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MASTERFLUX

Brushless DC Motor Controller Specification 025F0400 & 025F0401

600A1884 Rev. B
07/13/20

Revision History

EC	Date	Rev	Description	By
EC95795	30APR20	A	Initial Release	R. Snyder
EC96817	13JUL20	B	Added 025F0400	R. Snyder

General Product Description

The 025F0400 & 025F0401 Motor Controllers have been designed to provide efficient control and fault monitoring for a dual DC powered brushless hermetic compressor system. The controllers will provide a constant speed as specified by the master controller speed command input unless one of the following limitations is exceeded. Power limitation, this is where the average power the drive is producing exceeds 2500 watts. This is calculated by Power out = motor supply * average motor current. If the load requires more than 2500 watts then the speed will be reduced accordingly. Voltage limitation is where the motor supply voltage is not high enough to achieve the commanded speed and or power.

When configuring the system only the master controller receives the speed command. Upon power-up, each controller monitors its speed input and passes this information over the serial port between controllers. When a controller detects a speed command it becomes the master controller and then assigns the slave via the serial port. Each controller will stay in this mode until power is turned off. Note when using a fixed resistor to set the speed, the resistor should only be used on 1 of the controllers. The 2nd one will become the slave on power-up, as noted above.

When the master controller is issued a command to run it will start the master compressor. After 5 seconds the slave controller will start the slave compressor. Each controller will run at 3000 RPM for 30 seconds to ensure proper oiling. After the delay, both compressors will attempt to run the compressor at the commanded speed. If the master and slave speeds are more than 250 RPM different for more than 30 seconds the controllers will fault with differential speed error. After a 30 second delay, the controllers will attempt to restart.

The following fault conditions are monitored continuously: under/over-voltage, over-current, drive over-temperature, compressor over-temperature, low speed, stall, communication error, and differential speed fault. Upon detection of a fault, the controller will shut down the motor. Depending on the cause of the fault the controller may pause to allow time for the fault to clear and then attempt to restart the motor. The controller will indicate the fault-state by a TTL output. The fault handling behavior is described further in the fault reporting section.

There are two variants 025F0400 & 025F0401 and each have application specific voltage limits.

An isolated user interface including an RS-232 serial port is supplied. Run/Stop and speed are controlled by a 0 to 5V analog input, or 0 – 90% PWM input. When the speed input is1V or less or the duty cycle is less than 10%, the motor is stopped. When the analog input is 1V or the PWM input is 10% the motor will run at 1800 RPM. When the analog input is at 5V or the PWM input is 90% the motor will run at 6500. Tachometer output is an open collector output signal with 5K pull up resistor. The output frequency is 0 to 2.6 kHz. When the controller is commanded to run from a stopped condition it will run the motor at 3000 RPM for 30 seconds after which point it will run the motor at the commanded input speed.

Two one-position screw lug connectors are provided for connecting the input power to the controller. Three one-position screw lug connectors will provide connections to the motor outputs for the compressor. A two-position locking connector is supplied to connect to the shell temperature switch from the compressor. The isolated control and indicator signals connect to an eight-pin locking Molex header. The RS-232 serial port is provided through a nine-pin male D-Sub connector. The connector pinouts are defined in appendix A.

The motor drive transistor assembly is cooled by a large aluminum finned heat sink. A temperature sensor embedded in the power assembly measures the module temperature. The heat sink provides the mounting points for the assembly. The heatsink is electrically isolated from the circuitry

Fixed Speed Resistor Chart

RPM	Ohms
1800	40000
1900	36305
2000	33119
2100	30343
2200	27903
2300	25741
2400	23813
2500	22082
2600	20519
2700	19102
2800	17811
2900	16629
3000	15543
3100	14543
3200	13618
3300	12760
3400	11963
3500	11219
3600	10524
3700	9873
3800	9262
3900	8688
4000	8147
4100	7636

RPM	Ohms
4200	7153
4300	6696
4400	6263
4500	5852
4600	5461
4700	5088
4800	4734
4900	4395
5000	4072
5100	3763
5200	3467
5300	3184
5400	2912
5500	2651
5600	2401
5700	2160
5800	1929
5900	1706
6000	1491
6100	1285
6200	1085
6300	892
6400	706
6500	526

Fixed Speed Resistor Formula

$$Resistor = -\frac{(30000 \times RPM) - 204400000}{(3 \times RPM) - 1640}$$

Note: Resistor to speed chart when using a fixed resistor is between J4 pins 6 and 7.

Operating Conditions			
Parameter	**Min.**	**Max.**	**Units**
025F0400			
Input power (D.C.)	55	110	V
V_M low voltage shutdown	45	55	V
V_M high voltage shutdown	110	130	V
025F0401			
Input power (D.C.)	120	420	V
V_M low voltage shutdown	100	120	V
V_M high voltage shutdown	420	450	V
All Models			
V_M input current		27	A
Standby power		3	W
Efficiency (at 1500 watt output, 3000 rpm)	95		%
Ambient	0 32	65 149	°C °F
Relative Humidity Range	20 – 90% non-condensing @ 0°C (32°F) to 50°C (122°F)		

Note: 65 °C is the ambient temperature that the electronics are rated for. The maximum temperature the heat-sink can reach before the microprocessor shuts the drive off is 100 °C (212 °F)
The system designer must provide sufficient airflow to keep the heat-sink temperature below its shutdown threshold at the maximum ambient temperature and maximum loading conditions. The controller may fault on overheat sink temperature before reaching the maximum rated current if the airflow is insufficient.

Electrical Characteristics				
Parameter	**Conditions**	**Min.**	**Max.**	**Units**
Isolated +5V User Supply	Iout <= 50 mA	4.95V	5.05V	V
Fault Output Low Voltage	I_{OL} = 8mA		0.6	V
Fault Output High Voltage	I_{OH} = -3mA	4		V
Tachometer Output Low Voltage	I_{OL} = 1mA		0.3	V
Analog Speed Input impedance			10K	Ohms
Analog input tolerance	All	+/- 0.1		V
Analog input vs motor speed **See Note 1.**	input <= 0.5V input = 1.0V input = 5.0V	0 1700 6400	 1900 6600	RPM
Digital Speed tolerance	All	+/- 1		%
Digital Speed Input low voltage	+5Vuser = 5.0V		0.8	V
Digital Speed Input high voltage	+5Vuser = 5.0V	4.0		
Digital Speed Input current			5	uA
Digital PWM input vs motor speed **See Note 2.**	PWM input <=15% PWM input = 20% PWM input = 80%	0 1700 6400	 1900 6600	RPM
Digital Speed Input frequency	All	50	500	Hz
VM - Ripple Current RMS	Input 20A, 100VDC		6	A
VM - Average Input Current			27	A
VM - charging current limiting **See Note 3.**	On initial application of power		5	A
VM - Fuse			30	A
Module Over temperature	All conditions	90 194	110 230	°C °F

Note 1: The 0 - 5VDC analog signal will provide the speed command. Once the input has gone above the start threshold (1.0V) the input will have to go below 0.5V to turn off (0.5V hysteresis).
Note 2: The 20 – 80% PWM signal will provide the speed command. Once the input has gone above the start threshold (20% duty cycle) the input will have to go below 15% duty cycle to turn off (5% hysteresis).
Note 3: To stay within the current ratings of the in-rush current limiting circuit, the power supply voltage transients must be less than 1 V/mS.

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. This interface is also used to pass master/slave parameters between controllers.

A special cable must be used to monitor faults when used in master/slave configuration.

Temperature - module temperature in °C
Power Supply – Volts
Current – average current delivered to the 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 STARTUP FAILED	If stalled or start-up-failed are detected by either controller both will stop the motors and activate their fault output then the controllers will delay for 30 seconds. After a delay period, the controllers will deactivate their fault output and attempt to start. The controllers will continually attempt to restart.
MOTOR OVERHEAT	If either compressor shell temperature switch opens both controllers will fault and activate their fault output then delay for 30 seconds. After a delay, the controllers will recheck the compressor shell temperature switch state and fault status. If no faults are present the controllers will deactivate the fault outputs and attempt to restart the motor.
UNDER / OVERVOLTAGE	If the motor voltage is outside of the operating limits, both controllers will fault and activate their fault output then delay for 30 seconds. After the delay period, the controllers will recheck the voltage conditions. If the voltage is within the operating limits the controllers will deactivate the fault outputs and attempt to restart.
OVERCURRENT	Hard current limit – if either controller detects an over-current condition both controllers will fault and activate their fault output then delay for 30 seconds. After a delay period, the controllers will deactivate the fault outputs and attempt to restart.
MODULE OVERHEAT	If either module temperature rises above 100 °C (212 °F) both controllers will shut down and activate their fault output then delay for 30 seconds. After a delay period, the controllers will recheck the module temperature. If the temperature has fallen below 100 °C (212 °F) the controllers will deactivate the fault outputs and attempt to restart the motor.
LOW SPEED	Each compressor must maintain a minimum speed of 1500 RPM for proper lubrication. If either controller detects a low-speed condition both controllers will fault and activate their fault output then delay for 30 seconds. After a delay period, the controllers will attempt to restart. If the controller is successful in restarting the motor and maintaining a speed above 1500 RPM for 30 seconds, the fault indicator will be deactivated.
CALIBRATION TIMEOUT EEPROM_WRITE FAILURE	A self-calibration is performed the first time power is applied to the drive. The calibration constants are determined and written to EEPROM. This one-time operation occurs during a functional test at the manufacturer. These error messages should not occur in the field.
COMMUNICATION ERROR	If the serial communication between the master and slave controllers has been lost or interrupted. Both controllers will fault and activate their fault output then delay for 30 seconds. After delay period if communication is reestablished the controllers will turn off the fault indicator and attempt to restart
SLAVE ERROR	This indicates that the error bit is set between controllers. If this bit is detected both controllers will fault then delay for 30 seconds. After the delay period if the bit condition is cleared the controllers will turn off their fault indicators and attempt to restart.
DIFFERENTIAL SPEED FAULT	If the actual speed between the master and slave exceeds 250 RPM for 30 seconds both controllers will fault and activate their fault outputs then delay for 30 seconds. After a delay period, the controllers will deactivate their fault output and attempt to restart.
MASTER ASSIGNMENT FAULT	If both controllers are assigned MASTER or the SLAVE controller detects external speed command then this error will occur and both controllers will fault then delay for 30 seconds. After the delay period if the bit condition is cleared the controllers will turn off their fault indicators and attempt to restart.

Appendix A

8-pin User Interface Connector Signal Description:

(Molex part number: 70543-0042 eight pin locking connector, mating connector: Molex part number 50-57-9408.)
Pin-1: NC
Pin-2: -V user (isolated user supply return)
Pin-3: -V user (isolated user supply return)
Pin-4: Digital speed command (input)
Pin-5: Tachometer (output)
Pin-6: +5V user (isolated user supply)
Pin-7: Analog speed command (input)
Pin-8: Fault (output)

2-pins for Motor Power Connection:

Pin-1: +Vm
Pin-2: -Vm

2-pin Compressor Temperature Connector Description:

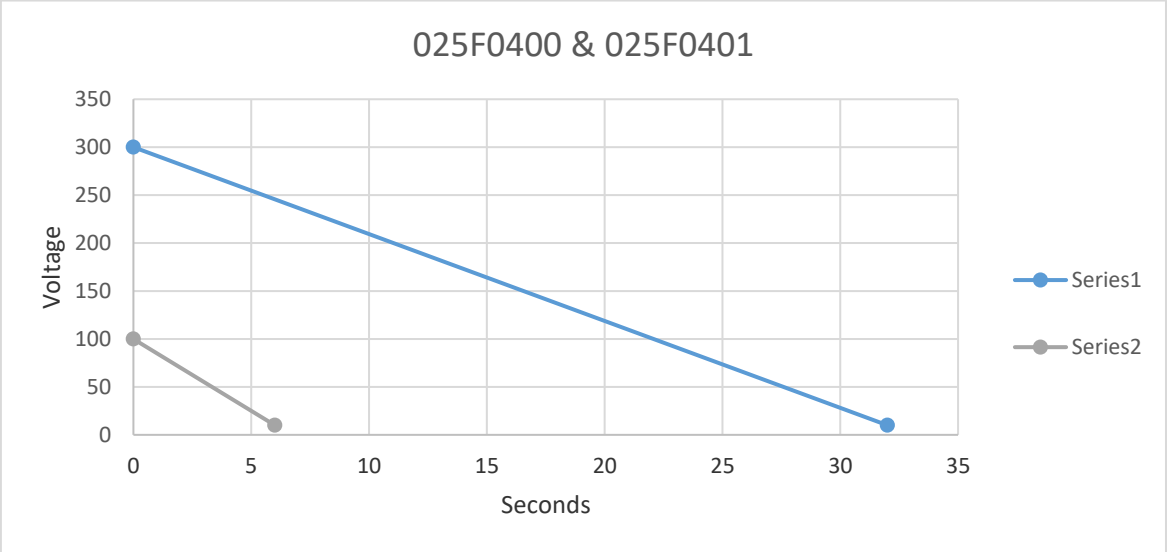
(Molex part number 70543-0001 two-pin locking connector, recommended mating connector Molex part number 50-57-9402)
Pin-1: +Stemp
Pin-2: -Stemp

3-pin for Motor Connector:

Pin-1: Motor Phase A (output)
Pin-2: Motor Phase B (output)
Pin-3: Motor Phase C (output)

9-pin Male RS-232 Serial connector:

(Amp part number 3-338309-2)
Pin-2: Rx
Pin-3: Tx
Pin-5: Ground



The graph above is a typical discharge rate of the bus capacitors after power has been removed with the initial charge of 300V.

Appendix B Configurations

The following controller model numbers have been tested with the listed compressors:

Model	Supported Compressor
025F0400	SIERRA04-0434XX SIERRA04-0982XX SIERRA17-0434XX SIERRA17-0982XX
025F0401	SIERRA06-0982XX