Brushless DC Motor Controller Specification

Assembly 025A0053

600A0053 Rev. 2
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Revision History

Date	Rev	Description	By
5/15/04	1	Initial release	J. Lawrence
7/28/04	2	Added disclaimer	J. Lawrence

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Device Overview

Features

- **Locked rotor detection**
- **Low speed detection**
- **FET thermal shutdown**
- **Motor case thermal shutdown**
- **Under/Over voltage shutdown**
- **Over current shutdown**
- **Up to 20A continuous current**

Description

The 025A0053 Motor Controller has been designed to provide efficient control and monitoring of a DC powered brushless hermetic compressor. The controller will provide a constant speed as specified by the speed setpoint input, independent of motor voltage and load. Fault conditions are monitored continuously. Upon detection of a fault, the motor is shut down. The controller will automatically attempt to restart the motor after the fault condition is cleared. The controller will indicate the fault state by a TTL output. On/Off and speed setpoint are controlled by a 0 to 5 volt analog input. The controller provides a TTL level tachometer output and an analog output proportional to motor current.

Wiring is provided for direct connection to a Masterflux Sierra compressor. The motor wire harness contains three motor phase wires and two wires to connect to the shell temperature switch. Power is supplied through two Anderson PowerPole connectors. Control and indicator signals connect to an eight-pin Molex header. Two fan connectors are available for connecting two 12 volt DC fans.

The motor drive transistors are cooled by a large aluminum finned heatsink. A temperature sensor embedded in the heatsink measures the heatsink temperature. The heatsink provides the mounting points for the assembly with two threaded holes at each end. The heatsink is electrically isolated from the circuitry.

The controller will operate from 0° to 50° C. The circuit board is conformal coated to protect it from corrosion.

Operation

On/Off and Speed Control

Motor on/off and speed setpoint are controlled by a zero to five volt analog input. When the setpoint input voltage rises above one volt the motor will turn on after a 3 second delay. When the setpoint input voltage falls below 0.5 volts the motor turns off. As the setpoint voltage is decreased from 1.0 to 0.5 volts, the minimum speed of 1800 RPM is held. A setpoint input voltage of 1 volt commands the minimum speed of 1800 RPM, five volts commands the maximum speed of 6500 RPM. The motor controller will run the motor at the setpoint speed independent of the load on the motor and the motor voltage provided that the speed is not limited by the motor voltage or maximum current. Five volts and ground are available on the control connector. Connect five volts to one leg of a potentiometer. Connect the other to ground. Connect the wiper of the potentiometer to the speed input for variable speed operation. The input impedance is 10K ohms. A low-pass filter consisting of a 10K ohm resistor and a 10 micro Farad capacitor is used for noise immunity.

Tachometer Output

The motor speed is indicated by a 0 to 5 volt square wave output. The frequency of the square wave is proportional to motor speed at 2.5 RPM/Hz. In the case of a stalled motor, there will be a brief period when the tachometer output is invalid. During a stalled condition, the controller will output a frequency that corresponds with the speed it is trying to achieve even though the motor is not spinning. The controller will quickly detect the stalled condition and shut down.

Motor Current Sense

An analog output is provided on the control connector to indicate motor current. The scaling is 4 Amps/Volt. The output impedance is 10K ohms.

Fault Indicator Output

The controller will signal a fault condition by outputting a logic high value on the fault indicator output. The output is a TTL level signal capable of directly driving an LED. The output can source or sink 25 mA of current. The fault indicator will be active after 10 unsuccessful attempts to restart the motor after a stall is detected, or 10 over temperature conditions of either the heatsink or the shell temperature sensor.

Fault Detection

The motor controller can detect the following faults:

- Locked rotor – if the controller detects a locked rotor it will shut down the motor, delay for 20 seconds and attempt to restart the motor. If the motor does not restart after 10 attempts, the controller will indicate a fault condition by activating the fault indicator output. The controller will continually attempt to restart the motor.

If the controller is successful in restarting the motor, the fault indicator will be deactivated.

- Low speed – The compressor must maintain a minimum speed of 1500 RPM for proper lubrication. If the controller detects a low speed condition, it will shut down the motor, delay for 20 seconds and attempt to restart the motor. If the motor does not restart after 10 attempts, the controller will indicate a fault condition by activating the fault indicator output. The controller will continually attempt to restart the motor. If the controller is successful in restarting the motor and maintaining a speed above 1500 RPM for 2 minutes, the fault indicator will be deactivated.
- Under/Over voltage – if the motor voltage is outside of the operating limits, the controller will shut down the motor and will delay for 10 seconds. After the delay period, the controller will recheck the voltage conditions. If the voltage is within the operating limits the motor will restart.
- Heatsink temperature above limit - if the heatsink temperature rises above 158°F the controller will shut down the motor and delay for 10 seconds. After the delay period the controller will recheck the heatsink temperature. If the temperature has fallen below 158°F the controller will restart the motor. If controller detects ten over temperature faults, the controller will indicate a fault condition by activating the fault indicator. The controller will continue to monitor the heatsink temperature. The controller will restart the motor and deactivate the fault indicator when the heatsink temperature falls below 158°.
- Compressor Shell temperature above limit - if the compressor shell temperature switch opens, the controller will shut down the motor and delay for 5 seconds. After the delay period the controller will recheck the compressor shell temperature switch state. If the compressor shell temperature switch is closed the controller will restart the motor. If controller detects ten over temperature faults, the controller will indicate a fault condition by activating the fault indicator. The controller will continue to monitor the switch state. The controller will restart the motor and deactivate the fault indicator when the compressor shell temperature switch is closed.

Engineering Specifications

Absolute Maximum Ratings

Parameter	Min.	Max.	Units
V_M	0	450	V
Speed Setpoint	-0.3	5.05	V
Fault output current sourced		25	mA
Fault output current sunk		25	mA

Note: Do not apply power to the controller when the controller is not connected to the compressor.

Operating Conditions

Parameter	Min.	Max.	Units
V_M	120	420	V
V_M low voltage shutdown	105	120	V
V_M high voltage shutdown	420	435	V
Temperature Range	0	50	°C

Electrical Characteristics

Parameter	Conditions	Min.	Max.	Units
V_{CC}	I_{OUT} < 50 mA	4.75	5.25	V
Fan Power	I_{OUT} < 100 mA	10.7	12.7	V
Tachometer				
Output Low Voltage	I_{OL} = 0.4 mA		0.6	V
Output High Voltage	I_{OL} = -0.1 mA	2.2		V
Fault				
Output Low Voltage	I_{OL} = 8.5 mA		0.6	V
Output High Voltage	I_{OL} = -3.0 mA	4.05		V
V_M				
Ripple Current RMS			TBD	A
Current	(Note 1)		20	A
Motor Current Sense				
Source impedance			10K	Ohms
I_{SENSE} Gain		3.8	4.2	A/V
Motor speed	Speed Setpoint = 1 V Speed Setpoint = 5 V	1650 6000	1950 7000	RPM
Note 1: Measured current is steady state. The controller presents a capacitive load to the system. On initial application of power, a substantial in-rush current will result if not limited by external components.				

Testing was done with the 025A0053 controller connected to a model SIERRA00013 compressor.

Connectors

Power

Motor power (V_M) is supplied through the power connector. The power connectors are Anderson Power Products Powerpole 30 Series part number 1330. This connector is self-mating. Connect the positive voltage to the red connector. Connect the return to the black connector.

Control

The control connector, reference designator JP1, is an eight pin shrouded header, Molex part number 70543-0042. The mating connector is Molex part number 50-57-9408.

Pin	Signal Name	Type
1	Motor Current	Output
2	Ground	Output
3	Not connected	
4	Not connected	
5	Tachometer	Output
6	+5 Volts	Output
7	On/Off Speed setpoint	Input
8	Fault	Output

Compressor

The three phase wires, reference designators M1, M2, and M3 have AMP Faston connectors, part number 61187-1. The shell temperature switch wires, reference designators JP4, have AMP Faston connectors, part number 2-520128-2.

Pin	Signal Name	Type
Blue	Phase A	Output
Orange	Phase B	Output
Yellow	Phase C	Output
Black	Shell Temperature Switch	Input/Output
Black	Shell Temperature Switch	Input/Output

Fan

Two fan connectors are available, reference designators JP2 and JP3. The connectors are Molex part number 22-23-2021. The mating connector is Molex part number 22-01-2027.

Pin	Signal Name	Type
1	+12 Volts	Output
2	Ground	Output