6020HRJ/8030J Switching Servo Controller

P/N: EDA107 (Revision: 1.02.00)

Dedicated to the Science of Motion
Aerotech, Inc.
101 Zeta Drive, Pittsburgh, PA, 15238
Phone: 412-963-7470 Fax: 412-963-7459
www.aerotech.com

Product Registration

Register online at: http://www.aerotech.com/prodreg.cfm

Technical Support

United States:

Phone: (412) 967-6440
Fax: (412) 967-6870
Email: service@aerotech.com

United Kingdom:

Phone: +44 118 9409400
Fax: +44 118 9409401
Email: service@aerotech.co.uk

Germany:

Phone: +49 911 9679370
Fax: +49 911 96793720
Email: service@aerotechgmbh.de

Japan:

Phone: +81(0)47-489-1741 (Sales)
Phone: +81(0)47-489-1742 (Service)
Fax: +81(0)47-489-1743
Email: service@aerotechkk.co.jp

Revision History

1.02.00	January 29, 2008
1.01.00	October 26, 2000
1.00.00	May 1987

TABLE OF CONTENTS

∇ ∇ ∇

LIST OF FIGURES

∇ ∇ ∇

LIST OF TABLES

∇ ∇ ∇

CHAPTER 1: DESCRIPTION

The 6020HRJ/8030J is a single amplifier designed to replace the original 6020HR/8030 amplifier. Many features were added to the design without sacrificing compatibility with current applications.

The suffix “J” was added to the model number to indicate the JAN quality level of components used in the power stage. The JAN (Joint ARMY/NAVY) quality level is imposed on qualified semiconductor manufacturers by the U.S. military. Military handbook 217-C (Reliability Prediction of Electronic Equipment) defines JAN components to have a base failure rate five times less than commercial hermetic devices, and ten times less than plastic devices. Experience has shown that most power amplifier failures occur in the power stage. Since the 6020HRJ is operated under reduced stress and fatigue conditions, higher reliability can be expected.

The following protection circuits were added to the amplifier.

1. Short circuit protection (output terminal to output terminal or output terminal to ground).
2. Bus overvoltage
3. Bus undervoltage
4. Low level control undervoltage

All but #1 are reset automatically when the condition(s) return to normal.

The rectifier and filter are integral to the 6020HRJ/8030J, like the original 6020HR.

∇ ∇ ∇

CHAPTER 2: SPECIFICATIONS

2.1. Maximum Ratings

Table 2-1: 6020HRJ/8030J Amplifier Ratings and Characteristics

Specifications	Units	6020HRJ	8030J
Peak Output Current	Amps	±24	±33
Pulse Output Current	Amps	±20	±30
Continuous Output Current	Amps	±10	±15
Input Voltage		80 VAC C.T. ±10%	110 VAC C.T. ±10%
Operating Temperature	°C	0 to 50	
Storage Temperature	°C	-30 to 85	

2.2. Electrical Characteristics

Table 2-2: 6020HRJ/8030J Electrical Characteristics

Specifications		6020HRJ	8030J
Pre-Amplifier			
Voltage Gain		100db (open loop)	
Offset		Adjustable to 0	
Drift		10mV/0c	
Power Amplifier			
Gain		2 a/v	3 a/v
Current Limit		4 to 20 amps	6 to 30 amps
Bandwidth		DC to 1kHz	
Power Output:	Peak	1000 watts	1500 watts
	Continuous	440 watts	900 watts
Switching Frequency		5 kHz	3 kHz
Form Factor		$\sqrt{1+\left(\frac{1.73}{LIo}\right)}$	$\sqrt{1+\left(\frac{3.86}{LIo}\right)^2}$
Ripple Current (amps)		Ip/p = 6/L (mH)	Ip/p = 13.3/L (mH)
Regenerative Energy		40 joules	20 joules
Torque Limits		(TB1-6 to 7 or 7 to 8) Limits to 3 amps	
Shutdown		(TB1-8 to 6) Limits to 1 amps	
Minimum Inductance		.75 mH	2.2 mH
Power Supply	Input Voltage	80 VAC C.T.	110 VAC C.T.
	Frequency	50/60 Hz	
	External ±15VDC	30 mA (max)	

2.3. Mechanical Characteristics

Table 2-3: 6020HRJ/8030J Mechanical Characteristics

Specifications	6020HRJ/8030J
Weight	9 lbs
Dimensions	6.7” W x 7.5” L x 6.5” H
Mounting Dimensions	5 ½” x 3 $^{5}/_{8}$”
Mounting Screws	¼ - 20, 3.8” max depth into controller base plate

∇ ∇ ∇

CHAPTER 3: INSTALLATION and OPERATION

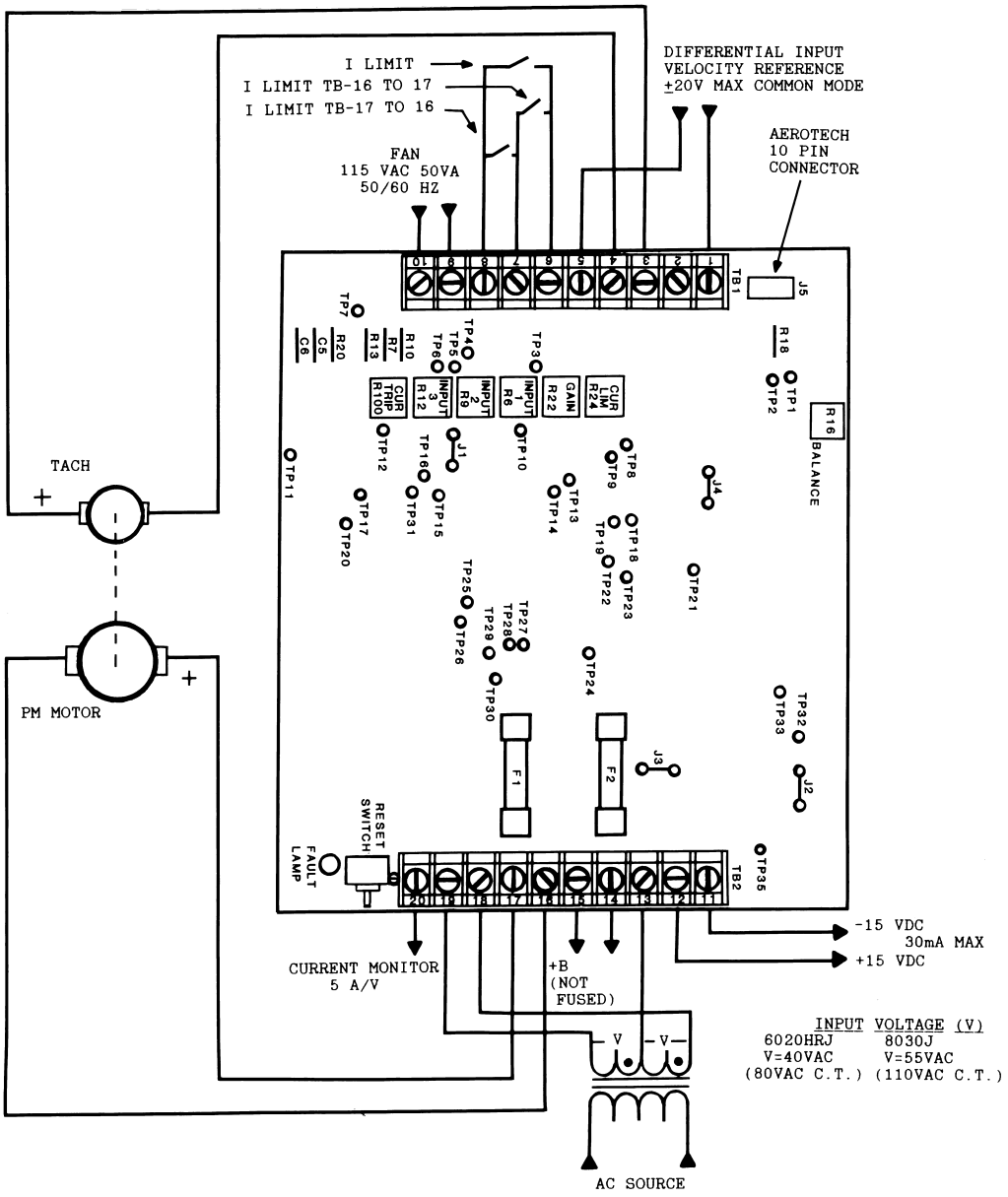

Figure 3-1: Controller Diagram

3.1. Selecting 6020HRJ or 8030J Operation

When ALL FOUR jumpers (J1-J4) are connected, the amplifier must operate as a 6020HRJ. When ALL FOUR jumpers are disconnected, the amplifier must operate as an 8030J amplifier.

3.2. Input/Output Connections

3.2.1. AC Inputs (TB1-9, 10 TB2-13, 18, 19)

115VAC, 50/60 Hz, 50 VA are required for the cooling fan. The connections are made at TB1-9 and 10. Always make sure that the fan is operational before operating the amplifier. The AC input for the power amplifier is made at terminals TB2-18 and 19 with TB2-13 connected to the center tap of the source. The following 50/60 Hz voltages should be used (refer to Figure 3-1).

For 6020HRJ operation, use 80 VAC center tapped (C.T.) ±10%.

For 8030J operation, use 110 VAC (C.T.) ±10%.

Use only terminal TB2-13 for the center tap connection.

The amplifier must be installed in an earth grounded enclosure. Operator access to the amplifier must be prevented while the unit is connected to the mains power source.

3.2.2. Motor Connections (TB2-16, 17)

The motor is connected between terminals TB2-16 and 17. Make sure the correct motor is being applied to the amplifier. Check for shorts between motor leads and ground and between motor leads before connecting the motor to the amplifier. A choke may have to be inserted if motor inductance is too small. Total inductance must be greater than .75 mH for 6020HRJ and 2.2 mH for 8030J operation.

3.2.3. Supplies for External Use (TB2-11, 12, 14, 15, TB1-4, 6, TB2-13 Common)

Regulated +15 VDC, 30 mA DC maximum at terminal TB2-12 and –15VDC, 30 mA DC maximum at terminal TB2-11 are available with respect to commons TB1-4, 6, and TB2-13. Unregulated bus voltage (60 VDC nominal 6020HRJ, 80 VDC nominal for 8030J) is available at TB2-14 and TB2-15.

The current drawn from this supply + load current should not exceed the continuous current capability of the unit. The common for this supply **must** be TB2-13.

3.2.4. Pre-Amplifier Inputs (TB-1, 2, 3, 5, TB1-4 Common)

Four inputs are available for input and feedback signals. Inputs 1, 2, and 3 (TB1-1, 2, and 3 respectively) sum to the inverting input of the pre-amplifier. TB1-5 provides a non-inverting signal to the pre-amplifier. In addition, TB1-1 and TB1-5 provide a differential input for attenuating common mode from remote signal sources. All input signal commons should be connected to TB1-4 or 6.

3.2.5. Directional Current Limits (TB1-6, 7, and 8)

TB1-6, 7, and 8 are available to inhibit current of a specific polarity for limited travel loads. Connecting TB1-6 to TB1-7 limits current between output terminals TB2-16 and TB2-17 at 3 amps or less without inhibiting current between TB2-17 and 16. Likewise, connecting TB1-7 to TB1-8 limits current between TB2-17 and TB2-16 at 3 amps or less without inhibiting current between TB2-16 and TB2-17. Connecting TB1-6 to TB1-8 limits current in both directions at 1 amp or less.

3.3. Adjustments

3.3.1. Current Limit (R24)

The maximum value of motor current can be set by adjusting R24 (CW rotation decreases maximum current). The current monitor, TB2-20 (5A/volt) and common may be used to set the desired level. To set, monitor TB2-20 with an oscilloscope (TB1-4 or 6 common) and command the motor to step or reverse speed. Adjust R24 to obtain the desired peak current.

3.3.2. Gain and Scale Factor Adjustments (R6, R9, R12, and R22)

Scale factor adjustments are R6, R9, and R12 for inputs 1, 2, and 3 respectively. The GAIN adjustment is R22. Connect the tach to input 3 and turn R12 and R22 fully CW. The AC power can now be switched ON. If the motor “runs away”, then reverse the tach connection to input 3. If the motor rotates slowly in either direction, adjust the balance pot R16. Adjust R22 CCW until the motor oscillates, then adjust CW until oscillation ceases. Continue for 1/8 to 1/16 turn further CCW. Apply velocity commands or position error signal to input 1 or 2. Utilize the differential input TB1-2 and TB1-5 when possible. Adjust R6 or R9 to obtain proper speed for the input being used.

Input 1 will command greater speed than input 2 because R7 is smaller than R10. If the speed is too fast with the scale factor full CCW, increase R7 or R10. If the speed is too slow with the scale factor full CW, R12 can be adjusted CCW. If R12 is adjusted, R22 will require readjustment.

3.3.3. Balance Adjustment (R16)

The pre-amplifier balance (R16) should be adjusted so that the motor does not turn when zero velocity is commanded. A high-resolution multi-turn pot is used. If it is determined that the balance is difficult to adjust, then R18 can be increased. Increasing R18 may decrease bandwidth and R22 may need readjustment.

3.3.4. Overcurrent Trip Adjustment (R100)

This adjustment sets the trip level of the overcurrent circuit. This level is factory set and should not be adjusted.

3.4. Procedure for Checking and Optimizing Performance

The pre-amplifier compensation for the 6020HRJ/8030J has been factory sealed so that a position loop bandwidth of 10 to 20 Hz is possible when the correct motor and load are applied. Problems in attaining a stable position loop response are usually a result of poor velocity loop response where the latter depends predominantly on system inertia, motor torque constant, and the setting of the GAIN pot R22 (see Section 3.3.2.).

If the required position loop response is difficult to attain after following the procedure in Section 3.3.2., then compare actual motor load parameters against the following:

MOTOR TORQUE CONSTANT – "KT" – 28 OZ-IN/AMP

SYSTEM INERTIA (MOTOR and TABLE) – "J" - .4 OZ-IN-SEC^2

TACH VOLTAGE CONSTANT – 3V/1000 RPM

If "new" motor and load parameters vary considerably from the above values, use the following procedure to reselect the pre-amplifier compensation elements:

$$C6 = \frac{KT\ (new)\ Vtach\ (new)\ 1.79 \times 10^{-3}}{J\ (new) \qquad (R13\ or\ R10)^*}$$

and

$$R20 = \frac{5.1}{C6}$$

* depending on what input is used for tach

C6 in micro farads
R13, R20 in kilo ohms
J in oz-in-sec
Vtach in volts/1000 RPM

∇ ∇ ∇

CHAPTER 4: MAINTENANCE

This solid state servo controller requires no maintenance. If it is desired, the balance can be checked as mentioned in Section 3.3.3. at three or six month intervals. The PC card and heat sinks can be checked for an accumulation of dirt if operated in a dirty environment.

4.1. Fuse Replacement

The replacement of fuses are as follows:

- 6020HRJ, F1 should be rated 10A (slow blow).
- 8030J, F1 should be rated 15A (slow blow).
- F2 for both amplifiers should be rated 20A (slow blow).

4.2. Troubleshooting

Troubleshooting will be aimed at determining whether the unit is defective and needs to be returned to the factory for repair. The symptoms will be those for a motor/tach system.

Table 4-1: Troubleshooting

Symptom	Possible Cause	Procedure
Amplifier shuts down with fault indication	Overcurrent trip	If the fault was due to overcurrent, the amplifier must be reset with the switch. Besides a direct output to ground, or output to output short, overcurrents can be caused by: defective motor commutator, commutator arching to ground at high speeds, an improper motor application causing control instability.
	Abnormal input voltage Low level power supply voltage abnormal	If amplifier does not reset after pressing the reset switch, check the AC input voltage (Section 3.2.1). Check the output voltage (terminal 15 (+) to 13(-)), this voltage should be no more than 87VDC or no less than 45VDC. Check fuse F2. If external ±15VDC (terminals 11 and 12) are in use, disconnect them to verify that there is no overload.
	Excessive load regeneration	If the amplifier resets itself automatically following a shutdown, check the following: If fault is prevalent during an accelerating or decelerating period, check AC input voltage (Section 3.2.1). If condition seems to subside when the current limit adjustment is increased (Section 3.3.1), the problem may be excessive load regeneration, and the use of a shunt regulator may be in order. If condition subsides when the current limit level is reduced, the problem could be poor input AC source regulation

Table 4-1: Troubleshooting (continued)

Symptom	Possible Cause	Procedure
Amplifier shuts down with no fault indication	Open fuse F1	If F1 is open (motor fuse), first verify that the fuse and jumpers J1-J4 were in place for amplifier operation (6020HRJ or 8030J) – see Section 3.1. An open F1 fuse may be caused by high duty cycle operation or excessive loading.
	Open fuse F2 Defective amplifier	If fuse F2 is open, the cause is usually a fault in the amplifier's power stage. To verify this, check the following with an ohmmeter before replacing F2: Place the (+) lead of the ohmmeter (x1 scale) on terminal 15 and the (-) lead to terminal 16, then 17. Note ohm readings. Place the (-) lead on terminal 13 and the (+) lead on terminal 16, then 17. Again, note readings. None of the four readings should be less than 20Kohms. If ohmmeter polarities are not observed, low resistance readings will be measured for a good power stage.
Motor runs away	Reverse tach connection	Reverse tach connections to amplifiers
	Open tach connection	Check for absence of tach voltage at input to amplifier
	Improper scaling	Check scaling adjustments (Section 3.3.2). If terminals 2 or 3 are used for the tach signal, adjust R9 or R12 CW.
	Defective amplifier	The pre-amplifier may be latching up. Short terminals 6 and 8 (shutdown). If this corrects the problem, the per-amplifier is defective. If the problem persists, the power section is probably defective.
Poor servo response or output performance	Improper adjustments	Verify current limit adjustment (Section 3.3.1) is set correctly. Re-check gain adjustment (R22) - Section 3.3.2.
	Improper set-up	Is the amplifier being used in a proper application? Check status of jumpers J1 – J4 (Section 3.1). Check contact connections to terminals 6, 7, and 8 (torque limits) – see Figure 3-1 Circuits should be totally open circuited when torque limit is not requested. Verify that R18 is in place.
	Improper motor application	Make sure that the correct motor is being used with the amplifier (Section 3.4).

Table 4-1: Troubleshooting (continued)

Symptom	Possible Cause	Procedure
System oscillates	Improper adjustments	Re-check scaling and GAIN adjustments (Section 3.3.2). First turn the gain adjustment (R22) CW. Next, turn the tach scaling (either R9 or R13 depending on tach connection) CW.
	Improper motor application	If adjustments do not resolve the oscillation, review the motor specifications and verify that the amplifier is being applied to the correct motor. If necessary, the compensation components may have to be changed (Section 3.4).

∇ ∇ ∇

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.

∇ ∇ ∇

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

∇ ∇ ∇

APPENDIX C: TECHNICAL CHANGES

C.1. Current Changes Revision: 1.02.00

Section(s) Affected	Description
Section 3.2.1	Earth ground enclosure information added

C.2. Archived Changes

Version	Section(s) Affected	Description
1.01.00	-	No changes recorded
1.00.00		New manual

∇ ∇ ∇

INDEX

∇ ∇ ∇

READER'S COMMENTS

6020HRJ/8030J Switching Servo Controller
P/N: EDA107, January 29, 2008
Revision: 1.02.00

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.

Name
Title
Company Name
Address

Mail your comments to:
AEROTECH, INC. Technical Writing Department 101 Zeta Drive Pittsburgh, PA. 15238 U.S.A.

Fax to:
412-967-6870
Email:
service@aerotech.com