User Manual

Power PMAC Clipper

Power PMAC Clipper

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OPERATING CONDITIONS

All Delta Tau Data Systems, Inc. motion controller, accessory, and amplifier products 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 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.

SAFETY INSTRUCTIONS

Qualified personnel must transport, assemble, install, and maintain this equipment. Properly qualified personnel are persons who are familiar with the transport, assembly, installation, and operation of equipment. The qualified personnel must know and observe the following standards and regulations:

IEC364resp.CENELEC HD 384 or DIN VDE 0100
IEC report 664 or DIN VDE 0110
National regulations for safety and accident prevention or VBG 4

Incorrect handling of products can result in injury and damage to persons and machinery. Strictly adhere to the installation instructions. Electrical safety is provided through a low-resistance earth connection. It is vital to ensure that all system components are connected to earth ground.

This product contains components that are sensitive to static electricity and can be damaged by incorrect handling. Avoid contact with high insulating materials (artificial fabrics, plastic film, etc.). Place the product on a conductive surface. Discharge any possible static electricity build-up by touching an unpainted, metal, grounded surface before touching the equipment.

Keep all covers and cabinet doors shut during operation. Be aware that during operation, the product has electrically charged components and hot surfaces. Control and power cables can carry a high voltage, even when the motor is not rotating. Never disconnect or connect the product while the power source is energized to avoid electric arcing.

Warning

A Warning identifies hazards that could result in personal injury or death. It precedes the discussion of interest.

Caution

A Caution identifies hazards that could result in equipment damage. It precedes the discussion of interest.

Note

A Note identifies information critical to the understanding or use of the equipment. It follows the discussion of interest.

REVISION HISTORY				
REV.	**DESCRIPTION**	**DATE**	**CHG**	**APPVD**
0	Preliminary	10/13/14	Sgm	RN
1	Released	07/21/15	RN	RN
2	Update motor setup	04/15/16	Sgm	Sgm
3	Added KC and CE certification	02/06/19	SM	RN
A	Added part number options table for ACC-24S3, ACC-51S, ACC-84S, ACC-8TS, ACC-8FS, ACC-34AA, ACC-28B Added UKCA Marking to front cover and added description in Agency of Approval section	08/09/21	SM	AA
B	Updated UKCA standard	01/27/22	AE	SF

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INTRODUCTION

The Power Clipper is a 4 axis motion controller combining the intelligence and capability of a Power PMAC CPU with the convenience and savings of a low cost platform that is 100% hardware compatible with its Turbo PMAC family member the Turbo PMAC Clipper.

It supports virtually any type of feedback device (with the optional ACC-84S and ACC-51S) and can drive directly the following types of motors with the optional Clipper Drive Stack:

- 3-phase AC/DC brushless servo (synchronous) -- rotary/linear
- 2-phase stepper
- DC brush

Note

The Power Clipper can also provide pulse and direction PFM output signals to third-party stepper drives.

The number of axes in a Power Clipper application can be expanded to 8 with the optional ACC-24S3.

The Power Clipper comes with 32 general-purpose digital I/O points which can be expanded through the optional ACC-34AA, ACC-24S3 or EtherCat. These can be configured as input or outputs in groups of eight. The default factory settings are 16 inputs and 16 outputs.

The outstanding trajectory planner, built-in software PLCs (programmable in Power PMAC script and / or C language), and other features make the Power Clipper a very scalable machine automation controller-drive which can be virtually integrated in any kind of motion control application.

Documentation

In conjunction with this manual, the following manuals are essential for the proper operation and use of the Power Clipper:

- Power PMAC Software Reference Manual
- Power PMAC User Manual

These manuals are available for download, to registered members, at Delta Tau Forums.

Downloadable Power PMAC Script

Caution

Some code examples require the user to input specific information pertaining to their system hardware. When user information is required, a commentary ending with **–User Input** is inserted.

This manual contains downloadable code snippets in Power PMAC script. These examples can be copied and pasted into the editor area of the IDE software. Care must be taken when using pre-configured Power PMAC code, some information may need to be updated to match hardware or system specific configurations. Downloadable code found in this manual is enclosed in the following format:

```
// Power PMAC script format example
GLOBAL MyCounter = 0;           // Arbitrary global variable, counter
GLOBAL MyCycles = 10;           // Arbitrary global variable, number of cycles --User Input

OPEN PLC ExamplePLC             // Open PLC buffer
WHILE (MyCounter < MyCycles)    // While counter is less than number of cycles
{                               // Start while loop
    MyCounter ++                // Increment MyCounter by 1
}                               // End while loop
MyCounter = 0                   // Reset Mycounter
DISABLE PLC ExamplePLC          // Disable PLC
CLOSE                           // Close PLC buffer
```

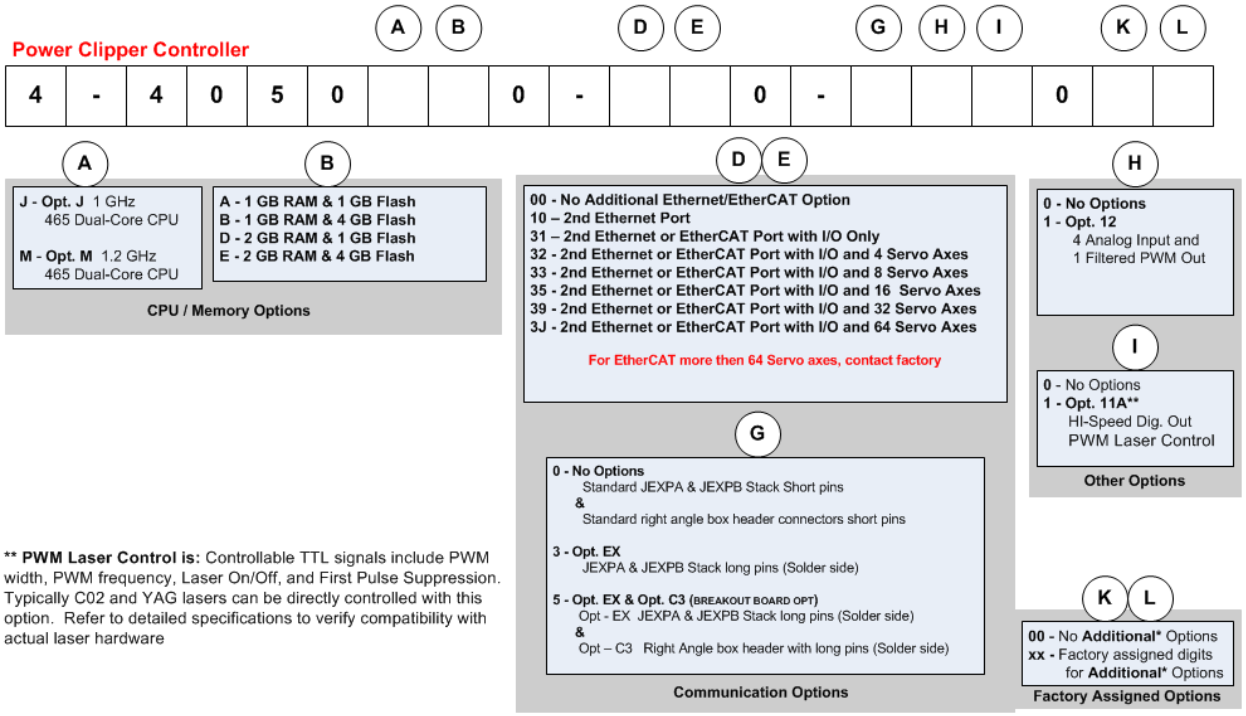
Caution

It is the user's responsibility to manage the application's PLCs properly. The code samples are typically enclosed in a PLC buffer with the user defined name **ExamplePLC**.

It is the user's responsibility to use the PLC examples presented in this manual properly, and incorporate the statement code in the application project accordingly.

SPECIFICATIONS

Part Number



The Power Clipper comes standard with a powerful set of hardware and software capabilities, plus a full set of options and accessories.

ACC-24S3

Part Number	Description
3-4050000-000-000000	4-Channel expansion
3-4050000-000-010000	4-Channel expansion with 4 analog inputs & 1 Filtered PWM output

ACC-51S

Part Number	Description
3-3674-0-0002-000000	2 channel 4096x interpolator stack board for sinusoidal encoders
3-3674-0-0012-000000	4 channel 4096x interpolator stack board for sinusoidal encoders

ACC-84S

Part Number	Description
3-3936-0-0002-000000	4-Channel SSI serial encoder protocol
3-3936-0-0003-000000	4-Channel ENDAT serial encoder protocol
3-3936-0-0006-000000	4-Channel Yaskawa Sigma II & III serial encoder protocol
3-3936-0-0008-000000	4-Channel Panasonic serial encoder protocol
3-3936-0-000B-000000	4-Channel BISS-C serial encoder protocol
3-3936-0-000D-000000	4-Channel Mitsubishi serial encoder protocol
3-3936-0-000E-000000	4-Channel 1S serial encoder protocol
3-3936-0-0XY2-000000	XY2-100 serial link for 2-axis and 3-axis laser scan heads and galvanometers
3-3936-0-0TBC-000000	4-Channel table based compare protocol

ACC-8TS

Part Number	Description
3T0-603673-10X	Stack interface board for use with 1 or 2 ACC-28B A/D connector boards (Contact tech support at Delta Tau Before ordering and/or implementing this accessory to avoid conflicts with Filtered PWM clock settings.)

ACC-8FS

Part Number	Description
3F0-603673-10X	4-Channel direct PWM stack breakout board for Power Clipper and ACC-24S3

ACC-34AA

Part Number	Description
3-2817A-10000-00	Sinking configuration, no rail mount
3-2817A-10003-00	Sinking configuration, with rail mount
3-2817A-20000-00	Sourcing configuration, no rail mount
3-2817A-20003-00	Sourcing configuration, with rail mount

ACC-28B

Part Number	Description
3-2678A-0A200-00	2-Channel 16 bit A/D converter, analog input connector DB-25, no rail mount
3-2678A-1A200-00	4-Channel 16 bit A/D converter, analog input connector DB-25, no rail mount
3-2678A-0B200-00	2-Channel 16 bit A/D converter, analog input connector Terminal Block, no rail mount
3-2678A-1B200-00	4-Channel 16 bit A/D converter, analog input connector Terminal Block, no rail mount
3-2678A-0A204-00	2-Channel 16 bit A/D converter, analog input connector DB-25, with rail mount
3-2678A-1A204-00	4-Channel 16 bit A/D converter, analog input connector DB-25, with rail mount
3-2678A-0B204-00	2-Channel 16 bit A/D converter, analog input connector Terminal Block, with rail mount
3-2678A-1B204-00	4-Channel 16 bit A/D converter, analog input connector Terminal Block, with rail mount

Standard Configuration

The standard configuration of the Power Clipper provides the following features:

CPU

- 1.0 GHz Dual-Core Power PC 465EX CPU

Memory

- 1 GB DDRAM3 active memory, 1 GB NAND Flash non-volatile memory

Communications Ports

- 100 Mbps Ethernet port for host communications
- RS-232 port
- USB 2.0 Host port
- USB 2.0 Device port

Servo Interface

4 channels servo interface, each including:

- Quadrature encoder (with index) interface
- UVW digital Hall sensor interface
- Serial encoder interface, with software selectable protocol, from the following:
    - SSI
    - EnDat 2.1/2.2 (2.1-compatible features only) with delay compensation
    - Hiperface
    - Yaskawa Sigma I
    - Yaskawa II/III/V (no position reset or fault clear)
    - Tamagawa FA-Coder

  - Panasonic (no servo clock output)
  - Mitutoyo
  - Kawasaki
  - Basic quadrature (no index, no capture)
- Filtered PWM analog output (~13-bit resolution)
- Pulse & direction output
- Input flags (home, +limit, -limit, user) at 5V CMOS levels (24V tolerant)
- Position compare (EQU) output
- Amplifier-enable output and amplifier-fault input flags
- Brake control output

General-Purpose I/O

- JIO Port: 16 5V CMOS I/O points, direction selectable by byte (flat cable connection to Opto-22 or equivalent)
- JTHW Port: 16 5V CMOS I/O points, direction selectable by byte (flat cable connection to Delta Tau ACC-34x boards)

Stacking Connector Configuration

The standard configuration of the Power Clipper comes with:

- The "short-pin" version of the expansion port connectors. These support accessories that stack on top of the Power Clipper (e.g. ACC-24S3, 8AS, 8FS, 8TS, 51S, and 84S), but not those that stack under it (e.g. LV Stack Amplifier).
- The "short-pin" version of the right-angle box header connectors. These support flat cable connections to field wiring, but not connections through breakout boards that stack under it (e.g. Delta Tau's stack breakout board or custom breakout boards).

Options

The following options can be ordered for the Power Clipper board:

CPU Options

- 1.2 GHz Dual-Core Power PC 465EX CPU

Memory Options

The following optional memory configurations can be ordered:

- 1 GB DDRAM3 active memory, 4 GB NAND Flash non-volatile memory
- 2 GB DDRAM3 active memory, 1 GB NAND Flash non-volatile memory
- 2 GB DDRAM3 active memory, 4 GB NAND Flash non-volatile memory

Communications Port Options

Added Ethernet Port ,1 Gbps, EtherCAT compatible

EtherCAT Software License Options (require 2nd Ethernet port option)

When the second Ethernet port option is ordered, software license options can also be ordered to support EtherCAT data transfers. The following software license options can be ordered:

- EtherCAT I/O only (no servo axes)
- EtherCAT I/O with 4 servo axes
- EtherCAT I/O with 8 servo axes
- EtherCAT I/O with 16 servo axes
- EtherCAT I/O with 32 servo axes
- EtherCAT I/O with 64 servo axes

Analog I/O Option

4-channels 12-bit ADC plus 1 additional channel filtered-PWM analog output (~13 bits)

Digital Laser Control Output Option

Programmable PWM laser-control IC with output drivers

Stacking Connector Options

- "Long-pin" version of expansion-port connectors to support communications interface to boards that stack under Power Clipper (e.g. LV Stack Amplifier). "Short-pin" version of right-angle box header connectors that only support flat cable connections for field wiring.
- "Long-pin" version of expansion-port connectors to support communications interface to boards that stack under Power Clipper (e.g. LV Stack Amplifier). "Long-pin" version of right-angle box header connectors to support connections through breakout boards that stack under it (e.g. Delta Tau's stack breakout board or custom breakout boards).

Accessories

The following accessory boards can be used with the Power Clipper board:

ACC-24S3 4-Channel Axis Expansion Stack Board

The ACC-24S3 can be stacked on top of the Power Clipper to provide an additional 4 channels of servo interface circuitry and 32 additional digital I/O points equivalent to what is on the Power Clipper itself. Optionally, it can provide 4 additional 12-bit ADCs and 1 additional filtered-PWM analog output (~13 bits).

Only one ACC-24S3 board can be used with the Power Clipper. If it is installed on top of the Power Clipper, only one small stack board (ACC-8AS, 8FS, 8TS, 51S, 84S) can be installed directly on the Power Clipper between it and the ACC-24S3. Two of these small stack boards can be installed on top of the ACC-24S3.

ACC-8AS 4-Channel 2-Phase 16-Bit True-DAC Stack Board

The ACC-8AS can be stacked on top of either the Power Clipper or the ACC-24S3 to provide 4 channels of 16-bit "true DAC" output with two DACs per channel. This board is mainly used for very high-precision servo applications that require more resolution than the filtered-PWM analog outputs on the Power Clipper and the ACC-24S3. The dual-phase DAC outputs support the "sine-wave output" control mode where brushless motor commutation is performed by the Power PMAC.

The true-DAC outputs of the ACC-8AS *can* be used simultaneously with the filtered-PWM analog output on the same channel of the Power Clipper or ACC-24S3 without interference.

ACC-8FS 4-Channel Direct-PWM Interface Stack Board

The ACC-8FS can be stacked on top of either the Power Clipper or the ACC-24S3 to provide 4 channels of 3-phase direct-PWM output through Mini-D 36-pin connectors to "power block" amplifiers. This board is mainly used for applications where the Power Clipper is performing both the commutation and digital current loop closure for brushless motors.

The 3-phase PWM outputs of the ACC-8FS *cannot* be used simultaneously with the filtered-PWM analog output on the same channel of the Power Clipper or ACC-24S3. However, they *can* be used simultaneously with the PFM (pulse-and-direction) outputs of the same channel of the Power Clipper or ACC-24S3 without interference.

The ADC inputs passed through the ACC-8FS *can* be used simultaneously with the Option 12 ADCs on the Power Clipper or ACC-24S3 without interference.

ACC-8TS Bridge Stack Board to ACC-28B ADCs

The ACC-8TS can be stacked on top of either the Power Clipper or the ACC-24S3 to provide a flat-cable interface to one or two ACC-28B 4-channel 16-bit ADC boards.

The ADC inputs passed through the ACC-8TS *can* be used simultaneously with the Option 12 ADCs on the Power Clipper or ACC-24S3 without interference.

ACC-51S 4-Channel Sinusoidal Encoder Interpolator Stack Board

The ACC-51S can be stacked on top of either the Power Clipper or the ACC-24S3 to provide 4 channels of sinusoidal encoder interpolation with 16,384 states per line.

The sinusoidal encoder inputs passed through the ACC-51S *cannot* be used simultaneously with the main quadrature encoder inputs of the same channel of the Power Clipper or ACC-24S3 without interference. However, it is possible to pass digital quadrature signals through the ACC-51S.

ACC-84S 4-Channel Serial Encoder Interface Stack Board

The ACC-84S can be stacked on top of either the Power Clipper or the ACC-24S3 to provide 4 channels of serial-encoder interface. The ACC-84S can be ordered from the factory with a single encoder protocol installed from the following list:

- EnDat2.2 with additional information, no delay compensation
- BiSS-B/C
- Yaskawa II/III/V with position reset and fault clear
- Tamagawa FA-Coder with servo clock output
- Mitsubishi
- SSI (no capabilities over Power Clipper's built-in interface)
- Panasonic (no capabilities over Power Clipper's built-in interface)
- Mitutoyo (no capabilities over Power Clipper's built-in interface)

The serial-encoder inputs on the ACC-84S *can* be used simultaneously with the serial-encoder input on the same channel of the Power Clipper or ACC-24S3 without interference.

Clipper 4-Channel Breakout Board

The Clipper 4-Channel Breakout Board can be stacked *under* the Power Clipper board to provide discrete connectors for each channel and each I/O functionality. It also provides optical isolation and driver circuitry for axis flags and general-purpose I/O.

The Clipper 4-Channel Breakout Board *cannot* be used to provide connections for the ACC-24S3 Axis Expansion Board.

Clipper 4-Channel LV Stack Amplifier

The Clipper 4-Channel LV (Low-Voltage) Stack Amplifier can be stacked *under* the Power Clipper board or its 4-Channel Breakout board to provide the power amplifier circuitry for 4 motors with up to 60VDC supply and a rating of up to 5A(rms) continuous, 15A(rms) peak. Each motor can be 1-phase (e.g. DC brush motor), 2-phase (e.g. stepper motor), or 3-phase (e.g. brushless servo motor).

The Clipper 4-Channel LV Stack Amplifier *cannot* be used to provide the power stage for the ACC-24S3 Axis Expansion Board.

ACC-28B 4-Channel 16-Bit ADC Board

The ACC-28B provides 2 or 4 channels of 16-bit A/D converters on a DIN-rail mountable board. It can be connected to the Power Clipper or ACC-24S3 by flat cable through an ACC-8TS bridge stack board.

ACC-34 Family Multiplexed I/O Boards

The ACC-34 family of multiplexed I/O boards each provide 32 general-purpose digital inputs and 32 general-purpose digital outputs. Up to 32 of these DIN-rail mountable boards can be connected to the JTHW multiplexer port on the Power Clipper through standard flat cables. Due to the multiplexed access and serial data transfers, these I/O points cannot react as quickly as the I/O points on the Power Clipper itself.

Environmental Specifications

Specification	Description	Range
Ambient operating Temperature EN50178 Class 3K3 – IEC721-3-3	Minimum operating temperature	0°C (32°F)
	Maximum operating temperature	45°C (113°F)
Storage Temperature Range EN 50178 Class 1K4 – IEC721-3-1/2	Minimum Storage temperature	-25°C (-13°F)
	Maximum Storage temperature	70°C (158°F)
Humidity Characteristics with NO condensation and NO formation of ice IEC721-3-3	Minimum Relative Humidity	5% HU
	Maximum Relative Humidity up to 35°C (95°F)	95% HU
	Maximum Relative Humidity from 35°C up to 50°C (122°F)	85% HU
De-rating for Altitude	0 ~ 1000m (0 ~ 3300ft)	No de-rating
	1000 ~ 3000m (3300 ~ 9840ft)	-0.01%/m
	3000 ~ 4000m (9840 ~ 13000ft)	-0.02%/m
Environment ISA 71-04	Degree 2 environments	
Atmospheric Pressure EN50178 class 2K3	70 KPa to 106 KPa	
Shock	Unspecified	
Vibration	Unspecified	
Air Flow Clearances	3" (76.2mm) above and below unit for air flow	
Cooling	Natural convection and built-in CPU fan	
Standard IP Protection	IP20 IP 55 can be evaluated for custom applications	

Electrical Specifications

Digital Power Supply

The +5V and ground reference lines from the power supply should be connected to TB1 terminal block of the Power PMAC Clipper board using 18 AWG stranded wire. The power requirement (± 5%) is:

+5 V (20W) @ 3.5 A (Four-channel configuration with a typical load of encoders)
+5 V (20W) @ 5.5 A (Eight-channel ACC-24S3 configuration with a typical load of encoders)

Note

Clipper base board requires 2.75A with no other connections. Size your application accordingly to your encoder load. The above assumes typical encoder loads at ~100mA per encoder.

DAC Outputs Power Supply

The ±12V lines from the supply, including the ground reference, can be brought in from the TB1 terminal block.

+12 to +15 V (4.5W) @ 0.30 A (Four-channel configuration with a typical DAC load)
-12 to -15 V (3.8W) @ 0.25 A

+12 to +15 V (4.5W) @ 0.50 A (Eight-channel configuration with a typical DAC load)
-12 to -15 V (3.8W) @ 0.45 A

Flags Power Supply

Each channel of PMAC has five dedicated digital inputs on the machine connector: PLIMn, MLIMn (overtravel limits), HOMEn (home flag), FAULTn (amplifier fault), and USERn. A power supply from 5 to 24V must be used to power the circuits related to these inputs. This power supply can be the same used to Power PMAC Clipper and can be connected from the TB1 terminal block.

Agency Approval and Safety

Item	Description
CE Mark	EN61326-1
EMC	EN55011 Class A Group 1 EN61000-4-2 EN61000-4-3 EN61000-4-4 EN61000-4-5 EN61000-4-6
Flammability Class	UL 94V-0
KC	EMI: KN 11 EMS: KN 61000-6-2
UKCA	2016 No. 1091

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RECEIVING AND UNPACKING

Delta Tau products are thoroughly tested at the factory and carefully packaged for shipment. When the Power PMAC Clipper is received, there are several things to be done immediately:

- Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered the board.
- Remove the Power PMAC Clipper from the shipping container and remove all packing materials. Check all shipping material for connector kits, documentation, or other small pieces of equipment. Be aware that some connector kits and other equipment pieces may be quite small and can be accidentally discarded if care is not used when unpacking the equipment. The container and packing materials may be retained for future shipment.
- Verify that the part number of the board received is the same as the part number listed on the purchase order.
- Inspect for external physical damage that may have been sustained during shipment and report any damage immediately to the commercial carrier that delivered the board.
- Electronic components in this product are design-hardened to reduce static sensitivity. However, use proper procedures when handling the equipment.
- If the Power PMAC Clipper is to be stored for several weeks before use, be sure that it is stored in a location that conforms to published storage humidity and temperature specifications.

Use of Equipment

The following restrictions will ensure the proper use of the Power PMAC Clipper:

- The components built into electrical equipment or machines can be used only as integral components of such equipment.
- The Power PMAC Clipper must not be operated on power supply networks without a ground or with an asymmetrical ground.
- If the Power PMAC Clipper is used in residential areas, or in business or commercial premises, implement additional filtering measures.
- The Power PMAC Clipper may be operated only in a closed switchgear cabinet, taking into account the ambient conditions defined in the environmental specifications.

Delta Tau guarantees the conformance of the Power PMAC Clippers with the standards for industrial areas stated in this manual, only if Delta Tau components (cables, controllers, etc.) are used.

MOUNTING

The location of the Power PMAC Clipper is important. Installation should be in an area that is protected from direct sunlight, corrosives, harmful gases or liquids, dust, metallic particles, and other contaminants. Exposure to these can reduce the operating life and degrade performance of the board.

Several other factors should be carefully evaluated when selecting a location for installation:

- For effective cooling and maintenance, the Power PMAC Clipper should be mounted on a smooth, non- flammable vertical or horizontal surface.
- At least 10 mm (0.4 inches) top and bottom clearance must be provided for air flow.
- Temperature, humidity and Vibration specifications should also be taken in account.

Caution

Unit must be installed in an enclosure that meets the environmental IP rating of the end product (ventilation or cooling may be necessary to prevent enclosure ambient from exceeding 45° C [113° F]).

The Power PMAC Clipper can be mounted as a stand-alone controller using standoffs. At each of the four corners of the board and at the center edges, there are mounting holes that can be used for this.

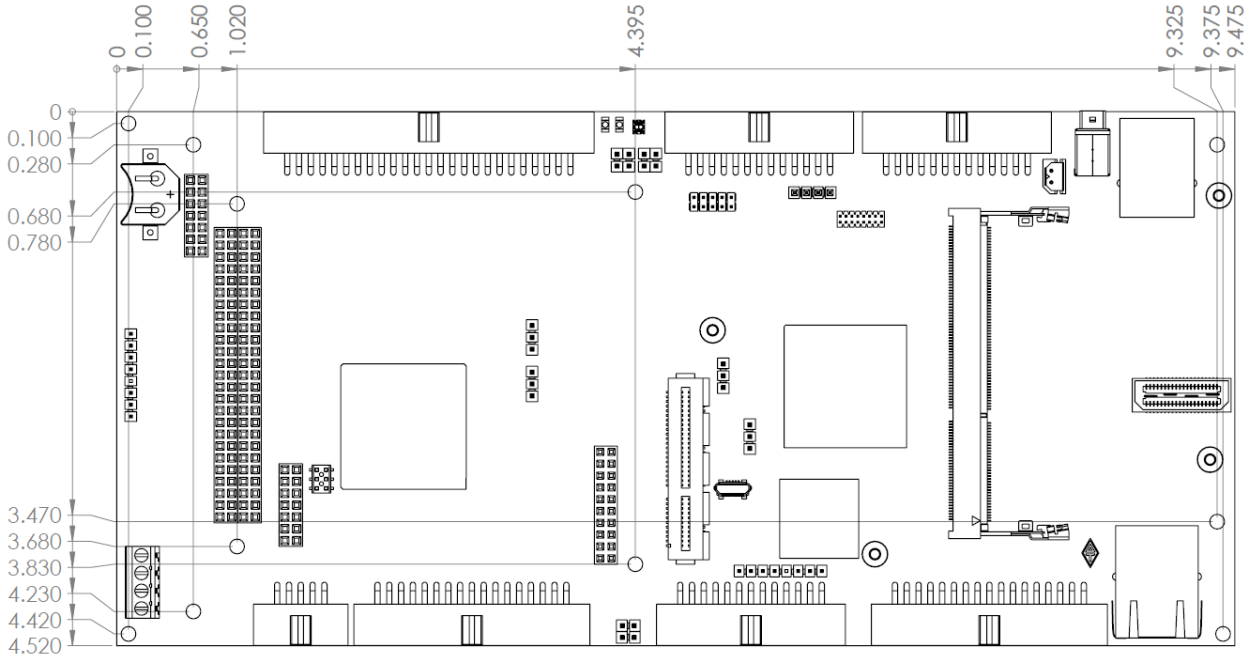
If the Power PMAC Clipper is mounted to a back panel, the back panel should be unpainted and electrically conductive to allow for reduced electrical noise interference. The back panel should be machined to accept the standoffs pattern of the board.

The board can be mounted to the back panel using four standoffs and internal-tooth lock washers. It is important that the teeth break through any anodization on the board's mounting gears to provide a good electrically conductive path in as many places as possible. Mount the board on the back panel so there is airflow at both the top and bottom areas of the board (at least 0.4 inches).

Physical Specifications

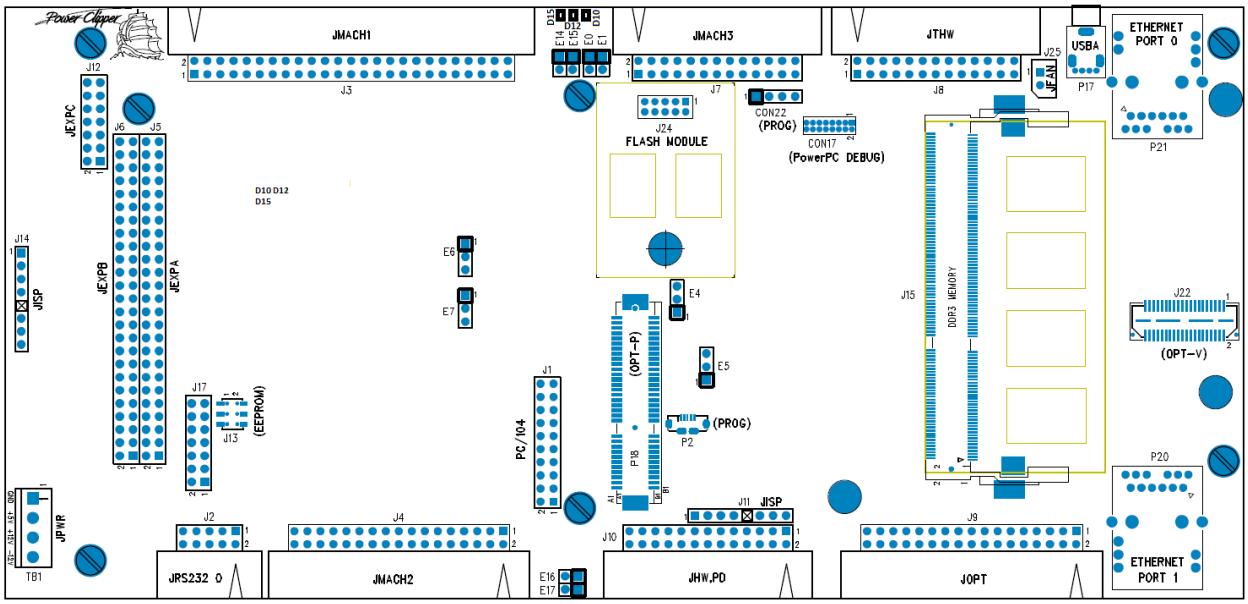
Board Dimensions Rev101

Top View



Board Layout Rev101

Top View



Mounting are holes shown with screw heads.

CONNECTIONS AND SOFTWARE SETUP

WARNING

Installation of electrical equipment is subject to many regulations including national, state, local, and industry guidelines and rules. The following are general recommendations but it is important that the integration be carried out in accordance with all regulations pertaining to the installation.

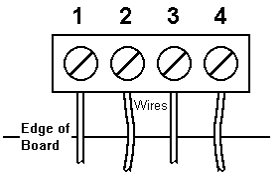
Default Jumper Configurations

The following table shows the default jumper configurations:

Jumper	Position Description	Notes
E0	CPU RESET	Do Not Install
E1	Install E1 to bypass watchdog timer for bootstrap software load.	Do Not Install
E4	Factory use only, should always be 1-2.	Do Not change
E5	Not currently used	Not Installed
E6	Selection between handwheel input or serial encoder input on Gate3[i].Chan[0].SerialEncDataA 1-2 FOR SENC1 2-3 ENC-HW-1	Default 1-2
E7	Selection between handwheel input or serial encoder input on Gate3[i].Chan[1].SerialEncDataA 1-2 FOR SENC2 2-3 ENC-HW-2	Default 1-2
E14	Install to make GPIO 0-7 lines inputs Remove jumper to make GPIO 0-7 lines outputs	Installed (Required for MuxIO)
E15	Install to make GPIO 8-15 lines inputs Remove jumper to make GPIO 8-15lines outputs	Not Installed (Required for MuxIO)
E16	Install to make GPIO 16-23 lines inputs Remove jumper to make GPIO 16-23 lines outputs	Not Installed
E17	Install to make GPIO 24-31 lines inputs Remove jumper to make GPIO 24-31 lines outputs	Installed

TB1 (JPWR): Power Supply Input

This 4-pin terminal block is used to bring the 5VDC logic power and +/-12VDC DAC supply into the Power PMAC Clipper.

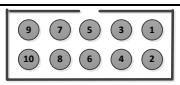
TB1 (JPWR): Power Supply 4-Pin Terminal Block				
Pin#	**Symbol**	**Function**	**Description**	**Notes**
1	GND	Common	Digital Common	
2	+5V	Input	Logic Voltage	Supplies all PMAC digital circuits
3	+12V	Input	DAC Supply Voltage	Ref to Digital GND
4	-12V	Input	DAC Supply Voltage	Ref to Digital GND

Note

For +5V and GND, 18 gauge (AWG) stranded wire is recommended. For +12V and -12V, a minimum of 22 gauge (AWG) stranded wire is recommended.

J2: Serial Port

This connector allows communicating with Power PMAC Clipper from a host computer through a RS-232 port. Delta Tau provides the Accessory 3L cable that connects the PMAC to a DB-9 connector.

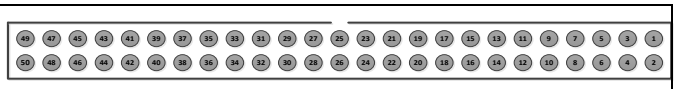
J2 (JRS232) Serial Port Connector 10-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1			No Connection	
2	DTR	Bidirect	Data Terminal Ready	Tied to "DSR"
3	TXD/	Output	Send Data	Host receive data
4	CTS	Input	Clear to Send	Host ready bit
5	RXD/	Input	Receive Data	Host transmit data
6	RTS	Output	Request to Send	PMAC ready bit
7	DSR	Bidirect	Data Set Ready	Tied to "DTR"
8			No Connection	
9	GND	Common	Digital Common	
10	RESET_SW#	Input	Hardware CPU Reset	Ground is Reset

10-pin female flat cable connector T&B Ansley P/N 609-1041

Standard flat cable stranded 10-wire T&B Ansley P/N 171-10

J3: Machine Connector (JMACH1 Port)

The primary machine interface connector is JMACH1, labeled J3 on the Power PMAC Clipper. It contains the pins for four channels of machine I/O: analog outputs, incremental encoder inputs, amplifier fault and enable signals and power-supply connections.

J3 (JMACH1): Machine Port Connector 50-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	+5V	Output	+5V Power	For encoders, 1
2	+5V	Output	+5V Power	For encoders, 1
3	GND	Common	Digital Common	For encoders, 1
4	GND	Common	Digital Common	For encoders, 1
5	CHA1	Input	Encoder A Channel Positive	2
6	CHA2	Input	Encoder A Channel Positive	2
7	CHA1/	Input	Encoder A Channel Negative	2,3
8	CHA2/	Input	Encoder A Channel Negative	2,3
9	CHB1	Input	Encoder B Channel Positive	2
10	CHB2	Input	Encoder B Channel Positive	2
11	CHB1/	Input	Encoder B Channel Negative	2,3
12	CHB2/	Input	Encoder B Channel Negative	2,3
13	CHC1	Input	Encoder C Channel Positive	2
14	CHC2	Input	Encoder C Channel Positive	2
15	CHC1/	Input	Encoder C Channel Negative	2,3
16	CHC2/	Input	Encoder C Channel Negative	2,3
17	CHA3	Input	Encoder A Channel Positive	2
18	CHA4	Input	Encoder A Channel Positive	2
19	CHA3/	Input	Encoder A Channel Negative	2,3
20	CHA4/	Input	Encoder A Channel Negative	2,3
21	CHB3	Input	Encoder B Channel Positive	2
22	CHB4	Input	Encoder B Channel Positive	2
23	CHB3/	Input	Encoder B Channel Negative	2,3
24	CHB4/	Input	Encoder B Channel Negative	2,3
25	CHC3	Input	Encoder C Channel Positive	2
26	CHC4	Input	Encoder C Channel Positive	2
27	CHC3/	Input	Encoder C Channel Negative	2,3

28	CHC4/	Input	Encoder C Channel Negative	2,3
29	DAC1	Output	Analog Output Positive 1	4
30	DAC2	Output	Analog Output Positive 2	4
31	DAC1/	Output	Analog Output Negative 1	4,5
32	DAC2/	Output	Analog Output Negative 2	4,5
33	AENA1/	Output	Amplifier-Enable 1	
34	AENA2/	Output	Amplifier -Enable 2	
35	FAULT1/	Input	Amplifier -Fault 1	
36	FAULT2/	Input	Amplifier -Fault 2	
37	DAC3	Output	Analog Output Positive 3	4
38	DAC4	Output	Analog Output Positive 4	4
39	DAC3/	Output	Analog Output Negative 3	4,5
40	DAC4/	Output	Analog Output Negative 4	4,5
41	AENA3/	Output	Amplifier -Enable 3	
42	AENA4/	Output	Amplifier -Enable 4	
43	FAULT3/	Input	Amplifier -Fault 3	
44	FAULT4/	Input	Amplifier -Fault 4	
45	ADCIN_1	Input	Analog Input 1	
46	ADCIN_2	Input	Analog Input 2	
47	FLT_FLG_V	Input	Amplifier Fault pull-up V+	
48	GND	Common	Digital Common	
49	+12V	Input	DAC Supply Voltage	7
50	-12V	Input	DAC Supply Voltage	7

Note

- **Note 1**: These lines can be used as +5V power supply inputs to power PMAC's digital circuitry.
- **Note 2**: Referenced to digital common (GND). Maximum of ±12V permitted between this signal and its complement.
- **Note 3**: Leave this input floating if not used (i.e. digital single-ended encoders).
- **Note 4**: ±10V, 10 mA max, referenced to common ground (GND).
- **Note 5**: Leave floating if not used. Do not tie to GND.
- **Note 7**: Can be used to provide input power when the TB1 connector is not being used.

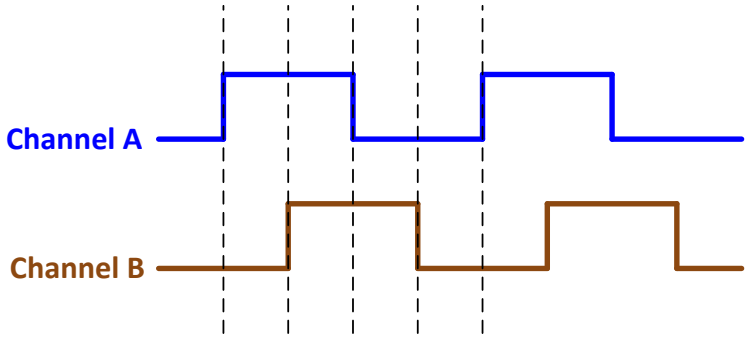
50-pin female flat cable connector T&B Ansley P/N 609-5041. Standard flat cable stranded 50-wire T&B Ansley P/N 171-50. Phoenix varioface module type FLKM 50 (male pins) P/N 22 81 08 9

Note

Use an encoder cable with high quality shield.

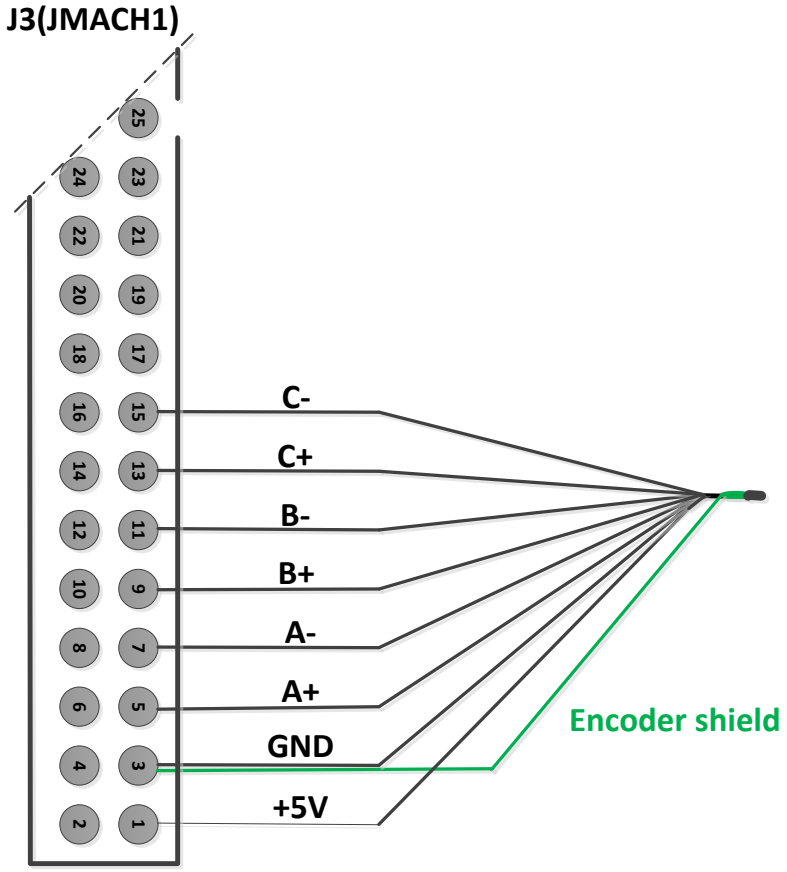
The standard encoder inputs on the Power PMAC Clipper are designed for differential quadrature type signals.

Quadrature encoders provide two digital signals to determine the position of the motor. Each nominally with 50% duty cycle, and nominally 1/4 cycle apart. This format provides four distinct states per cycle of the signal, or per line of the encoder. The phase difference of the two signals permits the decoding electronics to discern the direction of travel, which would not be possible with a single signal.



Typically, these signals are 5V TTL/CMOS level whether they are single-ended or differential. Differential signals can enhance noise immunity by providing common mode noise rejection. Modern design standards virtually mandate their use in industrial systems.

Differential Quadrature Encoder Wiring for Channel #1



Note

- For single-ended encoders, leave the complementary signal pins floating – do not ground them. Alternately, some open collector single ended encoders may require tying the negative pins to ground in series with a 1-2 KOhm resistors.
- Some motor manufacturers bundle the hall sensors with the motor-lead cable. The hall sensors must be brought into J7 connector.

Configuring Quadrature Encoders

The Power Clipper default settings are configured for quadrature encoders. Minimal setup is required to configure them; quadrature encoder signals are processed as a single 32-bit read in the encoder conversion table (ECT). 1/T extension is done in the Gate3 "hardware".

The default ECT settings for the first incremental quadrature encoder will be:

```
EncTable[1].type = 1;                                   // Single 32-bit read
EncTable[1].pEnc = Clipper[0].Chan[0].ServoCapt.a;      // Primary source, ch 1 Servo Capture
EncTable[1].pEnc1 = Sys.Pushm;                          // Secondary source, none
EncTable[1].index1 = 0;                                 // left shift, none
EncTable[1].index2 = 0;                                 // right shift, none
EncTable[1].index3 = 0;                                 //
EncTable[1].index4 = 0;                                 //
EncTable[1].ScaleFactor = 1/256;                        // Scale Factor, LSB location
```

Note

The hardware 1/T extension produces 8 bits of fractional data, thus the (1 / 256) 0.00390625 scale factor.

Channel Number	Quadrature Encoder Source Address
1	Clipper[0].Chan[0].ServoCapt.a
2	Clipper[0].Chan[1].ServoCapt.a
3	Clipper[0].Chan[2].ServoCapt.a
4	Clipper[0].Chan[3].ServoCapt.a

Note

The top level structure name “Clipper” is an alias for “Gate3”. Either may be used when referring to any “Gate3” structures with the Power Clipper. This manual will use “Clipper”.

Activating the corresponding channel is sufficient to display counts in the position window when the motor / encoder shaft is moved by hand.

```
Motor[1].ServoCtrl = 1;          // Channel activation
```

The position and velocity source(s) must be pointing to the proper ECT result. With quadrature encoders, they are initialized by the firmware as:

```
Motor[1].pEnc = EncTable[1].a;  // Position
Motor[1].pEnc2 = EncTable[1].a; // Velocity
Motor[2].pEnc = EncTable[2].a;  // Position
Motor[2].pEnc2 = EncTable[2].a; // Velocity
Motor[3].pEnc = EncTable[3].a;  // Position
Motor[3].pEnc2 = EncTable[3].a; // Velocity
Motor[4].pEnc = EncTable[4].a;  // Position
Motor[4].pEnc2 = EncTable[4].a; // Velocity
```

Counts per User Units

With quadrature encoders, the number of counts per user units (usually revolution) is 4 times the specified number of lines of the encoder. For example, a 1,000–line rotary encoder should result in 4,000 motor units per revolution.

Quadrature Encoder Count Error

With quadrature encoders, the Power Clipper has the capability of trapping encoder count (loss) errors. This is described in detail in the Encoder Count Error section of this manual.

Quadrature Encoder Loss Detection

Loss of the feedback sensor signal is potentially a very dangerous condition in closed-loop control, because the servo loop no longer has any idea what the true physical position of the motor is – usually

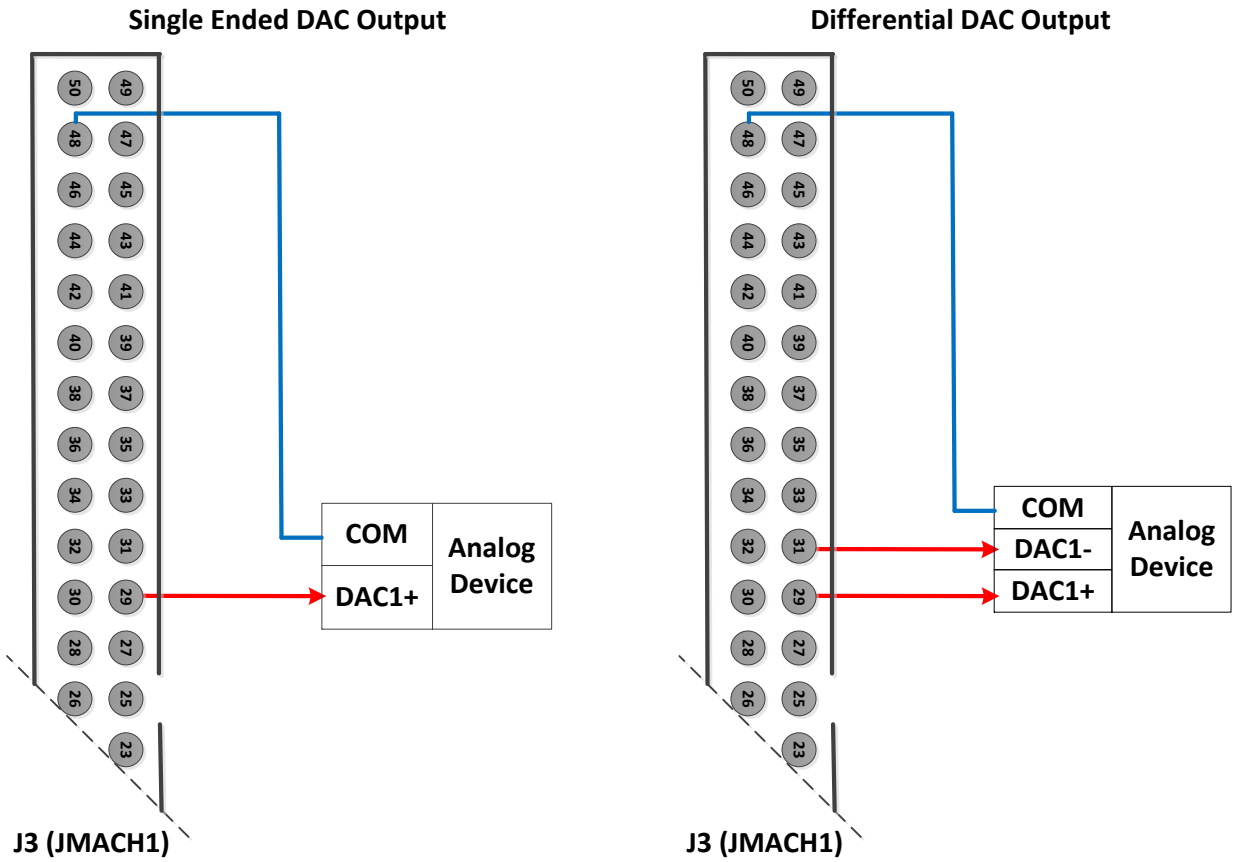
Warning	it thinks it is "stuck" – and it can react wildly, often causing a runaway condition.

With quadrature encoders, the Power Clipper has the capability of detecting the loss of an encoder signal. This is described in detail in the Encoder Loss Detection section of this manual.

Note	Note the distinction between the encoder count error, which reports loss of counts due to bad transitions of the quadrature signals, and encoder loss, which indicates that one or more quadrature signals are completely missing.

Wiring the DAC Output

Example for Clipper Channel #1

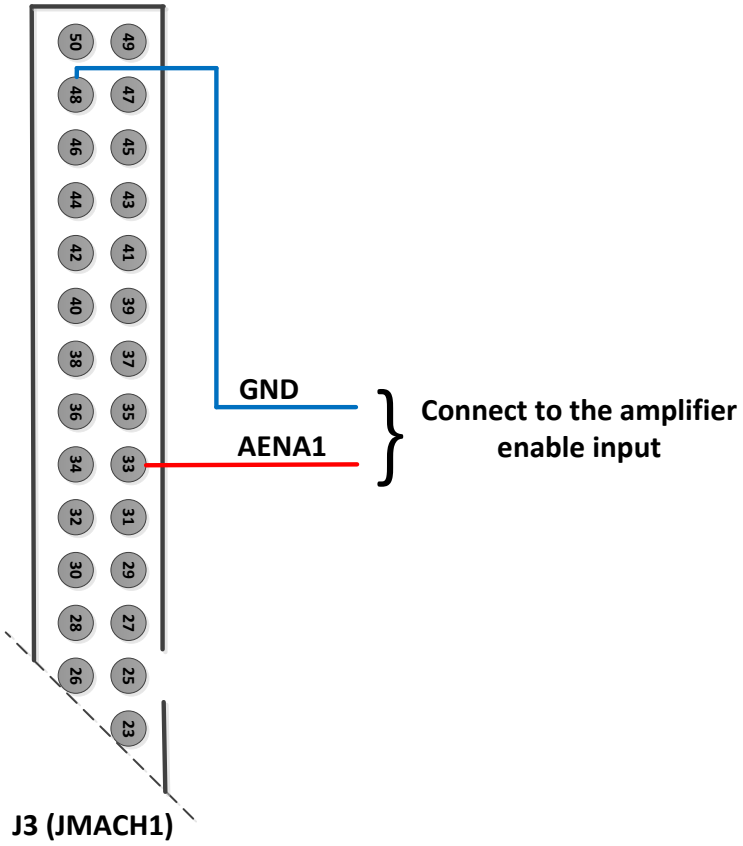


Note	The analog outputs are intended to drive high-impedance inputs with no significant current draw (10mA max). The 220Ω output resistors will keep the current draw lower than 50 mA in all cases and prevent damage to the output circuitry, but any current draw above 10 mA can result in noticeable signal distortion. Software setup for analog outputs can be found in the Drive-Motor setup section.

Amplifier Enable Signal (AENAn/DIRn)

Most amplifiers have an enable/disable input that permits complete shutdown of the amplifier regardless of the voltage of the command signal. PMAC's AENA line is meant for this purpose. AENA1- is pin 33. This signal is an open-collector output and an external 3.3 kΩ pull-up resistor can be used if necessary.

Example for Clipper Channel #1

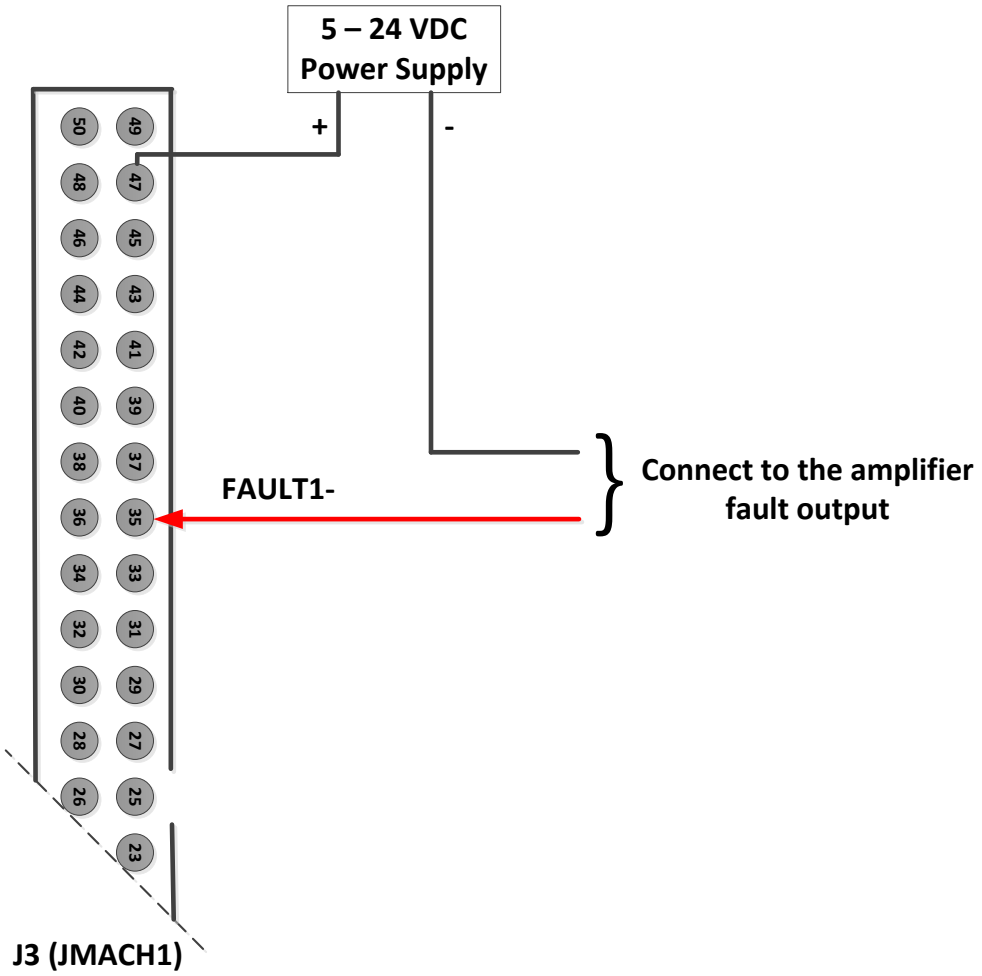


Amplifier Fault Signal (FAULT-)

This input can take a signal from the amplifier so PMAC knows when the amplifier is having problems, and can shut down action.

The polarity is programmable with **Motor[x].AmpFaultLevel** (**Motor[1].AmpFaultLevel** for motor 1) and the return signal is ground (GND). FAULT1- is pin 35. With the default setup, this signal must actively be pulled low for a fault condition. In this setup, if nothing is wired into this input, PMAC will consider the motor not to be in a fault condition.

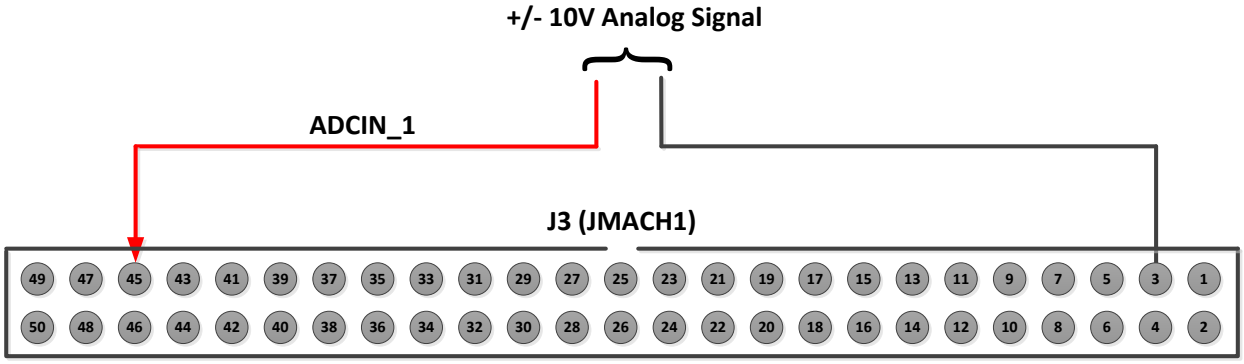
Example for Clipper Channel #1



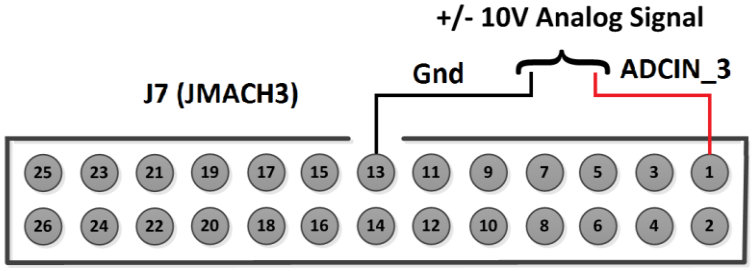
Analog Inputs

The Power PMAC Clipper provides four 12-bit analog inputs with a ±10Vdc range. The first two inputs are on JMACH1 pins 45 (ADCIN_1) and 46 (ADCIN_2) referenced to pin 3 (digital ground). Inputs 3 and 4 are on the JMACH3 connector pins 1 (ADCIN_3) and 2 (ADCIN_4). These are also referenced to digital ground.

Example for Analog Input 1



Example for Analog Input 3



Setting up the Analog (ADC) Inputs

The analog inputs accept ±10V single-ended signals only.

The ADC data resides in the upper 12 bits of the 32-bit structure elements in the following table. The structure elements do not allow bit definitions of the upper 12 bits, hence scaling (shifting) would be required to obtain the raw ADC data. Using the explicit address registers with PTR definitions is one alternative:

ADCIN_n/ Connector	Structure	Address
ADCIN_1, J3	Clipper[0].Chan[0].AdcEnc[0]	$900030
ADCIN_2, J3	Clipper[0].Chan[0].AdcEnc[1]	$900034
ADCIN_3, J7	Clipper[0].Chan[0].AdcEnc[2]	$900038
ADCIN_4, J7	Clipper[0].Chan[0].AdcEnc[3]	$90003C

Note

The explicit address register(s) can be found by subtracting **Sys.piom** from **Clipper[0].Chan[0].AdcEnc[n].a** (n=0-3).

Note

The ADC input data must be in the "unpacked" format to be read properly; **Clipper[0].Chan[0].PackInData = 0**.

Raw ADC Data (in bits)

```
Sys.WpKey = $AAAAAAAA;                  // Disable Write-Protection
Clipper[0].Chan[0].PackInData = 0;      // Unpack Input Data all ADCs J3, J7

PTR ADCIN_1->S.IO:$900030.20.12;       // ADCIN_1 J3 [bits]
PTR ADCIN_2->S.IO:$900034.20.12;       // ADCIN_2 J3 [bits]
PTR ADCIN_3->S.IO:$900038.20.12;       // ADCIN_3 J7 [bits]
PTR ADCIN_4->S.IO:$90003C.20.12;       // ADCIN_4 J7 [bits]
```

Alternately use of bit shifting in PLC and Program with the structure, **Clipper[0].Chan[0].AdcEnc[n]**, as in:

Bit shifting example

```
                            // This method is most efficient and uses the least PMAC resources
GLOBAL MyAnalog1 = 0;       // Global variable for shifted analog value initialized to zero

OPEN PLC ExamplePLC
. . .
MyAnalog1 = Clipper[0].Chan[0].AdcEnc[0] >> 20; // shift right by 20 bits before assignment
. . .
CLOSE
```

Since the analog inputs have 12 bits of resolution (4,096 software counts) spanning over the full range of the input voltage, wiring a ±10V voltage produces the following counts in software:

Single-Ended [VDC]	**Software Counts**
-10	-2048
0	0
10	+2048

Scaled ADC Data (in volts)

For general purpose usage, the ADC data (reported in bits) can be easily scaled and converted into "user" voltage. In the example PLC below:

- The global parameter **ADCnZeroOffset** represents the voltage offset with a zero volt input. This is user adjustable.
- The pointer **ADCIN_n** reports the raw ADC data in software counts, units of 12-bit (±2048).

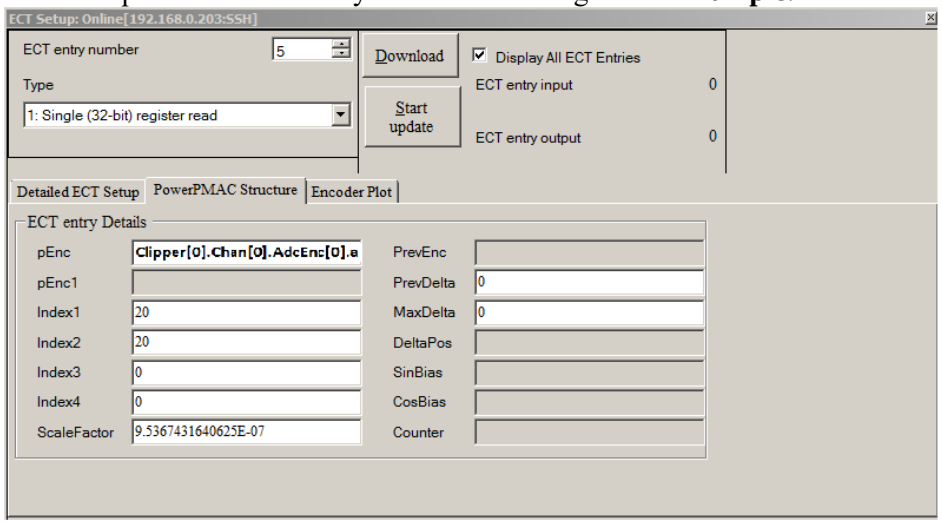
- The global parameter **ADCnVoltsIn** reports the ADC data in "user" volts.

Where **n** is the ADC channel number (1 - 4).

```
GLOBAL ADC1VoltsIn = 0;                 // Voltage input, ADCIN_1
GLOBAL ADC2VoltsIn = 0;                 // Voltage input, ADCIN_2
GLOBAL ADC3VoltsIn = 0;                 // Voltage input, ADCIN_3
GLOBAL ADC4VoltsIn = 0;                 // Voltage input, ADCIN_4

GLOBAL ADC1ZeroOffset = 0.038;          // Zero Volt Offset1,  [volt] --USER ADJUSTABLE
GLOBAL ADC2ZeroOffset = 0.038;          // Zero Volt Offset2,  [volt] --USER ADJUSTABLE
GLOBAL ADC3ZeroOffset = 0.038;          // Zero Volt Offset3,  [volt] --USER ADJUSTABLE
GLOBAL ADC4ZeroOffset = 0.038;          // Zero Volt Offset4,  [volt] --USER ADJUSTABLE

OPEN PLC PtrExamplePLC
ADC1VoltsIn  = (ADCIN_1  * 10 / 2048) - ADC1ZeroOffset ;
ADC2VoltsIn  = (ADCIN_2  * 10 / 2048) - ADC2ZeroOffset ;
ADC3VoltsIn  = (ADCIN_3  * 10 / 2048) - ADC3ZeroOffset ;
ADC4VoltsIn  = (ADCIN_4  * 10 / 2048) - ADC4ZeroOffset ;
CLOSE

OPEN PLC ShiftExamplePLC                // More efficient less resources
ADC1VoltsIn  = ((Clipper[0].Chan[0].AdcEnc[0] >> 20) * 10 / 2048) - ADC1ZeroOffset ;
ADC2VoltsIn  = ((Clipper[0].Chan[0].AdcEnc[1] >> 20) * 10 / 2048) - ADC2ZeroOffset ;
ADC3VoltsIn  = ((Clipper[0].Chan[0].AdcEnc[2] >> 20) * 10 / 2048) - ADC3ZeroOffset ;
ADC4VoltsIn  = ((Clipper[0].Chan[0].AdcEnc[3] >> 20) * 10 / 2048) - ADC4ZeroOffset ;
CLOSE
```

Using the ADC for Servo Feedback

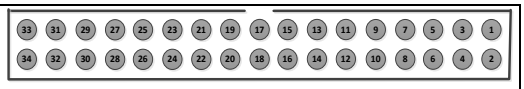
Using the ADC data for servo feedback requires bringing it into the Encoder Conversion Table (ECT) into which the motor's position and velocity elements are assigned to. **Example**:




```
EncTable[5].pEnc = Clipper[0].Chan[0].AdcEnc[0].a;
EncTable[5].pEnc1 = Sys.pushm;
EncTable[5].index1 = 20;
EncTable[5].index2 = 20;
EncTable[5].index3 = 0;
EncTable[5].index4 = 0;
EncTable[5].index5 = 0;
EncTable[5].ScaleFactor = 1 / EXP2(20);

Motor[5].pEnc = EncTable[5].a;
Motor[5].pEnc2 = EncTable[5].a;
```

J4: Machine Connector (JMACH2 Port)

This machine interface connector is labeled JMACH2 or J4 on the Power PMAC Clipper. It contains the pins for four channels of machine I/O: end-of-travel input flags, home flag and pulse-and-direction output signals. In addition, the B_WDO output allows monitoring the state of the Watchdog safety feature.

J4 (JMACH2): Machine Port CPU Connector 34-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	FLG_1_2_V	Input	Flags 1-2 Pull-Up	
2	FLG_3_4_V	Input	Flags 3-4 Pull-Up	
3	GND	Common	Digital Common	
4	GND	Common	Digital Common	
5	HOME1	Input	Home-Flag 1	10
6	HOME2	Input	Home-Flag 2	10
7	PLIM1	Input	Positive End Limit 1	8,9
8	PLIM2	Input	Positive End Limit 2	8,9
9	MLIM1	Input	Negative End Limit 1	8,9
10	MLIM2	Input	Negative End Limit 2	8,9
11	USER1	Input	User Flag 1	
12	USER2	Input	User Flag 2	
13	PUL_1	Output	Pulse Output 1	
14	PUL_2	Output	Pulse Output 2	
15	DIR_1	Output	Direction Output 1	
16	DIR_2	Output	Direction Output 2	
17	EQU1	Output	Encoder Comp-Equal 1	
18	EQU2	Output	Encoder Comp-Equal 2	
19	HOME3	Input	Home-Flag 3	10
20	HOME4	Input	Home-Flag 4	10
21	PLIM3	Input	Positive End Limit 3	8,9
22	PLIM4	Input	Positive End Limit 4	8,9
23	MLIM3	Input	Negative End Limit 3	8,9
24	MLIM4	Input	Negative End Limit 4	8,9
25	USER3	Input	User Flag 3	

26	USER4	Input	User Flag 3	
27	PUL_3	Output	Pulse Output 3	
28	PUL_4	Output	Pulse Output 4	
29	DIR_3	Output	Direction Output 3	
30	DIR_4	Output	Direction Output 4	
31	EQU3	Output	Encoder Comp-Equal 3	
32	EQU4	Output	Encoder Comp-Equal 4	
33	B_WDO	Output	Watchdog Out	Indicator/driver
34	INIT-	Input	PMAC Reset	Low is Reset. See note 11

Note

- **Note 8:** Pins marked *PLIMn* should be connected to switches at the *positive* end of travel. Pins marked *MLIMn* should be connected to switches at the *negative* end of travel.
- **Note 9**: Must be conducting to 0V (usually GND) for PMAC to consider itself not into this limit. Automatic limit function can be disabled with **Motor[x].pLimits**.
- **Note 10**: Functional polarity for homing or other trigger use of HOMEn controlled by Encoder/Flag Variable **Clipper[0].Chan[j].CaptCtrl**. HMFLn selected for trigger by Encoder/Flag structure **Clipper[0].Chan[j].CaptFlagSel**. Must be conducting to 0V (usually GND) to produce a 0 in PMAC software.
- **Note 11**: Even if it is not used but connected, long cabling may pull this line low and cause PMAC to unintentionally reset.

34-pin female flat cable connector T&B Ansley P/N 609-3441. Standard flat cable stranded 34-wire T&B Ansley P/N 171-34. Phoenix varioface module type FLKM 34 (male pins) P/N 22 81 06 3

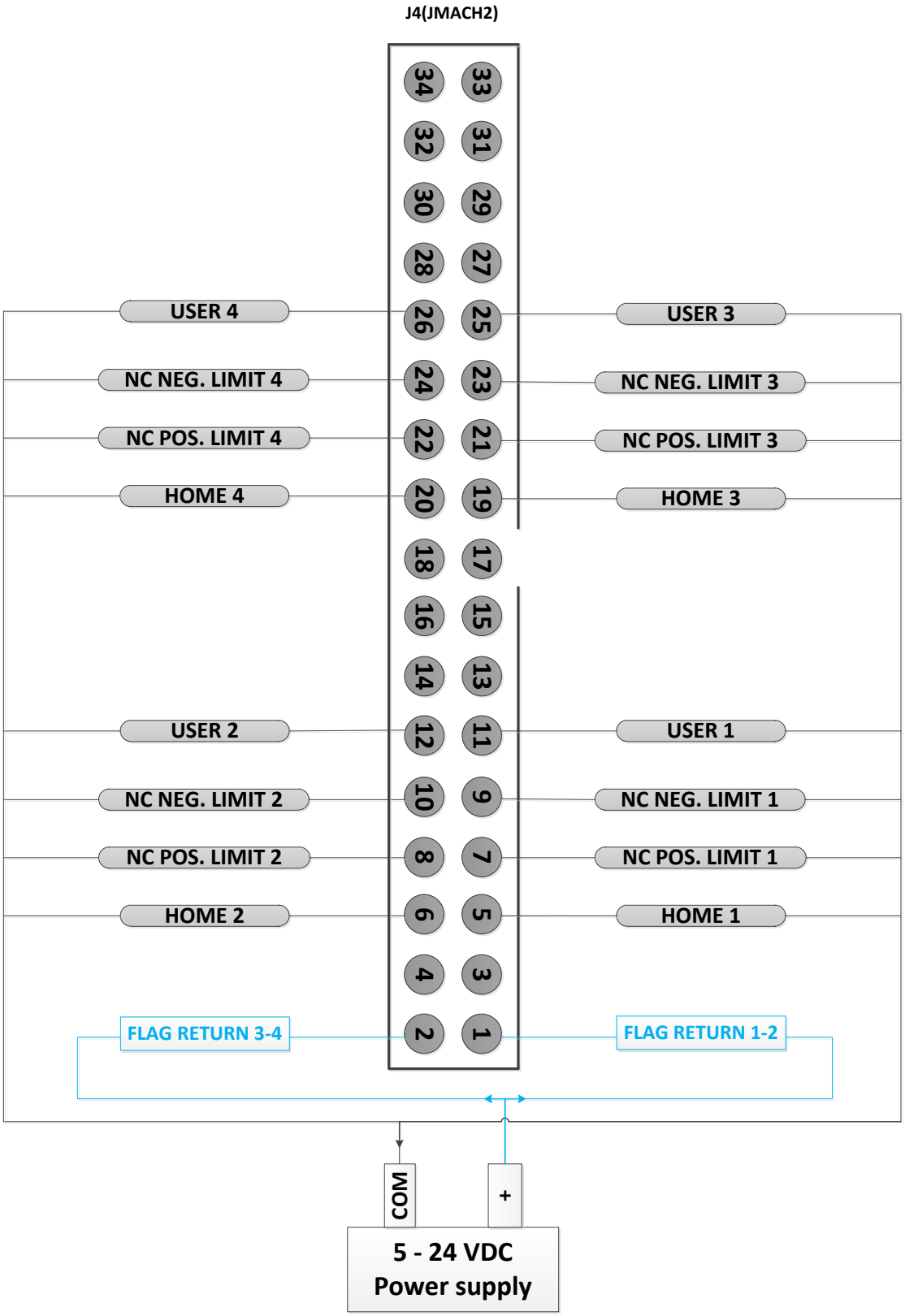
Overtravel Limits and Home Switches

When assigned for the dedicated uses, these signals provide important safety and accuracy functions. PLIMn and MLIMn are direction-sensitive over-travel limits that must conduct current to permit motion in that direction. If no over-travel switches will be connected to a particular motor, this feature must be disabled in the software by setting **Motor[x].pLimits= 0**.

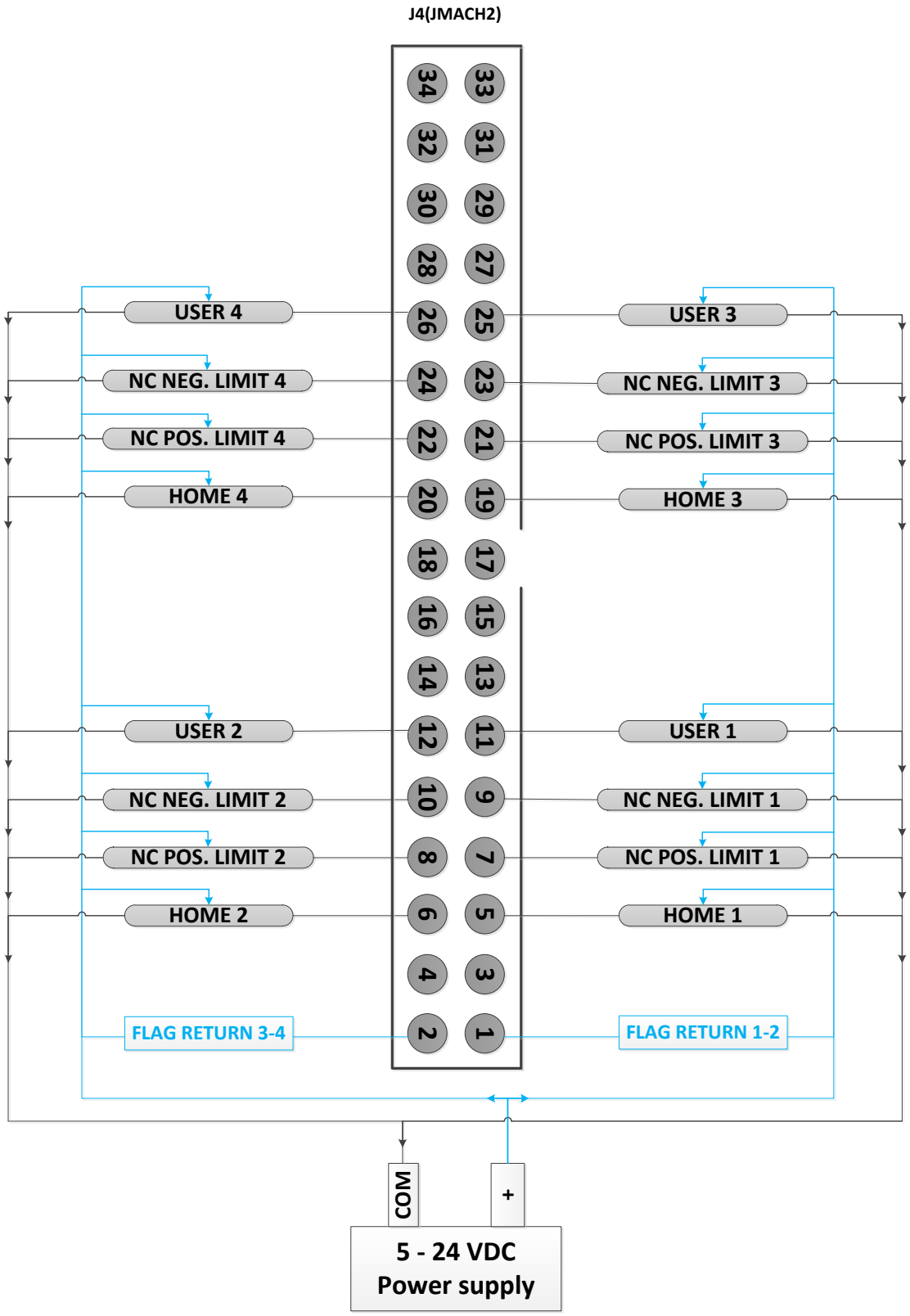
Wiring the Limits and Flags

PMAC expects a closed-to-ground connection for the limits to not be considered on fault. This arrangement provides a failsafe condition. Usually, a passive normally close switch is used. If a proximity switch is needed instead, use a 5 to 24V normally closed to ground NPN sinking type sensor.

Example for Normally Closed Switch



Example for 15-24V Proximity Switch



Note

While normally closed-to-ground switches are required for the overtravel limits inputs, the home switches could be either normally close or normally open types. The polarity is determined by the home sequence setup, through **Clipper[i].Chan[j].CaptCtrl**.

Limits and Flags [Axis 1- 4] Structure Elements

Either the user flags or other unassigned axis flags on the base board can be used as general-purpose I/O providing up to 20 inputs and 4 outputs at 5-24Vdc levels. The indicated Structure Elements allow accessing each particular line as shown below:

```
Clipper[0].Chan[0].AmpEna             ; AENA1 output status
Clipper[0].Chan[0].UserFlag           ; User 1 flag input status
Clipper[0].Chan[0].HomeFlag           ; Home flag 1 input status
Clipper[0].Chan[0].PlusLimit          ; Positive Limit 1 flag input status
Clipper[0].Chan[0].MinusLimit         ; Negative Limit 1 flag input status

Clipper[0].Chan[1].AmpEna             ; AENA2 output status
Clipper[0].Chan[1].UserFlag           ; User 2 flag input status
Clipper[0].Chan[1].HomeFlag           ; Home flag 2 input status
Clipper[0].Chan[1].PlusLimit          ; Positive Limit 2 flag input status
Clipper[0].Chan[1].MinusLimit         ; Negative Limit 2 flag input status

Clipper[0].Chan[2].AmpEna             ; AENA3 output status
Clipper[0].Chan[2].UserFlag           ; User 3 flag input status
Clipper[0].Chan[2].HomeFlag           ; Home flag 3 input status
Clipper[0].Chan[2].PlusLimit          ; Positive Limit 3 flag input status
Clipper[0].Chan[2].MinusLimit         ; Negative Limit 3 flag input status

Clipper[0].Chan[3].AmpEna             ; AENA4 output status
Clipper[0].Chan[3].UserFlag           ; User 4 flag input status
Clipper[0].Chan[3].HomeFlag           ; Home flag 4 input status
Clipper[0].Chan[3].PlusLimit          ; Positive Limit 4 flag input status
Clipper[0].Chan[3].MinusLimit         ; Negative Limit 4 flag input status
```

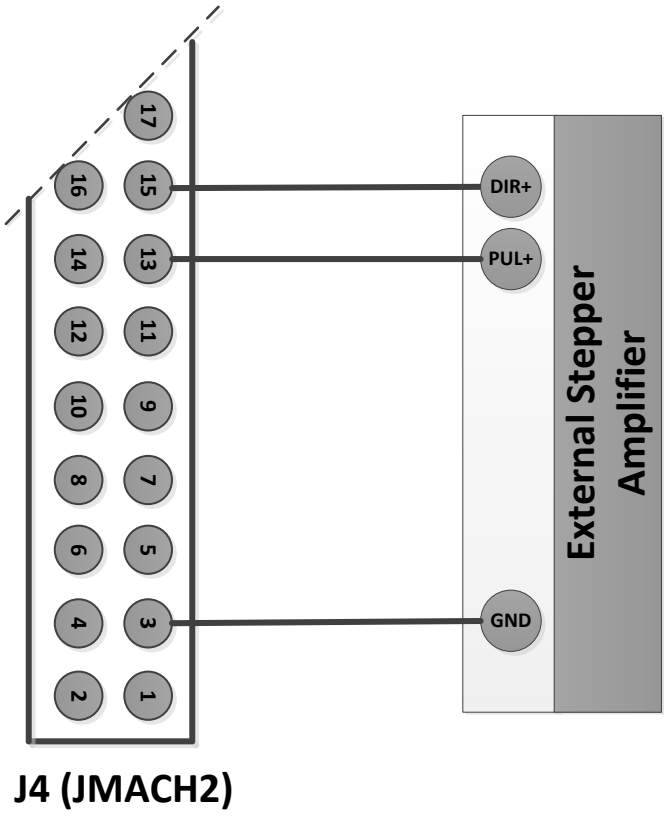
Note

When using these lines as regular I/O points the appropriate setting to disable the flag's feature by setting **Motor[x].pLimits = 0** and/or **Motor[x].pAmpEnable = 0**.

Step and Direction PFM Output (To External Stepper Amplifier)

The Power PMAC Clipper has the capability of generating step and direction (Pulse Frequency Modulation) output signals to external stepper amplifiers. The step and direction outputs can be connected in single-ended configuration for 5V (input signal) amplifiers.

Example for Clipper Channel #1



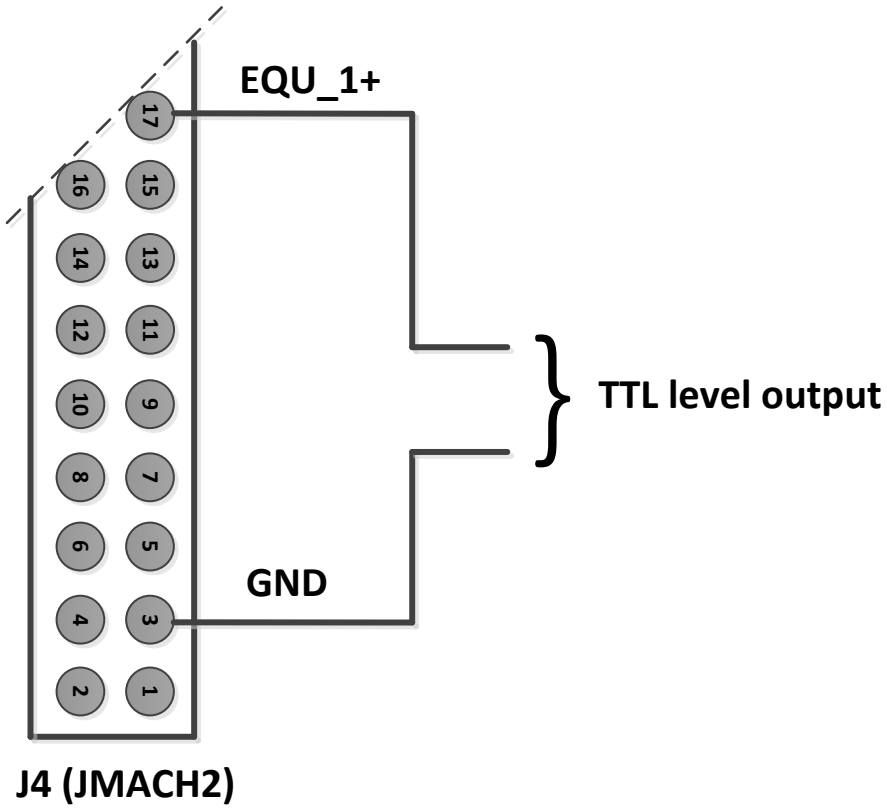
Note

Software setup for PFM outputs are covered in detail in the ***Pulse Frequency Modulation (PFM)*** section under ***DRIVE - MOTOR SETUP***.

Compare Equal Outputs

The compare-equals (EQU) outputs have a dedicated use of providing a signal edge when an encoder position reaches a pre-loaded value. This is very useful for scanning and measurement applications. Instructions for use of these outputs are covered in detail in the Power PMAC User Manual.

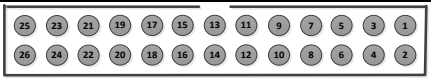
Example for Channel #1




```
Clipper[0].Chan[0].EquOut            ; EQU1, ENC1 compare output value
Clipper[0].Chan[1].EquOut            ; EQU2, ENC2 compare output value
Clipper[0].Chan[2].EquOut            ; EQU3, ENC3 compare output value
Clipper[0].Chan[3].EquOut            ; EQU4, ENC4 compare output value
```

J7: Machine Connector (JMACH3 Port)

This machine interface connector is labeled JMACH3 or J7 on the Power PMAC Clipper. It contains the pins for four channels of Gate3 serial encoders and is shared with the T, U, V, and W flags normally used for hall device commutation with the Clipper Drive stack accessory. Also on this connector are the third and fourth ADC inputs and four channels of brake outputs.

J7 (JMACH3): Machine Port 26-Pin Header			
Pin #	**symbol**	**Function**	**Description**
1	ADC3	Input	General Purpose ADC 3 (Requires Opt12)
2	ADC4	Input	General Purpose ADC 4 (Requires Opt12)
3	+5V	Output	
4	+5V	Output	
5	BRAKE1	Output	Brake output for Channel 1 (Open-collector Output)
6	BRAKE2	Output	Brake output for Channel 2 (Open-collector Output)
7	BRAKE3	Output	Brake output for Channel 3 (Open-collector Output)
8	BRAKE4	Output	Brake output for Channel 4 (Open-collector Output)
9	CHT1	Input	T-flag/Serial Encoder Data+ Input for channel 1
10	CHT2	Input	T-flag/Serial Encoder Data+ Input for channel 2
11	CHT3	Input	T-flag/Serial Encoder Data+ Input for channel 3
12	CHT4	Input	T-flag/Serial Encoder Data+ Input for channel 4
13	GND	Common	
14	GND	Common	
15	CHU1	Input	U-flag/Serial Encoder Data- input for channel 1
16	CHU2	Input	U-flag/Serial Encoder Data- input for channel 2
17	CHV1	Input	V-flag/Serial Encoder Clock+ input for channel 1
18	CHV2	Input	V-flag/Serial Encoder Clock+ input for channel 2
19	CHW1	Input	W-flag/Serial Encoder Clock- input for channel 1
20	CHW2	Input	W-flag/Serial Encoder Clock- input for channel 2
21	CHU3	Input	U-flag/Serial Encoder Data- input for channel 3
22	CHU4	Input	U-flag/Serial Encoder Data- input for channel 4
23	CHV3	Input	V-flag/Serial Encoder Clock+ input for channel 3
24	CHV4	Input	V-flag/Serial Encoder Clock+ input for channel 4
25	CHW3	Input	W-flag/Serial Encoder Clock- input for channel 3
26	CHW4	Input	W-flag/Serial Encoder Clock- input for channel 4

26-pin female flat cable connector T&B Ansley P/N 609-2641. Standard flat cable stranded 26-wire T&B Ansley P/N 171.26. Phoenix varioface module type FLKM 26 (male pins) P/N 22 81 05 0

Brake Software Setup

Caution

The brake's output signal has a limited current capability (about 100mA) and should be wired using external relays to the motor.

The following settings are required to synchronize the enabling/disabling of the motor with the brake output signal.

```
Motor[1].pBrakeOut = Clipper[0].Chan[0].OutFlagB.a; //
Motor[1].BrakeOutBit = 9;                           //
Motor[1].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[1].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
Motor[2].pBrakeOut = Clipper[0].Chan[1].OutFlagB.a; //
Motor[2].BrakeOutBit = 9;                           //
Motor[2].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[2].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
Motor[3].pBrakeOut = Clipper[0].Chan[2].OutFlagB.a; //
Motor[3].BrakeOutBit = 9;                           //
Motor[3].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[3].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
Motor[4].pBrakeOut = Clipper[0].Chan[3].OutFlagB.a; //
Motor[4].BrakeOutBit = 9;                           //
Motor[4].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[4].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
```

Note

For diagnostics, set **Motor[x].pBrakeOut = 0** and set the output using the **Clipper[0].Chan[j].OutFlagB** bit element.

Serial Encoder Software Setup

Configuring Gate3 serial encoder protocols is achieved through the following structure elements:

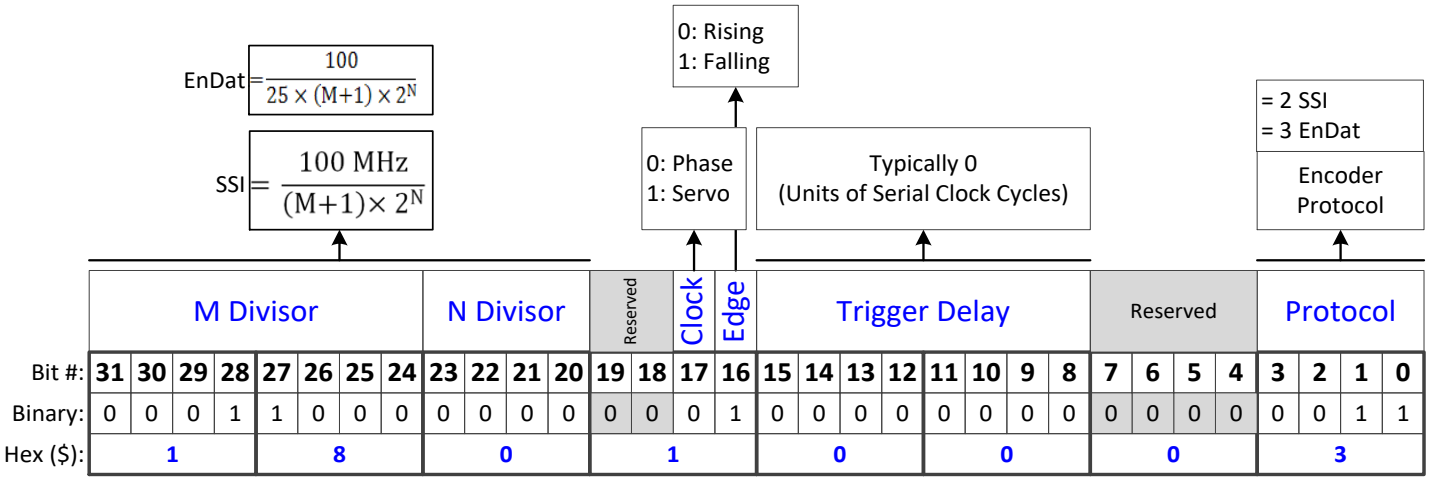
- Global Control Word, **Clipper[0].SerialEncCtrl**
- Channel Control Word, **Clipper[0].Chan[j].SerialEncCmd**
- Channel Enable Bit, **Clipper[0].Chan[j].SerialEncEna**

Global Control Register

The Global Control Word is a 4-channel control word (channels 1 – 4).

	Global Control Register
Channels 1 – 4	**Clipper[0].SerialEncCtrl**

Following, is a summary of the 32-bit serial control word. Detailed description can be found in the Power PMAC Software and User manuals.



- Bits [31 – 20] specify the serial encoder interface transmission frequency, using the equations in the diagram. This frequency is usually specified by the encoder manufacturer, and typically set in the range of 1 – 16 MHz.
- Bit #17 specifies the trigger source; Phase clock is recommended.
- Bit #16 specifies the active edge; Falling edge is recommended.
- Bits [15 – 8] specify a trigger delay used to compensate for transmission over long encoder lines.
- Bits [3 – 0] specify the encoder protocol of the serial encoder.

In the example diagram above, an EnDat encoder is configured at a 4 MHz serial clock triggered at falling edge of phase clock. Clipper[0].SerialEncCtrl = $18010003.

Channel Control Register

The channel control word is channel specific.

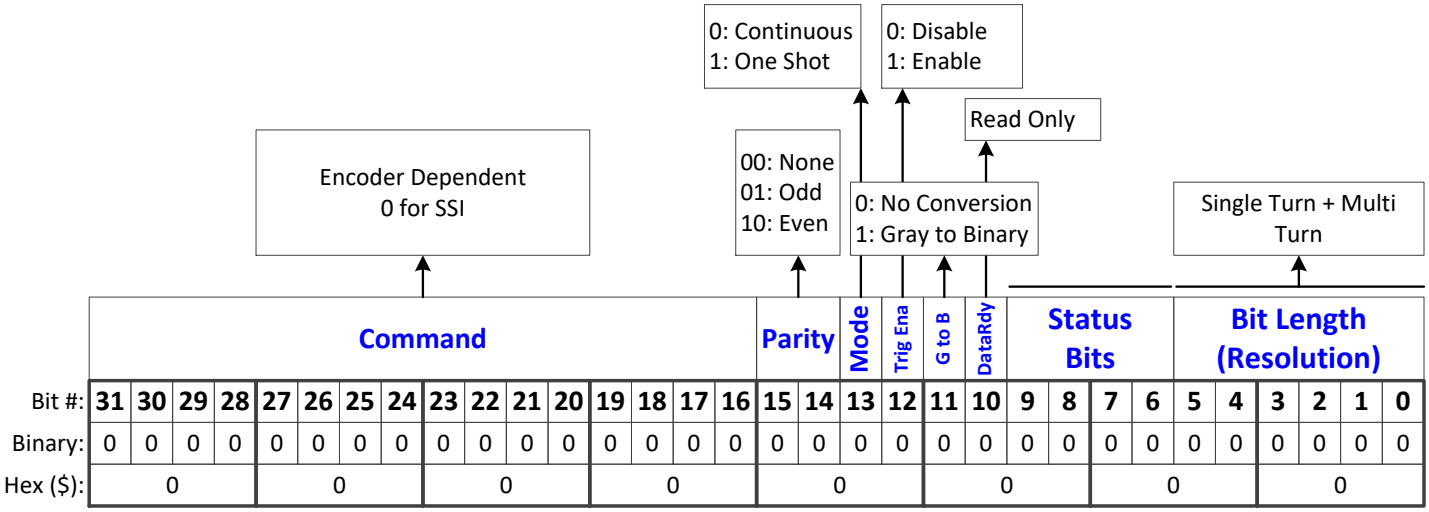
Channel	Channel Control Register
1	**Clipper[0].Chan[0].SerialEncCmd**
2	**Clipper[0].Chan[1].SerialEncCmd**
3	**Clipper[0].Chan[2].SerialEncCmd**
4	**Clipper[0].Chan[3].SerialEncCmd**

Following, is a summary of the 32-bit channel control word. Detailed description can be found in the Power PMAC Software and User manuals.

- Bits [31 – 16] specify the encoder command word. This is encoder specific, typical settings shown in the diagrams below.
- Bits [15 – 14] specifies the parity type, this is an encoder specific setting.

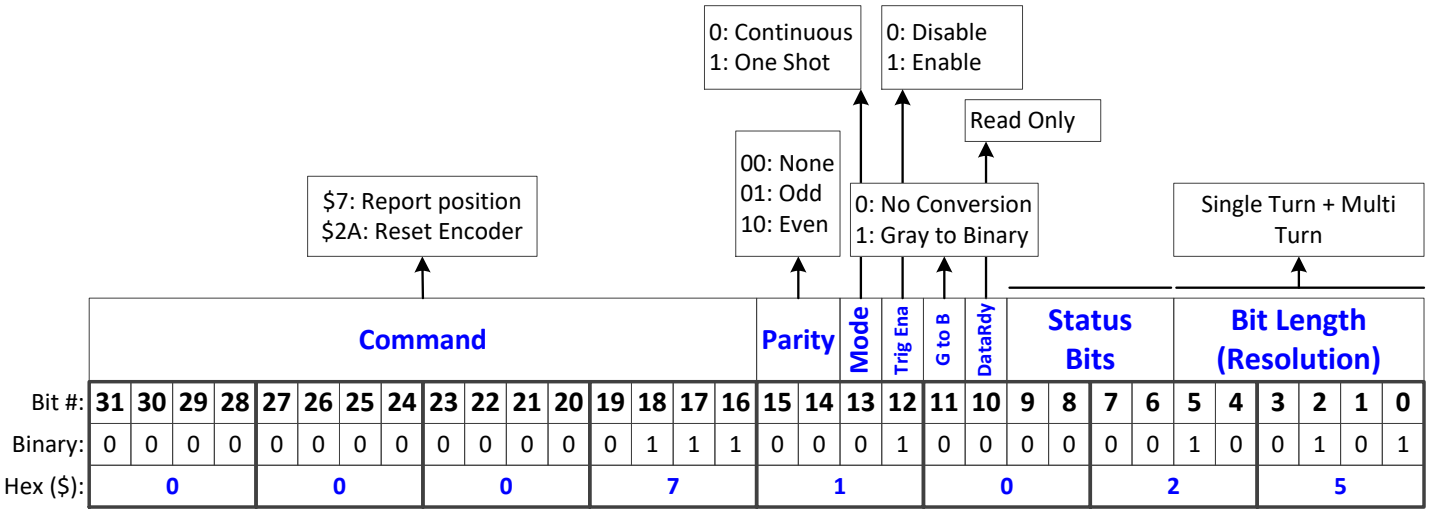
- Bit #13 specifies the trigger mode. Typically set to 0 for continuous (on-going position).
- Bit #12 is the trigger enable bit, must be set to 1 to trigger.
- Bit #11 specifies whether a Gray to Binary conversion is necessary.
- Bit #10 is a read-only bit.
- Bits [9 – 6] are status bits.
- Bits [5 – 0] specify the encoder protocol resolution (in bits).

SSI



EnDat

In this example, a 37-bit (25-bit Single-Turn, 12-bit Multi-Turn) EnDat 2.2 encoder configuration.



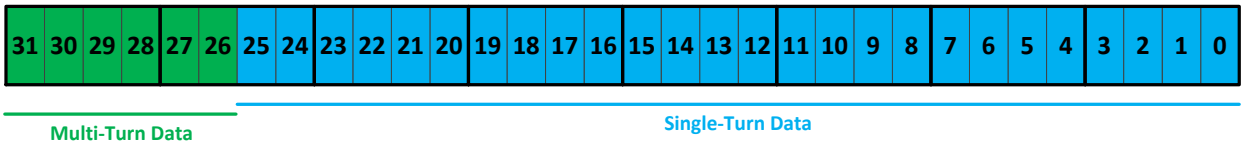
Serial Data Registers

The resulting serial encoder – position – data is found in the serial data registers A, and B.

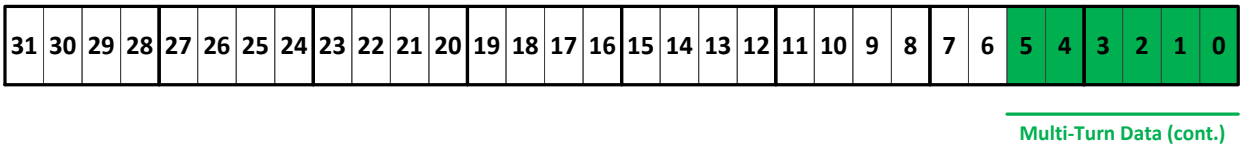
Ch. #	Serial Encoder Data Registers
1	**Clipper[0].Chan[0].SerialEncDataA** **Clipper[0].Chan[0].SerialEncDataB**
2	**Clipper[0].Chan[1].SerialEncDataA** **Clipper[0].Chan[1].SerialEncDataB**
3	**Clipper[0].Chan[2].SerialEncDataA** **Clipper[0].Chan[2].SerialEncDataB**
4	**Clipper[0].Chan[3].SerialEncDataA** **Clipper[0].Chan[3].SerialEncDataB**

With a 37-bit (25-bit single-turn, 12-bit multi-turn) serial encoder, the resulting position data would reside in the following bit fields:

PowerBrick[].Chan[].SerialEncDataA



PowerBrick[].Chan[].SerialEncDataB



Note

Knowing where the position data resides is essential for the proper setup functions of the motor/encoder.

Encoder Conversion Table

The Encoder Conversion Table ECT must be set up properly for the Power PMAC to increment the on-going position of the motor/encoder.

The source data for the ECT is typically serial register data A.

For the ECT, the number of bits of interest is the single-turn protocol resolution. Additionally, the Most Significant Bit MSB of this data must be positioned at bit #31 so that rollover is handled gracefully. With the 25-bit Single-Turn encoder, we apply a left shift of 7 bits (32 – Single-Turn data length) and adjust the scale factor accordingly:

```
EncTable[1].Type = 1;
EncTable[1].pEnc = Clipper[0].Chan[0].SerialEncDataA.a;
EncTable[1].index1 = 7;                 // Shift left 7 bits
EncTable[1].index2 = 0;                 // No right shift
EncTable[1].index3 = 0;
EncTable[1].index4 = 0;
EncTable[1].index5 = 0;
EncTable[1].index6 = 0;
EncTable[1].ScaleFactor = 1 / EXP2(7);  // 1/2^7
```

The position and velocity pointers, typically initiated by default by the firmware, should point to the result of the corresponding ECT entry. And activating the channel should allow the user to see counts in the position window of the IDE software:

```
Motor[1].ServoCtrl = 1;
Motor[1].pEnc = EncTable[1].a;
Motor[1].pEnc2 = EncTable[1].a;
```

Counts per User Units

For a rotary motor / serial encoder, the user should see $2^{\text{Single-Turn Bits}}$ encoder/motor units per revolution. With a 25-bit Single-Turn encoder: 2^{25} = 33,554,432 motor units / revolution.

For a linear serial scale, the user should see 1 / corresponding protocol resolution. With a 0.1 µm linear encoder: 1 / 0.0001 = 10,000 motor units / mm.

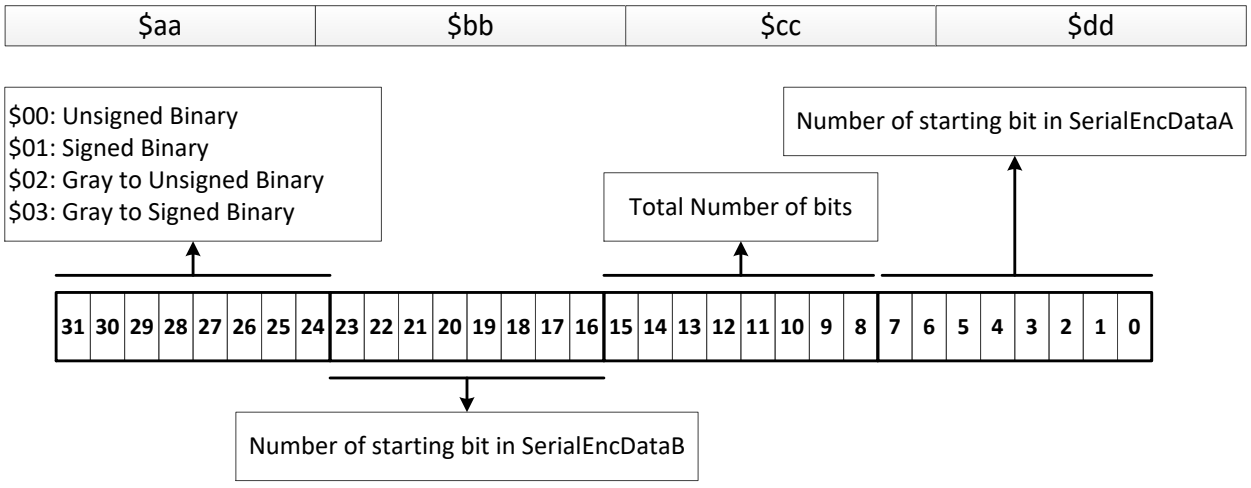
Absolute Power-On Position Read

With absolute serial encoders, the Power PMAC can be set up to read absolute position on power-up (assuming encoder power is provided), or at the receipt of the **HMZ** command.

The two essential structure elements for setting up an absolute position read are **Motor[x].pAbsPos**, and **Motor[x].AbsPosFormat.**

Motor[x].pAbsPos is typically set to the **Clipper[0].Chan[j].SerialEncDataA** register.

Motor[x].AbsoPosFormat is a 32-bit value consisting of four byte fields in the $*aabbccdd* format:



Examples:

- A 37-bit (25-bit Single-Turn, 12-bit Multi-Turn) serial EnDat rotary encoder is set to $01002500.
- A 25-bit (25-bit Single-Turn, no Multi-Turn) serial SSI rotary encoder is set to $00002500.
- A 25-bit serial SSI linear encoder is set to $00002500.

Note

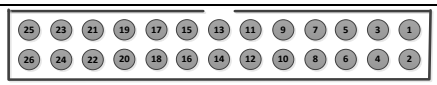
Linear serial absolute encoders and rotary encoders with no multi-turn data are set to read and interpret unsigned absolute position (always positive).

Issuing #nHMZ, where n is the channel number, reports the absolute position of the encoder. For setting up absolute position read on power-up:

```
Motor[4].PowerOnMode = Motor[4].PowerOnMode | $4
```

J8: Thumbwheel Multiplexer Port (JTHW Port)

Thumbwheel Multiplexer Port on the JTHW connector has 8 inputs and 8 outputs at TTL levels. These may be used as general purpose I/O if the MuxIO feature is not used. . The direction of the input and output lines on this connector are set by jumpers E14 and E15.

J8 (JTHW): Multiplexer Port Connector 26-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	GND	Common	PMAC Common	
2	GND	Common	PMAC Common	
3	DAT0	Input	Data-0 Input	Data input from multiplexed accessory
4	SEL0	Output	Select-0 Output	Multiplexer select output
5	DAT1	Input	Data -1 Input	Data input from multiplexed accessory
6	SEL1	Output	Select -1 Output	Multiplexer select output
7	DAT2	Input	Data -2 Input	Data input from multiplexed accessory
8	SEL2	Output	Select -2 Output	Multiplexer select output
9	DAT3	Input	Data -3 Input	Data input from multiplexed accessory
10	SEL3	Output	Select -3 Output	Multiplexer select output
11	DAT4	Input	Data -4 Input	Data input from multiplexed accessory
12	SEL4	Output	Select -4 Output	Multiplexer select output
13	DAT5	Input	Data -5 Input	Data input from multiplexed accessory
14	SEL5	Output	Select -5 Output	Multiplexer select output
15	DAT6	Input	Data -6 Input	Data input from multiplexed accessory
16	SEL6	Output	Select -6 Output	Multiplexer select output
17	DAT7	Input	Data -7 Input	Data input from multiplexed accessory
18	SEL7	Output	Select -7 Output	Multiplexer select output
19	N.C.	N.C.	No Connection	
20	GND	Common	PMAC Common	
21	N.C.	N.C.	No Connection	
22	GND	Common	PMAC Common	
23	N.C.	N.C.	No Connection	
24	GND	Common	PMAC Common	
25	+5V	Output	+5VDC Supply	Power supply out
26	INIT-	Input	PMAC Reset	Low is Reset

Note

- The direction of the input and output lines on this connector are set by jumpers E14 and E15.
- If E14 is removed or E15 is installed then the multiplexing feature of the JTHW port cannot be used.

26-pin female flat cable connector T&B Ansley P/N 609-2641
Standard flat cable stranded 26-wire T&B Ansley P/N 171.26
Phoenix varioface module type FLKM 26 (male pins) P/N 22 81 05 0

Thumbwheel Port Digital Inputs and Outputs

To configure the I/O for the default jumper settings the following must be set:

```
Sys.WpKey = $AAAAAAAA;
Clipper[0].GpioDir[0] = $00FFFF00     // Direction Control
Clipper[0].GpioPol[0] = $0            // Polarity Control
```

Note that polarity and direction control can be modified to the users need for the JTHW bits if not using this port for multiplexed I/O:

```
Sys.WpKey = $AAAAAAAA;
Clipper[0].GpioDir[0] = $00FF0000     // Direction Control for JTHW all inputs (1=out, 0=in)
                                      // Also install E15
Clipper[0].GpioPol[0] = $0000FFFF     // Invert Polarity Control of JTHW only
```

The inputs and outputs on the thumbwheel multiplexer port J8 may be used as discrete, non-multiplexed I/O. In this case, these I/O lines can be accessed through structures:

```
                                      // Inputs
Clipper[0].GpioData[0].0              // DAT0
Clipper[0].GpioData[0].1              // DAT1
Clipper[0].GpioData[0].2              // DAT2
Clipper[0].GpioData[0].3              // DAT3
Clipper[0].GpioData[0].4              // DAT4
Clipper[0].GpioData[0].5              // DAT5
Clipper[0].GpioData[0].6              // DAT6
Clipper[0].GpioData[0].7              // DAT7
Clipper[0].GpioData[0].0.8            // DAT0-7 8 bit byte
                                      // Outputs
Clipper[0].GpioData[0].8              // SEL0
Clipper[0].GpioData[0].9              // SEL1
Clipper[0].GpioData[0].10             // SEL2
Clipper[0].GpioData[0].11             // SEL3
Clipper[0].GpioData[0].12             // SEL4
Clipper[0].GpioData[0].13             // SEL5
Clipper[0].GpioData[0].14             // SEL6
Clipper[0].GpioData[0].15             // SEL7
Clipper[0].GpioData[0].8.8            // SEL0-7 8 bit byte
```

Configuring Multiplexed I/O on the JTHW port

The JTHW port can be used to multiplex large numbers of inputs and outputs on the using the MuxIO feature. Up to 32 of the multiplexed I/O boards may be daisy-chained on the port, in any combination. To configure the JTHW port for multiplexed I/O the default jumper settings of E14 and E15 must be as follows:

E14	Install to make GPIO 0-7 lines inputs Remove jumper to make GPIO 0-7 lines outputs	Installed (Required for MuxIO)
E15	Install to make GPIO 8-15 lines inputs	Not Installed (Required for MuxIO)

	Remove jumper to make GPIO 8-15lines outputs	

Also the direction control and polarity must be at the default settings. Complete instructions for use of this I/O are covered in detail in the Power PMAC User Manual.

For the multiplexed digital I/O on ACC-34 boards, the application will access the I/O points through their image words in Power PMAC memory. The values in the image words for output ports are automatically copied to the actual outputs on the ACC-34 boards, and the values in the image words for input ports are automatically copied from the actual inputs on the ACC-34 boards.

The data structure elements (32-bit unsigned integers) for these image words are **MuxIo.PortA[n].Data** (inputs) and **MuxIo.PortB[n].Data** (outputs), where n (= 0 to 31) is the index for the board as set by the DIP switches on the board. Standard Power PMAC bit addressing may be used:

```
MuxIo.PortA[0].Data.0       // first input bit
MuxIo.PortA[0].Data.0.4     // first four input bits (nibble)
MuxIo.PortB[0].Data.0       // first output bit
MuxIo.PortB[0].Data.0.4     // first four output bits (nibble)
```

An M-variable can be assigned to the entire element, an individual bit of the element, or to a consecutive set of bits. When the assignment is made through the IDE, an application-specific name can be given to the variable. For example:

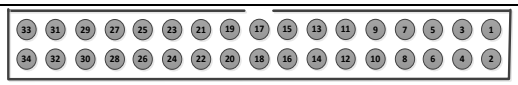
```
ptr PartClamp->MuxIo.PortB[1].Data.17        // 1-bit value
ptr LocatorArray->MuxIo.PortA[0].Data.8.12   // 12-bit value
```

Typical setup for multiplexed I/O control:

```
Sys.WpKey = $AAAAAAAA
MuxIo.Enable=0
MuxIo.pOut = Clipper[0].GpioData[0].a
MuxIo.OutBit = 8
MuxIo.pIn = Clipper[0].GpioData[0].a
MuxIo.InBit = 0
MuxIO.PortA[0].Enable=1;
MuxIO.PortA[0].Dir=0;
MuxIO.PortA[0].AutoParityCheck=0
MuxIO.PortB[0].Enable=1;
MuxIO.PortB[0].Dir=1;
MuxIO.PortB[0].AutoParityCheck=0
MuxIO.ClockPeriod=250;
MuxIO.Enable=1
```

J9: General-Purpose Digital Inputs and Outputs (JOPT Port)

This connector provides 16 general-purpose inputs or outputs at TTL levels. Each input and each output has its own corresponding ground pin in the opposite row. The direction of the input and output lines on this connector are set by jumpers E16 and E17. 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.

J9 (JOPT): I/O Port Connector 34-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	MI8	Input	Machine Input 8	12, 13
2	GND	Common	PMAC Common	
3	MI7	Input	Machine Input 7	12, 13
4	GND	Common	PMAC Common	
5	MI6	Input	Machine Input 6	12, 13
6	GND	Common	PMAC Common	
7	MI5	Input	Machine Input 5	12, 13
8	GND	Common	PMAC Common	
9	MI4	Input	Machine Input 4	12, 13
10	GND	Common	PMAC Common	
11	MI3	Input	Machine Input 3	12, 13
12	GND	Common	PMAC Common	
13	MI2	Input	Machine Input 2	12, 13
14	GND	Common	PMAC Common	
15	MI1	Input	Machine Input 1	12, 13
16	GND	Common	PMAC Common	
17	MO8	Output	Machine Output 8	11, 13
18	GND	Common	PMAC Common	
19	MO7	Output	Machine Output 7	11, 13
20	GND	Common	PMAC Common	
21	MO6	Output	Machine Output 6	11, 13
22	GND	Common	PMAC Common	
23	MO5	Output	Machine Output 5	11, 13
24	GND	Common	PMAC Common	
25	MO4	Output	Machine Output 4	11, 13

26	GND	Common	PMAC Common	
27	MO3	Output	Machine Output 3	11, 13
28	GND	Common	PMAC Common	
29	MO2	Output	Machine Output 2	11, 13
30	GND	Common	PMAC Common	
31	MO1	Output	Machine Output 1	11, 13
32	GND	Common	PMAC Common	
33	+5	Output	+5 Power I/O	
34	GND	Common	PMAC Common	

Note

- **Note 11**: To configure MO1 - MO8 as inputs install jumper E16. To configure MO1 - MO8 as outputs remove jumper E16.
- **Note 12**: To configure MI1 - MI8 as inputs install jumper E17. To configure MI1 - MI8 as outputs remove jumper E17.
- **Note 13**: Includes a 10K ohm pull-up resistor to +5V.

34-pin female flat cable connector T&B Ansley P/N 609-3441; Standard flat cable stranded 34-wire T&B Ansley P/N 171-34; Phoenix varioface module type FLKM 34 (male pins) P/N 22 81 06 3

General Purpose I/O (J6) Structures

To configure the I/O for the default jumper settings the following must be set:

```
Sys.WpKey = $AAAAAAAA;
Clipper[0].GpioDir[0] = $00FFFF00     // Direction Control
Clipper[0].GpioPol[0] = $00000000     // Polarity Control
```

Note that polarity and direction control can be modified to the users need for the JOPT bits. If using the JTHW port for multiplexed I/O the JTHW bits must be left at default:

```
Sys.WpKey = $AAAAAAAA;
Clipper[0].GpioDir[0] = $FFFFFF00     // Direction Control for JOPT all outputs (1=out, 0=in)
                                      // Also remove E17
Clipper[0].GpioPol[0] = $FFFF0000     // Invert Polarity Control of JOPT only
```

The lines on the JOPT general-purpose I/O connector are accessed with the following structures:

```
                                      // Inputs
Clipper[0].GpioData[0].24              // MI1
Clipper[0].GpioData[0].25              // MI2
Clipper[0].GpioData[0].26              // MI3
Clipper[0].GpioData[0].27              // MI4
Clipper[0].GpioData[0].28              // MI5
Clipper[0].GpioData[0].29              // MI6
Clipper[0].GpioData[0].30              // MI7
Clipper[0].GpioData[0].31              // MI8
Clipper[0].GpioData[0].24.8            // Inputs as 8-bit byte
                                      // Outputs
Clipper[0].GpioData[0].16              // MO1
Clipper[0].GpioData[0].17              // MO2
Clipper[0].GpioData[0].18              // MO3
Clipper[0].GpioData[0].19              // MO4
Clipper[0].GpioData[0].20              // MO5
Clipper[0].GpioData[0].21              // MO6
Clipper[0].GpioData[0].22              // MO7
```

```
Clipper[0].GpioData[0].23              // MO8
Clipper[0].GpioData[0].16.8            // Outputs as 8-bit byte
```

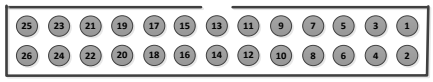
An M-variable can be assigned to an individual bit of an element, or to a consecutive set of bits. When the assignment is made through the IDE, an application-specific name can be given to the variable. For example:

```
ptr LaserOn->Clipper[0].GpioData[0].21          // 1-bit value
ptr OverrideKnob->Clipper[1].GpioData[0].24.4   // 4-bit value
```

Once the assignment is made, the application can use the declared variable name in the application.

J10: Handwheel and Pulse/Dir Connector (JHW/PD Port)

JHW/PD port provides two differential Quadrature encoder inputs (HW1 and HW2) and two differential PFM outputs or PWM output pairs. There is no index channel on HW1 and HW2. The Serial encoders on Power Clipper's channels 1 and 2 are shared with HW1 and HW2 respectively and jumpers E6 and E7 select which is active. Default E6 and E7 settings are 1-2 to enable the serial encoder inputs on Power Clipper's channels 1 and 2. These must be set to 2-3 to enable the handwheel encoders HW1 and HW2.

J10 (JHW) Handwheel Encoder Connector 26-Pin Header			
Pin#	**Symbol**	**Function**	**Description**
1	GND	Common	Reference voltage
2	+5V	Output	Supply voltage
3	HWA1+	Input	HW1 channel A+
4	HWA1-	Input	HW1 channel A-
5	HWB1+	Input	HW1 channel B+
6	HWB1-	Input	HW1 channel B-
7	HWA2+	Input	HW2 channel A+
8	HWA2-	Input	HW2 channel A-
9	HWB2+	Input	HW2 channel B+
10	HWB2-	Input	HW2 channel B-
11	PUL1+	Output	PULSE1+ output
12	PUL1-	Output	PULSE1- output
13	DIR1+	Output	DIRECTION1+ output
14	DIR1-	Output	DIRECTION1- output
15	PUL2+	Output	PULSE2+ output
16	PUL2-	Output	PULSE2- output
17	DIR2+	Output	DIRECTION2+ output
18	DIR2-	Output	DIRECTION2- output
19-22	TBD		
23	HWANA+	Output	OPT12 Filtered PWM DAC+
24	HWANA-	Output	OPT12 Filtered PWM DAC-
25	GND	Common	Reference voltage
26	+5V	Output	Supply voltage

26-pin female flat cable connector T&B Ansley P/N 609-2641. Standard flat cable stranded 26-wire T&B Ansley P/N 171.26. Phoenix varioface module type FLKM 26 (male pins) P/N 22 81 05 0

Handwheel Encoder Software Setup

To enable the handwheel encoders in software set **Clipper[i].Chan[j].SerialEncEna=0**, (j=1,2). The encoder counter is available in **Clipper[i].Chan[j].SerialEncDataA**. This has 8 bits of 1/T fractional counts. Use **EncTable[x].Type=1** to read this location with an **EncTable[x].ScaleFactor=1/256**. To reset the counter set **Clipper[i].Chan[j].SerialEncCmd=$400**. Bit 11 of **Clipper[i].Chan[j].SerialEncCmd** is used to change the count direction of the encoder. Bit 31 of **Clipper[i].Chan[j].SerialEncDataB** is the status of the encoder count error flag. The sample clock for these encoders is controlled by **Clipper[i].EncClockDiv**.

```
Sys.WpKey = $AAAAAAAA;

// Typical ECT setup for HW1
Gate3[0].Chan[0].SerialEncEna=0
EncTable[5].Type=1
EncTable[5].pEnc=Gate3[0].Chan[0].SerialEncDataA.a
EncTable[5].pEnc1=sys.pushm
EncTable[5].index1=0
EncTable[5].index2=0
EncTable[5].index3=0
EncTable[5].index4=0
EncTable[5].ScaleFactor=1/256

// Typical ECT setup for HW2
Gate3[0].Chan[1].SerialEncEna=0
EncTable[6].Type=1
EncTable[6].pEnc=Gate3[0].Chan[6].SerialEncDataA.a
EncTable[6].pEnc1=sys.pushm
EncTable[6].index1=0
EncTable[6].index2=0
EncTable[6].index3=0
EncTable[6].index4=0
EncTable[6].ScaleFactor=1/256

// Typical pointers for encoder count direction
PTR CountDirHW1->U.IO:$90005C.11.1
PTR CountDirHW2->U.IO:$9000DC.11.1

// Typical pointers for encoder count error
PTR CountErrHW1->U.IO:$90001C.11.1
PTR CountErrHW2->U.IO:$90009C.11.1
```

Handwheel PFM Software Setup

The handwheel pulse and direction connections are common to the Power Clippers channel's 1 and 2 pulse frequency modulation outputs (PFM) and would be setup according to the "Pulse Frequency Modulation Output (Step and Direction)" section of this manual.

Handwheel Option-12 DAC Software Setup

The Option-12 DAC uses the pulse and direction output of channel 3. Set PWM mode on phase D of channel 3 (set bit 3 to zero). Set the proper PWM clocks for channel 3 if not already done:

```
Sys.WpKey = $AAAAAAAA;
                                                // Clocks - Phase and Servo
Clipper[0].PhaseFreq=10000; // 10KHz Phase
Clipper[0].PhaseClockDiv=0;
Clipper[0].ServoClockDiv=3; // 2.25KHz Servo
Clipper[0].AdcAmpStrobe=$ffffc
Clipper[0].Chan[2].PwmFreqMult=5 // 30KHz PWM
Sys.PhaseOverServoPeriod=1/( Clipper[0].ServoClockDiv+1)
Sys.ServoPeriod=1000*( Clipper[0].ServoClockDiv+1)/Clipper[0].PhaseFreq
Clipper[0].Chan[2].OutputMode= Clipper[0].Chan[2].OutputMode&( Clipper[0].Chan[2].OutputMode^8)
```

The DAC is available at the following register:

Gate3[0].Chan[2].Pwm[3].a

Handwheel 5th motor using the Option -12 DAC

Using one of the handwheel encoders and the Option-12 DAC a complete 5th motor can be created with axis flags form the JOPT port:

```
// Typical pointers for encoder count direction
PTR CountDirHW1->U.IO:$90005C.11.1

// Typical pointers for encoder count error
PTR CountErrHW1->U.IO:$90001C.11.1

Sys.WpKey = $AAAAAAAA;
                                              // Clocks - Phase and Servo
Clipper[0].PhaseFreq=10000; // 10KHz Phase
Clipper[0].PhaseClockDiv=0;
Clipper[0].ServoClockDiv=3; // 2.25KHz Servo
Clipper[0].AdcAmpStrobe=$ffffc
Clipper[0].Chan[2].PwmFreqMult=5 // 30KHz PWM
Sys.PhaseOverServoPeriod=1/( Clipper[0].ServoClockDiv+1)
Sys.ServoPeriod=1000*( Clipper[0].ServoClockDiv+1)/Clipper[0].PhaseFreq
Clipper[0].Chan[2].OutputMode= Clipper[0].Chan[2].OutputMode&( Clipper[0].Chan[2].OutputMode^8)

                                           // Typical ECT setup for HW1
CountDirHW1=0                              // CW decode for HW1 //--USER ADJUSTABLE
Gate3[0].Chan[0].SerialEncEna=0
EncTable[5].Type=1
EncTable[5].pEnc=Gate3[0].Chan[0].SerialEncDataA.a
EncTable[5].pEnc1=sys.pushm
EncTable[5].index1=0
EncTable[5].index2=0
EncTable[5].index3=0
EncTable[5].index4=0
EncTable[5].ScaleFactor=1/256

Motor[5].ServoCtrl=1                       // Motor #5 activation
Motor[5].pDac=Gate3[0].Chan[2].Pwm[3].a    // DAC pointer
Motor[5].pEnc=EncTable[5].a                // ECT entry of HW1
Motor[5].pEnc2=EncTable[5].a
```

Use the JOPT port I/O to provide flags for motor 5. For example to use JOPTO:

MI1 is +LIM
MI2 is –LIM
MI3 is AFAULT
MO1 is AENA

```
Motor[5].pLimits= Clipper[0].GpioData[0].a      // MI1
Motor[5].LimitBits=24                           // MI1 is bit #24, MI2 is bit #25
Motor[5].pAmpFault= Clipper[0].GpioData[0].a    // MI3
Motor[5].AmpFaultBit=26                         // MI3 is bit #26
Motor[5].AmpFaultLevel=0                           //--USER ADJUSTABLE
Motor[5].pAmpEnable= Clipper[0].GpioData[0].a   // MO1
Motor[5].AmpEnablebit= 16                       // MO1 is bit #16
```

P2: USB Device Port

The USB "device" port is located next to the J10 connector inside the board. It is a "micro" USB connector and has an orthogonal orientation. When the Power PMAC CPU is not powered this port will allow a PC to view the flash RAM as a USB drive.

P20: EtherCat™/Ethernet Communications Port

This connector is used to connect to an EtherCat™ network. It can also serve as another Ethernet communication port.

P21: Ethernet Communications Port

This connector is used to establish communication over Ethernet between the PC and the Power PMAC Clipper. Delta Tau strongly recommends the use of RJ45 CAT5e or better shielded cable.

P17: USB Communications Port

The USB "host" port is located next to the Ethernet communication port at P21. It is a "Standard-A" format connector and has a vertical orientation. With this port, the Power PMAC CPU acts as the host computer and various peripheral devices can be connected through this port.

Probably the most common peripheral device used on this port is the "USB stick" flash drive. The Power PMAC CPU board will automatically recognize standardly formatted flash drives connected to this port. It is even possible to boot the CPU from this drive if the proper boot files are present on the drive.

It is also possible to use USB peripheral devices such as true disk drives and keyboards.

Caution

The electrical ground plane of any separately powered and grounded device connected through USB must be at the same level as the Power PMAC Clipper. Ground loops may result in causing damage on the Power PMAC Clipper.

Note

Use a shielded USB (category 6 or 7) cable. In noise sensitive environment, install ferrite cores at both Clipper and PC side.

LED Indicators

D10: This is a dual colored LED. When this LED is green, it indicates that power is applied to the +5V input when this LED is red, it indicates that the watchdog timer has tripped.

D12: This is a red colored LED. When this LED is lit it indicates that the "Power Good" subsystem has failed.

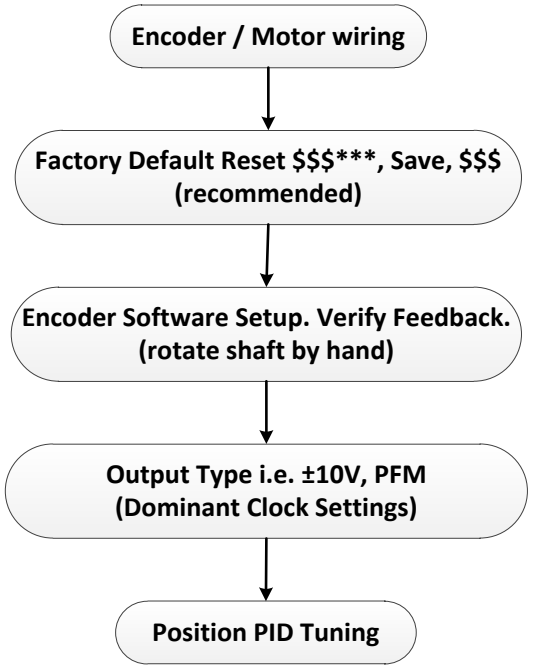
D15: This is an amber colored LED. When this LED is lit it indicates that the backplane reset has completed and Power PMAC is ready for communication.

DRIVE - MOTOR SETUP

The Power PMAC Clipper supports three types of outputs:

- Analog ±10V 13-bit Filtered PWM
- Pulse Frequency Modulation (PFM)
- Analog ±10V 16-bit True DAC with Acc-8AS

The following chart summarizes the steps to implement for setting up a motor properly with the Power PMAC Clipper:



Note

The following section assumes that feedback devices have been setup properly, and that moving the motor/encoder shaft by hand shows correct data in the position window.

Filtered PWM Output (Analog ±10V)

In this mode, the ±10V analog output is obtained by passing the digital PWM signal through a low pass 30KHz filter. This technique, although not as high performance as a true digital to analog converter, is more than adequate for most servo applications.

The duty cycle of the PWM signal controls the magnitude of the voltage output. This is handled internally by the PMAC, the user needs not to change any settings. However, the frequency of the PWM signal determines the output resolution and ripple magnitude (disturbance). The trade-off is as follows:

PWM Frequency ↑ Resolution ↓ Ripple ↓

The higher the PWM frequency, the lower is the resolution with a low-ripple signal output.
The lower the PWM frequency, the higher is the resolution with a high-ripple signal output.

Note

Some amplifiers operate in the ±5V range; this can be regulated using the motor command output limit, parameter **Motor[x].MaxDac**.

Both the resolution and the frequency of the Filtered PWM outputs are configured in software on the Power PMAC Clipper through **Clipper[0].PhaseFreq** and each channel's **Clipper[0].Chan[j].PwmFreqMult**. The **Clipper[0].PhaseFreq** also effects the servo interrupts. Therefore as **Clipper[0].PhaseFreq** is changed the **Clipper[0].ServoClockDiv** (servo clock divider), and **Sys.ServoPeriod** (servo interrupt time) will change. These four structures are all related and must be understood before adjusting parameters. The detailed information for these parameters can be found in the Power PMAC Software Reference Manual.

Clock Settings, Output Mode, Command Limit

The clock settings in this mode allowing a good compromise are a 30 KHz PWM Frequency, 10 KHz Phase, and 2.25 KHZ Servo.

```
Sys.WpKey=$AAAAAAAA
                                    // Clocks - Phase and Servo
Clipper[0].PhaseFreq=10000;         // 10KHz Phase
Clipper[0].PhaseClockDiv=0;
Clipper[0].ServoClockDiv=3;         // 2.25KHz Servo
Clipper[0].AdcAmpStrobe=$fffffc
Sys.PhaseOverServoPeriod=1/(Clipper[0].ServoClockDiv+1)
Sys.ServoPeriod=1000*(Clipper[0].ServoClockDiv+1)/Clipper[0].PhaseFreq

                                    // PWM setup
Clipper[0].Chan[0].PwmDeadTime=0;
Clipper[0].Chan[0].PackOutData=0;
Clipper[0].Chan[0].PackInData=0;
Clipper[0].Chan[0].PwmFreqMult=5;   // 30KHz PWM
```

Typical Motor Specific Settings

Power Clipper's DAC pointer must be Pwm[2] for each channel.

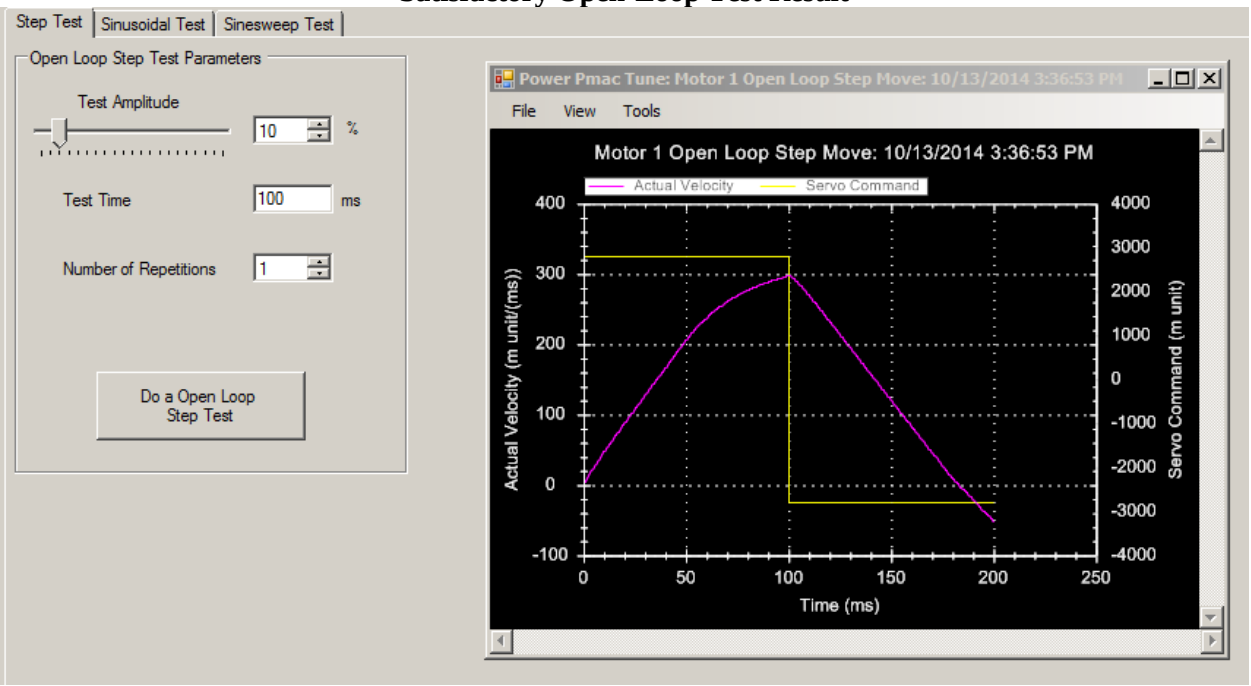
```
Motor[1].ServoCtrl=1
Motor[1].pDac=Gate3[0].Chan[0].Pwm[2].a
Motor[1].pEncStatus=Gate3[0].Chan[0].Status.a
Motor[1].pAmpEnable=Gate3[0].Chan[0].OutCtrl.a
Motor[1].pAmpFault=Gate3[0].Chan[0].Status.a
```

```
Motor[1].pLimits=Gate3[0].Chan[0].Status.a            //--USER ADJUSTABLE =0 for no flags wired
Motor[1].AmpFaultLevel=0                              //--USER ADJUSTABLE
Motor[1].MaxDac=16384
```

Open Loop Test: Encoder/Decode

The open-loop test is critical to verify the direction sense of the encoder counting versus the command output. A positive command should create a positive velocity and a position counting in the positive direction; a negative command should create a negative velocity and a position counting in the negative direction. The Open Loop test utility in the IDEs "Tune" tool can be used to execute and open loop test. It can also be carried manually from the terminal window while gathering position, velocity data or simply monitoring the motor velocity in the position window.

Satisfactory Open-Loop Test Result



The open-loop test is usually performed on an unloaded motor. The open loop command output is adjustable, start off with a conservative 1 to 2 percent command output (i.e. #1Out2) value and increment gradually until you see a satisfactory result.

If the failure persists (inverted saw tooth, as shown in the plot), or you observe oscillations in the response instead of a saw tooth, then most likely the direction sense of the encoder is opposite to the command output.

General recommendation for troubleshooting an unsuccessful open loop test
An inverted saw tooth response, most times, indicates that the direction sense of the encoder is opposite to that of the command output.

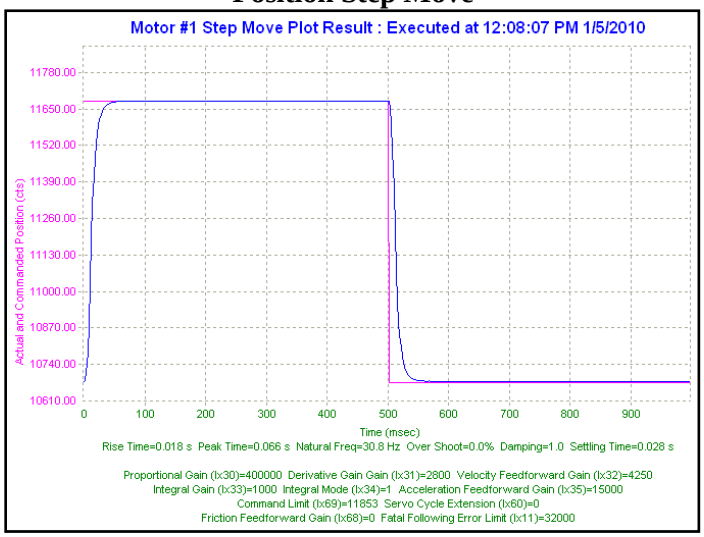
- Quadrature | Sinusoidal:
  Change **Clipper[0].Chan[j].EncCtrl** to 3 from 7 (default) or vice-versa.
- Absolute Serial Encoders (EnDat, SSI, BiSS, Yaskawa, Panasonic, Tamagawa, Mitutoyo):

The Power PMAC Clipper has no control on the direction sense of the serial data stream (packets). There are no software parameters that allow changing the direction sense of absolute serial encoders. Normally, it is set by jumpers or software at the encoder side.
Some amplifiers allow swapping the DAC+ and DAC- signal to invert the direction travel of the motor. Otherwise, two of the motor leads have to be swapped.
If the motor/axis direction does not comply now with the machine design then negative jog commands can be issued for positive motion, and vice versa. Similarly, for motion programs, the motor can then assigned to a negative axis definition.

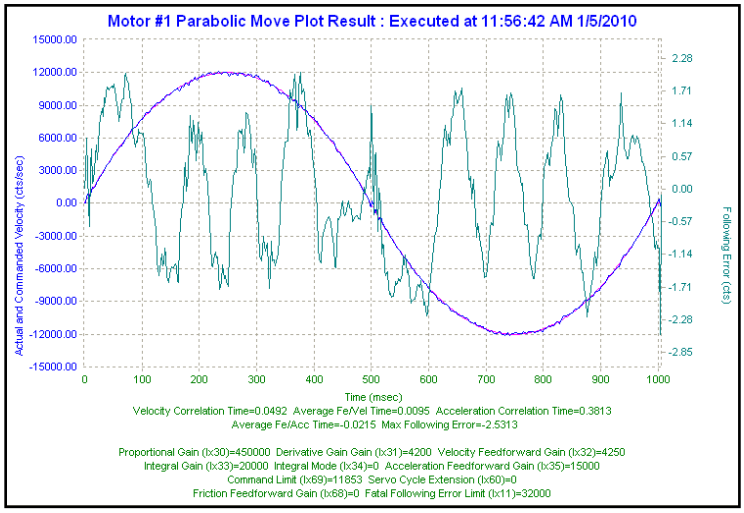
Position-Loop PID Gains

The position-loop tuning is done as in any Power PMAC PID-Loop setup. The IDEs "Tune" tool automatic or interactive utility can be used to fine-tune the PID-Loop. Satisfactory Step and Parabolic move responses would look like:

Position Step Move



Position Parabolic Move



Note

At this point of the setup, the motor(s) is ready to accept Jog commands.

Typical Settings for Four Channels of Filtered PWM Setup:

```
Sys.WpKey=$AAAAAAAA
                                    // Clocks - Phase and Servo
Clipper[0].PhaseFreq=10000;         // 10KHz Phase
Clipper[0].PhaseClockDiv=0;
Clipper[0].ServoClockDiv=3;         // 2.25KHz Servo
Clipper[0].AdcAmpStrobe=$fffffc;
Sys.PhaseOverServoPeriod=1/(Clipper[0].ServoClockDiv+1)
Sys.ServoPeriod=1000*(Clipper[0].ServoClockDiv+1)/Clipper[0].PhaseFreq

                                    // PWM setup
Clipper[0].Chan[0].PwmDeadTime=0;
Clipper[0].Chan[0].PackOutData=0;
Clipper[0].Chan[0].PackInData=0;
Clipper[0].Chan[0].PwmFreqMult=5;   // 30KHz PWM

Clipper[0].Chan[1].PwmDeadTime=0;
Clipper[0].Chan[1].PackOutData=0;
Clipper[0].Chan[1].PackInData=0;
Clipper[0].Chan[1].PwmFreqMult=5;

Clipper[0].Chan[2].PwmDeadTime=0;
Clipper[0].Chan[2].PackOutData=0;
Clipper[0].Chan[2].PackInData=0;
Clipper[0].Chan[2].PwmFreqMult=5;

Clipper[0].Chan[3].PwmDeadTime=0;
Clipper[0].Chan[3].PackOutData=0;
Clipper[0].Chan[3].PackInData=0;
Clipper[0].Chan[3].PwmFreqMult=5;

                                    // Motor and PID Setup
//************** Motor1
Motor[1].ServoCtrl=1;
Motor[1].pDac=Clipper[0].Chan[0].Pwm[2].a;
Motor[1].pEncStatus=Clipper[0].Chan[0].Status.a;
Motor[1].pAmpEnable=Clipper[0].Chan[0].OutCtrl.a;
Motor[1].pAmpFault=Clipper[0].Chan[0].Status.a;
Motor[1].pLimits=Clipper[0].Chan[0].Status.a
Motor[1].AmpFaultLevel=1
Motor[1].MaxDac=16384

//< PID & Safety >
Motor[1].Servo.Kp=51.702454;
Motor[1].Servo.Kvfb=1438.4297;
Motor[1].Servo.Ki=0.0099164471;
Motor[1].Servo.Kvff=1438.4297;
Motor[1].Servo.Kaff=19470.463;
Motor[1].Servo.Kvifb=0;
Motor[1].Servo.Kviff=0;
Motor[1].Servo.Kfff=0;
Motor[1].FatalFeLimit=20000;
Motor[1].MaxSpeed=2048;
Motor[1].InvAmax=20;
Motor[1].JogTa=50;
Motor[1].JogTs=20;
Motor[1].JogSpeed=102.4;
Motor[1].Servo.MaxPosErr=100000

//************** Motor2
```

```
Motor[2].ServoCtrl=1;
Motor[2].pDac=Clipper[0].Chan[1].Pwm[2].a;
Motor[2].pEncStatus=Clipper[0].Chan[1].Status.a;
Motor[2].pAmpEnable=Clipper[0].Chan[1].OutCtrl.a;
Motor[2].pAmpFault=Clipper[0].Chan[1].Status.a;
Motor[2].pLimits=Clipper[0].Chan[1].Status.a
Motor[2].AmpFaultLevel=1
Motor[2].MaxDac=16384

//< PID & Safety >
Motor[2].Servo.Kp=51.702454;
Motor[2].Servo.Kvfb=1438.4297;
Motor[2].Servo.Ki=0.0099164471;
Motor[2].Servo.Kvff=1438.4297;
Motor[2].Servo.Kaff=19470.463;
Motor[2].Servo.Kvifb=0;
Motor[2].Servo.Kviff=0;
Motor[2].Servo.Kfff=0;
Motor[2].FatalFeLimit=20000;
Motor[2].MaxSpeed=2048;
Motor[2].InvAmax=20;
Motor[2].JogTa=50;
Motor[2].JogTs=20;
Motor[2].JogSpeed=102.4;
Motor[2].Servo.MaxPosErr=100000

//************** Motor3
Motor[3].ServoCtrl=1;
Motor[3].pDac=Clipper[0].Chan[2].Pwm[2].a;
Motor[3].pEncStatus=Clipper[0].Chan[2].Status.a;
Motor[3].pAmpEnable=Clipper[0].Chan[2].OutCtrl.a;
Motor[3].pAmpFault=Clipper[0].Chan[2].Status.a;
Motor[3].pLimits=Clipper[0].Chan[2].Status.a
Motor[3].AmpFaultLevel=1
Motor[3].MaxDac=16384

//< PID & Safety >
Motor[3].Servo.Kp=51.702454;
Motor[3].Servo.Kvfb=1438.4297;
Motor[3].Servo.Ki=0.0099164471;
Motor[3].Servo.Kvff=1438.4297;
Motor[3].Servo.Kaff=19470.463;
Motor[3].Servo.Kvifb=0;
Motor[3].Servo.Kviff=0;
Motor[3].Servo.Kfff=0;
Motor[3].FatalFeLimit=20000;
Motor[3].MaxSpeed=2048;
Motor[3].InvAmax=20;
Motor[3].JogTa=50;
Motor[3].JogTs=20;
Motor[3].JogSpeed=102.4;
Motor[3].Servo.MaxPosErr=100000

//************** Motor4
Motor[4].ServoCtrl=1;
Motor[4].pDac=Clipper[0].Chan[3].Pwm[2].a;
Motor[4].pEncStatus=Clipper[0].Chan[3].Status.a;
Motor[4].pAmpEnable=Clipper[0].Chan[3].OutCtrl.a;
Motor[4].pAmpFault=Clipper[0].Chan[3].Status.a;
Motor[4].pLimits=Clipper[0].Chan[3].Status.a
Motor[4].AmpFaultLevel=1
Motor[4].MaxDac=16384

//< PID & Safety >
Motor[4].Servo.Kp=51.702454;
Motor[4].Servo.Kvfb=1438.4297;
Motor[4].Servo.Ki=0.0099164471;
Motor[4].Servo.Kvff=1438.4297;
Motor[4].Servo.Kaff=19470.463;
Motor[4].Servo.Kvifb=0;
Motor[4].Servo.Kviff=0;
```

```
Motor[4].Servo.Kfff=0;
Motor[4].FatalFeLimit=20000;
Motor[4].MaxSpeed=2048;
Motor[4].InvAmax=20;
Motor[4].JogTa=50;
Motor[4].JogTs=20;
Motor[4].JogSpeed=102.4;
Motor[4].Servo.MaxPosErr=100000
```

Pulse Frequency Modulation Output (Step and Direction)

The Power Clipper has the capability of generating Pulse Frequency Modulation (Step and Direction) output signals for control of external devices such as stepper amplifiers. The maximum pulse frequency and minimum pulse width are typically provided by the third party device manufacturer.

The step and direction outputs are RS422 compatible, +5V level, and could be connected in either differential or single-ended configuration.

There are several methods that can be implemented for the setup of stepper motors. This document will describe open loop stepper setup only. For other method details refer to the Power PMAC User Manual.

Multi-Channel Setup Elements

PFM Clock Frequency: Clipper[0].PfmClockDiv
This divides down the master 100MHz clock to set the frequency of the internal PFM clock. This clock puts an upper and lower limit on the PFM output (1/4 - 1/8,000,000 of the internal PFM clock). The default frequency of approximately 3.125 MHz can provide a useful range of about 1 Hz to 400 KHz and should be sufficient for most users. The default is 5.

Encoder Sample clock Frequency: Clipper[0].EncClockDiv
This divides down the master 100MHz clock to set the frequency of the encoder sample clock. This frequency must be at least as great as the PFM clock frequency. The default frequency of approximately 3.125 MHz is compatible with the default PFM clock. The default is 5.

Channel-Specific Setup Elements

PFM Pulse Width: Clipper[0].Chan[j].PfmWidth
This controls the pulse width of the PFM output in PFM clock cycles with a range of 1 to 4095. Note there is no minimum gap between pulses. Pulses are generated faster than the previous pulses end will result in a continuously "on" state. The default is 15. This may be stepper drive dependent and can be calculated as follows:

Clipper[0].Chan[j].PfmWidth = PFM _CLK _ Freq(MHz)*PFM _ Pulse _Width(μsec) - 1

Output Mode Control: Clipper[0].Chan[j].OutputMode
This controls the output mode of the channel's Phases A, B, C & D. It must be set to 8 or higher to output PFM on Phase D.

Data Packing Control: Clipper[0].Chan[j].PackOutData
This must be set to 0 to disable packing so only the PFM command is written into Phase D.

Output Inversion Control: Clipper[0].Chan[j].OutputPol
This controls whether the pulse signals are inverted or not. A value of 0 or 1 means the PFM pulse is high-true; a value of 2 or 3 means that it is low true. This may be stepper drive dependent. The default is 0.

PFM Direction Inversion Control: Clipper[0].Chan[j].PfmDirPol

This controls the polarity of the PFM direction signal alone (it does not affect the pulse signal). A value of 0 means positive direction is low; a value of 1 means the negative direction is low. This may be stepper drive dependent. The default is 0.
Encoder Decode Control: Clipper[0].Chan[j].EncCtrl
Clipper[0].Chan[j].TimerMode
Clipper[0].Chan[j].TimerMode is set to 3 to feed back the internally generated PFM signal to the Clipper[0].Chan[j].TimerA register each servo cycle. This is in units of whole counts, with no fractional-count estimation (low 8 bits always zero). The "TimerA" register will be used in the ECT for feedback processing. If Clipper[0].Chan[j].EncCtrl is set to 3 or 7 this will allow the use of a "real" encoder for verification on the same channel.

Motor-Specific Setup Elements

Phase Task Control: Motor[x].PhaseCtrl
For pulse-and-direction control, bit 0 (value 1), bit 2 (value 4) and bit 3 (value 8) should be set to zero making the value of the entire element equal to 0.

Command Output Address: Motor[x].pDac
To use the PFM output register for the motor's servo output, Motor[x].pDac must be set to Clipper[0].Chan[j].Pfm.a.

Encoder Conversion Table Processing: EncTable[n]
The counter value used for feedback must be processed by the encoder conversion table (ECT). To get the pulse-count value from the "timer" register (no sub-count extension) select "Type 1" conversion (single-register read).
In the IDE menu specify the source register as the TimerA register for the channel using 32 bits starting at bit 0. With the low 8 bits always being zero a 1/256 multiplier is used. If setting up the entry manually, the following settings should be made (with the appropriate numerical indices):
EncTable[n].Type = 1
EncTable[n].pEnc = Clipper[0].Chan[j].TimerA.a
EncTable[n].index1 = 0
EncTable[n].index2 = 0
EncTable[n].index3 = 0
EncTable[n].MaxDelta = 0
EncTable[n].ScaleFactor = 1/256

Feedback Addresses: Motor[x].pEnc, Motor[x].pEnc2
These specifie what registers the motor reads for its outer (position) and inner (velocity) loop feedback. This will be the result from the encoder conversion table entry above and both are the same as in:
Motor[x].pEnc = EncTable[n].a.
Motor[x].pEnc2 = EncTable[n].a.

Parameters to Set Up Motor Servo Gains
For open loop stepper setup the following values provide a responsive and stable performance at the default servo update frequency for a motor scaled in units of pulses (counts):
Motor[x].Servo.Kp = 40
Motor[x].Servo.Kvfb = 0
Motor[x].Servo.Kvff = 40
Motor[x].Servo.Ki = 0.001

Command end positions can result with fractional-count components but the system can only resolve full count (pulse) values at rest. It is strongly advised to implement one count of true deadband to prevent dithering at rest with the following settings:
Motor[x].Servo.BreakPosErr = 1.0 // For motor scaled in counts (pulses)
Motor[x].Servo.Kbreak = 0 // Zero gain inside deadband zone

If a real feedback sensor is used, the motor's servo loop will be tuned as a velocity mode servo. This will not be covered here please refer to the Power PMAC User Manual for details of this procedure.

Typical Settings for Four Channels of Open Loop PFM Setup:

```
Sys.WpKey=$AAAAAAAA
                                    //Global Clock Settings
Clipper[0].PhaseFreq=9035.69;
Clipper[0].PhaseClockDiv=0;
Clipper[0].ServoClockDiv=3;
Clipper[0].AdcAmpStrobe=$ffffc;
Clipper[0].PfmClockDiv=5
Clipper[0].EncClockDiv=5
Sys.PhaseOverServoPeriod=1/(Clipper[0].ServoClockDiv+1)
Sys.ServoPeriod=1000*(Clipper[0].ServoClockDiv+1)/Clipper[0].PhaseFreq

                                    //Channel PFM Hardware Settings
Clipper[0].Chan[0].PfmWidth=15    //May be stepper drive specific
Clipper[0].Chan[0].OutputMode=8
Clipper[0].Chan[0].PackOutData=0
Clipper[0].Chan[0].OutputPol=0    //May be stepper drive specific
Clipper[0].Chan[0].PfmDirPol=0    //May be stepper drive specific
Clipper[0].Chan[0].TimerMode=3

Clipper[0].Chan[1].PfmWidth=15
Clipper[0].Chan[1].OutputMode=8
Clipper[0].Chan[1].PackOutData=0
Clipper[0].Chan[1].OutputPol=0
Clipper[0].Chan[1].PfmDirPol=0
Clipper[0].Chan[1].TimerMode=3

Clipper[0].Chan[2].PfmWidth=15
Clipper[0].Chan[2].OutputMode=8
Clipper[0].Chan[2].PackOutData=0
Clipper[0].Chan[2].OutputPol=0
Clipper[0].Chan[2].PfmDirPol=0
Clipper[0].Chan[2].TimerMode=3

Clipper[0].Chan[3].PfmWidth=15
Clipper[0].Chan[3].OutputMode=8
Clipper[0].Chan[3].PackOutData=0
Clipper[0].Chan[3].OutputPol=0
Clipper[0].Chan[3].PfmDirPol=0
Clipper[0].Chan[3].TimerMode=3
                                        //Motor Control
Motor[1].PhaseCtrl=0
Motor[1].ServoCtrl=1
Motor[1].pDac=Clipper[0].Chan[0].Pfm.a
Motor[1].pAmpFault=0                    //May be stepper drive specific
Motor[1].pAmpEnable=0                   //May be stepper drive specific

Motor[2].PhaseCtrl=0
Motor[2].ServoCtrl=1
Motor[2].pDac=Clipper[0].Chan[1].Pfm.a
Motor[2].pAmpFault=0                    //May be stepper drive specific
Motor[2].pAmpEnable=0                   //May be stepper drive specific

Motor[3].PhaseCtrl=0
Motor[3].ServoCtrl=1
Motor[3].pDac=Clipper[0].Chan[2].Pfm.a
Motor[3].pAmpFault=0                    //May be stepper drive specific
```

```
Motor[3].pAmpEnable=0                  //May be stepper drive specific

Motor[4].PhaseCtrl=0
Motor[4].ServoCtrl=1
Motor[4].pDac=Clipper[0].Chan[3].Pfm.a
Motor[4].pAmpFault=0                   //May be stepper drive specific
Motor[4].pAmpEnable=0                  //May be stepper drive specific

                                       //Encoder Conversion Table
EncTable[1].Type = 1
EncTable[1].pEnc =  Clipper[0].Chan[0].TimerA.a
EncTable[1].index1 =  0
EncTable[1].index2 = 0
EncTable[1].index3 =  0
EncTable[1].MaxDelta =  0
EncTable[1].ScaleFactor = 1/256
Motor[1].pEnc = EncTable[1].a
Motor[1].pEnc2 = EncTable[1].a

EncTable[2].Type = 1
EncTable[2].pEnc =  Clipper[0].Chan[1].TimerA.a
EncTable[2].index1 =  0
EncTable[2].index2 = 0
EncTable[2].index3 =  0
EncTable[2].MaxDelta =  0
EncTable[2].ScaleFactor = 1/256
Motor[2].pEnc = EncTable[2].a
Motor[2].pEnc2 = EncTable[2].a

EncTable[3].Type = 1
EncTable[3].pEnc =  Clipper[0].Chan[2].TimerA.a
EncTable[3].index1 =  0
EncTable[3].index2 = 0
EncTable[3].index3 =  0
EncTable[3].MaxDelta =  0
EncTable[3].ScaleFactor = 1/256
Motor[3].pEnc = EncTable[3].a
Motor[3].pEnc2 = EncTable[3].a

EncTable[4].Type = 1
EncTable[4].pEnc =  Clipper[0].Chan[3].TimerA.a
EncTable[4].index1 =  0
EncTable[4].index2 = 0
EncTable[4].index3 =  0
EncTable[4].MaxDelta =  0
EncTable[4].ScaleFactor = 1/256
Motor[4].pEnc = EncTable[4].a
Motor[4].pEnc2 = EncTable[4].a
                                       //Motor Gains
Motor[1].Servo.Kp = 40
Motor[1].Servo.Kvfb = 0
Motor[1].Servo.Kvff = 40
Motor[1].Servo.Ki = 0.001
Motor[1].Servo.BreakPosErr = 1
Motor[1].Servo.Kbreak = 0

Motor[2].Servo.Kp = 40
Motor[2].Servo.Kvfb = 0
Motor[2].Servo.Kvff = 40
Motor[2].Servo.Ki = 0.001
Motor[2].Servo.BreakPosErr = 1
Motor[2].Servo.Kbreak = 0

Motor[3].Servo.Kp = 40
Motor[3].Servo.Kvfb = 0
Motor[3].Servo.Kvff = 40
Motor[3].Servo.Ki = 0.001
Motor[3].Servo.BreakPosErr = 1
Motor[3].Servo.Kbreak = 0

Motor[4].Servo.Kp = 40
```

```
Motor[4].Servo.Kvfb = 0
Motor[4].Servo.Kvff = 40
Motor[4].Servo.Ki = 0.001
Motor[4].Servo.BreakPosErr = 1
Motor[4].Servo.Kbreak = 0
```

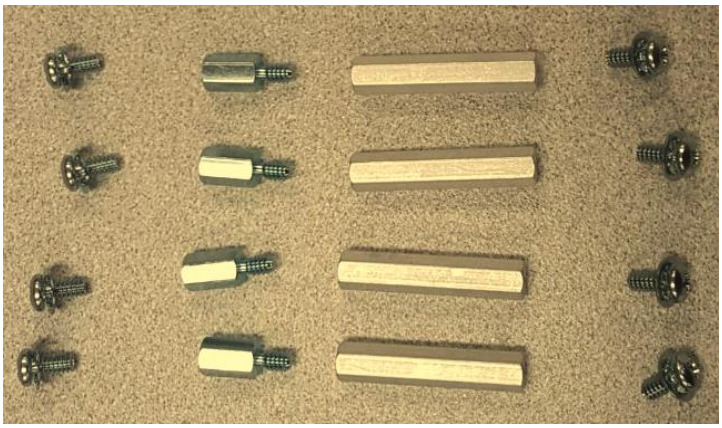
ACC-24S3 4-CHANNEL AXIS EXPANSION STACK BOARD

The ACC-24S3 provides an additional 4 channels of servo interface circuitry, 32 additional digital I/O and the option for 4 additional 12-bit ADCs and 1 filtered-PWM analog output. The setup of the axis expansion is virtually the same as the Power PMAC Clipper base board with the exception that "Clipper[0]" references are replaced with "Clipper[1]", the activation and addition of new motors (5-8) and pointers and different addresses for the direct addressed ADCs and the ECT setup. These differences will be detailed in the following sections. Code for the complete configuration of four motors (5-8 both filtered PWM and stepper) is included in the final section of this chapter "Motor Setup Code".

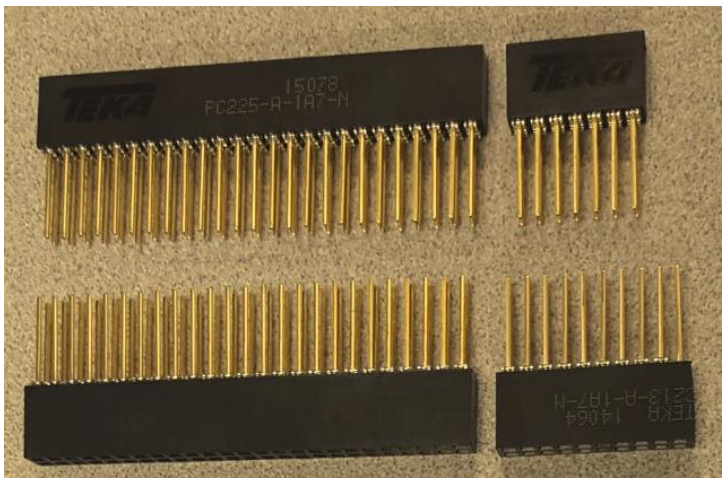
Hardware Assembly

All power is through the JEXPx connectors – no other power connections are needed. The supplied JEXPx extension connectors and standoff hardware are used to mount the ACC-24S3 to the Power Clipper.

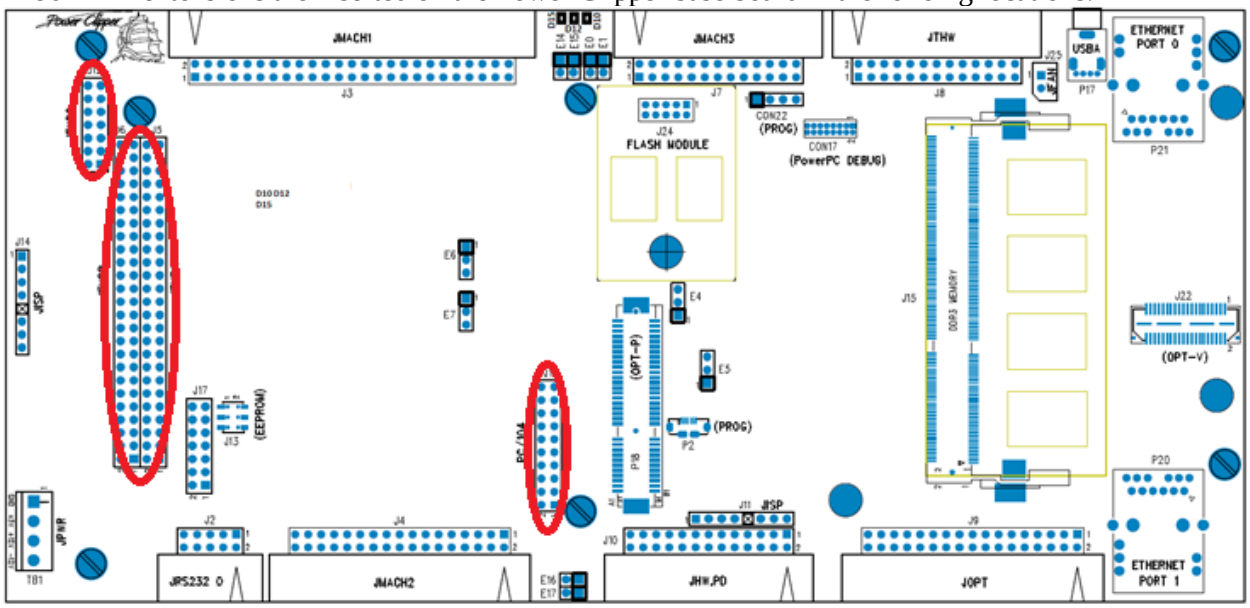
There are four sets of standoff hardware:



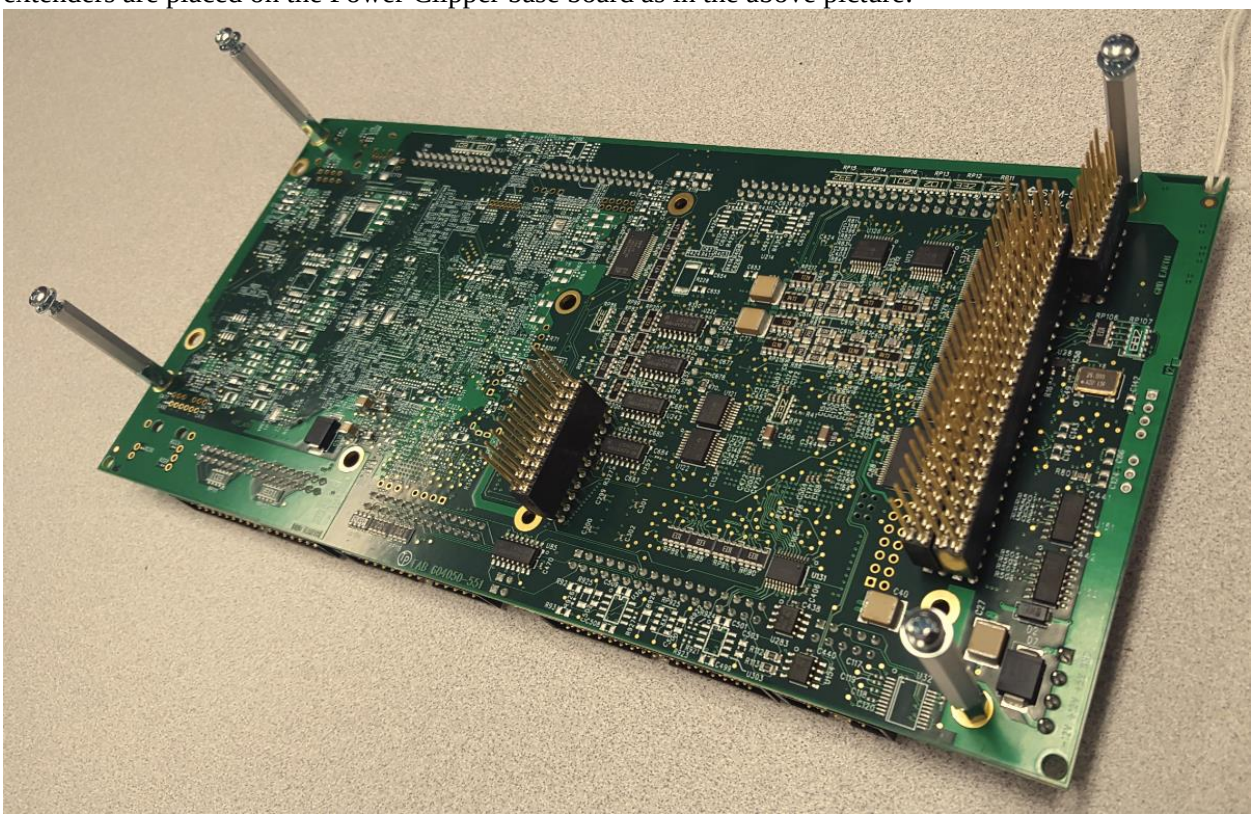
There are also four JEXPx extension connectors:



The JEXPx extensions are inserted on the Power Clipper base board in the folloing locations:



The stanoff hardware and the will fit onto the ACC-24S3 as in the following picture (although the JEXPx extenders are placed on the Power Clipper base board as in the above picture:



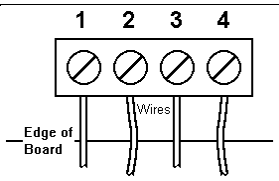
Default Jumper Configurations

The following table shows the default jumper configurations:

Jumper	Position Description	Note
E0	Not currently used	Not Installed
E1	Not currently used	Not Installed
E4	Not currently used	Not Installed
E5	Not currently used	Not Installed
E6	Selection between handwheel input or serial encoder input on Gate3[i].Chan[0].SerialEncDataA 1-2 FOR SENC1 2-3 ENC-HW-1	Default 1-2
E7	Selection between handwheel input or serial encoder input on Gate3[i].Chan[1].SerialEncDataA 1-2 FOR SENC2 2-3 ENC-HW-2	Default 1-2
E14	Install to make GPIO 0-7 lines inputs Remove jumper to make GPIO 0-7 lines outputs	Installed (Required for MuxIO)
E15	Install to make GPIO 8-15 lines inputs Remove jumper to make GPIO 8-15lines outputs	Not Installed (Required for MuxIO)
E16	Install to make GPIO 16-23 lines inputs Remove jumper to make GPIO 16-23 lines outputs	Not Installed
E17	Install to make GPIO 24-31 lines inputs Remove jumper to make GPIO 24-31 lines outputs	Installed

TB1 (JPWR): Power Supply Input

This 4-pin terminal block is used to bring the 5VDC logic power and +/-12VDC DAC supply into the ACC-24S3 and Power PMAC Clipper stack. The power connector on the base board may be used instead but not both simultaneously as this could lead to ground loop wiring.

TB1 (JPWR): Power Supply 4-Pin Terminal Block				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	GND	Common	Digital Common	
2	+5V	Input	Logic Voltage	Supplies all PMAC digital circuits
3	+12V	Input	DAC Supply Voltage	Ref to Digital GND
4	-12V	Input	DAC Supply Voltage	Ref to Digital GND

Note

For +5V and GND, 18 gauge (AWG) stranded wire is recommended. For +12V and -12V, a minimum of 22 gauge (AWG) stranded wire is recommended.

J3: Machine Connector (JMACH1 Port)

The primary machine interface connector is JMACH1, labeled J3 on the ACC-24S3, contains the pins for: analog outputs, incremental encoder inputs, amplifier fault and enable signals and power-supply connections. Use the same hardware wiring setup as the base Power PMAC Clipper board.

Configuring Quadrature Encoders

Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])
- Motors 5-8 are used (or motors other than used on the base board)
- ECT entries 5-8 are used (or entries other than used on the base board)

The default ECT settings for the first incremental quadrature encoder (typically motor 5) will be:

```
EncTable[5].type = 1;                                   // Single 32-bit read
EncTable[5].pEnc = Clipper[1].Chan[0].ServoCapt.a;      // Primary source, ch 1 Servo Capture
EncTable[5].pEnc1 = Sys.Pushm;                          // Secondary source, none
EncTable[5].index1 = 0;                                 // left shift, none
EncTable[5].index2 = 0;                                 // right shift, none
EncTable[5].index3 = 0;                                 //
EncTable[5].index4 = 0;                                 //
EncTable[5].ScaleFactor = 1/256;                        // Scale Factor, LSB location
```

Channel Number	Quadrature Encoder Source Address
5	Clipper[1].Chan[0].ServoCapt.a
6	Clipper[1].Chan[1].ServoCapt.a
7	Clipper[1].Chan[2].ServoCapt.a
8	Clipper[1].Chan[3].ServoCapt.a

Activating the corresponding channel is sufficient to display counts in the position window when the motor / encoder shaft is moved by hand.

```
Motor[5].ServoCtrl = 1;          // Channel activation
```

The position and velocity source(s) must be pointing to the proper ECT result. With quadrature encoders, they are initialized by the firmware as:

```
Motor[5].pEnc = EncTable[5].a;  // Position
Motor[5].pEnc2 = EncTable[5].a; // Velocity
Motor[6].pEnc = EncTable[6].a;  // Position
Motor[6].pEnc2 = EncTable[6].a; // Velocity
Motor[7].pEnc = EncTable[7].a;  // Position
Motor[7].pEnc2 = EncTable[7].a; // Velocity
Motor[8].pEnc = EncTable[8].a;  // Position
Motor[8].pEnc2 = EncTable[8].a; // Velocity
```

Wiring the DAC Output

Use the same hardware wiring setup as the base Power PMAC Clipper board.

Amplifier Enable Signal (AENAn/DIRn)

Use the same hardware wiring setup as the base Power PMAC Clipper board.

Amplifier Fault Signal (FAULT-)

Use the same hardware wiring setup as the base Power PMAC Clipper board.

Analog Inputs

Use the same hardware wiring setup as the base Power PMAC Clipper board.

Setting up the Analog (ADC) Inputs

Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1
- Direct address is different
- Program nomenclature enumeration should be 5-8

ADCIN_n/ Connector	Structure	Address
ADCIN_5, J3	Clipper[1].Chan[0].AdcEnc[0]	$904030
ADCIN_6, J3	Clipper[1].Chan[0].AdcEnc[1]	$904034
ADCIN_7, J7	Clipper[1].Chan[0].AdcEnc[2]	$904038
ADCIN_8, J7	Clipper[1].Chan[0].AdcEnc[3]	$90403C

Raw ADC Data (in bits)

```
Sys.WpKey = $AAAAAAAA;                  // Disable Write-Protection
Clipper[1].Chan[0].PackInData = 0;      // Unpack Input Data all ADCs J3, J7

PTR ADCIN_5->S.IO:$904030.20.12;       // ADCIN_5 J3 [bits]
PTR ADCIN_6->S.IO:$904034.20.12;       // ADCIN_6 J3 [bits]
PTR ADCIN_7->S.IO:$904038.20.12;       // ADCIN_7 J7 [bits]
PTR ADCIN_8->S.IO:$90403C.20.12;       // ADCIN_8 J7 [bits]
```

Alternately use of bit shifting in PLC and Program with the structure, **Clipper[1].Chan[0].AdcEnc[n]**, as in:

Bit shifting example

```
                            // This method is most efficient and uses the least PMAC resources
GLOBAL MyAnalog1 = 0;       // Global variable for shifted analog value initialized to zero

OPEN PLC ExamplePLC
. . .
MyAnalog5 = Clipper[1].Chan[0].AdcEnc[0] >> 20; // shift right by 20 bits before assignment
. . .
CLOSE
```

Scaled ADC Data (in volts)

```
GLOBAL ADC5VoltsIn = 0;                  // Voltage input, ADCIN_5
GLOBAL ADC6VoltsIn = 0;                  // Voltage input, ADCIN_6
GLOBAL ADC7VoltsIn = 0;                  // Voltage input, ADCIN_7
GLOBAL ADC8VoltsIn = 0;                  // Voltage input, ADCIN_8

GLOBAL ADC5ZeroOffset = 0.038;           // Zero Volt Offset5,  [volt] --USER ADJUSTABLE
GLOBAL ADC6ZeroOffset = 0.038;           // Zero Volt Offset6,  [volt] --USER ADJUSTABLE
GLOBAL ADC7ZeroOffset = 0.038;           // Zero Volt Offset7,  [volt] --USER ADJUSTABLE
GLOBAL ADC8ZeroOffset = 0.038;           // Zero Volt Offset8,  [volt] --USER ADJUSTABLE

OPEN PLC PtrExamplePLC
ADC5VoltsIn  = (ADCIN_5  * 10 / 2048) - ADC5ZeroOffset ;
ADC6VoltsIn  = (ADCIN_6  * 10 / 2048) - ADC6ZeroOffset ;
ADC7VoltsIn  = (ADCIN_7  * 10 / 2048) - ADC7ZeroOffset ;
ADC8VoltsIn  = (ADCIN_8  * 10 / 2048) - ADC8ZeroOffset ;
CLOSE

OPEN PLC ShiftExamplePLC                 // More efficient less resources
ADC5VoltsIn  = ((Clipper[1].Chan[0].AdcEnc[0] >> 20) * 10 / 2048) - ADC5ZeroOffset ;
ADC6VoltsIn  = ((Clipper[1].Chan[0].AdcEnc[1] >> 20) * 10 / 2048) - ADC6ZeroOffset ;
ADC7VoltsIn  = ((Clipper[1].Chan[0].AdcEnc[2] >> 20) * 10 / 2048) - ADC7ZeroOffset ;
ADC8VoltsIn  = ((Clipper[1].Chan[0].AdcEnc[3] >> 20) * 10 / 2048) - ADC8ZeroOffset ;
CLOSE
```

Using the ADC for Servo Feedback

Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])
- Motors 5-8 are used (or motors other than used on the base board)
- ECT entries 5-8 are used (or entries other than used on the base board)

```
EncTable[5].pEnc = Clipper[0].Chan[0].AdcEnc[0].a;
EncTable[5].pEnc1 = Sys.pushm;
EncTable[5].index1 = 20;
EncTable[5].index2 = 20;
EncTable[5].index3 = 0;
EncTable[5].index4 = 0;
EncTable[5].index5 = 0;
EncTable[5].ScaleFactor = 1 / EXP2(20);

Motor[5].pEnc = EncTable[5].a;
Motor[5].pEnc2 = EncTable[5].a;
```

J4: Machine Connector (JMACH2 Port)

This machine interface connector is labeled JMACH2 or J4 on the ACC-24S3 contains pins for four channels of machine I/O: end-of-travel input flags, home flag and pulse-and-direction output signals. In addition, the B_WDO output allows monitoring the state of the Watchdog safety feature. Use the same hardware wiring setup as the base Power PMAC Clipper board. Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])

Limits and Flags [Axis 1- 4] Structure Elements

Either the user flags or other unassigned axis flags on the base board can be used as general-purpose I/O providing up to 20 inputs and 4 outputs at 5-24Vdc levels. The indicated Structure Elements allow accessing each particular line as shown below:

```
Clipper[1].Chan[0].AmpEna             ; AENA1 output status
Clipper[1].Chan[0].UserFlag           ; User 1 flag input status
Clipper[1].Chan[0].HomeFlag           ; Home flag 1 input status
Clipper[1].Chan[0].PlusLimit          ; Positive Limit 1 flag input status
Clipper[1].Chan[0].MinusLimit         ; Negative Limit 1 flag input status

Clipper[1].Chan[1].AmpEna             ; AENA2 output status
Clipper[1].Chan[1].UserFlag           ; User 2 flag input status
Clipper[1].Chan[1].HomeFlag           ; Home flag 2 input status
Clipper[1].Chan[1].PlusLimit          ; Positive Limit 2 flag input status
Clipper[1].Chan[1].MinusLimit         ; Negative Limit 2 flag input status

Clipper[1].Chan[2].AmpEna             ; AENA3 output status
Clipper[1].Chan[2].UserFlag           ; User 3 flag input status
Clipper[1].Chan[2].HomeFlag           ; Home flag 3 input status
Clipper[1].Chan[2].PlusLimit          ; Positive Limit 3 flag input status
Clipper[1].Chan[2].MinusLimit         ; Negative Limit 3 flag input status

Clipper[1].Chan[3].AmpEna             ; AENA4 output status
Clipper[1].Chan[3].UserFlag           ; User 4 flag input status
Clipper[1].Chan[3].HomeFlag           ; Home flag 4 input status
Clipper[1].Chan[3].PlusLimit          ; Positive Limit 4 flag input status
Clipper[1].Chan[3].MinusLimit         ; Negative Limit 4 flag input status
```

Step and Direction PFM Output (To External Stepper Amplifier)

The ACC-24S3 has the capability of generating step and direction (Pulse Frequency Modulation) output signals to external stepper amplifiers. Use the same hardware wiring setup as the base Power PMAC Clipper board. Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])
- Motors 5-8 are used (or motors other than used on the base board)
- ECT entries 5-8 are used (or entries other than used on the base board)

Compare Equal Outputs

The compare-equals (EQU) outputs have a dedicated use of providing a signal edge when an encoder position reaches a pre-loaded value. This is very useful for scanning and measurement applications. Use the same hardware wiring setup as the base Power PMAC Clipper board. Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])

Instructions for use of these outputs are covered in detail in the Power PMAC User Manual.

```
Clipper[1].Chan[0].EquOut            ; EQU1, ENC1 compare output value
Clipper[1].Chan[1].EquOut            ; EQU2, ENC2 compare output value
Clipper[1].Chan[2].EquOut            ; EQU3, ENC3 compare output value
Clipper[1].Chan[3].EquOut            ; EQU4, ENC4 compare output value
```

J7: Machine Connector (JMACH3 Port)

This machine interface connector is labeled JMACH3 or J7 on the ACC-24S3 contains pins for four channels of Gate3 serial encoders and is shared with the T, U, V, and W flags normally used for hall device commutation with the Clipper Drive stack accessory. Also on this connector are the third and fourth ADC inputs and four channels of brake outputs. Use the same hardware wiring setup as the base Power PMAC Clipper board.

Brake Software Setup

Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])
- Motors 5-8 are used (or motors other than used on the base board)

The following settings are required to synchronize the enabling/disabling of the motor with the brake output signal.

```
Motor[5].pBrakeOut = Clipper[1].Chan[0].OutFlagB.a; //
Motor[5].BrakeOutBit = 9;                           //
Motor[5].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[5].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
Motor[6].pBrakeOut = Clipper[1].Chan[1].OutFlagB.a; //
Motor[6].BrakeOutBit = 9;                           //
Motor[6].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[6].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
Motor[7].pBrakeOut = Clipper[1].Chan[2].OutFlagB.a; //
Motor[7].BrakeOutBit = 9;                           //
Motor[7].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[7].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
Motor[8].pBrakeOut = Clipper[1].Chan[3].OutFlagB.a; //
Motor[8].BrakeOutBit = 9;                           //
Motor[8].BrakeOffDelay = 1;                         // msec, Brake Off Delay --USER INPUT
Motor[8].BrakeOnDelay = 1;                          // msec, Brake On Delay --USER INPUT
```

Serial Encoder Software Setup

Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])
- Motors 5-8 are used (or motors other than used on the base board)
- ECT entries 5-8 are used (or entries other than used on the base board)

J8: Thumbwheel Multiplexer Port (JTHW Port)

Thumbwheel Multiplexer Port on the JTHW connector provides 16 general-purpose inputs or outputs at TTL levels. Use the same hardware wiring setup as the base Power PMAC Clipper board. Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])

Thumbwheel Port Digital Inputs and Outputs

The inputs and outputs on the thumbwheel multiplexer port J8 may be used as discrete, non-multiplexed I/O. In this case, these I/O lines can be accessed through structures:

```
                                        // Inputs
Clipper[1].GpioData[0].0                // DAT0
Clipper[1].GpioData[0].1                // DAT1
Clipper[1].GpioData[0].2                // DAT2
Clipper[1].GpioData[0].3                // DAT3
Clipper[1].GpioData[0].4                // DAT4
Clipper[1].GpioData[0].5                // DAT5
Clipper[1].GpioData[0].6                // DAT6
Clipper[1].GpioData[0].7                // DAT7
Clipper[1].GpioData[0].0.8              // DAT0-7 8 bit byte
                                        // Outputs
Clipper[1].GpioData[0].8                // SEL0
Clipper[1].GpioData[0].9                // SEL1
Clipper[1].GpioData[0].10               // SEL2
Clipper[1].GpioData[0].11               // SEL3
Clipper[1].GpioData[0].12               // SEL4
Clipper[1].GpioData[0].13               // SEL5
Clipper[1].GpioData[0].14               // SEL6
Clipper[1].GpioData[0].15               // SEL7
Clipper[1].GpioData[0].8.8              // SEL0-7 8 bit byte
```

Configuring Multiplexed I/O on the JTHW port

Multiplexed I/O may be used on the ACC-24S3 if it is not currently enabled for use on the Power Clipper base board. Use the same hardware wiring setup as the base Power PMAC Clipper board. Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])

Typical setup for multiplexed I/O control:

```
Sys.WpKey = $AAAAAAAA
MuxIo.Enable=0
MuxIo.pOut = Clipper[1].GpioData[0].a
MuxIo.OutBit = 8
MuxIo.pIn = Clipper[1].GpioData[0].a
MuxIo.InBit = 0
MuxIO.PortA[0].Enable=1;
MuxIO.PortA[0].Dir=0;
MuxIO.PortA[0].AutoParityCheck=0
MuxIO.PortB[0].Enable=1;
MuxIO.PortB[0].Dir=1;
MuxIO.PortB[0].AutoParityCheck=0
MuxIO.ClockPeriod=250;
MuxIO.Enable=1
```

J9: General-Purpose Digital Inputs and Outputs (JOPT Port)

This connector provides 16 general-purpose inputs or outputs at TTL levels. Use the same hardware wiring setup as the base Power PMAC Clipper board. Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])

General Purpose I/O (J6) Structures

The lines on the JOPT general-purpose I/O connector are accessed with the following structures:

```
                                    // Inputs
Clipper[1].GpioData[0].24            // MI1
Clipper[1].GpioData[0].25            // MI2
Clipper[1].GpioData[0].26            // MI3
Clipper[1].GpioData[0].27            // MI4
Clipper[1].GpioData[0].28            // MI5
Clipper[1].GpioData[0].29            // MI6
Clipper[1].GpioData[0].30            // MI7
Clipper[1].GpioData[0].31            // MI8
Clipper[1].GpioData[0].24.8          // Inputs as 8-bit byte
                                    // Outputs
Clipper[1].GpioData[0].16            // MO1
Clipper[1].GpioData[0].17            // MO2
Clipper[1].GpioData[0].18            // MO3
Clipper[1].GpioData[0].19            // MO4
Clipper[1].GpioData[0].20            // MO5
Clipper[1].GpioData[0].21            // MO6
Clipper[1].GpioData[0].22            // MO7
Clipper[1].GpioData[0].23            // MO8
Clipper[1].GpioData[0].16.8          // Outputs as 8-bit byte
```

J10: Handwheel and Pulse/Dir Connector (JHW/PD Port)

JHW/PD port provides two differential Quadrature encoder inputs (HW1 and HW2) and two differential PFM outputs or PWM output pairs. Use the same hardware wiring setup as the base Power PMAC Clipper board.

Handwheel Encoder Software Setup

Use the same software setup as the base Power PMAC Clipper board with the following differences:

- Gate3 index is 1 (Clipper[1])
- Use motors not in current use
- Use ECT entries not in current use
- Direct address pointers for encoder count direction and error are different

```
Sys.WpKey = $AAAAAAAA;

// Typical ECT setup for HW1
Gate3[1].Chan[0].SerialEncEna=0
EncTable[9].Type=1
EncTable[9].pEnc=Gate3[1].Chan[0].SerialEncDataA.a
EncTable[9].pEnc1=sys.pushm
EncTable[9].index1=0
EncTable[9].index2=0
EncTable[9].index3=0
EncTable[9].index4=0
EncTable[9].ScaleFactor=1/256

// Typical ECT setup for HW2
Gate3[1].Chan[1].SerialEncEna=0
EncTable[10].Type=1
EncTable[10].pEnc=Gate3[1].Chan[6].SerialEncDataA.a
EncTable[10].pEnc1=sys.pushm
EncTable[10].index1=0
EncTable[10].index2=0
EncTable[10].index3=0
EncTable[10].index4=0
EncTable[10].ScaleFactor=1/256

// Typical pointers for encoder count direction
PTR CountDirHW1->U.IO:$90405C.11.1
PTR CountDirHW2->U.IO:$9040DC.11.1

// Typical pointers for encoder count error
PTR CountErrHW1->U.IO:$90401C.11.1
PTR CountErrHW2->U.IO:$90409C.11.1
```

Motor Setup Code

Typical Settings for Four Channels of Filtered PWM Setup:

```
Sys.WpKey=$AAAAAAAA
                                    // Clocks - Phase and Servo
Clipper[1].PhaseFreq=10000;         // 10KHz Phase
Clipper[1].PhaseClockDiv=0;
Clipper[1].ServoClockDiv=3;         // 2.25KHz Servo
Clipper[1].AdcAmpStrobe=$ffffc;
Sys.PhaseOverServoPeriod=1/(Clipper[1].ServoClockDiv+1)
Sys.ServoPeriod=1000*(Clipper[1].ServoClockDiv+1)/Clipper[1].PhaseFreq

                                    // PWM setup
Clipper[1].Chan[0].PwmDeadTime=0;
Clipper[1].Chan[0].PackOutData=0;
Clipper[1].Chan[0].PackInData=0;
Clipper[1].Chan[0].PwmFreqMult=5;   // 30KHz PWM

Clipper[1].Chan[1].PwmDeadTime=0;
Clipper[1].Chan[1].PackOutData=0;
Clipper[1].Chan[1].PackInData=0;
Clipper[1].Chan[1].PwmFreqMult=5;

Clipper[1].Chan[2].PwmDeadTime=0;
Clipper[1].Chan[2].PackOutData=0;
Clipper[1].Chan[2].PackInData=0;
Clipper[1].Chan[2].PwmFreqMult=5;

Clipper[1].Chan[3].PwmDeadTime=0;
Clipper[1].Chan[3].PackOutData=0;
Clipper[1].Chan[3].PackInData=0;
Clipper[1].Chan[3].PwmFreqMult=5;

                                    // Motor and PID Setup
//************** Motor1
Motor[5].ServoCtrl=1;
Motor[5].pDac=Clipper[1].Chan[0].Pwm[2].a;
Motor[5].pEncStatus=Clipper[1].Chan[0].Status.a;
Motor[5].pAmpEnable=Clipper[1].Chan[0].OutCtrl.a;
Motor[5].pAmpFault=Clipper[1].Chan[0].Status.a;
Motor[5].pLimits=Clipper[1].Chan[0].Status.a
Motor[5].AmpFaultLevel=1
Motor[5].MaxDac=16384

//< PID & Safety >
Motor[5].Servo.Kp=51.702454;
Motor[5].Servo.Kvfb=1438.4297;
Motor[5].Servo.Ki=0.0099164471;
Motor[5].Servo.Kvff=1438.4297;
Motor[5].Servo.Kaff=19470.463;
Motor[5].Servo.Kvifb=0;
Motor[5].Servo.Kviff=0;
Motor[5].Servo.Kfff=0;
Motor[5].FatalFeLimit=20000;
Motor[5].MaxSpeed=2048;
Motor[5].InvAmax=20;
Motor[5].JogTa=50;
Motor[5].JogTs=20;
Motor[5].JogSpeed=102.4;
Motor[5].Servo.MaxPosErr=100000

//************** Motor2
Motor[6].ServoCtrl=1;
Motor[6].pDac=Clipper[1].Chan[1].Pwm[2].a;
Motor[6].pEncStatus=Clipper[1].Chan[1].Status.a;
Motor[6].pAmpEnable=Clipper[1].Chan[1].OutCtrl.a;
```

```
Motor[6].pAmpFault=Clipper[1].Chan[1].Status.a;
Motor[6].pLimits=Clipper[1].Chan[1].Status.a
Motor[6].AmpFaultLevel=1
Motor[6].MaxDac=16384

//< PID & Safety >
Motor[6].Servo.Kp=51.702454;
Motor[6].Servo.Kvfb=1438.4297;
Motor[6].Servo.Ki=0.0099164471;
Motor[6].Servo.Kvff=1438.4297;
Motor[6].Servo.Kaff=19470.463;
Motor[6].Servo.Kvifb=0;
Motor[6].Servo.Kviff=0;
Motor[6].Servo.Kfff=0;
Motor[6].FatalFeLimit=20000;
Motor[6].MaxSpeed=2048;
Motor[6].InvAmax=20;
Motor[6].JogTa=50;
Motor[6].JogTs=20;
Motor[6].JogSpeed=102.4;
Motor[6].Servo.MaxPosErr=100000

//************** Motor3
Motor[7].ServoCtrl=1;
Motor[7].pDac=Clipper[1].Chan[2].Pwm[2].a;
Motor[7].pEncStatus=Clipper[1].Chan[2].Status.a;
Motor[7].pAmpEnable=Clipper[1].Chan[2].OutCtrl.a;
Motor[7].pAmpFault=Clipper[1].Chan[2].Status.a;
Motor[7].pLimits=Clipper[1].Chan[2].Status.a
Motor[7].AmpFaultLevel=1
Motor[7].MaxDac=16384

//< PID & Safety >
Motor[7].Servo.Kp=51.702454;
Motor[7].Servo.Kvfb=1438.4297;
Motor[7].Servo.Ki=0.0099164471;
Motor[7].Servo.Kvff=1438.4297;
Motor[7].Servo.Kaff=19470.463;
Motor[7].Servo.Kvifb=0;
Motor[7].Servo.Kviff=0;
Motor[7].Servo.Kfff=0;
Motor[7].FatalFeLimit=20000;
Motor[7].MaxSpeed=2048;
Motor[7].InvAmax=20;
Motor[7].JogTa=50;
Motor[7].JogTs=20;
Motor[7].JogSpeed=102.4;
Motor[7].Servo.MaxPosErr=100000

//************** Motor4
Motor[8].ServoCtrl=1;
Motor[8].pDac=Clipper[1].Chan[3].Pwm[2].a;
Motor[8].pEncStatus=Clipper[1].Chan[3].Status.a;
Motor[8].pAmpEnable=Clipper[1].Chan[3].OutCtrl.a;
Motor[8].pAmpFault=Clipper[1].Chan[3].Status.a;
Motor[8].pLimits=Clipper[1].Chan[3].Status.a
Motor[8].AmpFaultLevel=1
Motor[8].MaxDac=16384

//< PID & Safety >
Motor[8].Servo.Kp=51.702454;
Motor[8].Servo.Kvfb=1438.4297;
Motor[8].Servo.Ki=0.0099164471;
Motor[8].Servo.Kvff=1438.4297;
Motor[8].Servo.Kaff=19470.463;
Motor[8].Servo.Kvifb=0;
Motor[8].Servo.Kviff=0;
Motor[8].Servo.Kfff=0;
Motor[8].FatalFeLimit=20000;
Motor[8].MaxSpeed=2048;
Motor[8].InvAmax=20;
```

```
Motor[8].JogTa=50;
Motor[8].JogTs=20;
Motor[8].JogSpeed=102.4;
Motor[8].Servo.MaxPosErr=100000
```

Typical Settings for Four Channels of Open Loop PFM Setup:

```
Sys.WpKey=$AAAAAAAA
                                    //Global Clock Settings
Clipper[1].PhaseFreq=9035.69;
Clipper[1].PhaseClockDiv=0;
Clipper[1].ServoClockDiv=3;
Clipper[1].AdcAmpStrobe=$fffffc;
Clipper[1].PfmClockDiv=5
Clipper[1].EncClockDiv=5
Sys.PhaseOverServoPeriod=1/(Clipper[1].ServoClockDiv+1)
Sys.ServoPeriod=1000*(Clipper[1].ServoClockDiv+1)/Clipper[1].PhaseFreq

                                    //Channel PFM Hardware Settings
Clipper[1].Chan[0].PfmWidth=15    //May be stepper drive specific
Clipper[1].Chan[0].OutputMode=8
Clipper[1].Chan[0].PackOutData=0
Clipper[1].Chan[0].OutputPol=0    //May be stepper drive specific
Clipper[1].Chan[0].PfmDirPol=0    //May be stepper drive specific
Clipper[1].Chan[0].TimerMode=3

Clipper[1].Chan[1].PfmWidth=15
Clipper[1].Chan[1].OutputMode=8
Clipper[1].Chan[1].PackOutData=0
Clipper[1].Chan[1].OutputPol=0
Clipper[1].Chan[1].PfmDirPol=0
Clipper[1].Chan[1].TimerMode=3

Clipper[1].Chan[2].PfmWidth=15
Clipper[1].Chan[2].OutputMode=8
Clipper[1].Chan[2].PackOutData=0
Clipper[1].Chan[2].OutputPol=0
Clipper[1].Chan[2].PfmDirPol=0
Clipper[1].Chan[2].TimerMode=3

Clipper[1].Chan[3].PfmWidth=15
Clipper[1].Chan[3].OutputMode=8
Clipper[1].Chan[3].PackOutData=0
Clipper[1].Chan[3].OutputPol=0
Clipper[1].Chan[3].PfmDirPol=0
Clipper[1].Chan[3].TimerMode=3
                                        //Motor Control
Motor[5].PhaseCtrl=0
Motor[5].ServoCtrl=1
Motor[5].pDac=Clipper[1].Chan[0].Pfm.a
Motor[5].pAmpFault=0                    //May be stepper drive specific
Motor[5].pAmpEnable=0                   //May be stepper drive specific

Motor[6].PhaseCtrl=0
Motor[6].ServoCtrl=1
Motor[6].pDac=Clipper[1].Chan[1].Pfm.a
Motor[6].pAmpFault=0                    //May be stepper drive specific
Motor[6].pAmpEnable=0                   //May be stepper drive specific

Motor[7].PhaseCtrl=0
Motor[7].ServoCtrl=1
Motor[7].pDac=Clipper[1].Chan[2].Pfm.a
Motor[7].pAmpFault=0                    //May be stepper drive specific
Motor[7].pAmpEnable=0                   //May be stepper drive specific

Motor[8].PhaseCtrl=0
Motor[8].ServoCtrl=1
Motor[8].pDac=Clipper[1].Chan[3].Pfm.a
Motor[8].pAmpFault=0                    //May be stepper drive specific
```

```
Motor[8].pAmpEnable=0                  //May be stepper drive specific

                                       //Encoder Conversion Table
EncTable[5].Type = 1
EncTable[5].pEnc =  Clipper[1].Chan[0].TimerA.a
EncTable[5].index1 =  0
EncTable[5].index2 = 0
EncTable[5].index3 =  0
EncTable[5].MaxDelta =  0
EncTable[5].ScaleFactor = 1/256
Motor[5].pEnc = EncTable[5].a
Motor[5].pEnc2 = EncTable[5].a

EncTable[6].Type = 1
EncTable[6].pEnc =  Clipper[1].Chan[1].TimerA.a
EncTable[6].index1 =  0
EncTable[6].index2 = 0
EncTable[6].index3 =  0
EncTable[6].MaxDelta =  0
EncTable[6].ScaleFactor = 1/256
Motor[6].pEnc = EncTable[6].a
Motor[6].pEnc2 = EncTable[6].a

EncTable[7].Type = 1
EncTable[7].pEnc =  Clipper[1].Chan[2].TimerA.a
EncTable[7].index1 =  0
EncTable[7].index2 = 0
EncTable[7].index3 =  0
EncTable[7].MaxDelta =  0
EncTable[7].ScaleFactor = 1/256
Motor[7].pEnc = EncTable[7].a
Motor[7].pEnc2 = EncTable[7].a

EncTable[8].Type = 1
EncTable[8].pEnc =  Clipper[1].Chan[3].TimerA.a
EncTable[8].index1 =  0
EncTable[8].index2 = 0
EncTable[8].index3 =  0
EncTable[8].MaxDelta =  0
EncTable[8].ScaleFactor = 1/256
Motor[8].pEnc = EncTable[8].a
Motor[8].pEnc2 = EncTable[8].a
                                       //Motor Gains
Motor[5].Servo.Kp = 40
Motor[5].Servo.Kvfb = 0
Motor[5].Servo.Kvff = 40
Motor[5].Servo.Ki = 0.001
Motor[5].Servo.BreakPosErr = 1
Motor[5].Servo.Kbreak = 0

Motor[6].Servo.Kp = 40
Motor[6].Servo.Kvfb = 0
Motor[6].Servo.Kvff = 40
Motor[6].Servo.Ki = 0.001
Motor[6].Servo.BreakPosErr = 1
Motor[6].Servo.Kbreak = 0

Motor[7].Servo.Kp = 40
Motor[7].Servo.Kvfb = 0
Motor[7].Servo.Kvff = 40
Motor[7].Servo.Ki = 0.001
Motor[7].Servo.BreakPosErr = 1
Motor[7].Servo.Kbreak = 0

Motor[8].Servo.Kp = 40
Motor[8].Servo.Kvfb = 0
Motor[8].Servo.Kvff = 40
Motor[8].Servo.Ki = 0.001
Motor[8].Servo.BreakPosErr = 1
Motor[8].Servo.Kbreak = 0
```