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Compumotor

KH Series User Guide

Compumotor Division
Parker Hannifin Corporation
p/n 88-006936-02 Y1

Parker

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P R E - I N S T A L L A T I O N

PLEASE READ THIS ENTIRE MANUAL CAREFULLY BEFORE ATTEMPTING TO INSTALL OR OPERATE THE KH SERIES SYSTEM. IF ANY QUESTIONS ARISE WHICH ARE NOT ANSWERED TO YOUR SATISFACTION WITHIN THIS MANUAL PLEASE CALL PARKER COMPUMOTOR FOR ASSISTANCE AT 1-800-358-9068, or in CALIFORNIA AT 1-800-345-2084 or (707) 778-1244.

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SECTION 1 INTRODUCTION 1

1.1 DESCRIPTION 1
1.2 INTERFACE OPTIONS 4
1.3 THEORY OF OPERATION 5

SECTION 2 INSPECTION 9

SECTION 4 QUICK START-UP PROCEDURE 13

SECTION 5 INSTALLATION AND HOOK-UP 15

5.1 GENERAL 15
5.1.1 RECOMMENDATION 15

5.2 DRIVE MOUNTING. 15
5.2.1 PANEL LAYOUT 16
5.2.2 PANEL MOUNTING 17

5.3 MOTOR MOUNTING. 18
5.3.1 COUPLERS 19

5.4 WIRING. 20

5.4.1 MOTOR CONNECTIONS. 20
5.4.2 MOTOR BRAKING. 21
5.4.3 RESOLVER CONNECTIONS 22
5.4.4 LINE POWER CONNECTIONS 23
5.4.4.1 SAFETY INTERLOCK SWITCH 23
5.4.4.2 FUSES 23
5.4.5 INDEXER CONNECTIONS. 24
5.4.6 DRIVE ENABLE/FAULT CONNECTIONS 25
5.4.7 RS-232 CONNECTIONS 26

SECTION 6 OPERATION 27

6.1 GENERAL 27

6.2 POWERING UP THE SYSTEM. 27

6.3 VISUAL INDICATORS 28
6.3.1 STATUS 28
6.3.2 REGEN ACTIVE 28
6.3.3 MAX CURR 28
6.3.4 ERROR. 28

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6.3.5 SHORT CIRCUIT. 30
6.3.6 TEMP 30
6.3.7 AMP OFF. 30

6.4 BASIC SOFTWARE SERVO COMMANDS 30

6.5 INDEXER FUNCTIONS 32

6.6 INDEXER INPUTS AND OUTPUTS. 32
6.6.1 STEP INPUT 33
6.6.2 DIRECTION INPUT. 33
6.6.3 REMOTE POWER SHUTDOWN. 33
6.6.4 FAULT RESET. 34
6.6.5 IN POSITION. 34
6.6.6 DRIVE FAULT. 34

6.7 DRIVE ENABLE/FAULT 4-PIN PHOENIX CONNECTOR. 35

6.7.1 DRIVE ENABLE INPUT 35
6.7.2 DRIVE FAULT OUTPUT 35

6.8 TUNING. 36
6.8.1 THEORY 36
6.8.1.1 PROPORTIONAL GAIN TERM. 39
6.8.1.2 INTEGRAL GAIN TERM. 39
6.8.1.3 DERIVATIVE GAIN TERM. 39
6.8.1.4 VELOCITY GAIN TERM. 39
6.8.2 PUSHBUTTON TUNING OF THE KH SERVO SYSTEM 39
6.8.3 RS-232C TUNING OF THE KH SERVO SYSTEM. 42
6.8.4 APPLICATION SPECIFIC TUNING. 43
6.8.4.1 DEFAULT TUNING PARAMETERS 43
6.8.4.2 OPTIMIZING TUNING PARAMETERS. 43
6.8.4.3 COMMON TUNING PROBLEMS. 44
6.8.4.4 GENERAL TUNING CONSIDERATIONS 45

SECTION 7 MAINTENANCE AND TROUBLESHOOTING 47

7.1 MOTOR MAINTENANCE 47

7.2 DRIVE MAINTENANCE 47

7.3 DIAGNOSTIC LEDS 47

7.4 ERROR CODES 48

7.5 RS-232C PROBLEMS. 50

7.6 RETURNS 50

Artisan Technology Group - Quality Instrumentation ... Guaranteed | (888) 88-SOURCE | www.artisantg.com

SECTION 8 SPECIFICATIONS - ELECTRICAL 53

8.1 DRIVE 53
8.1.1 INPUT POWER 53
8.1.2 OUTPUT POWER. 53
8.1.3 ENVIRONMENTAL 53
8.1.4 INDEXER CONNECTOR INPUTS TO DRIVE 53
8.1.5 INDEXER CONNECTOR OUTPUTS FROM DRIVE. 55
8.1.6 RS-232C CONNECTOR 56
8.1.7 DRIVE/ENABLE FAULT PHOENIX CONNECTOR. 56
8.1.8 FUSING. 57

8.2 MOTORS. 58
8.2.1 BASIC DESIGN. 58
8.2.2 OPERATING TEMPERATURE 59
8.2.3 OPERATING PARAMETERS. 59
8.2.4 RADIAL LOADING. 60

8.3 RESOLVER. 63

8.4 MOTOR-DRIVE COMPATIBILITY 64

SECTION 9 SPECIFICATIONS - MECHANICAL 65

9.1 DRIVE 65

9.2 MOTORS. 67

9.3 COUPLERS. 71

SECTION 10 SPECIFICATIONS - PERFORMANCE 73

10.1 SPEED vs. TORQUE CURVES 73

10.2 POSITIONAL ACCURACY 75

SECTION 11 DRIVE OPTIONS 77

11.1 CUSTOM LENGTH CABLES. 77

11.2 MOTOR BRAKES. 78

APPENDICES 79

A NOISE SUPPRESSION RECOMMENDATIONS 79
B ERROR CODE SUMMARY. 85
C SERVO COMMAND SUMMARY 87

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TABLE OF FIGURES

FIGURE	DESCRIPTION	
1-1	KH DRIVE FRONT PANEL	3
1-2	KH DIGITAL SERVO SYSTEM	5
1-3	BASIC ELEMENTS OF A BRUSHLESS MOTOR	5
1-4	RESOLVER MECHANICAL DRAWING AND WINDINGS	7
4-1	INDEXER HOOK-UP FOR TEST	14
5-1	KH DRIVE SUGGESTED PANEL LAYOUT	17
5-2	MOTOR BRAKING DIAGRAM	22
5-3	KH DRIVE LINE POWER CONNECTIONS	24
5-4	KH RS-232C DAISY CHAIN CONFIGURATION	26
6-1	LIMIT SWITCH HOOK-UP	35
6-2	KH SERVO LOOP	37
6-3	KH PUSHBUTTON COMMAND SUMMARY	41
8-1	KH STEP INPUT SCHEMATIC	54
8-2	KH DIRECTION INPUT SCHEMATIC	54
8-3	KH REMOTE SHUTDOWN INPUT SCHEMATIC	54
8-4	KH FAULT RESET INPUT SCHEMATIC	55
8-5	KH DRIVE FAULT OUTPUT SCHEMATIC	55
8-6	KH IN POSITION OUTPUT SCHEMATIC	55
8-7	KH DRIVE ENABLE/FAULT PHOENIX SCHEMATIC	56
8-8	KH DRIVE FAULT PHOENIX SCHEMATIC	56
8-9	STATOR WINDING CONFIGURATION	58
8-10	SHAFT REVOLUTION/ELECTRICAL CYCLE RELATIONSHIP	58
8-11	MOTOR OPERATION TEMPERATURE CORRECTION FACTORS	59
8-12	MAXIMUM RADIAL LOAD vs. SPEED AND DISTANCE FROM FLANGE	60

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9-1	KH DRIVE DIMENSIONAL DRAWINGS	65
9-2	KH DRIVE CONNECTIONS	66
9-3	KH 250-260 MOTOR DRAWINGS	68
9-4	KH 710 MOTOR DRAWING	69
9-5	KH 720-740 MOTOR DRAWINGS	70
9-6	KH MOTOR COUPLERS	71
10-1	SPEED vs. TORQUE CURVES	74
10-2	ABSOLUTE POSITIONAL ACCURACY	75
A-1	NOISE SUPPRESSION DEVICES	80

TABLE OF EQUATIONS

EQUATION	DESCRIPTION	
1-1	FREQUENCY OF STATOR CURRENTS	6
1-2	PHASE VOLTAGE OF ROTOR WAVEFORM	7
6-1	COMMANDED VELOCITY	38
6-2	MAGNITUDE OF COMMANDED CURRENT	38

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HOW TO USE THIS MANUAL

This manual is designed to help you install, develop, and maintain your system. Each chapter begins with a list of specific objectives that should be met after you have read the chapter. This section is intended to help you find and use the information in this manual.

ASSUMPTIONS

This user guide assumes that you have the skills or fundamental understanding of the following information.

- IBM (or IBM-Compatible) computer experience
- Basic electronics concepts (voltage, switches, current, etc.)
- Basic motion control concepts (torque, velocity, distance, force etc.)
- Basic serial communication concepts (specifically RS-232C).

With this basic level of understanding, you will be able to effectively use this manual to install, develop, and maintain your system.

CONTENTS OF THIS MANUAL

This user guide contains the following information.

Section 1: Introduction

This section provides a description of the product and a brief account of its specific features and theory of operation.

Section 2: Inspection

This section contains a detailed list of items the user should have received with the KH Series shipment.

Section 3: Warranty

This section contains the Compumotor warranty.

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Section 4: Quick Start-up Procedures

This section is provided for users familiar with servo controls and drives. The instructions presented will ensure proper connection of necessary power and signals, and will allow a basic move to be executed.

Section 5: Installation and Hook-up

This section provides instructions for the user to properly mount the system and make all electrical and non-electrical connections. Upon completion of this section, the system should be completely installed and ready to perform basic operations.

Section 6: Operation

Procedures presented in this section are intended to assist the user in quickly and safely operating the KH Drive. Once the system has been properly installed and initial adjustments completed there should be little or no adjustment required to maintain normal operation of the drives.

Section 7: Maintenance and Troubleshooting

This section covers all maintenance and problem solving information necessary to continued safe and efficient operation of the KH System. Full information on troubleshooting via the diagnostic LEDs are included as well.

Section 8: Specifications - Electrical

This section contains information on system electrical specifications.

Section 9: Specifications - Mechanical

This section contains information on system mechanical specifications.

Section 10: Specifications - Performance

This section contains information on system performance specifications.

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Section 11: Drive Options

This sections discusses various drive options that are available from Parker Compumotor.

Appendices

This section contains technical data arranged by topic.

INSTALLATION PROCESS OVERVIEW

To ensure trouble-free operation, you should pay special attention to the environment in which the KH Series equipment will operate, the layout and mounting, and the wiring and grounding practices used. These recommendations are intended to help you easily and safely integrate KH Series equipment into your manufacturing facility. Industrial environments often contain conditions that may adversely affect solid state equipment. Electrical noise or atmospheric contamination, may also affect the KH Series System.

DEVELOPING YOUR APPLICATION

Before you attempt to develop and implement your application, there are several issues that you should consider and address.

1. Recognize and clarify the requirements of your application. Clearly define what you expect the system to do.

2. Assess your resources and limitations. This will help you find the most efficient and effective means of developing and implementing your application.

3. Follow the guidelines and instructions outlined in this user guide. Do not skip any steps or procedures. Proper installation and implementation can only be ensured if all procedures are completed in the proper sequence.

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INSTALLATION RECOMMENDATION

Before you attempt to install this product, you should complete the following steps:

1. Review this entire manual. Become familiar with the manual's contents so that you can quickly find the information you need.

2. Develop a basic understanding of all system components, their functions, and interrelationships.

3. Complete the basic system configuration and wiring instructions (in a simulated environment, not a permanent installation) provided in Section 4, Getting Started.

4. Perform as many basic moves and functions as you can with the preliminary configuration. You can only perform this task if you have reviewed the entire manual. You should try to simulate the task(s) that you expect to perform when you permanently install your application (however, do not attach a load at this time). This will give you a realistic preview of what to expect from the complete configuration.

5. After you have tested all of the system's functions and used or become familiar with all of the system's features, carefully read Section 5, Installation.

6. After you have read Section 5 and clearly understand what must be done to properly install the system, you should begin the installation process. Do not deviate from the sequence or installation methods provided.

7. Before you begin to customize your system, check all of the system functions and features to ensure that you have completed the installation process correctly. The successful completion of these steps will prevent subsequent performance problems and allow you to isolate and resolve any potential system difficulties before they affect your system's operation.

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WARNINGS (Personal Injury) & CAUTIONS (System Damage)

Warning and caution notes alert you to possible dangers that may occur if you do not follow instructions correctly. Situations that may cause bodily injury are presented as warnings. Situations that may cause system damage are presented as cautions. These notes will appear in bold face and the word warning or caution will be centered and in all capital letters. Refer to the examples shown below.

WARNING

ALL AC POWER MUST BE DISCONENECTED

PRIOR TO INSTALLATION WIRING.

CAUTION

SYSTEM DAMAGE WILL OCCUR IF YOU POWER UP

THE SYSTEM IMPROPERLY.

RELATED PUBLICATIONS

The following publications may be helpful resources.

Seyer, Martin. RS-232C Made Easy: Connecting Computers, Printers, Terminals and Modems. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1984

1988 Parker Compumotor Motion Control Catalog

Operations manual for the IBM or IBM-compatible computer that you will use with the KH Drive.

Schram, Peter (editor). The National Electric Code Handbook (Third Edition). Quincy, MA: National Fire Protection Association

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SECTION 1 **INTRODUCTION**

1.1 DESCRIPTION

The KH Series is a brushless servo positioning system consisting of a brushless servomotor, brushless resolver feedback, and a microprocessor based closed-loop drive amplifier. Digital electronics simplify the system's operation and maintenance, improving performance.

The KH Drive accepts digital STEP and DIRECTION inputs, controlling position, velocity, and acceleration. The onboard microprocessor monitors both the pulse inputs and the resolver feedback, then determines the proper phase current levels to apply to each of the motor's stator windings. The series offers maximum speeds of 6000 RPM, maximum continuous torques of 4100 oz·in and maximum peak torques of 8000 oz·in.

Closed-loop performance is simplified by microprocessor control and a sophisticated servo control algorithm (PIDV). The loop is closed around the motor shaft; the feedback information is obtained from the motor's resolver. All servo performance parameters are stored in a non-volatile EEPROM (memory), eliminating analog tuning potentiometer adjustments required in conventional systems. KH Series motor/drives are supplied as packaged systems that are factory compensated for typical load and performance requirements.

KH Series systems are easily installed and operated by personnel with little or no training in servo systems. In most applications no adjustments will be required. For some applications simple pushbutton adjustments will optimize the servo drive's performance to handle a particular load. In addition, an RS-232 interface is provided to access all servo parameters for ease of adjustment and to report back motor/driver status information.

The power amplifier section of KH Series drives utilizes a rugged bipolar 10 kHz pulse width modulation (PWM) current control scheme, improving reliability, power regulation, and low speed smoothness.

This manual pertains specifically to the KH Drive. For more information about the KH Drive, or any other Compumotor product, please contact your local Field Applications Engineer, or contact Compumotor directly at 1-800-358-9068 (in California at 1-800-345-2084, or (707) 778-1244).

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Your KH Drive features:

* Brushless servomotor
* Brushless resolver feedback
* Speeds to 6000 RPM
* Torques to 4100 oz·in. continuous (8000 oz·in. peak)
* USER PROGRAMABLE resolutions (200 - 32768 steps/rev.)
* 5000 steps per revolution STANDARD
* Microprocessor control: no drift, no analog pots to adjust
* Fan cooled drive enclosure
* 10 kHz PWM switching frequency
* Accepts digital STEP and DIRECTION inputs
* Servo parameters factory set and stored in non-volatile EEPROM (memory)
* High noise immunity due to optical isolation and brushless resolver technology
* Simple pushbutton adjustment of servo gains
* LED Status/Fault Indicators
* RS-232 INTERFACE

Figure 1-1 illustrates what the KH Drive looks like. Each section of the drive is described in full detail in this manual.

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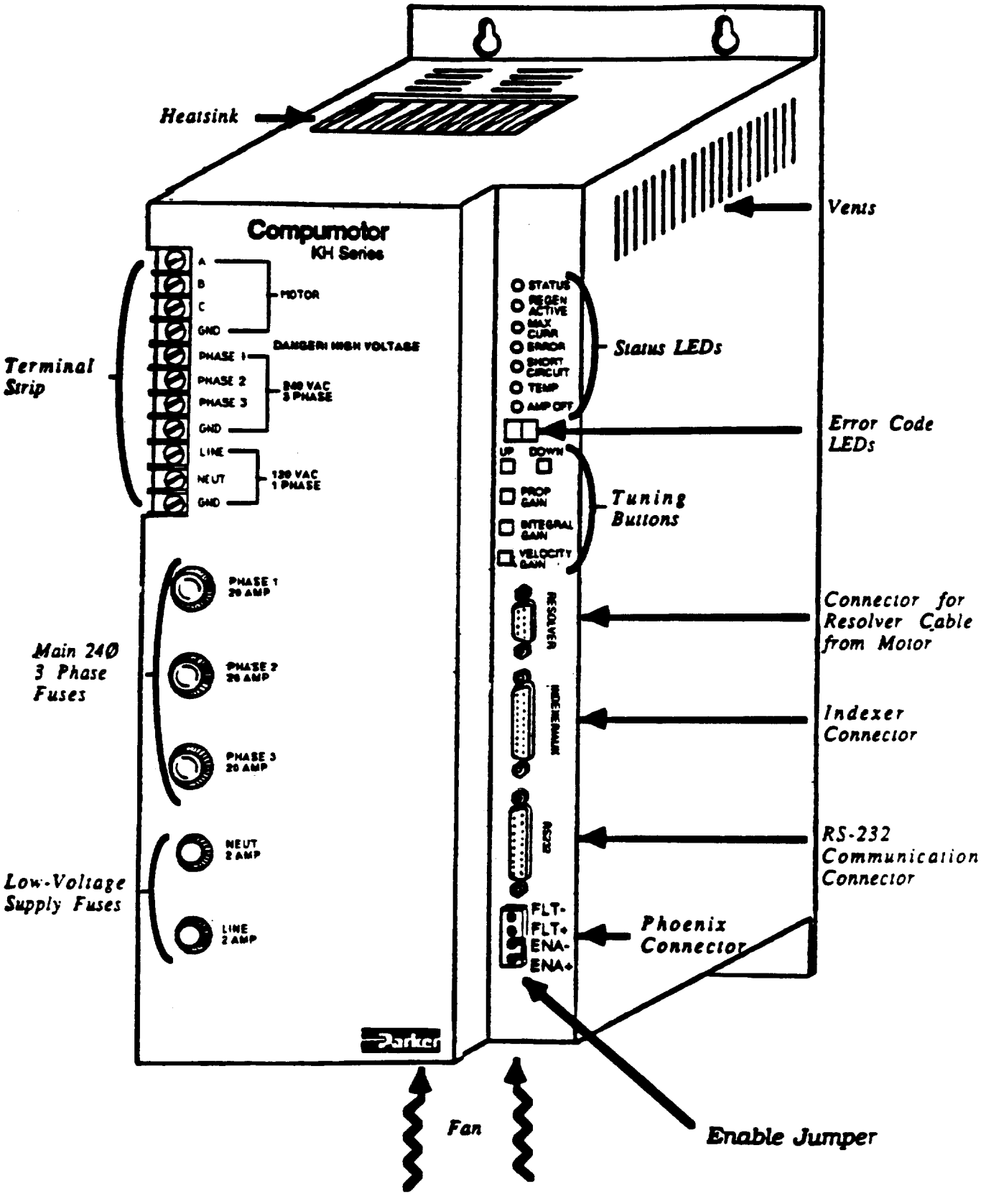


Figure 1-1. KH Drive Front Panel Diagram

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1.2 INTERFACE OPTIONS

The KH Series servo systems have pushbutton and RS-232C tuning, fault outputs, and a hardware enable input. Fault error information (e.g. excess average current, excess following error, loss of resolver signal, etc.) is displayed as a unique two digit number on the front panel as an operator aid.

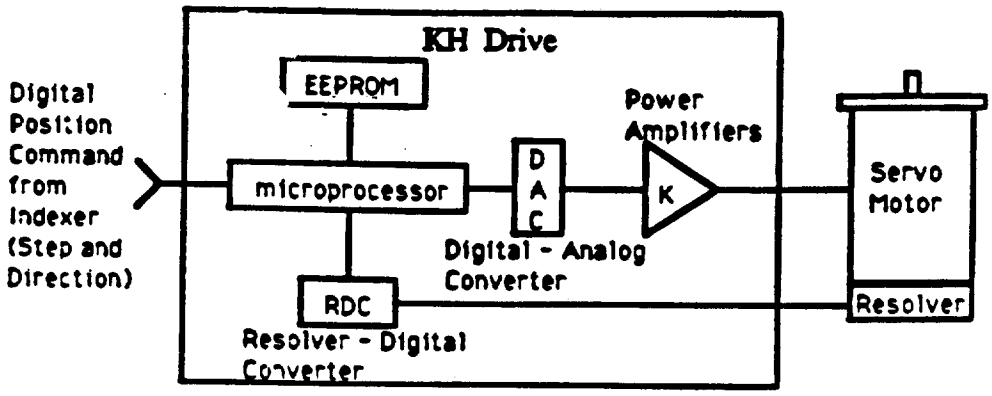
The "X" version of the KH Drive system is called the KHX Drive. It contains the servo controller and a complete, RS-232C based indexer that executes the Compumotor "X" programming language. Motion control parameters such as distance, velocity and acceleration can be combined into sequences along with time delays, loops, and programmable outputs. These sequences can be controlled either via RS-232C or via external inputs that can control and time program execution. Trigger inputs can be used to coordinate program execution with external events. Multiple motion control programs can be stored in non-volatile memory and executed automatically or according to external sequence and trigger controls. The "X" language is based on simple commands, and uses ordinary decimal numbers. Any CRT, handheld terminal, computer, or programmable controller with an RS-232C interface can be used to program the system. This manual does not discuss the KHX Drive system. If you would like more information about the KHX Drive, please call your local Field Applications Engineer or contact Compumotor directly at 1-800-358-9068 (in California 1-800-345-2084 or 707-778-1244).

The STEP and DIRECTION version is designed to be compatible with all Compumotor indexers. The drive moves the motor one increment in the specified direction for each STEP pulse received. Both the STEP and DIRECTION inputs are optically isolated and can be driven by an external pulse generator. The KH System has programmable resolution, so that convenient motor increments may be specified. This version is described here in this manual (KH Drive).

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1.3 THEORY OF OPERATION

The KH Digital Servo System is composed of three major components: the servo motor, the drive, and the resolver. Figure 1-2 illustrates the topology of the KH drive system.



KH DIGITAL SERVO SYSTEM

FIGURE 1-2

The KH motor is a brushless, 3-phase, wye wound, 4-pole pair AC synchronous motor. Figure 1-3 illustrates the basic construction of the KH servo motor. The permanent magnets are attached to the rotor and held in place by metal bands and composite fiber materials to allow high speed performance. The rotors are precision balanced resulting in both low and high speed smoothness. The windings are located in the outer portion of the motor (stator). This inside out construction allows better heat dissipation than conventional brush type motors. As a result, higher continuous torque and horsepower ratings are achieved within a given motor size.

Basic Elements of a Brushless Motor

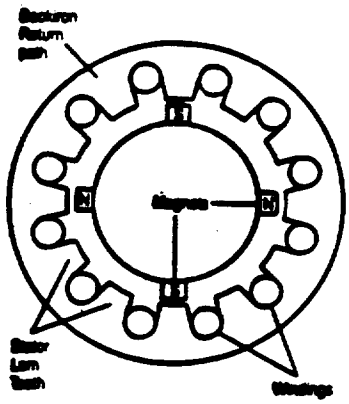


FIGURE 1-3

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The term "brushless DC" is usually reserved for motors that are stator wound to produce a trapezoidal back EMF (Electro-Motive Force) waveform. The KH Series motors are wound to produce sinusoidal back EMF waveforms which result in smoother operation when compared to trapezoidal type motors.

The drive component of the system is a 3-phase inverter that controls the amplitude, frequency, and phase of each of the three motor stator currents. Controlling the amplitude of the stator current relates directly to the magnitude of the torque being generated. Since the motor is "synchronous," controlling the frequency of the stator currents controls the mechanical rotation of the shaft. Equation 1-1 describes this relationship.

$$\omega_e = \omega_R \times (P/2)$$

ω_e = electrical frequency of the stator currents
ω_R = mechanical frequency of the shaft
$P/2$ = number of motor pole pairs

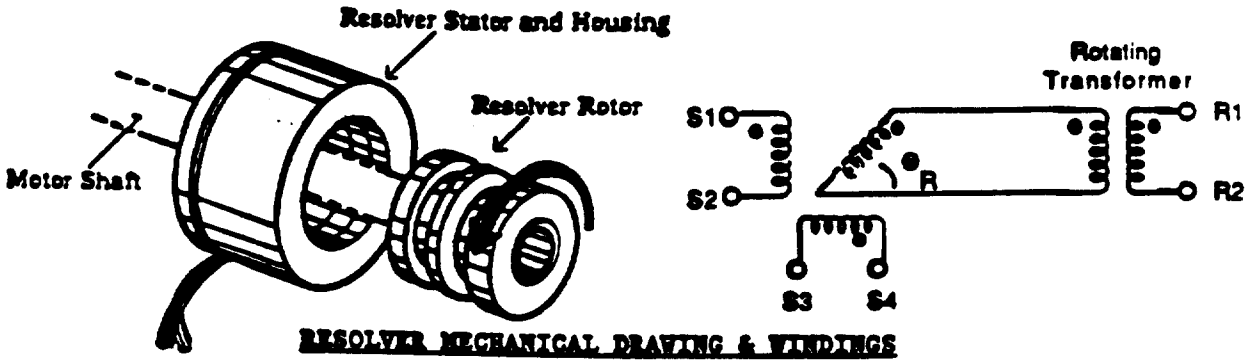
EQUATION 1-1

Controlling the phase of each of the motor's stator currents ensures a balanced 3-phase operation as well as minimal torque ripple. To determine whether motor current is as commanded to be, actual motor current is read by the drive, and voltage pulse widths to the stator are modulated accordingly.

The resolver is a two speed, brushless, pancake type. The rotor windings of the resolver are mounted directly to the motor shaft and the stator windings are mounted to the motor housing. No internal couplers are used.

Figure 1-4 illustrates the electrical characteristics of the resolver. Windings S1/S2, and S3/S4 are the stator windings and are excited with a sine and cosine function respectively.

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RESOLVER MECHANICAL DRAWING & WINDINGS

FIGURE 1-4

A voltage is induced in the rotor winding and coupled back to the resolver housing through a rotating transformer. The phase voltage of the rotor waveform from the terminals R1 and R2 are compared to the reference input S3 and S4 (see Equation 1-2).

$$V_{S1\text{-}S2} = A \sin(\omega_e t)$$

$$V_{S3\text{-}S4} = A \cos(\omega_e t)$$

$$V_{R1\text{-}R2} = A \cos(\omega_e t - \theta_R)$$

where (θ_R) is the actual rotor position

EQUATION 1-2

The rotor position is determined by the phase difference between $V_{S3\text{-}S4}$ and $V_{R1\text{-}R2}$. This position point is read approximately every 512 microseconds.

The function of the KH Drive is to servo to a digital position command from an indexer. The indexer provides both STEP and DIRECTION inputs to the drive and the motor mounted resolver feeds back actual position of the shaft. If the actual position of the shaft is different from the commanded position from the indexer, a positional error is produced that in turn commands current to the motor to correct the positional error. This is what is meant by the term "servoing."

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SECTION 2

INSPECTION

Your complete KH Drive system should arrive in two boxes. Each box should be inspected upon receipt for obvious damage. Report any damage to the shipping company immediately; Compumotor cannot be held responsible for damage occurring in shipment. After carefully unpacking both boxes be sure to inspect their contents and verify that you have the following items:

BOX 1

1. KH Drive unit

2. Motor cable (round MS connector at one end, 4 leads with spade terminals on the other end):

   KH250-260 motors --- p/n 71-007200-25
   KH710-740 motors --- p/n 71-007130-25

3. Resolver cable (round MS connector at one end, 9 pin "D" connector on the other end):

   All KH motors --- p/n 71-007127-50

4. This manual: p/n 88-006936-02

BOX 2

1. KH servo motor:

   KH250 motor --- p/n 71-007191-01
   KH260 motor --- p/n 71-007192-01
   KH710 motor --- p/n 71-006765-01
   KH720 motor --- p/n 71-006766-01
   KH730 motor --- p/n 71-006767-01
   KH740 motor --- p/n 71-006768-01

If you did not receive all of these items please contact Compumotor Customer Service at (800) 722-2282 and refer to the above part numbers.

NOTE: KH DRIVES AND MOTORS ARE CONFIGURED, OR MATCHED, AT THE FACTORY FOR SEVERAL IMPORTANT REASONS. IF MORE THAN ONE KH DRIVE-MOTOR SYSTEM IS RECEIVED, MAKE SURE THAT MOTORS AND DRIVES WITH MATCHING SERIAL NUMBER INFORMATION ARE KEPT TOGETHER AND INSTALLED TOGETHER.

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SECTION 4

QUICK START UP PROCEDURE

This section is provided for users familiar with servo controls and drives. Before final mounting of the motor and drive please read Section 5. A complete description of powering up the system can be found in Section 6.2.

1. Connect the motor cable and resolver cable between the KH Drive and the servo motor.

2. Measure and verify your incoming 3-Phase 240 V.A.C. line. Connect, BUT DO NOT ENERGIZE, both the 3-Phase 220-240 V.A.C. and the 1-Phase 110-120 V.A.C. to the drive. Be sure that the 3-Phase ground is the same as the 1-Phase ground. See Figure 5-3.

3. Connect a Compumotor indexer to the KH Drive connector marked Indexer/Aux (see Figure 4-1)

4. Energize the 3-phase power.

   NOTE: IF 3-PHASE POWER IS TURNED OFF, ALLOW AT LEAST 30 SECONDS TO DISCHARGE INTERNAL CAPACITOR BEFORE RE-ENERGIZING.

5. Energize the 1-phase control power.

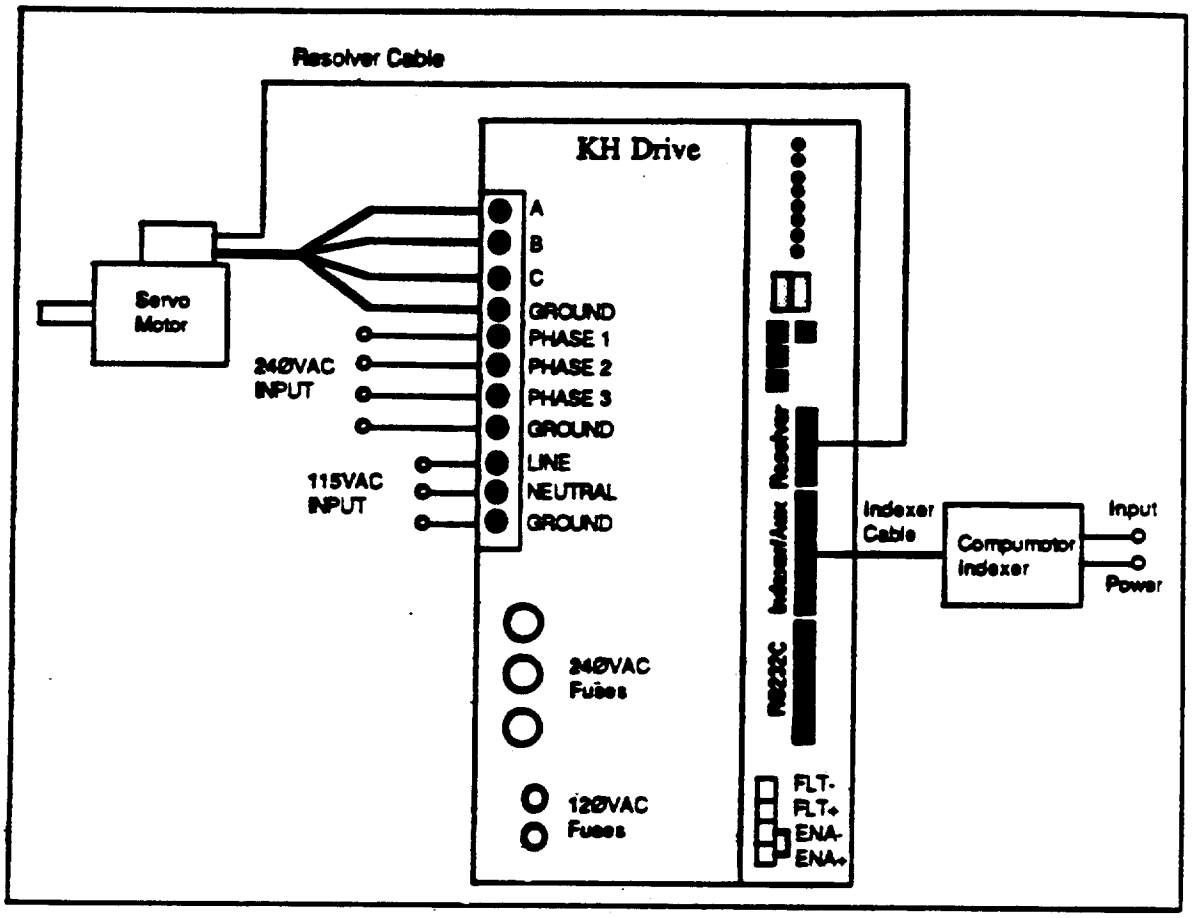
6. The drive should now power up with its STATUS light glowing green and the motor shaft stiff.

   IF THE MOTOR RAPIDLY SPINS AND THE DRIVE FLASHES ERROR #20, THEN IT IS LIKELY THAT THE MOTOR HAS BEEN HOOKED UP TO THE WRONG DRIVE. MAKE SURE THAT BOTH THE MOTOR AND DRIVE HAVE LABELS WITH MATCHING SERIAL NUMBER INFORMATION. REFER TO SECTION 8.4 FOR MORE INFORMATION ABOUT MOTOR-DRIVE COMPATIBILITY.

   If an error flashes on the LED display refer to TROUBLESHOOTING, Section 7.4.

7. Initiate a move.

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INDEXER HOOKUP FOR TEST

FIGURE 4-1

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SECTION 5 INSTALLATION AND HOOKUP

5.1 GENERAL

Safety is the primary concern when installing any motion control system. This section outlines installation guidelines with the safety of the operator and the equipment in mind. All Compumotor hardware should be installed in conformity with local and national electrical and safety codes.

This chapter details all aspects of installation and hookup of the KH Drive. If you are not familiar with this system, it is recommended that you set up the KH Drive on a workbench to ensure that the drive's basic functions are working, and that you fully understand the KH. Please refer to Section 6.2 for complete start-up procedures.

5.1.1 RECOMMENDATIONS

The following recommendations are intended as an aid in easily and safely integrating Compumotor equipment to specific applications.

Serious attention should be paid to the environment in which the equipment will be operating. Proper mounting, wiring, and grounding will ensure trouble-free operation. The KH Drive is designed to operate in an industrial environment, however severe atmospheric contamination, electrical noise, and/or temperature extremes can affect performance of the system. Therefore, we strongly suggest that both drive and motor be operated within design specifications (see Sections 8,9,& 10).

5.2 DRIVE MOUNTING

The KH Drive should be installed in an enclosure which will protect it from atmospheric contaminants such as oil, moisture, and dirt. The National Electrical Manufacturers Association (NEMA) has established standards which define the degree of protection provided by electrical enclosures. If the application environment is industrial in nature and may contain airborne contaminants the enclosure should conform to NEMA TYPE 12 standards. Proper layout of components is necessary to ensure sufficient cooling of equipment within the enclosure.

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5.2.1 PANEL LAYOUT

An efficient panel layout is essential for trouble free operation of the KH Drive. The KH Drive is fan cooled and designed to maintain acceptable heatsink temperatures while operating in a 0 to +50°C ambient. When designing your panel layout it is essential to allow sufficient space for unrestricted airflow through each drive. Because the fan draws air upward over the heatsink, the air directly beneath the unit must not exceed the recommended maximum ambient temperature of 50°C. The limiting factor is the heatsink temperature, which must be no greater than 65°C. The KH Drive has a temperature sensor mounted to the heatsink and will disable the drive to prevent the drive from overheating. Should this occur, the TEMP LED indicator on the drive will light, indicating an over temperature condition. Additionally, the two-digit error code display will flash error #11.

The KH Drive produces heat and therefore the mounting enclosure should be an open vented system. Plan to dissipate 500 watts for each KH Drive[1*] in your panel. The actual dissipation will vary depending on the application duty cycle, motor size, and load inertia.

The following rules should be observed when mounting KH Series drives in an enclosure (see figure 5-1):

1. The vertical distance between the KH Drive and other equipment, or the top and bottom of the enclosure, should be no less than 6 inches.

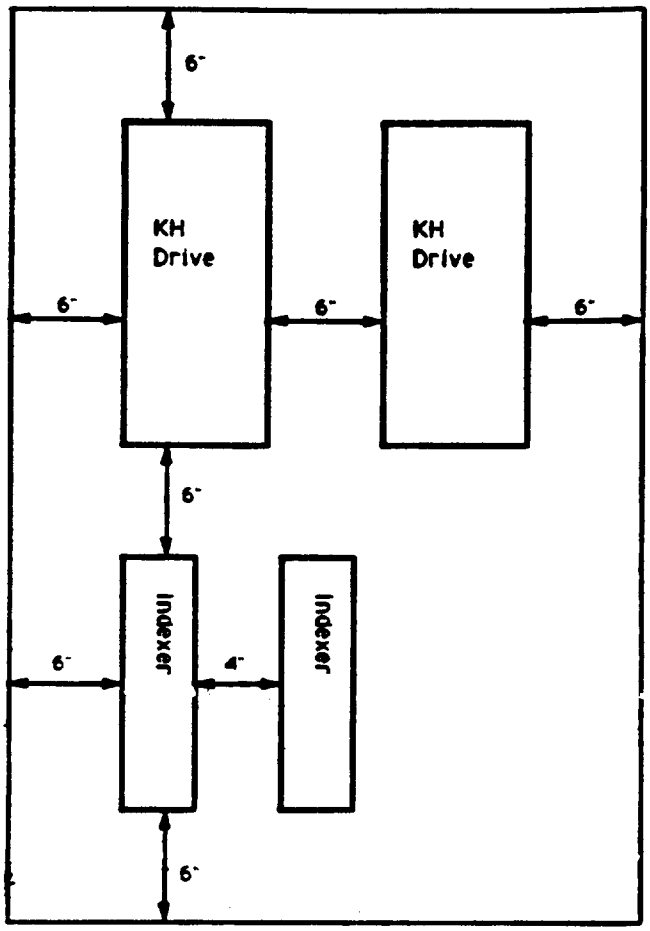
2. The horizontal distance between the KH Drive and other equipment, or the side walls of the enclosure, should be no less than 6 inches.

3. Because motor/drive products produce more heat than indexers, drives should not be mounted directly below indexers.

4. Large heat producing equipment such as transformers should not be mounted directly beneath the KH Drive.

[1*] operating at it's maximum allowable current in continuous duty.

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SUGGESTED PANEL LAYOUT

FIGURE 5-1

5.2.2 PANEL MOUNTING

The KH Drive is provided with "L" shaped mounting brackets, notched with keyhole type slots to accept screws on either end in order to facilitate mounting on flat panel surfaces. Refer to Section 9.1 for drive dimensions and keyhole slot locations. Since the KH Drive weighs approximately 32 lbs you should plan for suitable hardware such as 10-32 or 1/4 x 20 screws into captured nuts. Since it is possible that the fan may vibrate the mounting screws loose it is advisable to utilize locking type fasteners.

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For proper safety in servicing the equipment it is essential that the electrical connections for the KH Drive motor be equipped with a safety interlock switch (Section 5.4.4.1) so that service personnel can isolate the equipment from accidental actuation during service periods.

The KH Drive is designed to operate at 220-240 V.A.C. (3 phase) with an additional 110-120 V.A.C. (1 phase) input. Consequently, only qualified personnel should install and/or service the equipment as serious injury or death could result from mishandling of electrical components.

5.3 MOTOR MOUNTING

The KH brushless motor should be mounted using the four flange bolts provided and should be centered by the pilot on the front face. Refer to Section 9.2 for actual mechanical dimensions. Foot mounting is less desireable because the torque of the motor is not evenly distributed through the motor case. Side loads exerted on motor shafts can be seriously increased by a longer lever arm when a side mount is used as opposed to a recommended flange mount.

Motors used with the KH Drive will produce substantial torques as well as rapid accelerations. A combination of these forces can shear shafts and mounting hardware if the mounting design is faulty. Rapid acceleration can produce shock and vibration loads that require heavier hardware than normally required. The motor itself, under certain load profiles, can generate low frequency vibrations within the mounting structure as well. These vibrations can cause fasteners to work free if not locked. Therefore it is recommended that elastic nut type fasteners be used.

CAUTION

VIBRATIONS PRODUCED BY A CYCLING MOTOR CAN INDUCE METAL FATIGUE WITHIN STRUCTURAL MEMBERS.

For the best mounting design have all plans reviewed by a mechanical engineer.

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5.3.1 COUPLERS

Shaft misalignments are to be expected due to fabrication tolerances. Common shaft misalignment problems include parallel, angular, and end float misalignment.

Parallel misalignment is the offset of two shaft centerlines where the centerlines remain parallel to each other. Angular misalignment occurs when the shaft centerlines are not parallel, but intersecting at some angle greater or less than zero degrees. End Float is a variance in the relative distance between the ends of the two shafts.

Special couplings are available which can help you accommodate these misalignment problems while maintaining desired torque. Coupling types include single-flex, double-flex, and rigid types. A single-flex coupler will correct only for angular misalignment while a double-flex handles both angular and parallel problems. Depending upon their design both types may or may not accommodate end play problems. Rigid couplings do not compensate for any misalignments whatsoever and are therefore not recommended for most applications.

When joining two shafts that are fixed in the radial and angular direction, a double-flex coupling should be employed. Single-flex couplings are not recommended for this application because uncompensated parallel misalignment will eventually bend shafts and place bearings under unacceptable loads. Single-flex couplings are indicated if only one of the shafts are free to move radially. In this application a double-flex coupling is not advisable as it may allow too much freedom of movement leading to destructive vibration generation.

Applications for rigid couplings are extremely limited. They should be employed only if the motor is on floating mounts that allow for alignment compensation.

Check any coupling selected to ensure that the application falls within the range of coupling performance capabilities.

Parker Compumotor offers a line of suitable couplers for use with the KH Series systems. These couplings can solve problems encountered due to the metric shaft on the KH Series motors. Refer to Section 9.3 for a complete listing of all available couplers from Compumotor.

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5.4 WIRING

WARNING

ALL AC POWER MUST BE DISCONNECTED PRIOR TO INSTALLATION WIRING. FAILURE TO OBSERVE SAFE WORKING PRACTICES WHEN INSTALLING OR SERVICING THIS EQUIPMENT CAN BRING YOU INTO CONTACT WITH LIFE THREATENING VOLTAGES.

5.4.1 MOTOR CONNECTIONS

The KH Drive is provided with a preassembled motor cable. The motor end of the cable consists of a MS type connector, Amphenol part No. 97B-3106-24-22S for KH710 - KH740 motors, and Part No. PT06A-14-5S for KH250 - KH260 motors. The drive end consists of four (4) leads with spade terminals and should be completely attached to the system prior to application of any power. Note that the ground wire is connected at the spade terminal to an uninsulated stranded wire that touches the motor cable shield.

Motor connections to the KH Drive are marked "MOTOR A", "MOTOR B", "MOTOR C" on the main screw terminal block located on the front panel Terminals are marked as follows:

DRIVE		MOTOR CABLE
A		A = ORANGE/WHITE STRIPE
B		B = BLUE/WHITE STRIPE
C	MOTOR	C = GRAY/WHITE STRIPE
GND		GND = GREEN/WHITE STRIPE WITH SHIELD CONNECTION

The standard motor cable provided with the KH Drive is a 4 conductor, 12 AWG, 25 foot cable. If the motor and drive need to be mounted further apart than 25 feet, Compumotor can provide cables with the MS connector installed for cable lengths of up to 100 feet. To obtain these it is necessary to order them separately. See Section 11.1 for more information.

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Installations where wire lengths are in excess of 100 feet are not recommended. It is recommended that the motor cable be installed in conduit to minimize the noise coupling as well as for safety. Motor power cables should not be installed in the same conduit with resolver or indexer logic cables.

5.4.2 MOTOR BRAKING

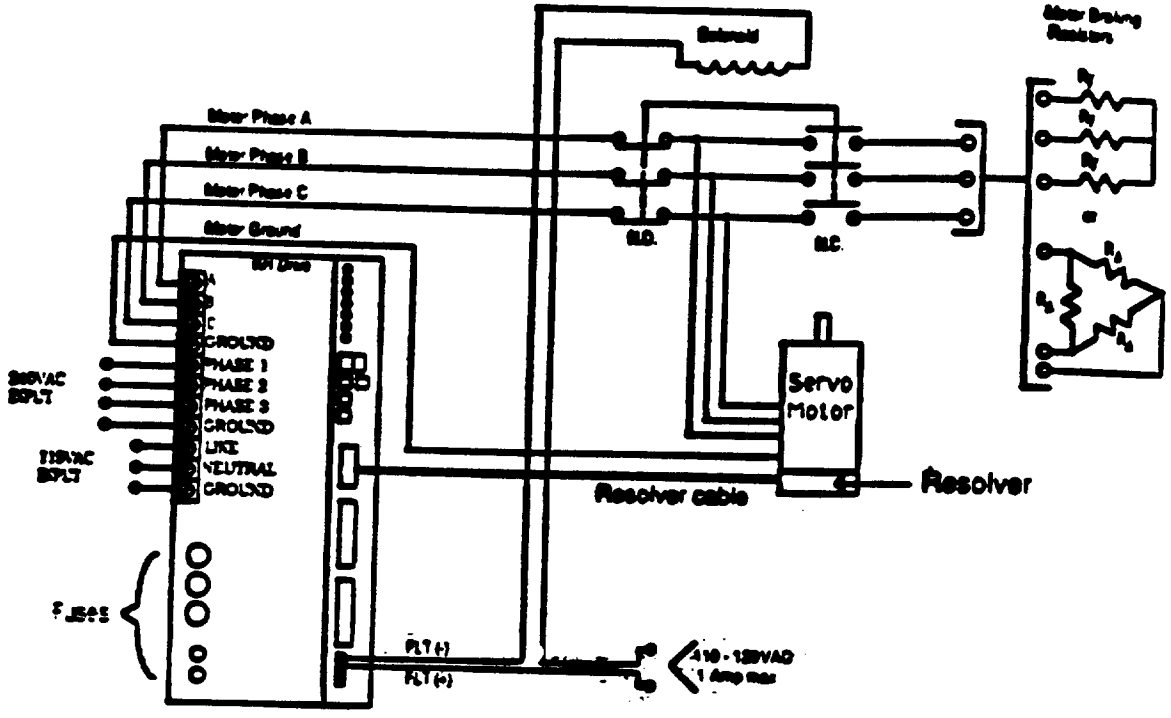
Under normal operation, the lack of STEP pulses constitutes a zero position and velocity command and the motor shaft should not be turning. When pulses are issued to the KH Drive, the shaft rotates in the direction commanded by the DIRECTION input. Accelerating the motor is accomplished by increasing the number of STEP pulses per unit time. Accordingly, decelerating the motor, or braking, is accomplished by decreasing the number of STEP pulses per unit time. If the commanded deceleration rate is too high, the KH may develop an excessive position error causing the amplifier to disable and freewheel its load. If a freewheeling load is unacceptable it may be necessary to employ auxiliary braking resistors.

Figure 5-2 illustrates a typical resistor braking scheme. In this scenario the motor contactor is energized first to provide a direct connection between the motor and drive. The motor contactor [N.O.(Normally Open)/N.C.(Normally Closed)] can be controlled by the FLT+/FLT-relay outputs on the KH Drive. If the amplifier faults for any reason or if either line voltage (240 V.A.C or 120 V.A.C.) is lost, the contactor connects the motor braking resistors across the motor. The motor braking resistors can be sized by analyzing specific applications.

If the total load inertia is less than five times the rotor inertia, then non-inductive 100 watt power resistors can be used as the braking resistors. For a "wye" configuration use 5 Ohms or more, for a "delta" configuration use 15 Ohms or more. If quicker stopping action is required, the braking resistors can be lowered, but the power rating must increase.

It is important to note that braking resistors provide very little braking at zero velocity. If stand still braking is required then the motor can be ordered from the factory with the spring type motor brake option. Please contact the factory for more information.

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Note: The solenoid is shown energized. The normally open switches are open during a drive fault or absence of power.

MOTOR BRAKING DIAGRAM

FIGURE 5-2

5.4.3 RESOLVER CONNECTIONS

The KH Drive is provided with a preassembled 50-foot resolver cable (Belden type 9536, 24 AWG, 33pF/ft, 25.2 Ohms/1000ft). The motor end of the cable includes an MS type connector, Amphenol part No. PT06E-14-19S. The drive end incorporates a 9 pin "D" style connector. Refer to Section 9.2 for the drive end connector pin out. Compumotor recommends that the 9-pin "D" connector be inserted, tightly screwed down, and excess cable coiled.

The KH Drive utilizes a phase detection scheme in determining the motor's position. It is essential that the real impedance of cable not be changed significantly in order to maintain positional accuracy over the 0 - 100°C motor operating temperature. A thermal compensation network is mounted in the motor housing and is designed to maintain a constant phase shift as a function of resolver temperature. It is therefore VERY IMPORTANT that the resolver cable NOT BE

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CUT. If the cable must be longer than 50 feet there are two alternatives: (1) Compumotor can supply a 100 foot cable (p/n 71-007127-100) or (2) use Belden Cable #9863 (24 AWG, 12.2 pF/ft, 31.8 Ohms/1000 ft). A very slight degradation in absolute position accuracy, as a function of motor temperature, will be noticed when using any cable not 50 foot long. Cable runs longer than 100 feet are not recommended.

5.4.4 LINE POWER CONNECTIONS

The KH Drive is designed to be operated from a 3-phase 240 V.A.C. line in conjunction with a single phase 100-130 V.A.C. line. Figure 5-3 illustrates the various ways to provide the main input power. The three input phase terminals feed a 3-phase rectifier that has current in-rush protection. The 1-phase input provides power for both the fan and the low voltage power supply. It has current in-rush protection as well.

An 5 KVA isolation transformer may be used but is not necessary if proper grounding procedures are followed. There is no ground fault detection in the drive so special care must be taken to ensure that the incoming three phase power ground is at the same potential as the single phase ground.

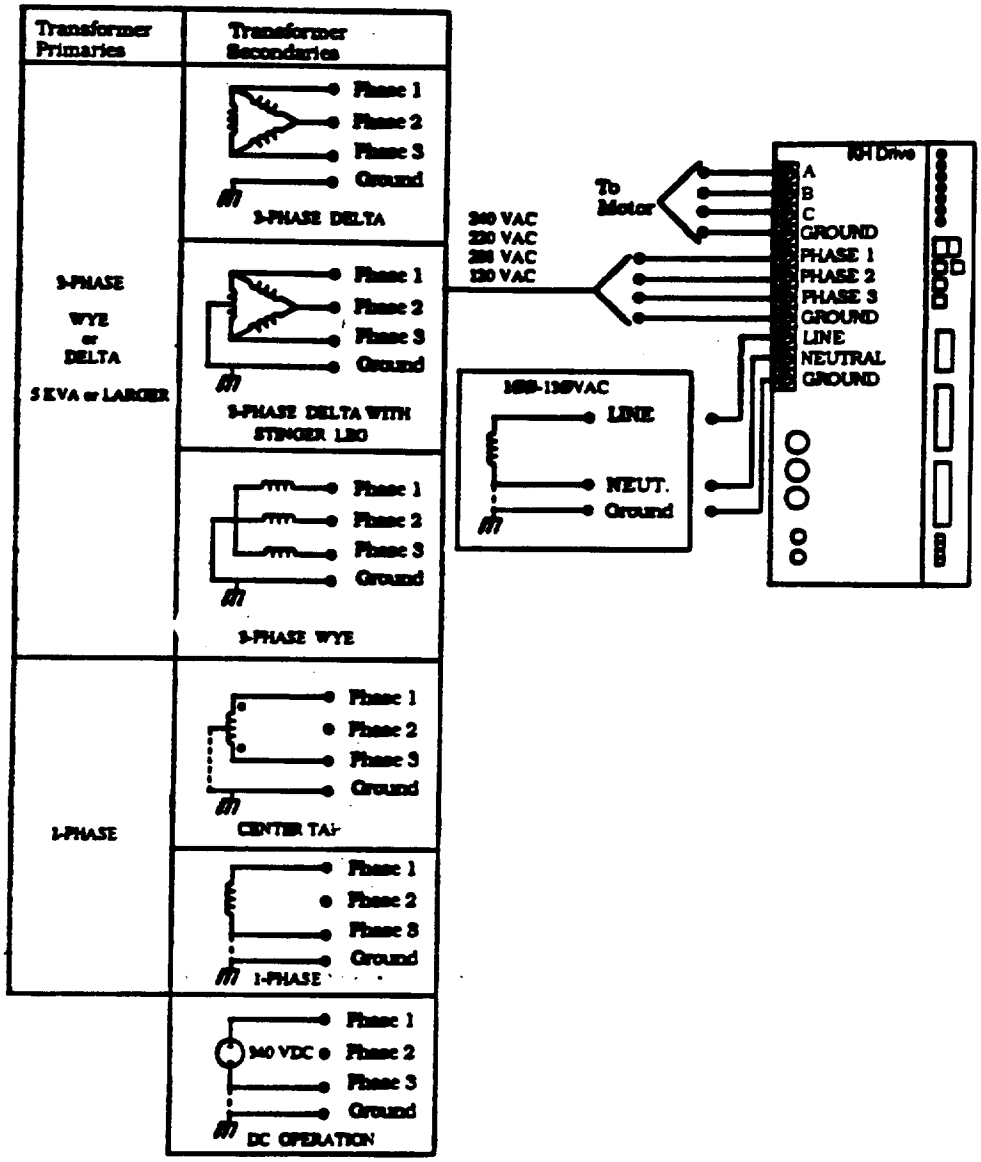
5.4.4.1 SAFETY INTERLOCK SWITCH

A 3-Phase safety interlock switch should be placed between the drive and the power source to provide a convenient way to de-energize the drive in an emergency and/or service situation. A resetable circuit breaker can also be used.

5.4.4.2 FUSES

The drive is fused for both the 240 V.A.C. 3-Phase power (20 A) and the 120 V.A.C. 1-Phase power (2 A). These fuses are accessible from the front panel (see Figure 1-1). Extra line fusing or circuit breakers can also be used but should be rated similarly to the internal fuse ratings.

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KH DRIVE LINE POWER CONNECTIONS

FIGURE 5-3

5.4.5 INDEXER CONNECTIONS

The indexer connector on the KH Drive is a 25-pin "D" type connector which is compatible with indexer to motor/drive cables supplied with all Compumotor indexers. If you have purchased a Compumotor indexer simply connect the cable provided with your indexer to the drive.

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The following inputs and outputs are located on the KH Drive's 25 pin indexer "D" connector:

INPUTS:

STEP+	PIN 1
STEP-	PIN 14
DIRECTION+	PIN 2
DIRECTION-	PIN 15
REMOTE SHUTDOWN+	PIN 16
REMOTE SHUTDOWN-	PIN 17
FAULT RESET+	PIN 7
FAULT RESET-	PIN 19

OUTPUTS:

IN POSITION+	PIN 10
IN POSITION-	PIN 22
DRIVE FAULT+	PIN 9
DRIVE FAULT-	PIN 21

A complete description of these indexer connections can be found in Section 6.6.

5.4.6 DRIVE ENABLE/FAULT CONNECTIONS (4-PIN PHOENIX)

The KH Drive has two signals on the 4-pin Phoenix connector, DRIVE ENABLE (ENA+ and ENA-) and FAULT (FLT+ and FLT-).

The DRIVE ENABLE is a normally closed input that may be used to disable the KH. The KH Drive is shipped with a wire jumper between ENA+ and ENA-. If this jumper is left installed the KH will <u>not</u> be disabled due to this input.

The FAULT output is normally closed while the drive is operating properly. A complete description of these connections can be found in Section 6.7.

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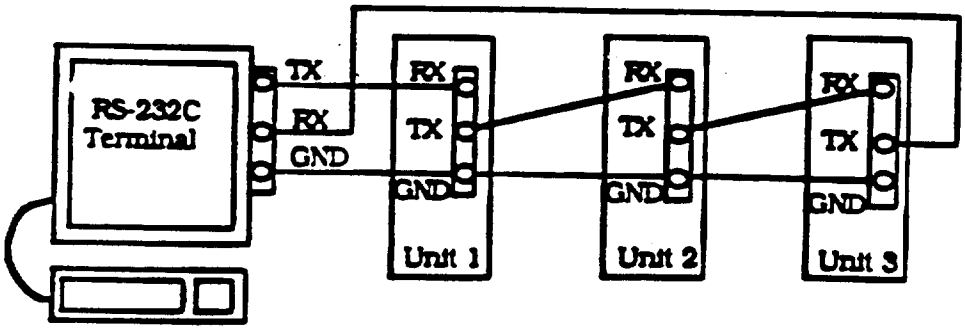
5.4.7 RS-232 CONNECTOR

The KH Drive can communicate via RS-232C to any terminal or host computer which can be configured for RS-232C. The KH Drive has a set of commands which can be used for configuring the drive, tuning gain parameters, and displaying various drive variables. A complete list of KH commands is found in Appendix C.

The RS-232 connector is a standard 25-pin "D" type connector. The KH Drive has a three wire, optically isolated implementation of this interface and provides RECEIVE DATA (pin 2), TRANSMIT DATA (pin 3), and GROUND (pin 7) signals on the connector. All other pins are not connected. The RS-232C communications are compatible with EIA RS-232C specifications. Proper shielding of the RS-232C signal wires is strongly recommended. The shield should be connected to an earth ground point on the terminal.

The communication format is fixed at 9600 baud, 8 data bits, 1 stop bit, and no parity. No handshaking is supported.

Figure 5-4 shows a multiple drive connection (daisy chain) of RS-232 ports from one controlling terminal or computer.



KH RS-232C DAISY CHAIN CONFIGURATION

FIGURE 5-4

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SECTION 6

OPERATION

6.1 GENERAL

Procedures presented in this section are intended to assist the user in quickly and safely operating the KH Drive. Once the system has been properly installed (see Section 5) and initial adjustments completed there should be little or no adjustment required to maintain normal operation of the drives.

6.2 POWERING UP THE SYSTEM

In order to become familiar with the operating procedures of the KH Drive system it is recommended that the first start-up be attempted without connecting the motor to its intended load.

1) Make certain that the motor shaft is clear of cables or loose objects which could tangle when the shaft turns.

2) Verify that all cables (motor, resolver, and indexer) are properly connected, as detailed in Section 5.4.

3) The motor should be firmly supported to prevent it from shifting while running during the test.

4) Measure and verify the incoming 3-Phase 240 V.A.C. line and the 1-Phase 120 V.A.C. line.

5) Energize both the 240 3-Phase and the 120 1-Phase power. You may energize either the 3-phase power or the 1-phase power first. If you energize the 3-phase power first, or if you energize both the 3-Phase and the 1-Phase power simultaneously, the drive will come up in the enabled (servoing) state. If, on the other hand, you energize the 1-phase first the drive will come up faulted with error #18 displayed (no voltage at the 220-240 V.A.C. connector). Energizing the 3-phase power and commanding the amplifier to turn ON will remove error #18.

WARNING

SAFETY PRECAUTION: DO NOT GRAB HOLD OF THE MOTOR SHAFT WHILE THE MOTOR IS ENERGIZED.

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6.3 VISUAL INDICATORS

There are seven LED indicators on the KH Drive. They are functionally described here. See Figure 1-1 for an illustration of the KH Drive front panel for the location of status LEDs.

6.3.1 STATUS

The STATUS LED will normally be green when the drive is properly powered up and running.

If the STATUS LED is red then the microprocessor requires resetting. It will be necessary to cycle the 110-120 V.A.C. power.

6.3.2 REGEN ACTIVE

This LED is normally off.

The REGENeration circuit ACTIVE LED will blink on when the motor is generating power that is being dissipated in the internally connected power dump resistors. This is a normal function when the motor is decelerating.

If this LED is on more than 10% of the move time or for more than 5 seconds in duration then the motor sizing and duty cycle calculations should be reconsidered. It may be necessary to decrease the commanded acceleration/deceleration or to increase the motor size to lower the regenerative bus voltage.

6.3.3 MAX CURR

This LED is normally off.

The MAX CURRent LED is yellow if the user specified peak current [CCP (CONFIGURE MAXIMUM CURRENT PEAK)] has been reached. Meeting this peak current limit will not cause the drive to fault out. This LED is a warning. It indicates the frequency at which the amplifier is commanded to send the user specified peak current to the motor.

6.3.4 ERROR

This LED is normally off.

The ERROR LED will be red only if the microprocessor detects an error condition. This LED will not be lit if the drive is commanded to be off. When the drive faults the error LED will glow and the numerical LED display will show the numerical error code.

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A summary of the KH error codes is shown below:

ERROR CODES

CODE		CONDITION
11		Drive over temperature
16	*	Amplifier off
17	*	Indexer Shutdown
18		No voltage present at 220-240 V.A.C. input. 110 V.A.C. ok.
19		Short circuit detected at motor terminals
20		Following error exceeded
22		Maximum average current exceeded
23		Drive disabled by Drive Enable input on Phoenix connector.
30		EEPROM checksum error
60	*	Amplifier off due to RS-232C command
61		Incoming indexer pulses (not allowed when KH is powered up)
70		Resolver signal not present (check resolver connection)

* Denotes error code available with the RSE (Report Servo Errors) command only which do not appear on the front panel display.

SEE SECTION 7.4 FOR TROUBLESHOOTING INFORMATION

NOTE: USE THE RSE (REPORT SERVO ERRORS) COMMAND WHENEVER AN ERROR EXISTS. THE LED ERROR CODE DISPLAY WILL ONLY INDICATE ONE ERROR EVEN IF MORE ACTUALLY EXIST. BY USING THE RSE COMMAND ALL ERRORS WILL BE DISPLAYED ON YOUR TERMINAL.

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6.3.5 SHORT CIRCUIT

This LED is normally off.

The SHORT CIRCUIT LED is red if the drive detects a short in the motor circuit. This can be either a phase to phase short or a phase to ground short. This can be caused by incorrect wiring, improper motor selection, or a defective motor. This error can only be cleared by turning the AC power off for at least 30 seconds, correcting the wiring, and then powering back up.

6.3.6 TEMP

This LED is normally off.

The TEMP LED is red if the drive has detected that the heatsink temperature is too high. The recommended maximum ambient temperature for the KH Drive is 50°C.

6.3.7 AMP OFF

This LED is normally off.

The AMP OFF LED is red whenever the amplifier is off, either due to a drive fault or due to the drive being commanded to be off (via the OFF command or the ENABLE plug).

6.4 INTRODUCTION TO RS-232C COMMANDS

The KH Drive has over 30 software commands that may be used for tuning the drive, defining various parameters, displaying drive variables, and more. All software commands are sent to the drive over the RS-232C serial communications interface. Any terminal or computer that has a RS-232C port can communicate with the KH Drive. Section 5.4.7 details the hook-up of the RS-232C port, and Section 7.5 offers troubleshooting guidelines in case you have difficulties in establishing communication.

The purpose of this section is to let the user know that the following commands are available, and to instruct the user about the command format.

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Commands for defining and reporting tuning parameters:

CPG	CONFIGURE PROPORTIONAL GAIN
CIG	CONFIGURE INTEGRAL GAIN
CDG	CONFIGURE DERIVATIVE GAIN
CVG	CONFIGURE VELOCITY GAIN

Commands for defining and reporting other drive parameters:

CMR	CONFIGURE MOTOR RESOLUTION
CDB	CONFIGURE DEADBAND
CPE	CONFIGURE POSITION ERROR
CCA	CONFIGURE CURRENT AVERAGE
CCP	CONFIGURE CURRENT PEAK
CPB	CONFIGURE PUSH BUTTON

Commands for reporting drive variables:

DCA	DISPLAY CURRENT AVERAGE
DCP	DISPLAY CURRENT PEAK
DVS	DISPLAY VELOCITY SETPOINT
DVA	DISPLAY VELOCITY ACTUAL
DCI	DISPLAY CURRENT INSTANTANEOUS
DPS	DISPLAY SETPOINT POSITION
DIC	DISPLAY INDEXER COUNTER
DPR	DISPLAY RESOLVER POSITION
DPA	DISPLAY POSITION ACTUAL
DPE	DISPLAY POSITION ERROR
RSE	REPORT SERVO ERRORS
RV	REVISION LEVEL

Miscellaneous Commands:

E	ENABLE COMMUNICATIONS INTERFACE
F	DISABLE COMMUNICATIONS INTERFACE
OFF	AMPLIFIER OFF
ON	AMPLIFIER ON
RFS	RETURN DRIVE PARAMETERS TO FACTORY SETTING
S	STOP
SV	SAVE

APPENDIX C FULLY DESCRIBES EACH COMMAND AND GIVES EXAMPLES.

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If RS-232C communications have been correctly established, the drive will echo the characters transmitted to it. All invalid commands will be ignored by the KH.

When the KH Drive is first powered-up, the drive is in "front panel mode," meaning it is listening to the front panel pushbuttons and not to the commands being sent over RS-232C. Sending the E (ENABLE COMMUNICATIONS INTERFACE) command to the drive via RS-232C will instruct the drive to enter "RS-232C mode," where the drive listens to the RS-232C commands, and not the front panel pushbuttons.

6.5 INDEXER FUNCTIONS

Compumotor offers a variety of indexers which are compatible with the KH Drive. The indexer will typically be set up for 1 revolution equals 25,000 steps. The KH default setting is 5,000 steps per revolution. If nothing is changed the motor will run five (5) times as fast and move five times as far as the indexer settings. There are several options to make the indexer and drive compatible. The easiest is to use the CMR (CONFIGURE MOTOR RESOLUTION) command on the KH Drive to set up the motor for 25,000 steps per revolution. Since the KH is limited to a 500 kHz step input, however, increasing the KH's resolution will limit the maximum speed. Alternatively, most Compumotor indexers allow for numerous motor resolutions. Typically both the indexer and KH's resolution are adjusted to meet the application speed/accuracy requirements. Compumotor recommends that the indexer and motor resolutions match whenever possible in order to avoid any possible confusion.

6.6 INDEXER INPUTS AND OUTPUTS

The following is a functional description of the indexer inputs and outputs.

All indexer inputs and outputs are optically isolated. See Sections 8 and 9 for complete electrical specifications and pinouts for these connections.

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INPUTS

6.6.1 STEP + (PIN 1) / STEP - (PIN 14)

The **STEP** input pulse causes the motor position to be incremented one unit of feedback resolution. The resolver feedback used with the KH Drive is digitized to 5,000 steps per revolution (factory default). Optional resolutions of 200 to 32,768 steps per revolution are programmable by using the **CMR** (CONFIGURE MOTOR RESOLUTION) command. By applying **STEP**s at various rates the motor is made to rotate at proportional velocities. **STEP** pulses applied first slowly, and then ramping up in pulse frequencies have the effect of accelerating the motor.

Attempting to accelerate the motor too quickly can cause the motor to lag behind the commanded position. There is an adjustable user defined value for maximum following error which will shut down the drive if exceeded [See **CPE** (CONFIGURE FOLLOWING ERROR) command]. The default **CPE** is one motor revolution. There is also a **IN POSITION** output to indicate if the motor is within the specified deadband or not.

This differential **STEP** input is optically isolated to eliminate external noise from affecting the drive. This signal should be between 3.0 and 5.0 volts, and capable of supplying 20 milliamps of current. The **STEP** input requires a pulse at least 1 microsecond long to be acknowledged by the drive as a single positional step.

6.6.2 DIRECTION + (PIN 2) / DIRECTION - (PIN 15)

The **DIRECTION** input controls the direction of rotation of the motor. When this signal is not activated the motor shaft rotates clockwise as viewed from the flange end of the motor. The motor shaft rotates counter-clockwise if the **DIRECTION** input is activated. This input is isolated similarly to the **STEP** input, but the opto couplers are slower. Current must flow through the opto LED for more than 10 microseconds in order to activate it.

6.6.3 REMOTE POWER SHUTDOWN + (PIN 16) / REMOTE POWER SHUTDOWN - (PIN 17)

Activation of the **REMOTE POWER SHUTDOWN** input causes the drive to stop supplying current to the motor. This will allow the motor to freewheel and is intended to allow manual positioning of the motor or load.

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WARNING

ACTIVATION OF THE REMOTE POWER SHUTDOWN IS NOT INTENDED TO ACT AS AN EMERGENCY STOP FOR THE MOTOR. IF REMOTE POWER SHUTDOWN IS USED IN THIS MANNER THE MOTOR WILL LIKELY MOVE BEYOND THE NORMAL STOPPING POSITION, POSSIBLY ENDANGERING LIFE, LIMB, and PROPERTY. SEE SECTION 5.4.2 FOR SUGGESTIONS ON INSTALLING BRAKING RESISTORS FOR EMERGENCY STOPS.

6.6.4 FAULT RESET + (PIN 7) / FAULT RESET - (PIN 19)

The FAULT RESET input will reset the microprocessor and clear an ERROR or DRIVE FAULT condition if the condition causing the fault has been removed. The exception to this is the short circuit fault in which case the AC power for the 110-120 V.A.C. line must be removed for at least 30 seconds before cycling power.

OUTPUTS

6.6.5 IN POSITION + (PIN 10) / IN POSITION - (PIN 22)

The IN POSITION output is off whenever the actual position of the motor is outside the user defined deadband. This output is active when the absolute value of the position following error is less than the deadband. This deadband is specified by the CDB (CONFIGURE DEADBAND) command.

6.6.6 DRIVE FAULT + (PIN 9) / DRIVE FAULT - (PIN 21)

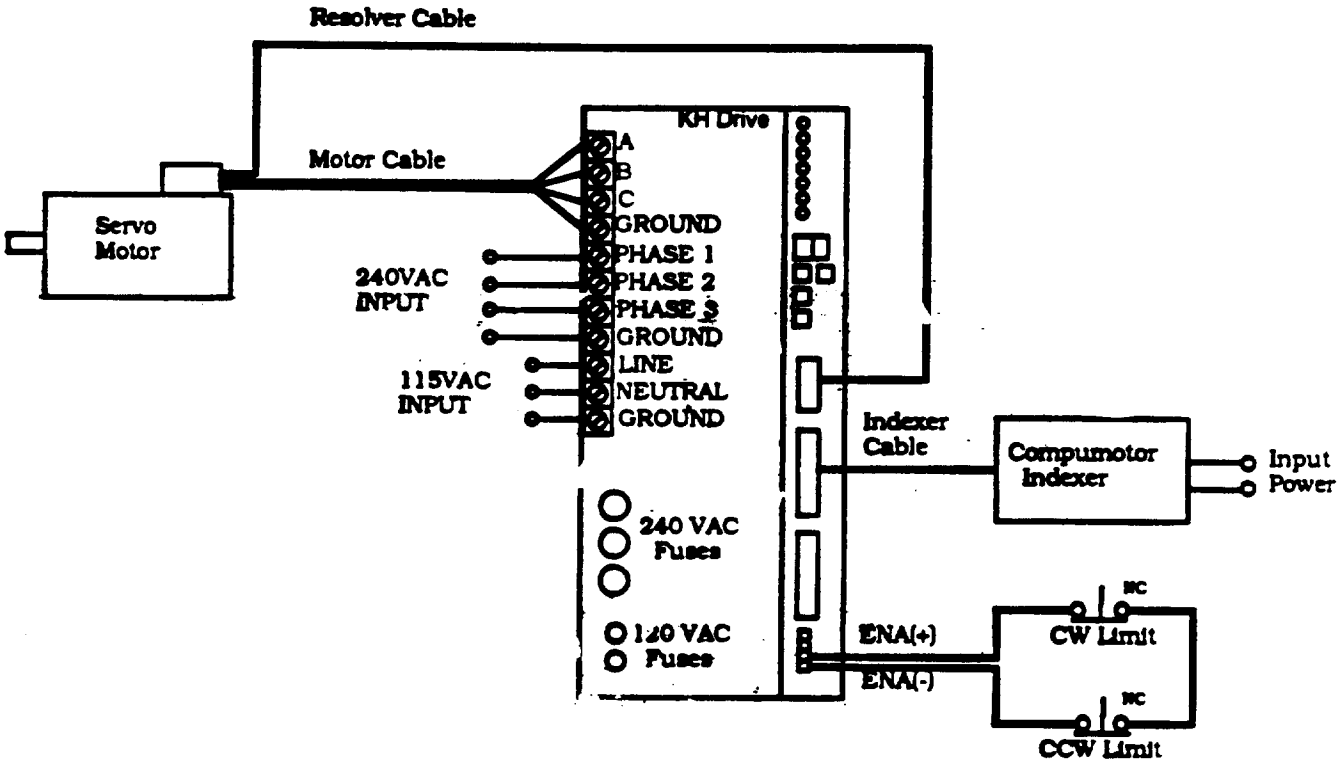
The DRIVE FAULT output is normally active. The output is off when the drive is shut down for any reason, including absence of power to the drive. Faults originating in the amplifier may include drive over-temperature condition, motor short circuit, and bus under-voltage. Faults originating in the controller may include shutdown, excess following error, and average current limit exceeded. Once the condition causing the fault has been cleared and the drive reset, normal operation may resume.

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6.7 DRIVE ENABLE/FAULT 4-PIN PHOENIX CONNECTOR

6.7.1 DRIVE ENABLE + / DRIVE ENABLE -

The DRIVE ENABLE input can be used to enable or disable operation of the Drive. This input requires a normally closed connection from ENA(+) to ENA(-) terminal. A jumper is supplied from the factory. If you want hardwired end-of-travel limit switches to bypass the indexer, you should connect them in series to this input.



LIMIT SWITCH HOOK-UP

FIGURE 6-1

6.7.2 DRIVE FAULT OUTPUT RELAY (+/-)

This output is identical to the DRIVE FAULT OUTPUT on the indexer connector. The FAULT output can drive a solid state relay that switches braking resistors into the motor circuit in the event of a fault. This is recommended if there are safety implications with the motor "freewheeling" during a power failure, or due to drive faults. See Section 5.4.2 for more information on braking resistors.

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6.8 TUNING

6.8.1 TUNING THEORY

The KH Drive can be divided into two major areas: the digital controller board and the analog amplifier board. Positioning compensation (PROPORTIONAL, INTEGRAL, and DERIVATIVE gains) as well as VELOCITY gain are set by the user, and handled by the digital controller board. Figure 6-2 shows a block diagram of the KH servo loop.

The controller board sends two digitized waveforms from its DACs to the analog amplifier board. These waveforms represent two of the three commanded motor stator currents. The analog amplifier board compares these commands to the actual measured motor current to determine the proper output voltage pulse widths.

The position of the motor's shaft is sensed by the controller via the resolver attached to the rotor of the motor. This positional information is used by the controller to electrically commutate the motor.

The current command to the amplifier from the controller is based on several quantities, not just the position of the servo motor's shaft. It is based on a desired position, which is generated by an indexer, and on previous position errors. An indexer generates a stream of pulses which the controller collects with an up/down (i.e. clockwise/counterclockwise) counter. The resultant pulse count, at any given instant, is the desired position.

The controller subtracts the motor's actual position from this desired position to determine the positional error. The positional error is the difference between where we want the motor to be and where it actually is. This positional error is put into an equation, along with previous positional errors, to generate the motor current command for the amplifier. The equation is a mathematical function that is evaluated at periodic time intervals. In the case of the KH Drive, the equation is an approximation of an analog, continuous-time PID network. The analog, continuous-time PID is traditionally used quite often for the purpose of stabilizing conventional servo systems and consists of several potentiometers, resistors, and capacitors. In the KH Drive the potentiometers, capacitors, and resistors are replaced with digital logic, controlled by a microprocessor.

The KH Drive's equation is the discrete-time equivalent to a continuous-time PID network. It is called a discrete-time PID network because it operates on sampled digital data rather than on continuous analog data. The sampling-rate of the KH Drive controller is the rate at which the servo algorithm is evaluated

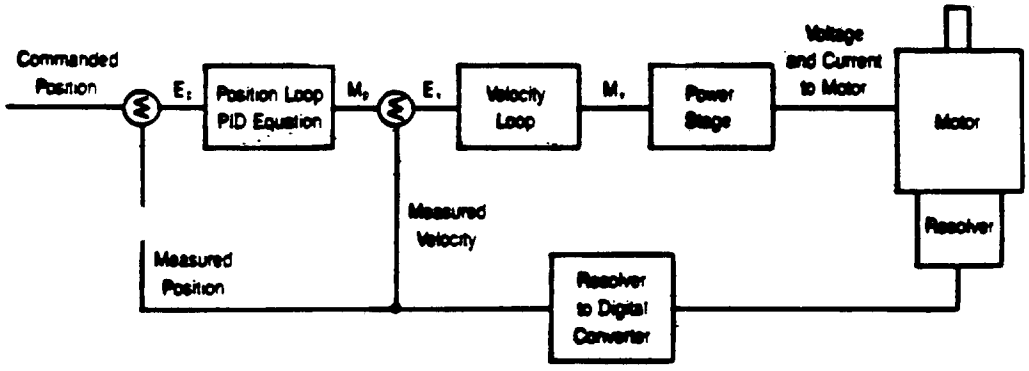
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and the motor current command to the amplifier is changed. The sampling-rate of the KH Drive controller is 512 microseconds. By using such a fast rate, excellent dynamic response is achieved.

The mathematical model for the tuning algorithm is based on the four gain values that are selected and the feedback from the resolver:

proportion, integral, derivative & velocity

The resolver is read once every 512 microseconds. This provides position information. The desired position is compared to the actual position and an error value is generated.



E_p = System Positional Error
M_p = System Positional Correction Factor (Commanded Velocity)
E_v = System Velocity Error
M_v = System Velocity Correction Factor

KH SERVO LOOP

FIGURE 6-2

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The commanded velocity (positional correction) is calculated from the following formula:

$$M_P = [K_P \times e(t)] + [K_I \times \Sigma e(t)] + [K_D \times (e(t) - e(t-1))]$$

where,

M_P = System Positional Correction Factor

K_P = Proportional Gain

$e(t)$ = Positional error

K_I = Integral Gain

$\Sigma e(t)$ = Sum of previous positional errors

K_D = Derivative Gain

EQUATION 6-1

The magnitude of the commanded current is calculated from the following formula:

$$M_v = K_v \cdot E_v$$

Where:

M_v = Magnitude of motor current command

K_v = Velocity gain

E_v = System velocity error

EQUATION 6-2

The proportional term primarily affects stiffness. The derivative term affects settling time and dynamic response. The Integral term affects the final positional accuracy. However, all gains are coupled and interact to a certain extent.

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6.8.1.1 PROPORTIONAL GAIN

Proportional gain affects system stiffness and accuracy. As the proportional gain is adjusted higher the influence of the feedback signal becomes greater. If gain is sufficiently high the system will oscillate. This happens because very small resolver changes are amplified into very large error signals and the inertia of the motor and load will not allow the system to follow the electronic commands fast enough. System lag time will eventually reach a point where the feedback and the command signals are in phase, causing oscillation. When this occurs there is no alternative but to reduce the gain to below the oscillation threshold.

6.8.1.2 INTEGRAL GAIN

Integral gain allows the system to compensate for steady state position errors (i.e. due to friction). Integral gain also works to reduce velocity ripple. This is accomplished by slowing the electronic response time so that it more closely resembles the response of the mechanical components of the loop.

6.8.1.3 DERIVATIVE GAIN

Derivative gain adds dampening effects to the system. In the case of a system oscillating at the end of a move, or around changes in velocity, increasing the derivative gain will reduce the oscillation. The derivative gain adds phase lead to compensate for the system's natural phase lag.

6.8.1.4 VELOCITY GAIN

This gain is used to affect the overall responsiveness of the system. If the system is too sluggish the velocity gain can be increased. On the other hand, if the system is overshooting badly, or there is excessive ringing for which the derivative term is not able to adequately compensate, reduce the velocity gain.

6.8.2 PUSHBUTTON TUNING AND OTHER FEATURES

The KH Drive has five pushbuttons on the front panel which provide a simple pushbutton method of fine tuning system performance to a specific attached load. The KH Drive is factory preset for typical user loads and for the individual motor supplied with the system. For many applications little or no adjustment is required by the user.

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On the front panel of the KH Drive there are five pushbuttons and a two digit LED display. The buttons are labeled "UP", "DOWN", "P", "I", and "V". The button labeled "P" selects the PROPORTIONAL term in tuning the drive. The one labeled "I" selects INTEGRAL while button "V" selects VELOCITY. In order to select DERIVATIVE control one must press both the "I" and "V" buttons at the same time. Figure 6-2 lists the functionality of all five buttons.

Select one of the buttons (P,I, or V) and hold it down. The two digit display will light to indicate the present value for the term selected. While holding the button for the term selected push the "UP" button once and release it to increase the value of the term by one count. Push the "DOWN" button once and release it to decrease the value of the term by one count. Repeated pushes on the "UP" or the "DOWN" button will cause the term to continue to increase or decrease by one unit for each push of the button. Hold the term button down while using the "UP" and "DOWN" buttons. If none of the term buttons are selected the display will not be lighted and no value changes will occur from pressing the "UP" or "DOWN" buttons.

The selected value will be immediately used. This allows one to adjust the motor while observing its performance.

If you adjust the gains and the system appears unstable, use the RFS (RETURN TO FACTORY SETTINGS) command or the pushbutton combination to return to the factory settings. To reinstall default values using the pushbuttons, push both the "P" and "I" buttons and release them at the same time (see Figure 6-3).

In order to set a DEVICE ADDRESS for the RS-232 port on the KH Drive press the "P" and "V" buttons while at the same time using the "UP" and "DOWN" buttons to choose a device address between 1 and 15. Default address is "1". If multiple KH Drives are connected in an RS-232C daisy-chain then each drive requires a unique device address.

After tuning or changing a device address, it is necessary to SAVE the new values into the non-volatile memory (EEPROM). This is accomplished by pressing all three term buttons (P, I, & V) at the same time and releasing them.

Any software controlled drive faults, except for motor short circuit condition, can be RESET by pushing both the "UP" and "DOWN" buttons and releasing them at the same time.

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KH PUSHBUTTON COMMAND SUMMARY

UP	DOWN	P	I	V	CONDITION
0	0	0	0	0	display off/unless error led is on
0	0	+	0	0	display current PROPORTIONAL value
+	0	+	0	0	increase PROPORTIONAL value
0	+	+	0	0	decrease PROPORTIONAL value
0	0	0	+	0	display current INTEGRAL value
+	0	0	+	0	increase INTEGRAL value
0	+	0	+	0	Decrease INTEGRAL value
0	0	0	0	+	display current VELOCITY value
+	0	0	0	+	increase VELOCITY value
0	+	0	0	+	decrease VELOCITY value
0	0	0	+	+	display current DERIVATIVE value
+	0	0	+	+	increase DERIVATIVE value
0	+	0	+	+	decrease DERIVATIVE value
0	0	+	0	+	display current DEVICE ADDRESS
+	0	+	0	+	increase DEVICE ADDRESS (max of 15)
0	+	+	0	+	decrease DEVICE ADDRESS (min of 1)
0	0	+	+	0	return to factory default
0	0	+	+	+	SAVE tuning values
+	+	0	0	0	RESET

+ = PUSHED

0 = NOT PUSHED

Other combinations are ignored.

FIGURE 6-3

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6.8.3 RS-232 TUNING OF THE KH SERVO SYSTEM

The tuning process of the front panel switches can be duplicated via the RS-232 communication port. If this is desirable, connect the computer or terminal to the RS-232 connector on the drive. See Section 5.4.7 for RS-232C hook-up information.

The following commands can be used to change the tuning parameters in the same manner as pushbutton tuning:

CPG	CONFIGURE THE PROPORTIONAL GAIN
CIG	CONFIGURE THE INTEGRAL GAIN
CDG	CONFIGURE THE DERIVATIVE GAIN
CVG	CONFIGURE THE VELOCITY GAIN

EXAMPLE: CPG25 Will change the Proportional gain to 25% of its maximum value.

All commands must be followed by a space or carriage return (as a delimiter).

These same commands can be used to report back the current gain settings to the terminal screen.

EXAMPLE: 1CPG will respond *PROPORTIONAL_GAIN=25_PERCENT

The "1" in front of the CPG command is necessary. It is a device address identifier. This is to prevent multiple drives on a daisy-chain from all reporting at once.

The P,I,D and V gains represent a certain percent of maximum. If it is necessary to tune the drive with gains at either end of the 0 - 99 percent range, it may be necessary to alter the maximum values with the following commands:

CPM	CONFIGURE PROPORTIONAL MAXIMUM
CIM	CONFIGURE INTEGRAL MAXIMUM
CDM	CONFIGURE DERIVATIVE MAXIMUM
CVM	CONFIGURE VELOCITY MAXIMUM

These commands can change the maximum values, or can be used to report the current settings, just like the above example. The SV (SAVE) command will save the current gain percent and maximum values in non-volatile memory.

See Appendix C for the complete list of all software commands.

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6.8.4 APPLICATION SPECIFIC TUNING

This section further explains the tuning procedure for your particular application.

6.8.4.1 DEFAULT TUNING PARAMETERS

The KH Drive has a set of default tuning parameters. Your system will be shipped from the factory with the appropriate default values saved in memory. These defaults are based on the assumption of a load to rotor inertia of 5 to 1 or less, that the load is mostly inertia, that it is directly and solidly coupled to the motor, and that a 4% positional overshoot is tolerable. If you change any of the gain settings, the RFS (RETURN FACTORY SETTINGS) command will restore the factory defaults. The RFS command also affects some other system variables, so see Appendix C for a complete description of the RFS command. The following table lists the default gain settings for each KH Series motor:

GAINS:

MOTOR	CPG	CPM	CIG	CIM	CDG	CDM	CVG	CVM
250	30	1000	15	1280	0	30	20	10000
260	30	1000	15	1280	0	30	25	10000
710	35	1000	20	1280	4	30	50	10000
720	35	1000	40	1280	4	30	75	12000
730	35	1000	40	1280	4	30	50	20000
740	40	1000	40	1280	4	30	60	20000

6.8.4.2 OPTIMIZING TUNING PARAMETERS

Once the system is installed and the motor connected to its load, determine whether any fine tuning is necessary by observing the response of the system to commands from the indexer and by observing how "stiff" the system is when at rest.

With the motor at rest try and deflect the shaft. It should not be easy to turn the shaft away from its rest position. If it feels very soft the velocity gain probably needs to be increased. A very soft system will not respond quickly to move commands. If the shaft feels stiff be certain to check that the system is not vibrating. If it is vibrating the velocity gain may be too high. This will cause the drive to provide excess current and can shorten the life of mechanical components. In extreme cases the vibration will grow in amplitude producing ever more violent motions until the drive faults or something breaks. For this reason tuning of the KH Drive should always be approached with some degree of caution.

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6.8.4.3 COMMON TUNING PROBLEMS:

* **EXCESSIVE POSITIONAL ERRORS**

Excessive positional errors may be due to the load inertia. The amount of load inertia affects the torque required for a given acceleration. If the load inertia is larger that 10 times the motor's rotor inertia it may be necessary to trade some speed performance for final position accuracy. To do this, reduce the VELOCITY gain and increase the INTEGRAL gain.

Positional errors may also be due to friction. Significant friction in the load may cause end-of-move positional errors. It may be necessary to trade system response for final positional accuracy. To do this increase the INTEGRAL gain, increase the DERIVATIVE gain and if necessary decrease PROPORTIONAL or VELOCITY gains.

* **INADEQUATE RESPONSE**

Load inertia may cause a slow system response. In a system where the load inertia is larger than the factory settings allow, it may be possible to increase the system response time by allowing the overshoot to increase. To do this, increase the VELOCITY gain, increase the PROPORTIONAL gain and decrease the INTEGRAL gain.

The system's response may also be inadequate due to high torque requirements at high acceleration. Some systems may have very little inertia, but need high torques for very high accelerations. In this case it may be desireable to narrow the range of values that the system can handle in order to optimize the move profile for a light load. To do this increase the PROPORTIONAL and VELOCITY gains while decreasing the INTEGRAL term.

* **SHAFT AND COUPLING VIBRATION**

If the load is coupled to the shaft through a non-rigid coupler, the shaft and coupler oscillate at a frequency greater than would be possible for the system as a whole. In this case it may be necessary to trade system response for system stability. To do this increase the INTEGRAL and DERIVATIVE gains while decreasing VELOCITY or PROPORTIONAL gains.

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6.8.4.4 GENERAL TUNING CONSIDERATIONS

Remember that all tuning terms are interactive and it may take some experimentation to find the exact combination of values to get the best performance for a specific application.

Generally, the VELOCITY term should be set first, followed by PROPORTIONAL, then INTEGRAL and finally the DERIVATIVE term.

Remember to save tuning parameters in non-volatile memory before powering down the KH Drive. Either use the appropriate pushbutton combination (see Figure 6-2) or the RS-232C SV (SAVE) command.

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SECTION 7 MAINTENANCE AND TROUBLESHOOTING

7.1 MOTOR MAINTENANCE

The motor should be inspected regularly to ensure that no bolts or couplings have worked loose during normal operation. This can prevent minor problems from developing into anything more serious.

The motor is brushless and the bearings are sealed, so no maintenance, other than regular visual inspection, is necessary.

7.2 DRIVE MAINTENANCE

The KH Drive requires very little maintenance, but the NEMA cabinet should be regularly inspected to make sure that the air filters are kept clean. The KH Drive requires good air flow for proper cooling.

7.3 DIAGNOSTIC LEDS

The seven diagnostic LEDs on the front of the KH Drive are:

* STATUS
* REGENeration ACTIVE
* MAXimum CURRent exceeded
* ERROR
* SHORT CIRCUIT
* TEMPerature
* AMPlifier OFF

These indicators are functionally described in Section 6.3. Refer to Section 6.3 if more information is needed.

If the STATUS LED turns red, the microprocessor needs resetting; cycle the 110-120 V.A.C. power.

The REGEN ACTIVE LED is a warning. If the LED is on for more than 10% of the move, or longer than 5 seconds, then the acceleration and deceleration rates should be decreased, or the motor selection should be reconsidered.

The MAX CURR LED is only a warning. If this LED is on for more than 20% of the move, then the acceleration and deceleration rates should be lowered, or the top velocity may be too high.

If the ERROR LED is on then the drive should be faulted out, and a two-digit error code should be flashing on the display. See Section 7.4 below to troubleshoot the appropriate error.

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The **SHORT CIRCUIT, TEMP AND AMP OFF** LEDs correspond to error codes number 19, 11, and 16 respectively. See Section 7.4 below to troubleshoot the appropriate error.

7.4 ERROR CODES

All of the possible 2-digit error codes are described below, along with some troubleshooting information. Error codes marked with an asterisk (*) are not available on the front panel display. They may only appear when the **RSE**(RETURN SERVO ERRORS) command is used.

16 * **AMPLIFIER OFF**. This only indicates that the amplifier is off -- no current is being sent to the motor. This error should always be accompanied by the causing error.

17 * **INDEXER SHUTDOWN**. The **REMOTE POWER SHUTDOWN** input on the indexer connector has be activated, causing the drive to shutdown. Removing this input will re-enable the drive.

18 **NO BUS VOLTAGE**. The 3-phase 240 volt power to the KH Drive is either not present, or at a lower voltage than 105 V. Make sure that the 3-Phase power is correctly connected, and then command the drive to turn on (ON command).

19 **OVER-CURRENT (SHORT CIRCUIT)**. A short circuit between motor phases, or between any phase and ground will cause the drive to fault. This may be due to improper motor wiring to the drive or due to a bad motor. In some cases an extremely high acceleration may cause this error. Power down the complete KH Drive, correct the wiring, and power-up the system. This fault cannot be removed by typing the ON command.

20 **FOLLOWING ERROR EXCEEDED**. The user defined following error limit has been exceeded. The CPE (CONFIGURE POSITION ERROR) command can alter the following error limit. The factory default is one revolution (5,000 motor steps). Faulting out due to a following error may be due to a too fast of an acceleration rate or possibly bad servo tuning. The user must decide whether to increase the following error limit or to change his motion profile so that the drive no longer faults out.

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22 **AVERAGE CURRENT LIMIT EXCEEDED.** The user specified average current limit has been exceeded. The CCA (CONFIGURE CURRENT AVERAGE) command can alter the average current limit. If the drive continues to fault out, then you may have to reduce the acceleration rate of your move. The average current of the drive is calculated over a rolling 2.56 second time period.

23 **DRIVE ENABLE INPUT NOT CONNECTED.** The drive enable input on the 4-pin Phoenix connector has been inactivated. For drive operation, a normally closed switch or wire jumper is necessary between the ENA+ and ENA- input. The KH is shipped with a jumper installed.

30 **EEPROM (MEMORY) ERROR.** This error will occur only at power up if new software is put into the KH Drive, or if a drive is sent to you without a motor. The commutation procedure is normally done at the factory (complete motor-drive systems sent to you have already been configured); this is needed only when error 30 exists. It only needs to be done once and the result saved.

NOTE: THE COMMUTATION PROCEDURE SETS UP THE DRIVE FOR A PARTICULAR MOTOR. EACH DRIVE IS SHIPPED WITH CERTAIN HARDWARE SETTINGS THAT OPTIMIZE THE DRIVE FOR ONE OF TWO POSSIBLE MOTOR RANGES. SECTION 8.4 EXPLAINS MOTOR-DRIVE COMPATIBILITY ISSUES AND LISTS THE PROCEDURE.

60 ***RS-232C COMMAND.** The drive has been commanded to be off by the OFF command. Typing ON will turn the drive back on if no other errors exist.

61 **INCOMING INDEXER PULSES.** When the KH is reset or commanded ON, no step pulses are accepted when the amplifier is first enabled (this would constitute infinite acceleration). Make sure that the indexer connected to the KH is not sending out any pulses, and then command the drive to turn on (ON command).

70 **RESOLVER DISCONNECTED.** The resolver feedback signal from the motor to the drive is missing. This feedback is required to operate the drive. Make sure the resolver connection is secured, and then command the drive to turn on again (ON command).

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7.5 RS-232C PROBLEMS

If there are problems communicating with the KH Drive, try the following procedure to troubleshoot the communications interface.

1. Make certain the transmit of the host is wired to the receive of the peripheral, and receive of the host is wired to the transmit of the peripheral.

   Try switching the receive and transmit wires on either the host or peripheral if there is still no communication.

2. Configure the host and peripheral to the same baud rate, number of data bits, number of stop bits, and parity.

3. If you receive double characters, for instance typing A and receiving AA, then the computer is set for half duplex. Change the setup to full duplex.

4. Use DC common or signal ground as a reference, not earth ground.

5. Cable lengths should not exceed 50 ft. unless you are using some form of line driver, optical coupler, or shield. As with any control signal, be sure to shield the cable to earth ground at one end only.

6. To test the terminal or terminal emulation software for proper three-wire communication, unhook the peripheral device and transmit a character. You should not receive an echoed character. If you do, you are in half duplex mode. Connect the host's transmit and receive lines and send another character. You should receive the echoed character. If not consult the manufacturer of the host's serial interface for proper pin outs.

7.6 RETURNS

Should return of your KH Drive be necessary for repairs or upgrades, please do the following:

1. Get the serial number and the model number of the unit, and a purchase order number to cover repair costs in the event the unit is determined to be out of warranty by Compumotor upon inspection.

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2. Call Compumotor for a Return Material Authorization number (RMA) at 800-358-9068. In California, call 800-345-2084, or (707) 778-1244.

3. Clearly mark all packages as follows and ship the unit to:

Parker Compumotor
5500 Business Park Drive
Rohnert Park, CA 94928
(707) 584-7558 (800) 358-9068
RMA # _____

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SECTION 8 ELECTRICAL SPECIFICATIONS

8.1 DRIVE

8.1.1 INPUT POWER

MAIN
Voltage : 105-250 V.A.C., 3-phase or 1-phase
Frequency : 47-66 Hz.
Current : 20 amps maximum continuous (RMS).

LOW VOLTAGE
Voltage : 95-130 V.A.C., 1-phase
Frequency : 47-66 Hz.
Current : 2 amps maximum continuous (RMS).

8.1.2 OUTPUT POWER (to motor) (rated at 50°C)

Voltage : 350 VDC, maximum
Frequency : 10 kHz PWM, 400 Hz maximum fundamental stator current
Current : 20.0 amps continuous per phase sinusoidal (14.14 Arms)
40.0 amps per phase peak (28.28 Arms)

8.1.3 ENVIRONMENTAL

Storage Temperature : -40 to +85°C
Operating temperature : 32°F to 122°F (0°C to 50°C)
With adequate air flow (10 cfm)
Humidity : 0-95%, non-condensing

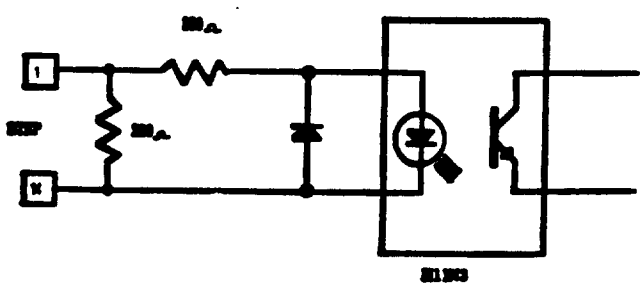
8.1.4 INDEXER CONNECTOR INPUTS TO DRIVE

All indexer inputs are isolated. Example: DIR+ is pin 2, DIR- is pin 15. Applying 5 Volts (capable of supplying 20 milliamps) to pin 2 with respect to pin 15 will activate this input; the return current path is pin 15.

All inputs with the exception of the STEP input require 4.0 to 12.0 volts, capable of supplying 20 milliamps of current. The STEP input requires 3.0 to 5.0 volts.

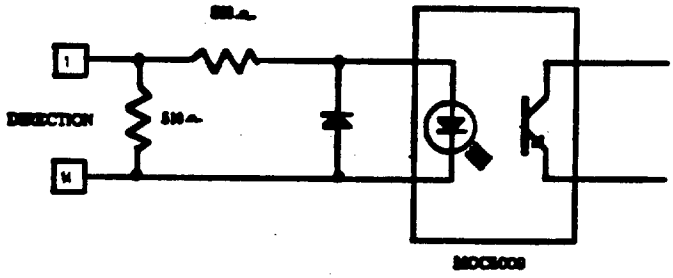
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STEP (pins 1/14) Optically isolated. Pulse width 1 microsecond minimum; step rate 500 kHz maximum. Step input is triggered on the rising edge of the current pulse.



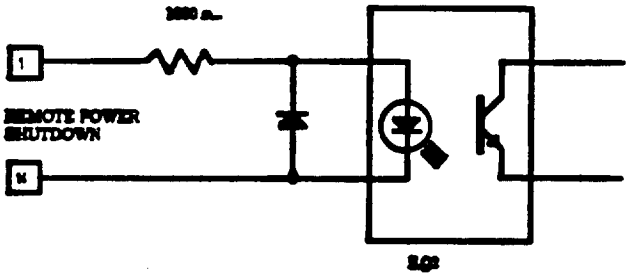
KH STEP INPUT SCHEMATIC - FIGURE 8-1

DIRECTION (pins 2/15) Optically isolated. Must be held active for at least 10 microseconds prior to rising edge of **STEP** input. Presence of current causes counter-clockwise motion.



KH DIRECTION INPUT SCHEMATIC - FIGURE 8-2

REMOTE SHUTDOWN (pins 16/17) Optically isolated. Presence of current causes amplifier to turn off (no current will be sent to the motor phases).

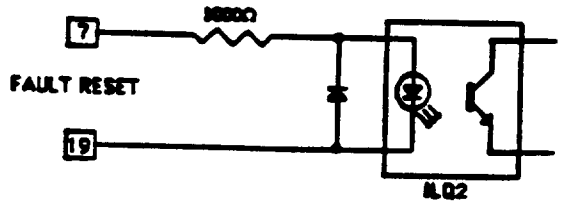


KH REMOTE SHUTDOWN INPUT SCHEMATIC - FIGURE 8-3

FAULT RESET (pins 7/19) Optically isolated. Presence of current holds the microprocessor in reset, removing current from this input will allow the microprocessor to re-initialize the KH Drive.

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FAULT RESET (pins 7/19) Optically isolated. Presence of current holds the microprocessor in reset, removing current from this input will allow the microprocessor to re-initialize the KH Drive.

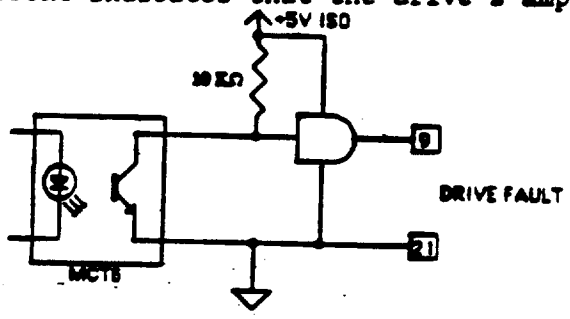


KH FAULT RESET INPUT SCHEMATIC - FIGURE 8-4

8.1.5 INDEXER CONNECTOR OUTPUTS FROM DRIVE

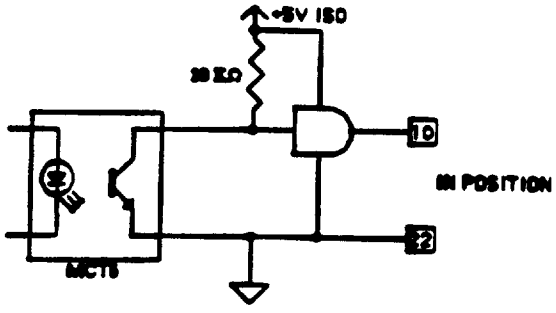
All indexer outputs are capable of supplying up to 300 milliamps of current.

DRIVE FAULT (pins 9/21) Optically isolated. Presence of current indicates that the drive's amplifier is on.



KH DRIVE FAULT OUTPUT SCHEMATIC - FIGURE 8-5

IN POSITION (pins 10/22) Optically isolated. Presence of current indicates that the motor shaft is within the user specified deadband.



KH IN-POSITION OUTPUT SCHEMATIC - FIGURE 8-6

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8.1.6 RS-232C CONNECTOR

The RS-232C communications interface of the KH Drive meets all EIA RS-232-C and CCITT V.28 specifications. Protocol is fixed at 9600 baud, 8-data bits, 1-stop bit, no parity.

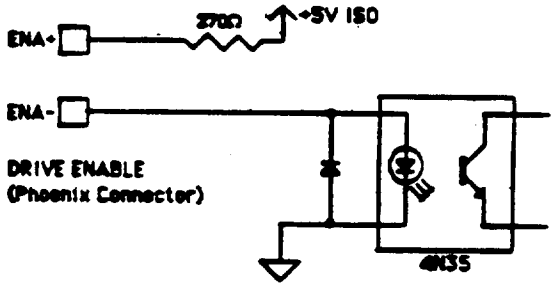
RECEIVE (pin 2) Optically isolated.

TRANSMIT (pin 3) Optically isolated.

SIGNAL GROUND (pin 7) Isolated ground (not earth ground)

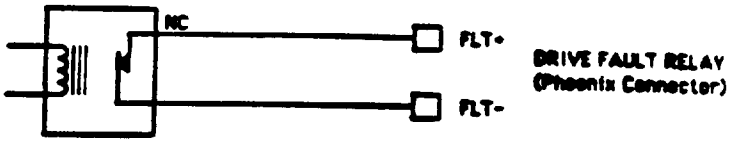
8.1.7 DRIVE ENABLE/FAULT PHOENIX CONNECTOR

DRIVE ENABLE (ENA) Optically isolated input. Isolated 5 Volt pull-up is already supplied, connecting ENA+ to ENA- with a wire jumper enables the drive's amplifier.



KH DRIVE ENABLE/FAULT PHOENIX SCHEMATIC - FIGURE 8-7

DRIVE FAULT (FLT) Isolated (relay) output. Closed relay contact when the amplifier is on, open contact when drive's amplifier is off. The relay contact can handle 1 Amp @ 28 VDC or 120 VAC, resistive.



KH DRIVE FAULT PHOENIX SCHEMATIC - FIGURE 8-8

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8.1.8 FUSING, INTERNAL TO DRIVE

240 V.A.C. FUSES

5AG TYPE BUSS FNQ 20 AMP, 20 MILLISECOND DELAY, 500 V.
13/32 X 1-1/2 INCH

ALTERNATIVE:

5AG TYPE LITTLEMAN FLQ 20 AMP, 20 MILLISECOND DELAY, 500 V.
13/32 X 1-1/2 INCH

120 V.A.C. FUSES

3AG TYPE BUSS MDA-2 2 AMP, SLOW BLOW, 250 V.
1/4 X 1-1/4 INCH

Fuses for the KH Drive are all accessible from the front of the drive. The fuse holders are clearly identifiable on the panel. There are no fuses installed within the drive.

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8.2 MOTORS

NOTE: ALL OF THE FOLLOWING DATA IS INDEPENDENT OF THE KH DRIVE.

8.2.1 BASIC DESIGN

Brushless AC Synchronous (4-pole pair)

a) Stator: 8-pole, 3-phase wye connected

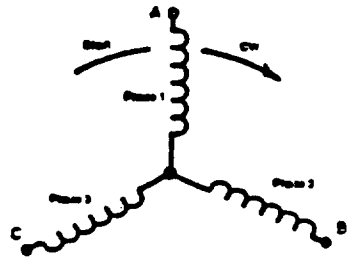


FIGURE 8-9

b) Rotor: 8-pole, (SmCo) permanent magnet

c) 4 electrical cycles produce 1-mechanical shaft revolution

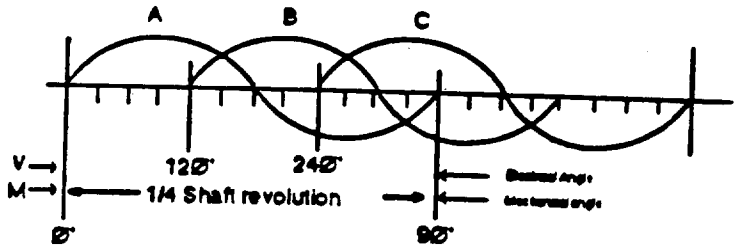


FIGURE 8-10

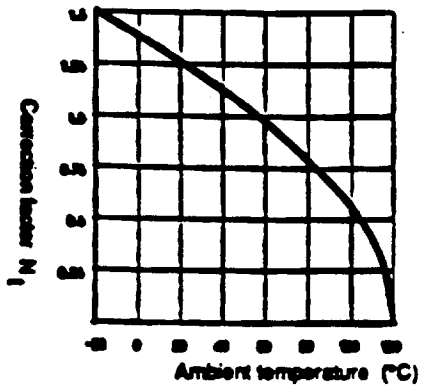
KH MOTOR CABLE

MOTOR	MS CONTACT	WIRE COLORS
PHASE A	A	ORANGE/WHITE
PHASE B	B	BLUE/WHITE
PHASE C	C	GRAY/WHITE
MOTOR GROUND	D	GREEN/WHITE

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8.2.2 OPERATING TEMPERATURE

100°C MAXIMUM (motor only, not drive)



The nominal torque of the motor is referred to as Δt = 65°C in air. The curve is referred to as a max motor temperature of 125°C

FIGURE 8-11

MOTOR:

Maximum winding temperature limit (ambient + rise) 150°C
Insulation class F, minimum 155°C
Dielectric Strength, (winding-to-frame), minimum 1000 V.

8.2.3 PARAMETERS

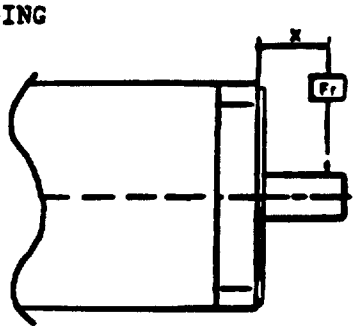
Note: The following data is independent of the KH-Drive.

Parameters	Units	KH250	KH260	KH710
Constant, Torque	oz-in/Arms	82	164	74
Constant, Voltage (sinusoidal)	Vrms/Krpm	35.19	70.37	31.73
Current, Rated (line)	Arms	4.4	4.4	14
Current, Peak (2-second max)	Arms	13.2	13.2	42
Inductance (terminal)	mH	5.6	11.3	5.1
D.C. Resistance (terminal)	Ohms	2.0	3.0	0.6

Parameters	Units	KH720	KH730	KH740
Constant, Torque	oz-in/Arms	156	234	312
Constant, Voltage (sinusoidal)	Vrms/Krpm	66.50	99.80	132.99
Current, Rated (line)	Arms	14	14	14
Current, Peak (2-second max)	Arms	42	42	42
Inductance (terminal)	mH	5.1	7.7	10.2
D.C. Resistance (terminal)	Ohms	0.6	0.8	1.0

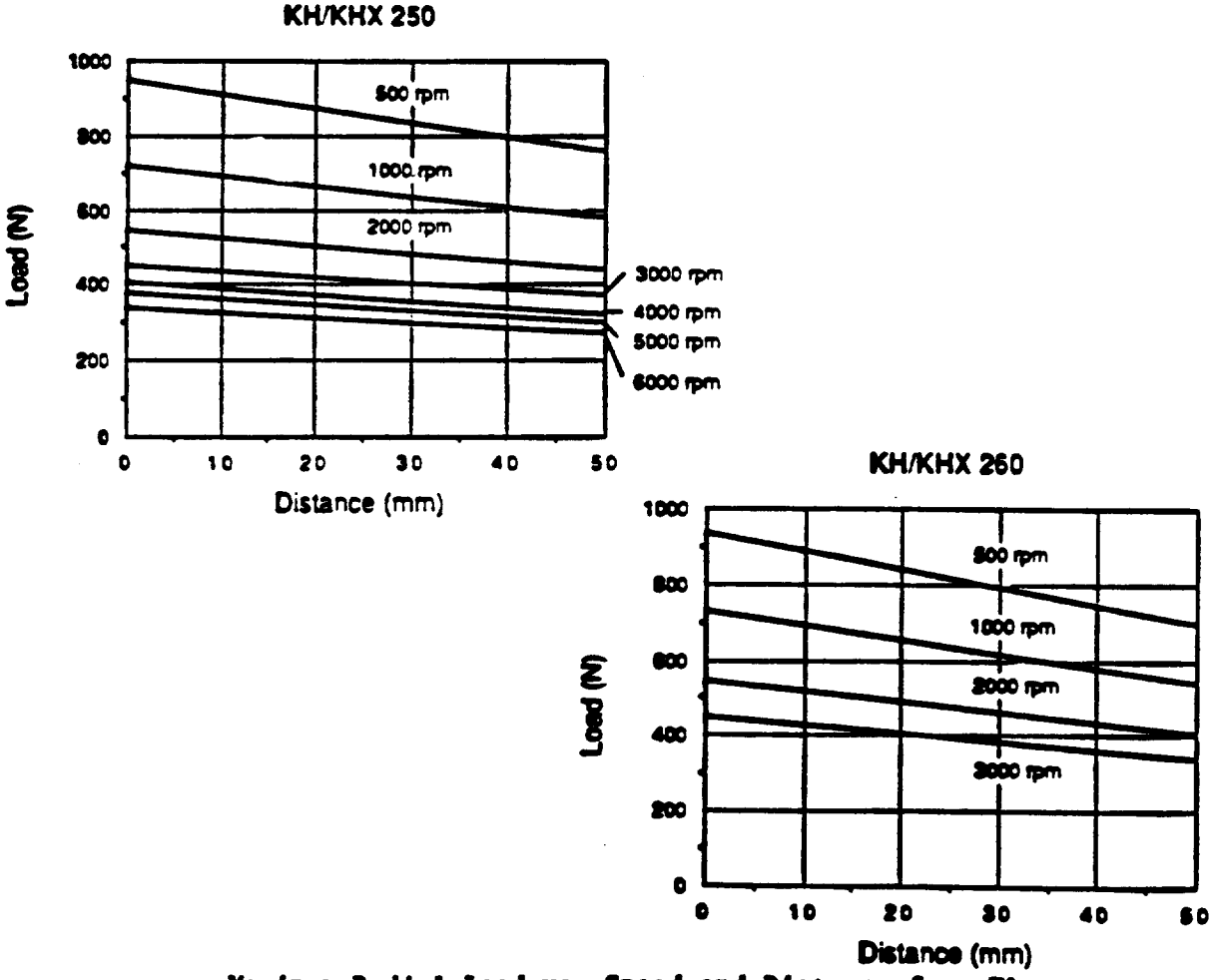
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8.2.4 RADIAL LOADING



Fr = Load Force in Newtons (N) X = distance in mm 1 Newton = .2248 lbs.

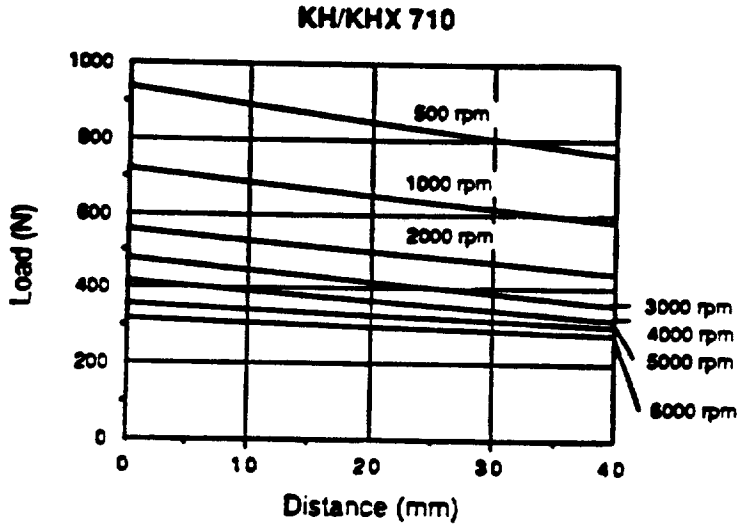
Maximum radial load on shaft vs.
speed and distance from flange.
referred to life expectancy = 20,000 h

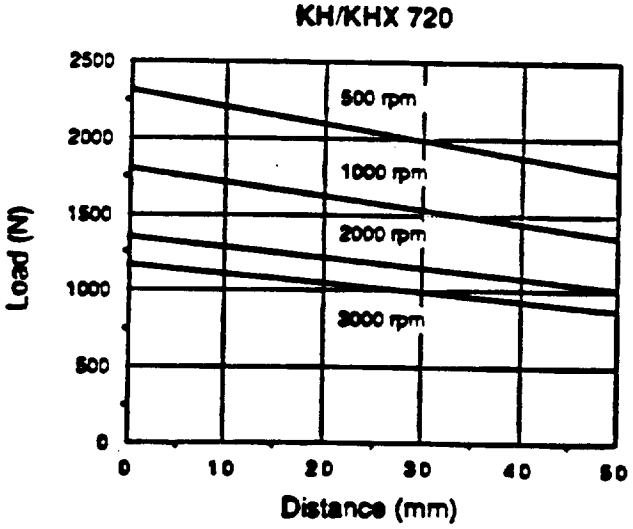


Maximum Radial Load vs. Speed and Distance from Flange

FIGURE 8-12

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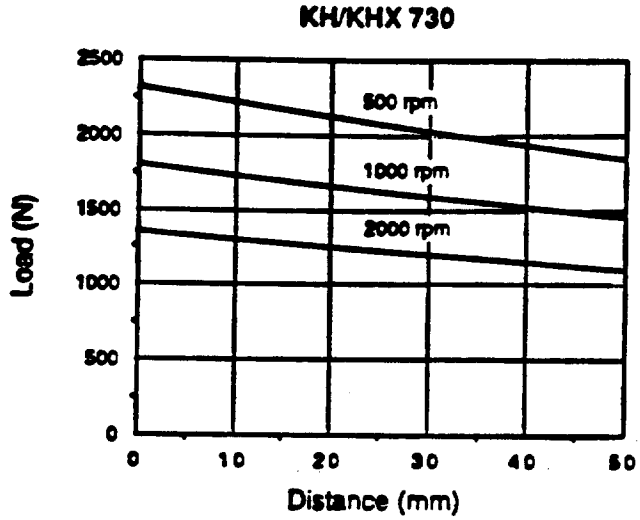


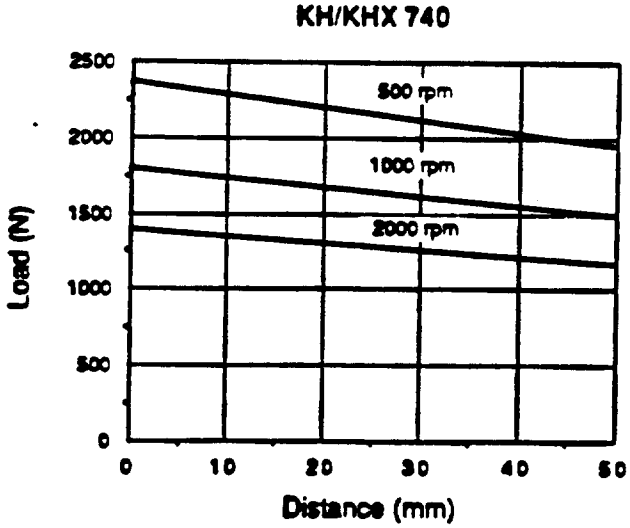


Maximum Radial Load vs. Speed and Distance from Flange

FIGURE 8-12 (CONT.)

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Maximum Radial Load vs. Speed and Distance from Flange

FIGURE 8-12 (CONT.)

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8.3 RESOLVER

NOTE: ALL OF THE FOLLOWING DATA IS INDEPENDENT OF THE KH DRIVE.

* **Sensitivity, nominal tolerance, 61 mv/deg**
* **Accuracy [Error], maximum tolerance, +/-10 arc minutes**
* **Operating temperature range (-)55°C to 125°C**
* **Approved Vendor: Clifton Precision**
  Model # JSMBH-21-J-1

KH RESOLVER CABLE

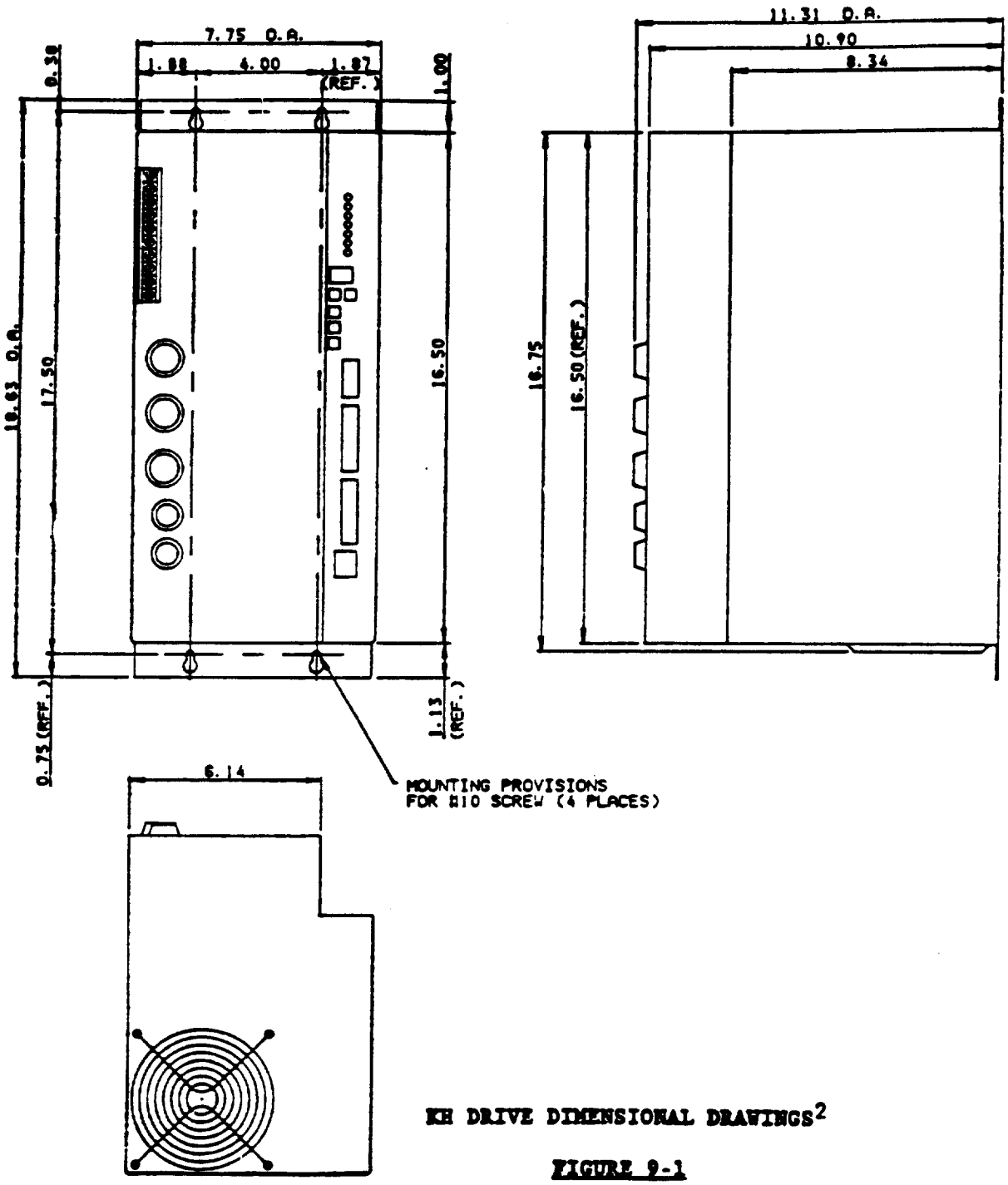
RESOLVER SIGNAL	MS CONTACT	WIRE COLOR	9 PIN D CONTACT
Rotor 1	A	WHITE	4
Rotor 2	B	BROWN	9
Stator 1	C	BLUE	3
Stator 2	D	GREEN	6
Stator 3	E	RED	1
Stator 4	F	BLACK	7
		SHIELD	5

The MS type connector on the resolver cable is Amphenol Part No. PT06E-14-19S

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SECTION 9 **MECHANICAL SPECIFICATIONS**

9.1 **DRIVE**



KH DRIVE DIMENSIONAL DRAWINGS[2]

FIGURE 9-1

[2] All dimensions are in inches unless otherwise specified.

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8.4 MOTOR DRIVE COMPATIBILITY

The motor current control on the analog amplifier board in the KH Drive is optimized for two different motor ranges:

RANGE 1	RANGE 2
KH250	KH730
KH260	KH740
KH710	
KH720	

Compumotor configures each drive to operate with a given motor range before the KH System is shipped. Contact the factory if you wish to drive a motor range that is different than the range for which your drive has been configured.

KH Drives and Motors are matched at the factory for several reasons. Different motors can take different amounts of current and require different tuning parameters for typical loads. The CMTR (Configure Motor Type) command is used to set up a drive for a particular motor. By issuing the CMTR command, motor current levels and default parameters are recalled from memory. Do not run a small motor at a higher current level, as the motor will burn up.

In addition, each KH Drive and motor system has undergone a commutation procedure at the factory. The FMCA (Find Motor Commutation Angle) command is used to find the angular offset between the resolver's magnetic pole and the motor's magnetic pole. This procedure is necessary for proper operation of the drive.

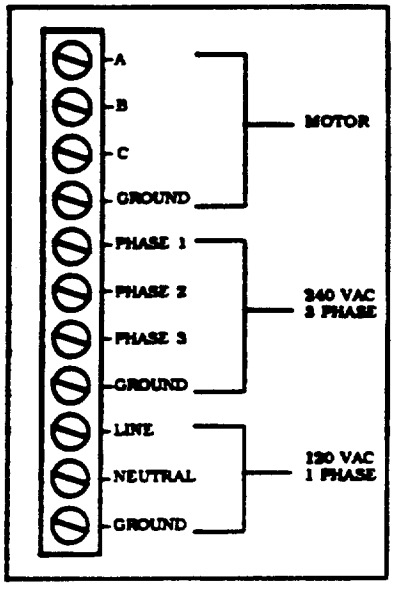
The following information is provided in case it is necessary to perform the motor drive configuration that is normally done at Compumotor's factory. This command sequence will set up a drive for a particular motor size and perform the commutation (See Appendix C for information on these commands).

WARNING

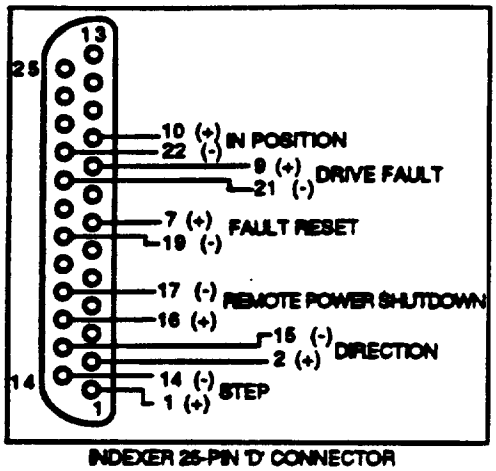
THIS COMMUTATION PROCEDURE CAUSES VIOLENT MOTOR MOTION. ALL LOADS SHOULD BE REMOVED FROM THE MOTOR SHAFT BEFORE THIS PROCEDURE CONTINUES.

```
1E          (enable RS-232C Communications)
1OFF        (turn drive off)
1CMTRxxx    (set drive up for the motor; xxx = 250 - 740)
1FMCA       (commutate the motor)
1SV         (save commutation)
1ON         (enable the drive)
```

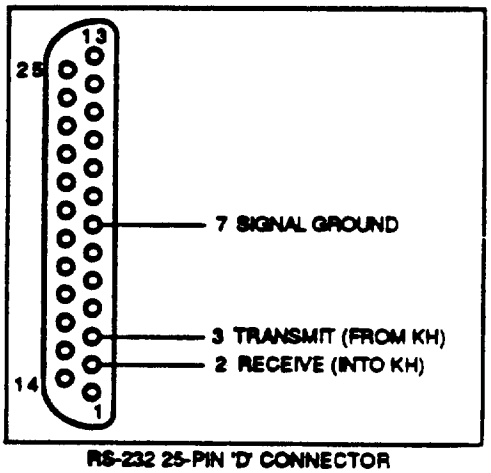

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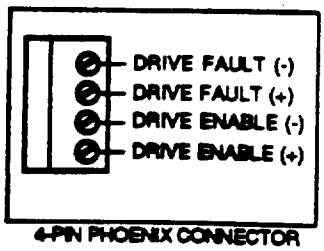
Power Terminal Strip



INDEXER 25-PIN 'D' CONNECTOR



RS-232 25-PIN 'D' CONNECTOR



4-PIN PHOENIX CONNECTOR

KH DRIVE CONNECTIONS

FIGURE 9-2

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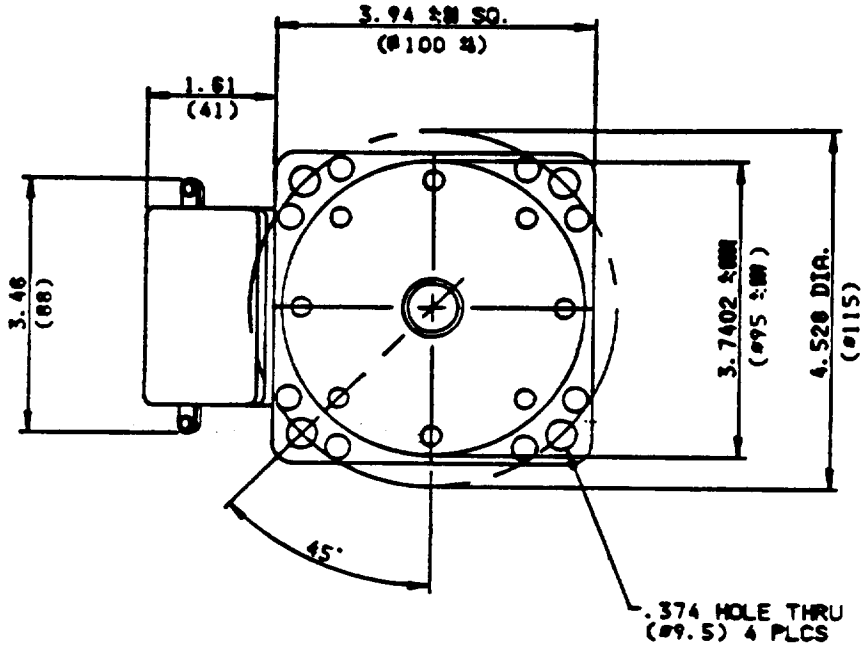
Note: The following data is independent of the KH-Drive.

Parameters	Units	KH250	KH260	KH710
Constant, Mechanical Time	ms	2.3	1.3	1.8
Constant, Thermal Time	minutes	41	40	36
Torque, Continuous, Rated	oz-in	340	680	1034
Torque, Peak, Max w/o saturation	oz-in	1020	2040	3100
Speed, Rated	rpm	5300	2600	6000
Acceleration @ Rated Torque	rad/sec^2	10900	13700	15200
Rotor Inertia (motor only)	kgm^2 10^{-6}	220	350	480
Weight	lbs	11.0	15.5	19.5
Shaft, Radial-Play	in/lb	.001	.001	.001
Material	- - -	303 s.s.	303 s.s.	303 s.s.
Bearing Class, Internal/ External	ABEC	3/1	3/1	3/1

Parameters	Units	KH720	KH730	KH740
Constant, Mechanical Time	ms	1.8	1.6	1.4
Constant, Thermal Time	minutes	63	67	68
Torque, Continuous, Rated	oz-in	2068	3115	4106
Torque, Peak, Max w/o saturation	oz-in	6200	9345	12318
Speed, Rated	rpm	2700	1800	1300
Acceleration @ Rated Torque	rad/sec^2	7000	7200	7500
Rotor Inertia (motor only)	kgm^2 10^{-6}	2100	3050	3850
Weight	lbs	37.0	48.0	59.0
Shaft, Radial-Play	in/lb	.001	.001	.001
Material	- - -	303 s.s.	303 s.s.	303 s.s.
Bearing Class, Internal/ External	ABEC	3/1	3/1	3/1

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MOTOR SIZES		
MOTOR	"A" DIM.	DIM (mm)
KH/KHX 250	6.65	(169)
KH/KHX 260	8.39	(213)



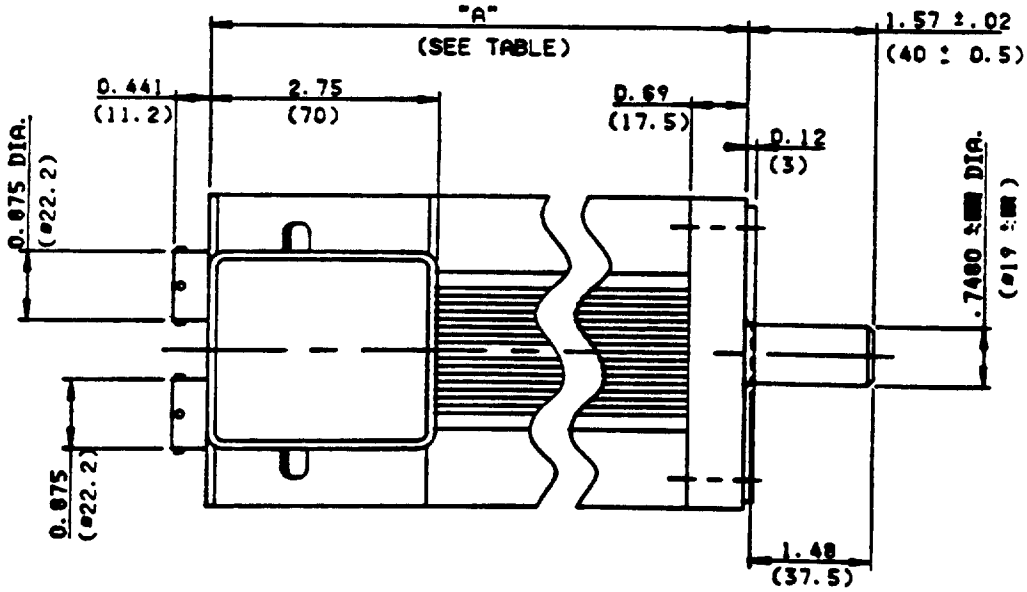


FIGURE 9-3

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MOTOR SIZES		
MOTOR	"A" DIM.	DIM (mm)
KH/KHX 710	10.12	(257)

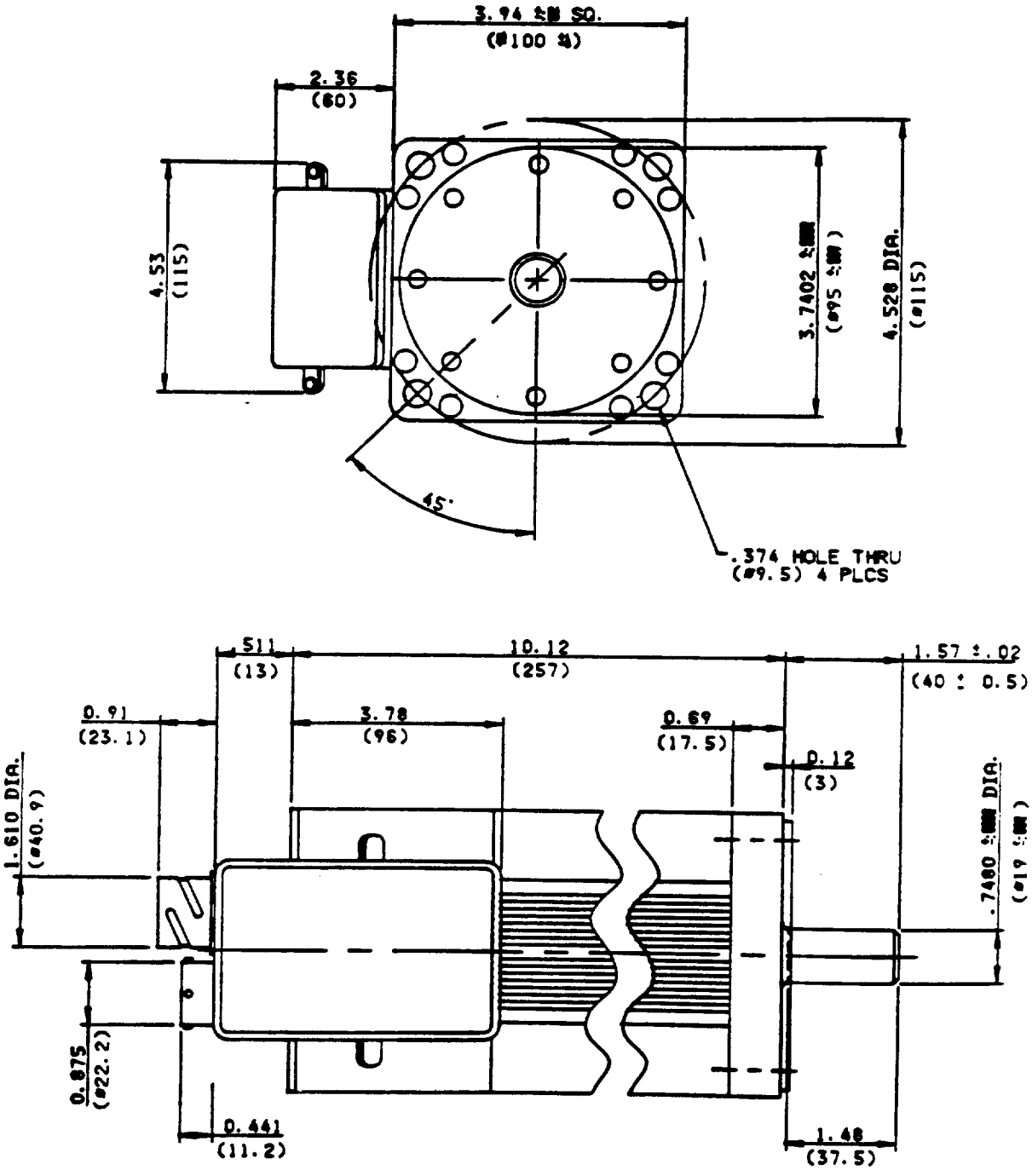
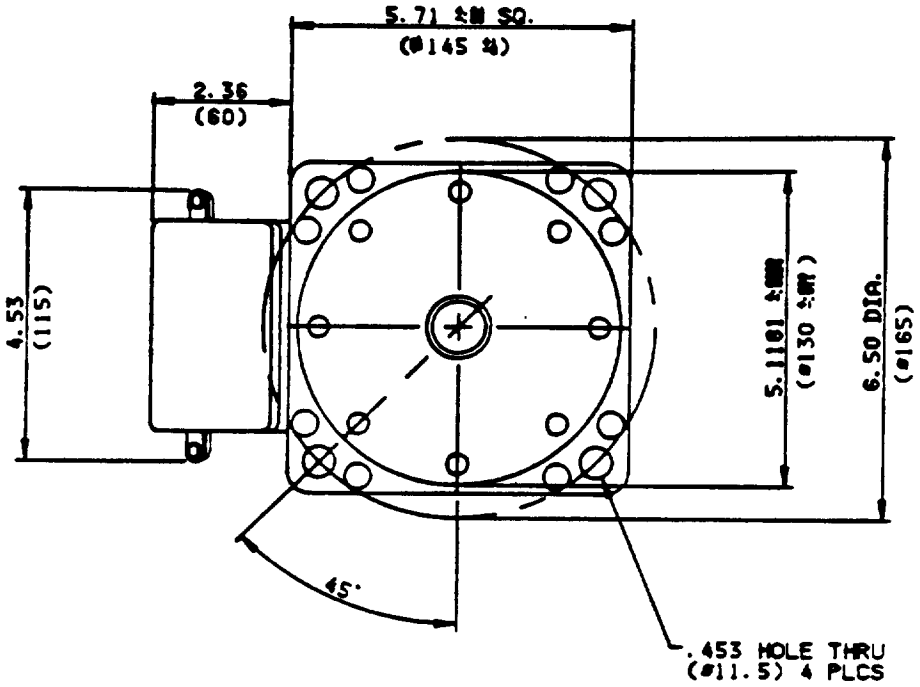


FIGURE 9-4

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MOTOR SIZES		
MOTOR	"A" DIM.	DIM (mm)
KH/KHX 720	10.79	(274)
KH/KHX 730	12.91	(328)
KH/KHX 740	15.04	(382)



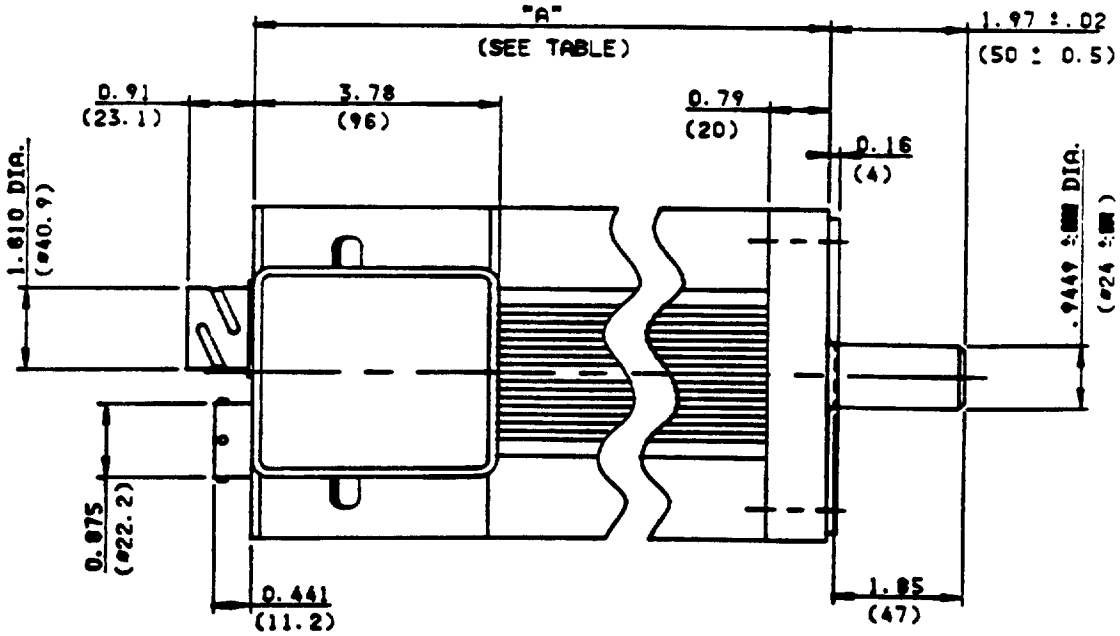


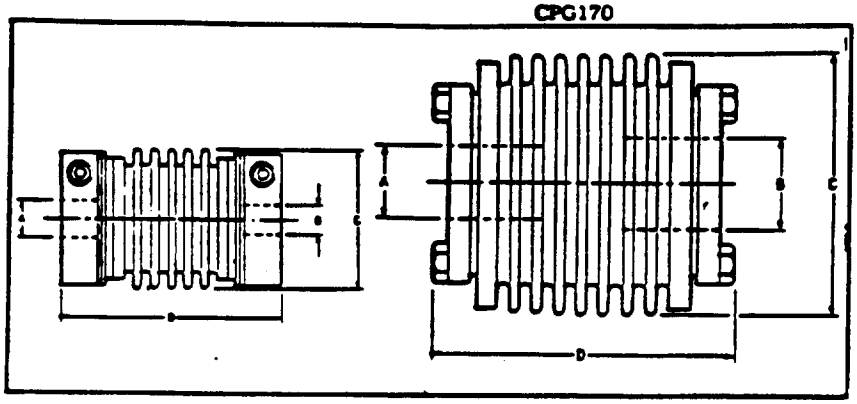
FIGURE 9-5

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9.3 COUPLERS

Coupling Model No's
CPG12

Coupling Model No's
CPG20
CPG30
CPG60
CPG170



Coupling Sizes in inches

Coupling Model No.	Motor Model	A Shaft Size inch	B Output Bore Dia inch	C Outer Dia inch	D Overall Length inch	Inertia oz·in²
CPG12-10	KH-250	0.748	0.625	1.575	2.441	2.187
CPG12-12			0.750	1.575	2.441	2.187
CPG20-10	KH-260	0.748	0.625	2.205	2.520	9.295
CPG20-12			0.750	2.205	2.520	9.295
CPG30-12	KH-710	0.748	0.750	2.598	2.795	16.402
CPG30-14			0.875	2.598	2.795	16.402
CPG80-14	KH-720	0.945	0.875	3.228	3.110	32.805
CPG80-16			1.000	3.228	3.110	32.805
CPG80-14	KH-730	0.945	0.875	3.228	3.110	32.805
CPG80-16			1.000	3.228	3.110	32.805
CPG170-14	KH-740	0.940	0.875	3.228	3.150	32.805
CPG170-16			1.000	3.228	3.150	32.805

Coupling Sizes in millimeters

Coupling Model No.	Motor Model	A Shaft Size mm	B Output Bore Dia mm	C Outer Dia mm	D Overall Length mm	Inertia 10^{-6}kgm²
CPG12-10	KH-250	19.000	15.875	40.000	62.000	40.0000
CPG12-12			19.050	40.000	62.000	40.0000
CPG20-10	KH-260	19.000	15.875	56.000	64.000	170.000
CPG20-12			19.050	56.000	64.000	170.000
CPG30-12	KH-710	19.000	15.875	66.000	71.000	300.000
CPG30-14			19.050	66.000	71.000	300.000
CPG80-14	KH-720	24.000	22.225	82.000	79.000	600.000
CPG80-16			25.400	82.000	79.000	600.000
CPG80-14	KH-730	24.000	22.225	82.000	79.000	600.000
CPG80-16			25.400	82.000	79.000	600.000
CPG170-14	KH-740	24.000	22.225	82.000	80.000	600.000
CPG170-16			25.400	82.000	80.000	600.000

*oz refers to mass

FIGURE 9-6

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SECTION 10 **SPECIFICATIONS - PERFORMANCE**

10.1 SPEED-TORQUE CURVES

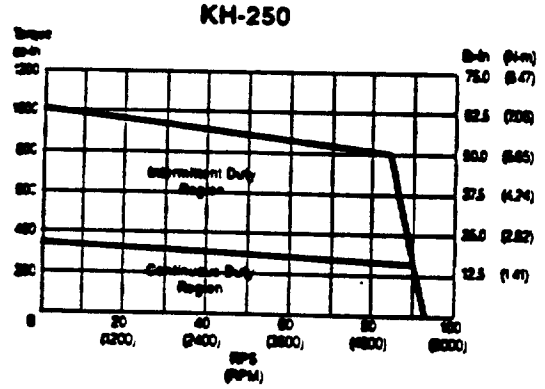
The following curves represent the available shaft torque at different operating speeds. The KH is designed to operate from a 3-phase 240 V.A.C. 50/60 Hz line. The curves below represent operation at that input voltage, and the actual motor torque may vary +/- 10% due to motor fabrication variances.

For operation at other than 240 V.A.C., the output torque stays relatively constant and the top end speed falls off at the ratio of the input voltage. (ie. A KH 250 operating at 240 V.A.C. has a rated speed of 5400 RPM; operating at 120 V.A.C., it will have a rated speed of 2700 RPM.)

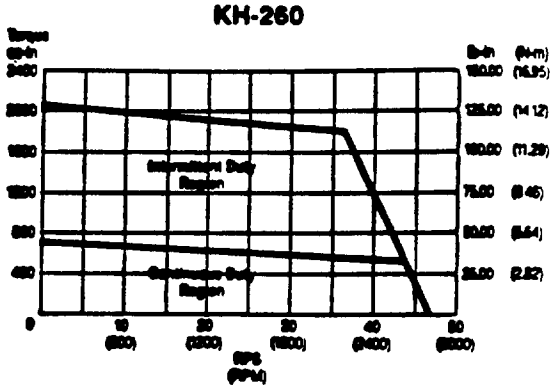
Continuous Duty means steady state operation for drive ambient temperatures of 50°C. Intermittent Duty means operation for 2.5 seconds or less.

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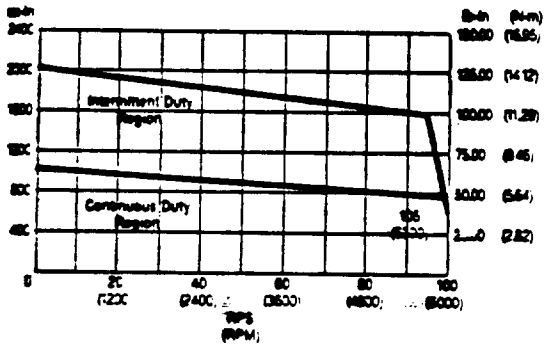
KH-250



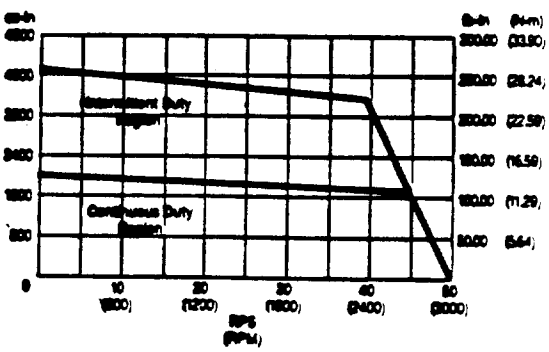
KH-260



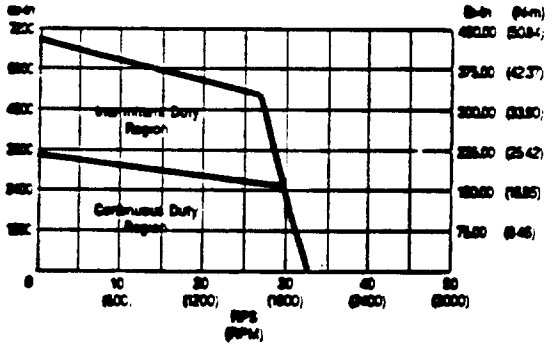
KH-710



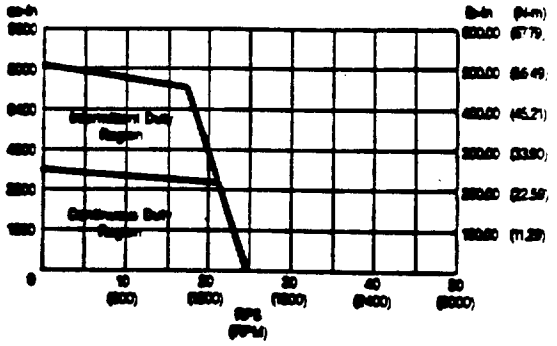
KH-720



KH-730



KH-740



SPEED vs. TORQUE

FIGURE 10-1

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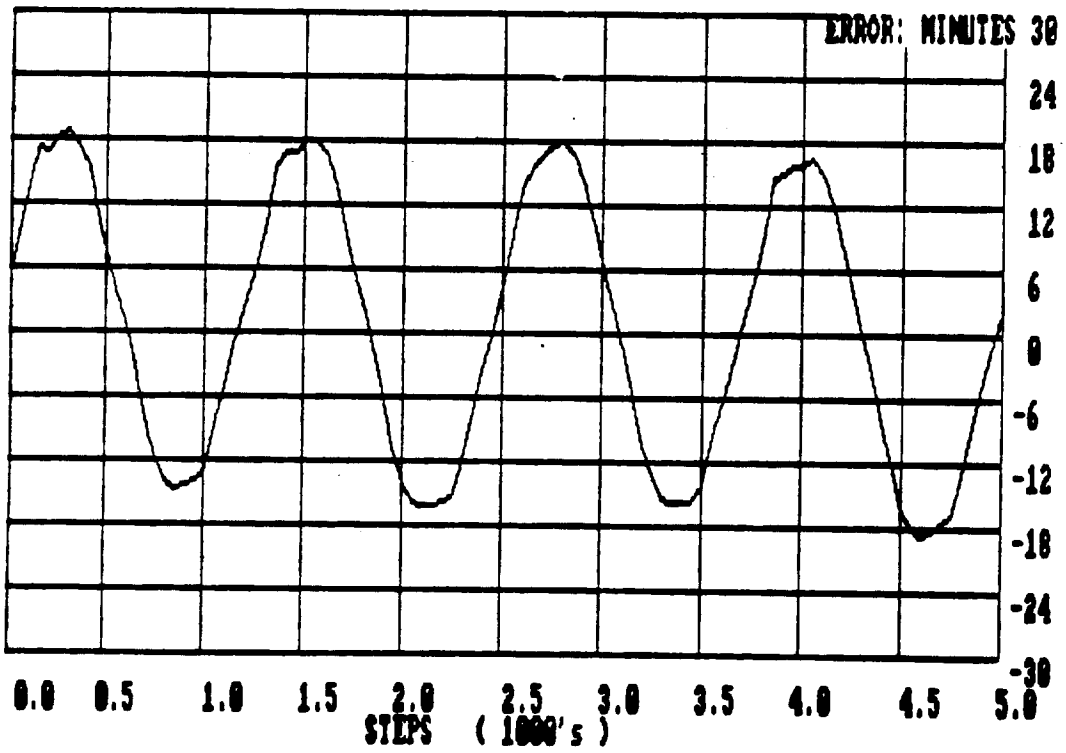
10.2 POSITIONAL ACCURACY

Repeatability +/- 0.088 degrees, unloaded.

NO LOAD POSITION ACCURACY = +/- 20 arc minutes

= +/- .33 degrees

This measurement is made with the drive at a steady state temperature between 0°C to +50°C. The accuracy is cyclic and a typical curve is shown below. The motor resolution is set to a factory default setting of 5000 steps = 1 mechanical revolution.



ABSOLUTE POSITIONAL ACCURACY

FIGURE 10-2

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SECTION 11 **DRIVE OPTIONS**

11.1 CUSTOM LENGTH CABLES

For the KH250-260 motors the following motor cables are available from Parker Compumotor:

Compumotor Part No.	Length
71-7200-25	25 Ft. (standard)
71-7200-50	50 Ft.
71-7200-100	100 Ft.

For the KH710-740 motors the following motor cables are available from Parker Compumotor:

Compumotor Part No.	Length
71-7130-25	25 Ft. (standard)
71-7130-40	40 Ft.
71-7130-50	50 Ft.
71-7130-100	100 Ft.

The following resolver cables are available from Parker Compumotor:

Compumotor Part No.	Length
71-007127-50	50 ft. (standard)
71-007127-100	100 ft.

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11.2 MOTOR BRAKES

These brakes are mounted directly behind the motor and come completely assembled from the factory. When ordering the brake option, please specify the motor type.

BRAKE CHARACTERISTICS	KH250 KH260 KH710	KH720 KH730 KH740	UNITS
Supply voltage	24	24	VDC
Supply current	1	1	A
Static braking torque	1345	4956	oz·in
Dynamic braking torque	1133	3965	oz·in
Inertia	.007	.063	oz·in·sec^2
Build-up time	90	140	ms
Release time	60	80	ms
Mass	3.9	11	lbs

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APPENDIX A

NOISE SUPPRESSION RECOMMENDATIONS

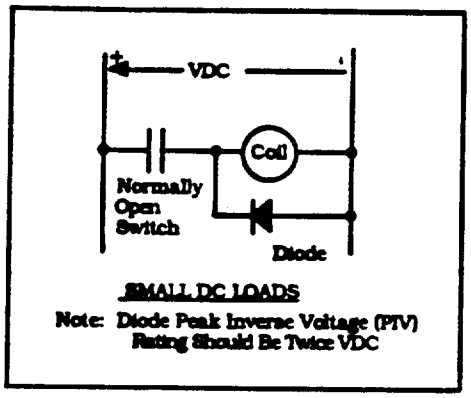
This appendix discusses the sources and methods of suppressing electrical noise.

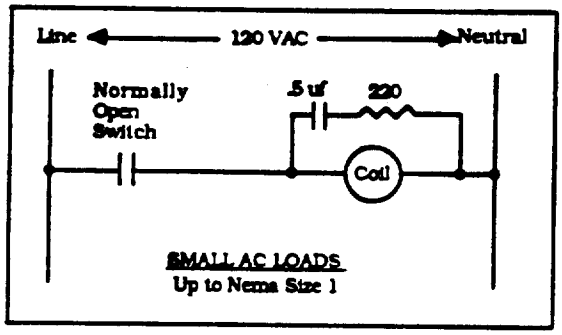
ELECTRICAL NOISE

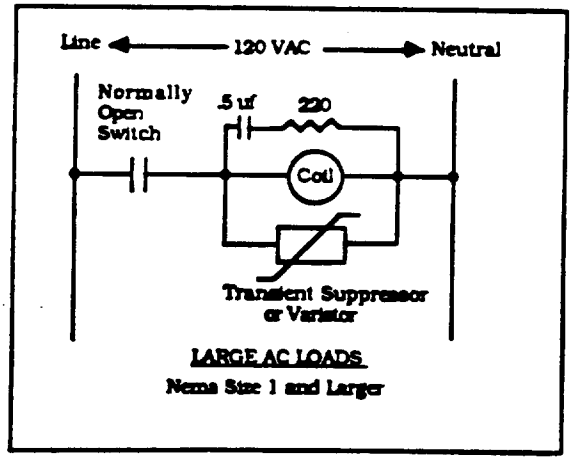
When a KH Drive is operated in an environment where there is an excess amount of electrical noise, special care must be taken to eliminate sources of possible noise interference. Compumotor recommends that the KH Drive be mounted in a NEMA enclosure to protect the drive from electrical noise (among other environmental considerations).

Noise suppression devices may be necessary when sources of electrical noise are connected to the same AC power source or are in close proximity to electronic equipment. You may also need to install noise suppression devices if you have multiple drives attached to the same AC power source. Figure A-1 shows some recommended suppression devices for most loads. For best results, install these devices as close as possible to the inductive load.

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NOISE SUPPRESSION DEVICES

FIGURE A-1

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Noise related difficulties can range in severity from minor positioning errors to damaged equipment from runaway motors. In microprocessor-controlled equipment electrical disturbances may cause the processor to misinterpret instructions or access the wrong data. This can be catastrophic. The KH Drive is designed with a watchdog timer that shuts down the system if the program is adversely affected by noise. Noise is generated by the following sources:

* Power line disturbances
* Externally conducted noise
* Transmitted noise
* Ground loops

The following electrical devices are particularly apt to generate unwanted electrical noise conditions:

* Coil-driven devices (conducted and power line noise)
* SCR-fired heaters (transmitted and power line noise)
* Motors and motor drives (transmitted and power line noise)
* Electric welders (transmitted and power line noise)

POWER LINE DISTURBANCES

Power line disturbances are usually easy to resolve due to the wide variety of line filtering equipment and isolation transformers that are available. You will have to use line filtering equipment when other devices connected to the local power line are switching large amounts of current (especially if the switching occurs at a high frequency).

EXTERNALLY CONDUCTED NOISE

Externally conducted noise is similar to power line noise, but the disturbances are created on signal and ground wires that are connected to the drive. This kind of noise can affect logic circuit ground or the processor's power supply. The problem in this instance is that control equipment often shares a common DC ground wire that may be connected to several devices (such as a DC power supply, programmable controller, remote switches, etc.).

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When a source of noise like a relay or solenoid is attached to the DC ground it may cause disturbances within the drive.

To solve the noise problem cause by DC mechanical relays and solenoids, you must connect a diode backwards across the coil to clamp the induced voltage kick that the coil will produce. The diode should be rated at four times the coil voltage and ten times the coil current. Using solid state relays is another way to eliminate this problem. See Figure A.1

Furthermore, power supplies and programmable controllers often have DC common tied to Earth (AC power ground). As a rule, it is preferable to have the drive signal ground or DC common floating with respect to Earth. This prevents sources of electrical noise that are grounded to Earth from sending noise into the drive. When you cannot float the signal ground, you should make the Earth ground connection at only a single point.

TRANSMITTED NOISE

Transmitted noise is picked up by external connections to the drive. As with all electrical equipment, the drive chassis should be connected to Earth ground using a gas tight seal.

When high current contacts open, they draw an arc, producing a burst of broad spectrum radio frequency noise that can be picked up on the drive's wiring. High current and high voltage wires have an electrical field around them, and may induce noise on signal wiring, especially when they are tied in the same wiring bundle or conduit.

When this kind of problem occurs, it is time to think about shielding signal cables. A proper shield surrounds the signal wires to intercept electrical fields, but this shield must be tied to Earth to drain the induced voltages. At the very least, wires should be run in twisted pairs to limit straight line antenna effects.

Most Compumotor cables have shields tied to Earth, but in some cases the shields must be grounded at installation time. Connections external to the NEMA enclosure must be shielded.

GROUND LOOPS

Ground loops are the most mysterious noise problems. They seem to occur most often in systems where a controlling computer is using RS-232C communication. Symptoms like garbled transmissions and intermittent operation are typical.

The problem occurs in systems where multiple Earth ground connections exist, particularly when these connections are far apart.

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DEFEATING NOISE

The best time to handle electrical noise problems is before they occur. When a motion system is in the design process, the designer should consider the following set of guidelines for system wiring in order of importance:

1. Put surge suppression components on all electrical coils: Resistor/capacitor filters, MOVs, Zener and clamping diodes.

2. Shield all remote connections, use twisted pairs. Shield should be tied to Earth at one end.

3. Put all microelectrical components in an enclosure. Keep noisy devices outside, watch internal temperature.

4. Ground signal common wiring at one point. Float this ground from Earth if possible.

5. Tie all mechanical grounds to Earth at one point. Run chassis and motor grounds to the frame, frame to Earth.

6. Isolate remote signals. Solid state relays or opto isolators are recommended.

7. Filter the power line. Use common RF filters, isolation transformers for the worst cases.

A noise problem must be identified before it can be solved. The obvious way to approach a problem situation is to eliminate potential noise sources until the symptoms disappear.

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REFERENCES

Information about the equipment referred to may be obtained by calling the numbers listed below.

* Corcom line filters, (312) 680-7400
* Opto-22 optically isolated relays, (714) 891-5861
* Crydom optically isolated relays, (213) 322-4987
* Potter Brumfield optically isolated relays, (812) 386-1000
* General Electric MOVs (315) 456-3266
* Teal Electronics Corporation - specializing in power line products, (800) 888-TEAL

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APPENDIX B

ERROR CODE SUMMARY

CODE	CONDITION
11	Drive over temperature
16 *	Amplifier off
17 *	Indexer Shutdown
18	No voltage present at 220-240 V.A.C. input. 110 V.A.C. ok.
19	Short circuit detected at motor terminals
20	Following error exceeded
22	Maximum average current exceeded
23	Drive disabled by Drive Enable input on Phoenix connector.
30	EEPROM checksum error
60 *	RS-232C command
61	Incoming indexer pulses (not allowed when KH is powered up)
70	Resolver signal not present (check resolver connection)

* Denotes error code available with the RSE (RETURN SERVO ERRORS) command only. The code does not appear on the front-panel display.

THIS TABLE IS INTENDED ONLY AS A QUICK REFERENCE.

REFER TO SECTION 7.4 FOR TROUBLESHOOTING INFORMATION

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APPENDIX C

SOFTWARE REFERENCE

The information in this appendix will enable you to

* Identify the four types of commands.
* Use this appendix as a reference for the function, range, default, and sample use of each command

DEFINITION AND DESCRIPTION OF COMMAND TYPES

TYPE	DESCRIPTION
MOTION	Motion commands affect motor motion
STATUS	Status commands respond (report back) with information. These commands must be prefixed with a device address.
SETUP	Setup commands define setup conditions for the application. They include the following types of commands: * Tuning * General (set current, return to factory settings, etc.)
PROGRAMMING	Programming commands affect programming and program flow.

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DESCRIPTION OF FORMAT (DEFINITION OF FIELDS)

When using this appendix you can find information arranged as shown below.

SYNTAX

NAME:	Command Name
SYNTAX:	The command's required and/or optional parameters.
DEFAULT:	The factory default setting
RANGE:	The range of values for the parameter(s)
VALID:	Revision history. The revision of software when the command was added or modified. (See RV, Report Software Revision command)
RESPONSE:	Syntax for the response. This will include the number of characters returned, their range and format, and any delimiters.
TYPE:	Setup, Motion, Status, Programming
ATTRIBUTES:	Immediate, Buffered, Device Address Optional, Device Address Required, Savable in Sequence
DESCRIPTION:	The description of the command

The format for sending a COMMAND is

aCOMMANDd

where a = a device address (1 - 15)
and,
d = a delimiter (a space or a carriage return)

The device address is really only necessary in two instances.

1. To send a command to only one of several drives hooked-up in a daisy-chain manner, the device address must precede the COMMAND. Without the device address, all units will execute the command.

2. All report back commands require a device address. This prevents multiple daisy-chained units from attempting to answer the terminal at the same time.

The factory default device address of a KH Drive is device #1. The device address may be changed with the front panel pushbuttons (Section 6.8.2).

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CCA

NAME: Configure Current Average
SYNTAX: <a>CCAn
DEFAULT: n = Motor/Drive size dependent
RANGE: n = Motor/Drive size dependent
VALID:
RESPONSE: aCCA *AVERAGE_CURRENT_LIMIT=n_AMPERES[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports a new maximum average current. If the average current commanded exceeds the value defined by CCA command the controller will disable the amplifier and indicate an error.

SEE ALSO: CCP
EXAMPLES:

Command	Description
CCA1Ø	Set maximum average current to 1Ø amps
1CCA	*AVERAGE_CURRENT_LIMIT=1Ø.ØØ_AMPERES

CCP

NAME: Configure Current Peak (Maximum)
SYNTAX: <a>CCPn
DEFAULT: n = Motor/Drive size dependent
RANGE: n = Motor/Drive size dependent
VALID:
RESPONSE: aCCP *PEAK_CURRENT_LIMIT=n_AMPERES[cr]
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports the peak maximum current that will be sent to the motor. The value entered will become the new peak current limit.

SEE ALSO: CCA
EXAMPLES:

Command	Description
CCP4Ø	Set peak current to 4Ø rps
1CCP	*PEAK_CURRENT_LIMIT=4Ø.ØØØ_AMPERES

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CDB

NAME: Configure Deadband
SYNTAX: <a>CDBn
DEFAULT: n = Ø
RANGE: n = Ø-1ØØ,ØØØ,ØØØ
VALID:
RESPONSE: aCDB *SLIP_FAULT_DEADBAND=n_STEPS[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: The CDB command defines/reports the new deadband value in motor steps. If deadband is exceeded the IN POSITION output on the indexer connector will turn off. When the IN POSITION line is active it indicates that the absolute value of the following error is within the deadband region. This is useful when you need to know if the motor shaft is within a certain tolerance range with respect to the commanded position.

SEE ALSO: DPE
EXAMPLES:

Command	Description
CDB5Ø	Sets the deadband to 5Ø steps
1CDB	*SLIP_FAULT_DEADBAND=5Ø_STEPS

CDG

NAME: Configure Derivative Gain
SYNTAX: <a>CDGn
DEFAULT: n = Motor/Drive dependent
RANGE: n = Ø - 99
VALID:
RESPONSE: aCDG *DIFFERENTIAL_GAIN=n_PERCENT[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: This command defines/reports the derivative gain to be used for tuning. When you tune the drive using the Derivative Gain (CVG) command, you are actually setting a percentage of the Derivative Gain Maximum (CDM).

SEE ALSO: CDM
EXAMPLES:

Command	Description
CDG3Ø	Sets the derivative gain to 3Ø% of the maximum value
1CDG	*DIFFFERENTIAL_GAIN=3Ø_PERCENT

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CDM

NAME: Configure Derivative Maximum
SYNTAX: <a>CDMn
DEFAULT: n = Motor/Drive Dependent
RANGE: n = Ø-32,767
VALID:
RESPONSE: aCDM *DIFFERENTIAL_GAIN_MAXIMUM=n[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports the maximum derivative gain you may use for tuning purposes. If you enter a valid number, it will become the new maximum derivative gain. When you tune the drive using the Configure Derivative Gain (CDG) command, you will actually set a percentage of the maximum derivative gain.

SEE ALSO: CDG
EXAMPLES:

Command	Description
CDM5ØØ	Sets the maximum derivative gain to 5ØØ units
1CDM	*DIFFERENTIAL_GAIN_MAXIMUM=5ØØ

CIG

NAME: Configure Integral Gain
SYNTAX: <a>CIGn
DEFAULT: n = Motor/Drive dependent
RANGE: n = Ø - 99
VALID:
RESPONSE: aCIG *INTEGRAL_GAIN=n_PERCENT[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports the integral gain to be used for tuning. When you tune the drive using Configure Integral Gain (CIG), you are actually setting a percentage of the Maximum Integral Gain (CIM).

SEE ALSO: CIM
EXAMPLES:

Command	Description
CIG7Ø	Sets the integral gain to 7Ø% of the maximum integral gain.
1CIG	*INTEGRAL_GAIN=7Ø_PERCENT

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CIM

NAME:	Configure Integral Maximum
SYNTAX:	**<a>CIMn**
DEFAULT:	**n** = Motor/Drive Dependent
RANGE:	**n** = Ø - 32,767
VALID:	
RESPONSE:	**aCIM** *INTEGRAL_GAIN_MAXIMUM=n[cr]
TYPE:	Setup
ATTRIBUTES:	Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION:	This command defines/reports the maximum integral gain you may use for tuning purposes. If you enter a valid number, it will become the new maximum integral gain. When you tune the drive using the Configure Integral Gain (CIG) command, you are actually setting the percentage of the maximum integral gain.
SEE ALSO:	CIG

EXAMPLES:

Command	Description
CIM1ØØØ	Sets the maximum integral gain to 1,ØØØ
CIG45	Sets the integral gain to 45% of the maximum integral gain
1CIM	*INTEGRAL_GAIN_MAXIMUM=1ØØØ

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CMR

NAME: Configure Motor Resolution
SYNTAX: <a>CMRn
DEFAULT: n = 5,ØØØ
RANGE: n = 2ØØ-32768
VALID: CMR values 200 - 999 valid in revision Y9 and higher
RESPONSE: aCMR *MOTOR_RESOLUTION=n_STEPS/REV[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: You can define the motor resolution using this command. You must shut down the drive with the OFF command before defining a new resolution.

Changing motor resolution with the **CMR** command does not affect the system's dynamic performance. The microprocessor converts the commanded position to the appropriate absolute resolver position mathematically.

Before you define the new resolution, you must issue the **OFF** command to shut down the drive. After the **CMR** command is executed, you must issue the **ON** command to re-enable the drive. You must issue a Save (**SV**) command after changing the resolution to store the value in EEPROM.

It should be noted that this command changes the values and responses of any other command that uses motor steps. You should configure motor resolution before you use any of the other commands that are defined in motor steps.

When you use motor resolutions that are not powers of 2, an excessive following error fault will be generated after the motor turns more than ±65,535.99 revolutions. For applications that require long continuous moves, use any of the following resolutions:

- 1,Ø24
- 2,Ø48
- 4,Ø96
- 8,192
- 16,384
- 32,768

SEE ALSO: **OFF, ON, SV**
EXAMPLES:

Command	Description
OFF	Turns Amplifier off
CMR4Ø96	Defines a motor resolution of 4,Ø96 steps per revolution
ON	Turns amplifier on
SV	Saves the new resolution to EEPROM
1CMR	*MOTOR_RESOLUTION=4096_STEPS/REV

This example demonstrates the procedure required to change the motor's resolution.

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CMTR

NAME: Configure Motor
SYNTAX: <a>CMTRn
DEFAULT: Motor Dependant
RANGE: n = 25Ø, 26Ø, 71Ø, 72Ø, 73Ø, 74Ø
VALID:
RESPONSE: aCMTR *MOTOR_TYPE=n[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: This command configures the drive to the motor size that is being used. Compumotor configures every motor and drive system. This command allows you to select the proper current values and factory defaults for the various motor sizes that you may use with the drive. Each KH Drive is set for one of two possible motor ranges. Optimal performance can not be obtained if the drive is configured for a different motor or motor range than is actually being used. See Section 8.4 for more information about Motor-Drive compatibility.

SEE ALSO: FMCA
EXAMPLES:

Command	Description
CMTR71Ø	Configure drive to motor size 71Ø
1CMTR	*MOTOR_TYPE=KH71Ø

CPB

NAME: Configure Push Button
SYNTAX: <a>CPBn
DEFAULT: n = 1
RANGE: n = Ø, 1
VALID: Revision Y9 and higher
RESPONSE: aCPB *PUSHBUTTONS_ENABLED(DISABLED)[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: This command allows you to control user access to the front panel pushbuttons. Since tuning parameters can be modified via the pushbuttons, and changing these values can effect servo performance, it may be desirable to disable this interface. The CPB1 command enables the pushbuttons and CPBØ will disable them. This command needs to be saved and will take effect the next time the KH is powered up.

SEE ALSO: E, F, SV
EXAMPLES:

Command	Description
CPB1	Access to front panel pushbuttons set
1CPB	*PUSHBUTTONS_ENABLED

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CPE

NAME: Configure Position Error
SYNTAX: <a>CPEn
DEFAULT: n = 5ØØØ
RANGE: n = Ø - 327,679,999
VALID:
RESPONSE: aCPE *MAXIMUM_POSITION_ERROR=n_STEPS[cr]
TYPE: Setup
ATTRIBUTES: Independent, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports the value for the maximum allowable position error. If a value is supplied, it will become the new maximum position (or following) error. If the actual position error exceeds this maximum value, then the drive will fault and indicate error #20.

SEE ALSO: CDB
EXAMPLE:

Command	Description
CPE4ØØØ	Sets maximum following error to 4,ØØØ
1CPE	*MAXIMUM_POSITION_ERROR=4ØØØ_STEPS

CPG

NAME: Configure Proportional Gain
SYNTAX: <a>CPGn
DEFAULT: n = Motor/Drive dependent
RANGE: n = Ø - 99
VALID:
RESPONSE: aCPG *PROPORTIONAL GAIN=n_PERCENT[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports the proportional gain to be used for tuning. When you tune the drive using the Configure Proportional Gain (CPG) command, you are actually setting a percentage of the Proportional Gain Maximum (CPM).

SEE ALSO: CPM
EXAMPLES:

Command	Description
1CPG4	Configure the proportional gain to four percent of the maximum value.
1CPG	*PROPORTIONAL_GAIN=4_PERCENT

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CPM

NAME: Configure Proportional Maximum
SYNTAX: <a>CPMn
DEFAULT: n = Motor/Drive Dependent
RANGE: n = Ø - 32,767
VALID:
RESPONSE: aCPM *PROPORTIONAL_GAIN_MAXIMUM=n[cr]
TYPE: Setup
ATTRIBUTES: Independent, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: This command defines/reports the maximum Proportional Gain you can use for tuning purposes. If a valid number is entered, it will become the new maximum proportional gain. When you tune the drive using the proportional gain (CPG), you will actually set a percentage of the Maximum Proportional Gain. The Save (SV) command must be used to retain the value in non-volatile memory.

SEE ALSO: CPG, SV
EXAMPLES:

Command	Description
CPM6ØØØ	Sets maximum proportional gain to 6.ØØØ
1CPM	*PROPORTIONAL_GAIN_MAXIMUM=6ØØØ

CVG

NAME: Configure Velocity Gain
SYNTAX: <a>CVGn
DEFAULT: n = motor/drive dependent
RANGE: n = Ø-99
VALID:
RESPONSE aCVG *VELOCITY_GAIN=n_PERCENT[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved

DESCRIPTION: This command defines/reports the velocity gain to be used for tuning. When you tune the drive using the Configure Velocity Gain (CVG), you are actually setting a percentage of the Velocity Gain Maximum (CVM).

SEE ALSO: CVM
EXAMPLE:

Command	Description
CVG6Ø	Sets the maximum velocity gain to 6Ø%
1CVG	*VELOCITY_GAIN=6Ø_PERCENT

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CVM

NAME: Configure Velocity Maximum
SYNTAX: <a>CVMn
DEFAULT: n = Motor/Drive Dependent
RANGE: n = Ø - 32,767
VALID:
RESPONSE: aCVM *VELOCITY_GAIN_MAXIMUM=n[cr]
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional (Required for Reportback), Independently Saved
DESCRIPTION: This command defines/reports the maximum velocity gain to be used for tuning. When you tune the drive using the Velocity Gain (CVG) command, you are actually setting a percentage of the Velocity Gain Maximum (CVM).

SEE ALSO: CVG
EXAMPLES:

Command	Description
CVM3ØØØ	Sets velocity gain maximum to 3,ØØØ.
CVGØØ	Sets velocity gain to 6Ø% of the maximum value.
1CVM	*VELOCITY_GAIN_MAXIMUM=3ØØØ

DCA

NAME: Display current average
SYNTAX: aDCA
DEFAULT: None
RANGE: None
VALID:
RESPONSE: aDCA *AVERAGE_CURRENT=n_AMPERES
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: The DCA command periodically reports the average current flowing through the motor in amperes. This information is reported and repeatedly updated until a key is pressed. To get this number, 256 data points of the peak instantaneous current are averaged to provide a value computed at 1Ø millisecond intervals.

SEE ALSO: DCP, DCI
EXAMPLES:

Command	Description
1DCA	*AVERAGE_CURRENT=Ø1.732_AMPERES

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DCI

NAME: Display Current Instantaneous
SYNTAX: **aDCI**
DEFAULT: None
VALID:
RESPONSE: **aDCI *CURRENT=n_AMPERES**
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: The **DCI** command periodically reports motor current on an instantaneous basis. This number is reported in amperes and is repeatedly updated until a key is pressed. This number is a single sampling of the current.

SEE ALSO: **DCP, DCA**
EXAMPLES:

Command	Description
1DCI	*AVERAGE_CURRENT=+Ø2.32_AMPERES

DCP

NAME: Display Current Peak
SYNTAX: **aDCP**
DEFAULT: None
RANGE: None
VALID:
RESPONSE: **aDCP *PEAK_CURRENT=n_AMPERES**
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: The display current peak command will periodically display/report the largest instantaneous current value commanded to the motor since the amplifier was enabled. This value is reported in amperes and is repeatedly updated until any character is sent to the controller. The controller samples the instantaneous current at 512 microsecond intervals. Each reading is compared to the largest previous reading. If the new value is larger, it will become the new value.

SEE ALSO: **DCA, DCI**
EXAMPLES:

Command	Description
1DCP	*PEAK_CURRENT=18.651_AMPERES

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DFS

NAME: Display Flags for Servo Parameters
SYNTAX: **aDFS**
DEFAULT: None
RANGE: b = Ø, 1
VALID:
RESPONSE: *bbbb_bbbb_bbbb_bbbb_bbbb_bbbb_bbbb_bbbb[cr]
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: The display flags of Servo Command returns all the drives status flags as a 32 bit response. Each bit refers to a status flag as shown on the chart below. The associated number for each flag corresponds to each binary (1 or Ø) response is in the following order:
*31,3Ø,29,28,.....3,2,1,Ø

Bit	
31 27 23 19 15	these bits are all reserved for
3Ø 26 22 18 14	future use they all return zeroes
29 25 21 17 13	
29 24 2Ø 16 12	

Bit			
11	circuit disabled (plug)	Ø = no	1 = yes
1Ø	high voltage problem	Ø = no	1 = yes
9	indexer pulses at power up	Ø = no	1 = yes
8	failed EEPROM checksum	Ø = no	1 = yes
7	power dump overtemp	Ø = no	1 = yes
6	average current exceeded	Ø = no	1 = yes
5	max position error exceeded	Ø = no	1 = yes
4	remote indexer shutdown	Ø = no	1 = yes
3	pwm hardware shutdown	Ø = no	1 = yes
2	drive over temp	Ø = no	1 = yes
1	overcurrent	Ø = no	1 = yes
Ø	amplifier off	Ø = no	1 = yes

SEE ALSO: None
EXAMPLES: None

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DIC

NAME: Display Indexer Counter
SYNTAX: **aDIC**
DEFAULT: None
RANGE:
VALID:
RESPONSE: **aDIC** *INDEXER_COUNTER=±n
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: The Display Indexer Counter command will display the amount of single step commands it has received from the Indexer. It will be periodically updated. This value could differ from that of the indexer, since the driver may not have been enabled when some step commands were sent. This command is useful when looking for possible problems in the Indexer to Driver interface.

SEE ALSO: None
EXAMPLES:

Command	Response
1DIC	*INDEXER_COUNTER=+ØØØØØØ2ØØØ

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NAME: Display Position Actual
SYNTAX: **aDPA**
DEFAULT: None
RANGE:
VALID:
RESPONSE: **aDPA** *ACTUAL_POSITION=±n_STEPS
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: The display position actual command displays the actual system position in motor steps. The value will be periodically updated. The function is canceled by sending any character to the controller. The value is a cumulative count based on the shaft position when the drive was enabled and is scaled by the **CMR** command. The resolver actual count, regardless of **CMR** value is always based on 32,768 counts per revolution of the motor shaft. The scale factor used to display the value reported with this command is calculated by the following formula:

(32,768*65,536)/CMR

Results are truncated. This can cause a small non-cumulative error in position if the **CMR** resolution does not evenly divide into 2,147,483,648

SEE ALSO: **DPS**
EXAMPLES:

Command	Description
1DPA	*ACTUAL_POSITION=+ØØØØØØ5ØØØØ_STEPS

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DPE

NAME:	Display Position Error
SYNTAX:	**aDPE**
DEFAULT:	None
RANGE:	None
VALID:	
RESPONSE:	**aDPE** *POSITION_ERROR_=±n_STEPS
TYPE:	Status
ATTRIBUTES:	Immediate, Device Address Required, Never Saved
DESCRIPTION:	This command reports the difference between the position setpoint and the current position. The **PIDV** algorithm uses this number and previous positional errors to determine the amount of current that is sent to the motor. The larger the position error, the larger the control signal output to correct the error. This value is also used by the controller to see if the motor is within the deadband specified by the **CDB** command.
SEE ALSO:	**CDB, DPS, DPA**
EXAMPLES:	

Command	Description
1DPE	*POSITIONAL_ERROR=+ØØØØØØØ12_STEPS

DPR

NAME:	Display Resolver Position
SYNTAX:	**aDPR**
DEFAULT:	None
RANGE:	Ø-16383
VALID:	
RESPONSE:	**aDPR** *RESOLVER=n
TYPE:	Status
ATTRIBUTES:	Immediate, Device Address Required, Never Saved
DESCRIPTION:	This command repeatedly reports the actual resolver position. For one rotation of the motor shaft the resolver position will go through two complete resolver ranges (Ø-16383). This resolver information is not scaled by the **CMR** command. This command is useful to check for proper resolver connection.
SEE ALSO:	**None**
EXAMPLES:	

Command	Description
1DPR	*RESOLVER=1242Ø

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DPS

NAME: Display Setpoint Position
SYNTAX: **aDPS**
DEFAULT: None
RANGE: None
VALID:
RESPONSE: **aDPS** *POSITION_SETPOINT=±n_STEPS
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: This command reports the absolute position setpoint. This reporting is continued until any character is sent to the indexer through an RS-232C interface.

The position setpoint indicates the KH's commanded position for **PIDV** computation.

SEE ALSO: **DPA, DPE**
EXAMPLES:

Command	Response
1DPS	*POSITION_SETPOINT=+ØØØØ25ØØ1Ø_STEPS

DVA

NAME: Display Velocity Actual
SYNTAX: **aDVA**
DEFAULT: None
RANGE: None
VALID:
RESPONSE: **aDVA** *ACTUAL_VELOCITY=_n_RPM
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: This number is reported in revolutions per minute. This value is the calculated velocity being read from the resolver over a 512 microsecond period. Velocity is reported until a key is pressed.

SEE ALSO: **DVA**
EXAMPLES:

Command	Description
1DVA	*ACTUAL_VELOCITY=+ØØØØØØØ1ØØ_RPM

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DVS

NAME: Display/Report Velocity Setpoint
SYNTAX: **aDVS**
DEFAULT: None
RANGE: None
VALID:
RESPONSE: **aDVS** *VELOCITY_SETPOINT=+n
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: This number is reported in steps per second and is repeatedly updated until a key is pressed. This number is calculated at 512 microsecond intervals. This value is the commanded velocity being sent to the velocity part of the servo loop by the PID loop.

SEE ALSO: **DVA**
EXAMPLES:

Command	Description
1DVS	*VELOCITY_SETPOINT=+ØØØØØØ142Ø

E

NAME: Enable Communications Interface
SYNTAX: **<a>E**
DEFAULT: Communications Enabled
RANGE: None
VALID:
RESPONSE: None
TYPE: Programming
ATTRIBUTES: Immediate, Device Address Optional, Never Saved
DESCRIPTION: This command allows the drive to accept commands over the RS-232C communications interface. You can re-enable the RS-232C communications with this command if you had previously disabled the interface with the Disable Communications Interface (**F**) command. Unless the **CPB** command has been used, the drive will power-up with the front panel pushbuttons enabled and the RS-232C interface disabled. If several units are using the same RS-232C interface (by a daisy-chain), the **E** and **F** commands can help streamline programming.

SEE ALSO: **F**
EXAMPLES:

Command	Description
F	Disables all units on the RS-232C interface
4E	Enables Device 4
CCA2Ø	Sets CCA =2Ø amps for unit 4 only
E	Enables communication with all units

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NAME: Disable Communications Interface
SYNTAX: <a>F
DEFAULT: None
RANGE: None
VALID:
RESPONSE: None
TYPE: Programming
ATTRIBUTES: Immediate, Device Address Optional, Never Saved
DESCRIPTION: The Disable Communications Interface (F) command is useful when you are programming multiple units on a single interface. Axes that are not intended to process global commands receive device specific F commands. This allows you to program other units without specifying a device identifier on every command.

SEE ALSO: E
EXAMPLES:

Command	Description
1F	Disables the communications interface on units with device address 1
3F	Disables the communications interface on units with device address 3

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FMCA

NAME: Find Motor Commutation Angle
SYNTAX: **<a>FMCA**
DEFAULT: None
RANGE: None
VALID:
RESPONSE: **FMCA** *OFFSET_IS_n_COMMUTATION_IS_DONE
TYPE: Setup
ATTRIBUTES: Immediate, Device Address Optional
DESCRIPTION: Use this command if a new motor is being used or if a new resolver has been mounted on the motor, or if a resolver has been re-mounted on the motor. The use of this command is highly unusual, it will cause the motor to rotate under program control in the drive. While it is rotating the user has no control over the motor. Once you start this sequence of events you will have to cut off the AC power if you wish to stop the motor before the commutation procedure is completed. ***Disconnect all loads to the motor before issuing this command. THIS COMMAND CAUSES VIOLENT MOTION.***

The function of this command is to match the resolver rotor pole with the motor rotor pole by finding the commutation angle. ***Once commutation is completed, the save command must be issued after commutation is completed to save all the information to the EEPROM.***

SEE ALSO: **CMTR**
EXAMPLES:

Command	Description
FMCA	*OFFSET_IS_Ø216_COMMUTATION_IS_DONE

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^H

NAME:	Backspace
SYNTAX:	^H (Control H, ASCII 8)
DEFAULT:	None
RANGE:	None
VALID:	
RESPONSE:	None
TYPE:	Programming
ATTRIBUTES:	Immediate, Not Addressable, Never Saved
DESCRIPTION:	This command allows you to delete the last character that you entered. Once a command has been sent to the KH, the ^H command will not prevent execution of that command. A new character may be entered at that position to replace the existing character. (^H indicates that the Ctrl key is held down when the H key is pressed.) This command prompts the indexer to backup one character in the command buffer, regardless of what appears on the terminal. On some terminals, the ^H and the left arrow keys produce the same character.
SEE ALSO:	None
EXAMPLE:	None

K

NAME:	Kill
SYNTAX:	<a>K
DEFAULT:	None
RANGE:	None
VALID:	
RESPONSE:	None
TYPE:	Motion
ATTRIBUTES:	Immediate, Device Address Optional, Never Saved
DESCRIPTION:	The Kill (K) command is an emergency stop command and should only be used as such. This command causes indexing to cease immediately. There is NO deceleration of the motor. The Kill command may cause the motor to lose torque (i.e., large loads at high speed), the load could be driven past limit switches and cause damage to the mechanism and possibly to the operation.
SEE ALSO:	None
EXAMPLES:	None

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OFF

NAME: Off
SYNTAX: **<a>OFF**
DEFAULT: ON
RANGE: None
VALID:
RESPONSE: None
TYPE: Programming
ATTRIBUTES: Immediate, Device Address Optional, Never Saved.
DESCRIPTION: This command allows you to shut the amplifier off and remove current from the motor. When you issue an **OFF** command, a LED will be on to indicate that the drive is shut down. You must issue an **ON** command to re-energize the motor and clear the fault.

The **OFF** command removes motor torque, allowing you to move the motor manually.

SEE ALSO: **ON**
EXAMPLES:

Command	Description
OFF	Powers down the motor (no torque)

ON

NAME: On
SYNTAX: **<a>ON**
DEFAULT:
RANGE: None
VALID:
RESPONSE: None
TYPE: Programming
ATTRIBUTES: Immediate, Device Address Optional, Never Saved
DESCRIPTION: This command turns the amplifier back on from the off state. If you issue the **OFF** command to shut the drive down, issuing the **ON** command re-enables the current to the motor, restoring motor torque.

SEE ALSO: **OFF**
EXAMPLES:

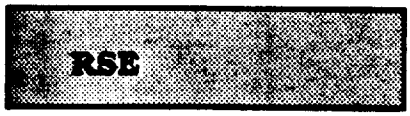
Command	Description
ON	Turns the motor on

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RFS

NAME:	Return Drive Parameters to Factory Setting
SYNTAX:	<a>RFS
DEFAULT:	None
RANGE:	None
VALID:	
RESPONSE:	None
TYPE:	Setup
ATTRIBUTES:	Immediate, Device Address Optional, Never Saved
DESCRIPTION:	Return the drive to factory setting. The following settings are changed: Deadband (CDB) to Ø Gains (CIG, CDG, CVG, CPG) to Factory Default Motor Resolution (CMR) to 5ØØØ steps Average Current (CCA) to Factory Default Peak Current (CCP) to Factory Default Following Error (CPE) to 5ØØØ steps Returns to Front Panel mode (F)
SEE ALSO:	None
EXAMPLES:	None

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NAME: Report Servo Errors
SYNTAX: **aRSE**
DEFAULT: None
RANGE: x = NO_ERRORS, 11, 16, 17, 18, 19, 2Ø, 22, 23, 3Ø, 6Ø, 61, 7Ø
VALID:
RESPONSE: **aRSE** *x[cr]
TYPE: Status
ATTRIBUTES: Immediate, Device Address Required, Never Saved
DESCRIPTION: You can find out what error condition exists in the servo drive using this command. If you see any red LEDs light up, you should start troubleshooting the unit using the RSE command. The possible error messages are:

11	Over-temperature
16	Amplifier off (CRT ONLY)
17	Indexer shut down (CRT ONLY)
18	Bus undervoltage
19	Motor Short circuit
2Ø	Following error exceeded
22	Maximum average current exceeded
23	Enable plug not inserted
3Ø	Checksum error in EEPROM
6Ø	RS-232C command drive told off (CRT ONLY)
61	Incoming indexer pulses
7Ø	Resolver is disconnected

SEE ALSO: None
EXAMPLE:

Command	Response
1RSE	*DRIVE_DISABLED_BY__#16_AMPLIFIER_OFF__#18_NO_VOLTAGE_AT_23ØVAC_CONNECTOR

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RV

NAME: Revision Level
SYNTAX: **aRV**
DEFAULT:
RANGE: **n = Ø - 9, x = A - Z**
VALID:
RESPONSE: **aRV *92-ØØ6981-Ø3xn[cr]**
TYPE: **Status**
ATTRIBUTES: **Immediate, Device Address Required, Never Saved**
DESCRIPTION: **The Revision (RV) command responds with the software part number and its revision level. The response is in the form shown below:**

***92-006981-nnxn[cr]**
part number revision level

The part number identifies which product the software is written for, as well as any special features that the software may include. The revision level identifies when the software was written. Record this information for future use. This information is useful if it is necessary to consult Parker Compumotor's Applications Department.

SEE ALSO: None
EXAMPLES:

Command	Response
1RV	***92-ØØ6981-Ø3Y9**

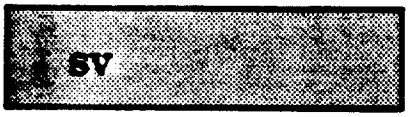
The software is identified by 92-ØØ6891. The revision level is identified by Ø3Y9.

S

NAME: Stop
SYNTAX: **<a>S**
DEFAULT: **None**
RANGE: **None**
VALID:
RESPONSE: **None**
TYPE:
ATTRIBUTES: **Immediate, Device Address Optional, Never Saved**
DESCRIPTION: **The Stop command behaves just like the OFF command.**

SEE ALSO: **OFF**
EXAMPLE: **None**

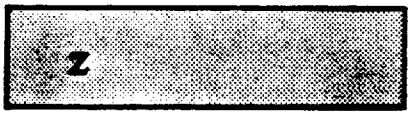
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NAME: Save Setup
SYNTAX: <a>SV
DEFAULT: None
RANGE: None
VALID:
RESPONSE: aSV *[cr]
TYPES: Programming
ATTRIBUTES: Immediate, Device Address Optional, Never Saved
DESCRIPTION: The SV command will save any new parameters you have defined. Values not changed, will stay that way. The save procedure may take several seconds to complete. An asterisk (*) will be sent to the terminal after a successful save.

SEE ALSO: None
EXAMPLES:

Command	Description
SV *[cr]	All drive parameters that can be saved are stored in non-volatile memory.



NAME: System Reset
SYNTAX: <a>Z
DEFAULT: None
RANGE: None
VALID:
RESPONSE: None
TYPE: Programming
ATTRIBUTES: Immediate, Device Address Optional, Never Saved
DESCRIPTION: The Reset (Z) command is equivalent to cycling AC power to the indexer. This command returns all internal settings to their power-up values.

When you use the Reset command, the indexer is busy for a couple of seconds and ignores all commands.

Any changes that you do not save before issuing this command will be lost.

This command sets all position counters to zero.

SEE ALSO: None
EXAMPLES: None

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