

HARDWARE REFERENCE MANUAL

Brick Motion Controller



Programmable Servo Amplifier

5xx-603869-xUxx

May 2, 2007



DELTA TAU
Data Systems, Inc.

NEW IDEAS IN MOTION ...

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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:

IEC 364 resp. 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.

After removing the power source from the equipment, wait at least 10 minutes before touching or disconnecting sections of the equipment that normally carry electrical charges (e.g., capacitors, contacts, screw connections). To be safe, measure the electrical contact points with a meter before touching the equipment.

The following text formats are used in this manual to indicate a potential for personal injury or equipment damage. Read the safety notices in this manual before attempting installation, operation, or maintenance to avoid serious bodily injury, damage to the equipment, or operational difficulty.

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 user's understanding or use of the equipment. It follows the discussion of interest.

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INTRODUCTION

The Brick Motion Controller is a fully scalable automation controller utilizing the intelligence and capability of its embedded Turbo PMAC2. With the ability to store programs locally and built-in PLC execution, it is programmable for virtually any kind of automation application. This allows for complete machine motion and logic control.

This product has 4 or 8 (optional) axes of analog +/-10V filtered-PWM (12-bit resolution) or pulse and direction outputs as standard. Options are available for dual true-DAC analog outputs at 18-bit resolution or Direct-PWM with current loop. Feedback with quadrature incremental encoders is standard. Options for sinusoidal, resolver or serial encoders are available.

The Brick Motion Controller provides a standard I/O capability of 16 inputs and 8 outputs at 12-24volts fully protected and isolated with separate commons for each bank of 8 inputs. Outputs are rated for 1 ampere each and are thermal-fuse protected. Outputs can be current sinking or sourcing depending on use of common emitter or common collector connections. Additional I/O is an option (up to 64 inputs and 32 outputs). Also an option for up to four 16 bit analog inputs is available.

The Brick Motion Controller's functionality doesn't stop there, but also includes features such as extensible I/O via ModBus TCP master, or ModBus TCP slave for third party HMI hardware. Our PC-based HMI package connected through USB 2.0 or Ethernet makes the Brick Motion Controller a powerful single-source solution.

Brick Motion Controller Features

The Brick Motion Controller is capable of controlling up to eight axes with direct-PWM commands.

- Motorola DSP 56k digital signal processor
- Turbo PMAC2 CPU (for kinematics, open servo, NC applications)
- Fully Configurable via USB2.0 and/or Ethernet TCP/IP (100 Base-T)
- Operation from a PC
- Stand-alone operation
- Linear and circular interpolation
- 256 motion programs capacity
- 64 asynchronous PLC program capability
- Rotating buffer for large programs
- 36-bit position range (± 64 billion counts)
- Adjustable S-curve acceleration and deceleration
- Cubic trajectory calculations, splines
- Set and change parameters in real time
- Torque, Velocity and Position control standard
- Small footprint saves space
- Full rated temperature cooling standard (no need for additional fans)
- 16 inputs (expandable to 32 with option) fully-protected and isolated with separate commons for two banks of eight
- Eight thermal-fuse protected outputs (expandable to 16 with option) rated for 0.5A @ 24VDC each (Flexible outputs allow for sinking or sourcing of current depending on whether the common emitter or common collector is used.)

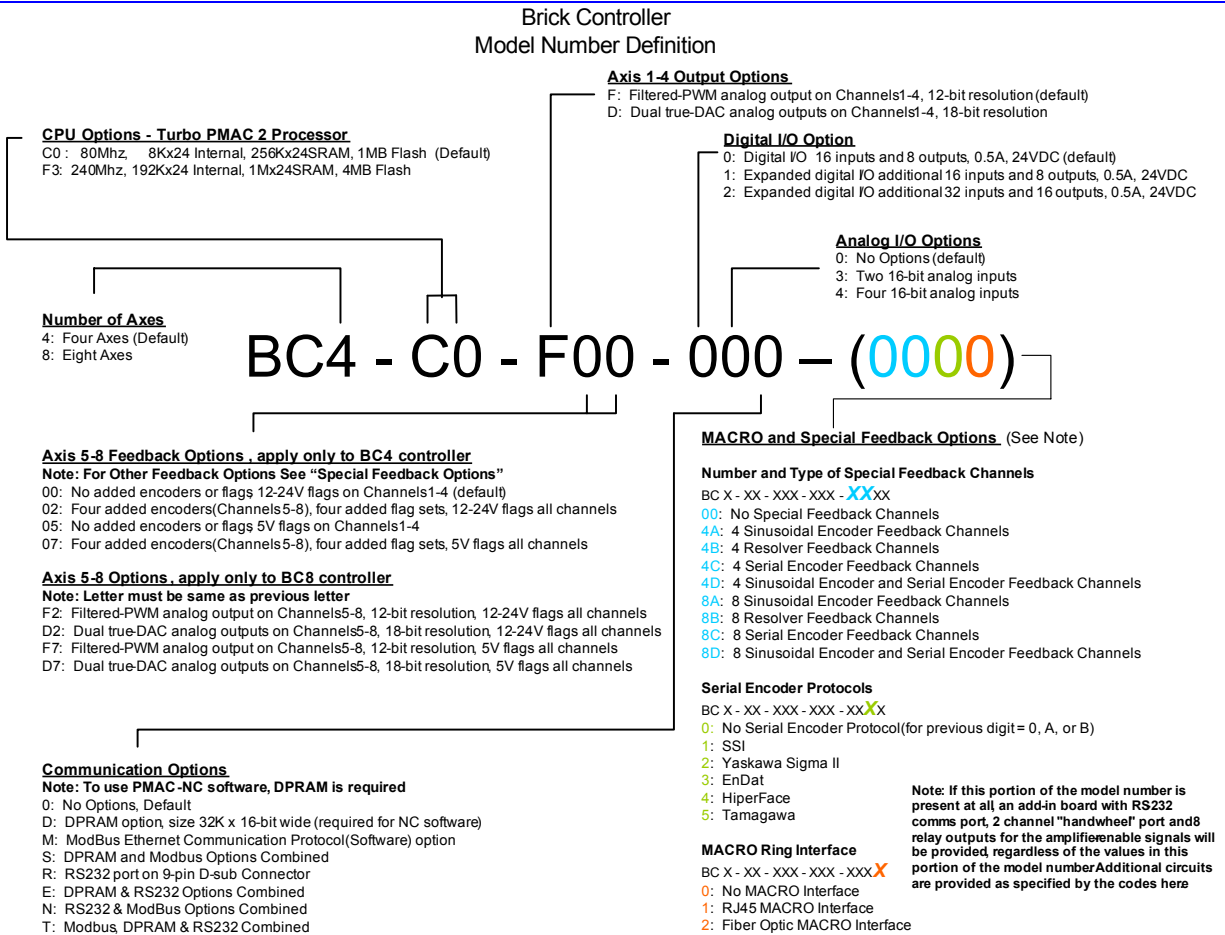


**Brick Motion
Controller**

- Primary encoder for each axis with TTL differential/single-ended inputs with A, B quadrature channels and C index channel, 10 MHz cycle rate, and digital Hall-effect inputs
- Five flags per axis using DB-25: HOME, PLIM, MLIM and USER inputs; EQU compare
- Optional analog inputs and outputs, $\pm 5\text{VDC}$
- Optional two PWM outputs.
- Optional Dual Port RAM (Required for NC)
- Optional Modbus Protocol
- Optional Sinusoidal encoder feedback
- Optional Resolver feedback
- Optional EnDat, Hiperface interfaces.

SPECIFICATIONS

Part Number



Brick Motion Controller Options

CPU Options

- Option C0 – 80MHz Turbo CPU with 8Kx24 internal memory, 1Mx24 256Kx24 SRAM, 1Mx8 flash memory
- Option F3 – 240MHz Turbo CPU with 192Kx24 internal memory, 1Mx24 SRAM, 4Mx8 flash memory

Axis 1-4 Output Options

- Filtered-PWM analog output on Channels 1-4, 12-bit resolution (default)
- Dual true-DAC analog outputs on Channels 1-4, 18-bit resolution

Secondary Encoder Options

- Four secondary encoder inputs, and flags 12-24V.
- Four secondary encoder inputs, and flags 5V.

Digital I/O Option

- Digital I/O 16 inputs and 8 outputs, 0.5A, 24VDC (default)
- Expanded digital I/O additional 16 inputs and 8 outputs, 0.5A, 24VDC
- Expanded digital I/O additional 32 inputs and 16 outputs, 0.5A, 24VDC

Analog I/O Options

- Two 16-bit analog inputs
- Four 16-bit analog inputs

Communication Options

- DPRAM option, size 32K x 16-bit wide (required for use with NC software)
- ModBus Ethernet Communication Protocol (Software) option
- DPRAM and Modbus options combined
- RS232 port on 9-pin D-sub connector
- DPRAM & RS232 options combined
- Modbus & DPRAM options combined
- Modbus, DPRAM & RS232 options combined

MACRO and Special Feedback Options

Number and Type of Special Feedback Channels

- No Special Feedback Channels
- 4 Sinusoidal Encoder Feedback Channels
- 4 Resolver Feedback Channels
- 4 Serial Encoder Feedback Channels
- 4 Sinusoidal Encoder and Serial Encoder Feedback Channels
- 8 Sinusoidal Encoder Feedback Channels
- 8 Resolver Feedback Channels
- 8 Serial Encoder Feedback Channels
- 8 Sinusoidal Encoder and Serial Encoder Feedback Channels

Serial Encoder Protocols

- No Serial Encoder Protocol (for previous digit = 0, A, or B)
- SSI Serial Absolute Encoder Interface
- Yaskawa Sigma II Serial Absolute Encoder Interface
- EnDat Serial Absolute Encoder Interface
- HiperFace Serial Absolute Encoder Interface
- Tamagawa Serial Absolute Encoder Interface

MACRO Ring Interface

- RJ45 MACRO Interface
- Fiber Optic MACRO Interface

RECEIVING AND UNPACKING

Delta Tau products are thoroughly tested at the factory and carefully packaged for shipment. When the Brick Motion Controller is received, there are several steps that should be performed immediately:

1. Observe the condition of the shipping container and report any damage immediately to the commercial carrier that delivered the drive.
2. Remove the control from the shipping container and remove all packing materials. Check all shipping material for connector kits, documentation, diskettes, CD ROM, 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.
3. Verify that the part number of the unit received is the same as the part number listed on the purchase order.
4. Inspect the unit for external physical damage that may have been sustained during shipment and report any damage immediately to the commercial carrier that delivered the drive.
5. Electronic components in this product are design-hardened to reduce static sensitivity. However, use proper procedures when handling the equipment.
6. If the Brick Motion Controller 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 stated in this manual.

Use of Equipment

The Brick Motion Controller is a Turbo PMAC2 controller. So parallel with this manual the user needs to use the Turbo Software Reference Manual and the Turbo User Manual. Always download the latest manual revision from the Delta Tau website: www.deltatau.com

Note:

If Ethernet communications are used, Delta Tau Systems 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 should be implemented.

Maximum length for Ethernet cable should not exceed 100m (330ft).

SYSTEM WIRING

WARNING:

Installation of electrical control equipment is subject to many regulations including national, state, local, and industry guidelines and rules. General recommendations can be stated but it is important that the installation be carried out in accordance with all regulations pertaining to the installation.

Noise Problems

When problems do occur often it points to electrical noise as the source of the problem. When this occurs, turn to controlling high-frequency current paths. If the grounding instructions do not work, insert chokes in the motor phases. These chokes can be as simple as several wraps of the individual motor leads through a ferrite ring core (such as Micrometals T400-26D). This adds high-frequency impedance to the outgoing motor cable thereby making it harder for high-frequency noise to leave the control cabinet area. Care should be taken to be certain that the core's temperature is in a reasonable range after installing such devices.

Wiring Earth-Ground

Panel wiring requires that a central earth-ground location be installed at one part of the panel. This electrical ground connection allows for each device within the enclosure to have a separate wire brought back to the central wire location. Usually, the ground connection is a copper plate directly bonded to the back panel or a copper strip with multiple screw locations. The Brick Motion Controller is brought to the earth-ground via the fourth pin on the J1 connector, located at the bottom of the unit through a heavy gauge, multi-strand conductor to the central earth-ground location.

Earth Grounding Paths

High-frequency noises from the PWM controlled power stage will find a path back to the drive. It is best that the path for the high-frequency noises be controlled by careful installation practices. The major failure in problematic installations is the failure to recognize that wire conductors have impedances at high frequencies. What reads 0 Ohms on a DVM may be hundreds of Ohms at 30MHz. Consider the following during installation planning:

1. Star point all ground connections. Each device wired to earth ground should have its own conductor brought directly back to the central earth ground plate.
2. Use unpainted back panels. This allows a wide area of contact for all metallic surfaces reducing high frequency impedances.
3. Conductors made up of many strands of fine conducts outperform solid or conductors with few strands at high frequencies.
4. Motor cable shields should be bounded to the back panel using 360-degree clamps at the point they enter or exit the panel.
5. Motor shields are best grounded at both ends of the cable. Again, connectors using 360-degree shield clamps are superior to connector designs transporting the shield through a single pin. Always use metal shells.
6. Running motor armature cables with any other cable in a tray or conduit should be avoided. These cables can radiate high frequency noise and couple into other circuits.

Connectors

X1-X8: Encoder Input (1 to 8)

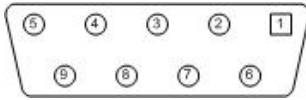
The main encoder input channels for the Brick Motion Controller support only differential quadrature feedback. 5V supply to power the encoder is provided.

- 4-axis drives with no Option 01 or Option 02 have only X1 to X4, for a total of four encoders
 - Option 01 adds two extra S. encoders: X5 and X6, for a total of six encoders
 - Option 02 adds two more S. encoders on top of Option 01: X7 and X8 for a total of eight encoder feedbacks.
- 6-axis drives with no Option 02 have only X1 to X6, for a total of six encoders
Option 02 adds two extra S. encoders: X7 and X8 for a total of eight encoder feedbacks.
- 8-axis drives have a default of eight encoders (X1 to X8) and there are no additional encoder options.

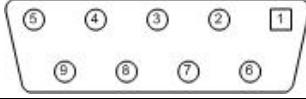
X1-X8 Encoder Input (1-8) (Female DB-15 Connector)			
Pin #	Symbol	Function	Notes
1	CHAN+	Input	Axis n Encoder A+
2	CHBn+	Input	Axis n Encoder B+
3	CHCn+	Input	Axis n Encoder Index+
4	ENCPWRn	Output	Encoder Power 5V
5	CHUn+ / DIRn+	In/Out	Axis n U Commutation+ / If set for Steppers, axis #n Direction output +
6	CHWn+ / PULn+	In/Out	Axis n W Commutation+ / If set for Steppers, axis #n Pulse output +
7	2.5V	Output	2.5V Reference power
8	Stepper Enable #n	Input	Short pin 8 to pin 4 (5V) to enable stepper output for channel #n*
9	CHAN-	Input	Axis n Encoder A-
10	CHBn-	Input	Axis n Encoder B-
11	CHCn-	Input	Axis n Encoder Index-
12	GND	Common	Common GND
13	CHVn+ / DIRn-	In/Out	Axis n V Commutation+ / If set for Steppers, axis #n Direction output -
14	CHTn+ / PULn-	In/Out	Axis n T Commutation+ / If set for Steppers, axis #n Pulse output -
15	ResOut#n	Output	Resolver excitation output for channel #n

Because the same pinouts are used for all encoders, n stands for encoder number 1 to 8: n=1 / axis 1, n=2 / axis 2, etc.
For spacing specifications between the DB- connectors, see Appendix A of this manual.

X9-10: Analog I/O Ch5 (X9) and Ch6 (X10), (Optional)

X9/10 (Female DB-9 Connector)			
Pin #	Symbol	Function	Notes
1	AGND		Common
2	ADC5/6+	Input	16-bit Analog Input, channel 5/6+ *
3			
4			
5			
6	ADC5/6-	Input	16-bit Analog Input, channel 5/6+ *
7			
8			
9			
For spacing specifications between the DB- connectors, see Appendix A of this manual.			

X11-12: Analog I/O Ch7 (X11) and Ch8 (X12), (Optional)

X11/12 (Female DB-9 Connector)			
Pin #	Symbol	Function	Notes
1	AGND		Common
2	ADC7/8+	Input	12-bit Analog Input, channel 7/8+ *
3			
4			
5			
6	ADC7/8-	Input	12-bit Analog Input, channel 7/8+ *
7			
8			
9			
For spacing specifications between the DB- connectors, see Appendix A of this manual.			

X13: USB 2.0 Connector

This connector is used in conjunction with USB A-B cable, which can be purchased from any local computer store and is provided when Option 1A is ordered. The A connector is connected to a PC or Hub device; the B connector plugs into the J9-USB port.

X14: RJ45, Ethernet Connector

This connector is used for Ethernet communications from the Geo PMAC Drive to a PC.

Note:

Delta Tau Systems strongly recommends the use of RJ45 CAT5e or better shielded cable.

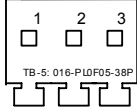
Newer network cards have the Auto-MDIX feature that eliminates the need for crossover cabling by performing an internal crossover when a straight cable is detected during the auto-negotiation process.

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).

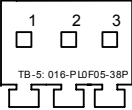
X15: Watchdog

The X15 connector allows the user to send an output from the Brick Motion Controller to the machine if a watchdog condition has occurred at the Drive. This is an important safety feature because the Geo is totally disabled when it is in watchdog condition and this output will allow the other machine's hardware/logic to bring the drive to a safe condition.

Watchdog (X15) (Phoenix 3-pin Terminal Block)			
Pin #	Symbol	Function	Notes
1	N.O.	Output	Normally open contact
2	N.C.	Output	Normally closed contact
3	COM	Input	Watchdog common
3-pin terminal block connector at the front. Part Type: FRONT-MC 1, 5/3-ST-3.81 p/n: 1850673			

TB1: Power Connector

The TB1 connector at the bottom panel allows the user to supply 24V DC power for the Brick Controller.

Watchdog (TB1) (Phoenix 3-pin Terminal Block)			
Pin #	Symbol	Function	Notes
1	+24VDC	Input	
2	Chassis GND	Input	
3	+24V return	Input	

S1: Re-Initialization on Reset Control

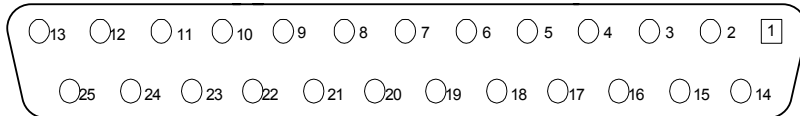
Hold switch in during power cycle for PMAC re-initialization.

S2: Firmware Reload Enable

Hold switch in during power cycle for PMAC firmware reload.

J4 Limit Inputs (1-4 Axis)

The Brick Motion Controller limit and flag circuits give the flexibility to wire in standard 12V to 24V limits and flags or wire in 5V level limits and flags on a channel basis. The default is set for the standard 12V to 24V inputs, but if the resistor pack is added to the circuit, the card can read 5V inputs.

J4 Limit Inputs (Female DB-25 Connector)			
Pin #	Symbol	Function	Description
1	USER1	Input	User Flag 1
2	MLIM1	Input	Negative Limit 1
3	FL_RT1	Input	Flag Return 1
4	USER2	Input	User Flag 2
5	MLIM2	Input	Negative Limit 2
6	FL_RT2	Input	Flag Return 2
7	USER3	Input	User Flag 3
8	MLIM3	Input	Negative Limit 3
9	FL_RT3	Input	Flag Return 3
10	USER4	Input	User Flag 4
11	MLIM4	Input	Negative Limit 4
12	FL_RT4	Input	Flag Return
13	GND	Common	
14	PLIM1	Input	Positive Limit 1
15	HOME1	Input	Home Flag 1
16	BEQU1	Output	Compare Output, EQU 1, signal is TTL (5V) level
17	PLIM2	Input	Positive Limit 2
18	HOME2	Input	Home Flag 2
19	BEQU2	Output	Compare Output, EQU 2, signal is TTL (5V) level
20	PLIM3	Input	Positive Limit 3
21	HOME3	Input	Home Flag 3
22	BEQU3	Output	Compare Output, EQU 3, signal is TTL (5V) level
23	PLIM4	Input	Positive Limit 4
24	HOME4	Input	Home Flag 4
25	BEQU4	Output	Compare Output, EQU 4, signal is TTL (5V) level

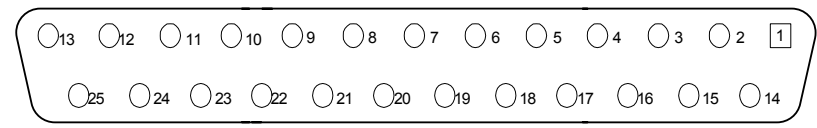
If RP39 (limits 1), RP43 (limits 2), RP47 (limits 3) and RP51 (limits 4) are installed to the unit, the voltage level of the flags can be lowered to 5V. User needs to specify these when ordering the unit.
 RP39, RP43, RP47 and RP51 for 5V flags: 1Kohm Sip, 8-pin, four independent Resistors
 RP39, RP43, RP47 and RP51 for 12-24Vflags: Empty bank (Default)
 See Appendix B for Schematic

J5 Limit Inputs (5-8 Axis)

The Brick Motion Controller limit and flag circuits give the flexibility to wire in standard 12V to 24V limits and flags or wire in 5V level limits and flags on a channel basis. The default is set for the standard 12V to 24V inputs, but if the resistor pack is added to the circuit, the card can read 5V inputs.

Note:

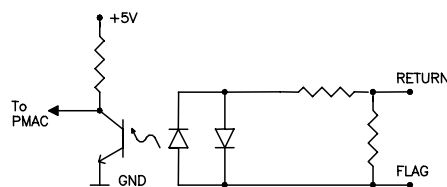
J5 comes only with the 8-axis configuration.

J5 Limit Inputs (Female DB-25 Connector)			
Pin #	Symbol	Function	Description
1	USER5	Input	User Flag 5
2	MLIM5	Input	Negative Limit 5
3	FL RT5	Input	Flag Return 5
4	USER6	Input	User Flag 6
5	MLIM6	Input	Negative Limit 6
6	FL RT6	Input	Flag Return 6
7	USER7	Input	User Flag 7
8	MLIM7	Input	Negative Limit 7
9	FL RT7	Input	Flag Return 7
10	USER8	Input	User Flag 8
11	MLIM8	Input	Negative Limit 8
12	FL RT8	Input	Flag Return 8
13	GND	Common	
14	PLIM5	Input	Positive Limit 5
15	HOME5	Input	Home Flag 5
16	BEQU5	Output	Compare Output, EQU 5, signal is TTL (5V) level
17	PLIM6	Input	Positive Limit 6
18	HOME6	Input	Home Flag 6
19	BEQU6	Output	Compare Output, EQU 6, signal is TTL (5V) level
20	PLIM7	Input	Positive Limit 7
21	HOME7	Input	Home Flag 7
22	BEQU7	Output	Compare Output, EQU 7, signal is TTL (5V) level
23	PLIM8	Input	Positive Limit 8
24	HOME8	Input	Home Flag 8
25	BEQU8	Output	Compare Output, EQU 8, signal is TTL (5V) level

If J5 is present and RP89 (limits 5), RP93 (limits 6), RP97 (limits 7) and RP101 (limits 8) are installed to the unit, the voltage level of the flags can be lowered to 5V. User needs to specify these when ordering the unit.
 RP89, RP93, RP97 and RP101 for 5V flags: 1Kohm Sip, 8-pin, four independent Resistors
 RP89, RP93, RP97 and RP101 for 12-24V flags: Empty bank. (Default)
 See Appendix B for Schematic

Limit and Flag Circuit Wiring

The Brick Motion Controller allows the use of sinking or sourcing position limits and flags to the controller. The opto-isolator IC used is a PS2705-4NEC-ND quad phototransistor output type. This IC allows the current to flow from return to flag (sinking) or from flag to return (sourcing).

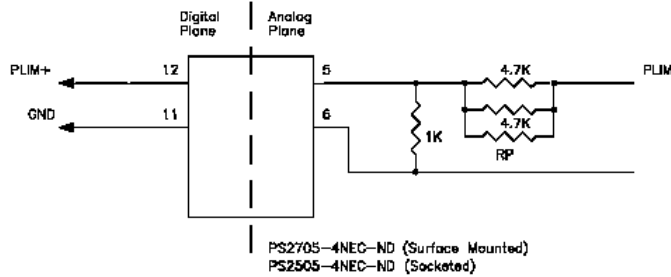


A sample of the positive limit circuit is shown below. The 4.7K resistor packs used will allow 12-24V flag inputs. If 0-5V flags are used, then a 1KΩ resistor pack (RP) can be placed in:

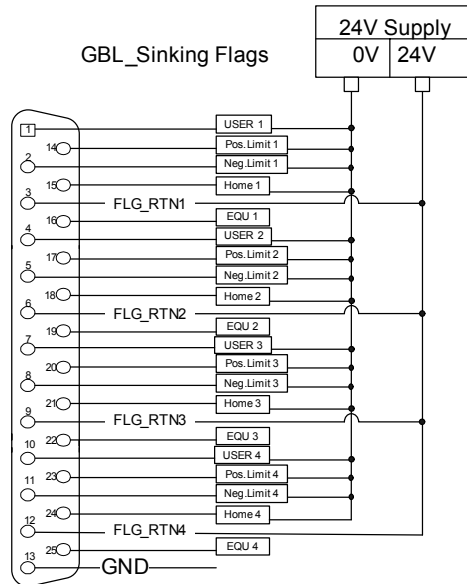
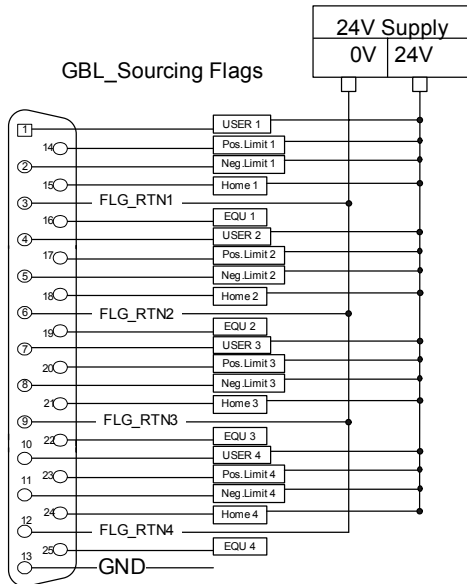
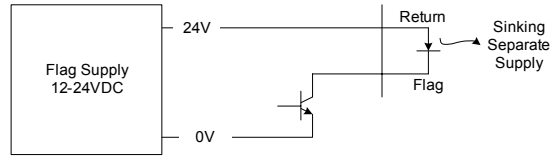
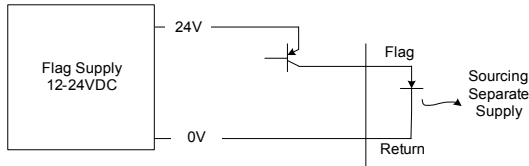
Flags 1-4: RP39 (channel 1), RP43 (channel 2), RP 47 (channel 3), RP51 (channel 4)

Flags 5-8: RP89 (channel 5), RP93 (channel 6), RP 97 (channel 7), and RP 101 (channel 8).

If these resistor packs are not added, all flags (\pm Limits, Home, and User) will be referenced from 12-24V.



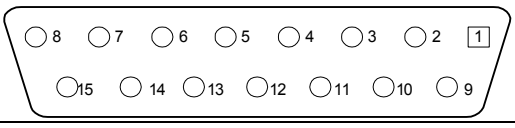
Sample J4/J5, Flags Wiring Diagrams



J4 and J5 pinout is the same; J4 is for axis 1-4 and J5 for 5-8.

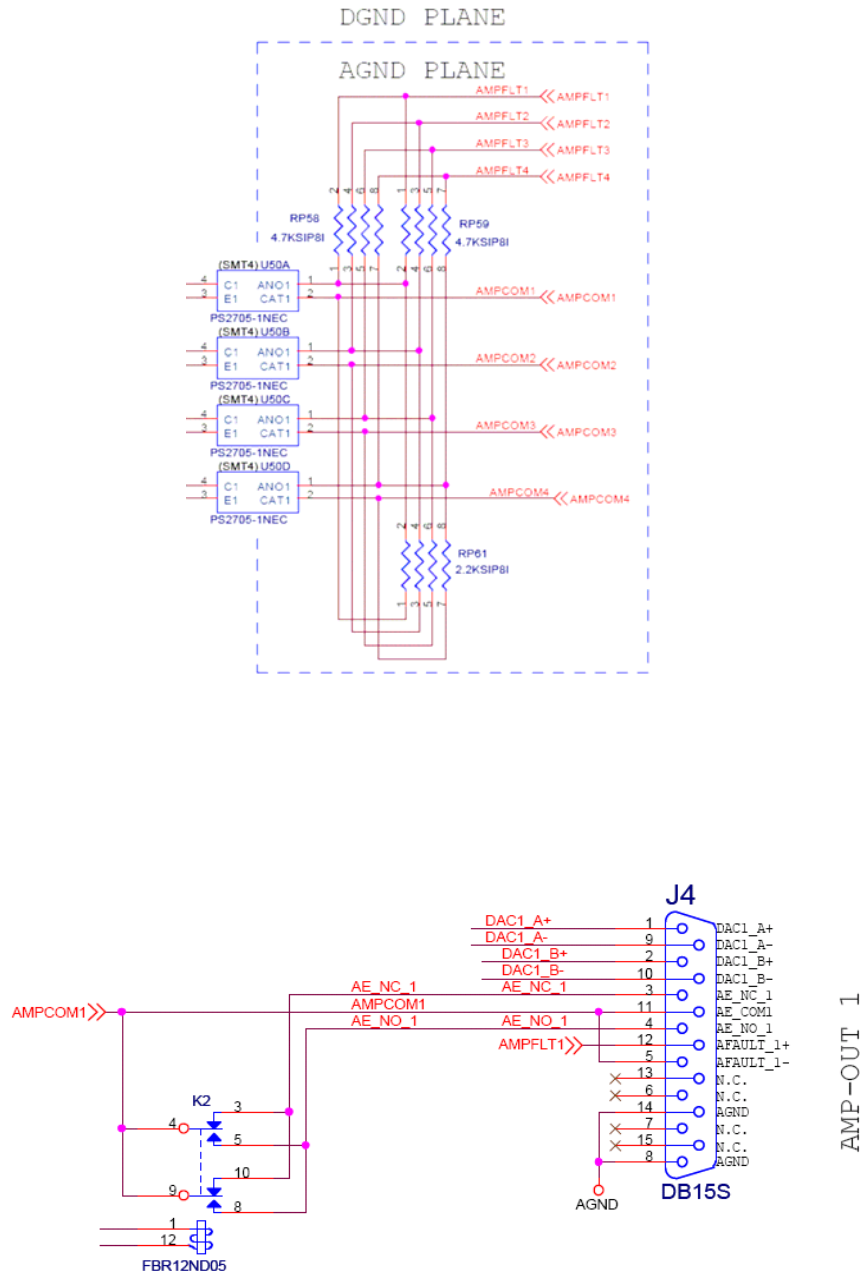
For the Flags, sinking and sourcing may be mixed depending on the FLG_RTNI input (n=1-8 depending on the channel).

AMP1-AMP8: Amplifier connections (1 to 8)

AMP1-AMP8 Amplifier connections (1-8) (Female DB-15 Connector)			
Pin #	Symbol	Function	Notes
1	DACnA+	Output	DAC A output channel n +
2	DACnB+	Output	DAC B output channel n +
3	AE_NCn+	Output	Amplifier Enable Relay Normally Open channel n +
4	AE_NOOn+	Output	Amplifier Enable Relay Normally Closed channel n
5	AFAULTn-	Input	Amplifier Fault channel n -
6	N.C.		No connection
7	N.C.		No connection
8	AGND	Common	Analog Ground
9	DACnA -	Output	DAC A output channel n -
10	DACnB -	Output	DAC B output channel n -
11	AE_COMn	Common	Amplifier Enable Relay Common channel n
12	AFAULTn+	Input	Amplifier Fault channel n +
13	N.C.		No connection
14	AGND	Common	Analog Ground
15	N.C.		No connection

Because the same pinouts are used for all amplifiers, n stands for amplifier number 1 to 8: n=1 / axis 1, n=2 / axis 2, etc.

Amplifier Fault / Amplifier Enable diagrams



J6: General Purpose I/O

General purpose I/O is available on the Brick Motion Controller. All I/O is electrically isolated from the drive. Inputs can be configured for sinking or sourcing applications. All Inputs are 12-24VDC. All Outputs are 24V nominal operation, 0.5A maximum current. Outputs are robust against ESD and overload.

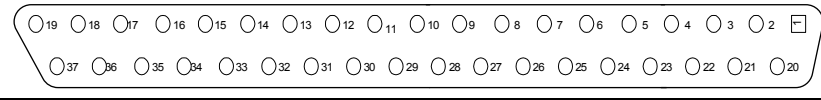
J6 General Purpose I/O (Female DB-37 Connector)			
Pin #	Symbol	Function	Description
1	GPIN01	Input	Input 1
2	GPIN03	Input	Input 3
3	GPIN05	Input	Input 5
4	GPIN07	Input	Input 7
5	GPIN09	Input	Input 9
6	GPIN11	Input	Input 11
7	GPIN13	Input	Input 13
8	GPIN15	Input	Input 15
9	IN_COM 01-08	Input	Input 01 to 08 Common
10	N.C		Not Connected
11	COM_EMT	Input	Common Emitter *
12	GP01-	Output	Sourcing Output 1 **
13	GP02-	Output	Sourcing Output 2 **
14	GP03-	Output	Sourcing Output 3 **
15	GP04-	Output	Sourcing Output 4 **
16	GP05-	Output	Sourcing Output 5 **
17	GP06-	Output	Sourcing Output 6 **
18	GP07-	Output	Sourcing Output 7 **
19	GP08-	Output	Sourcing Output 8 **
20	GPIN02	Input	Input 2
21	GPIN04	Input	Input 4
22	GPIN06	Input	Input 6
23	GPIN08	Input	Input 8
24	GPIN10	Input	Input 10
25	GPIN12	Input	Input 12
26	GPIN14	Input	Input 14
27	GPIN16	Input	Input 16
28	IN_COM 09-16	Input	Input 09 to 16 Common
29	COM_COL	Input	Common Collector **
30	GP01+	Output	Sinking Output 1 *
31	GP02+	Output	Sinking Output 2 *
32	GP03+	Output	Sinking Output 3 *
33	GP04+	Output	Sinking Output 4 *
34	GP05+	Output	Sinking Output 5 *
35	GP06+	Output	Sinking Output 6 *
36	GP07+	Output	Sinking Output 7 *
37	GP08+	Output	Sinking Output 8 *
<p>*For sinking outputs, connect the COM_EMT (pin11) line to the Analog Ground of the Power supply and the outputs to the individual plus output lines, e.g. GP01+</p> <p>**For sourcing outputs, connect the COM_COL (pin29) line to 12-24V and the outputs to the individual minus output lines, e.g., GP01-</p> <p>Do not mix topologies, i.e., all sinking or all sourcing outputs. If the common emitter is used, the common collector should be unconnected. Conversely, if the common collector is used, the common emitter should be unconnected.</p>			

Suggested M-Variable Addressing for the General Purpose I/O (J6)

Suggested M-var. #	Address	Notes		
M0->	Y:\$78800,0,1	Input 1 Data Line, J6 Pin 1		
M1->	Y:\$78800,1,1	Input 2 Data Line, J6 Pin 20		
M2->	Y:\$78800,2,1	Input 3 Data Line, J6 Pin 2		
M3->	Y:\$78800,3,1	Input 4 Data Line, J6 Pin 21		
M4->	Y:\$78800,4,1	Input 5 Data Line, J6 Pin 3		
M5->	Y:\$78800,5,1	Input 6 Data Line, J6 Pin 22		
M6->	Y:\$78800,6,1	Input 7 Data Line, J6 Pin 4		
M7->	Y:\$78800,7,1	Input 8 Data Line, J6 Pin 23		
M8->	Y:\$78801,0,1	Input 9 Data Line, J6 Pin 5		
M9->	Y:\$78801,1,1	Input 10 Data Line, J6 Pin 24		
M10->	Y:\$78801,2,1	Input 11 Data Line, J6 Pin 6		
M11->	Y:\$78801,3,1	Input 12 Data Line, J6 Pin 25		
M12->	Y:\$78801,4,1	Input 13 Data Line, J6 Pin 7		
M13->	Y:\$78801,5,1	Input 14 Data Line, J6 Pin 26		
M14->	Y:\$78801,6,1	Input 15 Data Line, J6 Pin 8		
M15->	Y:\$78801,7,1	Input 16 Data Line, J6 Pin 27		
M32->	Y:\$078802,0,1	Output 1 Data Line	12	30
M33->	Y:\$078802,1,1	Output 2 Data Line	13	31
M34->	Y:\$078802,2,1	Output 3 Data Line	14	32
M35->	Y:\$078802,3,1	Output 4 Data Line	15	33
M36->	Y:\$078802,4,1	Output 5 Data Line	16	34
M37->	Y:\$078802,5,1	Output 6 Data Line	17	35
M38->	Y:\$078802,6,1	Output 7 Data Line	18	36
M39->	Y:\$078802,7,1	Output 8 Data Line	19	37
Do not mix topologies, i.e., all sinking or all sourcing outputs. If the common emitter is used, the common collector should be unconnected. Conversely, if the common collector is used, the common emitter should be unconnected.			Sourcing	Sinking

J7: Extra General Purpose I/O (Optional)

General purpose I/O is available on the Brick Motion Controller. All I/O is electrically isolated from the drive. Inputs can be configured for sinking or sourcing applications. All Inputs are 12-24VDC. All Outputs are 24V nominal operation, 0.5A maximum current. Outputs are robust against ESD and overload.

J7 General Purpose I/O (Female DB-37 Connector)			
Pin #	Symbol	Function	Description
1	GPIN17	Input	Input 17
2	GPIN19	Input	Input 19
3	GPIN21	Input	Input 21
4	GPIN23	Input	Input 23
5	GPIN25	Input	Input 25
6	GPIN27	Input	Input 27
7	GPIN29	Input	Input 29
8	GPIN31	Input	Input 31
9	IN_COM 17-24	Input	Input 17 to 24 Common
10	N.C		Not Connected
11	COM_EMT	Input	Common Emitter **
12	GPO9-	Output	Sourcing Output 9 **
13	GPO10-	Output	Sourcing Output 10 **
14	GPO11-	Output	Sourcing Output 11 **
15	GPO12-	Output	Sourcing Output 12 **
16	GPO13-	Output	Sourcing Output 13 **
17	GPO14-	Output	Sourcing Output 14 **
18	GPO15-	Output	Sourcing Output 15 **
19	GPO16-	Output	Sourcing Output 16 **
20	GPIN18	Input	Input 18
21	GPIN20	Input	Input 20
22	GPIN22	Input	Input 22
23	GPIN24	Input	Input 24
24	GPIN26	Input	Input 26
25	GPIN28	Input	Input 28
26	GPIN30	Input	Input 30
27	GPIN32	Input	Input 32
28	IN_COM 25-32	Input	Input 25 to 32 Common
29	COM_COL	Input	Common Collector *
30	GPO9+	Output	Sinking Output 9 *
31	GPO10+	Output	Sinking Output 10 *
32	GPO11+	Output	Sinking Output 11 *
33	GPO12+	Output	Sinking Output 12 *
34	GPO13+	Output	Sinking Output 13 *
35	GPO14+	Output	Sinking Output 14 *
36	GPO15+	Output	Sinking Output 15 *
37	GPO16+	Output	Sinking Output 16 *

*For sinking outputs, connect the COM_EMT (pin11) line to the Analog GND of the Power supply and the outputs to the individual plus output lines, e.g. GPO9+

**For sourcing outputs, connect the COM_COL (pin29) line to 12-24V and the outputs to the individual minus output lines, e.g., GPO9-

Do not mix topologies, i.e., all sinking or all sourcing outputs. If the common emitter is used, the common collector should be unconnected. Conversely, if the common collector is used, the common emitter should be unconnected.

Suggested M-Variable Addressing for the optional General Purpose I/O (J7)

Suggested M-var. #	Address	Notes		
M40->	Y:\$78803,0,1	Input 17 Data Line, J7 Pin 1		
M41->	Y:\$78803,1,1	Input 18 Data Line, J7 Pin 20		
M42->	Y:\$78803,2,1	Input 19 Data Line, J7 Pin 2		
M43->	Y:\$78803,3,1	Input 20 Data Line, J7 Pin 21		
M44->	Y:\$78803,4,1	Input 21 Data Line, J7 Pin 3		
M45->	Y:\$78803,5,1	Input 22 Data Line, J7 Pin 22		
M46->	Y:\$78803,6,1	Input 23 Data Line, J7 Pin 4		
M47->	Y:\$78803,7,1	Input 24 Data Line, J7 Pin 23		
M48->	Y:\$78804,0,1	Input 25 Data Line, J7 Pin 5		
M49->	Y:\$78804,1,1	Input 26 Data Line, J7 Pin 24		
M50->	Y:\$78804,2,1	Input 27 Data Line, J7 Pin 6		
M51->	Y:\$78804,3,1	Input 28 Data Line, J7 Pin 25		
M52->	Y:\$78804,4,1	Input 29 Data Line, J7 Pin 7		
M53->	Y:\$78804,5,1	Input 30 Data Line, J7 Pin 26		
M54->	Y:\$78804,6,1	Input 31 Data Line, J7 Pin 8		
M55->	Y:\$78804,7,1	Input 32 Data Line, J7 Pin 27		
M56->	Y:\$078805,0,1	Output 9 Data Line	12	30
M57->	Y:\$078805,1,1	Output 10 Data Line	13	31
M58->	Y:\$078805,2,1	Output 11 Data Line	14	32
M59->	Y:\$078805,3,1	Output 12 Data Line	15	33
M60->	Y:\$078805,4,1	Output 13 Data Line	16	34
M61->	Y:\$078805,5,1	Output 14 Data Line	17	35
M62->	Y:\$078805,6,1	Output 15 Data Line	18	36
M63->	Y:\$078805,7,1	Output 16 Data Line	19	37
Do not mix topologies, i.e., all sinking or all sourcing outputs. If the common emitter is used, the common collector should be unconnected. Conversely, if the common collector is used, the common emitter should be unconnected.			Sourcing	Sinking

J8: Extra General Purpose I/O (Optional)

General purpose I/O is available on the Brick Motion Controller. All I/O is electrically isolated from the drive. Inputs can be configured for sinking or sourcing applications. All Inputs are 12-24VDC. All Outputs are 24V nominal operation, 0.5A maximum current. Outputs are robust against ESD and overload.

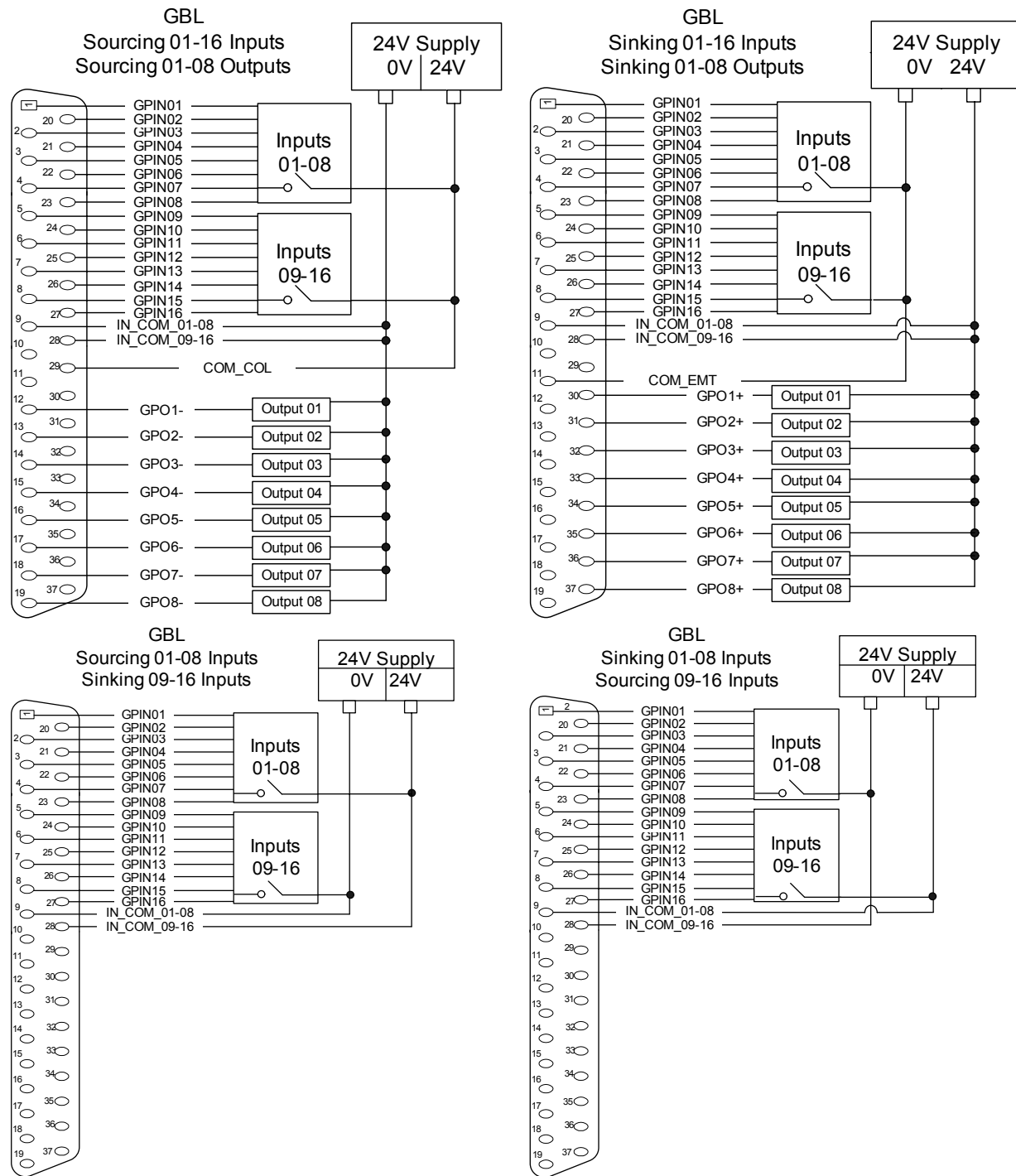
J8 General Purpose I/O (Female DB-37 Connector)			
Pin #	Symbol	Function	Description
1	GPIN33	Input	Input 33
2	GPIN35	Input	Input 35
3	GPIN37	Input	Input 37
4	GPIN39	Input	Input 39
5	GPIN41	Input	Input 41
6	GPIN43	Input	Input 43
7	GPIN45	Input	Input 45
8	GPIN47	Input	Input 47
9	IN_COM 33-40	Input	Input 33 to 40 Common
10	N.C		Not Connected
11	COM_EMT	Input	Common Emitter *
12	GP17-	Output	Sourcing Output 17 **
13	GP18-	Output	Sourcing Output 18 **
14	GP19-	Output	Sourcing Output 19 **
15	GP20-	Output	Sourcing Output 20 **
16	GP21-	Output	Sourcing Output 21 **
17	GP22-	Output	Sourcing Output 22 **
18	GP23-	Output	Sourcing Output 23 **
19	GP24-	Output	Sourcing Output 24 **
20	GPIN34	Input	Input 34
21	GPIN36	Input	Input 36
22	GPIN38	Input	Input 38
23	GPIN40	Input	Input 40
24	GPIN42	Input	Input 42
25	GPIN44	Input	Input 44
26	GPIN46	Input	Input 46
27	GPIN48	Input	Input 48
28	IN_COM 41-48	Input	Input 41 to 48 Common
29	COM_COL	Input	Common Collector **
30	GP17+	Output	Sinking Output 17 *
31	GP18+	Output	Sinking Output 18 *
32	GP19+	Output	Sinking Output 19 *
33	GP20+	Output	Sinking Output 20 *
34	GP05+	Output	Sinking Output 21 *
35	GP22+	Output	Sinking Output 22 *
36	GP23+	Output	Sinking Output 23 *
37	GP24+	Output	Sinking Output 24 *

*For sinking outputs, connect the COM_EMT (pin11) line to the Analog Ground of the Power supply and the outputs to the individual plus output lines, e.g. GPO1+
 **For sourcing outputs, connect the COM_COL (pin29) line to 12-24V and the outputs to the individual minus output lines, e.g., GPO1-
 Do not mix topologies, i.e., all sinking or all sourcing outputs. If the common emitter is used, the common collector should be unconnected. Conversely, if the common collector is used, the common emitter should be unconnected.

Suggested M-Variable Addressing for the General Purpose I/O (J8)

Suggested M-var. #	Address	Notes		
M64->	Y:\$78A00,0,1	Input 33 Data Line, J6 Pin 1		
M65->	Y:\$78A00,1,1	Input 34 Data Line, J6 Pin 20		
M66->	Y:\$78A00,2,1	Input 35 Data Line, J6 Pin 2		
M67->	Y:\$78A00,3,1	Input 36 Data Line, J6 Pin 21		
M68->	Y:\$78A00,4,1	Input 37 Data Line, J6 Pin 3		
M69->	Y:\$78A00,5,1	Input 38 Data Line, J6 Pin 22		
M70->	Y:\$78A00,6,1	Input 39 Data Line, J6 Pin 4		
M71->	Y:\$78A00,7,1	Input 40 Data Line, J6 Pin 23		
M72->	Y:\$78A01,0,1	Input 41 Data Line, J6 Pin 5		
M73->	Y:\$78A01,1,1	Input 42 Data Line, J6 Pin 24		
M74->	Y:\$78A01,2,1	Input 43 Data Line, J6 Pin 6		
M75->	Y:\$78A01,3,1	Input 44 Data Line, J6 Pin 25		
M76->	Y:\$78A01,4,1	Input 45 Data Line, J6 Pin 7		
M77->	Y:\$78A01,5,1	Input 46 Data Line, J6 Pin 26		
M78->	Y:\$78A01,6,1	Input 47 Data Line, J6 Pin 8		
M79->	Y:\$78A01,7,1	Input 48 Data Line, J6 Pin 27		
M80->	Y:\$078A02,0,1	Output 17 Data Line	12	30
M81->	Y:\$078A02,1,1	Output 18 Data Line	13	31
M82->	Y:\$078A02,2,1	Output 19 Data Line	14	32
M83->	Y:\$078A02,3,1	Output 20 Data Line	15	33
M84->	Y:\$078A02,4,1	Output 21 Data Line	16	34
M85->	Y:\$078A02,5,1	Output 22 Data Line	17	35
M86->	Y:\$078A02,6,1	Output 23 Data Line	18	36
M87->	Y:\$078A02,7,1	Output 24 Data Line	19	37
Do not mix topologies, i.e., all sinking or all sourcing outputs. If the common emitter is used, the common collector should be unconnected. Conversely, if the common collector is used, the common emitter should be unconnected.			Sourcing	Sinking

Sample J6/J7, I/O Wiring Diagrams



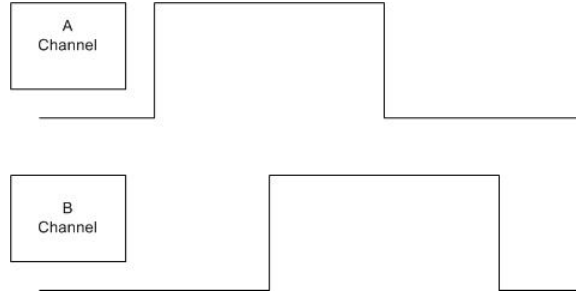
J6 and J7 pinout is the same, J6 is default I/O. J7 (Inputs 17-32 and Outputs 9-16) is installed only when Digital I/O Option1 is ordered. J8 (Inputs 33-48 and Outputs 17-24) is installed only when Digital I/O Option2 is ordered.

Setting up Quadrature Encoders

Digital quadrature encoders are the most common position sensors used with Geo Drives. Interface circuitry for these encoders comes standard on board-level Turbo PMAC controllers, UMAC axis-interface boards, Geo drives, and QMAC control boxes.

Signal Format

Quadrature encoders provide two digital signals that are a function of the position of the encoder, each nominally with 50% duty cycle, and nominally one-quarter 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.



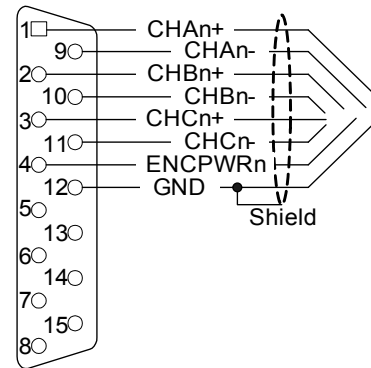
Typically, these signals are at 5V TTL/CMOS levels, whether single-ended or differential. The input circuits are powered by the main 5V supply for the controller, but they can accept up to +/-12V between the signals of each differential pair, and +/-12V between a signal and the GND voltage reference.

Differential encoder signals can enhance noise immunity by providing common-mode noise rejection. Modern design standards virtually mandate their use for industrial systems, especially in the presence of PWM power amplifiers, which generate a great deal of electromagnetic interference.

Hardware Setup

The Geo Drive accepts inputs from up to eight digital encoders and provides encoder position data to the motion processor. X1 is encoder 1 connector and X2 is encoder 2 and respectively up to X8. The differential format provides a means of using twisted pair wiring that allows for better noise immunity when wired into machinery.

Geo Drives encoder interface circuitry employs differential line receivers. The wiring diagram on the right shows an example of how to connect the Geo drive to a quadrature encoder.



Function	Pin #
CHAn+	1
CHAn-	9
CHBn+	2
CHBn-	10
CHCn+	3
CHCn-	11
ENCPWR	4
GND	12

Encoder Decode	Value	Description
17mn0	3	Clockwise decode
	7	Counter clockwise decode
m = 0 for axis 1-4 (n = 1-4) and m = 1 for axis 5 – 8 (n = 1-4)		

Encoder Loss Setup

The Brick Motion Controller has encoder-loss detection circuitry for each encoder input. Designed for use with encoders with differential line-driver outputs, the circuitry monitors each input pair with an exclusive-or (XOR) gate. If the encoder is working properly and connected to the Brick Motion Controller, the two inputs of the pair should be in opposite logical states – one high and one low – yielding a true output from the XOR gate.

Note

A single-ended encoder cannot be used on the channel Encoder-Loss Errors

For the Brick Motion Controller Controller Encoder-loss detection bits come in the locations shown in the table below.

Channel#	Address	Description
Encoder #1	Y:\$78807,0,1	Encoder #1 Loss Input Signal
Encoder #2	Y:\$78807,1,1	Encoder #2 Loss Input Signal
Encoder #3	Y:\$78807,2,1	Encoder #3 Loss Input Signal
Encoder #4	Y:\$78807,3,1	Encoder #4 Loss Input Signal
Encoder #5	Y:\$78807,4,1	Encoder #5 Loss Input Signal
Encoder #6	Y:\$78807,5,1	Encoder #6 Loss Input Signal
Encoder #7	Y:\$78807,6,1	Encoder #7 Loss Input Signal
Encoder #8	Y:\$78807,7,1	Encoder #8 Loss Input Signal

As of this writing, there is no automatic action taken on detection of encoder loss. Users who want to take action on detecting encoder loss should write a PLC program to look for a change in the encoder loss bit and take the appropriate action. Generally, the only appropriate response is to kill (open loop, zero output, disabled) the motor with lost encoder feedback; other motors may be killed or aborted as well.

This next example program reacts to a detection of encoder loss. This is a more serious condition than a count error, so a “kill” command is issued when the loss is detected. The example is for a single axis only, but is easy to duplicate for multiple axes.

```
; Substitutions and definitions
#define Mtr1OpenLoop      M138  ; Motor status bit
Mtr1OpenLoop->Y:$0000B0,18,1  ; Standard definition
#define EnclLossIn        M180  ; Input loss-detection bit
EnclLossIn->Y:$078807,0,1    ; Brick Motion Controller Ch1 loss bit
#define Mtr1EncLossStatus P180  ; Internal latched status
#define Lost              0      ; Low=true fault here
#define OK                1      ; High is encoder present
; Program (PLC) to check for and react to encoder loss
OPEN PLC 18 CLEAR
; Logic to disable and set fault status
IF (Mtr1OpenLoop=0 AND EnclLossIn=Lost)    ; Closed loop, no enc
    CMD^K                                  ; Kill all motors
    Mtr1EncLossStatus=1                    ; Indicate encoder loss
ENDIF
; Logic to clear fault status
IF (Mtr1OpenLoop=1 AND EnclLossIn=OK AND Mtr1EncLossStatus=0)
    Mtr1EncLossStatus=0                    ; Indicate valid encoder signal
ENDIF
CLOSE
```

For more details about Encoder Loss look into the Turbo USERS Manual chapter: *Making Your Application Safe*.

Setting up the Analog Inputs (optional)

The Brick Motion Controller can be ordered with two or four 16-bit hi-resolution analog to digital converters.

The Brick Motion Controller uses the Burr Brown ADS8361. *See Appendix B for partial Schematics*

When selected for bipolar mode, differential inputs allow the user to apply input voltages to ± 5 volts (10Vp-p).

To read the A/D data, the user needs to set the ADC strobe word for the second gate array to I7106 = \$1FFFFFF. Also, the user needs to create M-variable definitions that point to the ADC inputs (M-variables that are used are suggested ones) for channels 5 to 8.

Bipolar

The data received is a signed 16-bit number scaled from $-5V$ to $+5V$ (-32768cts to 32767cts).

```
M5061->Y:$78105,8,116,s ;ch5 A-D channel
```

```
M5062->Y:$7810D,8,16,s ;ch6 A-D channel
```

```
M5063->Y:$78115,8,16,s ;ch7 A-D channel
```

```
M5064->Y:$7811D,8,16,s ;ch8 A-D channel
```

Filtered DAC Outputs Configuration (optional)

The Brick Motion Controller analog $\pm 10V$ outputs are produced by filtering a PWM signal. This technique has been used for some time now by some other DeltaTau products (PMAC2A-PC/104) and many of our competitors. Although this technique does not contain the same levels of performance as a true Digital to Analog converter (DAC), for most servo applications it is more than adequate. Passing the PWM signal through a 10KHz low pass filter creates the $\pm 10V$ signal output. The duty cycle of the PWM signal is what generates the magnitude the voltage output. The frequency of the PWM signal determines the magnitude and frequency of ripple on that $\pm 10V$ signal. As you lower the PWM frequency and subsequently increase your output resolution, you increase the magnitude of the ripple as well as slow down the frequency of the ripple as well. Depending on the system, this ripple can effect performance at different levels.

Both the resolution and the frequency of the Filtered PWM outputs are configured in software on the Brick Motion Controller through the variable **I7m00**. This I7m00 variable also effects the phase and servo interrupts. Therefore as we change I7m00 we will also have to change **I7m01** (phase clock divider), **I7m02** (servo clock divider), and **I10** (servo interrupt time). These four variables are all related and must be understood before adjusting parameters. I7mn6 (m=1, n=1-4) needs to be set for PWM output.

When the analog I/O option is ordered the Brick Motion Controller comes with 2 or 4 analog ($\pm 10VDC$) output signals. These analog output signals are filtered PWM signals, 12-bit analog outputs. These outputs can be either single-ended or differential. For a single-ended analog output use the DACn+ side of the signal and leave the DACn- floating; do not ground it. For a differential command output, connect the positive side of the DACn+, and the negative side DACn-.

To limit the range of each signal to $\pm 5V$, use parameter Ixx69. Any analog output not used for dedicated servo purposes may be utilized as a general-purpose analog output. Usually this is done by defining an M-variable to the digital-to-analog-converter register (suggested M-variable definitions M502, M602,

etc.), then writing values to the M-variable. The analog outputs are intended to drive high-impedance inputs with no significant current draw. 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.

The following I-variables must be set properly to use the digital-to-analog (filtered DAC) outputs:

```
I7000 = 1001           ; PWM frequency 29.4kHz, PWM 1-4
I7001 = 5             ; Phase Clock 9.8kHz
I7002 = 3             ; Servo frequency 2.45kHz
I7003 = 1746          ; ADC frequency
I7100 = 1001          ; PWM frequency 29.4kHz, PWM 5-8
I7103 = 1746          ; ADC frequency
I70n6 = 0             ; Output mode: PWM
Ixx69 = 1001          ; DAC limit 10Vdc
I10    = 3421867      ; Servo interrupt time
```

n = channel number from 1 to 8

xx = motor number from 1 to 8

Parameters to Set up Global Hardware Signals

I7000 determines the frequency of the **MaxPhase** clock signal from which the actual phase clock signal is derived. It also determines the PWM cycle frequency for Channels 1 to 4. This variable is set according to the equation:

$$I7000 = \text{INT}[117,964.8 / (4 * \text{PWMPFreq}(\text{KHz})) - 1]$$

The Clipper Board filtered PWM circuits were optimized for about 30KHz. The minimum frequency **I7000** should be set to is 1088 (calculated as 27.06856KHz)

I7001 determines how the actual phase clock is generated from the **MaxPhase** clock, using the equation:

$$\text{PhaseFreq}(\text{kHz}) = \text{MaxPhaseFreq}(\text{kHz}) / (I7001+1)$$

I7001 is an integer value with a range of 0 to 15, permitting a division range of 1 to 16. Typically, the phase clock frequency is in the range of 8 kHz to 12 kHz. About 9 KHz is standard, set **I7001** = 5.

I7002 determines how the servo clock is generated from the phase clock, using the equation:

$$\text{ServoFreq}(\text{KHz}) = \text{PhaseFreq}(\text{KHz}) / (I7002+1)$$

I7002 is an integer value with a range of 0 to 15, permitting a division range of 1 to 16. On the servo update, which occurs once per servo clock cycle, PMAC updates commanded position (interpolates) and closes the position/velocity servo loop for all active motors, whether or not commutation and/or a digital current loop is closed. Typical servo clock frequencies are 1 to 4 kHz. The PMAC standard is about 2 KHz, set **I902** = 3.

I10 tells the Clipper Board interpolation routines how much time there is between servo clock cycles. It must be changed any time **I7000**, **I7001**, or **I7002** is changed. **I10** can be set according to the formula:

$$I10 = (2 * I7000 + 3) (I7001 + 1) (I7002 + 1) * 640 / 9$$

I10 should be set to 3421867.

I7003 determines the frequency of four hardware clock signals used for machine interface channels 1-4; This can be left at the default value (I7003=*) unless the on board Option-12 ADCs are used. The four

hardware clock signals are SCLK (encoder sample clock), PFM_CLK (pulse frequency modulator clock), DAC_CLK (digital-to-analog converter clock), and ADC_CLK (analog-to-digital converter clock).

Parameters to Set Up Per-Channel Hardware Signals

I70n6 is the output mode; “n” is the output channel number (i.e. for channel 1 the variable to set would be I7016, I7026 for channel 2 etc.). On Pmac1 there is only one output and one output mode, DAC output. On PMAC2 boards, each channel has 3 outputs, and there are 4 output modes. Since this board was designed to output filtered PWM signals we want to configure at least the first output as PWM. Therefore the default value of 0 is the choice. For information on this variable, consult the Turbo Software Reference Manual.

Ixx69 is the motor output command limit. The analog outputs on PMAC1 style boards and some PMAC2 accessories are 16-bit or 18-bit DACs, which map a numerical range of -32,768 to +32,767 into a voltage range of -10V to +10V relative to analog ground (AGND). For our purposes of a filtered PWM output this value still represents the maximum voltage output; however the ratio is slightly different. With a true DAC, $I_{xx69}=32767$ allows a maximum voltage of 10V output. With the filtered PWM circuit, I_{xx69} is a function of I7000. A 10V signal in the output register is no longer 32767 as was in PMAC1, a 10V signal corresponds to a value equal to I7000. Anything over I7000 will just rail the DAC at 10V. For example:

Desired Maximum Output Value = 6V

$$I_{xx69} = 6/10 * I7000$$

Desired Maximum Output Value = 10V

$$I_{xx69} = I7000 + 10 \quad ; \text{ add a little headroom to assure a full } 10V$$

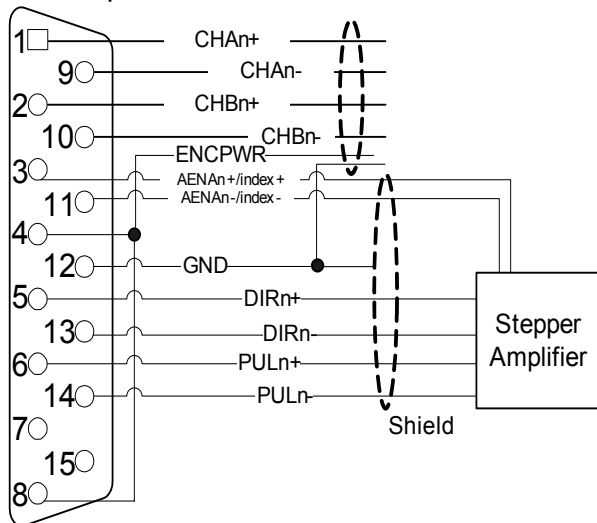
Setting up for Pulse and Direction Output

The following section shows how to quickly setup the key variables for a stepper motor (PFM) system.

The step and direction outputs are RS422 compatible and are capable of being connected in either differential mode or single ended configurations for 5V input drivers.

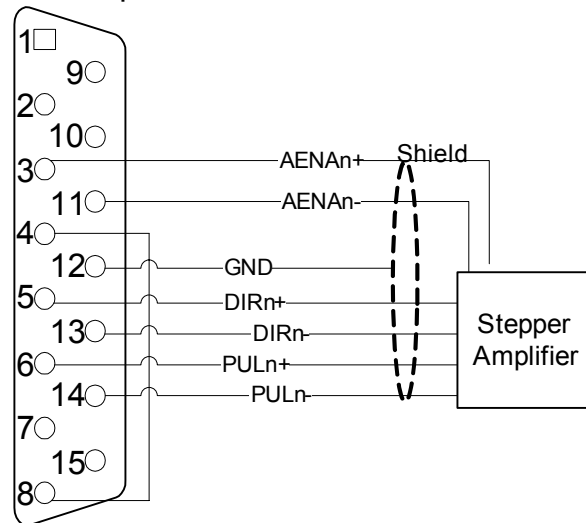
Below are two examples for wiring the Brick Motion Controller to the stepper Amplifier. The user needs to write pin 8 to pin 4 so as to enable the Stepper output and the AENA.

GBL_Stepper output wiring X1-X8,
quadrature encoder feedback,
Amplifier Enable lines are used



Short pin 8 to pin 4 to enable Stepper Output

GBL_Stepper output wiring X1-X8,
no encoder feedback
Amplifier Enable lines are used



Short pin 8 to pin 4 to enable Stepper Output

(For Older version Brick Motion Controllers: Jumpers E21(E31) through E24(E34) must be jumpered in the inside of the unit for PFM outputs and E25(35) through E28(38) must be jumpered for amplifier enable outputs. Pin 8 was not connected to anything)

Software Setup

After having the hardware ready for steppers the user needs to set the software for Pulse and direction output as well. There are several I-variables that must be set up properly for proper operation of the Pulse and direction output in a Brick Motion Controller system. It is recommended for the user to also look into the **Turbo Software reference** and the **Turbo Users** manual. The most important ones are analyzed below and we can separate them into two categories:

Multi-Channel Servo IC I-Variables

I7m00: Servo IC m MaxPhase/PWM Frequency Control

Typically, this will be set to the same value as the variable that controls the system clocks: I7000 (channels 1-4) I7100 (channels 5-8). If a different PWM frequency is desired, then the following constraint should be observed in setting this variable:

$$\frac{2 * PWMFreq(kHz)}{PhaseFreq} = \{ Integer \}$$

I7m03: Servo IC m Hardware Clock Frequency Control

The hardware clock frequencies for the Servo IC should be set according to the devices attached to it. There is no reason that these frequencies have to be the same between ICs. There is seldom a reason to change this value from the default. At default this value will be 2258, which is to a PFM clock of approximately 10 MHz, (which is about 10 times greater than normally needed). Therefore, this value is not normally changed. Refer to the Turbo Software Reference manual for changing these variables.

I7m04: PFM Pulse Width Control

The pulse width is specified in PFM clock cycles and has a range of 1 to 255 cycles. The default value is 15. Since the default value of PFM clock is actually set to 9.8304 MHz, the default output pulse width will be $15/9,830,400 = 1.5258 \mu\text{S}$. Note that when the PFM clock values are changed, the PFM pulse width values must be evaluated for proper stepper drive operation.

The user of a typical stepper drive should not need to modify these control variables. However, PFM pulse width should be increased if the stepper drive's input cannot handle the speed of the pulse output. This often occurs with slow opto-couplers used on stepper drive inputs.

Single-Channel I-Variables

Each Servo IC has four channels n , numbered 1 to 4. For the first (standard) Servo IC on the Brick Motion Controller, the channel numbers 1 – 4 on the Servo IC are the same as the channel numbers 1 – 4 on the board. For the second (optional) Servo IC on the Brick Motion Controller, the channel numbers 1 – 4 on the Servo IC correspond to board channel numbers 5 – 8. The most important variables are:

I7mn0: Servo IC m Channel n Encoder Decode Control

Typically, I7mn0 is set to 3 or 7 for x4 quadrature decode, depending on which way is up. If the channel is used for open-loop stepper drive, I7mn0 is set to 8 to accept internal pulse-and-direction.

Caution:

If I7mn0 and I7mn8 are not matched properly, motor runaway will occur.

I7mn6: Servo IC m Channel n Output Mode Select

I7mn6 determines whether the A and B outputs are DAC or PWM, and whether the C output is PFM (pulse-and-direction) or PWM. Typically, it is set to 0, either for 3-phase PWM, or to 3 for DACs and PFM.

Set the output mode for the Brick Motion Controller for Pulse Frequency Modulation output (PFM), I7mn6 equal to 2.

I7mn8: Servo IC m Channel n PFM Direction Signal Invert Control

The polarity of the direction output is controlled by this I-variable. This output establishes an active low or high output.

This I-variable works in conjunction with I7mn0. To operate correctly with the Brick Motion Controller, if I7mn0 is set to 0, then I7mn8 is set to 0. If I7mn0 is set to 4, then I7mn8 is set to 1.

Caution:

If I7mn0 and I7mn8 are not matched properly, motor runaway will occur.

The Brick Motion Controller applies its gain formulas the same way it does for a classic servo system. The basic difference with a stepper system is that most of the times, the typical encoder feedback interface is handled using electronic circuitry rather than a physical encoder.

When the stepper output interface is selected, it allows the use of an electronic encoder feedback or a physical encoder feedback. When used with an actual physical encoder, the axis should be tuned as if it were a typical servomotor.

The process of tuning the simulated feedback loop is identical to tuning a servomotor with the exception that some of the parameters become more predictable.

Ixx30: Motor xx Proportional Gain

To create a closed loop position response with a natural frequency of approximately 25 Hz and a damping ratio of 1, use the following calculation:

$$Ixx30 = \frac{660,000}{Ixx08 * PFMCLK (MHz)}$$

Example:

PFMCLK is set to default of 9.83 MHz, and Ixx08 is set to default of 96. $Ixx30 = 660,000 / (96 * 9.83) = 700$.

Ixx31 Motor x Derivative Gain

Derivative Gain is set to 0 because the motor system behaves like a velocity-loop servo drive. This parameter sets the system damping which should be unnecessary.

Ixx32 Motor xx Velocity Feedforward Gain

Use the following equation to establish a value for Ixx32:

$$Ixx32 = 6660 * ServoFreq (kHz)$$

where ServoFreq (kHz) is the frequency of the servo interrupt as established by I7m00, I7m01, and I7m02.

Example:

ServoFreq is set to default of 2.26 kHz (I7m00 = 6527, I7m01 = 0, I7m02 = 3). $Ixx32 = 6660 * 2.26 = 15,050$.

Note:

If Ixx30 were set differently from the above calculation, then Ixx32 would change inversely. For instance, if Ixx30 were twice the above calculation, then Ixx32 would be half its calculation.

Ixx33 Motor xx Integral Gain

Typically, This I-variable should be set to 0. The digital electronic loop does not present offsets or disturbances that need correction in the PMAC.

Ixx33 may be set to force zero steady-state errors, should they be present with electronic encoder feedback.

Ixx34 Motor xx Integration Mode

The default value of 1 is sufficient for this, since usually Ixx33 is set to zero. When Ixx33 is set to 0, this I-variable has no effect.

Ixx35 Motor xx Acceleration Feed-forward Gain

Start with this I-variable set to 0. Typically, this value does not need to be changed. However, Ixx35 might be adjusted to compensate for the small time delays created by the electronics when accelerating the stepper. The effect of adjusting Ixx35 will be to reduce a slight following error during motor acceleration.

Ixx36 - Ixx39 Motor xx Notch Filter Coefficients

These values should be set to their default value of 0. Since filter parameters adjust the way the gains operate due to physical resonance of a system, there is no need to set these I-variables.

Example: User wants channels 5 to 8 to be used with stepper motors. First the user needs to wire the Stepper drive, and so as to enable the Stepper output pin 8 needs to be shorted to pin 4 (+5V) for X5 to X8. Assume for this example that all the stepper motors that will be used do not have encoders for feedback.

For this example, the factory defaults for the other variables will allow the PFM outputs to be commanded with a low true Amplifier Fault and \pm Limits plugged in. If this is not the case, modify Ixx24.

For this type of system, make sure I7mn6 is set for PWM and PFM output mode.

```
I7116=2      ;CH5A and CH5B outputs will be PWM and CH5C output will be PFM
I7126=2      ;CH6A and CH6B outputs will be PWM and CH6C output will be PFM
I7136=2      ;CH7A and CH7B outputs will be PWM and CH7C output will be PFM
I7146=2      ;CH8A and CH8B outputs will be PWM and CH8C output will be PFM

I7110 = 8    ;Simulated feedback for channel 5
I7120 = 8    ;Simulated feedback for channel 6
I7130 = 8    ;Simulated feedback for channel 7
I7140 = 8    ;Simulated feedback for channel 8

I502=$078104 ;Command output to CH1A address (default address + 2) for
              ;Stepper
I602=$07810C ;Command output to CH2A address (default address + 2)
              ;for Stepper
I702=$078114 ;Command output to CH3C address (default address + 2)
              ;for Stepper
I802=$07811C ;Command output to CH4C address (default address +2)
              ;for Stepper
```


Watchdog Timer

Brick Motion Controller has an on-board watchdog timer. This subsystem provides a fail-safe shutdown to guard against software and hardware malfunction. To keep it from tripping the hardware circuit for the watchdog timer requires that two basic conditions be met. First, it must see a DC voltage greater than approximately 4.75V. If the supply voltage is below this value, the circuit's relay will trip and the card will shut down, Brick Motion Controller uses its own DC to DC converter to create 5V and +/-15V from the user supplied 24VDC. This prevents corruption of registers due to insufficient voltage.

The second necessary condition is that the timer must see a square wave input (provided by the Turbo PMAC software) of a frequency greater than approximately 25 Hz. In the foreground, the servo-interrupt routine decrements a counter (as long as the counter is greater than zero), causing the least significant bit of the timer to toggle. This bit is fed to the timer itself. At the end of each background cycle, the CPU resets the counter value to a maximum value set by variable I40 (or to 4096 if I40 is set to the default of 0). If the card, for whatever reason, due either to hardware or software problems, cannot set and clear this bit repeatedly at 25 Hz or greater, the timer will trip and the Turbo PMAC system will shut down.

Actions on Watchdog Timer Trip

When the timer trips due to either under-voltage or under-frequency, the system is latched into a reset state, with a red LED indicating watchdog failure. The processor stops operating and will not communicate. All Servo, MACRO, and I/O ICs are forced into their reset states, which force discrete outputs off, and proportional outputs (DAC, PWM, PFM) to zero-level. In Turbo PMAC2 systems there is a hard-contact relay with both normally open and normally closed contacts. In a system, these outputs should be used to drop power to the amplifiers and other key circuitry if the card fails. Once the watchdog timer has tripped, power to the Turbo PMAC must be cycled off and on, or the INIT/hardware reset line must be taken low, then high, to restore normal functioning.

Diagnosing Cause of Watchdog Timer Trip

Because the watchdog timer is designed to trip on a variety of hardware and software failures, and the trip makes it impossible to query the card, it can be difficult to determine the cause of the trip. The following procedure is recommended to figure out the cause:

1. Reset the Turbo PMAC normally, just power cycle the cycle power. If it does not trip again immediately, there is an intermittent software or hardware problem. Check for the following:
 - Software events that overload the processor at times (e.g. additional servo-interrupt tasks, intensive lookahead) or possible erroneous instruction (look for firmware or program checksum).
Review the Evaluating the Turbo PMAC's Computational Load section of the Turbo USERS manual.
 - 5V power-supply disturbances
 - Loose connections
2. If there is an immediate watchdog timer trip in Step 1, power up with the re-initialization switch pressed and hold in. If it does not trip now, there is a problem in the servo/phase task loading for the frequency, or an immediate software problem on the board. Check for the following:
 - Phase and servo clock frequencies vs. the number of motors used by Turbo PMAC. These frequencies may need to be reduced.
 - A PLC 0 or PLCC 0 program running immediately on power-up (I5 saved at 1 or 3) and taking too much time.
 - User-written servo or phase program not returning properly.
3. If there is an immediate watchdog timer trip in Step 2, check for hardware issues:

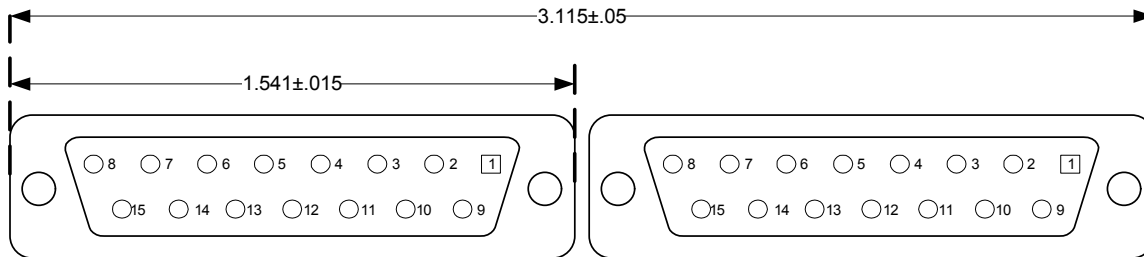
- Disconnect any accessories and cables other than the logic power and repeat to see if they are causing the problem
- Check for adequate 24V power supply levels (check at the Brick Motion Controller connector side, not at the supply)
- Inspect for hardware damage

4. If the watchdog insists after all the above, you should contact DeltaTau Inc. to get an RMA number, and ship the drive for repairs.

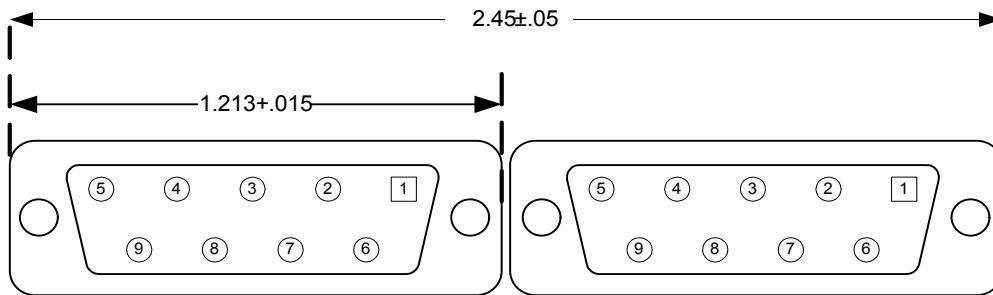
APPENDIX A

DB- Connector Spacing Specifications

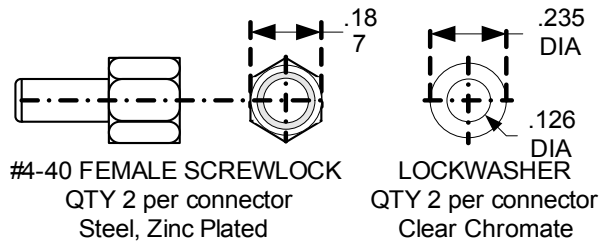
X1-8: DB-15 Connectors for encoder feedback



X9-12: DB-9 Connectors for Analog I/O



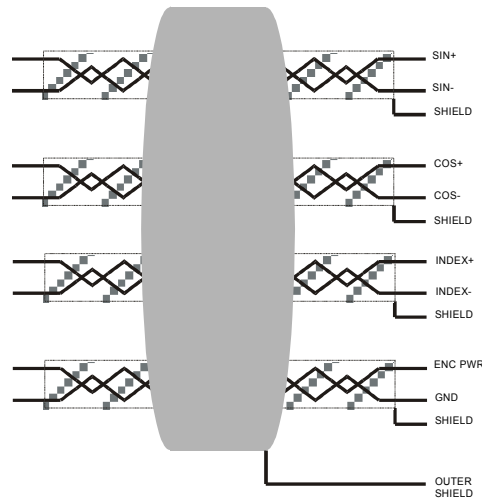
Screw Lock Size for all DB-connectors



Type of Cable for Encoder Wiring

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

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



EXAMPLE OF DOUBLE SHIELDED
4 TWISTED PAIR CABLE

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

Note:

It has been observed that there is an inconsistency in the shielding styles that are used by different encoder manufacturers.

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

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

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

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

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

Note:

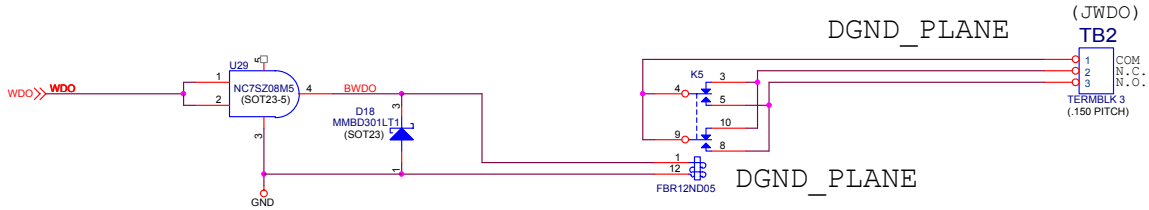
If noise is a problem in the application, careful attention must be given to the method of grounding that is used in the system. Amplifier and motor grounding can play a significant role in how noise is generated in a machine.

Noise may be reduced in a motor-based system by the use of inductors placed between the motor and the amplifier.

APPENDIX B

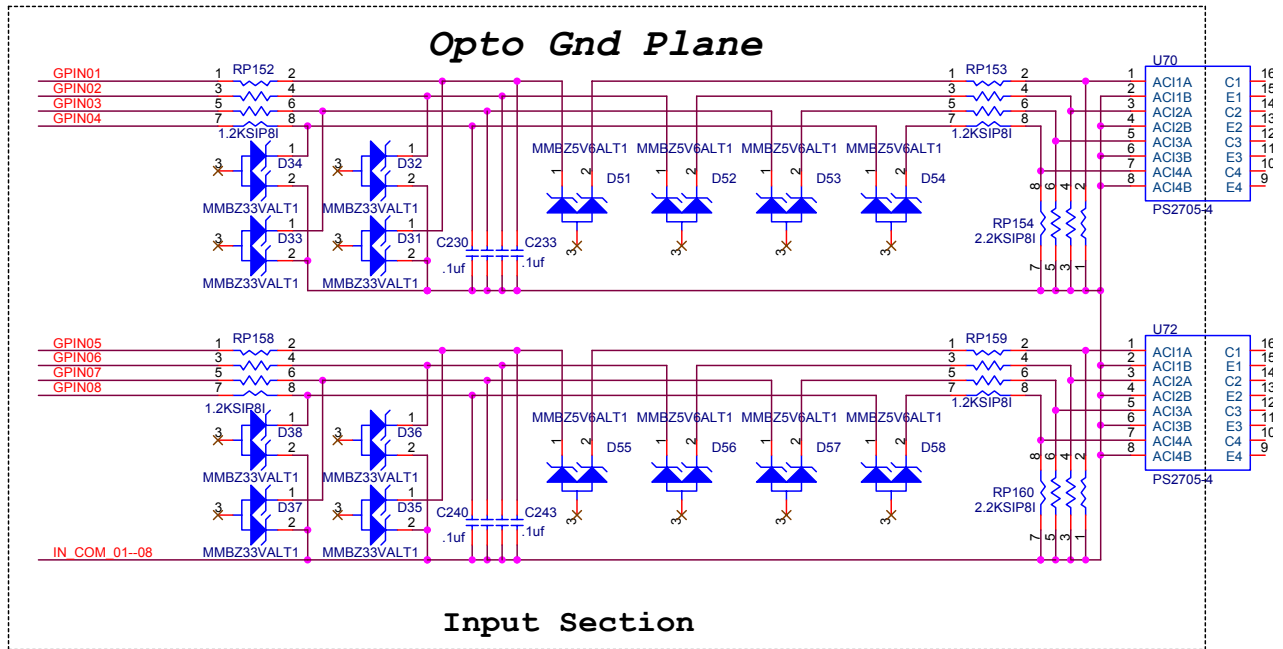
Schematics

X15: Watchdog

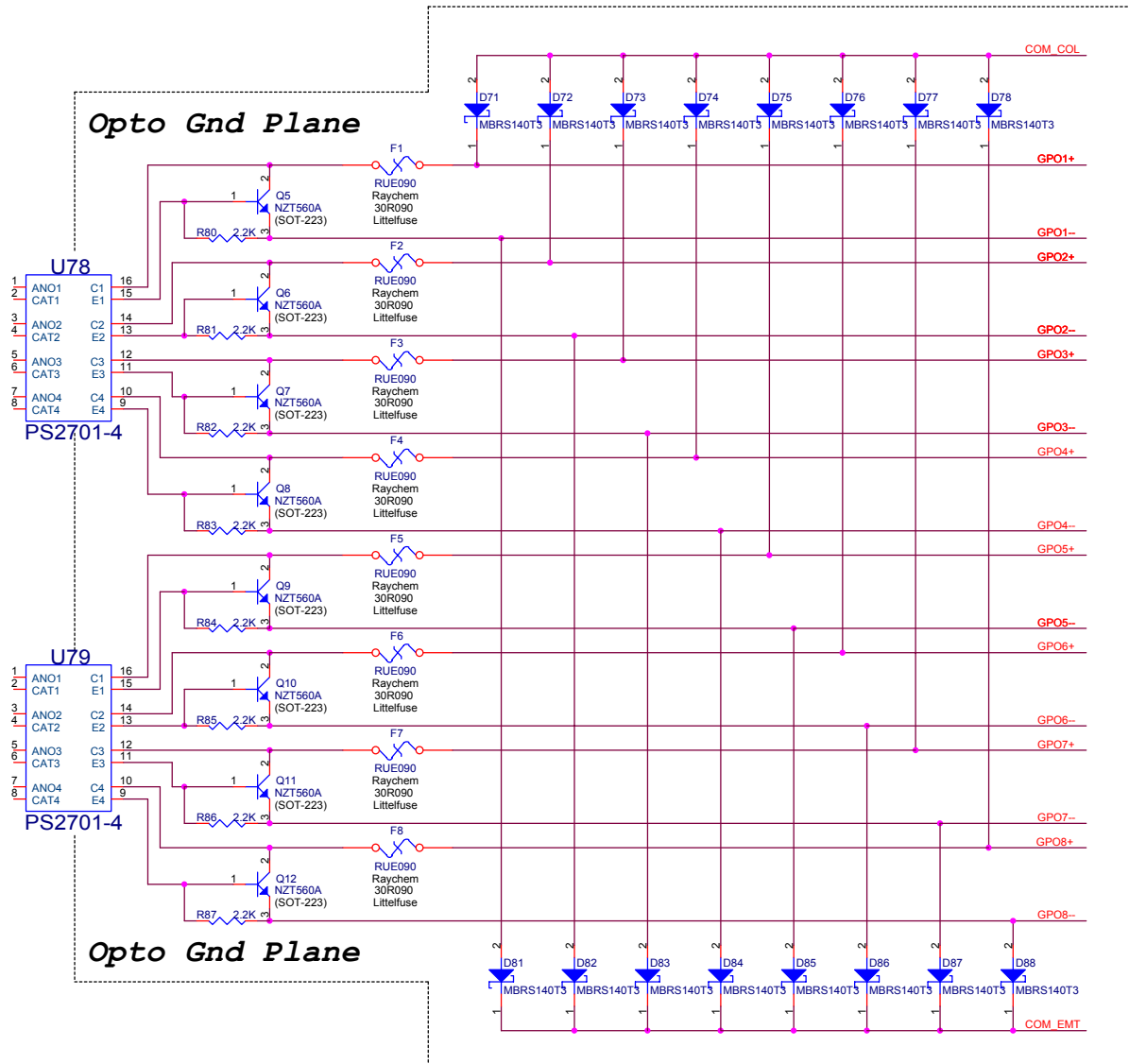


J6 and J7: General Purpose I/O

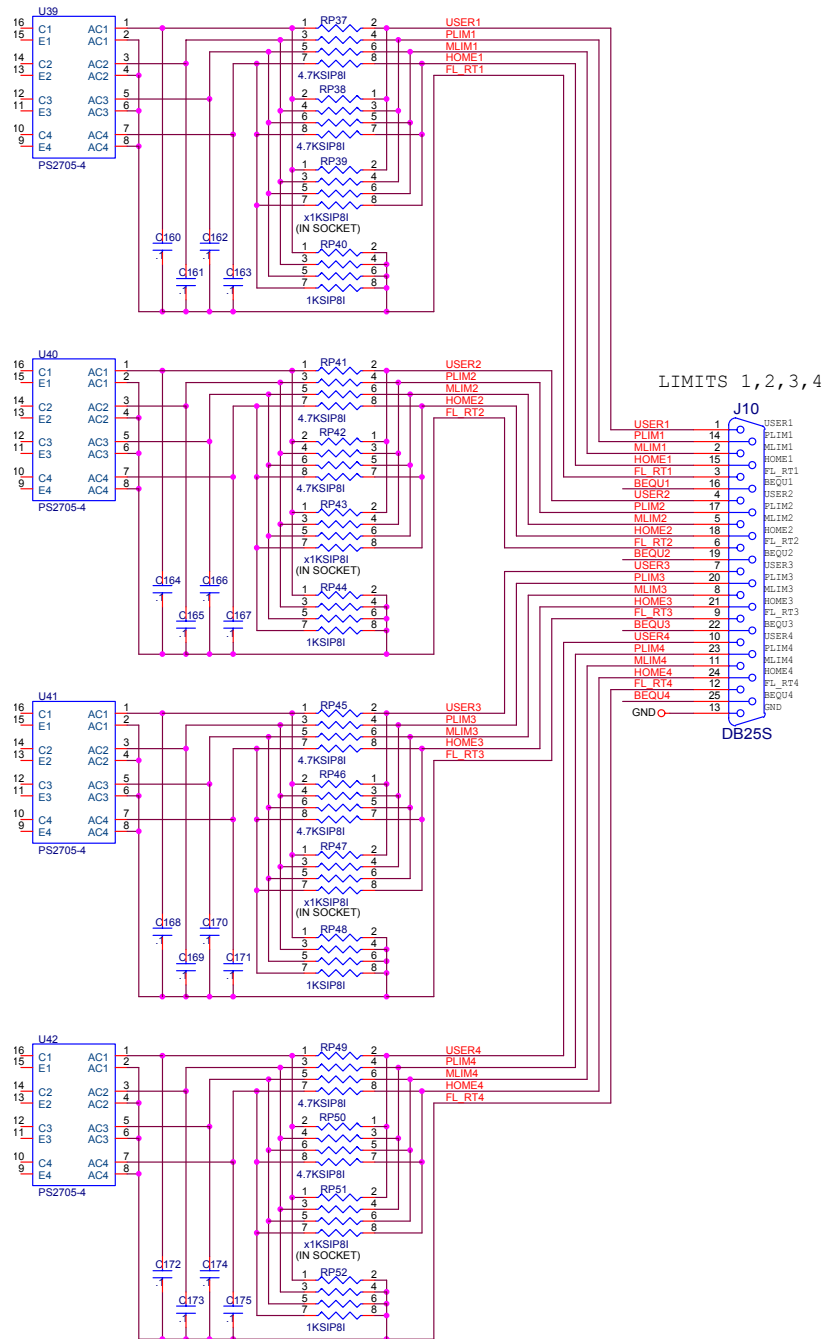
Inputs



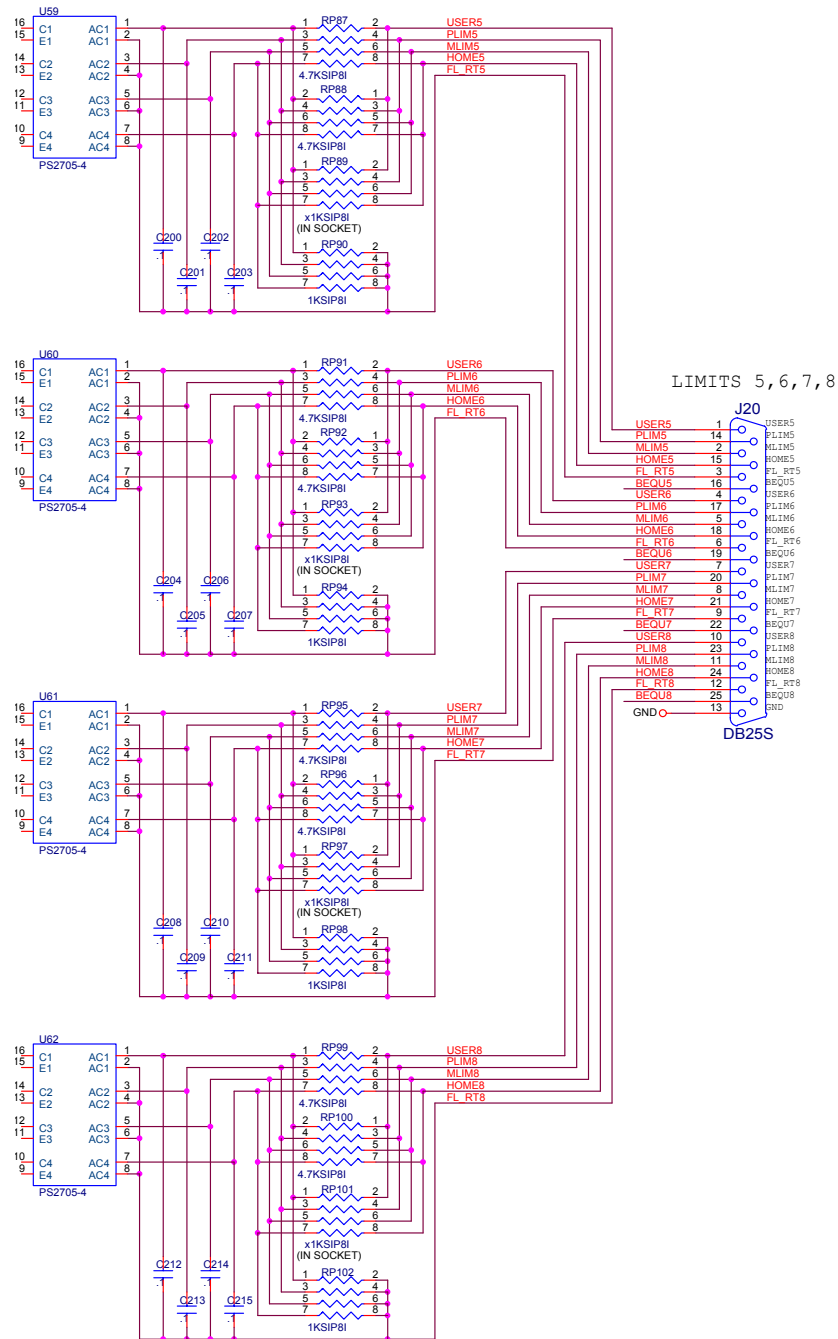
Outputs



J4: Limit Inputs for Axis 1-4



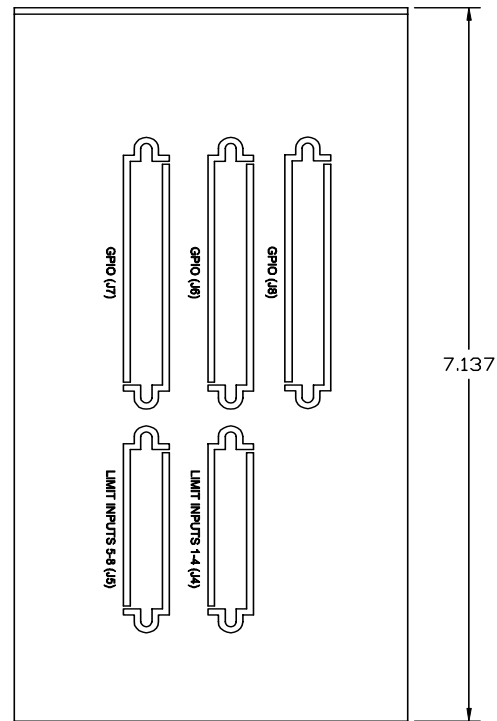
J5: Limit Inputs for Axis 5-8



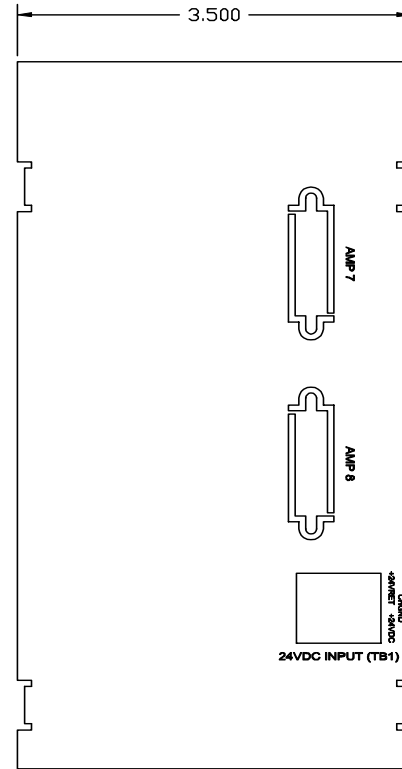
Dimensional Layout and Connector location

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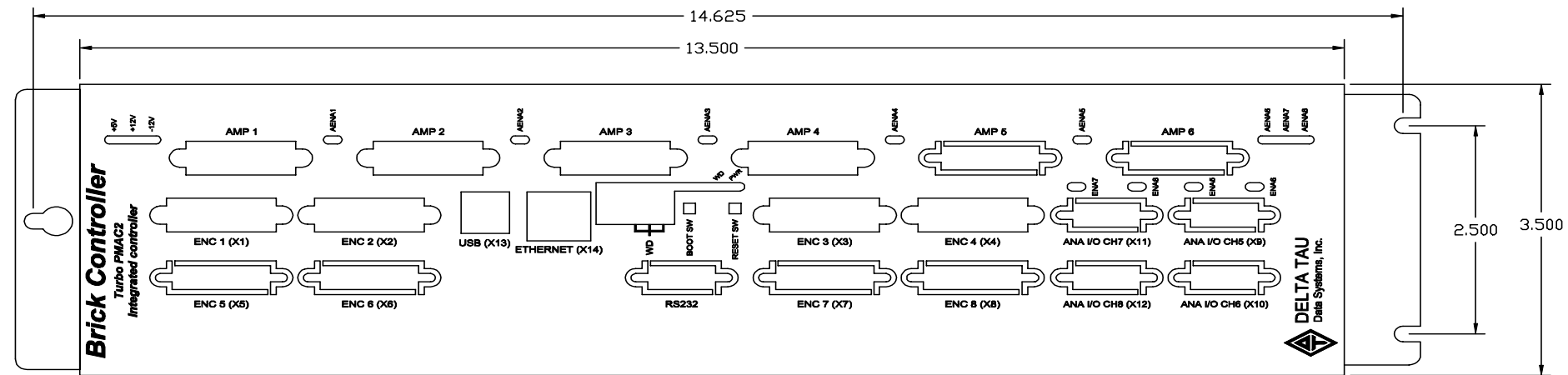
REVISIONS				
REV.	DESCRIPTION	DATE	CHGD	APPROVED
2-	NEW DRAWING RELEASE	4-19-07	N.G.	JEFF S.



TOP VIEW



BOTTOM VIEW



UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± FRAC .XX ± .03 .XXX ± .010 ± .	PROJECT	BRICK CONTROLLER		DELTA TAU DATA SYSTEMS, INC.
	NEXT LEVEL	MULTIPLE		
MATERIAL	SEE NOTES	APPROVALS	DATE	ARTWORK, BRICK CONTROLLER, TURBO PMAC2
FINISH	SEE NOTES	DRAWN	4-19-07	SIZE DWG. NO. 400-603869 DASH NO. -102 REV -
DO NOT SCALE DRAWING	FILE	400-3869-102.DWG	4-19-07	SCALE NONE SHEET 1 OF 1