MASTERFLUX

BRUSHLESS DC MOTOR CONTROLLER
PRODUCT SPECIFICATION
ASSEMBLIES 025F0140-01, -02, -03, -04, -05, -06, -07, -08, -09

October 2, 2015

600A0589 Rev. L

REVISION HISTORY

ECN #	Date	Rev	Description	By
EC15205	12/12/06	A	Initial Release	RT
EC23512	01/28/09	B	Added -05 Voltage Code References	JM
EC40691	08/04/11	C	Added PWM input frequency	DS
EC48535	10/15/12	D	Correct PWM 80%	DS
EC48878	10/31/12	E	Added 025F0140-06 model 90V-260V	DS
EC53131	07/02/13	F	Added speed resistor chart	DS
EC53710	08/05/13	G	Added 025F0140-07 model 70V-145V	ZS
	09/25/13	H	Added 025F0140-08 same as -03 4000 watt	DS
EC58106	04/04/14	J	Added cap discharge chart	DS
EC62396	11/14/14	K	Added -09 model, new voltage trip limits	RT
EC68249	10/2/15	L	Change -08 To 1800 rpm start up for 30s	RT

General Product Description

The 025F0140 Motor Controller has been designed to provide efficient control and fault monitoring of a DC powered brushless hermetic compressor. The controller will provide a constant speed as specified by the speed command inputs unless one of the following limitations are exceeded.

- Power limitation – This occurs when the average power the drive is producing exceeds 2500 Watts (4000 watts for 025F0140-08). If the load requires more than the defined wattage then the speed will be reduced accordingly. The power is calculated by:

$$Power = (Motor\ supply) \times (Average\ Motor\ Current)$$

- Voltage limitation – This occurs when the motor supply voltage is not high enough to achieve the commanded speed and/or power.

There are nine variants of the 025F0140 controller (025F0140-01, 025F0140-02, 025F0140-03, 025F0140-04, 025F0140-05, 025F0140-06, 025F0140-07, 025F0140-08 and 025F0140-09). Each has an application specific voltage limit and power limit.

An isolated user interface including a RS-232 serial port is supplied. Run, stop, and speed are controlled by a 0V to 5V analog input, or 0% to 80% PWM input. Analog and PWM duty cycle input in relation to motor speeds are listed below:

- Analog input is less than 1V or the PWM is less than 15% – the motor is stopped.
- Analog input is 1V or the PWM input is 20% – the motor will run at 1800 RPM.
- Analog input is at 5V or the PWM input is 80% – the motor will run at 6500 RPM.

Tachometer output is an open collector output signal with a 5K pull-up resistor. The output frequency is 0 to 2.6KHz. When the controller is commanded to run from a stopped condition it will run the motor at 3000 RPM for 30 seconds (see -08 note below) after which point it will run the motor at the commanded input speed.

Note: The -08 configuration is programmed to run at ***1800 RPM*** for this first 30s after startup is commanded.

The following fault conditions are continuously monitored: under voltage, over voltage, over-current, drive over-temperature, pump over-temperature, low speed, and locked rotor. 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 fault handling behavior is described further in the fault reporting section. The controller will indicate the fault-state by a TTL output.

Two one-position screw lug connectors are provided for connecting the input power to the controller. Three one-position screw lug connectors will provide connection 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. Each connector function is labeled on the printed circuit board. The RS-232 serial port is provided through a nine-pin male D-Sub connector. The connector pin outs 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 with threaded holes at each end. An optional machined heat sink with gasket sealing for thru panel mounting will be available. The heat sink 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**
025F0140-01			
V_M Input power (DC)	90	165	V
V_M low voltage shutdown	75	90	V
V_M high voltage shutdown	165	190	V
Maximum power limit	-	2500	W
025F0140-02			
V_M Input power (DC)	115	325	V
V_M low voltage shutdown	95	115	V
V_M high voltage shutdown	325	375	V
Maximum power limit	-	2500	W
025F0140-03			
V_M Input power (DC)	120	420	V
V_M low voltage shutdown	100	120	V
V_M high voltage shutdown	420	450	V
Maximum power limit	-	2500	W
025F0140-04			
V_M Input power (DC)	55	110	V
V_M low voltage shutdown	45	55	V
V_M high voltage shutdown	110	130	V
Maximum power limit	-	2500	W
025F0140-05			
V_M Input power (DC)	75	125	V
V_M low voltage shutdown	65	75	V
V_M high voltage shutdown	125	140	V
Maximum power limit	-	2500	W
025F0140-06			
V_M Input power (DC)	95	255	V
V_M low voltage shutdown	85	95	V
V_M high voltage shutdown	255	265	V
Maximum power limit	-	2500	W
025F0140-07			
V_M Input power (DC)	70	145	V
V_M low voltage shutdown	60	70	V
V_M high voltage shutdown	145	160	V
Maximum power limit	-	2500	W
025F0140-08			
V_M Input power (DC)	120	420	V
V_M low voltage shutdown	100	120	V
V_M high voltage shutdown	420	450	V
Maximum power limit	-	4000	W

025F0140-09			
V_M Input power (DC)	56	124	V
V_M low voltage shutdown	45	55	V
V_M high voltage shutdown	125	135	V
Maximum power limit	-	2500	W
All Models			
V_M input current		27	A
Standby power		3	W
Efficiency (@ 1500W output, 3000 RPM)	95		%
Ambient Temperature	0 32	65 149	°C °F
Relative Humidity Range	IEC68-2-30, Damp heat-cyclic 20% – 90% non-condensing @ 0°C (32°F) to 50°C (122°F)		

Operating Conditions (continued)

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 over heat sink temperature before reaching the maximum rated current if air flow is insufficient.

Absolute Maximum Ratings

Parameters	Min.	Max.	Units
V_M input voltage (steady state)	0	450	V
V_M input voltage (transient, slew rate)		1	V/ms
Analog speed input (referenced to -V_{user})	-0.3	+5V_{user} + 0.3	V
Digital speed input (referenced to -V_{user})	-0.3	+5V_{user} + 0.3	V
Fault output (referenced to -V_{user})	-0.3	+5V_{user} + 0.3	V
Fault output current sourced		10	mA
Fault output current sunk		10	mA
Tachometer output current sunk	1		mA
Tachometer output (referenced to -V_{user})	-0.3	+5V_{user} + 0.3	V
Storage Temperature	-40 -40	85 185	°C °F

Electrical Characteristics

Parameter	Conditions	Min.	Max.	Units
Isolated +5V User Supply	I_{out} ≤ 50 mA	4.95	5.05	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	Ω
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	$+5V_{user}$ = 5.0V		0.8	**V**
Digital Speed Input high voltage	$+5V_{user}$ = 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
V_M – Ripple Current RMS	Input 20A, 100VDC		6	A
V_M – Average Input Current			27	A
V_M – charging current limiting **See Note 3.**	On initial application of power		5	A
V_M – 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 19.2K 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 – Module temperature in °C
- Power Supply – Voltage
- 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

Fault	Description
STALLED	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 after 30 seconds.
STARTUP FAILED	The controller will detect if the motor has failed to start. After a 20 second pause the controller will attempt to restart the motor. If the motor does not start after 10 attempts, the controller will indicate a fault condition by activating the fault indicator output. The controller will continually attempt to start the motor. If the controller is successful in starting the motor, the fault indicator will be deactivated after 30 seconds.
MOTOR OVERHEAT	If the compressor shell temperature switch opens, the controller will shut down the motor and delay for 2 minutes. The controller will indicate the fault condition by activating the fault indicator. 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 and deactivate the fault indicator.
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.

Fault Reporting (continued)

OVER CURRENT	Hard current limit – if the controller detects an over-current condition it will shut down the motor and activate the fault indicator. The power must be cycled to clear this fault.
MODULE OVERHEAT	If the module temperature rises above 100 °C (212 °F) the controller will shut down the motor and delay for 2 minutes. After the delay period the controller will recheck the module temperature. If the temperature has fallen below 100 °C (212 °F) the controller will restart the motor. The controller will indicate a fault condition by activating the fault indicator. The controller will continue to monitor the module temperature. The controller will restart the motor and deactivate the fault indicator when the module temperature falls below 100 °C (212 °F).
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 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 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 functional test at the manufacturer. These error messages should not occur in the field.

Appendix A

8-pin User Interface Connector Signal Description:
Molex Part #: 70543-0042 (Eight pin locking connector)
Molex Part #: 50-57-9408 (Mating connector)

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: $+V_M$
Pin-2: $-V_M$

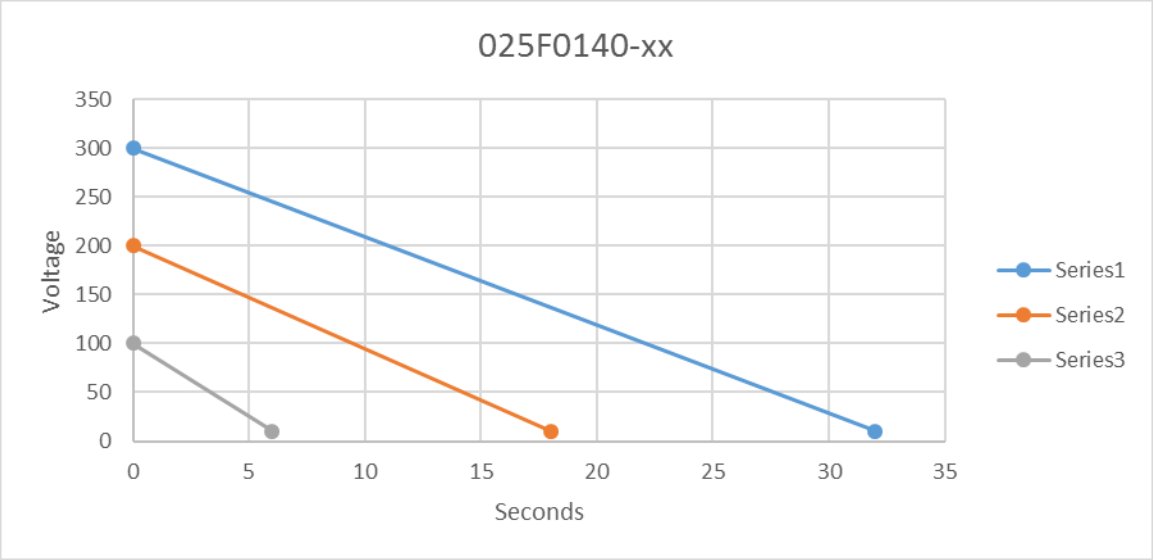
2-pin Compressor Temperature Connector Description:
Molex Part #: 70543-0001 (Two pin locking connector)
Molex Part #: 50-57-9402 (Recommended mating connector)

Pin-1: $+S_{temp}$
Pin-2: $-S_{temp}$

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 #: 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 100V, 200V or 300V depending on the controller model.