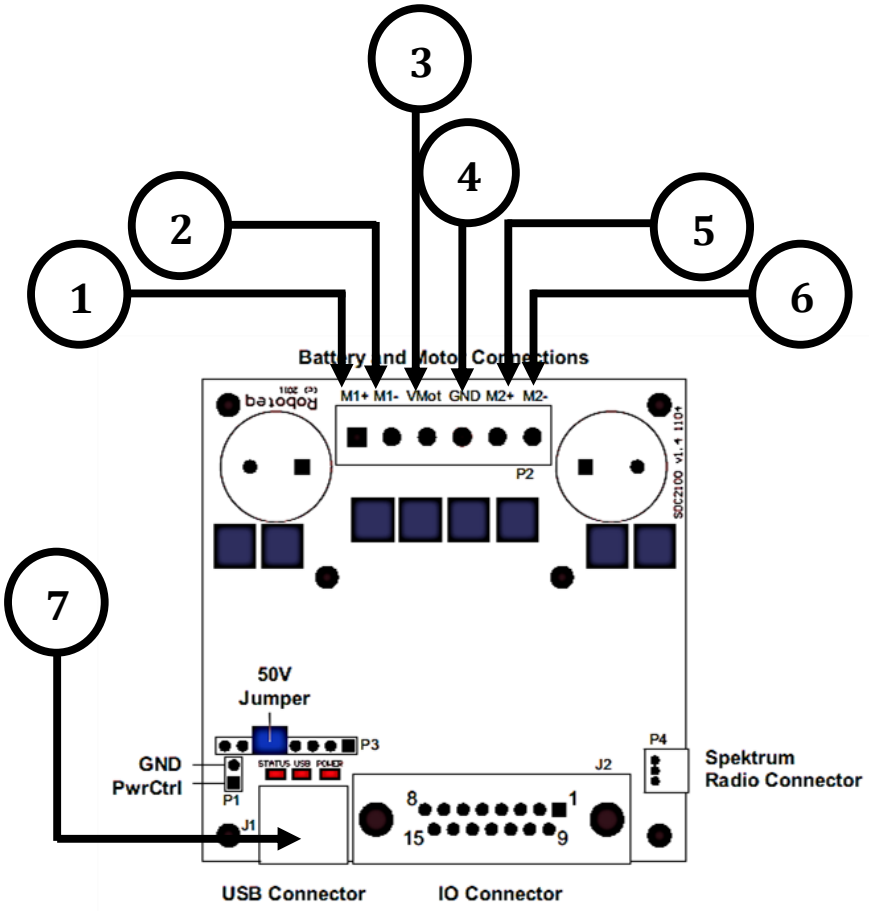
ภาพที่ จ – 10 รายละเอียดทางกล



ภาพที่ จ – 11 รายละเอียดทางกล (ต่อ)

การเชื่อมต่อ*บอร์ด* Motion Controller

สำหรับการนำบอร์ด Motion Controller ใช้งานนั้นก่อนอื่นจะต้องรู้วิธีการ ต่อใช้งานบอร์ดก่อนโดยสามารถทำตามคำอธิบายด้านล่างนี้



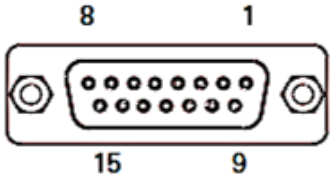
ภาพที่ จ – 12 การอธิบายตำแหน่งการต่อ

การต่อเข้ากับแหล่งจ่ายและการต่อไปยังมอเตอร์

1. ต่อไปยังสายไฟบวกของมอเตอร์ช่องที่ 1
2. ต่อไปยังสายไฟลบของมอเตอร์ช่องที่ 1
3. สำหรับต่อไฟบวก 0 – 30 โวลท์ ให้กับบอร์ด
4. สำหรับต่อกราวน์ ให้กับบอร์ด
5. ต่อไปยังสายไฟบวกของมอเตอร์ช่องที่ 2
6. ต่อไปยังสายไฟลบของมอเตอร์ช่องที่ 2
7. สำหรับเชื่อมต่อเข้ากับคอมพิวเตอร์ผ่านสาย USB

การต่อสายควบคุมผ่าน หัวต่อแบบ DB 16

สำหรับการต่อสายควบคุมผ่าน หัวต่อแบบ DB 16 นั้นจะสามารถต่อ เพื่อรับค่าจาก Encoder ได้ 2 ตัว, ต่อการควบคุมของตัว Radio Control รวมไปถึงการต่อรับ – ส่งค่า ผ่านช่องทาง RS232 โดยผ่านสายสัญญาณ Tx และ Rx ได้อีกด้วย ซึ่งคุณสมบัติต่างๆ ที่กล่าวมาข้างต้น เป็นเพื่อนส่วนหนึ่งของการต่อเท่านั้น ส่วนรายละเอียดอื่นๆ สามารถศึกษาได้จาก Data sheet ของตัวบอร์ด Motion Controller ได้



ภาพที่ จ – 13 หัวต่อแบบ DB 16

ตารางที่ จ – 10 แสดงรายละเอียดในการเชื่อมต่อเพื่อไปใช้งาน

รูปแบบที่ต้องการใช้งาน	**ขาสัญญาณที่ต้องต่อ**
1. รับส่งข้อมูลผ่าน RS232	ต่อขา 2, 3, 5 หรือ 2, 3, 13 เพราะขา 5 กับ ขา 13 เป็นขา GND
2. รับ Encoder 1	ต่อขา 4, 8, 14, 5 หรือ 4, 8,14, 13 เพราะขา 5 กับ ขา 13 เป็นขา GND
3. รับ Encoder 2	ต่อขา 10, 14, 15, 5 หรือ 10, 14, 15, 13 เพราะขา 5 กับ ขา 13 เป็นขา GND