Brushless DC Motor Controller Specification

Assembly 025A0054

600A0057 Rev. B
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Revision History

Date	Rev	Description	By
6/10/2004	A	Initial release	J. Lawrence
7/28/04	B	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 45A continuous current**

Description

The 025A0054 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 of 1800 RPM, 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. The controller provides a TTL level tachometer output and an analog output proportional to motor current.

Packard Metri-Pack connectors are used on the three motor phase wires and power input wires. An AMP Universal Mate-N-Lock connector is used on the motor shell temperature switch wires. 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 65° C. The circuit board is conformal coated to protect it from corrosion.

Operation

Power On/Off Switch

There are two options for switching the controller on and off. Option one applies continuous power to the controller and a low current (less than 100 mA) switch is used to switch the power to the control electronics only. The motor controller handles the high current switching for the motor. A small amount of leakage current will be present in the off state. The second option is to use a high current switch (at least 50 Amps). The switch handles both the current for the control electronics and the motor. There is no leakage current in the off state. Using option one the motor is switched on and off by connecting the +VM_FUSED output signal located on the control connector to the POWER ON/OFF input through a switch. If option two is used then +VM_FUSED must be connected to POWER ON/OFF. Since the on-board microprocessor measures the voltage on the POWER ON/OFF input signal to determine under/over voltage faults, it is important that the switched +VM_FUSED output is connected to the POWER ON/OFF input for accurate motor voltage monitoring.
As the voltage rises above approximately 14 volts, the onboard microcontroller will start a 1 second delay timer which allows time for the power supply to stabilize. After the delay, the motor will start provided that the motor voltage is within the specified operating range.

Speed Control

The speed setpoint is fixed at 1800 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.

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 25 milli Volts/Amp. 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 185°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 185°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 185°.
- 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.

Diagnostic Messages

The motor controller will report fault status on the serial port should a fault condition occur. The controller will also report the software version on power up. Following is a list of messages that can potentially be sent on the serial port:

MasterFlux Version x.xx 025A0054	Power up message. x.xx is software version number followed by controller part number
MV	Motor voltage is outside of limits
LS	Low speed
LR	Locked rotor detected
OTH	Over temperature heatsink
OTS	Over temperature motor shell

The serial port is configured for 9600 baud, 8 data bits, 1 stop bit, no parity, no flow control.

Engineering Specifications

Absolute Maximum Ratings

Parameter	Min.	Max.	Units
V_M	0	63	V
Speed Setpoint	-0.3	5.05	V
Power On/Off	0	63	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	20	51	V
V_M low voltage shutdown	18	20	V
V_M high voltage shutdown	51	55	V
Temperature Range	0	65	°C

Electrical Characteristics

Parameter	Conditions	Min.	Max.	Units
+5 Volts	I_{OUT} < 50 mA	4.75	5.25	V
+12 Volts	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
Power On/Off				
Supply Current	V_M = 48 V (Note 1)		35	mA
V_M				
Leakage Current	Power On/Off < 18 V		4.5	mA
Ripple Current RMS			TBD	A
Current	Power On/Off >= 20 V (Note 1)		45	A
Motor Current Sense				
Source impedance			10K	Ohms
I_{SENSE} Gain		0.022	0.027	V/A
Motor speed	When not limited by compressor loading	1750	1850	RPM
Serial Port Transmit				
Output Low Voltage	I_{OL} = 8.5 mA		0.6	V
Output High Voltage	I_{OL} = -3.0 mA	4.05		V
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.				

Connectors

Power

Motor power (V_M) is supplied through the power connector. The power connector is a Packard Metri-Pack 630 series part number 12129938. The mating connector part number is 12129939.

Pin	Signal Name	Type
A	+48 Volts	Input
B	Ground	Input

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	Power On/Off	Input
4	+VM_FUSED	Output
5	Tachometer	Output
6	+5 Volts	Output
7	Speed setpoint	Input
8	Fault	Output

Compressor

The compressor wire harness connector is a Packard Metri-Pack 630 series part number 12052623. The mating connector part number is 12015664.

Pin	Signal Name	Type
A	Phase A	Output
B	Phase B	Output
C	Phase C	Output
D	Not used	

Shell Temperature Switch

The shell temperature switch wire harness connector is an AMP Universal Mate-N-Lock part number 350778-1. The mating connector part number is 350777-1. Connect to a normally closed switch.

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

Serial Port

A serial port is provided, reference designator J2. The connector is a Molex part number 22-23-2041. The mating connector is Molex part number 10-11-2043-P. The software does not currently support serial input.

Pin	Signal Name	Type
1	+5 Volts	Output
2	Transmit	Output
3	Receive	Input
4	Ground	Output