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P51X
User Guide

Power/Drive/Indexer Unit
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 P51X Power/Drive/Indexer Unit. You should have also received the ICL SYSTEM USER GUIDE that is the software and applications user guide for this device. These two manuals form the reference set for the P51X Power/Drive/Indexer Units. Since the P51X is a member of the entire ICL System family of products, it is necessary to define the features available on the P51X.

The standard features included on the P51X indexer are:

Communications Method.....	RS-232C up to 19,200 Baud.
Programmable Inputs.....	Five total. Stop, jog plus, jog minus and hold inputs can be assigned to any of the programmable inputs.
Limit Inputs.....	Home reference, clockwise limit (CWL), and counterclockwise limit (CWL).
Programmable Outputs	Three total.
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 road map 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 or suggestions that you might have in helping us achieve our goal.

This manual will guide the first time user of the P51X 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), **Functional Overview** (SECTION 1.3) and (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.

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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:

1. Because potentially lethal voltages can be present around this drive, only qualified service and installation personnel should install this device.
2. All connections or configurations should be to made with the power sources disconnected from the system.

The P51X has been designed for motors up to a size 34 two stack (M342).

1.3 FUNCTIONAL OVERVIEW

The P51X series package provides you with a completely integrated Power/Drive/Indexer unit. Each packaged system includes a motor, full/half step drive, power supply, indexer, power cord, connectors and a full enclosure.

An important feature of the P51X is that it provides the user with half step capability. By half stepping a motor, its motion is smoother and the positioning resolution greatly enhanced. Half stepping involves taking each of the motor's mechanical full steps and electrically creating two 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 will be obtained. The P51X Series uses a bipolar chopper method of current control that will yield excellent speeds and torque's. This technique involves over-driving the windings with high voltages to decrease the current rise times, and then controlling the current by high frequency (20 KHz) current chopping. The P51X provides output currents up to 3.5 amps per phase and will drive 4-phase motors rated at up to 5.0 Amps per phase (bifilar rating).

The integral 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.

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CONNECTIONS TO THE P51X UNIT INCLUDE:

AC Power:	115 or 230 VAC, +/- 10%, 50/60 Hz
DC Power:	5-24 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 P51X, 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 5 user programmable inputs. Dedicated jog plus, jog minus, stop and hold inputs may be assigned to any of the inputs or not used at all.
Outputs:	Has connections for three user programmable outputs.
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 P51X Series Power/Drive/Indexer units. An assumption is made here that the user has an IBM PC® or compatible to communicate with the P51X.

1.	Ensure that the P51X is configured for the AC power source, 115 or 230 VAC. (Section 2 - Installation and Configuration)
2.	Ensure that the current switch settings are set for the motor that you are running. (Section 2.4.3. - Current Switch Settings)
3.	Select the Step Resolution desired. (Section 2.4.4 - Step Resolution Settings)
4.	Select the baud rate desired. (Section 2.2.2 - Baud Rate Switch Settings)
5.	Plug the motor connector into the socket labeled motor. (Section 2.4.2 - Motor Connections)
6.	Refer to Section 3.3 - Performing Motion.
7.	Plug into your power source G. (Section 2.6 - Power Section)

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1.5 MOTOR COMPATIBILITY

The P51X may be purchased as a complete packaged unit with a compatible motor. Motors packaged with the P51X have been selected to provide the optimum speed versus torque performance for a given package for series configurations. (See Appendix D for performance curves.)

The P51X 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 that is capable of bipolar operation, characterized by the need for current to flow in both directions in each coil of the motor. Most motors that 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.**

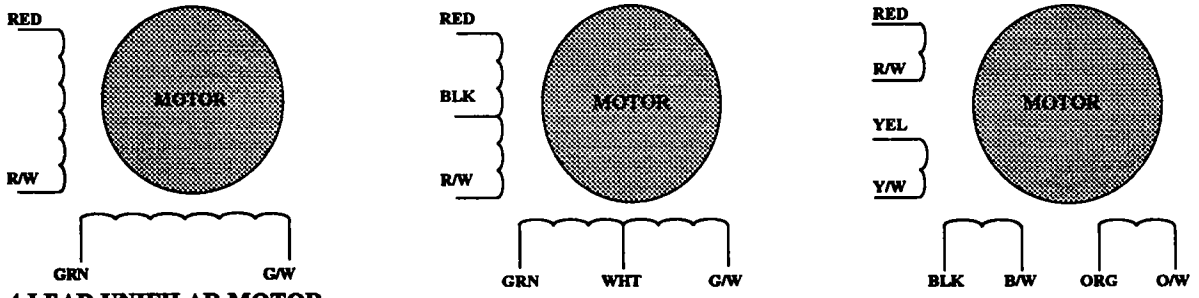


DIAGRAM 1.5

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Motor Heating..... The P51X series drives are capable of operating a motor connected in series or parallel configuration. Motors wired in series that come packaged with the P51X can be run continuous at high speeds without overheating. Motors wired in parallel that come packaged with the P51X cannot be run continuously 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 0.7 to 3.5 Amps per phase for the P51X. 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 it's 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 1.5 mH - 80 mH on all models of P51X drives (Bi Filar). The recommended motor inductance is 5 mH - 40 mH.

Size..... Recommended motor size for the P51X Series is size 16, size 23 and up to size 34 two stack 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 P51X Series drives are designed to minimize the current rise time 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 half stepping. The unstable areas of a full stepped motor are characterized by erratic motion and a severe loss of torque. A half stepped motor will exhibit less resonance than a full stepped motor.

Sample performance curves are provided in Appendix D 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 P51X Series units. This section should be read in its entirety 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, encoder, I/O signals, etc., to prevent noise problems.

The P51X drive switches 38 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 P51X 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. Provide a separate AC line for the drive. Do not use the same AC line for equipment that is sensitive to electrical noise.

5. Shield the logic signal lines of equipment sensitive to electrical noise and ensure that the shield is taken to a low impedance earth ground.

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2.1.2 COOLING

Drive/Indexer..... The enclosure of the P51X is a heat sink that allows for heat dissipation produced by the internal components. During operation the heat sink 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. 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 heat sink surface temperature less than 65°C. Since the drive is convection cooled, it is recommended that you allow a minimum of three inches on all sides for air flow. Operating in an enclosed area may require external cooling in order to keep the heat sink temperature less than 65°C (i.e., forced air fan). A rule of thumb if you are not able to measure the heat sink temperature: the heat sink temperature is within limits if you can comfortably hold your finger on it more than 3 seconds.

Motor ..... Control's Division complete model M-Series motors are rated at 212°F (100°C) maximum allowable case temperature, the MT-Series and MH-Series motors are rated at 285°F (140°C) maximum allowable case temperature. When connected in parallel, motors can overheat if operated for extended periods of time without a cool down period. 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.

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2.1.3 MOUNTING

The P51X is a self-contained package requiring minimal concern for mounting methods and positions. A dimensional outline of the P51X is given in Figure 2.1.3.

Mounting brackets have been provided to mount or secure the P51X. The recommended mounting position is vertical with the heat sink exposed to allow convection and heat removal from the drive. It is recommended that you allow a **minimum of three inches** on all sides for air flow. The user should refrain from mounting where the heat sink 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.

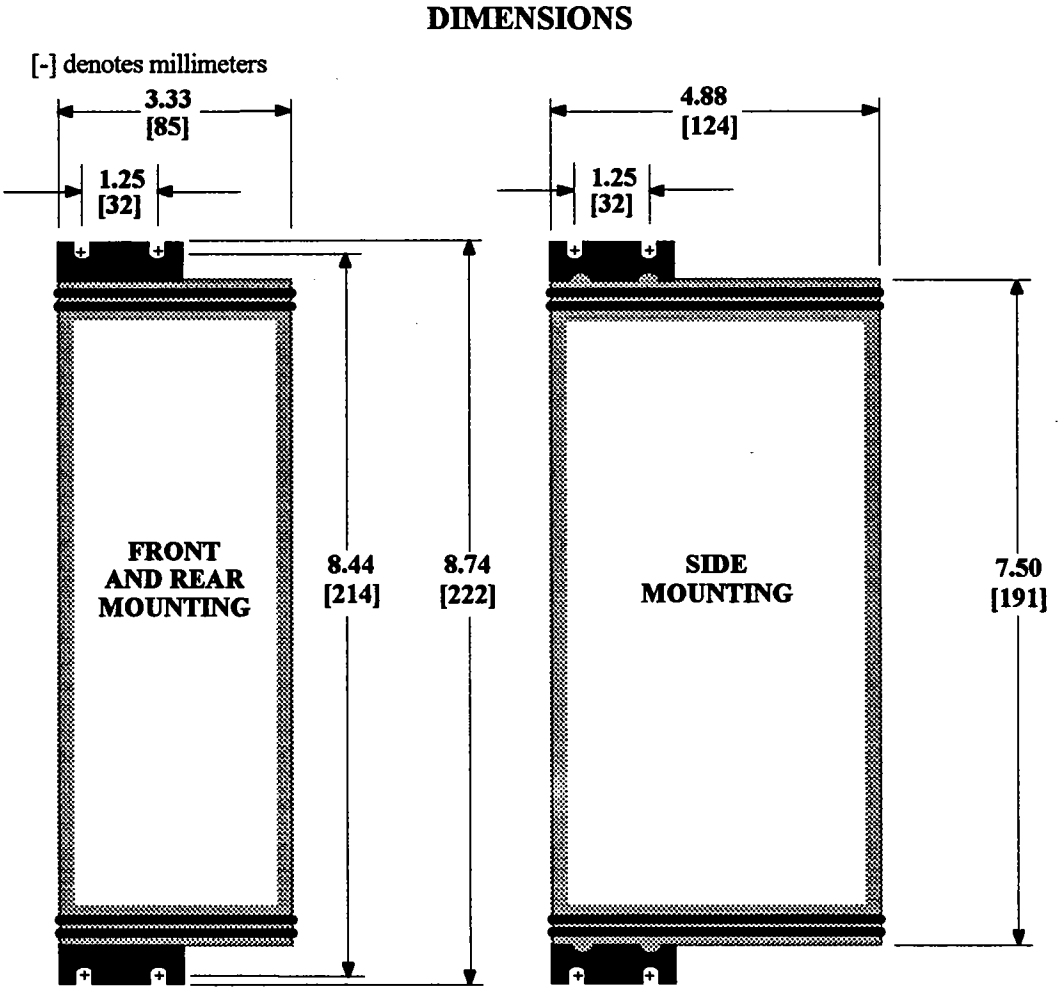


FIGURE 2.1.3

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2.2 COMMUNICATIONS

2.2.1 HOST DEVICE

A copy of the API communications program, APICOM™ is available upon request. For IBM® compatible personal computers, communication programs such as PROCOMM™, QMODEM™ and PC-TALK™ may also be utilized. These programs allow the user to interface an IBM PC® or compatible with the P51X controller. To begin operation, you must utilize the prewired RS-232 cable set to connect the serial port on your computer to the P51X RS-232 communications port. Next you must boot your computer system, then install the Controls Division disk into drive A: and type APICOM™ <Return>. This program can be customized to the users computer for baud rate,, comm-port and other features. More detailed instructions are available on the program disk via the <Help Menu> command. The program settings for communications can be set by the <Configuration Menu> command, and are preset for **serial port #1, 9600 baud, full duplex, software handshaking (XON/XOFF), 8 data bits, 1 stop bit and no parity**. You can now follow the instructions displayed via the <Main Menu> command to use your computer as a dumb terminal or to pass files back and forth to the P51X.

If you have an ASCII terminal available, you may also use this device to communicate with the P51X. Simply connect the terminal's serial port to the P51X RS-232 communications port utilizing the prewired cable set and set the baud rate to match the P51X. The communications mode and format must have the following settings: **full duplex, software handshaking (XON/XOFF), 8 data bits, 1 stop bit and no parity**.

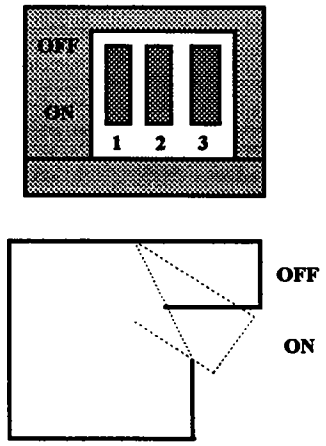
The P51X allows the user the ability to configure it's output for the size and shape of the host's display. The ICL parameter "T" allows the user to fix the number of lines transmitted to the host device prior to pausing. This allows viewing of a large motion program or directories on a display as small 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 P51X Baud Rate Settings is established on switch block #2. 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 P51X.

The available settings are:

Baud Rate Switch Settings Switch Block #2 P51X	
Baud Rate	**[123]**
19200	000
9600 *	100
4800	010
2400	110
1200	001
600	101
300	011
300	111
* Factory default	



SWITCH BLOCK # 2

SWITCH # 1-3 BAUD RATE SELECTION

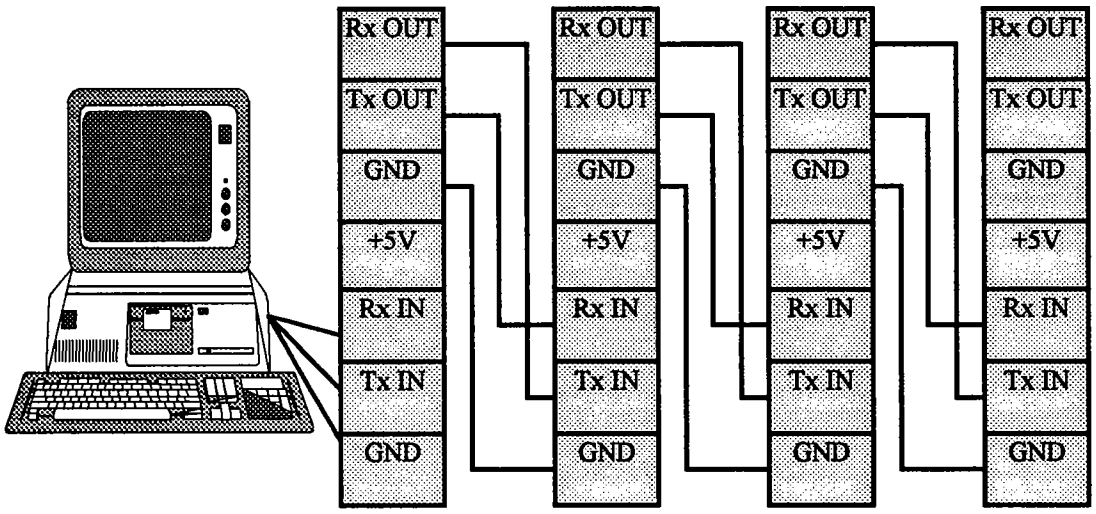
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2.2.3 RS-232 CONNECTIONS

The P51X 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 P51X does support software handshaking (XON/XOFF). The host device used for communications should have its handshaking enabled through software. See the previous section on "Communicating with the P51X" for programs that can be used with IBM® compatible personal computers. The communication default parameters are: **full duplex, software handshaking (XON/XOFF), 8 data bits, 1 stop bit and no parity**.

2.2.4 DAISY CHAINING

Up to 36 Indexers may be daisy chained to a single RS-232 port. It is necessary that each P51X 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 "Daisy Chain Wiring Diagram" depicts the proper method of connection.



RS - 232 from Host Device **7 - Pin Connector**

DIAGRAM 2.2.4

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2.3 POWER SECTION

2.3.1 AC CONNECTIONS

**** CAUTION ****

The user must remove gain access to the internal selector switch to configure the P51X for 220VAC.. You must remove all screws present in the enclosure to gain access.

When re-installing the enclosure, be sure to secure the heat sink bar to the enclosure to prevent heat damage to the P51X.

If configured for 230 VAC, place a label near the AC input as a reminder to prevent damage during installation.

The factory default configuration is 115 VAC.

**** CONSULT FACTORY IF YOU HAVE ANY QUESTIONS. ****

A three prong 115 VAC 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

2.3.2 DC CONNECTIONS

Ensure that your DC power source is a minimum of 2 amps at 5-24 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 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 DC supply return is connected to OUTCOM, output common pin of the plug type connector.

OPTO1 ..... Supplies optical-isolation voltage to the limit inputs; CW, CCW and HOME.

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

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2.4 DRIVE SECTION

2.4.1 INTRODUCTION

To provide the user with the greatest amount of versatility; dip switches for current control have been provided to configure the drive for a specific motor.

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.

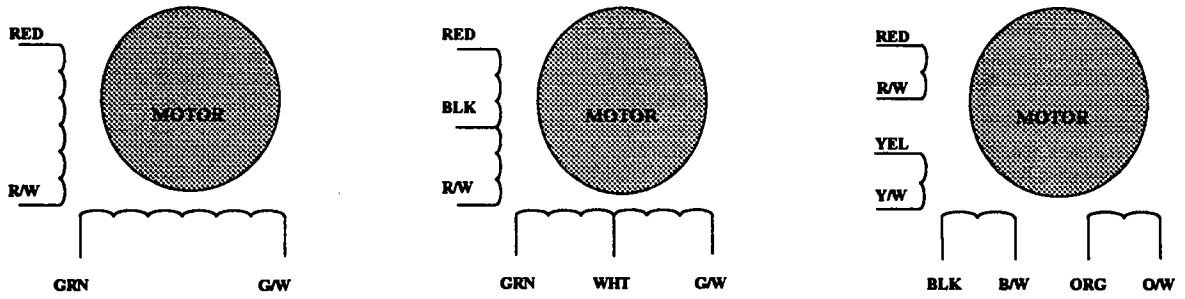
2.4.2 MOTOR CONNECTIONS

Motor connections are made on the 7 pin pluggable connector provided with the drive. 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' 2.4.2 and 2.4.3 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. Never connect anything other than the motor to the motor terminals.

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: 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.

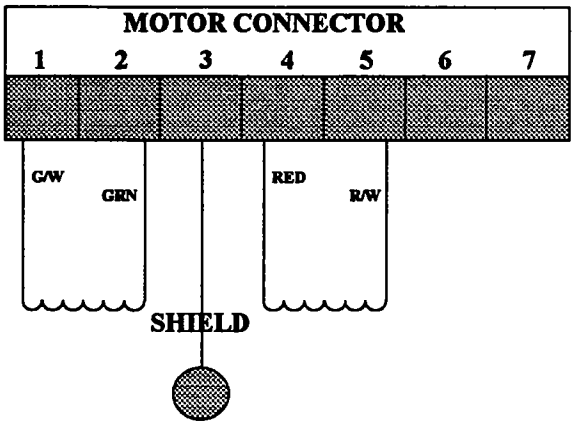


4 LEAD UNIFILAR MOTOR **6 LEAD BIFILAR MOTOR** **8 LEAD BIFILAR MOTOR**

DIAGRAM 2.4.2

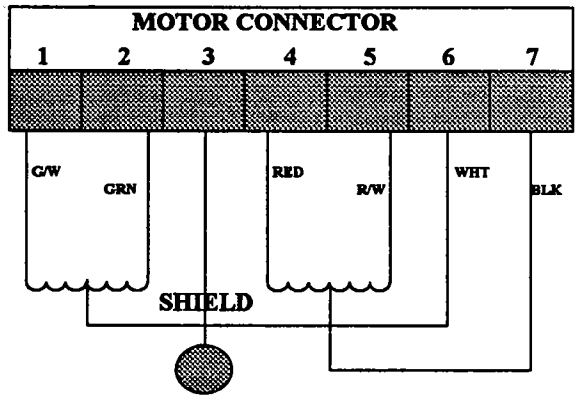
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Our examples use a 4, 6 or 8 lead motor rated at 1 amp per phase current for a unipolar drive scheme (I=1), 5 ohm resistance, 10 mH per phase inductance (L=10). Since the P51X uses a bipolar drive scheme you would apply a multiplier to the unipolar rating to arrive at the proper current settings for your connection method. Examples follow:



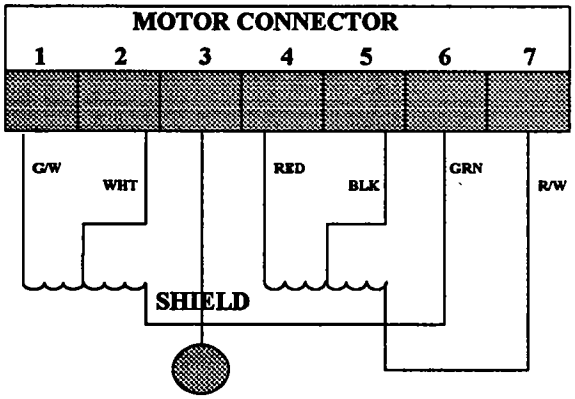
4 LEAD MOTOR

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

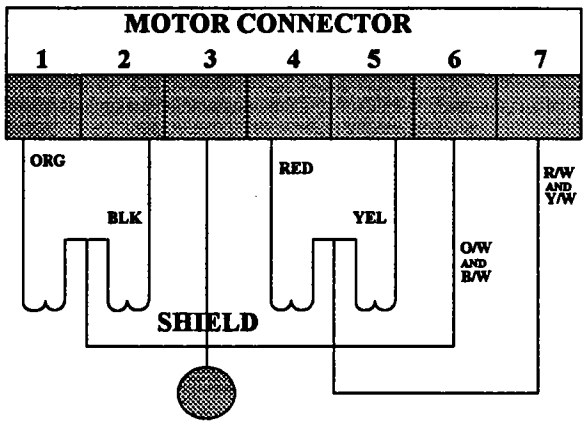
Connecting a 6 lead motor in series provides excellent low speed torque but reduced performance at higher speeds. The drive output current would be .7 amps (I*.707).The inductance seen by the drive would be 40 mH (L*4).



6 LEAD MOTOR (HALF WINDING)

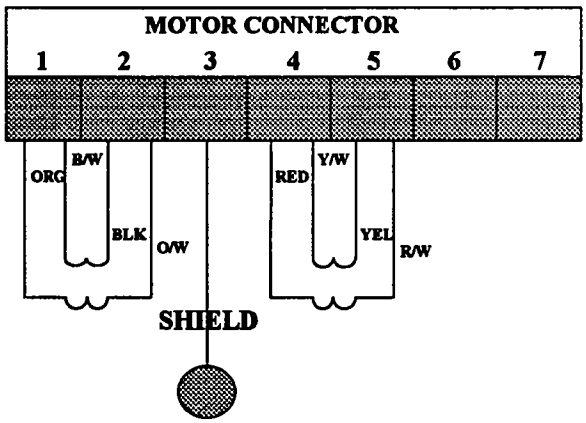
Connecting a 6 lead motor to utilize only half of the motor windings allows the user to achieve higher speeds but results in reduced low speed torque. The drive output current would be 1 amp (I*1). The inductance seen by the drive would be 10 mH (L*1).

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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).



8 LEAD MOTOR (HALF WINDING)

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).

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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. The P51X models are capable of providing 0.7 to 3.5 amps per phase.

CURRENT SETTINGS - API MOTOR

P51X Packages	Torque (Ounce-inch)	Width/Length (Inches)	Bifilar(1) Current Amps/Phase	Switch Setting (2) 12345678	Complete Model Motor
P51X-A231A	(3)	2.3/2.0	3.80	00100011	A231-08A
P51X-M231	60	2.3/2.0	3.80	00100011	M231-08
P51X-M232	100	2.3/3.3	4.70	10001111	M232-09
P51X-M233	150	2.3/4.0	4.60	01010111	M233-09
P51X-M341	150	3.4/2.5	4.80	00011111	M341-09
P51X-M342	300	3.4/3.7	4.60	01010111	M342-09
P51X-MT230	50	2.3/1.5	1.84	11111010	MT230-04
P51X-MT231	100	2.3/2.0	3.30	00010101	MT231-07
P51X-MT232	150	2.3/3.0	3.30	00010101	MT232-06

NOTES:

1. Bifilar current rating is for 6 or 8 lead motors.
2. See DIAGRAM 2.4.3 for location of Switch Block #1. A "0" indicates that the switch is "OFF" and a "1" indicates the switch is "ON".
3. 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 P51X prior to connecting to the drive. Refer to sections (1.5 Motor Compatibility) and (2.4.2 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.**

SWITCH BLOCK # 1

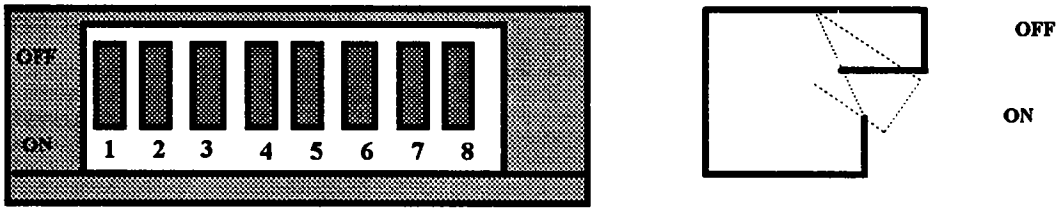


DIAGRAM 2.4.3

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P51X SERIES MOTOR CURRENT SETTINGS

Bilar Motor(1) (6 or 8 lead) Rated Current Per Phase	Unifilar Motor(2) (4 lead) Rated Current Per Phase	Dip Switch Settings (OFF/UP=0) (ON/DOWN=1) 12345678
1.00	0.70	11001100
1.14	0.80	01011100
1.28	0.90	01000010
1.42	0.99	10010010
1.56	1.09	00001010
1.70	1.19	00011010
1.84	1.29	11111010
1.98	1.39	11100110
2.12	1.48	01110110
2.26	1.58	10101110
2.40	1.68	00111110
2.54	1.78	00100001
2.68	1.88	11010001
2.82	1.97	01001001
2.98	2.09	01011001
3.12	2.18	10000101
3.26	2.28	00010101
3.40	2.38	00001101
3.54	2.48	11101101
3.68	2.58	01111101
3.82	2.67	10100011
3.96	2.77	10110011
4.10	2.87	00101011
4.24	2.97	11011011
4.38	3.07	11000111
4.52	3.16	01010111
4.66	3.26	10001111
4.80	3.36	00011111
4.96	3.47	11111111

NOTES:

1. Bifilar Motors have two windings per stator pole. These windings can be connected differently to provide different results (see Section 2.4.2).
2. Unifilar Motors have one winding per stator pole and can only be connected one way.

**** CAUTION ****

API motor ratings are based on a unipolar drive scheme. Since the P51X 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 0.7

Parallel connection 1.4

See Section 2.4.2 for additional information.

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2.4.4 STEP RESOLUTION SETTINGS

The P51X Series drive allows the user the versatility to select a step resolution that best matches his application requirements. For a standard 1.8^{o} step motor there are two software selectable resolutions of 200 full steps or 400 half steps per revolution. The P51X Series drive utilizes the ICL parameter MR to control the Motor Resolution, if **MR = 200** the drive is in full step mode, if **MR = 400** the drive is in half step mode. Determine the resolution that best meets your needs and set the parameter MR as indicated.

P51X CONFIGURATION SETTINGS

Motor Model _____ Date: _____

AC Power Configuration _____

Baud Rate Setting _____

Current Setting _____

Step Resolution _____ MR = _____

12345678

Switch Block #1 _____

Switch Block #2 _____

NOTES:

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2.5 INPUT/OUTPUT SIGNALS

2.5.1 OVERVIEW

In their simplest form, the P51X's inputs and outputs (I/O's), provide the ability for interaction between the P51X and external devices. Type of external devices includes other P51X's, programmable controllers, limit switches, relays, status lights (LED'S), foot pedals, counters, optical sensors, pressure sensors, etc. The default state of all I/O's can be defined by the user as "ACTIVE" or "INACTIVE". When the status of the input's changes, 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 P51X 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.

2.5.2 PROGRAMMABLE AND LIMIT INPUT

Inputs are either programmable inputs #1 - #5, dedicated inputs CWL, CCWL and HOME, or special inputs JOG+, JOG-, STOP and HOLD which can be assigned to any of input's 1-5. 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.

2.5.2.1 INPUT ASSIGNMENTS

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	HOME	14
INPUT 7 *	7	CCWL	15
INPUT 8 *	8	CWL	16

* Inputs 6 through input 13 are not available to the user of the P51X.

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

Example 1 ..... **JP=1 JM=2 HI=3 SI=5**
Assign JOG+ to input #1,, JOG- to input # 2, HOLD to input 3 and STOP to input 5.

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

Example 2 ..... **SI=0** STOP Input is declined.

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2.5.2.2 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 P51X, the limit must be taken low for a minimum of 1.0 ms.

Programmable inputs, inputs 1 to 5, 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 P51X, the input must be taken low for a minimum of 2.0 ms 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, HOME (14), CCWL (15) and CWL (16). In the following example the user has determined that an application requires a normally closed switch on inputs 2, 3, 4 and for CW and CCW limits. When the switches are opened, the P51X 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=00000011 <Return>**. The P51X will now interpret the inputs defaults as: 1 and 5 as active low, and 2, 3 and 4 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 "I1=01110000", "I2=10000011". The input status now shows that #2, #3, #4, #9, #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".

   Factory defaults for input definitions are:

   ID1 = 00000000
   ID2 = 00000000

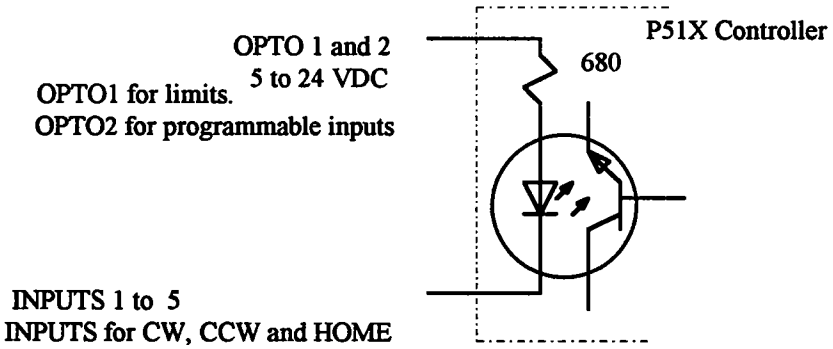
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2.5.2.3 LIMIT INPUT ACTION

When utilizing the clockwise limit (CWL), and the counter clockwise limits (CCWL), the user may select hard or soft limits. The P51X is configured at the factory for hard limits. With hard limits the P51X will immediately stop the drive pulse train when a limit input is "ACTIVE" in that direction. The user may configure the P51X for soft limits by adjustment of parameter "LA". With soft limits the P51X 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 deceleration 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 user's 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 1.0 ms, the input signal will be recognized by the P51X.

2.5.2.4 INPUT CONNECTIONS



Typical Input Schematic.

DIAGRAM 2.5.2.4

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2.5.3 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.

2.5.3.1 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

* Outputs 4 through 8 are not available to the user of the P51X.

When outputs 1 to 3 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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2.6.2 ENCODER CONNECTIONS

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 P51X to operate correctly.

1. Motor resolution is established by software configuration on the P51X. We will assume that the P51X is configured for 400 steps per revolution, thus we will set **MR=400**. The standard encoders supplied by the Controls Division are 1000 line encoders. After going through the quadrature detection circuit of the P51X 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.

COMMAND	DESCRIPTION
RESET 0	Resets the P51X 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=200	Sets base speed at .5 revolutions per second (RPS).
D=1000	Sets decel rate to 1 second or less.
H=4000	Sets parabolic ramp high speed at 10 RPS.
M=4000	Sets slew speed to 10 RPS.
MR=400	Sets motor resolution to 400 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 400	Move the motor 400 steps, one shaft revolution.
VER P VER E	Verify the motor and encoder position.
"P = 400"	Motor position is 400.
"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.

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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 and configuration switches have been made, the drive may be powered up. Plug the 3 pin mating plug into the drive and then the power cord into the 115 VAC source or 230 VAC source that the P51X has been configured for, **review Section 2.3**. 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 software 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 P51X. You should also ensure that your host device has been configured to communicate with the P51X. Once this has been established we are ready to apply power to the P51X. When power is applied the P51X 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
P51X, Copyright 1993
Software Version x.x"

0>

If your host device was not connected to the P51X via it's RS-232 interface when power was applied to the P51X, you did not see the sign-on message. 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 P51X 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 is Section 3.2.2.

If after following the troubleshooting instructions you are still unable to establish communications with the P51X 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.

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If your display device is less than 25 lines and 80 characters wide. You should re-configure the P51X to establish the proper settings.

The screen width parameter	"SC" is used to define the number of characters available 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 <Return>** command will instruct the P51X to transmit 10 lines and pause until any character is typed.

3.2.2 TROUBLESHOOTING RS-232

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

1. Utilize the prewired RS-232 cable set supplied with the P51X. Verify that the host device transmit line (usually pin 2) is connected to the Rx IN of the P51X, and the receive line (usually pin 3) of the host device is connected to the Tx IN of the P51X. The DC common or signal ground of the host device (usually pin 7 on a 25 pin D and pin 5 on a 9 pin D connector) is connected to the GND IN of the P51X, NOT earth ground.

2. Note: Some serial ports require hardware 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 P51X, 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 P51X 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 P51X 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 (pin 2) and receive (pin 3) 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 pinouts.

7. If the data output from the P51X to the host device becomes mixed, (i.e. Dropping characters or complete lines), the baud rate may be set too 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 P51X 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 P51X utilizing MOVE, POSITION, RUN and SLEW commands. It is assumed that the P51X is set at 400 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=200	Set base speed to 1/2 revolution per second.
MR=400	Set motor resolution for half step MODR 400 step per revolution.
H=8000	Set highest speed limit to 20 revolutions per second. NOTE: for full/half step drives this value is about 30000 as it is used to control the pulse width.
A= 1000	Set acceleration time to 1000ms.(1 Second)
D= 1000	Set deceleration time to 1000ms.(10 Second)
M= 4000	Set maximum speed for 10 revolutions per second.
MOVE 4000	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 4000 to denote 10 revolutions "P" in CW direction.
MOVE -8000	The motor will move CCW, 20 revolutions and stop.
VERIFY P	Read the parameters and make special note of the current "P" value is -4000 to denote 10 revolutions in CCW direction from the initial position. "N" will be 8000 to denote the last index distance.
POSITION 400	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 = 400"
POSITION 400	This time the indexer will not move the motor since it is already at the commanded position.

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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

PROBLEM	PROCEDURE
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	Verify flag 0 to see if motion is being commanded. Example: **VER F0;** "F0 = 1" motion is being commanded "F0 = 0" no motion is 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

PROBLEM	PROCEDURE
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, parameter "M" 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.

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MOTOR RUNS VERY HOT

PROBLEM	PROCEDURE
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

PROBLEM	PROCEDURE
Improper acceleration rate.....	Check that the acceleration rate of the drive is not too fast or slow for the motor to maintain synchronism with the driven load. Decrease the acceleration rate, parameter "A".
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 P51X and motor for service.

For assistance contact your local API representative or Motion Automation Company (MAC). OR

American Precision Industries

Controls Division
45 Hazelwood Drive
Amherst, NY 14228-2278

OR

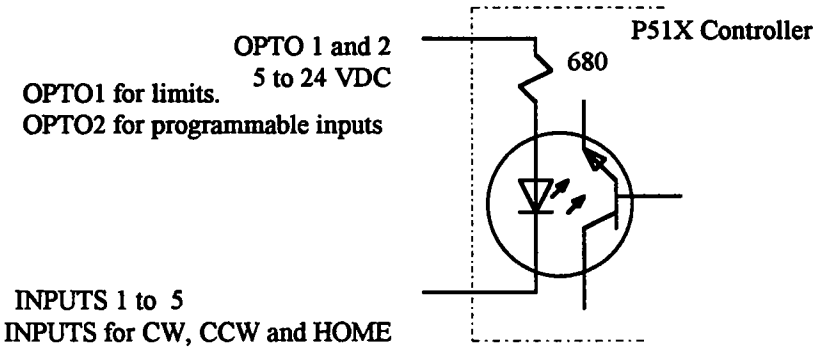
Telephone
(716) 691-9100
FAX
(716) 691-9181

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 P51X when making any of the following connections. Please read the following procedures and only make the necessary connections required for the testing of each input.



Typical Input Schematic.

DRAWING 3.4

3.4.1 CWL AND CCWL INPUTS

1. Wire the CWL input at this time and return AC power to the P51X.

2. We now wish to cause the motor to run in the clockwise direction, type the following; **B=200 <Return> + RUN <Return>**. The motor will begin to rotate clockwise at 1/2 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 #8 of the INPUT DEFINITION parameter **"ID2"; ID2=xxxxxxx**. 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 2, 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 P51X.

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=XXXXXXX**. 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 2. The motor will stop rotating when the CCWL input switch is active.

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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 P51X.

3. Before we check the HOME input, some parameters must be set to provide speeds for searching for home. Type the following; **B=200 M=2000 A=1000 D=1000 <Return> + HOME <Return>**. The motor will start at 1/2 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 P51X when making any of the following connections.

1. Disconnect AC power from the P51X before proceeding.

2. Wire the INPUT switches to the P51X as shown in drawing 3.4. 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, **Ver 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. Note: The P51X 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.

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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 DRAWING 3.4"**, using the internal power supply of the P51X or utilizing an external power supply as shown.

1. Wire only the Jog+ input at this time and return AC power to the P51X.

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 = 1xxxxxx <Return>**. 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=400 <Return>**. When the Jog+ input #1 switch is activated the motor will rotate clockwise at one revolution per second. This input in 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 P51X.

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: . 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 P51X.

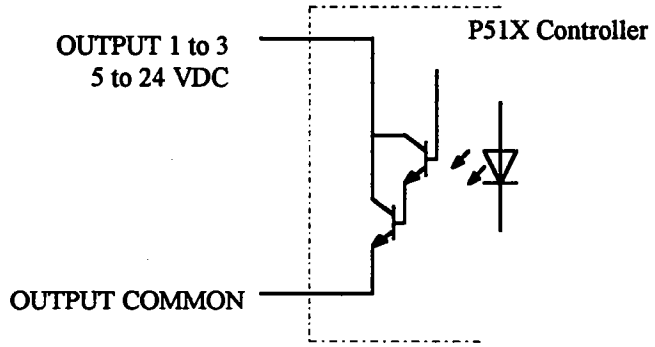
2. Define input #3 as the STOP input with the following command; **"SI=3"**. Type: **B=400 RUN <Return>**, The motor will begin to run at 1 revolution per second. If the motor does not start to rotate, the "INPUT DEFINITION", parameter "ID1" for bit #3 needs to be changed by typing the following command: **ID1 = XX1XXXXX <Return>**. Utilize the "x" character 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.

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3.5 PROGRAMMABLE OUTPUTS

The following procedures are used in checking the programmable outputs. The user should disconnect the AC power from the P51X when making any of the following connections. Below are shown connection diagrams for the P51X's outputs.



Typical output, current sinking to Output Common

OUTPUT DRAWING

TESTING PROGRAMMABLE OUTPUTS

1. Disconnect AC power from the P51X before proceeding.

2. Wire the P51X'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 O1 <Return>**, the host will display **"O1 = 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 theoutputs again and the host will display **"O1 = 10000000"**. This denotes that output 1 is now active or sinking 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]" 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 P51X 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 P51X to operate correctly.

1. Motor resolution is established by setting parameter MR on the P51X. We will assume that the P51X is configured for 400 steps per revolution, thus we will set **MR=400**. The standard encoders supplied by the Controls Division are 1000 line encoders. After going through the quadrature detection circuit of the P51X 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.

COMMAND	DESCRIPTION
RESET 0	Resets the P51X 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=200	Sets base speed at .5 revolutions per second (RPS).
D=1000	Sets decel rate to 1 second or less.
H=8000	Sets parabolic ramp high speed at 20 RPS.
M=4000	Sets slew speed to 10 RPS.
MR=400	Sets motor resolution to 400 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 400	Move the motor 20,000 steps.
VER P VER E	Verify the motor and encoder position.
"P = 400"	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.

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POSITION MAINTENANCE

To utilize the position maintenance capability of the P51X 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=15", the motor is considered on position when the encoder is within fifteen counts of the commanded position. To prevent the ICL System from "hunting for position" the Dead Band Window has a recommended minimum value based upon Motor Resolution and Encoder Resolution.

For MR < ER ..... The recommended minimum value to avoid either is calculated by the following:
DW =[{Integer(ER / MR)} * 2 + 1]
* The absolute minimum is software enforced at one motor step or (ER/MR).

For MR > ER ..... The recommended minimum value is 3 due to the mechanical variations in the motor.

For MR < 3* ER..... The recommended minimum value is 3 due to the mechanical variations in the motor.

For MR > 3*ER..... The recommended minimum value is 0.

3. For our test procedures "ER = 4000" and "MR = 400", thus the minimum value of the Dead Band Window is "DW = 21".

4. Next we must define the Maximum Correction Velocity, "CV", that will be allowed during error correction. For the case where "MR=400", and "CV=4000", 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 = 10 <Return>.**

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 P51X 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:

COMMAND	DESCRIPTION
DW=25	Sets dead band window to twenty-five encoder counts.
CV=4000	Sets the maximum correction velocity to 10 RPS.
CG=10	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 1200	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=1200 and E = 12000).

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STALL DETECT

To utilize the Stall Detect capability of the P51X 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.

COMMAND	DESCRIPTION
PE=2000	Sets position error to 1/2 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 (30,000 pulses).

Manually stall the motor. The following message should appear:

"#36 MOTOR HAS STALLED"

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3.6.2 TROUBLE SHOOTING

Example assumes 4,000 encoder counts per shaft revolution:

COMMAND	DESCRIPTION
EF=01000000	Sets Position maintenance function on.
CV=4000	Sets the maximum correction velocity to 10 RPS.
CG=40000	Sets the correction gain value.
DW=25	Sets the dead band window to 25 motor pulses.
ER=4000	Set encoder resolution.
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.

PROBLEM	SOLUTION
Motor is Hunting (bi-directional)	Verify that parameters "ER" and "MR" are set correctly.
Motor is Hunting (one direction only)	Verify that the encoder is connected to the P51X. Verify that the encoder position parameter "E" increases for a positive move.
If the motor is correcting at constant 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 times to zero, ("R=0", "S=0", "Q=0").
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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SWITCH BLOCK # 1

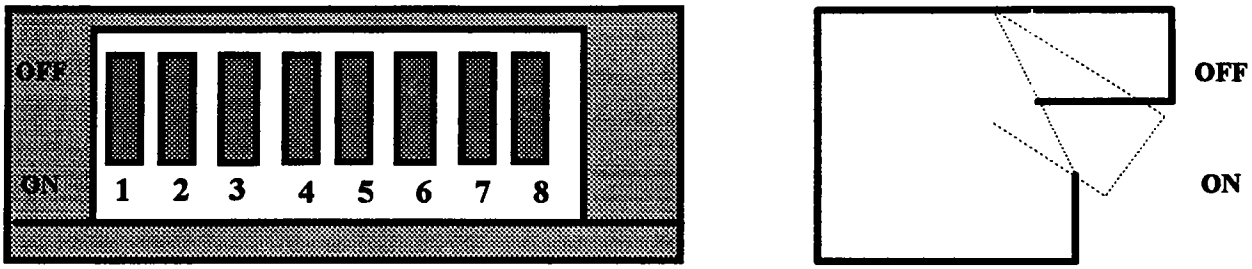


DIAGRAM 2.4

Motors size 23 and 34 supplied with these packages come with the following features:

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

CURRENT SETTINGS
API MOTOR

P51X Packages	Torque (Ounce-inch)	Width/Length (Inches)	Bifilar(1) Current Amps/Phase	Switch Setting (2) 12345678	Complete Model Motor
P51X-A231A	(3)	2.3/2.0	3.80	00100011	A231-08A
P51X-M231	60	2.3/2.0	3.80	00100011	M231-08
P51X-M232	100	2.3/3.3	4.70	10001111	M232-09
P51X-M233	150	2.3/4.0	4.60	01010111	M233-09
P51X-M341	150	3.4/2.5	4.80	00011111	M341-09
P51X-M342	300	3.4/3.7	4.60	01010111	M342-09
P51X-MT230	50	2.3/1.5	1.84	11111010	MT230-04
P51X-MT231	100	2.3/2.0	3.30	00010101	MT231-07
P51X-MT232	150	2.3/3.0	3.30	00010101	MT232-06

1. Bifilar current rating is for 6 or 8 lead motors.

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

3. 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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DIP SWITCH SETTINGS

P51X SERIES MOTOR CURRENT SETTINGS

Bilar Motor(1) (6 or 8 lead) Rated Current Per Phase	Unifilar Motor(2) (4 lead) Rated Current Per Phase	Dip Switch Settings (OFF/UP=0) (ON/DOWN=1) 12345678
1.00	0.70	11001100
1.14	0.80	01011100
1.28	0.90	01000010
1.42	0.99	10010010
1.56	1.09	00001010
1.70	1.19	00011010
1.84	1.29	11111010
1.98	1.39	11100110
2.12	1.48	01110110
2.26	1.58	10101110
2.40	1.68	00111110
2.54	1.78	00100001
2.68	1.88	11010001
2.82	1.97	01001001
2.98	2.09	01011001
3.12	2.18	10000101
3.26	2.28	00010101
3.40	2.38	00001101
3.54	2.48	11101101
3.68	2.58	01111101
3.82	2.67	10100011
3.96	2.77	10110011
4.10	2.87	00101011
4.24	2.97	11011011
4.38	3.07	11000111
4.52	3.16	01010111
4.66	3.26	10001111
4.80	3.36	00011111
4.96	3.47	11111111

NOTES:

1. Bifilar Motors have two windings per stator pole. These windings can be connected differently to provide different results (see Section 2.4.2).
2. Unifilar Motors have one winding per stator pole and can only be connected one way.

**** CAUTION ****

API motor ratings are based on a unipolar drive scheme. Since the P51X 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 0.7

Parallel connection 1.4

See Section 2.4.2 for additional information.

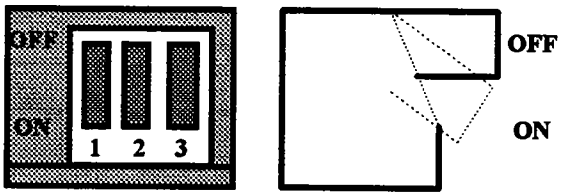
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BAUD RATE SETTINGS

The P51X Baud Rate Settings is established on switch block #2. 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 P51X.

The available settings are:

Baud Rate Switch Settings Switch Block #2 P51X	
Baud Rate	**[123]**
19200	000
9600 *	100
4800	010
2400	110
1200	001
600	101
300	011
300	111
* Factory default	



SWITCH BLOCK # 2

SWITCH # 1-3 BAUD RATE SELECTION

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PERFORMANCE CURVES

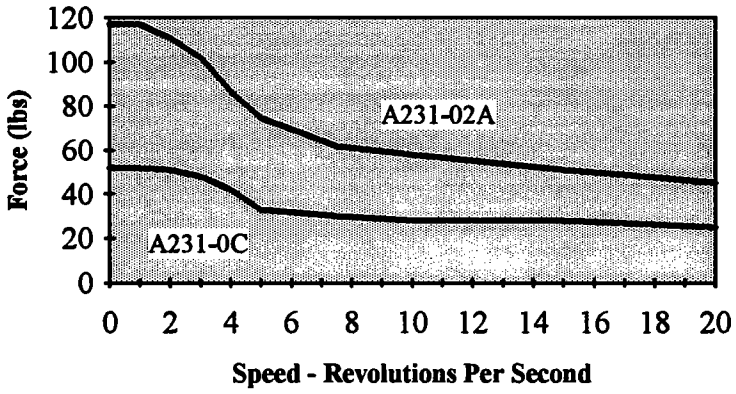
SYSTEM SELECTIONS /MOTOR DIMENSIONS

Each system includes a Power Supply, Drive, and Motor

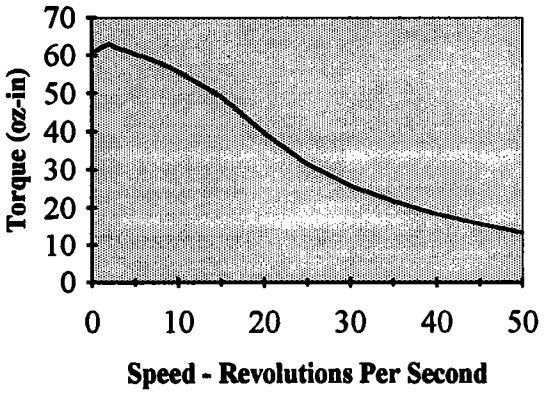
Base System	With Indexer	With Indexer/Encoder	Static Oz-in (N-m)	Motor Width in. (mm)	Motor Lengt in. (mm)	Model Motor
P51-A231*	P51X-A231*	N/A	N/A	2.23 (57)	2.00 (51)	A231-08*
P51-M231	P51X-M231	P51X-M231E	60 (0.42)	2.23 (57)	2.00 (51)	M231-08
P51-M232	P51X-M232	P51X-M232E	100 (0.71)	2.23 (57)	3.25 (83)	M232-09
P51-M233	P51X-M233	P51X-M233E	150 (1.06)	2.23 (57)	4.00 (102)	M233-09
P51-M341	P51X-M341	P51X-M341E	150 (1.06)	3.35 (85)	2.45 (62)	M341-09
P51-M342	P51X-M342	P51X-M342E	300 (2.12)	3.35 (85)	3.70 (93)	M342-09
P51-MT230	P51X-MT230	P51X-MT230E	50 (0.35)	2.30 (57)	1.50 (38)	MT230-04
P51-MT231	P51X-MT231	P51X-MT231E	100 (.71)	2.30 (57)	2.00 (51)	MT231-07
P51-MT232	P51X-MT232	P51X-MT232E	150 (1.06)	2.30 (57)	3.00 (76)	MT232-06

SPEED/FORCE CURVE

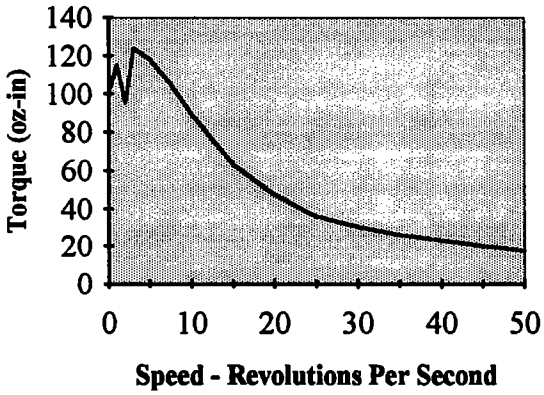
* Suffix 'A' - 0.050" Lead; 'C' - 0.250" Lead



P51X-M231



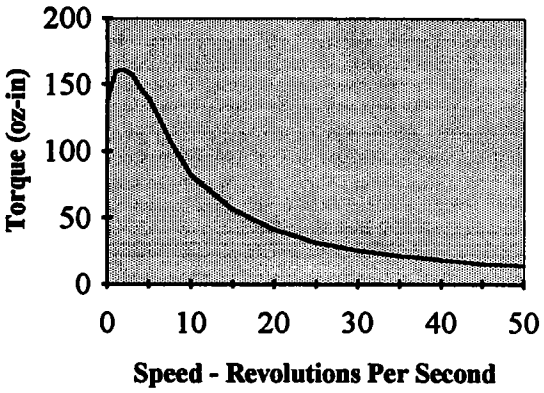
P51X-M232



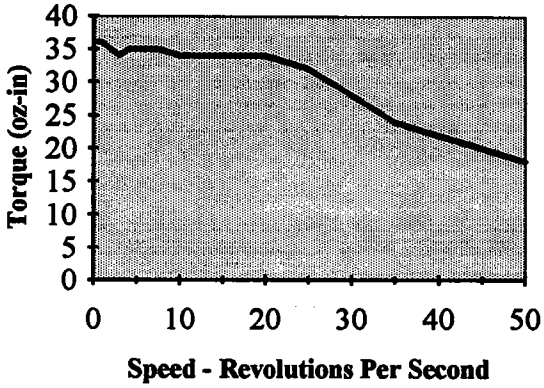
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PERFORMANCE CURVES (CONT.)

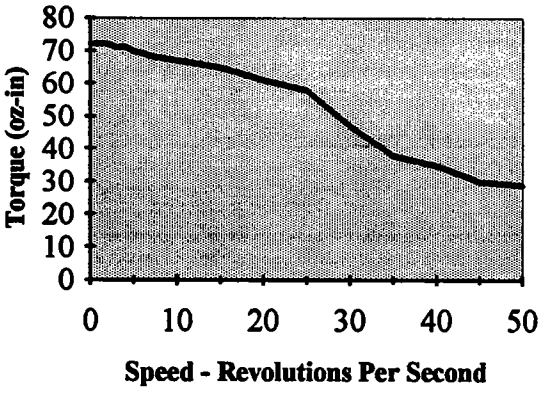
P51X-M233



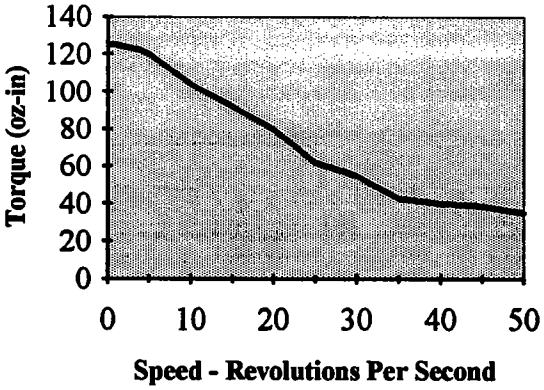
P51X-MT230



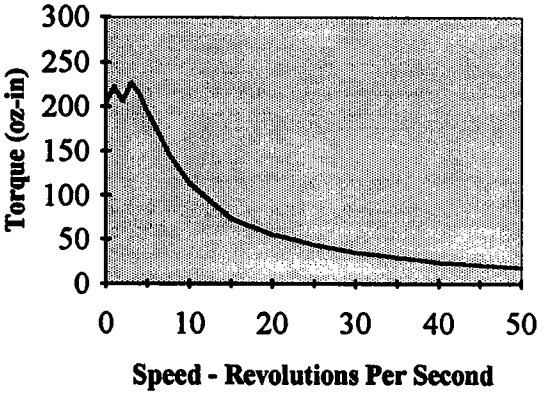
P51X-MT231



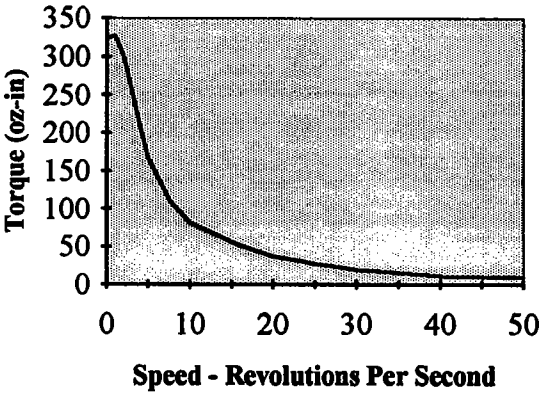
P51X-MT232



P51X-M341



P51X-M342



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P51X SPECIFICATIONS

GENERAL:

Drive Type	2 Phase, bipolar chopper, constant current
Stepping Modes	Full and Half Step modes Software Selectable

POWER REQUIREMENTS:

AC Supply	115 VAC or 230 VAC, 50/60 Hz User Selectable
DC Supply	5-24 VDC. 2 amp rating for optical-isolation of INPUTS and OUTPUTS
Output Rating	Dip Switch Selectable P51X .7-3.5 Amps per phase

PHYSICAL:

Dimensions	P51X 3.0"W x 7.5"H x 4.8"L
Weight	P51X 2.8 lbs.

TEMPERATURE:

Storage	40^{O}F to $+185^{O}$F (-40^{O}C to $+85^{O}$C)
Operating	149^{O}F (65^{O}C) maximum case temperature.

MOTOR:

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

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ICL SYSTEM (OPERATIONAL)

Acceleration	Optimal non-linear mathematical function USER RAMPS
Accuracy	+ / - 0 pulses
Positioning Range	+ / - 2.1 billion pulses
Speed Range	0 to 80,000 pulses per second
	+ / - 1% maximum speed

STORED PROGRAMS

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

COMMUNICATIONS (RS-232)

Baud rates	300, 600, 1200, 2400, 4800, 9600 or 19200
Mode	Full Duplex, Software Handshaking (XON/XOFF)
Format	8 Data Bits, 1 Stop Bits, No Parity,
	ASCII Characters

DISCRETE I/O

OPTO1	5-24VDC @ 750ma. (minimum)
OPTO2	5-24VDC @ 950ma. (minimum)

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" through 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 P51X.

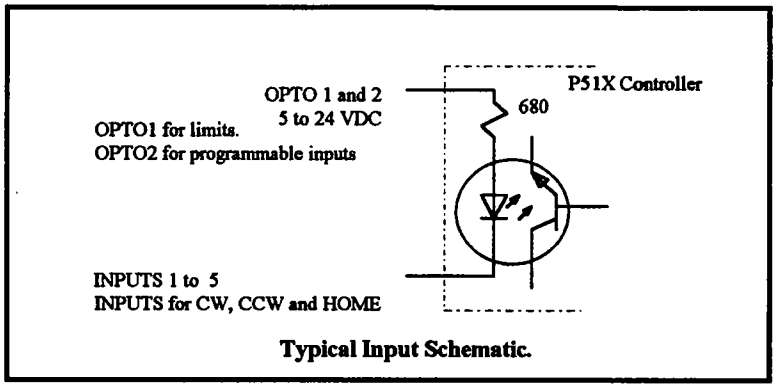
Inputs (Programmable)	Five TTL Compatible Inputs at voltage OPTO2. The inputs are optically isolated and may be driven by providing a negative signal with respect to the OPTO2 input. The input driver must be capable of providing a minimum sink current of 10mA to ensure proper operation. The maximum reverse voltage on these terminals is -3 VDC with respect to the OPTO2 input (OPTO2+3 VDC.)
Inputs (Limits)	Three TTL Compatible Inputs for CWL, CCWL and HOME at voltage OPTO1. The inputs are optically isolated and may be driven by providing a negative signal with respect to the OPTO1 input. The input driver must be capable of providing a minimum sink current of 10mA to ensure proper operation. The maximum reverse voltage on these terminals is -3 VDC with respect to the OPTO1 input (OPTO1+3 VDC.)
Outputs (Programmable)	Three TTL Compatible current sinking outputs at voltage OPTO2. Outputs are optically isolated, with a maximum sink current of 35mA.

ENCODER INPUTS:

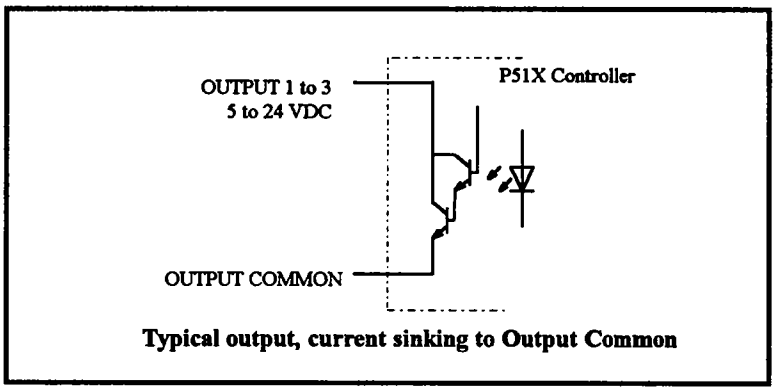
Encoder Inputs	Dual-Channel (A and B) Incremental Optical Encoder with Z channel input for encoder index pulse. A +5VDC, ground and shield are supplied for encoder use.

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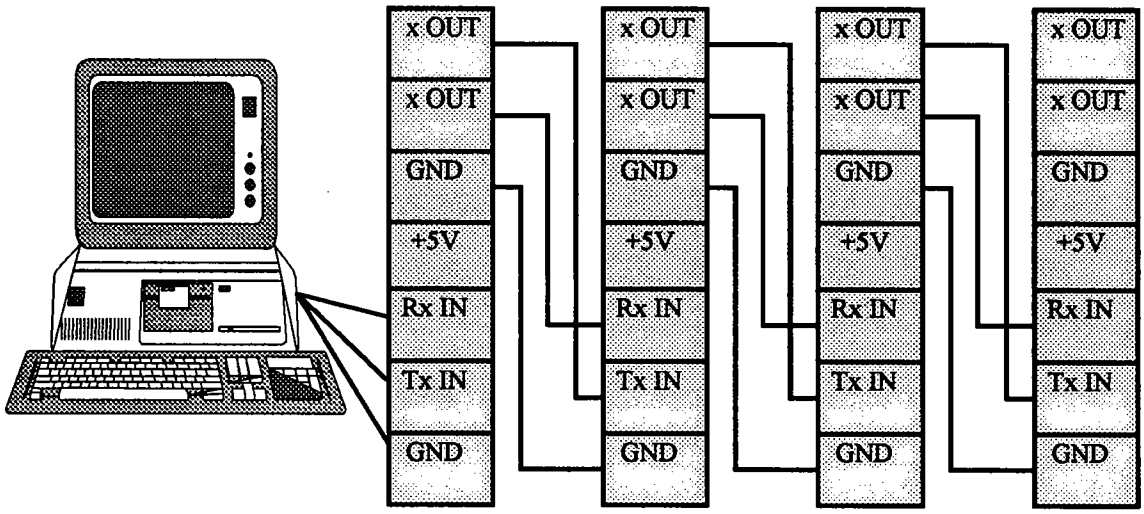
P51X WIRING DIAGRAMS



Typical Input Schematic.



Typical output, current sinking to Output Common



RS - 232 from Host Device

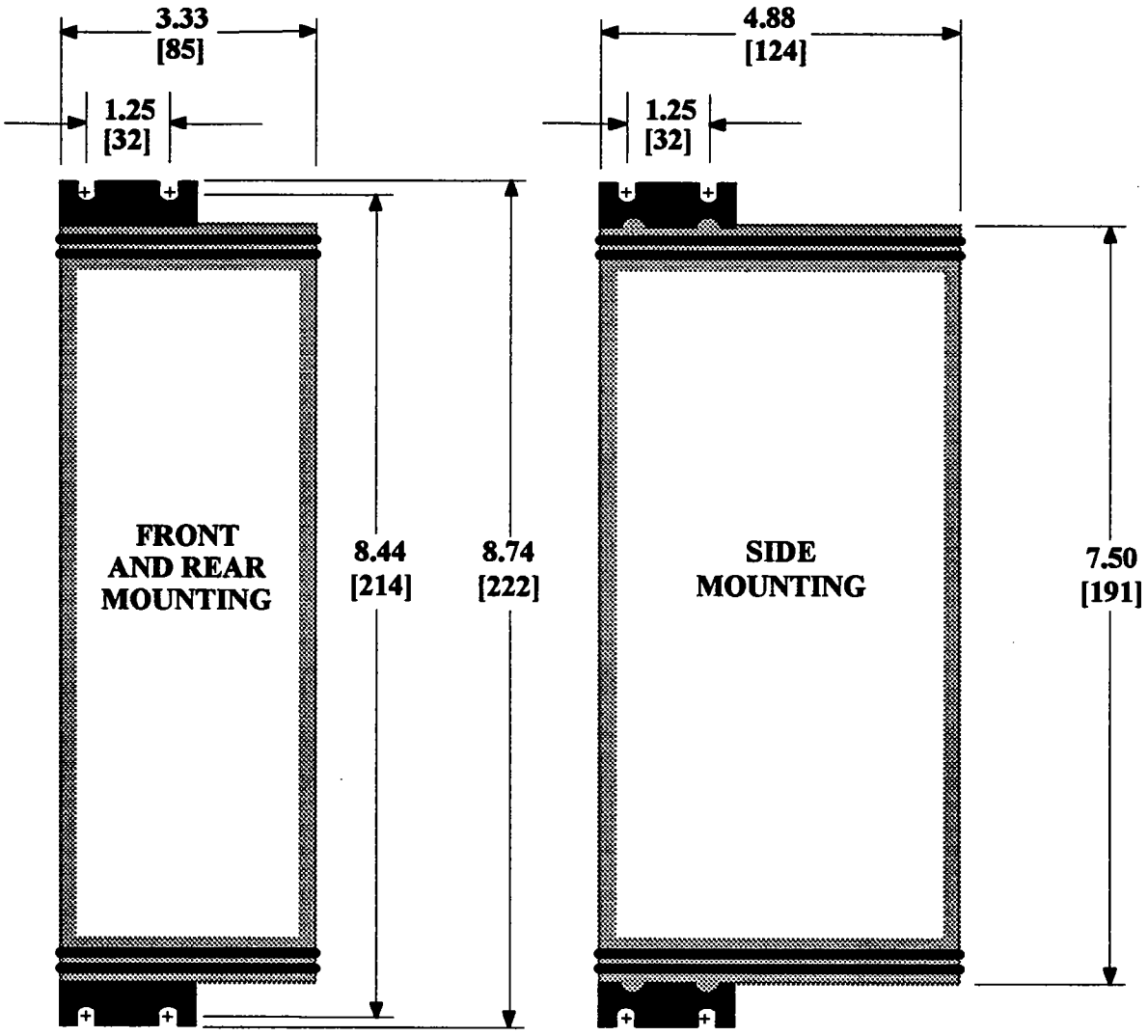
7 - Pin Connector

DAISY CHAIN WIRING DIAGRAM

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MOUNTING DIMENSIONS

[-] denotes millimeters



Subject to change without notice.

Drive to be mounted vertically with a 3" horizontal and 2" vertical clearance between drives.

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