

# INTRODUCTION MANUAL

# PMAC

PMAC Products

3A0-PMACIM-xIMx

December 7, 2004



**DELTA TAU**  
Data Systems, Inc.

*NEW IDEAS IN MOTION ...*

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All Delta Tau Data Systems, Inc. motion controller products, accessories, and amplifiers contain static sensitive components that can be damaged by incorrect handling. When installing or handling Delta Tau Data Systems, Inc. products, avoid contact with highly insulated materials. Only qualified personnel should be allowed to handle this equipment.

In the case of industrial applications, we expect our products to be protected from hazardous or conductive materials and/or environments that could cause harm to the controller by damaging components or causing electrical shorts. When our products are used in an industrial environment, install them into an industrial electrical cabinet or industrial PC to protect them from excessive or corrosive moisture, abnormal ambient temperatures, and conductive materials. If Delta Tau Data Systems, Inc. products are directly exposed to hazardous or conductive materials and/or environments, we cannot guarantee their operation.

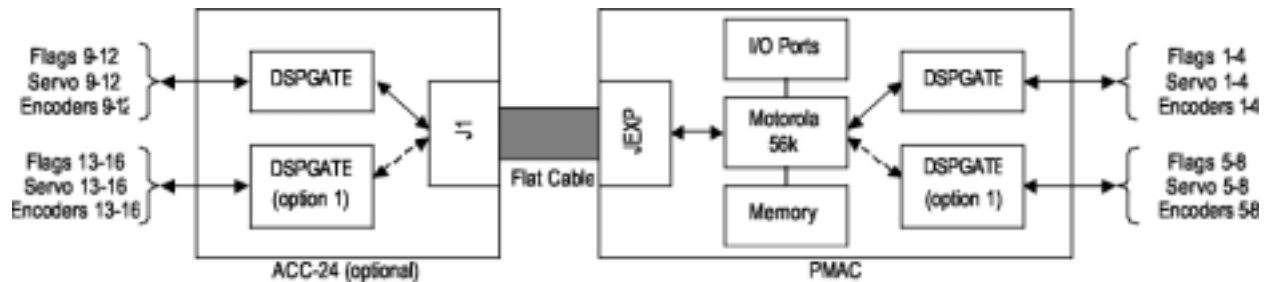
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## DESCRIPTION OF PMAC

PMAC, pronounced *Pe'-MAC*, stands for Programmable Multi-Axis Controller. It is a family of high-performance servo motion controllers capable of commanding up to 32 axes of motion simultaneously with a high level of sophistication.



- The PMAC is available in different hardware versions and these cards differ from each other in their form factor, the nature of the bus interface, and in the availability of certain I/O ports.
- The main component in PMAC is its CPU: the Motorola's Digital Signal Processor (DSP) DSP56k. The power of the DSP56k and the brilliant Delta Tau firmware design is what makes PMAC such an excellent controller. PMAC is provided with several CPU types, speeds and memory options.
- PMAC's CPU communicates with the axes through specially designed custom gate array ICs, referred to as DSPGATES. Each DSPGATE contains four consecutively numbered channels. There are two types of DSPGATES: the PMAC(1) type and the PMAC2 type. The main difference between these two types is the kind of motor command signals that they can provide. The PMAC(1) type can output only a  $\pm 10V$  (DAC) command signal per channel whereas the PMAC2 type can output either a digital PWM set of outputs, a pulse and direction (stepper) set of outputs or two  $\pm 10V$  (DAC) outputs per channel.
- Each PMAC channel provided by a PMAC(1) type DSPGATE has one DAC output, one encoder input and four dedicated flag inputs: two end-of-travel limits, one home input and one amplifier fault input. Most applications require a single PMAC channel per motor. Two PMAC channels per motor are necessary, for example, for dual-feedback applications (two encoders per motor) or analog sinusoidal commutation (two analog DAC outputs per motor).
- Each PMAC2 channel provided by a PMAC2 type DSPGATE has a set of servo command signals, one encoder input, five supplemental input flags and four dedicated flag inputs: two end-of-travel limits, one home input and one amplifier fault input. Most applications require a single PMAC2 channel per motor. Two PMAC2 channels per motor are necessary, for example, for dual-feedback applications requiring two encoders per motor.
- Any non-Turbo PMAC can control up to eight motors or axis as long as enough channels is provided. Every PMAC contains one DSPGATE, which has channels 1 through 4 (PMAC Mini has only two channels). If Option-1 is ordered (not available on PMAC-Lite or PMAC Mini), a second DSPGATE is provided, which has channels 5 through 8. If ACC-24 is ordered, a third DSPGATE is provided, which has channels 9 through 12. If ACC-24 Option-1 is ordered as well, a fourth DSPGATE is provided, which has channels 13 through 16.
- A Turbo PMAC can control up to 32 axes. When ordered with Option-1, the main Turbo PMAC board will contain two DSPGATE chips for a total of eight channels. Up to four ACC-24 with eight channels each can be added to the Turbo PMAC for a total of 30 channels. The ACC-24 connects to the main PMAC board through a flat cable to its JEXP port.
- PMAC has its own on-board memory. This allows PMAC to keep its configuration parameters, programs and variables for a given application. Therefore, any version of PMAC may run as a standalone controller or commanded by a host computer either over a serial port or over a bus port.

- Any PMAC has on board general-purpose digital inputs and outputs. This, in combination with the available PLC programming method, makes PMAC not only a motion controller but a multi-purpose PLC device as well.
- Several other I/O ports are available in most PMACs for the expansion of I/O lines, the connection of optional analog to digital converters and the addition of either vacuum fluorescent or LCD display devices.

## Turbo PMAC

The Turbo PMAC family should be selected based on the following features:

- Up to 32 axis of motion control in up to 16 different coordinate systems (motor groups) using up to 40 channels. The Turbo PMAC can be either PMAC(1) or PMAC2 type.
- Advanced lookahead (tighter acceleration and velocity control) and inverse kinematics (robotics) built-in features.
- Improved overall firmware features including better data array programming, more efficient analog inputs multiplexing, both regular and extended servo algorithms on the standard firmware, completely independent communication ports and optional second serial port.



## PMAC2

The PMAC2 family should be selected based on the following features:

- PMAC2 is the only option to control digital amplifiers requiring direct PWM digital control signals. Also, the PMAC2 is more efficient for drives that requires pulse and direction signals such as stepper motor drives.
- PMAC2 has two DAC (analog  $\pm 10V$ ) outputs per channel. This makes PMAC2 more efficient for the control of amplifiers through analog sinusoidal commutation requiring two DAC signals per motor.
- PMAC2 can directly interface with MLDT position feedback devices.
- The highly improved capture and compare features of PMAC2 in comparison to the PMAC(1) type allow the high precision synchronization of position feedback devices (encoders) with especially dedicated digital inputs and outputs.
- Through its handwheel port, two extra full encoder inputs are standard in any PMAC2. Also, a single parallel feedback device can be interfaced to any standard PMAC2 board.
- The PMAC2 Ultralite does not have any on-board DSPGATE chips. Usually, the DSPGATE chips are connected at long distances from the PMAC2 Ultralite to a UMAC MACRO system through either a fiber optic or twisted pair link. This not only allows a long distance connection (from ten feet to two miles with glass fiber) to motors, amplifiers and I/O devices, but also reduces wiring complexity and electromagnetic noise.



The PMAC2 style DSPGATEs have the following features that can control virtually any kind of motor or amplifier:

- Three top-and-bottom PWM output signal pairs (when the digital side is used)
- Two 18-bit serial DAC output lines with clock and strobe (when the analog side is used)
- One pulse-and-direction output signal pair (when the stepper side is used)
- One 3-channel (A, B and C) quadrature differential encoder input with hardware capture and compare
- Four capture-capable input flags (HOME, +LIMIT, -LIMIT and Amplifier FAULT)
- Five supplemental input flags, for hall commutation, sub-count data or error code

## **PMAC(1)**

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The PMAC(1) type, the first developed member of the PMAC family, should be selected based on the following features:

- Cost efficient when controlling amplifiers that require a single analog  $\pm 10V$  control signal.
- On-board 5 to 24V range general-purpose digital I/O port (PMAC2 is limited to 5V operation.)
- Dedicated control panel with automatic functions supported in PMAC's firmware (not available in PMAC Mini).



## **PMAC Lite**

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The PMAC Lite is recommended for applications with three or four channel requirements in either a PC based or stand alone environment. The term Lite stands for the limitation to only one DSPGATE Gate-Array IC on board, thus limiting the number of axis of control to four. The PMAC Lite is available in PMAC(1) or PMAC2 format, as a Turbo or non-Turbo type and with PCI bus form factor. The number of channels can always be expanded, from 4 to 12, through the use of either an ACC-24P or ACC-24P2 for PMAC(1) or PMAC2 type respectively.

## **PMAC Mini**

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The PMAC Mini is recommended for applications with one or two channel requirements in either a PC based or stand alone environment. The term Mini stands for the limitation to one half DSPGATE Gate-Array IC on board, thus limiting the number of axis of control to two. The PMAC Mini is available in PMAC(1) or PMAC2 format with PCI bus form factor. The number of channels can always be expanded, from 2 to 10, through the use of either an ACC-24P or ACC-24P2 for PMAC(1) or PMAC2 type respectively.

## **PMAC2 Ultralite**

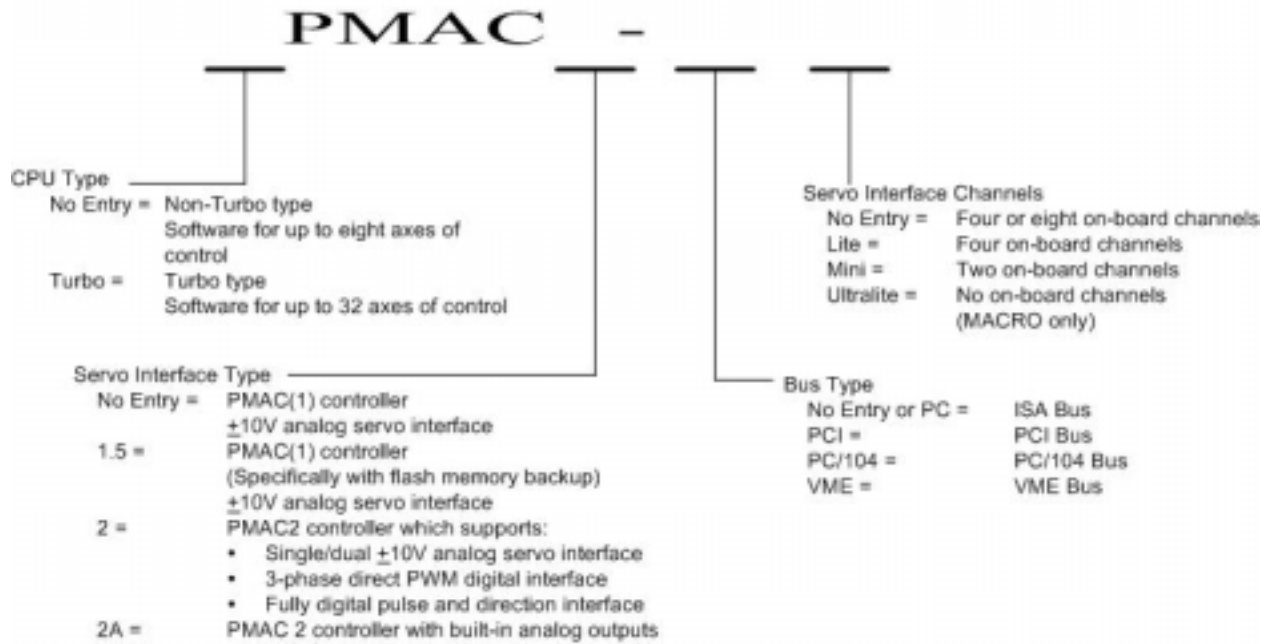
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The term Ultralite stands for no DSPGATE Gate-Array ICs on board of this kind of PMAC2. The ASICs are located in a different set of boards, usually remotely located from PMAC2, referred as UMAC MACRO systems. In fact, the PMAC2 UltraLite in combination with the UMAC MACRO system could be seen as a PMAC2 divided in two halves: the central processing portion that contains the DSP processor and the distributed circuitry that connects to motors, amplifiers and different I/O points.

The PMAC2 Ultralite and the UMAC MACRO (Motion And Control Ring Optical) systems are linked with a fiber optic or twisted pair connection. This clever distribution of components brings many benefits:

- Drastic reduction of wiring complexity
- Elimination of interference by electromagnetic noise and long distance connections (3000 m, ~2 miles with glass fiber).

## PMAC Motion Controller Nonenclature



**Example:**

**Turbo PMAC2 – PCI Ultralite**

PMAC with 32 axes firmware for the PCI bus with MACRO fiber optics interface and no on-board axes outputs

**PMAC2A – PC/104**

PMAC with eight axes firmware for the PC/104 Bus with ±10V analog outputs and PMAC2 type firmware



## PMAC Motion Controllers Chart

Board Name	PCI	PC-104	VME	USB	MACRO	RS-232 / 422	1-2 Axes	1-4 Axes	1-8 Axes	1-32 Axes	Analog $\pm 10$ V Commands	Digital PWM Commands	Stepper Commands
PMAC PCI Mini	•					•	•				•		
PMAC PCI Lite	•			•		•	•	•			•		
PMAC PCI	•			•		•	•	•	•		•		
PMAC2 PCI Lite	•			•		•	•	•			•	•	•
PMAC2 PCI	•			•		•	•	•	•		•	•	•
PMAC2 PCI Ultralite	•				•	•	•	•	•		•	•	•
Turbo PMAC PCI Lite	•			•		•	•	•			•		
Turbo PMAC PCI	•			•		•	•	•	•	•	•		
Turbo PMAC2 PCI Lite	•			•		•	•	•			•	•	•
Turbo PMAC2 PCI	•			•		•	•	•	•	•	•	•	•
Turbo PMAC2 PCI Ultralite	•				•	•	•	•	•	•	•	•	•
PMAC2A-PC/104		•		•		•	•	•	•		•	•	•
PMAC VME			•	•		•	•	•	•		•		
Turbo PMAC VME			•	•		•	•	•	•	•	•		
PMAC2 VME Ultralite			•	•	•	•	•	•	•		•	•	•
PMAC2 VME			•	•		•	•	•	•		•	•	•
Turbo PMAC2 VME			•	•		•	•	•	•	•	•	•	•



## PMAC CONNECTORS AND INDICATORS

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### Display Port Outputs (JDISP Port)

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The JDISP connector (J1) allows connection of the ACC-12A liquid crystal displays, or of the ACC-12C vacuum fluorescent display. Both text and variable values may be shown on these displays through the use of the **DISPLAY** command, executing in either motion or PLC programs.

### Control-Panel Port I/O (JPAN Port)

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The JPAN connector (J2 on PMAC PC, Lite, VME) is a 26-pin connector with dedicated control inputs, dedicated indicator outputs, a quadrature encoder input, and an analog input (requires PMAC OPT-15). The control inputs are low true with internal pull-up resistors. They have predefined functions unless the control-panel-disable I-variable (I2) has been set to 1. If this is the case, they may be used as general-purpose inputs by assigning M-variable to their corresponding memory-map locations (bits of Y address \$FFC0). This port is not present on the PMAC-Mini board.

### Thumbwheel Multiplexer Port I/O (JTHW Port)

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The Thumbwheel Multiplexer Port, or Multiplexer Port, on the JTHW (J3) connector has eight input lines and eight output lines. The output lines can be used to multiplex large numbers of inputs and outputs on the port, and Delta Tau provides accessory boards and software structures (special M-variable definitions) to capitalize on this feature. Up to 32 of the multiplexed I/O boards may be daisy-chained on the port, in any combination.

### Serial Port Connection

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For serial communications, use a serial cable to connect the PC's COM port to the PMAC's serial port connector (J4 on PMAC PC, Lite, and VME; J1). Delta Tau provides cables for this purpose: ACC-3D connects PMAC PC or VME to a DB-25 connector; ACC-3L connects PMAC Lite to a DB-9 connector. Standard DB-9-to-DB-25 or DB-25-to-DB-9 adapters may be needed for a particular setup.

### General-Purpose Digital Inputs and Outputs (JOPTO Port)

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PMAC's JOPTO connector (J5 on PMAC PC, Lite, and VME) provides eight general-purpose digital inputs and eight general-purpose digital outputs. Each input and each output has its own corresponding ground pin in the opposite row. The 34-pin connector was designed for easy interface to OPTO-22 or equivalent optically isolated I/O modules. Delta Tau's ACC-21F is a six-foot cable for this purpose.

### Machine Connectors

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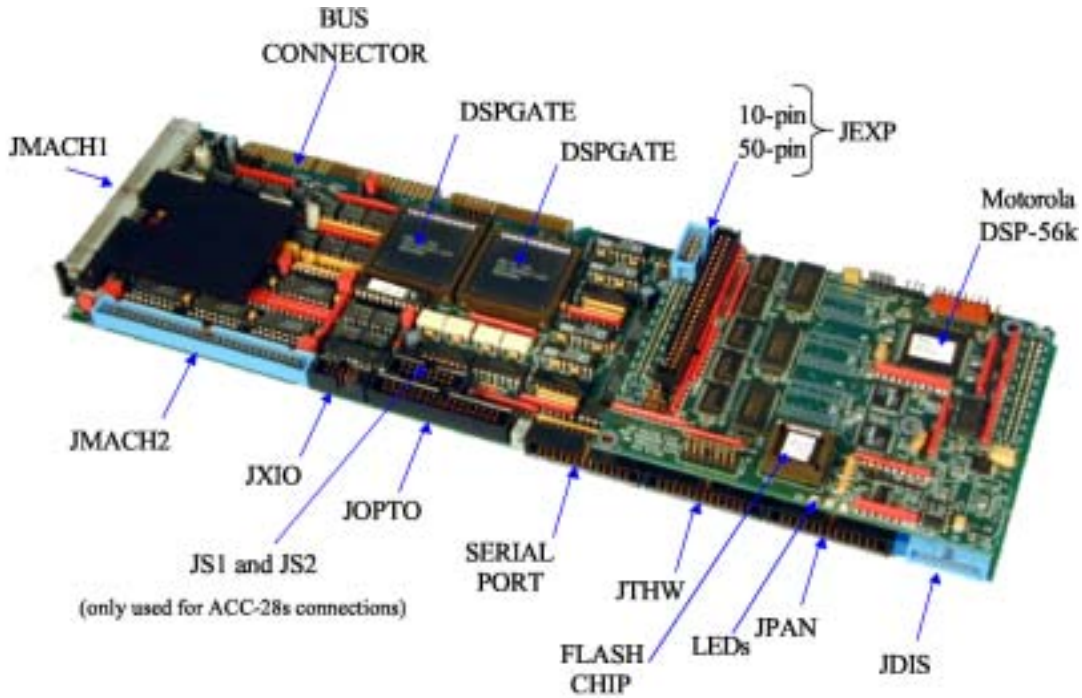
The primary machine interface connector is JMACH1 (J8 on PMAC PC, J11 on PMAC Lite, P2 on PMAC VME). It contains the pins for four channels of machine I/O: analog outputs, incremental encoder inputs, and associated input and output flags, plus power-supply connections. The next machine interface connector is JMACH2 (J7 on PMAC PC, P2A on PMAC VME, not available on a PMAC Lite). Essentially, it is identical to the JMACH1 connector for one to four more axes. It is present only if the PMAC card has been fully populated to handle eight axes (Option-1) because it interfaces the optional extra components.

### LED Indicators

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PMACs with the Option CPU have three LED indicators: red, yellow, and green. The red and green LEDs have the same meaning as with the standard CPU: when the green LED is lit, this indicates that power is applied to the +5V input; when the red LED is lit, this indicates that the watchdog timer has tripped and shut down the PMAC.

The new yellow LED located beside the red and green LEDs, when lit, indicates that the phase-locked loop that multiplies the CPU clock frequency from the crystal frequency on the Option CPU is operational and stable. This indicator is for diagnostic purposes only; it may not be present on some boards.



*Note:*

1. The yellow LED is not present on a battery-backed PMAC; it is present only on Option CPUs with flash memory.
2. JMACH2 connector and second DSPGATE chip present only on a PMAC with Option-1 (8-axis PMAC).

## PMAC System Configuration Incompatibilities

In general, PMAC, its options, and its accessories can be mixed and matched at will. However, there are some combinations that are not permissible. These combinations are listed below.

### JEXP Expansion Port Accessories

The non-Turbo PMAC can interface with two off-board DSPGATES whereas the Turbo PMAC can interface with eight offboard DSPGATES. The ACC-24P/V can have either only one DSPGATE or a second DSPGATE when ACC-24P/V Option-1 is ordered. The ACC-51P can have only one DSPGATE.

Due to bus drive limitations, a limit of four with an absolute maximum of six expansion port (JEXP) accessories is recommended on any PMAC. In addition, the address spaces for ACC-14D/V and ACC-36P/V boards on the JEXP expansion port are limited to six. One ACC-14D/V occupies a full address space; four ACC-36P/V boards occupy one address space.

## JTHW Thumbwheel Multiplexer Port Accessories

A total of 32 boards can be plugged into the thumbwheel multiplexer port (JTHW).

The ACC-27 Opto-Isolated I/O board cannot be used with any other accessory that connects through the thumbwheel multiplexer port (JTHW): the ACC-8D OPT-7 R/D converter (if absolute power-on position is desired); the ACC-8D OPT-9 Yaskawa Encoder Interface, or any of the ACC-34 family of serial I/O boards. This is because the ACC-27 uses the port in non-multiplexed fashion.

There is a limit of 256 addresses for multiplexed accessories on the JTHW thumbwheel multiplexer port: the ACC-8D OPT-7 R/D converter (if absolute power-on position is desired); the ACC-8D OPT-9 Yaskawa Encoder Interface, or any of the ACC-34 family of serial I/O boards.

- An ACC-8D OPT-7 board occupies one address.
- An ACC-8D OPT-9 board occupies one address.
- An ACC-34 type board occupies eight consecutive addresses, starting with an address divisible by 8.

There are no known cases of anyone using all of these address spaces.

## JPAN Control Panel Port Accessories

The ACC-16D control panel and the ACC-39 handwheel encoder converter cannot be used on the same PMAC because both use the entire JPAN control panel port. This port is not present on the PMAC Mini board.

## JDISP Display Port Accessories

Only one display can be connected to the JDISP display port. This includes any of the ACC-12 family of displays.

## JSx Port Accessories

Each ACC-28 A/D converter board must interface to a separate DSPGATE gate array IC on PMAC or ACC-24P/V through its JSx connector. Therefore, the limitations on numbers of ACC-28s for a PMAC system are as follows:

PMAC, no Opt 1; no ACC-24P/V	1 ACC-28	PMAC with Opt 1; ACC-24P, No Opt 1	3 ACC-28s
PMAC, with Opt 1; no ACC-24P/V	2 ACC-28s	PMAC, no Opt 1; ACC-24P with Opt 1	3 ACC-28s
PMAC, no Opt 1; ACC-24P, no Opt 1	2 ACC-28s	PMAC with Opt 1; ACC-24P with Opt 1	4 ACC-28s
The Turbo PMAC is capable of addressing a total of 10 DSPGATEs (40 channels) for a total of 10 ACC-28s.			



## PMAC2 CONNECTORS AND INDICATORS

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### J1: JANA Analog Input Port

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This port provides up to 16 analog inputs at 0-5V or -2.5V to +2.5V (software selectable) for optional on-board 12-bit analog-to-digital converters. Option-12 provides eight channels of analog input; Option-12A provides an additional eight channels. These options are not available on PMAC2 Ultralite boards.

### J2: JTHW Multiplexer Port

---

The Thumbwheel Multiplexer Port, or Multiplexer Port, on the JTHW (J2) connector has eight input lines and eight output lines. The output lines can be used to multiplex large numbers of inputs and outputs on the port, and Delta Tau provides accessory boards and software structures (special M-variable definitions) to capitalize on this feature. Up to 32 of the multiplexed I/O boards may be daisy-chained on the port, in any combination:

- ACC-8D OPT-7 Resolver-to-digital converter board
- ACC-8D OPT-9 Yaskawa absolute encoder interface board
- ACC-34x Digital I/O boards

### J3: JIO Digital I/O Port

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This port provides 32 digital I/O lines at 5V CMOS levels. It is intended for general purpose I/O interfaced through buffers such as Opto-22™ or Grayhill. Without a buffer circuitry each line can drive a maximum of 20 mA. ACC-21A provides a convenient method for connection of this port to Opto-22™ or Grayhill type boards.

### J4: JMACRO Port

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This port sends and receives MACRO data between a regular PMAC2 and an ACC-42 MACRO interface board. Because the full MACRO interface is present on the Ultralite board itself, this port is not present on a PMAC2 Ultralite board.

### J5: JRS232/JRS422 Serial Port

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This port provides a serial interface for the PMAC2 boards. On the PC (PCI) bus versions of PMAC2, the RS232 interface is standard. Option-9L is a small piggyback board that replaces the RS232 port with an RS422 port. On the VME or Lite versions of PMAC2, both RS232 and RS422 ports are present on the standard configuration; jumpers are used to select which port is used. For serial communications, use a serial cable to connect the PC's COM port to the PMAC's serial port connector. Delta Tau provides cables for this purpose: ACC-3D connects to the RS-422 port and ACC-3L connects to the RS-232 port. Standard DB-9-to-DB-25 or DB-25-to-DB-9 adapters may be needed for a particular setup.

### J6: JDISP Display Port

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The JDISP connector allows connection of the ACC-12A liquid crystal displays, or of the ACC-12C vacuum fluorescent display. Both text and variable values may be shown on these displays through the use of the **DISPLAY** command, executing in either motion or PLC programs.

### J7: JHW Handwheel Port

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This port provides two differential 2-channel encoder inputs, quadrature or pulse-and-direction, and two differential output sets. The first set can be a PWM top-bottom pair or a PFM pulse-and-direction pair (software selectable); the second is a PWM top-bottom pair.

### J8: JEQU Position Compare Port

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This port provides four or eight position compare outputs that toggle at user-set positions of the respective encoder counts. As shipped, these are open-collector (sinking) outputs rated to 24V from a ULN2803A drive; the socketed driver IC can be replaced with a sourcing driver (UDN2981A).

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## JMACH: Machine Connectors

The JMACH ports contains all of the servo interface circuitry for machine interface channels and are distributed in channel pairs: Typically, JMACH1 is used for motors 1 and 2, JMACH2 for motors 3 and 4, JMACH3 for motors 5 and 6, and JMACH4 for motors 7 and 8. The high-density 100-pin connector contains 5V digital interface signals for two sets of encoders, drives, and flags. Typically an ACC-8 family interface board or equivalent is used to buffer, isolate, and/or transform these signals. These ports are not present on the Ultralite versions of PMAC2.

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## LED Indicators

PMAC2s have three LED indicators: red, yellow, and green. When the green LED is lit, this indicates that power is applied to the +5V input; when the red LED is lit, this indicates that the watchdog timer has tripped and shut down the PMAC. The yellow LED located beside the red and green LEDs, when lit, indicates that the phase-locked loop that multiplies the CPU clock frequency from the crystal frequency on the Option CPU is operational and stable. This indicator is for diagnostic purposes only.

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## TB1 (2/4-Pin Terminal Block)

This terminal block can be used to provide the input for the power supply for the circuits on the PMAC2 board when it is not in a bus configuration. When the PMAC2 is in a bus configuration, these supplies come automatically through the bus connector from the bus power supply; in this case, this terminal block should not be used.

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*Note:*

Unless Option-12 (Analog-to-Digital Converters) is included on the board, only pins 1 and 2 will be provided on this terminal block.

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## TB2 (3-Pin Terminal Block)

This terminal block provides the output for PMAC2's watchdog timer relay, both normally open and normally closed contacts.

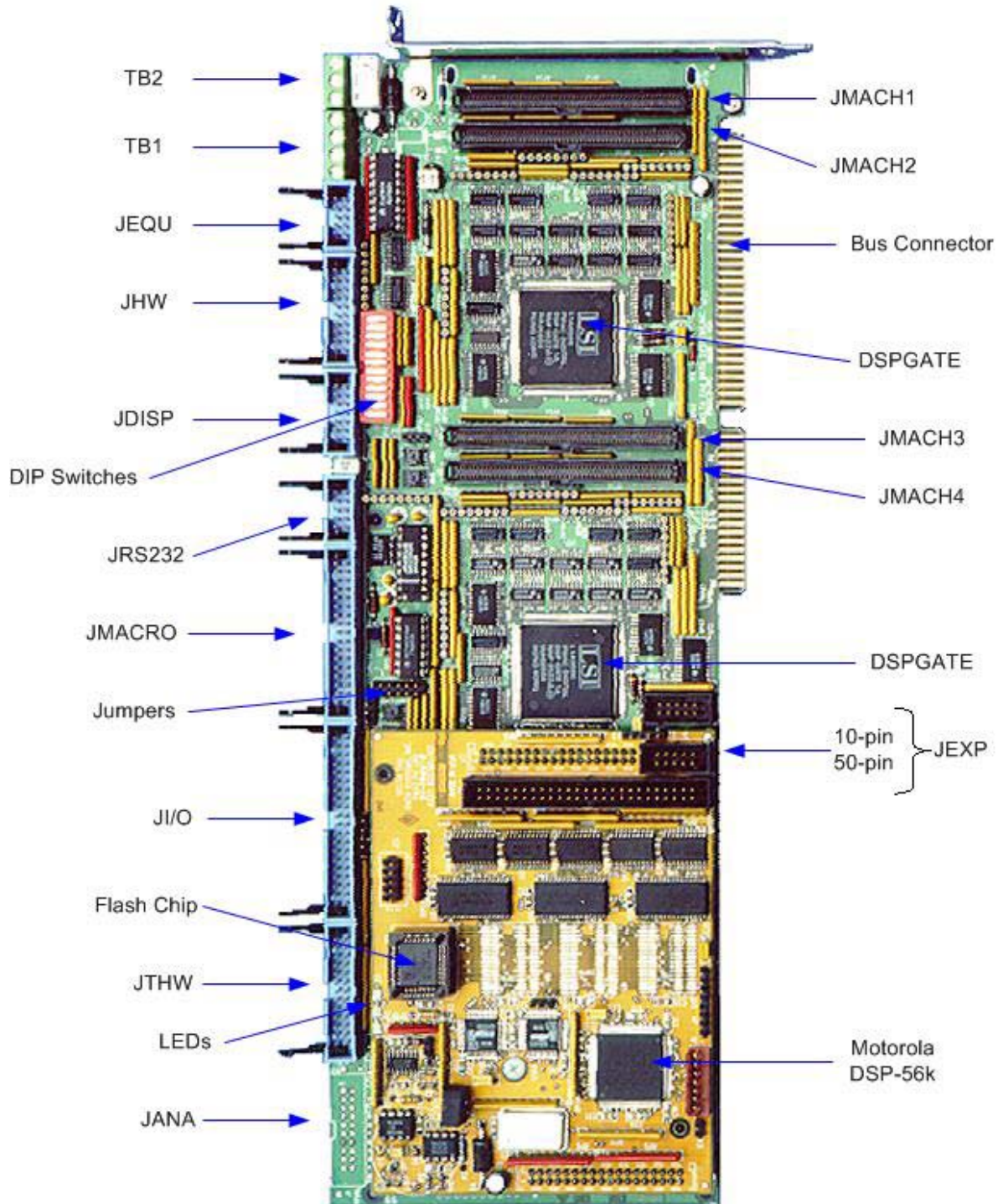
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*Note:*

The normally closed relay contact is open while PMAC2 is operating properly—it has power and the watchdog timer is not tripped—and closed when the PMAC2 is not operating properly—either it has lost power or the watchdog timer has tripped. The normally open relay contact is closed while PMAC2 is operating properly and open when PMAC2 is not operating properly.

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**Note:**

Connectors JMACH3/JMACH4 and second DSPGATE chip is present only on a PMAC2 with Option 1. Connectors layout and availability may be different for other than the PMAC2-PC models.

## PMAC2 System Configuration Incompatibilities

In general, PMAC, its options and its accessories can be mixed and matched at will. However, there are some combinations that are not permissible. These combinations are listed below.

### JEXP Expansion Port Accessories

The non-Turbo PMAC2 can interface with two off-board DSPGATEs whereas the Turbo PMAC2 can interface with eight offboard DSPGATEs. The ACC-24P2 can have either only one DSPGATE or a second DSPGATE when ACC-24P2 Option-1 is ordered. The ACC-51P can have only one DSPGATE.

Due to bus drive limitations, a limit of four with an absolute maximum of six expansion port (JEXP) accessories is recommended on any PMAC. In addition, the address spaces for ACC-14D/V and ACC-36P/V boards on the JEXP expansion port are limited to six. One ACC-14D/V occupies a full address space; four ACC-36P/V boards occupy one address space.

### JTHW Thumbwheel Multiplexer Port Accessories

A total of 32 boards can be plugged into the thumbwheel multiplexer port (JTHW).

The ACC-27 Opto-Isolated I/O board cannot be used with any other accessory that connects through the thumbwheel multiplexer port (JTHW): the ACC-8D OPT-7 R/D converter (if absolute power-on position is desired); the ACC-8D OPT-9 Yaskawa Encoder Interface, or any of the ACC-34 family of serial I/O boards. This is because the ACC-27 uses the port in non-multiplexed fashion.

There is a limit of 256 addresses for multiplexed accessories on the JTHW thumbwheel multiplexer port: the ACC-8D OPT-7 R/D converter (if absolute power-on position is desired); the ACC-8D OPT-9 Yaskawa Encoder Interface, or any of the ACC-34 family of serial I/O boards.

- An ACC-8D OPT-7 board occupies one address.
- An ACC-8D OPT-9 board occupies one address.
- An ACC-34 type board occupies eight consecutive addresses, starting with an address divisible by eight.

There are no known cases of anyone using all of these address spaces.

### JDISP Display Port Accessories

Only one display can be connected to the JDISP display port. This includes any of the ACC-12 family of displays.

### JSx Port Accessories

Each ACC-28B A/D converter board must interface to a separate DSPGATE gate array IC on PMAC2 or ACC-24P2 through its JSx connector. Therefore, the limitations on numbers of ACC-28s for a PMAC2 system are as follows:

PMAC2, no Opt 1; no ACC-24P2	1 ACC-28	PMAC2 with Opt 1; ACC-24P2, no Opt 1	3 ACC-28s
PMAC2 with Opt 1; no ACC-24P2	2 ACC-28s	PMAC2, no Opt 1; ACC-24P2 with Opt 1	3 ACC-28s
PMAC2, no Opt 1; ACC-24P2, no Opt	2 ACC-28s	PMAC2 with Opt 1; ACC-24P2 with Opt 1	4 ACC-28s

The Turbo PMAC2 is capable of addressing a total of ten DSPGATEs (40 channels) for a total of ten ACC-28s. The interface of ten ACC-28s for a total of 40 analog inputs is accomplished with a PMAC2 with Option-1 and four ACC-24Ps each with Option-1.

## TURBO PMAC OPEN SERVO

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Turbo PMAC's Open Servo software feature permits users to custom algorithm in a high-level language that will execute on Turbo PMAC's high-priority servo interrupt. This algorithm can be used either for actual servo control functions, or for other tasks that must execute at a very high priority, such as very high-frequency I/O, special pre-processing of feedback data, or special post-processing of servo commands.

Open Servo algorithms are written in a text editor and downloaded with the PEWIN32PRO PMAC Executive program. The algorithm is compiled into DSP machine code in the host computer before being downloaded into Turbo PMAC's active memory. This process is identical to writing PMAC compiled PLCC programs.

Open Servo algorithms may be retained in Turbo PMAC's non-volatile flash memory using the **SAVE** command. When executed, they replace only the standard servo-loop algorithm for the motor. All other tasks, including trajectory generation, motion and PLC program executions, and safety checking, are still executed by the Turbo PMAC's built-in firmware.

The Open Servo feature is a second method for creating user-written servo algorithms in Turbo PMAC. Previously, this could be done only by writing the algorithm in assembly language for the DSP56300 family using Motorola's cross-assembler, and downloading the assembled code to the Turbo PMAC. The Open Servo feature permits these algorithms to be written without the need to understand and use assembly language.

The compiled Open Servo program is similar to the compiled PLC programs, but there are two key differences:

- Open Servo algorithms run on the servo interrupt, with guaranteed execution every cycle (or the Turbo PMAC will watchdog); compiled PLC programs either run on the real-time interrupt (PLCC 0) with possible pre-emption by motion program calculations, or in background (PLCC 1 – 31) with no deterministic execution rate.
- Open Servo algorithms have specific access mechanisms to special registers used for servo functions.

### Requirements

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The Open Servo requires a Turbo PMAC controller either Turbo PMAC(1), Turbo PMAC2, UMAC, or QMAC with version 1.938 or newer firmware to execute the algorithm. It requires a PC running PEWIN32PRO version 3.2 or the newer PMAC Executive program.

### Proportional Control Programming Example

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The following algorithm shows one of the simplest possible Open Servo algorithms, implementing a simple proportional control law using the motor's Ixx30 parameter as the proportional gain.

```
OPEN SERVO                ; Following lines to be compiled
CLEAR                    ; Not necessary, but acceptable
COPYREG P30              ; Copy following error into P30 P35=P30*I(ITOF
                        ; (MTRNUM*100+30))/65536; Multiply by gain,
                        scale
RETURN(FTOI(P35))        ; Make an integer and output
CLOSE
```

## Operators

+	Addition
-	Subtraction
*	Multiplication
/	Division
%	modulo, remainder
&	Bit-by-bit <b>AND</b>
	Bit-by-bit <b>OR</b>
^	Bit-by-bit <b>XOR</b>

## Comparators

=	Equal to
>	Greater than
<	Less than
~	Approximately equal to [within 0.5]
!=	Not equal to
!>	Not greater than, less than or equal to
!<	Not less than, greater than or equal to
!~	Not approximately equal to [not within

## Functions

<b>SIN</b>	Trigonometric sine
<b>COS</b>	Trigonometric cosine
<b>TAN</b>	Trigonometric tangent
<b>ASIN</b>	Trigonometric arc sine
<b>ACOS</b>	Trigonometric arc cosine
<b>ATAN</b>	Trigonometric arc tangent
<b>ATAN2</b>	Special 2-argument, 4-quadrant arc tangent
<b>ABS</b>	Absolute value
<b>INT</b>	Greatest integer within
<b>EXP</b>	Exponentiation
<b>LN</b>	Natural logarithm
<b>SQRT</b>	Square root

## Special Built-in Functions

<b>FLIMIT</b>	Saturation-check function
<b>MTRNUM</b>	Returns executing motor number
<b>COPYREG</b>	Copies important motor registers into P-Variables

## Logical Control

<b>IF / [ELSE] / ENDIF</b>	Branching constructs
<b>WHILE / ENDWHILE</b>	Looping constructs