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Part# MA830
List Price $50 U.S.
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Rev 5

MA830

PC830 User Manual

Single Axis Brushless Servo Drive

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1 Getting Started

Introduction

This chapter provides a step-by-step introduction to setting up the PC830. This procedure uses the minimum possible equipment to run an unloaded motor and sets motor speed from a PC's serial port. It is strongly recommended that all first time users go through this procedure to become familiar with the PC830 and the PC interface software before installing the servo system in a machine.

1.1 Setting Up the Hardware

What you will need

To go through this product introduction procedure you will need the following items.

- PC830 Servo Drive
- Appropriate Brushless Motor with nothing attached to the shaft
- PC Running Windows 95/98 or WindowsNT
- 830 Tools Floppy Disk
- Motor Power and Feedback Cables (TB1, J3)
- RS-232 Communications Cable (J1)
- DB-44 Connector Mate (J2)
- AC Power Line (TB1)

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Wiring connections

Connect the motor, feedback, and AC Power cables as shown in the following Connection Diagram but **do not apply the AC Power at this time**. It is highly recommended that Pacific Scientific motor and feedback cables be used during setup since improper cabling is the number one cause of start up problems.

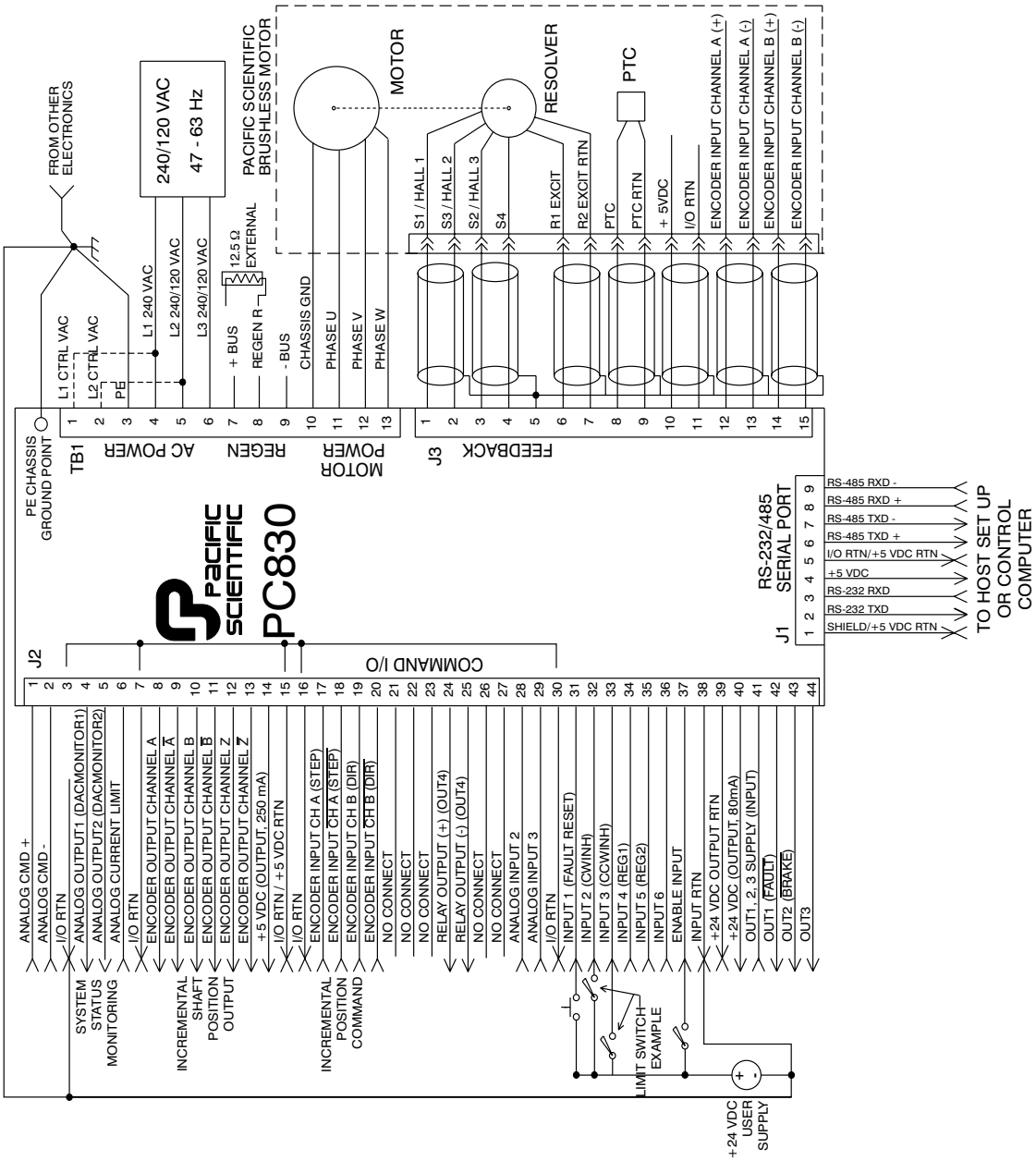
The RS-232 cable made by Pacific Scientific (order number CS-232-5600) can be used to connect the 9 pin serial port socket on the PC830 to the PC. If this cable is unavailable, a simple 3 wire cable can be made using the wiring diagram shown on page 2-6.

If you are using the drive's +24 Vdc supply, connect I/O RTN (J2-38) to +24 VDC output RTN (J2-39).

The last connection needed is to provide the hardware enable to the PC830 via J2-37 and +24V on J2-40. Preferably connect a toggle switch between J2-37 and J2-40. If a toggle switch is not available a clip lead that can connect or not connect J2-40 to J2-37 will do.

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Connection diagram



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1.2 Installing 830 Tools

Procedure

To install 830 Tools, perform the following:

1. Insert the 830 Tools diskette in your disk drive (A: or B:). From the Windows95 or NT **Start** menu select **Run.** At the Command Line, type **A:\setup.exe (or B:\ setup.exe) and click on OK.**
2. The install wizard will guide you through the installation.

Note: *When finished, the 830 Tools disk should be removed from the PC and stored in a safe place.*

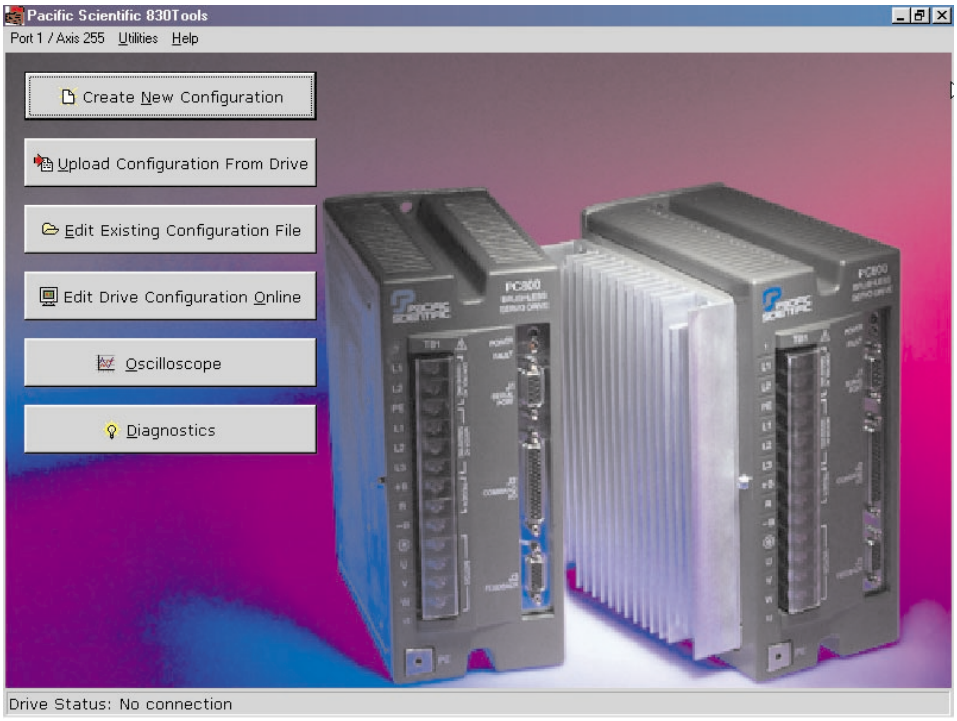
1.3 Starting 830 Tools

Procedure

To begin using 830 Tools, perform the following:

1. Select **Start|Program Files|830 Tools** or double click on the icon and the following window will appear:

830 Tools main menu



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1.4 Getting Around in 830 Tools

Movement keys

830 Tools is a standard Windows application and the normal cursor movement keys operate the same way as in all windows applications.

- **<F1>** gives context sensitive on-line help

1.5 Configuring Your System

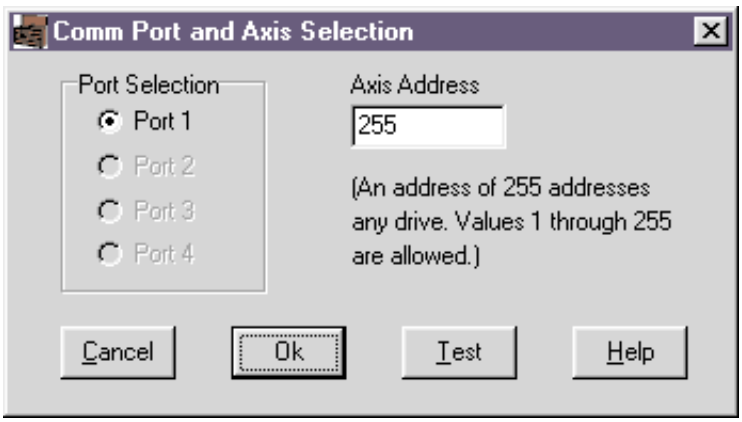
Applying AC Power

Carefully check all wiring connections and ensure that J2-37 is not connected to J2-40. Apply AC power to your controller.

Serial Port

To specify the PC serial port that is connected to the PC830:

1. Select **Port|Axis 255** and the following dialogue box will appear:



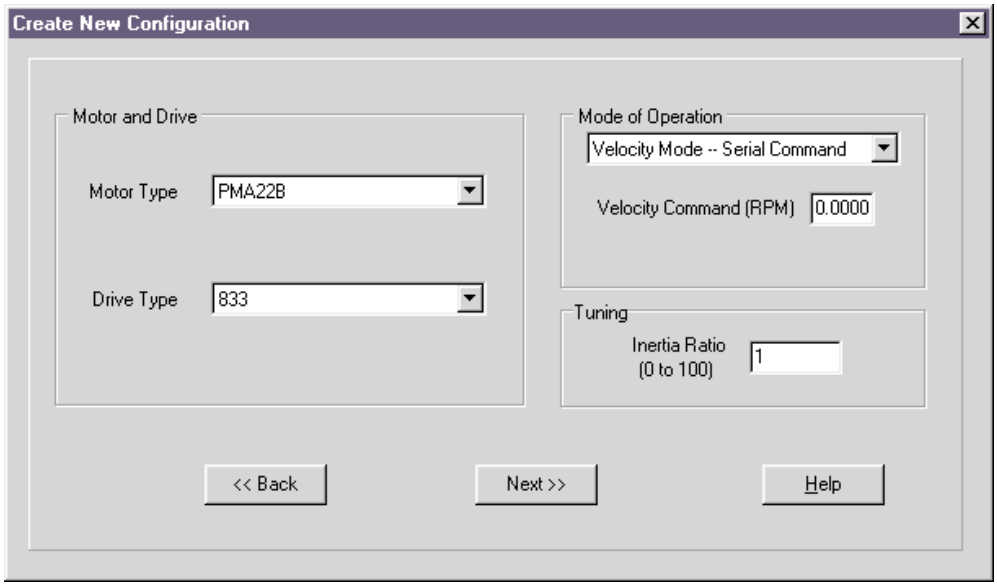
2. Specify the serial port and the axis address that you want to use.
3. To verify your settings, click on **Test**.

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1.6 Configuring Your Drive

Procedure

Click on the **Create New Configuration** button and the following will appear:



- Select motor type from the drop down list box.

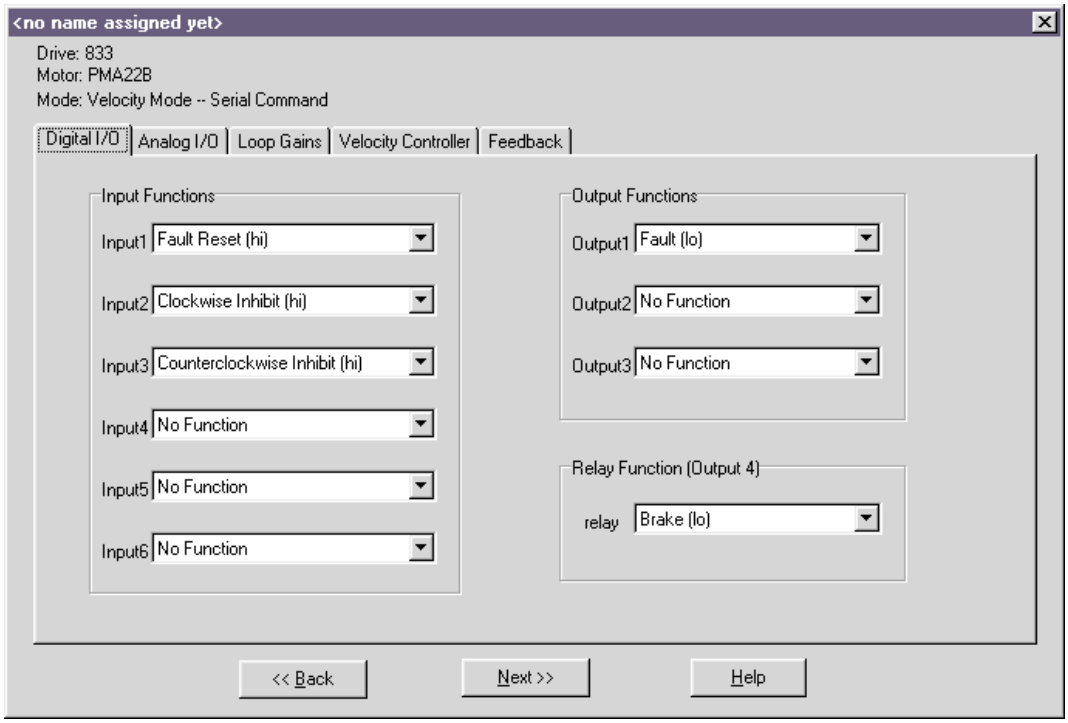
  Note: To add a motor to the database please see Section 1.13, "*Editing the Motor Database*."

- Select drive type from the drop down list box.
- Select **Velocity Mode - Serial Command** as the mode of operation from the drop down list box.
- Enter an inertia ratio.
  Inertia Ratio = Load Inertia/Motor Inertia
- Click on **Next**.

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Advanced configuration

These tabs allow the user to configure additional features of the PC830. During this initial set up the default values on each of these tabs will be used.

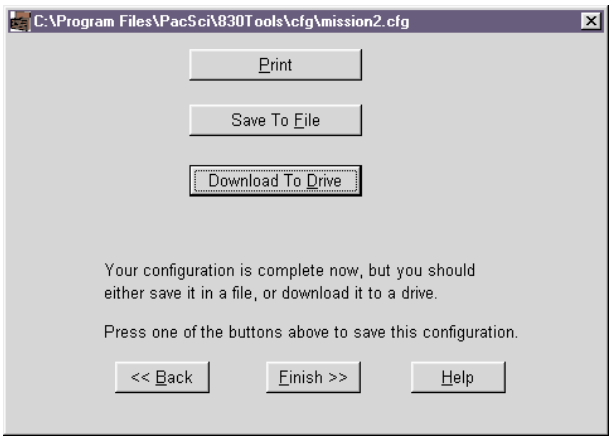


- Click on **Next**.

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Download to drive

To send the completed configuration to the drive:

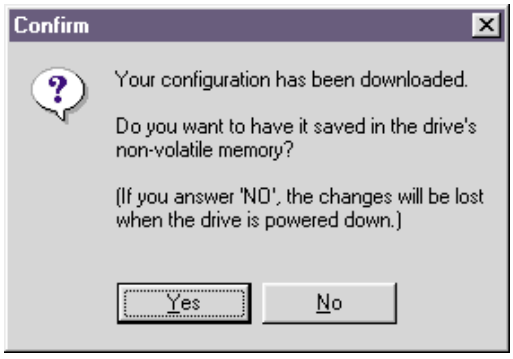


- Click on **Download to Drive**.

Note: *Pacific Scientific recommends that you save the configuration to a file as a backup.*

NVSave to drive

To save the configuration to the drive's non-volative memory:



- Click on **Yes** to save to non-volatile memory.
- Click on **Finish**.

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Verifying set up

To verify that the set up procedure worked, turn the control AC power OFF and then ON again. The Power LED should be BLINKING. If both LEDs are still blinking, repeat the set up procedure.

The PC830 has been configured as a serial port commanded controller. The current loop has been compensated properly for the selected motor and the servo parameters have been setup to give medium response (approximately 75 Hz velocity loop bandwidth) with the unloaded motor. Additional default settings have also been made.

Enabling Drive

The controller can be enabled at this time by closing the switch between the Enable input (J2-37) and +24 Vdc (J2-40). Once enabled, the Power LED should be ON. The commanded motor speed will be the power up default, set to 0 during configuration. Because the parameters were saved in non-volatile memory, the controller can now be power cycled and, after power-up, be ready to run with the parameters established during this session.

WARNING



Before proceeding, the motor should be attached or temporarily clamped to the table or bench. The inertial forces created during speed steps may make the motor hop around.

Getting Help

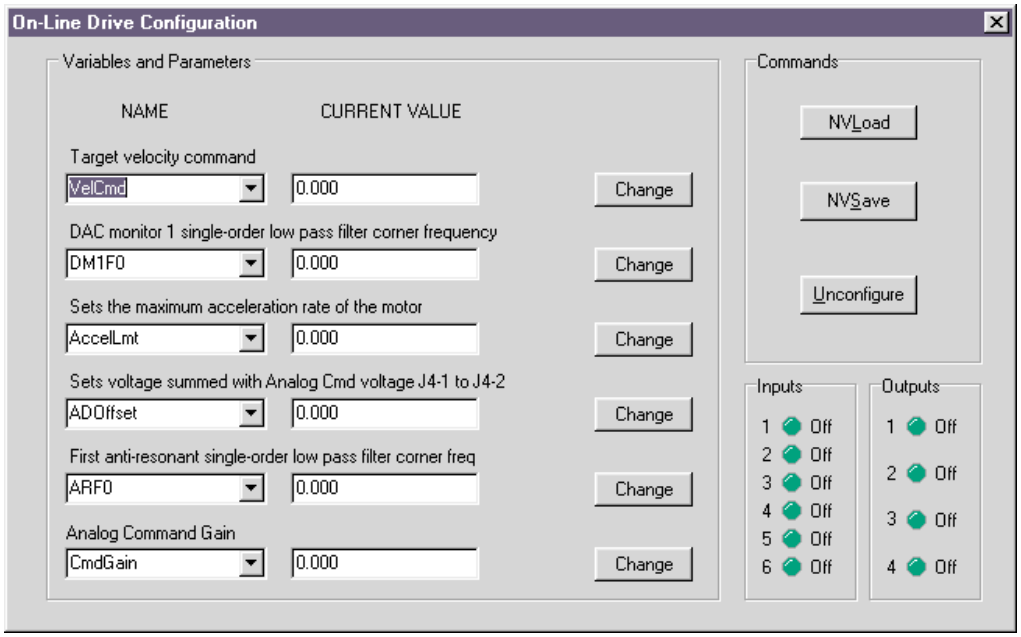
To get help information on a particular key word press the **<F1>** key while the cursor is located somewhere on that word in the Variable box.

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1.7 Changing Variables On-Line

Changing motor velocity

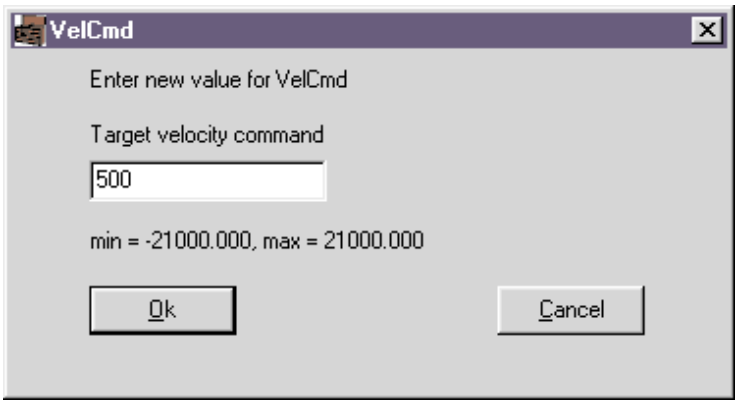
- Click on the **Edit Drive Configuration On-Line** button to activate the variables window.
- Select **VelCmd** from the **Variable** dropdown list box. The current value of VelCmd will be displayed.



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Changing a variable

To change the value of a VelCmd, click on **Change** and the following window will appear:



- Type in a new value.
- Click on **<OK>** and the new value will be sent to the drive.

1.8 Reviewing and Editing Parameters

The Off-line Parameter Edit tab will be displayed. The parameter values displayed are based upon selections made during Drive set up in Section 1.6. These values are stored in the PC only at this point. They are downloaded to the drive when you click on the **Download to Drive** Button.

A parameter value on the PC can be edited by selecting the appropriate control and setting it to the desired value.

Getting Help

Context sensitive help is also available in the Parameter Edit Window. Press **<F1>** to get help information about a highlighted variable. Information about all variables is available in this way.

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1.9 Downloading Parameters to the PC830

Changes to values on the Parameter Edit Window only affect the PC RAM copy. Changes made in the Parameter Edit Window must be downloaded to the drive in order to take affect.

Click on the **Download to Drive** button and parameters will be downloaded from the PC to the PC830.

Note: *830 Tools sets the drive variable Enable to 0 at the beginning of the download. To enable the drive you can use the Variables screen to set Enable = 1. If the downloaded parameters were NVSaved, turning control AC power OFF and then ON again will also return Enable to its default value of 1.*

1.10 Uploading Parameters from the PC830

It is also possible to upload the current parameter values in the drive's RAM to the Parameter Edit Window on the PC by using the symmetric **Upload from Drive** button.

1.11 Saving Parameters on Disk

Click on the **Save to File** button. Type the File Name **STARTING.CFG** and click on **Save**. The parameters will be saved on disk in a file named STARTING.CFG.

1.12 Opening a Disk File

Click on the **Edit Existing Configuration** button. Select the file that you would like to open from the list of files displayed. The parameter edit tab will be read from the disk and displayed. You can maintain a record of the drive's parameters in this manner.

If it is ever required to make a duplicate of an existing drive, open the file in this way and then click on the **Download to Drive** button to download the parameters to the new drive.

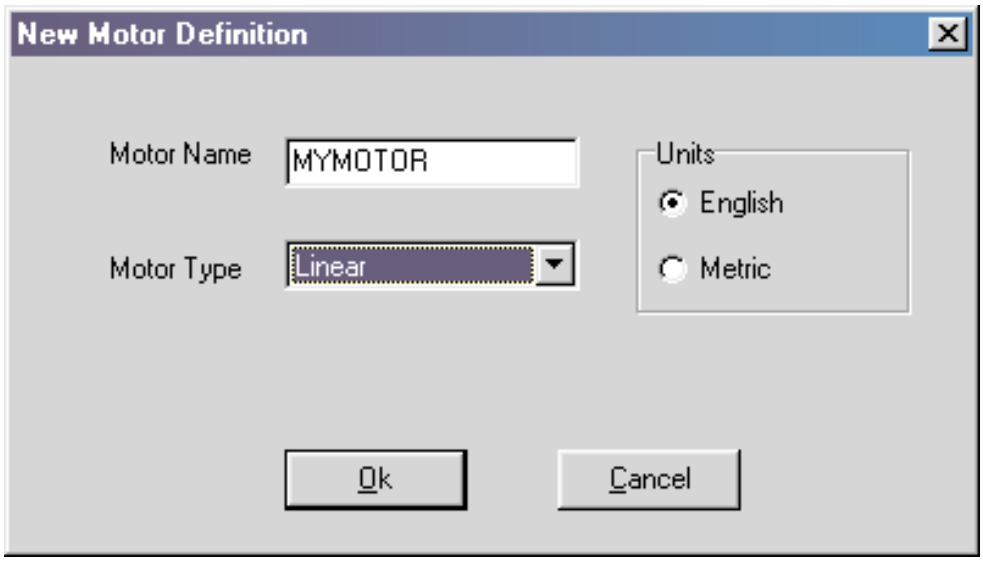
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1.13 Editing the Motor Database

Add a Motor

To edit the motor database:

1. Select **Utilities | Edit Motor Database**.
2. Click on **New Motor** to add a motor to the database. The following window will appear:

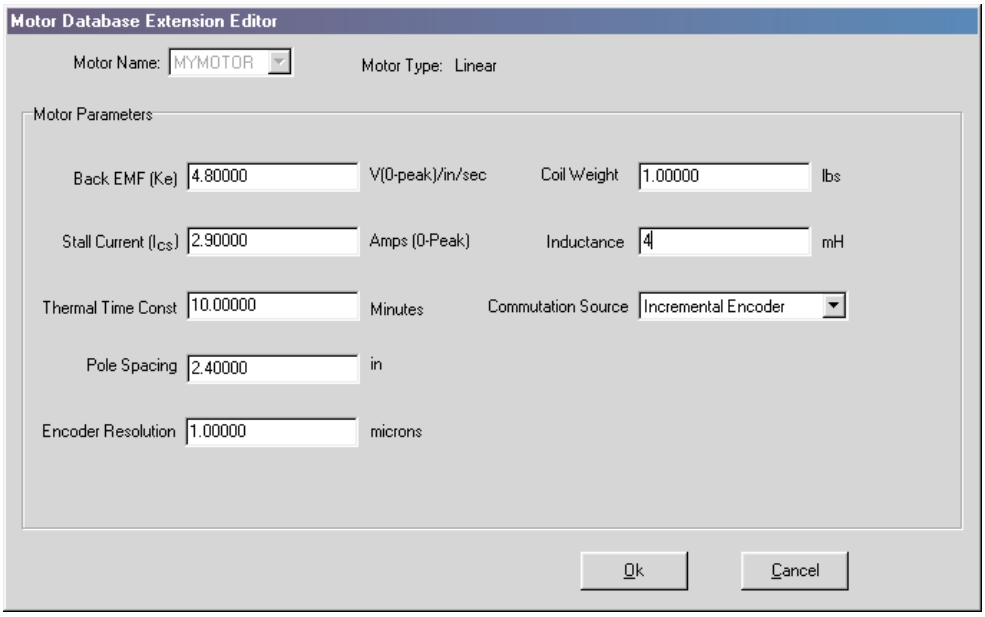


3. Enter in a name for the motor. For example, MYMOTOR.
4. Select either **Rotary** or **Linear** as the **Motor Type**.
5. Select either **English** or **Metric** as the units.
6. Click on **OK**.

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Procedure (cont'd)

7. Enter the motor parameters in the motor database editor screen.



8. Click on **OK**. The motor will now appear as a Motor Type when a **New Configuration** is created.

1.14 Exiting 830 Tools

To exit 830 Tools, click on the close window icon.

You should now know how to start and exit 830 Tools, configure your drive, edit and save parameters values, and configure a drive using parameters stored in a disk file.

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2 Interfaces and Connections

Introduction

This chapter describes all of the connections to the PC830 and provides the information required to interface to it.

In the list below an overbar on a signal name means that the signal is active low logic. For example, "$\overline{\text{Fault}}$" indicates the drive is faulted when it is pulled low.

Earth Ground

Chassis Ground, M4 x 12 screw with flat and lock washer.

2.1 PC830 Power Board Connector

TB1

13 Position Terminal Strip

Pin	Label	Description
TB1-1	L1	240/120 VAC Control Power
TB1-2	L2	240/120 VAC Control Power
TB1-3	PE	Chassis Ground
TB1-4	L1	240/120 VAC (Input)
TB1-5	L2	240/120 VAC (Input)
TB1-6	L3	240/120 VAC (Input)
TB1-7	+B	+ Bus
TB1-8	R	Regen Transistor
TB1-9	-B	- Bus
TB1-10	PE	Chassis Ground
TB1-11	U	Motor Phase U
TB1-12	V	Motor Phase V
TB1-13	W	Motor Phase W

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AC Power

L1, L2 (TB1-1, 2)
240 VAC
/ 120 VAC
Control Power

These terminals connect the 240/120 VAC power provided by the user to the drive's control voltage power supply.

If a single supply is used for bus power and control power, externally connect control L1, L2 (TB1-1, 2) to bus power L1, L2 (TB1-4, 5). **Control power L1, L2 are NOT connected internally to bus power L1, L2.**

Note: *The control voltage for the PC830 controllers is input to a switching power supply. This input will accept voltages ranging from 85 to 265 Vac.*

Chassis Ground

PE (TB1-3)

Convenience connector point for the user to connect the drive's control power and bus power to protective earth ground. This pin is directly connected to the chassis and thus to the Chassis Ground Stud. Local electrical code may require using the Earth Ground Chassis stud for this function.

AC Power

L1, L2, L3
(TB1-4, 5, 6)
240 VAC
/ 120 VAC

These terminals connect the 240/120 VAC power provided by the user to the drive's power output stage bus to drive the motor. For single phase operation use any two of these terminals and leave the third terminal open.

Regeneration Interface

+B, R, -B
(TB1-7, 8, 9)
+Bus, Regen
Resistor, - Bus

These terminals provide the connection points for an external resistor to absorb regenerated energy from the motor. An external regeneration resistor goes from + B to R. **-Bus (-B) on TB1-9 is usually left open.**

Caution! High Voltage!



During normal operation +B, R, and -B operate at the bus power voltages. A 240 Vac system operates at ≅ 400 Vdc. These are dangerous voltages.

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External Regen Resistor

The table below lists the recommended values for an external regen resistor. To order from Pacific Scientific use part number REG-833.

Note: *Regen Resistance MUST be in the range of 11.25 Ω to 13.75 Ω.*

Model	Resistance
PC8x3 and PC8x4	12.5 Ω (±10%), 200 W, 1,500 V Isolation

For safety it is recommended that the resistor be mounted on a grounded panel or use a grounding wire connected to a mounting screw. The terminals of the resistor must not be grounded.

Warning!



Wait 10 minutes after Bus Power is removed for the bus cap voltage to decay to a safe level before touching regen resistor or wiring. The voltage on the bus caps can be monitored with a voltmeter from +BUS (TB1-7) to -BUS (TB1-9).

Motor Power

PE (TB1-10) Motor Case Ground

This termination provides a convenient point for the motor ground connection and motor power wire shield. Local electrical code may require using the Earth Ground Chassis stud for this function.

U, V, W (TB1-11, 12, 13) Motor Phase

These three terminations provide the 3-phase power output to the brushless motor. Observe motor polarity on these connections. For example, connect U on the drive to U on the motor.

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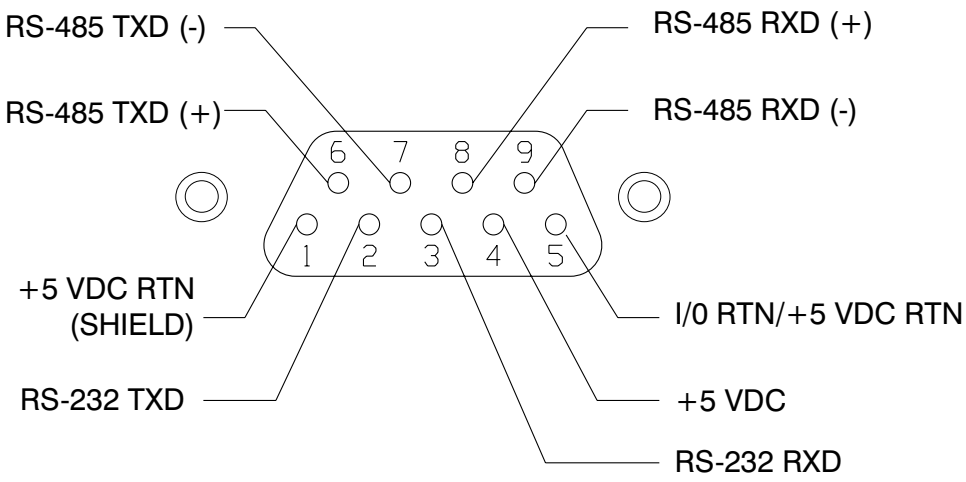
2.2 Serial Port

J1

The serial port (J1), utilizes the 9 contact female D subminiature style connector shown below. A brief description of each signal is included in the J1 I/O table on following page. For additional information, please refer to the Serial Communications Transceiver Schematic at the end of this section.

J1 Diagram

The figure below illustrates the pin-out for the 9 pin connector. It shows the front view looking at the PC830.



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I/O Table

Pin Number	Input/Output	Explanation
J1-1	+5 VDC RTN/ Shield	Common/shield - serial port interface
J1-2	RS-232 TXD	RS-232 transmitter output (from PC830)
J1-3	RS-232 RXD	RS-232 receiver input (to PC830)
J1-4	+5 VDC	+5 Vdc output (250 mA maximum between J1-4 & J1-5)
J1-5	I/O RTN/+5 VDC RTN	Common serial port interface
J1-6	RS-485 TXD (+)	RS-485 transmitter output (from PC830)
J1-7	RS-485 TXD (-)	
J1-8	RS-485 RXD (+)	RS-485 receiver input (to PC830)
J1-9	RS-485 RXD (-)	

Note: *An adapter can be powered from the serial port +5 Vdc output on J1-4 as long as the load current on J1-4, J2-14, and J3-10 total less than 250 mA.*

The information provided in this section should be used to connect the PC830 to your computer for use with 830 Tools. Two communication links are available, RS-232 and RS-485. RS-485 allows a single computer to communicate with up to 32 PC830s in multi-axis configurations. 830 Tools defaults to communicate with axis 255 upon start up.

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2.2.1 RS-232 Connections

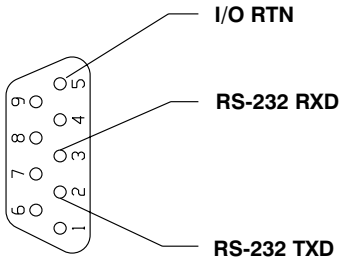
RS-232 Connections

RS-232 connections on J1 are shown below. Cable wiring required for connecting to either 9 or 25 pin serial ports of most computers are also shown.

Note: *Pinouts vary among computer manufacturers. Check the hardware reference manual for your machine before wiring.*

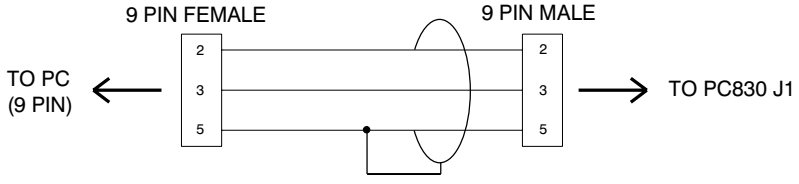
Cabling diagram

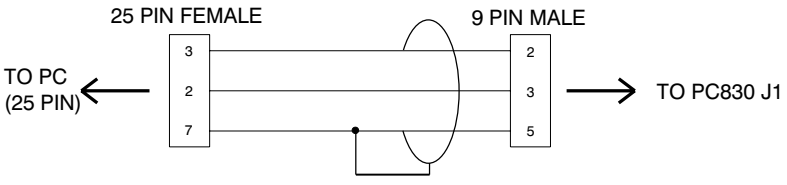
A 6 foot (1.8 m) RS-232 Cable with 9 pin connectors and a 9 pin to 25 pin adapter is available from Pacific Scientific. The Pacific Scientific order number is RS-232-5600.



9 CONTACT FEMALE D SUBMINIATURE CONNECTOR

TYPICAL CABLES





Note: *Shielded wiring is recommended for the serial communications cable to minimize potential errors from electrical noise.*

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2.2.2 RS-485/RS-422 Connections

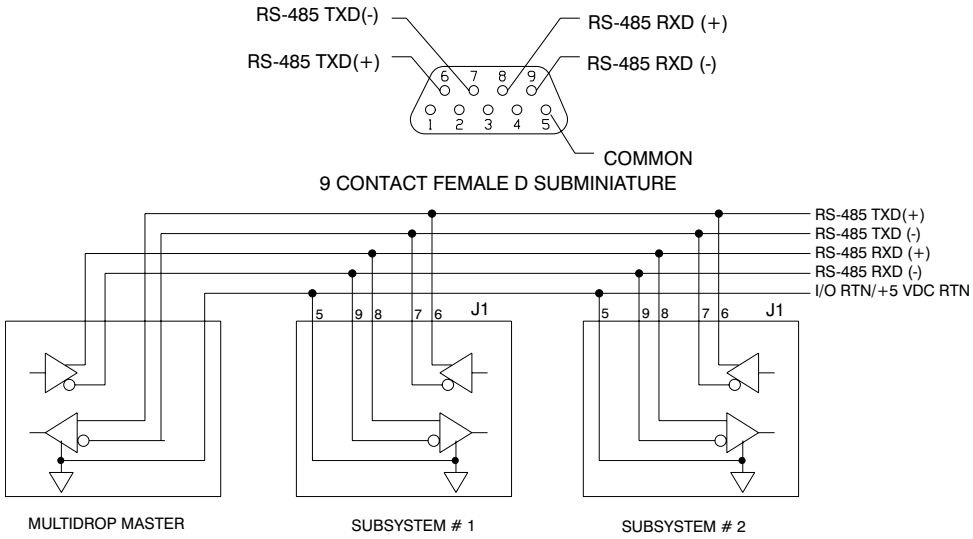
RS-485/RS-422 Connections

Up to 32 PC830s can be connected in parallel to a multidrop master. The PC830s must each have a unique address, set in software. Once the address is set, the Axis Selection function in 830 Tools must be used to select the designated axis address. Then, either the RS-232 or the RS-485 link can be used to communicate with the selected axis.

For example, the RS-232 link can be used to completely setup and test an individual axis before connecting it into the multi-axis configuration.

RS-485/RS-422 connections to J1 are shown below. A multidrop interconnection diagram, showing multiple axes connected to a single host is also shown.

Connection diagram



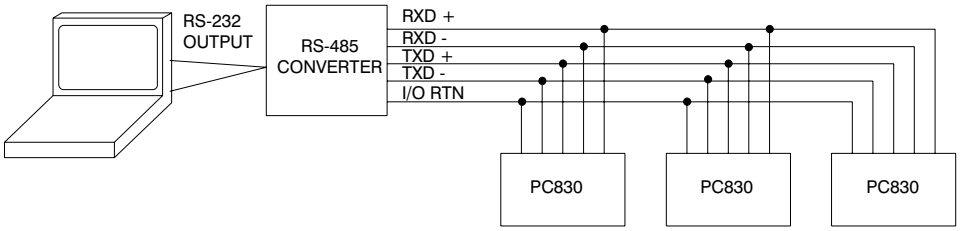
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RS-232/RS-485 converter installation

It is often convenient to use an RS-232 to RS-485/RS-422 converter so that an RS-232 port, available on all PCs, can be used to connect to multiple axes. The figure below shows a typical installation, using the B & B Model 422 RS-232 to RS-422 adapter. RS-232 to RS-485/RS-422 adapters are available from many sources.

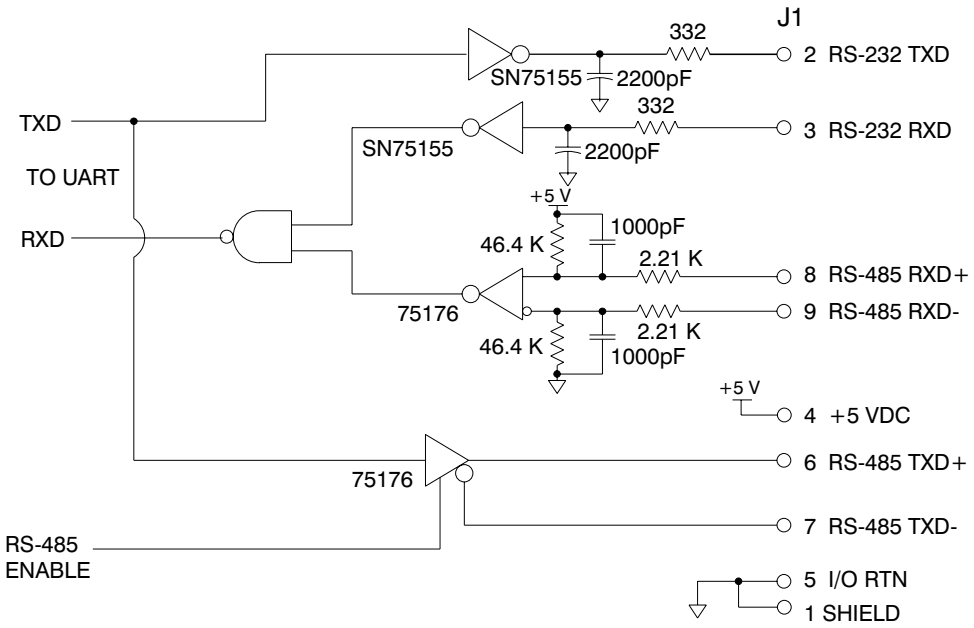
Note: *An adapter can be powered from the serial port +5 Vdc output on J1-4 as long as the load current on J1-4, J2-14, and J3-10 total less than 250 mA.*

Installation diagram



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PC830 Serial Communications Transceiver Schematic



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2.3 Command I/O

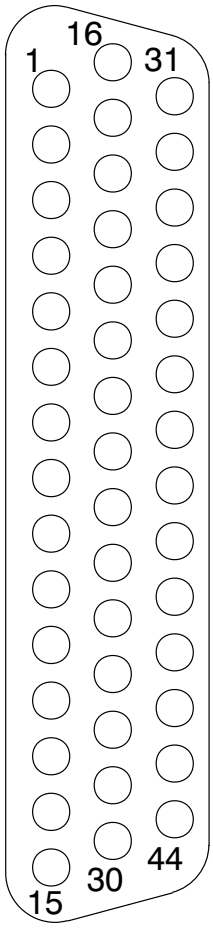
J2 44 Position D subminiature female

Pin	Description	Pin	Description
J2-1	Analog Command Input (+)	J2-23	No Connect
J2-2	Analog Command Input (-)	J2-24	Relay Output (+) (Out4)
J2-3	I/O RTN	J2-25	Relay Output (-) (Out4)
J2-4	Analog Output1 (DacMonitor1)	J2-26	No Connect
J2-5	Analog Output2 (DacMonitor2)	J2-27	No Connect
J2-6	Analog Current Limit Input	J2-28	Analog Input 2
J2-7	I/O RTN	J2-29	Analog Input 3
J2-8	Encoder Output Channel A	J2-30	I/O RTN
J2-9	Encoder Output Channel $\overline{A}$	J2-31	Input 1 (Fault Reset)
J2-10	Encoder Output Channel B	J2-32	Input 2 (CwInh)
J2-11	Encoder Output Channel $\overline{B}$	J2-33	Input 3 (CcwInh)
J2-12	Encoder Output Channel Z	J2-34	Input 4 (Reg1)
J2-13	Encoder Output Channel $\overline{Z}$	J2-35	Input 5 (Reg2)
J2-14	+5 VDC (Output)	J2-36	Input 6
J2-15	I/O RTN/ +5 VDC RTN	J2-37	Enable Input
J2-16	I/O RTN	J2-38	Input RTN
J2-17	Command Encoder Input Channel A (Step)	J2-39	+24 VDC Output RTN
J2-18	Command Encoder Input Channel A (Step)	J2-40	+24 VDC (Output)
J2-19	Command Encoder Input Channel B (Dir)	J2-41	Out1, 2, 3 Supply (Input)
J2-20	Command Encoder Input Channel B (Dir)	J2-42	Out1 ($\overline{Fault}$)
J2-21	No Connect	J2-43	Out2 ($\overline{Brake}$)
J2-22	No Connect	J2-44	Out3

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J2 Diagram

The figure below illustrates the pin-out for the 44 pin connector. It shows the front view looking at the PC830.

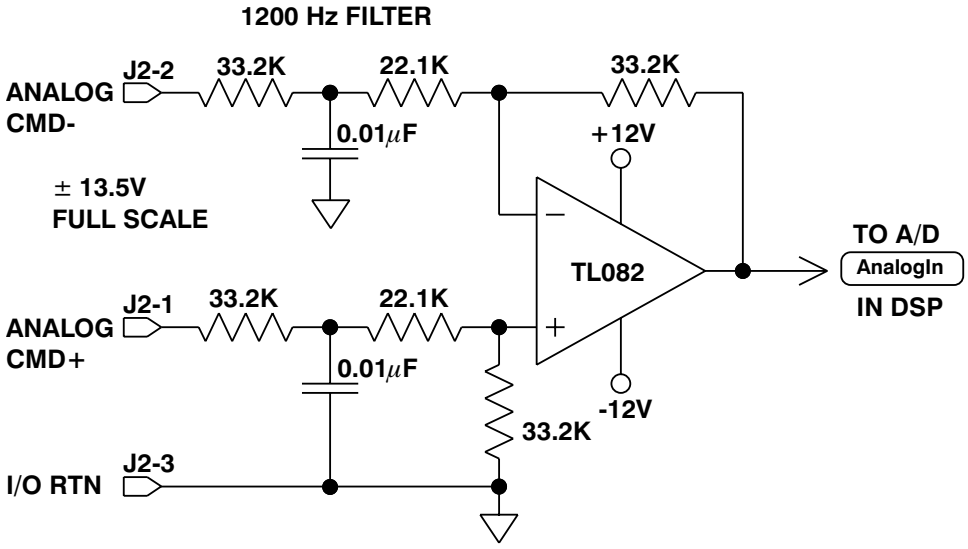


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Command I/O

Analog CMD (+), (-) Inputs J2-1, 2

These inputs accept the analog command from the user. This is a differential input to an A/D. It has a maximum single ended input range with respect to I/O RTN on either input of ± 21V and an input impedance of 50kΩ. The full scale differential command input range is ± 13.5 V. The offset and single pole low pass bandwidth of this signal is adjustable via a software setup parameter. When used as a motion command the gain from this input is also adjustable via a software setup parameter.



Note: *Always connect I/O RTN (J2-3) to the signal ground of the source. Failure to do so may result in erratic operation.*

I/O RTN J2-3, 7, 15, 16

This terminal is signal common for the analog and non-optically isolated digital inputs and outputs. These pins are internally connected in the drive.

For protection against line surges, one of the I/O RTN pins must be connected to Earth ground. Pacific Scientific recommends making this connection at an earth ground point in the cabinet reserved for single point grounding of all I/O Returns (drives and supplies).

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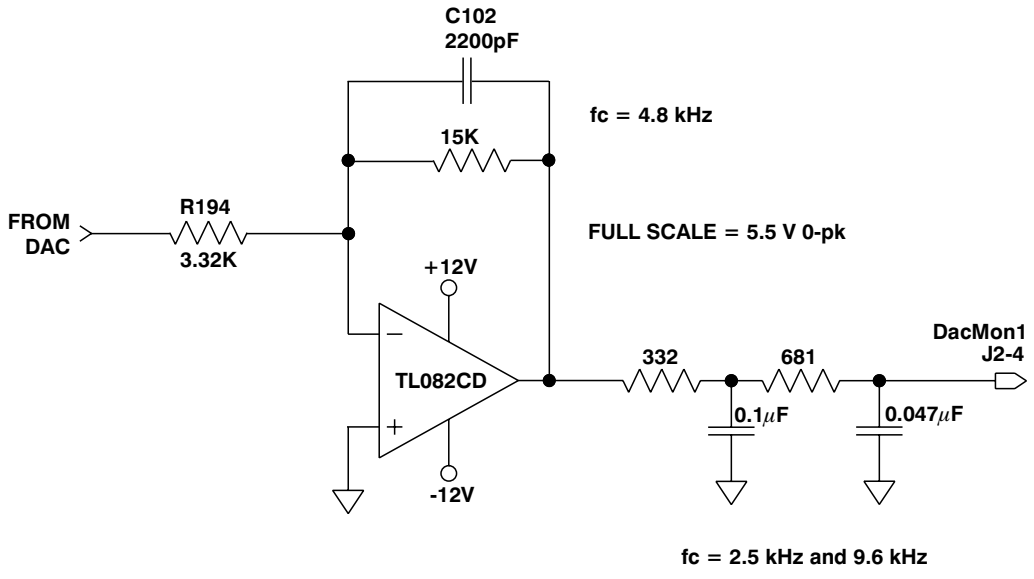
Command I/O Continued

DAC Monitor 1, 2 Outputs J2-4, 5

These analog outputs are general purpose monitor points. The output range is ± 5.5 V with a resolution of 11V/65536 = 0.168 mV. The source impedance is 1 kΩ, which yields a maximum short circuit to I/O RTN current of ± 5 mA. These outputs are updated every 250 μS. There is a 2.5 kHz, 4.8 kHz and a 9.6 kHz analog Low Pass Filter on these outputs.

Each DAC MONITOR can be mapped by software to be one of a number of internal variables. The scale factor and the frequency of a single low pass filter pole are software adjustable on each output by the DM1Gain, DM1F0 and DM2Gain, DM2F0 software parameters for DAC Monitor 1 and 2 respectively. Variables marked with a "∗" are not range clamped and are allowed to wrap around when the signal exceeds the output dac's voltage range. The other variables will clamp at maximum when they exceed the analog voltage range. The table on the following page lists the defined signal mappings.

DacMon



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Dac Monitor List Table

DMxMap	Variable	Description	DAC Out Units (DMxGain = 1)
0	AnalogOutx	Actual Analog Output Command	V/V
1	VelFB	Measured Velocity (DM2 Default)	1 V/kRPM
2	VelCmdA	Actual Velocity Command (VelCmdA)	1 V/kRPM
3	VelErr	Velocity Error	1 V/kRPM
4	FVelErr	Compensated Velocity Error	1 V/kRPM
5	Position	Measured Position*	1 V/Rev
6	PosError	Position Error*	1 V/Rev
7	PosCommand	Commanded Position*	1 V/Rev
8	Icmd	Commanded Torque Current	1 V/A
9	IFB	Measured Torque Current (DM1 Default)	1 V/A
10	AnalogIn	Filtered A/D Input	1 V/V
11	EncFreq	Encoder Frequency	1 V/Hz
12	EncPos	Encoder Position*	10 V/4096 Cnts
13	ItFilt	Filtered Output Current Amplitude	1 V/100%
14	HSTemp	Measured Heat Sink Temperature	1 V/°C
15		Commutation Electrical Angle*	1 V/Cycle
16	IU	Motor Phase U Output Current	1 V/A
17	IV	Motor Phase V Output Current	1 V/A
18	IW	Motor Phase W Output Current	1 V/A
19		Motor Phase U Voltage Duty Cycle	1 V/100%
20		Motor Phase V Voltage Duty Cycle	1 V/100%
21		Motor Phase W Voltage Duty Cycle	1 V/100%
22	VBus	Drive Bus Voltage	1 V/V
23	ResPos	Resolver Absolute Position*	1 V/Rev
24		Commanded non-torque current	1 V/A
25		Measured non-torque current	1 V/A
26		Torque Voltage Duty Cycle	1 V/100%
27		Non-torque Voltage Duty Cycle	1 V/100%
28	VelCmd	Velocity Command (VelCmd)	1 V/kRPM
29	DigitalCmdFreq	Digital Command Frequency	1 V/Hz
30	I^2*t	I^2*t Filtered Current	1 V/%Ipeak^2

*These variables are allowed to wrap around when the signal exceeds the output voltage range.

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J2 Command I/O Continued

Analog Current Limit J2-6	This input limits the current flow to the motor when a voltage is applied with respect to I/O RTN.
CH A OUT $\overline{\text{CH A OUT}}$, CH B Out, $\overline{\text{CH B Out}}$ Outputs J2-8, 9, 10, 11	These two output pairs are differential TTL incremental position signals generated by the Resolver feedback electronics. These outputs are quadrature encoded to emulate an optical encoder. The resolution of these signals, i.e. the emulated line count, is set by the EncOut parameter. These outputs are buffered by 26LS31 type RS-422 compatible line drivers. Maximum recommended load current is ± 20 mA, which corresponds to a minimum line-to-line load resistance of 100 Ω. This drive capacity corresponds to ten RS-422 compatible inputs such as the PC830 encoder inputs. These outputs are indefinitely short circuit proof to I/O RTN.
CH Z OUT $\overline{\text{CH Z OUT}}$ Outputs J2-12, 13	These two terminals function as a differential, TTL marker pulse. The output pulse occurs once per motor shaft revolution starting at resolver position = 0 and its width is approximately one quadrature encoder width. This output comes from an 26LS31 type RS-422 compatible line driver. Maximum recommended load current is ± 20 mA, which corresponds to a minimum line-to-line load resistance of 100 Ω. This drive capacity corresponds to ten RS-422 compatible inputs such as the PC830 encoder inputs. This output is indefinitely short circuit proof to I/O RTN.
+5 VDC, I/O RTN/+5 VDC RTN Output J2-14, J2-15	These two connections provide an auxiliary power supply for the user. This output is 5 Vdc ± 5% and is short circuit protected at 1 A nominal. The maximum load limit for all connections to this supply is 250 mA. The +5 VDC RTN (J2-15) is connected to I/O RTN (J2-3, J2-7, J2-16, J2-30).

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J2 Command I/O Continued

Encoder Inputs

CH A IN, CH $\overline{A}$ IN, CH B IN, CH $\overline{B}$ IN,
Step +, Step -, Dir +, Dir -,
Step Up +, Step Up -, Step Dn +, Step Dn -

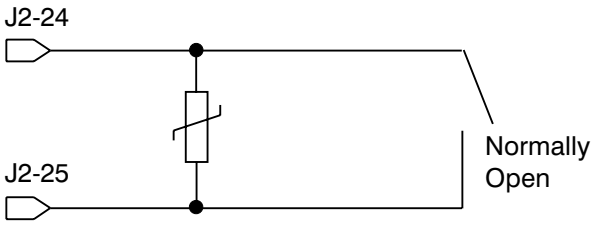
J2-17, 18, 19, 20

These inputs are used as a quadrature encoder, step and direction, or up and down count format incremental signal source. The decoding mode is set by the EncMode parameter. The scale factor of this incremental position command input is fully adjustable with software parameters. Full decoding speed or more noise immune slow speed decoding is software selectable.

These two input pairs are differential and are detected by 26LS32 type RS-422 compatible line receivers. As differential inputs, the recommended common mode range is $<\pm$ 7 V with respect to I/O RTN and the guaranteed differential voltage logic thresholds are $>\pm$ 0.2 V. Recommended drivers should be able to source and sink > 3 mA to/from these inputs. Each of these inputs have internal bias networks to allow easy connection to single ended sources. When an input is open circuited it will bias itself to between 2.2 and 2.5 V, thus the remaining input pair terminal will have a single ended guaranteed logic low for inputs < 2.0 V and a guaranteed logic high for inputs > 2.7V. These levels are compatible with a TTL driver combined with a pull up resistor. Pull up resistor should be < 470Ω.

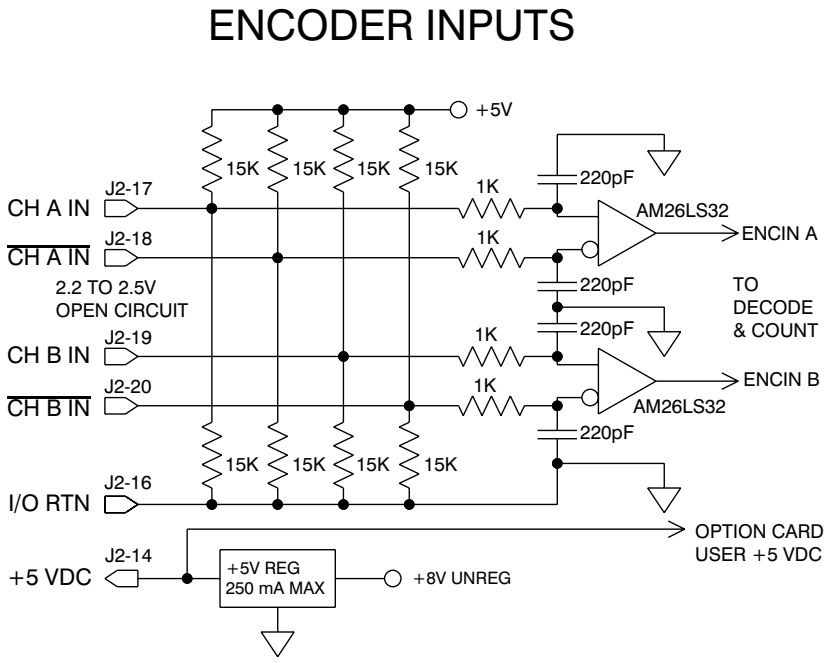
Relay Outputs
J2-24, 25

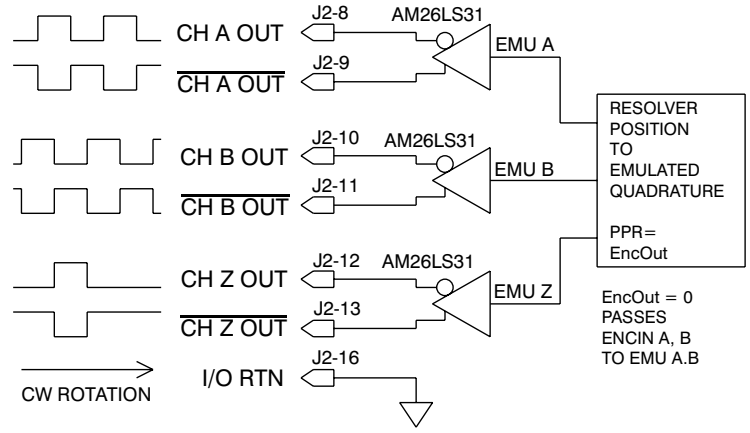
These relay outputs are normally open. They are rated for 1 Amp at 30 VDC. These relays may be opened/closed by Out4. When the drive has no control power the relay is open.



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J2 Encoder I/O Interface Schematics Diagram

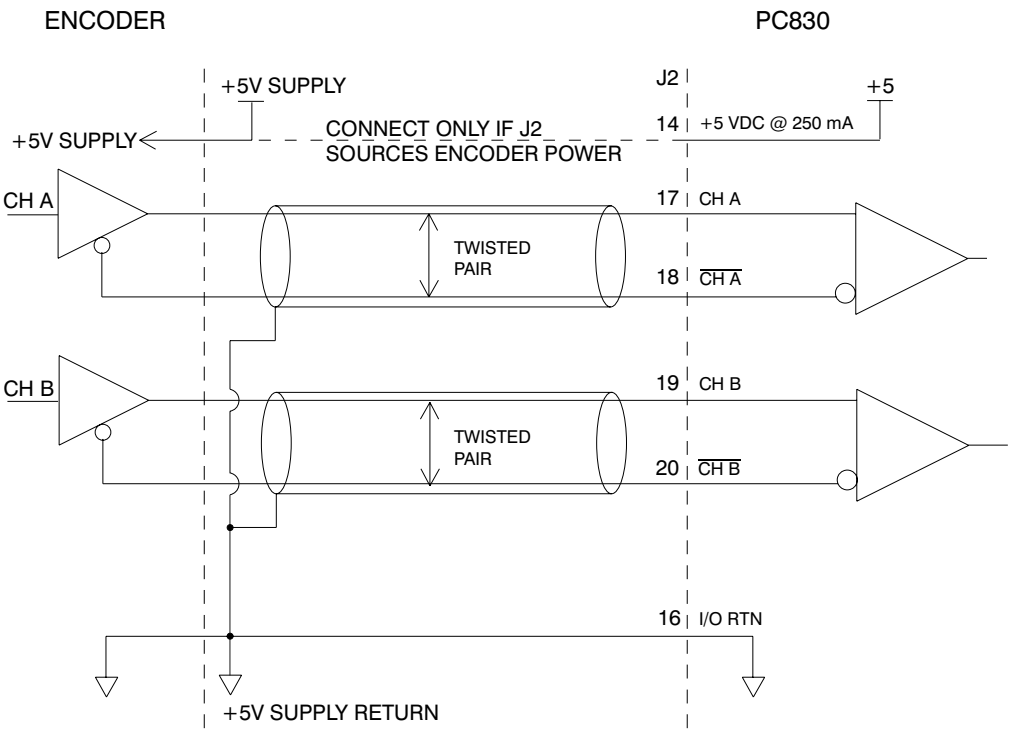




PC830 BASE UNIT ENCODER I/O

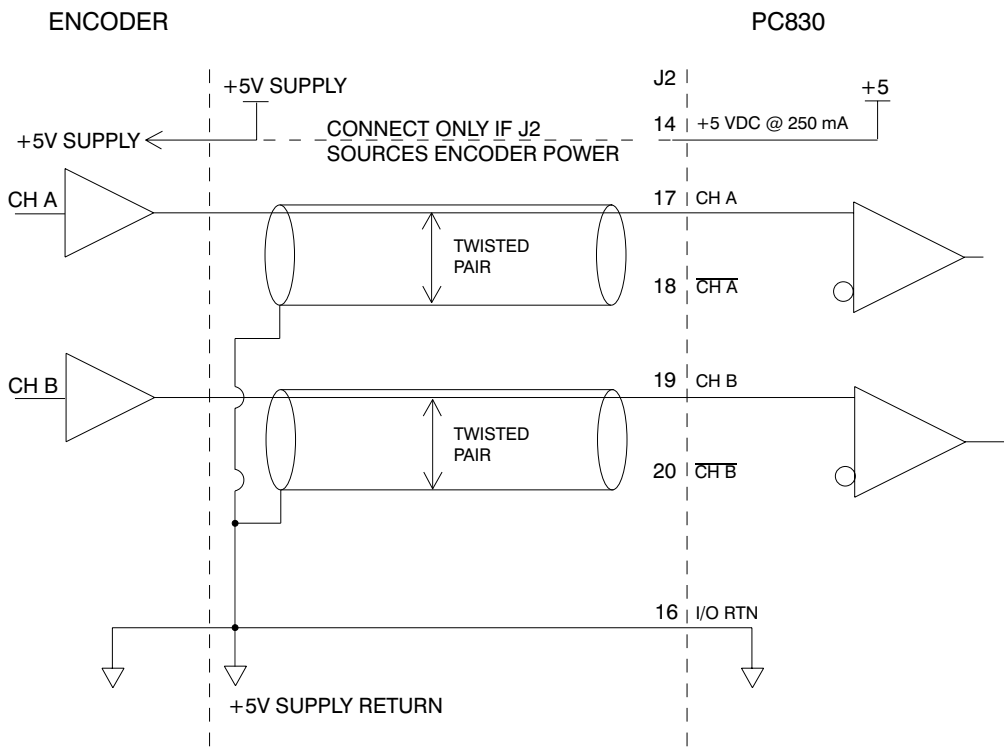
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Using TTL differential line drivers



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Using TTL single-ended drivers



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J2 Command I/O Continued

Auxiliary Analog Inputs J2-28, 29

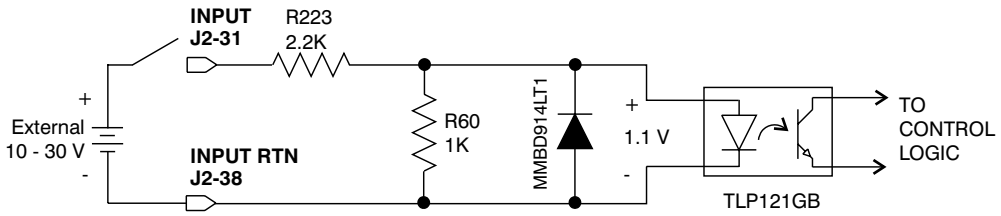
Not Used.

Inputs 1-6 J2-31, 32, 33, 34, 35, 36

These six optically isolated I/O connections are user programmable discrete 24 V inputs. These inputs share a floating return (J2-38) with the Enable Input (J2-37). A minimum drive capability of 4 mA is required to fully power the opto. The user must supply 10 - 30 V to these inputs.

Note: *5 V inputs CAN NOT be used.*

Each of the inputs is set and read by software every 2 mSec. Each one can be configured to be any of the available functions and the configuration can be changed on the fly via digital communications. The user's default configuration is stored in the non-volatile memory. The present state of each of these lines can be read via digital communications. The logic polarity of these signals is also software programmable. That is, an input can be defined to be active low or active high. For edge triggered functions the active edge is programmable.



Logic State	InpX with respect to Input RTN
Low	0 to +2 V
Undefined	+2 V to + 10 V
High	+10 V to + 30 V

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J2 Command I/O Continued

The list below describes the subset of the available functions and the mappings used as the factory defaults for each of the inputs.

Fault Reset Input

Input 1: This input is used to reset the amplifier following a fault. This input is programmed active high so that an open circuited input does not activate the function. During Fault Reset active the output stage is disabled and the reset condition will be held in hardware for approximately 0.1 sec after Fault Reset is returned inactive.

CwInh Input

Input 2: This input prevents further motion in the clockwise shaft motion direction. This input is programmed active high so that an open circuited input does not activate the function. If the shaft is already moving in the clockwise direction, then the motor will decelerate to zero velocity with the maximum torque allowed by the user set output current limits. This input will have no effect on motion in the counterclockwise direction. This input is useful for a clockwise over travel limit switch.

CcwInh Input

Input 3: Analogous to the CwInh input, except that this input prevents counterclockwise motion.

Reg1 Input

Input 4: This high speed input latches motor position within 50 μsec after a transition.

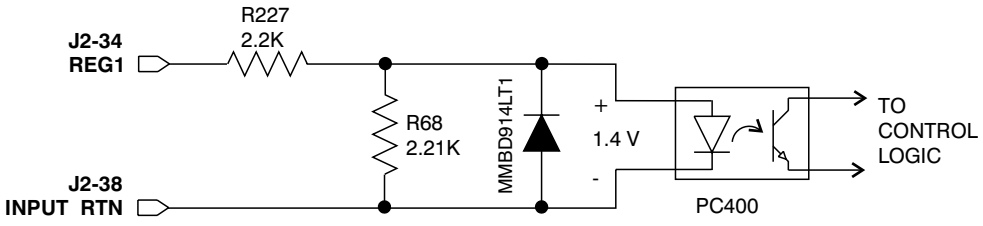
Reg2 Input

Input 5: Analogous to Reg1 input.

Input Mapped Off

Input 6: Input Mapped Off

Reg1 Input J2-34



Note: Probe inputs have a 50 μsec latch time.

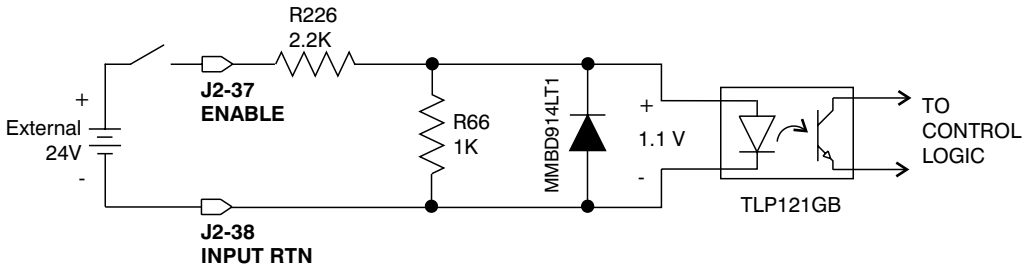
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J2 Command I/O Continued

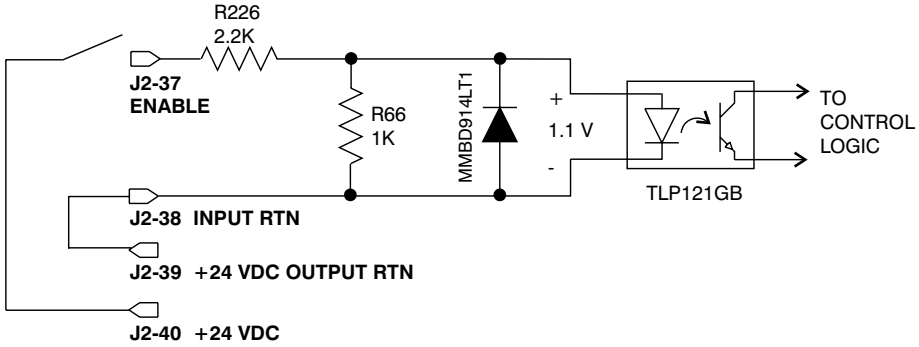
Enable Input
J2-37

This optically isolated input is used to enable the drive and is active high. The output stage is disabled when this input is inactive. A minimum drive capability of 4 mA is required. The user must supply 10 V - 30 V to drive this input. This input is filtered with a 1 mSec time constant low pass filter to prevent false triggering from noise. The Enable input shares a floating return (J2-38) with Inputs 1 - 6.

Note: *5 V input CAN NOT be used.*



Note: *If the drive's 24 V supply is being used, connect as shown below.*



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J2 Command I/O Continued

Input RTN
J2-38

This terminal is the floating common return for the six optically isolated digital inputs and the optically isolated Enable input.

+24 VDC RTN,
+24 VDC (Output)
J2-39, J2-40

These two connections provide an auxiliary floating power supply for the user. This output is 24 Vdc ± 10 % and is short circuit protected at 100 mA nominal. The maximum load limit for all connections to this supply is 80 mA. + 24 VDC RTN is not connected to Input RTN.

Out1, 2, 3
Supply (Input)
J2-41

The PC830 requires an external 12 - 24 VDC power source for the outputs. This power source must be capable of supplying at least 150 mA.

Outputs
J2-42, 43, 44

These optically isolated outputs are current sourcing at 0 to 50 mA maximum. External output supply should be limited to 30 V. These outputs are short circuit protected. Current folds back to about 25 mA during a short circuit. The external output supply (J2-41) is shared by the three outputs.

V_{ON}	1.9 V @ 25 mA 2.25 V @ 50 mA
I_{OFF}	5 μa
Response time	1 msec
Clamp voltage	40 V (nominal)

Each of the outputs is set and written to by software every 2 mSec. Each one can be configured to be any of the available functions and the configuration can be changed on the fly via digital communications. The user's default configuration is stored in the non-volatile memory. The present state of commanded outputs can be read via digital communications. The logic polarity of these signals is also software programmable. That is, an output can be defined to be active low or active high. For edge triggered functions the active edge is programmable.

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J2 Command I/O Continued

The list below describes the subset of the available functions and the mappings used as the factory defaults for each of the outputs.

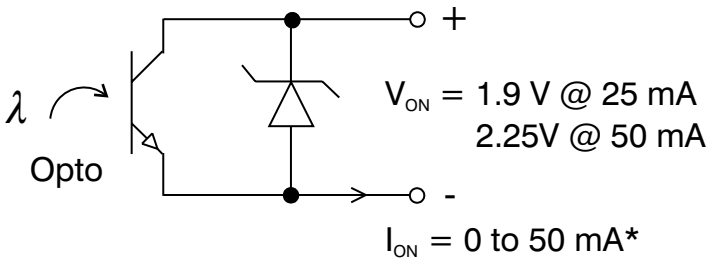
$\overline{\text{Fault}}$ Output — **Output 1:** This output is low when the drive is faulted or has no control power. This line can be used to indicate a problem with the drive.

$\overline{\text{Brake}}$ Output — **Output 2:** This output is low when the control power is off, or when control voltage is on and the drive is disabled (Enabled = 0). This output is pulled high otherwise. This output is intended to drive a normally open relay that in turn powers a mechanical brake on the motor shaft for applications that require a positive shaft lock when the servo drive is off.

Output Mapped Off — **Output 3:** Output Mapped Off

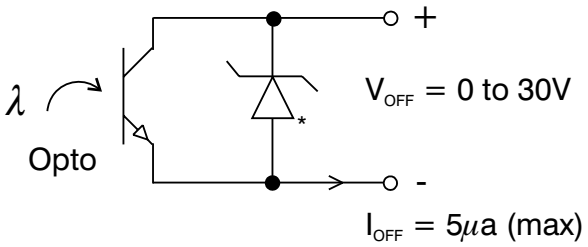
Outputs

ON State



*During short circuit folds back to 25 mA

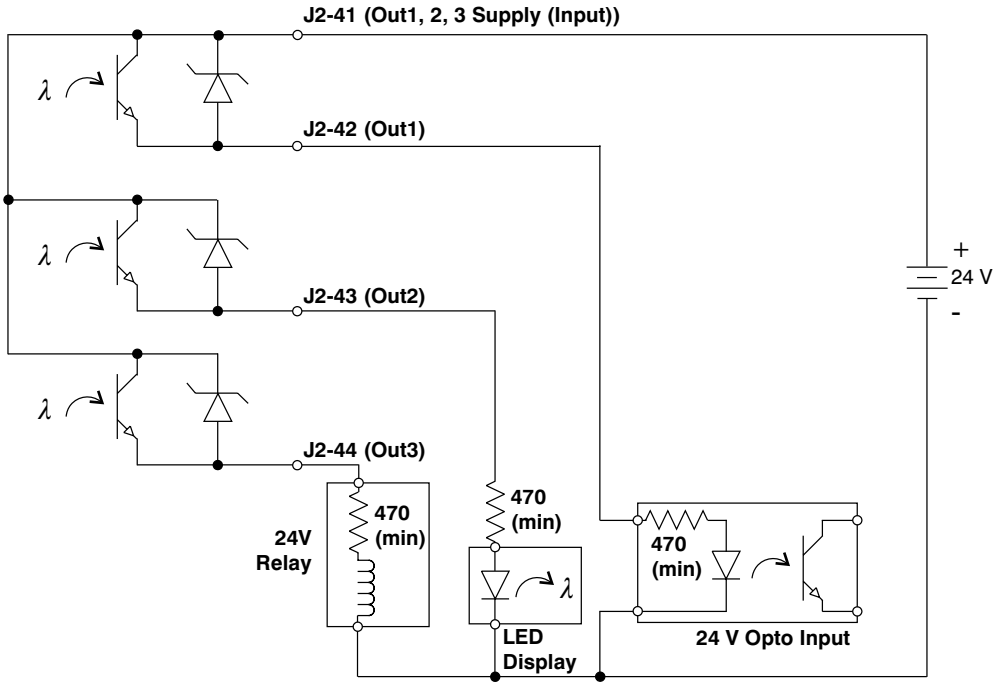
OFF State



*36V Transient Surge Protector clamps @ 40 V nominal

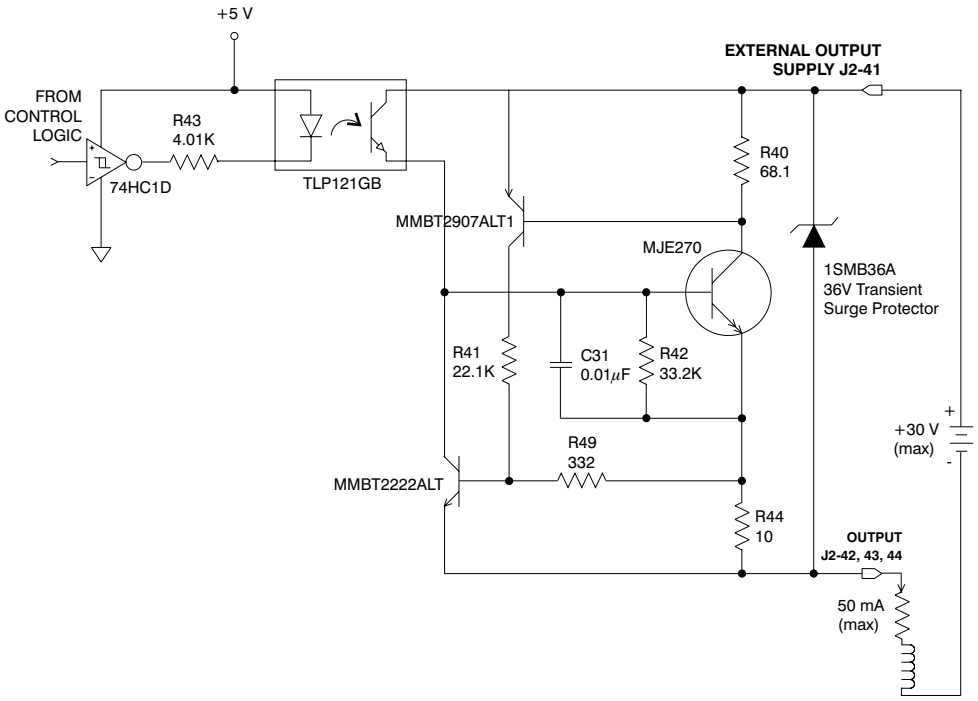
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Outputs Driving Typical Loads



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Output Schematic



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2.4 PC800 Base Servo Drive User I/O Connections

J3 FEEDBACK 15 Position D subminiature female

Pin	Description
1	RESOLVER S1 SIN + (Input) / Hall 1
2	RESOLVER S3 SIN - (Input) / Hall 2
3	RESOLVER S2 COS + (Input) / Hall 3
4	RESOLVER S4 COS - (Input)
5	SHIELD (I/O RTN)
6	RESOLVER R1 EXCITATION (Output)
7	RESOLVER R2 EXCITATION RTN (Output)
8	MOTOR PTC (Input)
9	MOTOR PTC RTN (Input)
10	+5 VDC
11	I/O RTN
12	FEEDBACK ENCODER CHANNEL A (+)
13	FEEDBACK ENCODER CHANNEL A (-)
14	FEEDBACK ENCODER CHANNEL B (+)
15	FEEDBACK ENCODER CHANNEL B (-)

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Feedback

Resolver S1, S2, S3, S4 Inputs J3-1, 2, 3, 4	These connections provide the inputs for the resolver's sine/cosine outputs. Differential inputs with 75 Vμsec common mode impulse range and 25 kΩ input impedance. **Note:** *This only applies if a Resolver feedback device is being used.*
Hall1, Hall2, Hall3 J3-1, 2, 3	These three single-ended hall channel sensor inputs are detected by +5 Vdc CMOS compatible commutation signals with 60° spacing. These inputs are each internally pulled-up to +5 Vdc via a 10 kΩ resistor. These input signals are low pass filtered in hardware at 10 kHz. **Note:** *This only applies if a Hall feedback sensor is being used.*
Resolver R1 Excitation, R2 Excitation RTN Outputs J3-6, 7	These connections provide the resolver excitation output. 9.2 V rms at 6510.42 Hz 75 mA rms maximum load. These outputs are fully short circuit protected to I/O COMMON or to each other at room temperature (25°C), but at ambient temperatures above 50°C, shorts longer than 5 minutes may cause damage.
Motor PTC, PTC RTN Inputs J3-8, 9	These two inputs are intended to connect to a positive temperature coefficient thermistor or normally closed thermostatic switch imbedded in the motor windings. When the resistance between these terminals becomes greater than 6.2 kΩ the drive will fault and indicate a Motor Over Temperature fault. This circuit directly interfaces with Pacific Scientific's standard motor PTC. **Note:** *PTC RTN is connected to I/O RTN.*

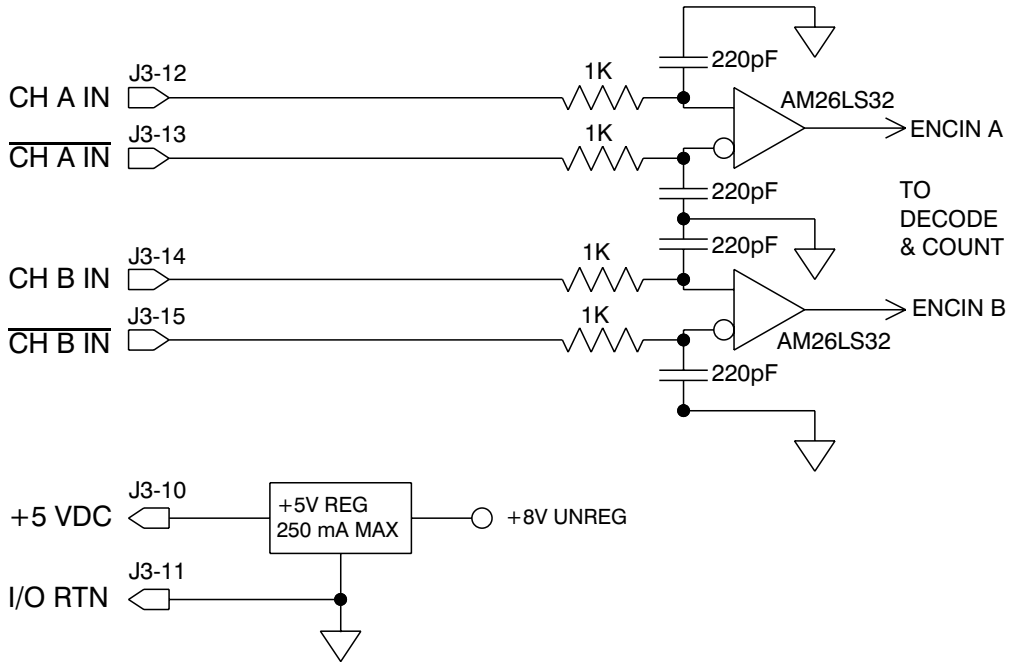
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Feedback Continued

Encoder Inputs
J3-12, 13, 14, 15

CH A, $\overline{\text{CH A}}$, CH B, $\overline{\text{CH B}}$,

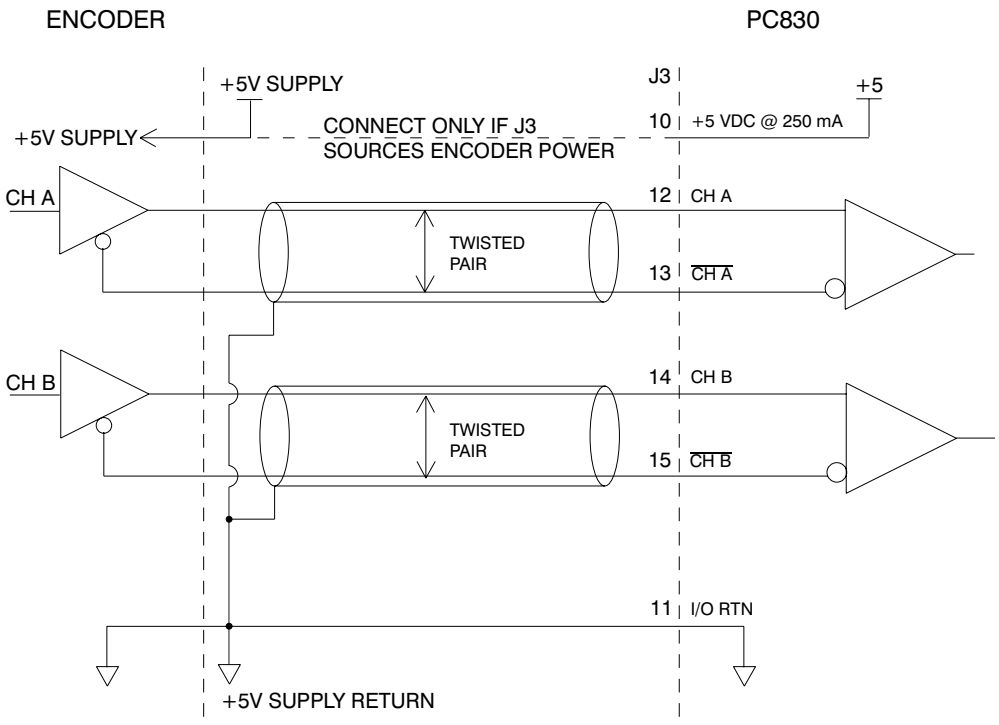
These differential inputs expect quadrature encoder feedback signals. These two input pairs are differential and are detected by 26LS32 type RS-422 compatible line receivers. As differential inputs, the recommended common mode range is 7 V with respect to I/O RTN and the guaranteed differential voltage logic thresholds are ± 0.2 V. Recommended drivers should be able to source and sink > 3 mA to/from these inputs.



Note: *An adapter can be powered from the serial port +5 Vdc output on J1-4 as long as the load current on J1-4, J2-14, and J3-10 total less than 250 mA.*

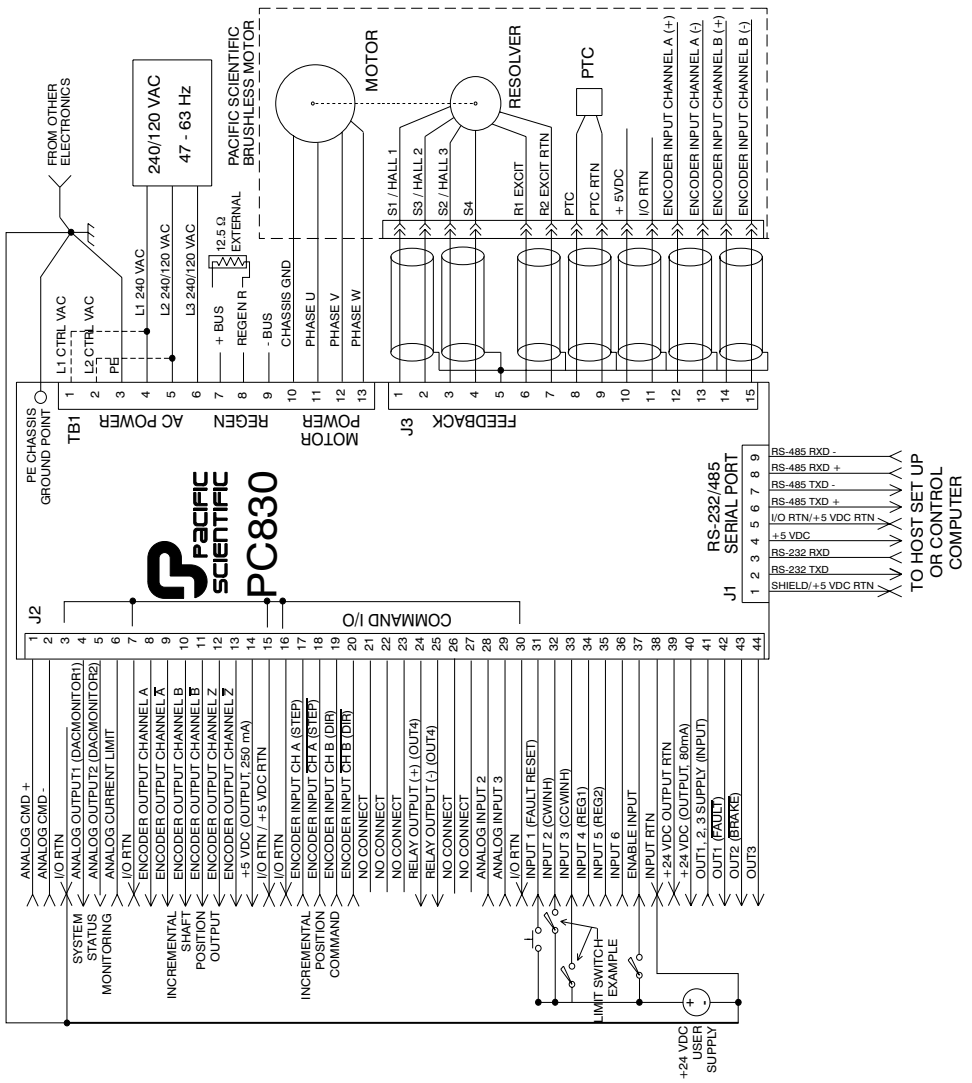
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Using TTL differential line drivers



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Drive Wiring Diagram



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3 Mappable I/O Functions

Introduction

The PC830 has six user mappable inputs (J2-31 to J2-36), three user mappable outputs (J2-42 to J2-44), and one mappable relay output (J2-24, 25) which are available for users to interface to external devices; proximity switch, PLC, LED.

Inputs Table (InpMapX)

The following table lists the mappable input functions available for the Digital Inputs.

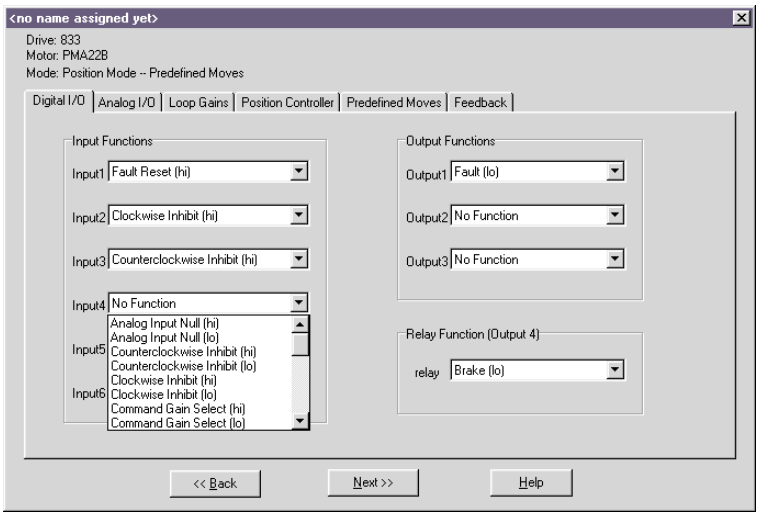
Mappable Input Function	Description
Analog Input Null	Nulls the analog input by setting ADOffset to old ADOffset minus AnalogIn
Counterclockwise Inhibit (default)	Inhibits motor motion in the counterclockwise direction when asserted
Clockwise Inhibit (default)	Inhibits motor motion in the clockwise direction when asserted
Command Gain Select	Switches the analog input scale factor between CmdGain and CmdGain2
Enable 2	Second enable function
Fault Reset (default)	Resets drive faults
Gearing On	Turns electronic gearing on
Home Switch Input	Home switch input for a homing move
Move Select Bit 0, 1, 2	Determines the active move
No Function	Turns off mappable input functionality
Position Mode Select	Switches the active mode of operation to position mode
Run Stop	Selects between normal operation and setting the velocity command to zero
Start Move	Initiates the preset move as defined by the current state of the MoveSelectBit inputs
Velocity Command Source	Selects between VelCmd and VelCmd2

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Procedure

To assign a mappable input function to a digital input, perform the following.

1. Click on **Create New Configuration** or **Edit Exisiting Configuration** button.
2. Select the appropriate **Motor and Drive Type** and the **Mode of Operation**. Click on **Next**.
3. Click on the **Digital I/O Tab**. Select the input that is being assigned a function.
4. Select the desired function from the drop-down list-box.



Active hi/lo

Each of the digital inputs can be defined as either active high or active low. If the mappable input function (bit) is configured as active high (low) then if the input is HIGH (LOW) then the mappable input function (bit) will be asserted. For example, if Fault Reset is configured as active high, when the input is high, Fault Reset will be asserted.

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Analog Input Null

In Analog Torque Mode or Analog Velocity Mode, the Command voltage can be nulled to:

- Reduce drift at zero volt command.
- Set 50% analog offset for commanding bi-directional motion with a single polarity adjustable voltage command source.

Related Parameters

See AnalogIn and ADF0 in On-Line Help.

Setup

1. Connect the Analog command source to J2-1 and J2-2.
2. Activate the input momentarily to offset the command for zero motion.
3. To reduce drift, command zero volts and remove small offsets with the null.
4. To set bi-directional motion with a single polarity input, convert a 0 to 10V analog command to ±5V by commanding 5.0V on the analog input when you null the analog input. Use Command Gain (**CmdGain**) to scale the input voltage for appropriate output.

Command Gain Select

In Torque Mode or Velocity Mode (except Serial Velocity), the command scale can be switched between **CmdGain** value and **CmdGain2** value for:

- A Direction input that changes polarity of a jog command.
- A complex motion input that changes speed.
- An input to command zero motion.

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Setup

1. Click on the **Edit Drive Configuration Online** button.
2. Change the value of **CmdGain2** to the desired value:

   For Direction set CmdGain2 = (- CmdGain).

   To Change speed set CmdGain2 = NonZero value.

   To hold zero command set CmdGain2 = 0.

When you activate the **Command Gain Select input**, the command will switch from a scale of Command Gain **CmdGain** to a scale of **CmdGain2**.

Related Parameter(s)

See **CmdGain, CmdGain2, and BlkType(Operation Mode)** in On-line Help.

Gearing On

In Position Mode, the Digital Command source can be turned on by activating **Gearing On** input, and turned off by deactivating the **Gearing On** input. Deactivate Gearing On to:

- Perform a Homing Move
- Perform a move to a flying shear start position
- Hold zero speed until next input

An Absolute Move will abort Gearing (Gearing On = 0)

Setup

1. Click on the **Digital I/O** tab. Setup a **Start Move** input and **Move Select Bit** inputs for starting the move.
2. Click on the **Predefined Moves** tab. Setup a **Home** move.

   OR

   Setup an **Absolute** move to Position 0 or the known start position.
3. To hold zero speed the **Gearing On** input is all that is needed.

Related Parameter(s)

See **EncMode, DigitalCmd, and DigitalCmdFreq** in On-Line Help.

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Position Mode Select

In Torque Mode or Velocity Mode, the mode can be switched between Torque and Position, or Velocity and Position. After switching to **Position Mode** the drive will perform:

- Electronic Gearing
- Predefined moves
- Hold Position

Setup

1. For Electronic Gearing, provide a Digital Command Source such as an encoder or step and direction signals.

   Click on the **Edit Drive Configuration OnLine** button.

   Set **EncMode** to the type of Digital Command Source provided.

2. To define moves, click on the **Predefined Moves** tab, and the **Digital I/O** tab to define **MoveSelectBits** and **StartMove** inputs.

3. To Hold Position, activate the input.

Related Parameter(s)

See **CmdGain, VelCmd and BlkType(Operation Mode)** in On-line Help.

Run Stop

In any operating mode, the command source can be switched to 0 rpm for Clutch/Brake with **NO** holding torque. **StopTime** sets the amount of time before disabling the motor after the **RunStop** function is activated. This allows for a controlled stop. In **Velocity Mode** or **Position Mode** use **DecelLmt** to decelerate the motor before it disables.

Setup

1. Click on the **Edit Drive Configuration Online** button.

2. Change the value of **StopTime**. When you activate the **RunStop** input, the command will switch from operating speed to 0 rpm, and the drive will disable after **StopTime**.

Related Parameters

See **StopTime** in On-Line Help.

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Velocity Command Source

In Torque Mode , the command source can be switched between VelCmd and VelCmd2 for:

- Torque inhibit if VelCmd2 = 0.
- Torque preset select if VelCmd2 is non-zero.

In Velocity Mode, the command source can be switched between VelCmd and VelCmd2 for:

- Clutch/Brake with holding torque if VelCmd2 = 0.
- Velocity preset select if VelCmd2 is non-zero.

In Position Mode, the command source can be switched between VelCmd and VelCmd2 for:

- Switching between electronic gearing follower and velocity preset command.

Setup

1. Click on the **Edit Drive Configuration OnLine** button.
2. Change **VelCmd2** to the desired preset value.
3. Activate the input mapped for **Velocity Command Source** to select VelCmd2 value.

Related Parameter(s)

See **VelCmd, VelCmd2, BlkType(Operation Mode)** in On-Line Help.

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Outputs Table (OutMapX)

The following table lists the mappable output functions available for the Digital and Relay Outputs.

Mappable Output Function	Description
Brake (default)	Indicates when the motor is not powered and a mechanical brake is needed to hold the motor
Electrical Revs	Square wave whose frequency is equal to the motor electrical frequency
Enabled	Indicates whether power can flow to the motor
Excess Position Error	Asserted when there is excess following error for an extended period of time (following error limit is defined by PosErrorMax)
Fault (default)	Indicates whether the drive has faulted and is disabled
Mechanical Revs	Square wave whose frequency is equal to the resolver's electrical frequency which is typically equal to the mechanical Rev/sec
Move Done	Indicates that a move is complete.
No Function	Turns off mappable output functionality
Zero Speed	Activated when the motor's speed goes below the speed threshold set by the parameter ZeroSpeedThresh

Active hi/lo

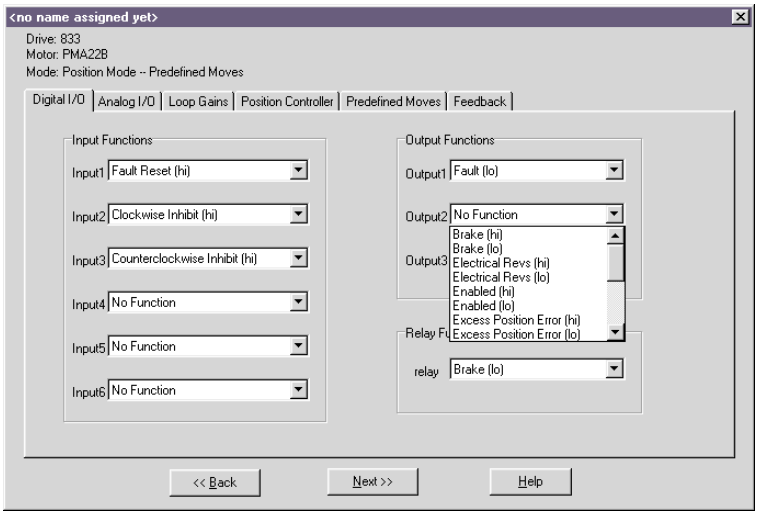
Each of the digital outputs can be defined as either active high or active low. If the mappable output function (bit) is configured as active HIGH (LOW) then when the function (bit) is asserted, the output will be HIGH (LOW). For example, if Move Done is configured as active high, when the move is complete the output will go high.

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Procedure

To assign a mappable output function to a digital output:

1. Click on **Create New Configuration** or **Edit Exisiting Configuration** button.
2. Select the appropriate **Motor and Drive Type** and the **Mode of Operation**. Click on **Next**.
3. Click on the **Digital I/O Tab**. Select the output or relay that is being assigned a function.
4. Select the desired function from the drop-down list-box.



Excess Position Error

In Position Mode, indicates synchronization failure for:

- Warning the master when out of synchronization
- Preventing a position error fault from disabling the drive

Setup

1. Click on **Edit Drive Configuration OnLine** button.
2. Change **PosErrorMax** to the appropriate Motor Counts as a trip threshold (Motor Counts = 65536 counts/rev).

Related Parameter(s)

See **PosErrorMax, KPP, and KVFF** in On-Line Help.

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Move Done

When executing Predefined Moves, the **Move Done** output will activate when the motor feedback reaches the final move position. InPosLimit sets the window of motor counts to determine if the motor is near final position. A smaller window (InPosLimit = 2) will provide more accurate results, and will take longer to settle. Use the **MoveDone** output to tell the master control that the drive is done with the move and in final position.

Setup

1. Click on the **Edit Drive Configuration OnLine** button.
2. Change **InPosLimit** to the appropriate Motor Counts as a trip threshold (Motor Counts = 65536 counts/rev, 6 counts = 1/10000 rev).

Related Parameter(s)

See **InPosLimit** in On-Line Help.

Zero Speed

In any Operating Mode, the **Zero Speed Output** can be used to indicate:

- If the motor is near zero speed when ZeroSpeedThresh is near 0.
- If the motor is at speed when ZeroSpeedThresh is set near target speed.

Setup

1. Click on the **Edit Drive Configuration OnLine** button.
2. Change **ZeroSpeedThresh** near but not past the desired target speed. There will be velocity ripple that can cause output bounce if the threshold is set too close to the target.

Related Parameter(s)

See **ZeroSpeedThresh** in On-Line Help.

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Application Examples

The following are a few application example setups for the PC830.

Homing

Typically motion control applications require the machine to be homed to a predefined starting position, prior to performing its normal operations. Generally, a mechanical home switch or a marker pulse is referenced (off an encoder) to provide the homing reference position.

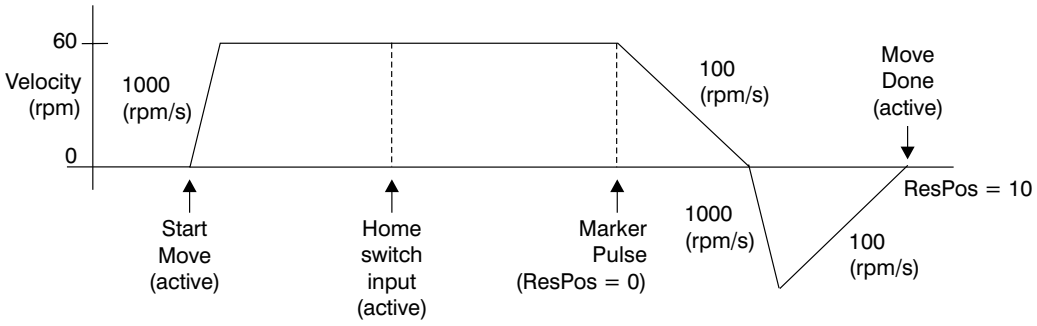
A motor (with a resolver) drives a load through a 0.5 inch/rev lead screw. To home the machine, the load is required to move at 30 in/min in the clockwise direction. This is in the direction toward a proximity switch (which will be used as the home switch). After the switch is triggered, the load continues to move in the same direction until a marker pulse is seen. In this case, the marker pulse is from the resolver (ResPos = 0). The motor then decelerates to a complete stop to a position beyond the marker pulse and then reverses direction back toward the marker pulse coming to rest at resolver position of **ResPos** = 10. The drive then activates an output to signal a PLC that the move is done.

First calculate the speed of the motor while it's advancing toward the home switch:

Run Speed = 2 rev/in * 30 in/min = 60 rpm

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Motion profile



Procedure

1. Create a New Configuration and select **Position Mode - Predefined Moves** as the mode of operation.
2. Click on **Digital I/O Tab**. Set up a **Home Switch Input**, a **StartMove** Input, and a **MoveSelectBit**. Set up a **MoveDone** output.
3. Click on the **Predefined Moves** tab. Setup a **Home** move using the following parameters:

Move Type:	Home
Run Speed:	60 rpm
Accel Rate:	1000 rpm
Decel Rate:	100 rpm
Distance Offset:	10 counts
Reg Select:	n/a
Homing Mode:	Home Switch + Marker Pulse
Home Direction:	Clockwise

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Clutch/Brake

A thermal cut and seal machine uses an analog input signal to command a geared motor (gear ratio 10:1) to spin a pinch roller that feeds material into the thermal cutter and sealer. There is a 2.5 volt signal available to command speed. The roller has a diameter of 3.82 inches and must advance roughly 24 inches of material in 1 second. A PLC provides an input to emulate a clutch/brake operation commanding zero velocity and stopping motor motion. A second input from the PLC also reverts the drive to maintain motor position during the cut and seal process. The cycle is then repeated.

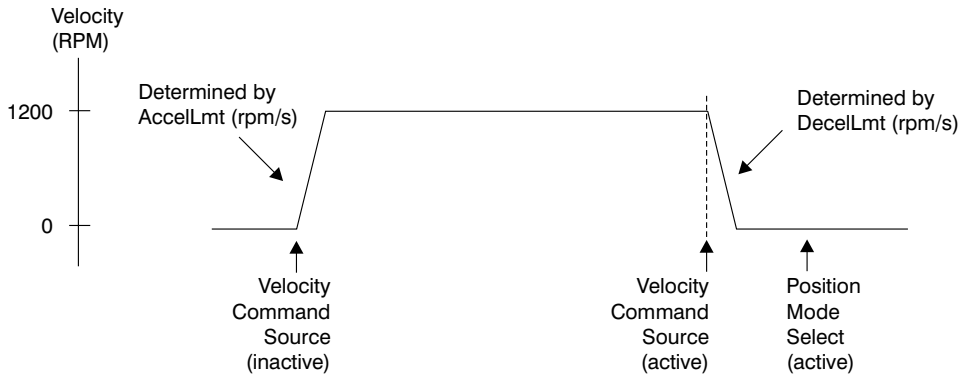
First calculate the required **CmdGain** to provide the necessary speed for the 1 second move:

Roller Circumference =
π * Roller Diameter = π * 3.82 inch = 12 inch

Distance for motor to move =
10 * (24 inch move / 12 inch/rev) = 20 revs

Velocity = 20 rev/sec (1200 rpm) =
CmdGain (krpm/V) * AnalogIn (V)
CmdGain = 1.2 Krpm / 2.5 V = 0.48 Krpm/V

Motion profile



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Procedure

1. Create a New Configuration and select **Velocity Mode** as the mode of operation.
2. Click on the **Digital I/O Tab**. Select **Velocity Command Source** as the function on Input4 to switch between the source of two unique velocity commands.
3. Select **Position Mode Select** as the function on Input5 to switch between velocity and position modes of operation. This step is optional depending upon whether your application can tolerate a small amount of drift when commanding zero velocity as an analog input. When using this mode of operation during the brake mode VelCmd is equal to zero.
4. Set **VelCmd2** = zero. The direction of the velocity move will be controlled by the polarity of the value entered.
5. Set **AccelLmt** and **DecelLmt** to the desired clutch activation acceleration and brake activation deceleration respectively.

Note: ***VelCmd*** *is the velocity commanded through the analog input, encoder frequency input, or the serial port depending upon the mode of operation selected.* ***VelCmd2*** *is a stored value of velocity that can only be changed serially.*

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Gearing (w/ phase correction)

An encoder with a 1024 line count is mounted to a continuous web embosser machine. A PC830 is setup as a position follower such that for every 1 rev of the encoder the PC830 commands the follower motor to move 1 rev (ratio of 1:1 in encoder revs to motor revs). The drive will be required to phase advance the follower motor ¼ rev when an input from a PLC occurs. Likewise, the drive will also be required to decrement the follower motor (phase retard) by ¼ rev when another input occurs. These phase advance/retard moves will allow the servo to emboss the imprints into the web ahead or behind where they typically would be without any phase adjustment.

First calculate the required gearing ratio between the master encoder and the slave motor. A 1024 line count encoder will output 4096 quadrature counts per encoder revolution.

1 motor rev = 65536 resolver counts (**PulsesOut**)
1 encoder rev = 4096 encoder counts (**PulsesIn**)

PulsesOut cannot exceed 32767, therefore, divide **PulsesIn** and **PulsesOut** by four to maintain the desired ratio. The new values should then be:

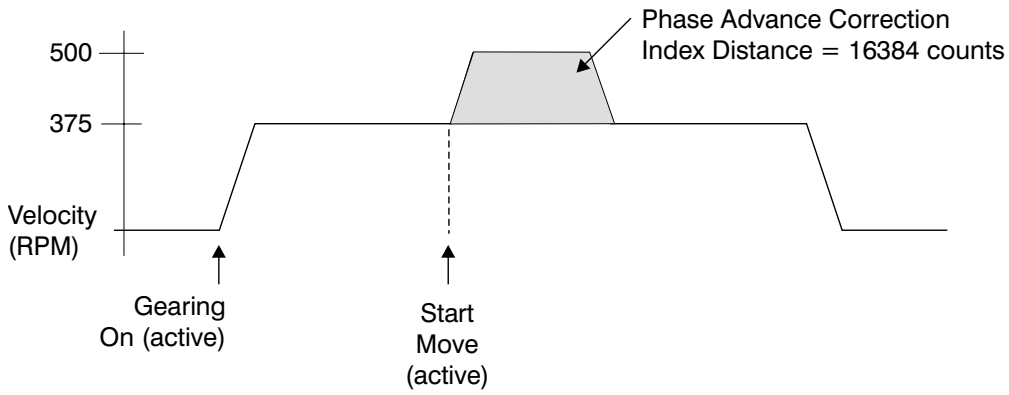
PulsesOut = 16384
PulsesIn = 1024

The phase advance and phase retard index move distances must also be calculated. The motor must perform an index move of ¼ rev (65536/4 = 16384 counts). Therefore, program two preset incremental moves of **Distance** =16384 counts and –16384 counts. Phase correction moves are commanded on top of gearing. To prevent backward motion of the follower, ensure that RunSpeed < DigitalCmdFreq.

Note: *It may be necessary to refine the tuning of the system in order to reduce the steady state position following error (position lag). Steady state position following error can be minimized by increasing the velocity feedforward gain (**Kvff**). Setting **Kvff** to 100% will reduce this error to zero, however at the expense of potential excessive overshoot. Therefore, your system may require that **Kvff** be set to a value less than 100% (typically around 70-80%). For additional information on tuning refer to Chapter 4 (Servo Loop Tuning).*

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Motion profile



Procedure

1. Create a New Configuration and select **Position Mode – Electronic Gearing** as the mode of operation.
2. Set desired number of commanded motor **Pulses Out** per the number of encoder **Pulses In**.
3. Click on the **Digital I/O** tab. Select **Gearing On** as the function for the input to initiate gearing.
4. Select **Start Move** as the function on the input used to initiate a preset incremental move.
5. Click on the **Predefined Moves** tab. Define an **Incremental** move for the phase advance index move.
6. Create a second incremental move for the phase retard index move.

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Registration Moves

Registration marks can be used to perform preset registration moves based upon activation of a registration input. Typically, these moves can be used to advance a product a predefined distance after activation of a proximity sensor input. All registration inputs must be tied to a dedicated registration input on either Input 4 (J2-34) or Input 5 (J2-35).

A conveyor processing material is being driven by a one inch diameter roller (directly coupled to a motor) incrementing at a constant speed of 1000 rpm. There are marks on the material spaced evenly every eight inches on the conveyor. These marks are detected by a proximity sensor interfaced into Input 4 on the PC830 as a registration input. Once the sensor is activated, the motor advances the conveyor one more inch before coming to a complete stop within 75 milliseconds. After the motor has come to a complete stop, the drive activates an output signaling a nearby PLC that the registration move is complete. The PLC initiates the cycle to repeat itself.

Calculate move parameters

First, calculate distance to move (Distance Offset) after sensing registration input:

Roller Circumference = π * Roller Diameter
= π * 1 inch = 3.1415 inch

Distance for motor to move = 1 inch move / 3.1415 inch/rev
= 0.31832 revs

Distance Offset = 0.31832 motor rev * 65536 counts/motor rev
= 20861 counts

Next, calculate the minimum deceleration rate necessary to ensure coming to a complete stop within the 75 millisecond specification.

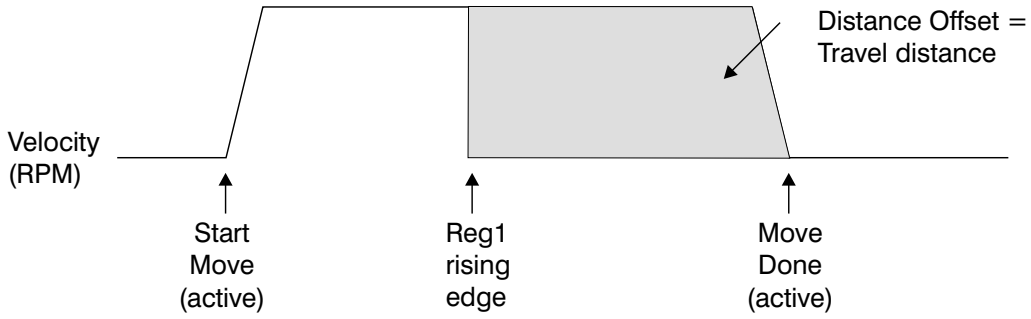
Decel Rate = 2 * 0.31832 revs * 60 / $(0.075 \text{ seconds})^2$
= 6791 rpm/s

Finally, calculate the minimum distance the motor should move to ensure the registration input is seen every cycle.

Distance = 8 inch * 0.31832 rev/inch * 65536 counts/rev
= 166892 counts

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Motion profile



Procedure

1. Create a New Configuration and select **Position Mode - Predefined Moves** as mode of operation.
2. Click on the **Digital I/O** tab. Select **Start Move** as the function on Input3 to initiate a preset move.
3. Select **Move Select Bit 0** as the function on Input4 to setup a preset move based upon an external input.
4. Select **Move Done** as the function on Out3.
5. All registration moves must be tied to a dedicated registration input on either Input 4 (J2-34) or Input 5 (J2-35). Select **No Function** for either Input 4 or Input 5 on the Digital I/O Tab.
6. Click on the **Predefined Moves** tab. Setup an **Incremental Registration** move. The registration move is the number of counts set in the **Distance Offset** window. This move is activated by the user as active on the rising or falling edge of this input.

   Distance Offset: 20861 counts
   Run Speed: 1000 rpm
   Reg Select: Reg 1 (Inp4)
   Accel Rate: 10000 rpm/s
   Reg 1 Active Edge: Rising Edge
   Decel Rate: 10000 rpm/s (> min 6791 rpm/s)
   Distance: 200000 counts (> min 166892 counts)

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Jog Moves

A motor is mechanically linked to a pulley (with a 1.91 inch diameter) which drives a conveyor at 50 in/sec. The motor rotates the pulley at a constant speed to feed products past a scanning station. Occasionally, the drive will be required to run the conveyor at two additional speeds (100 in/sec and 25 in/sec) to meet production needs and running different products through the scanning station.

First calculate the required motor velocity(s) to advance the conveyor:

Pulley Circumference =
π * Pulley Diameter = π * 1.91 inch = 6 inch (1 motor rev)

Velocity1 =
(50 inch/sec) * (1 rev/6 inch) * (60 sec/min) = 500 rpm

Velocity2 =
(100nch/sec) * (1 rev/6 inch) * (60 sec/min) = 1000 rpm

Velocity3 =
(25 inch/sec) * (1 rev/6 inch) * (60 sec/min) = 250 rpm

VelCmd2 is a storable serial velocity command that will be used to set the speed for Velocity1. Velocity2 and Velocity3 will obtained by use of the analog input on the PC830. Either the user can provide their own external analog signal OR make use of the drives ability to produce an analog offset (using **ADOffset**). For this example, ADOffset will be set to 1 volt. This will be used to calculate the appropriate scaling factor to scale this analog signal into a speed reference.

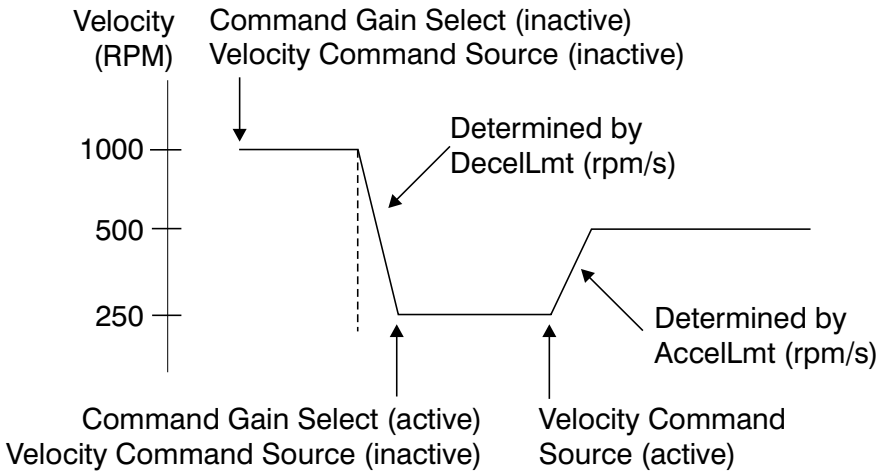
Velocity2 = 1000 rpm =
CmdGain (krpm/V) * (AnalogIn (V) + ADOffset (V))
CmdGain = 1.0 krpm / 1.0 V = 1.0 krpm/V

Velocity3 = 250 rpm =
CmdGain2 (krpm/V) * (AnalogIn (V) + ADOffset (V))
CmdGain2 = 0.25 krpm / 1.0 V = 0.25 krpm/V

Note: *If an external analog signal is provided to vary the analog input, then a wide range of jogging speeds are possible.*

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Motion profile



Procedure

1. Create a New Configuration and select **Velocity Mode — Analog Command** as the mode of operation.
2. Click on the **Digital I/O** tab. Select **Command Gain Select** as the fucntion for the input to be used to select scaling/polarity of incoming analog command signal.
3. Select **Velocity Command Source** as the function of the input to be used to set serial velocity command.
4. Click on the **Velocity Controller** tab. Set **Offset Voltage** as desired analog signal command OR provide appropriate incoming external analog signal with the appropriate voltage (the latter may be preferred as it would permit variable speeds to be achieved).
5. Click on the **Edit Drive Configuration Online** button. Set **CmdGain** and **CmdGain2** to desired values for scaling and polarity.
6. Set **VelCmd2** to desired speed (a setting of 0 rpm would represent a STOP input)

Note: VelCmd2 is NOT tied to the analog input signal coming into the drive.

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4 Selecting Modes of Operation

Introduction

The PC830 has three distinct modes of controlling the motor shaft and three distinct sources for the shaft command:

Modes

- Torque Control
- Velocity Control
- Position Control

Commands

- Analog Command
- Incremental Digital Pulse Command
- Serial Port Command

Mode of Operation	Command Source
Position Mode - Predefined Moves	Digital Inputs
Position Mode - Step and Direction	Step and Direction
Position Mode - Electronic Gearing	External Encoder
Velocity Mode - Analog Command	Differential Analog Input
Velocity Mode - Frequency Command	Frequency/Pulse
Velocity Mode - Serial Command	RS-232/RS-485
Torque Mode - Analog Command	Differential Analog Input
Torque Mode - Frequency Command	Frequency/Pulse

Each of the drive's operating modes can be easily set up using **Create New Configuration** or **Edit Existing Configuration** buttons of 830 Tools. The following sections give the details on these operating modes and their command source.

Refer to Appendix B for control block diagrams and additional information on velocity and position loops.

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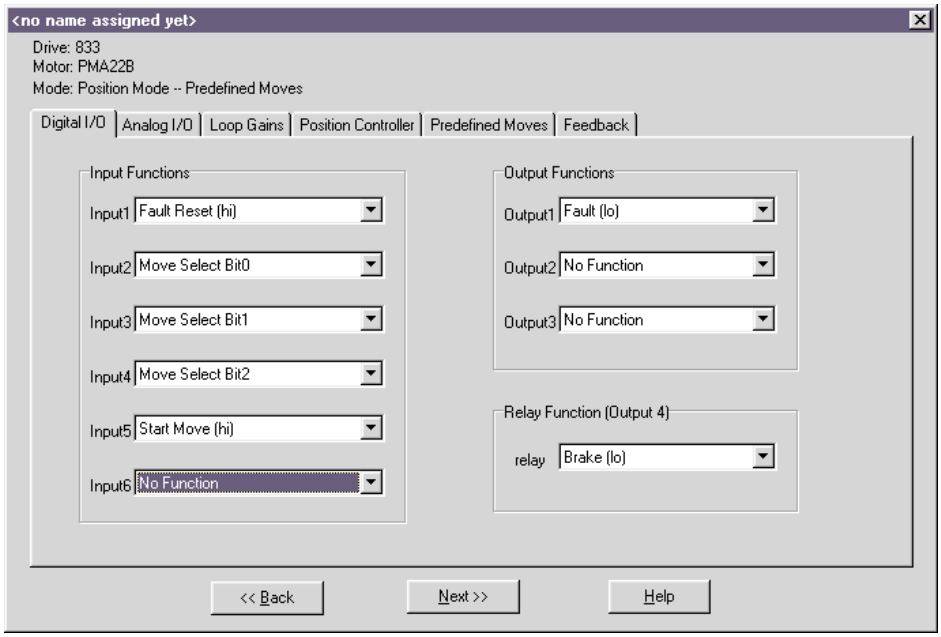
4.1 Position Mode - Predefined Moves

This mode allows the user to define up to 8 distinct moves. The predefined moves may be selected and then triggered using the digital inputs on J2-31 through J2-36.

Procedure

1. Create a New Configuration and select **Position Mode - Predefined Moves** as the mode of operation.
2. Click on the **Digital I/O Tab** to define MoveSelectBits and a StartMove input.

Digital I/O Tab



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Selecting a move

The active move is selected based on the binary state of the MoveSelectBit(s) and initiated by a change of state on the StartMove. The table below indicates which predefined move will be activated upon a StartMove state change.

Move #	MoveSelectBit2	MoveSelectBit1	MoveSelectBit0
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

ActiveMove = 4*(MoveSelectBit2) + 2*(MoveSelectBit1) +1*(MoveSelectBit0)

Move Types

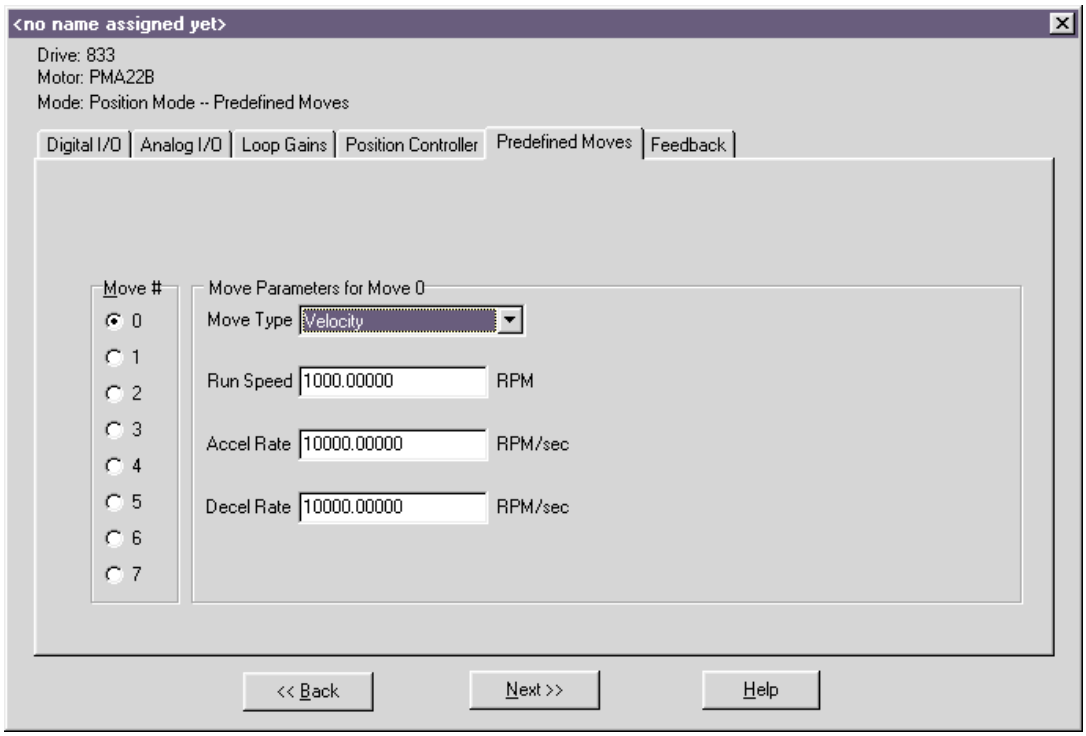
The following table lists the move types available:

Move Type	Description
Hold Position	The motor aborts motion and holds position.
Velocity	The motor ramps up/down to a predefined runspeed.
Incremental	The motor travels a predefined distance.
Absolute	The motor travels to a predefined position relative to the home (0) position. (Turns gearing off)
Incremental Registration	The motor starts an incremental move. If a transition occurs on the registation input before the move is complete, the motor moves to the latched position + Distance Offset.
Absolute Registration	The motor starts an absolute move. If a transition occurs on the registation input before the move is complete, the motor moves to the latched position + Distance Offset. (Turns gearing off)
Home	The motor searches for a home reference, establishes a home position, and returns to the home position. (Turns gearing off)

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3. Click on the **Predefined Moves Tab** to configure the parameters associated with each of the predefined moves.

Velocity Move



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Homing

The homing functionality of the PC830 allows the user to establish a home position based on four different home references. The table below lists each of the references used for homing, and describes how each establishes the home position.

Home reference	Description
Home Switch	Transition of Home Switch (Requires one of the Digital Inputs to be mapped to the HomeSwitch function.)
Marker Pulse	Internal resolver marker pulse*
Home Switch + Marker Pulse	Transition of Home Switch then marker pulse
Use Present Position	Current position is established as home position

Marker pulse using resolver

If using resolver feedback, all home moves to a marker pulse will be based on resolver position equal to zero (ResPos = 0).

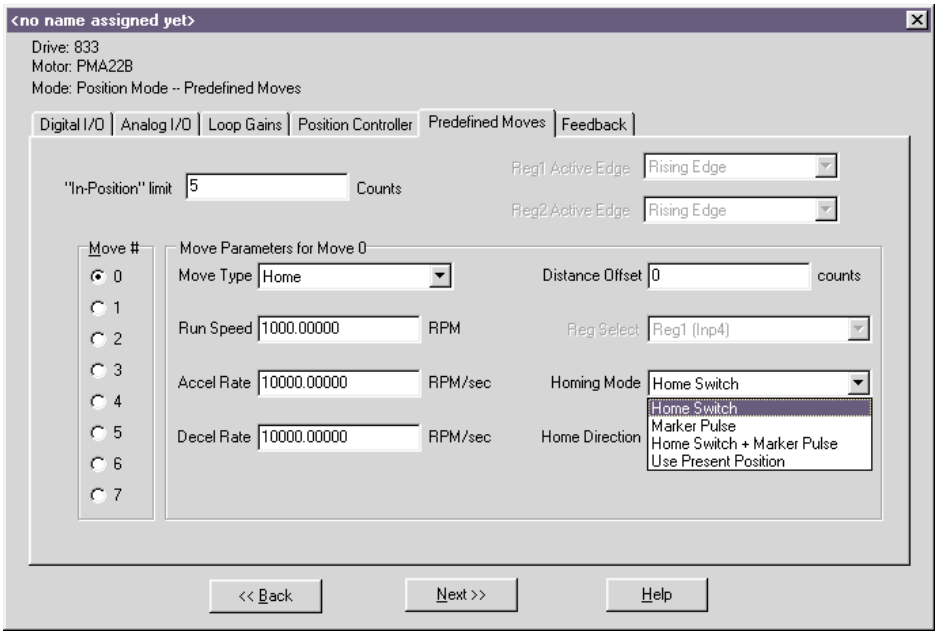
Marker pulse using encoder

If using encoder feedback, all home moves to a marker pulse will be based off the marker pulse output from the encoder. This channel must be physically wired to one of the two dedicated registration inputs, Input 4 (J2-34) or Input 5 (J2-35). Select this input using the **Reg Select** pull-down tab. The **Active Edge** (rising edge or falling edge) must also be defined for the registration input.

*__Note:__ *If using encoder feedback, the physical Z channel from the encoder is used as the marker pulse. Select Reg1 (Inp4) if the encoder Z channel is to be connected to digital Input4 or Reg2(Inp5) when connecting to digital Input5. Make sure the mapping for the input used is set to No Function.*

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Home Move parameters



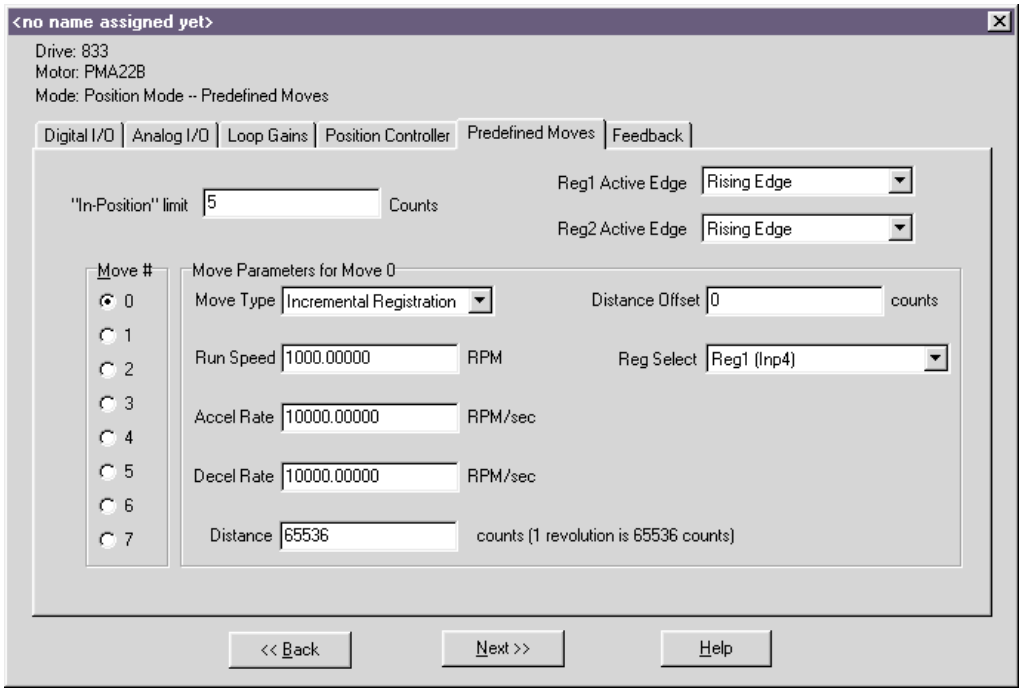
Procedure

1. Select **Home** as the Move Type.
2. Select the **Homing Mode** (Home Switch, Marker Pulse, Home Switch + Marker Pulse, Use Present Position) to determine the reference for homing.
3. Select **Home Direction** of motor rotation for home move as clockwise or counterclockwise.
4. Define the **Distance Offset** position the motor should move to after the home switch input has been detected.
5. If **Home Switch** was selected, click on the **Digital I/O Tab**. Select **Home Switch Input** as the function for the desired input.

Home Position = Position of Home Reference + Distance Offset
Position = Position - Home Position
The motor will then perform an absolute move to the home position.

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Registration Move Parameters



Procedure

1. Select either **Incremental or Absolute Registration** as the Move Type.
2. Select **Reg1 (Inp4)** or **Reg2 (Inp5)** as the registration input.

   Note: *Verify that there is **No Function** defined for the registration input.*
3. Select the **Active Edge** for the registration input.
4. Set the **Distance** to the desired value.
5. Set the **Distance Offset** to the desired value. This is the distance that the motor will travel upon registration.

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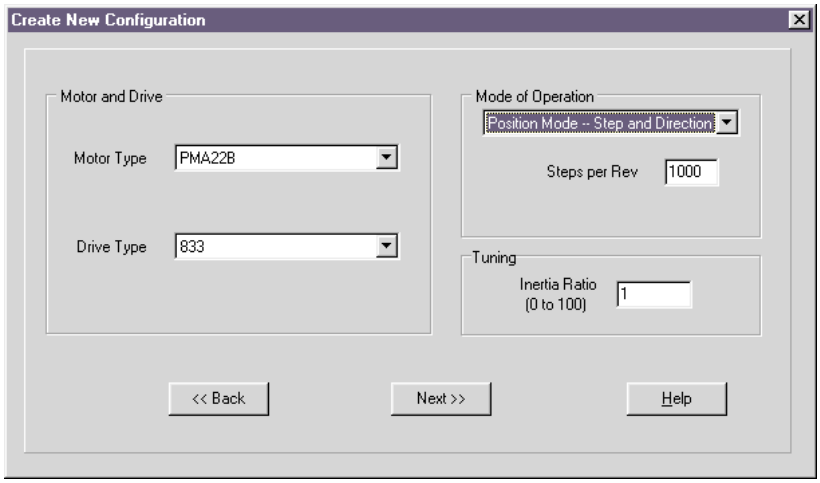
4.2 Position Mode - Step and Direction

This mode allows the PC830 to be controlled by a stepper indexer feeding it with step and direction signals on J2-17 through J2-20. Predefined moves are also available in this mode.

Procedure

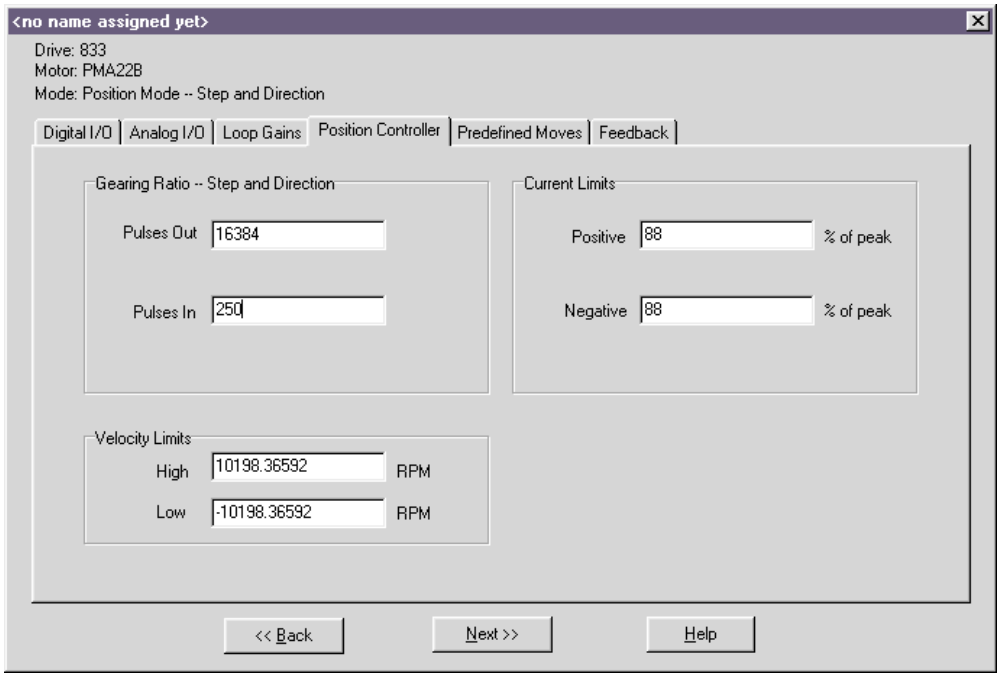
1. Select **Position Mode - Step and Direction** from the Mode of Operation dropdown list box.
2. Specify the number of steps per motor revolution. This number must be evenly divisible by four. For industry standard step sizes, select from the table below.

Steps/Rev	Motor Mechanical Deg/Step
200 (Full)	1.8
400 (Half)	0.9
1000 (1/5)	0.36
2000 (1/10)	0.18
5000 (1/25)	0.072
25000 (1/125)	0.0144
50000 (1/250)	0.0072



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Step and Direction



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4.3 Position Mode - Electronic Gearing

This mode configures the PC830 to follow external encoder signals applied to the encoder inputs on J2-17 to J2-20. Predefined moves are also available in this mode.

Procedure

1. Select **Position Mode - Electronic Gearing** from the Mode of Operation dropdown list box.
2. Enter the number of motor resolver counts (PulsesOut) (1/65536 of a rev) that you want the motor to move for the specified number of input encoder quadrature counts (PulsesIn).

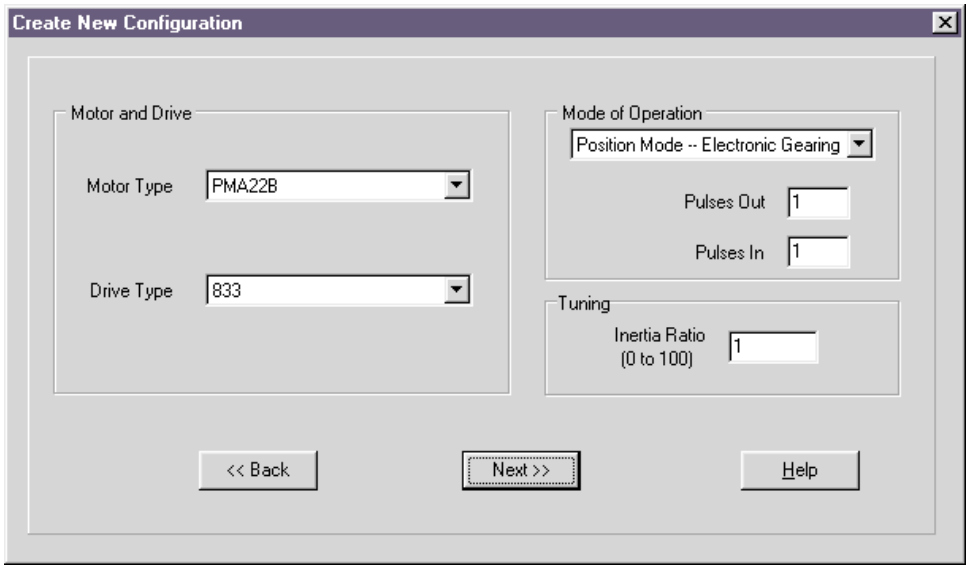
Example

If the input encoder line count (PulsesIn) is 1024 (4096 quadrature counts per encoder revolution) and the motor should make one revolution for every encoder revolution, then:

1 rev = 65,536 resolver counts per

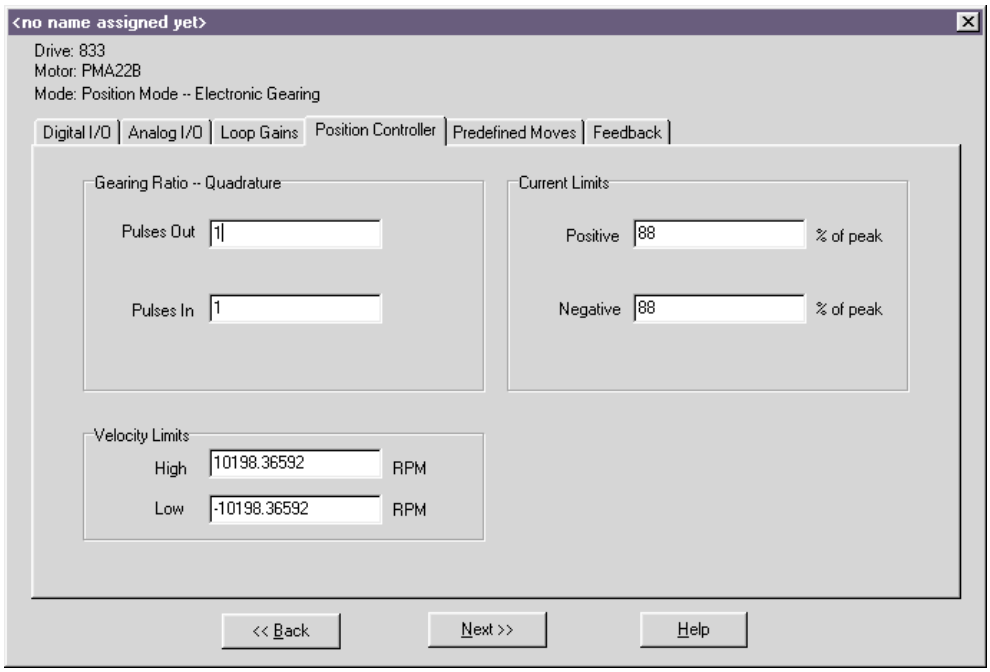
1 rev = 4096 encoder counts.

Because 65,536 is greater than the maximum value for PulsesOut, divide both numbers by four. This results in 16,384 motor resolver counts for 1024 input encoder counts.



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Electronic Gearing



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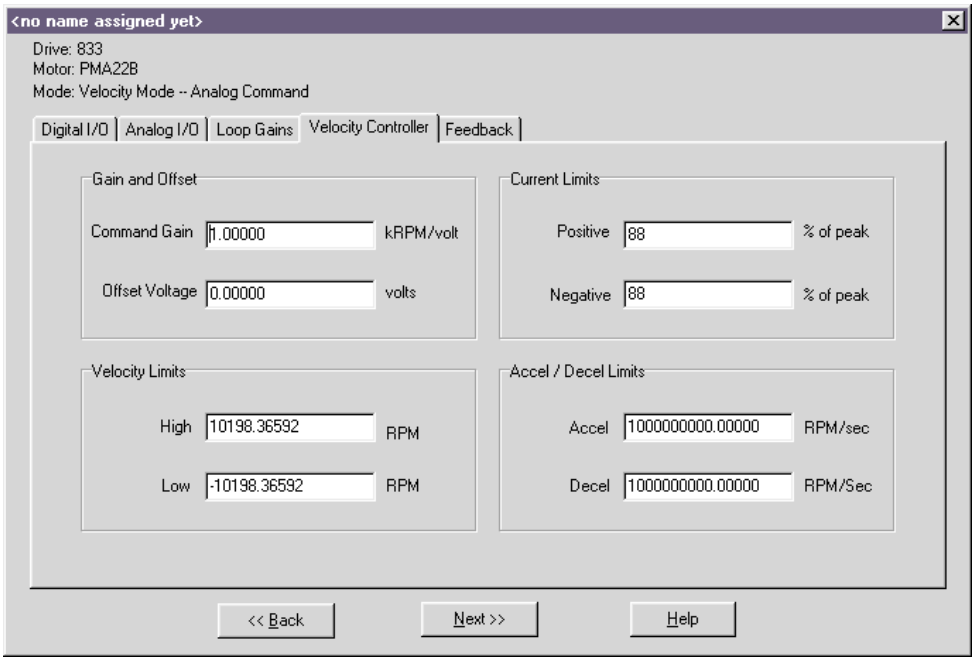
4.4 Velocity Mode - Analog Command

This mode allows the differential analog voltage between terminals J2-1 and J2-2 to set the motor's shaft velocity. The output shaft velocity per input volt, is set by the `CmdGain` parameter in kRPM/V and should be set by the user to the desired value.

Procedure

1. Select **Velocity Mode - Analog Command** from the Mode of Operation dropdown list box.
2. Set **CmdGain** to the desired value.
   Motor Velocity[kRPM] = AnalogIn[V]*CmdGain[kRPM/V]

Velocity Controller



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4.5 Velocity Mode - Frequency Command

This mode is the same as the Velocity Mode Analog Command except that the command input comes from the Incremental Command inputs on J2-17 through J2-20. The frequency on these input terminals is the variable `DigitalCmdFreq` and is substituted for the `AnalogIn` input to the `CmdGain` scaling. The units on `CmdGain` are kRPM/kHz.

Motor Velocity[kRPM] =
EncFreq[kHz]*CmdGain[kRPM/kHz]

4.6 Velocity Mode - Serial Command

This mode is the same as the Velocity Mode Analog Command except that the command input is the value of Velocity Command (`VelCmd`) set over the serial port. Note that `VelCmd` is a non-volatile parameter and when the PC830 servo powers up in this mode the initial value of the velocity command is this non-volatile value. Changing `VelCmd` over the serial port then sets a new volatile velocity command. Changing the non-volatile velocity command requires the additional step of issuing the `NVSave` command.

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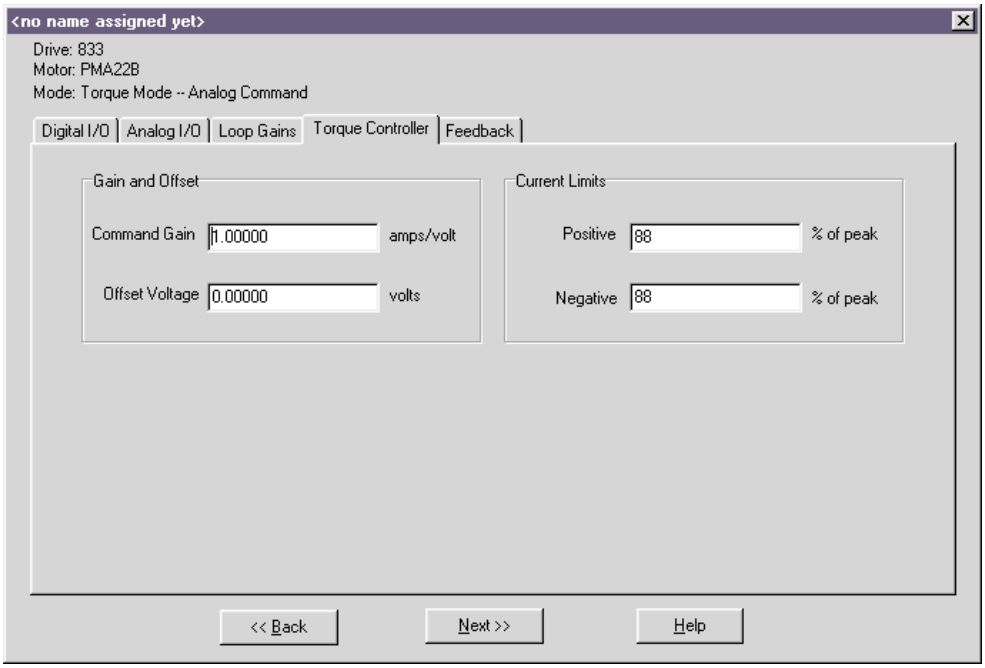
4.7 Torque Mode - Analog Command

This mode allows the differential analog voltage between terminals J2-1 and J2-2 to set the motor's current. Since torque command = Current command (`Icmd`) *Kteff, controlling current is equivalent to controlling torque. The analog input directly controls motor shaft torque. The output current amplitude in amps per input volt, is set by the `CmdGain` parameter directly in Amp/V and should be set by the user to the desired value.

Procedure

1. Select the **Torque Mode - Analog Command** from the Mode of Operation dropdown list box.
2. Set **CmdGain** to the desired value.

Torque Controller



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4.8 Torque Mode - Frequency Command

This mode is the same as the Torque Mode Analog Command except that the command input comes from the Incremental Position Command inputs on J2-17 through J2-20. The frequency on these input terminals is the variable `DigitalCmdFreq` and is substituted for the `AnalogIn` input to the `CmdGain` scaling. The units on `CmdGain` become Amp/kHz.

Icmd = CmdGain[A/kHz]*Digital Command Frequency

Icmd = Icmd*Kteff

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5 Tuning

Please read this section completely before tuning the drive. Refer to Appendix B for additional information.

Introduction

Tuning parameters are used to optimize system performance. The system is ulimately limited by the machine mechanics and power available from the driving motor. This chapter will review the tuning process. In general, start with the most significant limiting factor and increase the limit as high as possible.

The hierarchy of tuning limits follows this sequence:

- Position loop bandwidth is limited by velocity loop bandwidth.
- Velocity loop bandwidth is limited by current loop bandwidth and mechanical system natural resonant frequency.
- Current loop bandwidth is limited by the drive electronics.

Current Loop Settings

Proportional Gain (KIP)

Proportional Current Loop Gain “KIP” is set to provide 1000 Hz current loop bandwidth. The current loop bandwidth is independent of the mechanical system. KIP is preset by 830 Tools to the correct value based on motor model.

Default

KIP[V/A] = 6.28 * MotorInductance[mH], for 1000 Hz Current BW

Adjust

Preset by 830 Tools, do not change.

For unsupported motor models only, use formula described

Limits

1000 Hz to 1500 Hz

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Velocity Loop Settings

Proportional Gain (KVP)

The Proportional Velocity Loop Gain “KVP” is set based on two variables. Pacific Scientific selects a default bandwidth (BW) of 75 Hz to reduce the unknown to one variable. The system inertia is the second variable. Pacific Scientific chooses a default system inertia that is twice the motor inertia. Pacific Scientific assumes the load inertia and motor inertia are a 1:1 ratio as default. This default configuration should cover applications that have a load:motor inertia ratio from 0:1 to approximately 6:1 without user adjustment. The user is allowed to set inertia ratio in the “new configuration” window of 830 Tools. If the user sets the inertia ratio too high, the motor will buzz and vibrate the shaft. The motor current feedback will oscillate from +peak to -peak, and this can be seen with the softscope.

Integral Gain (KVI)

The Integral Velocity Loop Gain “KVI” is set based on the default velocity BW of 75 Hz. KVI is used to reduce steady state error from the velocity loop. KVI removes velocity error when you are holding zero speed, or running at constant speed. Pacific Scientific sets KVI to a stable default value when the load inertia is less than a 6:1 ratio to the motor inertia. When the load inertia is larger than 6:1, and the inertia ratio parameter is at default 1:1, you can see velocity overshoot and oscillation in the motor motion.

Anti-resonance filters (ARF0/ARF1)

The Anti-Resonance Filters “ARF0” and “ARF1” are used as separate low pass filters in the velocity loop to filter out undesired high frequency velocity loop noise. The defined filter frequency is the crossover frequency for the low pass filter. The filters reduce resonance problems by filtering the noise that excites mechanical resonances at 20dB/decade above the defined frequency. Each filter individually adds 45° of electrical phase shift (lag) to the velocity loop at the defined frequency. This phase lag can become part of the cause for mechanical resonance if the mechanical natural resonant frequency is lower than the velocity loop crossover (In Band). In band resonances are very unlikely for a well designed mechanical system.

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Default

$$KVP[A/rad/s] = \frac{75[Hz] * 6.28 * (J_m (\text{Inertia Ratio}+1))[Lb-in-s^2]}{\text{MotorKteff}\left[Lb-in/A\right]}$$

KVI[Hz] = 75[Hz] / 15

motorKteff[Lb-in/A] = 0.08454 * Ke[v/krpm] * 0.866

ARF0[Hz] = 75[Hz] * 2

ARF1[Hz] = 75[Hz] * 10

Adjust

Increasing KVP will increase performance and response

Decreasing KVP will reduce performance and response

Increasing KVI increases stiffness, and reducing KVI increases sponginess

Increasing ARF's reduces effect of filter on high frequency noise and allows higher velocity loop BW

Limits

Velocity loop BW should be 0 to 400 Hz. Velocity loop BW is also limited by ARF0 and ARF1.
Inertia_ratio should be < 100:1

KVI should be 15 times < velocity loop BW, look for velocity oscillation or overshoot. Range 0 to 636 Hz.

ARF0 should be ≥ velocity BW * 2 and < 1,000,000[Hz]

ARF1 should be ≥ velocity BW * 2 and < 1,000,000[Hz]

ARF0 and ARF1 filter values should increase proportionally with Veloicy loop BW. The default BW is 75 Hz, assuming an inertia ratio of 2*J_M. If you increase BW using KVP, you should also increase the filters with the following relation:

New ARFx = (Default ARFx)*K

K = (New KVP*2)/(Default KVP*M)

M = (Inertia_ratio+1)

Contact factory for notch filter information (used for In Band resonances).

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Position Loop Settings

Proportional Gain (KPP)

The Proportional Position Loop Gain "KPP" is set based on velocity BW of 75Hz. The velocity command from the position loop is generated from position error and KPP. For larger values of KPP, the velocity command is larger for a given position error. KPP provides position synchronization with a small constant position error while following a position command frequency. The position error will be proportional to the speed command by the value of KPP. If KPP is set too large compared to velocity BW, you can see velocity overshoot or oscillation, similar to a large KVI.

Feedforward Gain (KVFF)

The Velocity Feedforward Gain "KVFF" is used in applications that require near zero position error. KVFF is implemented in parallel with KPP to inject additional velocity command without requiring position error. If KVFF = 100 percent, the position command frequency is sent directly to the velocity loop as an open loop command. Instead of driving velocity with position error on top of zero speed, KVFF allows us to drive velocity with position error on top of target speed with nominally zero error. KVFF typically causes overshoot, and only helps in applications that require position synchronization, like electronic gearing.

Default	KPP[Hz] = 75[Hz] / 5
	KVFF[%] = 0[%]
Adjust	Increasing KPP reduces position error, decreasing KPP increases position error.
	Increasing KVFF reduces position error and increases overshoot.
Limits	KPP should be < velocity BW / 5 and 100 Hz maximum
	KPP ranges from 0 to 100 Hz
	KVFF should be < 200% and typically < 100%
	KVFF ranges from 0 to 200 %

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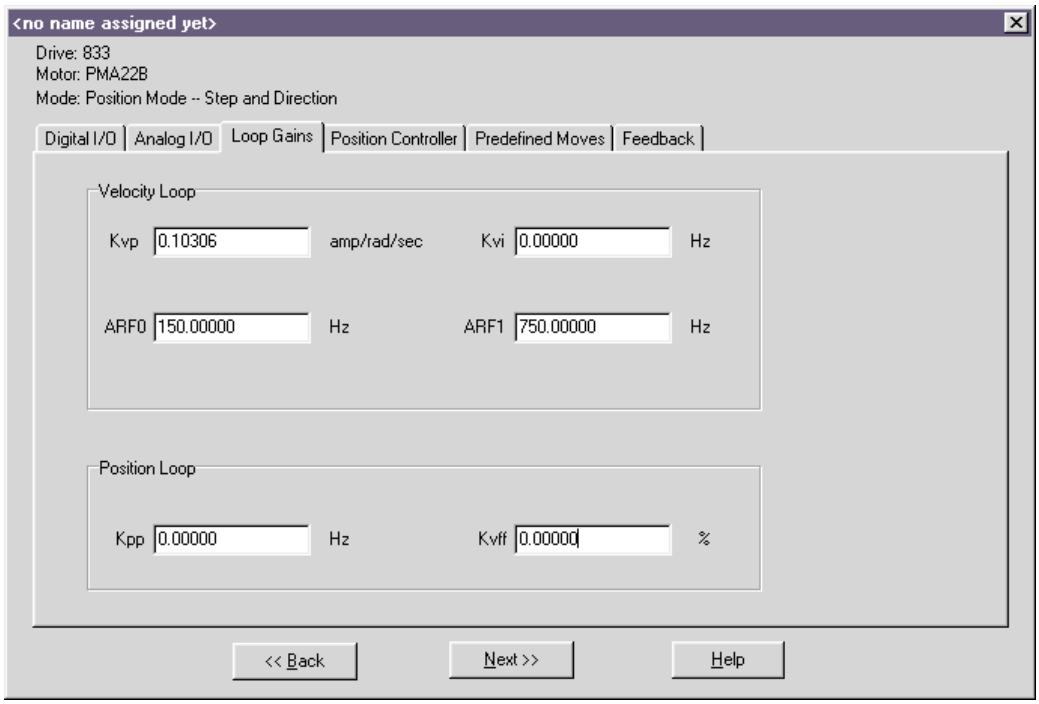
Manual Tuning with SoftScope

Refer to Appendix B for additional details.

Velocity Loop

Procedure

1. **Create New Configuration** for correct motor and drive models using 830 Tools. Use the default setup, including inertia ratio of 1:1 for the Step and Direction mode of operation.
2. In the **LoopGains** tab of the parameter edit window set KVI, KPP, and KVFF:



Set KVI = 0

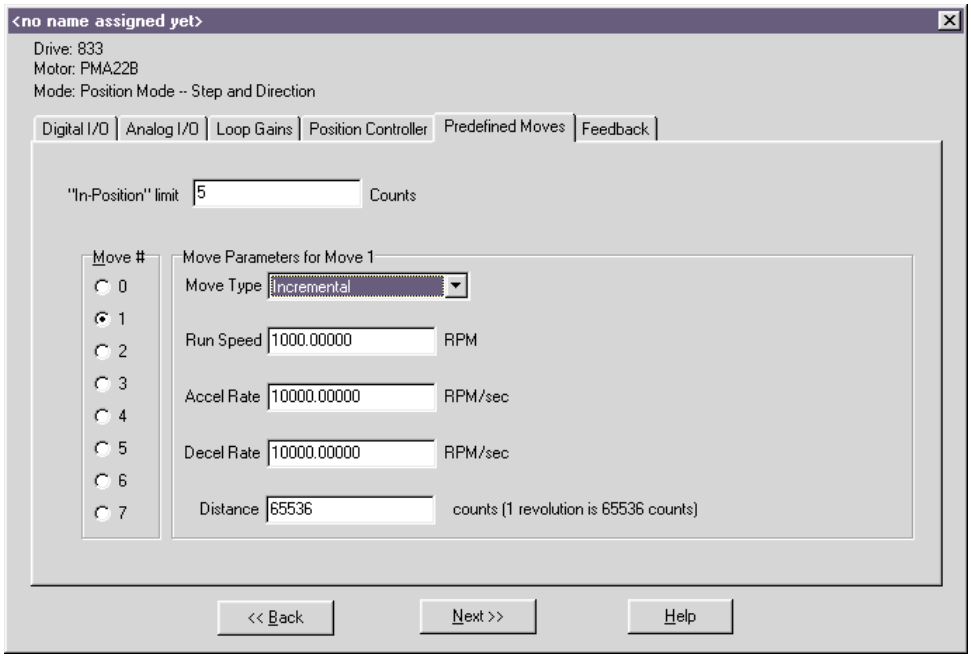
Set KPP = 0

Set KVFF = 100

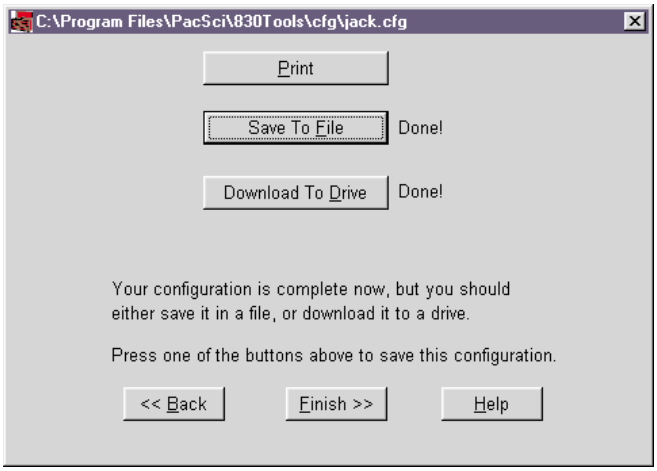
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Procedure (cont'd)

3. In the **Predefined Moves** tab of the parameter edit window set **Move0** as **Incremental** with default profile settings.



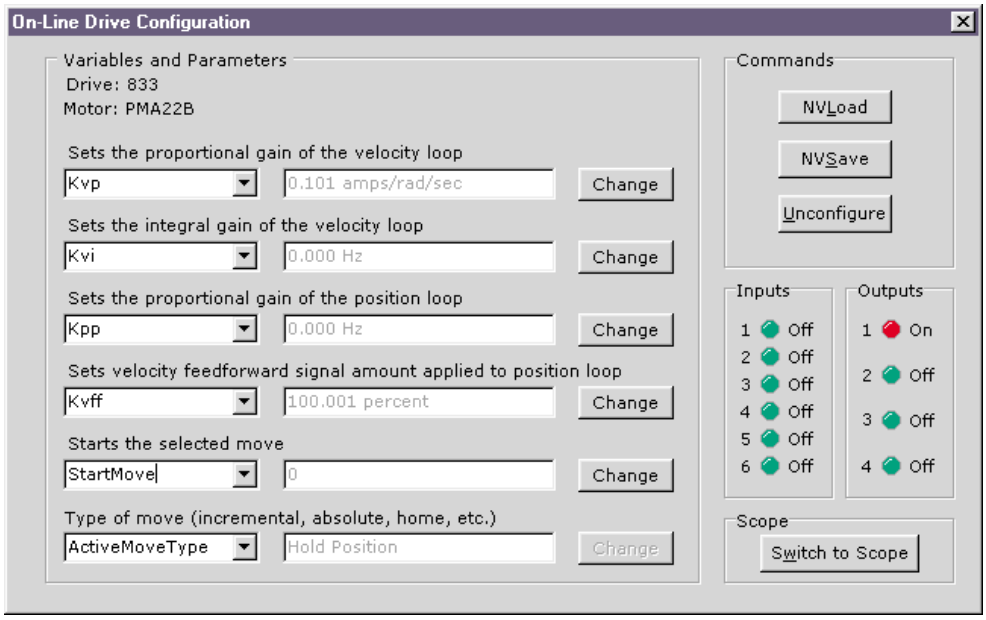
4. Save the Configuration to disk and download to drive.



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Procedure (cont'd)

5. Click on **Edit Drive Configuration Online** button. In the **Variables and Parameters** window type **KVP** in the first box, **KVI** in the second box, **KPP** in the third box, **KVFF** in the fourth box, and **StartMove** in the fifth box.

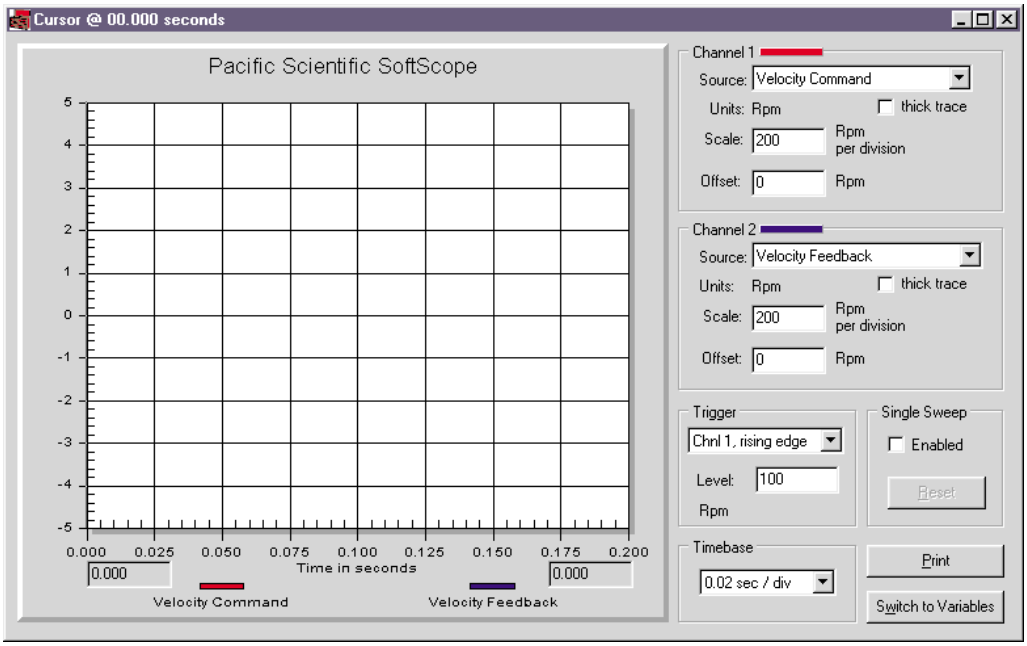


6. Click on **Switch to Scope** and the Oscilloscope will appear.

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Procedure (cont'd

7. Setup Channel 1 for **Velocity Command** and Channel 2 for **Velocity Feedback**. Set the Scales at **200 rpm/div**. Set the Trigger to **Chn1 rising edge** at **100 rpm level**. Set the Timebase to **0.02 sec/div**.

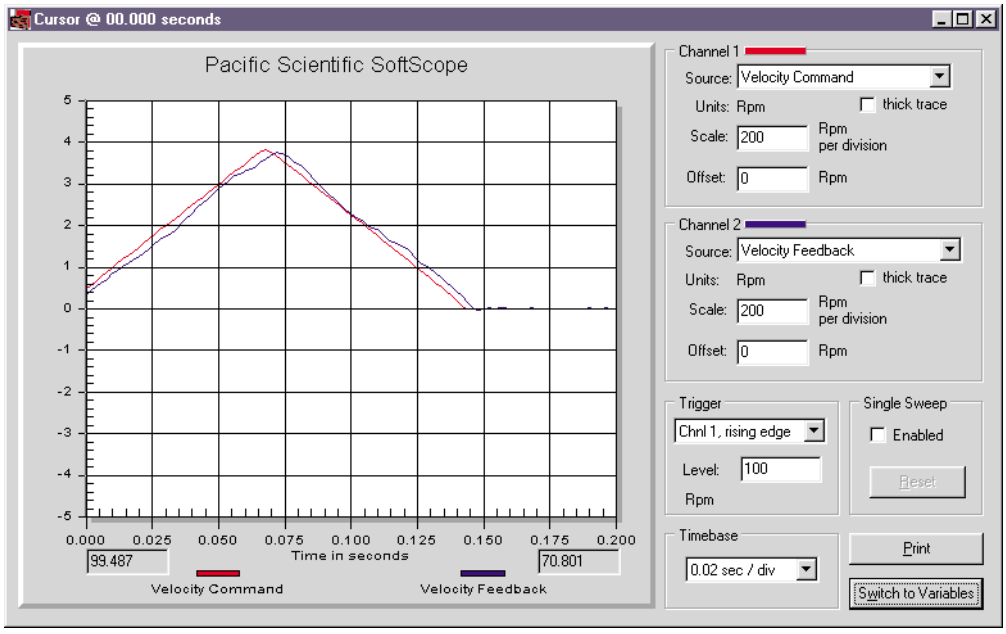


8. Use the **Switch to Variables** button to command an index move and the **Switch to Scope** button to monitor progress.

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Procedure (cont'd

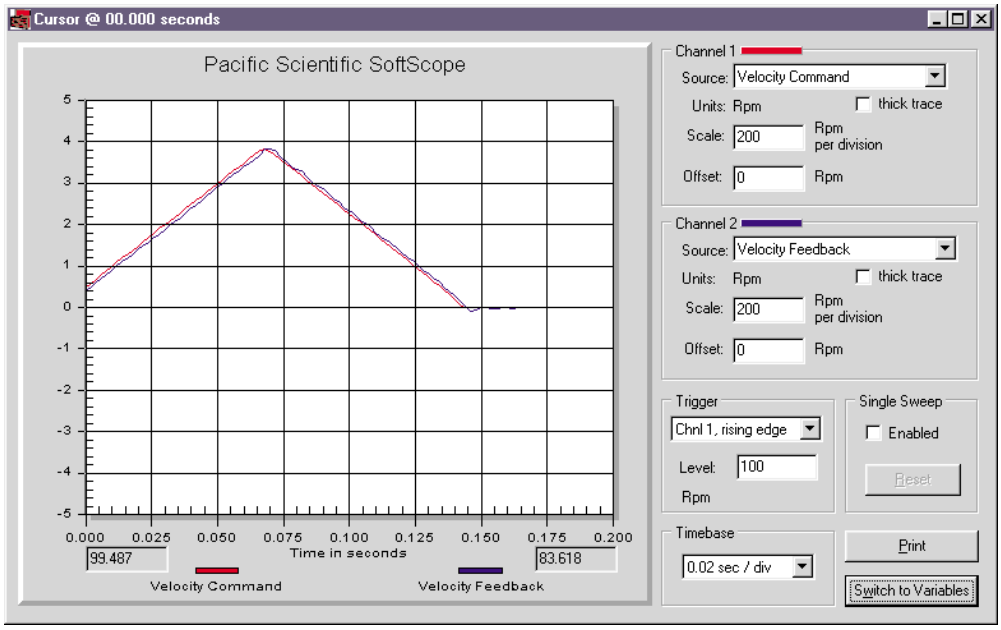
9. In the Variables window, change the StartMove variable from 0 to 1 to start a move. This can be mapped as an input, but you can not change it in software if it is mapped. Slowly increase KVP between move commands, using the change button.



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Procedure (cont'd

10. In the Scope window, monitor **Velocity Feedback** to see how it follows the command. Look for velocity error at speed changes. Increase KVP to optimize performance and miminize velocity error. If the motor starts to buzz, KVP is too large. Disable the drive and reduce KVP 20%.

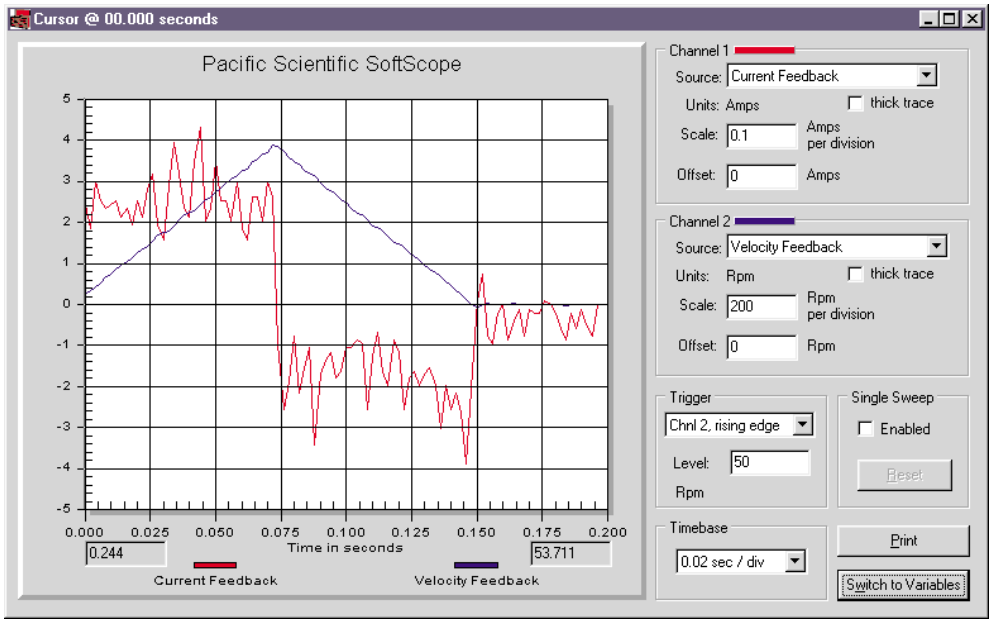


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Tip

You can get more information by monitoring **Current Feedback** instead of **Velocity Command**. When monitoring current, look for oscillations or spikes that are not related to profile rate changes. If these current oscillations are greater than ± 5% of peak rated current, KVP is too large. Also, if the current is oscillating, it reduces available rated current used to drive the profile.

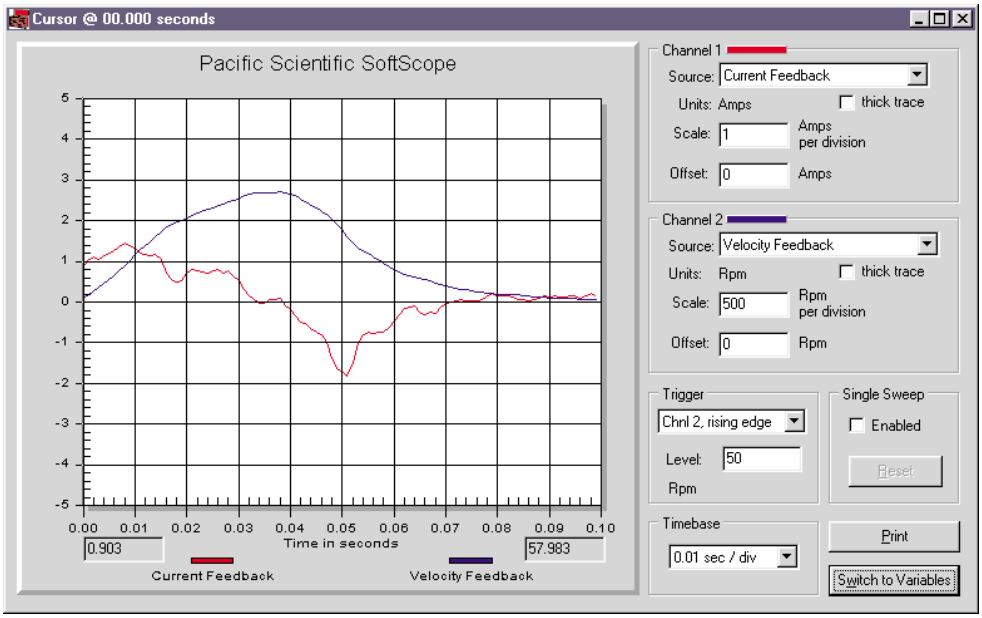
After KVP is optimized, slowly increase KVI up to a maximum of 5. Look for overshoot or oscillation during moves, and reduce KVI if unstable. Then set KVFF = 0 and slowly increase KPP to a maximum of 15. Look for overshoot or oscillation, and reduce if unstable.



In this waveform, the current feedback is extremely low and the ripple shown is acceptable (normal) because it is much less than ± 5% of peak rated current.

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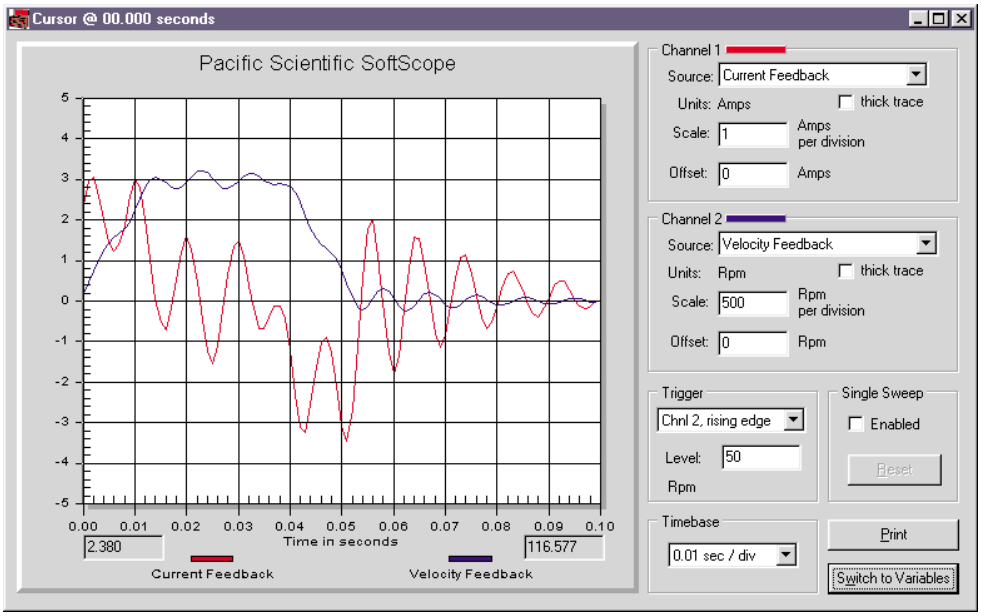
Overdamped



The overdamped (undershooting) velocity loop does not respond to velocity changes (disturbances) quickly. It has soft, smooth motion. It requires extra time to settle. Increasing KVI and/or KVP will bring the system closer to critically damped. Remember, when increasing KVP, the ARFx filters may need to be increased proportionally.

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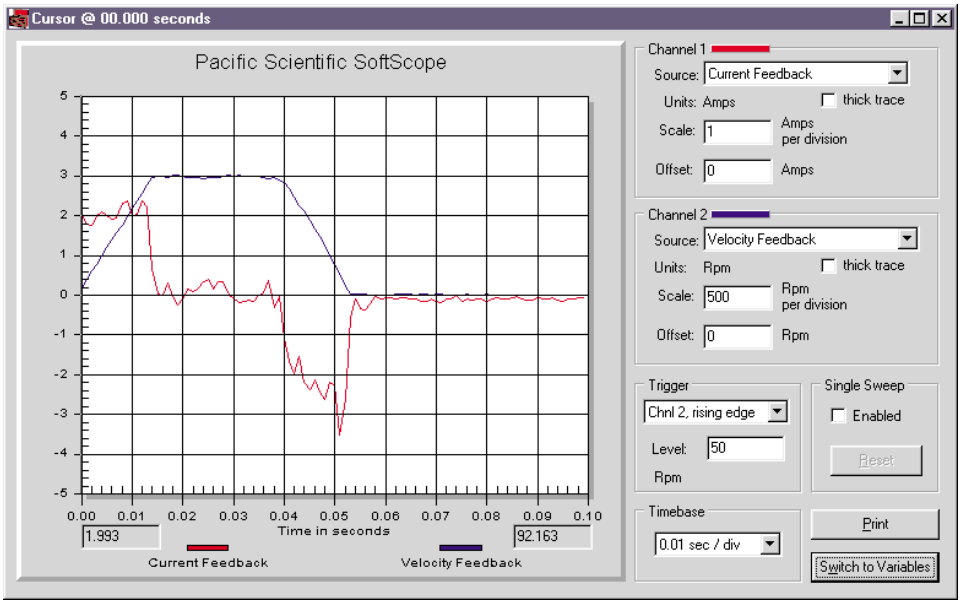
Underdamped



The underdamped (overshooting) velocity loop is an unstable waveform. It has wasted oscillatory motion. It requires extra time to settle. Decreasing KVI and/or increasing KVP will bring the system closer to critically damped. Remember, when increasing KVP, the ARFx filters may need to be increased proportionally. In this waveform, the oscillating current is a result of the ARFx filters being set too low.

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Critically damped



The critically damped velocity loop follows the command without overshoot or undershoot. It has the shortest settling time and no wasted motion. Get as close to this waveform as possible.

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High Inertial Load

Refer to Appendix B for additional details.

The maximum inertia for any given system is predominantly limited by the required system performance and the mechanical system.

Inertia affects system performance in two ways.

1. It limits response because torque is required to accelerate an inertial load. Larger inertia will require larger torque to accelerate. Acceleration is a measure of performance, and is limited by the motor and drive combination. If the load to motor inertia ratio is very large, you will not be able to accelerate the load inertia quickly, and this limits response to speed changes or speed disturbances.
2. Large inertial loads limit available continuous torque because the velocity loop gain needs to be larger for larger inertial loads. Large values of velocity loop gain amplify velocity feedback noise as current commands. The current ripple, due to velocity feedback noise, increases measured rms current and component temperature.

Inertia affects the mechanical system by requiring a proportionally stiff load to motor coupling to maintain a given system bandwidth. A directly coupled load can have higher inertia ratios than a belt system due to stiffness of the coupling device. When coupling stiffness is lowered, the system's natural resonant frequency is lowered. If the system's natural resonant frequency is lowered close to the velocity bandwith crossover frequency, then the mechanical system may be exited by noise in the velocity loop. Under certain conditions, the mechanical system will resonate.

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Mechanical Resonance

Excitation

There is always a mechanical natural resonant frequency. It is only a problem if it becomes excited. To reduce the possibility of excitation, mechanical systems should be designed with very high natural resonant frequencies. If the natural resonant frequency is much greater than the servo loop bandwidth, there will be no problems. The mechanical natural resonant frequency is dependent upon drive train coupling stiffness and load + motor inertia ratio.

In order to increase the mechanical system natural resonant frequency either decrease total system inertia or increase coupling stiffness.

Inertia Ratio

When the motor current is commanded sinusoidally above the mechanical systems natural resonant frequency, the load can decouple from the motor and the load will no longer follow the motor. When the commanded frequency is at the mechanical resonant frequency, the load is moving exactly opposite from the command (approx. 180° phase lag) and the movement can become violent. If the load decouples (command frequency > resonant frequency), the mechanical system looks like a motor only system to the drive. In a servo velocity loop total inertia and loop gain determine system bandwidth, when the system jumps from fully loaded (coupled) to unloaded (decoupled) the bandwidth jumps from BW to BW*Inertia ratio. If the inertia ratio is 10:1 and the fully loaded bandwidth is 75 Hz, then the decoupled BW will be 750 Hz. The system will be unstable for any BW more than the drives limit of 400 Hz. We could either reduce the fully loaded BW to 40 Hz by reducing gain, or we could reduce the inertia ratio to 5:1 to resolve the issue of resonance. This method allows the system to ride through the resonance without going unstable because the decoupled bandwidth remains below 400 Hz.

Filtering

There is another method to resolve the issue of resonance. The Anti-Resonance Filters can be used to prevent noise from exciting a resonance frequency. This method works very well if the resonant frequency is much greater than the operating velocity loop bandwidth. You can estimate where to place the filters by measuring the current feedback oscillation frequency using the softscope.

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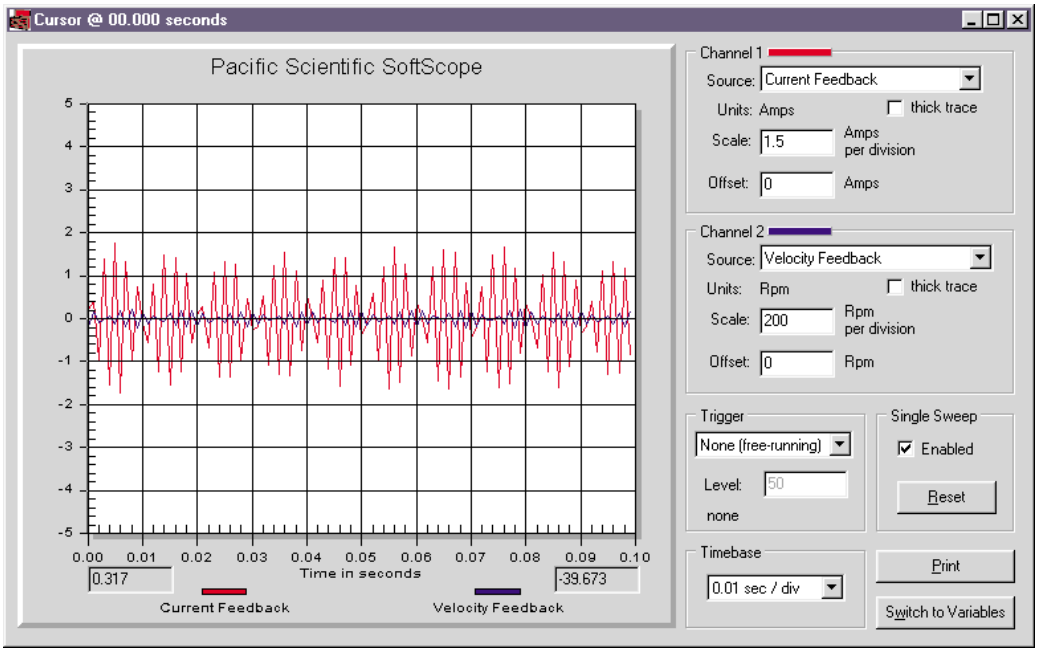
Example

To get a fair estimate, set:

KPP = 0
KVI = 0
KVFF = 100
KVP = (25[Hz]*MotorInertia*6.28/Kteff)
ARF0 = ARF1 = 10,000

With the motor enabled and holding zero speed, slowly increase KVP.

Monitor current feedback with the softscope. When the current begins to oscillate > 5% of the drive IPeak, capture the waveform and disable the drive. Now measure the positive peak to next positive peak cycle time (Tc) of the current feedback waveform (Frequency = 1/Tc). It is easier to count the number of peaks in 10 divisions and divide into total time.



This screen capture is not a true representation of the signal waveform due to the sample resolution. However, counting the peaks over 10 divisions shold provide adequate results in most cases.

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Procedure

In this example there is an oscillation of 450 Hz.

1. Set ARF0 = ARF1 = 450 Hz/2.0 = 225 Hz.
2. Monitor current again. If oscillation is gone, increase KVP to excite it again and repeat procedure. If oscillation is the same frequency, reduce ARF0 and ARF1 to reduce the amplitude of the oscillation further.
3. Repeat until the oscillation gets worse, or the oscillation frequency changes to match the filter frequency. In either of these two cases, KVP will need to be reduced and/or ARFs will need to be increased.

Inertia and Bandwidth

Overview

The velocity loop bandwidth (BW) is very useful information when setting KVI and KPP parameters. These parameters are totally dependent on the value of the velocity loop bandwidth. Unfortunately, BW is not readily available. It must be calculated based on the total system inertia. It is the total system inertia value that is the most difficult number to acquire. Once the inertia is known, the BW equation is easy to solve.

Bandwith

BW is the range of frequencies where the motor can adequately follow the command. As the BW is increased, the system response is increased. A higher frequency command is a faster changing command. Think of feedback error as a command. Higher BW systems respond to feedback disturbances faster. How do you calculate BW?

$$BW[Hz] = KVP * Kteff / (6.28 * Jt[Lb\text{-}in\text{-}s^2])$$

$$Kteff[Lb\text{-}in/A] = Ke[V/krpm] * 0.08454 * 0.866$$

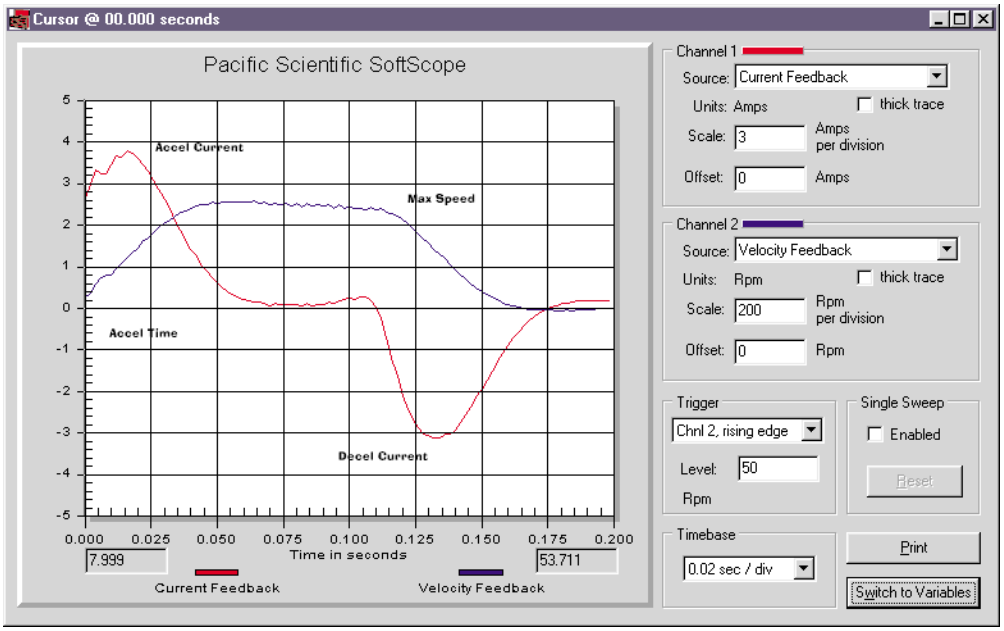
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Inertia

There are two ways to calculate total system Inertia.

1. Measure all the mechanical parts separately. Using a software sizing package similar to “Optimizer”, enter all the mechanical data. The sizing package should have a data point for total reflected system inertia.

2. During installation of the prototype machine, when you are going to test the drive anyway, perform the standard motor/drive setup. You need to be able to create stable motor motion to perform this test. If the motor is unstable, read through the tuning section to determine how to make it stable. Setup an index move. The move has to be aggressive to create substantial accel current in order to increase signal to noise ratio. Run the index move and use the softscope to monitor velocity feedback and current feedback.



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From the scope traces record accel current, traverse current, decel current, traverse max velocity, and time to accel to traverse velocity.

Factor out friction and load force from the current

Inertial Current[A] = accel current - traverse current
note: polarity matters

or

Inertial Current[A] = (accel current - decel current)/2
note: polarity matters

Inertial Current[A] = (3.8*3 + 3.2*3)/2 = 10.5[A]

Inertial Torque[Lb-in] = Inertial Current[A] * Kteff[Lb-in/A]

Inertial Torque[Lb-in] = 10.5*2.28 = 23.94[Lb-in]

Determine acceleration rate

AccelRate[rpm/s] = traverse velocity[rpm] / acceltime

AccelRate[rad/s^2] = AccelRate[rpm/s] * 0.10467

AccelRate[rad/s^2] = (2.5*200/0.05)*0.10467 = 1046.7 [rad/s^2]

Determine Inertia

Inertia[Lb-in-s^2] = Inertial Torque[Lb-in] / AccelRate[rad/s^2]

Inertia[Lb-in-s^2] = 23.94/1046.7 = 0.0229 [Lb-in-s^2]

By calculating mechanical system = 0.024 [Lb-in-s^2]

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6 Diagnostics and Protection Circuits

Introduction

The drive is fully protected against “normal” abuse and has two LEDs on the front panel to indicate drive status. The servo drive has the following specific protections:

- Output motor short circuit protection line-to-line and line-to-neutral.
- Interface to Pacific Scientific's standard motor PTC or a normally closed thermostat to sense motor over temperature.
- Internal monitoring of the power stage heat sink temperature for drive over temperature.
- Bus over voltage detection.
- Bus under voltage fault with adjustable threshold.
- Incorporating the measured heat sink temperature there is an excessive current I*t fault. This fault limits the peak current time and intelligently changes the continuous current fault trip dependent on the measured heat sink temperature to limit the continuous output current.
- Control voltage under voltage detection.
- The user +5V output is short circuit to I/O RTN protected.
- The user +24V output is short circuit protected.
- All control outputs are short circuit to I/O RTN protected.
- When a drive is powered up without valid parameters the power stage cannot be enabled and no damage occurs to the drive.

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Fault generation

The following sequence will occur when the protection circuits generate a fault. The fault source is latched, the output stage is disabled, the Fault mappable output function is activated, and the LED indicates the appropriate fault code. Faults are cleared by activating the Fault Reset input or by turning the 120/240 VAC Control Power OFF and then ON again.

Drive Status LEDs

See the following table for a detailed list of drive status LED codes.

Drive Status	Fault LED (Red)	Power LED (Green)
Faulted	If FaultCode < 6, Blinking If FaultCode ≥ 6, On	On
Enabled	Off	On
Disabled	Off	Blinking
Unconfigured	Blinking	Blinking
Unplugged	Off	Off

Note: *If FaultCode < 6, the red LED will blink the faultcode at a frequency of 1 Hz (on and off in 1 sec) then it will be off for 2 seconds before blinking the sequence again.*

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FaultCode List

Note: *If FaultCode < 6 , the Fault LED will blink the value of FaultCode. For example, if FaultCode = 2, the Fault LED will blink twice, pause for 2 seconds, and repeat the sequence. There is a 2 second pause between each Fault LED sequence.*

Fault LED	FaultCode	Fault Description
Blinking	1	Velocity feedback (VelFB) over speed*
	2	Motor over temperature
	3	User +5V low
	4	Continuous current fault
	5	Drive over current (instantaneous)

Fault LED	FaultCode	Fault Description
On	6	Control ±12 V under voltage
	7	Not Assigned
	9	Bus over voltage detected by DSP, External Regen Fault
	10	Not Assigned
	11	Bus under voltage* (Only if VBus < VBusThresh)
	12	Ambient temperature too low
	13	Encoder alignment failed*
	14	Software and non-volatile memory versions not compatible
	15	Hardware not compatible with software version
	16	UnConfigured drive fault
	17	Two AInNull events too close together
	18	Position following error fault
	19	Parameter memory error*
	20	Initialization fault*
	21	Drive over temperature
	22	Resolver Fault

*To further identify this fault see software variable ExtFault.

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ExtFault The following table lists the values for ExtFault.

ExtFault	ExtFault Description
1	Absolute Resolver Overspeed. |VelFB| > 21038 RPM
2	Variable Resolver Overspeed. |VelFB| > max(VelLmtxx)*1.5
3	Calibration data corrupted*
4	Excessive dc offset in current feedback sensor*
5	DSP incompletely reset by line power dip*
8	Excessive dc offset in Analog Command A/D*
9	Not Assigned
10	DSP stack overflow*
12	Software and control card ASIC incompatible*
13	Actual Model not same as stored in NV memory*
14	Unable to determine power stage*
15	Drive non-volatile parameters corrupt*
16	RAM failure*
17	Calibration RAM failure*
18	Encoder alignment: no motion fault
19	Encoder alignment: excessive motion fault
20	Encoder alignment: motor not settled
21	Encoder alignment: test failed
22	Encoder alignment: motion overflow fault
23	Hall Commutation: invalid configuration
24	Hall Commutation: overspeed
25	Hall Commutation: invalid hall state
26	Hall Commutation: invalid hall transition
27	I*t Drive
28	I^2*t Motor

*These fault states CANNOT be reset with the Fault Reset function and require the line control power to be turned OFF and ON again.

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Fault LED Troubleshooting

Introduction

A table of faults and their possible causes is listed below.

If FaultCode < 6 , the Fault LED will blink the value of FaultCode. For example, if FaultCode = 2, the Fault LED will blink twice. If Faultcode ≥6 the Fault LED is ON.

FaultCode	Possible Cause
1	Loose or open circuit wiring to the resolver feedback connector J3.
	Actual motor speed exceeded 1.5 * (Max Of |VelLmtLo| or |VelLmtHi|) or 21,038 RPM which is the over speed trip level.
	For Encoder velocity feedback (RemoteFB = 2) check that EncIn is set properly.
2	Loose or open circuit wiring to motor PTC thermal sensor (J3-8, J3-9).
	High ambient temperature at motor.
	Insufficient motor heat sinking from motor mounting.
	Operating above the motor's continuous current rating.
3	Short circuited wiring on the output (J2-25).
4	Mechanically jammed motor.
	Motion profile accelerations too high.
	Machine load on the motor increased by a friction.
	Problem with wiring between drive and motor yielding improper motion.
	Drive and/or motor under sized for application.
	Note: *See HSTemp, ItFilt, and ItF0 for information on measuring thermal margin in an application.*

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FaultCode	Possible Cause
5	Motor power wiring (TB1-4, 5, or 6) short circuit line-to-ground/neutral.
	Motor power cable length is enough longer than the data sheet specification to cause excessive motor line to earth ground/neutral capacitance.
	Internal motor winding short circuit.
	Insufficient motor inductance causing output over current faults.
	KIP or KII improperly set causing excessive output current overshoots.

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Fault LED ON The Fault LED will be ON when FaultCode ≥ 6.

FaultCode	Possible Cause
6	Insufficient control AC voltage on TB1-1 to TB1-2.
	External short on signal connector.
	Internal drive failure.
7	Not Assigned.
9	Disconnected external regeneration resistor on TB1.
	External regeneration resistor ohmage too large yielding Bus OverVoltage fault.
	External regeneration resistor short circuit.
	Motor AC power input voltage too high.
10	Not Assigned.
11	Check the measured bus voltage VBus and the fault threshold VBusThresh to make sure they are consistent.
12	Ambient temperature is below drive specification. Drive's internal temperature sensor has a wiring problem.
13	Encoder Alignment failure. See ExtFault for additional information.
14	Not Assigned.
15	Attempt to upgrade the drive's software will not work. Contact factory for upgrade details.
	Resolver wiring error. Remove J2 and J3 connectors. Turn AC power OFF and then ON again. If FaultCode = 2, then correct resolver excitation wiring.
	Internal failure. Return to factory for repair.
16	Unconfigured drive (Red and Green LEDs blinking after power up) was fully configured with the drive motor power enable active. This fault can be reset or the control AC power turned OFF and then ON again to get the drive-motor operating.

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Fault LED ON

FaultCode	Possible Cause
17	The AInNull function was re-activated too soon after going inactive. This can be caused by switch bounce on the input pin mapped to activate AInNull.
18	The motor is either stalled or partially jammed.
	The value for PosErrorMax is set too sensitive for the loop tuning and commanded motion profiles.
19	Glitch while last saving the NV parameters. Corrupted NV memory contents. Hardware problem with the NV memory. Re-Download parameters to restore drive operation.
20	Initialization Failure. See ExtFault for additional information.
21	High drive ambient temperature. Restriction of cooling air due to insufficient space around unit.
	Operating above the drive's continuous current rating.
	Note: *See HSTemp, ItFilt, and ItF0 for information on measuring thermal margin in an application.*
22	Resolver signal is lost or intermittent. Check resolver cable.

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Appendix A Specifications

A.1 Output Power Specifications

	PC8x2	PC8x3	PC8x4
Peak Output Current (RMS)[1]			
5 seconds, (0 to 40°C) Ambient	5.3A_{RMS}	10.6A_{RMS}	21.2A_{RMS}
Continuous Output Current (RMS)[2]			
Convection (0 to 40°C) Ambient	2.7A_{RMS}	3.6A_{RMS}	7.1A_{RMS}
Forced Air (0 to 40°C) Ambient[3]	N/A	5.3A_{RMS}	10.6A_{RMS}
Peak Output Power			
Idealized Electrical Max (rectangular torque vs. speed)	2.25kW	4.5kW	9.0kW
Drive & Motor System Output Power			
240 VAC three phase[4] (5 seconds)	1.35 to 1.58kW	2.7 to 3.15kW	5.4 to 6.3kW
240 VAC single phase (1 second)	1.25 kW	2.5 kW	5.0 kW
120 VAC single phase (1 second)	.63 kW	1.25 kW	2.5 kW

1 To convert A_{RMS} to A (0-pk) multiply A_{RMS} * 1.41.
Peak current (5 sec): PC833 = 15A (0-pk), PC834 = 30A (0-pk)

2 Above 40°C ambient, linearly derate so that 50°C rating = 0.67*40°C rating.

3 Forced air requires 3.6” x 1” fan mounted 2” below the drive.

4 Varies with the motor. Maximum peak output power with most motors is between 60% to 70% of Idealized Electrical Max.

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A.1 Output Power Specifications (Cont'd)

	PC8x2	PC8x3	PC8x4
Continuous Output Power Drive & Motor System @ Convection Ambient			
240 VAC three phase	1.1kW	1.5kW	3.0kW
240 VAC single phase	1.1kW	1.5kW	2.0kW*
120 VAC single phase	550W	750W	1.0kW*
RMS Line Current @ Continuous Output Power Convection Ambient			
240 VAC three phase	4.5 A	6 A	12 A
240 VAC single phase	9 A	12 A	16 A*
120 VAC single phase	9 A	12 A	16 A*

*Single phase operation of the PC8x4 requires derating of continuous output power to avoid excessive line and front end currents.

Power Stage Efficiency @ P_{cont}	98%	98%	98%
Shunt Regulator Power			
Peak Power (500 mSec)	12.8kW	12.8kW	12.8kW
Continuous Power**	800W	800W	800W
Maximum External Regen Duty Cycle	6%	6%	6%
Bus Capacitance Energy Absorption			
From 320V Nominal Bus	20J	30J	40J

**See Appendix E, *Using External Regen* for additional information.

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A.1 Output Power Specifications (Cont'd)

	PC8x2	PC8x3	PC8x4
Output Current Ripple Freq f_s	20 kHz	20 kHz	16 kHz
Minimum Motor Inductance l-l	4.0mH	2.0mH	1.25mH
Maximum Motor Inductance l-l	4H	2H	1H
Maximum Motor Power Cable Length	----------50 m/164ft----------		

A.2 Input Power Specifications

The drive is capable of direct line operation. All units are fully isolated and do not require external isolation transformers. Also, the inrush current on the connection to the line is internally limited to a safe level for the drive. There are no voltage selection or ranging switches required to operate within the specified voltage input ranges. It is the responsibility of the user to supply appropriate fuses or circuit breakers in the TB1 AC Power motor power lines to comply with local electrical codes.

The control input power required should be between 15 and 25 Watt. The AC input motor power depends on output power and the losses in the power stage. The control power input has a single UL/CSA rated fuse in line with one of the AC line inputs.

PC800 Control Power Supply

Input Voltage Range	85 to 265 VAC, 47 - 440 Hz single phase or 130 to 370 Vdc	
Ride Through Time For AC Line Drop	90 VAC 50 Hz	>0.7 50 Hz cycle
	120 VAC 60 Hz	>2.1 60 Hz cycles
	240 VAC 60 Hz	>13.3 60 Hz cycles

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PC830 Motor AC Power Supply

Model Number	Voltage Range	Phases	Transformer Suggested kVA	Maximum AC Line* kVA
PC8x2	90-265 Vac	1 or 3	1.5 to 3 kVA	100 kVA
PC8x3	90-265 Vac	1 or 3	2 to 4 kVA	100 kVA
PC8x4	180-265 Vac	3	3 to 6 kVA	250 kVA

*Maximum AC Line is specified to limit the line surges coupled to the drive.

Bus Voltage (nominal, standard drive)

240 VAC Three Phase Input . . . . 320 VDC

120 VAC Single Phase Input . . . 155 VDC

PC830 Inrush Current & Fusing

Model Number	Inrush Peak Current	Inrush Pulse Width	Fuse Type	Manufacturer, Part Number
PC8x2	300 A 0-p	1.0 msec	10 A 250 V Time Delay	Bussmann, MDA-10
PC8x3	300 A 0-p	1.5 msec	20 A 250 V Time Delay	Bussmann, MDA-20
PC8x4	300 A 0-p	2.0 msec	30 A 250 V Slo-Blo	Littlefuse, FLM 30

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A.3 Performance Characteristics

Note: *Unless otherwise specified, the below specifications are worst case limits and apply over the specified operating ambient temperature and over the specified operating line voltage.*

Motor Current Control

Motor Phase Current Waveform	Back EMF Matched Pseudo Sine
Motor Shaft Torque (Ignoring motor magnetic saturation)	
Peak (hot)[5]	K_t (Nm/A_{RMS})*Drive Ipeak (A_{RMS})
Instantaneous	K_t (Nm/A_{RMS})*IFB/$\sqrt{2}$
Bandwidth	
Maximum Bandwidth	1.5 kHz
Recommended Bandwidth	1.0 kHz
Bandwidth Variation For Fixed Motor L	± 10%
Bandwidth Variation For ± 25%	
AC Line Variation	± 2%
Update Period	62.5 μsec
Recommended Motor Electrical Frequency	< 400 Hz

5 Multiply by 1.06 for cold K_T (PMA motors).

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Analog Command

Maximum Differential Range	±13.5 Volts
Maximum Single Ended Range	±21 Volts
Full Scale Tolerance	±5% (worst case)
	±1% (typical)
Linearity	0.1% Full Scale
Monotonic to	$< 2^{-16}$ Full Scale
S/N Ratio Referred to Full Scale	
Full A/D Bandwidth	14 bits
150 Hz A/D Bandwidth	16 bits
10 Hz A/D Bandwidth	18 bits
Offset	Adjustable to 0
Maximum Unadjusted Offset	50 mV
Offset Drift	250 μV/°C typ.
CMRR	> 30 dB @ 60 Hz

Digital Position Commands

Modes	Quadrature Encoder, Step & Direction, or Up & Dn Count
Maximum Input Rate For Fast Decode	
Quadrature Decode Max Line Frequency	800 kHz
Step/Dir Decode Max Step Frequency	800 kHz
Up/Dn Count Max Frequency	800 kHz
Minimum Fast Decode Pulse Width	0.6 μSec
Fast Decode Direction Setup Time	0.6 μSec
Fast Decode Direction Hold Time	0.6 μSec
Relative Timing For Filtered Decode	4, 8, or 16 to 1 e.g. Max Step Freq 800, 200, 100, or 50 kHz

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Velocity Loop

Maximum Stable Bandwidth	> 400 Hz
Update Period	250 μSec
Range	0 to 21,000 RPM
Command Resolution	< 0.001 RPM
Velocity Loop Compensation Parameters	
KVP Range (Depends on Ipeak)	0 to 12.6 (I_{peak})(1/rad/sec)
KVP Resolution	16 bit
KVI Range	0 to > 200 Hz
KVI Resolution	16 bit
ARF0* Range	0.01 to > 1e5 Hz
ARF1* Range	0.01 to > 1e5 Hz
ARZ0* Range	0 to > 1e5 Hz or off
ARZ1* Range	20 to > 1e5 Hz or off
CMDGAIN Range	0 to ±15,000 RPM/V
	0 to ±10(I_{peak}) V^{-1}
CMDGAIN Resolution	≥ 16 bit mantissa

*ARx0 set to a negative number allows complex poles/zeros. In this case, ARx1 becomes the Q and the corresponding |ARx0| is the frequency in Hz.

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Position Loop

Maximum Stable Bandwidth	> 100 Hz
Update Period	1 mSec
Position Range	0 to ± 32768 Rev
Position Error Range	0 to ± 4500 Rev
Command Resolution	2^{-16} Rev = 0.33 arc min
Position Loop Compensation Parameters	
KPP Range	0 Hz to > 150 Hz
KPP Resolution	16 bit
KVFF Range	0 to 199.9%
KVFF Resolution	16 bit

General

Max Delay AC Line To Control Supply On	1.0 Sec
Max Delay AC Line To Fully Operational	2.0 Sec

Environmental

Storage Temperature	-40°C to 70°C
Humidity, non-condensing	10% to 90%
Altitude	1500 m (5000 feet)

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A.4 Resolver Feedback Specifications

Note: *Unless otherwise specified, the below specifications are worst case limits and apply over the specified operating ambient temperature and over the specified operating line voltage.*

Resolver Position Signal

Resolution/Rev	24 bits = 0.0013 arc min
Repeatability	$< \pm 2^{-18}$ Rev = ±0.08 arc min rms
Noise	
No Filtering	$< 2^{-16}$ Rev rms = 0.3 arc min rms
150 Hz Single Pole Filtered	$< 2^{-17}$ Rev rms = 0.16 arc min rms
10 Hz Single Pole Filtered	$< 2^{-19}$ Rev rms = 0.04 arc min rms
dc Offset Temperature Drift	$< 2^{-18}$ Rev/°C = 0.08 arc min/°C
Absolute Accuracy	
Drive only	$\pm 2^{-12}$ Rev = ±5.3 arc min
Drive with 20 arc min resolver	$\pm 2^{-9.75}$ Rev = ±25 arc min
Software Update Time	1 mSec

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Resolver Velocity Signal

Resolution	< 0.001 RPM
Quanta	= 0.0143 RPM
Noise	
No Filtering	< 3 RPM rms
150 Hz Single Pole Filtered	< 0.6 RPM rms
10 Hz Single Pole Filtered	< 0.06 RPM rms
DC Accuracy	
Typical @ 25°C	±0.01%
Worst case	±0.05%
Ripple	
Drive only	0.75% p-p at 1000 RPM
Drive with 20 arc min resolver	3% p-p at 1000 RPM
Offset	< 0.0001 RPM
Software Update Time	250 μSec

Emulated Encoder Output Signals

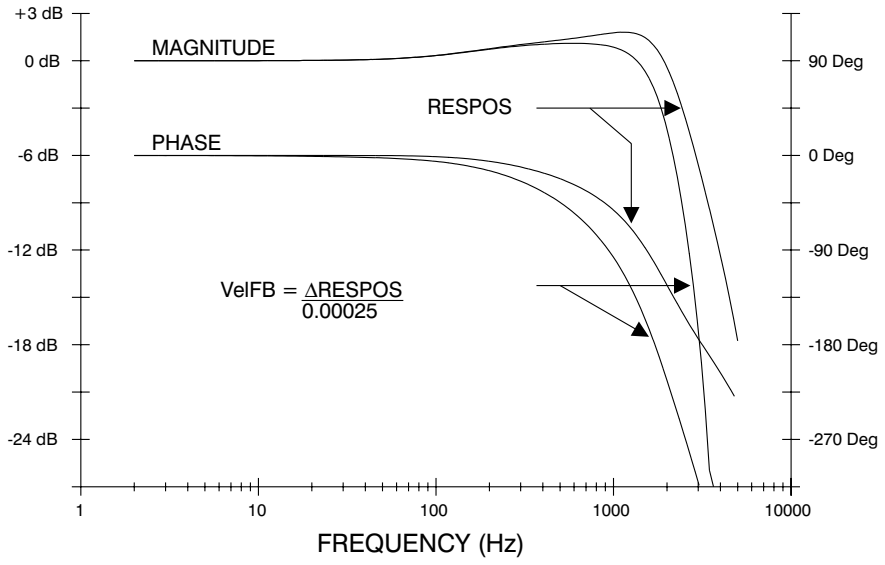
Available Resolutions (PPR)	
Binary	128, 256, 512, 1024, 2048, 4096, 8192, 16384
Decimal	125, 250, 500, 1000, 2000, 4000, 8000, 16000
Maximum Output Line Frequency	833 kHz
Max Recommended Speed @ 16384 PPR	2900 RPM
Max Recommended Speed @ 4096 PPR	11600 RPM
Marker Pulse Width	≈ 1 Quadrature Pulse

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General

-3 dB Bandwidth	> 1500 Hz
-45° Phase Lag	> 400 Hz
Resolver Excitation Frequency	6510.42 Hz
Max Tracking Rate	> 48600 RPM
Max Recommended Rate	25 kRPM
Max Tracking Acceleration	> $16x10^6$ RPM/Sec
Maximum Feedback Cable Length	50 m/164 ft

Nominal Frequency Response



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The PC830 packaging is totally enclosed single axis panel mount. The figure on the next page gives the key dimensions for use in physically mounting the product. When mounting multiple units on one panel there should be at least 20 mm (0.75") of air space on the sides and 40 mm (1.5") or air space above and below the unit.

When mounting multiple drives in a row some customers have found the stiffness of the drive and their mounting panel to be too low. To increase the mounted mechanical integrity, connect to the threaded insert on the top front edge.

The overall drive panel dimensions and the mounted depth not including mating connectors is listed in the below chart. The extra depth for mating connectors is 1.0" or less.

Dimensions

Model	Height	Width	Depth
PC8x2	198.1 mm/7.8"	88.1 mm/3.47"	158 mm/6.22"
PC8x3	198.1 mm/7.8"	88.1 mm/3.47"	158 mm/6.22"
PC8x4	198.1 mm/7.8"	114 mm/4.49"	158 mm/6.22"

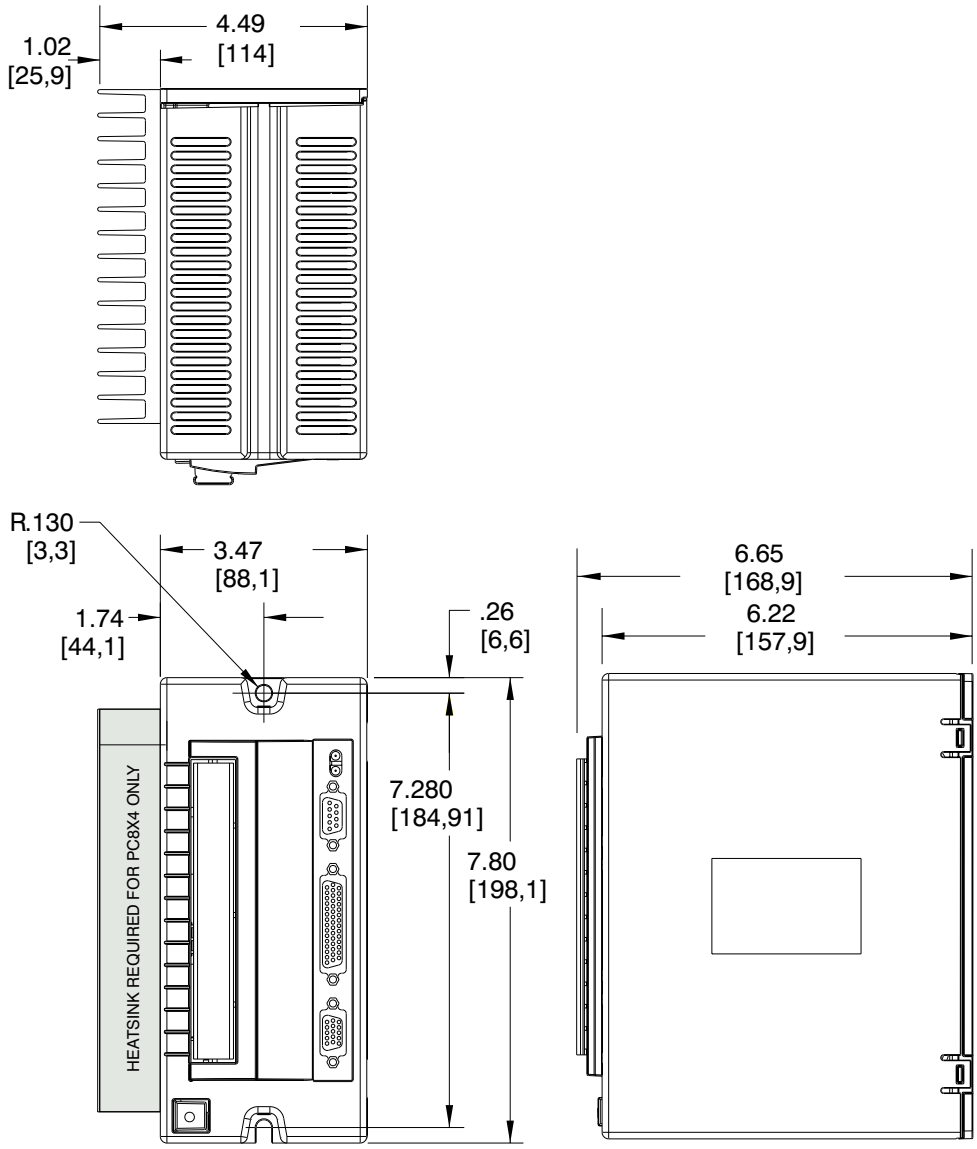
Weight

Model	Weight
PC8x2	1.9 kg/4 lb
PC8x3	2 kg/4.3 lb
PC8x4	2.6 kg/5.7 lb

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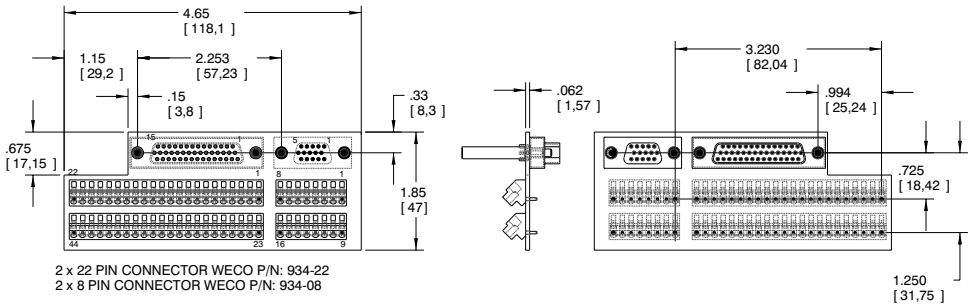
Drive Mechanical Outline

PC8X2/3/4



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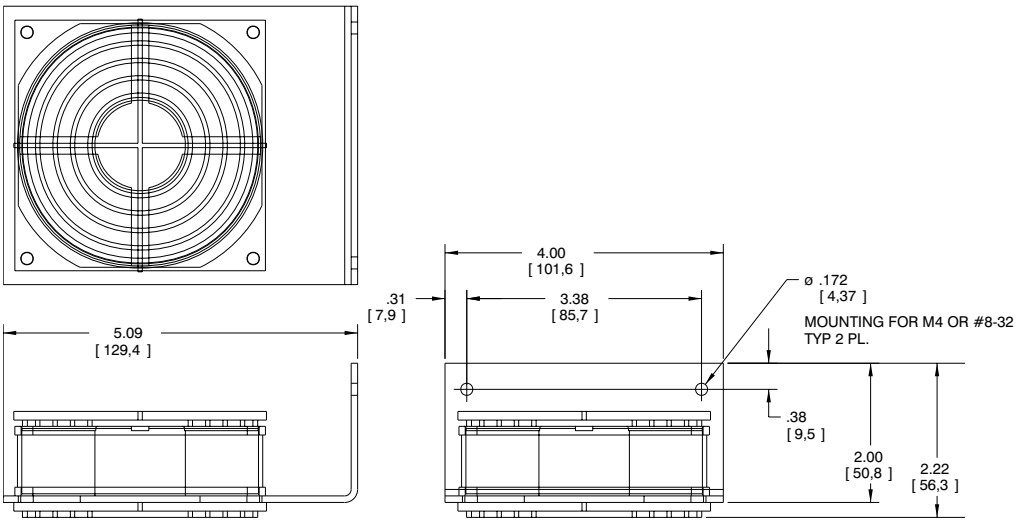
PC830 Terminal Block Adapter



2 x 22 PIN CONNECTOR WECO P/N: 934-22
2 x 8 PIN CONNECTOR WECO P/N: 934-08

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Fan Option Kit



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Appendix B Servo Loop Parameters

Introduction

This chapter describes setting parameters associated with the velocity and position loops. In many cases, satisfactory operation is achieved using **Create New Configuration** or **Edit Existing Configuration** buttons. However, in some cases the user must adjust control loop parameters due to large mismatches between motor and load inertia, mechanical resonance, backlash, etc. This chapter provides guidance for handling these situations.

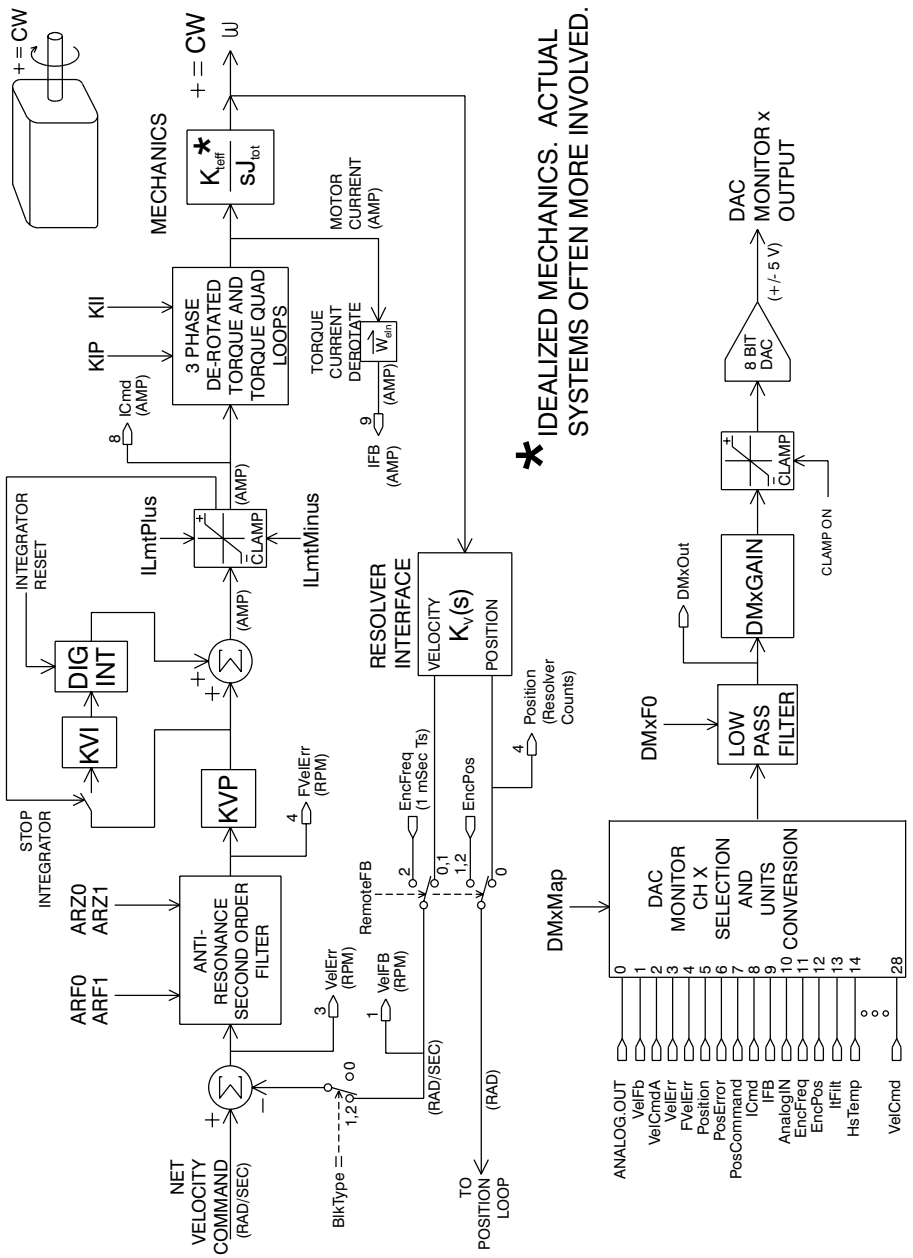
Note: *The two anti-resonant zeroes (`ARZ0` and `ARZ1`) are assumed to both be off (set to zero) for this discussion.*

B.1 Velocity Loop

Velocity loop bandwidth is the key indicator of system performance. Systems with fast settling time must have high velocity loop bandwidth. Conversely, if the velocity loop bandwidth is low, attempting to achieve fast settling time by increasing the position loop bandwidth, `KPP`, leads to overshoot and ringing.

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Velocity Loop



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Velocity loop bandwidth

The velocity loop bandwidth (f_{vc}) is given by the equation:

$$f_{vc}(Hz) = \frac{KVP * K_T \; \sqrt{3}/2}{2\pi * J_{TOT}} \approx 0.138 * KVP * \frac{K_T}{J_{TOT}}$$

where:

KVP is the velocity loop proportional gain in amps/(rad/sec)

K_T is the 0-peak line-line motor torque constant in lb-in/amp

J_{TOT} is the total inertia (motor total + load total) in lb-in-sec^2.

(Any consistent set of units for K_T, J_{TOT}, such as MKS, that yields K_T/J_{TOT} in rad/sec^2/amp will work)

The motor torque constant is the value of K_T peak published in the Pacific Scientific Motion Control Solutions catalog.

Note: *f_{vc} is the unity gain open-loop crossover frequency of the idealized rigid single mass system. See hardware specifications for maximum f_{vc} value.*

Default bandwidth

The **Create New Configuration** and **Edit Existing Configuration** buttons set KVP to achieve a velocity loop bandwidth of 75 Hz. 830 Tools assumes there is matched load on the motor shaft and the motor has no mechanical brake or other secondary devices installed.

f_{vc} Velocity Loop Bandwidth (Hz) = 75 Hz (default)

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Load inertia

From the formula for bandwidth, it is seen that bandwidth changes inversely with total inertia. If the load inertia equals the motor plus resolver inertia, the velocity loop bandwidth will be half the values shown. If the load inertia is ten times the motor plus resolver inertia, the bandwidths will be one eleventh these values. Clearly `KVP` must be increased to compensate for increased load inertia if bandwidth is to be maintained. Typically, load inertia up to 3(motor + resolver) give acceptable performance without further optimization.

The most common servo setup problem is adding large load inertia without a corresponding increase in KVP.

The value of `KVP` to achieve a desired bandwidth can easily be calculated as follows:

$$KVP = \frac{2\pi * f_{vc} * J_{TOT}}{K_{TRMS} \Big/ \frac{\sqrt{3}}{2\sqrt{2}}} \approx 10.26 * f_{vc} * \frac{J_{TOT}}{K_{TRMS}}$$

Example calculation

For example, to achieve 75 Hz bandwidth with a PMA22 motor having 20 to 1 load inertia = 0.011 lb-in-sec^2:

J_{TOT}[1] = 0.00039 + 0.011 = 0.01139 lb-in-sec^2

K_T[2] = 4.31 lb-in/amp

$$KVP = 10.26 * 75 * \frac{0.01139}{4.31} = 2.03$$

1 Motor plus resolver inertia (0.00039 lb-in-sec^2) for the PMA22 motor can be found in the catalog or 830 Tools' motor data screen.

2 K_T can be found in the catalog as $K_{T\ RMS}$ (4.31 lb-in/amp) or by using the Back EMF Constant, K_E (31.2 Volts/kRPM) shown on 830 Tools' motor data screen in the following formula:
$K_{T\ RMS} = K_{E\ RMS} * 1.06 \Big/ \sqrt{3}$ (volts/krpm).

$K_{T\ 0\text{-}PK} = K_{T\ RMS} * 0.707$

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830 Tools can also be used to make the calculation. Simply enter the total inertia in place of the motor plus resolver inertia when using the **Create New Configuration** or **Edit Existing Configuration** buttons and 830 Tools will calculate the appropriate value for `KVP` to achieve 75 Hz bandwidth.

There is no specific answer to the general question "What should the bandwidth be?" In general, the higher the velocity loop bandwidth, the faster the settling time will be and the better the rejection of torque disturbances (increased stiffness). Typically, velocity loop bandwidths range from 30 to 100 Hz. However, too high a bandwidth can lower the damping of resonance in mechanical linkages, causing excessive ringing and/or wear in coupled mechanics. Remember, it is the resulting motion at the end of any mechanical linkages that typically matters, not the response at the motor shaft.

Problems with high load inertia

It would seem from the above that setting `KVP` is simply a matter of increasing its value to compensate for load inertia. Unfortunately, the following problems often interfere, particularly when the load inertia is large compared with the motor's inertia:

1. Mechanical resonance between motor and load cause high frequency oscillation.
2. Backlash between motor and load effectively unload the motor over a small angle. Within this small angle the increased bandwidth results in oscillation.
3. Ripple in the velocity feedback signal results in large motor ripple current if `KVP` is large.

As a general rule, any system with `KVP` set higher than 5 times the medium bandwidth setting will require adjustment to the default `ARF0` and `ARF1` settings.

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Resonance

Mechanical resonance is caused by springiness between motor inertia and load inertia. This may result from belts, flexible couplings, or the torsional stiffness of shafts. **In general, the stiffer the couplings, the higher the resonance frequency and the easier it is to tune the system for good performance.**

If the velocity loop breaks into an oscillation at a frequency well above the calculated velocity loop bandwidth, a resonance problem may well exist. A second symptom is that the frequency of oscillation is relatively constant in the presence of changes to `ARF0` and `ARF1`.

ARF0 & ARF1

Two digital anti-resonant low-pass filters `ARF0` and `ARF1` are included in the velocity loop. Their purpose is to lower the gain above f_{vc} and especially at any resonant frequency > f_{vc} so that oscillations do not occur. Recommended values are shown below:

f_{vc} (Hz)	**25**	**75**	**200**
ARF0 (Hz)	100	150 (default)	1500
ARF1 (Hz)	200	750 (default)	$1x10^5$

If the velocity loop bandwidth cannot be raised to an acceptable value without encountering a resonant oscillation, the procedure on the following page is recommended.

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Procedure

1. Set both ARF0 and ARF1 to 400 Hz and set KVP low enough to prevent oscillation.
2. Increase KVP slowly until oscillation at the resonant frequency just begins. Then, reduce KVP slightly until the oscillation just stops. Compute the velocity loop bandwidth using the formula given at the beginning of this section. If the velocity loop bandwidth is less than .25 times the value of ARF0 and ARF1, then proceed to Step 3. Otherwise, go to Step 4.
3. Decrease both ARF0 and ARF1 by 20% and go back to Step 2.
4. The velocity loop bandwidth should now be approximately one quarter the value of ARF0 and ARF1. For margin, reduce KVP, ARF0, and ARF1 by 20%.

Backlash

Some backlash may be unavoidable, especially when gear reduction is used. If backlash is present, the inertia match must be good (load inertia should be roughly equal to motor inertia) for good servo performance. Gearing reduces the inertia reflected to the motor by the square of the gear reduction from motor to load. Therefore, select a gear ratio to give the required match.

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Current ripple

The velocity feedback signal in standard PC830 drives operating with the standard 20 arcmin resolver can have up to 3% p-p ripple. The resulting motor torque current ripple, with no `ARF0/ARF1` filtering, can be calculated using the following formula:

$$\text{Current ripple (amps p-p)} = \frac{3}{100} * \text{Speed (RPM)} * \frac{2\pi}{60} * KVP$$

$$\approx 0.003 * \text{Speed (RPM)} * KVP$$

There can be cause for concern when this p-p number exceeds 40% of the drive's or motor's current rating. The motor current should be monitored using Dac Monitors on J2-4 to insure actual ripple current, with `ARF0/ARF1` filtering, is not excessive.

Motor current ripple can often be reduced by lowering the `ARF0`, `ARF1` low-pass filter break frequencies. This benefit is limited by velocity loop bandwidth and stability constraints. Velocity feedback ripple, and hence motor current ripple, can also be reduced by specifying a higher accuracy resolver.

KVI

The parameter `KVI` sets the so called "lag-break" frequency of the velocity loop. `KVI` is equal to the frequency in Hz where the velocity loop compensation transitions from predominantly integral characteristics to predominantly proportional characteristics. Drive rejection of torque disturbances increase as `KVI` increases. Default values for `KVI` are shown below:

f_{vc} (Hz)	**25**	**75**	**200**
KVI (Velocity Loop Lag-Break Freq. (Hz))	1.7	5.0 (default)	13.3

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If the drive is to be used within a position loop (either with `BlkType` = 2 or when using an external position drive and `BlkType` = 1), `KVI` should be equal to or less than 0.1 times the velocity loop bandwidth. If no position loop is used, `KVI` can be set to 0.25 times the velocity loop bandwidth (or higher if some ringing can be tolerated). In general, the response to a velocity command step (or truncated ramp) will have velocity overshoot for non-zero values of `KVI`.

B.2 Position Loop

When `BlkType` is set equal to 2, a position loop is configured outside the velocity loop. **The velocity loop must be set up and evaluated in terms of bandwidth before attempting to setup the position loop.**

KPP

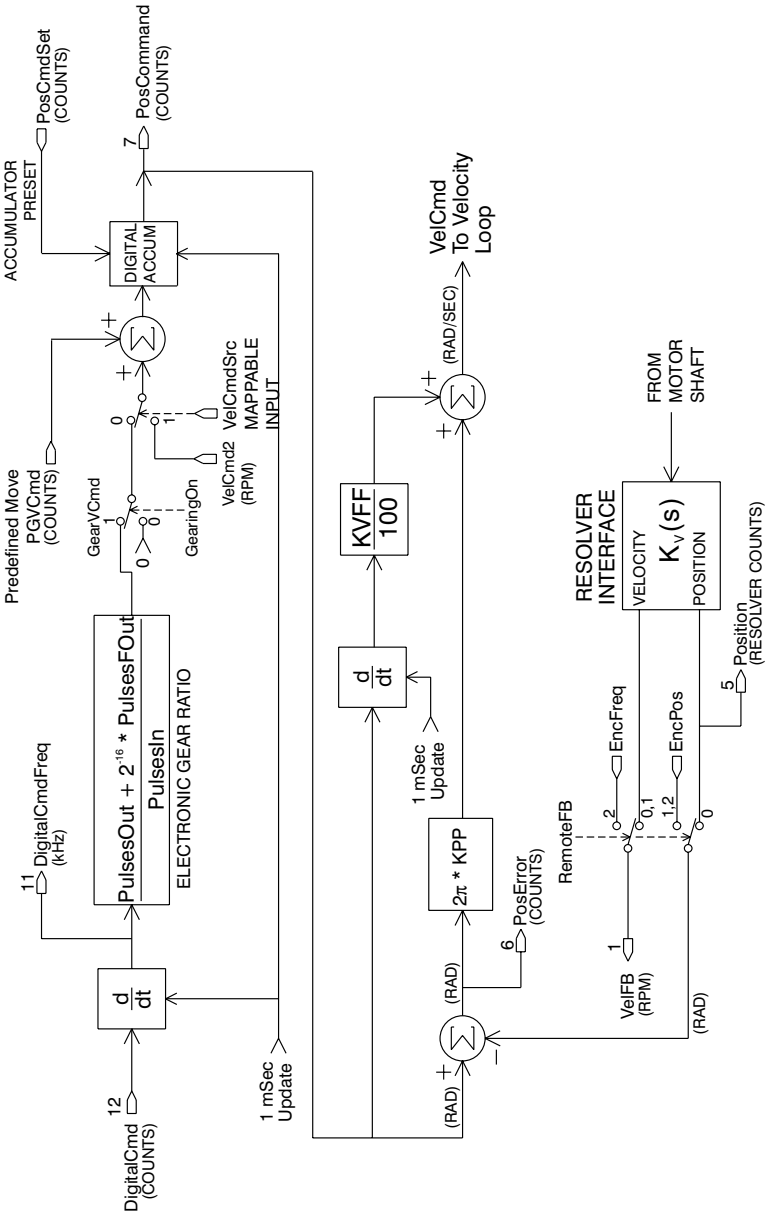
The position loop proportional gain, `KPP`, determines the settling time of the position loop. `KPP` is the bandwidth of the position loop, in Hz, assuming an ideal velocity loop. Recommended values for `KPP` are shown below:

f_{vc} (Hz)	**25**	**75**	**200**
KPP (Position Loop Bandwidth (Hz))	5	15 (default)	50

In general, the higher the value of `KPP`, the faster the settling time. However, **trying to set `KPP` to a high value with inadequate velocity loop bandwidth results in overshoot and ringing.** A good trade off is to set `KPP` to 0.2 times the velocity loop bandwidth. Slightly higher values can be used if overshoot can be tolerated.

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Position Loop



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KVFF

`KVFF` is the velocity feed forward gain. In the absence of velocity feed forward (`KVFF` = 0), the commanded velocity is proportional to the position (following) error. This means that the actual position will lag the commanded position by a value proportional to the speed. The error will be smaller for larger values of `KPP`.

The following table gives a feel for the following error magnitude.

Speed (RPM)	**KPP (Hz)**	**Following Error (revolutions)**
1000	10	0.27
2000	10	0.53
5000	10	1.33
1000	20	0.13
2000	20	0.27
5000	20	0.66

Note: *The following error can easily exceed one complete motor revolution. In many electronic gearing applications, such following errors are not acceptable (real gears don't have following errors!) Also, stepper systems don't have such errors.*

Feed forward takes advantage of the fact that the PC830 DSP knows the frequency of the encoder or step inputs and hence knows how fast the motor should be going at a given instant. All or part of this velocity can be added to the velocity command to reduce following error. If `KVFF` is set to 100 (%), then the steady state following error reduces to zero.

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Overshoot

Setting KVFF equal to 100% can result in position overshoot. Somewhat lower values may be required if this is a problem. KVFF set to 70%-80% typically achieves the fastest step response with no overshoot. However, setting KVFF to less than 100% will give steady state following error when running at constant speed.

B.3 Advanced Velocity Loop Tuning

Continuous time transfer function approximation

The transfer function for the velocity loop compensation block is given below:

$$\frac{FVelErr}{VelErr}(s) = \frac{\left(\frac{s}{w_z}\right)^2 + \frac{1}{Q_z}\frac{s}{\omega_z} + 1}{\left(\frac{s}{\omega_f}\right)^2 + \frac{1}{Q_f}\frac{s}{\omega_f} + 1}$$

$$\frac{ICmd}{VelErr}(s) = \frac{\left(\frac{s}{\omega_z}\right)^2 + \frac{1}{Q_f}\frac{s}{\omega_z} + 1}{\left(\frac{s}{\omega_f}\right)^2 + \frac{1}{Q_f}\frac{s}{\omega_f} + 1}$$

Definitions for the terms used in the equations above are shown on the following page.

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For ARx0 > 0 both roots are real and:

$$\omega_x = 2\pi\sqrt{(ARx0)(ARx1)}$$

$$Q_x = \frac{\sqrt{(ARx0)(ARx1)}}{Arx0 + ARx1}$$

For ARx0 < 0 roots are a complex pair and:

$$\omega_x = -2\pi ARx0$$

$$Q_x = ARx1$$

Note: *When* `ARZ0` *and* `ARZ1` *are both zero, the numerator of* $\frac{FvelErr}{VelErr}(s)$ *reduces to 1. If* `ARZ0` *or* `ARZ1` *is individually 0 the numerator reduces to* $\frac{s}{2\pi ARZx} + 1$.

Discrete time transfer function

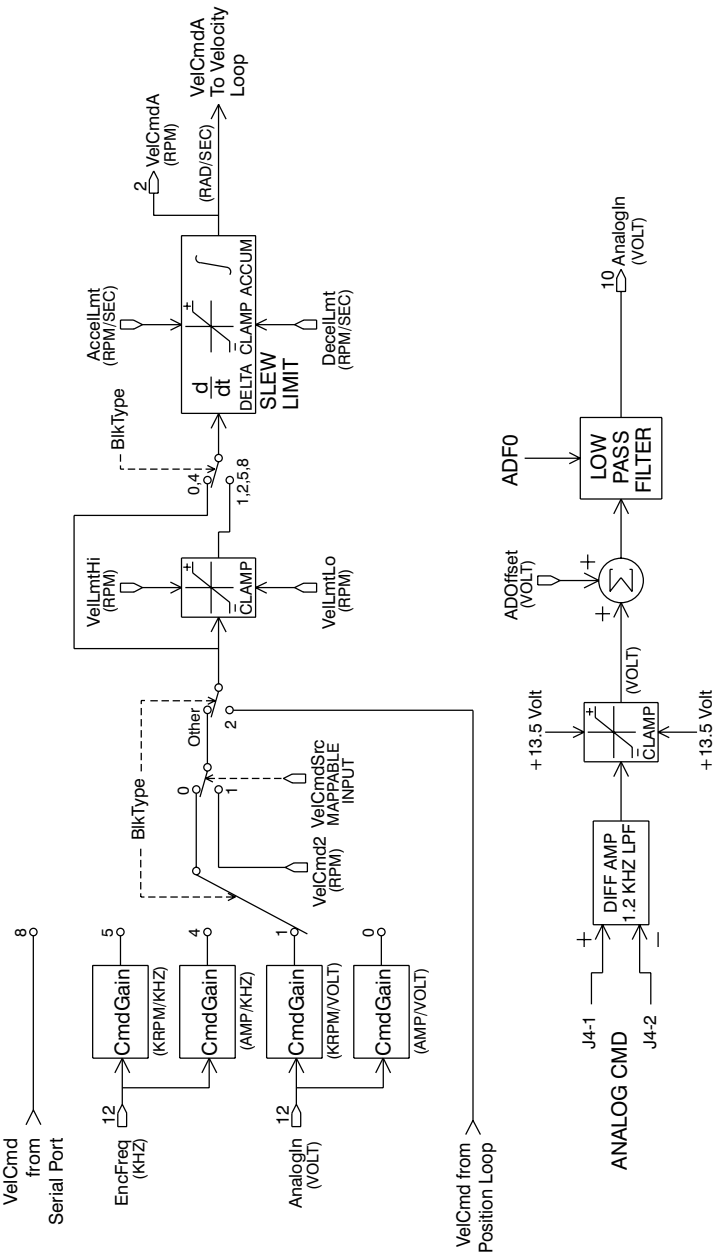
The velocity loop compensation is actually implemented as a digital discrete time system function on the DSP. The continuous time transfer function is converted to the discrete time domain by a backward Euler mapping:

$$s \rightarrow \frac{1}{T_s}(1 - z^{-1})$$

where $T_s = 250\ \mu$sec.

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Mode Selection and Command processing



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Appendix C Model Identification

C.1 Basic Servo Drive Package Order Numbering System

P C 8 X X - 0 0 1 - X

PC8 = Servo Drive Family Designation

3 = Command Interface Designation
3 = RS-232/485, ± 10 Vdc, Step/Dir, Indexing

3 = Power Level
2 = 2.7 A_{RMS} cont. @ 25 °C, 5.3 A_{RMS} pk.
3 = 3.6 A_{RMS} cont. @ 25 °C, 10.6 A_{RMS} pk.
4 = 7.1 A_{RMS} cont. @ 25 °C, 21.2 A_{RMS} pk.

- 001 = Customization Code
001 = Standard Unit
XYZ = Factory Assigned Hardware Customization

X = Accessories
N = No accessories
A = Basic connector kit
T = TB adapter connector kit

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Example Order Numbers

Order #	Model #	Description
PC833-001-T	PC833-001-T	10.6 A_{RMS} peak standard servo drive
	CA800-TB	TB adapter PC803 connector kit
	MA830	*PC830 User Manual*
PC834-001-A	PC834-001-A	21.2 A_{RMS} peak standard servo drive
	CA800	Basic PC804 connector kit
	MA830	*PC830 User Manual*
PC834-001-N	PC834-001-N	21.2 A_{RMS} peak standard servo drive
	MA830	*PC830 User Manual*

C.2 PC800 Accessories

Connector Mate Kits

CA800 — 15-pin and 44-pin d-subminiature mates for the PC80x servo drive.

CA800-TB — 15-pin and 44-pin d-subminiature terminal block adapter mates for the PC80x servo drive.

Manual and Documentation Kits

MA830 — *PC830 User Manual*

Regen Resistors

PRK-200 — External regen resisitor kit

Fan Kits

PFK-120 — 120 VAC Fan

PFK-240 — 240 VAC Fan

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Appendix D Compliance

D.1 Use Conforming with Requirements

Use conformity

The equipment described herein has been developed, produced, tested and documented in accordance with the corresponding standards. During use conforming with requirements, the equipment is not dangerous for people or equipment. Use conforming with requirements means that the safety recommendations and warnings detailed in this manual are complied with and that the applicable regulations for safety (machine directives, etc.) and noise suppression (EMC Directives) are observed while operating the drive.

At the end of its lifetime, dispose of or recycle the drive according to the regulations applicable at that time.

D.2 CE-Approval

Introduction

The CE initials confirm that the PC832, PC833 and PC834 drives satisfy all requirements of CE Directives.

The equipment is not ready to operate without additional installations (cable, motor, etc.). Thus, all necessary tests and measurements had to be made on a typical installation. The test installation with all peripheral devices, as well as the test results and measurements are recorded in detail in documentation that is available from the manufacturer on request. The test installation, to which the Declaration of Conformity refers to, is pictured on D-7.

Note: *If the connection method on your machine is different from the one picture on D-7, or in the event of use of components other than those that we have specified, adherence to interference limit values cannot be guaranteed.*

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Declaration of Conformity

In our Declaration of Conformity, we affirm our compliance with Directive 73/23/EEC (Low voltage Directive) and with Directive 89/336/EEC (EMC Directive).

For the PC832/PC8x3/PC8x4, EMC testing was done according to EN61800-3 (Emission limits according to chapter 6.3.1 of that regulation, First environment / restricted distribution).

During assembly of our product in a machine, startup (that is, normal operation) is prohibited until the end-product complies with Directive 89/392/EEC (Machine Directive) and directive 89/336/EEC (EMC Directive).

The machine manufacturer must prove that the complete system conforms with all relevant European Directives.

Drive conformance to specified standards is certified by the Declaration of Conformity on the following page.

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CE Declaration of Conformity

This is to certify that:

Pacific Scientific
110 Fordham Road
Wilmington, MA 01887 USA

Declares that the product(s):

Designation *DIGITAL SERVO DRIVE*

Type *PC832, PC833, PC834*

comply with the following relevant regulations:

CE Guideline	*72/23/EEC*	*Low Voltage Directive*
Applied harmonized standards:		EN 50178: 1997
CE Guideline	*89/336/EEC*	*EMC Directive*
Applied harmonized standards:		EN 61800-3: 1995

Manufacturer's Contact:	Peter Deneault Compliance Engineer

Issued By:	Pacific Scientific President, William T. Fejes
Place, Date:	Wilmington, MA, USA, 11-17-99

Legally binding Signature



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D.3 Qualified Personnel for Installation and Commissioning

Installation

Installation and wiring of the drive must be completed only by qualified personnel having a basic knowledge of electronics, installation of electronic and mechanical components, and all applicable wiring regulations.

Commissioning

Commissioning of the machine utilizing the drives must be done only by qualified personnel having broad knowledge of electronics and motion control technology.

D.4 Safety requirements

Your responsibility

As the user or person applying this unit, you are responsible for determining the suitability of this product for the application. In no event will Pacific Scientific Company be responsible or liable for indirect or consequential damage resulting from the misuse of this product.

Read this manual completely to effectively and safely operate the PC830.

European Directives

Comply with the applicable European standards and Directives. In Germany these include:

- DIN VDE 0100 (instructions for setting up power installations with rated voltages below 1000 V).
- DIN - EN 60 204 - Part 1, (VDE 0113, part 1) instructions relative to electric equipment in machines for industrial use.
- prDIN EN 50178, (VDE 0160) equipping high-voltage current installations with electronic operating means.

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Safety Requirements

The following requirements must be met to ensure compliance with the Low Voltage Directive:

- Never connect or disconnect any drive connectors or terminals while the power is switched on.
- The climatic conditions shall be in accordance with EN 50178 climatic class: Type B, temperature and relative humidity: Class 3K3.
- This drive is to be installed inside a motor/control cabinet accessible by qualified personnel only.
- Electronic drives contain electrostatic sensitive devices which can be damaged when handled improperly. Qualified personnel must follow ESD protection measures. For example: wear grounded heel and wrist straps when contacting drive.
- The discharge time for the bus capacitors may be as long as 5 minutes. After disconnecting the drive from the ac mains be sure to wait 5 minutes before removing the drive's cover and exposing live parts.
- Follow IEC 536-2 and IEC 1140 for installation protection against electric shock.
- Installation shall be performed in accordance with local electric codes, local accident prevention rules, EN 50178 and EN 61800-3.
- Due to high leakage current this drive is to be permanently installed, i.e. hard wired. The PE connection shall be made by two separate conductors between the earth ground and the two PE terminals on the device.
- Consult the factory before using this product on a circuit protected by a residual-current-operated protective device (RCD).
- External, supply line, fusing is required. PC833: Bussman, MDA-20, PC834: Littlefuse, FLM 30.
- Motor cable shield must be connected to protective earth.
- All covers shall be closed during operation.
- During periods of extreme regeneration or excessively high input voltage the temperature of the regen resistor may exceed 70 °C.
- When using an external regen resistor, if regen cabling is accessible during normal machine operation, regen resistor cable should be rated at 450 VDC and shielded with shield connected to PE.

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D.5 Installing the PC800 Servo Drive

Much of the connection information presented in this section is summarized in the figures on the following page.

D.5.1 Mounting the Drive

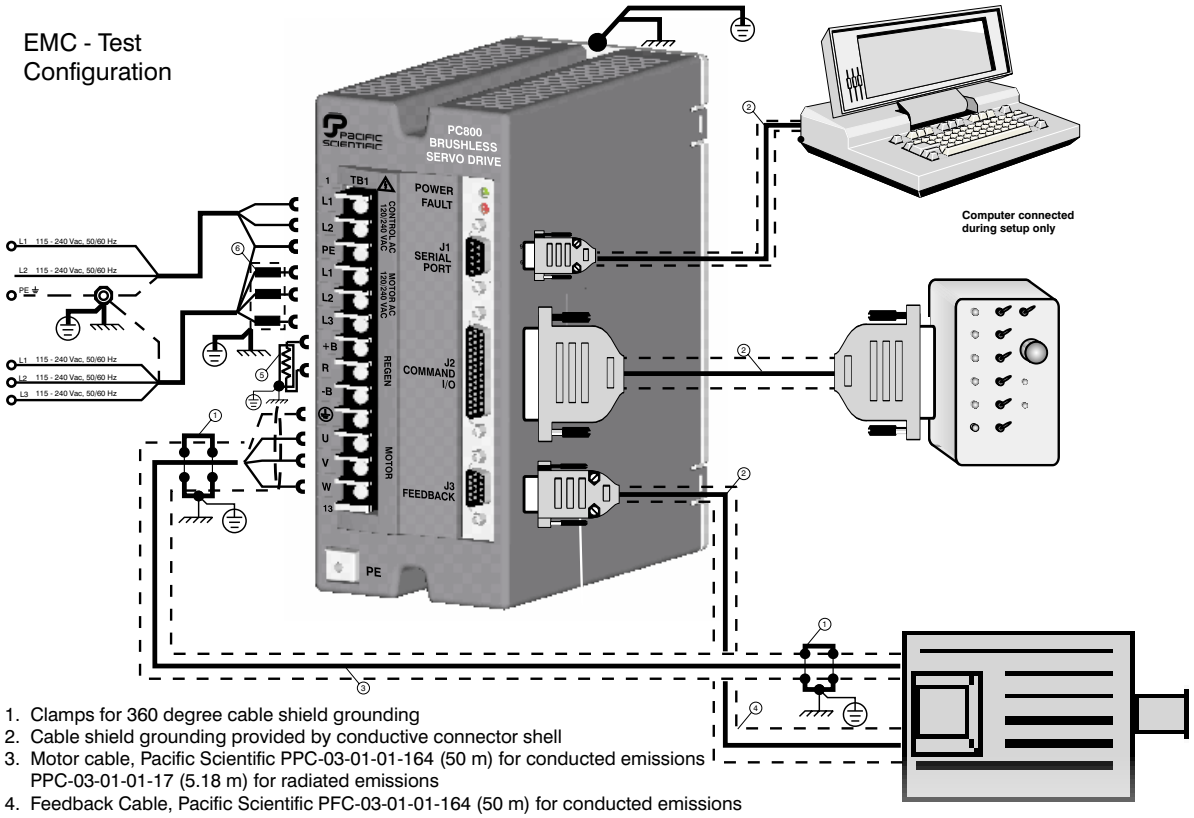
The PC800 drives are designed for operation in a cabinet. Follow these installation instructions:

- Mount the drives vertically inside a cabinet on a flat, solid, electrically conductive, mounting surface which is connected to PE (protective earth ground) and is capable of supporting the weight of the unit.
- Remove the paint on the mounting surface over an area extending at least 12 mm (0.5”) from the mounting bolts to achieve good electrical connection over a large area between the drive and grounded mounting surface.
- Install conductive clamps near the drive on the mounting panel (ground plane) for electrically connecting the outer shield of certain cables (defined below) to the panel. The conductive clamps can also be attached to PE on the front of the drive. Remove about 10mm (0.5”) of the outer jacket of these cables where the clamp will be to expose the braided shield before inserting under the clamp and tightening. The length of the cable between the drive connection and the clamp should be as short as possible not exceeding 0.6 meters (two feet). If a ground plane is available at the other end of these cables, use a conductive clamp at that end to connect the shield to that ground plane as well.
- Provide a minimum unobstructed space of 100 mm (4”) above and below the drive. With convection cooling, provide 40mm (1.6”) free space on either side of each unit. With forced air cooling, no free space is required on either side of each unit.
- Insure the environment within the cabinet meets the requirements defined in section A.3.

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CE Block diagram (8X3/8X4)

EMC - Test Configuration



1. Clamps for 360 degree cable shield grounding
2. Cable shield grounding provided by conductive connector shell
3. Motor cable, Pacific Scientific PPC-03-01-01-164 (50 m) for conducted emissions
   PPC-03-01-01-17 (5.18 m) for radiated emissions
4. Feedback Cable, Pacific Scientific PFC-03-01-01-164 (50 m) for conducted emissions
   PFC-03-01-01-17 (5.18 m) for radiated emissions
5. External Regen Resistor, Pacific Scientific REG-833.
6. Line filter used for testing, MTE 50CE4

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Mounting Guidelines

The figures on the following pages give the key dimensions for use in physically mounting the product.

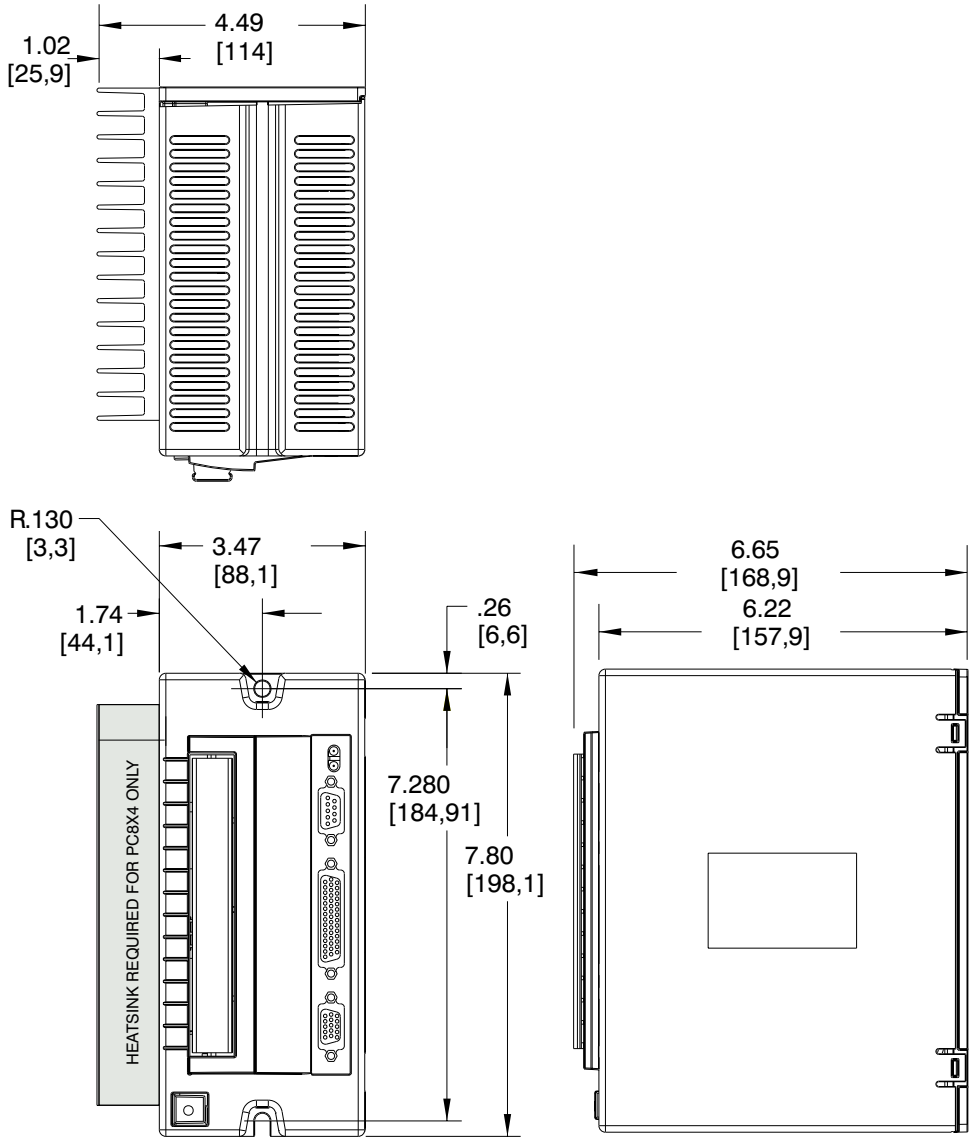
When mounting multiple drives in a row some customers have found the stiffness of the drive and their mounting panel to be too low. To increase the mounted mechanical integrity, connect to the threaded insert on the top front edge.

The overall drive panel dimensions and the mounted depth not including mating connectors is listed in the below chart. The extra depth for mating connectors is 1.0" or less.

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Mounting Dimensions

PC832/PC833 /PC834



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D.5.2 Connecting to AC Power

The PC800 series drives are functionally compatible with all standard forms of three phase ac lines:

- Grounded neutral WYE
- Open-Delta Grounded Leg
- TEE

AC Power

The AC power source for connector TB1 (control power supply) can be either single phase 115-240 VAC referenced to neutral (PE) or a symmetrical 115-240 VAC to neutral.

Fusing

Use slow blow fuses in series with TB1 pins 1, 2, and 3 as shown in the figure on pages D-7.

Model	Fuse
PC8x2	Bussman, MDA-10
PC8x3	Bussman, MDA-20
PC8x4	Littlefuse, FLM 30

D.5.3 Connection to PE Ground

TB1-3 **must be connected to Protective Earth ground (this pin is marked with the PE symbol).** The connection at the Protective Earth ground end **must be hard wired** (not utilize pluggable connections)

A ground fault detector (RCD) can **not** be depended upon for safety.

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D.5.4 Grounding Shields for Safety and Low Emissions/ Susceptibility

Dangerous voltages, resulting from cable capacitance, exists on some cable shields if the shields are not connected to PE ground. Proper grounding of shields is also required to reduce radiated and conducted emissions as well as to protect against susceptibility to external and self generated noise. Follow these shielding requirements carefully:

- The drive end of the motor cable shield must be connected to the PE or ⏚ location on the TB1 connector. The shield must also be clamped to the ground plane as described above. If cable with a separate inner foil shield and outer braided shield is used (Pacific Scientific CE cables for example), connect the foil shield to the PE or ⏚ location on the TB1 connector and clamp the outer braided shield to the ground plane. If the leads for a motor holding brake are run with the motor leads, the holding brake leads must be separately shielded and the shield connected to the PE or ⏚ location on the TB1 connector.
- The resolver cable should have inner shields around each twisted pair as well as an overall outer braided shield. The inner shields should be connected to J3 pin 5 while the outer shield should be clamped to the ground plane.
- The control leads to the J2 connector should have an outer braided shield with the shield terminated through a conductive shell or clamped to the ground plane.
- When using an external regen resistor, if regen cabling is accessible during normal machine operation, regen resistor cable should be rated at 450 VDC and shielded with shield connected to PE.

D.5.5 Grounding the Motor Case

Insure that the motor's case is connected to PE ground. This is accomplished by the fourth wire in the motor cable connecting TB1-10 ⏚ to the motor case.

If the motor is not properly grounded, dangerous voltages can be present on the motor case due to capacitive coupling between the motor windings and case.

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D.5.6 Long Motor Power Cables

The PC800 drives do not require additional filtering in the motor leads as long as the motor power cable (between drive connector TB1 and the motor) is less than 10 meters (32 feet) long. For longer motor power cables, an external balun must be added in series with the cable. Additional information can be found in Pacific Scientific Application Notes 106 ("Reducing Motor Drive Line Noise") and 107 ("Reducing Motor Drive Radiated Emissions").

Note: *Balun part number is 104-090003-01.*

Current Rating	60 A sinewave pk (42 A RMS) 5 sec 20 A sinewave pk (14 A RMS) cont
Inductance	340 uh nominal
Energy Rating	7,200 uj nominal
Resistance	0.021 ohm nominal
Gap	10 mil

D.6 Requirements for Safe Operation of the Drive

It is the machine builder's responsibility to insure that the complete machine complies with the Machine Directive (EN60204). The following requirements relate directly to the servo controller:

Emergency Stop

If personal injury can result from motor motion, the user must provide an external hardwired emergency stop circuit outside the drive. This circuit must simultaneously remove power from the drive's motor power terminal TB1-11, TB1-12, and TB1-13 and disable the drive (by disconnecting J2 pin 37 from I/O RTN).

Note: *The motor will coast under this condition with no braking torque.*

If breaking torque is required to quickly stop the motor, a dynamic brake can be added that loads the motor's windings resistively. The motor should not be loaded until the servo drive is disabled. Note that the holding brake which is optional on Pacific Scientific motors is not intended to stop a spinning motor. It is designed to prevent a stopped motor from rotating due to an applied torque.

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Avoiding Unexpected Motion

Always remove power from TB1 before working on the machine or working anywhere where injury can occur due to machine motion.

Avoiding Electrical Shock

Never power the servo drive with the cover removed or with anything attached to circuitry inside the cover.

If the drive must be removed from the cabinet, wait at least five minutes after turning off power before removing any cables from the drive or removing the drive from the mounting panel.

Never connect or disconnect any wiring to the drive while power is applied. Always power down and wait five minutes before connecting or disconnecting any wires to the terminals.

Avoiding Burns

The temperature of the drive's heat sink and housing as well as an external regen resistor can exceed 70°C. Therefore, there is a danger of severe burns if these regions are touched.

D.7 Preventing Damage to the Drive

Follow these guidelines to prevent damage to the servo drive during operation:

- Never plug or unplug connectors with power applied.
- Never connect or disconnect any wires to terminals with power applied
- Never plug or unplug an option card with control power applied
- If the drive indicates a fault condition, find the cause of the fault and fix it prior to resetting the fault or power-cycling the drive.

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EMC

The following requirements must be met to ensure compliance with the EMC Directives:

Warning!



Not intended to be used on a low-voltage public network which supplies domestic premises. May cause radio-frequency interference.

Line filter

To meet the conducted EMC requirements an external line filter is necessary. It is the responsibility of the customer to choose appropriate filtering for their application, Pacific Scientific is willing to assist in this choice. The CE test setup included a 50CE4 line filter manufactured by MTE. CE testing was performed using 50 m motor and resolver cables, the maximum lengths specified, to prove worst case conducted emissions compliance. For CE testing with 50 m cables, a motor cable balun was added to the motor wiring (Pacific Scientific # 104-090003-01). The line filter should be mounted as close as possible to the drive. To provide maximum high frequency filtering remove any paint from between the filter, the drive and the conductive surface, ground plane they are bonded to.

MTE Corporation

1-800-455-4MTE or 414-253-8200
http://www.mtecorp.com

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Shielding & Grounding

To meet radiated EMC requirements the serial, Command I/O, motor and resolver cables should be shielded and grounded at the drive end. To guarantee maximum high frequency radiated noise reduction, the shields should have 360 degree termination to ground. Clamp the exposed portion of the shields to the front of the drive with the clamp supplied to terminate. The serial and command I/O cables can be terminated to ground through the D-sub connector if it provides 360 degree shield termination. It may also be necessary to add ferrites to the Command I/O and serial cables. Once again it is important to remove the paint from any grounding surfaces.

To avoid the risk of crosstalk, the motor and resolver cables should be kept away from sensitive signal cables such as telephone and intercommunication lines.

D.8 UL Recognition

UL Recognized File number E137798

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Appendix E Using External Regen

Introduction

An estimated 10% of applications will require that the PC800 be equipped with a regen resistor.

Need for Regen

The clearest indication that an external regen resistor is needed is that the drive will fault on over-voltage when the motor decelerates. The Fault LED will be solid on and the variable FaultCode will show ‘over-voltage’ or ‘external regen fault’.

As the motor decelerates, mechanical energy is regenerated back to the drive. Initially this energy goes into the bus capacitors and pumps-up their voltage. With an external regen resistor connected the pump-up of the bus voltage is clamped at about 400VDC. Without a regen resistor, the voltage can continue to rise and at about 425V an over-voltage fault occurs.

The need for regen is strong function of maximum motor speed. Below some speed, roughly (1/3 to 1/4) system rated speed, an external regen resistor is unlikely to be needed. For an explanation of why this is so see the section at the end of this appendix, “Regen Need is a Strong Function of Maximum Motor Speed.”

Monitoring Bus Voltage

There may be a few applications where bus voltage pump up is excessive, but not high enough to trip the hardware over-voltage fault (423V). Bus voltage is considered excessive if it exceeds 390-400 VDC.

The built-in oscilloscope can be used to monitor how much the bus voltage (VBus) pumps up at motor deceleration. If the scope shows the bus voltage reaching 390 VDC to 400VDC, then connect an external regen resistor to insure long term reliable operation.

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Regen R Characteristics

Pacific Scientific offers a regen resistor for the PC800 family (Part #PRK-200). The same regen resistor is used for the PC8x4, PC8x3 and PC8x2. It is a 12.5 Ω, 200W, metal clad, panel mount resistor supplied with a short cable for attachment to the drive.

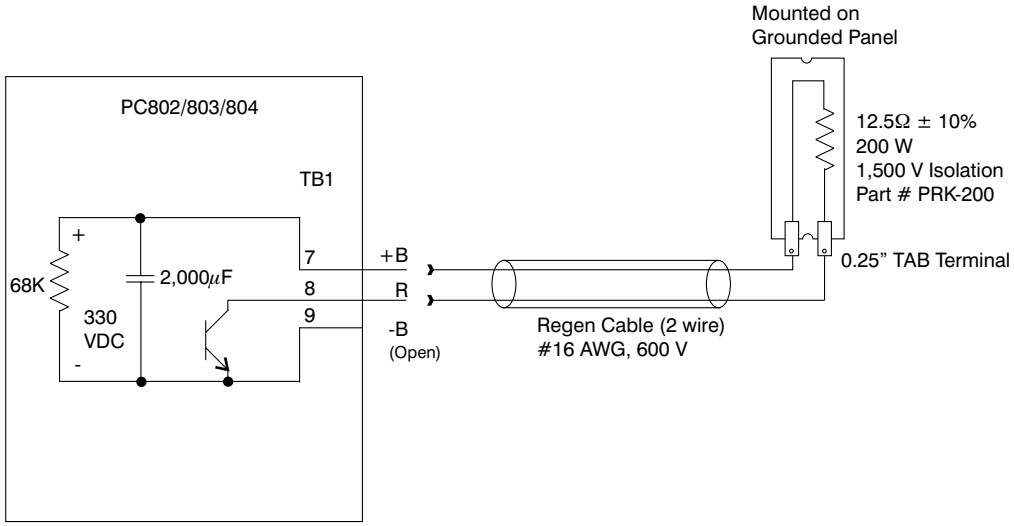
Ohms	12.5 Ω ± 10%
Watts	200 watts (manufacturer rating 300 watts)
Terminals	0.25 inch standard fast-on
Isolation	3,500 V to case
Cable	2 ft, #16AWG, with spade lugs (for TB1)

Mounting and Wiring

The PC800 the regen resistor is mounted external to the drive. The Pacific Scientific supplied PC800 regen resistor comes with a cable long enough so that it can be mounted adjacent to the drive and wired to the drive.

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Regen Mounting



Caution - High Voltage

During normal operation +B, R, and -B operate at the bus power voltages. A 240 Vac system operates at ≅ *400 Vdc.* *These are dangerous voltages.*

Warning!

Wait 10 minutes after Bus Power is removed for the bus cap voltage to decay to a safe level before touching regen resistor or wiring. The voltage on the bus caps can be monitored with a voltmeter from +BUS (TB1-7) to -BUS (TB1-9).

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Drive Regen Terminals

TB1-7 (marked +B) to TB1-8 (marked R)

The resistor terminals are standard 0.25″ fast-ons. The resistor can be mounted any distance from the drive using a customer supplied cable. Recommended cable wire is #16 AWG, 600V rated, teflon.

Safety

The terminals of the regen resistor must be shielded from contact as they are electrically connected to the +Bus of the drive. The regen terminals are at dangerous, potentially lethal, voltages whenever the drive bus power is on and for about 10 minutes after bus power is turned off.

To prevent the metal case of the resistor from becoming a safety hazard in the event of internal resistor failure the resistor case should be grounded by attaching it to a grounded panel.

Non-PacSci Regen Resistors

Customer supplied regen resistor(s) can be used. Be sure the resistance seen by the drive is within 10% of 12.5 Ω and the isolation of the resistive element is a minimum of 1,500 V. Two 25 Ω resistors in parallel form a 12.5 Ω resistor.

High Power Regen

In an application with very high average regenerated power it may be necessary to increase the wattage of the regen resistor. Quick test: 'Does water boil on the surface of the resistor'?

One way to increase the regen resistor power handling capability is to blow air on it.

A simple way to increase regen power handling capability is to replace a single 12.5 Ω regen resistor with four similar 12.5 Ω resistors wired in series-parallel. Series parallel wiring is two pairs wired in series (25 Ω each pair) and the two pairs wired in parallel (12.5 Ω total). Use a meter to check the resistance of a combination is 12.5 Ω before attaching it to the drive. Four 200W regen resistors wired in series parallel can handle 800W.

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Fusing

If the regen transistor in the drive should fail shorted, then the power into the external regen resistor will increase to far above its ratings. For three phase 240 VAC bus power, the power in the regen resistor will be about 8.2 kW (320 VDC across 12.5 ohms equals 25.6 ADC). After a few minutes, the regen resistor will typically open, but in the meantime the high heat can cause melting and damage to nearby components. A remote regen resistor mount, on top of a cabinet, can minimize the potential harm.

A single 200W regen resistor can (in some cases) be fused, but the fuse type and rating must be carefully chosen. Due to the resistance a large pulse of current is not available to clear a fuse. While not tested, analysis of fuse time-current curves indicates the following fuse should work with a single 12.5 Ω regen resistor and a drive operated on a three phase 240 VAC line:

10A, Time Delay, 250V

Buss MDA 10 or Littlefuse 326010

If bus power is single phase (240 VAC, 208 VAC, or 120 VAC), regen fusing is difficult and not recommended. Fusing of high power (800W) regen is also not recommended.

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Regen Need is a Strong Function of Maximum Motor Speed

If maximum motor speed is not too high, a drive typically will not need regen, because the rotational energy can be handled by the drive caps and motor resistance. The following example uses a PC804 with a simple inertia.

Example

If the deceleration time from very high speed to zero speed at full torque takes 100 msec, then the peak shaft power at the beginning of the deceleration can be estimated at about 6kW. The shape of the power pulse is triangular, so the rotational energy to be absorbed is 300 joules (=0.5 x 6,000 watts x 100 msec). The caps in the PC804 are rated to absorb ≅ 40 joules. The copper loss of a medium size motor operating at the drive continuous rating of 10A (0 to pk) is often in the 100 watt range, so at x3 pk current the motor copper loss will be in the 900 watt range. Therefore, in 100 msec, the motor copper for a full current deceleration will absorb about 90 joules (=900 watts x 100 msec). The balance of 170 joules (= 300 joules - 40 joules - 90 joules) will be dissipated in the regen resistor.

Now reduce the max speed in half. The rotational energy is reduced by four to 75 joules. The deceleration time is reduced by two, so motor copper energy loss is reduced by two to 45 joules. The bus cap absorption energy remains at 40 joules. As a result, the 75 joules of rotational energy is handled by the copper loss and bus caps without the need of a regen resistor. If the max speed had been reduced to about one third, then the copper loss or cap alone could handle the rotational energy.

Fraction of Rated Speed	Rotational	Cap Rated	Cu	Regen R
Full	300 j	40 j	90 j	170 j
Half	75 j	40 j	45 j	0 j
Third	33 j	40 j	30 j	0 j

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High Inertia

Rotational energy is proportional to inertia. At high speeds a high inertia means lots of regen R wattage needed. However, from the above example, once the speed is low enough so that the copper losses (from a full torque acceleration) are the same as the rotational losses, the copper losses also increase in proportion to the inertia. This is because if inertia increases by 'n' it takes 'n' times longer to decelerate. If the speed is not too high, even with a high inertia, external regen may not be needed. Counter-intuitively the greatest need for external regen is when the decelerating torque is low and the speed is high.

In summary, the need for regen is a strong function of maximum motor speed. Below some speed, roughly (1/3 to 1/4) system rated speed, an external regen resistor is unlikely to be needed.

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Appendix F Comcoder or Encoder Feedback Setup

Introduction

The PC830 servo drive can commutate a motor using any one of the following feedback devices:

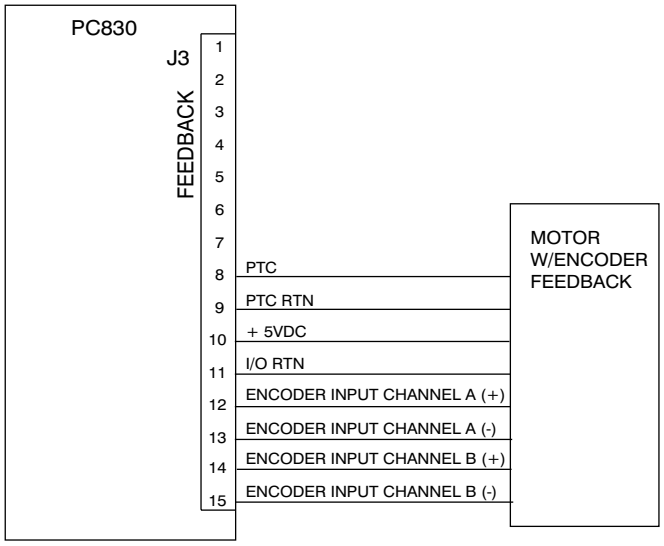
- Resolver
- Incremental Encoder
- Comcoder (hall/encoder).

Configuring the PC830 for a motor with an Incremental Encoder

Using an Incremental Encoder

To wire-up an incremental encoder for primary feedback on the PC830 perform the following:

1. Connect the encoder signals, PTC and Encoder +5V supply as shown in the diagram below:

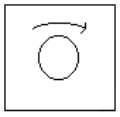


2. Click on **Edit Drive Configuration Online** button and select the variable **EncPos**.

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Procedure (cont'd)

3. With the motor disabled, rotate the shaft in the clockwise direction as viewed from the shaft end (as shown in the picture below).



4. If EncPos decreases as the shaft is rotated, swap A and $\overline{A}$ connections and repeat Step 3.
5. Click on the **Create New Configuration** button. Select the proper motor, drive, and desired mode of operation. Click on **Next**.
6. Click on the **Feedback Tab**. Select **Incremental Encoder** as the Commutation Source.
7. Enter the correct encoder line count.
8. Click on **Save to File** and give the configuration a name.
9. Click on **Download to Drive** to send the complete configuration to the drive.
10. After the download is complete, click on **YES** to save the configuration to non-volatile memory.
11. Turn AC power OFF and then ON again.

Incremental encoders are not absolute feedback devices. Therefore, an alignment procedure must be performed. The motor should perform its encoder alignment check upon power up AND assertion of the hardware enable.

For additional information on incremental encoder alignment consult the online help of the PC830 software "Encoder Alignment Overview" or contact Pacific Scientific Applications Engineering for assistance.

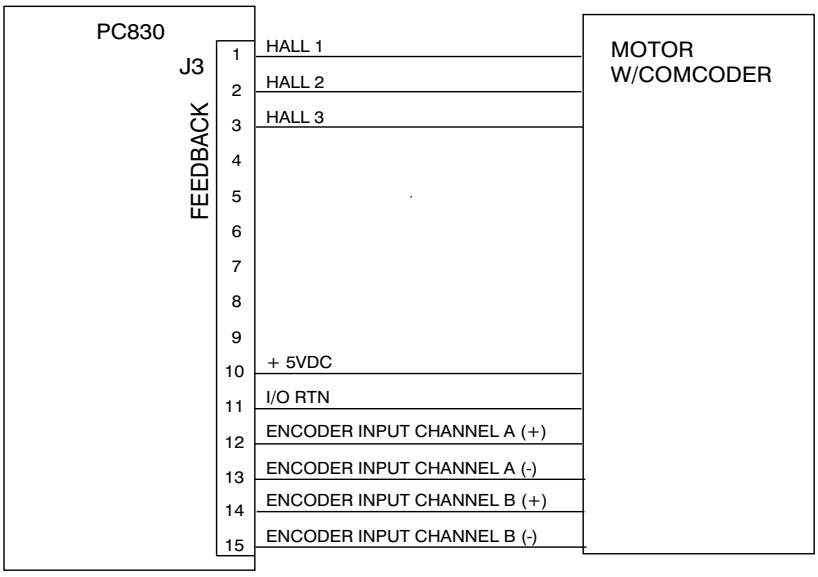
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Configuring the PC830 for a motor with a Comcoder

Using a Comcoder

To wire-up a comcoder (hall/encoder) for primary feedback on the PC830 perform the following:

1. Connect the comcoder as shown in the diagram below:



Procedure (cont'd)

2. Click on the **Edit Drive Configuration Online** button and select the variable **HallState.**
3. With the motor disabled, rotate the shaft slowly in the clockwise direction. Verify that **HallState** repeats the following sequence (... 6, 4, 5, 1, 3, 2, …).
4. If **HallState** does not sequence in this manner, then swap any two hall sensor phases and repeat step 3.
5. Click on the **Create New Configuration** button. Select the proper motor, drive, and desired mode of operation. Click on **Next**.
6. Click on the **Feedback** Tab. Select **Comcoder (Hall/Encoder)** as the Commutation Source.
7. Enter in the correct encoder line count.

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8. Click on **Save to File** and give the configuration a name.
9. Click on **Download to Drive** to send the complete configuration to the drive.
10. After the download is complete, click on **YES** to save the configuration to non-volatile memory.
11. Turn AC power OFF and then ON again.

When the hardware enable is asserted, the motor will initially use the hall signals for commutation. After the first hall state transition occurs, the drive will adjust the commutation angle and start commutation off the encoder. To ensure the adjusted commutation angle is within 5 electrical degrees of the correct angle, the PC830 limits the maximum velocity and maximum acceleration rate the motor can rotate at until this transition occurs as the motor is still not properly aligned during this period.

For additional information on the Comcoder (Hall/Encoder) alignment process, contact Pacific Scientific Application Engineering for assistance.

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Appendix G Simple ASCII Protocol

Note: *This applies to firmware version 2.00 and higher.*

Introduction

The PC830 supports a simple ASCII protocol for serial communications with devices like PLCs or other electronics capable of handling ASCII strings.

The simple ASCII protocol command formats are given below. The notation is as follows:

{ } indicates optional field.

<> indicates one character.

[ ] indicates a string of characters.

Each character is sent using its ASCII representation.

Command Message Format

<STX> {[Addr]} [CmdCode] [PDID] [=Value] {[:CS]} <CR>

Description of fields

STX	= Framing character denoting start of message.
Addr	= Address of drive (0-255). Optional field.
CmdCode	= R for read, W for Write, C for Command.
PDID	= The ID number of the variable/parameter. To distinguish floats from integers, 10000 was added to PDID of integers.
Value	= Value (data) to be written to parameter/variable. Only used for W (write) messages.
CS	= Checksum. Optional field.
CR	= Framing character denoting end of message.

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Reply Message Format

<STX> [RspCode] {[Value]} {[:CS]} <CR>

Description of fields

STX	= Framing character denoting start of message.
RspCode	= V if Value (data) is returned. E is error is returned.
Value	= Value of variable/parameter.
CS	= Checksum. This optional field is used only if the command message used a checksum.
CR	= Framing character used to denote end of message.

If the command message is valid:

1. The reply to a read returns the value of the variable/parameter.
2. The reply to a write command also returns the value of the variable/parameter after it was written.
3. The reply to a command is simply an echo of the message received.

Examples

1. Write Move1Distance (Integer #10100) a value of -6553600 without using the optional Address field:

   Command Sent: "<STX> W 10100 = -6553600 :214 <CR>"

   Message Received: "<STX>V-6553600:38<CR>"

2. Read Move1Distance (Integer #10100) without using the optional Address field:

   Command Sent: "<STX> R 10100 :190 <CR>"

   Message Received: "<STX>V-6553600:38<CR>"

3. Write Move1RunSpeed (Float #98) a value of 60.0 RPM with the Address field:

   Command Sent: "<STX> 255 W98 = 60.0 :31 <CR>"

   Message Received: "<STX>V59.9992:9<CR>"

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Examples (cont'd)

4. Read Move1RunSpeed (Float #98) with the Address field.

   Command Sent: "<STX> 255 R98:185 <CR>"

   Message Received: "<STX>V59.9992:9<CR>"

5. Execute NVSave (Command #1).

   Command Sent: "<STX> C1 <CR>"

   Message Received: "<STX>C1<CR>"

Guidelines

1. The Serial ASCII Protocol ignores white space between fields.
2. The Checksum is the decimal sum, modulo 256, of all the characters from after the initial framing character (STX), up to and including the ":" character.
3. Due to floating point conversions, a floating point value sent to the drive may not be exactly equal to the value received from the drive.
4. Address 0 is a global address. All drives will process a message sent to address 0 but will NOT reply. Address 255 is a default address and all drives will process messages sent to Address 255 and WILL return a reply. Therefore, when multi-dropping PC830 drives, assign a unique address (between 1-254, inclusive) to each drive.



Caution

Pacific Scientific strongly recommends the use of the optional CS (checksum) field for safe and reliable operation of the PC830.

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Pre-defined Identifiers Used in the PC830

Values for Error Codes

ReadOnly	65
Bounds_Error	66
No_Such_Command	67
Variable_Not_Implemented	68

Identifier Codes for Commands

NVLoad	0
NVSave	1
Unconfigure	2

Identifier Codes for Integer Variables

CfgD	10001
ILmtMinus	10002
ILmtPlus	10003
DM1Map	10005
Enable	10006
Enabled	10007
EncIn	10008
EncPos	10009
FaultCode	10010
Inp1	10012
Inp2	10013
Inp3	10014
Inp4	10015
Inp5	10016
Inp6	10017
Inputs	10018
KpEnc	10019
KiEnc	10020
KdEnc	10021
ElecAngTau	10022

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EncAlignTime	10023
EncAlignTestDist	10024
EncAlignRampIcmd	10025
Out1	10026
Out2	10027
Out3	10028
Out4	10029
Outputs	10030
PosCommand	10031
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Values for InpMapX (10066-10071)

Convert value from hex to decimal for Serial ASCII Protocol

No_Function	0x0000
Fault_Reset_Inp_Hi	0x8001
Fault_Reset_Inp_Lo	0x0001
RunStop_Inp_Hi	0x8002
RunStop_Inp_Lo	0x0002
Enable2_Inp_Hi	0x8003
Enable2_Inp_Lo	0x0003
VelCmdSrc_Inp_Hi	0x8004
VelCmdSrc_Inp_Lo	0x0004
CW_Inhibit_Inp_Hi	0x8005
CW_Inhibit_Inp_Lo	0x0005
CCW_Inhibit_Inp_Hi	0x8006
CCW_Inhibit_Inp_Lo	0x0006
AInNull_Inp_Hi	0x8007
AInNull_Inp_Lo	0x0007
PosBlk_Select_Inp_Hi	0x8008
PosBlk_Select_Inp_Lo	0x0008
CmdGain_Select_Inp_Hi	0x8009
CmdGain_Select_Inp_Lo	0x0009
Start_Move_Inp_Hi	0x800A
Start_Move_Inp_Lo	0x000A
Move_Select_Bit0_Inp_Hi	0x800B
Move_Select_Bit0_Inp_Lo	0x000B
Move_Select_Bit1_Inp_Hi	0x800C
Move_Select_Bit1_Inp_Lo	0x000C
Move_Select_Bit2_Inp_Hi	0x800D
Move_Select_Bit2_Inp_Lo	0x000D
Gearing_On_Inp_Hi	0x800E
Gearing_On_Inp_Lo	0x000E
Home_Switch_Inp_Hi	0x800F
Home_Switch_Inp_Lo	0x000F

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Values for OutMapX (10072-10075)

Convert value from hex to decimal for Serial ASCII Protocol

No_Function	0x0000
Fault_Out_Hi	0x8001
Fault_Out_Lo	0x0001
Enabled_Out_Hi	0x8002
Enabled_Out_Lo	0x0002
Brake_Out_Hi	0x8003
Brake_Out_Lo	0x0003
MechRev_Out_Hi	0x8004
MechRev_Out_Lo	0x0004
ElecRev_Out_Hi	0x8005
ElecRev_Out_Lo	0x0005
Zero_Speed_Out_Hi	0x8006
Zero_Speed_Out_Lo	0x0006
Excess_PosErr_Out_Hi	0x8007
Excess_PosErr_Out_Lo	0x0007
Move_Done_Out_Hi	0x8008
Move_Done_Out_Lo	0x0008

Values for Pre-defined Move Types

(10092, 10099, 10106, 10113, 10120, 10127, 10134, 10141, 10148)

Move_Type_None	0
Move_Type_Velocity	1
Move_Type_Incremental	2
Move_Type_Absolute	3
Move_Type_Home	4
Move_Type_Incr_Reg	5
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Values for Homing Modes

(10098, 10105, 10112, 10119, 10126, 10133, 10140, 10147, 10154)

Home_Mode_Switch	0
Home_Mode_Marker	1
Home_Mode_Switch_And_Marker	2
Home_Mode_Present_Position	3

Values for CommSrc

(Commutation Source, 10063)

Commsrc_Resolver	0
Commsrc_Encoder	1
Commsrc_Hall_Encoder	2

Values for DriveStatus

(DriveStatus, 10180)

DriveStatus_Unconfigured	0
DriveStatus_Faulted	1
DriveStatus_Enabled	2
DriveStatus_Disabled	3

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