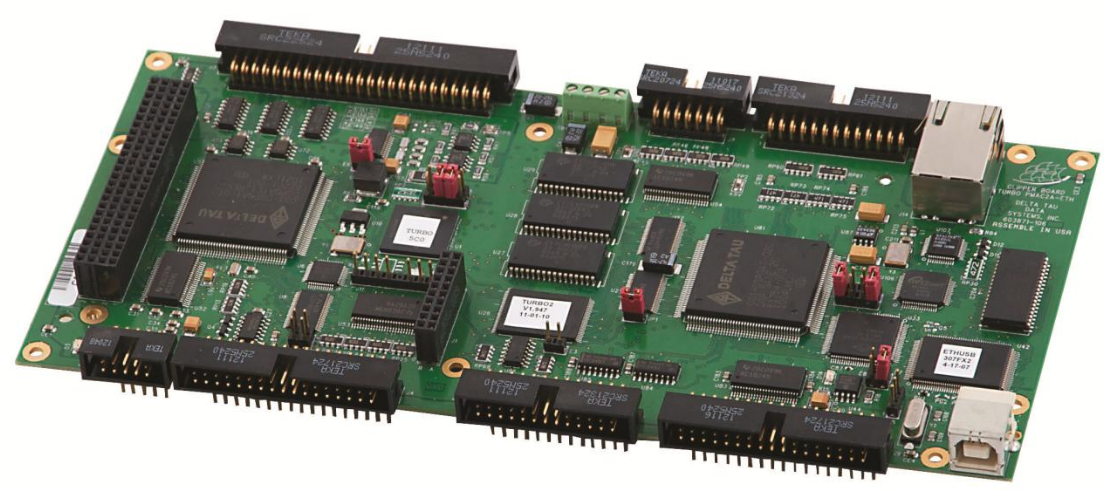
HARDWARE REFERENCE MANUAL

Turbo PMAC Clipper



Turbo PMAC Clipper

4xx-603871-xAxx

April 15, 2014

DELTA TAU
Data Systems, Inc.

NEW IDEAS IN MOTION …

Copyright Information

To report errors or inconsistencies, call or email:

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Operating Conditions

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

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

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**
9	Changed name of manual to Turbo PMAC Clipper	11/03/09	CP	DD
10	Adjusted diagram on P.31	12/16/09	CP	SM
11	Added pulse and direction setup, updated fifth motor setup	06/10/10	RN	SM
12	Updated power supply information	03/17/12	GS	SM
13	General formatting and corrections	04/15/14	MC	RN

Note

Older revision correction notes have been removed for clarity.

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INTRODUCTION

The Turbo PMAC Clipper is a multi-axis stand-alone controller. It has the full power of Turbo PMAC2 CPU and provides a minimum of 4 axes of servo or stepper control. It comes with 32 general-purpose digital I/O points, handwheel port, USB, Ethernet and RS-232 communications links.
The optional axis expansion board provides a set of four additional servo channels and extra I/O ports.

The Turbo PMAC Clipper can be interfaced with several different type of encoders and it supports three types of outputs:

- Analog ±10V 12-bit Filtered PWM
- Analog ±10V 18-bit True DAC (Optional)
- Pulse Frequency Modulation (PFM)

Documentation

In conjunction with this user manual, the Turbo Software Reference Manual and Turbo PMAC User Manual are essential for proper use, motor setup, and configuration of the Turbo PMAC Clipper. It is highly recommended to refer to the latest revision of the manuals found on Delta Tau's website, under Support>documentation>Manuals: Delta Tau Manuals

Downloadable Turbo 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 samples in Turbo PMAC script. These examples can be copied and pasted into the editor area in the Pewin32pro2. Care must be taken when using pre-configured Turbo PMAC code, some information may need to be updated to match hardware and system specific configurations. Downloadable Turbo PMAC Scripts are enclosed in the following format:

```
// TURBO PMAC SCRIPT EXAMPLE
P1=0                                                  ; Set P1=0 at download
Open PLC 1 Clear                                      ; Open PLC Buffer 1, clear contents
CMDP"Turbo PMAC Clipper Manual Test PLC"              ; Send unsolicited response to host port
P1=P1+1                                               ; Counter using variable P1
Disable PLC 1                                         ; Disable plc 1
Close                                                 ; Close open buffer
```

Caution

All PLC examples are stated in PLC number 1. It is the user's responsibility to arrange their application PLCs' properly and handle power-on sequencing for various tasks.

It is the user's responsibility to use the PLC examples presented in this manual properly. That is, incorporating the statement code in the application configuration, and handling tasks in a sequential manner. For example, with serial absolute encoders, setting up the global control registers should be executed before trying to read absolute position, and absolute phase referencing. Furthermore, other PLC programs (which would be trying to move motors) should be disabled until these functions are executed.

Caution

Often times, downloadable example codes use suggested M-variables, it is the user's responsibility to make sure they are downloaded, or perform necessary changes to use the intended registers.

SPECIFICATIONS

Part Number

Clipper Controller

						A	B		C			F		G	H		J	K	L
4	-	3	8	7	1			-	2	0	0		-			0			

A B – CPU / Memory / Firmware Options

- **C0 - Opt. 5C0** 80MHz DSP563xx CPU, 256Kx24 SRAM, 1Mx8 flash* **(Standard)**
- **C3 - Opt. 5C3** 80MHz DSP563xx CPU, 1Mx24 SRAM, 4Mx8 flash*
- **F3 - Opt. 5F3** 240MHz DSP563xx CPU, 1Mx24 SRAM, 4Mx8 flash*

C

- **2 - PMAC2 (Standard)***

F

- **4 – No Options**
- **5 - Opt. 2** Dual Port RAM
- **6 - Opt. 15F** ModBus Comm.
- **7 - Opt. 2 & Opt. 15F** Dual Port. RAM **&** ModBus Comm.

G – Communication Options

- **0 - No Options** Standard JEXPA & JEXPB Stack Short pins **&** Standard right angle box header connectors short pins
- **3 - Opt. EX** JEXPA & JEXPB Stack long pins (Solder side)
- **5 - Opt. C4 (BREAKOUT BRD OPT)** JEXPA & JEXPB Stack long pins (Solder side) **&** Right Angle box header connectors with long pins (Solder side)

H J – Other Options

H:
- **0 - No Options**
- **1 - Opt. 12** 2-channels 12-bit A/D converter & 1 12-bit D/A converter

J:
- **0 -** No Options
- **1 - Opt. 11A** HI-Speed Dig. Out PWM Laser Control

K L – Factory Assigned Options

- **00** - No **Additional*** Options
- **xx** - Factory assigned digits for **Additional*** Options

* If **Opt. 10xx (specific firmware version)** or any other **Additional Option** is required, contact factory for digits **K** and **L** (**Factory Assigned** digits).
If Opt. 10xx is not ordered the latest firmware is used.

Options

CPU Options

- C0: 80MHz Turbo PMAC2 CPU (standard)
  8Kx24 internal memory, 256Kx24 SRAM , 1MB flash memory
- C3: 80MHz Turbo PMAC2 CPU
  8Kx24 internal memory, 1Mx24 SRAM, 4M flash memory
- F3: 240MHz Turbo PMAC2 CPU
  192Kx24 internal memory, 1Mx24 SRAM, 4M flash memory

Communication Options

- Opt.2 Dual Port RAM (required for NC software/applications)
- Opt.15F Modbus Communication for additional I/O's.
- Opt.EX JEXPA & JEXPB stack long pins
- Opt.C4 JEXPA & JEXPB stack and connectors long pins for breakout board option

Axis Output

- 18-bit true DAC or 12-bit filtered PWM (default) ±10V analog output
- Pulse And Direction (PFM)

Encoder Input

- Four encoder inputs, and two handwheel quadrature input (default)
- Additional four encoder inputs (Acc-1P) and two handwheel encoder (Acc-1P Option1)

Digital Inputs/Outputs

- 32 general-purpose TTL-level I/O points (default)
- Additional 8 general-purpose I/O and multiplexed I/O (Acc-1P Option1)

Analog Inputs

- Two 12-bit analog inputs, and a 12-bit filtered PWM (±10V) outputs (Opt.12)
- Additional two 12-bit analog inputs, and a 12-bit filtered PWM (±10V) outputs (Acc-1P Option2)

Host Communication

- USB 2.0, Ethernet 100 Base T, RS232 (default)

Stackable Accessories

- ACC-1P PC/104-format Channel 5-8 board
- ACC-8AS 4-channel dual 16-bit true-DAC output board
- ACC-8ES 4-channel dual 18-bit true-DAC output board
- ACC-8FS 4-channel direct-PWM output board
- ACC-8TS 4-channel ADC-interface board
- ACC-51S 2/4-channel high-resolution encoder interpolator board
- ACC-84S 4-channel serial encoder interface. The supported protocols:
  - SSI Synchronous Serial Interface
  - EnDat 2.2 EnDat 2.2 interface from HEIDENHAIN
  - BiSS B Renishaw Biss B Unidirectional
  - BiSS C Renishaw Biss C Unidirectional
  - Yaskawa Yaskawa Sigma II and Sigma III feedback support
  - Panasonic Panasonic Feedback Style
  - Tamagawa Tamagawa Feedback Style
  - Mitutoyo Mitutoyo Feedback Style

Environmental Specifications

Description	Specification	Notes
Operating Temperature	0°C to 45°C	
Storage Temperature	-25°C to 70°C	
Humidity	10% to 95 %	Non-Condensing

Electrical Specifications

Digital Power Supply

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

+5 V (20W) @ 4 A (Eight-channel configuration with a typical load of encoders)

WARNING

Boards with **revisions 103 and below** have the following requirement:

Mininumum 10 msec rise time

6A @ +5V (±5%) (30 W)

The Clipper Board and other stackable accessories each require a 1A @ 5VDC power supply for normal operation; however, the Clipper board has an in-rush current requirement that can reach 3A, so a 6A @ 5VDC power supply is recommended.

DAC Outputs Power Supply

The ±12V lines from the supply, including the ground reference, can be brought in either from the TB1 terminal block or from the JMACH1 connector.

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

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 Turbo PMAC Clipper and can be connected from the TB1 terminal block or the J3 (JMACH1) connector.

RECEIVING AND UNPACKING

Delta Tau products are thoroughly tested at the factory and carefully packaged for shipment. When the Turbo 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 Turbo 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 Turbo 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 Turbo PMAC Clipper:

- The components built into electrical equipment or machines can be used only as integral components of such equipment.
- The Turbo PMAC Clipper must not be operated on power supply networks without a ground or with an asymmetrical ground.
- If the Turbo PMAC Clipper is used in residential areas, or in business or commercial premises, implement additional filtering measures.
- The Turbo 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 Turbo 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 Turbo 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 Turbo PMAC Clipper should be mounted on a smooth, non- flammable vertical or horizontal surface.
- At least 100 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]).

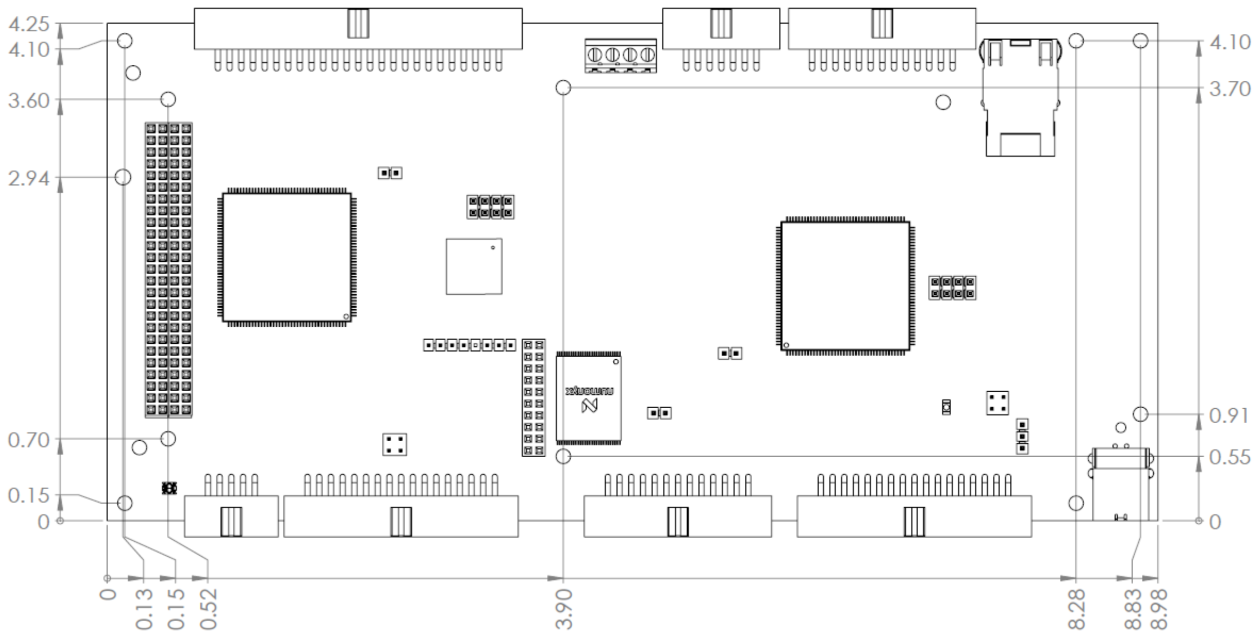
The Turbo PMAC Clipper can be mounted as a stand-alone controller using standoffs. At each of the four corners of the board and at the center edges, there are mounting holes that can be used for this.

The order of the Acc-1P or other stacked accessories with respect to the Clipper Board does not matter. If the Turbo 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 and Layout

Top View



Rev106

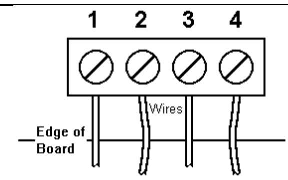
CONNECTIONS AND SOFTWARE SETUP

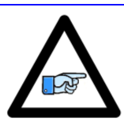
WARNING

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.

TB1: Power Supply Input

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

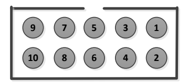


Note

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 Turbo 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. This port can be used as a primary communication mean or employed as a secondary port that allows simultaneous communication.

J2 (JRS232) Serial Port Connector 10-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	PHASE	Output	Phasing Clock	
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	SERVO	Output	Servo Clock	
9	GND	Common	Digital Common	
10	+5V	Output	+5Vdc Supply	Power supply out

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

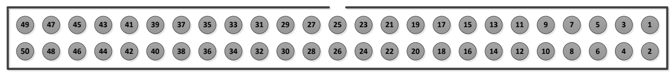
The baud rate for the RS-232 serial port is set by variable I54. At power-up reset, The Turbo PMAC Clipper sets the active baud based on the setting of I54 and the CPU speed I52. Note that the baud rate frequency is divided down from the CPU's operational frequency. The factory default baud rate is 38400. This baud rate will be selected automatically on re-initialization of the Clipper, either in hardware power cycle or in software using the **`$$$***`** command.

To change the baud rate setting on the Turbo PMAC Clipper, set I54 to the corresponding value of desired frequency. Restart the software (Pewin32Pro2), and adjust to the correct baud rate in the communication setup window. Then issue a **SAVE** and a reset (**$$$**), or recycle power on the Clipper. For odd baud rate settings, refer to the Turbo Software Reference Manual.

I54	Baud Rate	I54	Baud Rate
8	9600	**12**	**38,400**
9	14,400	13	57,600
10	19,200	14	76,800
11	28,800	15	115,200

J3: Machine Connector (JMACH1 Port)

The primary machine interface connector is JMACH1, labeled J3 on the Turbo 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	6
36	FAULT2/	Input	Amplifier -Fault 2	6
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	6
44	FAULT4/	Input	Amplifier -Fault 4	6
45	ADCIN_1	Input	Analog Input 1	Option-12 required
46	ADCIN_2	Input	Analog Input 2	Option-12 required
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 6**: Functional polarity controlled by variable Ixx24. Must be conducting to 0V (usually GND) to produce a 0 in PMAC software. Automatic fault function can be disabled with Ixx24.
- **Note 7**: Can be used to provide input power when the TB1 connector is not being used.

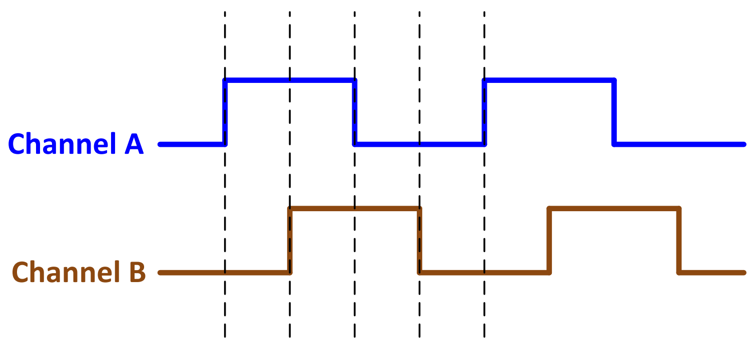
50-pin female flat cable connector T&B Ansley P/N 609-5041
Standard flat cable stranded 50-wire T&B Ansley P/N 171-50
Phoenix varioface module type FLKM 50 (male pins) P/N 22 81 08 9

Note

Use an encoder cable with high quality shield.

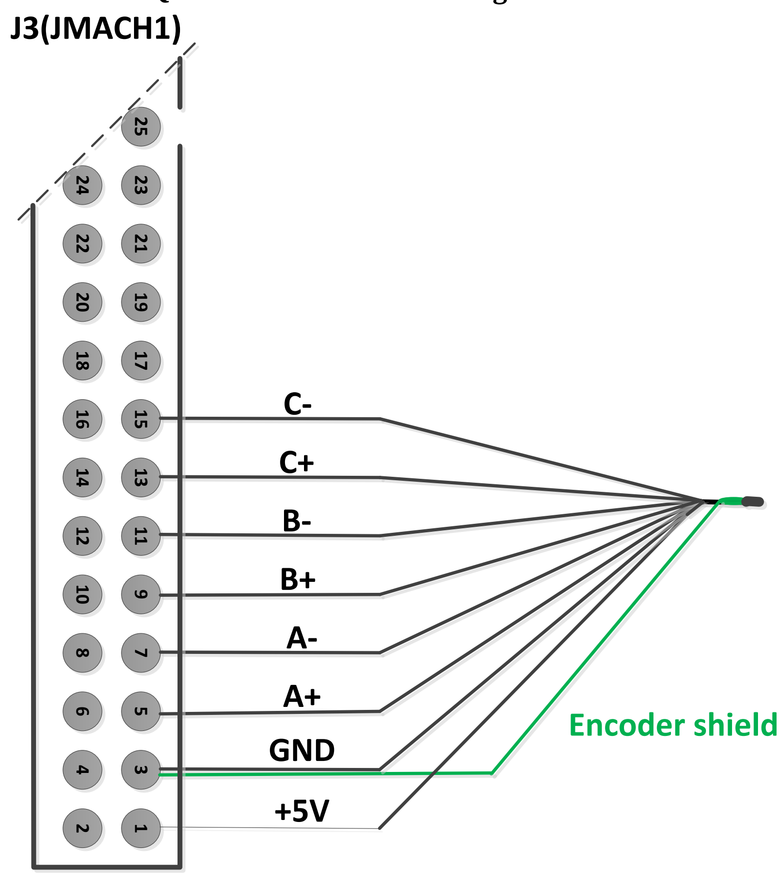
The standard encoder inputs on the Turbo PMAC Clipper are designed for differential quadrature type signals.

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.

Setting up Quadrature Encoders

Digital Quadrature Encoders use the 1/T incremental entry in the encoder conversion table. Position and velocity pointers should, by default, be valid and in most cases no software setup is required, activating (Ixx00=1) the corresponding channel is sufficient to see encoder counts in the position window when the motor/encoder shaft is moved by hand.

```
I100,4,100 = 1 ; Servo IC0 Channels 1-4 activated
I500,4,100 = 1 ; Servo IC0 Channels 5-8 activated                        (First Acc-1P)
I900,4,100 = 1 ; Servo IC0 Channels 9-12 activated                       (Second Acc-1P)
```

Setting up Sinusoidal Encoders

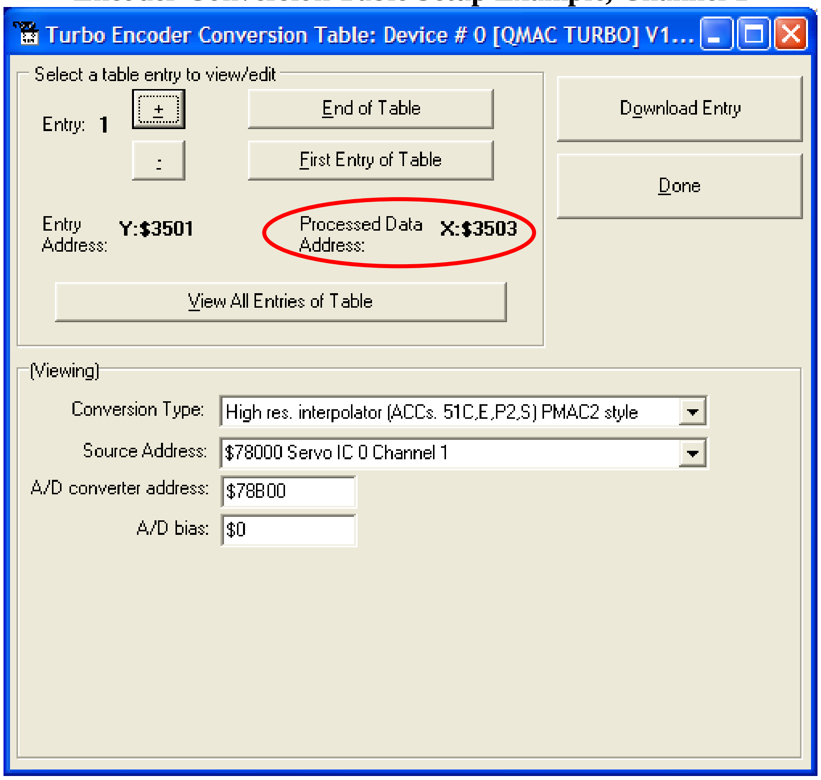
For sinusoidal position feedback, the Acc-51S, sine wave input interpolator, stacks on top of the Turbo PMAC Clipper or on top of the Acc-1P 5-8 axis board. Channels 1 – 4 of the ACC-51S correspond to PMAC channels 1 – 4 if the ACC-51S is connected to the main Turbo PMAC Clipper; channels 1 – 4 of the ACC-51S correspond to PMAC channels 5 – 8 if the ACC-51S is connected to the ACC-1P board.

Note

- ACC-51S channels 1 – 4 become PMAC channels 1 – 4 if ACC-51S jumper E1 connects pins 2 and 3.
- ACC-51S channels 1 – 4 become PMAC channels 5 – 8 if ACC 51S jumper E1 connects pins 1 and 2.

The Sinusoidal position feedback is set up through the Encoder Conversion Table (ECT) as a high resolution interpolation entry.

Encoder Conversion Table Setup Example, Channel 1



1. Conversion Type: High res. interpolator, PMAC2 Style
2. Enter Source Address (see table below)
3. Enter A/D Converter Address (see table below)
4. A/D Bias: always zero

Channel #	Source Address	A/D converter Address
1	$78000	$78800
2	$78008	$78802
3	$78010	$78804
4	$78018	$78806

Channel #	Source Address	A/D converter Address
5	$78100	$78808
6	$78108	$7880A
7	$78110	$7880C
8	$78118	$7880E

Note

Results are found in the processed data address, which the position and velocity feedback pointers (Ixx03, Ixx04) are usually assigned to.

The equivalent Turbo PMAC script code for 8-channel entries

```
// Channel 1
I8000=$FF8000  ; High resolution interpolator              (Clipper & Acc-51S)
I8001=$078800  ; A/D converter address                     (Clipper & Acc-51S)
I8002=$000000  ; Bias Term and Entry result                (Clipper & Acc-51S)
// Channel 2
I8003=$FF8008  ; High resolution interpolator              (Clipper & Acc-51S)
I8004=$078802  ; A/D converter address                     (Clipper & Acc-51S)
I8005=$000000  ; Bias Term and Entry result                (Clipper & Acc-51S)
// Channel 3
I8006=$FF8010  ; High resolution interpolator              (Clipper & Acc-51S)
I8007=$078804  ; A/D converter address                     (Clipper & Acc-51S)
I8008=$000000  ; Bias Term and Entry result                (Clipper & Acc-51S)
// Channel 4
I8009=$FF8018  ; High resolution interpolator              (Clipper & Acc-51S)
I8010=$078806  ; A/D converter address                     (Clipper & Acc-51S)
I8011=$000000  ; Bias Term and Entry result                (Clipper & Acc-51S)
// Channel 5
I8012=$FF8100  ; High resolution interpolator              (Acc-1P & Acc-51S)
I8013=$078808  ; A/D converter address                     (Acc-1P & Acc-51S)
I8014=$000000  ; Bias Term and Entry result                (Acc-1P & Acc-51S)
// Channel 6
I8015=$FF8108  ; High resolution interpolator              (Acc-1P & Acc-51S)
I8016=$07880A  ; A/D converter address                     (Acc-1P & Acc-51S)
I8017=$000000  ; Bias Term and Entry result                (Acc-1P & Acc-51S)
// Channel 7
I8018=$FF8110  ; High resolution interpolator              (Acc-1P & Acc-51S)
I8019=$07880C  ; A/D converter address                     (Acc-1P & Acc-51S)
I8020=$000000  ; Bias Term and Entry result                (Acc-1P & Acc-51S)
// Channel 8
I8021=$FF8118  ; High resolution interpolator              (Acc-1P & Acc-51S)
I8022=$07880E  ; A/D converter address                     (Acc-1P & Acc-51S)
I8023=$000000  ; Bias Term and Entry result                (Acc-1P & Acc-51S)
```

Position and Velocity feedback pointers should now be set to the corresponding ECT result:

```
I103=$3503 I104=$3503                ; (Clipper & Acc-51S)
I203=$3506 I204=$3506                ; (Clipper & Acc-51S)
I303=$3509 I304=$3509                ; (Clipper & Acc-51S)
I403=$350C I404=$350C                ; (Clipper & Acc-51S)
I503=$350F I504=$350F                ; (Acc-1P & Acc-51S)
I603=$3512 I604=$3512                ; (Acc-1P & Acc-51S)
I703=$3515 I704=$3515                ; (Acc-1P & Acc-51S)
I803=$3518 I804=$3518                ; (Acc-1P & Acc-51S)
```

Note

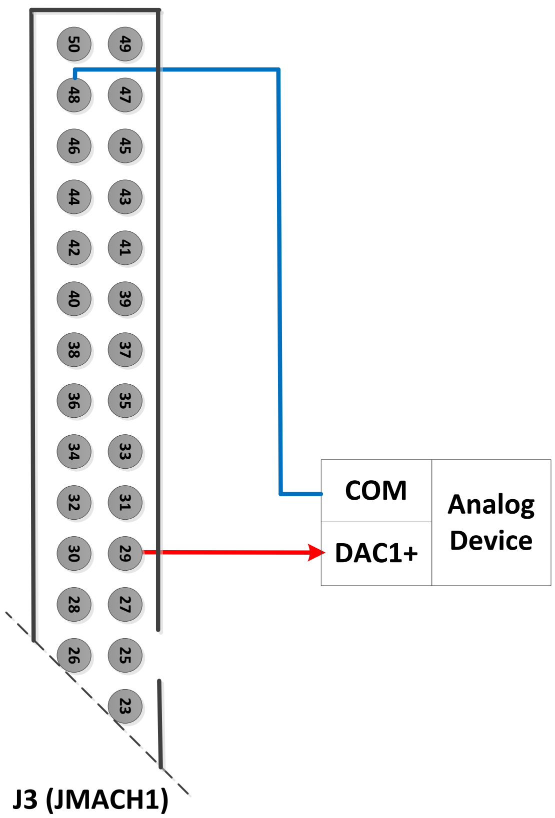
At this point of the setup, you should be able to move the motor/encoder shaft by hand and see ‘motor’ counts in the position window.

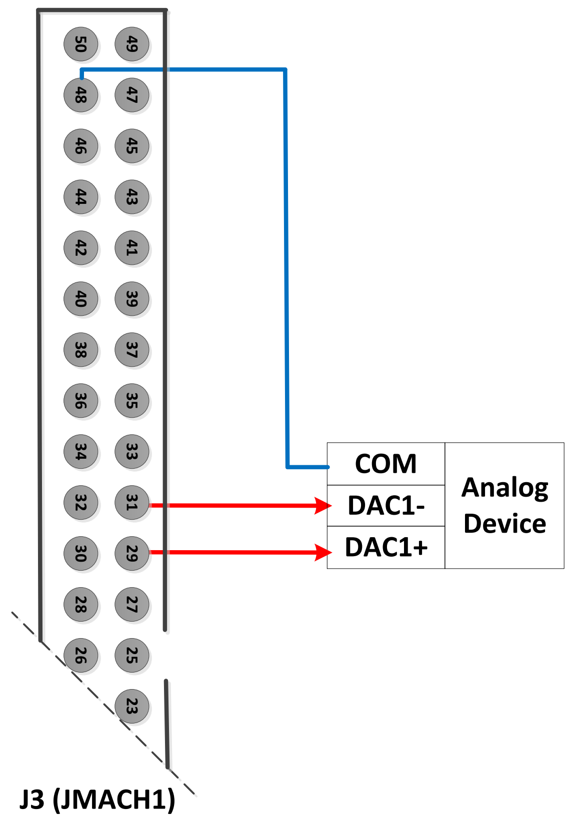
Counts per User Units

With the interpolation of x 4096 in Turbo PMAC, there are 128 (4096/32) motor counts per sine/cosine cycles. Motor counts can be monitored in the motor position window upon moving the motor by hand.
Examples:
A **1024 Sine/Cosine** periods per revolution of a rotary encoder produces 1024 x 128 = **131,072 cts/rev.**
A **20 µm** linear encoder resolution produces 128/0.02 = **6400 cts/mm.**

Wiring the DAC Output

Example for Clipper Channel #1





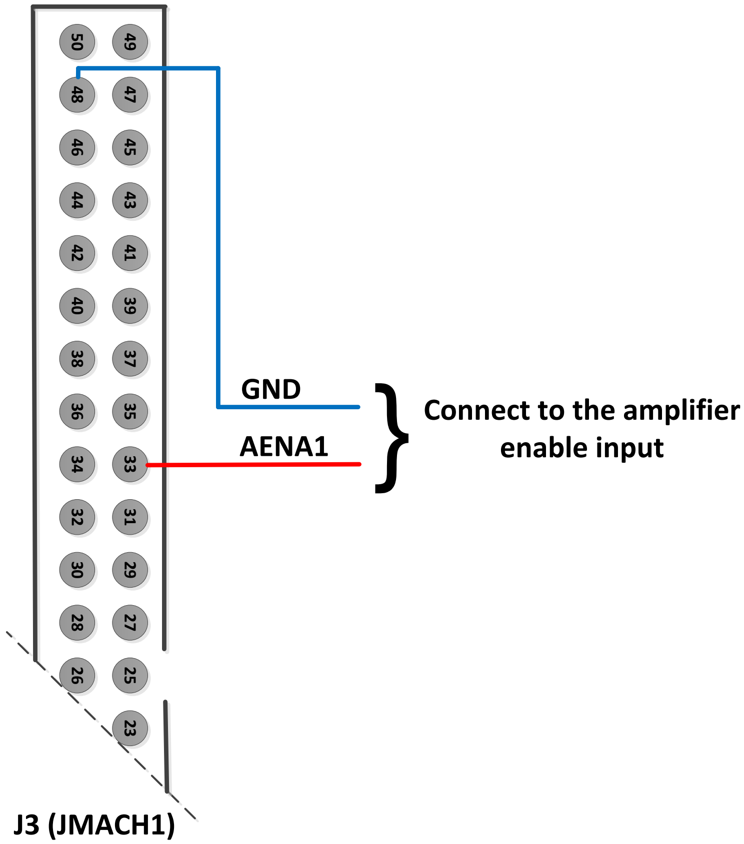
Note

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.

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.

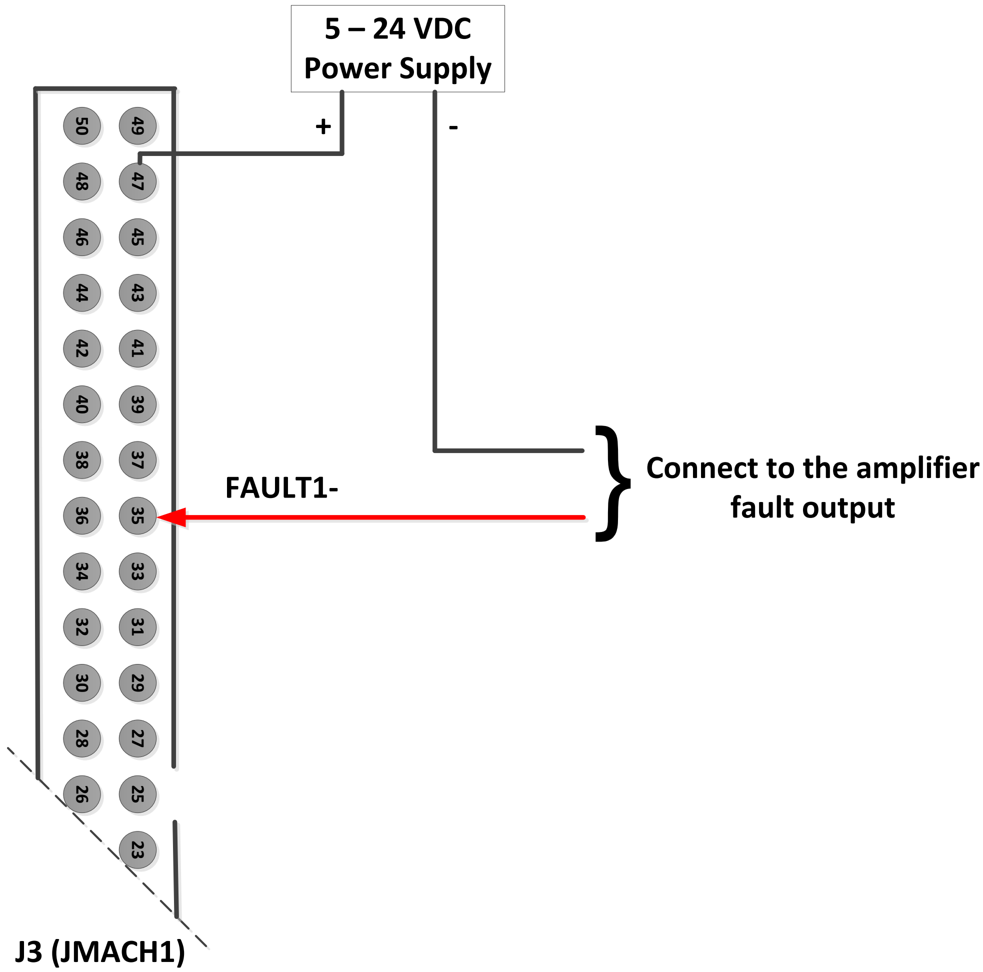
Example for Clipper Channel #1



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 I-variable Ixx24 (I124 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.

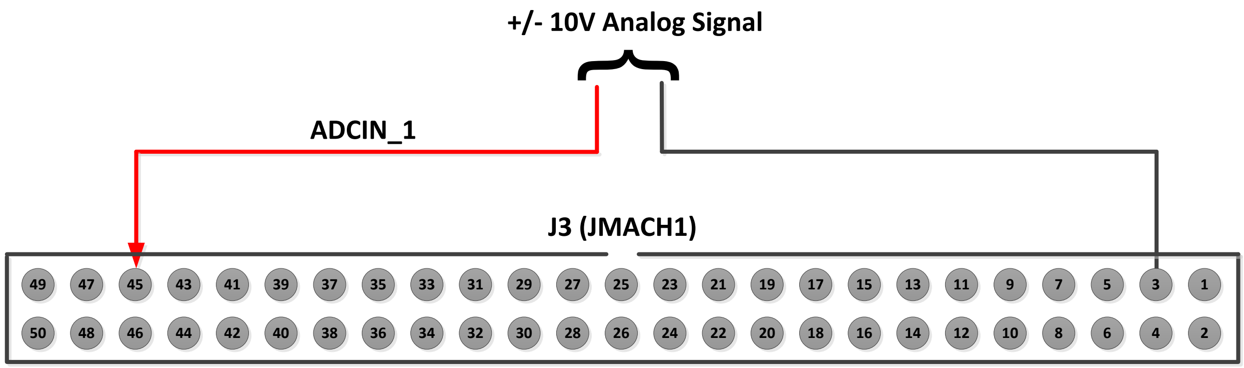
Example for Clipper Channel #1



Optional Analog Inputs

The optional analog-to-digital converter inputs are ordered either through Option-12 on the Turbo PMAC Clipper or Option-2 on the axis expansion board. Each option provides two 12-bit analog inputs with a ±10Vdc range, and one 12-bit filtered PWM DAC output.

Example for Analog Input 1



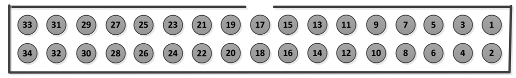
The M-variables associated with these inputs provided a range of values between +2048 and –2048 for the respective ±10Vdc input range. The following is the software procedure to setup and read these ports.

Analog Inputs Setup

```
I7003 = 1746                          ;Set ADC clock frequency at 4.9152 MHz
I7006 = $1FFFFF                       ;Clock strobe set for bipolar inputs
M105->Y:$78005,12,12,S                ;ADCIN_1 on JMACH1 connector pin 45
M205->Y:$7800D,12,12,S                ;ADCIN_2 on JMACH1 connector pin 46
```

J4: Machine Connector (JMACH2 Port)

This machine interface connector is labeled JMACH2 or J4 on the Turbo 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 Ixx24.
- **Note 10**: Functional polarity for homing or other trigger use of HOMEn controlled by Encoder/Flag Variable I70n2. HMFLn selected for trigger by Encoder/Flag Variable I70n3. 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

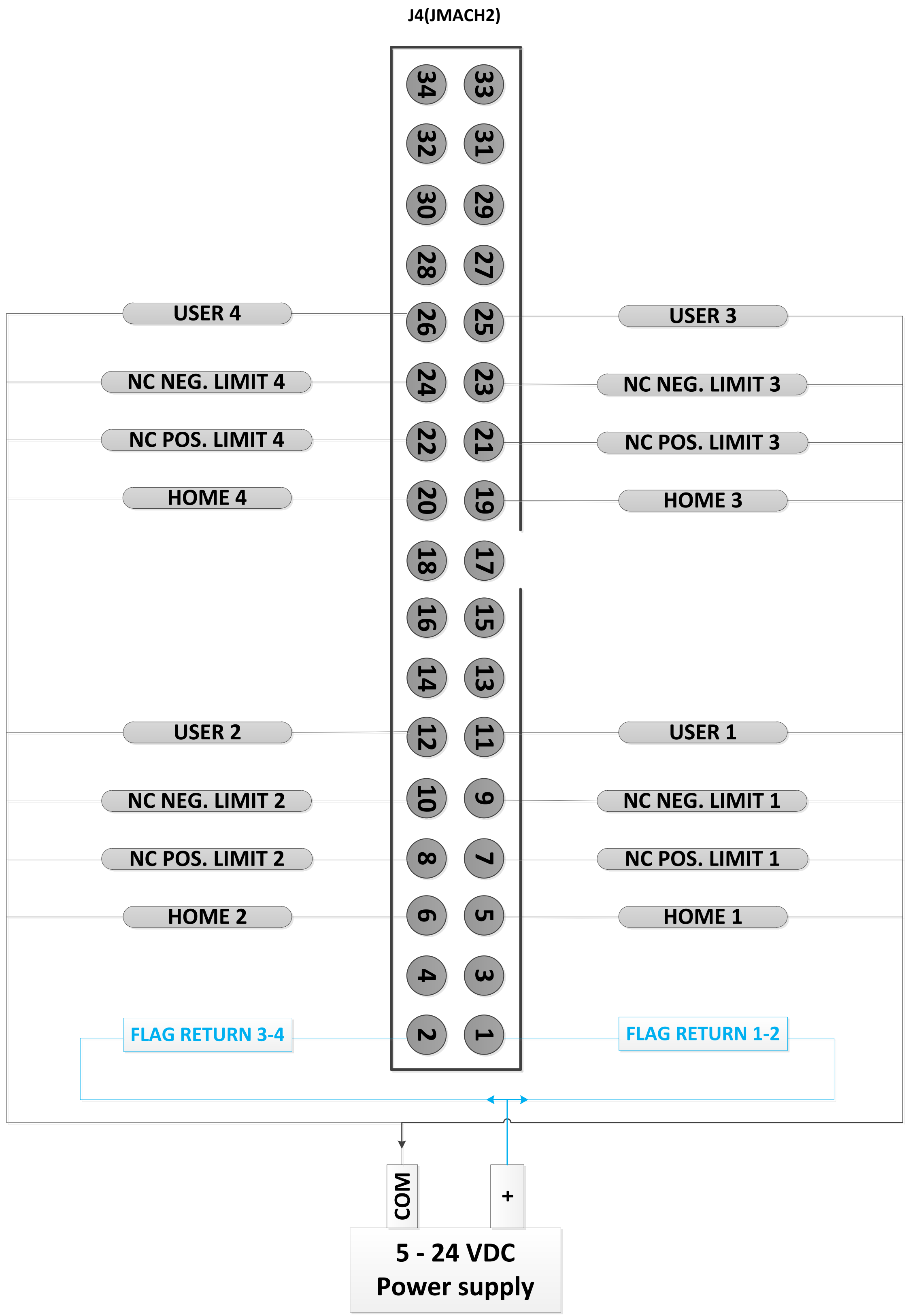
Overtravel Limits and Home Switches

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 setup through the PMAC Ixx24 variable.

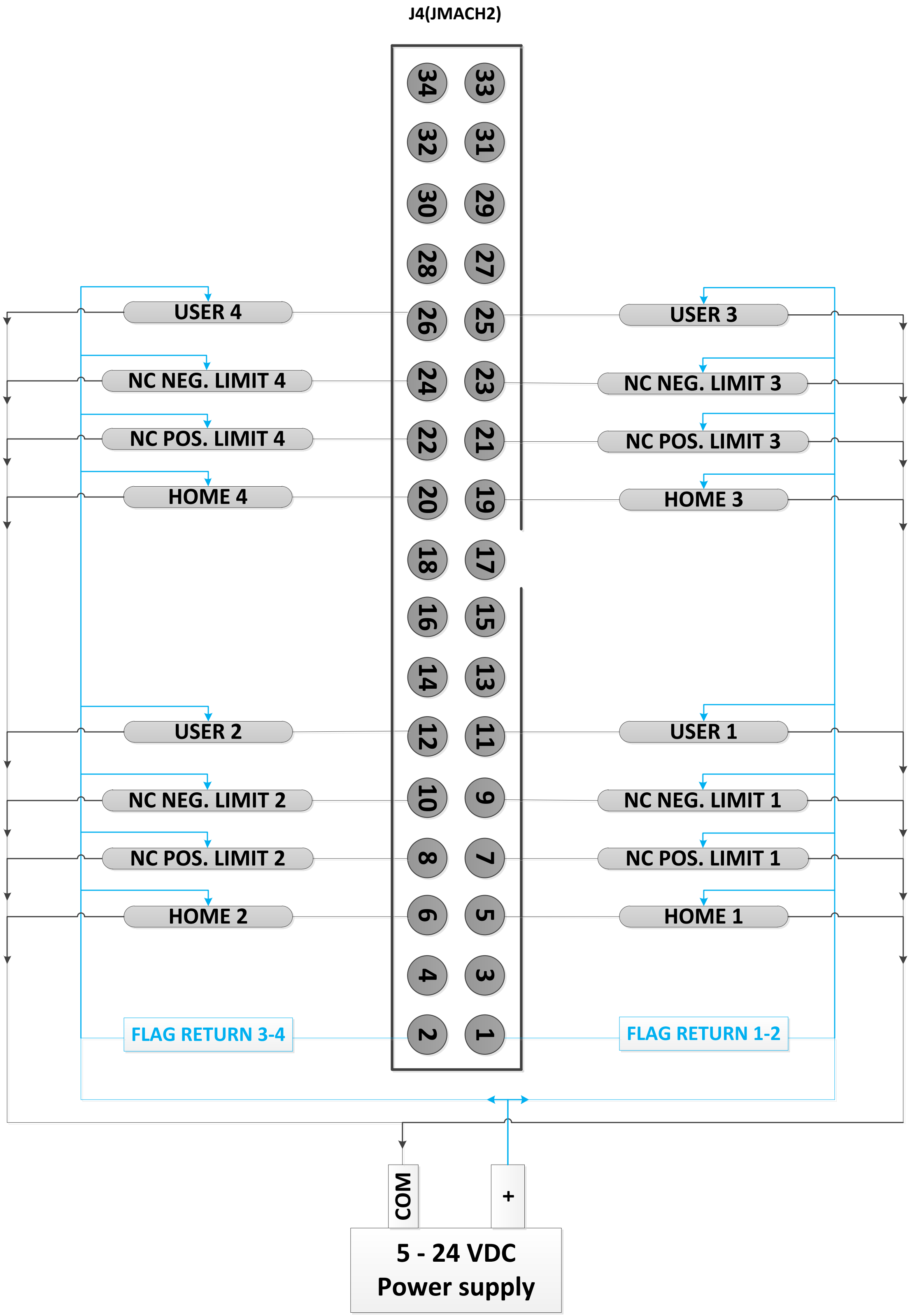
Wiring the Limits and Flags

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 Close 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 the I-variables I7mn2.

Limits and Flags [Axis 1- 4] Suggested M-Variables

Either the user flags or other not assigned axes flag on the base board can be used as general-purpose I/O for up to 20 inputs and 4 outputs at 5-24Vdc levels. The indicated suggested M-variables definitions allow accessing each particular line as shown below:

```
M114->X:$078005,14                    ; AENA1 output status
M115->X:$078000,19                    ; User 1 flag input status
M120->X:$078000,16                    ; Home flag 1 input status
M121->X:$078000,17                    ; Positive Limit 1 flag input status
M122->X:$078000,18                    ; Negative Limit 1 flag input status

M214->X:$07800D,14                    ; AENA2 output status
M215->X:$078008,19                    ; User 2 flag input status
M220->X:$078008,16                    ; Home flag 2 input status
M221->X:$078008,17                    ; Positive Limit 2 flag input status
M222->X:$078008,18                    ; Negative Limit 2 flag input status

M314->X:$078015,14                    ; AENA3 output status
M315->X:$078010,19                    ; User 3 flag input status
M320->X:$078010,16                    ; Home flag 3 input status
M321->X:$078010,17                    ; Positive Limit 3 flag input status
M322->X:$078010,18                    ; Negative Limit 3 flag input status

M414->X:$07801D,14                    ; AENA4 output status
M415->X:$078018,19                    ; User 4 flag input status
M420->X:$078018,16                    ; Home flag 4 input status
M421->X:$078018,17                    ; Positive Limit 4 flag input status
M422->X:$078018,18                    ; Negative Limit 4 flag input status
```

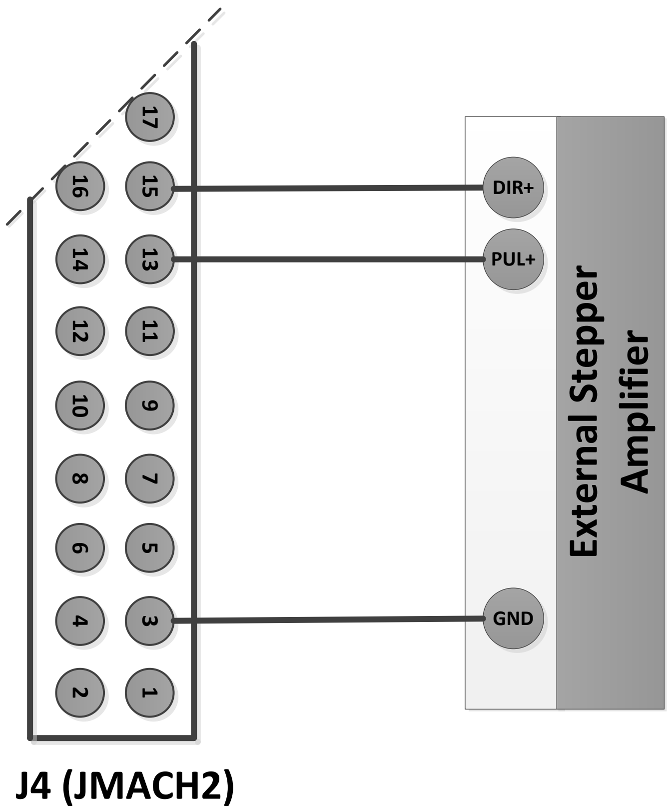
Note

When using these lines as regular I/O points the appropriate setting of the Ixx24 variable must be used to enable or disable the safety flags feature.

Step and Direction PFM Output (To External Stepper Amplifier)

The Turbo PMAC Clipper or the Acc-1P 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



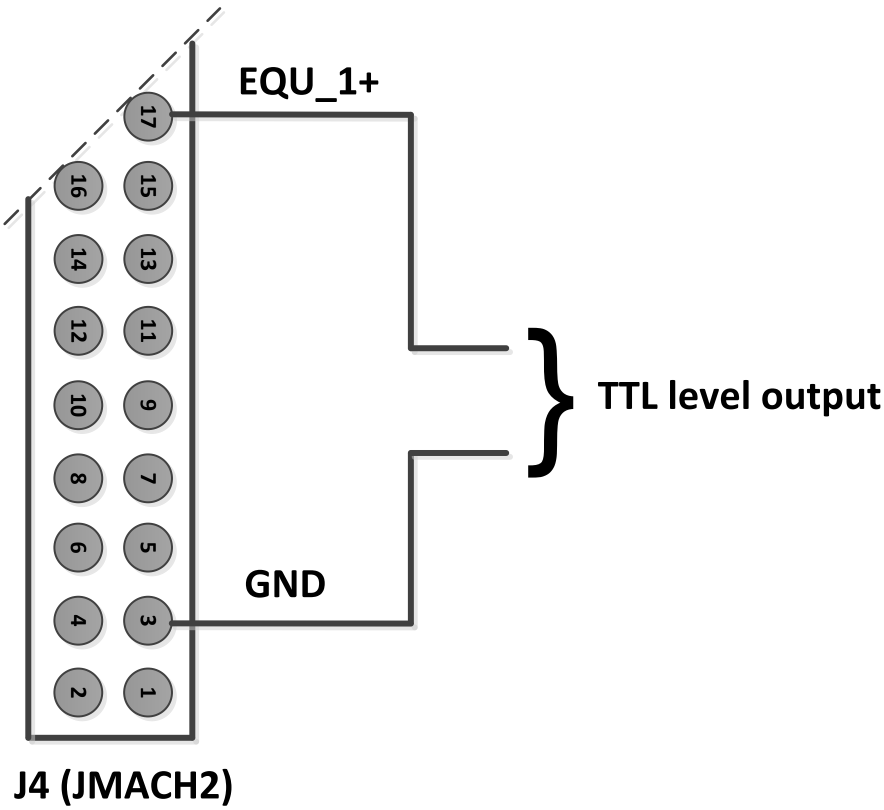
Software setup for PFM output can be found in the Drive-Motor setup section.

Note

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 Turbo PMAC User Manual.

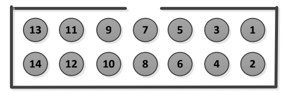
Example for Channel #1




```
M116->X:$078000,9                    ; EQU1, ENC1 compare output value
M216->X:$078008,9                    ; EQU2, ENC2 compare output value
M316->X:$078010,9                    ; EQU3, ENC3 compare output value
M416->X:$078018,9                    ; EQU4, ENC4 compare output value
```

J7: Machine Connector (JMACH3 Port)

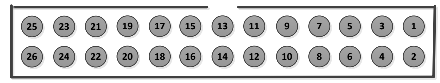
This machine interface connector is labeled JMACH3 or J7 on the Turbo PMAC Clipper. It contains the pins for four channels of U, V, and W flags normally used for hall device commutation.

J7 (JMACH3): Machine Port 14-Pin Header				
Pin#	**Symbol**	**Function**	**Description**	*Notes*
1	GND	Common	Digital Common	
2	GND	Common	Digital Common	
3	CHU1+	Input	U-Flag Channel 1	
4	CHU2+	Input	U-Flag Channel 2	
5	CHV1+	Input	V-Flag Channel 1	
6	CHV2+	Input	V-Flag Channel 2	
7	CHW1+	Input	W-Flag Channel 1	
8	CHW2+	Input	W-Flag Channel 2	
9	CHU3+	Input	U-Flag Channel 3	
10	CHU4+	Input	U-Flag Channel 4	
11	CHV3+	Input	V-Flag Channel 3	
12	CHV4+	Input	V-Flag Channel 4	
13	CHW3+	Input	W-Flag Channel 3	
14	CHW4+	Input	W-Flag Channel 4	

14-pin female flat cable connector Delta Tau P/N 014-R00F14-0K0, T&B Ansley P/N 609-1441
171-14 T&B Ansley standard flat cable stranded 14-wire
Phoenix varioface modules type FLKM14 (male pins) P/N 22 81 02 1

J8: Thumbwheel Multiplexer Port (JTHW Port)

Thumbwheel Multiplexer Port on the JTHW connector has 8 inputs and 8 outputs at TTL levels. The output lines can be used to multiplex large numbers of inputs and outputs on the port, and Delta Tau provides accessory boards and software structures (special M-variable definitions) to capitalize on this feature. In this form, some of the SELn outputs are used to select which of the multiplexed I/O are to be accessed. Up to 32 of the multiplexed I/O boards may be daisy-chained on the port, in any combination.

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

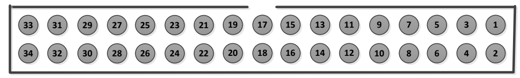
Thumbwheel Port Digital Inputs and Outputs

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 M-variables:

```
M40->Y:$78402,8,1                     ; SEL0 Output
M41->Y:$78402,9,1                     ; SEL1 Output
M42->Y:$78402,10,1                    ; SEL2 Output
M43->Y:$78402,11,1                    ; SEL3 Output
M44->Y:$78402,12,1                    ; SEL4 Output
M45->Y:$78402,13,1                    ; SEL5 Output
M46->Y:$78402,14,1                    ; SEL6 Output
M47->Y:$78402,15,1                    ; SEL7 Output
M48->Y:$78402,8,8,U                   ; SEL0-7 Outputs treated as a byte
M50->Y:$78402,0,1                     ; DAT0 Input
M51->Y:$78402,1,1                     ; DAT1 Input
M52->Y:$78402,2,1                     ; DAT2 Input
M53->Y:$78402,3,1                     ; DAT3 Input
M54->Y:$78402,4,1                     ; DAT4 Input
M55->Y:$78402,5,1                     ; DAT5 Input
M56->Y:$78402,6,1                     ; DAT6 Input
M57->Y:$78402,7,1                     ; DAT7 Input
M58->Y:$78402,0,8,U                   ; DAT0-7 Inputs treated as a byte
```

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/Os (J6) Suggested M-Variables

The lines on the JOPT general-purpose I/O connector will be mapped into PMAC's address space in register Y:$78400. Typically, these I/O lines are accessed individually with M-variables. Following is a suggested set of M-variable definitions to use these data lines.

```
M0->Y:$78400,0   ; Digital Output M01
M1->Y:$78400,1   ; Digital Output M02
M2->Y:$78400,2   ; Digital Output M03
M3->Y:$78400,3   ; Digital Output M04
M4->Y:$78400,4   ; Digital Output M05
M5->Y:$78400,5   ; Digital Output M06
M6->Y:$78400,6   ; Digital Output M07
M7->Y:$78400,7   ; Digital Output M08
M8->Y:$78400,8   ; Digital Input MI1
M9->Y:$78400,9   ; Digital Input MI2
M10->Y:$78400,10 ; Digital Input MI3
M11->Y:$78400,11 ; Digital Input MI4
M12->Y:$78400,12 ; Digital Input MI5
M13->Y:$78400,13 ; Digital Input MI6
M14->Y:$78400,14 ; Digital Input MI7
M15->Y:$78400,15 ; Digital Input MI8
M32->X:$78400,0,8 ; Direction Control bits 0-7  (1=output,  0 = input)
M34->X:$78400,8,8 ; Direction Control bits 8-15 (1=output,  0 = input)
M40->X:$78404,0,24 ; Inversion control (0 = 0V, 1 = 5V)
M42->Y:$78404,0,24 ; J9 port data type control (1 = I/O)
```

In order to properly setup the digital outputs, an initialization PLC must be written scanning through once on power-up/reset, then disabling itself:

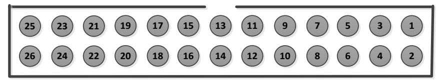
```
//==================================== PLC SCRIPT CODE =====================================//
OPEN PLC1 CLEAR
M32=$FF        ;BITS 0-8 are assigned as output
M34=$0         ;BITS 9-16 are assigned as input
M40=$FF00      ;Define inputs and outputs
M42=$FFFF      ;All lines are I/O type
DIS PLC1       ;Disable PLC1 (scanning through once on power-up/reset)
CLOSE
```

After loading this program, set I5=2 or 3 and ENABLE PLC1.

Note

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

JHW/PD port provides two Quadrature encoder inputs and PFM or PWM output pairs from the DSPGate2 supplemental channels 1* and 2*.

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	TBD		
20	TBD		
21	TBD		
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

J12: Ethernet Communications Port

This connector is used to establish communication over Ethernet between the PC and the Turbo PMAC Clipper. A crossover cable is required if you are going directly to the Clipper from the PC Ethernet card, and not through a hub.

Delta Tau strongly recommends the use of RJ45 CAT5e or better shielded cable. Newer network cards have the Auto-MDIX feature that eliminates the need for crossover cabling by performing an internal crossover when a straight cable is detected during the auto-negotiation process. For older network cards, one end of the link must perform media dependent interface (MDI) crossover (MDIX), so that the transmitter on one end of the data link is connected to the receiver on the other end of the data link (a crossover/patch cable is typically used). If an RJ45 hub is used, then a regular straight cable must be implemented. Maximum length for Ethernet cable should not exceed 100m (330ft).

J13: USB Communications Port

This connector is used to establish USB (A-B type cable) communication between the host PC and the Turbo PMAC Clipper. This type of USB cable can be purchased at any local electronics or computer store. It may be ordered from Delta Tau as well.

Pin#	Symbol	Function
1	VCC	N.C
2	D-	Data-
3	D+	Data+
4	Gnd	GND
5	Shell	Shield
6	Shell	Shield

Caution

The electrical ground plane of the host PC connected through USB must be at the same level as the Turbo PMAC Clipper. Ground loops may result in ESD shocks causing the damage of the communication processor on the Turbo 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.

JP11: OPT-11 Shunt

Not present if OPT-11 is installed. For internal use only.

LED Indicators

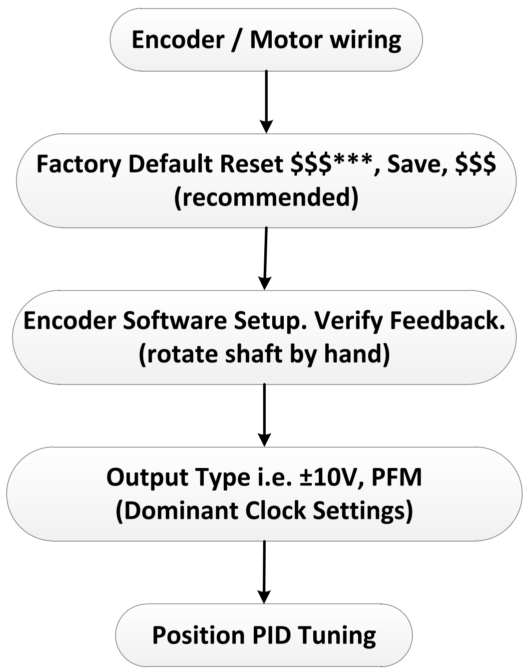
D3: This is a dual color LED. When this LED is green, it indicates that power is applied to the +5V input when this LED is red, it indicates that the watchdog timer has tripped.

DRIVE - MOTOR SETUP

The Turbo PMAC Clipper supports three types of outputs:

- Analog ±10V 12-bit Filtered PWM
- Analog ±10V 18-bit True DAC with Acc-8ES
- Pulse Frequency Modulation (PFM)

The following chart summarizes the steps to implement for setting up a motor properly with the Turbo 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 10 KHz low pass filter. This technique, although not as performing 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 Ixx69.

Both the resolution and the frequency of the Filtered PWM outputs are configured in software on the Turbo PMAC Clipper through the variable **I7000**. This variable also effects the phase and servo interrupts. Therefore as we change **I7000** we will also have to change **I7001** (phase clock divider), **I7002** (servo clock divider), and **I10** (servo interrupt time). These four variables are all related and must be understood before adjusting parameters. The detailed information for these parameters can be found in the Turbo Software Reference Manual.

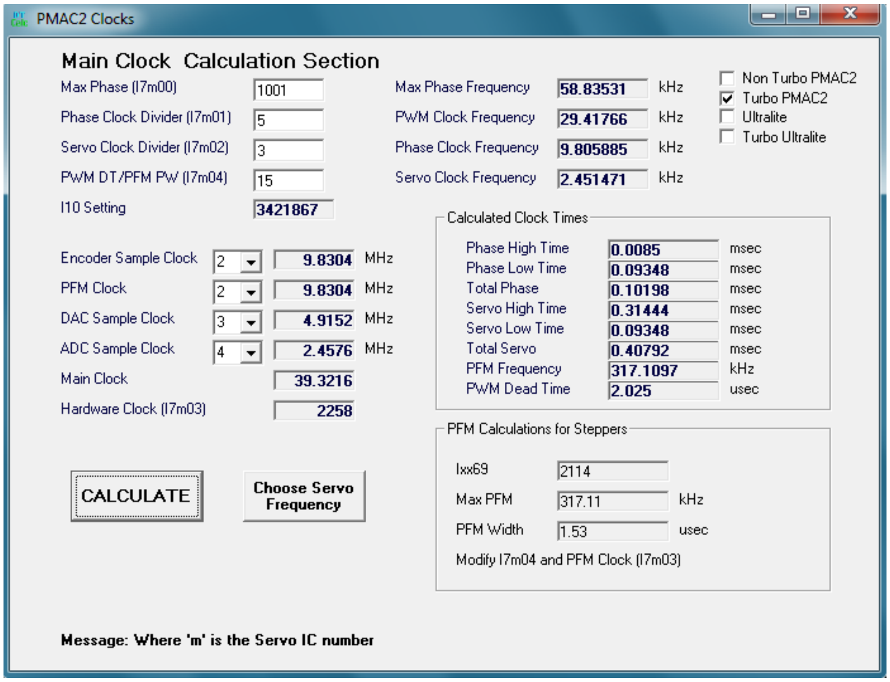
Note

- Filtered PWM Output Configuration sets the Max PWM frequency very high (29KHz). This setting can be problematic with Direct PWM commutation on the same servo IC.
- The ACC-28A and ACC-28B cannot be used on the same servo IC since the PWM frequency settings are out of range for these products.

Clock Settings, Output Mode, Command Limit

Most commonly used and suggested clock settings in this mode allowing a good compromise are a 29.4 KHz PWM Frequency, 9.8 KHz Phase, and 2.45 KHZ Servo.

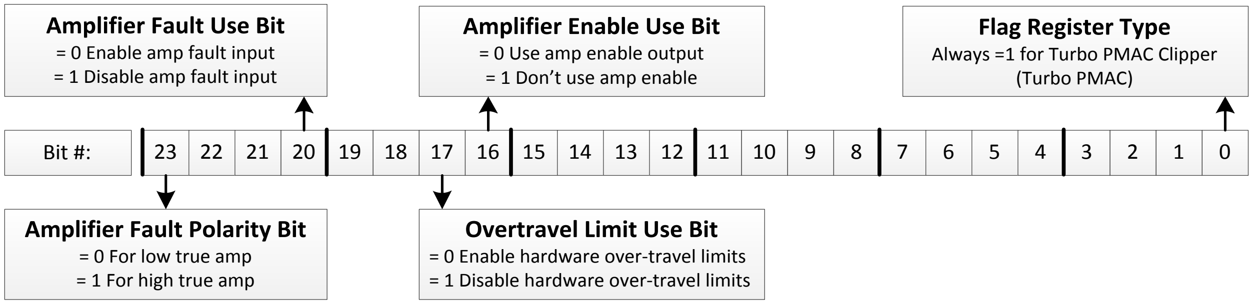
DT Calculator Link




```
I7000     = 1001       ; PWM Frequency 29.4 KHz, PWM 1-4
I7001     = 5          ; Phase Clock 9.8 KHz, Servo IC 0
I7002     = 3          ; Servo Clock 2.45 KHz, Servo IC 0
I7003     = 1746       ; ADC frequency, Servo IC 0

I7100     = 1001       ; PWM Frequency 29.4 KHz, PWM 5-8         (Acc-1P)
I7101     = 5          ; Phase Clock 9.8 KHz, Servo IC 1         (Acc-1P)
I7102     = 3          ; Servo Clock 2.45 KHz, Servo IC 1        (Acc-1P)
I7103     = 1746       ; ADC frequency, Servo IC 1               (Acc-1P)

I10       = 3421867    ; Servo Interrupt Time

I169,4,100 = 1001      ; DAC Limit 10 VDC
I7016,4,10 = 0         ; Output Mode, PWM axis 1-4 (Default)

I569,4,100 = 1001      ; DAC Limit 10 VDC                        (Acc-1P)
I7116,4,10 = 0         ; Output Mode, PWM axis 5-8 (Default)     (Acc-1P)
```

Flag Control, Ixx24

The following diagram showcases important bit settings pertaining to flags, and amplifier information:



Example:

Setting Ixx24 for a low true amplifier and disabling the over-travel limit switches yields $20001.

```
I124,4,100      = $20001
```

I2T Protection: Ixx57, Ixx58

I2T is a software thermal model (PMAC internal calculation) used to protect motor and drive from exceeding current specifications. For a safe setup, the lower limit of continuous and peak current specifications between the motor and drive should be selected.

Example:

A Turbo PMAC Clipper driving a torque-mode amplifier that has a gain of 3 amperes/volt and a continuous current rating of 10 amperes, with a motor rated to 12 amperes continuous.

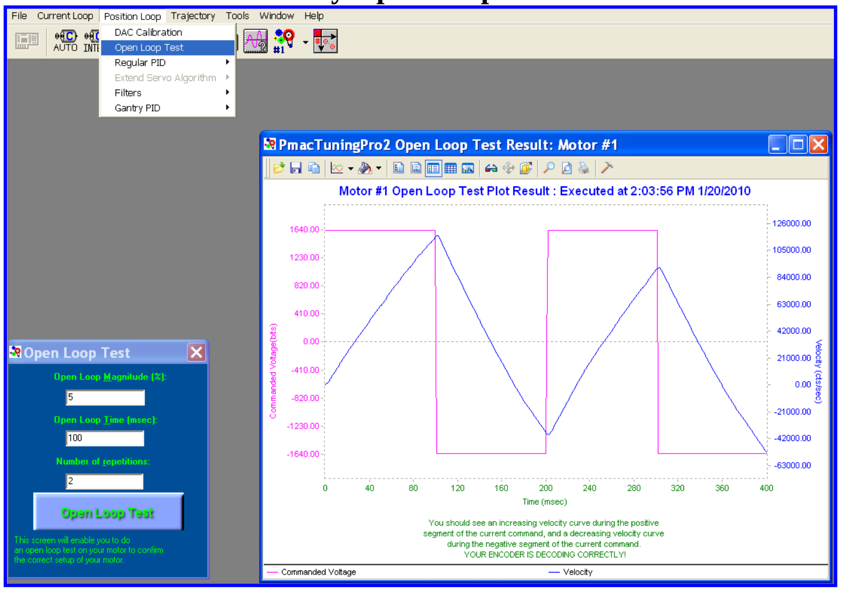
Using the amplifier's continuous current rating of 10 Amps:

```
#define ContCurrent    10      ; Continuous Current Limit [Amps] -User Input
#define MaxADC         30      ; full range ADC reading, Amplifier Spec. -User Input
#define I2TOnTime      2       ; Time allowed at peak Current, Amp/motor spec [sec] -User Input
#define ServoClk       2.45    ; Servo Clock, pre-defined in suggested clocks [Khz]

I157 = INT(I7000*ContCurrent/MaxADC)
I158 = INT((I7000*I7000-I157*I157)*ServoClk*1000*I2TOnTime/(I7000*I7000))
I257=I157      I357=I157      I457=I157      I557=I157
I657=I157      I757=I157      I857=I157
I258=I158      I358=I158      I458=I158      I558=I158
I657=I158      I757=I158      I857=I158
```

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 PMACTuningPro2 Software 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.

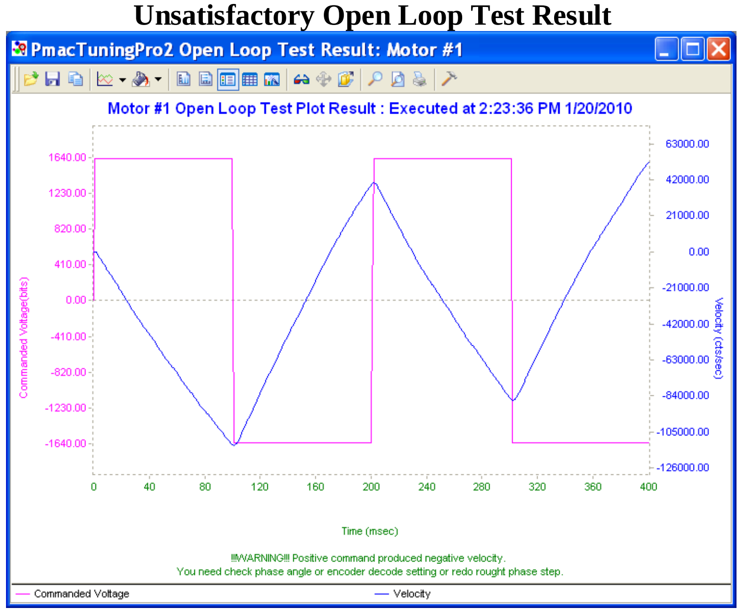
Satisfactory Open-Loop Test Result



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. #nO2) 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.

Unsatisfactory Open Loop Test Result



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.

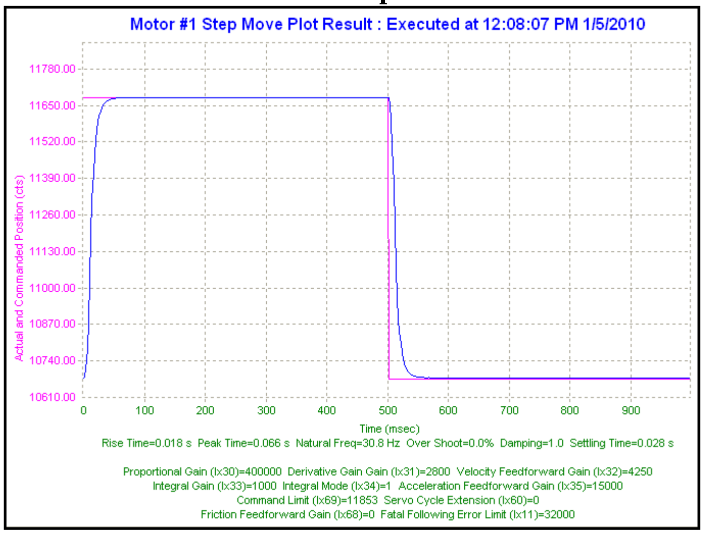
- Quadrature | Sinusoidal:
  Change I7mn0 to 3 from 7 (default) or vice-versa.
- Absolute Serial Encoders (EnDat, SSI, BiSS, Yaskawa, Panasonic, Tamagawa, Mitutoyo):
  The Turbo PMAC Clipper has no control on the direction sense of the serial data stream (packets). There are no software parameters that 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.

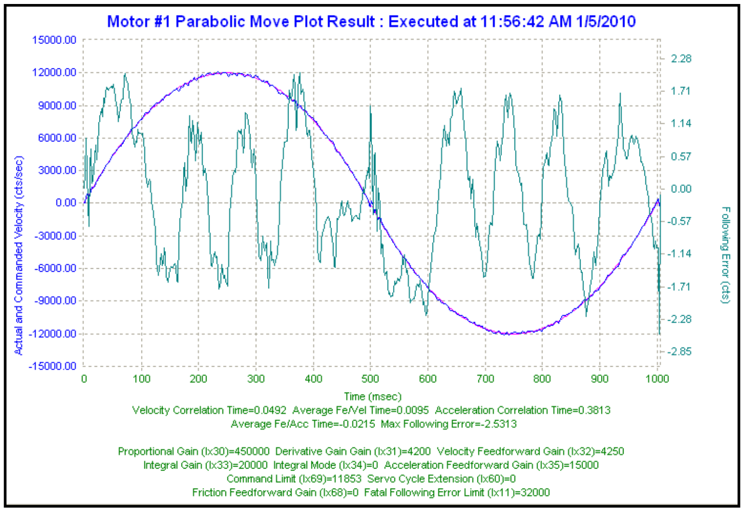
Position-Loop PID Gains: Ixx30…Ixx39

The position-loop tuning is done as in any Turbo PMAC PID-Loop setup. The PMACTuningPro2 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.

True DAC Output (±10V)

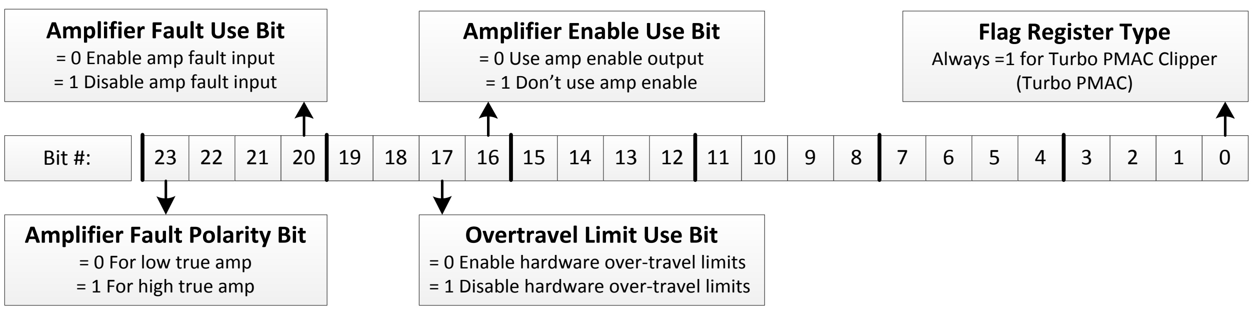
Clock Settings, Output Mode

Default Clock settings are suitable for most applications. Output mode is set to DAC. The following is a 4-channel true DAC setting's Turbo PMAC script code for a Turbo PMAC Clipper and Acc-8ES.

```
I7000     = 6527        ; Servo IC 0 PWM Frequency 4.5 KHz, Max Phase Frequency 9 KHz
I7001     = 0           ; Servo IC 0 Phase Clock 9 Khz
I7002     = 3           ; Servo IC 0 Servo Clock 2.25

I10       = 3713991     ; Servo Interrupt Time

I7016,4,10 = 3          ; Output Mode, DAC axis 1-4
I7005     = $7FFFC0     ; Servo IC 0 DAC Strobe, 18-bits DAC circuit for Acc-8ES
```

Flag Control, Ixx24

The following diagram showcases important bit settings pertaining to flags, and amplifier information:



Example:
Setting Ixx24 for a low true amplifier and disabling the over-travel limit switches yields $20001.

```
I124,4,100      = $20001
```

I2T Protection: Ixx57, Ixx58

I2T is a software thermal model (PMAC internal calculation) used to protect motor and drive from exceeding current specifications. For a safe setup, the lower limit of continuous and peak current specifications between the motor and drive should be selected.

Example:
A Turbo PMAC Clipper driving a torque-mode amplifier that has a gain of 3 amperes/volt and a continuous current rating of 10 amperes, with a motor rated to 12 amperes continuous.

Using the amplifier's continuous current rating of 10 Amps:

```
#define ContCurrent    10      ; Continuous Current Limit [Amps] -User Input
#define MaxADC         30      ; full range ADC reading, Amplifier Spec. -User Input
#define I2TOnTime      2       ; Time allowed at peak Current, Amp/motor spec [sec] -User Input
#define ServoClk       2.25    ; Servo Clock [Khz]

I157 = INT(I7000*ContCurrent/MaxADC)
I158 = INT((I7000*I7000-I157*I157)*ServoClk*1000*I2TOnTime/(I7000*I7000))
I257=I157       I357=I157       I457=I157       I557=I157
I657=I157       I757=I157       I857=I157
I258=I158       I358=I158       I458=I158       I558=I158
I657=I158       I757=I158       I857=I158
```

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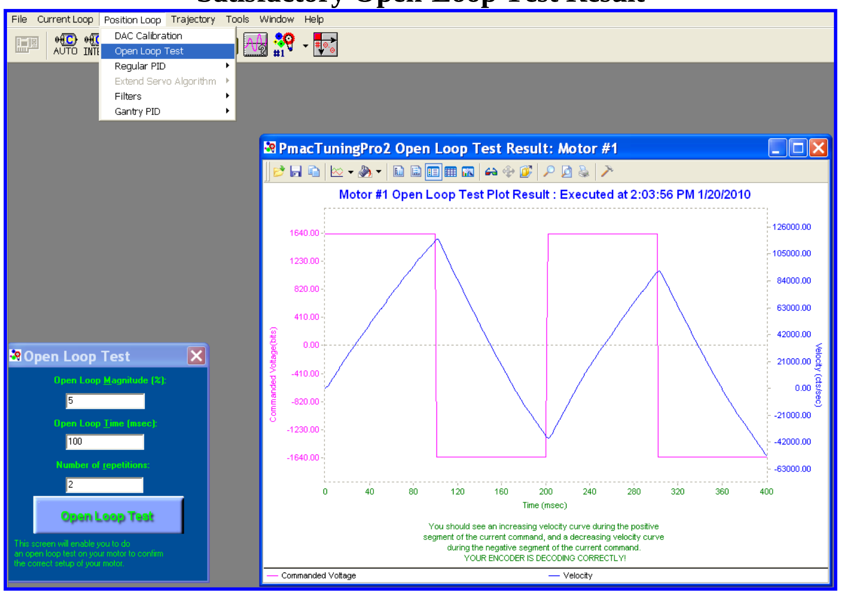
The open-loop test is critical to verify the direction sense of the encoder counting versus the command output. A positive command should create a positive velocity and a position counting in the positive direction; a negative command should create a negative velocity and a position counting in the negative direction. The Open Loop test utility in the PMACTuningPro2 Software 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



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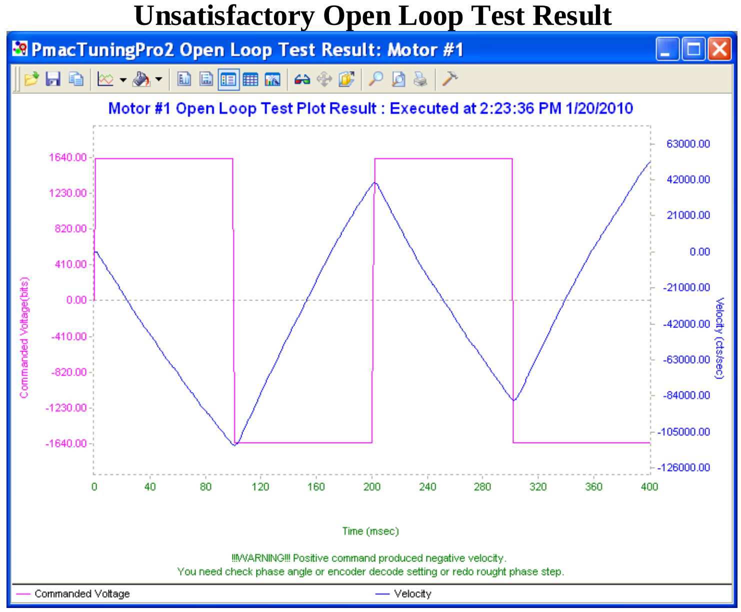
If the failure persists (inverted saw tooth, as shown in the plot), or you observe oscillations in the response instead of a saw tooth, then most likely the direction sense of the encoder is opposite to the command output.

Unsatisfactory Open Loop Test Result



General recommendation for troubleshooting an unsuccessful open loop test

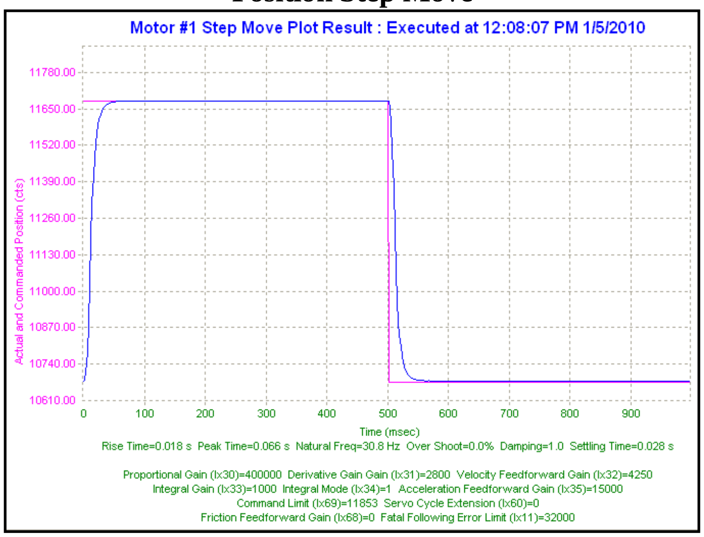
An inverted saw tooth response, most times, indicates that the direction sense of the encoder is opposite to that of the command output.

- Quadrature | Sinusoidal:
  Change I7mn0 to 3 from 7 (default) or vice-versa.
- Absolute Serial Encoders (EnDat, SSI, BiSS, Yaskawa, Panasonic, Tamagawa, Mitutoyo):
  The Turbo 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.
  .

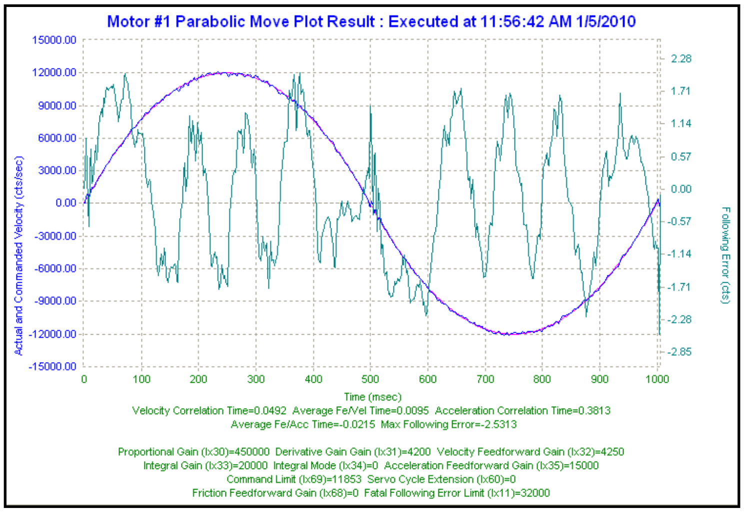
Position-Loop PID Gains: Ixx30…Ixx39

The position-loop tuning is done as in any Turbo PMAC PID-Loop setup. The PMACTuningPro2 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



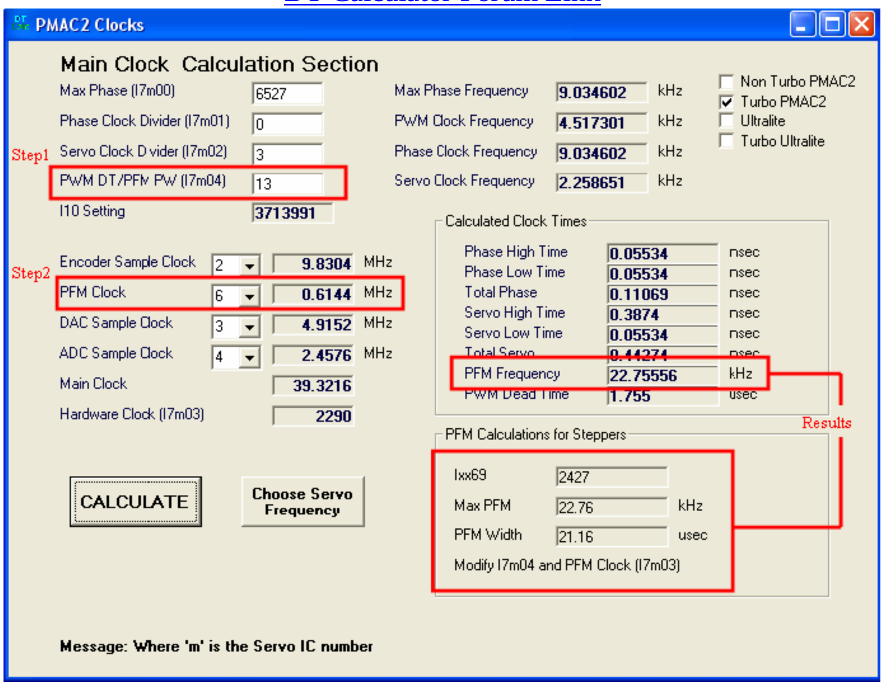
Note

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

Pulse and Direction Output (PFM)

The Pulse and direction (**P**ulse **F**requency **M**odulation) output pins are located on the J4 (JMACH2) connector. The stepper drive specifications dictate the choice of the maximum PFM clock frequency, and pulse width.

DT Calculator Forum Link



Step 1: Choose Max PFM clock by changing the PFM clock divider. Click on calculate to see results.
Step 2: Choose PFM Pulse width by changing I7m04. Click on calculate to see results.

The output frequency control Ixx69 specifies the maximum command output value which corresponds to the maximum PFM Frequency.

PFM Clock Settings Example

Take a desired PFM clock frequency of 0-20 KHz, and a pulse width of ~20 μsec:

```
// Channels 1-4 PFM Clock Settings
I7003       = 2290      ; Servo IC 0 PFM Clock divider equal to 6
I7004       = 13        ; Servo IC 0 PFM Pulse Width Control equal to 13
I169,4,100 = 2427      ; Channels 1-4 Output Command Limit

// Channels 5-8 PFM Clock Settings
I7103       = 2290      ; Servo IC 1 PFM Clock divider equal to 6         (First Acc-1P)
I7104       = 13        ; Servo IC 1 PFM Pulse Width Control equal to 13  (First Acc-1P)
I569,4,100 = 2427      ; Output Command Limit                            (First Acc-1P)

// Channels 9-12 PFM Clock Settings
I7203       = 2290      ; Servo IC 2 PFM Clock divider equal to 6         (Second Acc-1P)
I7204       = 13        ; Servo IC 2 PFM Pulse Width Control equal to 13  (Second Acc-1P)
I969,4,100 = 2427      ; Output Command Limit                            (Second Acc-1P)
```

Note

The following example assumes that there is no encoder attached to the motor, and the feedback is internally generated.

PFM Setup Example

```
// Encoder Conversion Table, for channels 1-4
I8000=$C78000          ; Entry 1 incremental encoder, no extension
I8001=$C78008          ; Entry 2 incremental encoder, no extension
I8002=$C78010          ; Entry 3 incremental encoder, no extension
I8003=$C78018          ; Entry 4 incremental encoder, no extension

// Channels 1-4 Output Mode Select, Encoder/Decode
I7016,4,10 = 3 ; Servo IC 0, Channels 1-4 Output Mode Select to PFM
I7010,4,10 = 8 ; Servo IC 0, Channels 1-4 Encoder Decode, Internal Pulse and Direction

// Channels 1-4 Command Output Register
I102=$78004            ; Channel 1, PFM
I202=$7800c            ; Channel 2, PFM
I302=$78014            ; Channel 3, PFM
I402=$7801C            ; Channel 4, PFM

// Encoder Conversion Table, for channels 5-8
I8004=$C78100          ; Entry 5 incremental encoder, no extension         (First Acc-1P)
I8005=$C78108          ; Entry 6 incremental encoder, no extension         (First Acc-1P)
I8006=$C78110          ; Entry 7 incremental encoder, no extension         (First Acc-1P)
I8007=$C78118          ; Entry 8 incremental encoder, no extension         (First Acc-1P)

// Channels 5-8 Output Mode Select, Encoder/Decode
I7116,4,10 = 3 ; Servo IC 1, Channels 5-8 Output Mode Select to PFM        (First Acc-1P)
I7110,4,10 = 8 ; Servo IC 1, Channels 5-8 Encoder Decode, Internal Pulse and Dir.  (First Acc-1P)

// Channels 5-8 Command Output Register
I502=$78104            ; Channel 5, PFM                                    (First Acc-1P)
I602=$7810C            ; Channel 6, PFM                                    (First Acc-1P)
I702=$78114            ; Channel 7, PFM                                    (First Acc-1P)
I802=$7811C            ; Channel 8, PFM                                    (First Acc-1P)

// Encoder Conversion Table, for channels 9-12
I8008=$C79200          ; Entry 9 incremental encoder, no extension         (Second Acc-1P)
I8009=$C79208          ; Entry 10 incremental encoder, no extension        (Second Acc-1P)
I8010=$C79210          ; Entry 11 incremental encoder, no extension        (Second Acc-1P)
I8011=$C79218          ; Entry 12 incremental encoder, no extension        (Second Acc-1P)

// Channels 9-12 Output Mode Select, Encoder/Decode
I7216,4,10 = 3 ; Servo IC 2, Channels 9-12 Output Mode Select to PFM       (Second Acc-1P)
I7210,4,10 = 8 ; Servo IC 2, Channels 9-12 Encoder Decode, Internal Pulse and Dir.(Second Acc-1P)

// Channels 9-12 Command Output Register
I902=$78204            ; Channel 9, PFM                                    (Second Acc-1P)
I1002=$7820C           ; Channel 10, PFM                                   (Second Acc-1P)
I1102=$78214           ; Channel 11, PFM                                   (Second Acc-1P)
I1202=$7821C           ; Channel 12, PFM                                   (Second Acc-1P)
```

In PFM mode, it is possible to:

- Write directly to the PFM output register using the suggested M-Variable definition (Mxx07)
  The corresponding channel has to be deactivated in this mode (Ixx00=0)
- Issue open loop commands to a channel/motor, e.g.:#1O5
  The corresponding channel has to be activated in this mode (Ixx00=1)
- Issue closed loop commands to a channel/motor, e.g.: #1J=1000
  The corresponding channel has to be activated (Ixx00=1) and the position loop PID gains have to be implemented.

Writing directly to the PFM register

```
// Channels 1-4 Suggested M-Variables, PFM command output
M107->Y:$78004,8,16,S  ; Channel 1, Min=0, Max= Calculated I169
M207->Y:$7800C,8,16,S  ; Channel 2, Min=0, Max= Calculated I269
M307->Y:$78014,8,16,S  ; Channel 3, Min=0, Max= Calculated I369
```

```
M407->Y:$7801C,8,16,S  ; Channel 4, Min=0, Max= Calculated I469

// Channels 5-8 Suggested M-Variables, PFM command output
M507->Y:$78104,8,16,S  ; Channel 5, Min=0, Max= Calculated I569            (First Acc-1P)
M607->Y:$7810C,8,16,S  ; Channel 6, Min=0, Max= Calculated I669            (First Acc-1P)
M707->Y:$78114,8,16,S  ; Channel 7, Min=0, Max= Calculated I769            (First Acc-1P)
M807->Y:$7811C,8,16,S  ; Channel 8, Min=0, Max= Calculated I869            (First Acc-1P)

// Channels 9-12 Suggested M-Variables, PFM command output
M907->Y:$78204,8,16,S  ; Channel 9, Min=0, Max= Calculated I969            (Second Acc-1P)
M1007->Y:$7820C,8,16,S ; Channel 10, Min=0, Max= Calculated I1069          (Second Acc-1P)
M1107->Y:$78214,8,16,S ; Channel 11, Min=0, Max= Calculated I1169          (Second Acc-1P)
M1207->Y:$7821C,8,16,S ; Channel 12, Min=0, Max= Calculated I1269          (Second Acc-1P)
```

Writing directly to the suggested M-variable(s) values proportional to Ixx69 produces corresponding frequencies:

Suggested M-Variable	Output Frequency PFM [KHz]
0	0
1213	11
2427	22

Issuing Open-Loop Commands

Activating the motor channel should be sufficient at this point to allow open loop commands. Note that an open loop command of zero magnitude (#nO0) will result in a zero frequency output, and an open loop command of 100 (#nO100) will result in the maximum calculated frequency output.

```
I100,4,100=1   ; Channels 1-4 active
I500,4,100=1   ; Channels 5-8 active                                       (First Acc-1P)
I900,4,100=1   ; Channels 9-12 active                                      (Second Acc-1P)
```

Going back to the setup example, these are some open loop commands resulting frequencies:

Open Loop Command	Output Frequency PFM [KHz]
0	0
50	11
100	22

Issuing Closed-Loop Commands

Issuing closed-loop commands requires activating the channel, setting the flag control, assigning the position and velocity pointers, and implementing PID gains.

Activating channels, Ixx00

```
I100,4,100=1   ; Channels 1-4 active
I500,4,100=1   ; Channels 5-8 active                                       (First Acc-1P)
I900,4,100=1   ; Channels 9-12 active                                      (Second Acc-1P)
```

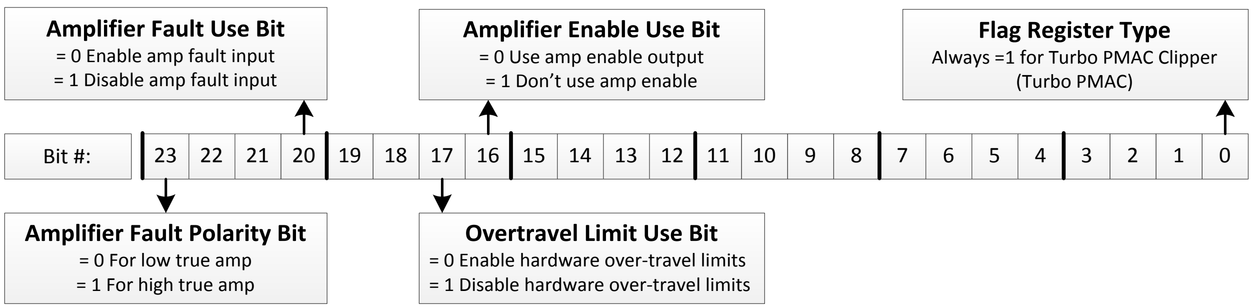
Assigning position and velocity pointers, Ixx03 and Ixx04

```
I103=$3501 I104=$3501             ; Channel 1 position and velocity pointers
I203=$3502 I204=$3502             ; Channel 2 position and velocity pointers
I303=$3503 I304=$3503             ; Channel 3 position and velocity pointers
I403=$3504 I404=$3504             ; Channel 4 position and velocity pointers

I503=$3505 I504=$3505             ; Channel 5 position and velocity pointers   (First Acc-1P)
```

```
I603=$3506 I604=$3506              ; Channel 6 position and velocity pointers   (First Acc-1P)
I703=$3507 I704=$3507              ; Channel 7 position and velocity pointers   (First Acc-1P)
I803=$3508 I804=$3508              ; Channel 8 position and velocity pointers   (First Acc-1P)

I903=$3509 I904=$3509              ; Channel 9 position and velocity pointers  (Second Acc-1P)
I1003=$350A I1004=$350A            ; Channel 10 position and velocity pointers (Second Acc-1P)
I1103=$350B I1104=$350B            ; Channel 11 position and velocity pointers (Second Acc-1P)
I1203=$350C I1204=$350C            ; Channel 12 position and velocity pointers (Second Acc-1P)
```

Flag Control, Ixx24

The following diagram showcases important bit settings pertaining to flags, and amplifier information:



Example:

Setting Ixx24 for a low true amplifier, disabling the over-travel limits and amplifier fault input yields $120001.

```
I124,4,100 = $120001               ; Channels 1-4
I524,4,100 = $120001               ; Channels 5-8                     (First Acc-1P)
I924,4,100 = $120001               ; Channels 9-12                    (Second Acc-1P)
```

Implementing PID gains, Ixx30..Ixx35

In PFM mode, the PID Gains can be determined using the following empirical equations:

$$\text{Ixx30} = \frac{660000}{\text{Ixx08} \times \text{PFM CLock[MHz]}}$$

$$\text{Ixx31} = 0$$

$$\text{Ixx32} = 6660 \times \text{Servo Freq.[KHz]}$$

$$\text{Ixx33..Ixx35} = 0$$

```
// Channels 1-4 PID Gains (with default clock settings):
I130,4,100 = 11190     ; Motors 5-8 Proportional Gain
I131,4,100 = 0         ; Motors 5-8 Derivative Gain
I132,4,100 = 15038     ; Motors 5-8 Velocity FeedForward Gain
I133,4,100 = 0         ; Motors 5-8 Integral Gain
I134,4,100 = 0         ; Motors 5-8 Integral Mode
I135,4,100 = 0         ; Motors 5-8 Acceleration FeedForward Gain

// Channels 5-8 PID Gains (with default clock settings):
I530,4,100 = 11190     ; Motors 5-8 Proportional Gain                 (First Acc-1P)
I531,4,100 = 0         ; Motors 5-8 Derivative Gain                   (First Acc-1P)
I532,4,100 = 15038     ; Motors 5-8 Velocity FeedForward Gain         (First Acc-1P)
I533,4,100 = 0         ; Motors 5-8 Integral Gain                     (First Acc-1P)
I534,4,100 = 0         ; Motors 5-8 Integral Mode                     (First Acc-1P)
I535,4,100 = 0         ; Motors 5-8 Acceleration FeedForward Gain     (First Acc-1P)
```

```
// Channels 9-12 PID Gains (with default clock settings):
I930,4,100 = 11190     ; Motors 9-12 Proportional Gain                    (Second Acc-1P)
I931,4,100 = 0         ; Motors 9-12 Derivative Gain                      (Second Acc-1P)
I932,4,100 = 15038     ; Motors 9-12 Velocity FeedForward Gain            (Second Acc-1P)
I933,4,100 = 0         ; Motors 9-12 Integral Gain                        (Second Acc-1P)
I934,4,100 = 0         ; Motors 9-12 Integral Mode                        (Second Acc-1P)
I935,4,100 = 0         ; Motors 9-12 Acceleration FeedForward Gain        (Second Acc-1P)
```

Note

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

Setup of a Fifth Motor Using Opt-12 on the Clipper Board

The DSPGATE2A supplemental channels are set with I6800-6807. Set these to the same values as specified for the filtered PWM outputs (leave I6804-I6807 at default).
Example Turbo PMAC script code for motor 5:

```
I6800  = 1001  ; PWM frequency 29.4kHz, PWM 1-4
I6801  = 5     ; Phase Clock 9.8kHz
I6802  = 3     ; Servo frequency 2.45kHz
I6803  = 1746  ; ADC frequency
I6816  = 0     ; Output mode: PWM, I68n6
I569   = 1001  ; Channel 5 DAC limit 10Vdc, Ixx69
```

The encoder decode I-variables are I68n0-68n9 (n = supplementary channels 1 and 2). Set these for your encoders as normal. Note there are no direct inputs for flags so capture I-variables are not used. The Output Command Registers (Ixx02) now must point to the DSPGATE2A 3rd Channel Outputs at $78414 and $7841C first and second supplemental registers respectively. The addresses of the DSPGATE2A Counters/Timers used in the encoder conversion table are $78410 and $78418 first and second supplementary registers respectively. When using the OPT-12 filtered PWM DAC on the hand-wheel port use the second output at $7841C. The encoder counter registers are at:

Mxx->X:$78411,0,24,s // first counter register
Mxx->X:$78419,0,24,s // second counter register

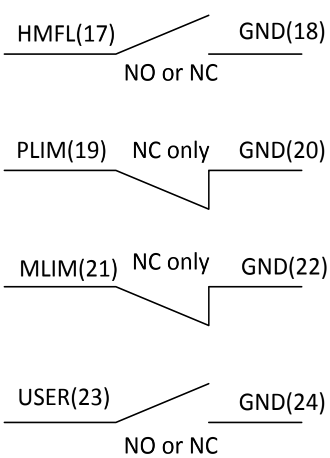
Flags access through JOPTO port.
The OPT-12 channel may also access its machine I/O such as the overtravels, home, and fault flags for one motor only. This is done through the JOPTO I/O lines (J9), by changing their function so that they would act as Home / Pos / Neg / User flags for only the first channel of the two supplemental channels; there are no flags for the second channel since these pins of the general I/O port of the PMAC2 gate2 are not brought out in this board. The following example sets up the OPT-12 for two motors (#9 and #10) of pulse and direction control with full machine I/O on motor #9.

Wiring example:

Flag Inputs	Port	Pin
HMFL1	J9	17
PLIM1	J9	19
MLIM1	J9	21
USER1	J9	23

Command Output	Port	Pin
PUL1+	J10	11
PUL1-	J10	12
DIR1+	J10	13
DIR1-	J10	14

Jumpers Settings	
E16	Install
E17	Remove



The equivalent Turbo PMAC script code Settings:

```
M32->X:$78400,0,8  ; Direction Control bits 0-7 (1=output, 0 = input)
M34->X:$78400,8,8  ; Direction Control bits 8-15 (1=output, 0 = input)
M40->X:$78404,0,24 ; Inversion control (0 = 0V, 1 = 5V)
M42->Y:$78404,0,24 ; J9 port data type control (1 = I/O)

//Power-up PLC:
Open plc 1 clear
M32 = $00            ; IO 1/8 inputs
M34 = $FF            ; IO 9/16 Outputs
M40 = $0             ; Do not invert anything
M42 = $FF0F          ; 1~4 GP I/O   5~8 flags   9~16 GP I/O
Disable plc 1
Close

I925=$78410        ; mot #9
I1025=$78418       ; mot #10 for this motor use I1024=$520001 to disable amp
                   ; fault and overtravel limits
I902  = $78414     ; mot #9
I1002 = $7841C     ; mot #10
I6810 = 8          ; Internal pulse and direction     ;mot #9
I6816 = 3          ; PFM on C
I6820 = 8          ; Internal pulse and direction     ;mot #10
I6826 = 3          ; PFM on C
```

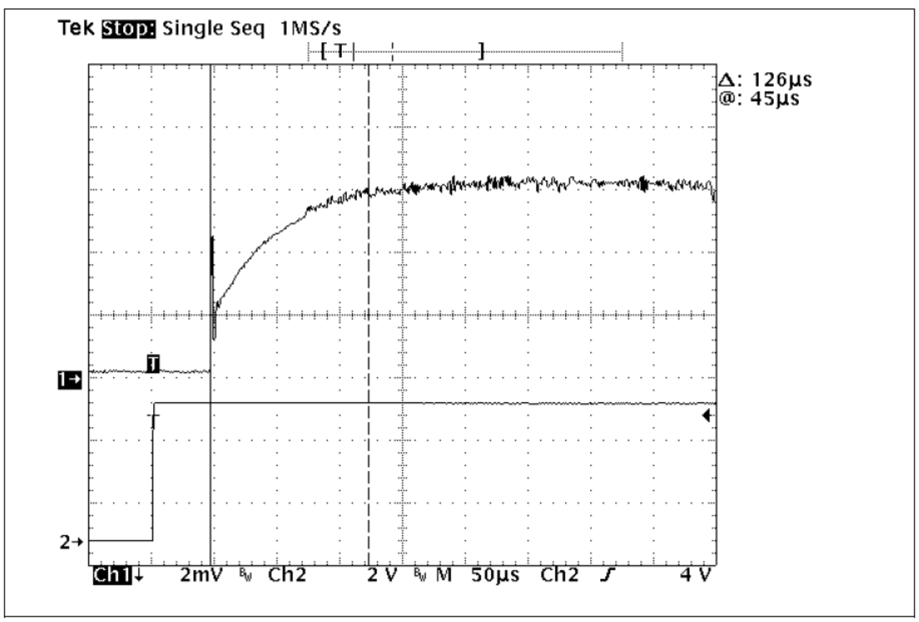
For motor #9 use I903 and I904 appropriate ECT entry performing a “No extension of quadrature encoder” pointing to $78410. For motor #10 use I1003 and I1004 appropriate ECT entry performing a “No extension of quadrature encoder” pointing to $78418.

LASER CONTROL OUTPUT

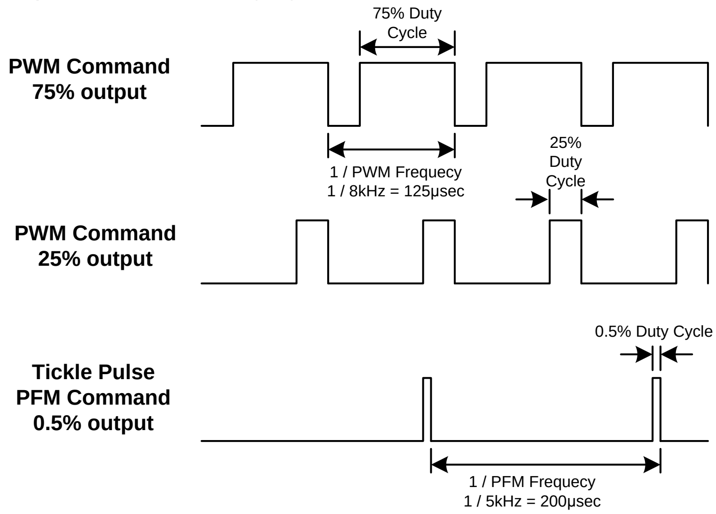
Clipper's Option 11 consists of a programmable lattice chip which can be programmed based upon customer's requirements. The main objective for this option is to be used as a laser controller. Different programs can be loaded in this chip based upon customers' requirements and each code will be designated an alpha-numeric suffix after options number if the code is developed by Delta Tau and can be ordered at a later time with the same suffix.
Clipper's option-11A is developed as a general command signal needed for CO2 lasers. Usually CO2 lasers require a few digital I/O signals in order to control the status and mode of the laser and a control signal, which based upon the signal features controls the output power of the laser. The laser can be in a few different modes:

- Disabled
- Standby
- Active

Controlling between disabled mode and other modes is usually done through a digital output, either directly if the device is TTL level or it would have to be done through a relay system. The difference between the "Standby" mode and "Active" mode is because of the signal type and shape. Usually in order to control the output power of the laser, a PWM (Pulse Width Modulation) signal is used and the positive duty cycle of the signal indicates the output power of the laser, varying from 0 to 100%. However, in order to ensure immediate response from the laser when an output is required, the gas needs to be kept ionized. This can be achieved by outputting a PFM signal. The frequency and duty cycle required for each of these modes differs based on the laser model and size and should be adjusted accordingly.
Assuming the following graph is the laser output response to a step command, the frequency of the modulation can be selected.



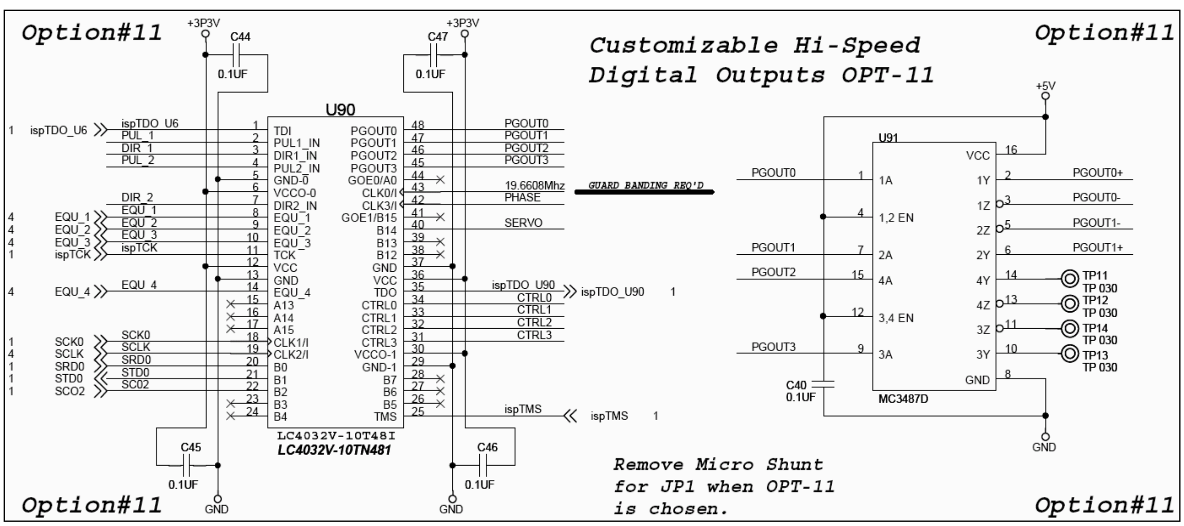
As you can see, the rise time for the laser is about 126µsec. This means in order for our modulation to fully cover the 0 to 100% range of the output, the frequency should be set close to 1/126µsec = 7936 Hz or 8kHz. The tickle pulse is required in order to reduce the time between the change of command to PWM and actual output of the laser. However calculating the signal requirements for the Tickle pulse is dependent on the laser and differs for different manufacturers. For example the laser shown in the above graph, requires a 5kHz signal with 0.5% duty cycle as its Tickle pulse.



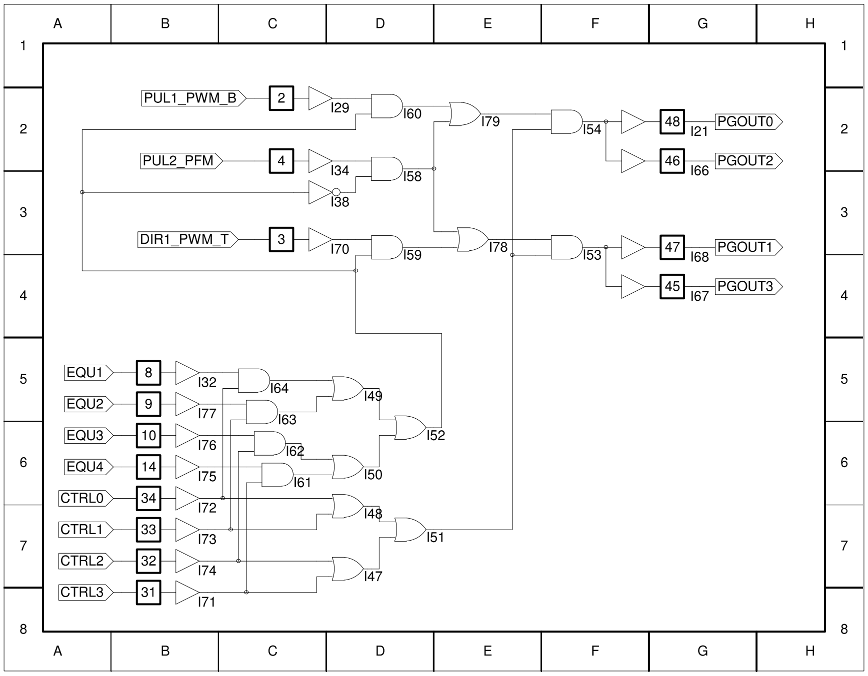
In the next section we will use this laser specific information to set up Option-11A. Please note that the values and settings here are just an example and your values might be different. Please refer to your laser documentation or contact the manufacturer for detailed information about your specific laser.

Understanding Option-11A Capabilities

Option-11A has been programmed to include a few logical gates controlling the output signals. In general there are a few signals available from the Clipper as inputs to the Lattice chip.



The following logic circuit is programmed as the Option-11A into the Lattice chip:



As you can see, the idea is to switch the output between PWM_B signal and PFM signal based upon either of the EQU outputs. EQU outputs are fast responding outputs which can either be activated manually or based upon position compare feature of the PMAC. CTRL outputs control which of the EQUs or what combination of EQUs will be used to control the output mode.
As an example, if a user wants to use EQU1 to switch between the Tickle pulse (PFM) and Output mode (PWM), then CTRL0 must be turned on. As a safety measure, no output will be generated unless at least one of the CTRL outputs is set to 1.

Clock Settings

The clock used for PWM is related to the Max Phase Clock, which is used to generate the Phase and Servo clock, selecting an appropriate PWM frequency which satisfies both the laser requirements and servo requirements can be challenging, especially if user is trying to use Filtered PWM outputs as DAC outputs for amplifier commands.

In most of the applications, the PWM frequency is a set value and is not change at all, however in some applications this is not the case and the PWM has to change based upon the material being cut or worked on. If you are required to change the PWM based upon the material, you won't be able to use the filtered PWM outputs directly available from the Clipper board and you have to use ACC-8ES (Analog Servo Interface) in order to get the DAC outputs for servo amplifier commands.
If the PWM frequency required for the laser is less than 30kHz required for the Filtered PWM outputs, which mostly is the case, then the PWM frequency of the DSPGate1 (30kHz) should be divisible by PWM frequency of the DSPGate2 which is used for generating the laser output signal. The clock source on the Clipper, by default, is the DSPGate1, which in this case needs to be changed to DSPGate2. In order to change the clock source, the following steps should be followed carefully in exact explained order or else you may cause a watchdog.
Switching the clock source:

1. Set **I19=6807**.

2. Issue **SAVE** and **$$$**.

3. Set **I6807=0** and **I7007=3** on the same line.

4. Issue **SAVE** and **$$$**.

This will change the clock source from DSPGate1 to DSPGate2. Once the clock source is switched, the following settings will give you different PWM frequencies on the laser output while keeping the 30 kHz PWM requirement for Filtered PWM outputs:

Laser Required PWM Frequecy (kHz)	10.01569027
Filtered PWM Frequecy (kHz)	**30.0165**
Phase Clock Divider	1
Servo Clock Divider	5
Phase Clock (kHz)	20.03138
Servo Clock (kHz)	4.006276

Settings

```
I6800 = 2943
I6801 = 0
I6802 = 4

I7000 = 981
I7001 = 2
I7002 = 4
```

Controlling the output

This section includes the memory address settings that you would need in order to change the PWM duty cycle, PFM frequency, EQU output mode and EQU selection.

Note

Please Set **I28=1** and issue a **SAVE** and **$$$** before the following settings become active. The I28=1 will disable the DISPLAY output port which in this case will over-write the CTRL outputs.

```
#define CTRL0   M7000
#define CTRL1   M7001
#define CTRL2   M7002
#define CTRL3   M7003

#define PWM     M7004
#define PFM     M7005

#define CTRL_TYP  M7006
#define CTRL_INV  M7007
#define CTRL_DAT  M7008
#define CTRL_DIR  M7009

#define PWM_CMD_VAL  M7010
#define PFM_CMD_VAL  M7011

#define EQU1_ON   M112=1M111=1
#define EQU1_OFF  M112=0M111=1
#define EQU2_ON   M212=1M211=1
```

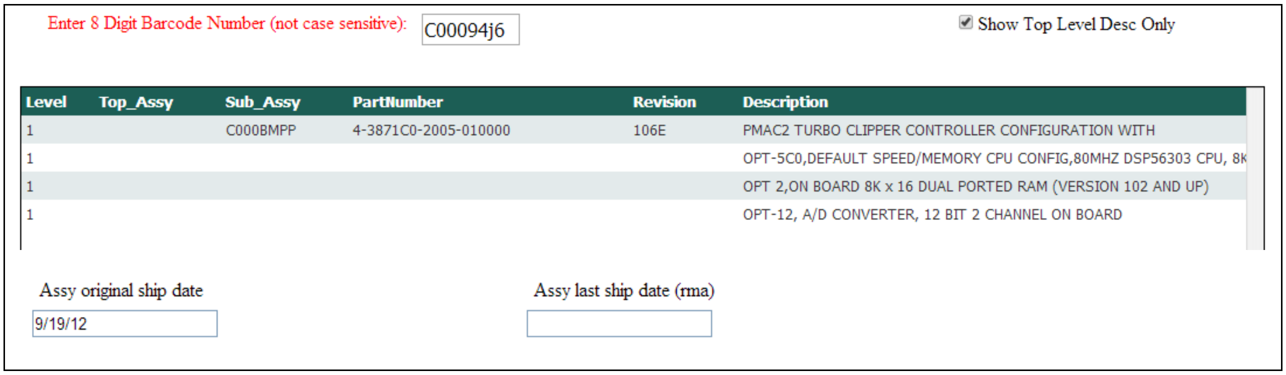
```
#define EQU2_OFF  M212=0M211=1
#define EQU3_ON   M312=1M311=1
#define EQU3_OFF  M312=0M311=1
#define EQU4_ON   M412=1M411=1
#define EQU4_OFF  M412=0M411=1

CTRL_TYP->Y:$078407,8,4
CTRL_INV->X:$078407,8,4
CTRL_DAT->Y:$078403,8,4
CTRL_DIR->X:$078403,8,4

PWM_CMD_VAL->Y:$078414,8,16,S
PFM_CMD_VAL->Y:$07841C,0,24,S

M111->X:$078005,11 ; ENC1 compare initial state write enable
M112->X:$078005,12 ; ENC1 compare initial state
M116->X:$078000,9 ; ENC1 compare output value

M211->X:$07800D,11 ; ENC2 compare initial state write enable
M212->X:$07800D,12 ; ENC2 compare initial state
M216->X:$078008,9 ; ENC2 compare output value

M311->X:$078015,11 ; ENC3 compare initial state write enable
M312->X:$078015,12 ; ENC3 compare initial state
M316->X:$078010,9 ; ENC3 compare output value

M411->X:$07801D,11 ; ENC4 compare initial state write enable
M412->X:$07801D,12 ; ENC4 compare initial state
M416->X:$078018,9 ; ENC4 compare output value

Open PLC 1 Clear
CTRL_DIR=$F
CTRL_DAT=$1
CTRL_TYP=$F
CTRL_INV=$0
I6816=0   ;PWM OUTPUT ON 1st Supplimental Channel
I6826=3   ;PFM Output on 2nd Supplimental Channel
Disable PLC 1
Close

PWM_CMD_VAL = 0          ; represents 50% duty cycle
PFM_CMD_VAL = 3000       ; Changes PFM frequency
```

Based upon the settings above you can change the PWM duty cycle by changing the value of `PWM_CMD_VAL` and the PFM frequency by changing `PFM_CMD_VAL`. The duty cycle of the PFM signal however will be changed based upon I6804 and I6803 settings.
PFM width = I6804 / PFM Clock
The EQU can be turned on and off manually to switch the output mode:
EQU on: M112=1 M111=0
EQU off: M112=0 M111=0
Also, Position Compare function can be used to control the EQU output. Please refer to Turbo User's Manual for detailed information about position compare functionality and settings.

TROUBLESHOOTING

Serial Number and Board Revisions Identification

The following **Serial Number Page** provides the users with information about their Turbo PMAC Clipper without having to open the enclosure by simply inserting the serial number and pressing the enter key:


Enter 8 Digit Barcode Number (not case sensitive): C00094j6

Show Top Level Desc Only

Level	Top_Assy	Sub_Assy	PartNumber	Revision	Description
1		C000BMPP	4-3871C0-2005-010000	106E	PMAC2 TURBO CLIPPER CONTROLLER CONFIGURATION WITH
1					OPT-5C0,DEFAULT SPEED/MEMORY CPU CONFIG,80MHZ DSP56303 CPU, 8K
1					OPT 2,ON BOARD 8K x 16 DUAL PORTED RAM (VERSION 102 AND UP)
1					OPT-12, A/D CONVERTER, 12 BIT 2 CHANNEL ON BOARD

Assy original ship date: 9/19/12

Assy last ship date (rma):

This page will display:

- Description and part number of the top assembly (Turbo PMAC Clipper)
- Part numbers and revision numbers of the sub-assembly boards
- Top assembly original ship date
- Top assembly last ship date (e.g. if it has ever been back for repair)

Note

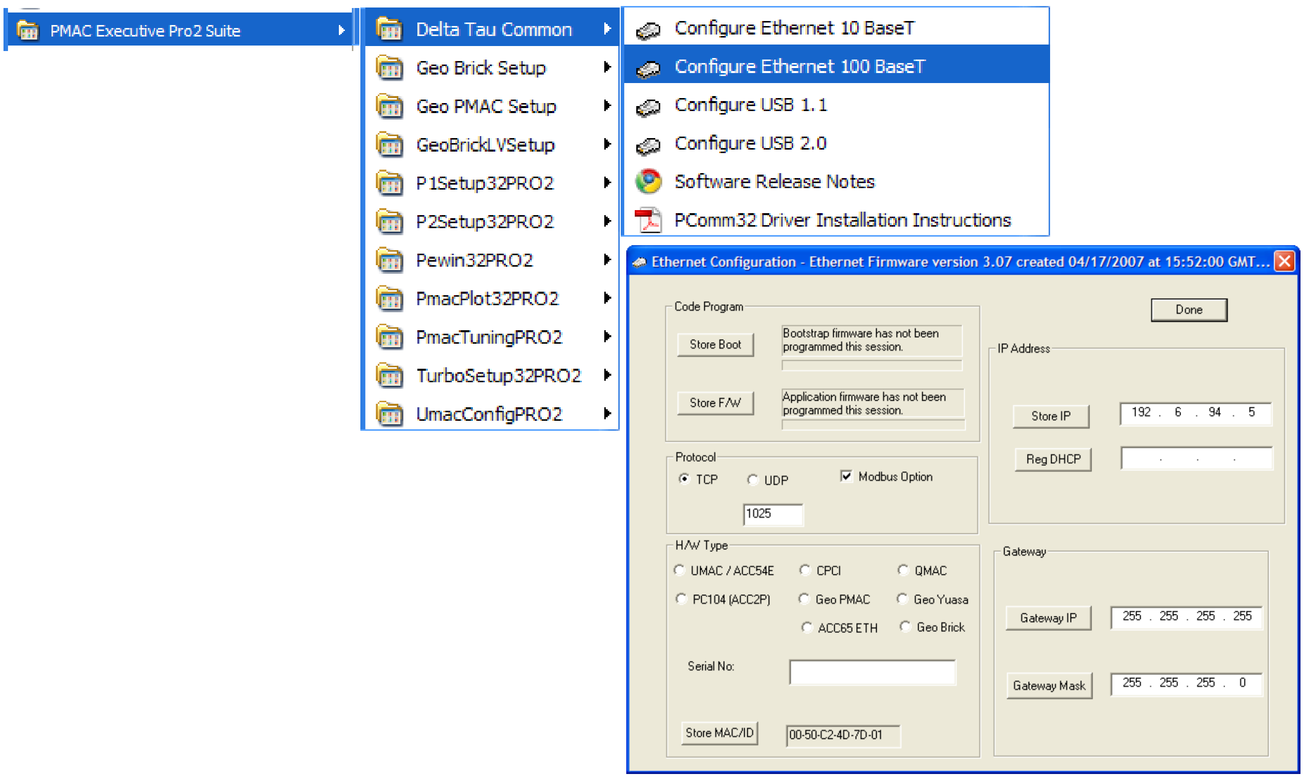
This page is strictly for identification purposes. Some information may not be meaningful to the user and pertains to Delta Tau's internal use only.

Write-Protect Disable – E8 Jumper

The E8 jumper is disabling the USB/Ethernet communication write-protection for

- Changing IP address, Gateway IP or MASK
- Enabling ModBus
- Reloading communication boot and firmware

These functions are accessible through the Configure Ethernet 100 BaseT utility found in the Windows Start menu under PMAC Executive Pro2 Suite > Delta Tau Common > Configure Ethernet 100 BaseT:



Note

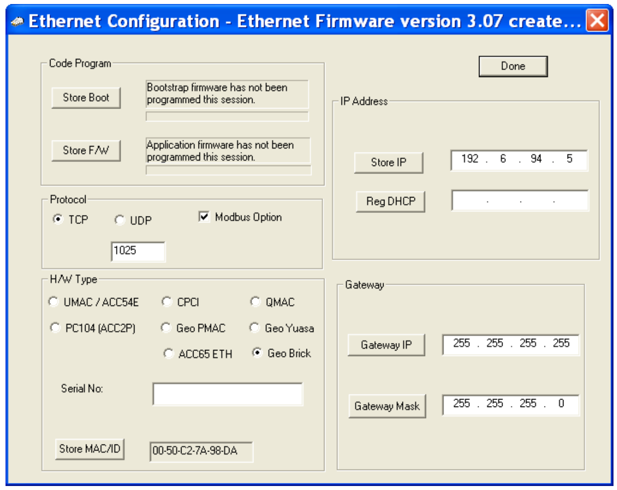
- This utility only works with USB communication.
- The Pewin32Pro2 or any other software communicating to the Clipper must be closed before launching this utility.

Changing IP Address, Gateway IP, Gateway Mask

In order to change any of these addresses, install the E8 jumper prior to pressing the corresponding Store button. The following steps ensure proper configuration:

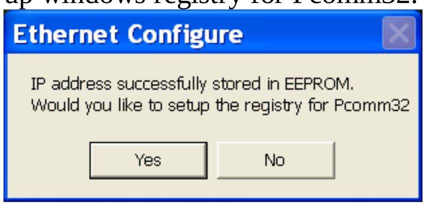
Step1: Change the desired address field
Step2: Install the E8 jumper
Step3: Press on the corresponding Store button

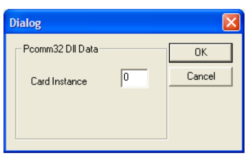
- Store IP for changing IP address
- Gateway IP for changing Gateway IP
- Gateway Mask for changing Gateway Mask

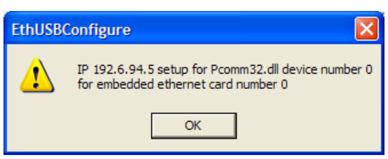


Step4: Remove the E8 jumper after the corresponding confirmation message is received:

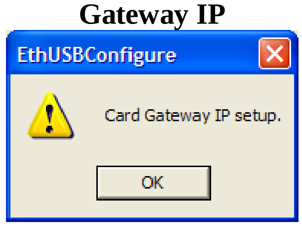
For changing the **IP address**, follow through the subsequent messages for setting up windows registry for Pcomm32.



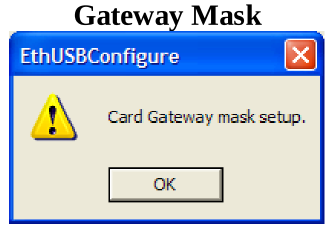




Gateway IP



Gateway Mask



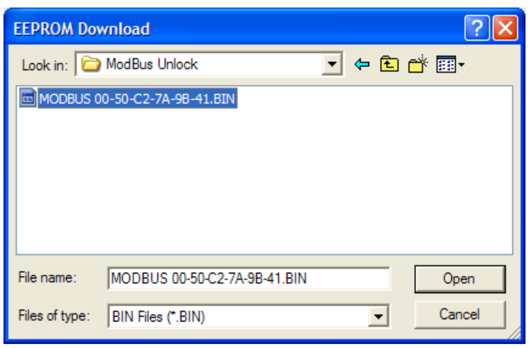
Step5: Click Done, and recycle logic power (5V) on the Clipper

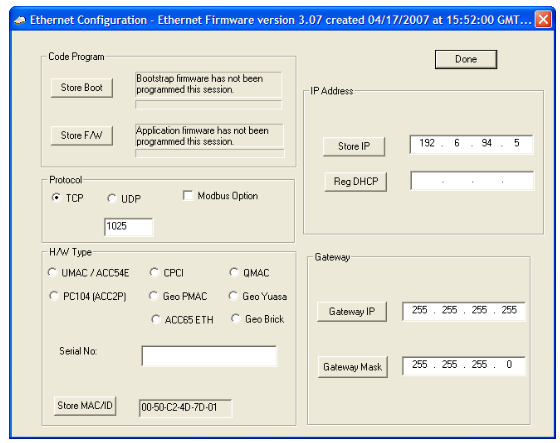
Enabling ModBus

A Turbo PMAC Clipper ordered initially with the ModBus option is normally enabled by factory. However, ModBus is a field upgradeable option. The user needs to provide Delta Tau (or their local distributor) with the MAC ID of the Clipper unit. This is found in the lower left hand side of the Ethernet 100 Base T utility. Upon purchase of the ModBus Option, a .BIN file is obtained from Delta Tau for this purpose. Installing this feature successfully requires the following procedure:

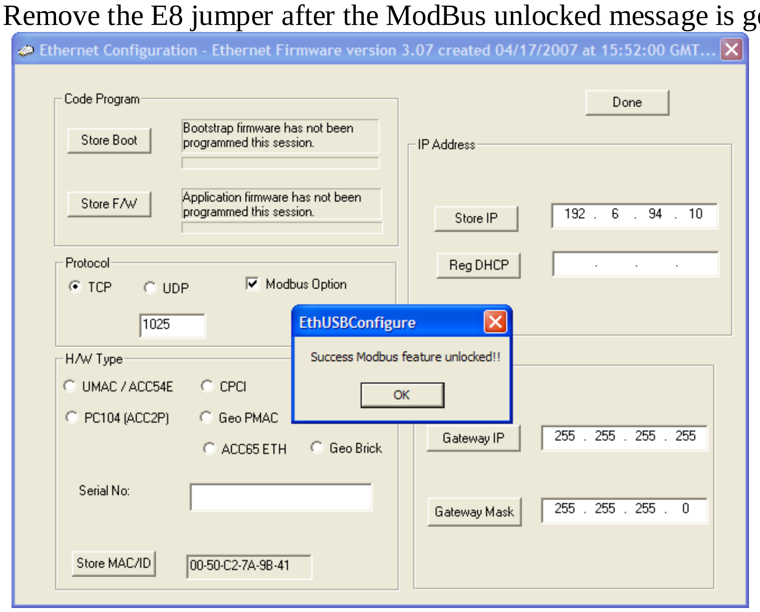
Step1: Install the E8 jumper

Step2: Click on **ModBus Option.** The utility will prompt for the .bin file.
MAKE SURE you open the correct file.





Step3: Remove the E8 jumper after the ModBus unlocked message is generated.



Step4: Click Done, and recycle logic power (5V) on the Clipper

Reloading Boot and Communication Firmware

The boot and firmware .IIC files are required for this procedure. They are normally obtained directly from Delta Tau, or downloaded from the PMAC forum Webpage. The following steps ensure proper configuration:

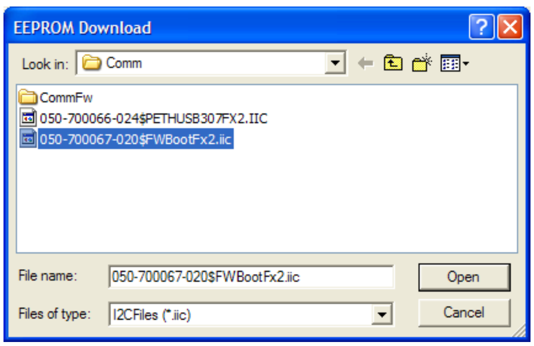
Caution

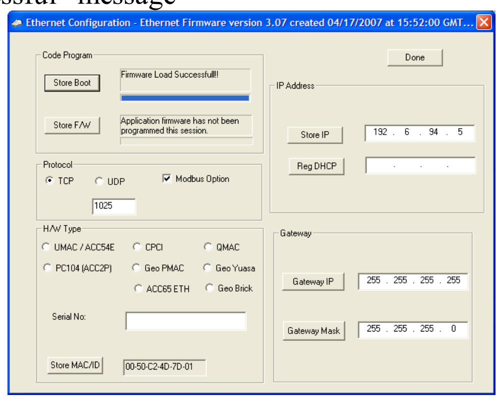
Downloading the wrong boot or communication files will severely corrupt the functionality of the communication processor.

Step1: Install the E8 jumper

Step2: Click on Store Boot

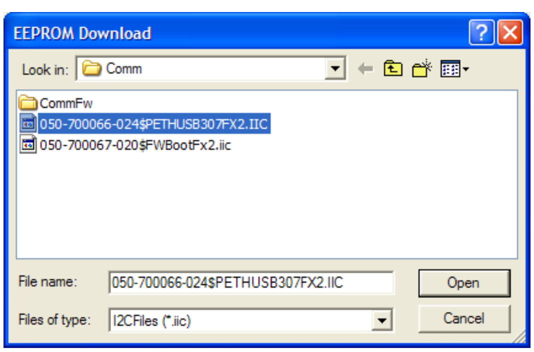
Step3: The utility will prompt for the boot file. MAKE SURE you open the correct .IIC file (ending with BootFx2.iic) and wait for “firmware load successful” message

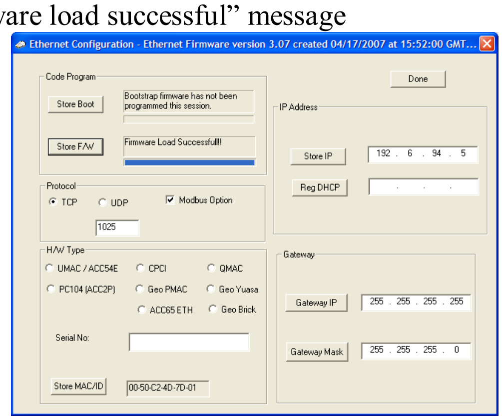




Step4: Click on Store F/W

Step5: The utility will prompt for the Firmware file. MAKE SURE you open the correct .IIC file (ending with ETHUSB307FX2.iic) and wait for “firmware load successful” message





Step6: Remove the E8 jumper. Click Done, and recycle logic power (5V) on the Clipper

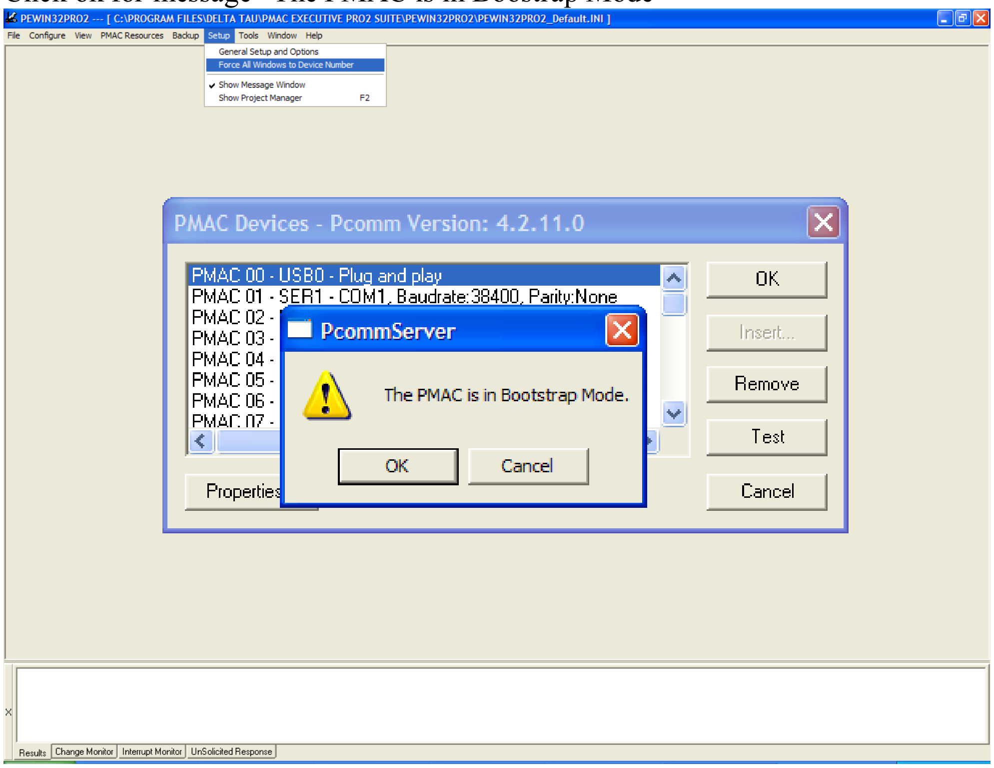
Reloading PMAC firmware – E13 Jumper

E13 jumper is putting Clipper into Bootstrap mode. The following steps ensure proper firmware reload/upgrade.

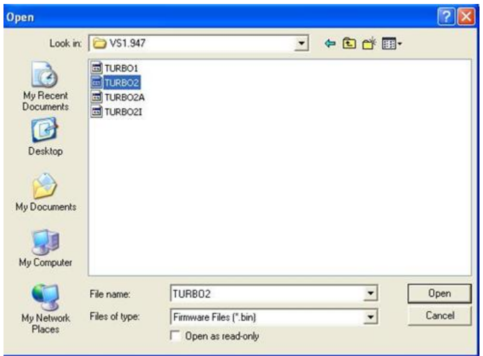
Step1: Jumper the E13 while power is off.

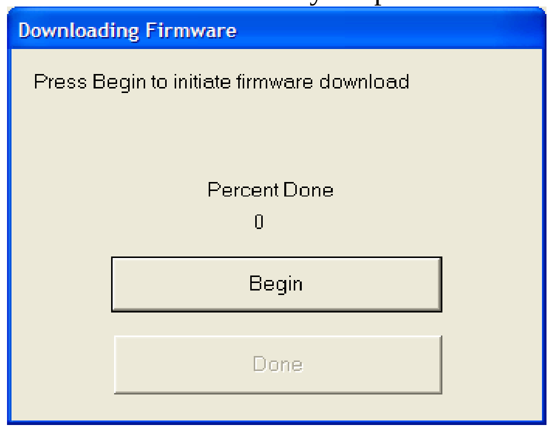
Step2: Power up the Clipper.

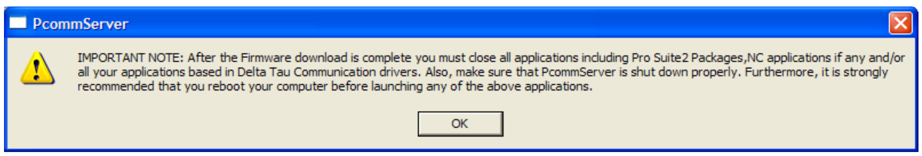
Step3: Launch the Pewin32Pro2.
Run the PMAC Devices window under Setup > Force All Windows To Device Number.
Click Test for the corresponding communication method.
Click ok for message “The PMAC is in Boostrap Mode”



Step5: The download utility will prompt for a .BIN file. MAKE SURE you open the correct file.



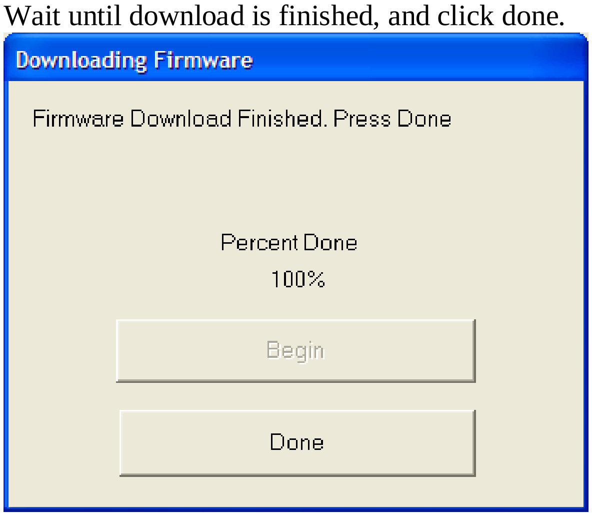




Note

The PMAC firmware file for Turbo PMAC Clipper MUST ALWAYS be TURBO2.BIN.

Step6: Wait until download is finished, and click done.



Step7: Close all PMAC applications (i.e. Pewin32Pro2), and turn off the power.

Step8: Remove the E13 jumper for normal operation.

Re-initialization jumper (Factory Reset)

The E3 jumper is used to reset the Turbo PMAC Clipper back to factory default settings, global reset.

Caution

Issuing a SAVE after power up (with the E3 jumper) will permanently erase any user configured parameters.

Re-initialization instructions: Power down the unit. Install the E3 jumper, then power back up. The factory default parameters are now restored from the firmware EEPROM into the active memory. Issue a SAVE and a $$$ to maintain this configuration.

Watchdog Timer

On a Turbo PMAC Clipper, the watchdog timer trigger illuminates the red WD LED and interrupts communication. It occurs if any of the following applies:

- PMAC CPU over-clocked:
  In this mode, the CPU signals that is has been overloaded with computation and cannot accomplish tasks in a timely manner. e.g. bad programming such as an infinite loop, or too much computation (Kinematics) requiring faster CPU option.

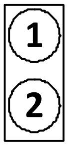
- Wrong clock settings:
  In this mode, the user has downloaded or written bad values to clock setting parameters.

- Logic power supply +5V failure:
  In this mode, the 5V logic power supply has failed. Check and monitor the 5VDC power.

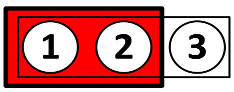
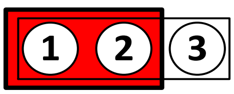
- Downloading wrong configuration file (I4900):
  In this mode, the user has reloaded a configuration file uploaded from a 4-axis unit (Servo IC 1 parameters set to zero) into an 8-axis unit, thus writing zero to the second Servo IC clock parameters. Commenting out variables I7100…7106 (or forcing them to hold the same values as I7000…I7106) eliminates the watchdog problem.

APPENDIX A: E-POINT JUMPERS

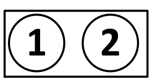
E0: Forced Reset Control

Jumper	Configuration	Default
E0: 	➢ Factory use only. The board will not operate with E0 installed	Factory Set

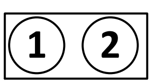
E1 – E2: Serial Port Selection (rev 102 and below only)

Jumper	Configuration	Default
E1: 	➢ 1 to 2 for main CPU ➢ 2 to 3 for Ethernet CPU	1 – 2
E2: 	➢ 1 to 2 for main CPU ➢ 2 to 3 for Ethernet CPU	1 – 2

E3: Normal/Re-Initializing Power-Up/Reset

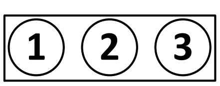
Jumper	Configuration	Default
E3: 	➢ 1 to 2 to re-initialize on power-up/reset, loading factory default settings ➢ Remove jumper for normal power-up/reset, loading user saved settings	Factory Set

E4: Watchdog Disable Jumper

Jumper	Configuration	Default
E4: 	➢ 1 to 2 to disable Watchdog timer (for test purposes only) ➢ Remove jumper to enable Watchdog timer	Factory Set

E5: Reserved for factory use only

Version 102 and higher

Jumper	Configuration	Default
E5: 	➢ Factory use only. The board will not communicate via Ethernet or USB if jumper E5 is installed	Factory Set

Version 101 and lower

Jumper	Configuration	Default
E5:	➢ Factory use only. The board will not communicate via Ethernet unless jumper is installed on pins 1 to 2	1 – 2

E6: ADC Inputs Enable

Jumper	Configuration	Default
E6:	➢ 1 to 2 to enable the Option-12 ADC inputs ➢ Remove jumper to disable the ADC inputs, which is necessary for reading current feedback signals from digital amplifiers	Factory Set

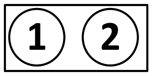
E7 – E8: USB/Ethernet Reset Jumpers

Jumper	Configuration	Default
E7:	➢ Factory use only. Install E7 for normal operation	1 – 2
E8:	➢ Install E8 to reload communication Boot/Firmware, or change IP Address ➢ Remove E8 to enable write protection for normal operation	Factory Set

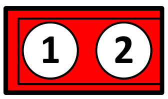
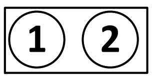
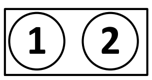
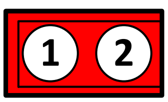
E10 – E12: Flash IC Jumpers

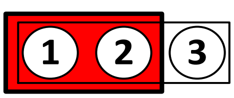
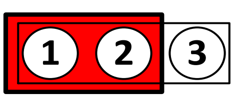
Jumper	Configuration	Default
E10:	➢ Remove E10 to read flash IC on power up/reset	Factory Set
E11:	➢ 1 to 2 to read flash IC on power up/reset	Factory Set
E12:	➢ 1 to 2 to read flash IC on power up/reset	Factory Set

E13: Power-Up/Reset Load Source

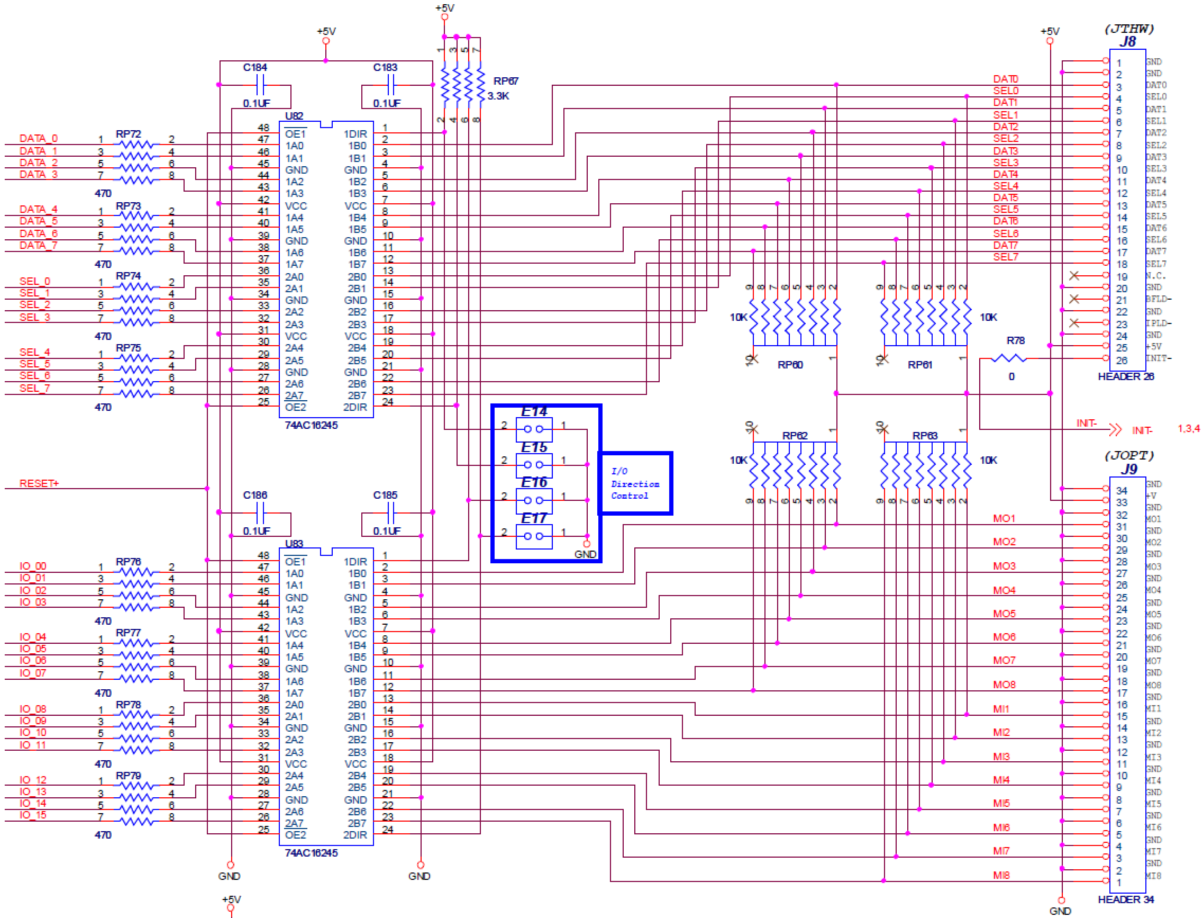
Jumper	Configuration	Default
E13: 	➢ 1 to 2 to reload firmware through serial or bus port ➢ Remove jumper for normal operation	Factory Set

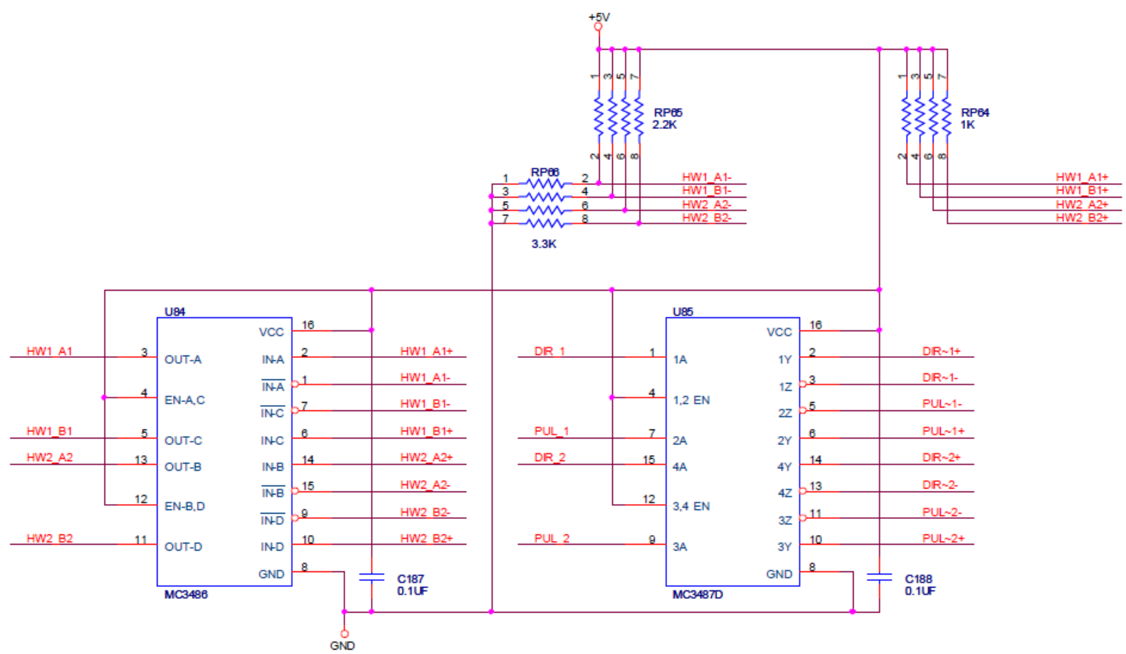
E14- E17: Ports Direction Control

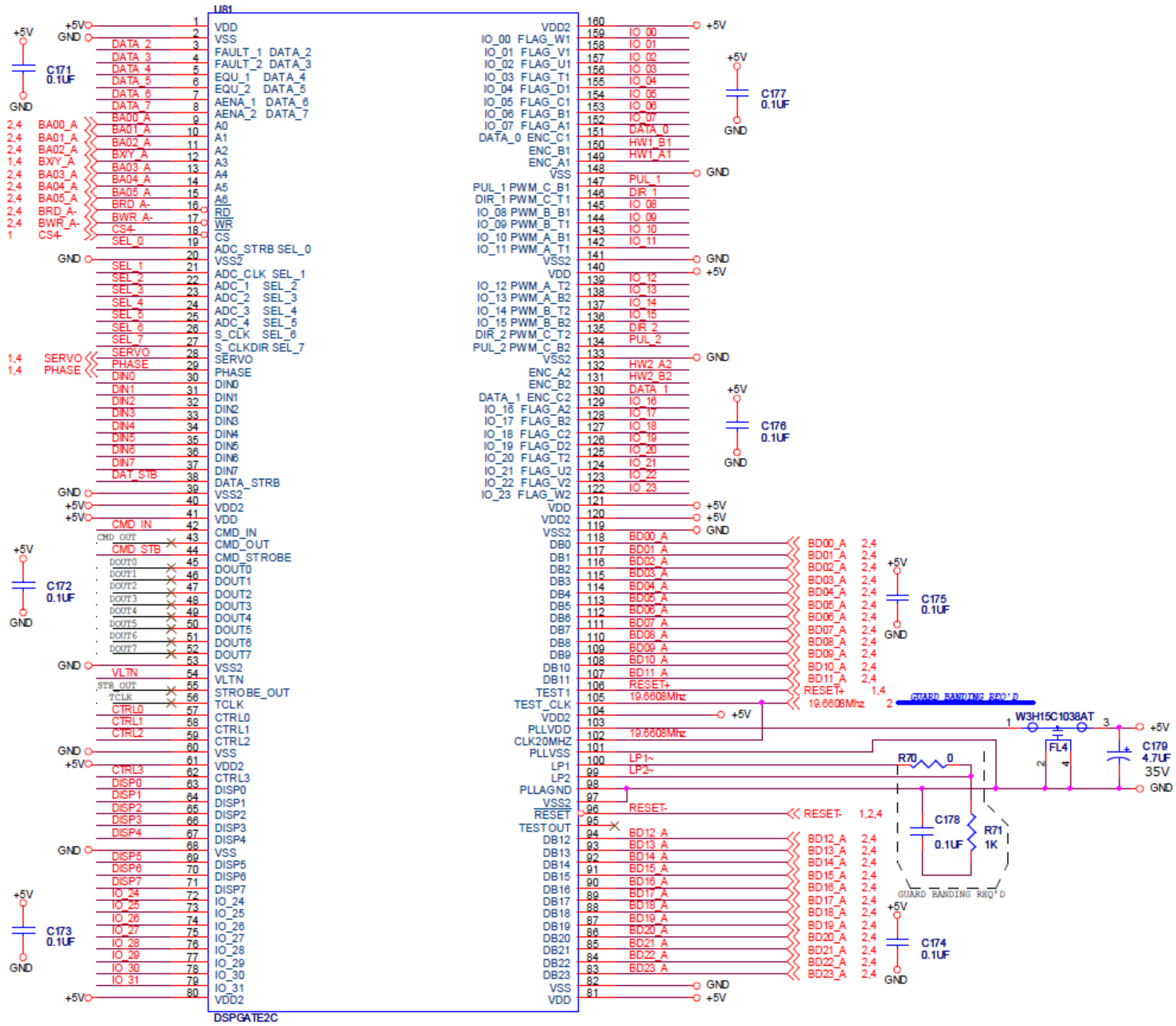
Jumper	Configuration	Default
E14: 	➢ 1 to 2 to make DATx lines inputs ➢ Remove jumper to make DATx lines outputs	Factory Set
E15: 	➢ 1 to 2 to make SELx lines inputs ➢ Remove jumper to make SELx lines outputs	Factory Set
E16: 	➢ 1 to 2 to make MOx lines inputs ➢ Remove jumper to make MOx lines outputs	Factory Set
E17: 	➢ 1 to 2 to make MIx lines inputs ➢ Remove jumper to make MIx lines outputs	Factory Set

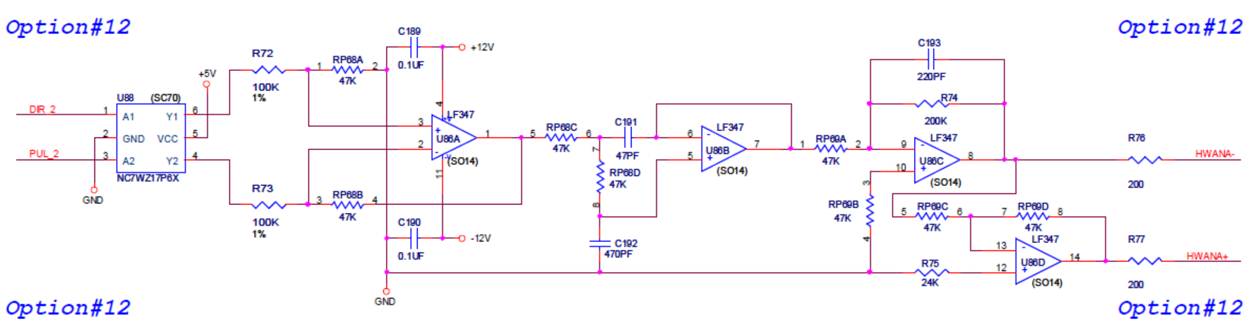
Jumper	Configuration	Default
E1: 	➢ 1 to 2 Turbo/Power/ ➢ 2 to 3 for Legacy MACRO CPUs Rev. 103 or older	Factory Set
E2: 	➢ 1 to 2 to sample at Servo Rate ➢ 2 to 3 to sample at Phase Rate	1 – 2

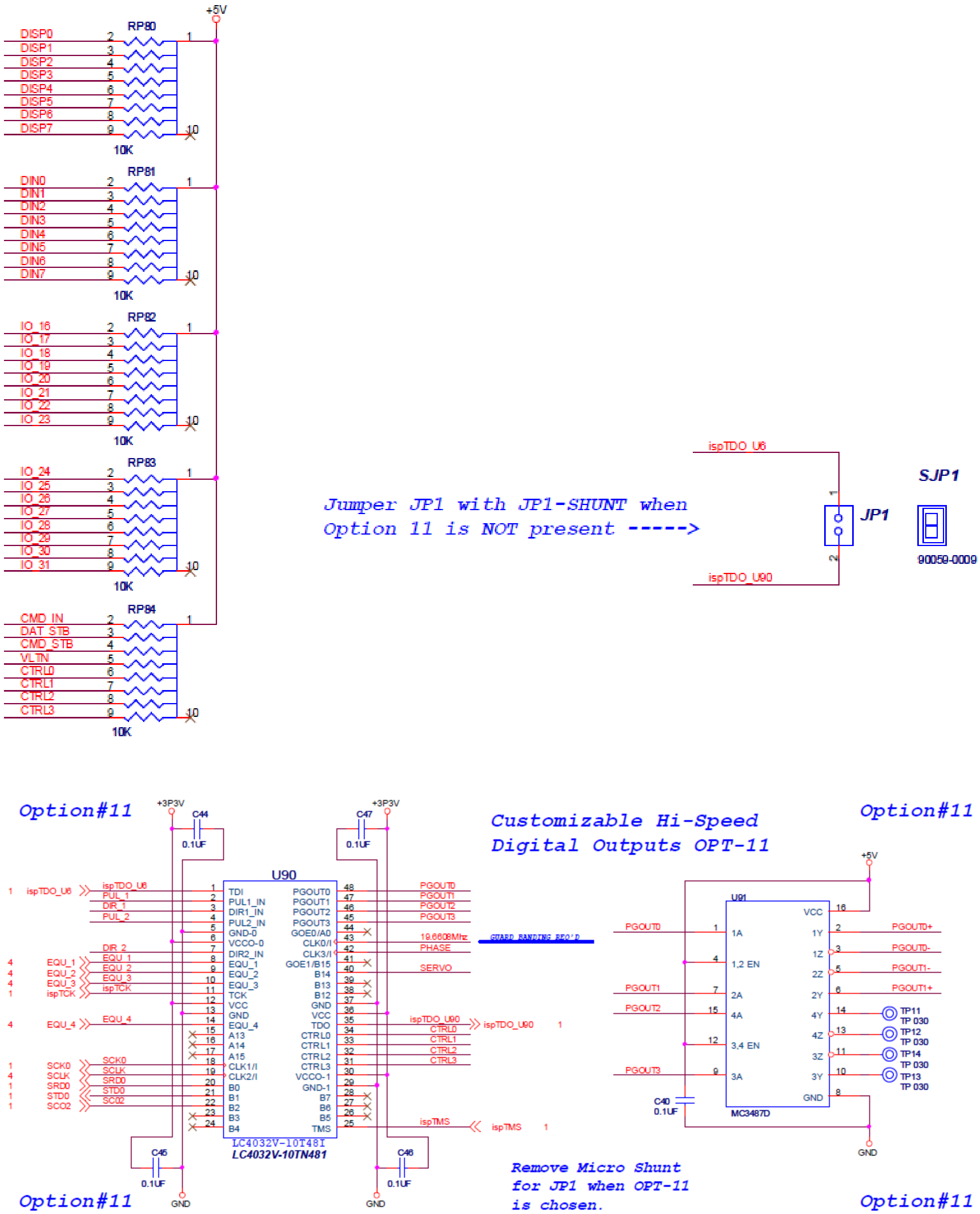
APPENDIX B: SCHEMATICS

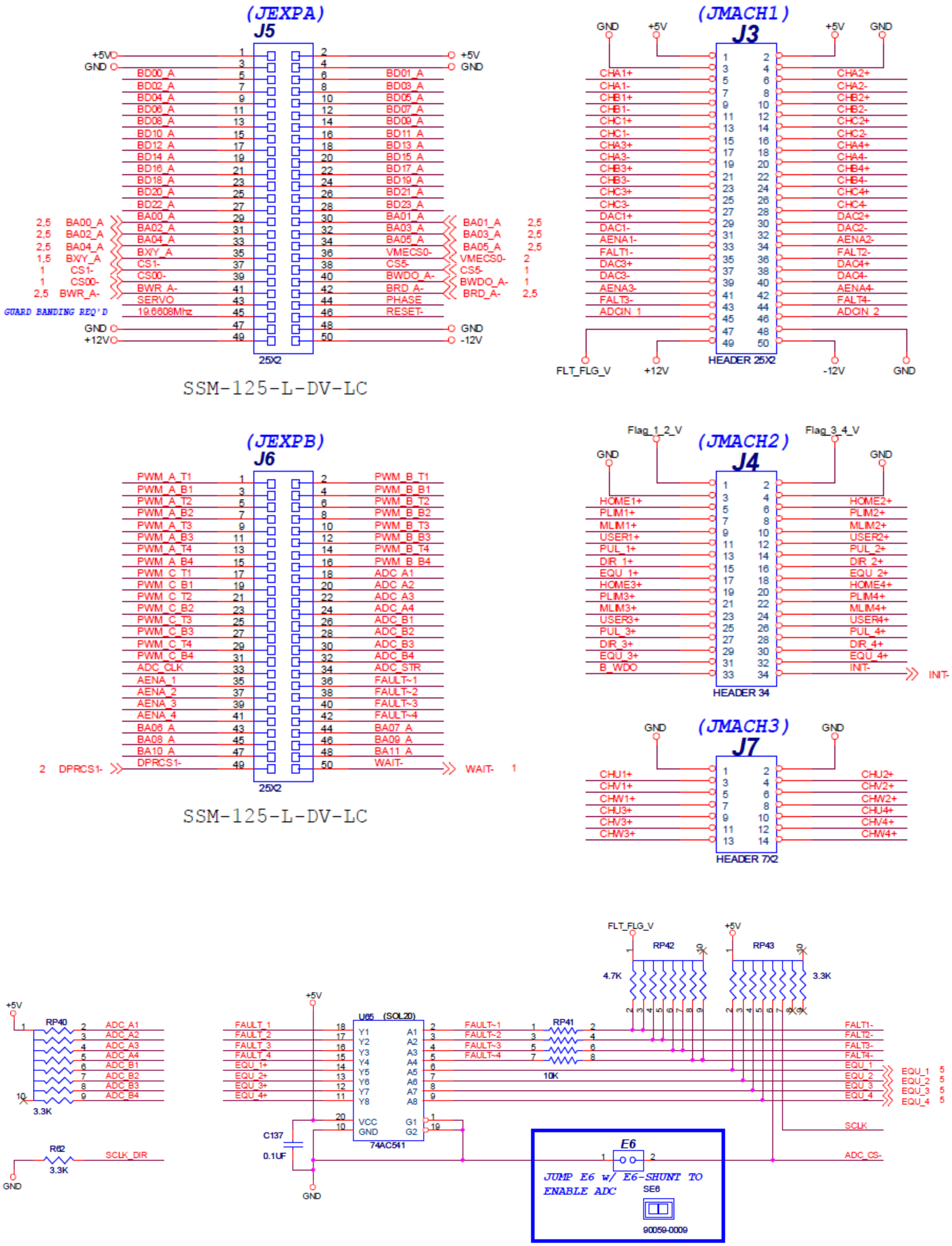


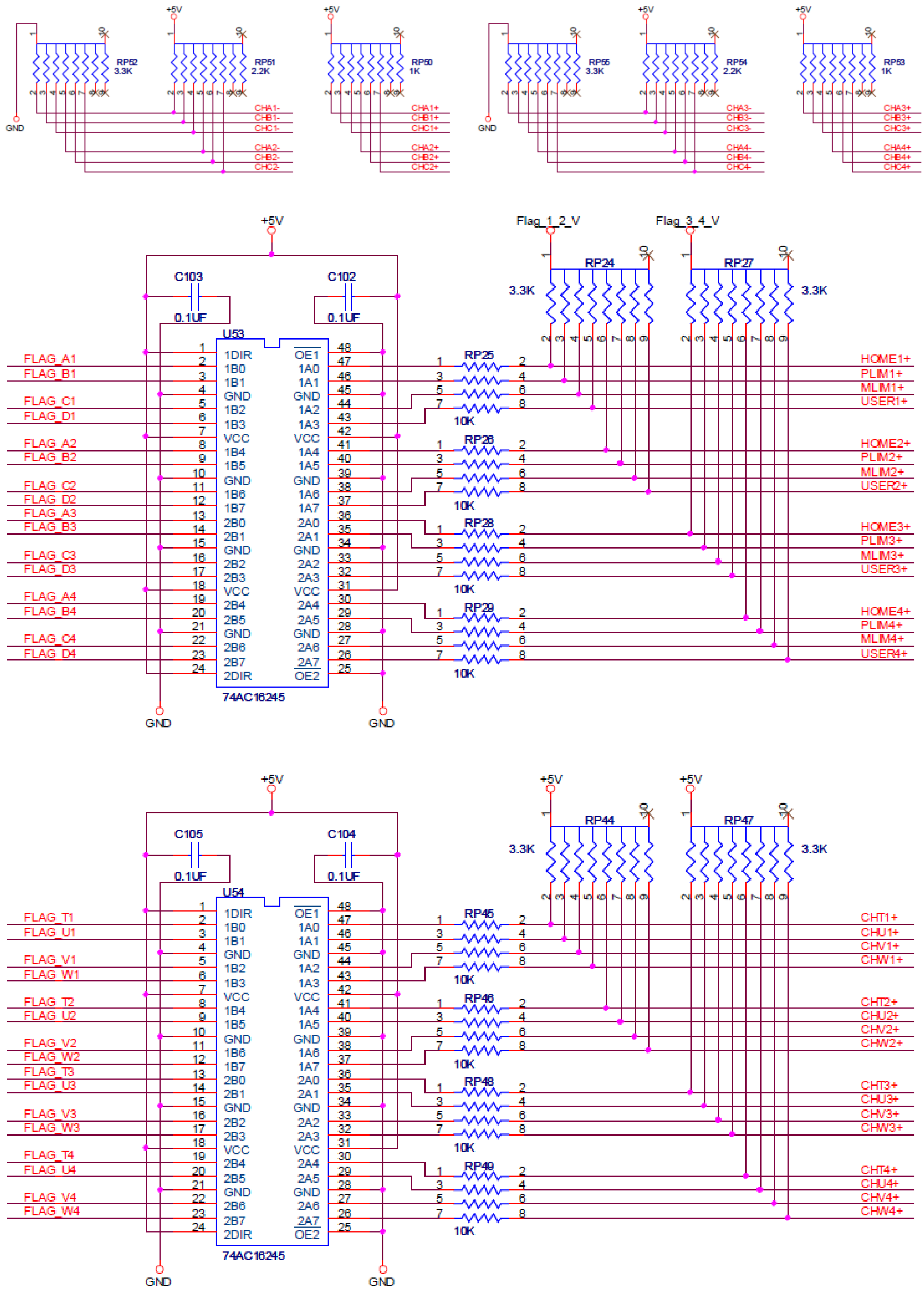


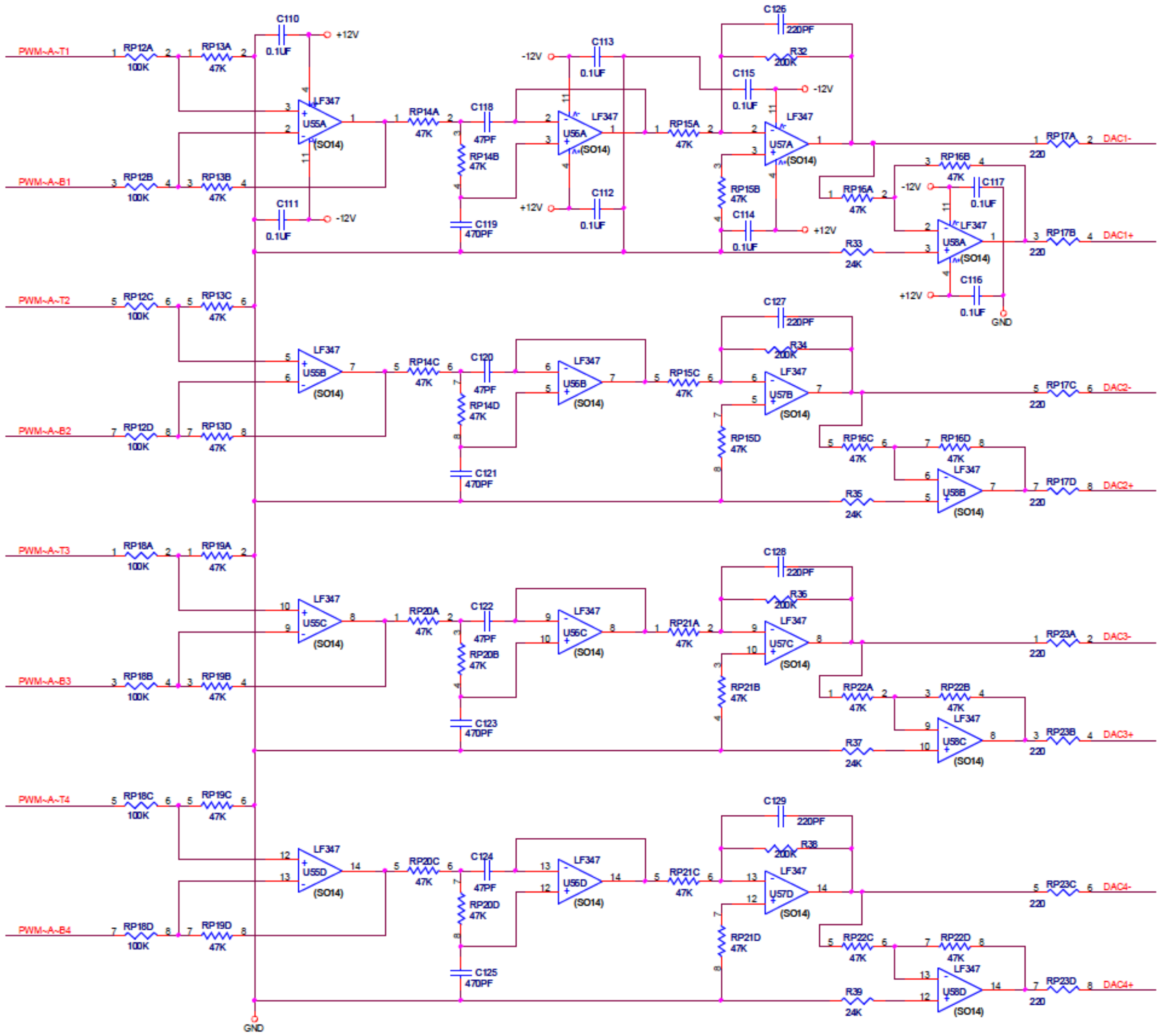

U81
DSPGATE2C


Option#12
Option#12
Option#12
Option#12

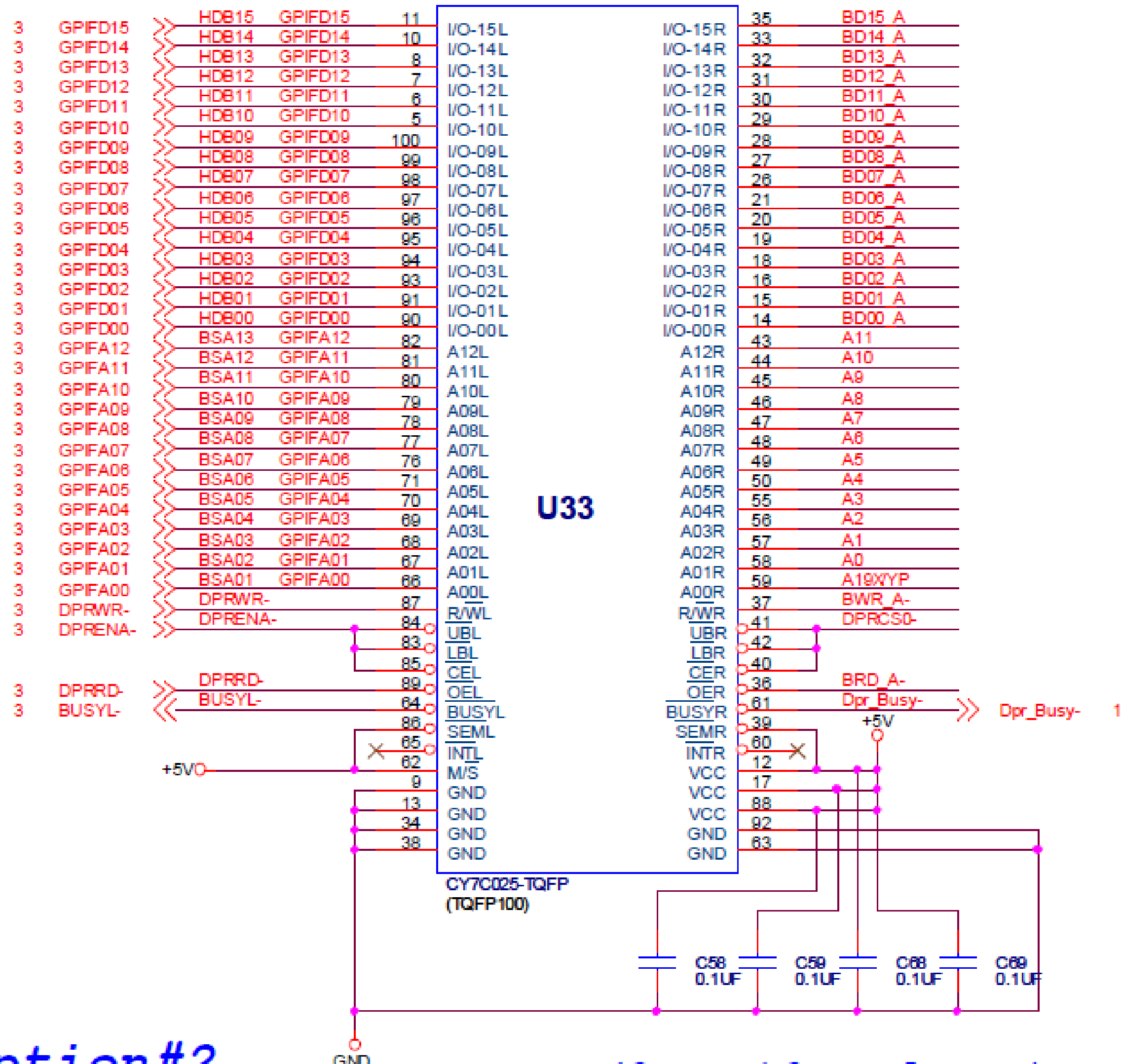

RP80
RP81
RP82
RP83
RP84
10K
+5V
Jumper JP1 with JP1-SHUNT when
Option 11 is NOT present ----->
ispTDO_U6
ispTDO_U90
JP1
SJP1
90059-0009
Option#11
Customizable Hi-Speed
Digital Outputs OPT-11
U90
LC4032V-10TN48I
U91
MC3487D
Remove Micro Shunt
for JP1 when OPT-11
is chosen.


(JEXPA)
J5
+5V GND
BD00_A BD02_A BD04_A BD06_A BD08_A BD10_A BD12_A BD14_A BD16_A BD18_A BD20_A BD22_A
BD01_A BD03_A BD05_A BD07_A BD09_A BD11_A BD13_A BD15_A BD17_A BD19_A BD21_A BD23_A
BA00_A BA02_A BA04_A BXY_A CS1- CS00- BWR_A- SERVO 19.6608Mhz
BA01_A BA03_A BA05_A VMECS0- CS5- BWDO_A- BRD_A- PHASE RESET-
GUARD BANDING REQ'D
GND +12V GND -12V
25X2
SSM-125-L-DV-LC
(JMACH1)
J3
GND +5V +5V GND
CHA1+ CHA1- CHB1+ CHB1- CHC1+ CHC1- CHA3+ CHA3- CHB3+ CHB3- CHC3+ CHC3- DAC1+ DAC1- AENA1- FALT1- DAC3+ DAC3- AENA3- FALT3- ADCIN_1
CHA2+ CHA2- CHB2+ CHB2- CHC2+ CHC2- CHA4+ CHA4- CHB4+ CHB4- CHC4+ CHC4- DAC2+ DAC2- AENA2- FALT2- DAC4+ DAC4- AENA4- FALT4- ADCIN_2
HEADER 25X2
FLT_FLG_V +12V -12V GND
(JEXPB)
J6
PWM_A_T1 PWM_A_B1 PWM_A_T2 PWM_A_B2 PWM_A_T3 PWM_A_B3 PWM_A_T4 PWM_A_B4 PWM_C_T1 PWM_C_B1 PWM_C_T2 PWM_C_B2 PWM_C_T3 PWM_C_B3 PWM_C_T4 PWM_C_B4 ADC_CLK AENA_1 AENA_2 AENA_3 AENA_4 BA06_A BA08_A BA10_A DPRCS1-
PWM_B_T1 PWM_B_B1 PWM_B_T2 PWM_B_B2 PWM_B_T3 PWM_B_B3 PWM_B_T4 PWM_B_B4 ADC_A1 ADC_A2 ADC_A3 ADC_A4 ADC_B1 ADC_B2 ADC_B3 ADC_B4 ADC_STR FAULT~1 FAULT~2 FAULT~3 FAULT~4 BA07_A BA09_A BA11_A WAIT-
25X2
SSM-125-L-DV-LC
(JMACH2)
J4
Flag_1_2_V Flag_3_4_V GND GND
HOME1+ PLIM1+ MLIM1+ USER1+ PUL_1+ DIR_1+ EQU_1+ HOME3+ PLIM3+ MLIM3+ USER3+ PUL_3+ DIR_3+ EQU_3+ B_WDO
HOME2+ PLIM2+ MLIM2+ USER2+ PUL_2+ DIR_2+ EQU_2+ HOME4+ PLIM4+ MLIM4+ USER4+ PUL_4+ DIR_4+ EQU_4+ INIT-
HEADER 34
(JMACH3)
J7
CHU1+ CHV1+ CHW1+ CHU3+ CHV3+ CHW3+
CHU2+ CHV2+ CHW2+ CHU4+ CHV4+ CHW4+
HEADER 7X2
RP40 3.3K R62 3.3K SCLK_DIR
U65 (SOL20) 74AC541 C137 0.1UF
FAULT_1 FAULT_2 FAULT_3 FAULT_4 EQU_1+ EQU_2+ EQU_3+ EQU_4+
RP41 10K RP42 4.7K RP43 3.3K
FALT1- FALT2- FALT3- FALT4- EQU_1 EQU_2 EQU_3 EQU_4 SCLK ADC_CS-
E6
JUMP E6 w/ E6-SHUNT TO ENABLE ADC
SE6
90059-0009


RP52
3.3K
RP51
2.2K
RP50
1K
RP55
3.3K
RP54
2.2K
RP53
1K
+5V
GND
CHA1-
CHB1-
CHC1-
CHA2-
CHB2-
CHC2-
CHA1+
CHB1+
CHC1+
CHA2+
CHB2+
CHC2+
CHA3-
CHB3-
CHC3-
CHA4-
CHB4-
CHC4-
CHA3+
CHB3+
CHC3+
CHA4+
CHB4+
CHC4+
C103
C102
0.1UF
U53
74AC16245
Flag_1_2_V
Flag_3_4_V
RP24
RP27
3.3K
RP25
RP26
RP28
RP29
10K
FLAG_A1
FLAG_B1
FLAG_C1
FLAG_D1
FLAG_A2
FLAG_B2
FLAG_C2
FLAG_D2
FLAG_A3
FLAG_B3
FLAG_C3
FLAG_D3
FLAG_A4
FLAG_B4
FLAG_C4
FLAG_D4
HOME1+
PLIM1+
MLIM1+
USER1+
HOME2+
PLIM2+
MLIM2+
USER2+
HOME3+
PLIM3+
MLIM3+
USER3+
HOME4+
PLIM4+
MLIM4+
USER4+
1DIR
OE1
2DIR
OE2
VCC
GND
C105
C104
U54
RP44
RP47
RP45
RP46
RP48
RP49
FLAG_T1
FLAG_U1
FLAG_V1
FLAG_W1
FLAG_T2
FLAG_U2
FLAG_V2
FLAG_W2
FLAG_T3
FLAG_U3
FLAG_V3
FLAG_W3
FLAG_T4
FLAG_U4
FLAG_V4
FLAG_W4
CHT1+
CHU1+
CHV1+
CHW1+
CHT2+
CHU2+
CHV2+
CHW2+
CHT3+
CHU3+
CHV3+
CHW3+
CHT4+
CHU4+
CHV4+
CHW4+



(8K x 16 Dual Port Ram)



Option#2

(8K x 16 Dual Port Ram)