Brushless DC Motor Controller
Product Specification
Assembly 025A0134

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Revision History

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EC24824	4/7/09	A	Release for document control	D. Stahl
EC29164	11/04/09	B	Corrected fault time/function in fault table	D. Stahl

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Device Overview

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General Product Description

The 025A0134 Motor Controller employs the use of an ST microprocessor for control of the motor resulting in improved control/performance. The 025A0134 Motor Controller shall be designed to provide efficient control and monitoring of a DC powered brushless hermetic compressor. The controller shall provide a constant speed as specified by the speed set-point input, independent of motor voltage and load unless one of the following limitations is exceeded.
Current limit, this is where the average current the motor requires to maintain the commanded speed exceeds 55 amps.
If the load requires more than 55 amps then the speed will be reduced accordingly.
Voltage limitation, this is where the motor supply voltage is not high enough to achieve the commanded speed.

Fault conditions are monitored continuously. Upon detection of a fault, the motor is shut down and the controller will indicate the fault state by a TTL level output.
For a Start-up Failed fault, Stall fault or Low Speed fault the controller will delay for ten seconds before attempting to restart the motor. If the controller is successful in restarting the motor, the fault indicator will be deactivated after 30 seconds.
For Under/Over Voltage fault the controller will delay for ten seconds then check if the voltage is within specification, if voltage is within specification the fault indicator will be deactivated and the controller will attempt to start the motor.

For a Motor Over-Temperature fault the controller will delay for five seconds then check if the thermal switch is closed, if the switch is closed the fault indicator will be deactivated and the controller will attempt to start the motor.
For a Controller Over-Temperature fault the controller will delay five seconds then check if the temperature has decreased by 5° C (9° F). If the temperature is within specification the fault indicator will be deactivated and the controller will attempt to start the motor.

If the controller detects eleven faults of any combination of Start-Up Failed fault or Stall fault or Low Speed fault it will stop trying to restart the motor and power must be cycled off and on before the motor can be restarted.

If the controller detects eleven faults of any combination of Controller Over-Temperature fault or Motor Over-Temperature fault, power must be cycled off and on before the motor can be restarted.

If the controller detects an Over-current fault it will deactivate the motor then activate the fault indicator and power must be cycled off and on before the motor can be restarted.

The speed set-point is controlled by a 0 to 5 volt non-isolated analog input.
The controller shall provide a TTL level tachometer output.

Control and indicator signals connect to a six pin Molex header.

The motor drive transistors shall be cooled by a large aluminum finned heatsink. A temperature sensor embedded in the heatsink will measure the heatsink temperature. The motor controller will shut down the motor if the heatsink temperature exceeds 100° C. The heatsink provides the mounting points for the assembly with two threaded holes at each end. The heatsink is electrically isolated from the circuitry.
There is no input fusing or reverse polarity protection provided.

The controller is specified to operate in an ambient temperature ranging from 0° (32°F) to 50°C (122°F).

The PCA conformal coating shall be a UL recognized type SR (silicone resin) based material to protect it from corrosion.

The controller will be capable of controlling the following compressor models.

MX01-0716Y3R134

Operation

Power On/Off Switch

There are two options for switching the controller on and off. **Option one** applies continuous power to the controller output drive circuitry and using a low current switch to supply power to (turn on) the control electronics. **Note:** When using this option bear in mind that there may be a substantial inrush current when the switch is turned on, if not limited by external components. The inrush current should be considered when selecting this switch. The motor controller handles the high current switching for the motor. With this option a small amount of leakage current will be present in the off state. **Option two** is to use a high current switch to apply power to the controller output drive circuitry, and the control electronics with a jumper connected to enable the drive. With this option there is no leakage current in the off state. With either option the onboard microcontroller will start a 10 second delay timer, which allows time for the power supply to stabilize. After the delay, the motor will attempt to start.
Note: 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.

Speed Control

The speed setpoint is controlled by a 0 to 5 volt analog non-isolated input. 0 to 1.0 volts commands 1800 RPM, 1.0 to 4.75 volts commands the maximum speed of 6500 RPM. At startup the motor controller will run the motor at 3000 RPM for a period of thirty seconds in order to ensure proper oiling of the mechanism and after thirty seconds the controller will run the motor at the commanded speed. If for any reason (such as excessive load) the motor should slow down to 1500 RPM the controller will output a fault and the motor will be shut down. 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 10K Ohm potentiometer. Connect the other to ground. Connect the wiper of the potentiometer to the speed input for variable speed operation.

Tachometer Output

The motor speed is indicated by a 0 to 5 volt non- isolated output. The frequency of the signal is proportional to motor speed. RPM = 2.5 X Hz.

Fault Indicator Output

The controller will signal a fault condition by outputting a logic high value on the fault indicator output. The fault indicator will be active after a stall is detected, or an under or over voltage or over temperature condition of either the heatsink or the shell temperature sensor.

Fan Power

Fan power shall be provided via two 2 pin straight friction lock connectors which each provide a regulated 12 volts and ground for powering two DC fans if required. Whenever the control circuitry is switched on power is provided to these two connectors.

Motor Voltage (VM)

The motor voltage (Vm) shall be brought out through a 0.5 amp 60 volt poly-fuse (F1) to pin 1 of a three pin connector JP6. Pin 2 of JP6 is connected to Ground and pin 3 is not used.

Electrical Ratings / Specifications

Absolute Maximum Ratings

Parameter	Min.	Max.	Units
V_M	0	35	V
Speed Setpoint	-0.3	5.05	V
Power On/Off	0	35	V
Fault output current sourced		-25	mA
Fault output current sunk		25	mA

Environmental Ratings

Parameter	Min.	Max.	Units
Operating Temperature Range	0	50	°C
Storage Temperature	-40	105	°C

Electrical Characteristics

Parameter	Conditions	Min.	Nom.	Max.	Units
V_{CC}	I_{OUT} < 50 mA	4.75	5.0	5.25	V
Tachometer					
Output Low Voltage	I_{OL} = 0.4 mA			0.6	V
Output High Voltage	I_{OH} = -0.1 mA	2.2			V
Fault					
Output Low Voltage	I_{OL} = 8.5 mA			0.6	V
Output High Voltage	I_{OH} = -3.0 mA	4.05			V
Voltage Fault					
High Voltage Shutdown		28.5	30	31.5	V
High Voltage Resume		28.5	29	30.5	V
V_{HS} - V_{HR}		1			
Low Voltage Shutdown		8.5	9	9.5	V
Low Voltage Resume		9.5	10	10.5	V
Temperature Fault					
High Temp Shutdown		95	100	105	° C
High Temp Resume		90	95	90	° C
T_{HS} - T_{HR}		5			° C
Power On/Off					
Current	V_M = 9 V (Note 1)			1	A
V_M					
Operating Range		9		30	V
Current	Power On/Off >= 9 V (Note 1)			55	A
JP2/JP3 Fan Power					
JP2	100ma Maximum	11.4	12	12.6	V
JP3	100ma Maximum	11.4	12	12.6	V
Motor Speed					
Minimum Speed	Command voltage 0 – 1.0V	1700	1800	1900	RPM
Maximum Speed	Command voltage 4.75 to 5	6400	6500	6600	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.					

Connectors

Power

Motor power (V_M) is supplied through a 4-position Metri-Pack connector part number 12052623. The part number for the pins is 12066493.

Control

The control connector, reference designator JP1, is a six pin shrouded header, AMP part number 5-103639-5. The mating connector is AMP part number 104257-5.

JP1

Pin	Signal Name	Type
1	Ground	Output
2	Power On/Off	Input
3	Fault	Output
4	Tachometer	Output
5	+5 Volts	Output
6	Speed set-point	Input

Fan Power

The two connectors JP2, and JP3 are for connecting fans if required. The connectors shall provide regulated 12 VDC. The connectors are 2 pin straight friction lock headers AMP part number 640456-2. The mating connector is Amp part number 770602-2.

JP2

Pin	Signal Name	Type
1	+12 Volt Fan High	Output
2	Ground	Output

JP3

Pin	Signal Name	Type
1	+12 Volt Fan High	Output
2	Ground	Output

Compressor

The three motor phase windings A, B, and C of the compressor is supplied through a AMP Faston connector, part number (1) 62057-1 and (2) 62057-7.

Shell Temp Switch

The shell temperature input terminals are AMP Part# 2-520128-2.

JP4

	Signal Name	Type
1	Shell Temperature Switch	Input/Output
2	Shell Temperature Switch	Input/Output

Vm OUT

The PCB shall include provision for the motor voltage Vm to be brought out through poly-fuse F1 to a 3 pin header with latch JP6 Molex Part # 70543-0002 mating connector is Molex Part # 14-56-7032.

JP6

Pin	Signal Name	Type
1	Vm	Output
2	Ground	Output
3	No connection	

Firmware Port

The PCB shall include provision for a firmware port which will be a 10 dual row header (JP7) Molex part # 90131-0125, mating connector is Molex part number 90143-0010. JP7 will not be populated except when used for development.

JP7

Pin	Signal Name	Type
1	Ground	Input
2	Icc Data	Input/Output
3	Ground	Input
4	Icc Clock	Input/
5	Ground	Input
6	Reset	Input
7	Vcc	Output
8	Vpp	Input
9	N.C.	N.C.
10	Ground	Input

Serial Port

The serial Port connector (JP5) is a 4 Pin shrouded header with latch Molex part # 70543-0038, mating connector is Molex part number 14-56-7042.

JP5

Pin	Signal Name	Type
1	Vcc	
2	Data	I/O
3	Clock	I/O
4	Ground	

The serial interface is configured for 19.2 K baud, 8 data bits, 1 stop bit, no parity, and no flow control. The controller will report the following operating parameters once per second over the serial interface:

Temperature - heatsink temperature in °C
Power Supply – Volts
Current – average current delivered to motor
Motor Speed – actual speed in RPM
Fault – in the event of a fault a brief description of the fault is reported (see below)

Fault Reporting	
STALLED	If the controller detects a locked rotor it will shut down the motor, activate the fault output then delay for 10 seconds. After the delay the controller will attempt to restart the motor. If the controller is successful in restarting the motor, the fault indicator will be deactivated after 30 seconds. If the motor does not restart after 11 attempts, it will stop trying to restart the motor and power must be cycled off and on before the motor can be restarted.
STARTUP FAILED	If the controller detects the motor has failed to start it will activate the fault output then delay for 10 seconds. After the delay the controller will attempt to restart the motor. If the controller is successful in restarting the motor, the fault indicator will be deactivated after 30 seconds. If the motor does not restart after 11 attempts, it will stop trying to restart the motor and power must be cycled off and on before the motor can be restarted.
MOTOR OVERHEAT	If the compressor shell temperature switch opens, the controller will shut down the motor and activate the fault output then delay for 5 seconds. After the delay the controller will recheck the compressor shell temperature switch state. If the compressor shell temperature switch is closed the controller will deactivate the fault indicator then attempt to restart the motor. If the controller gets 11 motor overheat conditions the power must be cycled off and on before the motor can be restarted.
UNDER / OVER VOLTAGE	If the motor voltage is outside of the operating limits, the controller will shut down the motor and activate the fault output then delay for 10 seconds. After the delay period, the controller will recheck the voltage conditions. If the voltage is within the operating limits the controller will deactivate the fault output and attempt to restart the motor.
OVER CURRENT	Hard current limit – If the controller detects an over current condition it will activate the fault indicator and require power to be cycled off and on before the motor can be restarted.
CONTROLLER OVERHEAT	If the controller (heatsink) temperature rises above 85°C (185°F) the controller will shut down the motor, activate the fault output then delay for 5 seconds. The controller requires the temperature to fall 5°C (9°F) below the set point before it will attempt to restart the motor. Once the temperature is within specification the controller will deactivate the fault indicator. If the controller gets 11 motor overheat conditions the power must be cycled off and on before the motor can be restarted.
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, activate the fault output then delay for 10 seconds. If the controller is successful in restarting the motor, the fault indicator will be deactivated after 30 seconds. If the controller gets 11 low speed conditions the power must be cycled off and on before the motor can be restarted.