2x150A/1x300A High Performance Forward/Reverse Brushed DC Motor Controller with USB, CAN and Encoder Inputs

Roboteq's XDC2xxx 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. Using CAN bus, up to 127 controllers can be networked 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 XDC2xxx features several Analog, Pulse and Digital I/Os which can be remapped as command or feedback inputs, limit switches, or many other functions.

The controller's two motor channels can either be operated independently or mixed to set the direction and rotation of a vehicle by coordinating the motion of each motor. The XDC2xxx is available in a single channel version with double the current.

Numerous safety features are incorporated into the controller to ensure reliable and safe operation. The controller's operation can be extensively automated and customized using Basic Language scripts. 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
- Terrestrial and Underwater Robotic Vehicles
- Automatic Guided Vehicles
- Police and Military Robots
- Flight simulators
- Telepresence Systems
- Animatronics

Features List

- USB, RS232, 0-5V Analog, or Pulse (RC radio) command modes
- CAN bus up to 1Mbit/s
- Auto switch between USB, RS232, CAN, Analog, or Pulse based on user-defined priority
- Built-in high-power power drivers for two brushed DC motors at up to 150A output per channel
- Available in single channel version up to 300A
- Full forward & reverse control on each channel. Four quadrant operation. Supports regeneration
- Built-in programming language for automation and customization
- Operates from a single 10V-30V (XDC2x30) or 10-60V (XDC2x60) power source
- Programmable current limit for each channel for protecting controller, motors, wiring and battery
- Up to 6 Analog Inputs for use as command and/or feedback
- Up to 4 Pulse Length, Duty Cycle or Frequency Inputs for use as command and/or feedback
- Up to 6 Digital Inputs for use as Deadman Switch, Limit Switch, Emergency stop or user inputs
- Dual Quadrature Encoder inputs with 32-bit counters
- Two general purpose 24V, 1A output for brake release or accessories
- Selectable min, max, center and deadband 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
- Optional 12V backup power input for powering safely the controller if the main motor batteries are discharged
- Power Control wire for turning On or Off the controller from external microcomputer or switch
- No consumption by output stage when motors stopped
- Regulated 5V output for powering Sensors, Encoders, RC radio, RF Modem or microcomputer
- Separate Programmable acceleration and deceleration for each motor
- Separate Programmable maximum forward and reverse power
- Ultra-efficient 1.5 mOhm ON resistance MOSFETs
- Stall detection and selectable triggered action if Amps is outside user-selected range
- Short circuit protection
- Overvoltage and Undervoltage protection
- Programmable Watchdog for automatic motor shutdown in case of command loss
- Overtemperature protection
- Diagnostic LED
- Extruded aluminum, heat sinking enclosure for operation harsh shock and temperature environment
- Efficient heat sinking. Operates without a fan in most applications.
- Dustproof and weather resistant. IP51 NEMA rating
- Power wiring via heavy AWG8 cables
- 9" (228.5mm) L, 5.5" W (140mm), 1.6" (40mm) H
- -40o to +85o C operating environment
- 3 lbs (1,350g)
- Easy configuration, tuning and monitor using provided PC utility
- Field upgradeable software for installing latest features via the internet

Orderable Product References

TABLE 1.

Reference	Number of Channels	Amps/Channel	Volts	Ethernet	Resolver
XDC2330	2	120	30	No	No
XDC2330S	1	240	30	No	No
XDC2460	2	150	60	No	No
XDC2460S	1	300	60	No	No

Important Safety Disclaimer

Dangerous uncontrolled motor runaway condition can occur for a number of reasons, including, but not limited to: command or feedback wiring 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

Power connections are made by means of heavy gauge wires located at the back of the controller.

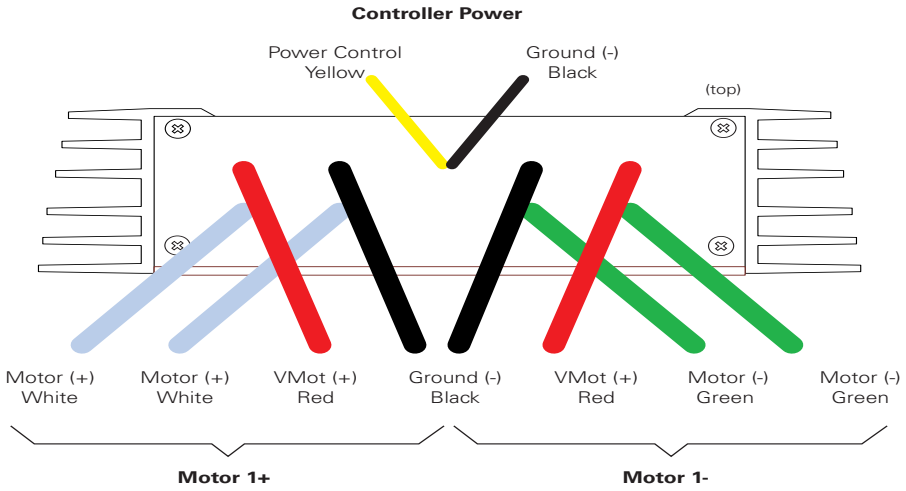


FIGURE 1. Rear Controller Layout

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

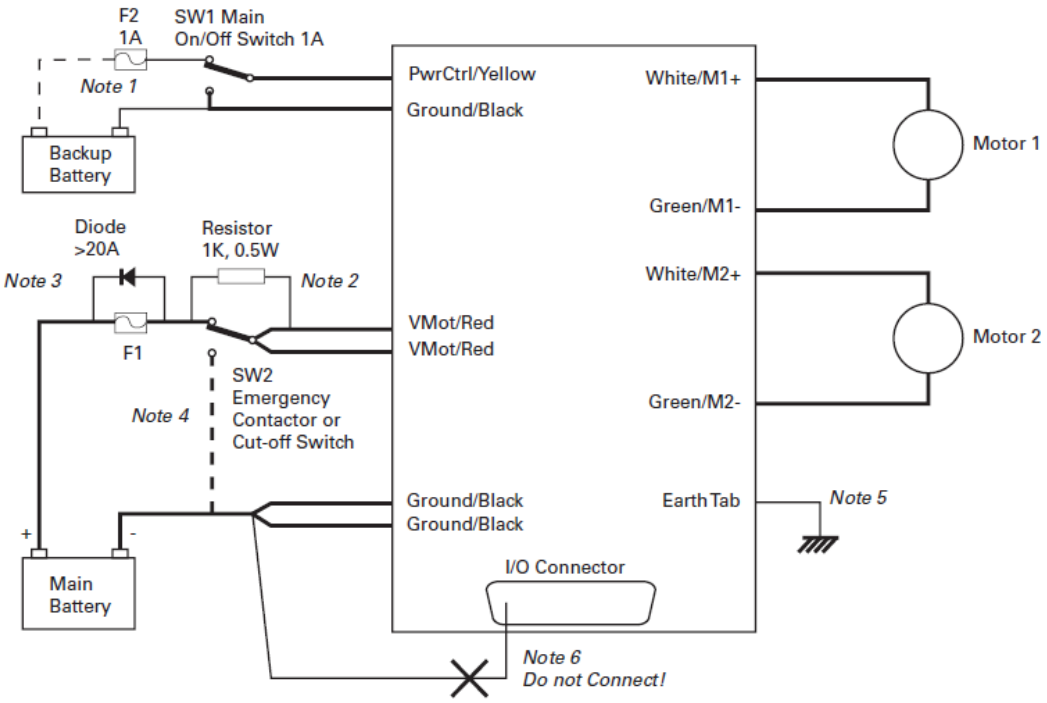


FIGURE 2. Powering the controller. Thick lines identify MANDATORY connections

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 are mandatory. The controller must be powered On/Off using switch SW1on the Power Control Header. Use a suitable high-current fuse F1 as a safety measure to prevent damage to the wiring in case of major controller malfunction.

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.

Electrostatic Discharge Protection

In accordance with IEC 61000-6-4, Roboteq Motor Controllers are designed to withstand ESD up to 4kV touch and 8kV air gap. This protection is implemented without any additional external connections required.

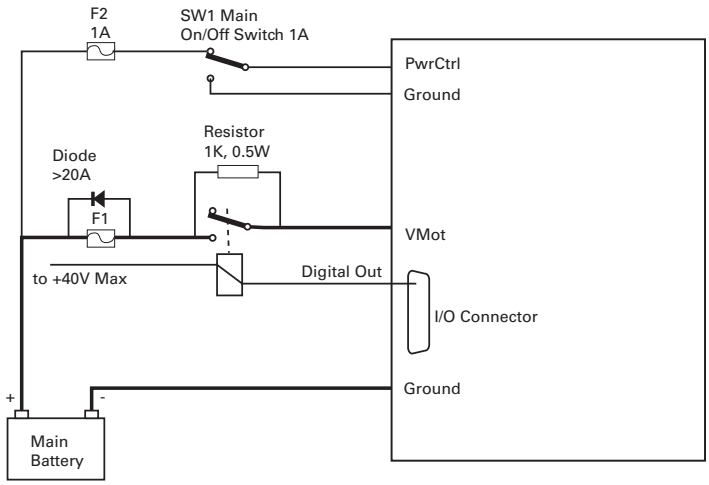
Some specifications, such as EN12895, require a higher level of protection. To maximize ESD protection, up to 8kV touch and 15kV air gap, you may connect the metallic heatsink of the controller to your battery negative terminal. See App Note 062918 for example connections.

Precautions and Optional Connections

Note 1: Backup battery to ensure motor operation with weak or discharged batteries, connect a second battery to the Power Control wire/terminal via the SW1 switch.
Note 2: Use precharge 1K, 0.5W 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 tabs when the controller is Off if there is any concern that the motors could be made to spin and generate voltage in excess of 30V.
Note 5: Beware not to create a path from the ground pins on the I/O connector and the battery 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.



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 1A 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 3.

Single Channel Motor Wiring

The single channel version of the controller (XDC2xxxS) requires that the output be parallel and that the load be wired as shown in the diagram below.

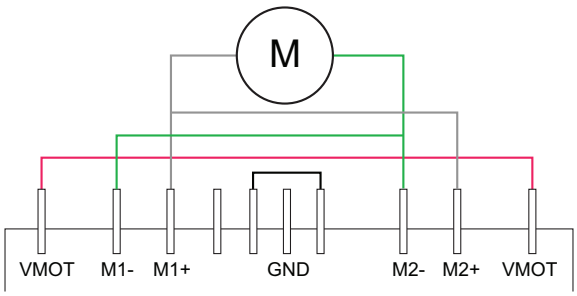


FIGURE 4. XDC2xxxS wiring diagram

Important Warning

This wiring is only possible on controllers fitted with the Single Channel version of the controller logic. Dual channel controllers will be damaged if wired as single channel. Verify that the PC utility identifies the controller as FBL2360S or XDC2460S before applying power to the load.

Encoder Wiring

The encoder connector is a 6-pin Molex Microfit 3.0, model 43645. Pin assignments are in Table 4, below.

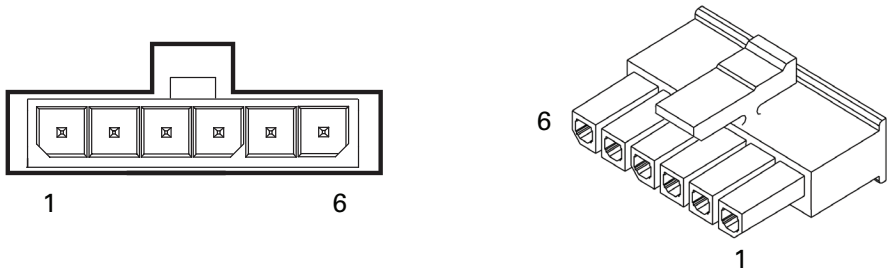


FIGURE 5. Encoder connector

TABLE 4.

Pin Number	1	2	3	4	5	6
Signal	5Vout	Enc1A	Enc1B	Enc2A	Enc2B	GND

Controller Mounting

During motor operation, the controller will generate heat that must be dissipated. The published amps rating can only be fully achieved if adequate cooling is provided. Good conduction cooling can be achieved by mounting the controller to a metallic surface, such as the chassis, cabinet, etc.

Commands and I/O Connections

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.

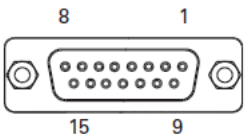


FIGURE 6. Connector Pin Locations

TABLE 5.

Connector Pin	Power	Dout	Com	RC	Ana	Dinput	Default Config
1		DOUT1					Motor Brake
9		DOUT2					Safety Contactor
2			TxOut				RS232Tx
10					ANA5	DIN5	AnaCmd1 (1)
3			RxIn				RS232Rx
11				RC4	ANA4	DIN4	AnaCmd2 (1)
4				RC1	ANA1	DIN1	RCRadio1
12				RC3	ANA3	DIN3	Unused
5	GND						
13	GND						
6			CANL				CAN Low
14	5VOut						
7			CANH				CAN High
15					ANA6	DIN6	Unused
8				RC2	ANA2	DIN2	RCRadio2
Note 1: Analog command is disabled in factory default configuration.							

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 ANA5 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 4 possible protocols: Standard CANOpen, and two simplified proprietary schemes (MiniCAN, RawCAN and RoboCAN). Please refer to the User Manual for details.

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 RS232 communication when interfacing to a computer.

RS485 Communication

RS485 is an industry standard for defining serial communication. Due to its balanced signaling, RS485 is effective over distances, even if other electrical signals are present. Its stability makes it well suited to connect multiple receivers to a single network.

You can operate RS485 in half-duplex mode and it is well suited for use with the Modbus protocol. On the 25-pin connector, 2-pins are pins are present.

Ethernet Communication

Ethernet communication is currently only available on the E versions of applicable Roboteq product. There is a connection port on the top of the unit for easy and rapid access. While the TCP and Modbus TCP protocols are supported, Serial is the preferred method to access all native commands.

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.

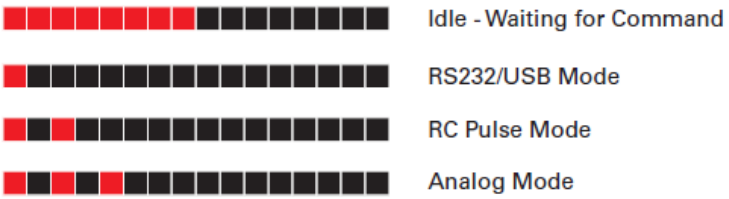


FIGURE 7. Normal Operation Flashing Patterns

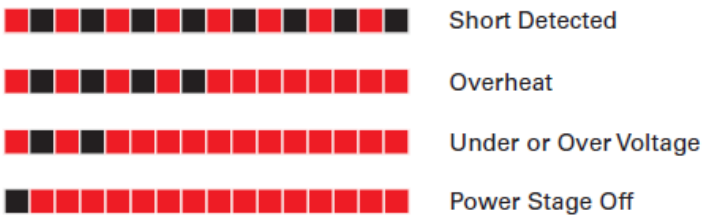


FIGURE 8. Exception or Fault Flashing Patterns

Additional status information may be obtained by monitoring the controller with the PC utility.

Measured and Calculated Amps

Including Amps sensors on the wires allows for fast and efficient acumulation of information. Battery amps are measured in real time and which allows for precise calculation of motor amps.

Secure Connection to AMP FASTON™ Tabs

Power Motor and Battery connections are made via standard 250mils (6.35mm) AMP FASTON Tabs. FASTON connectors provide a high current and very secure connection, proven over decades of use in the automotive industry. For maximum current handling, use connectors for AWG10 wires recognizable by their yellow plastic insulator.

FASTON connectors have an extremely tight fit and will not come off on their own. It is recommended, nevertheless, that the wiring is made so that the cables are never pulling the connector outward.

Frequent disconnects and reconnects will eventually loosen the connector's grip on the tab. If frequent disconnection is required, consider using Positive Lock connectors from TE Connectivity or their equivalent. These connectors have a spring loaded tab latch pin that will lock into the hole of the male tab.

Electrical Specifications

Absolute Maximum Values

The values in the table below should never be exceeded, permanent damage to the controller may result.

TABLE 6.

Parameter	Measure point	Model	Min	Typ	Max	Units
Battery Leads Voltage	Ground to VBat	XDC2x30			35	Volts
		XDC2x60			62	Volts
Reverse Voltage on Battery Leads	Ground to VBat	All	-1			Volts
Power Control Voltage	Ground to Pwr Control wire	All			35	Volts
Motor Leads Voltage	Ground to M1+, M1-, M2+, M2-	XDC2x30			35(1)	Volts
		XDC2x60			62 (1)	Volts
Digital Output Voltage	Ground to Output pins	All			30	Volts
Analog and Digital Inputs Voltage	Ground to any signal pin on 25 & 9-pin connectors	All			30	Volts
RS232 I/O pins Voltage	External voltage applied to Rx pins	All			30 (2)	Volts
Case Temperature	Case	All	-40		85	ºC
Humidity	Case	All			100 (3)	%

Note 1: Maximum regeneration voltage in normal operation. Never inject a DC voltage from a battery or other fixed source
Note 2: No voltage must be applied on Tx pin
Note 3: Non condensing

Power Stage Electrical Specifications (at 25ºC ambient)

TABLE 7.

Parameter	Measure point	Models	Min	Typ	Max	Units
Battery Leads Voltage	Ground to VBat	XDC2x30	0 (1)		35	Volts
		XDC2x60			62	
Motor Leads Voltage	Ground to M1+, M1-, M2+, M2-	XDC2x30	0 (1)		30 (2)	Volts
		XDC2x60			62 (2)	
Power Control Voltage	Ground to Power Control wire	All	0 (1)		62	Volts
Minimum Operating Voltage	VBat or Pwr Ctrl wires	All	9 (3)			Volts
Over Voltage protection range	Ground to VBat	XDC2x30	5	30 (4)	35	Volts
		XDC2x60	5	60	62	Volts

TABLE 7.

Parameter	Measure point	Models	Min	Typ	Max	Units
Under Voltage protection range	Ground to VBat	XDC2x30	0	5 (4)	35	Volts
		XDC2x60	0	5	62	Volts
Idle Current Consumption	VBat or Pwr Ctrl wires	All	50	100 (5)	150	mA
ON Resistance (Excluding wire resistance)	VBat to M+, plus M- to Ground at 100% power. Per channel	XDC2x30		6		mOhm
		XDC2x30S		3		mOhm
		XDC2x60		3		mOhm
		XDC2x60S		1.5		mOhm
Max Current per channel for 30s	Ch1 or Ch2 Motor current	XDC2x30			120	Amps
		XDC2x30S			240 (6)	Amps
		XDC2x60			150	Amps
		XDC2x60S			300	Amps
Continuous Max Current per channel	Ch1 or Ch2 Motor current	XDC2x30			70 (7)	Amps
		XDC2x30S			140 (6)(7)	Amps
		XDC2x60			80 (7)	Amps
		XDC2x60S			160 (6)(7)	Amps
Current Limit range	Ch1 or Ch2 Motor current	XDC2x30	10	100(8)	120	Amps
		XDC2x30S	10	200 (8)	240 (6)	Amps
		XDC2x60	10		150	Amps
		XDC2x60S	10		300 (6)	Amps
Stall Detection Amps range	Ch1 or Ch2 Motor current	XDC2x30	10	120(8)	120	Amps
		XDC2x30S	10	240 (8)	240 (6)	Amps
		XDC2x60	10	150	150	Amps
		XDC2x60S	10	300	300 (6)	Amps
Stall Detection timeout range	Ch1 or Ch2 Motor current	All	1	65000 (9)	65000	milliseconds
Short Circuit Detection threshold (10)	Between Motor wires or Between Motor wire and Ground	XDC22xx		500 (11)		Amps
		XDC24xxS		1000 (6)(11)		Amps
Short Circuit Detection threshold	Between Motor wires and VBat	All	No Protection. Permanent damage will result			
Motor Acceleration/ Deceleration range	Ch1 or Ch2	All	100	500 (12)	65000	milliseconds

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 VBat 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 VBat or PwrCtrl wires
Note 6: Current is sum of both synchronized channels. Current must be balanced between channel to obtain max current.
Note 7: Estimate. Limited by case temperature. Current may be higher with better cooling
Note 8: Factory default value. Adjustable in 0.5A increments
Note 9: Factory default value. Time in ms that Stall current must be exceeded for detection
Note 10: Controller will stop until restarted in case of short circuit detection
Note 11: Typical
Note 12: Factory default value. Time in ms for power to go from 0 to 100%

Command, I/O and Sensor Signals Specifications

TABLE 8.

Parameter	Measure point	Min	Typ	Max	Units
Main 5V Output Voltage	Ground to 5V pins on	4.8	5	5.2	Volts
5V Output Current	5V pins on RJ45 and DSub15			200 (1)	mA
Digital Output Voltage	Ground to Output pins			40	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
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		1000	Hz
Encoder count	Internal	-2.147		2.147	10^9 Counts
Encoder frequency	Encoder input pins			2000	kHz
Note 1: Sum of all 5VOut outputs					

Operating & Timing Specifications

TABLE 9.

Parameter	Measure Point	Min	Typ	Max	Units
Command Latency	Command to output change	0	0.5	1	ms
PWM Frequency	Ch1, Ch2 outputs	1	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

TABLE 10.

Parameter	Measure Point	Min	Typ	Max	Units
Scripting Flash Memory	Internal		32K		Bytes
Max Basic Language programs	Internal	2000		3000	Lines
Integer Variables	Internal		4096		Words (1)
Boolean Variables	Internal		8192		Symbols
Execution Speed	Internal	50 000	100 000		Lines/s
Note 1: 32-bit words					

Thermal Specifications

TABLE 11.

Parameter	Measure Point	Model	Min	Typ	Max	Units
Case Temperature	Case	All	-40		85 (1)	°C
Thermal Protection range	Case	All	80		90 (2)	°C
Power Dissipation	Case	All			70	Watts
Thermal resistance	Power MOSFETs to case	All			0.6	°C/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						

Mechanical Specifications

TABLE 12.

Parameter	Measure Point	Min	Typ	Max	Units
Weight	Case		452 (.99)		g (lbs)
Wire Length	Case	17 (43)			inches (cm)
Power Wire Gauge	Wire		8		AWG
Power Wire Diameter	Outside diameter		0.26 (6.6)		inches (mm)

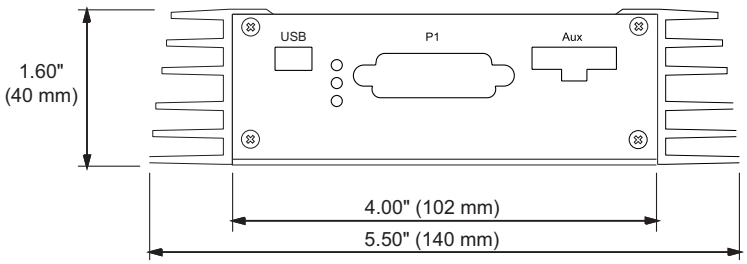


FIGURE 9. XDC2xxx Front View and Dimensions

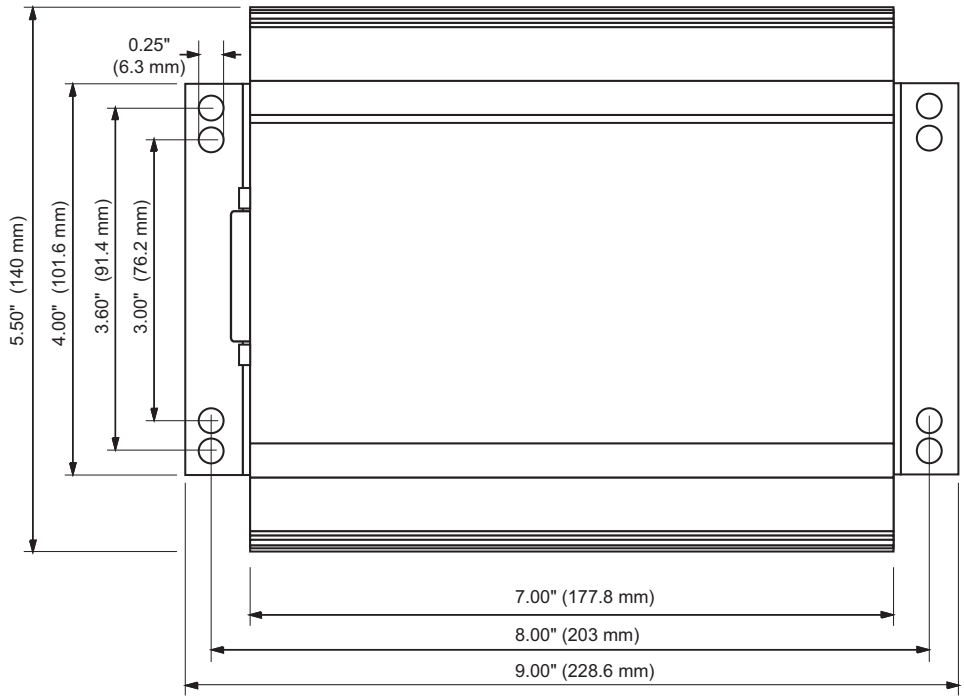


FIGURE 10. XDC2XXX Top View And Dimensions.