BM/BMS Series Brushless Motors Hardware Manual

P/N: EDA135 (Revision: 1.04)

Dedicated to the Science of Motion

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DECLARATION OF CONFORMITY

Manufacturer's Name and Address:	Aerotech, Inc. 101 Zeta Drive Pittsburgh, PA 15238-2897

Declares that the product: **BMS Motor Series**

Conforms to the following product specifications with the exception of the "VAC6" versions and the exceptions listed below.

IEC 60034-1:2004	Rotating Electrical Machines
IEC 61010-1:2001	Safety requirements for Electrical Equipment for measurement, control, and laboratory use.
Use:	This product is intended for light industrial manufacturing or laboratory use.

and complies with 73/23/EEC low voltage directive

Notes:
Safe operation of the motor requires over speed and over current protection. This may be done by the connected controller / amplifier combination.

Pittsburgh, PA
September 2006

David F. Kincel ____________________
Quality Assurance Manager

Alex Weibel ____________________
Engineer Verifying Compliance

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CHAPTER 1: INTRODUCTION

1.1. Product Overview

The BM/BMS series motors can replace standard brushless or brush-type motors when superior velocity smoothness and control, and higher acceleration are required. Higher acceleration results in higher machine throughput and performance.

Features:

- 50% more torque than brush DC servo motors
- 15 times the acceleration than brush DC servo motors
- 33% shorter length than brush DC servo motors
- Low to no maintenance
- top speeds up to 10,000 RPM
- a rated speed up to 4,000 RPM
- available with optional brake, front shaft seal, and gear reducers
- available in standard NEMA frame sizes
- choose encoder/HED or resolver feedback

1.1.1. BM Series

The BM series motors are available in ten different models with a rated power from 232 to 7,949 watts and torque ranging from 78 oz-in (0.55 N-m) to 4,480 oz-in (31.6 N-m).

The BM series are smaller and weigh less than brush or stepper motors of the same power capacity. The motors feature standard NEMA frame sizes allowing easy replacement of stepping motors. The motors have skewed stator laminations that provide smooth velocity control. Signal and motor power connections are made through separate MS-style or D sub connectors.

1.1.2. BMS Series

The BMS series motors are available in four different models with a rated power from 137 to 599 watts and torque ranging from 46 oz-in (0.33 N-m) to 405 oz-in (2.9 N-m).

The BMS series motors are manufactured with a slotless design and exhibit extremely smooth velocity regulation.

Figure 1-1: BM Series Brushless Motors

1.2. Warnings

The following warnings apply to the BM and BMS Series Motors. Failure to observe these precautions could result in serious injury to personnel and/or damage to the equipment.

Operators must be trained before allowing them to operate equipment.

If the equipment is used in a manner not specified by the manufacturer, protection of the equipment may be impaired. The user should practice caution when following the given procedures. Deviation from this may result in damage to the equipment.

To minimize the possibility of electrical shock and bodily injury when servicing the equipment, ensure that all electrical power switches are in the off position and disconnect main power.

Motors must be mounted securely before connecting cables and applying power.

Allow all system components to adjust to room temperature before installing. Do not apply power to system components if moisture is present on them.

The motor case temperature may exceed 75°C in some applications.

Do not disconnect motor connectors with power applied to motor.

1.3. Encoder Hall Effect Commutation

Aerotech brushless rotary motors are shipped from the factory with the correct motor phase to Hall effect device relationship established. This is essential for proper motor commutation.

Figure 1-2 shows the proper Hall effect to motor phasing for both clockwise (CW) and counterclockwise (CCW) motor rotation (viewed looking into the mounting flange of the motor).

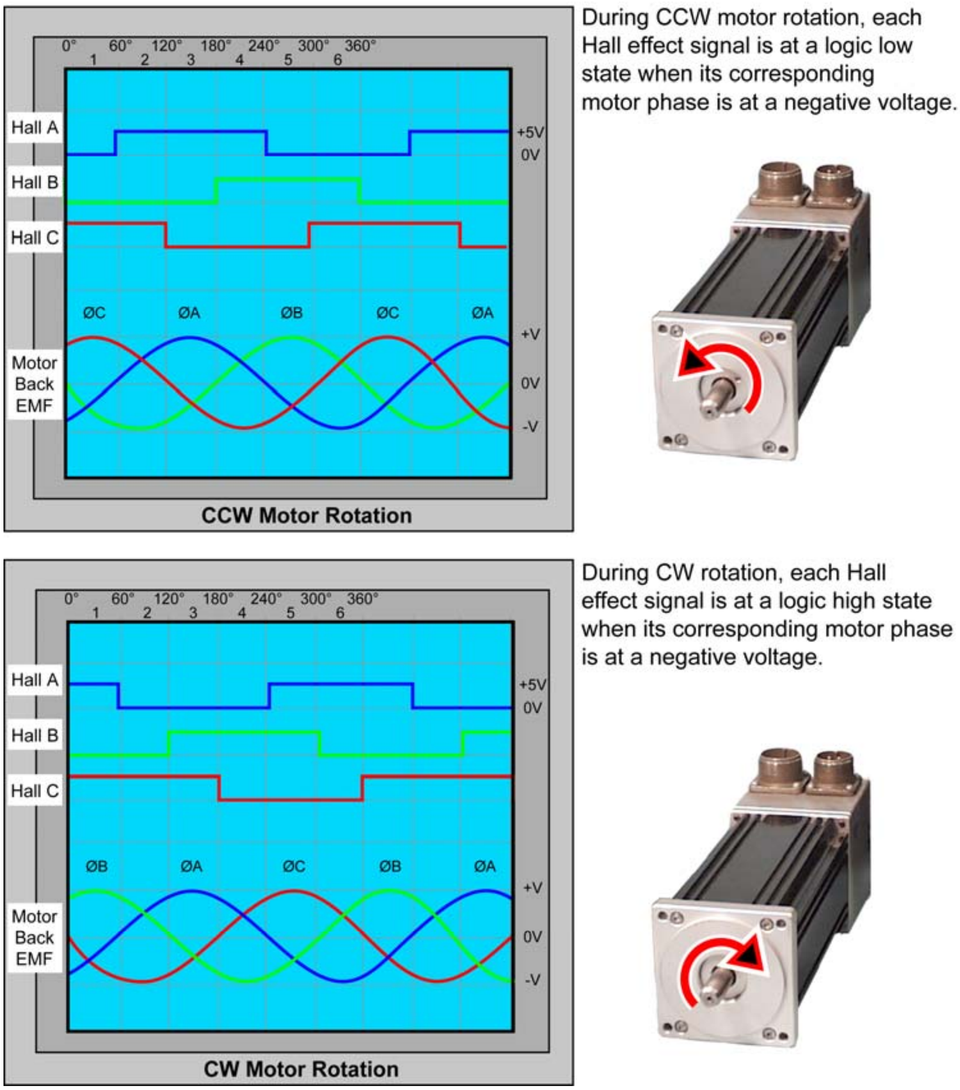


Figure 1-2: Hall Effect and Motor Phasing

The waveforms created by the motor phasing can be observed using a two-channel oscilloscope, a 5V power supply, and six (10,000 ohm, 1/4 watt) resistors (Figure 1-3). Three resistors should be wired in a Wye configuration

Disconnect the motor from the controller and connect it in the test configuration shown in Figure 1-3. Motor leads 1, 2, and 3 should be connected to the ends of the three resistors wired in a Wye configuration. The Hall common lead coming from the motor should be connected to the power supply common. The 5V Hall power lead should be connected to the 5V power line. The three Hall signal wires should be connected through the remaining three resistors to the 5V lead of the power supply.

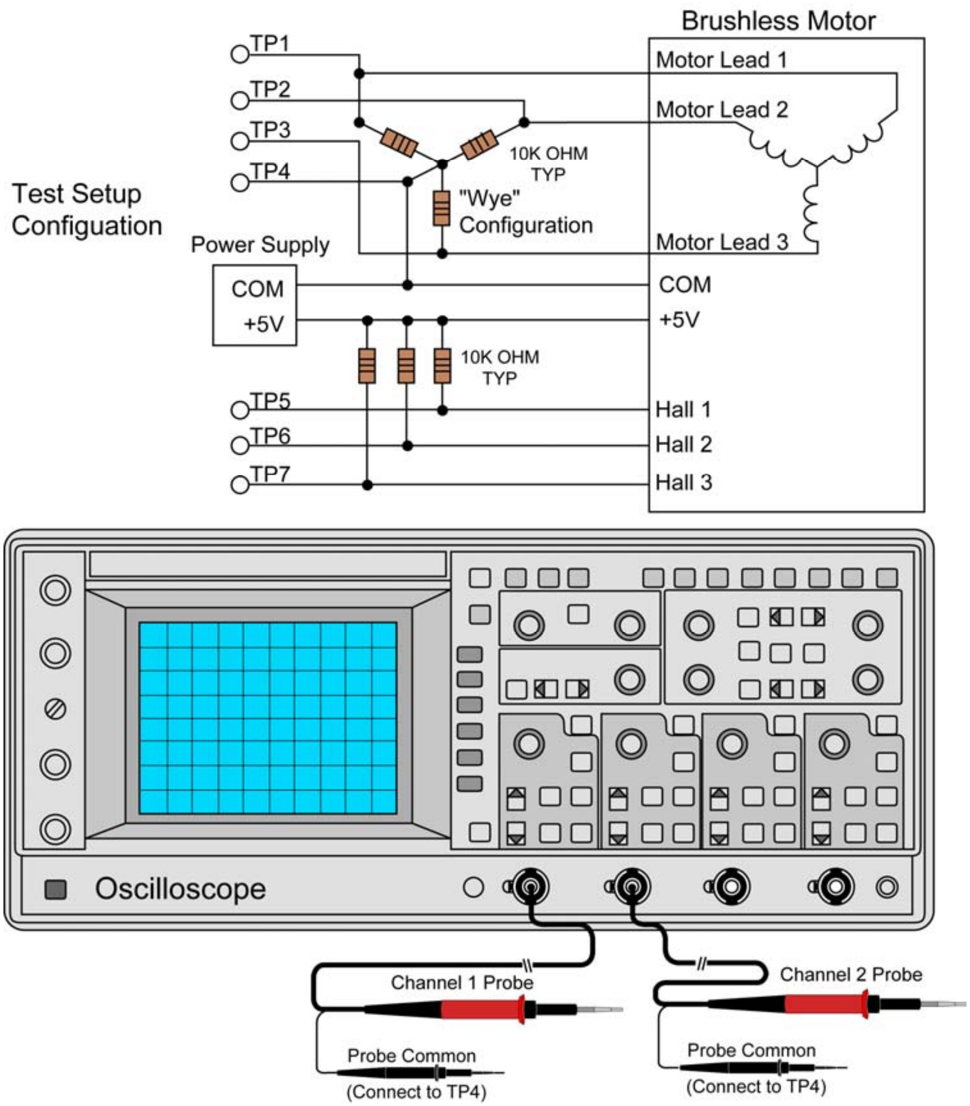


Figure 1-3: Wye Resistor Test Setup Configuration

WARNING

Motor voltage is monitored without power applied to the motor. Before performing these steps, remove all connections to the motor except the wye resistor network. Remove all mechanical connections to the motor shaft.

All measurements should be made with the probe common of each channel of the oscilloscope connected to a neutral reference test point (TP4, shown in Figure 1-4).

To determine the relative phasing/order of the three motor lead signals in relation to each other, connect channel 1 of the oscilloscope to TP1. Connect channel 2 to TP2 and move the motor in the positive direction (CW) by hand. Note the peak of the sine wave signal of channel 1 in comparison to the peak of the sine wave signal of channel 2. Next, disconnect channel 2 from TP2 and reconnect it to TP3 and again move the motor in the positive direction. Note the peak of the sine wave signal of channel 3 in comparison to the peak of the sine wave signal of channel 1.

Aerotech phasing configuration expects ØC to be the lead signal (in time), ØB to follow it, and ØA to follow ØB. This means that whichever signal has its sine wave peak farthest to the left should be designated as the ØC signal.

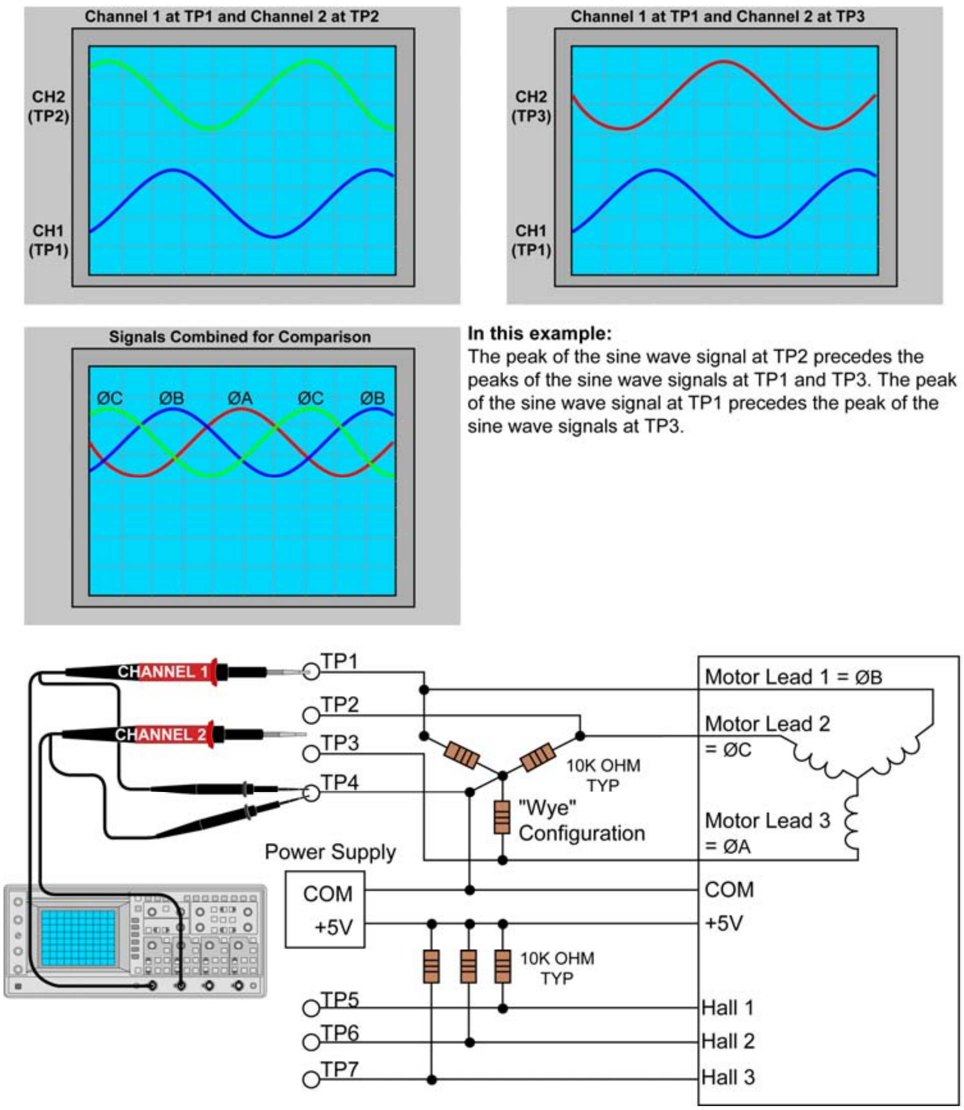


Figure 1-4: Motor Lead Phasing with Oscilloscope

After the motor leads have been tested, the next step is to determine the phase of the Hall signals. The expected (by an Aerotech system) relationship between motor and Hall leads is that the peak of a motor lead signal should correspond to the low voltage phase of the Hall signal (the relationship is shown in Figure 1-5).

With channel 1 still connected to one of the motor leads, connect channel 2 of the oscilloscope to TP5, TP6, and then TP7, while advancing the motor in the positive direction after each connection. Note which of the three Hall signals has the complimentary phase relationship to the motor lead that channel 1 is connected to.

Move channel 1 of the oscilloscope to the second motor lead and repeat the steps from above. Note which Hall signal corresponds to the currently selected motor lead and repeat the process for the 3rd motor lead

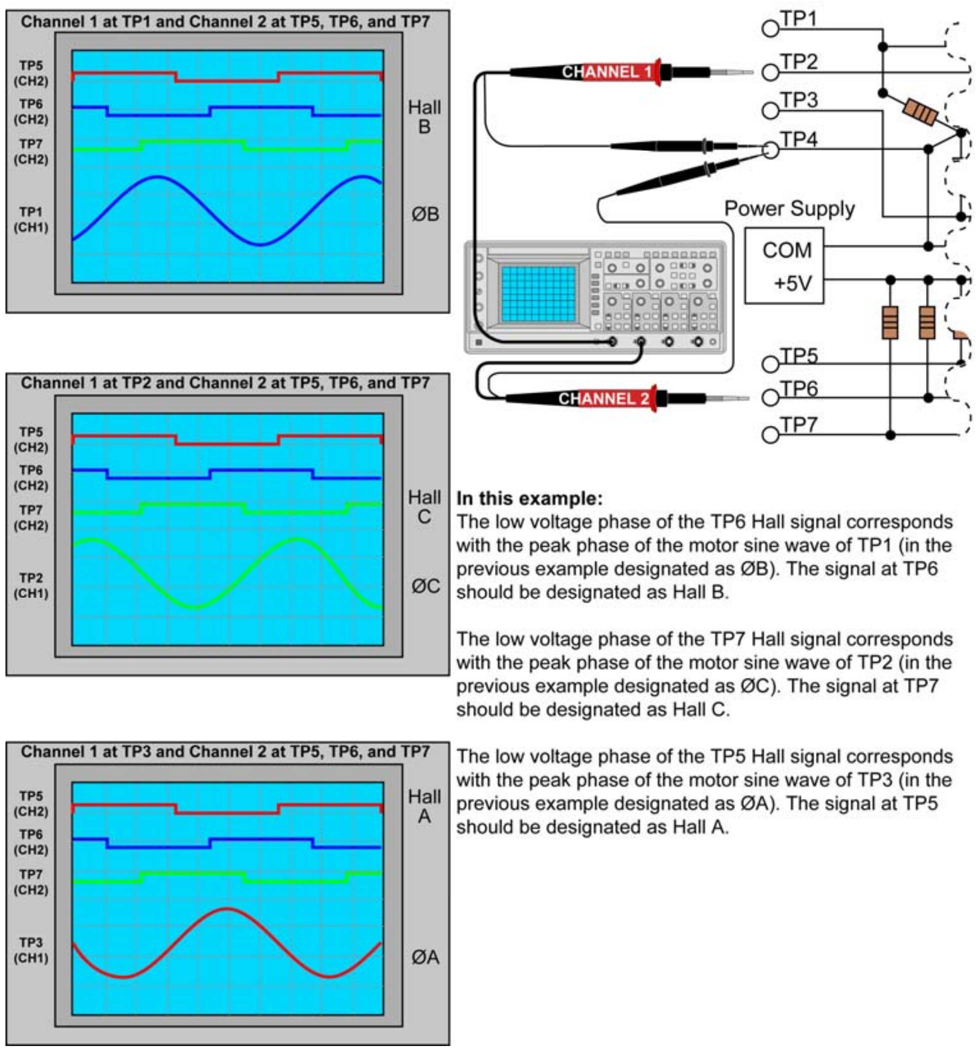


Figure 1-5: Hall Phasing with Oscilloscope

1.4. Resolver Commutation

An optional resolver can be used as the feedback device for a brushless rotary motor. The resolver is aligned at the factory, so that the null position of the resolver corresponds to a motor phase angle of zero degrees (refer to Figure 1-6). The null position of the resolver is considered to be the point at which the sine feedback signal is resting at a zero level and the cosine signal is resting at its positive peak.

The sine and cosine signals shown in Figure 1-6 represent demodulated waveforms. In actual operation, these signals are transmitted on a high frequency carrier (e. g., 5 KHz, 10 KHz).

The zero degree phase angle of the motor is defined as the position that the motor shaft will align to if phase A is energized with a positive voltage with respect to phases B and C. The 8 pole motors (4 pole pairs) have 4 zero degree points per revolution, and the 6 pole motors have 3 zero degree points per revolution.

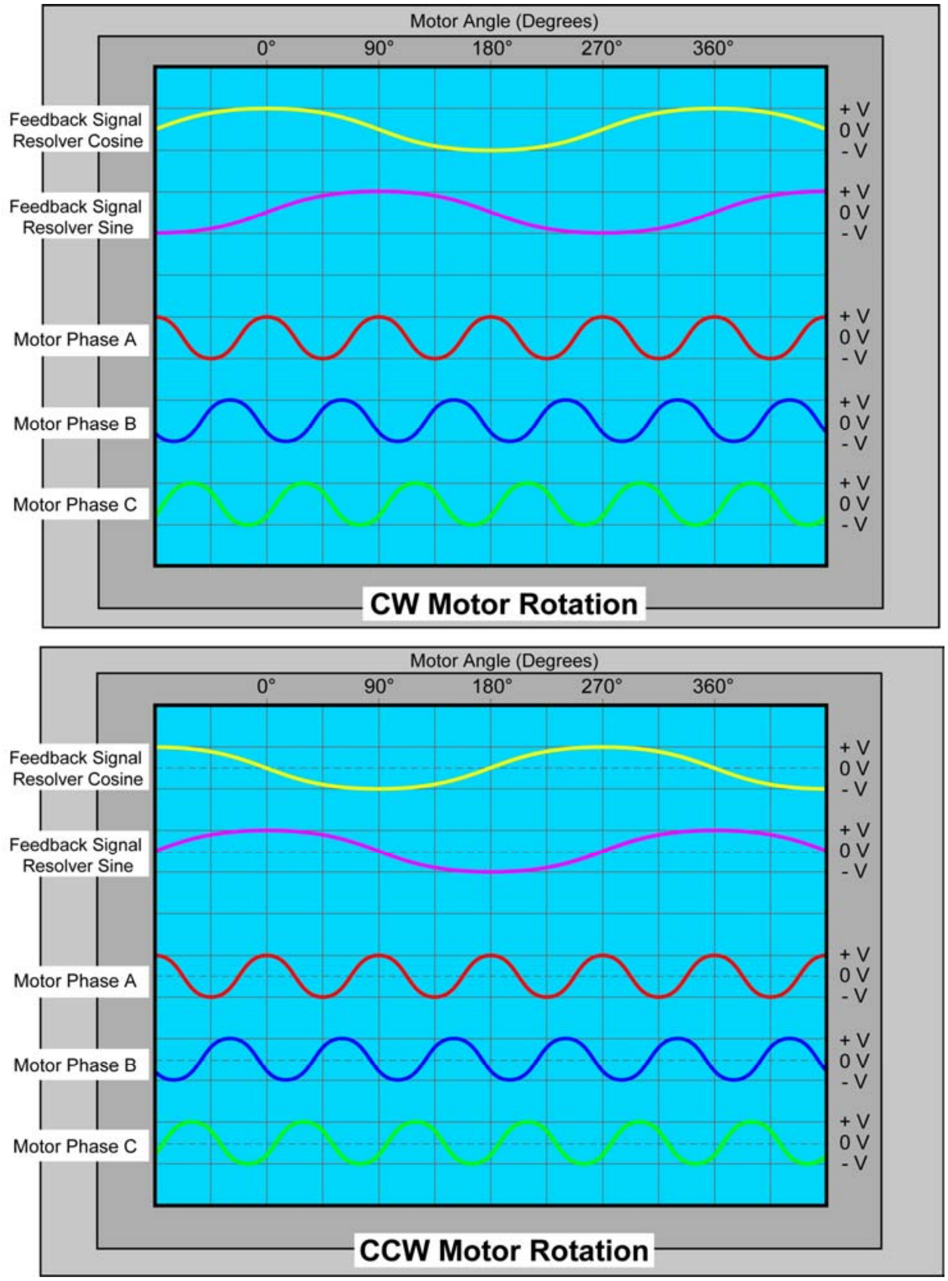


Figure 1-6: Resolver and Motor Phasing

1.5. Part Number and Ordering Information

Order information regarding part numbers and descriptions are shown in the following tables.

Table 1-1: BM Motor Part Number and Ordering Example

Ordering Example					
BM130-MS-E2000H-BK1					
	Where:	**130**	**-MS**	**-E2000H**	**-BK1**
		Motor Torque	Connector Type	Feedback Option	Options

Table 1-2: BM Motor Options

BM Series Rotary Servo Motors	
BM75	NEMA 23 – Tcont = 78.3 oz-in brushless motor
BM130	NEMA 23 – Tcont = 141.5 oz-in brushless motor
BM200	NEMA 23 – Tcont = 170.0 oz-in brushless motor
BM250	NEMA 34 – Tcont = 285 oz-in brushless motor
BM500	NEMA 34 – Tcont = 506 oz-in brushless motor
BM800	NEMA 42 – Tcont = 787 oz-in brushless motor
BM1400	NEMA 42 – Tcont = 1,366 oz-in brushless motor
BM2000	IEC 142 metric shaft & flange, Tcont = 130 lb-in brushless motor
BM3400	IEC 142 metric shaft & flange, Tcont = 210 lb-in brushless motor
BM4500	IEC 142 metric shaft & flange, Tcont = 280 lb-in brushless motor
Connector Style Option	
-MS	Military Style connectors for feedback and motor power (Standard)
Feedback Options (Encoder Resolution with Hall Tracks)	
-E1000H	Encoder, A quad B w/marker, 5 VDC, 1,000 line, line driver output
-E2000H	Encoder, A quad B w/marker, 5 VDC, 2,000 line, line driver output
-E2500H	Encoder, A quad B w/marker, 5 VDC, 2,500 line, line driver output (brake option not available on BM75, BM130)
-E5000H	Encoder, A quad B w/marker, 5 VDC, 5,000 line, line driver output (brake option not available on BM75, BM130)
-RS	Single speed brushless resolver (replaces encoder)
Options (Brushless Rotary Motors)	
-BK1	Brake, Holding torque = 0.8 N-m (112 oz-in), 24 VDC, 0.3 A for BM75, BM130 and BM200
-BK2	Brake, Holding torque = 1.7 N-m (240 oz-in), 24 VDC, 0.4 A for BM250, BM500
-BK3	Brake, Holding torque = 5.6 N-m (800 oz-in), 24 VDC, 0.7 A for BM800, BM1400
-BK5	Brake, Holding torque = 40.7 N-m (360 lb-in), 24 VDC, 0.7 A for BM2000, BM3400, BM4500
-NS	IP65 rated Nitrile front shaft seal (not available for BM75, BM130, BM200)
-VAC6	Vacuum prep for up to torr^{-6}
Accessories	
MCM1-3	Connector, MS Motor power mate (BM2000, BM3400, BM4500)
MCM-3	Connector, MS Motor power mate (BM75, BM130, BM200, BM250, BM500, BM800, BM1400)
MCF-3	Connector, MS Motor Feedback mate for all BM motors

Table 1-3: BMS Motor Part Number and Ordering Example (BMS60 – BMS100)

Ordering Example						
BMS100-A-D25-E1000H-BK1						
	Where:	**100**	**-A**	**-D25**	**-E1000H**	**-BK1**
		Motor Torque	Motor Winding	Connector Type	Feedback Option	Options

Table 1-4: BMS Motor Options (BMS60 – BMS100)

BMS Series Rotary Servo Motors	
BMS60	NEMA 23 – Tcont = 46.2 oz-in brushless motor
BMS100	NEMA 23 – Tcont = 80.0 oz-in brushless motor
Winding Options	
-A	Standard winding
-AH	Standard Winding with Hall board, required with AS style encoders
Connectors	
-DB25	25 conductor plastic D-Shell for feedback and motor power (std)
-MS	Military Style connectors for feedback and motor power
-FLY-x	Flying leads for feedback and motor power with custom length cable
Feedback Options	
-E1000H	1000 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E2000H	2000 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E2500H	2500 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E5000H	5000 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E500AS	500 line incremental amplified sine encoder w/ marker, requires –AH, max speed 4800rpm
-E1000AS	1000 line incremental amplified sine encoder w/ marker, requires –AH, max speed 2400rpm
-E1250AS	1250 line incremental amplified sine encoder w/ marker, requires –AH, max speed 1920rpm
Options (Brushless Rotary Motors)	
-BK1	Brake, Holding torque = 0.8 N-m (112 oz-in), 24 VDC, 0.3 A for BMS60, BMS100
-VAC6	Vacuum prep for up to torr^{-6}
Accessories	
MC-HPD25-M	Connector; HPD25 motor power mate for BMS60, BMS100 motors
MC-DB25-F	Connector; DB25 motor feedback mate for BMS60, BMS100 motors
MCM-3	Connector; MS motor power mate for BMS60, BMS100 motors
MCF-3	Connector; MS motor feedback mate for BMS60, BMS100 motors

Table 1-5: BMS Motor Part Number and Ordering Example (BMS280 – BMS465)

Ordering Example					
BMS280-AH-MS-E2000H-BK2					
Where:	**280**	**-AH**	**-MS**	**-E2000H**	**-BK2**
	Motor Torque	Motor Winding	Connector Type	Feedback Option	Options

Table 1-6: BMS Motor Options (BMS280 – BMS465)

BM Series Rotary Servo Motors	
BMS280	NEMA 23 – Tcont = 227.0 oz-in brushless motor
BMS465	NEMA 23 – Tcont = 404.8 oz-in brushless motor
Winding Options	
-AH	Standard winding with Hall board, required with AS style encoders
Connectors	
-MS	Military-style connectors for feedback and motor power
Feedback Options	
-E1000H	1000 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E2000H	2000 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E2500H	2500 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E5000H	5000 line incremental squarewave encoder w/ marker & hall effect track RS-422 line driver output
-E500AS	500 line incremental amplified sine encoder w/ marker, requires –AH, max speed 4800rpm
-E1000AS	1000 line incremental amplified sine encoder w/ marker, requires –AH, max speed 2400rpm
-E1250AS	1250 line incremental amplified sine encoder w/ marker, requires –AH, max speed 1920rpm
Options (Brushless Rotary Motors)	
-BK2	Brake, Holding torque = 0.8 N-m (112 oz-in), 24 VDC, 0.3 A for BMS60, BMS100
-NS	IP65 rated Nitrile front shaft seal
-VAC6	Vacuum prep for up to torr^{-6}
Accessories	
MCM-3	Connector; MS motor power mate for BMS280, BMS465 motors
MCF-3	Connector; MS motor feedback mate for BMS280, BMS465 motors

NOTE

Aerotech also offers a variety of brushless amplifiers. Refer to Aerotech's Motion Control Product Guide for more information.

1.6. Motor Specifications

The specifications for the BM series brushless motors are listed in Table 1-7, Table 1-8, Table 1-9, and Table 1-10. The specifications for the BMS series brushless motors are listed in Table 1-11 and Table 1-12.

Table 1-7: BM75, BM130, BM200 Motor Specifications (NEMA 23 Frame)

Motor Model	Units	BM75	BM130	BM200
Performance Specifications[1,5]				
Stall Torque, Continuous[2,8]	N-m (oz-in)	0.55 (78.3)	1.00 (141.5)	1.20 (170.0)
Peak Torque[3]	N-m (oz-in)	1.4 (196)	2.5 (354)	3.0 (425)
Rated Speed	rpm	4,000	4,000	4,000
Rated Power Output, Continuous	watts	232	419	503
Electrical Specifications[5]				
BEMF Constant (Line-Line, Max)	$Volts_{pk}$/krpm	6.7	16.0	14.5
Continuous Current, Stall[2,8]	Amp_{pk} Amp_{rms}	10.0 7.1	7.5 5.3	10.0 7.1
Peak Current, Stall[3]	Amp_{pk} Amp_{rms}	25.0 17.7	18.9 13.3	25.0 17.7
Torque Constant[4,9]	N-m/Amp_{pk} oz-in/Amp_{pk}	0.06 7.8	0.13 18.8	0.12 17.0
	N-m/Amp_{rms} oz-in/Amp_{rms}	0.08 11.1	0.19 26.5	0.17 24.0
Motor Constant[2,4]	N-m/√W oz-in/√W	0.052 7.33	0.088 12.43	0.107 15.18
Resistance, 25°C (Line-Line)	ohms	1.0	2.0	1.1
Inductance (Line-Line)	mH	0.80	1.80	1.10
Maximum Bus Voltage	VDC	340	340	340
Thermal Resistance	C/W	1.14	1.00	1.04
Number of Poles	P	8	8	8
Mechanical Specifications				
Motor Weight	kg lb	1.1 2.42	1.5 3.30	2.0 4.40
Rotor Moment of Inertia	$kg\text{-}m^2$ $oz\text{-}in\text{-}s^2$	5.20×10^{-6} 0.0007	9.20×10^{-6} 0.0013	1.30×10^{-5} 0.0018
Max Radial Load	N (lb)	89 (20)	89 (20)	89 (20)
Max Axial Load	N (lb)	89 (20)	89 (20)	89 (20)

Notes:
1. Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature.
2. Values shown @ 130°C rise above a 25°C ambient temperature, with motor mounted to a 250 mm x 250 mm x 6 mm aluminum heat sink.
3. Peak torque assumes correct rms current; consult Aerotech.
4. Torque constant and motor constant specified at stall.
5. All performance and electrical specifications ±10%.
6. Maximum winding temperature is 155°C.
7. Ambient operating temperature range 0°C - 25°C; consult Aerotech for performance in elevated ambient temperatures.
8. De-rate continuous torque and continuous current by 10% when using an encoder.
9. All Aerotech amplifiers are rated A_{pk}; use torque constant in N-m/A_{pk} when sizing.

Table 1-8: BM250 and BM500 Motor Specifications (NEMA 34 Frame)

Motor Model	Units	BM250	BM500
Performance Specifications(1,5)			
Stall Torque, Continuous(2,8)	N-m (oz-in)	2.0 (285)	3.6 (506)
Peak Torque(3)	N-m (oz-in)	5.0 (712)	8.9 (1,264)
Rated Speed	rpm	4,000	4,000
Rated Power Output, Continuous	watts	843	1496
Electrical Specifications(5)			
BEMF Constant (Line-Line, Max)	$Volts_{pk}$/krpm	23.2	24.7
Continuous Current, Stall(2,8)	Amp_{pk} Amp_{rms}	10.5 7.4	17.5 12.4
Peak Current, Stall(3)	Amp_{pk} Amp_{rms}	26.3 18.6	43.8 30.9
Torque Constant(4,9)	N-m/Amp_{pk} oz-in/Amp_{pk}	0.19 27.1	0.20 28.9
	N-m/Amp_{rms} oz-in/Amp_{rms}	0.27 38.4	0.29 40.9
Motor Constant(2,4)	N-m/√W oz-in/√W	0.171 24.24	0.270 38.28
Resistance, 25°C (Line-Line)	ohms	1.1	0.5
Inductance (Line-Line)	mH	1.30	2.80
Maximum Bus Voltage	VDC	340	340
Thermal Resistance	C/W	0.94	0.74
Number of Poles	P	8	8
Mechanical Specifications			
Motor Weight	kg (lb)	3.6 (7.92)	5.0 (11.0)
Rotor Moment of Inertia	kg-m^2 oz-in-s^2	$7.85x10^{-5}$ 0.0111	$1.39x10^{-4}$ 0.0197
Max Radial Load	N (lb)	178 (40)	178 (40)
Max Axial Load	N (lb)	89 (20)	89 (20)

Note:
1. Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature.
2. Values shown @ 130°C rise above a 25°C ambient temperature, with motor mounted to a 250 mm x 250 mm x 6 mm aluminum heat sink.
3. Peak torque assumes correct rms current; consult Aerotech.
4. Torque constant and motor constant specified at stall.
5. All performance and electrical specifications ±10%.
6. Maximum winding temperature is 155°C.
7. Ambient operating temperature range 0°C - 25°C; consult Aerotech for performance in elevated ambient temperatures.
8. De-rate continuous torque and continuous current by 10% when using an encoder.
9. All Aerotech amplifiers are rated A_{pk}; use torque constant in N-m/A_{pk} when sizing.

Table 1-9: BM800, BM1400 Motor Specifications (NEMA 42 Frame)

Motor Model	Units	BM800	BM1400
Electrical Specifications(1,5)			
Stall Torque, Continuous(2,8)	N-m (oz-in)	5.6 (787)	9.4 (1336)
Peak Torque(3)	N-m (oz-in)	13.9 (1966)	23.6 (3339)
Rated Speed	rpm	3,000	3,000
Rated Power Output, Continuous	watts	1744	2962
Electrical Specifications(5)			
BEMF Constant (Line-Line, Max)	$Volts_{pk}$/krpm	63.4	63.4
Continuous Current, Stall(2,8)	Amp_{pk} Amp_{rms}	10.6 7.5	18.0 12.7
Peak Current, Stall(3)	Amp_{pk} Amp_{rms}	26.5 18.7	45.0 31.8
Torque Constant(4,9)	N-m/Amp_{pk} oz-in/Amp_{pk}	0.52 74.2	0.52 74.2
	N-m/Amp_{rms} oz-in/Amp_{rms}	0.74 104.9	0.74 104.9
Motor Constant(2,4)	N-m/√W oz-in/√W	0.448 63.44	0.694 98.28
Resistance, 25°C (Line-Line)	ohms	1.2	0.5
Inductance (Line-Line)	mH	3.80	1.70
Maximum Bus Voltage	VDC	340	340
Thermal Resistance	C/W	0.85	0.70
Number of Poles	P	8	8
Mechanical Specifications			
Motor Weight	kg (lb)	6.6 (14.52)	10.7 (23.54)
Rotor Moment of Inertia	kg-m^2 oz-in-s^2	3.00×10^{-4} 0.0425	5.60×10^{-4} 0.0793
Max Radial Load	N (lb)	222 (50)	222 (50)
Max Axial Load	N (lb)	89 (20)	89 (20)

Note:
1. Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature.
2. Values shown @ 130°C rise above a 25°C ambient temperature, with motor mounted to a 300 mm x 300 mm x 13 mm aluminum heat sink.
3. Peak torque assumes correct rms current; consult Aerotech.
4. Torque constant and motor constant specified at stall.
5. All performance and electrical specifications ±10%.
6. Maximum winding temperature is 155°C.
7. Ambient operating temperature range 0°C - 25°C; consult Aerotech for performance in elevated ambient temperatures.
8. De-rate continuous torque and continuous current by 10% when using an encoder.
9. All Aerotech amplifiers are rated Apk; use torque constant in N-m/Apk when sizing.

Table 1-10: BM2000, BM3400, BM4500 Motor Specifications (IEC 142 Frame)

Motor Model	Units	BM2000	BM3400	BM4500
Performance Specifications(1,5)				
Stall Torque, Continuous(2)	N-m (lb-in)	14.7 (130)	23.7 (210)	31.6 (280)
Peak Torque(3)	N-m (lb-in)	44.1 (390)	71.2 (630)	94.9 (840)
Rated Speed(6)	rpm	2,400	2,400	2,400
Rated Power Output, Continuous	watts	3691	5962	7949
Electrical Specifications(5)				
BEMF Constant (Line-Line, Max)	$Volts_{pk}$/krpm	70.0	70.0	80.0
Continuous Current, Stall (2)	Amp_{pk} Amp_{rms}	16.5 11.7	26.7 18.9	31.1 22.0
Peak Current, Stall(3)	Amp_{pk} Amp_{rms}	49.7 35.1	80.3 56.7	93.5 66.1
Torque Constant(4,8)	N-m/Amp_{pk} lb-in/Amp_{pk}	0.89 7.9	0.89 7.9	1.01 9.0
	N-m/Amp_{rms} lb-in/Amp_{rms}	1.25 11.1	1.25 11.1	1.43 12.7
Motor Constant(2,4)	N-m/√W oz-in/√W	1.13 10.0	1.86 16.5	2.31 20.5
Resistance, 25°C (Line-Line)	ohms	0.54	0.20	0.17
Inductance (Line-Line)	mH	3.50	1.60	1.50
Maximum Bus Voltage	VDC	340	340	340
Thermal Resistance	C/W	0.78	0.80	0.69
Number of Poles	P	6	6	6
Mechanical Specifications				
Motor Weight	kg (lb)	15 (33.0)	23 (49.9)	30 (66.9)
Rotor Moment of Inertia	kg-m^2 lb-in-s^2	1.25×10^{-3} 0.0111	2.23×10^{-3} 0.0197	3.24×10^{-3} 0.0287
Max Radial Load	N (lb)	668 (150)	668 (150)	668 (150)
Max Axial Load	N (lb)	223 (50)	223 (50)	223 (50)

Note:
1. Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature.
2. Values shown @ 130°C rise above a 25°C ambient temperature, with motor mounted to a 305 mm x 305 mm x 12.7 mm aluminum heat sink.
3. Peak torque assumes correct rms current; consult Aerotech.
4. Torque constant and motor constant specified at stall.
5. All performance and electrical specifications ±10%.
6. Maximum winding temperature is 155°C.
7. Ambient operating temperature range 0°C - 25°C; consult Aerotech for performance in elevated ambient temperatures.
8. All Aerotech amplifiers are rated A_{pk}; use torque constant in N-m/A_{pk} when sizing.

Table 1-11: BMS60, BMS100 Motor Specifications (NEMA 23 Frame)

Motor Model	Units	BMS60	BMS100
Winding Designation		**-A**	**-A**
Performance Specifications(1,5)			
Stall Torque, Continuous(2)	N-m (oz-in)	0.33 (46.2)	0.56 (80.0)
Peak Torque(3)	N-m (oz-in)	1.31 (184.9)	2.26 (320.0)
Rated Speed	rpm	4,000	3,000
Rated Power Output, Continuous	watts	136.7	177.5
Electrical Specifications(5)			
BEMF Constant (Line-Line, Max)	$Volts_{pk}/k_{rpm}$	17.2	32.6
Continuous Current, Stall (2)	Amp_{pk} Amp_{rms}	2.3 1.6	2.1 1.5
Peak Current, Stall (3)	Amp_{pk} Amp_{rms}	9.2 6.5	8.4 5.9
Torque Constant(4,8)	$N\text{-}m/Amp_{pk}$ $oz\text{-}in/Amp_{pk}$	0.14 20.1	0.27 38.1
	$N\text{-}m/Amp_{rms}$ $oz\text{-}in/Amp_{rms}$	0.20 28.4	0.38 53.9
Motor Constant(2,4)	N-m/√W oz-in/√W	0.050 7.02	0.076 10.74
Resistance, 25°C (Line-Line)	ohms	8.4	12.9
Inductance (Line-Line)	mH	1.30	2.40
Maximum Bus Voltage	VDC	340	340
Thermal Resistance	C/W	1.73	1.35
Number of Poles	P	8	8
Mechanical Specifications			
Motor Weight	kg (lb)	1.1 (2.4)	1.5 (3.3)
Rotor Moment of Inertia	$kg\text{-}m^2$ $oz\text{-}in\text{-}s^2$	1.96×10^{-5} 0.0028	3.71×10^{-5} 0.0053
Max Radial Load	N (lb)	89 (20)	
Max Axial Load	N (lb)	89 (20)	

Notes:
1. Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature.
2. Values shown @ 75°C rise above a 25°C ambient temperature, with housed motor mounted to a 250 mm x 250 mm x 6 mm aluminum heat sink.
3. Peak torque assumes correct rms current; consult Aerotech.
4. Torque constant and motor constant specified at stall.
5. All performance and electrical specifications ±10%.
6. Maximum winding temperature is 100°C; thermistor trips at 100°C.
7. Ambient operating temperature range 0°C - 25°C. Consult Aerotech for performance in elevated ambient temperatures.
8. All Aerotech amplifiers are rated A_{pk}; use torque constant in $N\text{-}m/A_{pk}$ when sizing.

Table 1-12: BMS280, BMS465 Motor Specifications (NEMA 34 Frame)

Motor Model	Units	BMS280	BMS465
Winding Designation		**-A**	**-A**
Performance Specifications(1,5)			
Stall Torque, Continuous(2)	N-m (oz-in)	1.60 (227.0)	2.86 (404.8)
Peak Torque(3)	N-m (oz-in)	6.41 (908.0)	11.43 (1619.2)
Rated Speed	rpm	3,000	2,000
Rated Power Output, Continuous	watts	503.5	598.5
Electrical Specifications(5)			
BEMF Constant (Line-Line, Max)	$Volts_{pk}/k_{rpm}$	51.1	70.6
Continuous Current, Stall (2)	Amp_{pk} Amp_{rms}	3.8 2.7	4.9 3.5
Peak Current, Stall (3)	Amp_{pk} Amp_{rms}	15.2 10.7	19.6 13.9
Torque Constant(4,8)	$N\text{-}m/Amp_{pk}$ $oz\text{-}in/Amp_{pk}$	0.42 59.7	0.58 82.6
	$N\text{-}m/Amp_{rms}$ $oz\text{-}in/Amp_{rms}$	0.60 84.5	0.82 116.8
Motor Constant(2,4)	N-m/√W oz-in/√W	0.179 25.34	0.280 39.70
Resistance, 25°C (Line-Line)	ohms	5.7	4.4
Inductance (Line-Line)	mH	1.10	0.87
Maximum Bus Voltage	VDC	340	340
Thermal Resistance	C/W	0.93	0.72
Number of Poles	P	14	14
Mechanical Specifications			
Motor Weight	kg (lb)	3.60 (7.9)	5.00 (11.0)
Rotor Moment of Inertia	$kg\text{-}m^2$ $oz\text{-}in\text{-}s^2$	$4.66x10^{-4}$ 0.0660	$9.28x10^{-4}$ 0.1314
Max Radial Load	N (lb)	178 (40)	
Max Axial Load	N (lb)	89 (20)	

Notes:
1. Performance is dependent upon heat sink configuration, system cooling conditions, and ambient temperature.
2. Values shown @ 75°C rise above a 25°C ambient temperature, with housed motor mounted to a 250 mm x 250 mm x 6 mm aluminum heat sink.
3. Peak torque assumes correct rms current; consult Aerotech.
4. Torque constant and motor constant specified at stall.
5. All performance and electrical specifications ±10%.
6. Maximum winding temperature is 100°C; thermistor trips at 100°C.
7. Ambient operating temperature range 0°C - 25°C. Consult Aerotech for performance in elevated ambient temperatures.
8. All Aerotech amplifiers are rated A_{pk}; use torque constant in $N\text{-}m/A_{pk}$ when sizing.

1.6.1. Feedback Device Specifications

Table 1-13 contains the encoder specifications for the BM series brushless motors and Figure 1-7 shows the phasing of sine, cosine, and marker channels for rotary encoders.

Table 1-13: Encoder Specifications

Parameters	Values
Input Power	5VDC @ 400 mA max
Sink/Source Current	20 mA
Output Configuration	Differential line driver (26LS31)
Output Frequency	100KHz (all channels)
Operating Temperature	-10°C to 85°C
Storage Temperature	-30°C to 110°C
Resolution	1000 Cycles/Rev.
Commutation	4 Cycles/Rev.

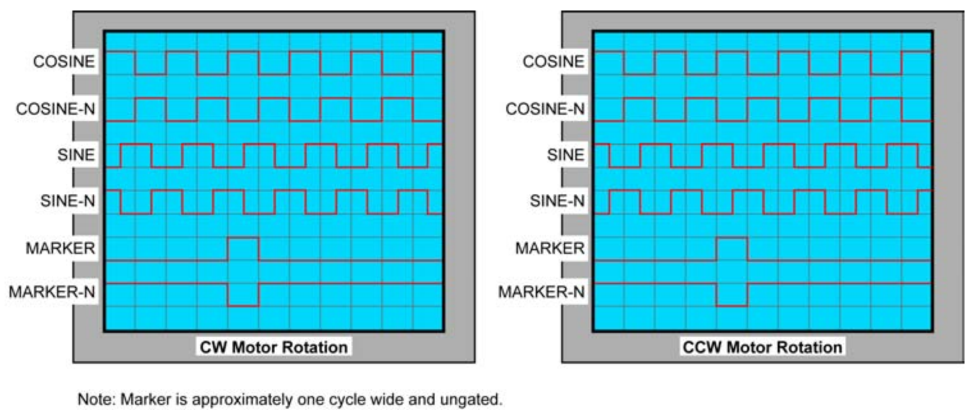


Figure 1-7: Phasing of Sine, Cosine, and Marker Channels for Rotary Encoder

Table 1-14 contains the resolver specifications; for phase relationships of resolver feedback signals, refer to Figure 1-6.

Table 1-14: Resolver Specifications

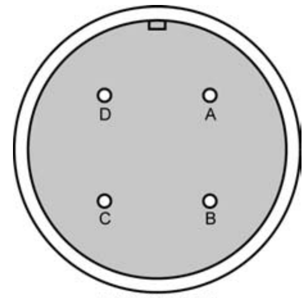
Parameters	Units	5 kHz Operation	10 kHz Operation
Input Voltage	$Volts_{rms}$	7	7
Input Current	mA	70 Max	50 Max
Input Power	Watts	0.31 Max	0.20 Max
Transformer Ratio	Output/Input	0.5	0.5
Phase Shift	Deg °	17 +/- 3	4 Max
Rotor DC Resistance	Ohms	40	40
Stator DC Resistance	Ohms	77	77
Null Voltage	mV	20	20
Electrical Error	Arc Min	+/- 15	+/- 15
Output Voltage	$Volts_{rms}$	3.5	3.5
Operating Temp	°C	-55 to 155	-55 to 155

1.6.2. Connector Pin Assignments

This section contains the pin assignment for the MS motor connector (Table 1-15), MS feedback connector (Table 1-16), and the optional resolver MS connector (Table 1-17) as well the D-sub motor and feedback connector (Table 1-18)

Table 1-15: Motor Power Connector Pin Assignment (MS3101A-10P)

Pin	Function
A	Motor Phase A
B	Motor Phase B
C	Motor Phase C
D	Motor Frame Ground



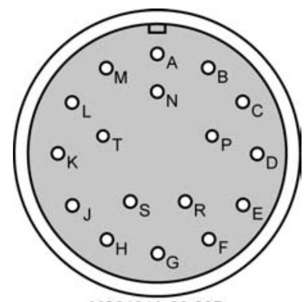
MS3101A-10P

Table 1-16: Feedback Connector Pin Assignment (MS3101A-20-29P)

Pin	Function	Pin	Function
A	Cosine	L	Hall Effect A-N (optional) **
B	Cosine-N	M	Hall Effect B
C	Sine	N	Hall Effect B-N (optional) **
D	Sine-N	P	Hall Effect C
E	Marker	R	Hall Effect C-N (optional) **
F	Marker-N	S	Brake + (optional)*
G	Common	T	Brake – (optional)*
H	+5V		
J	Shield (no connection to frame)		
K	Hall Effect A		

* 24 VDC @ 1 A max

** Not used on BMS280, BMS465 or with an AS encoder

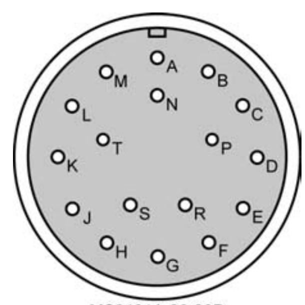


MS3101A-20-29P

Table 1-17: Resolver Connector Pin Assignment (MS3101A-20-29P)

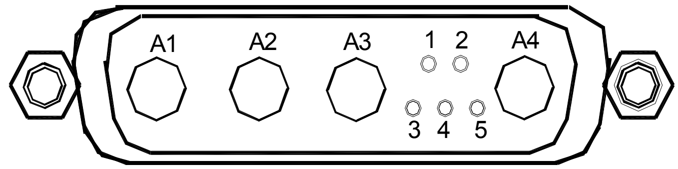
Pin	Function	Pin	Function
A	Sine +	L	
B	Sine –	M	
C	Cosine +	N	Sine Shield (no connection to frame)
D	Cosine –	P	Cosine Shield (no connection to frame)
E	Ref +	R	Reference Shield (no connection to frame)
F	Ref –	S	Brake + (optional)*
G		T	Brake – (optional)*
H			
J			
K			

* 24 VDC @ 1 A max

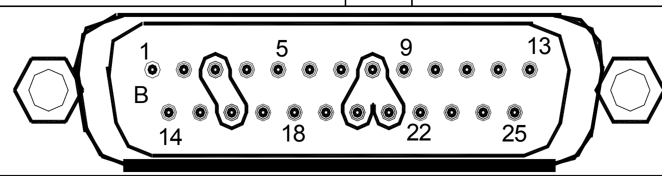


MS3101A-20-29P

Table 1-18: D-sub Connector Pin Assignment



Pin	Description	Pin	Description
A1	Motor Phase A	3	Reserved
A2	Motor Phase B	4	Reserved
A3	Motor Phase C	5	Reserved
1	Shield	A4	Motor Frame Ground
2	Reserved		



Pin	Description	Pin	Description
1	Shield	14	Cosine
2	External Shutdown (optional)**	15	Cosine-N
3	+5V	16	
4		17	Sine
5	Hall Effect B	18	Sine-N
6	Marker-N	19	
7	Marker	20	
8		21	Common
9		22	
10	Hall Effect A	23	
11	Hall Effect C	24	
12		25	Brake + (optional)*
13	Brake - (optional)*		

* Used with –BK option

** BMS60/BMS100 with thermistor connected

1.7. Installation

Motors are installed by bolting the motor flange to a mounting surface using four holes on the motor flange. The load is connected to the motor shaft using keyways and/or flats (See motor drawing for additional information and availability).

1.7.1. Wiring

External wiring to the motor must meet certain requirements. Wiring must be able to carry the rated current without overheating. The insulation of the wire must be rated for the voltage at which the motor will be operating. The Protective Ground must meet rated current requirements. Signal wiring (Encoder, Hall, etc…) must have the proper insulation voltage rating and current carrying capacity.

The motor power conductors must be sized to handle the maximum current of the motor. The motor fuse or other protective device typically determines this current. The insulation must be rated for the maximum voltage applied to the motor (300V wire insulation typical). As a minimum requirement the motor wiring must be shielded to reduce electromagnetic emissions.

The Protective Ground is a safety conductor that is used to ground the motor case. The Protective Ground conductor must have a current capacity that is at least equal to the motor wires. The insulation of the Protective Ground wire is standard Green/Yellow and must be rated for the maximum voltage that will be applied to the motor. The Protective Ground wire is usually bundled along with the motor wires, but system requirements may require that a separate Protective Ground wire is needed.

Signal wires should have a current capacity of at least 1 Amp. The insulation of the wires should have a rating of at least the maximum voltage (300 V typical) that will be applied to the motor. As minimum requirements the signal wires need to be bundled together within a shielded cable and signal and motor wires must not be bundled together. Motor wires must be shielded separately from the signal wires to prevent EMI interference.

1.7.2. Overcurrent Protection

Motors need to be provided with overcurrent protection to prevent motors from overheating. Overcurrent protection can be accomplished using programmable current limits, traps, overcurrent protection circuitry, or fusing. Typically, when the motor is part of an Aerotech integrated system, the motor will be overcurrent protected by at least one of these methods. If the motor is being installed in a system that was not configured by Aerotech the user is responsible for providing over current protection for the motor.

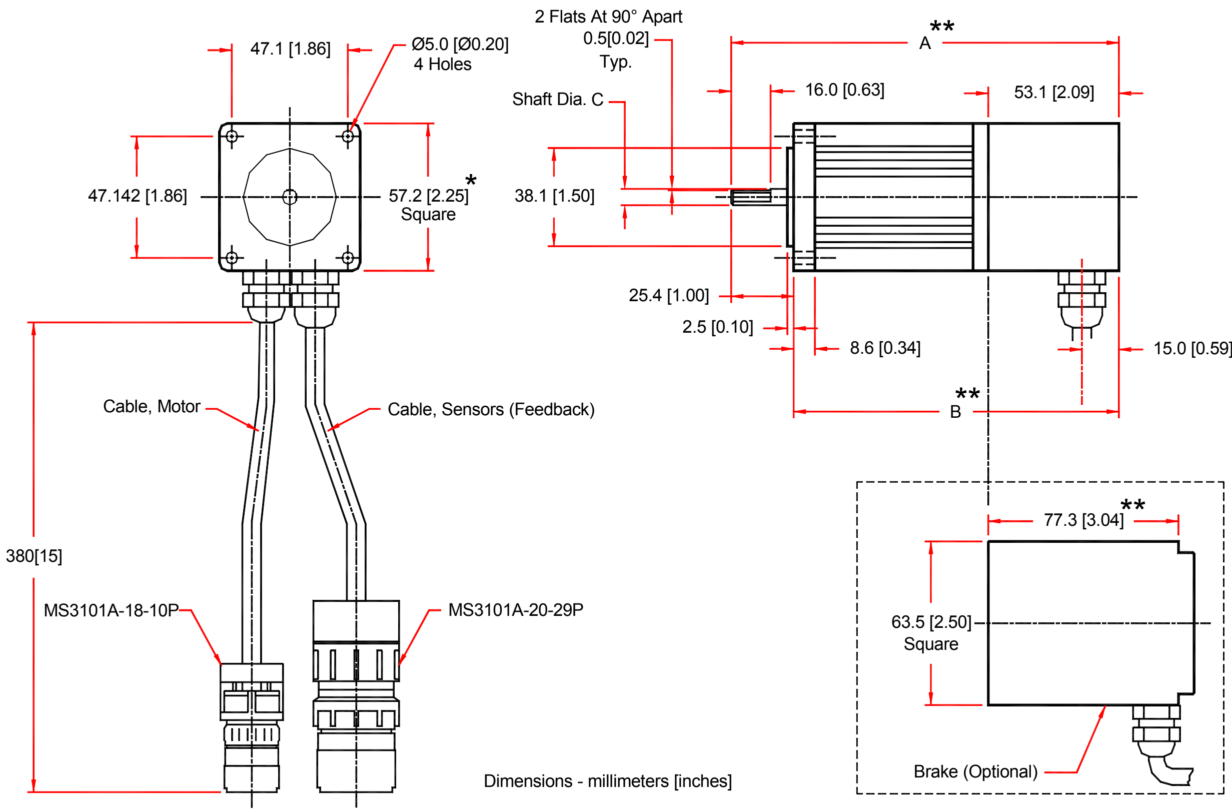
Fuses can be used to protect the motor against severe overloads. Fuse values should be selected according to the RMS current rating of the motor. For most applications slow-blow type fuses should be used. Fuse replacement information for Aerotech systems can be found in the document package for the system.

1.7.3. Cooling

Motors do not require cooling when operating within rated temperature range. External cooling directed at the motors can be beneficial in cases where the motor is operating near its maximum rating. The motor will also run cooler if it is kept clean of grease, dirt, and other accumulated material.

1.8. Brushless Motor Dimensions

The following figures show the outline dimensions of each model in BM series brushless motors.

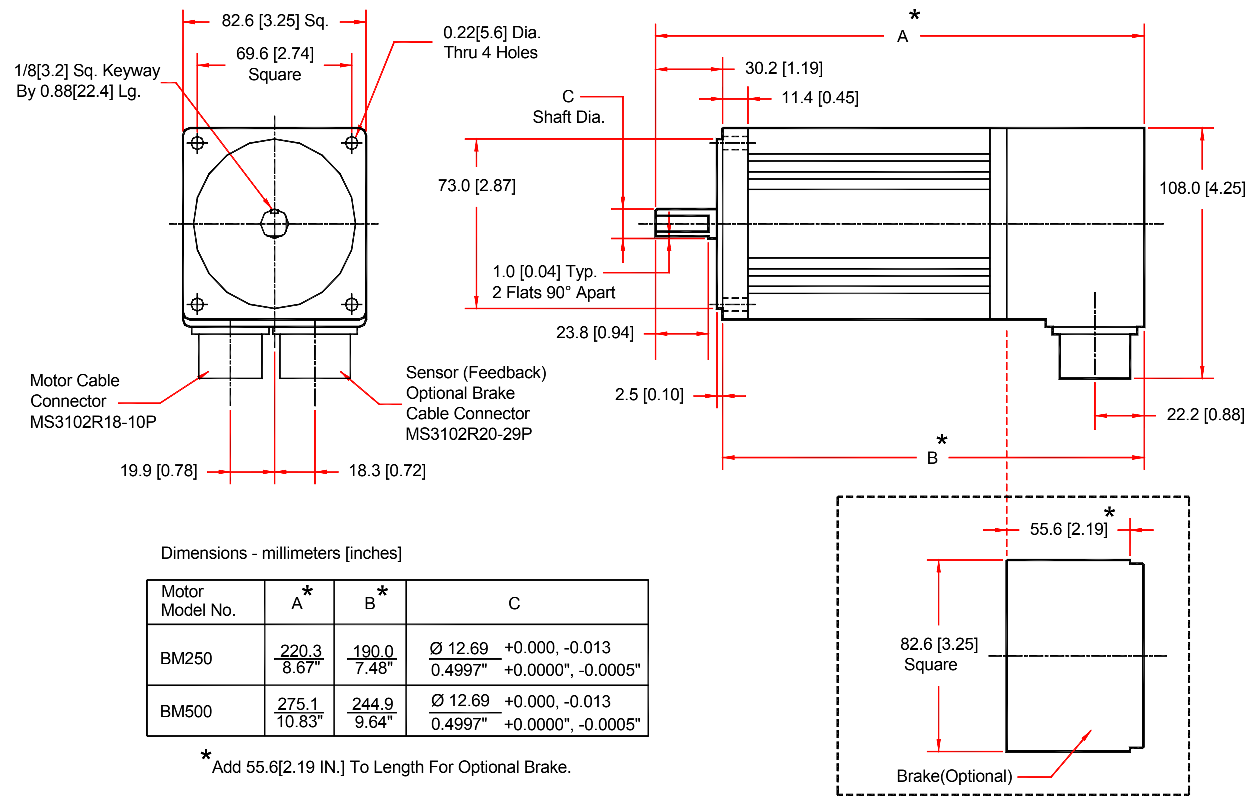


Motor Model No.	A **	B **	C
BM75	157.5 / 6.20"	132.1 / 5.20"	Ø 6,345 +0.000, -0.013 / 0.2498" +0.0000", -0.0005"
BM130	187.9 / 7.40"	162.6 / 6.40"	Ø 9,517 +0.000, -0.013 / 0.3747" +0.0000", -0.0005"
BM200	218.4 / 8.60"	193.0 / 7.60"	Ø 9,517 +0.000, -0.013 / 0.3747" +0.0000", -0.0005"

*Add 3.2[0.13 IN,] Per Side For Optional Brake.

**Add 77.2[3.04 IN.] To Length For Optional Brake.

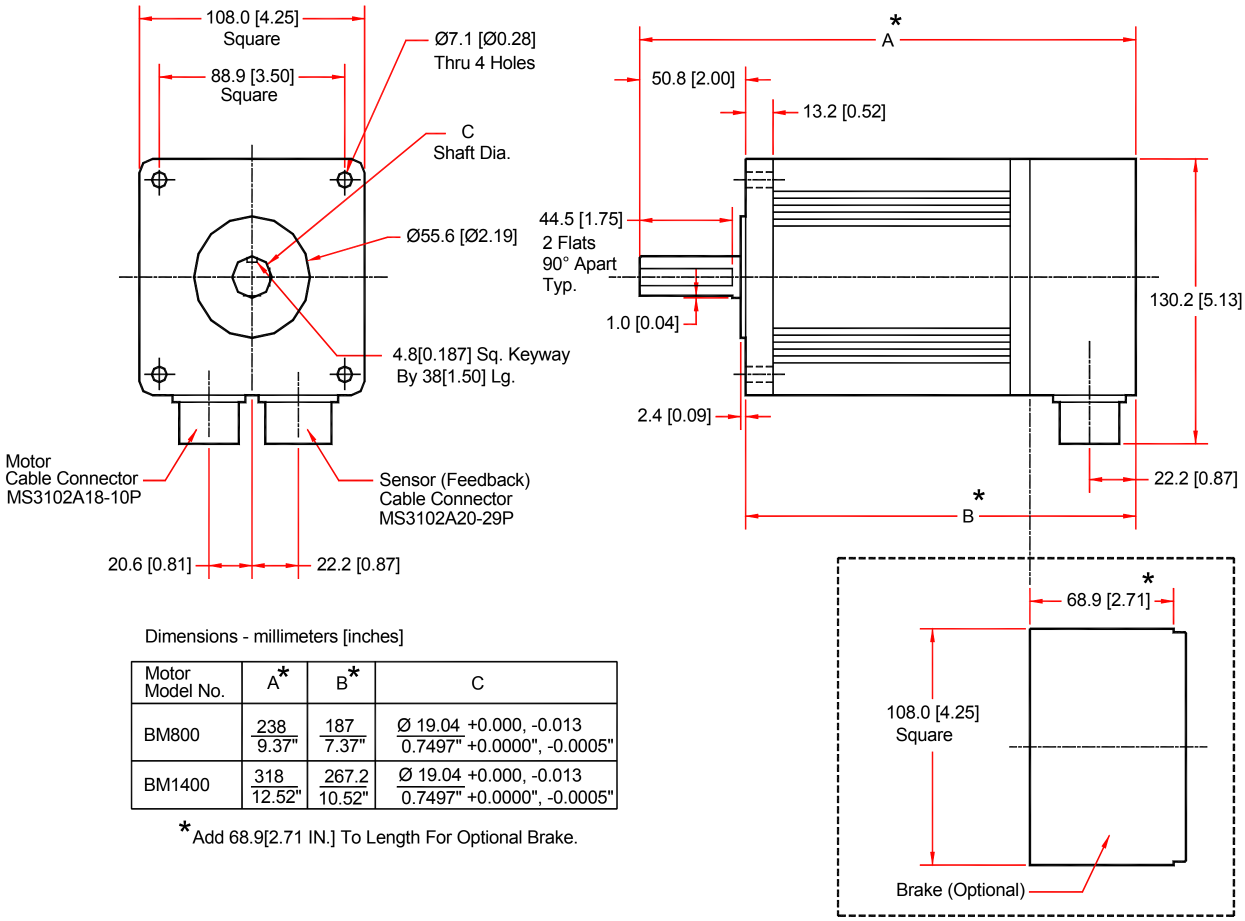
Figure 1-8: BM75, BM130, BM200 Model Dimensions (NEMA 23)



Motor Model No.	A*	B*	C
BM250	220.3 / 8.67"	190.0 / 7.48"	Ø 12.69 +0.000, -0.013 / 0.4997" +0.0000", -0.0005"
BM500	275.1 / 10.83"	244.9 / 9.64"	Ø 12.69 +0.000, -0.013 / 0.4997" +0.0000", -0.0005"

*Add 55.6[2.19 IN.] To Length For Optional Brake.

Figure 1-9: BM250, BM500 Model Dimensions (NEMA 34)

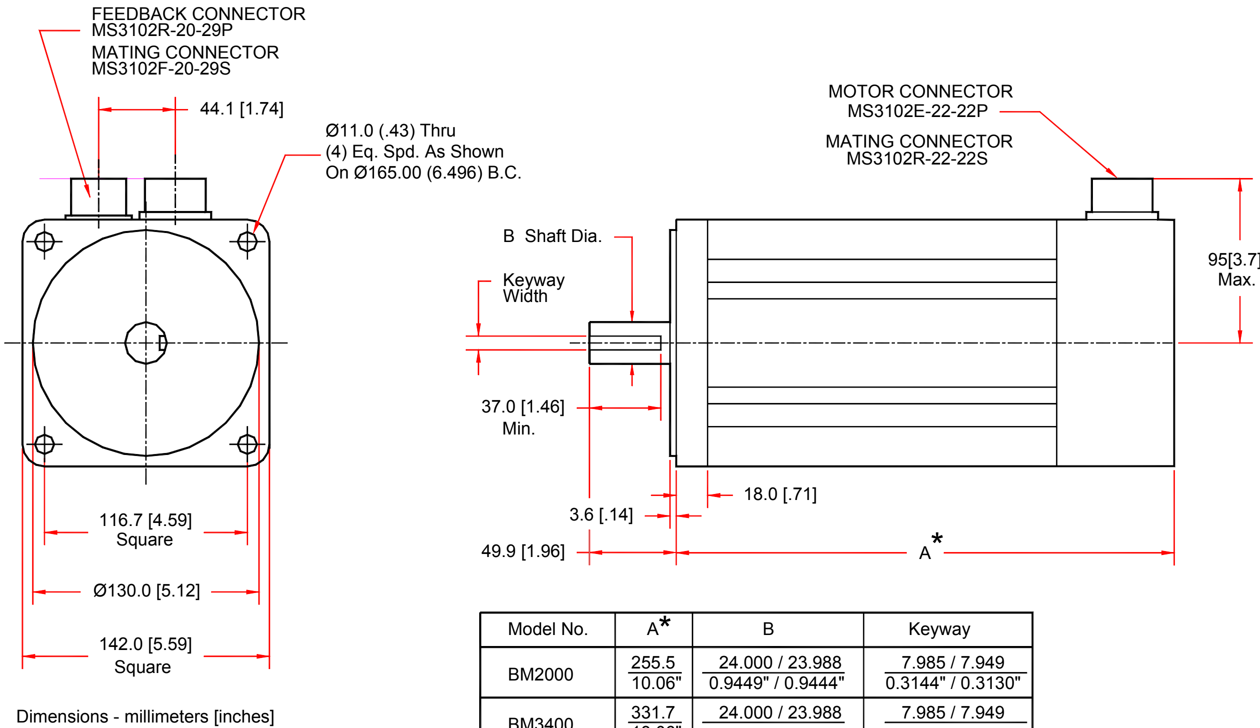


Dimensions - millimeters [inches]

Motor Model No.	A*	B*	C
BM800	238 9.37"	187 7.37"	Ø 19.04 +0.000, -0.013 0.7497" +0.0000", -0.0005"
BM1400	318 12.52"	267.2 10.52"	Ø 19.04 +0.000, -0.013 0.7497" +0.0000", -0.0005"

*Add 68.9[2.71 IN.] To Length For Optional Brake.

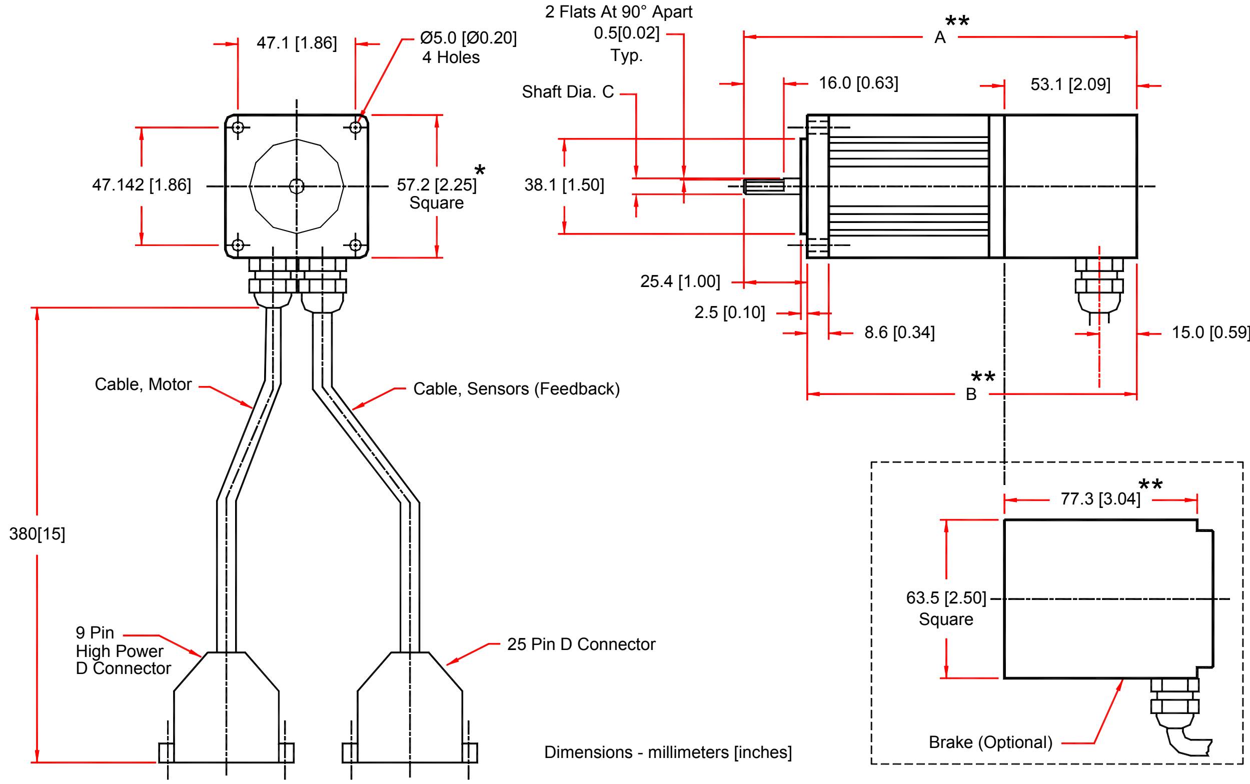
Figure 1-10: BM800, BM1400 Model Dimensions (NEMA 42)



Model No.	A*	B	Keyway
BM2000	255.5 / 10.06"	24.000 / 23.988 / 0.9449" / 0.9444"	7.985 / 7.949 / 0.3144" / 0.3130"
BM3400	331.7 / 13.06"	24.000 / 23.988 / 0.9449" / 0.9444"	7.985 / 7.949 / 0.3144" / 0.3130"
BM4500	408.0 / 16.06"	32.000 / 31.984 / 1.2598" / 1.2592"	9.985 / 9.949 / 0.3931" / 0.3917"

*Add 76[3.0] To Length For Optional Brake.

Figure 1-11: BM2000, BM3400, BM4500 Model Dimensions (IEC 142)

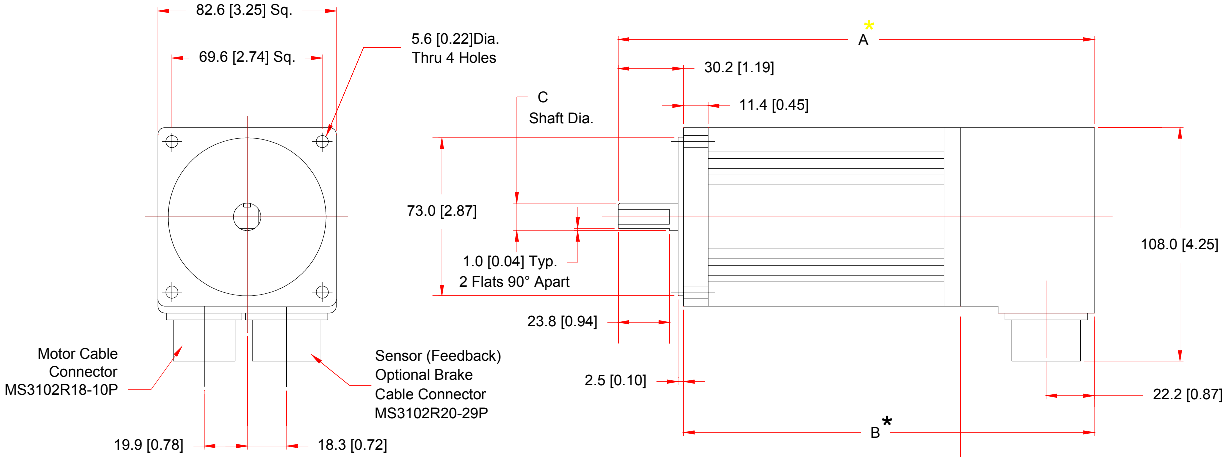


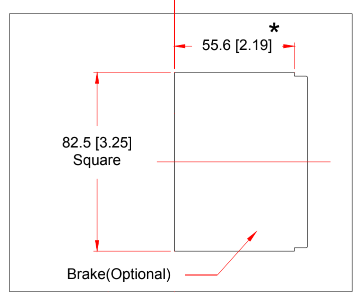
Motor Model No.	A**	B**	C	
BMS60	157.5 / 6.20"	132.1 / 5.20"	Ø 6,345 / 0.2498"	+0.000, -0.013 / +0.0000", -0.0005"
BMS100	187.9 / 7.40"	162.6 / 6.40"	Ø 9,517 / 0.3747"	+0.000, -0.013 / +0.0000", -0.0005"

*Add 3.2[0.13 IN,] Per Side For Optional Brake.

**Add 77.2[3.04 IN.] To Length For Optional Brake.

Figure 1-12: BMS60 and BMS100 Model Dimensions





Dimensions - millimeters [inches]

Motor Model No.	A*	B*	C
BMS280	220.3 / 8.67"	190.0 / 7.48"	Ø 12.69 +0.000, -0.013 / 0.4997" +0.0000", -0.0005"
BMS465	275.1 / 10.83"	244.9 / 9.64"	Ø 12.69 +0.000, -0.013 / 0.4997" +0.0000", -0.0005"

*Add 55.6[2.19 IN.] To Length For Optional Brake.

Figure 1-13: BMS280 and BMS465 Model Dimensions

1.9. Environmental Specifications

Temperature:	Ambient	
	Operating: 0° to 25°C, consult Aerotech for performance deration for ambient temperatures above 25°C	
	Storage: -20°C to 85°C	
Humidity:	Ambient conditions need to be such that condensation on the motor does not occur.	
Altitude	Up to 1000 m.	
Pollution	Pollution degree I (normally only non-conductive pollution).	
Use	Indoor use only.	

1.10. Preventative Maintenance

The motor and external wiring should be inspected monthly. Inspections may be required at more frequent intervals, depending on the environment and use of the system. Table 1-19 lists the recommended checks that should be made during these inspections.

WARNING

Aerotech equipment is not to be used in a manner not specified by Aerotech, Inc.

Table 1-19: Preventative Maintenance

Check	Action to be Taken
Inspect motor for dirt, grease and other accumulated material.	Clean and remove any accumulated material from motor.
Visually Check motor for loose or damaged parts / hardware. Note: Internal inspection is not required.	Correct and repair as required.
Check for fluids or electrically conductive material exposure.	Clean. Fluids or electrically conductive material must not be permitted to enter the motor. Note: Disconnect power to avoid shock hazard.
Visually inspect all cables and connections.	Tighten or re-secure any loose connections. Replace worn or frayed cables. Replace broken connectors.

1.11. Cleaning

Motors should be wiped clean with a clean dry cloth to remove any grease, dirt or other material that has accumulated on the motor. Fluids and sprays are not recommended because of the chance for internal contamination which may result in electrical shorts and/or corrosion. The electrical power must be disconnected from the motor while cleaning. Do not allow cleaning substances to enter into the motor or onto any of the connectors. Cleaning labels should be avoided to prevent removal of label information.

∇ ∇ ∇

APPENDIX A: GLOSSARY OF TERMS

Abbe Error	The positioning error resulting from angular motion and an offset between the measuring device and the point of interest.
Abbe Offset	The value of the offset between the measuring device and the point of interest.
Absolute Move	A move referenced to a known point or datum.
Absolute Programming	A positioning coordinate reference where all positions are specified relative to a reference or “home” position.
AC Brushless Servo	A servomotor with stationary windings in the stator assembly and permanent magnet rotor. AC brushless generally refers to a sinusoidally wound motor (such as BM series) to be commutated via sinusoidal current waveform. (see DC brushless servo)
Acceleration	The change in velocity as a function of time.
Accuracy	An absolute measurement defining the difference between actual and commanded position.
Accuracy Grade	In reference to an encoder grating, accuracy grade is the tolerance of the placement of the graduations on the encoder scale.
ASCII	American Standard Code for Information Interchange. This code assigns a number to each numeral and letter of the alphabet. Information can then be transmitted between machines as a series of binary numbers.
Axial Runout	Positioning error of the rotary stage in the vertical direction when the tabletop is oriented in the horizontal plane. Axial runout is defined as the total indicator reading on a spherical ball positioned 50 mm above the tabletop and centered on the axis of rotation.
Axis of Rotation	A centerline about which rotation occurs.
Back emf, Kemf	The voltage generated when a permanent magnet motor is rotated. This voltage is proportional to motor speed and is present whether or not the motor windings are energized.
Backlash	A component of bidirectional repeatability, it is the non-responsiveness of the system load to reversal of input command.
Ball Screw	A precision device for translating rotary motion into linear motion. A lead screw is a low-cost lower performance device performing the same function. Unit consists of an externally threaded screw and an internally threaded ball nut.
Ball Screw Lead	The linear distance a carriage will travel for one revolution of the ball screw (lead screw).
Bandwidth	A measurement, expressed in frequency (hertz), of the range which an amplifier or motor can respond to an input command from DC to -3dB on a frequency sweep.
Baud Rate	The number of bits transmitted per second on a serial communication channel such as RS-232 or modem.
BCD	Binary Coded Decimal - A number system using four bits to represent 0-F (15).

Bearing	A support mechanism allowing relative motion between two surfaces loaded against each other. This can be a rotary ball bearing, linear slide bearing, or air bearing (zero friction).
Bidirectional Repeatability	See Repeatability.
CAM Profile	A technique used to perform nonlinear motion that is electronically similar to the motion achieved with mechanical cams.
Cantilevered Load	A load not symmetrically mounted on a stage.
Closed Loop	A broad term relating to any system where the output is measured and compared to the input. Output is adjusted to reach the desired condition.
CNC	Computer Numerical Control. A computer-based motion control device programmable in numerical word address format.
Coefficient of Friction	Defined as the ratio of the force required to move a given load to the magnitude of that load.
Cogging	Nonuniform angular/linear velocity. Cogging appears as a jerkiness, especially at low speeds, and is due to magnetic poles attracting to steel laminations.
Commutation	The action of steering currents to the proper motor phases to produce optimum motor torque/force. In brush-type motors, commutation is done electromechanically via the brushes and commutator. A brushless motor is electronically commutated using a position feedback device such as an encoder or Hall effect devices. Stepping motors are electronically commutated without feedback in an open-loop fashion.
Commutation, 6-Step	Also referred to as trapezoidal commutation. The process of switching motor phase current based on three Hall effect signals spaced 120 electrical degrees beginning 30 degrees into the electrical cycle. This method is the easiest for commutation of brushless motors.
Commutation, Modified 6-Step	Also referred to as modified sine commutation. The process of switching motor phase current based on three Hall effect signals spaced 120 electrical degrees beginning at 0 electrical degrees. This method is slightly more difficult to implement than standard 6-step, but more closely approximates the motor's back emf. The result is smoother control and less ripple. Aerotech's BA series self-commutate using this method.
Commutation, Sinusoidal	The process of switching motor phase current based on motor position information, usually from an encoder. In this method, the three phase currents are switched in very small increments that closely resemble the motor's back emf. Sinusoidal commutation requires digital signal processing to convert position information into three-phase current values and, consequently, is most expensive to implement. The result, however, is the best possible control. All Aerotech controllers, as well as the BAS series amplifiers, commutate using this method.
Coordinated Motion	Multi-axis motion where the position of each axis is dependent on the other axis, such that the path and velocity of a move can be accurately controlled. Drawing a circle requires coordinated motion.
Critical Speed	A term used in the specification of a lead screw or ball screw indicating the maximum rotation speed before resonance occurs. This speed limit is a function of the screw diameter, distance between support bearings, and bearing rigidity.

Current Command	Motor driver or amplifier configuration where the input signal is commanding motor current directly, which translates to motor torque/force at the motor output. Brushless motors can be commutated directly from a controller that can output current phase A and B commands.
Current, Peak	An allowable current to run a motor above its rated load, usually during starting conditions. Peak current listed on a data sheet is usually the highest current safely allowed to the motor.
Current, rms	Root Mean Square. Average of effective currents over an amount of time. This current is calculated based on the load and duty cycle of the application.
Cycle	When motion is repeated (move and dwell) such as repetitive back-and-forth motion.
DC Brushless Servo	A servomotor with stationary windings in the stator assembly and permanent magnet rotor. (See AC Brushless Servo)
Deceleration	The change in velocity as a function of time.
Duty Cycle	For a repetitive cycle, the ratio of “on” time to total cycle time used to determine a motor’s rms current and torque/force.
Dwell Time	Time in a cycle at which no motion occurs. Used in the calculation of rms power.
Efficiency	Ratio of input power vs. output power.
Electronic Gearing	Technique used to electrically simulate mechanical gearing. Causes one closed loop axis to be slaved to another open or closed loop axis with a variable ratio.
Encoder Marker	Once-per-revolution signal provided by some incremental encoders to accurately specify a reference point within that revolution. Also known as Zero Reference Signal or Index Pulse.
Encoder Resolution	Measure of the smallest positional change which can be detected by the encoder. A 1000-line encoder with a quadrature output will produce 4000 counts per revolution.
Encoder, Incremental	Position encoding device in which the output is a series of pulses relative to the amount of movement.
Feedback	Signal that provides process or loop information such as speed, torque, and position back to the controller to produce a “closed loop” system.
Flatness (of travel)	Measure of the vertical deviation of a stage as it travels in a horizontal plane.
Force, Continuous	The value of force that a particular motor can produce in a continuous stall or running (as calculated by the rms values) condition.
Force, Peak	The maximum value of force that a particular motor can produce. When sizing for a specific application, the peak force is usually that required during acceleration and deceleration of the move profile. The peak force is used in conjunction with the continuous force and duty cycle to calculate the rms force required by the application.
Friction	The resistance to motion between two surfaces in contact with each other.
G.P.I.B.	A standard protocol, analogous to RS-232, for transmitting digital information. The G.P.I.B. interface (IEEE-488) transmits data in parallel instead of serial format. (See IEEE-488)

Gain	Comparison or ratio of the output signal and the input signal. In general, the higher the system gain, the higher the response.
Grating Period	Actual distance between graduations on an encoder.
Hall Effect Sensors	Feedback device (HED) used in a brushless servo system to provide information for the amplifier to electronically commutate the motor.
HED	Hall Effect Device. (See Hall Effect Sensors)
HMI	Human Machine Interface. Used as a means of getting operator data into the system. Also, refered to as an MMI.
Home	Reference position for all absolute positioning movements. Usually defined by a home limit switch and/or encoder marker.
Home Switch	A sensor used to determine an accurate starting position for the home cycle.
Hysteresis	A component of bidirectional repeatability. Hysteresis is the deviation between actual and commanded position and is created by the elastic forces in the drive systems.
I/O	Input / Output. The reception and transmission of information between control devices using discrete connection points.
IEEE-488	A set of codes and formats to be used by devices connected via a parallel bus system. This standard also defines communication protocols that are necessary for message exchanges, and further defines common commands and characteristics. (See G.P.I.B.)
Incremental Move	A move referenced from its starting point (relative move).
Inertia	The physical property of an object to resist changes in velocity when acted upon by an outside force. Inertia is dependent upon the mass and shape of an object.
Lead Error	The deviation of a lead screw or ball screw from its nominal pitch.
Lead Screw	A device for translating rotary motion into linear motion. Unit consists of an externally threaded screw and an internally threaded carriage (nut). (See Ball Screw)
Life	The minimum rated lifetime of a stage at maximum payload while maintaining positioning specifications.
Limit Switch	A sensor used to determine the end of travel on a linear motion assembly.
Limits	Sensors called limits that alert the control electronics that the physical end of travel is being approached and motion should stop.
Linear Motor	A motor consisting of 2 parts, typically a moving coil and stationary magnet track. When driven with a standard servo amplifier, it creates a thrust force along the longitudinal axis of the magnet track.
Load Carrying Capability	The maximum recommended payload that does not degrade the listed specifications for a mechanical stage.
Master-Slave	Type of coordinated motion control where the master axis position is used to generate one or more slave axis position commands.

MMI	Man Machine Interface used as a means of getting operator data into the system. (See HMI)
Motion Profile	A method of describing a process in terms of velocity, time, and position.
Motor Brush	The conductive element in a DC brush-type motor used to transfer current to the internal windings.
Motor, Brushless	Type of direct current motor that utilizes electronic commutation rather than brushes to transfer current.
Motor, Stepping	Specialized motor that allows discrete positioning without feedback. Used for noncritical, low power applications, since positional information is easily lost if acceleration or velocity limits are exceeded.
NC	Numerical Control. Automated equipment or process used for contouring or positioning (See CNC). Also, Normally Closed, referring to the state of a switch.
NEMA	National Electrical Manufacturer's Association. Sets standards for motors and other industrial electrical equipment.
Non-Volatile Memory	Memory in a system that maintains information when power is removed.
Open Collector	A signal output that is performed with a transistor. Open collector output acts like a switch closure with one end of the switch at circuit common potential and the other end of the switch accessible.
Open Loop	Control circuit that has an input signal only, and thus cannot make any corrections based on external influences.
Operator Interface	Device that allows the operator to communicate with a machine. A keyboard or thumbwheel is used to enter instructions into a machine. (See HMI or MMI)
Optical Encoder	A linear or angular position feedback device using light fringes to develop position information.
Opto-isolated	System or circuit that transmits signal with no direct electrical connections, using photoelectric coupling between elements.
Orthogonality	The condition of a surface or axis perpendicular (offset 90°) to a second surface or axis. Orthogonality specification refers to the error from 90° from which two surfaces of axes are aligned.
Overshoot	In a servo system, referred to the amount of velocity and/or position overrun from the input command. Overshoot is a result of many factors including mechanical structure, tuning gains, servo controller capability, and inertial mismatch.
PID	A group of gain terms in classical control theory (Proportional Integral Derivative) used in compensation of a closed-loop system. The terms are optimally adjusted to have the output response equal the input command. Aerotech controllers utilize the more sophisticated PID FVFA loop which incorporates additional terms for greater system performance.
Pitch (of travel)	Angular motion of a carriage around an axis perpendicular to the motion direction and perpendicular to the yaw axis.
Pitch Error	Positioning error resulting from a pitching motion.
PLC	Programmable Logic Controller. A programmable device that utilizes "ladder logic" to control a number of input and output discrete devices.

PWM	Pulse Width Modulation. Switch-mode technique used in amplifiers and drivers to control motor current. The output voltage is constant and switched at the bus value (160 VDC with a 115 VAC input line).
Quadrature	Refers to the property of position transducers that allows them to detect direction of motion using the phase relationship of two signal channels. A 1000-line encoder will yield 4000 counts via quadrature.
Radial Runout	Positioning error of the rotary stage in the horizontal direction when the tabletop is oriented in the horizontal plane. Radial runout is defined as the total indicator reading on a spherical ball positioned 50 mm above the tabletop and centered on the axis of rotation.
Ramp Time	Time it takes to accelerate from one velocity to another.
Range	The maximum allowable travel of a positioning stage.
RDC	Resolver to Digital Converter. Electronic component that converts the analog signals from a resolver (transmitter type) into a digital word representing angular position.
Repeatability	The maximum deviation from the mean (each side) when repeatedly approaching a position. Unidirectional repeatability refers to the value established by moving toward a position in the same direction. Bidirectional repeatability refers to the value established by moving toward a position in the same or opposite direction.
Resolution	The smallest change in distance that a device can measure.
Retroreflector	An optical element with the property that an input light beam is reflected and returns along the same angle as the input beam. Used with laser interferometers.
Roll (of travel)	Angular motion of a carriage around an axis parallel to the motion direction and perpendicular to the yaw axis.
Roll Error	Positioning error resulting from a roll motion.
Rotor	The rotating part of a magnetic structure. In a motor, the rotor is connected to the motor shaft.
RS-232C	Industry standard for sending signals utilizing a single-ended driver/receiver circuit. As such, the maximum distance is limited based on the baud rate setting but is typically 50-100 feet. This standard defines pin assignments, handshaking, and signal levels for receiving and sending devices.
RS-274	Industry standard programming language. Also referred to as G-code machine programming. A command set specific for the machine tool industry that defines geometric moves.
RS-422	Industry communication standard for sending signals over distances up to 4000 feet. Standard line driver encoder interfaces utilize RS-422 because of the noise immunity.
Runout	The deviation from the desired form of a surface during full rotation (360 degrees) about an axis. Runout is measured as total indicated reading (TIR). For a rotary stage, axis runout refers to the deviation of the axis of rotation from the theoretical axis of rotation.
Servo System	Refers to a closed loop control system where a command is issued for a change in position and the change is then verified

	via a feedback system.
Settling Time	Time required for a motion system to cease motion once the command for motion has ended.
Shaft Radial Load	Maximum radial load that can be applied to the end of the motor shaft at maximum motor speed.
Shaft Runout	Deviation from straight line travel.
Slotless	Describes the type of laminations used in a motor that eliminates cogging torque due to magnetic attraction of the rotor to the stator slots.
Stator	Non-rotating part of a magnetic structure. In a motor, the stator usually contains the mounting surface, bearings, and non-rotating windings.
Stiction	Friction encountered when accelerating an object from a stationary position. Static friction is always greater than moving friction, and limits the smallest possible increment of movement.
Straightness of Travel	Measure of the side-to-side deviation of a stage as it travels in a horizontal plane.
Torque	Rotary equivalent to force. Equal to the product of the force perpendicular to the radius of motion and distance from the center of rotation to the point where the force is applied.
Torque, Continuous	Torque needed to drive a load over a continuous time.
Torque, Peak	Maximum amount of torque a motor can deliver when the highest allowable peak currents are applied.
Torque, rms	Root Mean Square is a mathematical method to determine a steadfast or average torque for a motor.
Torque, Stall	The maximum torque without burning out the motor.
Total Indicated Reading (TIR)	The full indicator reading observed when a dial indicator is in contact with the part surface during one full revolution of the part about its axis of rotation.
Tuning	In a servo system, the process of optimizing loop gains (usually PID terms) to achieve the desired response from a stage or mechanism from an input command.
Unidirectional Repeatability	See Repeatability
Velocity Command	Motor driver or amplifier configuration where the input signal is commanding motor velocity. Motors with analog tachometers are normally driven by this driver configuration.
Wobble	An irregular, non-repeatable rocking or staggering motion of the table top of a rotary stage. Wobble is defined as an angular error between the actual axis of rotation and the theoretical axis of rotation.
Yaw (of travel)	Rotation about the vertical axis, perpendicular to the axis of travel. Angular movement (error) that affects straightness and positioning accuracy.
Yaw Error	Positioning error resulting from a yaw motion.

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APPENDIX B: WARRANTY AND FIELD SERVICE

Aerotech, Inc. warrants its products to be free from defects caused by faulty materials or poor workmanship for a minimum period of one year from date of shipment from Aerotech. Aerotech's liability is limited to replacing, repairing or issuing credit, at its option, for any products that are returned by the original purchaser during the warranty period. Aerotech makes no warranty that its products are fit for the use or purpose to which they may be put by the buyer, where or not such use or purpose has been disclosed to Aerotech in specifications or drawings previously or subsequently provided, or whether or not Aerotech's products are specifically designed and/or manufactured for buyer's use or purpose. Aerotech's liability or any claim for loss or damage arising out of the sale, resale or use of any of its products shall in no event exceed the selling price of the unit.

Laser Products

Aerotech, Inc. warrants its laser products to the original purchaser for a minimum period of one year from date of shipment. This warranty covers defects in workmanship and material and is voided for all laser power supplies, plasma tubes and laser systems subject to electrical or physical abuse, tampering (such as opening the housing or removal of the serial tag) or improper operation as determined by Aerotech. This warranty is also voided for failure to comply with Aerotech's return procedures.

Return Procedure

Claims for shipment damage (evident or concealed) must be filed with the carrier by the buyer. Aerotech must be notified within (30) days of shipment of incorrect materials. No product may be returned, whether in warranty or out of warranty, without first obtaining approval from Aerotech. No credit will be given nor repairs made for products returned without such approval. Any returned product(s) must be accompanied by a return authorization number. The return authorization number may be obtained by calling an Aerotech service center. Products must be returned, prepaid, to an Aerotech service center (no C.O.D. or Collect Freight accepted). The status of any product returned later than (30) days after the issuance of a return authorization number will be subject to review.

Returned Product Warranty Determination

After Aerotech's examination, warranty or out-of-warranty status will be determined. If upon Aerotech's examination a warranted defect exists, then the product(s) will be repaired at no charge and shipped, prepaid, back to the buyer. If the buyer desires an airfreight return, the product(s) will be shipped collect. Warranty repairs do not extend the original warranty period.

Returned Product Non-warranty Determination

After Aerotech's examination, the buyer shall be notified of the repair cost. At such time, the buyer must issue a valid purchase order to cover the cost of the repair and freight, or authorize the product(s) to be shipped back as is, at the buyer's expense. Failure to obtain a purchase order number or approval within (30) days of notification will result in the product(s) being returned as is, at the buyer's expense. Repair work is warranted for (90) days from date of shipment. Replacement components are warranted for one year from date of shipment.

Rush Service

At times, the buyer may desire to expedite a repair. Regardless of warranty or out-of-warranty status, the buyer must issue a valid purchase order to cover the added rush service cost. Rush service is subject to Aerotech's approval.

On-site Warranty Repair

If an Aerotech product cannot be made functional by telephone assistance or by sending and having the customer install replacement parts, and cannot be returned to the Aerotech service center for repair, and if Aerotech determines the problem could be warranty-related, then the following policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs. For warranty field repairs, the customer will not be charged for the cost of labor and material. If service is rendered at times other than normal work periods, then special service rates apply.

If during the on-site repair it is determined the problem is not warranty related, then the terms and conditions stated in the following "On-Site Non-Warranty Repair" section apply.

On-site Non-warranty Repair

If any Aerotech product cannot be made functional by telephone assistance or purchased replacement parts, and cannot be returned to the Aerotech service center for repair, then the following field service policy applies:

Aerotech will provide an on-site field service representative in a reasonable amount of time, provided that the customer issues a valid purchase order to Aerotech covering all transportation and subsistence costs and the prevailing labor cost, including travel time, necessary to complete the repair.

Company Address

Aerotech, Inc.
101 Zeta Drive
Pittsburgh, PA
15238-2897

Phone: (412) 963-7470
Fax: (412) 963-7459

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APPENDIX C: TECHNICAL CHANGES

C.1. Current Changes

Table C-1: Current Changes

Revision	Section(s) Affected	Description
1.04	All	Revised, updated with new graphics.

C.2. Archived Changes

Table C-2: Archived Changes

Version	Section(s) Affected	Description
1.03		Changes not recorded
1.02		Changes not recorded
1.01		Changes not recorded
1.00		Changes not recorded

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READER'S COMMENTS

BM/BMS Series Hardware Manual
P/N EDA135, October 26, 2006
Revision 1.04

Please answer the questions below and add any suggestions for improving this document.

Is the manual:

	Yes	No
Adequate to the subject		
Well organized		
Clearly presented		
Well illustrated		

How do you use this document in your job? Does it meet your needs? What improvements, if any, would you like to see? Please be specific or cite examples.

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