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DMC 60™ Reference Manual

Revised November 15, 2016
This manual applies to the DMC 60 rev. A

Overview

The DMC 60 is an electronic speed controller designed for driving brushed DC motors. It utilizes synchronous rectification to efficiently produce a variable output voltage that's controlled by a PWM Input Signal. This makes the DMC 60 ideal for use in robotics applications, including FIRST Robotics Competition.

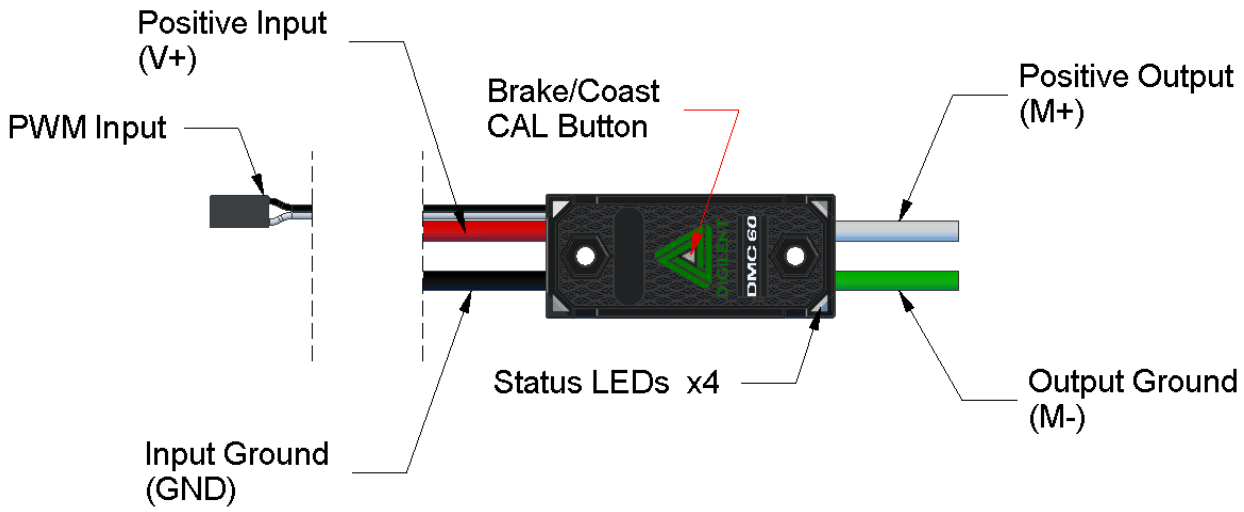
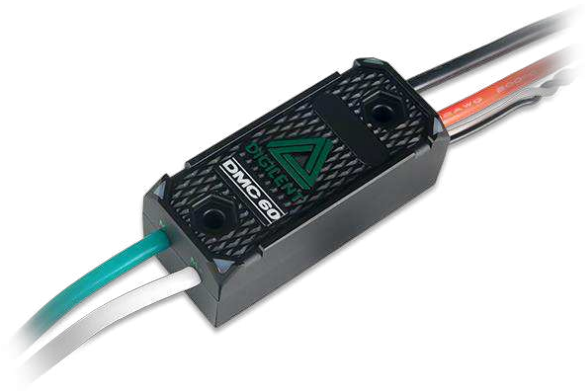


Figure 1. DMC 60 components.



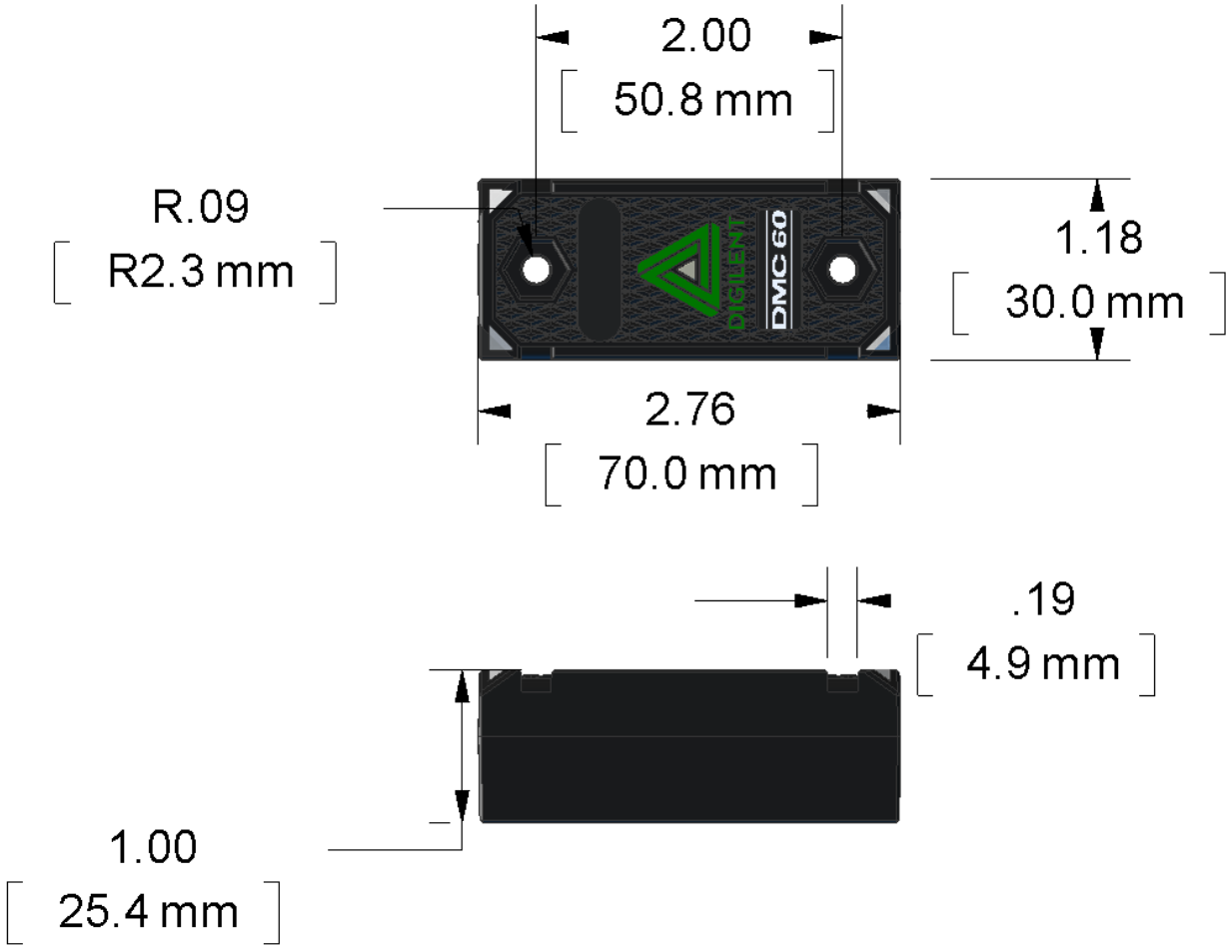
The DMC 60.

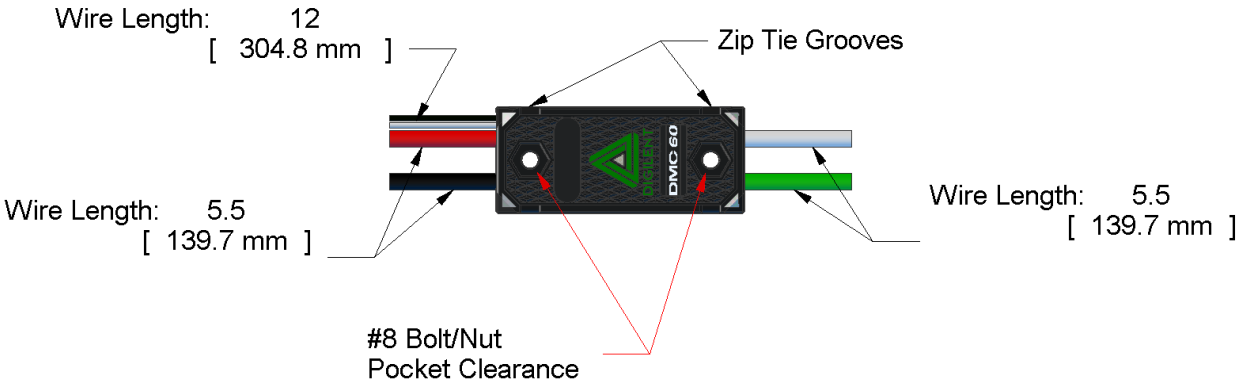
- Sealed, ruggedized, and compact aluminum case
- Tie-wrap and through-bolt mounting – drop-in replacement for Victor SP controller
- Four multi-color LED indicators sequence to indicate speed, direction, and status for easier debugging
- Brake / Coast Calibration button enables one-touch setting changes and calibration
- Large gauge input/output cables with flexible silicone insulation
- Integrated thermal sensing and protection – current-foldback to prevent overheating and damage
- 15.625 kHz output switching frequency ensures smooth and precise motor control

1 Electrical Specifications

PARAMETER	MIN	NOMINAL	MAX	UNIT
Input Voltage	6	12	28	V
Continuous Current			60	A
Surge Current (2 seconds)		100		A
PWM Input Signal Pulse Width	0.6	1 - 2	2.4	ms
PWM Input Signal Period	2.9		100	ms
PWM Input Signal Throttle Dead Band		4%		
PWM Input Signal Resolution		1		µs
PWM Input Signal Logic High Threshold	1.0			V
PWM Input Signal Logic Low Threshold			0.4	V
PWM Output Frequency		15625		Hz

2 Mechanical Dimensions and Mounting Information





The DMC 60's aluminum case is electrically isolated and may be mounted directly to a robot using zip-ties or #8-32 screws. The case may become hot after pro-longed use in high current applications. For optimum performance it is recommended that the DMC 60 be mounted in a location that allows airflow over the top of the case and around both sides of the case.

3 Connecting Input Power

Connect the black wire (labeled GND on the housing) of the DMC 60 to the ground, or negative terminal of the chosen power source. Connect the Red Wire (labeled V+ on the housing) of the DMC60 to the positive terminal of the chosen power source.

When powering the DMC 60 via a Power Distribution Panel (PDP) this typically means connecting the Red Wire of the DMC 60 to the Red Terminal of the PDP and the Black Wire of the DMC 60 to the Black Terminal of the PDP.

The DMC 60 does not feature output short circuit protection, and as such, shorting the output leads can result in catastrophic failure; therefore, it is recommended that a 40 Amp breaker (or fuse) be placed in line with the DMC 60's positive input lead (Red Wire).

Note: the DMC 60 does NOT include input reverse polarity protection. Reversing the polarity of the inputs may cause permanent damage to the DMC 60.

4 Connecting the Output

Connect the green wire (labeled M- on the housing) to the negative lead of the motor. Connect the white wire (labeled M+ on the housing) to the positive lead of the motor. The stall current associated with the motor may be very high. Therefore, it is recommended that these connections be made through crimped connectors or by soldering the leads directly together.

If the DMC 60 output leads aren't long enough to reach the motor, then they may be extended. It is recommended that 12 AWG (or thicker) stranded wire be used and that the wires be soldered directly together.

5 Connecting the PWM Input Signal

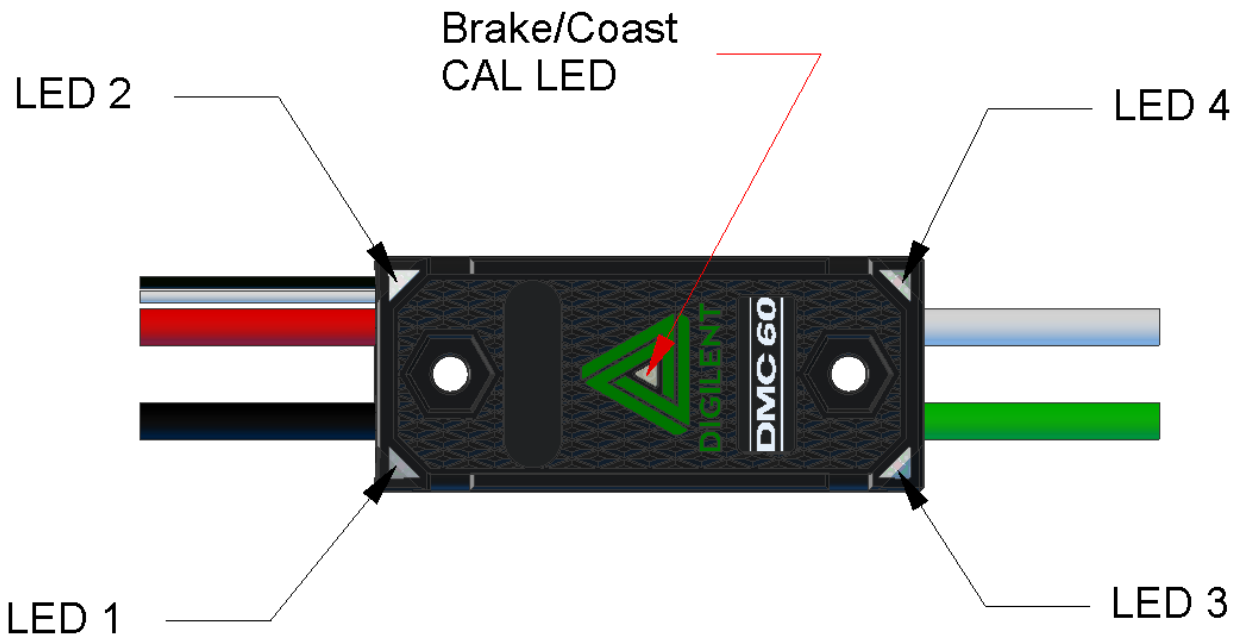
The DMC 60 continually measures the positive pulse width of the PWM Input Signal applied to the PWM Cable and maps it to an output voltage, or duty cycle. By default, a positive pulse width of 1.0 milliseconds corresponds to 100% duty cycle in the reverse direction (current flow from M- to M+), a positive pulse width of 2.0 milliseconds corresponds to 100% duty cycle in the forward direction (current flow from M+ to M-), and a positive pulse width of 1.5 milliseconds (+/- 4%) corresponds to neutral. When a neutral pulse width is detected the present Brake / Coast setting is applied to the output. The DMC 60 expects the PWM Input Signal to have an input period between 2.9 and 100 milliseconds. This allows the update rate to be as high as 344 Hz or as low as 10 Hz.

The DMC 60's PWM Input Cable features a 0.1" pitch 3-pin female header that is compatible with most RC / PWM Servo Controllers, allowing the DMC60 to be readily wired directly to those devices. The table below describes the pinout for the PWM Input Cable.

Wire Color	Signal Description
White	PWM Signal
Black	PWM Ground

6 Motor Controller LEDs

The DMC 60 contains four RGB (Red, Green, and Blue) LEDs and one Brake / CAL LED. The four RGB LEDs are located in the corners and are used to indicate status during normal operation, as well as when a fault occurs. The Brake / CAL LED is located in the center of the triangle, which is located at the center of the housing, and is used to indicate the current Brake/Coast setting. When the center LED is off the device is operating in coast mode. When the center LED is illuminated the device is operating in brake mode. The Brake/Coast mode can be toggled by pressing down on the center of the triangle and then releasing the button.



At power-on the RGB LEDs will display a progressive blue color, which continually gets brighter. This lasts for approximately five seconds. During this time the motor controller will not respond to an input signal, nor will the output drivers be enabled. After the initial power-on has completed the device will begin normal operation and

what gets displayed on the RGB LEDs will be a function of the input signal being applied, as well as the current fault state. Assuming that no faults have occurred the RGB LEDs will function as follows:

Servo Input Signal Applied	LED State
No Input Signal or Invalid Input Pulse Width	Alternate between top (LED1 and LED2) and bottom (LED3 and LED4) LEDs being on and off. When on, the LEDs display color is orange.
Neutral Input Pulse Width	All 4 LEDs on solid orange
Positive Input Pulse Width	LEDs blink green in a clockwise circular pattern (LED1->LED2->LED3->LED4->LED1). The rate at which the LEDs update is proportional to the duty cycle of the output and increases with increased duty cycle. At 100% duty cycle, all four LEDs turn on solid green.
Negative Input Pulse Width	LEDs blink red in a counter-clockwise circular pattern (LED1->LED4->LED3->LED2->LED1). The rate at which the LEDs update is proportional to the duty cycle of the output and increases with increased duty cycle. At 100% duty cycle, all four LEDs turn on solid red.

6.1 Brake/Coast Mode

How the DMC 60 responds when it detects a neutral input signal, or the loss of the input signal, depends on the Brake / Coast setting. When the DMC60 is configured for Brake Mode the M+ and M- leads are internally shorted when a neutral signal is detected, which will cause an attached motor to resist rotation. If an attached motor is spinning, then its speed will decrease at a much quicker rate than it would if the M+ and M- leads were allowed to float. When configured for Coast Mode the M+ and M- leads will float when a neutral input signal is detected.

The current Brake / Coast setting is displayed by the Brake / CAL LED, which is in the center of the triangle located at the center of the housing. When the device is operating in Brake Mode the LED will be illuminated Red. When the device is operating in Coast Mode the LED will be off. The Brake / Coast setting can be toggled by pressing down on the center of the triangle and then releasing the button.

The Brake / Coast setting is stored in non-volatile memory and is re-stored automatically after power cycles.

7 Input Signal Calibration

The DMC 60 accepts PWM input signals with a positive pulse width between 0.6 and 2.4 milliseconds. Due to variations in controllers it may be necessary to adjust, or calibrate, the pulse widths that correspond to the maximum forward and reverse duty cycles, as well as the neutral input.

To perform calibration, perform the following steps:

1. Press and hold the Brake / CAL button. After approximately 5 seconds the top and bottom LEDs will begin to alternate between Blue and Off. This indicates that calibration has started.
2. While continuing to hold the button, move the joystick back and forth between full forward and full reverse, ensuring to reach both extremes. This may be repeated more than once, but there is no required minimum.
3. Return the joystick to the neutral position.

4. Release the Brake / CAL button.
5. If calibration was successful then the top and bottom LEDs will quickly alternate between Green and Off and the new calibration constants will be stored in non-volatile memory. If calibration failed, then the top and bottom LEDs will quickly alternate between Red and Off and the device will continue to operate using the existing calibration constants.

Note: Calibration may only be performed while a servo input signal is present.

To restore default calibration:

1. Disconnect the power source from the DMC 60.
2. Hold the Brake / CAL button down.
3. While continuing to hold the button, apply power to the DMC 60.
4. Continue holding down the button until the top and bottom LEDs alternate quickly between Green and Off.
5. Release the Brake / CAL button.

8 Internal Temperature Monitoring and Over Temperature Protection

The DMC 60 features an onboard thermistor, which allows the temperature of the circuit board to be continuously monitored. When the motor controller detects that the temperature of the circuit board has exceeded 70°C it will begin to decrease the duty cycle of the output. Additionally, the color of the LED indicators will be changed to Cyan (forward) or Fuchsia (reverse) to indicate that the device is operating in reduced duty cycle mode. As the temperature continues to rise, the duty cycle will be further reduced at a rate of approximately 2.85% per degree C until the temperature of the PCB exceeds 100°C, at which point the output duty cycle will be set to 0% and an over temperature fault will be signaled. The motor controller will continue to operate with a decreased duty cycle until the temperature of the PCB falls below 70°C, at which point, it will resume outputting the duty cycle that corresponds to the input signal.

9 Input Voltage Monitoring and Under Voltage Protection

The Digilent Motor Controller's (DMC1 and DMC2) continuously monitor the input voltage. If the input voltage falls below 5.75 Volts (+/- 2%) for 5 or more seconds, then the output duty cycle will be set to 0% and an under voltage fault will be signaled. The output will remain disabled until the fault is cleared (3 seconds), at which point it may be re-enabled if the under-voltage condition is no longer present.

10 Fault Indicators

When a fault condition is detected the output duty cycle is reduced to 0% and a fault is signaled. The output will remain disabled for 3 seconds. During this time the onboard LEDs (LED1, LED2, LED3, and LED4) are used to indicate the fault condition. The fault condition is indicated by toggling between the top (LED1 and LED2) and bottom (LED3 and LED4) LEDs being on and off. The top LEDs will be Red during them on state. The color of the bottom LEDs depends on which faults are presently active. The table below describes how the color of the bottom

LEDs maps to the presently active faults.

Color	Over Temperature	Under Voltage
Green	☑	☒
Blue	☒	☑
Cyan / Aqua	☑	☑