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# P315X
# User Guide

Microstep Power/Drive/Indexer

Installation and User

Reference Manual



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# 1 INTRODUCTION

This User Guide is intended to be the hardware and operations reference guide for the P315X Power/Drive/Indexer Unit. You should have also received the ICL SYSTEM USER GUIDE which is the software and applications user guide for this device. These two manuals form the reference set for the P315X Power/Drive/Indexer Units. Since the P315X is a member of the entire ICL System family of products, it is necessary to define the features available on the P315X.

**The standard features included on the P315X indexer are:**

| | |
|---|---|
| Communications Method: | RS-232C up to 19,200 Baud. |
| **Programmable Inputs:** | **Thirteen total. Stop, jog plus, and jog minus inputs can be assigned to any of the 13 inputs.** |
| Limit Inputs: | Home reference, clockwise limit (CWL), and counterclockwise limit (CWL). |
| Programmable Outputs: | Eight total. |
| Fault Output: | Fault output signal when over-current, over-temperature or under-voltage is detected. |
| Encoder feedback: | Includes A, B and Z channels with stall detect and position maintenance. |

Our goal as a supplier is to provide the user with the proper tools to get his/her application up and running as quickly as possible. This includes designing products that are easy to learn, use, install, and maintain, in addition to providing the required documentation and support to quickly answer any questions that you might have. To help you get started, this section will provide you with a roadmap through this manual. Depending on your level of expertise, you can decide how to proceed. We hope you find our recommendations helpful and we welcome any comments/suggestions that you might have in helping us achieve our goal.

This manual will guide the first time user of the P315X Series packages through the familiarization and installation into the chosen application. After the initial installation is accomplished it can also serve as an ongoing reference manual for installation changes or future reference needs.

While this manual is intended to include as much available information as possible, it is designed to also be easy to use for those who will not be reading the entire manual or who only want to refer to specific sections. Users should classify themselves and proceed accordingly:

**First time users -**
We recommend that all first time users and those basically unfamiliar with step motor drives read the entire manual before proceeding with installation.

**Experienced users -**
Refer to the Precautions and Warnings, (SECTION 1.2) and Functional Overview (Section 1.3) (SECTION 1.4) before proceeding with your installation.

**Current users with specific information needs -**
The table of contents will guide you to the specific location for answers to your questions.

## 1.1 Unpacking and Inspection

Carefully remove the contents of the carton in which the unit was shipped. Inspect the carton and the drive and make note of any apparent physical damage. If severe damage is present then you should consider rejecting the shipment and making contact with the shipping company concerning in-transit damage claims. We have made every effort at the factory before shipment to fully inspect, test, and properly package this product so that it reaches you defect free and without damage.

All packaging materials should be saved and set aside in case a return shipment has to be made. The contents may include connectors, mounting screws, a motor, or other components - please compare these components to the parts list which is included on the shipper. Immediately report any discrepancies to the shipping location.

## 1.2 Precautions and Warnings

While we have designed these units with safety issues in mind, the user should keep the following precautions in mind:

-> Because potentially lethal voltages can be present around this drive, only qualified service and installation personnel should install this device.

-> All connections or configurations should be to made with the power sources disconnected from the system.

The P315X-L, designated as the "low power unit", has been designed for motors up to a size 34 one stack (M34). The P315X-H, designated as the "high power unit", produces higher currents and provides additional heatsinking to run motors larger than a size 34 one stack (M342 and above).

There may be applications where the user desires to use the P315X-H unit with smaller motors and in most cases this would be acceptable, provided the motor is rated for at least 2.0 amps per phase and it's inductance is greater than 5 mH per phase. Check with the factory if you have questions regarding this matter.



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## 1.3 Functional Overview

The P315X series packages provides you with a completely integrated Power/Drive/Indexer unit. Each packaged system includes a motor, microstep drive, power supply, indexer, integral heatsink, power cord, connectors and a full enclosure.

An important feature of the P315X is that it provides the user with microstepping capability. By microstepping a step motor, its motion is smoother and the positioning resolution greatly enhanced. Microstepping involves taking each of the motor's mechanical full steps and electrically creating many finer ones by precisely controlling the current flow to each of the windings.

All models contain the logic and power switching stages required to operate a large percentage of existing step motor designs. The logic section of the drive sets to direct current in and out of the motor phases in a proper sequence in order to cause the desired rotation.

The power switching stage controls the rate and amount of current flow into the motor windings as directed by the logic. In general, the faster the current is pumped through a winding during each step, the more torque and speed that will be obtained. The P315X Series uses a bipolar chopper method of current control which will yield excellent speeds and torques. This technique involves overdriving the windings with high voltages to decrease the current rise times, and then controlling the current by high frequency (20 KHz) current chopping. **The P315X-L (low power unit) provides output currents up to 6 amps per phase and will drive 4-phase motors rated at up to 8.5 Amps per phase (bifilar rating). The P315X-H (high power unit) provides output currents up to 8 amps per phase and will drive 4-phase motors rated at up to 11.3 Amps per phase (bifilar rating).**

The Integeral indexer is a self-contained, high speed microprocessor based controller. Features include RS-232 communications, programmable inputs and outputs that interface to external devices, battery backed user memory, encoder feedback and an English-like ICL command language. Ramping routines are automatically generated and/or can be placed under user control.

**Connections to the P315X unit include:**

AC Power:

115 VAC 50/60HZ.

DC Power:

5-15 VDC for optically isolated limits and inputs.

Motor:

Either 4, 6, or 8 lead hybrid step motors can be connected. Motor cable should have a ground (shield) wire that is connected to the ground pin on the motor connector (Earth Ground).

RS-232 Communications:

Establishes serial communication between the P315X, the host device and other indexers.

Limit Inputs:

Has connections for Clockwise Limit (CWL). Counter Clockwise Limit (CCWL) and Home reference switch (HOME).

Programmable Inputs:

Has connections for 13 user programmable inputs. Dedicated jog plus, jog minus and stop inputs may be assigned to any of the inputs or not used at all.

Outputs:

Has connections for eight user programmable outputs and a fault output.

Encoder:

Has connections for channels A,B and Z. Allows closed loop positioning with stall detect and position maintenance capabilities.

## 1.4 Quick Start

This section is provided only for those who either have experience with step motor drives or wish to learn the minimum required to hook-up and run the P315X Series Power/Drive/Indexer units. An assumption is made here that the user has an IBM PC or compatible to communicate with the P315X.

1) Ensure that the AC power source is 115 VAC.

2) Review Section 2 - Installation and Configuration.

3) Ensure that the current switch settings are set for the motor that you are running (Section 2.3.3).

4) Select the Microstep Resolution desired (Section 2.3.5).

5) Select the baud rate desired (Section 2.2.2).

6) Plug the motor connector into the socket labeled motor (Section 2.3.2).

7) Refer to the section on "Performing Motion" (Section 3.3).

8) Plug into your power source (Section 2.6).



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## 1.5 Motor Compatibility

The P315X may be purchased as a complete packaged unit with a compatible motor. Motors packaged with the P315X have been selected to provide the optimum speed versus torque performance for a given package and can be operated in either series or parallel configurations. (See appendix C for performance curves.)

The P315X Series is capable of running a wide range of step motors with it's bipolar chopping technique. The limits of these ranges fall into several categories:

**Winding Type**
The motor winding type should be basically a two phase motor which is capable of bipolar operation, characterized by the need for current to flow in both directions in each coil of the motor. Most motors which fall into the "HYBRID" motor classification will work. Step angles of 0.9 and 1.8 degrees are the most common. Appendix A lists the most common motors available through the Controls Division of API.

**Number of Leads**
Hybrid style motors have 4, 6, or 8 leads depending on how they are wound and connected. Diagram 1.5 shows these 3 basic configurations; note that the 4-lead motor is wound in a "UNIFILAR" fashion while the 6 and 8 lead motors are wound in a "BIFILAR" fashion. **ALL THREE OF THESE TYPES OF WINDINGS CAN BE OPERATED.**

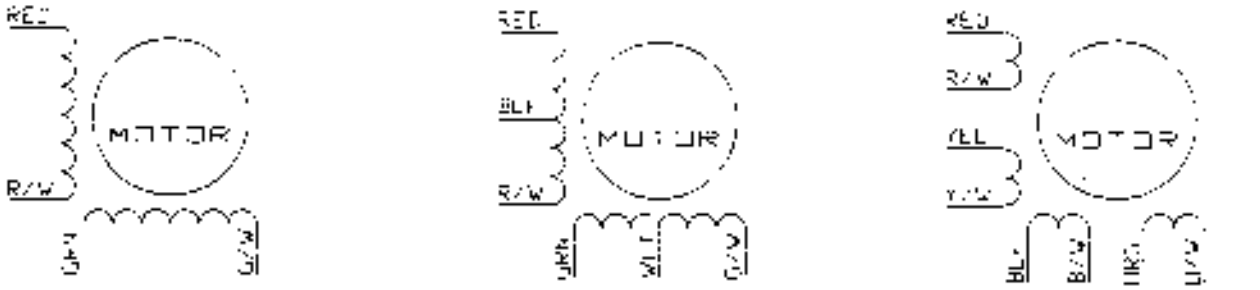



DIAGRAM 1.5

**Motor Heating**
The P315X series drives are capable of operating a motor connected in series or parallel configuration. Motors wired in series that come packaged with the P315X can be run continuous at high speeds without overheating. Motors wired in parallel that come packaged with the P315X cannot be run continuously above 5 rps unless extensive cooling is provided to the motor. Since most applications do not require continuous operation at high speeds the average core loss will be within safe limits. As the speed of the motor increases, the core loss, (eddy current and hysteresis) increases to a level where the motor loses torque. Motor core losses are related to motor heating and are not related to shaft power.

If you are attempting to use a motor that has not been supplied as part of a packaged system extreme care should be taken to ensure that the current rating and inductance ratings fall within the recommended ranges.

**Motor Current Rating**
The basic current output range is .2 to 6.0 Amps per phase for the P315X-L and 2.0 to 8 Amps per phase for the P315X-H. These are the ranges for the rating per phase of a 4 lead unifilar wound motor. If a 6 or 8 lead motor is being considered then its bifilar current rating should fall into these ranges when connected in series or parallel as determined by the application.

**Inductance**
The range of motor inductance is .5 mH - 80 mH on all models of P315X drives. The recommended motor inductance is 5 mH - 40 mH.

**Size**
Recommended motor sizes for the P315X Series is size 23 to size 42 motors.

**If a question remains about whether a particular motor can be operated, please contact the Controls Division for application assistance.**

## 1.6 Performance Expectations

Step motors are quite unique in many aspects of their design, performance and control. Many attributes of a step motor can be attractive to the application designer; such as their simplicity, digital nature, and inherent open loop capability. Other attributes have to be overcome to allow a step motor to perform the best in an application; such as resonant instability and loss of torque as a function of speed. It turns out that a step motor's driving electronics play just as important a role in performance as the motor itself. Since a motor's inductance acts to inhibit current buildup and decay, the faster that current can be moved, the more that torque producing current will be pumped through the windings.

The P315X Series drives are designed to minimize the current rise times through it's bipolar chopper. The user can expect to achieve relatively fast stepping rates with these drives running in an open loop capacity; in general, the lower the inductance of the driven motor (also, the higher the current rating), the faster the drive will be able to step the motor. **Low inductance motors can overheat if operated at high speeds for extended periods of time.** Actual temperature rise is duty cycle dependent.

Since all step motors exhibit resonant instability at lower speeds, the user should try to minimize their effect by microstepping. The unstable areas of a full or half stepped motor are characterized by erratic motion and a severe loss of torque. A microstepped motor will exhibit less resonance than a full stepped motor.

Another important feature designed into the P315X Series drive is mid-range stability. The drive will sense when the motor is operating in a region of resonant instability and modify the current wave form to prevent loss of torque. Mid-range stability has little effect at low speeds, below 5 RPS, but allows the motor to operate at much higher speeds and overcome potential resonant instability.

Sample performance curves are provided in **Appendix C** for your reference.



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# 2 INSTALLATION AND CONFIGURATION

The contents of this section will guide the user through the proper steps required to safely install and hook-up the P315X Series units. This section should be read in it's entirety for first-time installers and reviewed during the installation process.

## 2.1 Physical Requirements

### 2.1.1 System Grounding

All electrical equipment, components and enclosures should be properly grounded to ensure safety and to reduce the effects of electrical noise due to electromagnetic interference (EMI). It is recommended that single point grounding setup be utilized and all ground connections be continuous and permanent. Wherever possible, route high power lines (motor and power) away from logic signals (RS-232, step, direction, etc..) to prevent noise problems.

The P315X drive switches 170 VDC at 20 KHz to provide current to the motor. This 20 KHz chopping action may radiate or conduct electrical noise out the drive into the AC power line or along the motor cable into the attached equipment. Below are some general steps to be followed to prevent problems caused by the electrical noise generated by the P315X series drives.

1. Shield the motor cable (already done for you on Controls Division complete model motors) and ensure that the shield is taken to a low impedance earth ground.
2. Ground the motor casing to a low impedance earth ground.
3. Mount equipment that is sensitive to EMI as far as possible from the drive and motor.
4. Utilize an isolation transformer and filter to provide power to the drive. This will reduce the AC line noise generated by the drive from getting back into the AC line.
5. Provide a separate AC line for the drive. Do not use the same AC line for equipment that is sensitive to electrical noise.
6. Shield the logic signal lines of equipment sensitive to electrical noise and ensure that the shield is taken to a low impedance earth ground.

## 2.1.2 Cooling

**Drive/Indexer**
The enclosure of the P315X is a heatsink which allows for heat dissipation produced by the internal components. During operation the heatsink will become warm to the touch and should not be a concern to the user. An internal temperature sensor will shut down the drive if the internal air reaches 140°F (60°C) internally. If this Over-Temperature fault condition exists the status LED will be illuminated and the drive fault output will be active. Additional air cooling devices are not required except where ambient temperatures are high or high current motors are used. Consult the factory if these conditions exist.

The most fundamental rule to follow concerning proper cooling of the drives is to keep the heatsink surface temperature less than 75°C. Since the drive is convection cooled, it is recommended that you allow a minimum of one inch on all sides for air flow. Operating in an enclosed area may require external cooling in order to keep the heatsink temperature less than 75°C (ie. - forced air fan). A rule of thumb if you are not able to measure the heatsink temperature: the heatsink temperature is within limits if you can comfortably hold your finger on it more than 3 seconds.

**Motor**
Controls Division complete model motors are rated at 212°F (100°C) maximum allowable case temperature. When connected in parallel, motors can overheat if operated at high speeds for extended periods of time. Actual temperature rise is duty cycle dependent. Providing forced air cooling for the motors will extend duty cycles but in no case should the motor be allowed to exceed the rated maximums.

## 2.1.3 Mounting

The P315X is a self-contained package requiring minimal concern for mounting methods and positions. A dimensional outline of the P315X is given in Figure 2.1.3.
Mounting brackets have been provided to mount or secure the P315X. The recommended mounting position is vertical with the heatsink exposed to allow convection and heat removal from the drive. It is recommended that you allow a minimum of one inch on all sides for air flow. The user should refrain from mounting where the heatsink is unexposed or where easy access to the connectors or adjustments is not practical.

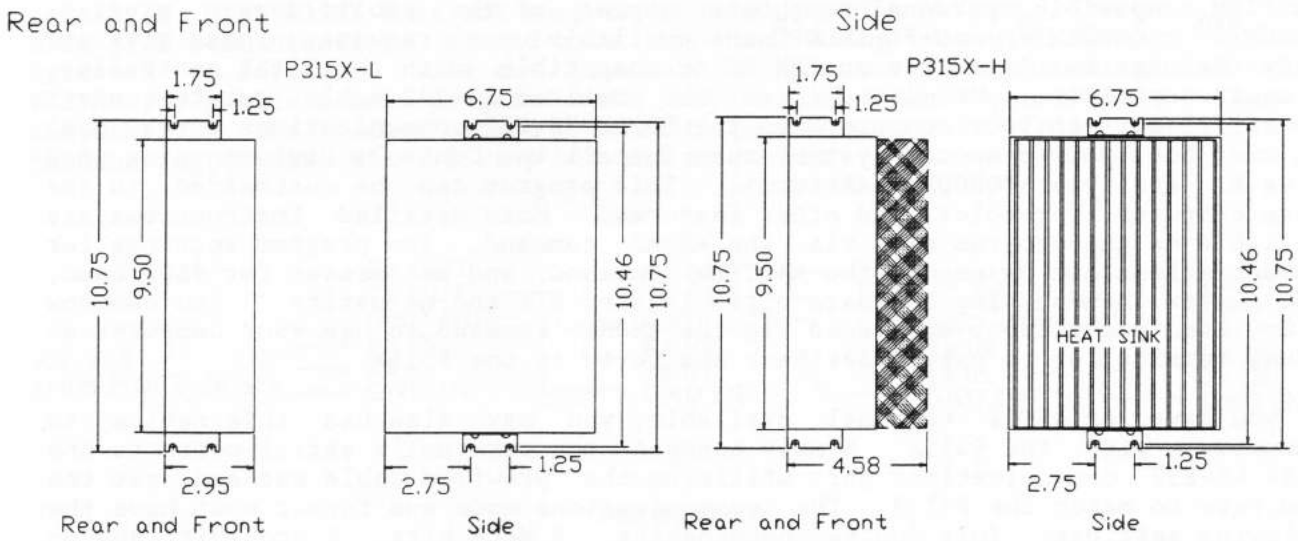
Should the drive need to be positioned more than 6 feet from the motor, consult the factory for the availability of motors with longer lead lengths.

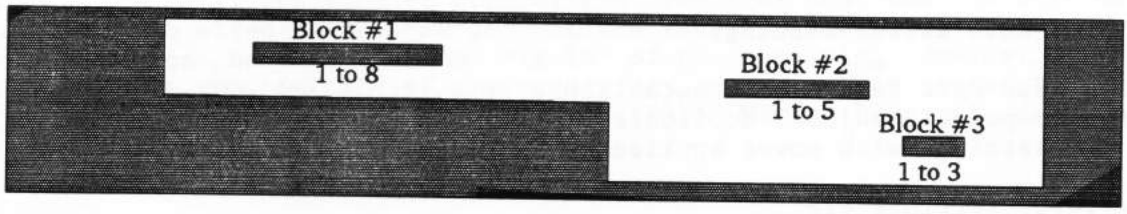


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## MOUNTING DIMENSIONS P315X SERIES




**Dip Switch Locations**

Figure 2.1.3

## 2.2 Communications

### 2.2.1 Host Device

For IBM compatible personal computers copies of the public domain programs PROCOM™ , QMODEM™ and PC-TALK™ are available upon request. These programs allow the user to interface an IBM PC or compatible with the P315X controller. To begin operation, you must utilize the prewired RS-232 cable set to connect the serial port on your computer to the P315X RS-232 communications port. Next you must boot your computer system, then install the Controls Division disk into drive A: and type "QMODEM" <Return>. This program can be customized to the users computer for color and other features. More detailed instructions are available on the program disk via the <HOME> command. The program settings for communications can be set by the <ALT-P> command, and are preset for 9600 baud, full duplex, handshaking, 8 data bits, 1 stop bit and no parity. You can now follow the instructions displayed via the <HOME> command to use your computer as a dumb terminal or to pass files back and forth to the P315X.

If you have an ASCII terminal available, you may also use this device to communicate with the P315X. Simply connect the terminal's serial port to the P315X RS-232 communications port utilizing the prewired cable set and set the baud rate to match the P315X. The communications mode and format must have the following settings: full duplex, handshaking, 8 data bits, 1 stop bit and no parity.

The P315X allows the user the ability to configure it's output for the size and shape of the host's display. The ICL parameter T" allows the user to fix the number of lines transmitted to the host device prior to pausing. This allows viewing of a large motion program or directories on a display as small as two lines. A second feature available through the ICL parameter screen width "SC" allows the user to define the display width of the host device.

### 2.2.2 Baud Rate Switch Settings

The P315X Baud Rate Settings is established on switch block #3. By using a ball point pen or pointed object, duplicate the switch settings given below. **DO NOT switch the settings with power applied to the P315X.**

The available settings are:

**Baud Rate Switch Settings**

| Baud Rate | Switch Block #3 P315X [1234] | |
|---|---|---|
| 19200 | 000 | |
| 9600 | 100 | |
| 4800 | 010 | |
| 2400 | 110 | |
| 1200 | 001 | |
| 600 | 101 | |
| 300 | 011 | |
| AUTO | 111 | (Auto baud rate selection - not enabled) |

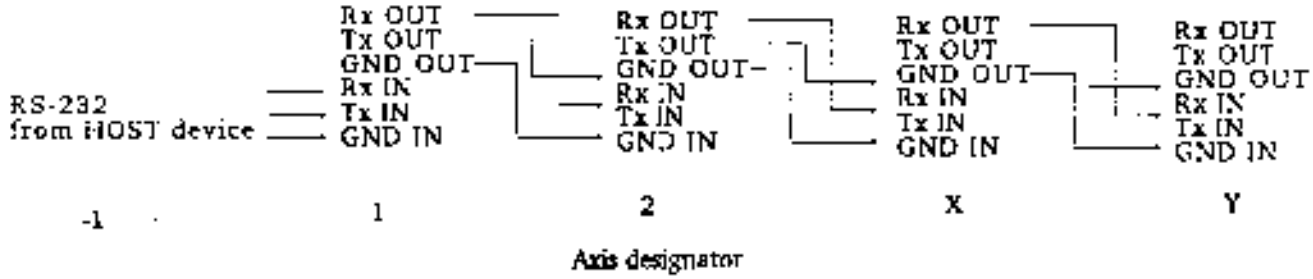


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### 2.2.3 RS-232 Connections

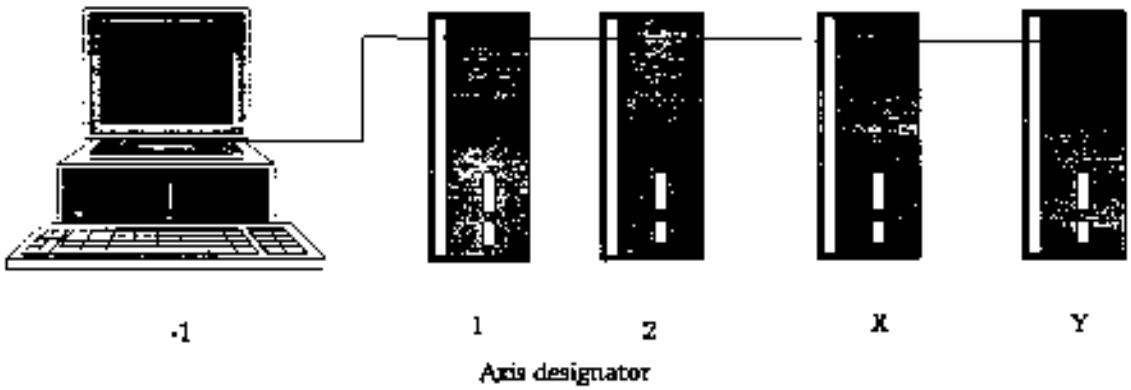
The P315X utilizes a three wire implementation of the RS-232 serial interface and provides Receive Data (Rx), Transmit Data (Tx) and Ground (GND) on the connector. The P315X does not support handshaking of any form. The host device used for communications should have its handshaking disabled through either hardware or software. See the previous section on "Communicating with the P315X" for public domain programs that can be used with IBM compatible personal computers. The communication default parameters are full duplex, no handshaking, 8 data bits, 1 stop bit and no parity.




P315X Wiring Diagram

### 2.2.4 Daisy Chaining

Up to 36 Indexers may be daisy chained to a single RS-232 port. It is necessary that each P315X have an exclusive axis designator defined by parameter "U", (see "ICL PARAMETER DESCRIPTIONS" for possible designators that can be set through software). The daisy chaining of controllers requires that the "Tx OUT" of the sending device be wired to the "Rx IN" of the receiving device, the "Rx OUT" of the sending device be wired to the "Tx IN" of the receiving device. The "GND OUT" is wired to the "GND IN" of the receiving device. This procedure applies to all the devices in a daisy chain. The "P315X Wiring Diagram" depicts the proper method of connection.



## 2.3 DRIVE SECTION

### 2.3.1 Introduction

To provide the user with the greatest amount of versatility, four adjustments can be made to configure the drive for the application.

1. Tells the unit the current rating of the motor.
2. Selects whether or not you desire to use the automatic low-power mode.
3. Establishes the microstep resolution desired.
4. Allows you to tune the optimum current profile for your application.

Depending on how you ordered your system, the unit will be set for a specific motor or to standard default conditions which may require you to go through a setup process for your application and motor.

When purchased as a packaged system complete with the motors, the settings will be found on a label affixed to the unit at the factory. If the listed motor differs or if no label can be found, follow the procedures in this section to verify and adjust the settings. **Disconnect power before proceeding.** Be sure to note any adjustments for future reference.

### 2.3.2 Motor Connections

Motor connections are made on the 7 pin pluggable connector provided with the drive. **Never connect anything other than the motor to the motor terminals.** If you purchased the drive with a motor, then the motor connections and current switch settings will already have been made. If not, then sections 2.3.2 and 2.3.3 will provide you with the proper drive settings, for your motor.

**SAFETY PRECAUTIONS: Do not supply power to the drive without having all of the motor leads firmly connected to their appropriate terminals. Connect center tap wires to Phase A Common and Phase B Common as required, connect the motor's shield to the terminal provided.**

If the motor turns in the wrong direction for your application, you may change the direction by reversing the motor leads going to the A+ and A- terminals on the 7 pin pluggable motor connector.

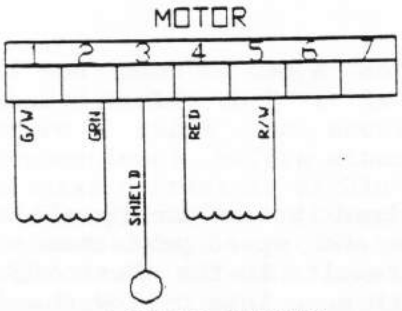
**MOTOR CONNECTIONS** (Terminal #'s 1-7)
The leads from the chosen motor will be connected at some or all of these terminals. Below are diagrams and comments depicting the possible connections for 4, 6 or 8 lead motors; the effect on current setting, and the effect on motor inductance.

**NOTE**: Our examples use a 4, 6 or 8 lead motor rated at 1 amp per phase current for a unipolar drive scheme (I-1), 5 ohm resistance, 10 mH per phase inductance (L-10). Since the P315 uses a bipolar drive scheme you would apply a multiplier to the unipolar rating to arrive at the proper current settings for your connection method. Examples follow.



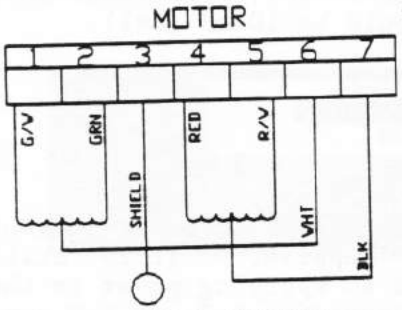
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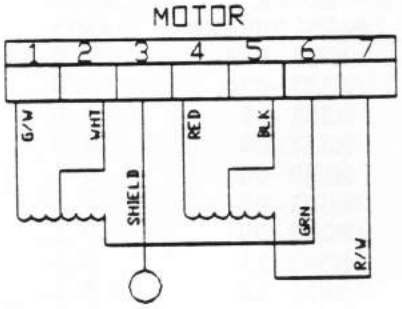

4 LEAD MOTOR

A 4 lead motor can only be hooked up in the configuration shown. The drive output current would be 1 amp (I*1). The inductance seen by the drive would be 10 mH (L*1).



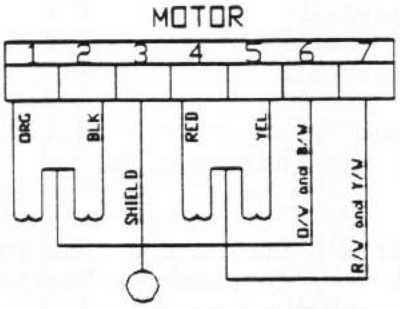

6 LEAD MOTOR

Connecting a 6 lead motor in series provides excellent low speed torque but reduced performance at higher speeds. The drive output current would be .7 amps (I*.707). The inductance seen by the drive would be 40 mH (L*4).



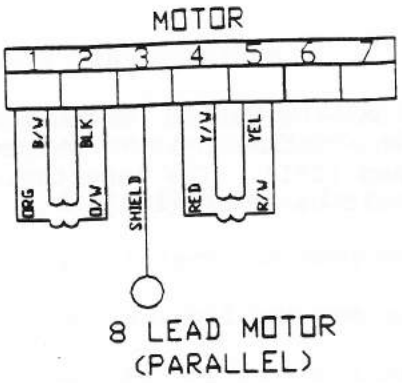

6 LEAD MOTOR
(HALF WINDING)

Connecting a 6 lead motor to utilize only half of the motor windings allows the user to achieve higher speeds but results in reduced low speed torque. The drive output current would be 1 amp (I*1). The inductance seen by the drive would be 10 mH (L*1).




8 LEAD MOTOR
(SERIES)

Connecting a 8 lead motor in series provides excellent low speed torque but reduced performance at higher speeds. The drive output current would be .7 amps (I*.707). The inductance seen by the drive would be 40 mH (L*4).




Connecting an 8 lead motor in parallel optimizes the torque and speed performance. This configuration results in the best high speed performance with some loss of low speed performance. **Note that this configuration may cause extra motor heating due to eddy current losses.** The drive output current would be 1.4 amps (I*1.414). The inductance seen by the drive would be 10 mH (L*1).

### 2.3.3 Current Switch Settings

If your drive and motor were purchased together as a package, then the current settings should have been previously made by your supplier. It is still advisable to verify that the settings are correct prior to applying power to the drive. Note that the P315X-L models are capable of providing 0.2 to 6.0 amps per phase and P315X-H models provide 2.0 to 8.0 amps per phase.

**Current Settings**

| P315X PACKAGES | STATIC TORQUE (Oz.-In.) | DIP SWITCH #2 (*) SERIES [12345] | PARALLEL [12345] | CONTROLS DIV. MOTOR PART NUMBER |
|---|---|---|---|---|
| P315X-A231A ** | 100 lbs. | 00100(L) | 11100(L) | A231-02A |
| P315X-A231C ** | 40 lbs. | 00100(L) | 11100(L) | A231-02C |
| P315X-M231 | 65 | 00100(L) | 11100(L) | M231-02 |
| P315X-M232 | 100 | 01100(L) | 00110(L) | M232-04 |
| P315X-M233 | 130 | 01010(L) | 00101(L) | M233-06 |
| P315X-M341 | 150 | 01010(L) | 10101(L) | M341-06 |
| P315X-M342 | 300 | 01100(H) | 01101(H) | M342-09 |
| P315X-M343 | 400 | 10010(H) | 00111(H) | M343-11 |
| P315X-M421 | 600 | 11010(H) | 11111(H) | M421-12 |
| P315X-M422 | 1100 | 11010(H) | 11111(H) | M422-12 |
| P315X-H421 | 900 | 10001(H) | N/A | H421-11 |
| P315X-H422 | 1800 | 01111(H) | N/A | H422-16 |
| P315X-H423 | 3000 | 01111(H) | N/A | H423-16 |

(L) - Switch settings denoted by (L) are for P315X-L series.

(H) - Switch settings denoted by (H) are for P315X-H series.

* - See **DIAGRAM** 2.3 for location of Switch Block #2. A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".

** - Linear Actuator Model. The packaged model suffix A includes a .050 inch lead (20 pitch), suffix C includes a .250 inch lead (4 pitch, 4 Start). Other lead screw pitches are available upon request.



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If you plan to use a motor that was not supplied as part of the package, you should verify that it is compatible with the P315X prior to connecting to the drive. Refer to sections 1.5 (Motor Compatibility) and 2.3.2 (Motor Connections) before attempting to connect the motor to the drive. If the closest current is within 10% of the rated current, it will probably suffice for most applications. Current settings 10% greater than the rated value should not be used unless special cooling precautions are taken or intermittent operation allows for liberal use of the Low Power state. These precautions should preclude motor temperatures greater than the maximums specified by the manufacturer. By using a ball point pen or pointed object, duplicate the switch settings given in the Appendix at the DIP switch on the drive. **DO NOT switch the settings with power applied to the motor.**




Dip Switch Locations

## Current Settings

| Amps per Phase | Switch Block #2 P315X-L [12345] | P315X-H [12345] |
|---|---|---|
| 0.2 | 10000 | N/A |
| 0.4 | 01000 | N/A |
| 0.6 | 11000 | N/A |
| 0.8 | 00100 | N/A |
| 1.0 | 10100 | N/A |
| 1.2 | 01100 | N/A |
| 1.4 | 11100 | N/A |
| 1.6 | 00010 | N/A |
| 1.8 | 10010 | N/A |
| 2.0 | 01010 | 00000 |
| 2.2 | 11010 | 10000 |
| 2.4 | 00110 | 01000 |
| 2.6 | 10110 | 11000 |
| 2.8 | 01110 | 00100 |
| 3.0 | 11110 | 10100 |
| 3.2 | 00001 | 01100 |
| 3.4 | 10001 | 11100 |
| 3.6 | 01001 | 00010 |
| 3.8 | 11001 | 10010 |
| 4.0 | 00101 | 01010 |
| 4.2 | 10101 | 11010 |
| 4.4 | 01101 | 00110 |
| 4.6 | 11101 | 10110 |
| 4.8 | 00011 | 01110 |
| 5.0 | 10011 | 11110 |

*****CAUTION*****

API motor ratings are based on a unipolar drive scheme. Since the P315 utilizes a bipolar drive method, the multiplier that must be applied to the unipolar rating to arrive at the proper current is as follows:

Series connection - .7
Parallel connection - 1.4

See Section 2.3.2 for additional information.

| | Switch Block #2 | |
|---|---|---|
| Amps per Phase | P315X-L [12345] | P315X-H [12345] |
| 5.2 | 01011 | 00001 |
| 5.4 | 11011 | 10001 |
| 5.6 | 00111 | 01001 |
| 5.8 | 10111 | 11001 |
| 6.0 | 01111 | 00101 |
| 6.2 | 11111 | 10101 |
| 6.4 | N/A | 01101 |
| 6.6 | N/A | 11101 |
| 6.8 | N/A | 00011 |
| 7.0 | N/A | 10011 |
| 7.2 | N/A | 01011 |
| 7.4 | N/A | 11011 |
| 7.6 | N/A | 00111 |
| 7.8 | N/A | 10111 |
| 8.0 | N/A | 01111 |
| 8.2 | N/A | 11111 |

### 2.3.4 Low Power Settings

The P315X can be configured for automatic low-power, (switch #5 on switch block #1). The current supplied to the motor windings will be reduced to 50% full power one (1) second after motion is complete. The drive is returned to full power upon receipt of the next step signal. This option is excellent to help control motor heating and reduce power consumption when not in motion.

Dip Switch Settings

Dip Switch Setting for Automatic Low-Power

| Switch (NOTE 1) Block #1 [12345678] | |
|---|---|
| xxxxlxxx | Automatic Low-Power Enabled |

NOTE 1 - See DIAGRAM 2.1.3 for location of Switch Blocks. A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".



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### 2.3.5 Microstep Resolution Switch Settings

The P315X Series drive allows the user the versatility to select a microstep resolution that best matches his application requirements. For a standard 1.8° step motor there are sixteen selectable resolutions that range from 200 to 50,800 steps per revolution. Refer to **APPENDIX B** and determine the resolution that best meets your needs and set the switches as indicated.

**Microstep Resolution**

| Steps per Revolution | Switch (NOTE 1) Block #1 12345678 |
|---|---|
| 200 | 0000xxxx |
| 400 | 1000xxxx |
| 1000 | 0100xxxx |
| 2000 | 1100xxxx |
| 5000 | 0010xxxx |
| 10000 | 1010xxxx |
| 12800 | 0110xxxx |
| 18000 | 1110xxxx |
| 20000 | 0001xxxx |
| 21600 | 1001xxxx |
| 25000 | 0101xxxx |
| 25400 | 1101xxxx |
| 25600 | 0011xxxx |
| 36000 | 1011xxxx |
| 50000 | 0111xxxx |
| 50800 | 1111xxxx |

NOTE 1 - See **DIAGRAM 2.1.3** for location of Switch Blocks. A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".

### 2.3.6 Tuning the P315X

The P315X series drives may be tuned to optimize the current wave form for optimum smoothness or relative accuracy as required by the application. Two adjustments are available to the user, these adjustments are made only after the drive has been configured to a specific motor, microstep resolution and is operating in the application (with load applied). The first adjustments are for Phase A and Phase B offset. The second adjustment is the addition of 3rd harmonic to the current wave form .

Below are two methods that may be used to determine the level of motor resonance in your system.

**Tachometer Method**

Using an oscilloscope to monitor the output of a tachometer attached to the motor shaft. The tachometer DC voltage output is proportional to the motor speed. This voltage will oscillate around an average voltage when the motor is resonating. The object of this method is to tune the drive for the lowest oscillation amplitude.

**Audible Method**

A stethoscope may be used when the motor is mounted in an inaccessible location. You will hear the audible vibration caused by the motor at resonance speeds. The object of this method is to tune the drive for the lowest amplitude of audible vibration.

### 2.3.6.1 Phase Offset Adjustment

The phase offset adjustment should not be attempted unless absolutely necessary, when performed incorrectly damage to the drive and motor may result, this adjustment is preset at the factory.

Phase A Offset - used to adjust the DC offset of the current for Phase A.
Phase B Offset - used to adjust the DC offset of the current for Phase B.

### 2.3.6.2 Current Profile Adjustment

You may select a current profile setting to optimize for smoothness or relative accuracy as required by the application. This adjustment will minimize the effects of torque ripple caused by the motor's detent torque. This adjustment is done by dip switch #1, see **Figure** 8.1.3 for location. Set the switches as indicated.

Current Profile Settings

| 3rd Harmonic Per Phase | Switch (NOTE 1) Block #1 [12345678] | 200 Steps Per Revolution Special case |
|---|---|---|
| -8% | xxxxx111 | 1 Phase |
| -5% | xxxxx011 | 1 Phase |
| -2% | xxxxx101 | 1 Phase |
| 0% | xxxxx000 | 2 Phase |
| 0% | xxxxx001 | 1 Phase |
| +2% | xxxxx100 | 2 Phase |
| +5% | xxxxx010 | 2 Phase |

NOTE 1 - See DIAGRAM 2.1.3 for location of Switch Block #1. A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".

**Two Hundred Steps per Revolution - Special Case**
The harmonics for 200 steps per revolution is a special case. Since there can be no harmonics for a full step wave form, either 2 phase on full step or 1 phase on full step may be selected. The 1 phase on full step will provide about half the torque as 2 phase on full step.



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**Procedures for runing the drive to the motor:**

1. To perform the phase offset adjustment the user must operate the motor in the primary resonance speed (usually between 0.25 - 1.25 revolutions per second).

2. Using one of the methods to determine the level of motor resonance in your system, adjust the Phase A and Phase B Offset.

3. Using one of the methods to determine the level of motor resonance in your system, adjust the Current Profile Settings (3rd harmonic).

4. Double the motor speed so that the motor is running rough at it's second resonance speed.

5. Repeat steps 2, 3 and 4 until no further improvement is noted.

The user may wish to record the drive configuration settings in the table provided below before proceeding to the section on drive connections. The access panel may be closed at this time as further internal adjustments are not required.

**P315X Configuration Settings**

Motor Model _____ Date: _____
Automatic Low-Power _____
Baud Rate Setting _____
Current Setting _____
Step Resolution _____

| | 12345678 |
|---|---|
| Switch Block #1 | _____ |
| Switch Block #2 | _____ |
| Switch Block #3 | _____ |

Notes:

## 2.4 INPUT/OUTPUT SIGNALS

### 2.4.1 Overview

In their simplest form, the P315X's inputs and outputs (I/O's), provide the ability for interaction between the P315X and external devices. Types of external devices includes other P315X's, programmable controllers, limit switches, relays, status lights (LED'S), foot pedals, counters, optical sensors, pressure sensors, etc. The state of all I/O's can be defined as "ACTIVE" or "INACTIVE". When the status of the inputs change, this change in state can be interpreted for taking appropriate action. The action can be either pre-defined or programmable depending on which input is "ACTIVE". A complete definition on how each I/O functions is included later in this manual.

The inputs and outputs of the P315X can be separated into the following groups; **Programmable and Limit Inputs** and **General Outputs**. In the following sections all of the inputs and outputs are defined along with methods of assigning their default states.

### 2.4.2 Programmable and Limit Input

Inputs are either programmable inputs #1 - #13, dedicated inputs CWL, CCWL and HOME, or special inputs JOG+, JOG-, and STOP, which can be assigned to any of inputs 1-13. In this section we will define the input names, assigned numbers, the method to set the default state of these inputs, and how the inputs may be utilized in the users system.

#### 2.4.2.1 Input Assignments

INPUTS:

| INPUT NAME | NUMBER | NAME | NUMBER |
|---|---|---|---|
| INPUT 1 | 1 | INPUT 9 | 9 |
| INPUT 2 | 2 | INPUT 10 | 10 |
| INPUT 3 | 3 | INPUT 11 | 11 |
| INPUT 4 | 4 | INPUT 12 | 12 |
| INPUT 5 | 5 | INPUT 13 | 13 |
| INPUT 6 | 6 | CWL | 14 |
| INPUT 7 | 7 | CCWL | 15 |
| INPUT 8 | 8 | HOME | 16 |

Special inputs JOG+, and STOP may be assigned to only one of the first 13 inputs. To do this the input number must be assigned to the appropiate ICL parameter name as denoted: JOG+ (JP), JOG- (JM) and STOP (SI).

Example: JP=11 JM=12 SI=13 Assign JOG+ to input # 11, JOG- to input # 12 and STOP to input # 13.

If one or all of the special inputs is declined then the appropriate parameter value would be 0.

Example: SI=0 STOP Input is declined.



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### 2.4.2.2 Input States

The CWL, CCWL and HOME limits are normally open with the pins internally pulled high at voltage OPTO 1. Limits are active when the normally open input switches are closed by taking them to the ground of the OPTO 1 supply. For the limit signal to be recognized by the P315X, the limit must be taken low for a minimum of 1ms.

Programmable inputs, inputs 1 to 13, are normally open with the pins internally pulled high at voltage OPTO 2. Inputs are active when the normally open input switches are closed by taking them to the ground of the OPTO 2 supply. For the input signal to be recognized by the P315X, the input must be taken low for a minimum of 2ms during the time the motion program is examining that input.

ICL Parameters I1 and I2 define the current status of the programmable and limit inputs while ICL parameter ID1 and ID2 define the default state of all inputs.

Each parameter is represented by an eight (8) bit number that defines the default state of the inputs. ID1 defines the default state of programmable inputs 1-8 and ID2 defines the defaults state of programmable inputs 9-13, CWL (14), CCWL (15) and HOME (16). In the following example the user has determined that an application requires a normally closed switch on inputs 2, 3 and 4. When the switches are opened, the P315X will interpret them to be "ACTIVE".

1. Check the current status of input definitions, VERIFY ID1 <Return>. The host device will display a string "ID1=00000000", showing that the default states of inputs 1 to 8 is "open" or floating high, and must be taken low to become "ACTIVE".

2. "ID1", the input definition parameter, is used to set the selected default states. All eight values must be entered or the command will not be accepted by the controller. Type the following:
   ID1=01110000 ID2=10000111 <Return>
   The P315X will now interpret the inputs defaults as: 1, 5, 6, 7, 8, 10, 11, 12 and 13 as active low, and 2, 3, 4, 9, 14, 15 and 16 as active high. The definitions are retained in the battery backed RAM.

3. Check the new status of the inputs with the VERIFY I command. The host will now display "I=01110000", "I2=10000111". The input status now shows that #2, #3, #4, #9, #14, #15 and #16 are "ACTIVE". Once the user attaches a normal closed switch to these inputs you may check the status again and all inputs will be "INACTIVE".

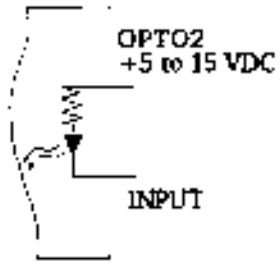
### 2.4.2.3 Limit Input Action

When utilizing the clockwise limit (CWL), and the counter clockwise limits (CCWL), the user may select hard or soft limits. The P315X is configured at the factory for hard limits. With hard limits the P315X will immediately stop the drive pulse train when a limit input is "ACTIVE" in that direction. The user may configure the P315X for soft limits by adjustment of parameter "LA". With soft limits the P315X will make a controlled deceleration and stop when a limit input is "ACTIVE" in that direction. The soft limit will cause the motor to decelerate utilizing the parameters for decelleration time, "D", and base speed, "B". If a limit input becomes "ACTIVE" while the motion program is commanding a move in that direction, the program will be terminated and returned to the immediate mode. The selection of hard or soft limits will be determined by the users application.

Limit inputs are normally open with the pins internally pulled high at voltage OPTO 1. When the normally open limit switches are closed by taking them to the ground of the OPTO1 supply, for a minimum of 1ms, the input signal will be recognized by the P315X.

### 2.4.2.4 Input Connections

P315X Inputs




### 2.4.3 Programmable Outputs

In this section we will define the output names, assigned number and the method by which the user can set the default states.

### 2.4.3.1 Output Assignment

PROGRAMMABLE OUTPUTS:

| NAME | NUMBER | TYPE |
|---|---|---|
| OUTPUT 1 | 1 | sinking |
| OUTPUT 2 | 2 | sinking |
| OUTPUT 3 | 3 | sinking |
| OUTPUT 4 | 4 | sinking |
| OUTPUT 5 | 5 | sinking |
| OUTPUT 6 | 6 | sinking |
| OUTPUT 7 | 7 | sinking |
| OUTPUT 8 | 8 | sinking |

When outputs 1 to 8 are open the pins are high internally at voltage OPTO 2 and when "ACTIVE" the pins are sinking current to OUTPUT COMMON. The user may decide that the output default state needs to be changed. The example following describes how this is accomplished.



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### 2.4.3.2 Output States

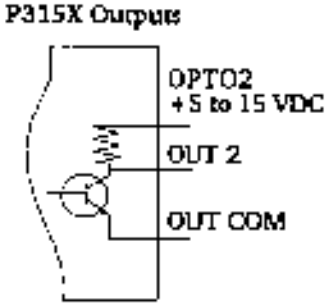
The parameter "OD", Output Definition, is represented by an eight (8) bit number that defines the default state of the P315X's outputs. The user has determined that the application requires two sinking outputs to be "ACTIVE" low .

1. Check the current status of outputs, VERIFY OD1 <Return>. The host device will display a string "OD1 - 00000000", showing that the default states of the outputs. Sinking outputs 1 to 8 are "open" and pulled high to voltage OPTO 2. When "ACTIVE" they will be sinking current to OUTPUT COMMON or "low".

2. "OD1", the output definition parameter is used to set the selected default states. All eight values must be entered or the command will not be accepted by the controller. Type the following:
   **OD=x11xxxxx <Return>**
   The P315X will now interpret the output defaults as: 1, 4, 5, 6, 7 and 8 as active when sinking current, outputs 2 and 3 are active when open (not sinking current). The definitions are retained in the battery backed RAM.

3. Check the new status of the outputs with the VERIFY O1 command. The host will now display "O=01100000".

### 2.4.3.3 Output Connections



## 2.5 ENCODER SECTION

### 2.5.1 Encoder Capability

The P315X is a stand-alone single-axis packaged Power/Drive/Indexer unit that interfaces with incremental encoders to provide the user with position feedback. Position feedback capabilities available on the P315X are "Stall Detect", "Position Maintenance", "Following" and "Home on Z-Channel".

If you purchased the P315X and will <u>not</u> be using encoder feedback, you can skip this section and continue to the next section.

The SAC-560 is capable of interfacing with optical encoders providing differential or single-ended, dual square wave in quadrature TTL compatible outputs. For good noise immunity differential TTL compatible line driver outputs such as 26LS31 are preferred. Maximum frequency is 256 KHz (prequadrature). Example, a 10000 line rotary encoder can be interfaced if the maximum shaft velocity is less than 25.6 revolutions per second.

Controls Division encoders (models E1000-250, E1000-375 and E1000-500).

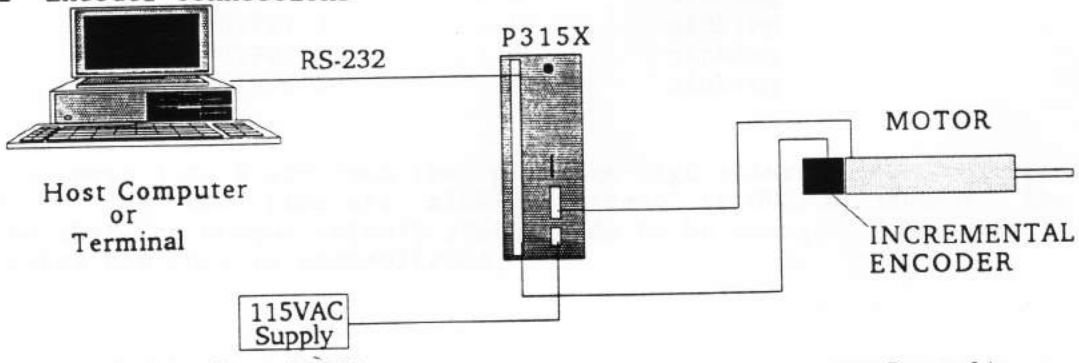
**Incremental Encoder**

If you have purchased a non-Controls Division incremental encoder you will have to wire the 9-pin connector yourself. If you purchased your incremental encoder as part of a packaged system it will be pre-wired. The P315X requires the standard phase A+, phase A-, phase B+, phase B- and optional phase Z+ and phase Z- inputs. The phase A and phase B inputs provide quadrature input signals. The P315X has an internal quadrature detection circuit. The optional phase Z inputs will allow the user to find the home reference position with respect to the index pulse. The Z-Channel will provide a single index pulse once per revolution for a rotary encoder.

**Encoder Resolution**

The resolution of an incremental encoder is defined as the number of distinct locations that are available in one revolution of the motor, (in some cases the encoder may not be coupled directly to the motor). The Controls Division encoders are 1000 lines per revolution, this is the pre-quadrature resolution. Thus the post-quadrature resolution of the encoder is 4000 pulses per revolution. The post-quadrature resolution of your encoder must be specified in ICL encoder resolution parameter "ER". In the case where "ER=4000", the ICL System will expect to receive 4000 encoder pulses per revolution of the motor shaft.

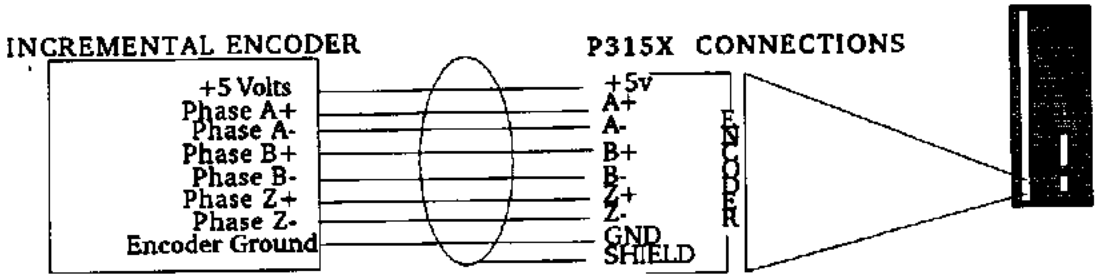
### 2.5.2 Encoder Connections






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**These encoder test procedures should be followed to prevent potential damage to your system.**

When using encoder functions, the ICL Parameters "ER" - Encoder Resolution and "MR" - Motor Resolution must be defined for the P315X to operate correctly.

1. Motor resolution is established by setting dip switches on the P315X. We will assume that the P315X is configured for 20000 steps per revolution, thus we will set MR=20000. The standard encoders supplied by the Controls Division are 1000 line encoders. After going through the quadrature detection circuit of the P315X it will have 4000 distinct locations per revolution, thus ER=4000. In cases where the encoder is not directly mounted to the motor, the user must determine the number of encoder pulses that will be received when the motor is displaced one shaft revolution.

2. Now we will verify that a move in the positive direction results in a positive change in the encoder position. Prior to performing a move we will set motion parameters "A", "B", "D", "H", and "M" to allow us to move the motor shaft.

| | |
|---|---|
| **Reset 0** | Resets the P315X to initial power-up state. |
| **EF=00000000** | Sets all encoder functions off. |
| **MUNITS** | Sets move unit of measure to motor pulses. |
| **A=1000** | Sets acceleration from "B" - base speed to "H" - high speed to one second. |
| **B=10000** | Sets base speed at .5 revolutions per second (RPS). |
| **D=1000** | Sets decel rate to 1 second or less. |
| **H=500000** | Sets parabolic ramp high speed at 25 RPS. |
| **M=400000** | Sets slew speed to 20 RPS. |
| **MR=20000** | Sets motor resolution to 20,000 steps per rev. |
| **ER=4000** | Sets encoder resolution to 4,000 counts per rev. |
| **E=0** | Sets encoder position to zero. |
| **P=0** | Sets motor positions to zero. |
| **PAUSE** | Set processing mode to single line. |
| **MOVE 20000** | Move the motor 20,000 steps. |
| **VER P VER E** | Verify the motor and encoder position. |
| "P = 20000" | Motor position is 20,000. |
| "E = 4000" | Encoder position is 4,000. |

If "E = -4000" the encoder wires for "A+" and "A-" must be switched and the example re-run. The value of "E" will be positive when moving in the positive direction.

## 2.6 POWER SECTION

### 2.6.1 AC Connections

Ensure that your power source is 95-132 VAC, 50/60 Hz.

A three prong power cord with a keyed 3 pin plug type connector is provided with the package. Simply plug the connector into the mating socket on the drive and plug into the power source. When power is present, the "POWER" LED will be illuminated. Pin out list follows:

AC Input Black Wire (Line) .....Line
AC Input White Wire (Neutral).....Neutral
AC Input Green Wire (Ground).....Ground

An isolation transformer can be used to enhance the system's electrical noise immunity.

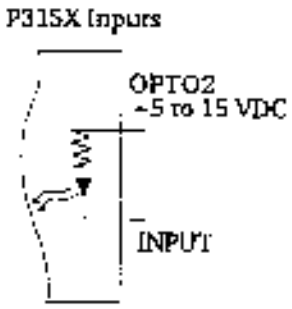
### 2.6.2 DC Connections

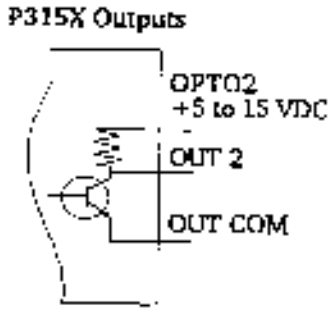
Ensure that your DC power source is a minimum of 2 amps at 5-15 VDC.

The DC power source is only required when the user is wiring the indexer into his application, such as limit switches, programmable inputs and outputs. This DC supply is utilized to power to the optical-isolation circuitry of the indexer. The positive of the supply is connected to the OPTO1 and OPTO2 pins of the plug type connectors. The supply return is connected to the OUTCM, output common pin of the plug type connector.

OPTO1 Supplies optical-isolation voltage to the limit inputs; CW, CCW and HOME, (inputs 14, 15 and 16).

OPTO2 Supplies optical-isolation voltage to all of the outputs and to the programmable inputs 1 to 13.






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## 2.7 SYSTEM STATUS

### 2.7.1 System Status LED'S

The P315X provides the user with LED's for indicating the current status of the drive.

**STEPPING (GREEN)**
This status LED is illuminated when the motor is stepping. When the motion is complete the status LED will turn off.

**OVER CURRENT (RED)**
When illuminated this LED indicates an over current fault condition. The drive fault output will become latched active if this condition exists. Check the drive for wiring problems and the step motor for shorts.

**OVER TEMPERATURE (RED)**
When illuminated this LED indicates that the drive temperature is above 60 °C. The drive fault output will become active if this condition exists. Additional cooling may be required to maintain a heatsink temperature less than 60 °C.

**UNDER VOLTAGE (RED)**
When the AC power drops below 95 VAC or the external reset input is active this LED is illuminated. The drives fault output will be active when these condition exists. Verify integrity of the AC supply. Verify that the external reset input is not active.

**NO POWER (YELLOW)**
This LED is illuminated whenever the motor is in the no-power mode due to either an active no-power input or a fault condition. Caution is required since the motor may not have torque sufficient to restrain loads.

**POWER (GREEN)**
When 115 VAC power is present, the "POWER" LED will be illuminated.

### 2.7.2 Drive Fault Output

The P315X provides the user with a drive fault output that can be used both as a visual indication and an electrical signal indication of the current status of the drive. The red status LED's provide a visual indication of a drive fault while an active drive fault output provides the electrical signal to notify the host. Note that when a fault condition exists the ICL System will also send the message "#31 DRIVE FAULT" via the RS-232 to the host.

The three possible fault conditions are OVER-CURRENT, OVER-TEMPERATURE and UNDER-VOLTAGE as indicated by the red LED's.

**OVER CURRENT (RED)**
When illuminated this LED indicates an over current fault condition. The drive fault output will become latched active if this condition exists. Check the drive for wiring problems and the step motor for shorts.

**OVER TEMPERATURE (RED)**
When illuminated this LED indicates that the drive temperature is above 60°C. The drive fault output will become active if this condition exists. Additional cooling may be required to maintain a heatsink temperature less than 60°C.

**UNDER VOLTAGE (RED)**
When the AC power drops below 95 VAC or the external reset input is active this LED is illuminated. The drives fault output will be active when these condition exists. Verify integrity of the AC supply. Verify that the external reset input is not active.

**To clear the drive fault condition a "RESET 0" command must be issued.**



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# 3 Start-up/Test Procedures

## 3.1 Applying Power

Once the drive is properly mounted and all of the required connections have been made, the drive may be powered up. Plug the 3 pin mating plug into the drive and then the power cord into 115 VAC source. Initial power should be applied with no pulses being fed to the drive. The motor will lock into position at it's rated static torque. If the automatic low-power mode has been selected then the static torque will decrease to about 50% of it's rated static torque after one second. Once the pulse input rate begins, the motor should begin to step in the set direction.

## 3.2 Establishing Communications

### 3.2.1 Test Procedure

Before proceeding with this section please ensure that all the appropriate communications connections have been made on the P315X. You should also ensure that your host device has been configured to communicate with the P315X. Once this has been established we are ready to apply power to the P315X. When power is applied the P315X will perform internal diagnostic tests. After successful completion of the tests a sign-on message will be sent to the host device that appears as follows:

```
"#0 American Precision Industries
    Smart Axis Controller, Copyright 1988
    Software Version x.x"

0>
```

If your host device was not connected to the P315X via it's RS-232 interface when power was applied to the P315X, you did not see the sign-on message. This occurs since the P315X doesn't support any communications handshaking. This does not prevent you from signing-on, it merely means that you will not see the sign-on message shown above. After connecting your host device to the P315X via the RS-232 interface and applying power to your device, you may begin communications. To verify that you are connected depress the **<ESC>** key on your keypad and you should now see the "0> " prompt on your device. If not depress the **<Return>** key. If you still don't see the prompt character on your display then you should refer to the "RS-232 Troubleshooting Procedures" that follows:

If after following the troubleshooting instructions you are still unable to establish communications with the P315X you should remove power and refer to the "Installation and configuration" section of this manual. Carefully review all wiring and settings make the necessary corrections and retry. If the problem is not located, please contact your Sales Representative for assistance.

If your display device is less than 25 lines and 80 characters wide. You should reconfigure the P315X to establish the proper settings.

The screen width parameter "SC" is used to define the number of characters avaliable per line on the host's display. To configure the output screen width to 40 characters, type the following; SC = 40 <Return>. The parameter "SC" can be a value from 20 to 80 characters depending on the host's display width.

The lines to display parameter "T", is used to define the number of lines sent to the host device before pausing. The T=10 command will instruct the P315X to transmit 10 lines and pause until any character is typed.

### 3.2.2 Troubleshooting

The procedures for troubleshooting three wire RS-232 serial communications are as follows:

1. Utilize the prewired RS-232 cable set supplied with the P315X. Verify that the host device transmit line (usually pin 2) is connected to the Rx IN of the P315X, and the receive line (usually pin 3) of the host device is connected to the Tx IN of the P315X. The DC common or signal ground of the host device (usually pin 7) is connected to the GND IN of the P315X, NOT earth ground.

2. Note: Some serial ports require handshaking. This can be disabled through hardware by jumpering RTS to CTS (usually pins 4 and 5) and DSR to DTR (usually pins 6 and 20).

3. Verify that the host device is set to the same baud rate as the P315X, 8 data bits, 1 stop bits and no parity.

4. If you receive double characters, for instance typing "A" and receiving "AA", your device is set for half duplex. Change the setup to full duplex.

5. A cable length of less than 50 feet is recommended between the host device and the last P315X in the daisy chain. If a shielded cable is used, be sure that only one end of the shield is connected to the earth ground.

6. To test the host device or the terminal emulation software, disconnect the P315X and transmit a character. You should not receive an echoed character, if you do, you are in the half duplex mode. Jumper the host's transmit and receive lines together and send another character. You should receive the echoed character. If not, please consult the manufacturer of the host device's serial interface for the proper pin outs.

7. If the data output from the P315X to the host device becomes mixed, (i.e. Dropping characters or complete lines), the baud rate may be set to high. The display buffer of the host device may not be able to handle the data stream. To correct this problem, ICL Parameter "T" will allow the user to fix the number of lines displayed prior to pausing. The baud rate settings of the system may also be reduced.



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## 3.3 Performing Motion

Before proceeding with this section it is assumed that communications between the P315X and your host device have been established; the motor is connected; and power has been applied.

### 3.3.1 Test Procedures

The following tests will perform motion on the P315X utilizing **MOVE**, **POSITION**, **RUN** and **SLEW** commands. It is assumed that the P315X is set at 10,000 steps per revolution and that you are using a 1.8° step motor. Note that the ICL commands are listed in bold type.

| COMMAND | COMMENTS |
|---|---|
| P=0 | Set current position to zero. |
| B=5000 | Set base speed to 1/2 revolution per second. |
| H=250000 | Set highest speed limit to 25 revolutions per second. NOTE: for full/half step drives this value is about 30000 as it is used to control the pulse width. |
| A= 10000 | Set acceleration time to 10000ms.(10 Seconds) |
| D= 10000 | Set deceleration time to 10000ms.(10 Seconds) |
| M= 125000 | Set maximum speed for 12.5 revolutions per second. |
| MOVE 10000 | The motor will start at base speed an accelerate toward the maximum speed then decelerate and stop after one revolution. For this short of a move the motor will not reach it's maximum speed, this is due to the long acceleration and deceleration times. The motion will be a triangular type profile. |
| VERIFY P | Read the parameters and make special note that the current position value 10000 to denote 1 revolution"P" in CW direction. |
| MOVE -20000 | The motor will move CCW, 2 revolutions and stop. |
| VERIFY P | Read the parameters and make special note of the current "P" value is -10000 to denote 1 revolution in CCW direction from the initial position. "N" will be 20000 to denote the last index distance. |
| POSITION 10000 | Use the absolute position command to return the motor to a position of 1 revolution from the initial position. |
| VERIFY P | The controller will report the current position. "P = 10000" |
| POSITION 10000 | This time the indexer will not move the motor since it is already at the commanded position. |

The next ICL commands to be utilized are the **RUN** and **SLEW** commands.

| COMMAND | COMMENTS |
|---|---|
| + | Set the next move direction to CW. |
| RUN | The motor will run at base speed CW and continue until a **STOP** command is issued. |
| STOP | Command the motor to stop. |
| SLEW | The motor will start at base speed in the last direction indexed or commanded, accelerate to the maximum speed and slew until commanded to stop. |
| STOP | Command the motor decelerate from maximum speed to base speed and stop. |
| <ESC> | Note the "escape key" can be used to abort a run or slew command, the index will stop without deceleration. |



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### 3.3.2 Troubleshooting

If a problem occurs or your system does not function properly (or as you expect it to operate), the operator should immediately turn off and disconnect all power to the drive before attempting any troubleshooting or repair. Only when you have identified and isolated the problem, can you effectively begin to resolve the problem.

The Initial step in troubleshooting is to verify that each component functions properly when operated independently. The motor should be disconnected from the load to isolate the drive from possible load related problems. You may have to dismantle your system then reassemble and test each component piece by piece to detect the problem. The following list of symptoms, causes, and corrections may help to guide the user through a problem solving session.

**MOTOR SHAFT FAILS TO TURN -**

No power to drive - check if AC voltage is present the green power LED is illuminated.

Motor current set to low - verify the current switch settings are set properly.

Open motor windings - check that each motor winding phase has the appropriate resistance with no open coils.

No incoming pulse - check for proper level and width of pulse at Logic Pin #2 (Step). The green stepping LED is illuminated if step pulses are being commanded.

No power logic - If the no-power LED is illuminated, verify that drive fault conditions do not exist.

Fixed load - check to see that driven load is not jammed or too large a load for the chosen motor size.

**MOTOR MOTION IS ERRATIC -**

Improper lead connections - confirm that the leads of the motor are connected with the proper sequence.

Motor current set to low - verify the current switch settings are set properly.

Winding continuity - check to see that each phase of the motor has the appropriate resistance with no shorts between windings or to the housing.

Incoming pulse integrity - confirm that the pulse rates being commanded are not too fast for the motor to maintain synchronism.

Resonant instability - confirm that the motor is not operating in a resonance range by adjusting the velocity.

Current profile adjustment - If the problem of rough microstepping exists then the following procedure is recommended. Adjust the pulse rate to achieve a shaft speed of one revolution per second, next adjust the dc-offset potentiometers to achieve smooth rotation of the motor shaft. The adjustment of the dc-offset potentiometers will fine tune the drive to the selected motor. Add 3rd harmonics to the current wave form, see section 2.3.6, to optimize for smoothness or relative accuracy.

**MOTOR RUNS VERY HOT -**

Normal operating mode - it is normal for step motors, when run at their rated current to be hot to the touch. In general, if the motor case temperature is less than 100°C, their is no cause for concern. **When a motor is configured for parallel operation at high speeds over extended periods of time, core heating may cause the motor to exceed specification, use of the automatic low-power mode is recommended to reduce heating.**

Current set too high - check to see that the current is set at the appropriate level for the motor being operated.

**MOTOR FAILS DURING ACCELERATION OR WHILE RUNNING -**

Improper acceleration rate - check that the increasing rate of pulses feed to the drive is not too fast or erratic for the motor to maintain synchronism with the driven load. Decrease the acceleration rate.

Erratic loading - if the driven load dramatically changes while motor is driving, it could overcome the speed/torque capability of system - try to run the motor with the load disconnected. Verify that the motor is sized correctly for your application.

Insufficient rotor inertia - if the motor stalls when operating at speed or during acceleration, you may need to add inertia to the motor shaft.

If all of the above remedies are attempted and the problem still remains, you may have to return the P315X and motor for service.

For assistance contact -

Your local API representative or Motion Automation Company (MAC).

or

**CONTROLS DIVISION**
45 Hazelwood Drive
Amherst, New York 14228-2278
716 691-9100
FAX 716-691-9181

To return a drive for service - Please call the number above to receive a **Return Material Authorization Number.** You will be instructed at that time where to return the drive for the most expeditious service.



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## 3.4 Inputs

The following procedures are used in checking the clockwise limit (CWL), the counterclockwise limit (CCWL) and the HOME input. The user should disconnect the AC power from the P315X when making any of the following connections. Please read the following procedures and only make the necessary connections required for the testing of each tested.

### 3.4.1 CWL and CCWL Inputs

1) Wire the CWL input at this time and return AC power to the P315X.

2) We now wish to cause the motor to run in the clockwise direction, type the following; **B-10000 + RUN <Return>**. The motor will begin to rotate clockwise at 1 revolution per second. If the motor does not start and the message "#25 LIMIT SWITCH ENCOUNTERED" is displayed, verify the default state of the CWL limit switch and make the proper adjustments to bit #6 of the INPUT DEFINITION parameter "ID2", (ID2-xxxxxlxx). To configure the indexer for CWL soft end of limit travel, **LA-xxx1xxxx <Return>**. To configure for hard end of limit travel, **LA=xxx0xxxx <Return>**. When the parameters "ID2" and "LA" are correctly set repeat procedure 12, the motor will stop rotating when the CWL input switch is active. Use the <ESC> key to terminate the motion.

3) Disconnect AC power before proceeding.

4) Wire the CCWL input switch and return the AC power to the P315X.

5) We now wish to cause the motor to run in the counter clockwise direction, type the following; - **RUN <Return>**. The motor will begin to rotate counter clockwise at 1 revolution per second. If the motor does not start and message "#25 LIMIT SWITCH ENCOUNTERED" is displayed, verify the default state of the CCWL limit switch and make the proper adjustments to bit #7 of the INPUT. DEFINITION parameter "ID2", (**ID2-xxxxxx1x**). To configure the indexer for CCWL soft end of limit travel, **LA-xxxx1xxx <Return>**. To configure for hard end of limit travel, **LA=xxxx0xxx <Return>**. When the parameter "ID2" and "LA" are correctly set repeat procedure 12. The motor will stop rotating when the CCWL input switch is active.

### 3.4.2 HOME Input

1) Disconnect AC power before proceeding.

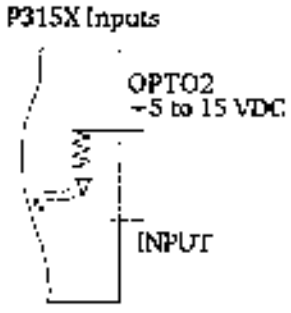
2) Only attempt to check the function of the home limit after the CWL and CCWL limit inputs have been checked as operational. We are now ready to check the HOME limit input, wire the HOME input and switch, return the AC power to the P315X.

3) Before we check the HOME input, some parameters must be set to provide speeds for searching for home. Type the following;
**B=10000 M=50000 A=1000 D=1000 + HOME <Return>**. The motor will start at 1 revolution per second in the clockwise direction and accelerate to 5 revolutions per second. If the motor encounters the CWL switch before the HOME limit switch then it will reverse direction and search in the counter clockwise direction. If the motor encounters the CCWL limit switch and displays message #23 "HOME NOT FOUND", verify the default state of the home switch and make the proper adjustments by setting bit #6 of the INPUT DEFINITION parameter "ID2", (see the section BASIC I/O").

4) Type + HOME <Return> to again search for home. When home is found the motor will reverse direction and run at base speed parameter "B" back to the home limit switch and stop. The current position parameter "P" and current encoder position parameter "E" are set to zero. The HOME limit switch has been verified as operational.

### 3.4.3 Programmable Inputs

The following procedures are used in checking the programmable inputs. The user should disconnect the AC power from the P315X when making any of the following connections. Below is a connection diagram for the P315X's inputs.






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Testing programmable inputs:

1) Disconnect AC power from the P315X before preceeding.

2) Wire the INPUT switches to the P315X as shown in the above drawing. When the wiring is completed you may return power to the controller.

   NOTE: If any of the inputs selected are "normally closed" switches the user should review the section on Basic I/O for setting the input definition parameter "ID".

3) Verify the status of the inputs; type, V I1 <Return>. The host will display the input status as an eight bit number representing inputs #1 - 8; "I1 = 00000000". A "0" denotes an inactive state and a "1" denotes that the input is active.

4) Activate input 1 and reverify the status of the inputs. The host will display "I1 = 10000000" denoting that input 1 is now active. This procedure can now be repeated for inputs 2 to 8. Activate input 9 and reverify the status of the inputs using the VER I2 command. The host will display "I2 = 10000000" denoting that input 9 is now active. This procedure can now be repeated for inputs 10 to 13. Inputs 14, 15 and 16 are reserved for the CWL, CCWL and HOME limits. Note: The P315X updates the current status of inputs after a command is executed. Thus it may be necessary to use the VERIFY command twice to read the expected result when in the immediate mode.

### 3.4.4 JOG inputs

Select two (2) inputs to be utilized as the Jog+ and Jog- inputs, in this case use inputs 1 and 2, wire as shown in "INPUTS.DWG", using the internal power supply of the P315X or utilizing an external power supply as shown.

1) Wire only the Jog+ input at this time and return AC power to the P315X.

2) Define input #1 as the JOG+ input with the following command; "JP=1". If the motor begins to rotate immediately, the "INPUT DEFINITION", parameter "ID1" for bit #1 needs to be changed by typing the following command: ID1 = 1xxxxxxx. Utilize the "x" symbol for the bits that you do not wish to change. When the parameter "ID1" is correctly set, the motor will stop rotating.

3) Set the Jog rate speed, parameter "J" to 1 revolution per second with J=10000 <Return>. When the Jog+ input #1 switch is activated the motor will rotate clockwise at one revolution per second. This input is now correctly wired. Disconnect AC power before proceeding.

4) Next wire input #2 as the Jog- input and switch. Return the AC power to the P315X.

5) Define input #2 as the JOG- input with the following command; "JM=2". If the motor begins to rotate immediately, the "INPUT DEFINITION", parameter "ID1" for bit #2 needs to be changed by typing the following command: ID1 = x1xxxxxx. Utilize the "x" symbol for the bits that you do not wish to change. When the parameter "ID1" is correctly set, the motor will stop rotating.

6) When the Jog- input switch #2 is activated the motor will rotate counter clockwise at one revolution per second. This input in now correctly wired. Disconnect AC power before proceeding.

### 3.4.5 STOP Input

1) Next, wire input #3 as the STOP input and return AC power to the P315X.

2) Define input #3 as the STOP input with the following command; "SI-3", Type: **B=10000 RUN <Return>**, The motor will begin to run at 1 revolution per second. If the motor does not start to rotate, the "INPUT DEFINITION", parameter "ID1" for bit #3 needs to be changed by typing the following command: **ID1=xx1xxxxx**. Utilize the "x" symbol for the bits that you do not wish to change. When the parameter "ID" is correctly set, repeat procedure 2 and the motor will begin rotating.

3) When the STOP input #3 switch is activated, the motor will stop rotating. The STOP input in now correctly wired. Disconnect AC power before proceeding.

## 3.5 Programmable Outputs

The following procedures are used in checking the programmable outputs. The user should disconnect the AC power from the P315X when making any of the following connections. Below are shown connection diagrams for the P315X's outputs.

<u>Testing programmable outputs:</u>

1) Disconnect AC power from the P315X before proceeding.

2) Wire the P315X's outputs to the external loads as shown in the above drawing. Notice that all outputs are current sinking outputs. When the wiring is completed you may return power to the controller.

3) To verify the status of the outputs; type, **V 01 <Return>**, the host will display "01 - 00000000". The host will display the output status as an eight bit number representing outputs #1 - 8: "I1 - 00000000". A "0" denotes an inactive state and a "1" denotes that the output is active. Activate output 1 by typing, **SET 1 <Return>**. Verify the status of the outputs again and the host will display "01 - 10000000". This denotes that output 1 is now active or sourcing current. The external device should now be active. The output may be deactivated by the **RESET 1 <Return>** command.

   NOTE: If any of the outputs selected are to act as "normally closed" switches and pass current when "INACTIVE", the user should review the section on Basic I/O for setting the output definition parameter "OD".

All inputs, limits and outputs have now been tested and the parameters for input definition "ID[n]", input definition "ID[n]" and output definition "OD[n]" have been verified as functional. We are now ready to create motion programs utilizing the I/O functions to control the program sequences.



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## 3.6 Encoder

The procedures within this section will test the position maintenance and stall detect features on the P315X Unit. These encoder test procedures should be followed to prevent potential damage to your system.

### 3.6.1 Test procedures

GENERAL

When using encoder functions, the ICL Parameters "ER" - Encoder Resolution and "MR" - Motor Resolution must be defined for the P315X to operate correctly.

1. Motor resolution is established by setting dip switches on the P315X. We will assume that the P315X is configured for 20000 steps per revolution, thus we will set MR=20000. The standard encoders supplied by the Controls Division are 1000 line encoders. After going through the quadrature detection circuit of the P315X it will have 4000 distinct locations per revolution, thus ER=4000. In cases where the encoder is not directly mounted to the motor, the user must determine the number of encoder pulses that will be received when the motor is displaced one shaft revolution.

2. Now we will verify that a move in the positive direction results in a positive change in the encoder position. Prior to performing a move we will set motion parameters "A", "B", "D", "H", and "M" to allow us to move the motor shaft.

   Example:

```
Reset 0          Resets the P315X to initial power-up state.
EF=00000000      Sets all encoder functions off.
MUNITS           Sets move unit of measure to motor pulses.
A=1000           Sets acceleration from "B" - base speed to "H" -
                 high speed to one second.
B=10000          Sets base speed at .5 revolutions per second (RPS).
D=1000           Sets decel rate to 1 second or less.
H=500000         Sets parabolic ramp high speed at 25 RPS.
M=400000         Sets slew speed to 20 RPS.
MR=20000         Sets motor resolution to 20,000 steps per rev.
ER=4000          Sets encoder resolution to 4,000 counts per rev.
E=0              Sets encoder position to zero.
P=0              Sets motor positions to zero.
PAUSE            Set processing mode to single line.
MOVE 20000       Move the motor 20,000 steps.
VER P VER E      Verify the motor and encoder position.
"P = 20000"      Motor position is 20,000.
"E = 4000"       Encoder position is 4,000.
```

   If "E = -4000" the encoder wires for "A+" and "A-" must be switched and the example re-run. The value of "E" will be positive when moving in the positive direction.

## POSITION MAINTENANCE

To utilize the position maintenance capability of the P315X the user must define parameters for the Dead Band Window - "DW", the Maximum Correction Velocity - "CV", and the Position Correction Gain - "CG". The dead band window is defined as the encoder error associated with a commanded physical position. In the case where "DW=5", the motor is considered on position when the encoder is within five counts of the commanded position. To prevent the ICL System from "hunting for position" the Dead Band Window has a pre-defined minimum value based upon Motor Resolution and Encoder Resolution.

| | |
|---|---|
| For "MR" < "ER" | The minimum value is calculated by the following:<br>"DW" = (Integer("ER"/"MR")) * 2 +1 |
| For "MR" > "ER" and "MR" < 3*"ER" | The minimum value is "3" due to the mechanical variations in the motor. |
| For "MR" > 3*"ER" | The minimum value is "0". |

3. For our test procedures "ER = 4000" and "MR = 20000", thus the minimum value of the Dead Band Window is "DW = 0".

4. Next we must define the Maximum Correction Velocity, "CV", that will be allowed during error correction. For the case where "MR=20000", and "CV=200000", the Maximum Correction Velocity is ten revolutions per second, ("CV" is entered in motor counts per second).

5. The Correction Gain parameter "CG" is utilized to automatically select a correction velocity based upon the actual position error. The selected correction velocity will be less than or equal to "CV", the Maximum Correction Velocity. Enter the following; "CG = 40000".

6. It is recommended that the user define his current position as zero before enabling position maintenance. Bit #2 of the Encoder Function parameter "EF" is used to enable position maintenance. In our test procedure we will move the motor a distance of three shaft revolutions and then manually move the motor shaft to demonstrate how the P315X will return to the original position. Note that because of the torque output of some motors you will need to put an inertia wheel on the motor shaft to allow you to turn the shaft. Enter the following:

| | |
|---|---|
| DW=5 | Sets dead band window to five motor pulses. |
| CV=40000 | Sets the maximum correction velocity to 10 RPS. |
| CG=40000 | Set the correction gain value. |
| Munits | Sets move unit of measure to motor pulses. |
| P=0 E=0 | Sets motor and encoder positions to zero. |
| UP=0 | Sets user position to zero. |
| EF=010XXXXX | Sets encoder functions to perform position maintenance. Set stall detect and following off. |
| Move 60000 | Move the motor shaft three revolutions. |

You can now move the motor shaft manually and view how it will return to its intended position (P=60000).



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## STALL DETECT

To utilize the Stall Detect capability of the P315X we must define parameters for the Maximum Position Error - "PE", and the Stall Detect Program Number - "SP". The Maximum Position Error is defined as the encoder error associated with a commanded physical position. In the case where "PE=2000" the motor is considered stalled if the instantaneous encoder position differs by more than 2000 encoder counts of the commanded position. To prevent the ICL System from a false stall condition, the value of "PE" must be large enough to account for the mechanical compliance of the system, (couplings, backlash).

7. For our test procedures the motor is considered stalled if the position error is one-half shaft revolution or greater. "PE=2000".

8. Bit #1 of the Encoder Function parameter "EF" is used to enable the stall detect function, "EF = 1XXXXXXX".

9. When a stall condition is detected, the ICL System will immediately transfer control to the program defined by the Stall Program Number parameter - "SP". If you do not wish to execute a program, then parameter "SP" should be set to "-1". In this case the system will respond to you with the message "#36 - MOTOR HAS STALLED". For our test purposes we will not use a stall program and will default to the standard system message. Note that because of the torque output of some motors you will need to put an inertia wheel on the motor shaft to allow you to stall the motor. When ready perform the following.

| | |
|---|---|
| PE=2000 | Sets position error to .5 shaft revolutions. |
| SP=-1 | Sets system to send message only. |
| EF=100XXXXX | Sets stall detect on. Sets position maintenance and following off. |
| UR=1 | Sets user resolution to 1 count per shaft revolution. |
| UUNITS | Selects user units as the move unit of measure. |
| MOVE 75 | Move 75 shaft revolutions (1,500,000 pulses). |

Manually stall the motor. The following message should appear.

"#36 MOTOR HAS STALLED"

### 3.6.2 Trouble Shooting

**Motor is Hunting (one direction only)** - Verify that the encoder is connected to the P315X. Verify that the encoder position parameter "E" increases for a positive move. Example assumes 4,000 encoder counts per shaft revolution:

| | |
|---|---|
| **EF=01000000** | Sets Position maintenance function on. |
| **CV=40000** | Sets the maximum correction velocity to 10 RPS. |
| **CG=40000** | Sets the correction gain value. |
| **DW=5** | Sets the dead band window to 5 motor pulses. |
| **ER=4000** | Sets encoder resolution to 4,000 encoder counts per shaft revolution. (1,000 line encoder is 4,000 counts post quadrature on the P315X). |
| **UR=1** | Set user resolution to one count per shaft revolution. |
| **UUNITS** | Set move unit of measure to user units. |
| **P=0** | Set motor position to zero. |
| **E=0** | Set encoder position to zero. |
| **MOVE 10** | Move the motor 10 shaft revolutions. |
| **Ver E** | Verify the value of "E". Should = 40,000. |
| **Move 5** | Move the motor 5 shaft revolutions. |
| **Ver E** | Verify the value of "E". Should = 60,000. |

**Motor is Hunting (bi-directional)** - Verify that parameters "ER" and "MR" are set correctly.

**Stepping LED is flashing ON/OFF** - If the LED is flashing at one second intervals; parameter "DW" is not large enough to account for motion occurring when entering the low-power mode. Increase the value for "DW" or set low-power, no-power, and power-up time to zero, ("R=0", "S=0", "Q=0"). Verify that the automatic low-power switch setting on the P315X is off, (Switch Block #1 - Switch #5).

**No-Power LED is flashing ON/OFF** - The parameter "DW" is not large enough to account for motion occurring when the system enters the no-power mode. Increase the value of "DW".

**The system stalls during normal motion** - Increase the value of the Position Error parameter - "PE" to one shaft revolution. Also verify that the parameters that control motion, "A", "B", "D", "M" and "H", are set correctly to accelerate and decelerate the load. You can refer to the "ICL USER GUIDE" section on "Performing Motion" for information on how to set the motion parameters.



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## 4 APPENDIX A API Motor Listing

| P315X PACKAGES | STATIC TORQUE (Oz.-In.) | WIDTH/ LENGTH (Inch.) | **DIP SWITCH #2 SERIES [12345] | PARALLEL [12345] | CONTROLS DIV. MOTOR PART NUMBER |
|---|---|---|---|---|---|
| P315X-A231A *** | 100 lbs. | 2.3/2.0 | 00100(L) | 11100(L) | A231-02A |
| P315X-A231C *** | 40 lbs. | 2.3/2.0 | 00100(L) | 11100(L) | A231-02C |
| P315X-M231 | 65 | 2.3/3.3 | 00100(L) | 11100(L) | M231-02 |
| P315X-M232 | 100 | 2.3/3.3 | 01100(L) | 00110(L) | M232-04 |
| P315X-M233 | 130 | 2.3/4.0 | 01010(L) | 00101(L) | M233-06 |
| P315X-M341 | 150 | 3.4/1.9 | 01010(L) | 10101(L) | M341-06 |
| P315X-M342 | 300 | 3.4/3.7 | 01100(H) | 01101(H) | M342-09 |
| P315X-M343 | 400 | 3.4/5.3 | 10010(H) | 00111(H) | M343-11 |
| P315X-M421 | 600 | 4.2/4.9 | 11010(H) | 11111(H) | M421-12 |
| P315X-M422 | 1100 | 4.2/7.0 | 11010(H) | 11111(H) | M422-12 |
| P315X-H421 | 900 | 4.2/6.2 | 10001(H) | N/A | H421-11 |
| P315X-H422 | 1800 | 4.2/8.62 | 01111(H) | N/A | H422-16 |
| P315X-H423 | 3000 | 4.2/11.2 | 01111(H) | N/A | H423-16 |

(L) - Switch settings are for P315X-L series

(H) - Switch settings are for P315X-H series

** - A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".

*** - Linear Actuator Model. The packaged model suffix A includes a .050 inch lead (20 pitch), suffix C includes a .250 inch lead (4 pitch, 4 Start). Other lead screw pitches are available upon request.

Motors supplied with these packages come with the following:

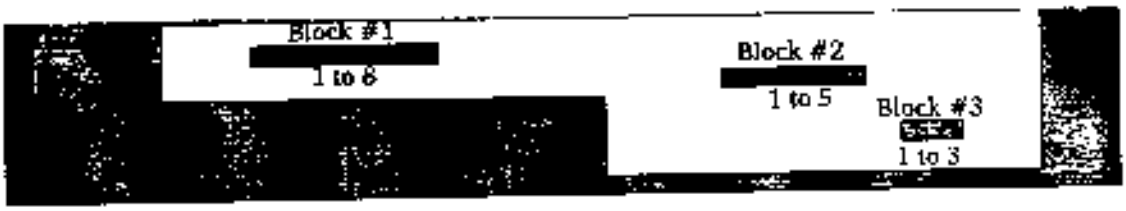
Size 23 and 34 motors are supplied with the following features:

-> Dual-shafted with a flat on the front shaft extension for positive load coupling.
-> Designed to accept a 1000 line Dual Channel Incremental Optical Encoder feature with Z channel home reference.
-> With 8 leads in twisted pairs in a six (6) foot shielded cable, with grou nd (shield) wire.

Size 42 motors are supplied with the following features:

-> Dual-shafted with a flat/woodruff key on the front shaft extension for positive load coupling.
-> Designed to accept a 1000 line Dual Channel Incremental Optical Encoder feature with Z channel home reference.
-> With 4 leads in twisted pairs in a six (6) foot shielded cable, with ground (shield) wire.

# 5 APPENDIX B Dip Switch Settings




Dip Switch Locations

## Current Settings

| Amps per Phase | Switch Block #2 P315X-L [12345] | P315X-H [12345] |
|---|---|---|
| 0.2 | 10000 | N/A |
| 0.4 | 01000 | N/A |
| 0.6 | 11000 | N/A |
| 0.8 | 00100 | N/A |
| 1.0 | 10100 | N/A |
| 1.2 | 01100 | N/A |
| 1.4 | 11100 | N/A |
| 1.6 | 00010 | N/A |
| 1.8 | 10010 | N/A |
| 2.0 | 01010 | 00000 |
| 2.2 | 11010 | 10000 |
| 2.4 | 00110 | 01000 |
| 2.6 | 10110 | 11000 |
| 2.8 | 01110 | 00100 |
| 3.0 | 11110 | 10100 |
| 3.2 | 00001 | 01100 |
| 3.4 | 10001 | 11100 |
| 3.6 | 01001 | 00010 |
| 3.8 | 11001 | 10010 |
| 4.0 | 00101 | 01010 |
| 4.2 | 10101 | 11010 |
| 4.4 | 01101 | 00110 |
| 4.6 | 11101 | 10110 |
| 4.8 | 00011 | 01110 |
| 5.0 | 10011 | 11110 |
| 5.2 | 01011 | 00001 |
| 5.4 | 11011 | 10001 |
| 5.6 | 00111 | 01001 |
| 5.8 | 10111 | 11001 |
| 6.0 | 01111 | 00101 |
| 6.2 | 11111 | 10101 |
| 6.4 | N/A | 01101 |
| 6.6 | N/A | 11101 |
| 6.8 | N/A | 00011 |
| 7.0 | N/A | 10011 |
| 7.2 | N/A | 01011 |
| 7.4 | N/A | 11011 |
| 7.6 | N/A | 00111 |
| 7.8 | N/A | 10111 |
| 8.0 | N/A | 01111 |
| 8.2 | N/A | 11111 |

***CAUTION***

API motor ratings are based on a unipolar drive scheme. Since the P315 utilizes a bipolar drive method, the multiplier that must be applied to the unipolar rating to arrive at the proper current is as follows:

Series connection - .7
Parallel connection - 1.4

See Section 2.3.2 for additional information.



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**Microstep Resolution**

| Steps per Revolution | Switch Block #1 12345678 |
|---|---|
| 200 | 0000xxxx |
| 400 | 1000xxxx |
| 1000 | 0100xxxx |
| 2000 | 1100xxxx |
| 5000 | 0010xxxx |
| 10000 | 1010xxxx |
| 12800 | 0110xxxx |
| 18000 | 1110xxxx |
| 20000 | 0001xxxx |
| 21600 | 1001xxxx |
| 25000 | 0101xxxx |
| 25400 | 1101xxxx |
| 25600 | 0011xxxx |
| 36000 | 1011xxxx |
| 50000 | 0111xxxx |
| 50800 | 1111xxxx |

Dip Switch Settings

**Current Profile Settings/Automatic Low-Power**

| 3rd Harmonic Per Phase | Switch Block #1 [12345678] | |
|---|---|---|
| -8% | xxxxx111 | |
| -5% | xxxxx011 | |
| -2% | xxxxx101 | |
| 0% | xxxxx000 | |
| 0% | xxxxx001 | |
| +2% | xxxxx100 | |
| +5% | xxxxx010 | |
| | xxxxlxxx | Automatic Low-Power Enabled |

The harmonics for 200 steps per revolution is a special case. Since there can be no harmonics for a full step wave form, either 2 phase on full step or 1 phase on full step may be selected. The 1 phase on full step will provide about half the torque as 2 phase on full step.

| Switch Block #1 [12345678] | 200 Steps Per Revolution Special case |
|---|---|
| xxxxx111 | 1 Phase |
| xxxxx011 | 1 Phase |
| xxxxx101 | 1 Phase |
| xxxxx000 | 2 Phase |
| xxxxx001 | 1 Phase |
| xxxxx100 | 2 Phase |
| xxxxx010 | 2 Phase |

## Baud Rate Settings

The P315X Baud Rate Settings is established on switch block #3. By using a ball point pen or pointed object, duplicate the switch settings given below. **DO NOT switch the settings with power applied to the P315X.**

The available settings are:

| Baud Rate | P315X [123] Switch Block #3 | |
|---|---|---|
| 19200 | 000 | |
| 9600 | 100 | |
| 4800 | 010 | |
| 2400 | 110 | |
| 1200 | 001 | |
| 600 | 101 | |
| 300 | 011 | |
| AUTO | 111 | (Auto baud rate selection - not enabled) |




Dip Switch Locations



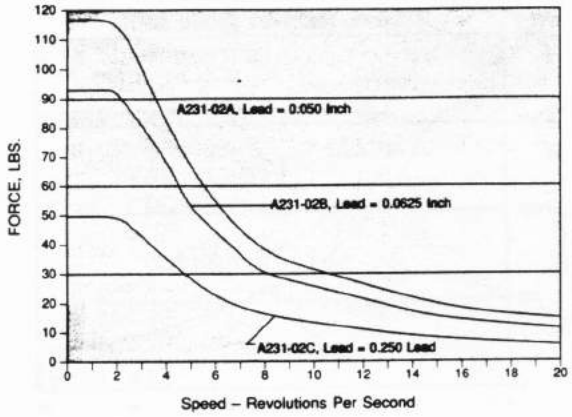
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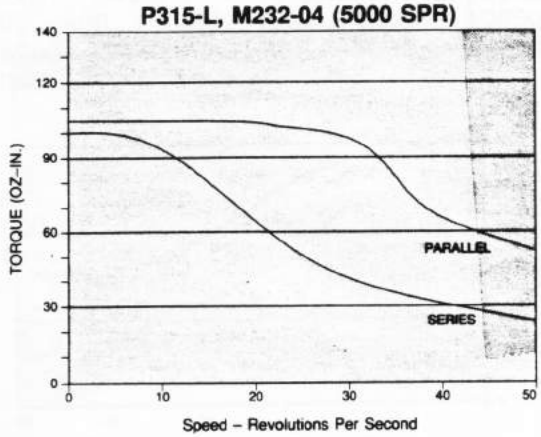
# 6 APPENDIX C Performance Curves

## P315 Series Speed/Torque Curves

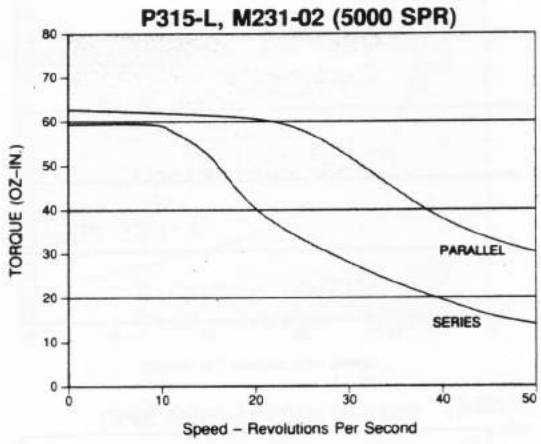
### TYPICAL SPEED/FORCE CURVE



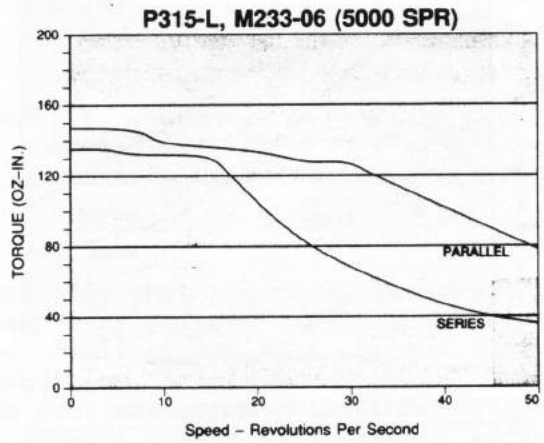

### P315-L, M232-04 (5000 SPR)



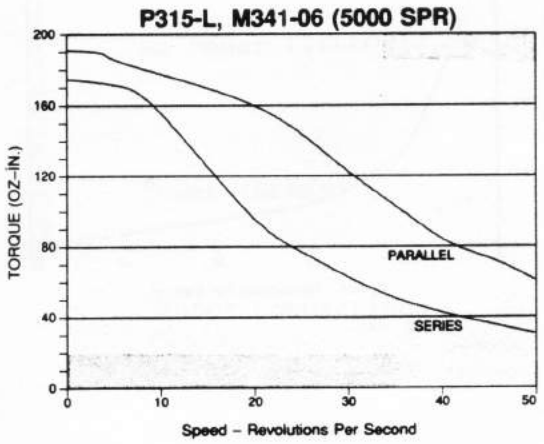

### P315-L, M231-02 (5000 SPR)



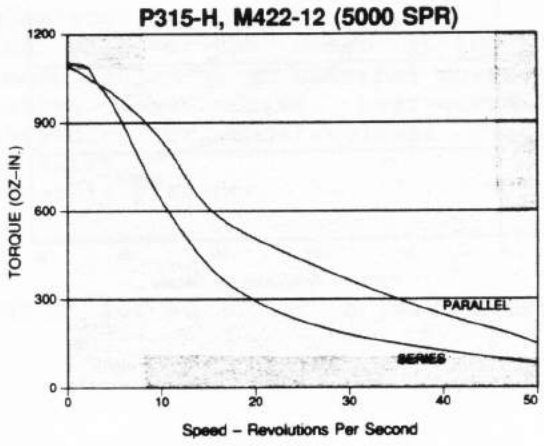

### P315-L, M233-06 (5000 SPR)

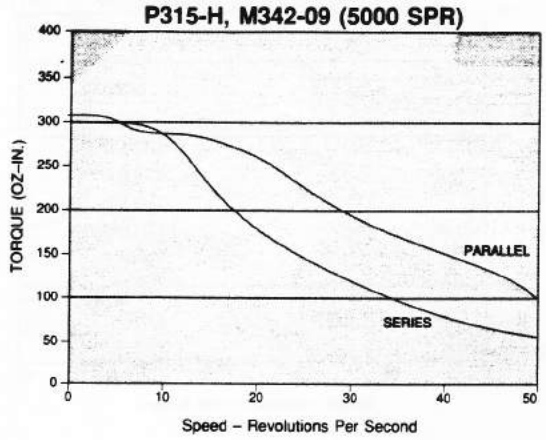


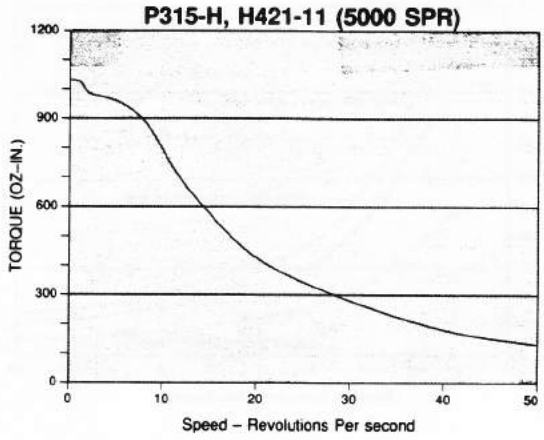

### P315-L, M341-06 (5000 SPR)

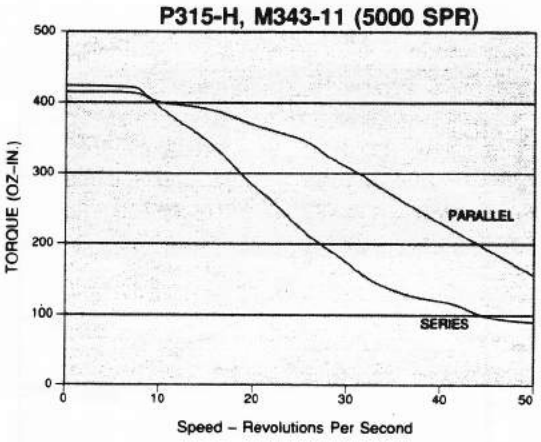


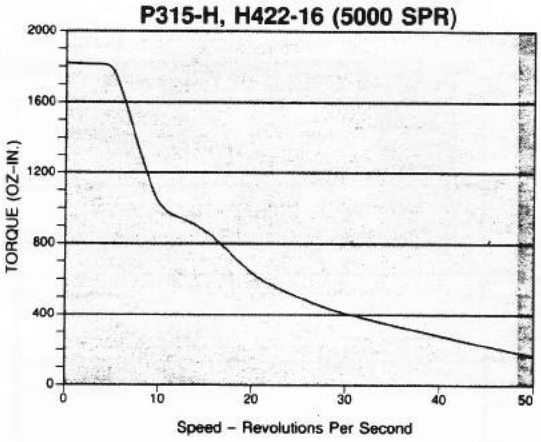

### P315-H, M422-12 (5000 SPR)

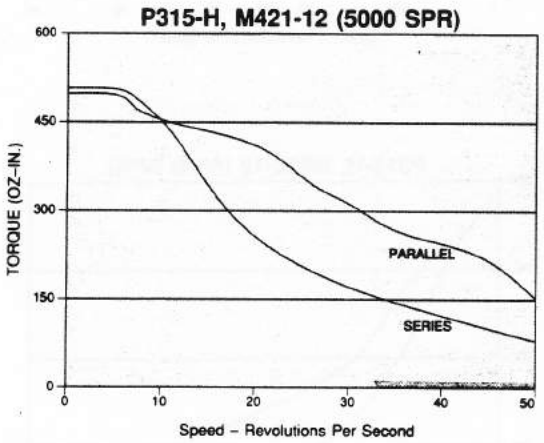


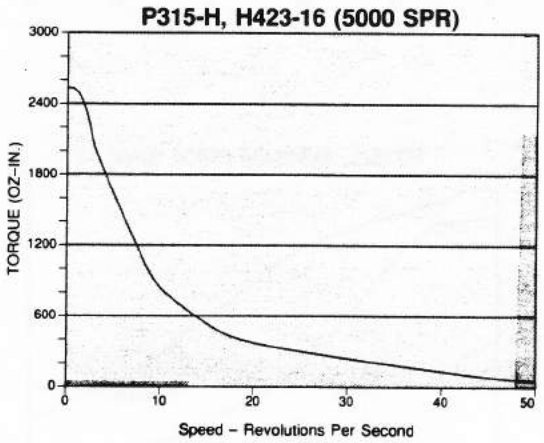





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# 7 APPENDIX D P315X Specifications

**GENERAL:**

| | |
|---|---|
| Drive Type ..... | 2 Phase, bipolar chopper, constant current |
| Stepping Modes ..... | Sixteen dip switch selectable microstep modes, 200, 400, 1000, 2000, 5000, 10000, 12800, 18000, 20000, 21600, 25000, 25400, 25600, 36000, 50000, 50800 |

**POWER REQUIREMENTS:**

| | |
|---|---|
| AC Supply ..... | 95-132 VAC, 50/60Hz |
| DC Supply ..... | 5-15 VDC. 2 amp rating for optical-isolation of INPUTS and OUTPUTS |
| Output Rating ..... | Dip Switch Selectable<br>**P315X-L** .2-6 Amps per phase<br>**P315X-H** 2.0-8 Amps per phase |

**PHYSICAL:**

| | |
|---|---|
| Dimensions ..... | **P315X-L** 1.75"W x 9.5"H x 6.75"L<br>**P315X-H** 3.38"W x 9.5"H x 6.75"L |
| Weight ..... | **P315X-L** 5.0 lbs.<br>**P315X-H** 9.0 lbs. |

**TEMPERATURE:**

| | |
|---|---|
| Storage ..... | -40°F to +185°F<br>(-40°C to +85°C) |
| Operating ..... | 162°F (75°C) maximum heatsink temperature. |

**STATUS LED'S**

| | |
|---|---|
| Stepping (GREEN) ..... | Illuminated only when the motor is stepping. |
| Over Current (RED)..... | Defines an over current fault condition. The drives fault output will become active if this condition exists. |
| Over Temperature (RED)... | Defines an over temperature fault condition. The drives fault output will become active if this condition exists. |
| Under Voltage (RED)..... | AC power dropped below 95 VAC. The drives fault output will be active when this condition exists. |
| No Power (YELLOW)..... | Illuminated whenever the motor is in the no-power mode caused by an external no-power input active or drive over-current, over-temperature or under-voltage fault conditions exist. |
| Power (GREEN)..... | 115 VAC power is present. |

**MOTOR:**

| | |
|---|---|
| Motor Connections ..... | Connections for 4, 6, or 8 lead hybrid motors. |

ICL SYSTEM (OPERATIONAL)

| | |
|---|---|
| Acceleration ..... | Optimal non-linear mathematical function<br>USER RAMPS |
| Accuracy ..... | +- 0 pulses |
| Positioning Range ..... | +- 2.1 billion pulses |
| Speed Range ..... | 0 to 750,000 pulses per second<br>+- 1% maximum speed |

STORED PROGRAMS

| | |
|---|---|
| Number of Programs ..... | 88 programs maximum |
| RAM capacity ..... | 32K |
| Auto-Start Program ..... | Selectable by program number |

COMMUNICATIONS (RS-232)

| | |
|---|---|
| Baud rates ..... | 300, 600, 120 , 2400, 4800, 9600 or 19200 |
| Mode ..... | Full Duplex, No Handshaking |
| Format ..... | 8 Data Bits, 1 Stop Bits, No Parity,<br>ASCII Characters |

DISCRETE I/O

| | |
|---|---|
| OPTO1 ..... | 5-15VDC @ 150ma. |
| OPTO2 ..... | 5-15VDC @ 350ma. |

All inputs are optically isolated, and are normally "High" or "INACTIVE". Inputs require closed contact to Opto Gnd to bring "Low" or "ACTIVE". All inputs, limits and outputs may be defined as "ACTIVE" "High" or "ACTIVE" "Low" thru the Intelli-Command Language (ICL) Parameters (ID and OD). Input configuration must remain stable for 2ms minimum during the times they are polled to be recognized by the P315X.

| | |
|---|---|
| Inputs (Programmable) ... | 13 TTL Inputs at voltage OPTO2. |
| Inputs (Limits) ..... | 3 TTL Inputs for CWL, CCWL and HOME at voltage OPTO1. |
| Outputs (Programmable) .. | 9 TTL current sinking outputs at voltage OPTO2. |

ENCODER INPUTS:

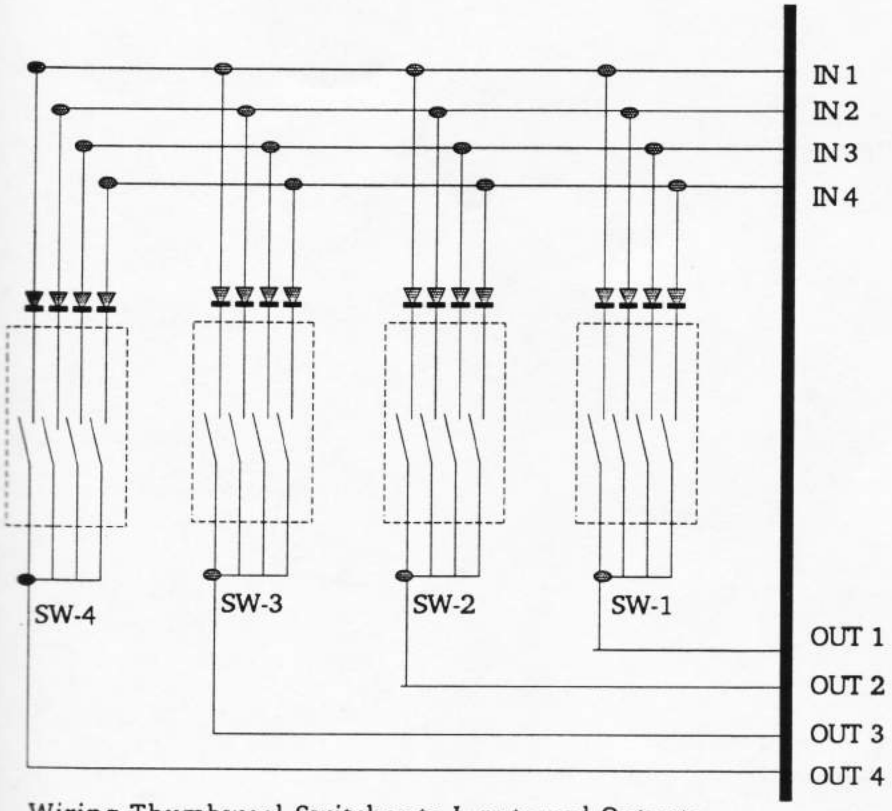
| | |
|---|---|
| Encoder Inputs ..... | Dual-Channel (A and B) Incremental Optical Encoder with Z channel input for encoder index pulse. A +5VDC and ground are supplied for encoder use. |



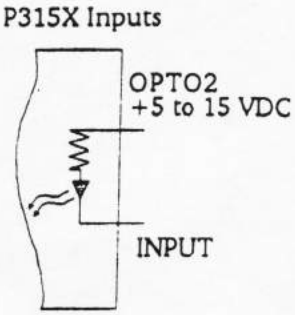
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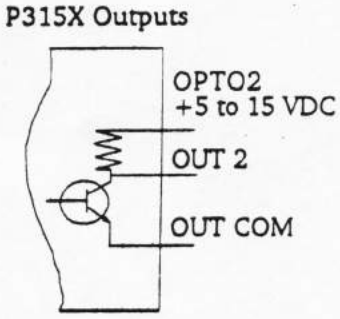
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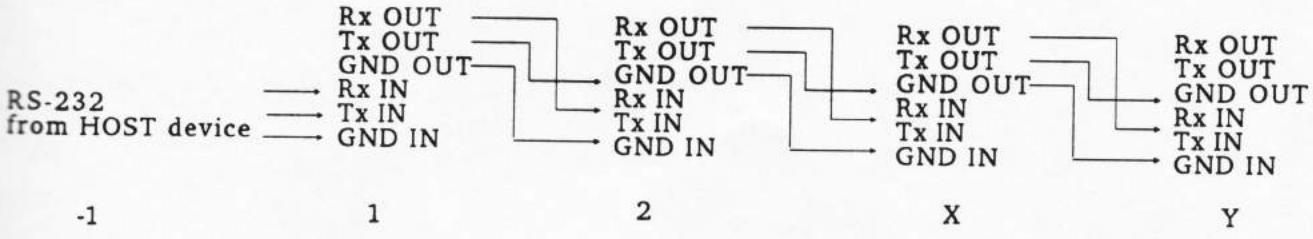
## 8 APPENDIX E P315X Wiring Diagrams




Wiring Thumbweel Switches to Inputs and Outputs



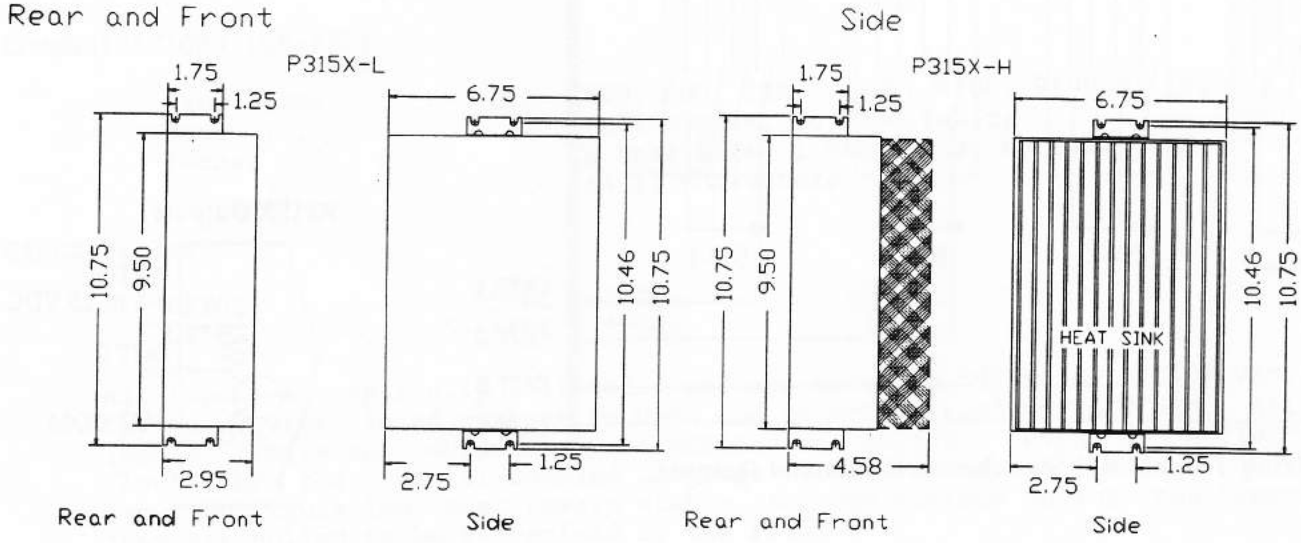




Axis designator

## 9 APPENDIX F Mounting Dimensions

MOUNTING DIMENSIONS P315X SERIES






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