Motor Controller Output Power Testing

Rev 1.3

Cross the Road Electronics

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Table of Contents

1. Description ... 3

2. Required Materials and Tools ... 3

3. Assembling the Load Resistor ... 4

4. Assembling the Test Fixture ... 4

5. Adding the Measurement Points ... 5

6. Resistive Load Test Description ... 6

7. Test Results ... 7

8. Revision history ... 8

1. Description

The purpose of this document is to describe a method of testing brushed DC motor controllers, to determine maximum power output, which is easy for users to replicate using resources that are affordable and readily available. The testing method described here is used to compare maximum power output of 4 models of brushed motor controllers used in FIRST Robotics. The test places a known resistive load at the output terminals of a motor controller at full throttle over three different input voltage levels. The output voltage and load resistance are used to calculate output power. This test was developed by CTR-electronics and is intended to be reproduced by end users. A more detailed description of the test is provided in section 4 as well as the materials needed to perform the test. The test requires some knowledge of electrical wiring, a method of generating a PWM pulse and basic soldering skills. Software experience may be helpful in generating the PWM pulse but is not required.

2. Required Materials and Tools

There are a few items that are needed in order to create the test fixture. Most of these items are available from suppliers such as AndyMark and VEX Robotics. Some of the items will need to be sourced from other distributers. Table 1 lists the items needed as well as the supplier name and part number.

QUANTITY	ITEM	SUPPLIER	PART NUMBER	UNIT COST
2	Digital Voltmeter	DIGIKEY	614-1021-ND	$349.99
1	Talon SRX	CTR Electronics	14-838288	$89.99
1	Victor SP	VEX Robotics	217-9090	$59.99
1	SPARK	REV Robotics	REV-11-1200	$45.00
1	SD540	MINDSENSORS	SD540X1	$49.00
10	2 OHM 50 WATT RESISTOR	DIGIKEY	KAL50FB2R00	$3.25
1 FOOT	BLACK SILICONE WIRE	CTR Electronics	15-838766	$1.49
3 FOOT	GREEN SILICONE WIRE	CTR Electronics	15-838771	$1.49
1 FOOT	RED SILICONE WIRE	CTR Electronics	15-838782	$1.49
3 FOOT	WHITE SILICONE WIRE	CTR Electronics	15-838787	$1.49
1	PWM SIGNAL GENERATOR	TOWER HOBBIES	LXWGJ7	$32.99
1	PDP	CTR Electronics	14-806880	$199.99
1	VRM	CTR Electronics	14-868277	$45.99
1	12V LEAD ACID BATTERY	ANDYMARK	am-0844	$89.00 (COST FOR TWO)
1	60 AMP BREAKER	SNAP ACTION	MX5-M60	CONTACT SUPPLIER

Table 1

3. Assembling the Load Resistor

Both tests require a load of .2 ohms rated @ 500 Watts or greater. To create the proper load, wire the 10, 2 ohm, 50 watt resistors in parallel using 2 x 1/16" diameter copper or brass rod as shown in Image 1. These resistors can become very hot so be sure to mount them to a piece of thermally conductive material such as aluminum. A fan can be used to cool the resistors but is not required. Solder about 1 foot of the green silicone wire to the middle of one side of the resistor array. Do the same to the other side using the white silicon wire. Image 1 shows the assembled load resistor. It is also helpful to have some type of connector so switching between DUT's (device under test) is easy. Image 1 shows 2 Anderson PP15 used for this.

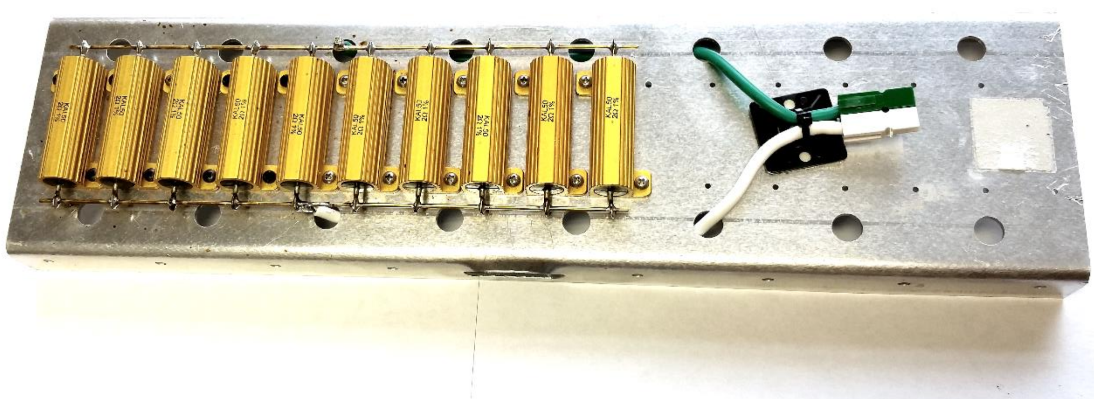

Image 1

4. Assembling the Test Fixture

The tests will require power from a 12 volt lead acid battery and a source for the PWM signal. Mount the PDP, VRM and PWM signal generator to a piece of ¾" plywood. The PWM signal generator is powered from any of the VRM's 5 volt outputs. Image 2 shows the assembled test fixture.

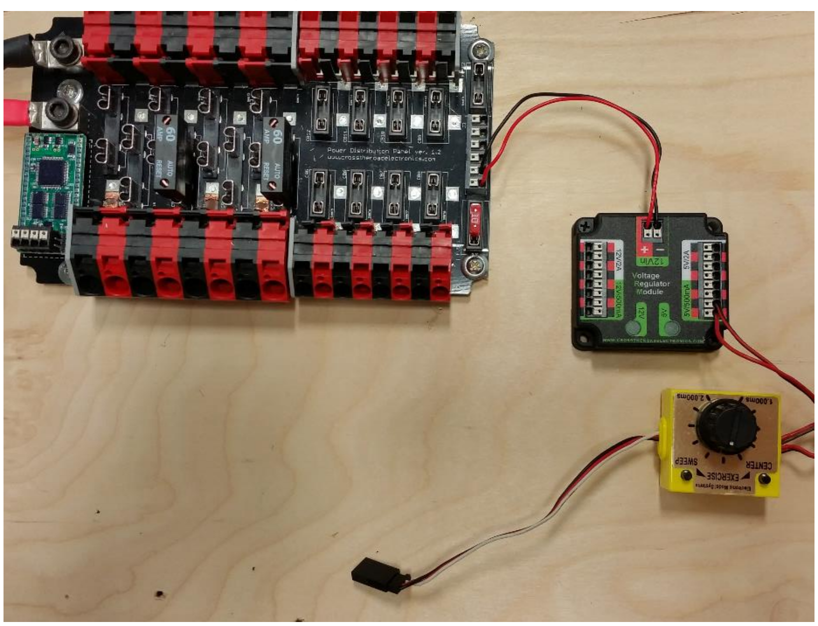

Image 2

5. Adding the Measurement Points

The test requires voltage measurements at two points; the input leads and output leads of the DUT. It is important that these two measurements are taken at the same point for all DUT's. Since the Victor SP and Talon SRX are leaded devices, the same wire and wire length should be chosen for non-leaded DUT's. The measurements are taken .5" from the device housing on both the input and output side. The exact distance is not as important as keeping the distances equal among all devices. Small gauge wire is added to each of the 4 leads to simplify measurement. Image 3 shows the modifications made to the Victor SP's input and output leads. Image 4 shows the leads used for non-leaded motor controllers.

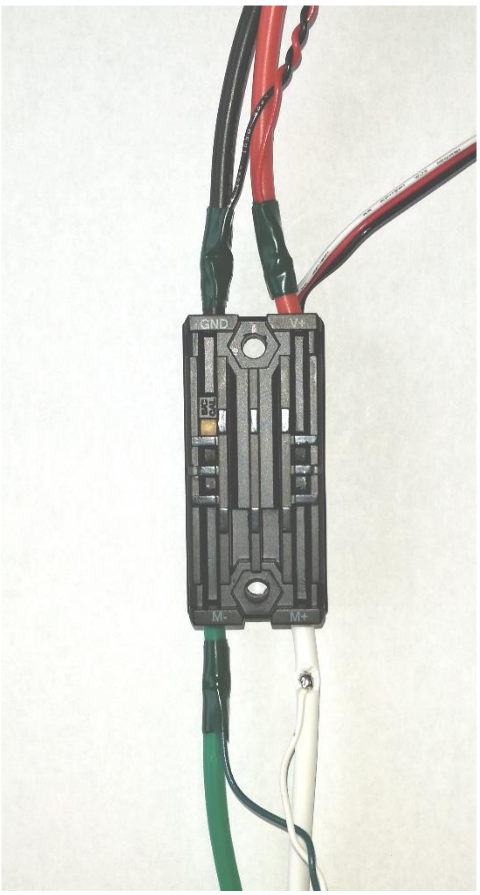

Image 3

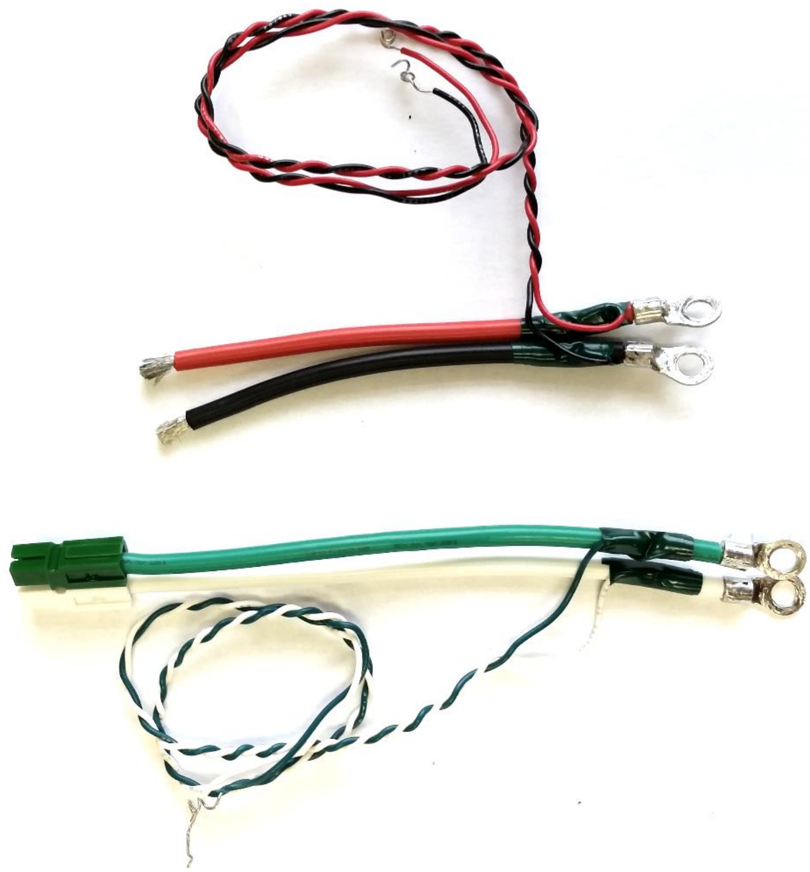

Image 4

6. Resistive Load Test Description

The resistive load test applies a known, fixed, resistive load to the DUT's output. This load will produce 50 amps of current draw at 10 volts (V/I). Power output can then be calculated using the equation Power (watts) = V*V/R. It is important that the measured input voltage is the same for all DUT's.

The load is connected directly to the DUT's motor output. Connect one device per test to any one of the high current slots on the PDP. A 60 amp breaker is required for this test. Connect a voltmeter to the input leads and connect a second voltmeter to the output leads of the DUT. It is important that the voltmeters are calibrated or at least have the same amount of error. To test this, prior to connecting the meters to the DUT's, place the leads of the two voltmeters in parallel and measure the battery voltage. Make sure the values are the same.

The test is performed at full throttle in the forward or reverse direction so it is important that the motor controllers be properly calibrated prior to testing.

Once the DUT is properly connected, adjust the PWM generator to full throttle. Note both the input and output voltages. Repeat the test as many times as desired per device. The actual value of the input voltage is not as important as keeping the value the same across all DUT's as the max power available is a function of the input voltage. For example; if DUT A is tested at an input voltage of 10.53V then DUT's B, C and D should all be tested at 10.53 volts. Note the voltage at the output for each DUT. Use these numbers to calculate power. The test was performed three times using three different input voltages. Page 7 shows the test results for the four motor controllers displayed from highest output to lowest output. Image 5 shows the final test configuration.

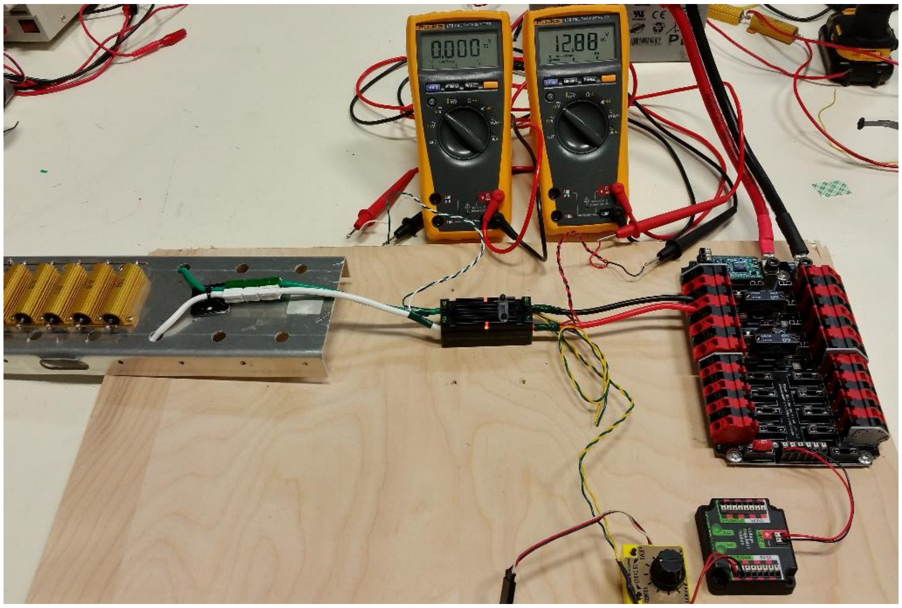

Image 5

7. Test Results

The test results displayed below show the difference in maximum power output for each of the four motor controllers tested. Power is expressed in watts and represents the power delivered to the load at the specified input voltage. The measurements taken are accurate to within +/- 10 millivolts. During the low voltage test (Test #2), motor controller SD540 was unable to output any voltage when the input voltage was below 9.5 volts. Several retest confirmed this behavior but are not recorded in this document. The manufacturer has contacted us to clarify that this behavior is the result of a safety feature unique to the SD540.

RESISTIVE LOAD TEST 1 – Vin = 11.05V				
DUT	Vin	Vout	ΔV	POWER (WATTS)
Victor SP	11.05	10.82	.23	585.4
Talon SRX	11.05	10.77	.28	580
SPARK	11.05	10.64	.41	566.4
SD540	11.05	10.18	.87	518

RESISTIVE LOAD TEST 2 – Vin = 8.21V				
DUT	Vin	Vout	ΔV	POWER (WATTS)
Victor SP	8.21	8.05	.16	324.0
Talon SRX	8.21	8.02	.19	321.6
SPARK	8.21	7.92	.29	313
SD540	UNABLE TO TEST DUE TO SAFETY FEATURE ACTIVATION			

RESISTIVE LOAD TEST 3 – Vin = 11.20V				
DUT	Vin	Vout	ΔV	POWER (WATTS)
Victor SP	11.20	10.96	.24	600
Talon SRX	11.20	10.93	.27	597
SPARK	11.20	10.80	.40	583
SD540	11.20	10.28	.92	528

8. Revision history

Rev 1.2 - initial release of document

Rev 1.3 - added language to clarify SD540 low voltage behavior.