



# MASTERFLUX

Brushless DC Motor Controller  
Specification  
Assemblies 025F0248

600A1099 Rev. D  
October 9<sup>th</sup>, 2018

## Revision History

<b>EC</b>	<b>Date</b>	<b>Description</b>	<b>Rev</b>
EC54318	09/03/13	Initial Release	A
EC58093	04/04/14	Added cap discharge chart	B
EC78107	04/25/17	Error correction, updated to show correct controller	C
EC86995	10/09/18	Added more detail of how to follow the 1V/mSec specification in Appendix B.	D

## General Product Description

The 025F0248 Motor Controller has 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 3800 watts. This is calculated by  $\text{Power out} = \text{motor supply} * \text{average motor current}$ . If the load requires more than 3800 watts 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 and or power.

When configuring the system only the master controller receives the speed command. Upon power-up each controller monitors its own 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 2<sup>nd</sup> 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.

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 is 1V 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 M5 press-fit connectors are provided for connecting the input power to the controller. Three M5 press-fit 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 dsub 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. The heatsink is electrically isolated from the circuitry.

**Calculate fixed speed resistor with the formula below.**

$$\text{Resistor} = \frac{30000 * \text{RPM} - 204400000}{3 * \text{RPM} - 1640}$$

RPM	Ohms	RPM	Ohms
1800	40000	4200	7153
1900	36305	4300	6696
2000	33119	4400	6263
2100	30343	4500	5852
2200	27903	4600	5461
2300	25741	4700	5088
2400	23813	4800	4734
2500	22082	4900	4395
2600	20519	5000	4072
2700	19102	5100	3763
2800	17811	5200	3467
2900	16629	5300	3184
3000	15543	5400	2912
3100	14543	5500	2651
3200	13618	5600	2401
3300	12760	5700	2160
3400	11963	5800	1929
3500	11219	5900	1706
3600	10524	6000	1491
3700	9873	6100	1285
3800	9262	6200	1085
3900	8688	6300	892
4000	8147	6400	706
4100	7636	6500	526

**Resistor to speed chart when using fixed resistor between J4 pins 6 and 7.**

<b>Absolute Maximum Ratings</b>			
<b>Parameter</b>	<b>Min.</b>	<b>Max.</b>	<b>Units</b>
V <sub>M</sub> input voltage (steady state)	0	800	V
V <sub>M</sub> input voltage (transient, slew rate)		1	V/mS
Analog Speed input (referenced to -V <sub>user</sub> )	-0.3	+5V <sub>user</sub> + 0.3	V
Digital Speed input (referenced to -V <sub>user</sub> )	-0.3	+5V <sub>user</sub> + 0.3	V
Fault output (referenced to -V <sub>user</sub> )	-0.3	+5V <sub>user</sub> + 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 <sub>user</sub> )	-0.3	+5V <sub>user</sub> + 0.3	V
<b>Storage Temperature</b>	-40°	85°	°C
	-40°	185°	°F

<b>Operating Conditions</b>			
<b>Parameter</b>	<b>Min.</b>	<b>Max.</b>	<b>Units</b>
025F0248			
V <sub>M</sub> Input power (D.C.) operating range	495	725	V
V <sub>M</sub> low voltage shutdown	460	480	V
V <sub>M</sub> low voltage resume	475	495	V
V <sub>M</sub> high voltage shutdown	740	760	V
V <sub>M</sub> high voltage resume	725	745	V
V <sub>M</sub> input current (continuous)		5	A
Standby power		5	W
Efficiency (at 1500 watt output, 3000 rpm)	92		%
Ambient	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)		

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.

Electrical Characteristics				
Parameter	Conditions	Min.	Max.	Units
Isolated +5V User Supply	$I_{out} \leq 50 \text{ mA}$	4.95V	5.05V	V
Fault Output Low Voltage	$I_{OL} = 8\text{mA}$		0.6	V
Fault Output High Voltage	$I_{OH} = -3\text{mA}$	4		V
Tachometer Output Low Voltage	$I_{OL} = 1\text{mA}$		0.3	V
Analog Speed Input impedance			10K	Ohms
Analog input tolerance	All	+/- 0.1		V
Analog input vs motor speed	input $\leq 0.5\text{V}$	0		RPM
	input = 1.0V	1700	1900	
<b>See Note 1.</b>	input = 5.0V	6400	6600	
Digital Speed tolerance	All	+/- 1		%
Digital Speed Input low voltage	+5V <sub>user</sub> = 5.0V		0.8	V
Digital Speed Input high voltage	+5V <sub>user</sub> = 5.0V	4.0		
Digital Speed Input current			5	uA
Digital Speed Input Frequency	ALL	50	500	Hz
Digital PWM input vs motor speed	PWM input $\leq 15\%$	0		RPM
	PWM input = 20%	1700	1900	
<b>See Note 2.</b>	PWM input = 80%	6400	6600	
V <sub>M</sub> - Ripple Current RMS	Input 5A, 600VDC		1	A
V <sub>M</sub> - Average Input Current			5	A
V <sub>M</sub> - charging current limiting see <b>See Note 3.</b>	On initial application of power		1	A
V <sub>M</sub> - Fuse			7.5	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 after the unit is operating and the inrush resistor has been bypassed by the relay. See Appendix B for more information.

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.

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 motor

Motor Speed – actual speed in RPM

Fault – in the event of a fault a brief description of the fault is reported (see below)

Electrical Characteristics				
Parameter	Conditions	Min.	Max.	Units
Isolated +5V User Supply	$I_{out} \leq 50 \text{ mA}$	4.95V	5.05V	V
Fault Output Low Voltage	$I_{OL} = 8\text{mA}$		0.6	V
Fault Output High Voltage	$I_{OH} = -3\text{mA}$	4		V
Tachometer Output Low Voltage	$I_{OL} = 1\text{mA}$		0.3	V
Analog Speed Input impedance			10K	Ohms
Analog input tolerance	All	+/- 0.1		V
Analog input vs motor speed	input $\leq 0.5\text{V}$ input = 1.0V input = 5.0V	0 1700 6400	1900 6600	RPM
<b>See Note 1.</b>				
Digital Speed tolerance	All	+/- 1		%
Digital Speed Input low voltage	+5V <sub>user</sub> = 5.0V		0.8	V
Digital Speed Input high voltage	+5V <sub>user</sub> = 5.0V	4.0		
Digital Speed Input current			5	uA
Digital Speed Input Frequency	ALL	50	500	Hz
Digital PWM input vs motor speed	PWM input $\leq 15\%$ PWM input = 20% PWM input = 80%	0 1700 6400	1900 6600	RPM
<b>See Note 2.</b>				
V <sub>M</sub> - Ripple Current RMS	Input 5A, 600VDC		1	A
V <sub>M</sub> - Average Input Current			5	A
V <sub>M</sub> - charging current limiting see <b>See Note 3.</b>	On initial application of power		1	A
V <sub>M</sub> - Fuse			7.5	A
Module Over temperature	All conditions	90 194	110 230	°C °F

<b>Fault Reporting</b>	
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 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 the 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 / OVER VOLTAGE	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.
OVER CURRENT	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 the 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 the 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 the 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 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 the 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)

### **Motor Power Connectors:**

M5 Press-fit +Vm

M5 Press-fit -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

### **Motor Connectors:**

M5 Press-fit Motor Phase A (output)

M5 Press-fit Motor Phase B (output)

M5 Press-fit Motor Phase C (output)

### **9-pin Male RS-232 Serial connector:**

(Amp part number 3-338309-2)

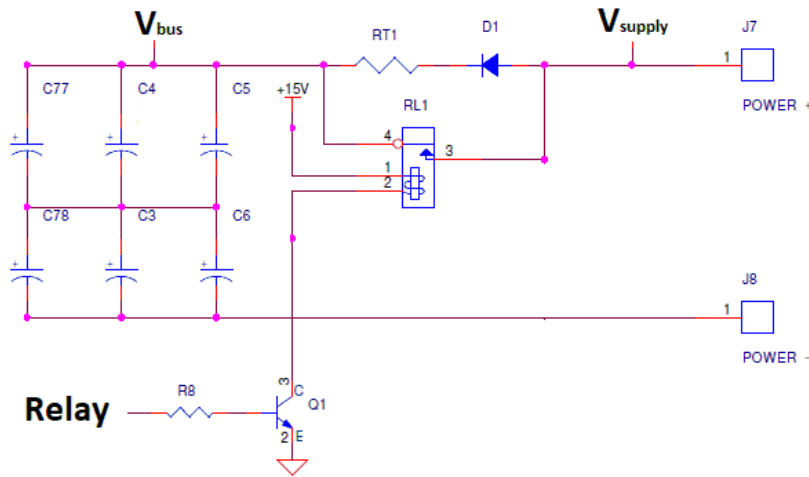
Pin-2: Rx

Pin-3: Tx

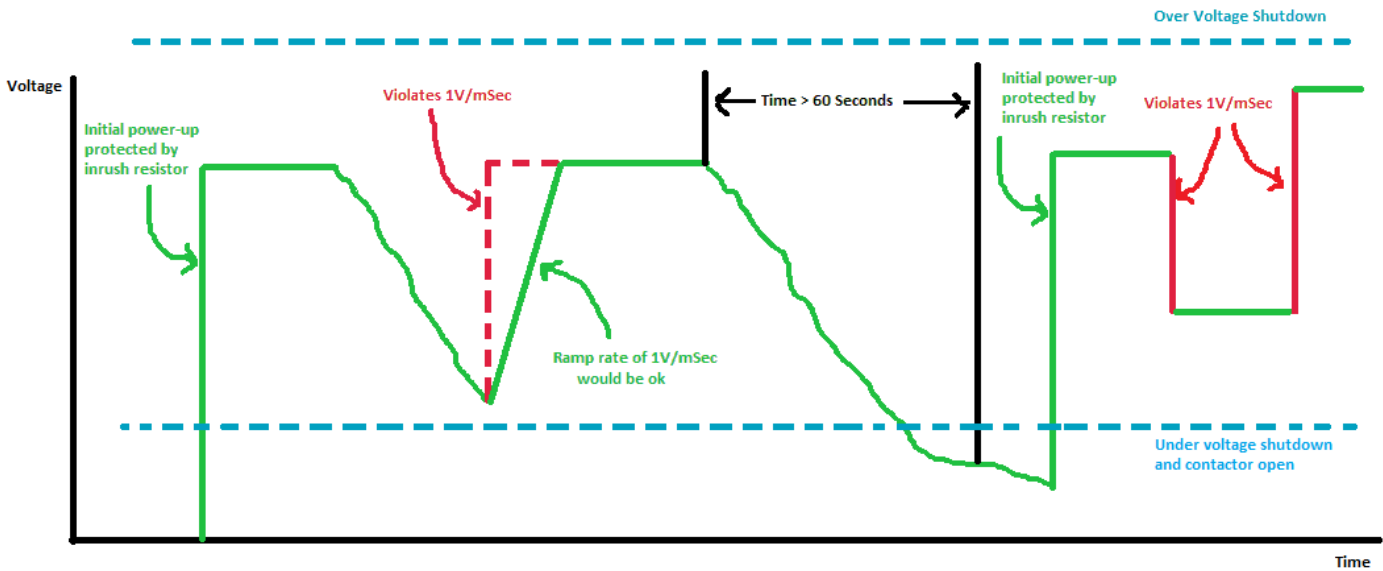
Pin-5: Ground

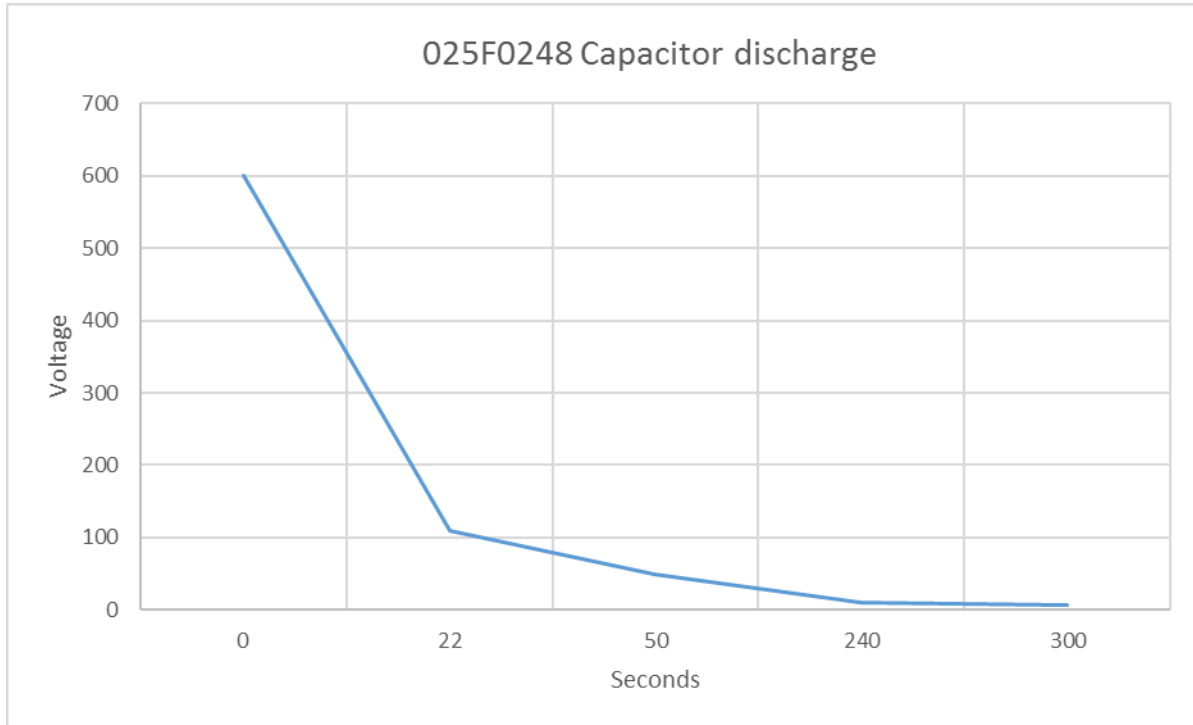
## Appendix B: Input voltage limitations

The controller is protected by an inrush resistor (RT1) for the first application of voltage. However, once voltage is applied, and the software determines the applied voltage to be stable (both  $V_{supply}$  and  $V_{bus}$  are measured), then RL1 is closed. After RL1 is closed, the input voltage at J7 and J8 must not transition at rates  $>1V/mSec$ . In order to open the relay RL1, voltage must be removed from J7 and J8 for more than 1 minute.



The figure below shows allowable transitions, and not allowable transitions.





The graph above is a typical discharge rate of the bus capacitors after power has been removed with the initial charge of 600V.

## Appendix C Configurations

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

025F0195  
025F0248  
SIERRA00072