# USER MANUAL

# Accessory 51P

4096x Interpolator for PMAC Boards

3Ax-603195-xUxx

May 20, 2004

DELTA TAU
Data Systems, Inc.
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# INTRODUCTION

## Overview

The ACC-51P Expansion Port Interpolator Accessory is a sine-wave input interpolator that interfaces analog quadrature encoders to Delta Tau Data System's PMAC (40Mhz or faster), PMAC2, Turbo PMAC or Turbo PMAC2.

The ACC-51P is a PCI-style board, so it may be mounted in a typical PCI expansion slot. The ACC-51P does not communicate through the PCI bus; the bus is only a convenience for mounting and power supply connections.

## Features

The Interpolator accepts inputs from two (optionally four) sinusoidal or quasi-sinusoidal encoders and provides encoder position data to the PMAC. This interpolator creates 4,096 steps per sine-wave cycle.

The Interpolator accepts a voltage-source (1Vp-p) signal from the encoder. A jumper selects between unterminated or 120Ω input termination.

The maximum sine-cycle frequency input is approximately 1.4MHz, which gives a maximum speed of about 5.734 billion steps per second.

When used with a 1000 line sinusoidal rotary encoder, there will be 4,096,000 discrete states per revolution (128,000 software counts). The maximum calculated electrical speed of this encoder would be 1,400 RPS or 84,000 RPM, which exceeds the maximum physical speed of most encoders.

The interpolator has a PCI bus connector that allows it to be placed next to the ISA or PCI models of PMAC on a computer motherboard. When placed next to the ISA models of PMAC (PMAC-PC, Turbo PMAC-PC, and Turbo PMAC2-PC), the interpolator accessory is installed in motherboards that have both ISA and PCI slots.

The Interpolator uses the PCI bus slot only to receive power. There is a connector provided to allow the interpolator to receive power when operated without a computer backplane.

## Board Configuration

### Base Configuration

The base version of the ACC-51P consists of a PCI slot board with two sinusoidal encoder inputs, each individually configurable to accommodate 1V p-p sinusoidal encoders.

### Options

**Option 1 (301-603195-OPT):** Provides the interface circuitry and connectors for two additional sinusoidal encoders, for a total of four encoders on the ACC-51P.

**Option 2 (302-603195-OPT):** Provides the on-board circuitry to read the absolute position of Stegmann SINCOS® and SINCODER® encoders using their digital interface, "HIPERFACE®".

***Note:***

The options described above must be installed at the factory.

## Indicators

Refer to the layout diagram of the expansion port interpolator for the location of the indicators on the board.

D5, D6, {D7, D8 Opt 1} AQUAD Indicators

These LEDs indicate the A-channel quadrature input.  When the encoder is operating normally, this indicator flickers with a rate dependent upon the speed of the moving encoder.

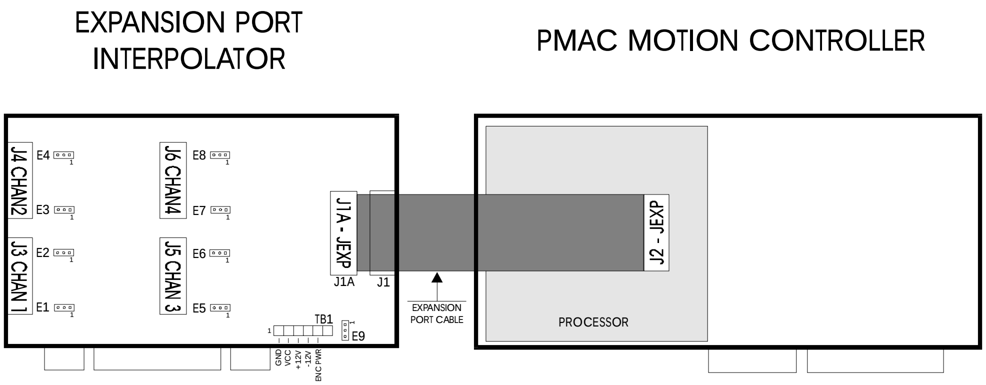
D5 is input #1, D6 is input #2.  With ACC-51P opt 1 D7 is input #3, D8 is input #4.

# CONNECTING THE EXPANSION PORT INTERPOLATOR TO PMAC PRODUCTS

The diagram below shows how the interpolator connects to the PMAC products. One ribbon cable connects the interpolator to the PMAC Processor's expansion port (J2).

***Note:***

On the PMAC2-Lite, the expansion port connector is J11. Be sure to check which connector is the JEXP connector on the PMAC.




When used with the ISA bus versions of PMAC, the expansion port cable is connected to J1A on the ACC-51P. The expansion port cable is connected to J1 when using the PCI versions of PMAC controllers. J1 and J1A are identical, and physically rotated 180º from each other.

## Expansion Port Cable

This three-inch cable is provided by Delta Tau Data Systems to interconnect the PMAC with the interpolator.

***Note:***

The expansion port cable carries high frequency data signals and is sensitive to outside noise. It is important to keep this cable as short as possible.

## Dipswitch Configuration

S1 is a 4-point dipswitch that determines whether the ACC-51P is to be connected to a regular (non-turbo) PMAC, or a Turbo PMAC. Switch S1-4 must be OFF on an ACC-51P to enable addressing of the board by a non-Turbo PMAC. For non-Turbo PMACs, S1-1 is used to determine which bank of four encoders will be accessed by hardware. For Turbo PMACs, S1-1, S1-2, and S1-3 are used to determine which bank of four encoders will be accessed by hardware.

The tables below show the addresses and switch settings used for the non-Turbo PMAC models:

| **Dipswitch S1 (POS 1 - ON)** | | | | |
|---|---|---|---|---|
| **ACC-51P Encoder Number** | **PMAC Channel Number** | **PMAC(1) Channel Address** | **PMAC(2) PC-Lite Channel Address** | **PMAC(2) Mini Ultralite Channel Address** |
| #1 | #9 | $C020 | $C040 | $C000 |
| #2 | #10 | $C024 | $C044 | $C004 |
| #3 | #11 | $C028 | $C048 | $C008 |
| #4 | #12 | $C02C | $C04C | $C00C |

| Dipswitch S1 (POS 1 - OFF) | | | | |
|---|---|---|---|---|
| **ACC-51P Encoder Number** | **PMAC Channel Number** | **PMAC(1) Channel Address** | **PMAC(2) Channel Address** | **PMAC (2) Mini, Ultralite Channel Address** |
| #1 | #13 | $C030 | $C060 | $C020 |
| #2 | #14 | $C034 | $C064 | $c024 |
| #3 | #15 | $C038 | $C068 | $C028 |
| #4 | #16 | $C03C | $C06C | $C02C |

Dipswitch S1 positions #2 and #3 are not used with non-Turbo PMAC models and should be left in the OFF position.

The memory mapping for non-Turbo PMAC models allows for a total of eight encoder channels to be selected. The dipswitch selects between upper and lower 4 channel banks of memory. This allows for two ACC-51Ps to be logically configured.

The table below shows the addresses and switch settings used for the Turbo PMAC models:

| **Interp SW1 Settings** | | | | **Turbo PMAC Servo IC # (m)** | **1st Channel** | **2nd Channel** | **3rd Channel** | **4th Channel** |
|---|---|---|---|---|---|---|---|---|
| 4 | 3 | 2 | 1 | | | | | |
| on | on | on | on | 2 | $78200 | $78204 | $78208 | $7820C |
| on | on | on | off | 3 | $78300 | $78304 | $78038 | $7830C |
| on | on | off | on | 4 | $79200 | $79204 | $79208 | $7920C |
| on | on | off | off | 5 | $79300 | $79304 | $79308 | $7930C |
| on | off | on | on | 6 | $7A200 | $7A204 | $7A208 | $7A20C |
| on | off | on | off | 7 | $7A300 | $7A304 | $7A308 | $7A30C |
| on | off | off | on | 8 | $7B200 | $7B204 | $7B208 | $7B20C |
| on | off | off | off | 9 | $7B300 | $7B304 | $7B308 | $7B30C |

The memory mapping for Turbo PMAC models allows for a total of 32 encoder channels to be selected. The dipswitch selects between any of the eight banks of memory. This allows for up to eight ACC-51Ps to be logically configured.

# Jumper Configurations

## Table of Jumpers

| Nomenclature | Physical Layout | Description | Factory Default |
|---|---|---|---|
| E1 | 1 - 2 - 3 | Encoder power<br>1 - 2 Uses internal 5V<br>2 - 3 User supplied at TB1 | 2 - 3 |
| E2, E3, E4 | 1 - 2 - 3 | Channel 1<br>1 - 2 Unterminated encoder inputs<br>2 - 3 Terminated encoder inputs<br>(E4 is index termination) | 2 - 3 |
| E5, E9, E10 | 1 - 2 - 3 | Channel 2<br>1 - 2 Unterminated encoder inputs<br>2 - 3 Terminated encoder inputs<br>(E10 is index termination) | 2 - 3 |
| E6, E7, E8 | 1 - 2 - 3 | Channel 1 index capture<br>1 - 2 Channel 2 is selected<br>2 - 3 Index capture is selected | 1 - 2 |
| E11, E12, E13 | 1 - 2 - 3 | Channel 3 (opt 1 only)<br>1 - 2 Unterminated encoder inputs<br>2 - 3 Terminated encoder inputs<br>(E13 is index termination) | 2 - 3 |
| E14, E18, E19 | 1 - 2 - 3 | Channel 4 (opt 1 only)<br>1 - 2 Unterminated encoder inputs<br>2 - 3 Terminated encoder inputs<br>(E19 is index termination) | 2 - 3 |
| E15, E16, E17 | 1 - 2 - 3 | Channel 3 index capture<br>1 - 2 Channel 4 is selected<br>2 - 3 Index capture is selected | 1 - 2 |

## E1 - Encoder Power Select

This jumper allows the use of internal Vcc (+5Vdc) to provide power to the encoders. External encoder power can be provided through the TB1 connector.

## E2, E3, E4, E5, E9, E10 - Encoder Input Select Channel 1 & 2

These jumpers allow selection of which type of input loading to be used for the encoder. A 120Ω termination is selectable. The inputs are approximately 17kΩ when not terminated.

## E6, E7, E8 - Index Capture Select for Channel 1

These jumpers allow selecting whether channel 2 is used for an encoder input or index capture for channel 1.

Channel 2 is not used when channel 1 index capture is selected.

## E11, E12, E13, E14, E18, E19 - Encoder Input Select (Option 1- Additional 2 Channels)

These jumpers allow selecting which type of input loading to use with the encoder. A 120Ω termination is selectable. The inputs are approximately 17KΩ when not terminated.

## E15, E16, E17 - Index Capture Select for Channel 3

These jumpers allow selecting whether channel 4 is used for an encoder input or index capture for channel 3.

Channel 4 is not used when channel 3 index capture is selected.

# Encoder Connections

1. Be sure to use shielded, twisted pair cabling for sinusoidal encoder wiring. Double insulated is the best. The sinusoidal signals are very small and must be kept as noise free as possible. Avoid cable routing near noisy motor or driver wiring.
2. The use of single-ended output style sinusoidal encoders at very slow speeds has been shown to provide large amounts of velocity-ripple. When very slow speeds are desired, it is best to use differential output style sinusoidal encoders. The 3line encoder table entry (which is available with Turbo PMAC models) has been designed to help adjust the offsets that may be present with single-ended encoders.
3. Hiperface commands are issued for all channels using the base address register. This value is defined as M11 in the example program. All four channels perform the command specified by M11 when issued.
4. The interpolation process uses high-resolution A-D converters. Inductors may be needed in series between the motor leads and the amplifier to reduce harmonic switching noises that may be passed through the motor housing into the encoder signal wiring.
5. Use a braided cable for directly grounding the motor housing in a typical sinusoidal encoder application. This provides the best high frequency path to ground for harmonic noise from the motor.

The connector at TB1 is used for stand-alone power. The encoder power input may be used when the board is plugged into a PCI bus. Jumper E9 selects power for the encoders from the PCI bus or TB1. When the ACC-51P is plugged into the PCI bus adjacent to other PCI cards, the connector spacing may not permit the use of TB1. Power may be supplied to the encoders at the encoder connectors (DSUBs). It is not necessary to feed the encoder power into the ACC51P.

# Sinusoidal Encoder Wiring

Sinusoidal encoders operate on the concept that two analog signal outputs have a profile that is 90° out of phase. They are available with different drive characteristics, some of which are described below.

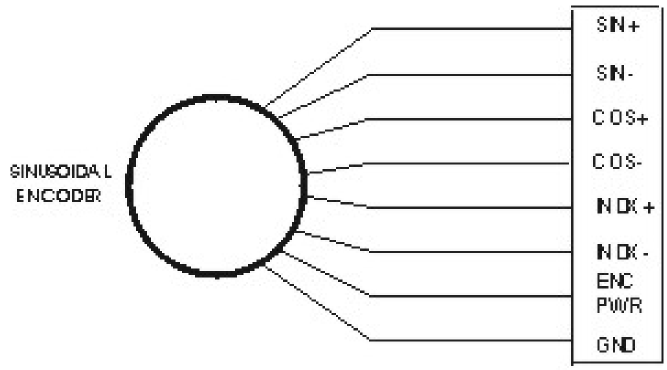
## Differential Format

The differential format provides a means of using twisted-pair wiring, which allows for better noise immunity when wired into machinery.

Two common output types are available with differential style sinusoidal encoders. They are current mode and voltage mode style encoder output.

The current mode encoder output uses a high impedance 11µA pk-pk output. The voltage mode output encoder uses a low impedance 1 V pk-pk output.

The voltage mode encoder type is connected to the interpolator as shown. Termination is usually selected by using jumpers on the interpolator board.




DIFFERENTIAL ENCODER CONNECTION

**Note:**

Voltage mode encoders are becoming the more popular choice for machine designs due to their lower impedance outputs. Lower impedance outputs represent better noise immunity, therefore more reliable encoder interfaces.

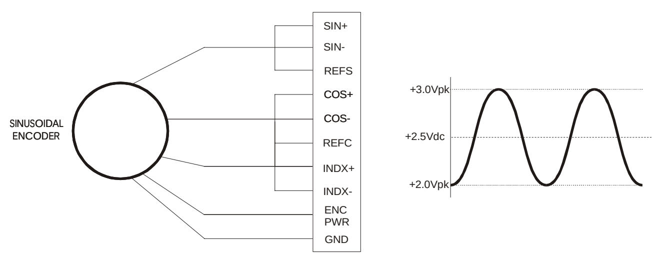
The ACC-51P uses voltage mode encoders only .

## Single-Ended Format

The single-ended formats provide a simpler means of using a sinusoidal encoder. Typically, fewer wires are needed and the encoders are always of the lower impedance voltage output type.

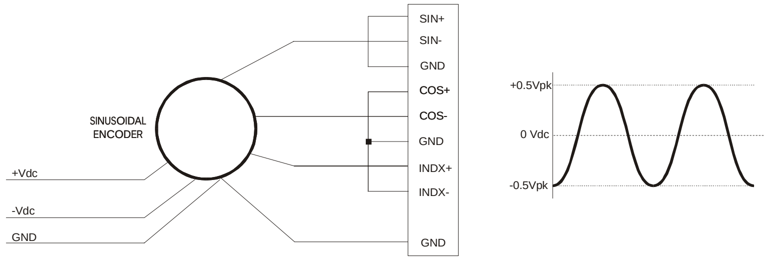
All the single-ended encoder formats shown here may have velocity-ripple effects at very slow speeds due to the effects of op-amp $V_{io}$ offsets. These offsets cause the sinusoidal signal to be centered at a value that is slightly different from the reference or servo ground.

The following diagram is a simple single-ended encoder-wiring interface. This encoder has SIN and COS outputs that provide a one-volt peak-to-peak output that has a voltage offset of 2.5Vdc. The SIN-, COS-, and INDEX- lines are tied to the 2.5V internal references on the interpolator card.



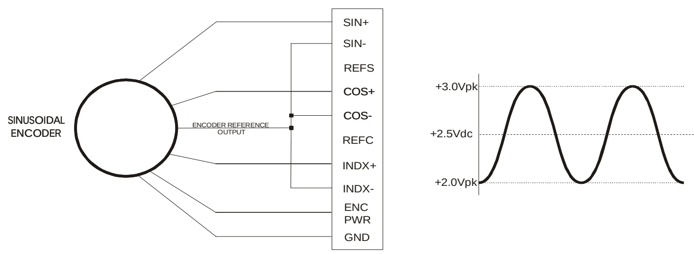

SINGLE-ENDED ENCODER CONNECTION

The following diagram is a similar to the previous diagram. This encoder has SIN and COS outputs that provide a one-volt peak-to-peak output that has a voltage offset of 0.0Vdc. The SIN-, COS-, and INDEX-lines are tied to the GND on the interpolator card and usually the encoder requires a bipolar supply.




ALTERNATE SINGLE-ENDED ENCODER CONNECTION

The following diagram is a single-ended encoder that provides a reference output. This encoder has SIN and COS outputs which provide a one-volt peak-to-peak output that has a voltage offset which is provided as an output of the encoder. The SIN-, COS-, and INDEX- lines are tied to the encoder's reference output. This type of encoder connection is expected to be more precise than the typical single-ended encoder as shown in the first diagram because the internal reference (usually set at 2.5Vdc) is the mechanism that establishes the offsets for the SIN+, COS+, and INDEX+ outputs.




SINGLE-ENDED ENCODER CONNECTION
USING THE ENCODER'S REFERENCE OUTPUT

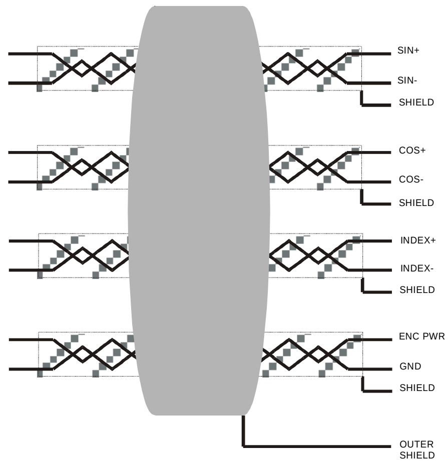
**Note:**

Do not connect the reference output of the encoder to the REFS and REFC lines on the interpolator card.

## Type of Cable for Encoder Wiring

Low-capacitance shielded twisted pair cable is ideal for wiring differential encoders.  The better the shield wires, the better the noise immunity to the external equipment wiring.  Wiring practice for shielded cables is not an exact science.  Different applications will present different sources of noise, which may require experimentation to achieve the desired results.  Therefore, the following recommendations are based upon some experiences that we at Delta Tau Data Systems have acquired.

If possible, the best cabling to use is a double-shielded twisted pair cable.  Typically there are four pairs used in a differential encoder's wiring.  The picture below shows how the wiring may be implemented for a typical differential encoder using double-shielded twisted-pair cable.




EXAMPLE OF DOUBLE SHIELDED
4 TWISTED PAIR CABLE

The shield wires should be tied to ground (Vcc return) at the interpolator end.  It is acceptable to tie the shield wires together if there are not enough terminals available.  Keep the exposed wire lengths as close as possible to the terminals on the interpolator.

***Note:***

There is an inconsistency in the shielding styles that are used by different encoder manufacturers.

Be sure to check pre-wired encoders to insure that the shield wires are not connected at the encoder's side.  Shield wires should only be connected on one side of the cable.

If the encoder has shield wires that are connected to the case ground of the encoder, ensure that the encoder and motor cases are sufficiently grounded and do not connect the shield at the interpolator end.

If the encoder has pre-wired double-shielded cable that has the outer shield connected at the encoder, then only connect the inner shield wires to the interpolator.  Be sure not to mix the shield interconnections.

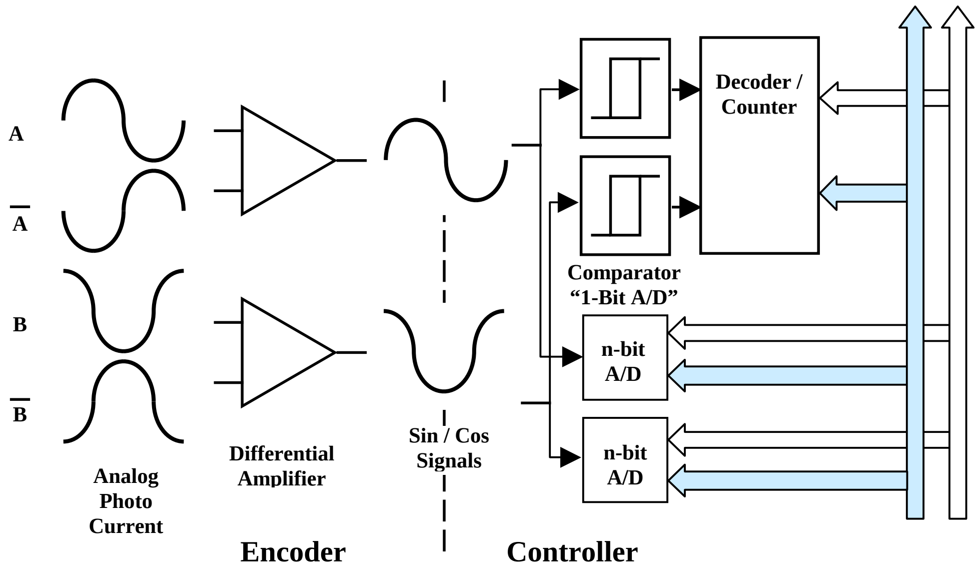
One possible cable type for encoders is Belden 8164 or ALPHA 6318.  This is a 4-pair individually shielded cable that has an overall shield.  This double-shielded cable has a relatively low capacitance and is a 100Ω impedance cable.

Cables for single-ended encoders need to be shielded for the best noise immunity.  Single-ended encoder types cannot take advantage of the differential noise immunity that comes with twisted pair cables.

***Note:***

If noise is a problem in the application, careful attention must be given to the method of grounding that is used in the system. Amplifier and motor grounding can play a significant role in how noise is generated in a machine. It is possible that noise will be reduced in a motor-based system by the use of inductors that are placed between the motor and the amplifier.

# PRINCIPLE OF OPERATION




The sine and cosine signals from the encoder are processed in two ways in the ACC-51 board (see diagram). First, they are sent through comparators that square up the signals into digital quadrature and sent into the quadrature decoding and counting circuit of the Servo IC on the ACC-51. The decoding must be set up for "quadrature times-4" decode (I9n0 or I7mn0 = 3 or 7) to generate 4 counts per line in the hardware counter.

The units of the hardware counter, which we will call "hardware counts", are thus ¼ of a line. For most users, this fact is an intermediate value, an internal detail that does not concern them. However, there are two cases in which this is important. First, if the sinusoidal encoder is used for PMAC-based brushless-motor commutation, the hardware counter, not the fully interpolated position value, will be used for the commutation position feedback. The units of Ixx71 will therefore be "hardware counts".

Second, if the hardware position-compare circuits in the Servo IC are used, the units of the compare register are hardware counts. (The same is true of the hardware position-capture circuits, but these scaling issues are often handled automatically through the move-until-trigger constructs).

The second, parallel, processing of the sine and cosine signals is through analog-to-digital converters, which produce numbers proportional to the input voltages. These numbers are used to calculate mathematically an arctangent value that represents the location within a single line. This is calculated to 1/4096 of a line, so there are 4096 unique states per line, or 1024 states per hardware count.

For historical reasons, PMAC expects the position it reads for its servo feedback software to have units of 1/32 of a "count". That is, it considers the least significant bit (LSB) of whatever it reads for position feedback to have a magnitude of 1/32 of a count for the purposes of its software scaling calculations. We call the resulting software units "software counts", and any software parameter that uses "counts" from the servo feedback (e.g. jog speed in counts/msec, axis scale factor in counts/engineering-unit) is using these "software counts". In most cases, such as digital quadrature feedback, these software counts are equivalent to hardware counts.

However, with the added resolution produced by the ACC-51 interpolator, software counts and hardware counts are no longer the same. The LSB produced by the interpolator (through the encoder conversion table processing) is 1/1024 of a hardware count, but PMAC software considers it 1/32 of a software count. Therefore, with the ACC-51, a software count is 1/32 the size of a hardware count.

The following equations express the relationships between the different units when using the ACC-51:

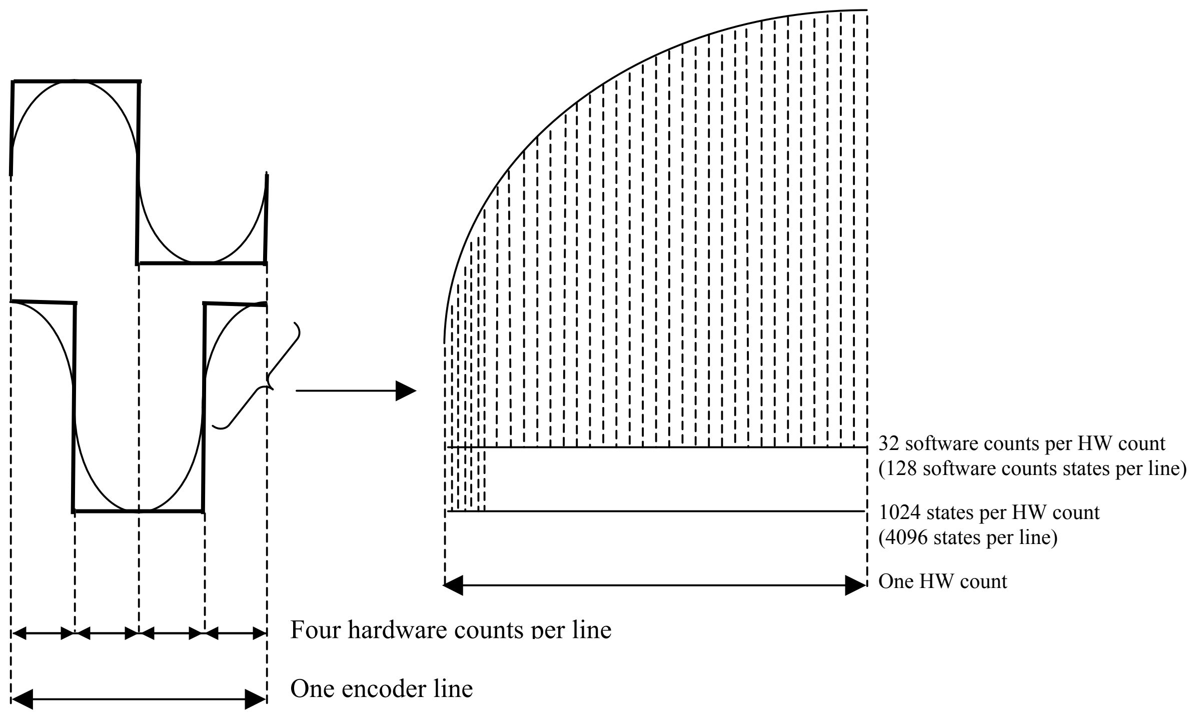
*1 line = 4 hardware counts = 128 software counts = 4096 states (LSBs)*

*¼-line = 1 hardware count = 32 software counts = 1024 states (LSBs)*

*1/128-line = 1/32-hardware count = 1 software count = 32 states (LSBs)*

*1/4096-line = 1/1024-hardware count = 1/32-software count = 1 state (LSB)*

Note that these are all just naming conventions. Even the position data that is fractional in terms of software counts is "real". The servo loop can see it and react to it, and the trajectory generator can command to it.




**Note:**

When changing the direction of the encoder during the setup process, normally the PMAC must be saved and $$$ reset for proper stability in the operation of the interpolator. Exception: PMAC2 (non-Turbo) requires special power-up configuration. Refer to the Setup section of the PMAC for details.

**Example 1**:

A 4-pole rotary brushless motor has a sinusoidal encoder with 2000 lines. It directly drives a screw with a 5-mm pitch. The encoder is used for both commutation and servo feedback.

The commutation uses the hardware counter. There are 8000 hardware counts per revolution, and 2 commutation cycles per revolution of the 4-pole motor. Therefore, Ix70 will be set to 2, and Ix71 will be set to 8000. Ix83 will contain the address of the hardware counter's phase capture register.

For the servo, we use the interpolated results of the conversion table. There are 128 "software counts" per line, or 256,000 software counts per revolution. With each revolution corresponding to 5 mm on the screw, there are 51,200 software counts per millimeter. The measurement resolution, at 4096 states per line, is 1/8,192,000 of a revolution, or 1/1,638,400 of a millimeter (~0.6 nanometers/state).

**Example 2**

A linear brushless motor has a commutation cycle of 60.96 mm (2.4 inches). It has a linear scale with a 20-micron line pitch. The scale is used for both commutation and servo feedback.

The commutation uses the hardware counter. There are 200 hardware counts per millimeter (5 microns per count), so 12,192 hardware counts per commutation cycle. Ix70 should be set to 1, and Ix71 should be set to 12,192.

The servo uses the interpolated results of the conversion table. With 128 "software counts" per line, and 50 lines per millimeter, there are 6400 software counts per millimeter (or 162,560 software counts per inch). The measurement resolution, at 4096 states per line, is 204,800 states per mm (~5 nanometers/state).

# PMAC (1) {40MHZ AND FASTER} WITH THE EXPANSION PORT INTERPOLATOR

The ACC-51P requires the PMAC to have firmware release 1.16G or later.

## PMAC (1) Parameters That Must Be Set

To get a non-Turbo PMAC (1) to properly process the interpolator's data, several parameters must be set:

### Encoder Decode Control I-Variables

I940, I945, I950, I955, I960, I965, I970, I975 are used to establish encoder decoding. They are set for each channel in the order that they are presented above.

A value of 7 is used for CCW x4 Quadrature decode (this is default value). Do not reverse the decode direction.

If the direction of the encoder needs to be reversed, swap the SIN and COS wiring at the 15-pin DSUB connectors. Swap both pairs of SIN+ and SIN- wires with COS+ and COS- wires.

***Note:***

The direction of the encoder counter must stay at 7. If reversed, the precision and stability of the system will be adversely affected.

### Encoder Input Filter Disable I-Variables

I941, I946, I951, I956, I961, I966, I971, I976 are used to establish encoder input filtering. This must be disabled for each channel that is used on the ACC-51P.

Set this value to 1 for every channel that is used on the ACC-51P. These I-variable values should correspond to the encoder decode values set in the previous paragraphs.

| | Dipswitch S1 (POS 1 - ON) | | | | Dipswitch S1 (POS 1 - OFF) | | | |
|---|---|---|---|---|---|---|---|---|
| **ACC-51P Encoder Number** | **PMAC(1) Channel Number** | **PMAC(1) Decode I-Variable** | **PMAC(1) Filter I-Variable** | **PMAC(1) Channel Address** | **PMAC(1) Channel Number** | **PMAC(1) Decode I-Variable** | **PMAC(1) Filter I-Variable** | **PMAC(1) Channel Address** |
| #1 | #9 | I940 | I941 | $C020 | #13 | I960 | I961 | $C030 |
| #2 | #10 | I945 | I946 | $C024 | #14 | I965 | I966 | $C034 |
| #3 | #11 | I950 | I951 | $C028 | #15 | I970 | I971 | $C038 |
| #4 | #12 | I955 | I956 | $C02C | #16 | I975 | I976 | $C03C |
| Dipswitch S1 positions #2 and #3 are not used with PMAC (1) and should be left in the OFF position. | | | | | | | | |

### Commutation Position I-Variables (Ix83)

The ACC-51P contains a quadrature-based encoder register that may be used for commutation position. The PMAC1 does not use the ACC-51's full interpolation to track a motor's position.

The number of commutation counts per pole revolution or linear scale distance is related to the pitch of the encoder's sinusoidal output multiplied by four. Therefore, commutation appears to the PMAC(1) as if it were a quadrature-based encoder.

The tables below show the addresses of the quadrature register in the ACC-51P:

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 1st Intrp | off | off | off | on |

| ACC51P Channel Address | Ix83 Value |
|---|---|
| $C020 | $C021 |
| $C024 | $C025 |
| $C028 | $C029 |
| $C02C | $C02D |

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 2nd Intrp | off | off | off | off |

| ACC51P Channel Address | Ix83 Value |
|---|---|
| $C030 | $C031 |
| $C034 | $C035 |
| $C038 | $C039 |
| $C03C | $C03D |

## Encoder Conversion Table

The encoder conversion table is a user-configurable list of entries that may be assigned to different specific data processing inputs. The interpolator is assigned into the encoder conversion table as a High Resolution Encoder Interpolator when using PEWIN's executive program conversion table setup menu. This 2-line encoder table entry uses a first line Y-word entry value (bit 16-23) of $Fx. The second line contains the values as shown in the following tables. Refer to the PMAC Software Reference manual for Encoder Conversion Table —Conversion Methods for details.

***Note:***

The Executive Program with release dates before third quarter of 1999, do not permit automated setup of the table in the Configure Encoder Table function. With older Executive Programs, you must manually configure the encoder table with memory write commands.

The following table describes the two lines of data values that must be entered into the encoder conversion table for the settings on the interpolator Dipswitch.

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 1st Intrp | off | off | off | on |

| 1st Line Setting | 2nd Line Setting | Meaning |
|---|---|---|
| $F0C020 | $00C022 | Expansion Port Incremental Encoder Channel 1 |
| $F0C024 | $00C026 | Expansion Port Incremental Encoder Channel 2 |
| $F0C028 | $00C02A | Expansion Port Incremental Encoder Channel 3 |
| $F0C02C | $00C02E | Expansion Port Incremental Encoder Channel 4 |

| **Example:** This example adds the entries to the end of the default encoder table. | | | |
|---|---|---|---|
| | WY:$072A, $F0C020, $00C022 | — | Result in X:$072B |
| | WY:$072C, $F0C024, $00C026 | — | Result in X:$072D |
| | WY:$072E, $F0C028, $00C02A | — | Result in X:$072F |
| | WY:$0730, $F0C02C, $00C02E | — | Result in X:$0731 |

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 2nd Intrp | off | off | off | off |

| 1st Line Setting | 2nd Line Setting | Meaning |
|---|---|---|
| $F0C030 | $00C032 | Expansion Port Incremental Encoder Channel 1 |
| $F0C034 | $00C036 | Expansion Port Incremental Encoder Channel 2 |
| $F0C038 | $00C03A | Expansion Port Incremental Encoder Channel 3 |
| $F0C03C | $00C03E | Expansion Port Incremental Encoder Channel 4 |

| **Example:** This example adds the entries to the end of the above encoder table. | | | |
|---|---|---|---|
| | WY:$0732, $F0C030, $00C032 | — | Result in X:$0733 |
| | WY:$0734, $F0C034, $00C036 | — | Result in X:$0735 |
| | WY:$0736, $F0C038, $00C03A | — | Result in X:$0737 |
| | WY:$0738, $F0C03C, $00C03E | — | Result in X:$0739 |

## Motor x Software Position Capture & Trigger Mode

Position capture for triggered moves with ACC-51P feedback into a (non-Turbo) PMAC controller must use the "software capture" method. Hardware position capture is not presently supported in this combination. When software position capture is selected, the means of capture are very flexible, but there is a potential delay of one software background cycle (1-2 msec in a typical application) in the capture, which can limit the accuracy of the capture.

The following variable setup must be made to support software capture on Motor x:

1. Ix25 must be set to the base address of the servo channel whose flag and/or index input is used to generate the trigger. Because this also sets the address of the amplifier and limit flags, this will almost always be the same channel as is used for the amplifier interface. If you want to use the index signal of the encoder to trigger a capture, it must be connected to the index input for the channel selected by Ix25, even if this is not the channel on the ACC-51P (which it usually will not be.
2. I9n2 and I9n3 for this channel must be set to specify which edge(s) of which signal(s) create the trigger condition.
3. Bit 16 of Ix03 must be set to 1 to specify software capture with trigger input.

## Encoder Servo Feedback I-Variables

Servo feedback is established from the set of I-variable pairs for each channel that is located at Ix03 and Ix04. These values are addresses that establish an encoder reference that is used by the servo feedback algorithms to maintain a motor's position.

The encoder table addresses are two-line entries for the ACC-51P. Refer to the Encoder Conversion Table reference above for the entry address used as the first line entry. Add 1 to the address value for the result address. The result address is placed into Ix03 and Ix04.

| **Example:** This example adds the entries to the end of the default encoder table. | | | **(Ix03, Ix04 value)** |
|---|---|---|---|
| | WY:$072A, $F0C020, $00C022 | — | Result in X:$072B |
| | WY:$072C, $F0C024, $00C026 | — | Result in X:$072D |
| | WY:$072E, $F0C028, $00C02A | — | Result in X:$072F |
| | WY:$0730, $F0C02C, $00C02E | — | Result in X:$0731 |

***Note:***

The encoder table addressing starts at memory location $720. PMAC processes all table entries until it finds an entry set to 00 (unused). There must not be any address gaps between the first and last encoder table entry.

***Note:***

Due to timing constraints with the interpolator's conversion processes, other types of conversions should be placed in the table before entries for the ACC-51P. The interpolator may place unnecessary wait states back to the PMAC's processor if the conversion table entries are placed at the beginning of the conversion table.

***Note:***

The encoder channels in the interpolator are additional to AB digital quadrature inputs that are present on the PMAC channels. The encoder inputs that are present on the PMAC's eight channels are still available for uses such as velocity feedback inputs or handwheel encoders.

## Using the PMAC Executive

The PMAC executive program is ideal for setting up the encoder conversion table. The interpolator is assigned into the encoder conversion table as a High Resolution Encoder Interpolator when using PEWIN's executive program conversion table setup menu.

1. Choose consecutive entries as desired for each encoder's configuration.
2. Select High Resolution Encoder Interpolator as the conversion style.
3. Be sure that the correct encoder source channel number is also selected.
4. Download the new encoder table data to PMAC and select the View All Encoder Entries function to verify that the entries are correct.

When finished, close the Configure Encoder Table window and type **SAVE** to store the new encoder table data.

***Note:***

Versions of the Executive Program that pre-date the releases of the ACC-51P do not permit automated setup of the table in the Configure Encoder Table function. With older Executive Programs, manually configure the encoder table with memory write commands.

With the above process completed, notice that the data from the interpolator appears in the position window (when Ix00=1).

# PMAC2-PC, -LITE AND EXPANSION PORT INTERPOLATOR

The ACC-51P requires the PMAC2 to have firmware release 1.16G or later.

## PMAC2-PC, -Lite Parameters That Must Be Set

The regular non-Turbo PMAC2 does not have I-variables to support the setup of encoder channels on the expansion port. Therefore, M-variables must be assigned to the setup registers.

### Encoder Decode Control M-Variables

M-Variables are recommended to establish encoder decoding for the PMAC2. The values shown below are recommended M-variables and should be assigned as follows:

| | |
|---|---|
| M940 -> X:$C040,24 | M960 -> X:$C060,24 |
| M945 -> X:$C044,24 | M965 -> X:$C064,24 |
| M950 -> X:$C048,24 | M970 -> X:$C068,24 |
| M955 -> X:$C04C,24 | M975 -> X:$C06C,24 |

A value of 7 is used for CCW x4 Quadrature decode. The value of 7 must be written to the M-variables assigned above every time the power is cycled on the ACC-51P interpolator card. Refer to the sample startup program below.

### Encoder Input Filter Disable M-Variables

M-Variables are recommended to disable the encoder input filters when used with the PMAC2. The values shown below are recommended M-variables and should be assigned as follows:

| | |
|---|---|
| M941 -> X:$C040,15 | M961 -> X:$C060,15 |
| M946 -> X:$C044,15 | M966 -> X:$C064,15 |
| M951 -> X:$C048,15 | M971 -> X:$C068,15 |
| M956 -> X:$C04C,15 | M976 -> X:$C06C,15 |

A value of 1 is used to disable the input filter for each channel used on the PMAC2. A value of 1 must be written to the M-variables assigned above every time the power is cycled to the ACC-51P. Refer to the sample startup program in this section.

### Alternate Encoder Decode Control M-Variables

M-Variables are recommended to poke the encoder direction into the X-memory side of the encoder conversion table for the PMAC2. Refer to the Encoder Conversion Table description in the next section for details of the values that these M-Variables should have. The values shown below are recommended M-variables and should be assigned as follows based upon the example of the encoder conversion table entries for two 4-axis interpolators that are addressed starting at the ninth entry in the encoder conversion table:

| | |
|---|---|
| M942 -> X:$72A,24 | M962 -> X:$732,24 |
| M947 -> X:$72C,24 | M967 -> X:$734,24 |
| M952 -> X:$72E,24 | M972 -> X:$736,24 |
| M957 -> X:$730,24 | M977 -> X:$738,24 |

A value of 7 is used for CCW x4 Quadrature decode. The value of 7 must be written to the M-variables assigned above every time the power is cycled on the ACC-51P interpolator card. Refer to the sample startup program in this section.

## Sample Startup PLC for PMAC2

A sample PLC program could be written as follows:

```
OPEN PLC1 CLEAR
   M940=7         ;Set encoder direction (either a value of 7 or 3).
   M941=1         ;Disable encoder input filter.
   M942=7         ;Set alternate encoder direction (must match value of
                  ;M940).
   M945=7
   M946=1
   M947=7
   M950=7
   M951=1
   M952=7
   M955=7
   M956=1
   M957=7
   M960=7
   M961=1
   M962=7
   M965=7
   M966=1
   M967=7
   M970=7
   M971=1
   M972=7
   M975=7
   M976=1
   M977=7
   DISABLE PLC1
CLOSE
```

## Commutation Position I-Variables (Ix83)

The ACC-51P contains a quadrature-based encoder register that may be used for commutation position. The PMAC2 does not use the ACC-51's full interpolation to track a motor's position.

The number of commutation counts per pole revolution or linear scale distance is related to the pitch of the encoder's sinusoidal output multiplied by four. Therefore, commutation appears to the PMAC2 as if it were a quadrature-based encoder.

The tables below show the addresses of the quadrature register in the ACC-51P:

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 1st Intrp | off | off | off | on |

| ACC51P Channel Address | Ix83 Value |
|---|---|
| $C040 | $C041 |
| $C044 | $C045 |
| $C048 | $C049 |
| $C04C | $C04D |

**Interp SW1 Settings:**

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| 2nd Intrp | off | off | off | off |

| ACC51P Channel Address | Ix83 Value |
|---|---|
| $C060 | $C061 |
| $C064 | $C065 |
| $C068 | $C069 |
| $C06C | $C06 |

## Encoder Conversion Table

The encoder conversion table is a user configurable list of entries that may be assigned to different specific data processing inputs. The interpolator is assigned into the encoder conversion table as a High Resolution Encoder Interpolator when using PEWIN's executive program conversion table setup menu. This 2-line encoder table entry uses a first line Y-word entry value (bit 16-23) of $Fx. The second line contains the values as shown in the following tables. Refer to the PMAC Software Reference manual for Encoder Conversion Table — Conversion Methods for details.

***Note:***

The Executive Program with release dates before third quarter of 1999 does not permit automated setup of the table in the Configure Encoder Table function. With older Executive Programs, you must manually configure the encoder table using memory write commands.

The following table describes the two lines of data values that need to be entered into the encoder conversion table for the settings on the interpolator Dipswitch.

**Interp SW1 Settings:**

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| 1st Intrp | Off | off | off | on |

| 1st Line Setting | 2nd Line Setting | Meaning |
|---|---|---|
| $F0C040 | $00C042 | Expansion Port Incremental Encoder Channel 1 |
| $F0C044 | $00C046 | Expansion Port Incremental Encoder Channel 2 |
| $F0C048 | $00C04A | Expansion Port Incremental Encoder Channel 3 |
| $F0C04C | $00C04E | Expansion Port Incremental Encoder Channel 4 |

**Example:**
This example adds the entries to the end of the default encoder table.

```
WY:$072A, $F0C040, $00C042   —   Result in X:$072B
WY:$072C, $F0C044, $00C046   —   Result in X:$072D
WY:$072E, $F0C048, $00C04A   —   Result in X:$072F
WY:$0730, $F0C04C, $00C04E   —   Result in X:$0731
```

**Interp SW1 Settings:**

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| 2nd Intrp | Off | Off | Off | Off |

| 1st Line Setting | 2nd Line Setting | Meaning |
|---|---|---|
| $F0C060 | $00C062 | Expansion Port Incremental Encoder Channel 1 |
| $F0C064 | $00C066 | Expansion Port Incremental Encoder Channel 2 |
| $F0C068 | $00C06A | Expansion Port Incremental Encoder Channel 3 |
| $F0C06C | $00C06E | Expansion Port Incremental Encoder Channel 4 |

**Example:**
This example adds the entries to the end of the default encoder table.

WY:$0732, $F0C060, $00C062 — Result in X:$0733
WY:$0734, $F0C064, $00C066 — Result in X:$0735
WY:$0736, $F0C068, $00C06A — Result in X:$0737
WY:$0738, $F0C06C, $00C06E — Result in X:$0739

## Motor x Software Position Capture & Trigger Mode

Ix03 is used to establish position capture (Index Position Input). Bit 16 of this variable must be set to 1 to function as software index capture. There is a background cycle delay (typically 2-3 msec) which limits the accuracy of the capture.

Ix25 is used for the address of the flags for the index capture. If limit switches are used on the axis, the encoder's index channel input must be physically cross wired to the same hardware index input as the flags for this function to work.

***Note:***

As of the printing of this manual, hardware index capture is not available for the PMAC2.

## Encoder Servo Feedback I-Variables

Servo feedback is established from the set of I-variable pairs for each channel that is located at Ix03 and Ix04. These values are addresses that establish an encoder reference that is used by the servo feedback algorithms to maintain a motor's position.

The following encoder table addresses are suggested when they are set up from the procedure that is outlined in Encoder Conversion Table in the PMAC Software Reference manual. Refer to the table below:

| | Ix03, Ix04 Value |
|---|---|
| Processed Encoder #1 | $720 |
| Processed Encoder #2 | $721 |
| Processed Encoder #3 | $722 |
| Processed Encoder #4 | $723 |
| Processed Encoder #5 | $724 |
| Processed Encoder #6 | $725 |
| Processed Encoder #7 | $726 |
| Processed Encoder #8 | $727 |
| Processed Sinusoidal Encoder #9 | $72B |
| Processed Sinusoidal Encoder #10 | $72D |
| Processed Sinusoidal Encoder #11 | $72F |
| Processed Sinusoidal Encoder #12 | $731 |
| Processed Sinusoidal Encoder #13 | $733 |
| Processed Sinusoidal Encoder #14 | $735 |
| Processed Sinusoidal Encoder #15 | $737 |
| Processed Sinusoidal Encoder #16 | $739 |

***Note:***

The encoder table addressing starts at memory location $720. PMAC2 processes all table entries until it finds an entry set to 00 (unused). There must not be any address gaps between the first and last encoder table entry.

***Note:***

Due to timing constraints with the interpolator's conversion processes, other types of conversions should be placed in the table before entries for the ACC-51P. The interpolator may place unnecessary wait states back to the PMAC2's processor if the conversion table entries are placed at the beginning of the conversion table.

***Note:***

The encoder channels in the interpolator are additional to AB digital quadrature inputs that are present on the PMAC2's channels. The encoder inputs that are present on the PMAC2's eight channels are still available for uses such as velocity feedback inputs or handwheel encoders.

## Using the PMAC Executive

The PMAC executive program is ideal for setting up the encoder conversion table. There is a list of configuration options in the Configure Encoder Table part of the executive.

1. Choose consecutive entries as desired for each encoder's configuration.
2. Select High Resolution Encoder Interpolator as the conversion style.
3. Be sure that the correct encoder source channel number is also selected.
4. Download the new encoder table data to PMAC and select the View All Encoder Entries function to verify that the entries are correct.

When finished, close the Configure Encoder Table window and type **SAVE** to store the new encoder table data.

***Note:***

Versions of the Executive Program that pre-date the releases of the ACC-51P do not permit automated setup of the table in the Configure Encoder Table function. With older Executive Programs, manually configure the encoder table using memory write commands.

With the above process completed, notice that the data from the interpolator appears in the position window (when Ix00=1).

# PMAC2-MINI, -ULTRALITE AND EXPANSION PORT INTERPOLATOR

The ACC-51P requires the PMAC2 to have firmware release 1.16G or later.

The address mapping for the PMAC2-MINI and PMAC2-Ultralite is slightly different than the PMAC2-PC described previously. The only difference between both sets of parameters that must be used between the PMAC2 products is the address locations.

The base address of $C040 is not available for the PMAC2-MINI and PMAC2- Ultralite. These addresses are used by channels 1-4 on the PMAC2.

## Parameters That are Set in the PMAC2-Mini and -Ultralite

The regular non-Turbo PMAC2 does not have I-variables to support the setup of encoder channels on the expansion port. Therefore, M-variables must be assigned to the setup registers.

### Encoder Decode Control M-Variables

M-Variables are recommended to establish encoder decoding for the PMAC2. The values shown below are recommended M-variables and should be assigned as follows:

| | |
|---|---|
| M940 -> X:$C000,0,24 | M960 -> X:$C020,0,24 |
| M945 -> X:$C004,0,24 | M965 -> X:$C024,0,24 |
| M950 -> X:$C008,0,24 | M970 -> X:$C028,0,24 |
| M955 -> X:$C00C,0,24 | M975 -> X:$C02C,0,24 |

The values shown above are available for the ACC-51P for use with the PMAC2-MINI and PMAC2- Ultralite products.

A value of 7 is used for CCW x4 Quadrature decode. The value of 7 must be written to the M-variables assigned above every time the power is cycled on the ACC-51P interpolator card. Refer to the sample startup program below.

### Encoder Input Filter Disable M-Variables

M-Variables are recommended to disable the encoder input filters when used with the PMAC2. The values shown below are recommended M-variables and should be assigned as follows:

| | |
|---|---|
| M941 -> X:$C000,15 | M961 -> X:$C020,15 |
| M946 -> X:$C004,15 | M966 -> X:$C024,15 |
| M951 -> X:$C008,15 | M971 -> X:$C028,15 |
| M956 -> X:$C00C,15 | M976 -> X:$C02C,15 |

The values shown above are available for the ACC-51P for use with the PMAC2-MINI and PMAC2- Ultralite products.

A value of 1 is used to disable the input filter for each channel used on the PMAC2. A value of 1 must be written to the M-variables assigned above every time the power is cycled to the ACC-51P. Refer to the sample startup program in this section.

## Alternate Encoder Decode Control M-Variables

M-Variables are recommended to poke the encoder direction into the X-memory side of the encoder conversion table for the PMAC2. Refer to the Encoder Conversion Table description in the next section for details of the values that these M-Variables should have. The values shown below are recommended M-variables and should be assigned as follows based upon the example of the encoder conversion table entries for two 4-axis interpolators that are addressed starting at the ninth entry in the encoder conversion table:

| | |
|---|---|
| M942 -> X:$72A,24 | M962 -> X:$732,24 |
| M947 -> X:$72C,24 | M967 -> X:$734,24 |
| M952 -> X:$72E,24 | M972 -> X:$736,24 |
| M957 -> X:$730,24 | M977 -> X:$738,24 |

The values shown above are available for the ACC-51P for use with the PMAC2-MINI and PMAC2- Ultralite products.

A value of 7 is used for CCW x4 Quadrature decode. The value of 7 must be written to the M-variables assigned above every time the power is cycled on the ACC-51P interpolator card. Refer to the sample startup program in this section.

## Sample Startup PLC for PMAC2

A sample PLC program could be written as follows:

```
OPEN PLC1 CLEAR
   M940=7         ; Set encoder direction (either a value of 7 or 3).
   M941=1         ; Disable encoder input filter.
   M942=7         ; Set alternate encoder direction (must match value of
                  ; M940).
   M945=7
   M946=1
   M947=7
   M950=7
   M951=1
   M952=7
   M955=7
   M956=1
   M957=7
   M960=7
   M961=1
   M962=7
   M965=7
   M966=1
   M967=7
   M970=7
   M971=1
   M972=7
   M975=7
   M976=1
   M977=7
   DISABLE PLC1
CLOSE
```

The values shown above are available for the ACC-51P for use with the PMAC2-MINI and PMAC2- Ultralite products.

## Commutation Position I-Variables (Ix83)

The ACC-51P contains a quadrature-based encoder register that may be used for commutation position. The PMAC2 does not use the ACC-51's full interpolation to track a motor's position.

The number of commutation counts per pole revolution or linear scale distance is related to the pitch of the encoder's sinusoidal output multiplied by 4. Therefore, commutation appears to the PMAC2 as if it were a quadrature-based encoder.

The tables below show the addresses of the quadrature register in the ACC51P:

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 1st Intrp | off | off | off | on |

| ACC51P Channel Address | Ix83 Value |
|---|---|
| $C000 | $C001 |
| $C004 | $C005 |
| $C008 | $C009 |
| $C00C | $C00D |

The values shown above are available for the ACC-51P for use with the PMAC2-MINI and PMAC2- Ultralite products.

| **Interp SW1 Settings:** | | **4** | **3** | **2** | **1** |
|---|---|---|---|---|---|
| | 2nd Intrp | off | off | off | off |

| ACC51P Channel Address | Ix83 Value |
|---|---|
| $C020 | $C021 |
| $C024 | $C025 |
| $C028 | $C029 |
| $C02C | $C02D |

## Encoder Conversion Table

The encoder conversion table is a user-configurable list of entries that may be assigned to different specific data processing inputs. The interpolator is assigned into the encoder conversion table as a High Resolution Encoder Interpolator when using PEWIN's executive program conversion table setup menu. This 2-line encoder table entry uses a first line Y-word entry value (bit 16-23) of $Fx. The second line contains the values as shown in the following tables. Refer to the PMAC Software Reference manual for Encoder Conversion Table — Conversion Methods for details.

***Note:***

The Executive Program with release dates before third quarter of 1999 do not permit automated setup of the table in the Configure Encoder Table function. With older Executive Programs, you must manually configure the encoder table using memory write commands.

The following table describes the two lines of data values that need to be entered into the encoder conversion table for the settings on the interpolator Dipswitch.

**Interp SW1 Settings:**

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| 1st Intrp | Off | off | off | on |

| 1st Line Setting | 2nd Line Setting | Meaning |
|---|---|---|
| $F0C000 | $00C002 | Expansion Port Incremental Encoder Channel 1 |
| $F0C004 | $00C006 | Expansion Port Incremental Encoder Channel 2 |
| $F0C008 | $00C00A | Expansion Port Incremental Encoder Channel 3 |
| $F0C00C | $00C00E | Expansion Port Incremental Encoder Channel 4 |

**Example:**
This example adds the entries to the end of the default encoder table.

WY:$072A, $F0C000, $00C002 — Result in X:$072B
WY:$072C, $F0C004, $00C006 — Result in X:$072D
WY:$072E, $F0C008, $00C00A — Result in X:$072F
WY:$0730, $F0C00C, $00C00E — Result in X:$0731

The values shown above are available for the ACC-51P for use with the PMAC2-MINI and PMAC2-Ultralite products.

**Interp SW1 Settings:**

| | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| 2nd Intrp | Off | Off | off | Off |

| 1st Line Setting | 2nd Line Setting | Meaning |
|---|---|---|
| $F0C020 | $00C022 | Expansion Port Incremental Encoder Channel 1 |
| $F0C024 | $00C026 | Expansion Port Incremental Encoder Channel 2 |
| $F0C028 | $00C02A | Expansion Port Incremental Encoder Channel 3 |
| $F0C02C | $00C02E | Expansion Port Incremental Encoder Channel 4 |

**Example:**
This example adds the entries to the end of the default encoder table.

WY:$0732, $F0C020, $00C022 — Result in X:$0733
WY:$0734, $F0C024, $00C026 — Result in X:$0735
WY:$0736, $F0C028, $00C02A — Result in X:$0737
WY:$0738, $F0C02C, $00C02E — Result in X:$0739

## Motor x Software Position Capture & Trigger Mode

Position capture for triggered moves with ACC-51P feedback into a (non-Turbo) PMAC controller must use the “software capture” method. Hardware position capture is not presently supported in this combination. When software position capture is selected, the means of capture are very flexible, but there is a potential delay of one software background cycle (1-2 msec in a typical application) in the capture, which can limit the accuracy of the capture.

The following variable setup must be made to support software capture on Motor x:

1. Ix25 must be set to the base address of the servo channel whose flag and/or index input is used to generate the trigger. Because this also sets the address of the amplifier and limit flags, this will almost always be the same channel as is used for the amplifier interface. If you want to use the index signal of the encoder to trigger a capture, it must be connected to the index input for the channel selected by Ix25, even if this is not the channel on the ACC-51P (which it usually will not be.
2. I9n2 and I9n3 for this channel must be set to specify which edge(s) of which signal(s) create the trigger condition.
3. Bit 16 of Ix03 must be set to 1 to specify software capture with trigger input.

## Encoder Servo Feedback I-Variables

Servo feedback is established from the set of I-variable pairs for each channel that is located at Ix03 and Ix04. These values are addresses that establish an encoder reference that is used by the servo feedback algorithms to maintain a motor's position.

The following encoder table addresses are suggested when they are set up from the procedure that is outlined in Encoder Conversion Table in the PMAC Software Reference manual. Refer to the table below:

| | **Ix03, Ix04 Value** |
|---|---|
| Processed Encoder #1 | $720 |
| Processed Encoder #2 | $721 |
| Processed Encoder #3 | $722 |
| Processed Encoder #4 | $723 |
| Processed Encoder #5 | $724 |
| Processed Encoder #6 | $725 |
| Processed Encoder #7 | $726 |
| Processed Encoder #8 | $727 |
| Processed Sinusoidal Encoder #9 | $72B |
| Processed Sinusoidal Encoder #10 | $72D |
| Processed Sinusoidal Encoder #11 | $72F |
| Processed Sinusoidal Encoder #12 | $731 |
| Processed Sinusoidal Encoder #13 | $733 |
| Processed Sinusoidal Encoder #14 | $735 |
| Processed Sinusoidal Encoder #15 | $737 |
| Processed Sinusoidal Encoder #16 | $739 |

***Note:***

The encoder table addressing starts at memory location $720. PMAC2 processes all table entries until it finds an entry set to 00 (unused). There must not be any address gaps between the first and last encoder table entry.

***Note:***

Due to timing constraints with the interpolator's conversion processes, other types of conversions should be placed in the table before entries for the ACC-51P. Otherwise, the interpolator may place unnecessary wait states back to the PMAC2's processor if the conversion table entries are placed at the beginning of the conversion table.

***Note:***

The encoder channels in the interpolator are additional to AB digital quadrature inputs that are present on the PMAC2's channels. The encoder inputs that are present on the PMAC2's eight channels are still available for uses such as velocity feedback inputs or handwheel encoders.

## Using the PMAC Executive

The PMAC executive program is ideal for setting up the encoder conversion table.  There is a list of configuration options in the Configure Encoder Table part of the executive.

1. Choose consecutive entries as desired for each encoder's configuration.
2. Select High Resolution Encoder Interpolator as the conversion style.
3. Be sure that the correct encoder source channel number is also selected.
4. Download the new encoder table data to PMAC and select the View All Encoder Entries function to verify that your entries are correct.

When finished, close the Configure Encoder Table window and type **SAVE** to store the new encoder table data.

With the above process completed, and after running the configuration startup PLC, notice that the data from the interpolator appears in the position window (when Ix00=1).

# TURBO PMAC MODELS AND THE EXPANSION PORT INTERPOLATOR

The ACC-51P requires the Turbo PMAC models to have firmware release 1.934 or later.

## I-Variables for Turbo UMAC Processor

Refer to the Turbo PMAC Software Reference Manual for a more detailed description of the use of the I-vars as described below.

To properly process the interpolator's data, several I-variables must be set:

### Encoder Decode Control I-Variables (I7mn0)

I7mn0 is used to establish encoder decoding. 'm' is the servo IC number as established by the ACC-51P Mapping table (in the previous section); 'n' is the channel number, which is the same as the encoder number (1-4) on the ACC-51P board. The encoder decode control I-variable is set for each channel that an interpolator is connected to.

Refer to the ACC-51P mapping table described in the Dipswitch and Mapping section of this manual for the servo IC number 'm' value.

A value of 7 is used as default for CCW x4 Quadrature decode. Changing the decode direction requires the operator to save the Turbo PMAC's parameters and perform a $$$ or cycle power.

***Note:***

The user MUST reset the PMAC if the encoder direction has been changed. If the encoder direction is changed, but the PMAC is not reset encoder instability will result!

### Motor xx Counts per N Commutation Cycles (Ixx71)

For a Turbo PMAC-commutated motor, this parameter defines the size of a commutation cycle in conjunction with Ixx70 (counts/cycle = Ixx71/Ixx70). The meaning of a "count" used in this parameter is "hardware counts". For example, if a sinusoidal encoder with 2000 lines is used, Ix71 will be set to 8000 hardware counts.

### Motor xx Number of Commutation Cycles (N) (Ixx70)

For a PMAC-commutated motor (Ixx01=1), Ixx70 is used in combination with Ixx71 to define the size of the commutation cycle, as Ixx71/Ixx70 counts. For example, a 4-pole rotary brushless motor has a sinusoidal encoder with 2000 lines. There are 8000 hardware counts per revolution, and 2 commutation cycles per revolution of the 4-pole motor. Therefore, Ix70 will be set to 2, and Ix71 will be set to 8000. Ix83 will contain the address of the hardware counter's phase capture register.

### Commutation Position I- Variables (Ixx83 )

The ACC51P contains a quadrature-based encoder register that may be used for commutation position. The PMAC2 does not use the ACC51's full interpolation to track a motor's position.

The number of commutation counts per pole revolution or linear scale distance is related to the pitch of the encoder's sinusoidal output multiplied by 4. Therefore, commutation appears to the PMAC2 as if it were a quadrature-based encoder.

The table below shows the addresses of the quadrature register in the ACC51P:

| ACC-51P Mapping Table<br>Ixx83 Encoder Address | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Interp SW1 Settings | | | | Turbo PMAC Servo IC # (m) | 1st Channel | 2nd Channel | 3rd Channel | 4th Channel |
| 4 | 3 | 2 | 1 | | | | | |
| on | on | on | on | 2 | $78201 | $78205 | $78209 | $7820D |
| on | on | on | off | 3 | $78301 | $78305 | $78039 | $7830D |
| on | on | off | on | 4 | $79201 | $79205 | $79209 | $7920D |
| on | on | off | off | 5 | $79301 | $79305 | $79309 | $7930D |
| on | off | on | on | 6 | $7A201 | $7A205 | $7A209 | $7A20D |
| on | off | on | off | 7 | $7A301 | $7A305 | $7A309 | $7A30D |
| on | off | off | on | 8 | $7B201 | $7B205 | $7B209 | $7B20D |
| on | off | off | off | 9 | $7B301 | $7B305 | $7B309 | $7B30D |

on=closed, off=open

## Encoder Conversion Table

The encoder conversion table is a user configurable list of entries that may be assigned to different specific data processing inputs. The interpolator is assigned into the encoder conversion table as a High Resolution Encoder Interpolator when using PEWIN's executive program conversion table setup menu.

An ECT entry in which the first hex digit of the first line is $F and the first hex digit of the second line is $0 processes the result of a high-resolution interpolator for analog "sine-wave" encoders, such as the ACC-51. This entry, when used with a high-resolution interpolator, produces a value with 4096 states per line. The entry must read both an encoder channel for the whole number of lines of the encoder, and a pair of A/D converters to determine the location within the line, mathematically combining the values to produce a single position value.

*Encoder Channel Address*: The first line of the three-line entry contains $F in the first hex digit and the base address of the encoder channel to be read in the low 19 bits (bits 0 to 18). If the bit-19 mode switch of the line is set to 0, Turbo PMAC expects a PMAC(1)-style Servo IC on the interpolator, as in the ACC-51P. If the bit-19 mode switch bit is set to1, Turbo PMAC expects a PMAC2-style Servo IC on the interpolator, as in the ACC-51E.

The following table shows the possible entries when PMAC(1)-style Servo ICs are used, as in the ACC-51P.

High-Res Interpolator Entry First Lines for PMAC(1)-Style Servo ICs

| Servo IC # | Channel 1 | Channel 2 | Channel 3 | Channel 4 |
|---|---|---|---|---|
| 2 | $F78200 | $F78204 | $F78208 | $F7820C |
| 3 | $F78300 | $F78304 | $F78308 | $F7830C |
| 4 | $F79200 | $F79204 | $F79208 | $F7920C |
| 5 | $F79300 | $F79304 | $F79308 | $F7930C |
| 6 | $F7A200 | $F7A204 | $F7A208 | $F7A20C |
| 7 | $F7A300 | $F7A304 | $F7A308 | $F7A30C |
| 8 | $F7B200 | $F7B204 | $F7B208 | $F7B20C |
| 9 | $F7B300 | $F7B304 | $F7B308 | $F7B30C |

*A/D Converter Address*: The second line of the entry contains $0 in the first hex digit and the base address of the first of two A/D converters to be read in the low 19 bits (bits 0 to 18). The second A/D converter will be read at the next higher address. The following table shows the possible entries when the ACC-51P, with PMAC(1) style Servo ICs, is used:

High-Res Interpolator Entry Second Lines for PMAC(1)-Style Servo ICs

| Servo IC # | Channel 1 | Channel 2 | Channel 3 | Channel 4 |
|---|---|---|---|---|
| 2 | $078202 | $078206 | $07820A | $07820E |
| 3 | $078302 | $078306 | $07830A | $07830E |
| 4 | $079202 | $079206 | $07920A | $07920E |
| 5 | $079302 | $079306 | $07930A | $07930E |
| 6 | $07A202 | $07A206 | $07A20A | $07A20E |
| 7 | $07A302 | $07A306 | $07A30A | $07A30E |
| 8 | $07B202 | $07B206 | $07B20A | $07B20E |
| 9 | $07B302 | $07B306 | $07B30A | $07B30E |

*A/D Bias Term*: The third line of the entry contains the bias in the A/D converter values. This line should contain the value that the A/D converters report when they should ideally report zero. Turbo PMAC subtracts this value from both A/D readings before calculating the arctangent. Many users will leave this value at 0, but it is particularly useful to remove the offsets of single-ended analog encoder signals.

This line is scaled so that the maximum A/D converter reading provides the full value of the 24-bit register (+/-$2^{23}$, or +/-8,388,608). It is generally set by reading the A/D converter values directly as 24-bit values, computing the average value over a cycle or cycles, and entering this value here.

*Conversion Result*: The result of the conversion is placed in the X-register of the third line of the entry. Careful attention must be paid to the scaling of this 24-bit result. The least significant bit (Bit 0) of the result represents 1/4096 of a line of the sine/cosine encoder.

When Turbo PMAC software reads this data for servo use with Ixx03, Ixx04, Ixx05, or Isx93, it expects to find data in units of 1/32 of a "count". Therefore, PMAC software regards this format as producing 128 "counts" per line. (The fact that the hardware counter used produces 4 counts per line is not relevant to the actual use of this format; this fact would only be used when reading the actual hardware counter for commutation or debugging purposes.)

*Example*: This format is used to interpolate a linear scale with a 40-micron pitch (40µm/line), producing a resolution of about 10 nanometers (40,000/4096), used as position feedback for a motor. PMAC considers a "count" to be 1/128 of a line, yielding a count length of 40/128 = 0.3125 µm. To set user units of millimeters for the axis, the axis scale factor would be:

$$AxisScaleFactor = \frac{1mm}{UserUnit} * \frac{1000\,\mu m}{mm} * \frac{count}{0.3125\,\mu m} = 3200\,\frac{counts}{UserUnit}$$

A 2-channel Expansion Port Interpolator uses 4-channel address field settings. 2 channel interpolators may not overlap 4 channel boundaries.

SW1 position #4 must always be on for Turbo PMAC products.

As an expansion port device, the interpolator input is seen as a whole number counter with three fractional digits. 32 sub-steps occur per single whole number step. Each change of the data is seen by PMAC as 1/32th (0.03125) count. Since PMAC uses fractional arithmetic, the result will be accurate to 1/32 of a whole number step. Refer to the Appendices section of this manual for information on how to display encoder position, which includes fractional data.

***Note:***

The encoder channels in the interpolator are additional to AB digital quadrature inputs that are present on the PMAC's channels. The digital encoder inputs are still available for uses such as velocity feedback inputs or handwheel encoders.

## Using the PMAC Executive

The PMAC executive program is ideal for setting up the encoder conversion table. There is a list of configuration options in the Configure Encoder Table part of the executive.

1. Choose consecutive entries as desired for each encoder's configuration.
2. Select High-Resolution Interpolator as the conversion style.
3. Be sure that the correct encoder source channel number is also selected.
4. Download the new encoder table data to PMAC and select the View All Encoder Entries function to verify that the entries are correct.

When finished, close the Configure Encoder Table window and type **SAVE** to store the new encoder table data.

With the above process completed, notice that the data from the interpolator appears in the position window (when Imn00=1).

To properly add the A/D interpolation data with the quadrature data, I7mn1 for the ACC-51P, channels must be set to 1 to disable the encoder filter.

## Example: Turbo PMAC with ACC-51P for Two Encoders

Two 3-line encoder table entries starting at the ninth line in the Encoder Conversion Table.

| Turbo PMAC - I Variable | Turbo PMAC Memory Location | |
|---|---|---|
| I8008=$F78200 | $3509 | |
| I8009=$078202 | $350A | |
| I8010=$000000 | $350B | ;data for I103 & I104 |
| I8011=$F78204 | $350C | |
| I8012=$078206 | $350D | |
| I8013=$000000 | $350E | ;data for I203 & I204 |

```
I103=$350B       ;position 1 feedback address
I104=$350B       ;velocity 1 feedback address

I203=$350E       ;position 2 feedback address
I204=$350E       ;velocity 2 feedback address

I7210=7          ;channel 9 decode
I7211=1          ;channel 9 filter disable (for proper
                  sequencing)

I7220=7          ;channel 10 decode
I7221=1          ;channel 10 filter disable (for proper
                  sequencing)
```

## Encoder Servo Feedback I- Variables

Servo feedback is established from the set of I-variables for each channel that is located at Ixx03 and Ixx04. These values are addresses that establish an encoder reference that is used by the servo feedback algorithms to maintain a motor's position.

The following encoder table addresses are suggested when they are set up from the procedure that is outlined in Encoder Conversion Table in the PMAC software manuals. Refer to the table below:

| | **Ixx03,Ixx04 Value** | **Conversion Table 1st Line Entry** | **Conversion Table 2nd line Entry** | **Conversion Table 3rd line Entry** |
|---|---|---|---|---|
| PROCESSED ENCODER #1 | $3501 | I8000 | n.a. (single-line entry) | |
| PROCESSED ENCODER #2 | $3502 | I8001 | n.a. | |
| PROCESSED ENCODER #3 | $3503 | I8002 | n.a. | |
| PROCESSED ENCODER #4 | $3504 | I8003 | n.a. | |
| PROCESSED ENCODER #5 | $3505 | I8004 | n.a. | |
| PROCESSED ENCODER #6 | $3506 | I8005 | n.a. | |
| PROCESSED ENCODER #7 | $3507 | I8006 | n.a. | |
| PROCESSED ENCODER #8 | $3508 | I8007 | n.a. | |
| PROCESSED ENCODER #9 | $350B | I8008=$FF8200 | I8009=$78205 | I8010=00 |
| PROCESSED ENCODER #10 | $350E | I8011=$FF8208 | I8012=$7820D | I8013=00 |
| PROCESSED ENCODER #11 | $3511 | I8014=$FF8210 | I8015=$78215 | I8016=00 |
| PROCESSED ENCODER #12 | $3514 | I8017=$FF8218 | I8018=-$7821D | I8019=00 |
| PROCESSED ENCODER #13 | $3517 | I8020=$FF8310 | I8021=-$78305 | I8022=00 |

These addresses are actually the default addresses used by Turbo PMACs for single-line encoder table references that represent axis 1 through 8. Processed encoder 9 through 12 represent sample entries for a UBUS interpolator with SW1 settings selected for all switches on or configurable slot #1(refer to tables in the previous section).

***Note:***

The encoder table addressing starts at memory location $3501. Turbo PMAC processes all table entries until it finds a first line entry set to 00 (unused). There must not be any address gaps between the first and last encoder table entry.

***Note:***

Due to timing constraints with the interpolator's conversion processes, it is recommended that the interpolator's encoder conversion table entries be placed at the contiguous end of the table. The interpolator may place unnecessary wait states back to the Turbo PMAC's processor if the conversion table entries are placed at the beginning of the conversion table.

## Motor xx Position Capture for Triggered Moves

Position feedback through the ACC-51P can be used to support position capture in Turbo PMAC "triggered moves". There are three types of these moves: homing search moves (the most common), on-line "jog-until-trigger" moves, and motion-program "move-until-trigger" RAPID-mode moves. In all three cases, the move ends at a pre-set distance from the position captured on the trigger condition. The position can be captured through either hardware or software means.

## Hardware Position Capture

The very accurate hardware position capture for triggered moves can be supported under certain circumstances with the ACC-51P and a Turbo PMAC controller. The Turbo PMAC must have V1.940 or newer firmware. The hardware trigger signal must be connected to the differential INDEX+/- inputs on the connector of the encoder whose position is to be captured. The INDEX+/- inputs are designed primarily for differential 1Vpp signal centered around 2.5V, but can be used for 0 – 5V digital inputs also.

The captured position will reflect the last "zero crossing" before the trigger of either the sine or cosine encoder signals.

The following variable setup must be made to implement hardware capture on Motor xx:

1. Ixx25 must be set to the base address of the encoder channel on the ACC-51P.
2. I7mn2 for the encoder channel must be set to 1 or 5 to capture on the rising or falling edge, respectively, of the INDEX+ input.
3. If amplifier flags and/or limit flags are used for the motor, Ixx42 and/or Ixx43, respectively, must be set to the address of the servo channel, usually on the Turbo PMAC board itself, used for these flags.
4. Bit 11 of Ixx24 must be set to 1 for the captured position register to be scaled correctly with the highly interpolated feedback. (Note that the ACC-51P does not support sub-count capture, so bit 12 of Ixx24 should be left at the default value of 0.)
5. Ixx97 must be set to the default value of 0 to specify hardware capture in triggered moves.

If it is desired to use both a flag (e.g. HOME) and the index for the homing trigger, the best method is first to use the flag alone with software position capture as described below, with the post-trigger move ending at the trigger position (Ixx26=0), then to use the index alone with hardware position capture to get the very accurate capture.

## Software Position Capture

When software position capture is selected, the means of capture are very flexible, but there is a potential delay of one software background cycle (1-2 msec in a typical application) in the capture, which can limit the accuracy of the capture.

If only the index input on the ACC-51P is used for the capture trigger, it is both easier and more accurate to use the hardware position capture described above.

The following variable setup must be made to support software capture on Motor xx:

1. Ixx25 must be set to the base address of the servo channel whose flag and/or index input is used to generate the trigger. With software capture, this does not have to be the same channel as the ACC-51P encoder used for position feedback. Typically, it will be the same channel as is used for the amplifier interface.
2. I7mn2 and I7mn3 for this channel must be set to specify which edge(s) of which signal(s) create the trigger condition.
3. If amplifier flags and/or limit flags are used on a different servo channel from the trigger flags (not likely in this case), Ixx42 and/or Ixx43, respectively, must be set to the address of the servo channel used for these flags
4. Ixx97 must be set to 1 to specify software capture with trigger input.

# HIPERFACE INTERFACE OPTION (OPT2)

The Hiperface interface option is designed to operate the digital portion of SINCOS and SINCODER devices from Stegmann Corporation. The High Resolution Interpolator with Hiperface option supports commands that apply to the motion needs of PMAC products. These commands include absolute position, encoder temperature, sine-output mux (sincoder), index on RS485 lines (sincoder), encoder reset, error status, and encoder type.

## SINCOS Encoders

A microcontroller inside SINCOS encoders provide a serial link, which is capable of transferring data to and from the encoder without affecting the sinusoidal output. Depending upon the model of encoder, different parameters pertaining to absolute position (single or multi-turn), encoder temperature, encoder type, and presence of encoder may be determined.

Absolute position is returned with a resolution of 16,384 counts per revolution in the SCS/SCM 60 and SCS/SCM 70 encoders.

The SCM 60 and SCM 70 models are capable of multi-turn absolute position reporting of up to 4096 revolutions of 16,384 steps per revolution. They have absolute position counters that roll over at 67,108,864 counts.

The SCS 60 and SCS 70 models are capable of single-turn absolute position reporting of 16,384 steps per revolution. They have absolute position counters that roll over at 16,384 counts.

***Note:***

An application for the SINCOS Hiperface interface option is PMAC's power-on position for establishing the commutation position in brushless servomotors. This application uses the SINCOS encoder models in single-turn configuration.

## SINCODER Encoders

A microcontroller inside SINCODER encoders provide a serial link, which is capable of obtaining data from the encoder without affecting the sinusoidal output. Parameters pertaining to encoder type, and presence of encoder may be determined on a SINCODER.

SINCODERs are also capable of changing the type of sinusoidal outputs that they provide. The power-up default output resolution is typically 1024 sine cycles per revolution. The SINCODER is capable of being switched into a mode that outputs one sine cycle per revolution.

The serial data line may be set to output the index pulse from the SINCODER. This output, when selected, sets the RS485 digital output until the index mark is reached. The RS485 line drops low when the index pulse is reached inside the encoder.

## How to Contact Stegmann Corporation

| | |
|---|---|
| USA: | Europe: (Encoder Division) |
| Ph: (937) 454-1956 | Ph: +49-771-807-121 |
| Fx: (937) 454-1955 | Fx: +49-771-807-100 |
| Web: http://www.stegmann.com | Web: http://www.stegmann.de |

# Using HIPERFACE through PMAC

Upon power-up the Hiperface interface will perform a Read Position Shifted command automatically, and leave its data in the output registers.

Implementing the Hiperface interface involves the use of three M-variables and their assignments for each channel used. A PLC program should be written that implements the transactions that are used with these M-variables.

Assign the m-variables as follows:

## FLAG M-Variables

| | PMAC | PMAC2 | Turbo |
|---|---|---|---|
| Channel 1 | M10->y:$C021,16,1 | M10->y:$C041,16,1 | M10->y:$78201,16,1 |
| Channel 2 | M20->y:$C021,17,1 | M20->y:$C041,17,1 | M20->y:$78201,17,1 |
| Channel 3 | M30->y:$C021,18,1 | M30->y:$C041,18,1 | M30->y:$78201,18,1 |
| Channel 4 | M40->y:$C021,19,1 | M40->y:$C041,19,1 | M40->y:$78201,19,1 |

## LSB Register M-Variables

| | PMAC | PMAC2 | Turbo |
|---|---|---|---|
| Channel 1 | M11->y:$C020,24 | M11->y:$C040,24 | M11->y:$78200,24 |
| Channel 2 | M21->y:$C024,24 | M21->y:$C044,24 | M21->y:$78204,24 |
| Channel 3 | M31->y:$C028,24 | M31->y:$C048,24 | M31->y:$78208,24 |
| Channel 4 | M41->y:$C02C,24 | M41->y:$C04C,24 | M41->y:$7820C,24 |

## MSB Register M-Variables

| | PMAC | PMAC2 | Turbo |
|---|---|---|---|
| Channel 1 | M12->y:$C021,0,8 | M12->y:$C041,0,8 | M12->y:$78201,0,8 |
| Channel 2 | M22->y:$C021,0,8 | M22->y:$C041,0,8 | M22->y:$78201,0,8 |
| Channel 3 | M32->y:$C021,0,8 | M32->y:$C041,0,8 | M32->y:$78201,0,8 |
| Channel 4 | M42->y:$C021,0,8 | M42->y:$C041,0,8 | M42->y:$78201,0,8 |

## Example Hiperface Program

In this example of the register interaction using the Hiperface interface, channel 1 will be used.

Write a PLC that contains the following:

```
M1->y:$0701                   ; Set m-variable to a timer.
OPEN PLC1 CLEAR               ; Open a program buffer.
M11= $42                      ; Command Hiperface to return absolute
                              ; position.
While( m10 = 1 and m11=0 ) wait  ; Loop until conversion is complete
M1=20                         ; Set timer register for 20 servo cycles
                              ; timing.
WHILE( M1 > 0 ) WAIT          ; Wait for Hiperface hardware to set
                              ; variables.
IF( m10=1 )                   ; Check for error condition.
     SEND"ERROR - CODE = "    ; Send MSG if so.
     CMD"m11"                 ; This is error number.
ELSE                          ; Not error, send position data.
     P1=(m12*16777216)+m11    ; Get the position value from 32 bits of
                              ; data.
SEND"Position is "
CMD"p1"
ENDIF
DIS PLC1                      ; Only let this PLC run once.
```

## Hiperface Commands

The following commands are available for Hiperface Encoders:

| SINCOS | SINCODER | Value | Description | 4TH Byte (8 Bits) | 3RD Byte (8 Bits) | 2ND Byte (8 Bits) | 1ST BYTE (8 BITS) |
|---|---|---|---|---|---|---|---|
| ✓ | | 030h | Enc Temperature | 00 | 00 | Bits 8-15 | Bits 0-7 |
| | ✓ | 038h | Set to 1024 Lines | 00 | 00 | 00 | 00h |
| | ✓ | 039h | Set to 1 line | 00 | 00 | 00 | 01h |
| ✓ | | 03Fh | Read Position Shifted | Bits 24-31 | Bits 16-23 | Bits 8-15 | Bits 0-7 |
| ✓ | | 042h | Read Position | Bits 24-31 | Bits 16-23 | Bits 8-15 | Bits 0-7 |
| ✓ | | 043h | Set Position to 00 | 00 | 00 | 00 | 00 |
| ✓ | ✓ | 050h | Error Status | 00 | 00 | 00 | Value |
| ✓ | ✓ | 052h | Encoder Type | RS485 mode | Enc Type | EErom Size | Channel |
| ✓ | ✓ | 053h | Encoder Reset | 00 | 00 | 00 | 00 |
| | ✓ | 054h | Set Index Output | 00 | 00 | 00 | 00 |
| | ✓ | 05Fh | Set Index Perm | 00 | 00 | 00 | 00 |

## 030h Encoder Temperature

This command returns a 16-bit value of encoder temperature in °C. Use the following equation to obtain the actual encoder temperature:

$$\text{Encoder Temp (°C)} = \frac{\text{Digital value} + 40}{2048}$$

## 38h Set Sincoder to 1024 Line Mode

This command sets a sincoder's MUX to 1024 lines/revolution mode. This is the default value for the SINCODER at power-up. The value returned should be 00 in the LSB registers.

## 039h Set Sincoder to 1 Line Mode

This command sets a sincoder's MUX to one line/revolution mode. The value returned should be 00 in the LSB registers.

## 03Fh Read SINCOS Absolute Position Shifted

This command returns the 32-bit absolute position counter value of the SINCOS encoder shifted by four bits. This function is required by the PMAC for proper data scaling when calculating power-on position.

This command executes at startup automatically.

## 042h Read SINCOS Absolute Position

This command returns the 32-bit absolute position counter value of the SINCOS encoder.

## 043h Set SINCOS Absolute Position to Zero

This command resets the encoder's absolute position counter to a value of zero. The value of the return registers is set to zero.

Typically, the encoder is preset by the motor manufacturer so that a zero on the encoder is the electrical zero of the motor. It is not intended for the end-user to reset the encoder position to zero in normal applications.

## 050h Read Encoder Error Status Register

This command returns the value that is stored in an error register inside the Hiperface encoder. After reading, this register is reset to 00.

| | | |
|---|---|---|
| **00h** | No Errors | |
| **01h** | Encoder analog signals are unreliable | |
| **02h** | Wrong synchronization or offset | |
| **03h** | Data field operations disabled | ❶ |
| **04h** | Analog monitoring inoperative | |
| **05h,06h,07h** | Internal hardware fault detected, encoder not operational | |
| **08h** | Counting register overflow | ❶ |
| **09h** | Transmitted parity is incorrect | |
| **0Ah** | Checksum of transmitted data is wrong | |
| **0Bh** | Invalid command code | |
| **0Ch** | Wrong number of data bytes sent | |
| **0Dh** | Illegal transmitted command argument | |
| **0Eh** | Selected field has READ ONLY status | ❶ |
| **0Fh** | Wrong access authorization specified | |
| **10h** | Data field definition error (field size is incorrect) | ❶ |
| **11h** | Specified field address not available | ❶ |
| **12h** | Selected field does not exist | ❶ |
| **1Ch, 1Dh** | Sampling error, encoder not operational | |
| **1Eh** | Permissible operating temperature exceeded | |
| ❶These error codes are related to functions that are not used by PMAC's Hiperface interface. They are provided here for reference purposes only. | | |

## 052h Read Encoder Characteristics

This command returns the encoder's characteristics. Four 8-bit data fields are returned from this command. They are:

| | | |
|---|---|---|
| **1st byte** | Channel | The number of optional analog inputs |
| **2nd byte** | EEPROM size | Encoder's built-in EEPROM size<br>(EEPROM size * 16) - 128 = EErom memory size in bytes |
| **3rd byte** | Encoder type | Type of encoder:<br>Multi-turn = 07h<br>Single-turn= 02h<br>SINCODER = 12h |
| **4th byte** | RS485 mode | Serial data mode<br>Should be E4h - 9600Baud, parity odd, 4.5mS timeout,<br>With 120Ω terminating resistor. |

## 053h Reset Encoder

This command is used for reinitializing the encoder.

## 054h Set Sincoder to Index Output Temporarily

This command sets the SINCODER to apply a low signal to the RS485 digital output lines until an internal index mark is detected.

The low signal occurs approximately 6mS after the command is received at the SINCODER. The output will go to high level to show the index mark present for the duration of the active index mark location. When the SINCODER is removed from the index mark, the signal will go low for approximately 5mS and then revert to the digital RS485 mode and await more Hiperface commands.

## 05Fh Set Sincoder to Index Output Permanently

This command sets the SINCODER to apply the index mark to the RS485 digital output lines.

The low signal occurs approximately 6mS after the command is received at the SINCODER. The output will go to high level to show the index mark present for the duration of the active index mark location.

When power is removed from the SINCODER, it will revert to the digital RS485 mode.

# CONNECTOR DESCRIPTIONS

## J1, J1A JEXP

These are two 50-pin headers that connect the interpolator to the matching Expansion Port connector on the PMAC, PMAC2, or Turbo PMAC processor.

| Pin # | Symbol | Function | Description | Notes |
|---|---|---|---|---|
| 1 | BD00 | I/O | Data bus bit 00 | |
| 2 | BD01 | I/O | Data bus bit 01 | |
| 3 | BD02 | I/O | Data bus bit 02 | |
| 4 | BD03 | I/O | Data bus bit 03 | |
| 5 | BD04 | I/O | Data bus bit 04 | |
| 6 | BD05 | I/O | Data bus bit 05 | |
| 7 | BD06 | I/O | Data bus bit 06 | |
| 8 | BD07 | I/O | Data bus bit 07 | |
| 9 | BD08 | I/O | Data bus bit 08 | |
| 10 | BD09 | I/O | Data bus bit 09 | |
| 11 | BD10 | I/O | Data bus bit 10 | |
| 12 | BD11 | I/O | Data bus bit 11 | |
| 13 | BD12 | I/O | Data bus bit 12 | |
| 14 | BD13 | I/O | Data bus bit 13 | |
| 15 | BD14 | I/O | Data bus bit 14 | |
| 16 | BD15 | I/O | Data bus bit 15 | |
| 17 | BD16 | I/O | Data bus bit 16 | |
| 18 | BD17 | I/O | Data bus bit 17 | |
| 19 | BD18 | I/O | Data bus bit 18 | |
| 20 | BD19 | I/O | Data bus bit 19 | |
| 21 | BD20 | I/O | Data bus bit 20 | |
| 22 | BD21 | I/O | Data bus bit 21 | |
| 23 | BD22 | I/O | Data bus bit 22 | |
| 24 | BD23 | I/O | Data bus bit 23 | |
| 25 | GND | | PMAC ground | |
| 26 | GND | | PMAC ground | |
| 27 | BA00 | Input | Address bit 00 | |
| 28 | BA01 | Input | Address bit 00 | |
| 29 | BA02 | Input | Address bit 00 | |
| 30 | BA03 | Input | Address bit 00 | |
| 31 | BA04 | Input | Address bit 00 | |
| 32 | BX/Y | Input | Address field X/Y | |
| 33 | CS2- | Input | Expansion port select CS2 | |
| 34 | CS3- | Input | Expansion port select CS3 | |
| 35 | CS04- | Input | Expansion port select CS04 | Not used |
| 36 | CS06- | Input | Expansion port select CS06 | Not used |
| 37 | CS10- | Input | Expansion port select CS10 | Not used |
| 38 | CS12- | Input | Expansion port select CS12 | Not used |
| 39 | CS14- | Input | Expansion port select CS14 | Not used |
| 40 | CS16- | Input | Expansion port select CS16 | Not used |
| 41 | BA12 | Input | Address bit 12 | |
| 42 | BA13 | Input | Address bit 13 | |
| 43 | BWR- | Input | Expansion port write select | |
| 44 | BRD- | Input | Expansion port read select | |
| **J1, J1A JEXP (Continued)** | | | | |

| Pin # | Symbol | Function | Description | Notes |
|---|---|---|---|---|
| 45 | GND | | PMAC ground | |
| 46 | GND | | PMAC ground | |
| 47 | RESET | I/O | System reset | |
| 48 | WAIT2- | Output | Wait state line | Open collector |
| 49 | SER | Input | Servo clock from PMAC | |
| 50 | PHA | Input | Phase clock from PMAC | Not used |

## J2 Programming Header (Option 2)

This 6-pin header is used by manufacturing to program the on-board processor.

| Pin # | Symbol | Function | Description | Notes |
|---|---|---|---|---|
| 1 | MISO | Input | | |
| 2 | VCC | | +5Vdc | |
| 3 | SCLK | Input | | |
| 4 | MOSI | Output | | |
| 5 | MRESET | Input | Hiperface option reset | |
| 6 | GND | | | |

## J3, J4 Encoder Inputs

These encoder connections use a 15-pin DSUB connector and provide accessibility through the rear of the computer.

J3 is for the first channel input and J4 is the second channel input to the expansion port interpolator.

| Pin # | Symbol | Function | Description | Notes |
|---|---|---|---|---|
| 1 | SIN+ | Analog input | Sinusoidal input+ | |
| 2 | REF | 2.5V output | A-D reference output | 5KΩ output |
| 3 | COS+ | Analog input | Cosine input+ | |
| 4 | REF | 2.5V output | A-D reference output | Connected to pin #2 |
| 5 | INDEX+ | Input | Index input | Analog or TTL levels |
| 6 | DATA+ | I/O | RS485 digital + | Hiperface (Option 4) |
| 7 | N.C. | | Not connected | |
| 8 | ENCPWR | Output | Encoder power | +5Vdc or user supplied |
| 9 | SIN- | Analog input | Sinusoidal input- | |
| 10 | GND | | Digital ground | |
| 11 | COS- | Analog input | Cosine input- | |
| 12 | GND | | Digital ground | |
| 13 | INDEX- | Input | Index input | Analog or TTL levels |
| 14 | DATA- | I/O | RS485 digital - | Hiperface (Option 4) |
| 15 | GND | | Digital ground | |

## J5, J6 Encoder Inputs (Option 1)

These encoder connections use a 16-pin header connector with polarizing nib.  The pinout of this connector supports IDC adapter cables which allow 15-pin DSUB connectors that use the same pinout as J3-J4 connector.

J5 is for the third channel input and J6 is the fourth channel input to the expansion port interpolator.

When using cable adapters that provide 15-pin DSUB connectors, use the connection table provided for J3 and J4.  A clip is provided with the connectors that use an available PCI slot for mounting when Option 1 is ordered.

| Pin # | Symbol | Function | Description | Notes |
|---|---|---|---|---|
| 1 | SIN+ | Analog input | Sinusoidal input+ | |
| 2 | SIN- | Analog input | Sinusoidal input- | |
| 3 | REF | 2.5V output | A-D reference output | 5KΩ output |
| 4 | GND | | Digital ground | |
| 5 | COS+ | Analog input | Cosine input+ | |
| 6 | COS- | Analog input | Cosine input- | |
| 7 | REF | 2.5V output | A-D reference output | Connected to pin #3 |
| 8 | GND | | Digital ground | |
| 9 | INDEX+ | Input | Index input | Analog or TTL levels |
| 10 | INDEX- | Input | Index input | Analog or TTL levels |
| 11 | DATA+ | I/O | RS485 digital + | Hiperface (Option 4) |
| 12 | DATA- | I/O | RS485 digital - | Hiperface (Option 4) |
| 13 | N.C. | | Not connected | |
| 14 | GND | | Digital ground | |
| 15 | ENCPWR | Output | Encoder power | +5Vdc or user supplied |
| 16 | N.C. | | Not connected | |

## P2 PCI Bus Interface

This card utilizes only the power supply connections from the PCI bus. Programmable power supply loading has been set to 15 Watts per the PCI bus specification.

The PCI connector provides mounting support for the expansion port interpolator. When used as a stand-alone device, power may be asserted through connector TB1.

| Pin # | Symbol | Function | Description |
|---|---|---|---|
| B01 | -12Vdc | | Power supply -12Vdc |
| A02 | +12Vdc | | Power supply +12Vdc |
| A18, A24, A30, A35, A37, A42, A48, A56, B03, B15, B17, B22, B28, B34, B38, B46, B49, B57 | GND | | Power supply return |
| A05, A08, A51, A52, B05, B06, B51, B52 | VCC | | Power supply +5Vdc |
| B09 | PRSNT#1 | Float | Power supply load selection #1 |
| B11 | PRSNT#2 | Grounded | Power supply load selection #2 |

## TB1 User Supplied Power

This 6-pin connector provides power if the Expansion Port Interpolator is not installed in a PCI bus.

In addition, external power may be provided for encoders through this connector. Jumper E9 allows providing external power to the encoders through pin 1 and pin 5.

| Pin # | Symbol | Function | Description | Notes |
|---|---|---|---|---|
| 1 | GND | | Power supply return | |
| 2 | +5Vdc | | +5Vdc | |
| 3 | +12Vdc | | +12Vdc | |
| 4 | -12Vdc | | -12Vdc | |
| 5 | ENCPWR | | Encoder power supply input | |
| 6 | N.C. | | Not connected | |

The spacing of boards in the PCI backplane might not allow the use of TB1. Provide encoder power at the DSUBs (J3, J4, J5, J6).

# APPENDICES

## Interpolator Memory Map

The base address for each model of PMAC is specified as follows:

| Dip Switch 1 | Select A | Select B |
|---|---|---|
| PMAC | $C020 | $C030 |
| PMAC2 | $C040 | $C060 |
| PMAC2-MINI<br>PMAC2-LITE | Not available | $C020 |
| PMAC2-Ultralite | $C000 | $C020 |
| Turbo 1st Slot | $78200 | $78300 |
| Turbo 2nd Slot | $79200 | $79300 |
| Turbo 3rd Slot | $7A200 | $7A300 |
| Turbo 4th Slot | $7B200 | $7B300 |

| | ADDR | X -Memory | Y-Memory |
|---|---|---|---|
| **1st Channel** | Base + 00h | Gate flags | 24 LSBs (Hiperface) |
| | Base + 01h | Phase raw count | Flags + 8MSBs (Hiperface) |
| | Base + 02h | Servo count | Ext $ADC_A$ |
| | Base + 03h | Capture | Ext $ADC_B$ |
| **2nd Channel** | Base + 04h | Gate flags | 24 LSBs (Hiperface) |
| | Base + 05h | Phase raw count | Flags + 8MSBs (Hiperface) |
| | Base + 06h | Servo count | Ext $ADC_A$ |
| | Base + 07h | Capture | Ext $ADC_B$ |
| **3rd Channel** | Base + 08h | Gate flags | 24 LSBs (Hiperface) |
| | Base + 09h | Phase raw count | Flags + 8MSBs (Hiperface) |
| | Base + 0Ah | Servo count | Ext $ADC_A$ |
| | Base + 0Bh | Capture | Ext $ADC_B$ |
| **4th Channel** | Base + 0Ch | Gate flags | 24 LSBs (Hiperface) |
| | Base + 0Dh | Phase raw count | Flags + 8MSBs (Hiperface) |
| | Base + 0Eh | Servo count | Ext $ADC_A$ |
| | Base + 0Fh | Capture | Ext $ADC_B$ |

Ext $ADC_A$ and Ext $ADC_B$ are addresses to the same A-D converter. When accessed twice, the sine data is followed by the cosine data.

## Viewing Actual Encoder Position

When using the PMAC executive program to view position, the data returned from the PMAC does not include the fractional part. The following information shows how to display the complete position information in a watch window.

As a sub-count interpolator device, the interpolator input is seen as a whole number counter with three fractional digits. 32 sub-steps occur per single whole number step. Each change of the data is seen by PMAC as 1/32th (0.03125) count. Since PMAC uses fractional arithmetic, the result will be represented with a resolution to 1/32 of a whole number step.

Refer to the recommended M-variable definitions for Mx62 assignments. There should be an M-variable assigned for each axis to be displayed. This variable points to the encoder actual position register.

Write a PLC that includes the following equation for each axis to be displayed as follows:

Px = Mx62 / (Ix08 * 32)

Where:

Ix08 is the gearing value for a particular axis (typically = 96)

Px is an available P-variable.

Mx62 is a pointer PMAC's actual position register.

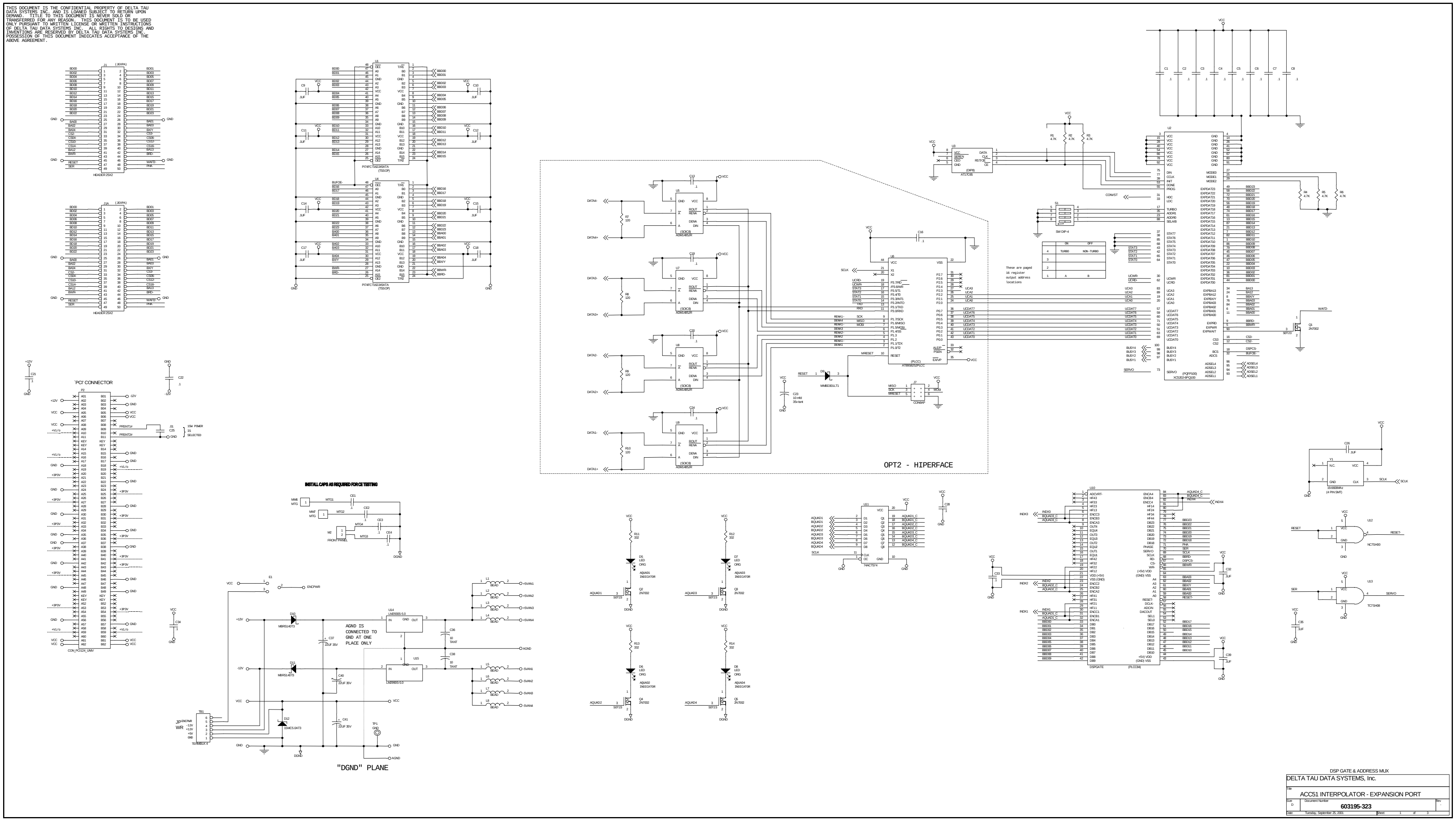
**Note:**

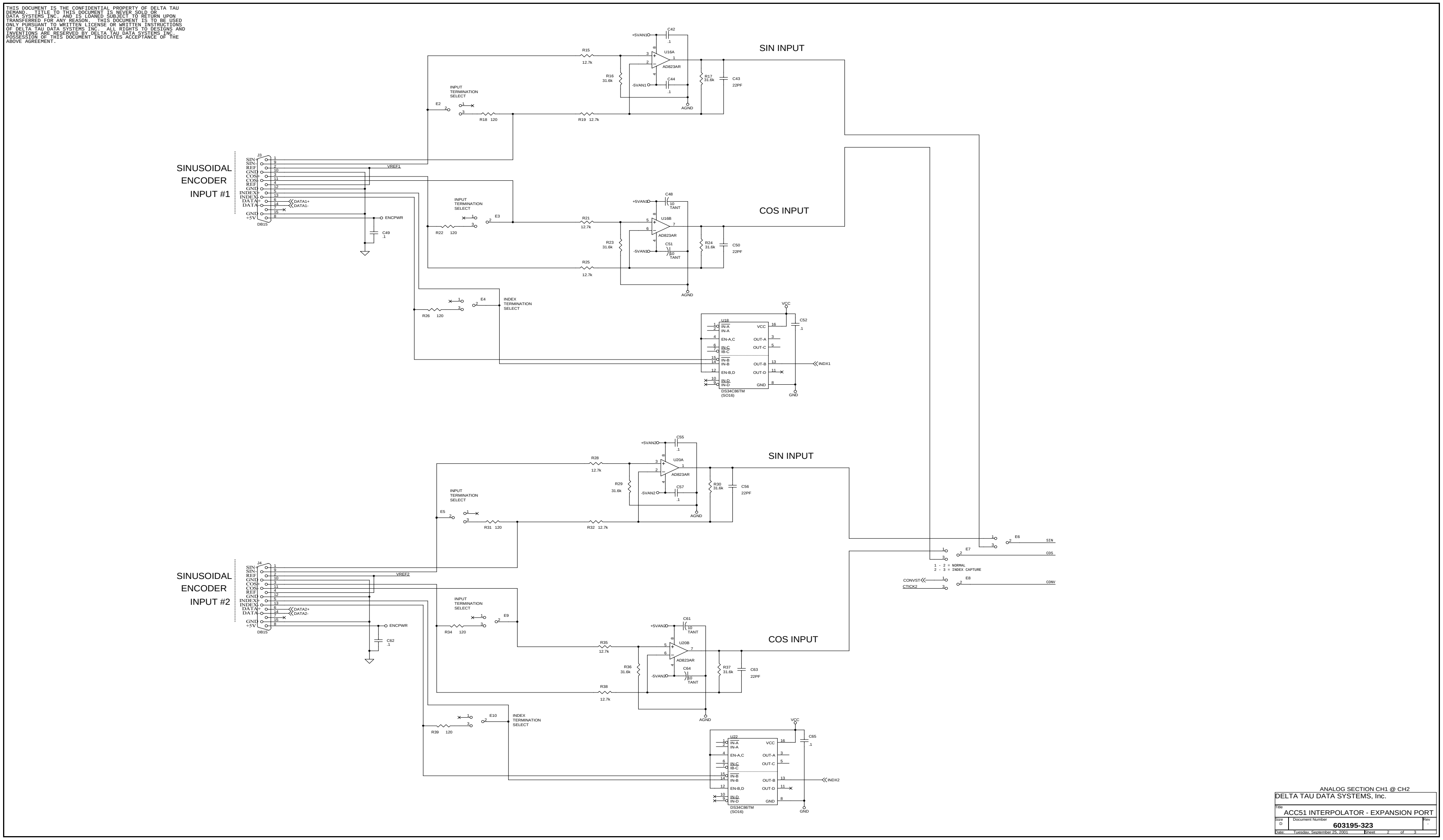
(Ix08 * 32) may be precalculated, since normally gearing is not changed during program operation.

Put Px into the watch window; the value displayed should be the actual position including the fractional data.

# SCHEMATICS

Schematics are shown for reference only. Delta Tau Data Systems Inc. makes no warranty as to the accuracy of these schematics.

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INDEX TERMINATION SELECT
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2 - 3 = INDEX CAPTURE
ANALOG SECTION CH1 @ CH2
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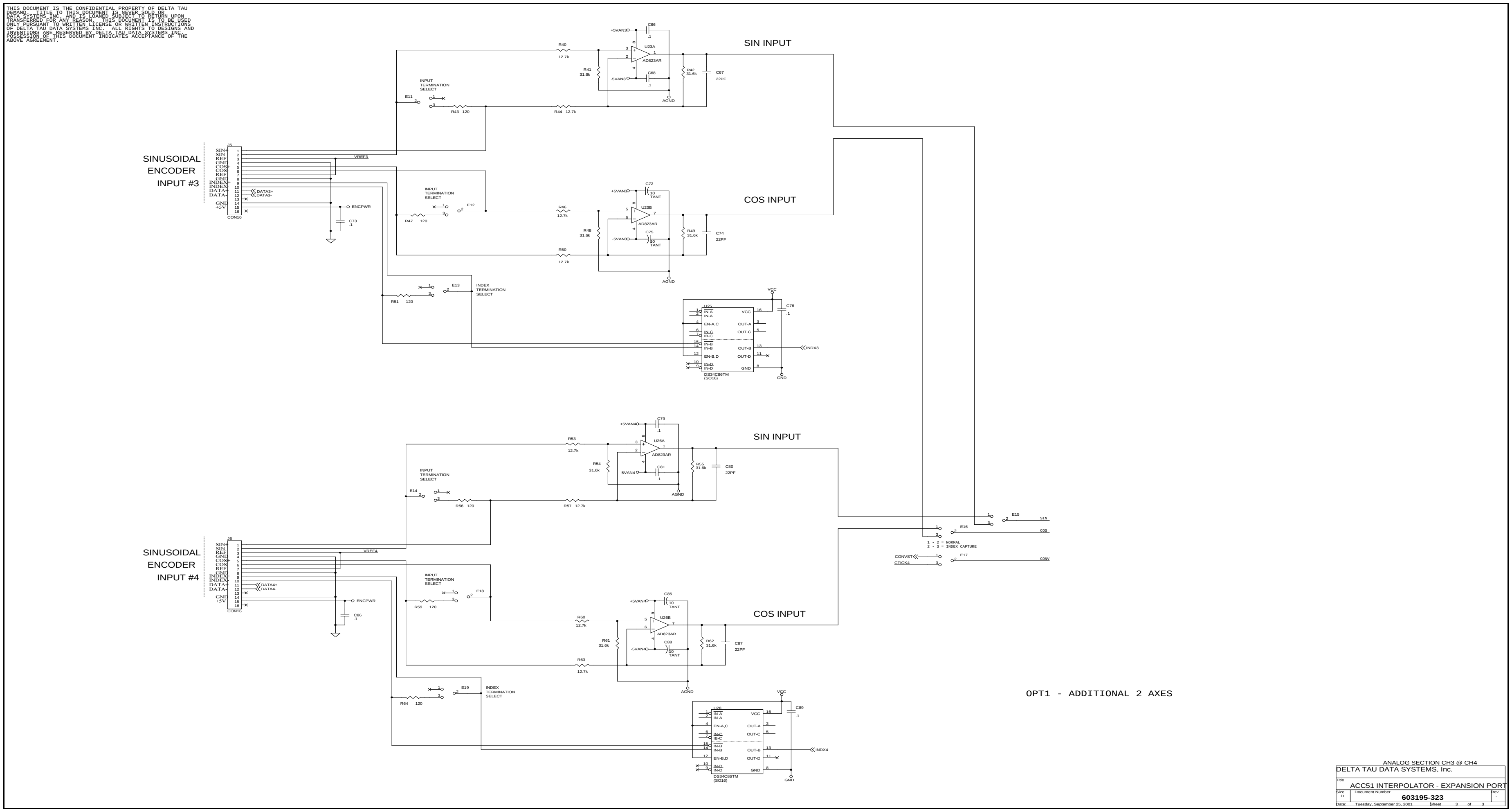
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COS INPUT
INPUT TERMINATION SELECT
INDEX TERMINATION SELECT
1 - 2 = NORMAL
2 - 3 = INDEX CAPTURE
OPT1 - ADDITIONAL 2 AXES
ANALOG SECTION CH3 @ CH4
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