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P315 User Guide

Microstep Power/Drive

Installation and User

Reference Manual

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P315 USER GUIDE

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1 INTRODUCTION

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.

The primary intention of this manual is to guide the first time user of the P315 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 Quick Start, (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 drive 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 drives 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 changes to the drive configuration should be made with any power sources turned off and disconnected from the drive.

The P315-L, designated as the "low power unit", has been designed for motors up to a size 34 single stack (M341). The P315-H, designated as the "high power unit", produces higher currents and provides additional heatsinking to run motors larger than a size 34 single stack (M342 and above).

Their may be applications where the user desires to use the P315-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.

1.3 Functional Overview

The P315 series combines bipolar chopper drive technology with an integral power section. Each packaged system includes a motor, drive, power supply, integral heatsink, power cord, connectors and a full enclosure. The P315 Series packages are directly compatible with the Controls Division's Indexers/Controllers for a total motion system solution. (Note: The P315X series packages provide you with a completely integrated Power/Drive/Indexer unit if you desire.)

The P315 Series provides the user with microstepping capability. By microstepping a step motor, its motion can be dramatically smoothed and the positioning resolution greatly enhanced without sacrificing its other attractive features. 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 acts 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 P315 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 P315-L (low power unit) will drive 4-phase motors rated at up to 6.0 Amps per phase (bifilar rating). The P315-H (high power unit) will drive 4-phase motors rated between 2.0 and 8.0 Amps per phase (bifilar rating).

Connections to the P315 drive include:

Power
The required AC power is 95-132 Volts, 50/60 Hz.
5 VDC, 100 milliamps for the optically isolated inputs/outputs.

Motor
Either 4, 6 or 8 lead hybrid motor leads can be connected to the drive. (See Section 1.5 for details)

Pulse Source
The P315 Series accept pulse and direction control inputs from a wide variety of sources. The maximum pulse rate is 1.0 MHz, (1,000,000 pulses per second, 0.5 microsecond pulse width).

Other Control Features
A no-power input is used to control a power down state, disabling the motor. A low-power input is used to reduce the current to 50% full power. An automatic low-power option may be selected to reduce the current to 50% full power one second after motion has been completed. The microstep resolution, automatic low-power and current supplied to the motor are controlled by setting dip switches on the drive.

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 P315 Series step motor drives. An assumption is made here that the user has a pulse train available to supply to the drive. If not, then other sections of the manual should be referred to as required.

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

2) Read section 2.2 - Drive Configuration and section 2.3 Drive Connections

3) Ensure that the drive current switch settings are set for the motor that you are running (Section 2.2.2).

4) Select the Microstep Resolution desired (Section 2.2.4).

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

6) Connect the required logic control lines (Section 2.3.3).

7) Plug into your power source (Section 2.4).

8) Supply control signals to the drive. The type of control utilized to supply step, direction and other control signals to the drive depends on the application and the available equipment. One option is to utilize an indexer, which can be purchased as an integrated package (P315X) or as a separate stand alone device. Another option is for the user to supply the required signals directly from his system. A brief synopsis of each option follows:

CONTROL SIGNALS:

USER INPUT
This is a valid option when the user system already contains a computer or programmable logic controller. With this method, the user provides TTL inputs directly to the step motor drive to control motion in the system. As a bare minimum, step and depending on the application, direction inputs must be provided to the step motor drive. Additionally, many applications will require efficient ramp routines to achieve the performance objectives of the system. It is the responsibility of the user when this is the selected method of control.

INDEXER
Select this option when the user's system does not contain a logic device; the motion sequences are complex; the motion sequences are changing frequently; or if performance requirements are demanding. The indexers offered by the Controls Division are self-contained, high speed microprocessor based controllers. Features include RS-232 communications, programmable inputs and outputs that interface to external devices, and an English-like command language. Ramping routines are automatically generated and/or can be placed under user control.

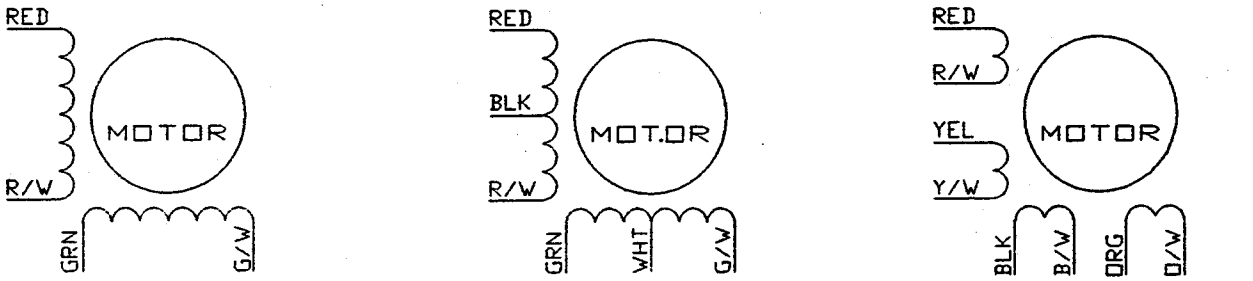
1.5 Motor Compatibility

The P315 may be purchased as a complete packaged drive with a compatible motor. Motors packaged with the P315 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 as noted in appendix A. Refer to appendix C for speed verse torque performance curves of packaged systems.

The P315 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. Figure 1 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.**



4 LEAD UNIFILAR MOTOR

6 LEAD BIFILAR MOTOR

8 LEAD BIFILAR MOTOR

Figure 1

Motor Heating
The P315 series drives are capable of operating a motor connected in series or parallel configuration. Motors wired in series that come packaged with the P315 can be run continuous at high speeds without overheating. Motors wired in parallel that come packaged with the P315 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 0.2 to 6.0 Amps per phase for the P315-L and 2.0 to 8.0 Amps per phase for the P315-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, (Section 2.3.2).

Inductance
The range of motor inductance is .5 mH - 80 mH on all models of P315 drives. The recommended motor inductance is 5 mH - 40 mH.

Size
Recommended motor sizes for the P315 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 P315 Series drives are designed to minimize the current rise times through it's bipolar chopper drive technique. 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 P315 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 user to operate the motor at much higher speeds and overcome potential resonant instability.

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

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 P315 Series drivers. 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. Where ever possible, route high power lines (motor and power) away from logic signals (RS-232, step, direction, etc..) to prevent noise problems.

The P315 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 P315 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

The enclosure of the P315 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 P315 is a self-contained package requiring minimal concern for mounting methods and positions. A dimensional outline of the P315 is given in Figure 2. Mounting brackets have been provided to mount or secure the P315. 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.

In general, the drive should be positioned close to the motor although step motors are fairly tolerant of long lead lengths. 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.

MOUNTING DIMENSIONS P315 SERIES

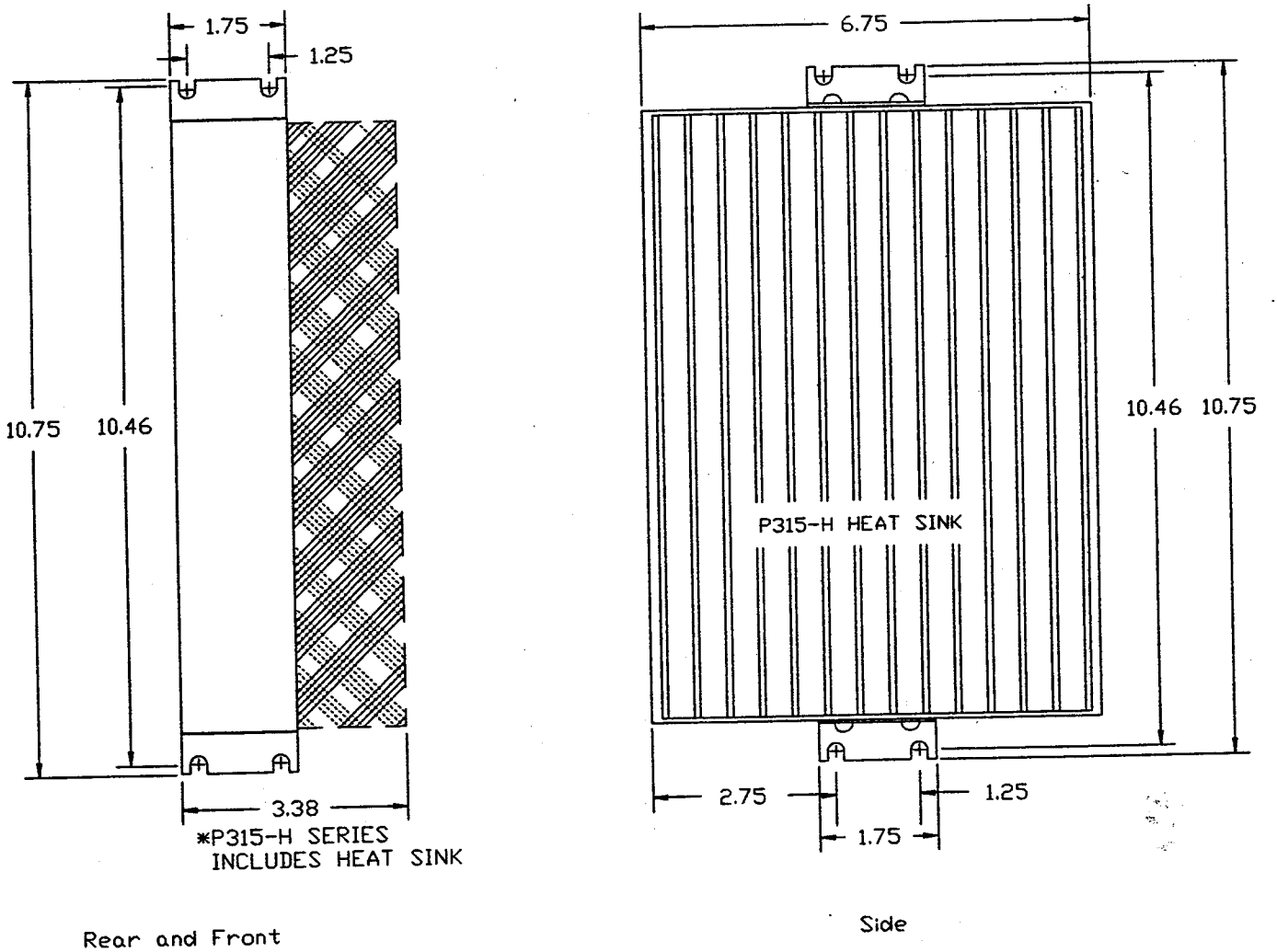


Figure 2

2.4 Drive Configuration

2.4.1 Introduction

To provide the user with the greatest amount of versatility, four adjustments can be made to configure the drive for the application. The first adjustment selects whether or not you desire to use the automatic low-power mode on the drive. The second adjustment tells the driver the current rating of the motor. The third setting establishes the microstep resolution desired. The fourth allows you to tune the optimum current profile for your application.

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

When purchased as a packaged system, (drive and motor), the settings will be found on a label affixed to the drive at the factory. Examine the label. If a motor is listed and corresponds to the selected motor, then continue with the microstep resolution switch settings, (Section 2.4.4). 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.

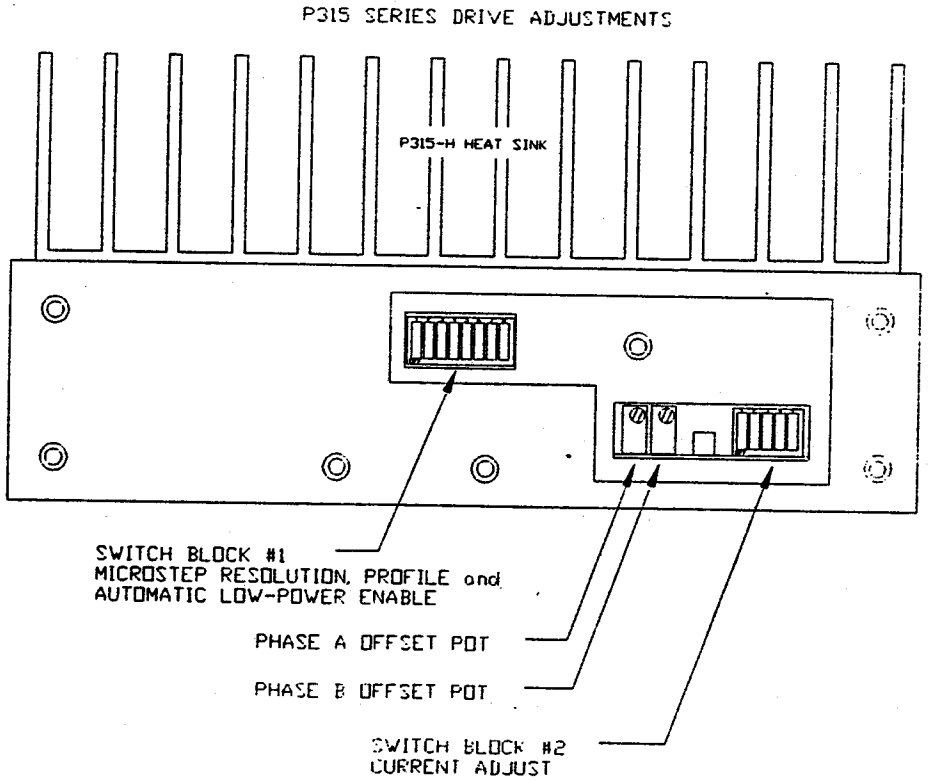


Diagram 2.4.1

2.4.2 Low Power Settings

The P315 can be configured for automatic low-power. 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. See Appendix B for Dip Switch Settings.

2.4.3 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 P315-L models are capable of providing 0.2 to 6.0 amps per phase and P315-H models provide 2.0 to 8.0 amps per phase.

Current Settings

P315 PACKAGES	STATIC TORQUE (Oz.-In.)	DIP SWITCH #2 (*) SERIES [12345]	PARALLEL [12345]	CONTROLS DIV. MOTOR PART NUMBER
P315-A231A **	100 lbs.	00100(L)	11100(L)	A231-02A
P315-A231C **	40 lbs.	00100(L)	11100(L)	A231-02C
P315-M231	65	00100(L)	11100(L)	M231-02
P315-M232	100	01100(L)	00110(L)	M232-04
P315-M233	130	01010(L)	00101(L)	M233-06
P315-M341	150	01010(L)	10101(L)	M341-06
P315-M342	300	01100(H)	01101(H)	M342-09
P315-M343	400	10010(H)	00111(H)	M343-11
P315-M421	600	11010(H)	11111(H)	M421-12
P315-M422	1100	11010(H)	11111(H)	M422-12
P315-H421	900	10001(H)	N/A	H421-11
P315-H422	1800	01111(H)	N/A	H422-16
P315-H423	3000	01111(H)	N/A	H423-16

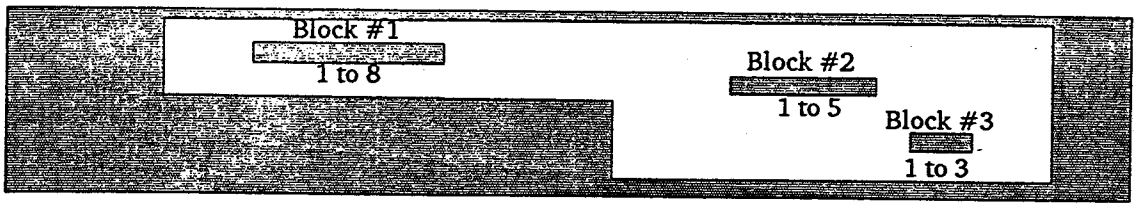
(L) - Switch settings denoted by (L) are for P315-L series.

(H) - Switch settings denoted by (H) are for P315-H series.

*** - See APPENDIX B 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.**

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 P315 prior to connecting to the drive. Refer to sections 1.5 (Motor Compatibility) and 2.5.2 (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



Dip Switch Locations

Current Settings

Amps per Phase	Switch Block #2 P315-L [12345]	P315-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

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

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.

2.2.3 Low Power Settings

The P315 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 **APPENDIX B** for location of Switch Blocks. A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".

2.2.4 Microstep Resolution Switch Settings

The P315 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.

2.2.5 Tuning the P315

The P315 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.

2.2.5.1 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.

2.2.5.2 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 **APPENDIX B** for location. Set the switches as indicated below.

Current Profile Settings

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

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

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.

Procedures for tuning 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.

P315 Configuration Settings

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

12345678

Switch Block #1 _____
Switch Block #2 _____

Notes:

2.3 Drive Connections

2.3.1 Introduction

This section will list and explain all the connections to the P315 Series drives which includes motor, logic and power connections.

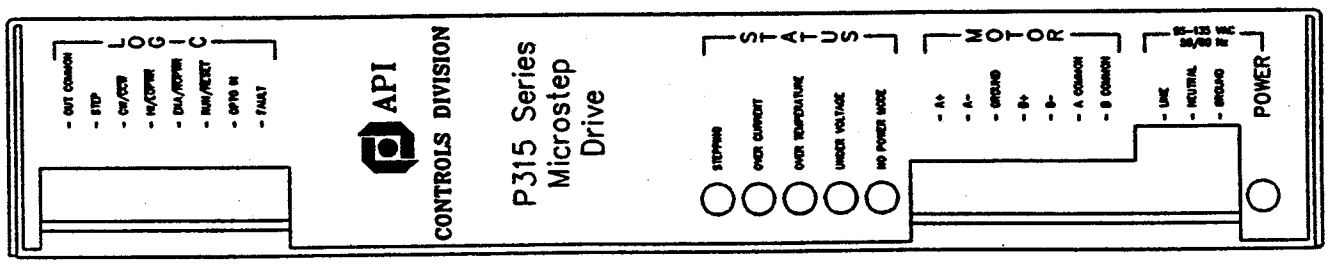


Figure 4

Connector Type

Three plug type connectors allow the user to make the necessary connections via recessed screw terminals which control a clamping action on the bare wire of each input. It is recommended that connections be made prior to plugging into the drive.

NOTE: 1.)Motor Connections are made on the 7 pin connector.
2.)Logic Connections are made on the 8 pin connector.
3.)Power Connections are made on the 3 pin keyed connector.

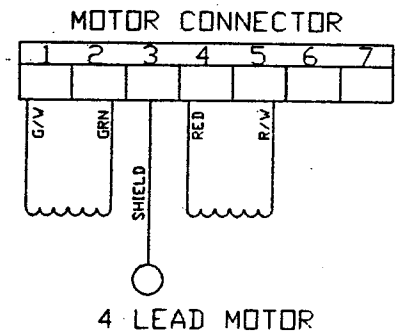
2.3.2 Motor Connections

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 refer to Section 2.2.2, Appendix A, and Appendix B for the proper drive settings.

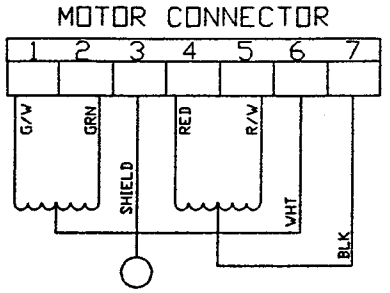
SAFETY PRECAUTIONS: Do not supply power to the drive without having all of the motor leads firmly connected to their appropriate terminals. Connect center tap wires to Phase A Common and Phase B Common as required, connect the motor's shield to the terminal provided.

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. (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.)

NOTE: Our examples use a 4, 6 or 8 lead motor rated at 1 amp per phase current (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 bifilar rating to arrive at the proper current settings for your connection method. Examples follow:

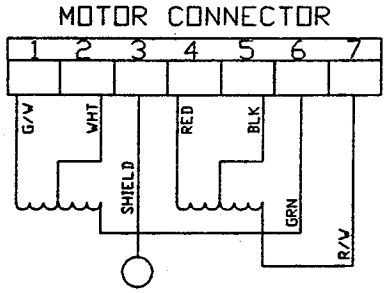


A 4 lead motor utilizes a bipolar drive scheme and can only be hooked up in the configuration shown. The drive output current would be 1 amp (I*1). The inductance seen by the drive would be 10 mH (L*1).



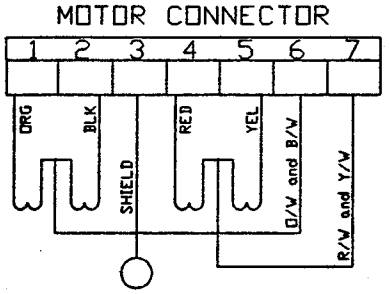
6 LEAD MOTOR

Connecting a 6 lead bifilar 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).



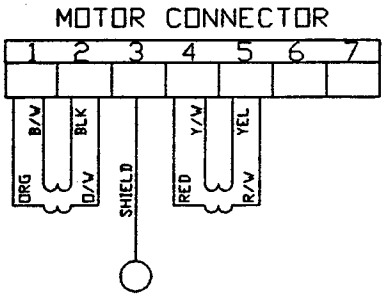
6 LEAD MOTOR
(HALF WINDING)

Connecting a 6 lead bifilar 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 bifilar 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).



8 LEAD MOTOR
(PARALLEL)

Connecting an 8 lead bifilar 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 Logic Connections

The logic inputs required by the P315 are made on the 8 pin connector and plugged into the drive section labeled "LOGIC". All logic inputs are optically isolated, the user is required to provide a 5 VDC source.

Each of the logic inputs is clamped "High" internally with a pull-up resistor and requires the user's controller to pull them "Low" to return of the "OPTO IN" supply. Each of the user's control lines should be capable of sinking at least 15 ma. The optical isolation feature electrically isolates the logic and power stages of the drive in order to protect both circuits and eliminate electrical noise problems.

The minimum logic connection required to operate the P315 Series drive is the pulse input. All other inputs will default to their "High" states during operation. If other states are required then the ability to take them "Low" should be available.

Logic input connections are made through use of an 8 pin pluggable connector. The connector may be pulled out by applying a force straight away from the drive. Connect each input by inserting 1/4 inch of stripped bare wire into the socket and tighten the pressure screw until the wire is firmly secured.

Notation and Conventions

All available logic inputs have two possible input states which will be referred to as "High" and "Low". When a logic terminal is open it is in a "High" state by default since it is clamped "High" internally with a pull-up resistor. Any notation which uses the "bar" convention will assume that the state indicated by the bar is activated by taking that logic terminal "Low" (ie. - CW/CCW denotes CCW direction of rotation when taken "Low").

OUTPUT COMMON (Terminal 1) - "OUT COMMON"
This terminal is the return for the FAULT OUTPUT.

STEP INPUT (Terminal 2) - "STEP"
The motor will step on the rising edge of each incoming pulse up to a rate of 1 MHz. The minimum input pulse width is .5 micro seconds.

DIRECTION (Terminal 3) - "CW/$\overline{\text{CCW}}$"
A "High" or open connection on this terminal would cause a Clockwise (CW) rotation of the motor as viewed from the output shaft end. When taken "Low", the direction will be counterclockwise (CCW). The direction input may be switched while the motor is rotating, but may cause the motor to lose synchronism if operating above it's Start/Stop torque capability.

LOW POWER (Terminal 4) - "HI/$\overline{\text{LOW POWER}}$"
This input allows the user to reduce the power to the motor to 50% of the high current setting. The "High" or open state provides full current to the motor. When taken "Low", the current is reduced to 50% of it's full rated power. This may be used to maintain a holding current on the motor or to help reduce motor heating.

POWER ENABLE (Terminal 5) - "ENA/$\overline{\text{NO POWER}}$"
This input allows the user to cut off power to the motor on command. The "High" or open state allows normal stepping of the motor at it's rated current. When taken "Low", all power is cut to the motor for the duration of the "Low" state. Incoming step pulses are ignored when this line is held "Low". This input can be used to issue an emergency stop command or to turn power off if holding torque is not required by the application, resulting in less heating and power consumption.

RUN/RESET (Terminal 6) - "RUN/$\overline{\text{RESET}}$"
This input commands the drive to reset the logical state of the drive microprocessor. A "High" or open state allows normal stepping of the motor at it's rated current. When taken "Low", all power is cut to the motor for the duration of the "Low" state. When the input is returned "High" the drive will automatically provide a ZERO PHASE state, (phase A at zero current, phase B at full current).

OPTO INPUT (Terminal 7) - "OPTO IN"
The user must provide +5 VDC here to operate the optical isolation feature.

FAULT OUTPUT (Terminal 8) - "FAULT"
This open collector output can be utilized to notify the users controller that a fault condition exists. Sinks current when fault occurs. Potential fault conditions are "Over Temperature", "Over Current" and "Under Voltage".

2.3.4 Power 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.

2.3.5 Status LED'S

The P315 drives provide 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.

2.4 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 65% 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. At this point, if the motor does not have any torque or will not properly rotate, refer to Section 3 for troubleshooting and possible remedies.

3 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, you can effectively begin to resolve the problem.

Initial step in troubleshooting is to isolate each system component and 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 - check to see that Logic Pin #5, (ENA/NO POWER) is "High" or open. If the no-power LED is illuminated, verify that drive fault conditions do not exist.. Verify Logic Pin #6, (RUN/RESET) is "High" or open.

Low power logic - verify Logic Pin #4 (HI/LO POWER) is "High" or open.

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 pulses being supplied to the driver are the proper level and width and that the rates 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 pulse rate.

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 2.2.5, 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.

No power logic - verify Logic Pin #5 (ENA/$\overline{\text{NO POWER}}$) is "High".

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 drive and motor for service.

For assistance contact -

Your local API representative.

Your local Motion Automation Company (distributor).

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.

APPENDIX A API Motor Listing

P315 PACKAGES	STATIC TORQUE (Oz.-In.)	DIP SWITCH #2 (*) SERIES [12345]	PARALLEL [12345]	CONTROLS DIV. MOTOR PART NUMBER
P315-A231A **	100 lbs.	00100(L)	11100(L)	A231-02A
P315-A231C **	40 lbs.	00100(L)	11100(L)	A231-02C
P315-M231	65	00100(L)	11100(L)	M231-02
P315-M232	100	01100(L)	00110(L)	M232-04
P315-M233	130	01010(L)	00101(L)	M233-06
P315-M341	150	01010(L)	10101(L)	M341-06
P315-M342	300	01100(H)	01101(H)	M342-09
P315-M343	400	10010(H)	00111(H)	M343-11
P315-M421	600	11010(H)	11111(H)	M421-12
P315-M422	1100	11010(H)	11111(H)	M422-12
P315-H421	900	10001(H)	N/A	H421-11
P315-H422	1800	01111(H)	N/A	H422-16
P315-H423	3000	01111(H)	N/A	H423-16

(L) - Switch settings denoted by (L) are for P315-L series.

(H) - Switch settings denoted by (H) are for P315-H series.

* - See **APPENDIX B** 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.

Motors supplied with these packages come with the following:

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

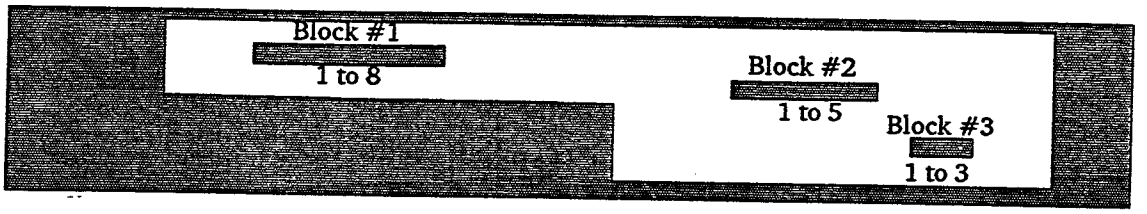
-> Dual-shafted with a flat on the front shaft extension for positive load coupling.
-> Designed to accept a 1000 line Dual Channel Incremental Optical Encoder feature with Z channel home reference.
-> With 8 leads in twisted pairs in a six (6) foot shielded cable.

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 8 leads in twisted pairs in a six (6) foot shielded cable.

APPENDIX B Dip Switch Settings

Current Settings



Dip Switch Locations

Amps per Phase	Switch Block #2 P315-L [12345]	P315-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

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

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 2.2 for additional information.

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

Current Profile Settings/Automatic low-power

3rd Harmonic Per Phase	Switch (NOTE 1) Block #1 [12345678]	
-8%	xxxxx111	
-5%	xxxxx011	
-2%	xxxxx101	
0%	xxxxx000	
0%	xxxxx001	
+2%	xxxxx100	
+5%	xxxxx010	
	xxxx1xxx	Automatic low-power enabled

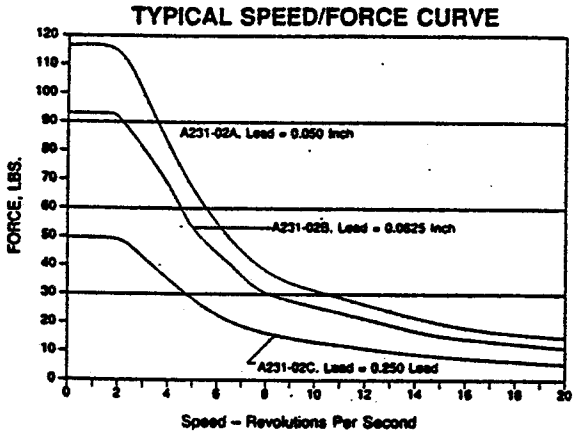
The harmonics for 200 steps per revolution is a special case. Since there can be no harmonics for a full step wave form, either 2 phase on full step or 1 phase on full step may be selected. The 1 phase on full step will provide about half the torque as 2 phase on full step.

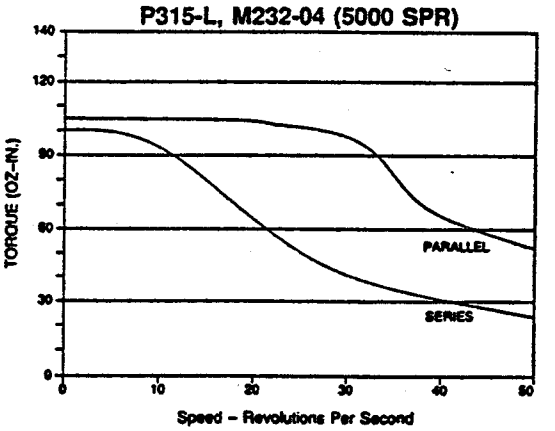
Switch (NOTE 1) Block #1 [12345678]	200 Steps Per Revolution Special case
xxxxx111	1 Phase
xxxxx011	1 Phase
xxxxx101	1 Phase
xxxxx000	2 Phase
xxxxx001	1 Phase
xxxxx100	2 Phase
xxxxx010	2 Phase

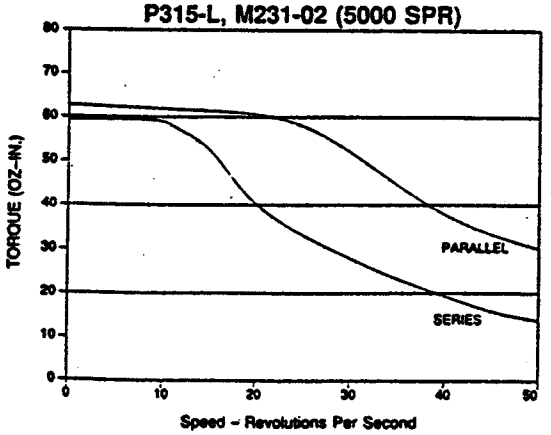
APPENDIX C Performance Curves

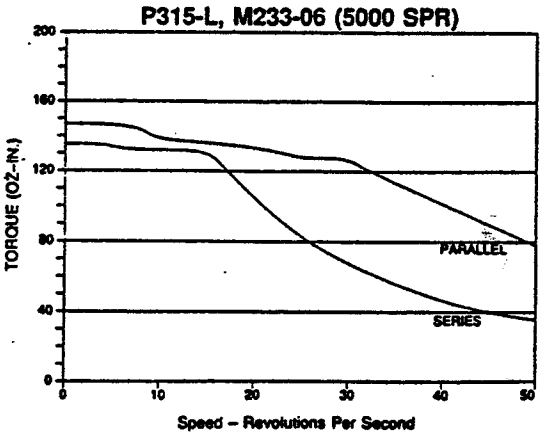
Power/Drive Part Number	Power/Drive/Indexer Part Number	Static Torque (Oz. In.)	Motor Width	Motor Length	Drive Version	Motor Model
P315-A231	P315X-A231	**	2.23" (57mm)	2.00" (51mm)	P315-L	A231-02
P315-M231	P315X-M231	60	2.23" (57mm)	2.00" (51mm)	P315-L	M231-02
P315-M232	P315X-M232	100	2.23" (57mm)	3.25" (83mm)	P315-L	M232-04
P315-M233	P315X-M233	150	2.23" (57mm)	4.00" (102mm)	P315-L	M233-06
P315-M341	P315X-M341	150	3.35" (85mm)	2.45" (62mm)	P315-L	M341-06
P315-M342	P315X-M342	300	3.35" (85mm)	3.70" (93mm)	P315-H	M342-09
P315-M343	P315X-M343	450	3.35" (106mm)	5.31" (135mm)	P315-H	M343-11
P315-M421	P315X-M421	650	4.20" (106mm)	4.74" (120mm)	P315-H	M421-12
P315-M422	P315X-M422	1100	4.20" (106mm)	7.00" (178mm)	P315-H	M422-12
P315-H421	P315X-H421	1000	4.28" (108mm)	6.20" (158mm)	P315-H	H421-11
P315-H422	P315X-H422	1900	4.28" (108mm)	8.63" (219mm)	P315-H	H422-16
P315-H423	P315X-H423	3000	4.28" (108mm)	11.15" (284mm)	P315-H	H423-16

** - Linear Accuator model. Force is 40-100 lbs.

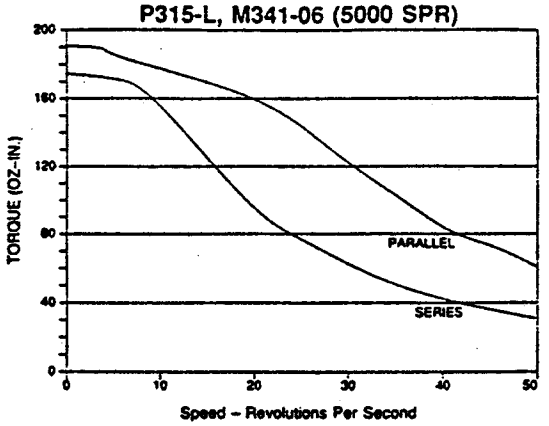




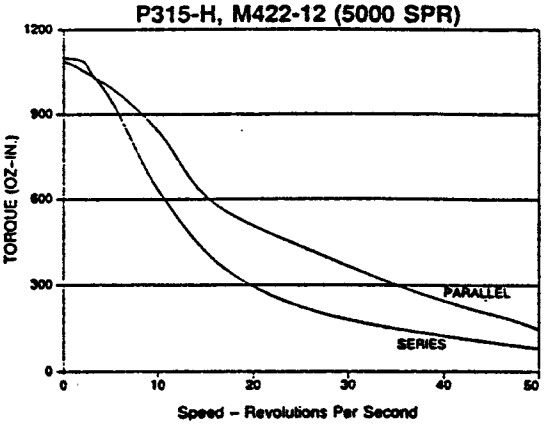




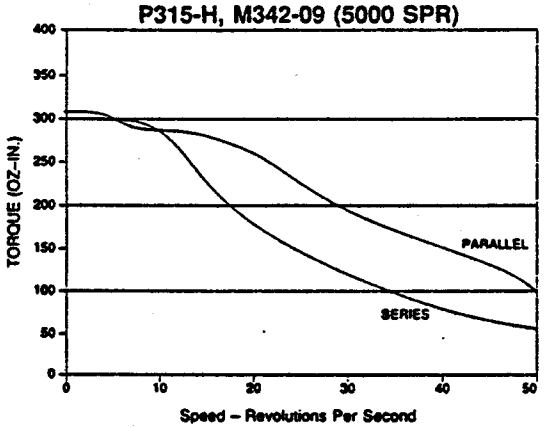
P315-L, M341-06 (5000 SPR)



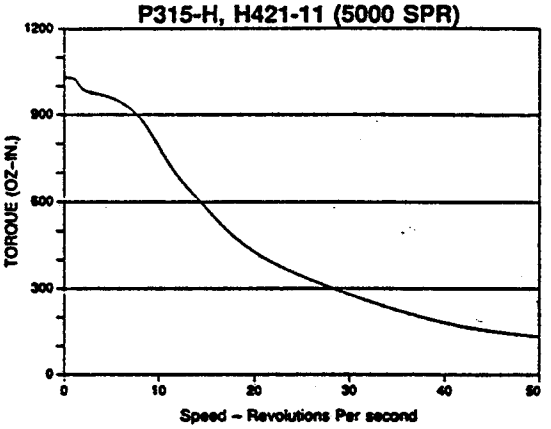
P315-H, M422-12 (5000 SPR)



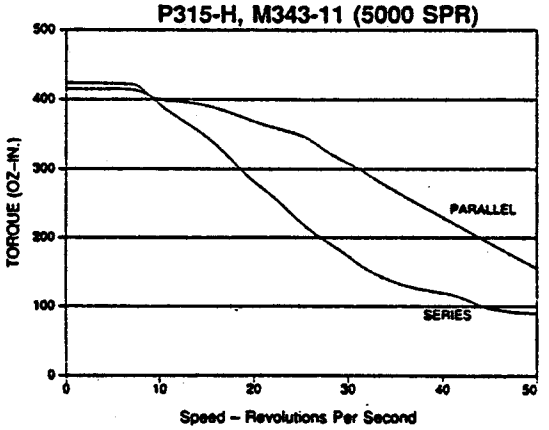
P315-H, M342-09 (5000 SPR)



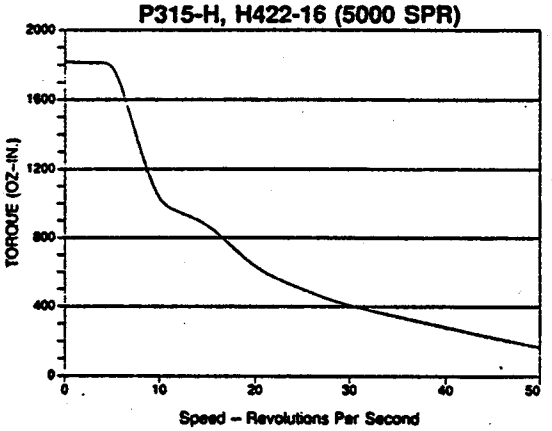
P315-H, H421-11 (5000 SPR)



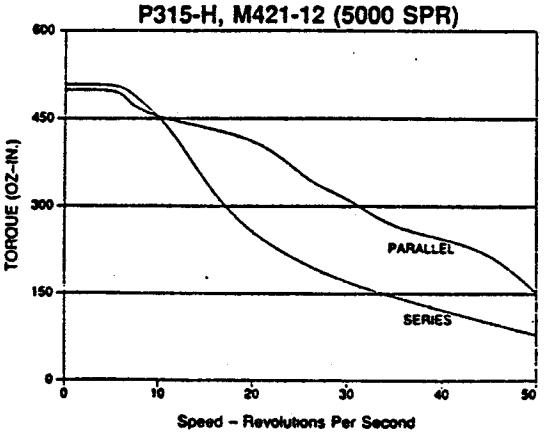
P315-H, M343-11 (5000 SPR)



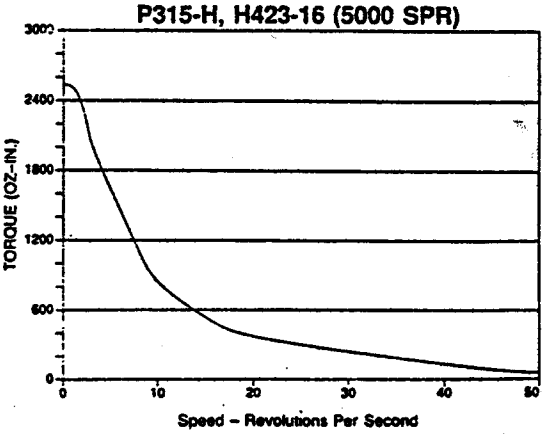
P315-H, H422-16 (5000 SPR)



P315-H, M421-12 (5000 SPR)



P315-H, H423-16 (5000 SPR)



APPENDIX D P315 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:

Input	95-132 VAC. 50/60Hz
Output Rating	Dip Switch Selectable P315-L .2-6 Amps per phase P315-H 2.0-8 Amps per phase

Physical:

Dimensions	P315-L 1.75"W x 9.5"H x 6.75"L P315-H 3.38"W x 9.5"H x 6.75"L
Weight	P315-L 5.0 lbs. P315-H 9.0 lbs.

Temperature:

Storage	$-40^{\circ}F$ to $+185^{\circ}F$ ($-40^{\circ}C$ to $+85^{\circ}C$)
Operating	$162^{\circ}F$ ($75^{\circ}C$) maximum heatsink temperature.

Logic Inputs:

Type	Optical isolated, TTL compatible.
OPTO IN	Optical isolation power. User supplies + 5 VDC, 100 milliamp minimum.
Level	Logic '1' (HIGH) > 2.0 VDC Logic '0' (LOW) < 0.8 VDC
Step	Step on trailing edge. Requires .5 microsecond minimum width at a maximum rate of 1 MHz.
Direction	"CW/$\overline{\text{CCW}}$"
Low Power	"HI/$\overline{\text{LO POWER}}$" Reduces motor current to 50% of full power.

Power Enable ..... "ENABLE/$\overline{\text{NO POWER}}$"
Reduces motor current to zero.

Reset ..... "RUN/$\overline{\text{RESET}}$"
Resets logic, ZERO PHASE A

Fault Output:

Type ..... Sinking output to Out Common, 5-24VDC, 60 milliamp maximum. Fault output is active when Over Current, Over Temperature or Under Voltage conditions exist .

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.

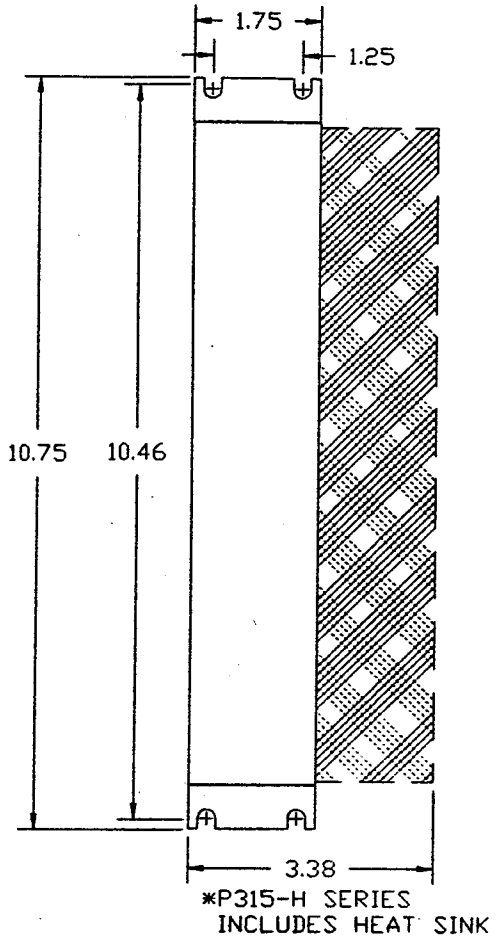
Power (GREEN)..... 115 VAC power is present.

Motor:

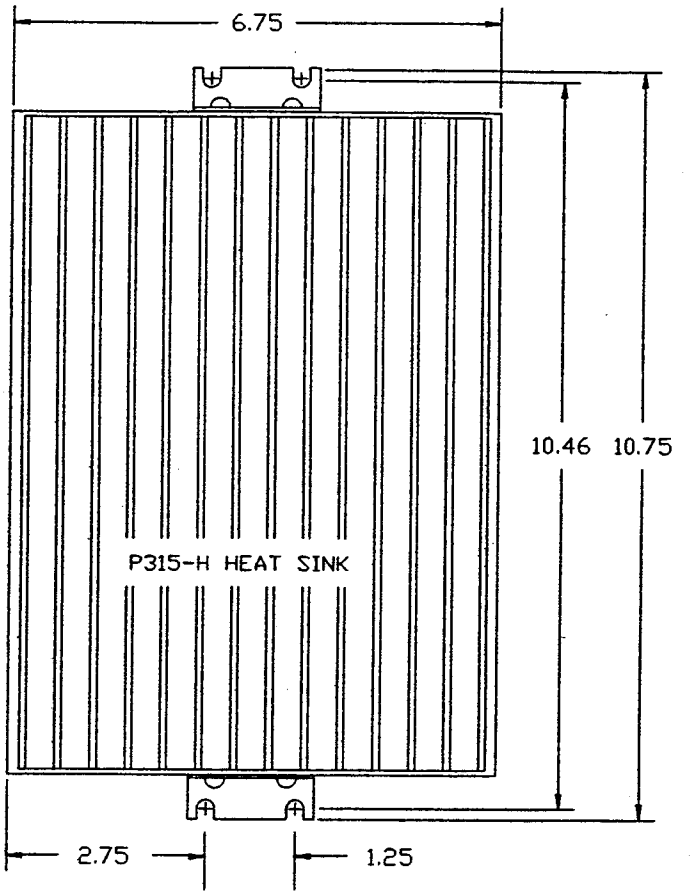
Motor Connections ..... Connections for 4, 6, or 8 lead hybrid motors.

APPENDIX E Physical Configuration

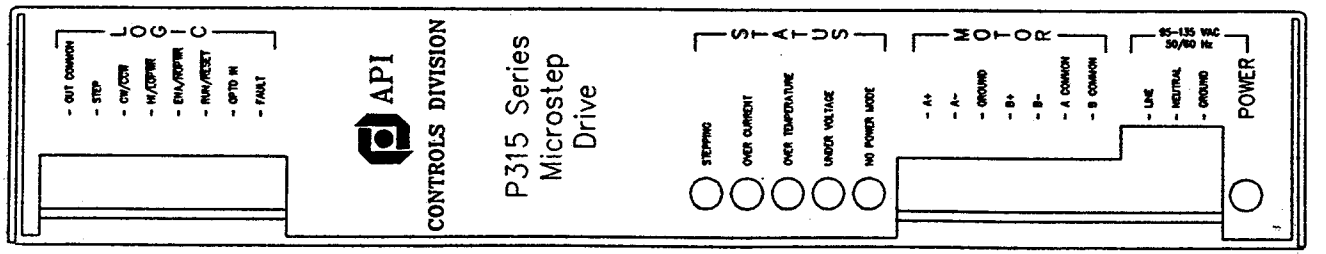
MOUNTING DIMENSIONS P315 SERIES



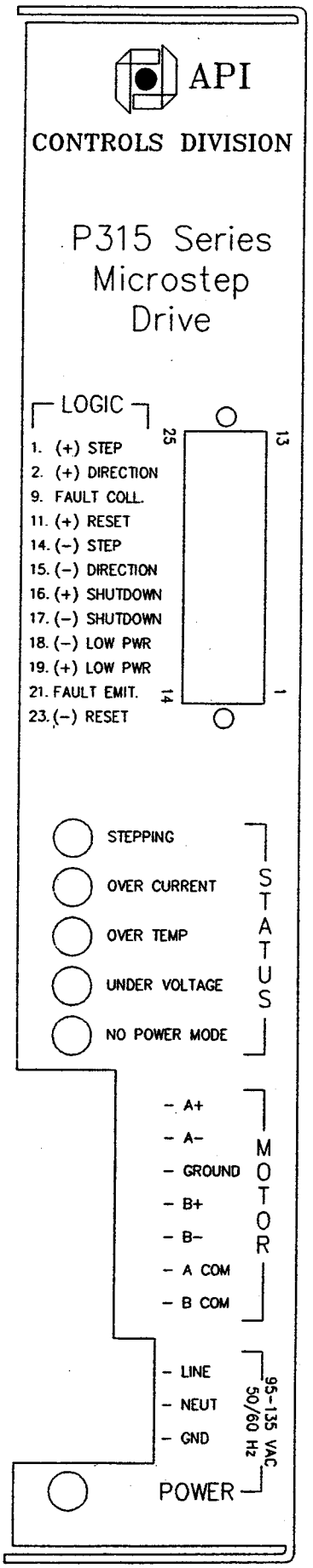
Rear and Front



Side



APPENDIX F Optional 25 pin D Logic Connector (P315-DO-DB25)



1.(+)STEP and 14.(-)STEP: These inputs are optically isolated and driven by producing a positive pulse to the (+)STEP with respect to the (-)STEP. These inputs may also be differentially driven. The step pulse must have a minimum of 200 nanosecond-pulse and a 40% - 60% duty cycle (2 MHz max pulse rate).

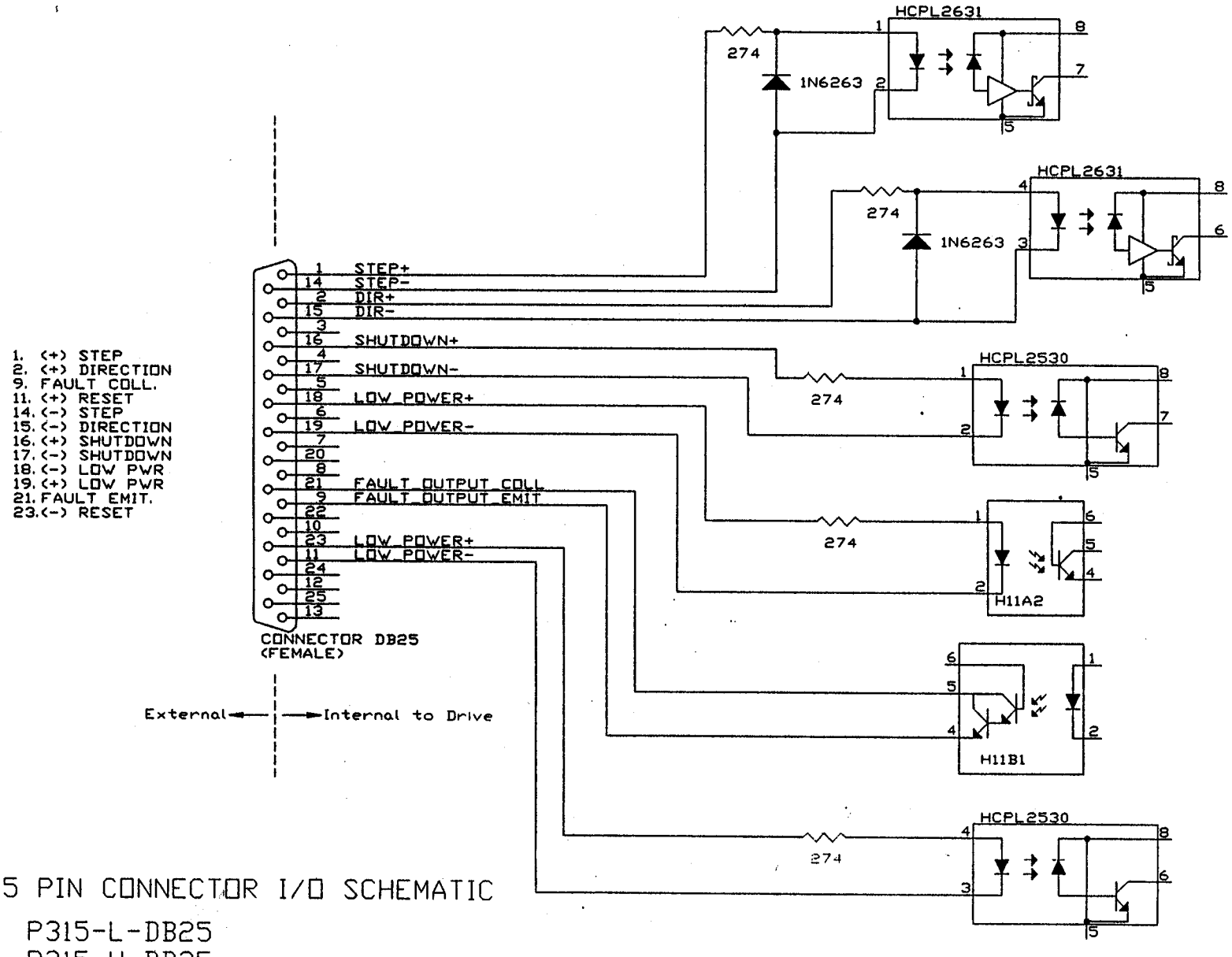
2.(+)DIRECTION and 15.(-)DIRECTION: These inputs are optically isolated and driven by producing a positive pulse to the (+)DIRECTION with respect to the (-)DIRECTION. These inputs may also be differentially driven. The direction input must be stable for at least 2 ms before the drive receives the first pulse.

9.FAULT COLL. and 21.FAULT EMIT.: These fault outputs work in conjunction to produce a fault signal if a fault condition arises. The output transistor will conduct when the drive is functioning properly. The transistor will not conduct when there is a fault condition. The different fault conditions are OVER CURRENT, OVER TEMPERATURE, or UNDER VOLTAGE

11.(+)RESET and 23. (-)RESET: These inputs are optically isolated and driven by producing a positive pulse to the (+) RESET with respect to the (-) RESET. This input allows you to reset the motor phase currents to the power up position. It must be active for 100 ms to reset and must be inactive for 100 ms before the first step pulse is received.

16.(+)SHUTDOWN and 17.(-)SHUTDOWN: These inputs are optically isolated and driven by producing a positive pulse to the (+) SHUTDOWN with respect to the (-) SHUTDOWN. This input can only be enabled when the motor is not moving. It must be active for 100 ms to shutdown and must be inactive for 100 ms before the first step pulse is received.

18.(-)LOW PWR. and 19.(+)LOW PWR.: These inputs are optically isolated and driven by producing a positive pulse to the (+) LOW PWR. with respect to the (-) LOW PWR.. This input allows you to take the motor to low power to reduce heat. It must be active for 100 ms to go into low power and must be inactive for 100 ms before the first step pulse is received.



25 PIN CONNECTOR I/O SCHEMATIC

P315-L-DB25
P315-H-DB25

AMERICAN PRECISION INDUSTRIES
CONTROLS DIVISION

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