INSTALLATION MANUAL

Geo Direct PWM Amplifiers

Direct PWM Amplifier

500-603700-xIxx

April 5, 2006

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:

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 Geo Drive family of "bookcase"-style servo amplifiers provides many new capabilities for users. This family of 1- and 2-axis 3-phase amplifiers, built around a common core of highly integrated IGBT-based power circuitry, supports a wide variety of motors, power ranges, and interfaces. The 2-axis configurations share common power input, bus, and shunt for a very economical implementation.

Three command interfaces are provided: direct-PWM, MACRO-ring, and integrated PMAC controller, each described in following sections. In all three cases, fully digital "direct PWM" control is used. Direct PWM control eliminates D-to-A and A-to-D conversion delays and noise, allowing higher gains for more robust and responsive tuning without sacrificing stability.

All configurations provide these power-stage features:

- Direct operation off AC power mains (100 – 240 or 300 – 480 VAC, 50/60 Hz) or DC power input (24 – 350 or 24 – 700 VDC)
- Integrated bus power supply including soft start and shunt regulator (external resistor required)
- Separate 24VDC input to power logic circuitry
- Complete protection: over voltage, under voltage, over temperature, PWM frequency limit, minimum dead time, motor over temperature, short circuit, over current, input line monitor
- Ability to drive brushed and brushless permanent-magnet servo motors, or AC induction motors
- Single-digit LED display and six discrete LEDs for status information
- Optional safety relay circuitry. Please contact factory for more details and pricing.
- Easy setup with Turbo PMAC and UMAC controllers.

User Interface

The Geo Drive family is available in different versions distinguished by their user interface styles.

Geo MACRO Drives

The Geo MACRO Drive interfaces to the controller through the 125 Mbit/sec MACRO ring, with either a fiber-optic or Ethernet electrical medium, accepting numerical command values for direct PWM voltages and returning numerical feedback values for phase current, motor position, and status. It accepts many types of position feedback to the master controller, as well as axis flags (limits, home, and user) and general-purpose analog and digital I/O. Typically, the Geo MACRO Drives are commanded by either a PMAC2 Ultralite bus-expansion board, or a UMAC rack-mounted controller with a MACRO-interface card. This provides a highly distributed hardware solution, greatly simplifying system wiring, while maintaining a highly centralized software solution, keeping system programming simple.

- Choices for main feedback for each axis: A/B quadrature encoder, sinusoidal encoder with EnDat™ or Hiperface™, SSI encoder, resolver
- Secondary A/B quadrature encoder for each axis
- General-purpose isolated digital I/O: 4 in, 4 out at 24VDC
- 2 optional A/D converters, 12- or 16-bit resolution

Geo PMAC Drives

The Geo PMAC Drive is a standalone-capable integrated controller/amplifier with a built-in full PMAC2 controller having stored-program capability. It can be operated standalone, or commanded from a host computer through USB2.0 or 100 Mbps Ethernet ports. The controller has the full software capabilities of a PMAC (see descriptions), with an internal fully-digital connection to the advanced Geo power-stage , providing a convenient, compact, and cost-effective installation for one and two-axis systems, with easy synchronization to other drives and controls.

- Choices for main feedback for each axis: A/B quadrature encoder, sinusoidal encoder with EnDat™ or Hiperface™, SSI encoder, resolver
- Secondary A/B quadrature encoder for each axis
- General-purpose isolated digital I/O: 8 in, 6 out at 24VDC
- 2 optional A/D converters 12- or 16-bit resolution

Geo Direct-PWM Drives

The direct-PWM interface versions accept the actual power-transistor on/off signals from the PMAC2 controller, while providing digital phase-current feedback and drive status to the controller for closed-loop operation. Interface to the direct-PWM amplifier is through a standard 36-pin Mini-D style cable. The drive performs no control functions but has protection features. Drive installation, maintenance, and replacement are simplified because there is less wiring (position feedback and I/O are not connected to the drive) and there are no variables to set or programs to install in the drive.

- Fully centralized control means that all gains and settings are made in the PMAC; no software setup of drive is required
- No position feedback or axis flags required at the drive

Compatible Motors

The Geo PWM Drive product line is capable of interfacing to a wide variety of motors. The Geo Brick can control almost any type of three-phase brushless motor, including DC brushless rotary, AC brushless rotary, induction, and brushless linear motors. Motor selection for an application is a science in itself and cannot be covered in this manual. However, some basic considerations and guidelines are offered. Motor manufacturers include a host of parameters to describe their motor.

Some basic equations can help guide an applications engineer to mate a proper drive with a motor. A typical application accelerates a load to a speed, running the speed for a while and then decelerating the load back into position.

Maximum Speed

The motor's maximum rated speed is given. This speed may or may not be achievable in a given system. The speed could be achieved if enough voltage and enough current loop gain are available. Also, consider the motor's feedback adding limitations to achievable speeds. The load attached to the motor also limits the maximum achievable speed. In addition, some manufacturers will provide motor data with their drive controller, which is tweaked to extend the operation range that other controllers may be able to provide. In general, the maximum speed can be determined by input voltage line-to-line divided by Kb (the motor's back EMF constant). It is wise to de-rate this a little for proper servo applications.

Torque

The torque required for the application can be viewed as both instantaneous and average. Typically, the instantaneous or peak torque is calculated as a sum of machining forces or frictional forces plus the forces required to accelerate the load inertia. The machining or frictional forces on a machine must be determined by the actual application. The energy required to accelerate the inertia follows the equation: t = JA, where t is the torque in pound-feet required for the acceleration, J is the inertia in pound-feet-second squared, and A is in radians per second per second. The required torque can be calculated if the desired acceleration rate and the load inertia reflected back to the motor are known. The t-JA equation requires that the motor's inertia be considered as part of the inertia-requiring torque to accelerate.

Once the torque is determined, the motor's specification sheet can be reviewed for its torque constant parameter (Kt). The torque required at the application divided by the Kt of the motor provides the peak current required by the amplifier. A little extra room should be given to this parameter to allow for good servo control.

Most applications have a duty cycle in which the acceleration profile occurs repetitively over time. Calculating the average value of this profile gives the continuous rating required by the amplifier. Applications also concern themselves with the ability to achieve a speed. The requirements can be reviewed by either defining what the input voltage is to the drive, or defining what the voltage requirements are at the motor. Typically, a system is designed at a 230 or 480V input line. The motor must be able to achieve the desired speed with this voltage limitation. This can be determined by using the voltage constant of the motor (Kb), usually specified in volts-per-thousand rpm. The application speed is divided by 1000 and multiplied by the motor's Kb. This is the required voltage to drive the motor to the desired velocity. Headroom of 20% is suggested to allow for good servo control.

Peak Torque

The peak torque rating of a motor is the maximum achievable output torque. It requires that the amplifier driving it be able to output enough current to achieve this. Many drive systems offer a 3:1 peak-to-continuous rating on the motor, while the amplifier has a 2:1 rating. To achieve the peak torque, the drive must be sized to be able to deliver the current to the motor. The required current is often stated on the datasheet as the peak current through the motor. In some sense, it can also be determined by dividing the peak amplifier's output rating by the motor's torque constant (Kt).

Continuous Torque

The continuous torque rating of the motor is defined by a thermal limit. If more torque is consumed from the motor than this on average, the motor overheats. Again, the continuous torque output of the motor is subject to the drive amplifier's ability to deliver that current. The current is determined by the manufacturer's datasheets stating the continuous RMS current rating of the motor and can also be determined by using the motor's Kt parameter, usually specified in torque output per amp of input current.

Motor Poles

Usually, the number of poles in the motor is not a concern to the actual application. However, it should be noted that each pole-pair of the motor requires an electrical cycle. High-speed motors with high motor pole counts can require high fundamental drive frequencies that a drive amplifier may or may not be able to output. In general, drive manufacturers with PWM switching frequencies (16kHz or below) would like to see commutation frequencies less than 400 Hz. The commutation frequency is directly related to the number of poles in the motor.

Motor Inductance

Typically, motor inductance of servomotors is 1 to 15 mH. The Geo drive product series can drive this range easily. On lower-inductance motors (below 1mH), problems occur due to PWM switching where heating currents flow through the motor, causing excessive energy waste and heating. If an application requires a motor of less than 1mH, external inductors are recommended to increase that inductance. Motors with inductance in excess of 15mH can still be driven, but are slow to react and typically are out of the range of high performance servomotors.

Motor Resistance

Motor resistance is not really a factor in determining the drive performance, but rather, comes into play more with the achievable torque or output horsepower from the motor. The basic resistance shows up in the manufacturer's motor horsepower curve.

Motor Back EMF

The back EMF of the motor is the voltage that it generates as it rotates. This voltage subtracts from the bus voltage of the drive and reduces the ability to push current through the motor. Typical back EMF ratings for servomotors are in the area of 8 to 200 volts-per-thousand rpm. The Geo drive product series can drive any range of back EMF motor, but the back EMF is highly related to the other parameters of the motor such as the motor inductance and the motor Kt. It is the back EMF of the motor that limits the maximum achievable speed and the maximum horsepower capability of the motor.

Motor Torque Constant

Motor torque constant is referred to as Kt and usually it is specified in torque-per-amp. It is this number that is most important for motor sizing. When the load that the motor will see and the motor's torque constant is known, the drive amplifier requirements can be calculated to effectively size a drive amplifier for a given motor. Some motor designs allow Kt to be non-linear, in which Kt will actually produce less torque per unit of current at higher output speeds. It is wise to de-rate the systems torque producing capability by 20% to allow headroom for servo control.

Motor Inertia

Motor inertial comes into play with motor sizing because torque to accelerate the inertia of the motor is effectively wasted energy. Low inertia motors allow for quicker acceleration. However, consider the reflective inertia from the load back to the motor shaft when choosing the motor's inertial. A high ratio of load-to-motor inertia can cause limited gains in an application if there is compliance in the transmission system such as belt-drive systems or rubber-based couplings to the systems. The closer the rotor inertia matches the load's reflected inertia to the motor shaft, the higher the achievable gains will be for a given system. In general, the higher the motor inertia, the more stable the system will be inherently. Mechanical gearing is often placed between the load and the motor simply to reduce the reflected inertia back to the motor shaft.

Motor Cabling

Motor cables are an integral part of a motor drive system. Several factors should be considered when selecting motor cables. First, the PWM frequency of the drive emits electrical noise. Motor cables must have a good-quality shield around them. The motor frame must also have a separate conductor to bring back to the drive amplifier to help quench current flows from the motor due to the PWM switching noise. Both motor drain wire and the cable shield should be tied at both ends to the motor and to the drive amplifier.

Another consideration in selecting motor cables is the conductor-to-conductor capacitance rating of the cable. Small capacitance is desirable. Longer runs of motor cable can add motor capacitance loading to the drive amplifier causing undesired spikes of current. It can also cause couplings of the PWM noise into the earth grounds, causing excessive noise as well. Typical motor cable ratings would be 50 pf per foot maximum cable capacitance.

Another factor in picking motor cables is the actual conductor cross-sectional area. This refers to the conductor's ability to carry the required current to and from the motor. When calculating the required cable dimensions, consider agency requirements, safety requirements, maximum temperature that the cable will be exposed to, the continuous current flow through the motor, and the peak current flow through the motor. Typically, it is not suggested that any motor cable be less than 14 AWG.

The motor cable's length must be considered as part of the application. Motor cable length affects the system in two ways. First, additional length results in additional capacitive loading to the drive. The drive's capacitive loading should be kept to no more than 1000 pf. Additionally, the length sets up standing waves in the cable, which can cause excessive voltage at the motor terminals. Typical motor cable length runs of 200 feet for 230V systems and 50 feet for 480V systems are acceptable. Exceeding these lengths may put other system requirements in place for either a snubber at the motor end or a series inductor at the drive end. The series inductor at the drive end provides capacitance loading isolation from the drive and slows the rise time of the PWM signal into the cable, resulting in less voltage overshoot at the motor.

SPECIFICATIONS

Part Number

Geo PWM Direct Digital Drive
Model Number Definition

G P L 03 1

<u>Voltage Rating (Direct Mains)</u>
L = 115 - 230 VAC
H = 115 - 480 VAC

<u>Continuous/Peak Current Rating</u>
(Sinusoidal RMS)
01 = 1.5/4.5 Amp (one or 3φ operation)
03 = 3/9 Amp (one or 3φ operation)
05 = 5/10 Amp (3φ input, for single φ need to derate 20%)
10 = 10/20 Amp (3φ input*)
15 = 15/30 Amp (3φ input*)
20 = 20/40 Amp (3φ input*)
30 = 30/60 Amp (3φ input*)
*For single phase input, need to derate 30%

<u>Number of Axes:</u>
1 = Single Axis
2 = Dual Axis

Product Width According to Ratings

<u>Single-Width Units:</u>
1.5/4.5 Dual Axis
3/9 Dual Axis
5/10 Single and Dual Axis
10/20 Single Axis and Dual Axis (240VAC)
15/30 Single Axis

<u>Double-Width Units:</u>
10/20 Dual Axis (480VAC)
15/30 Dual Axis
20/40 Single Axis
30/60 Single Axis

		GPx012	GPx051	GPx101	GPx151	GPx032	GPx052	GPL102	GPx201	GPx301	GPH102	GPx152
Axis	**Single axis**		√	√	√				√	√		
	Dual Axis	√				√	√	√			√	√
Sizing	**Low Profile**	√										
	Single Width		√	√	√	√	√	√				
	Double Width								√	√	√	√

Package Types

Geo package types provide various power levels and one or two axis capability with three different package types.

The Geo Drive has a basic package size of 3.3"W x 11"H x 8.0"D (84mm W x 280mm H x 203mm D). This size includes the heat sink and fan. In this package size, Single Width, the Geo can handle one or two low-to-medium power axes or only a single axis for medium to high power. GPL032 is a single width drive with no fan in the package.

The mechanical design of the Geo drive is such that it allows two heat sinks to be easily attached together so as to provide two high power axes in a double width configuration. This double package size is 6.5" W x 11" H x 8.0" D (165 mm W x 280 mm H x 203 mm D). It provides a highly efficient package size containing two axes of up to about 10kW each thus driving nearly 24kW of power, but using a single interface card. This results in a highly cost effective package.

There is also one more package type only for the low power (1.5A/4.5A) single width Geo drive, model GPx012. This package substitutes the heatsink and the fan with a smaller plate which has the same mounting pattern as the regular single width drive, making the units depth 2.2inches (56mm) less than the single width drive, 5.8" D (148mm D).

- Low Profile: GPx012 (only)
  3.3" wide (84 mm) (no heatsink, no fan), Maximum Power Handling ~1200 watts
  Package Dimensions: 3.3" W x 11" H x 5.8" D (84 mm W x 280 mm H x 148 mm D)
  Weight: 4.2 lbs. (1.9kgs)
- Single Width: GPH032, GPL051, GPH051, GPL052, GPH052, GPL101, GPL102 & GPH102
  3.3" wide (84 mm)(with heatsink and fan), Maximum Power Handling ~12000 watts
  GPL032 Single Width, with heatsink, no Fan (Weight 5.4lbs/2.45kgs)
  Package Dimensions: 3.3" W x 11" H x 8.0" D (84 mm W x 280 mm H x 203 mm D)
  Weight: 5.5 lbs. (2.50kgs)
- Double Width: GPL201, GPL301, GPL152, GPH201, GPH301, GPH102 and GPH152
  6.5" wide (165mm)(with heatsink and fan), Maximum Power Handling ~24,000 watts
  Package Dimensions: 6.5" W x 11" H x 8.0" D (165mm W x 280 mm H x 203 mm D)
  Weight 11.5 lbs. (5.2 kgs)

Electrical Specifications

230VAC Input Drives

		GxL051	GxL101	GxL151	GxL201	GxL301
Main Input Power	Nominal Input Voltage (VAC)	230				
	Rated Input Voltage (VAC)	97-265				
	Rated Continuous Input Current (A AC_{RMS})	3.3	6.6	9.9	13.2	19.8
	Rated Input Power (Watts)	1315	2629	3944	5259	7888
	Frequency (Hz)	50/60				
	Phase Requirements	1Φ or 3Φ	3Φ			
	Charge Peak Inrush Current (A)					
	Main Bus Capacitance (µf)	3380		5020	6800	
Output Power	Rated Output Voltage (V)	138				
	Rated Cont. Output Current per Axis	5	10	15	20	30
	Peak Output Current (A) for 2 seconds	10	20	30	40	60
	Rated Output Power per Axis (Watts)	1195	2390	3585	4780	7171
Bus Protection	Nominal DC Bus	325				
	Over-voltage Trip Level (VDC)	410				
	Under-voltage Lockout Level (VDC)	10				
Shunt Regulator Ratings	Turn-On Voltage (VDC)	392				
	Turn-Off Voltage (VDC)	372				
	Delta Tau Recommended Load Resistor (300 W Max.)	GAR78	GAR48		GAR48-3	
Control Logic Power	Input Voltage (VDC)	20-27				
	Input Current (A)	2A				
	Inrush Current (A)	4A				
Current Feedback	Resolution (bits)	12				
	Full-scale Signed Reading (±A)	16.26	32.53	48.79	65.05	97.58
Transistor Control	Delta Tau Recommended PWM Frequency (kHz) @rated current	12		10	8	
	Minimum Dead Time (µs)	1				
	Charge Pump Time (% of PWM period.)	5				

Note:

All values at ambient temperature of 0-45°C (113F) unless otherwise stated.

		Dual Axis				
		GxL012	GxL032	GxL052	GxL102	GxL152
	Output Circuits (axes)	2				
Main Input Power	Nominal Input Voltage (VAC)	230				
	Rated Input Voltage (VAC)	97-265				
	Rated Continuous Input Current (A AC_{RMS})	1.98	3.96	6.6	13.2	19.8
	Rated Input Power (Watts)	789	1578	2629	5259	7888
	Frequency (Hz)	50/60				
	Phase Requirements	1Φ or 3Φ		3Φ		
	Charge Peak Inrush Current (A)					
	Main Bus Capacitance (µf)	3380				5020
Output Power	Rated Output Voltage (V)	138				
	Rated Cont. Output Current per Axis	1.5	3	5	10	15
	Peak Output Current (A) for 2 seconds	4.5	9	10	20	30
	Rated Output Power per Axis (Watts)	359	717	1195	2390	3585
Bus Protection	Nominal DC Bus	325				
	Over-voltage Trip Level (VDC)	410				
	Under-voltage Lockout Level (VDC)	10				
Shunt Regulator Ratings	Turn-On Voltage (VDC)	392				
	Turn-Off Voltage (VDC)	372				
	Delta Tau Recommended Load Resistor (300 W Max.)	GAR78			GAR48	
Control Logic Power	Input Voltage (VDC)	20-27				
	Input Current (A)	2A				
	Inrush Current (A)	4A				
Current Feedback	Resolution (bits)	12				
	Full-scale Signed Reading (±A)	7.32	14.64	16.26	32.53	48.79
Transistor Control	Delta Tau Recommended PWM Frequency (kHz)	16		12		10
	Minimum Dead Time (µs)	1				
	Charge Pump Time (% of PWM period.)	5				

Note:

All values at ambient temperature of 0-45°C (113F) unless otherwise stated.

480VAC Input Drives

<table>
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<tr><td>Peak Output Current (A) for 2 seconds</td><td>10</td><td>20</td><td>30</td><td>40</td><td>60</td></tr>
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<tr><td>Delta Tau Recommended Load Resistor (300 W Max.)</td><td>GAR78</td><td colspan="2">GAR48</td><td colspan="2">GAR48-3</td></tr>
<tr><td rowspan="3">Control Logic Power</td><td>Input Voltage (VDC)</td><td colspan="5">20-27</td></tr>
<tr><td>Input Current (A)</td><td colspan="5">2A</td></tr>
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<tr><td rowspan="2">Current Feedback</td><td>Resolution (bits)</td><td colspan="5">12</td></tr>
<tr><td>Full-scale Signed Reading (±Amperes)</td><td>16.26</td><td>32.53</td><td>48.79</td><td>65.05</td><td>97.58</td></tr>
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<tr><td>Charge Pump Time (% of PWM period.)</td><td colspan="5">5</td></tr>
</table>

Note:

All values at ambient temperature of 0-45°C (113F) unless otherwise stated.

		GxH012	GxH032	GxH052	GxH102	GxH152
	Output Circuits (axes)	2				
Main Input Power	Nominal Input Voltage (VAC)	480				
	Rated Input Voltage (VAC)	300-525				
	Rated Continuous Input Current (A AC_{RMS})	1.98	3.96	6.6	13.2	19.8
	Rated Input Power (Watts)	1646	3292	5487	10974	16461
	Frequency (Hz)	50/60				
	Phase Requirements	1Φ or 3Φ		3Φ		
	Charge Peak Inrush Current (A)					
	Main Bus Capacitance (µf)	845				1255
Output Power	Rated Output Voltage (V) @ Rated Current	288				
	Rated Cont. Output Current per Axis	1.5	3	5	10	15
	Peak Output Current (A) for 2 seconds	4.5	9	10	20	30
	Rated Output Power per Axis (Watts)	748	1496	2494	4988	7482
Bus Protection	Nominal DC Bus	678				
	Over-voltage Trip Level (VDC)	828				
	Under-voltage Lockout Level (VDC)	20				
Shunt Regulator Ratings	Turn-On Voltage (VDC)	784				
	Turn-Off Voltage (VDC)	744				
	Delta Tau Recommended Load Resistor (300 W Max.)	GAR78			GAR48	
Control Logic Power	Input Voltage (VDC)	20-27				
	Input Current (A)	2A				
	Inrush Current (A)	4A				
Current Feedback	Resolution (bits)	12				
	Full-scale Signed Reading (±Amperes)	7.32	14.64	16.26	32.53	48.79
Transistor Control	Delta Tau Recommended PWM Frequency (KHz) @ rated current	12		10	8	
	Minimum Dead Time (µs)	1.6				
	Charge Pump Time (% of PWM period.)	5				

Environmental Specifications

Description	Unit	Specifications
Operating Temperature	°C	+0 to 45°C. Above 45°C, derate the continuous peak output current by 2.5% per °C above 45°C. Maximum Ambient is 55°C
Rated Storage Temperature	°C	-25 to +70
Humidity	%	10% to 90% non-condensing
Shock		Call Factory
Vibration		Call Factory
Operating Altitude	Feet (Meters)	To 3300 feet (1000 meters). Derate the continuous and peak output current by 1.1% for each 330 feet (100meters) above the 3300 feet
Air Flow Clearances	in (mm)	3" (76.2mm) above and below unit for air flow

Recommended Fusing and Wire Gauge

Model	Recommended Fuse (FRN/LPN)	Recommended Wire Gauge*
GxL012	15	14 AWG
GxL032	20	12 AWG
GxL051	20	12 AWG
GxL052	20	12 AWG
GxL101	20	12 AWG
GxL102	20	12 AWG
GxL151	25	10 AWG
GxL152	25	10 AWG
GxL201	25	10 AWG
GxL301	30	8 AWG
GxH012	15	14 AWG
GxH032	20	12 AWG
GxH051	20	12 AWG
GxH052	20	12 AWG
GxH101	20	12 AWG
GxH102	20	12 AWG
GxH151	25	10 AWG
GxH152	25	10 AWG
GxH201	25	10 AWG
GxH301	30	8 AWG
* See local and national code requirements		

Wire Sizes

Geo Drive electronics create a DC bus by rectifying the incoming AC electricity. The current flow into the drive is not sinusoidal but rather a series of narrow, high-peak pulses. Keep the incoming impedance small so that these current pulses are not hindered. Conductor size, transformer size, and fuse size recommendations may seem larger than normally expected. All ground conductors should be 8AWG minimum using wires constructed of many strands of small gauge wire. This provides the lowest impedance to high-frequency noises.

RECEIVING AND UNPACKING

Delta Tau products are thoroughly tested at the factory and carefully packaged for shipment. When the Geo PWM Drive is received, there are several things to be done 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 drive received is the same as the part number listed on the purchase order.
4. Inspect the drive 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 amplifier are design-hardened to reduce static sensitivity. However, use proper procedures when handling the equipment.
6. If the Geo PWM Drive 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 following restrictions will ensure the proper use of the Geo PWM Drive:

- The components built into electrical equipment or machines can be used only as integral components of such equipment.
- The Geo Drives are to be used only on grounded three-phase industrial mains supply networks (TN-system, TT-system with grounded neutral point).
- The Geo Drives must not be operated on power supply networks without a ground or with an asymmetrical ground.
- If the Geo Drives are used in residential areas, or in business or commercial premises, implement additional filter measures.
- The Geo Drives 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 Geo Drives 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 controller 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 the performance of the controller.

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

- For effective cooling and maintenance, the controller should be mounted on a smooth, non-flammable vertical surface.
- At least 3 inches (76mm) top and bottom clearance must be provided for airflow. At least 0.4 inches (10mm) clearance is required between controls (each side).
- Temperature, humidity and vibration specifications should also be considered.

The Geo Drives can be mounted with a traditional 4-hole panel mount, two U shape/notches on the bottom and two pear shaped holes on top. This keeps the heat sink and fan (single width and double width drives), inside the mounting enclosure. On the low profile units (low power), the heat sink and fan are replaced with a flat plate and the mounting enclosure itself is used as a heat sink. This reduces the depth of the Geo amplifier by about 2.2 inches (~56 mm) to a slim 5.8 inch D (150 mm D). Mounting is also identical to the single and double width drives through the 4-hole panel mount.

If multiple Geo drives are used, they can be mounted side-by-side, leaving at least to of a 0.4 inch clearance between drives. This means a 3.7 inch center-to-center distance (94 mm) with the single width and low profile Geo drives. Double width Geo amplifiers can be mounted side by side at 6.9 inch center-to-center distance (175 mm).

It is extremely important that the airflow is not obstructed by the placement of conduit tracks or other devices in the enclosure.

The drive 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 mounting bolt pattern of the drive. Make sure that all metal chips are cleaned up before the drive is mounted so there is no risk of getting metal chips inside the drive.

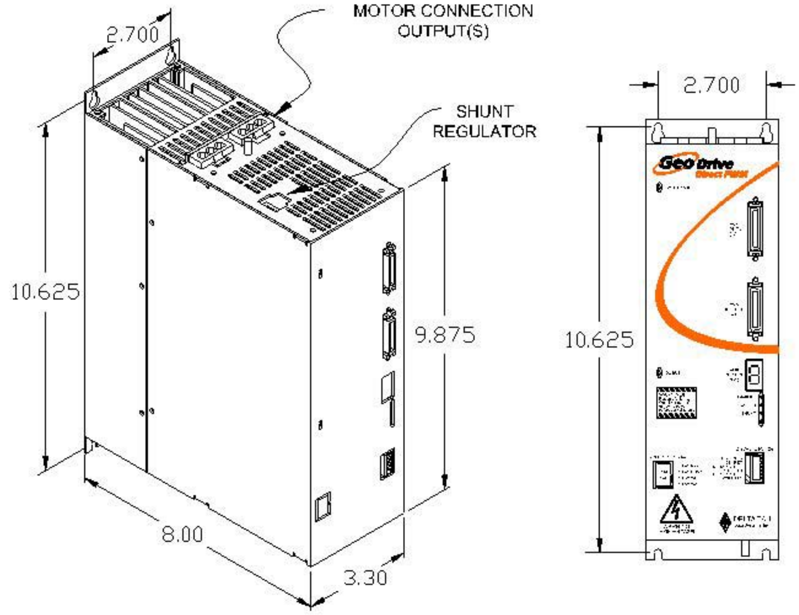
The drive is mounted to the back panel with four M4 screws and internal-tooth lock washers. It is important that the teeth break through any anodization on the drive's mounting gears to provide a good electrically conductive path in as many places as possible. Mount the drive on the back panel so there is airflow at both the top and bottom areas of the drive (at least three inches).

Caution:

Units 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]).

Note:

For more detail drawings (SolidWorks, eDrawings, DXF) visit our website under the product that you are looking for.



NOTE:
LEAVE 3 INCH CLEARANCE
ON TOP & BOTTOM FOR AIR
FLOW & CABLE BEND RADIUS.

NOTE:
APPEARANCE OF
USER INTERFACE
VARY UPON MODEL

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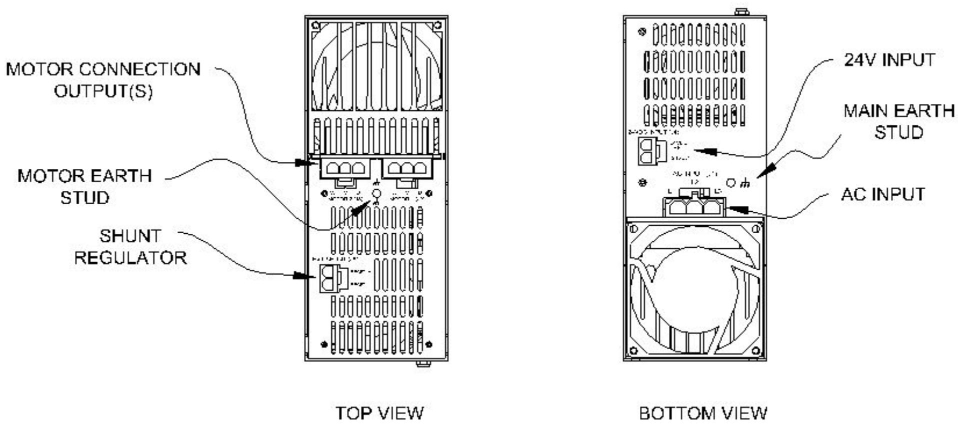
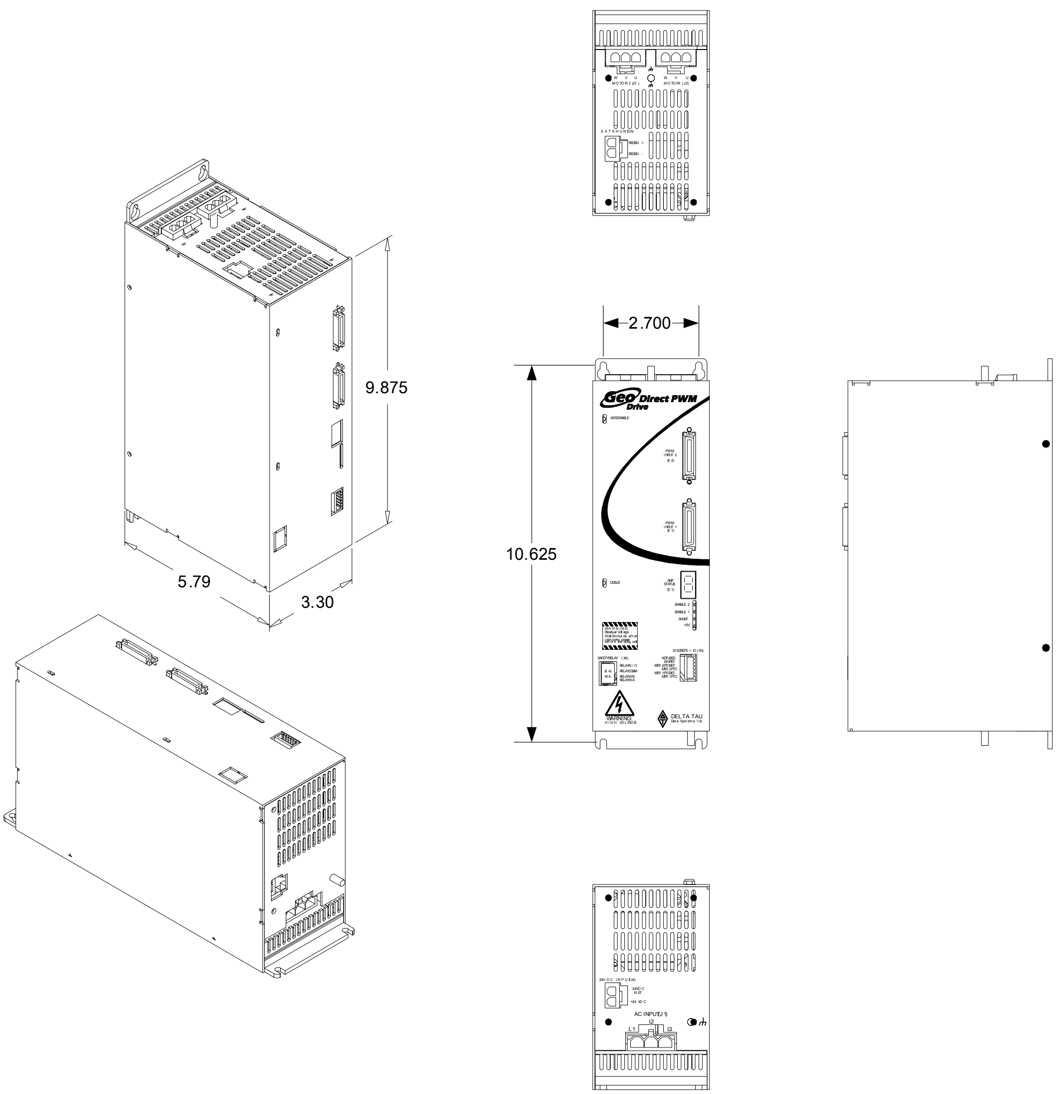


Low Profile

GPL012 and GPH012

	Width	Height	Depth	Weight
Mounting dimensions	3.30in./ 84mm	11.00in./ 280mm	5.80in./ 147mm	4.2lbs / 1.9kgs

GPL012 & GPH012
1.5/4.5 AMPS CONT/PEAK (300-603700)
PWM Version, Low Profile (flat plate),
Single wide no/Fan

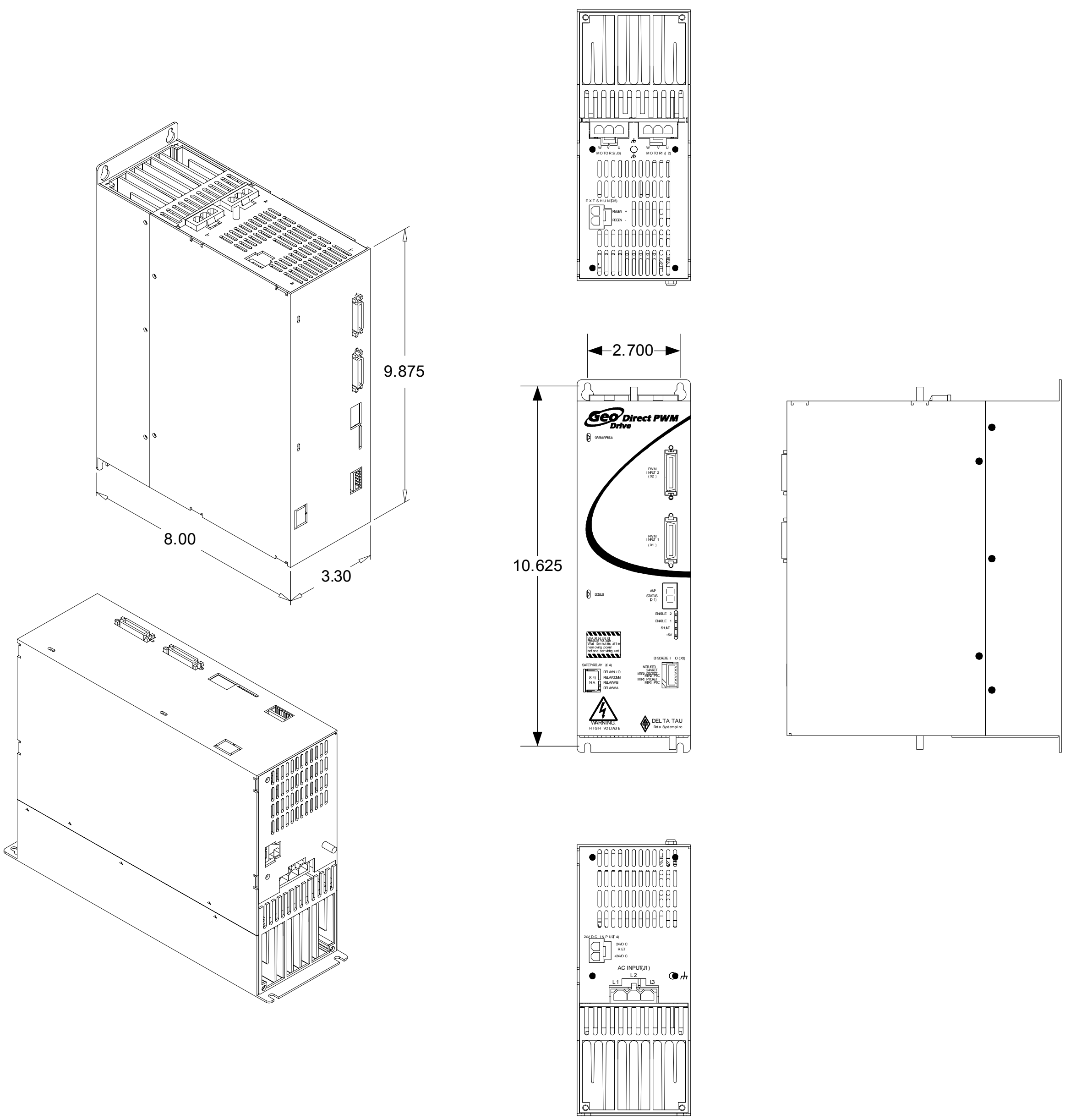


Single Width (No Fan)

GPL032

	Width	Height	Depth	Weight
Mounting dimensions	3.30in./ 84mm	11.00in./ 280mm	8.00in./ 203mm	5.4lbs/ 2.45kgs

GPL032
3.0/9.0 AMPS CONT/PEAK
PWM Version, Internal Heatsink Mtg,
Single wide no/Fan (301-603700)

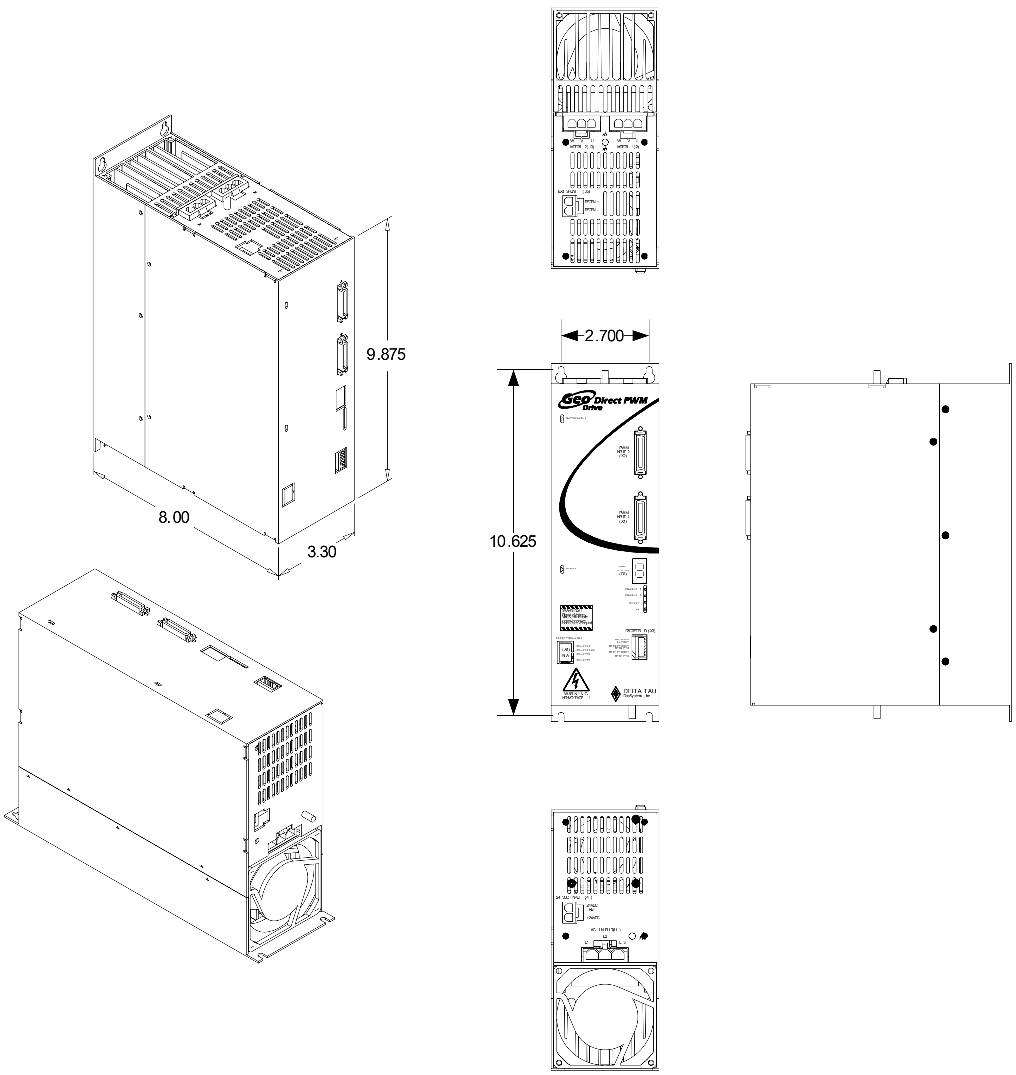


Single Width (w/Fan)

GPH032, GPL051, GPH051, GPL052, GPH052, GPL101, GPL102 and GPH102

	Width	Height	Depth	Weight
Mounting dimensions	3.30in./ 84mm	11.00in./ 280mm	8.00in./ 203mm	5.5lbs/ 2.5kgs

GPH032, GPL051, GPH051, GPL052, GPH052,
GPL101, GPL102 & GPH102
3.0/9.0 & 5.0/10.0 & 10.0/20.0 AMPS CONT/PEAK
PWM Version, Internal Heatsink Mtg ,
Single wide w/Fan (301-603700w-f)

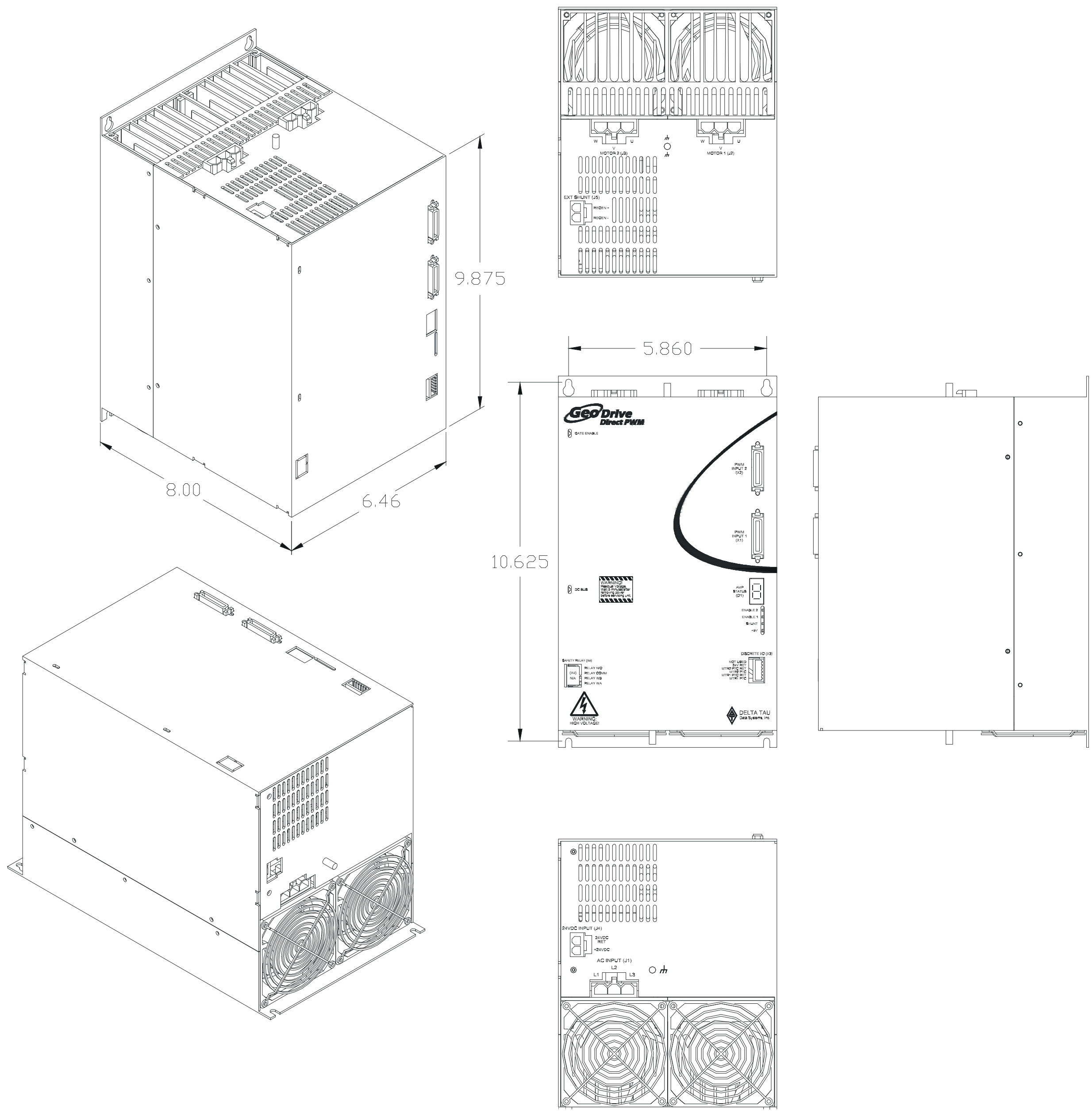


Double Width

GPL201, GPL301, GPL152, GPH201, GPH301, GPH102 and GPH152

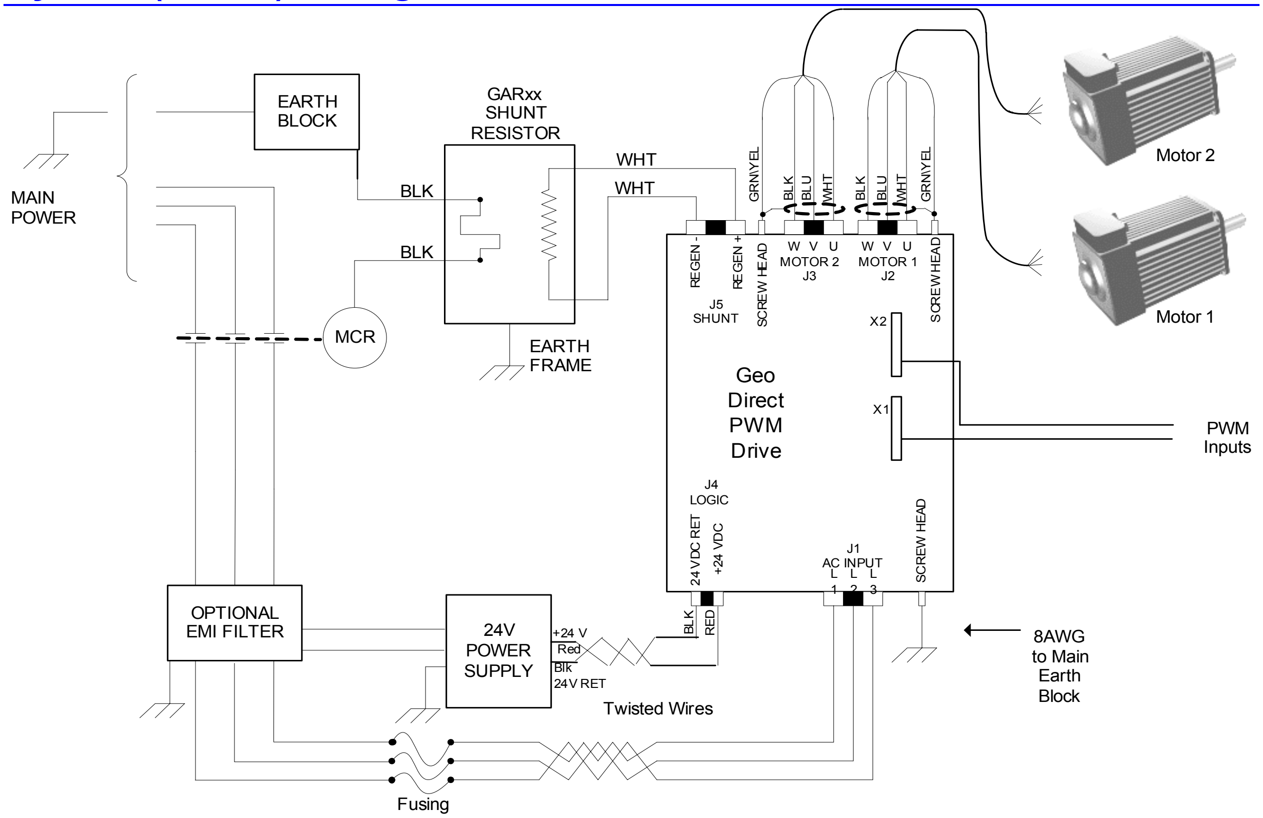
	Width	Height	Depth	Weight
Mounting dimensions	6.50in./ 165mm	11.00in./ 280mm	8.00in./ 203mm	11.5lbs/ 5.2kgs

PWM Version, Internal Heatsink Mtg,
Double wide with 2 Fans



CONNECTIONS

System (Power) 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.

Fuse and Circuit Breaker Selection

In general, fusing must be designed to protect the weakest link from fire hazard. Each Geo drive is designed to accept more than the recommended fuse ratings. External wiring to the drive may be the weakest link as the routing is less controlled than the drive's internal electronics. Therefore, external circuit protection, be it fuses or circuit breakers, must be designed to protect the lesser of the drive or external wiring.

High peak currents and high inrush currents demand the use of slow blow type fuses and hamper the use of circuit breakers with magnetic trip mechanisms. Generally, fuses are recommended to be larger than what the rms current ratings require. Remember that some drives allow three times the continuous rated current on up to two axis of motion. Time delay and overload rating of protection devices must consider this operation.

Use of GFI Breakers

Ground Fault Interrupter circuit breakers are designed to break the power circuit in the event that outgoing currents are not accompanied by equal and opposite returning currents. These breakers assume that if outgoing currents are not returning then there is a ground path in the load. Most circuit breakers of this type account for currents as low as 10mA PWM switching in servo drives coupled with parasitic capacitance to ground in motor windings and long cables generate ground leakage current. Careful installation practices must be followed. The use of inductor chokes in the output of the drive will help keep these leakage currents below breaker threshold levels.

Transformer and Filter Sizing

Incoming power design considerations for use with Geo Drives require some over rating. In general, it is recommended that all 3-phase systems using transformers and incoming filter chokes be allotted a 25% over size to keep the impedances of these inserted devices from affecting stated system performance. In general, it is recommended that all single-phase systems up to 1kW be designed for a 50% overload. All single-phase systems over 1kW should be designed for a 200% overload capacity.

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 following the grounding instructions does 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.

Operating Temperature

It is important that the ambient operating temperature of the Geo Drive be kept within specifications. The Geo Drive is installed in an enclosure such as a NEMA cabinet. The internal temperature of the cabinet must be kept under the Geo Drive Ambient Temperature specifications. It is sometimes desirable to roughly calculate the heat generated by the devices in the cabinet to determine if some type of ventilation or air conditioning is required. For these calculations the Geo Drive's internal heat losses must be known. Budget 100W per axis for 1.5 amp drives, 150W per axis for 3 amp drives, 200W per axis for 5 amp drives, 375W per axis for 10 Amp drives, and 500W per axis for 15 Amp drives.

From 0°C to 45°C ambient no de-rating required. Above 45°C, de-rate the continuous and peak output current by 2.5% per °C above 45°C. Maximum ambient is 55°C.

Single Phase Operation

Due to the nature of power transfer physics, it is not recommended that any system design attempt to consume more than 2kW from any single-phase mains supply. Even this level requires careful considerations. The simple bridge rectifier front end of the Geo Drive, as with all other drives of this type, require high peak currents. Attempting to transfer power from a single-phase system getting one charging pulse each 8.3 milliseconds causes excessively high peak currents that can be limited by power mains impedances. The Geo Drive output voltage sags, the input rectifiers are stressed, and these current pulses cause power quality problems in other equipment connected to the same line. While it is possible to operate drives on single-phase power, the actual power delivered to the motor must be considered. Never design expecting more than 1.5 HP total from any 115V single-phase system and never more than 2.5 HP from any 230V single-phase system.

Wiring AC Input, J1

The main bus voltage supply is brought to the Geo drive through connector J1. 1.5A continuous and 3A continuous Geo drives can be run off single-phase power. It is acceptable to bring the single-phase power into any two of the three input pins on connector J1. Higher-power drive amplifiers require three-phase input power. It is extremely important to provide fuse protection or overload protection to the input power to the Geo drive amplifier. Typically, this is provided with fuses designed to be slow acting, such as FRN-type fuses. Due to the various regulations of local codes, NEC codes, UL and CE requirements, it is very important to reference these requirements before making a determination of how the input power is wired.

Additionally, many systems require that the power be able to be turned on and off in the cabinet. It is typical that the AC power is run through some kind of main control contact within the cabinet, through the fuses, and then fed to a Geo drive. If multiple Geo drives are used, it is important that each drive has its own separate fuse block.

Whether single- or three-phase, it is important that the AC input wires be twisted together to eliminate noise radiation as much as possible. Additionally, some applications may have further agency noise reduction requirements that require that these lines be fed from an input filtering network.

The AC connections from the fuse block to the Geo drive are made via a cable that is either purchased as an option from Delta Tau (CABKITxx) or made with the appropriate connector kit (CONKITxx). (See Appendix A)

J1: AC Input Connector Pinout

Pin #	Symbol	Function	Description	Notes
3	L3	Input	Line Input Phase 3	
2	L2	Input	Line Input Phase 2	
3	L1	Input	Line Input Phase 1	(Not used for single Phase input)
On GPx201 and GPx301, there is a fourth pin for Ground connection. If DC bus is used, use L3 for DC+ and L2 for DC return. Connector is located at the bottom side of the unit.				

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 Geo drive is brought to the earth-ground via a wire connected to the M4 stud (5mm thread) on the top of the location through a heavy gauge, multi-strand conductor to the central earth-ground location. On the high power models (GPx201 and GPx301), a fourth pin is provided on the 3-phase AC input connector (J1) and on the motor output connectors to provide a ground connection.

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 handheld meter 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 bonded 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.

Wiring 24 V Logic Control

An external 24Vdc power supply is required to power the logic portion of the Geo drive. This power can remain on, regardless of the main AC input power, allowing the signal electronics to be active while the main motor power control is inactive. The 24V is wired into connector J4. The polarity of this connection is extremely important. Carefully follow the instructions in the wiring diagram. This connection can be made using 16 AWG wire directly from a protected power supply. In situations where the power supply is shared with other devices, it may be desirable to insert a filter in this connection.

The power supply providing this 24V must be capable of providing an instantaneous current of at least 1.5 amps to be able to start the DC-to-DC converter in the Geo drive. In the case where multiple drives are driven from the same 24V supply, it is recommended that each drive be wired back to the power supply terminals independently. It is also recommended that the power supply be sized to handle the instantaneous inrush current required to start up the DC-to-DC converter in the Geo drive.

J4: 24VDC Input Logic Supply Connector

Pin #	Symbol	Function	Description	Notes
1	24VDC RET	Common	Control power return	
2	+24VDC	Input	Control power input	24V+/-10%, @ 2A
Connector is located at the bottom side of the unit.				

Wiring the Motors

The cable wiring must be shielded and have a separate conductor connecting the motor frame back to the drive amplifier. The cables are available in cable kits (CABKITxx) from Delta Tau. (See Appendix A.)

Motor phases are conversed in one of three conventions. Motor manufacturers will call the motor phases A, B, or C. Other motor manufacturers call them U, V, W. Induction motor manufacturers may call them L1, L2, and L3. The drive's inputs are called U, V, and W. Wire U, A, or L1 to the drive's U terminal. Wire V, B, or L2 to the drive's V terminal. Wire W, C, or L3 to the drive's W terminal.

The motor's frame drain wire and the motor cable shield must be tied together at the mounting stud (5mm thread) on top of the Geo drive product.

J2: Motor 1 Output Connector Pinout

Pin #	Symbol	Function	Description	Notes
1	U	Output	Axis 1 Phase1	
2	V	Output	Axis 1 Phase2	
3	W	Output	Axis 1 Phase3	
On GPx201 and GPx301, there is a fourth pin for Ground connection. Connector is located at the top side of the unit.				

J3: Motor 2 Output Connector Pinout

Pin #	Symbol	Function	Description	Notes
1	U	Output	Axis 2 Phase1	2- Axis drives only
2	V	Output	Axis 2 Phase2	2- Axis drives only
3	W	Output	Axis 2 Phase3	2- Axis drives only
Connector is located at the top side of the unit (dual-axis units only).				

Wiring the Motor Thermostats

Some motor manufacturers provide the motors with integrated thermostat overload detection capability. Typically, it is in one or two forms: a contact switch that is normally closed or a PTC. These sensors can be wired into the Geo drive's front panel at connector X3. Motor 1 thermostat is wired to MTR1 PTC RET and MTR1 PTC. On 2-Axis drives, Motor 2 thermostat can be wired to MTR2 PTC RET and MTR2 PTC. These contacts have to be low impedance for the drive to be operational

If the motor overload protection is not required, these pins (MTR1 PTC and MTR1 PTC RET, MTR2 PTC and MTR2 PTC RET) should be jumpered together to disable this function in the drive. Otherwise, the drive status display will show a fault code 5 for motor #1 over temperature or an A for motor 2 over temperature.

Wiring the Regen (Shunt) Resistor, J5

The Geo Drive family offers compatible regen resistors as optional equipment. The regen resistor is used as a shunt regulator to dump excess power during demanding deceleration profiles. The GAR48 and GAR78 resistors are designed to dump the excess bus energy very quickly.

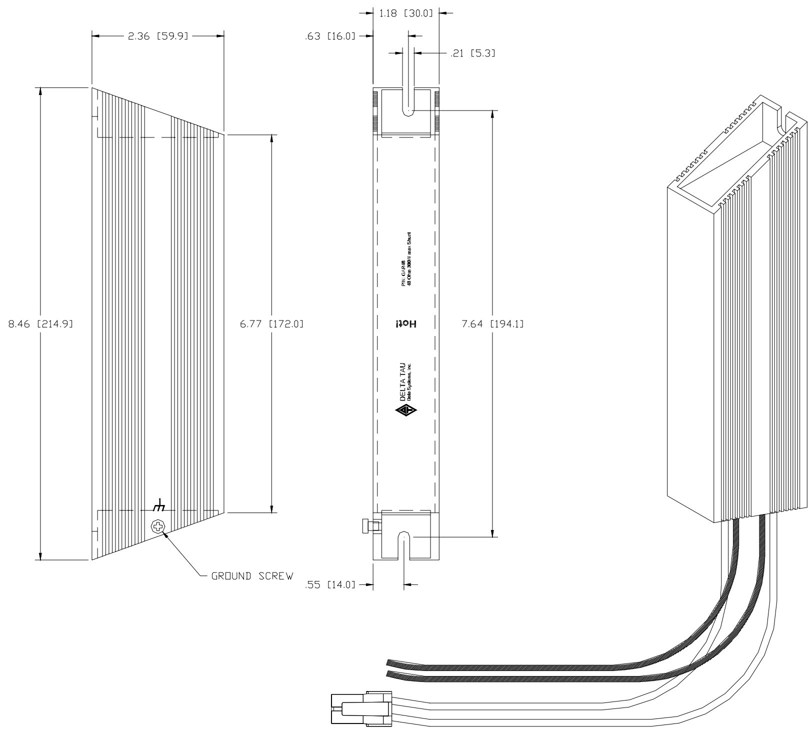
The regen circuit is also known as a shunt regulator. Its purpose is to dump power fed back into the drive from a motor acting as a generator. Excessive energy can be dumped via an external load resistor. The Geo product series is designed for operation with external shunt resistors of 48 Ω for the 10 and 15 amp versions or 78 Ω for the 1.5, 3, and 5 amp versions. These are available directly from Delta Tau as GAR48 and GAR78, respectively. These resistors are provided with pre-terminated cables that plug into connector J5.

Each resistor is the lowest ohm rating for its compatible drive and is limited for use to 200 watts RMS. There are times the regen design might be analyzed to determine if an external Regen resistor is required or what its ratings can be. The following data is provided for such purpose.

Caution:

The black wires are for the thermostat and the white wires are for the regen resistor on the external regen resistor (pictured below). These resistors can reach temperatures of up to 200 degrees C. These resistors must be mounted away from other devices and near the top of the cabinet. Additionally, precautions must be made to ensure the resistors are enclosed and cannot be touched during operation or anytime they are hot. Sufficient warning labels should be placed prominently near these resistors.

The GAR regen resistors incorporate a thermal overload protection thermostat that opens when the core temperature of the resistor exceeds 225 degrees C. This thermostat is available through the two black leads exiting the resistor. It is important that these two leads be wired in a safety circuit that stops the system from operating should the thermostat open.



J5: External Shunt Connector Pinout

Pin #	Symbol	Function
1	Regen-	Output
2	Regen+	Output
Connector is located at the top side of the unit DT Connector part number #014-000F02-HSG and pins part number #014-043375-001 Molex Crimper tool p/n#63811-0400		
For the high Current Drives**,** Gxx201 and Gxx301, this connect**o**r is a 3 pin Large Molex connector		
1	CAP-	Output
2	Regen-	Output
3	Regen+	Output
Connector is located at the top side of the unit. DT Connector part number #014-H00F03-049 and pins part number #014-042815-001. Molex Crimper tool p/n#63811-1500		

Shunt Regulation

When the motor is used to slow the moving load, this is called regenerative deceleration. Under this operation, the motor is acting as a generator consuming energy from the load while passing the energy into the DC Bus storage capacitors. Left unchecked, the DC Bus voltage can raise high enough to damage the drive. For this reason there are protection mechanisms built into the Geo Drive product such as shunt regulation and over-voltage protection.

The shunt regulator monitors the DC Bus voltage. If this voltage rises above a present threshold (Regen Turn On Voltage), the Geo Drive will turn on a power device intended to place the externally mounted regen resistor across the bus to dump the excessive energy. The power device keeps the regen resistor connected across the bus until the bus voltage is sensed to be below the Regen Turn Off voltage at which time the power device removes the resistor connection.

Minimum Resistance Value

The regen resistor selection requires that the resistance value of the selected resistor will not allow more current to flow through the Geo Drive's power device than specified.

Maximum Resistance Value

The maximum resistor value that will be acceptable in an application is one that will not let the bus voltage reach the drive's stated over voltage specification during the deceleration ramp time. The following equations defining energy transfer can be used to determine the maximum resistance value.

Energy Transfer Equations

Regen, or shunt, regulation analysis requires study of the energy transferred during the deceleration profile. The basic philosophy can be described as follows:

- The motor and load have stored kinetic energy while in motion.
- The drive removes this energy during deceleration by transferring to the DC bus.
- There are losses during this transfer, both mechanical and electrical, which can be significant in some systems.
- The DC bus capacitors can store some energy.
- The remaining energy, if any, is transferred to the regen resistor.

Kinetic Energy

The first step is to ascertain the amount of kinetic energy in the moving system, both the motor rotor and the load it is driving. In metric (SI) units, the kinetic energy of a rotating mass is:

$$E_K = \frac{1}{2} J\omega^2$$

where:
E_K is the kinetic energy in joules, or watt-seconds (J, W-s)
J is the rotary moment of inertia in kilogram-meter^2 (kg-m^2)
ω is the angular velocity of the inertia in radians per second (1/s)

If the values are not in these units, first convert them. For example, if the speed is in revolutions per minute (rpm), multiply this value by $2\pi/60$ to convert to radians per second.

When English mechanical units are used, there are additional conversion factors must be included to get the energy result to come out in joules. For example, if the rotary moment of inertia J is expressed in lb-ft-sec^2, the following equation should be used:

$$E_K = 0.678 J\omega^2$$

If the rotary moment of inertia J is expressed in lb-in-sec^2, the following equation should be used:

$$E_K = 0.0565 J\omega^2$$

In standard metric (SI) units, the kinetic energy of a linearly moving mass is:

$$E_K = \frac{1}{2} mv^2$$

where:
E_K is the kinetic energy in joules (J)
m is the mass in kilograms (kg)

v is the linear velocity of the mass in meters/second (m/s)

Here also, to get energy in Joules from English mechanical units, additional conversion factors are required. To calculate the kinetic energy of a mass having a weight of W pounds, the following equation can be used:

$$E_K = 0.678 \frac{W}{g} v^2 = 0.0211 W v^2$$

where:
E_K is the kinetic energy in joules (J)
W is the weight of the moving mass in pounds (lb)
g is the acceleration of gravity (32.2 ft/sec^2)
v is the linear velocity of the mass in feet per second (ft/sec)

Energy Lost in Transformation

Some energy will be lost in the transformation from mechanical kinetic energy to electrical energy. The losses will be both mechanical due to friction and electrical due to resistance. In most cases, these losses will comprise a small percentage of the transformed energy and can be safely ignored especially because ignoring losses leads to a conservative design. However, if the losses are significant and the system should not be over-designed, calculate these losses.

In metric (SI) units, the mechanical energy lost due to Coulomb (dry) friction in a constant deceleration to stop of a rotary system can be expressed as:

$$E_{LM} = \frac{1}{2} T_f \omega t_d$$

where:
E_{LM} is the lost energy in joules (J)
T_f is the resistive torque due to Coulomb friction in newton-meters (N-m)
ω is the starting angular velocity of the inertia in radians per second (1/s)
t_d is the deceleration time in seconds (s)

If the frictional torque is expressed in the common English unit of pound-feet (lb-ft), the comparable expression is:

$$E_{LM} = 0.678 T_f \omega t_d$$

In metric (SI) units, the mechanical energy lost due to Coulomb (dry) friction in a constant deceleration to stop of a linear system can be expressed as:

$$E_{LM} = \frac{1}{2} F_f v t_d$$

where:
E_{LM} is the lost energy in joules (J)
T_f is the resistive force due to Coulomb friction in newtons (N)
v is the starting linear velocity in meters/second (m/s)
t_d is the deceleration time in seconds (s)

If the frictional force is expressed in the English unit of pounds (lb) and the velocity in feet per second (ft/sec), the comparable expression is:

$$E_{LM} = 0.678 F_f v t_d$$

The electrical resistive losses in a 3-phase motor in a constant deceleration to stop can be calculated as:

$$E_{LE} = \frac{\sqrt{3}}{2} i_{rms}^2 R_{pp} t_d$$

where:
E_{LE} is the lost energy in joules (J)

i_{rms} is the current required for the deceleration in amperes (A), equal to the required deceleration torque divided by the motor's (rms) torque constant K_T
R_{pp} is the phase-to-phase resistance of the motor, in ohms (Ω)
t_d is the deceleration time in seconds (s)

Capacitive Stored Energy in the Drive

The energy not lost during the transformation is initially stored as additional capacitive energy due to the increased DC bus voltage. The energy storage capability of the drive can be expressed as:

$$E_C = \frac{1}{2} C \left(V_{regen}^2 - V_{nom}^2 \right)$$

where:
E_C is the additional energy storage capacity in joules (J)
C is the total bus capacitance in Farads
V_{regen} is the DC bus voltage at which the regeneration circuit would have to activate, in volts (V)
V_{nom} is the normal DC bus voltage, in volts (V)

Evaluating the Need for a Regen Resistor

Any starting kinetic energy that is not lost in the transformation and cannot be stored as bus capacitive energy must be dumped by the regeneration circuitry in to the regen (shunt) resistor. The following equation can be used to determine whether this will be required:

$$E_{excess} = E_K - E_{LM} - E_{LE} - E_C$$

If E_{excess} in this equation is greater than 0, a regen resistor will be required.

Regen Resistor Power Capacity

A given regen resistor will have both a peak (instantaneous) and a continuous (average) power dissipation limit. It is therefore necessary to compare the required peak and continuous regen power dissipation requirements against the limits for the resistor.

The peak power dissipation that will occur in the regen resistor in the application will be:

$$P_{peak} = \frac{V_{regen}^2}{R}$$

where:
P_{peak} is peak power dissipation in watts (W)
V_{regen} is the DC bus voltage at which the regeneration circuit activates, in volts (V)
R is the resistance value of the regen resistor, in ohms (Ω)

However, this power dissipation will not be occurring all of the time, and in most applications, only for a small percentage of the time. Usually, the regen will only be active during the final part of a lengthy deceleration, after the DC bus has charged up to the point where it exceeds the regen activation voltage. The average power dissipation value can be calculated as:

$$P_{avg} = P_{peak} \frac{\%on-time}{100}$$

where:
P_{avg} is average power dissipation in watts (W)
%on-time is the percentage of time the regen circuit is active

Note:

The Turn On voltage for the shunt circuitry for all low power Geo drives is 392V (high Power is 784V). There is a Hysteresis of 20V, so if the regen turns on @ 392V(784V) it will not turn off until it drops to 372V (744V).

Bonding

The proper bonding of shielded cables is imperative for minimizing noise emissions and increasing immunity levels. The bonding effect is to reduce the impedance between the cable shield and the back panel.

Power input wiring does not require shielding (screening) if the power is fed to the enclosure via metal conduit. If metal conduit is not used in the system, shielded cable is required on the power input wires along with proper bonding techniques.

Filtering

CE Filtering

The Geo Drive meets the CE Mark standards stated in the front of this manual. Apply proper bonding and grounding techniques, described earlier in this section, when incorporating EMC noise filtering components to meet this standard.

Noise currents often occur in two ways. The first is conducted emissions passed through ground loops. The quality of the system-grounding scheme inversely determines the noise amplitudes in the lines. These conducted emissions are of a common-mode nature from line-to-neutral (ground). The second is radiated high-frequency emissions that usually are capacitively coupled from line-to-line and are differential in nature.

When mounting the filters, make sure the enclosure has an unpainted metallic surface. This allows more surface area to be in contact with the filter housing and provides a lower impedance path between the housing and the back plane. The back panel should have a high frequency ground strap connection to the enclosure frame and earth ground.

Input Power Filtering

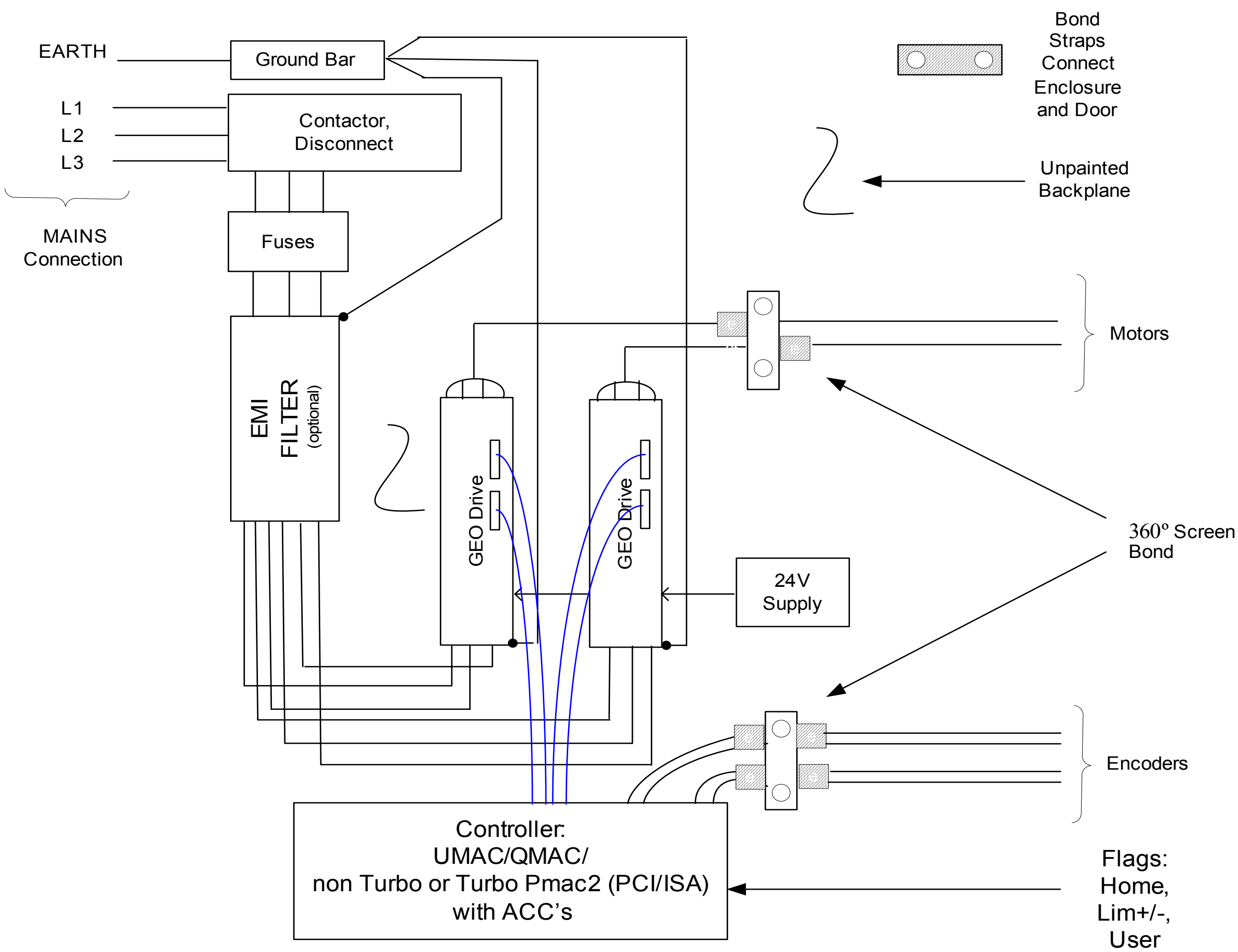
Caution:

To avoid electric shock, do not touch filters for at least 10 seconds after removing the power supply.

The Geo Drive electronic system components require EMI filtering in the input power leads to meet the conducted emission requirements for the industrial environment. This filtering blocks conducted-type emissions from exiting onto the power lines and provides a barrier for power line EMI.

Adequately size the system. The type of filter must be based on the voltage and current rating of the system and whether the incoming line is single or three-phase. One input line filter may be used for multi-axis control applications. These filters should be mounted as close to the incoming power as possible so noise is not capacitively coupled into other signal leads and cables. Implement the EMI filter according to the following guidelines:

- Mount the filter as close as possible to the incoming cabinet power.
- When mounting the filter to the panel, remove any paint or material covering. Use an unpainted metallic back panel.
- Filters are provided with a ground connection. All ground connections should be tied to ground.
- Filters can produce high leakage currents; they must be grounded before connecting the supply.
- Do not touch filters for a period of ten seconds after removing the power supply.



Motor Line Filtering

Motor filtering may not be necessary for CE compliance of Geo Drives. However, this additional filtering increases the reliability of the system. Poor non-metallic enclosure surfaces and lengthy, unbonded (or unshielded) motor cables that couple noise line-to-line (differential) are some of the factors that may lead to the necessity of motor lead filtering.

Motor lead noise is either common-mode or differential. The common-mode conducted currents occur between each motor lead and ground (line-to-neutral). Differential radiated currents exist from one motor lead to another (line-to-line). The filtering of the lines feeding the motor provides additional attenuation of noise currents that may enter surrounding cables and equipment I/O ports in close proximity.

Differential mode currents commonly occur with lengthy motor cables. As the cable length increases, so does its capacitance and ability to couple noise from line-to-line. While every final system is different and every application of the product causes a slightly different emission profile, it may become necessary to use differential mode chokes to provide additional noise attenuation to minimize the radiated emissions. The use of a ferrite core placed at the Geo Drive end on each motor lead attenuates differential mode noise and lowers frequency (30 to 60 MHz) broadband emissions to within specifications. Delta Tau recommends a Fair-Rite P/N 263665702 (or equivalent) ferrite core.

Common mode currents occur from noise spikes created by the PWM switching frequency of the Geo Drive. The use of a ferrite or iron-powder core toroid places common mode impedance in the line between the motor and the Geo Drive. The use of a common mode choke on the motor leads may increase signal integrity of encoder outputs and associated I/O signals.

I/O Filtering

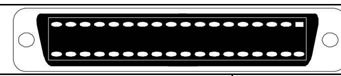
I/O filtering may be desired, depending on system installation, application, and integration with other equipment. It may be necessary to place ferrite cores on I/O lines to avoid unwanted signals entering and disturbing the Geo.

CONNECTORS

Connector Pinouts

X1: PWM Input 1

36-Pin Mini-D Connector



Pin#	Symbol	Function	Description	Notes
1	Reserved			
2	Reserved			
3	ADC_CLK1+	Command	A/D converter clock	
4	ADC_STB1+	Command	A/D converter strobe	
5	CURRENT1A+	Feedback	Phase A actual current data	Serial digital
6	CURRENT1B+	Feedback	Phase B actual current data	Serial digital
7	AENA1+	Command	Amplifier enable	High is enable
8	FAULT1+	Feedback	Amplifier fault	High is fault
9	PWMATOP1+	Command	Phase A top cmd	High is on command
10	PWMABOT1+	Command	Phase A bottom cmd	High is on command
11	PWMBTOP1+	Command	Phase B top cmd	High is on command
12	PWMBBOT1+	Command	Phase B bottom cmd	High is on command
13	PWMCTOP1+	Command	Phase C top cmd	High is on command
14	PWMCBOT1+	Command	Phase C bottom cmd	High is on command
15	GND	Common	Reference voltage	
16	+5V	Power	+5V Power	From controller
17	Reserved			
18	Reserved			
19	Reserved			
20	Reserved			
21	ADC_CLK1-	Command	A/D converter clock	
22	ADC_STB1-	Command	A/D converter strobe	
23	CURRENT1A-	Feedback	Phase A actual current DATA	Serial digital
24	CURRENT1B-	Feedback	Phase B actual current DATA	Serial digital
25	AENA1-	Command	Amplifier enable	Low is enable
26	FAULT1-	Feedback	Amplifier fault	Low is fault
27	PWMATOP1-	Command	Phase A top cmd	Low is on command
28	PWMABOT1-	Command	Phase A bottom cmd	Low is on command
29	PWMBTOP1-	Command	Phase B top cmd	Low is on command
30	PWMBBOT1-	Command	Phase B bottom cmd	Low is on command
31	PWMCTOP1-	Command	Phase C top cmd	Low is on command
32	PWMCBOT1-	Command	Phase C bottom cmd	Low is on command
33	GND	Common	Reference Voltage	
34	+5V	Power	+5V Power	From controller
35	Reserved			
36	Reserved			

A Mini-D 36-pin connector for first digital amplifier command outputs and current feedbacks. This connector provides the interface to a fully digital amplifier for the first channel.

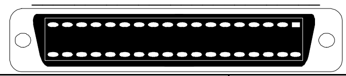
Note that current feedback data must be in serial digital form, already converted from analog in the amplifier.

For Cables see Appendix A

X2: PWM Input 2

36-Pin Mini-D Connector

Only on Dual axis drives



Pin#	Symbol	Function	Description	Notes
1	Reserved			
2	Reserved			
3	ADC_CLK2+	Command	A/D converter clock	
4	ADC_STB2+	Command	A/D converter strobe	
5	CURRENT2A+	Feedback	Phase A actual current data	Serial digital
6	CURRENT2B+	Feedback	Phase B actual current data	Serial digital
7	AENA2+	Command	Amplifier enable	High is enable
8	FAULT2+	Feedback	Amplifier fault	High is fault
9	PWMATOP2+	Command	Phase A top cmd	High is on command
10	PWMABOT2+	Command	Phase A bottom cmd	High is on command
11	PWMBTOP2+	Command	Phase B top cmd	High is on command
12	PWMBBOT2+	Command	Phase B bottom cmd	High is on command
13	PWMCTOP2+	Command	Phase C top cmd	High is on command
14	PWMCBOT2+	Command	Phase C bottom cmd	High is on command
15	GND	Common	Reference voltage	
16	+5V	Power	+5V Power	From controller
17	Reserved			
18	Reserved			
19	Reserved			
20	Reserved			
21	ADC_CLK2-	Command	A/D converter clock	
22	ADC_STB2-	Command	A/D converter strobe	
23	CURRENT2A-	Feedback	Phase A actual current DATA	Serial digital
24	CURRENT2B-	Feedback	Phase B actual current DATA	Serial digital
25	AENA2-	Command	Amplifier enable	Low is enable
26	FAULT2-	Feedback	Amplifier fault	Low is fault
27	PWMATOP2-	Command	Phase A top cmd	Low is on command
28	PWMABOT2-	Command	Phase A bottom cmd	Low is on command
29	PWMBTOP2-	Command	Phase B top cmd	Low is on command
30	PWMBBOT2-	Command	Phase B bottom cmd	Low is on command
31	PWMCTOP2-	Command	Phase C top cmd	Low is on command
32	PWMCBOT2-	Command	Phase C bottom cmd	Low is on command
33	GND	Common	Reference Voltage	
34	+5V	Power	+5V Power	From controller
35	Reserved			
36	Reserved			

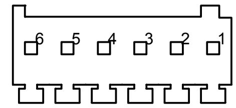
A Mini-D 36-pin connector for first digital amplifier command outputs and current feedbacks. This connector provides the interface to a fully digital amplifier for the first channel.

Note that current feedback data must be in serial digital form, already converted from analog in the amplifier.

For Cables see Appendix A

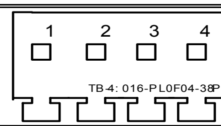
X3: Discrete I/O Terminal Block (6-Point)

6 pin Terminal Block



Pin #	Symbol	Function	Description
1	MTR1 PTC	Input	Motor thermal
2	MTR 1 PTC RTN	Return	
3	MTR2 PTC	Input	Motor thermal
4	MTR2 PTC RTN	Return	
5	FIELD GND	Common	
6	N.C.	Not Connected	
Part Type: FKMC 0,5/6-ST-2,5 p/n: 18 81 36 7			

X4: Safety Relay (Optional)



Pin #	Symbol	Function
1	RELAY WA	Safety Input 24V
2	RELAY WB	Safety Input Return
3	RELAY COM	Common
4	RELAY N/O	Relay Normally Open

If the Safety Relay option is installed, there is a dedicated Safety Input @24VDC (user supplied). When the Safety Input is asserted, then the hardware will cut the 20V power to the gate drive which will prevent all output from the power stage (the Gate Enable LED will turn off). If the user doesn't need to use the Safety Input and the drive has it installed, the user has to bypass it by wiring a 24VDC input to WA (pin 1) and the return (24VDC) to WB (pin 2).

Note:

There are no software configurable parameters to enable/disable or otherwise manipulate the Safety Input functionality.

J1: AC Input Connector Pinout

Pin #	Symbol	Function	Description	Notes
1	L3	Input	Line Input Phase 3	
2	L2	Input	Line Input Phase 2	
3	L1	Input	Line Input Phase 1	(Not used for single Phase input)
On Gxx201xx and Gxx301xx, there is a fourth pin for GROUND connection. If DC bus is used, use L3 for DC+ and L2 for DC return. Connector is located at the bottom side of the unit				

J2: Motor 1 Output Connector Pinout

Pin #	Symbol	Function	Description	Notes
1	U	Output	Axis 1 Phase1	
2	V	Output	Axis 1 Phase2	
3	W	Output	Axis 1 Phase3	
On Gxx201xx and Gxx301xx, there is a fourth pin for ground connection. Connector is located at the top side of the unit, for Ground connection use the screw with a lug				

J3: Motor 2 Output Connector Pinout (Optional)

Pin #	Symbol	Function	Description	Notes
1	U	Output	Axis 2 Phase1	2- Axis drives only
2	V	Output	Axis 2 Phase2	2- Axis drives only
3	W	Output	Axis 2 Phase3	2- Axis drives only
Connector is located at the top side of the unit, for Ground connection use the screw with a lug				

J4: 24VDC Input Logic Supply Connector

Pin #	Symbol	Function	Description	Notes
1	24VDC RET	Common	Control power return	
2	+24VDC	Input	Control power input	24V+/-10%, 2A
Connector is located at the bottom side of the unit				

J5: External Shunt Connector Pinout

Pin #	Symbol	Function
1	Regen-	Output
2	Regen+	Output
Connector is located at the top side of the unit DT Connector part number #014-000F02-HSG and pins part number #014-043375-001 Molex Crimper tool p/n#63811-0400		
For the high Current Drives, Gxx201xx and Gxx301xx , this connector is a 3 pin Large Molex connector		
1	CAP-	Output
2	Regen-	Output
3	Regen+	Output
Connector is located at the top side of the unit. DT Connector part number #014-H00F03-049 and pins part number #014-042815-001. Molex Crimper tool p/n#63811-1500		

DIRECT PWM COMMUTATION CONTROLLER SETUP

The Geo Drive must have the proper controller setup to command the amplifier/motor system. This section summarizes the key variables of both Turbo and non-Turbo PMAC2 controllers that would have to be modified for use with the amplifier. The Delta Tau setup software such as Turbo Setup (Application tool of the Pewin32 Pro Suite) will help set these parameters for the system automatically. For direct commutation of brushless and induction motors, read the details in the PMAC2 or the Turbo PMAC2 User Manual. To find out the details about these variables, refer to the Software Reference Manual for PMAC2 or Turbo PMAC2 (UMAC/QMAC).

Key Servo IC Variables

Non Turbo	Turbo	Type	Description
I900	I7m00	Clock	Max phase clock setting
I901	I7m01	Clock Divisor	Phase clock divisor
I902	I7m02	Clock Divisor	Servo clock divisor
I903	I7m03	Clock	Hardware clock settings
I904	I7m04	Clock	PWM dead time
I905	I7m05	Strobe	DAC strobe word
*	I7m06	Strobe	ADC strobe word (Must be set to $3FFFFF for Geo drives.)
I9n0	I7mn0	Channel	Encoder decode for channel
I9n6	I7mn6	Channel	Output mode for channel (Must be set to 0.)
* To change the ADC strobe word for a non-Turbo PMAC2 controller, issue a write command directly to the memory location of the Gate array channel connected to the amplifier. For non-Turbo PMAC2 channel 1-4, use memory location X:$C014. For non-Turbo PMAC2 channel 5-8, use memory location X:$C024. For example: `WX:$C014,$3FFFFF`.			

Key Motor Variables

Caution:

The ADC Strobe Word, I7m06, must be set to $3FFFFF for proper operation. Failure to set I7m06 equal to $3FFFFF could result in damage to the amplifier.

Non-Turbo	Turbo	Type	Description
Ix00	Ixx00	General	Motor enable
Ix01	Ixx01	General	Commutation enable
Ix25	Ixx24, Ixx25	General	Motor flag setup
Ix70	Ixx70	Commutation	Number of commutation cycles per Ix71
Ix71	Ixx71	Commutation	Counts per commutation cycle per Ix70
Ix72	Ixx72	Commutation	Commutation phase angle
Ix77	Ixx77	Commutation	Induction motor magnetization current
Ix78	Ixx78	Commutation	Induction motor slip gain
Ix83	Ixx83	Commutation	On-going phase position
Ix61	Ix61	Current Loop	Current loop integrator gain
Ix62	Ix62	Current Loop	Current loop forward path proportional gain
Ix66	Ix66	Current Loop	PWM scale factor
Ix76	Ix76	Current Loop	Current loop back bath proportional gain
Ix82	Ix82	Current Loop	Current loop feedback address
Ix84	Ix84	Current Loop	Current loop feedback ADC mask word
Ix57	Ixx57	I^2T	Continuous limit for I^2T
Ix58	Ixx58	I^2T	Integrated current limit

DC BRUSH MOTOR DRIVE SETUP

Commutation Phase Angle: Ixx72

Ixx72 controls the angular relationship between the phases of a multiphase motor. When Turbo PMAC is closing the current loop digitally for Motor xx, the proper setting of this variable is dependent on the polarity of the current measurements.

If the phase current sensors and ADCs in the amplifier are set up so that a positive PWM voltage command for a phase yields a negative current measurement value, Ixx72 must be set to a value less than 1024: 683 for a 3-phase motor, or 512 for a DC brush motor. If these are set up so that a positive PWM voltage command yields a positive current measurement value, Ixx72 must be set to a value greater than 1024: 1365 for a 3-phase motor, or 1536 for a DC brush motor. The testing described below shows how to determine the proper polarity.

The direct-PWM algorithms in the Turbo PMAC are optimized for 3-phase motors and will cause significant torque ripple when used with 2- or 4-phase motors. Delta Tau has created user-written phase algorithms for these motors; contact the factory if interested in obtaining these.

Note:

It is important to set the value of Ixx72 properly for the system. Otherwise, the current loop will have unstable positive feedback and want to saturate. This could cause damage to the motor, the drive, or both, if over current shutdown features do not work properly. If unsure of the current measurement polarity in the drive, consult the Testing PWM and Current Feedback Operation section of this manual.

For commutation with digital current loops, the proper setting of Ixx72 is unrelated to the polarity of the encoder counter. This is different from commutation with an analog current loops (sine-wave control), in which the polarity of Ixx72 (less than or greater than 1024) must match the encoder counter polarity. With the digital current loop, the polarity of the encoder counter must be set for proper servo operation; with the analog current loop, once the Ixx72 polarity match has been made for commutation, the servo loop polarity match is guaranteed.

Special Instructions for Direct-PWM Control of Brush Motors

Special settings are needed to use the direct-PWM algorithms for DC brush motors. The basic idea is to trick the commutation algorithm into thinking that the commutation angle is always stuck at 0 degrees, so current into the A phase is always quadrature (torque-producing) current. These instructions assume:

- The brush motor's rotor field comes from permanent magnets or a wound field excited by a separate means; the field is not controlled by one of the phases of this channel.
- The two leads of the brush motor's armature are connected to amplifier phases (half-bridges) that are driven by the A and C-phase PWM commands from Turbo PMAC. The amplifier may have an unused B-phase half-bridge, but this does not need to be present.

The following settings are the same as for permanent-magnet brushless servo motors with an absolute phase reference:

- Ixx01 = 1 (commutation directly on Turbo PMAC) or Ixx01=3 (commutation over the MACRO ring)
- Ixx02 should contain the address of the PWM A register for the output channel used or the MACRO Node register 0 (these are the defaults), just as for brushless motors.
- Ixx29 and Ixx79 phase offset parameters should be set to minimize measurement offsets from the A and B-phase current feedback circuits, respectively.
- Ixx61, Ixx62, and Ixx76 current loop gains are set just as for brushless motors.

- Ixx73 = 0, Ixx74 = 0: These default settings ensure that Turbo PMAC will not try to do a phasing search move for the motor. A "failed" search could keep Turbo PMAC from enabling this motor.
- Ixx77 = 0 to command zero direct (field) current.
- Ixx78 = 0 for zero slip in the commutation calculations.
- Ixx82 should contain the address of ADC B register for the feedback channel used (just as for brushless motors) when the ADC A register is used for the rotor (armature) current feedback. The B register itself should always contain a zero or near-zero value.
- Ixx81 > 0: Any non-zero setting here makes Turbo PMAC do a "phasing read" instead of a search move for the motor. This is a dummy read, because whatever is read is forced to zero degrees by the settings of Ixx70 and Ixx71, but Turbo PMAC demands that some sort of phase reference be done. (Ixx81=1 is fine.)
- Ixx84 is set just as for brushless motors, specifying which bits the current ADC feedback uses. Usually, this is $FFF000 to specify the high 12 bits.

Special settings for brush motor direct PWM control:

- Ixx70 = 0: This causes all values for the commutation cycle to be multiplied by 0 to defeat the rotation of the commutation vector.
- Ixx72 = 512 (90^{o}e) if voltage and current numerical polarities are opposite, 1536 (270^{o}e) if they are the same. If the amplifier would use 683 (120^{o}e) for a 3-phase motor, use 512 here; if it would use 1365 (240^{o}e) for a 3-phase motor, use 1536 here.
- Ixx96 = 1: This causes Turbo PMAC to periodically clear the integrator for the (non-existent) direct current loop, which could slowly charge up due to noise or numerical errors and eventually interfere with the real quadrature current loop.

Settings that do not matter:

- Ixx71 (commutation cycle size) does not matter because Ixx70 setting of 0 defeats the commutation cycle
- Ixx75 (Offset in the power-on phase reference) does not matter because commutation cycle has been defeated. Leaving this at the default of 0 is fine.
- Ixx83 (ongoing commutation position feedback address) doesn't matter, since the commutation has been defeated. Leaving this at the default value is fine.
- Ixx91 (power-on phase position format) does not matter, because whatever is read for the power-on phase position is reduced to zero.

Testing PWM and Current Feedback Operation

WARNING:

On many motor and drive systems, potentially deadly voltage and current levels are present. Do not attempt to work directly with these high voltage and current levels unless fully trained on all necessary safety procedures. Low-level signals on Turbo PMAC and interface boards can be accessed much more safely.

Most of the time in setting up a direct PWM interface, there is no need to execute all of the steps listed in these sections (or the Turbo Setup program will do them automatically). However, the first time this type of interface is setup, or there are problems, these steps will be of assistance.

For safety reasons, all of these tests should be done with the motor disconnected from any loads. All settings made as a result of these tests are independent of load properties, so will still be valid when the load is connected.

Before testing any of Turbo PMAC's software features for digital current loop and direct PWM interface, it is important to know whether the hardware interface is working properly. PMAC's M-Variables are used to access the input and output registers directly. The examples shown here use the suggested M-Variable definitions for Motor 1.

Purpose

The purpose of these tests is to confirm the basic operation of the hardware circuits on PMAC, in the drive, and in the motor, and to check the proper interrelationships. Specifically:

- Confirm operation of encoder inputs and decode
- Confirm operation of PWM outputs
- Confirm operation of ADC inputs
- Confirm correlation between PWM outputs and ADC inputs
- Determine proper current loop polarity
- Confirm commutation cycle size
- Determine proper commutation polarity

Preparation

First, define the M-Variables for the encoder counter, the three PWM output registers, the amplifier-enable output bit, and the two ADC input registers. Using the suggested definitions for Motor 1, utilizing Servo IC 0, Channel 1:

```
M101->X:$078001,0,24,S        ; Channel 1 Encoder position register
M102->Y:$078002,8,16,S        ; Channel 1 PWM Phase A command value
M104->Y:$078003,8,16,S        ; Channel 1 PWM Phase B command value
M107->Y:$078004,8,16,S        ; Channel 1 PWM Phase C command value
M105->Y:$078005,8,16,S        ; Channel 1 Phase A ADC input value
M106->Y:$078006,8,16,S        ; Channel 1 Phase B ADC input value
M114->X:$078005,14            ; Channel 1 Amp Enable command bit
```

Note:

The ADC values are declared as 16-bit variables even though typically, 12-bit ADCs are used; this puts the scaling of the variable in the same units as Ixx69, Ixx57, Ixx29, and Ixx79.

It is useful to monitor these values in the Watch window of the Executive program. Therefore, add the variable names to the Watch window which causes the program to repeatedly query Turbo PMAC for the values and display them. Then the hardware can be exercised with on-line commands issued through the Terminal window.

To prepare Turbo PMAC for these tests:

1. Set I100 to 0 to deactivate the motor.
2. Set I101 to 0 to disable commutation (This allows for manual use of these registers.)
3. Make sure that I7000, I7004, I7016, and I7017 are set up properly to provide the PWM signals desired.
4. If the Amplifier Enable bit is 1, set it to zero with the command **`M114=0`**.
5. Set Ixx00 and Ixx01 for all other motors to zero.

Position Feedback and Polarity Test

If the PWM command values observed in the Watch window are not zero, set them to zero with the command:

```
M102=0 M104=0 M107=0
```

The motor can be turned (or pushed) freely by hand now. As the motor is turned, monitor the M101 value in the Watch window. Look for the following:

- It should change as the motor is moved.

- It should count up in one direction, and count down in the other direction.
- It should provide the expected number of counts in one revolution or linear distance increment.
- As the motor is returned repeatedly to a reference position, it should report (approximately) the same position value each time.

If these things do not happen, check the encoder/resolver operation, its connection to Turbo PMAC and the Turbo PMAC decode variable I7mn0. Double-check that the sensor is powered. In addition, look at the encoder waveforms with an oscilloscope.

If the direction of motion to be the positive direction is known, check this here. If the direction is incorrect, invert it by changing I7mn0, usually from 7 to 3, or from 3 to 7. If the direction is not known, change it later, but make another change at that time to maintain the proper commutation polarity match; usually by exchanging two of the motor phase leads at the drive.

Note:

Because I100 has been set to 0, and I103 may not yet have been set properly, any change of position will not be reflected in the motor position window.

PWM Output and ADC Input Connection

WARNING:

Make sure before applying any PWM commands to the drive and motor in this fashion that the resulting current levels are within the continuous current rating of both drive and motor.

First, enable the amp, then apply a very small positive command value to Phase A and a very small negative command value to Phase B with the on-line commands:

```
M114=1                              ; Enable amplifier
M102=I7000/50 M104=-I7000/50 M107=0    ; A pos, B neg, C zero
```

This provides a command at 2% of full voltage into the motor; this should be well within the continuous current rating of both drive and motor. It is a good idea to make the sum of these commands equal to zero so as not to put a net DC voltage on the motor; putting all three commands on one line causes the changes to happen virtually instantaneously.

With power applied to the drive and the amplifier enabled (**`M114=1`**), current readings should be received in the ADC registers as shown by the M-Variables M105 and M106 in the Watch window.

Since the M-Variables are defined as +/-32,768 for full current range, which should correspond approximately to the instantaneous current limit. Make sure that the value read does not exceed the continuous current limit, usually, which is about 1/3 of the instantaneous limit. If well below the continuous current limit, increase the voltage command to 5% to 10% of maximum. For example:

```
M102=I7000/10 M104=-I7000/10 M107=0    ; 10% of maximum
```

PWM/ADC Phase Match

Command values from Turbo PMAC's Phase A PWM outputs should cause a roughly proportionate response of one sign or the other on Turbo PMAC's Phase A ADC input (whatever the phase is named in the motor and drive). The same is true for Phase B.

If no response is received on either phase, re-check the entire setup, including:

- Is the drive properly wired to Turbo PMAC, either directly or through an interface board?
- Is the motor properly connected to the drive?
- Is the drive properly powered, both the power stage, and the input stage?
- Is the interface board properly powered?
- Is the amplifier enabled (M114=1 on Turbo PMAC and LED indicator ON at the drive)?
- Is the amplifier in fault condition? If so, why? (Check the Status Display error Codes)

If only an ADC response is received on one phase, the phase outputs and inputs may not be matched properly. For example, the Phase B ADC may be reading current from the phase commanded by the Phase C PWM output. Confirm this by trying other combinations of commands and checking which ADC responds to which phase command. If there is not a proper match, change the wiring between Turbo PMAC and the drive. Changing the wiring between drive and motor will not help here.

Synchronous Motor Stepper Action

With a synchronous motor, this command should cause the motor to lock into a position, at least weakly, like a stepper motor. This action may be received temporarily on an induction motor, due to temporary eddy currents created in the rotor. However, an induction motor will not keep a holding torque indefinitely at the new location.

Current Loop Polarity Check

Observe the signs of the ADC register values in M105 and M106. These two values should be of approximately the same magnitude, and must be of the opposite sign from each other. (Again, remember that these readings may appear noisy. Observe the base value underneath the noise.) If M105 is positive and M106 is negative, the sign of the PWM commands matches the sign of the ADC feedback values. In this case, the Turbo PMAC phase angle parameter I172 must be set to a value greater than 1024 (1365 for a 3-phase motor).

If M105 is negative and M106 is positive, the sign of the PWM commands is opposite that of the ADC feedback values. In this case, I172 must be set to a value less than 1024 (683 for a 3-phase motor).

Make sure your I172 value is set properly before attempting to close the digital current loops on Turbo PMAC. Otherwise positive feedback will occur, creating unstable current loops which could damage the amplifier and/or motor.

If M105 and M106 have the same sign, the polarities of the current sense circuitry for the two phases is not properly matched. In this case, something has been miswired in the drive or between Turbo PMAC and the drive to give the two phase-current readings opposite polarity. One of the phases will have to be fixed.

Do not attempt to close the digital current loops on Turbo PMAC until the polarities of the current sense circuitry for the two phases have been properly matched. This will involve a hardware change in the current sense wiring, the ADC circuitry, or the connection between them. As an extra protection against error, make sure that Ixx57 and Ixx58 are set properly for I^2T protection that will shut down the axis quickly if there is saturation due to improper feedback polarity.

Troubleshooting

If not getting the current readings expected, probe the motor phase currents on the motor cables with a snap-on hall-effect current sensor. If the current is not seen when commanding voltages, check for phase-to-phase continuity and proper resistance when the motor is disconnected.

Setting up Non-Turbo PMACs for Brush Motor Control

It is possible to use PMAC2’s direct PWM and digital current loop for control of DC brush motors, both those with permanent-magnet fields, and those with wound fields. Because PMAC2’s digital current loop and commutation algorithms are combined, it is necessary to activate PMAC2’s commutation algorithm for the motor, even though it is not commutating the motor.

The sine-wave commutation is effectively disabled in this technique by telling PMAC2 that the motor has a commutation cycle of 1 count. Each count received causes a 360^oe phase increment, leaving the phase angle constant at all times for DC control. With the phase angle always at zero, PMAC2’s quadrature, or torque-producing, output voltage and feedback current are always equivalent to the motor’s rotor, or armature, voltage and current. PMAC2’s direct, or magnetization field, voltage and current are always equivalent to the motor’s stator, or wound field, voltage and current (if any).

Hardware Connection

In this technique, the rotor (armature) current is commanded by PMAC2 phases A and C. The motor armature leads should be connected between the two half-bridges of the amplifier driven by PMAC2 phases A and C, together forming a full H-bridge.

The armature current sensor should feed an A/D converter that is connected to one of the serial ADC inputs for the channel on PMAC2. If there is a wound field, the armature current reading must be fed into ADC A and the field current reading must be fed into ADC B.

If there is only a permanent magnet field, the armature current reading can be fed into either ADC A or ADC B, with Ix82 telling PMAC2 which one is used. If ADC A is used, the serial digital input for ADC B (+signal only) should be tied to GND so a zero feedback value is forced (alternately a background PLC can zero the direct current integrator register periodically). If ADC B is used, then PMAC uses the Compare A read/write register for the (non-existent) direct current feedback; in this case, a zero value should be written into this register on power-on/reset, and no other value should be written to it during the application.

If there is a wound field, it must be commanded from PMAC2's B phase, and the current feedback must be brought back into PMAC2's B-phase. If only uni-directional voltage and current are required for the field, the field windings can be commanded from a single half-bridge. If bi-directional voltage or current is required, a full H-bridge must be used, with PMAC2's B-phase commanding the two half bridges in anti-phase mode (also the command for the top of one half is used for the bottom of the other half).

I-Variable Setup

To set up a motor for this technique, the following I-variable settings must be made:

- Ix00 = 1 to activate the motor
- Ix01 = 1 to activate commutation algorithms
- Ix02 should contain the address of the PWM A register for the output channel used (this is the default), just as for brushless motors
- Ix70 = 4, Ix71 = 4: This defines a commutation cycle size of 4/4 = 1 count. The use of 4/4 instead of 1/1 allows us to rotate the angle $\pm 90^{o}$ for test and tuning purposes.
- Ix72 = 64 or 192 for 1/4 or 3/4 cycle between the armature (rotor) and field (stator). If a positive voltage output number creates a negative current feedback number, use 64; otherwise use 192.
- Ix73 = 0, Ix74 = 0: No power-on phase search will be required
- Ix75 = 0: Zero offset in the power-on phase reference
- Ix77 = 0 for motors without wound field. With a wound field, Ix77 determines the strength of the field; with field weakening functionality, Ix77 will be a function of motor speed.
- Ix78 = 0 for zero slip in the commutation calculations
- Ix81 = $80770: This tells PMAC2 to read the low 8 bits of Y:$0770 for the power-on phase position. This register is forced to zero on power-on/reset, so this setting forces the phase position to zero.
- Ix82 should contain the address of ADC B register for the feedback channel used (just as for brushless motors) when the ADC A register is used for the rotor (armature) current feedback. If there is a wound field, the stator field current feedback should be connected to ADC B. If there is a permanent magnet field, there will be no feedback to ADC B.
- Ix82 should contain the address one greater than that of the ADC B register for the feedback channel used when the ADC B register is used for the rotor (armature) current feedback. This is suitable for motors with only a permanent magnet field.
- Ix83 does not really matter here, because the commutation position is defeated by the single-count cycle size. However, it is fine to use the default value.
- Ix84 is set just as for brushless motors, specifying which bits the current ADC feedback uses.
- Ix61, Ix62, and Ix76 current loop gains are set just as for brushless motors.

PWM DRIVE COMMAND STRUCTURE

The amplifier functions in two modes: Default and Enhanced.

Default Mode

Default Mode is the mode the amplifier is in when it is first powered on or the power is re-cycled for any reason. Default mode is compatible with the full series of Delta Tau amplifiers and the A/D converters used on these amplifiers.

In this mode, the amplifier returns not only the currents for phases A and B but also the fault codes for the axes associated with those currents. The fault codes occupy the lower 12-bits on each phase.

For Default mode to work correctly, make sure that the A/D strobe word for the axis is set to the correct value for the A/D on the amplifier. For instance, the current Delta Tau amplifiers use a 12-bit Burr Brown part requiring a strobe word of $3FFFFF; this word is written to

X:$C014 as **WX:$C014, $3FFFFF** for non-Turbo. For Turbo PMAC **I7m06= $3FFFFF.**

This value can be saved to PMAC memory and sent to the amplifier on boot automatically.

Enhanced Mode

Enhanced mode is available on the Geo series of Delta Tau amplifiers and offers many more options. Like the Default mode, Enhanced mode requires that a special strobe word be written to the amplifier, and like Default mode, this word may be saved to PMAC memory and issued each boot automatically. Enhanced mode axes and Default mode axes may not be mixed on the same amplifier.

Enhanced mode not only offers the fault codes associated with any axis on the lower 12-bits of A current feedback, but many other options, including reading and writing the on-board EEprom, setting special SFRs for jumperless configuration of the amplifier and reading both bus voltage and IGBT temperatures.

To enter Enhanced Mode, the Strobe Word must be set to $C00003. Use the following command:

`Non-Turbo PMAC`	`WX:$C014, $C00003`
`Turbo PMAC`	`I7m06 = $C0003`

The above command is modal and subsequent communication will be in Enhanced Mode until the drive's power is cycled.

At present, the commands sent to axis one are active on all axes of the amplifiers, that is, if bus voltage from axis one is requested, bus voltage from all axes on that amplifier will be received. It is wise to code any software used to drive the amplifier so that the same command is sent to all axes, so that when independent control becomes available, the software will be both compatible and easily changed.

FPGA Command Register

The FPGA has a 4-bit command register located in the bits 22:19 of the strobe word. These bits are used to read data from the drive as well as write data to the FPGA Control Registers and the drive's onboard EEPROM. The MSB (bit 23) of the strobe word must be a 1 since it is the start bit. In addition, the strobe word LSB and LSB+1 are stop bits and must both be set to 1.

All requested data is returned in the lower 12 bits of the phase B current feedback for each axis. Write command data is written to bits 10:3 of the strobe word.

Command	Strobe Word Bit Numbers	PMAC Command Line (Strobe Word)	
Return the IGBT Temperature (default in enhanced mode)	22:19 = 0000	`WX:$C014` `I7m06`	`$800003`
Return the Bus Voltage	19	`WX:$C014` `I7m06`	`$880003`
Return the command value, RST Line Monitor Status and Control Register Value	20	`WX:$C014` `I7m06`	`$900003`
Return the Command Value, UART Recv'd Data Bit Status and One-Wire Read Register Value	20:19	`WX:$C014` `I7m06`	`$980003`
Write a data word to the FPGA SFRs	21	`WX:$C014`	`$A00xxx*`
Write a data word to the UART transmitter	21 & 19	`WX:$C014` `I7m06`	`$A80xxx*`

* The lower three nibbles will vary depending on the data written since the data is contained in bits 10:3 of the strobe word. However, the LSB and LSB+1 are stop bits and must be set to 1.

Description	Strobe Word Bit Numbers	PMAC Command Line Strobe Word
Return the IGBT Temperature (default in enhanced mode)	22:19 = 0000	`WX:$C014,$800003`
Return the Bus Voltage	19	`WX:$C014,$880003`
Return the command value, RST Line Monitor Status and Control Register Value	20	`WX:$C014,$900003`
Return the Command Value, UART Recv'd Data Bit Status and One-Wire Read Register Value	20:19	`WX:$C014,$980003`
Write a data word to the FPGA SFRs	21	`WX:$C014,$A00xxx *`
Write a data word to the UART transmitter	21 and 19	`WX:$C014,$A80xxx *`

* The lower three nibbles will vary depending on the data written since the data is contained in bits 10:3 of the strobe word. However, the LSB and LSB+1 are stop bits and must be set to 1.

Strobe Word

While in Default mode, the control word only sets up the operation of the A/D converter. In Enhanced mode, it takes on much more meaning. The significance of the Strobe word bits is illustrated in the following figure:

23	22	21	20	19	18	17	16	15	14	13	12
Start bit	CB[3]	CB[2]	CB[1]	CB[0]	x	x	x	x	x	x	x

11	10	9	8	7	6	5	4	3	2	1	0
x	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]	x	Stop bit	Stop bit

Note:

To send a command (CB[3:0]), the start bit and the two stop bits must be set.

Command Register (CB[3:0]):

$00 -> return the axis IGBT temperature in lower 12-bits of the 24-bit word containing the phase B current for the particular axis.

$01 -> return the BUS voltage in lower 12 bits of the 24-bit word containing the phase B current for the particular axis.

$02 -> return the current command, the status of the three phase line and the value of the local control register in lower 12 bits of the 24-bit word containing the phase B current for the particular axis.

$03 -> return the current command, the status of the UART received data bit and the value of one-wire read register in lower 12 bits of the 24-bit word containing the phase B current for the particular axis.

$04 -> write a data word (D[7:0]) to the local control register.

$05 -> write a data word (D[7:0]) to the UART transmitter

The result for any command is returned in the phase B current word, so for axis 1, the data will come back in Y-register $C006. The phase A current word will be unaffected and continue to return phase A current and the fault status word.

Any command remains in effect until the next command. Therefore, if the command to return IGBT temperature is issued, the 24-bit word at Y:$C006 (axis 1) will contain two A/D conversions: the upper 12-bits will be phase B currents with the lower 12-bits carrying the IGBT temperature, and Y:$C006 will continue to return this data as the long as the Strobe word contains this command. Of course, the data is refreshed in real time just as the phase currents.

In addition, a user program can communicate directly with the embedded EEprom on board using the UART built into the FPGA. Commands and procedure for doing this are located in the documentation associated with the DS2480B modem chip (included with this document).

IGBT Temperature and Bus Voltage

To read the IGBT temperature for each IGBT block on the amplifier, write $800003 to the A/D strobe word: X:$C014 (non-Turbo) I7m06 (Turbo). The 12-bit value of the IGBT temperature for each axis will be in the lower 12-bits of the register holding the B phase current for the axis.

For instance, for a PMAC if looking at Axis 1, find the temperature in the lower 12-bits of:

Non-Turbo	Turbo	Notes
`WX:$C014,$800003`	I7006=$80003	`;command to send temperature`
`RHY$C006`		`;command to read temperature`
M102->Y:$78006,8,16,s		

The same procedure will recover the Bus Voltage – the only difference being the command:

Non-Turbo	Turbo	Notes
`WX$C014,$880003`	I7006=$880003	`;command to send Bus Voltage`
`RHY$C006`	M102	`;command to read Bus Voltage`
M102->Y:$78006,8,16,s		

Drive SFRs (Special Function Registers)

The Drive has SFRs that are used to control various drive functions. To write to an SFR the upper three nibbles of the strobe word should be $A00 and bits 10:3 of the strobe word are used to set the individual bits of each SFR. The table below outlines the SFRs and their functions.

Description	bit	address, non - Turbo	address, Turbo	value
Set shunt regulator control for 120 VAC input (3U042 drives only)	3	`WX:$C014`	`I7m06`	,$A0000B
Set PWM control for DC brush motors	4			,$A00013
Turn off Line Monitor	5			$A00023

Once set, these bits remain set until reset with a write to the SFRs or power is cycled on the amplifier.

Shunt Regulator Control

This bit will set the shunt for either 230V or 460V operation on the Geo 3U amplifier.

Set PWM Control for DC Brush Motors

Setting this bit will reconfigure the amplifier to drive DC brush motors instead of 3-phase brushless motors. The number of DC brush motors that can be driven depends upon the number of axes available. For each 3-phase brushless axis, one DC brush axis is possible. Ensure that this bit is set as a configuration step only and not during operation.

Turn off Line Monitor

By default, the RST Line Monitor is active. This, however, is not convenient for test or maintenance purposes. Set this bit to disable the RST Line Monitor – the amplifier will no longer fault if a loss of phase occurs. The Line Monitor is re-activated when either the bit is explicitly set or power is cycled.

Reading and Writing the SFRs

Read the SFRs by writing $900003 to the Strobe Word: WX:$C014 (non-Turbo), I7m06 (Turbo). As an example, turn off the Line Monitor:

Non-Turbo	Turbo	Notes
WX$C014,$A00023	I7006=$A00023	;set bit
RHY:$C006	M102	;read line monitor
M102->Y:$78006,8,16,s		

The lower 12-bits of $C006/M102 will contain:

11	10	9	8	7	6	5	4	3	2	1	0
0	1	0	2/3phase flag	0	0	0	0	0	1	0	0

These 12-bits indicate that the current command is a read SFR command (bits 11:9), the status of the 3/3 phase flag (bit 8) and the status of the Line Monitor flag (bit 2).

Note:

Modifying the Control Register is a Read-Modify-Write procedure. To keep any previously set or cleared bits, first read the register, modify that value, and then write the register. Whatever is written to the Command Register is what is in the Command Register.

SETTING I^{2}T PROTECTION

It is important to set the I^{2}T protection for the amplifier/motor system for PMAC2 (non-Turbo or Turbo) direct PWM commutation. Normally, an amplifier has internal I^{2}T protection because it is closing the current loop. When PMAC2 (non-Turbo or Turbo) is closing the current loop, the amplifier cannot protect itself or the motor from over heating. Either set up the I^{2}T protection using one of the Setup Programs or manually set the Ixx69, Ixx57 and Ixx58 variables based on the following specifications:

Parameter	Description	Notes
MAX ADC Value	Maximum Current output of amplifier relative to a value of 32767 in Ix69 (non-Turbo), Ixx69 (Turbo).	Gxx01x = 8 Amps Gxx03x = 14.6 Amps Gxx05x = 16.2 Amps Gxx10x = 32.5 Amps Gxx15x = 48.8 Amps Gxx20x = 65 Amps Gxx30x = 97.6 Amps x = Position in part number is irrelevant.
Instantaneous Current Limit	The lower of the amplifier or motor system	RMS or Peak*
Continuous Current Limit	The lower of the amplifier or motor system	Usually RMS
I^{2}T protection time	Time at instantaneous limit	Usually two seconds
Magnetization Current	Ixx77(Turbo) Ixx77 (non-Turbo) value for induction motors	Only for induction motors
Servo Update Frequency	Default is 2258 Hz.	
* If specification given in RMS, calculate this value by 1.41 to obtain peak current for calculations.		

Example Calculations for Direct PWM commutated motor:
MAX ADC = 32.5A
Instantaneous Current Limit = 10A Peak
Continuous Current Limit = 5A RMS
I^{2}T protection time = 2 seconds
Magnetization Current (Ixx77) = 0
Servo Update = 2.258 kHz

$$Ixx69 = \frac{Ins\tan\tan eous\ Limit(Peak)}{MAX\ ADC} x32767xCos(30°)$$

if calculated Ix69 >32767, then Ix69 (non-Turbo)or Ixx69(Turbo) should be set equal to 32767

$$Ixx57 = \frac{Continuous\ Limit}{Ins\tan\tan eous\ Limit} xIxx69$$

$$Ixx58 = \frac{Ixx69^2 + Ixx77^2 - Ixx57^2}{32768^2} \times ServoUpdateRate(Hz) \times PermittedTime(\sec onds)$$

Based on the above data and equations, the following results:

Ixx69= 8731
Ixx57=4366
Ixx58=240

For details about I^{2}T protection, refer to the safety sections of the User Manual. Details about the variable setup can be found in the Software Reference manual.

CALCULATING MINIMUM PWM FREQUENCY

The minimum PWM frequency requirement for a system is based on the time constant of the motor. Calculate the minimum PWM frequency to determine if the amplifier will properly close the current loop. Systems with very low time constants need the addition of chokes or in-line inductive loads to allow the PMAC to properly close the current loop of the system. In general, the lower the time constant of the system, the higher the PWM frequency must be.

Calculate the motor time constant by dividing the motor inductance by the resistance of the phases.

$$\tau_{motor} = \frac{L_{motor}}{R_{motor}}$$

The relationship used to determine the minimum PWM frequency is based on the following equation:

$$\tau > \frac{20}{2\pi \times PWM(Hz)}$$

$$\therefore PWM(Hz) = \frac{20}{2\pi\tau}$$

Example:

$L_{moto\ r}$ = 5.80 mH

R_{motor} = 11.50 Ω

$$\tau_{motor} = \frac{5.80mH}{11.50\Omega} = 0.504m\,sec$$

Therefore, $PWM(Hz) = \frac{20}{2\pi \times (0.504m\,sec)}$ = 6316 Hz

Based on this calculation, set the PWM frequency to at least 6.32kHz.

TROUBLESHOOTING

The Geo Brick utilizes a scrolling single-digit 7-segment display. When any of the drive's output sections is enabled, the display will show **0**.

Error Codes

Some error codes are also transmitted to the Status Display. Not all errors reflect a message back to the host. In these cases, the no-message errors communicate only to the Status Display.

The response of the Geo Drive to an error depends on the error's severity. There are two levels of severity:

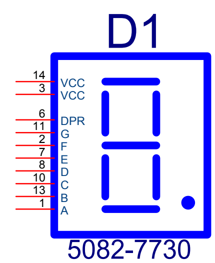
1. Warnings (simply called errors and not considered faults and do not disable operation).
2. Fatal errors (fatal faults that disable almost all drive functions, including communications).

Note:

The Geo Drive disables automatically at the occurrence of a fault.

D1: Geo Brick Drive Status Display Codes

The 7-segment display on the current model, 16 numeric codes plus two decimal points, provides the following codes:



Display	Description	Cause
0	Normal Operation	
1	Time Based Over Current on Axis 1	An internal timer has noticed that Axis 1 is taking more RMS current than the drive was designed to produce. Reduce loading.
2	Over Current – Axis 1.	Over current sensors have detected an excess of current through the motor leads. Typically, a shorted motor, shorted cable, extremely excessive current, or voltage commands from the controller through the power stage. The controller is the PMAC controller.
3	PWM Over Frequency Axis 1	PMAC or UMAC setup is incorrect. The I-variables for the phase clock frequency and PWM frequencies should be adjusted under the MAX PWM frequency.
4	Power Stage Over Temp Axis 1.	Heat sink temperature is above a factory pre-set range (approximately 75 ºC). Drawing excessive current through the amplifier, blocked airflow through the amplifier or operation in an ambient temperature above 45 ºC.
5	Motor Over Temp Axis 1	Normally-closed input on the front of the Geo drive amplifier connector X3 is detected in open circuit between pins 3 and 4.
6	Over Current – Axis 2.	Over current sensors have detected an excess of current through the motor leads. An internal timer has noticed that Axis 2 is taking more RMS current than the drive was designed to produce. Reduce loading.
7	Over Current Axis 2.	Over current sensors have detected an excess of current through the motor leads. Typically, a shorted motor, shorted cable, extremely excessive current, or voltage commands from the controller through the power stage. The controller is the PMAC controller.
8	PWM Over Frequency Axis 2	PMAC or UMAC setup is incorrect. The I-variables for the phase clock frequency and PWM frequencies should be adjusted under the MAX PWM frequency.
9	Heat Sink Over Temp Axis 2.	Heat sink temperature is above a factory pre-set range (approximately 75 ºC). Drawing excessive current through the amplifier, blocked airflow through the amplifier or operation in an ambient temperature above 45 ºC.

A	Motor Over Temp Axis 2	Normally closed input on the front of the Geo drive amplifier connector X3 is detected in open circuit between pins 3 and 4.
b	Over Voltage.	The bus voltage has exceeded a factor pre-set threshold of 820V for 480V drives or 420V for 230V drives. Lack of ability to dump the regenerated energy from the motor. A shunt regulator or dump resistor can help GAR 49 or GAR78. Another common cause can be excessively high input line voltage.
C	Under Voltage	The DC bus internal to the Geo drive has decreased below a factory pre-set threshold of 16 to 30Vdc (no AC input power to the drive).
d	Shunt Regulator Fault	Fatal fault where the internal drive electronics for the power stage that controls the shunt regulator has failed. If unable to reset this fault, the unit needs to be returned to the factory for repair. A short in the shunt regulator or motor leads can cause this fault code. The output drive transistors have gone into a linear mode instead of a switching mode (DSAT).
E	Ground Fault	A short in the shunt regulator or motor leads can cause this fault code. The output drive transistors have gone into a linear mode instead of a switching mode (DSAT).
F	Gate Drive Power Fault	Fatal fault where the internal drive electronics for the power stage that controls the six IGB outputs has failed. If unable to reset this fault, the unit needs to be returned to the factory for repair. A short in the shunt regulator or motor leads can cause this fault code. The output drive transistors have gone into a linear mode instead of a switching mode (DSAT).
L	Line Monitor	Line Monitor Fault detected. Indicates that the input AC line voltage is low or not present. The drive will determine if it is operating on single-phase or three-phase power when the drive is enabled. Once initialized for single-phase or three-phase power, the drive will detect the appropriate loss of power signals and indicate a Line Monitor fault within 30 milliseconds of loss of power.

Status LEDs

LED	Color	Description
ENABLE1	Green/Red	Green when first axis enabled. Red when drive is not enabled. (Unlit does not necessarily mean fault.)
ENABLE2	Green/Red	Green when second axis enabled. Red when drive is not enabled. (Unlit does not necessarily mean fault.)
DC BUS	Red	Lit when bus powered.
SHUNT	Yellow	Lit when drive is attempting to dump power through the external shunt regulator regen resistor.
+5V	Green	Lit when 5V logic has power.
GATE ENABLE	Green	Lit when Gate is enabled

APPENDIX A

PWM Cable Ordering Information

Cable	Length						Part Numbers
	600mm (24")	900mm (36")	1.5m (60")	1.8m (72")	2.1m (84")	3.6m (144")	
CABPWM-1	√						200-602739-024X
CABPWM-2		√					200-602739-036x
CABPWM-3			√				200-602739-060x
CABPWM-4				√			200-602739-072x
CABPWM-5					√		200-602739-084x
CABPWM-6						√	200-602739-144x

Mating Connector and Cable Kits

Geo Drives do not come with any connectors for the AC input, 24VDC input, Regen Resistor Output, or Motor Outputs. The user should purchase the appropriate Mating Connector and Cable Kits from Delta Tau Data Systems, Inc., or they can obtain the connectors and pins from other sources.

Cable sets can be purchased directly from Delta Tau to make the wiring of the system easier. Available cable kits (CABKITxx) are listed below.

For those manufacturing their own cable sets, the table below provides Connector Kits to use with each drive. Connector Kits (CONKITxx) include the MOLEX connectors and pins for the AC input, 24VDC power supply and the motor outputs.

Note:

Due to the variety and wide availability of D-type connectors and back shells for the encoders, CABKITs and CONKITs do not provide these parts.

For correct installation of the connector kit to the Cables, proper crimping tools are required. Check the Molex website to find the correct tool for the appropriate pin.

Cable kits have terminated cables on the drive end and flying leads on the other.

Mating Connector and Cable Kits

Connector Kit	Description
CONKIT1A	Mating Connector Kit for dual axis drives up to 5-amp continuous rating (Gxx012xx, Gxx032xx, Gxx052xx, GxL102xx): Includes Molex Connectors kits for two motors, AC input connection, and 24V power connection. Requires Molex Crimp tools for proper installation.
CABKIT1B	Includes Molex mating connectors pre-crimped for dual axis drives up to 5-amp continuous rated (Gxx012xx, Gxx032xx, Gxx052xx,GxL102). • 3 ft. AC Input Cable • 3 ft. 24VDC Power Cable • 10 ft. shielded Motor Cables
CONKIT1C	Mating Connector Kit for single axis drives up to 5-amp continuous rating (Gxx051xx): Includes Molex Connectors kits for two motors, AC input connection, and 24V power connection. Requires Molex Crimp tools for proper installation.

CABKIT1C	Includes Molex mating connectors pre-crimped for single axis drives up to 5-amp continuous rated (Gxx051xx). • 3 ft. AC Input Cable • 3 ft. 24VDC Power Cable • 10 ft. shielded Motor Cables
CONKIT2A	Mating Connector Kit for dual axis drives up to 15 amp continuous rating (GxH102xx, Gxx152xx): Includes Molex Connectors kits for: two motors, AC input connection, and 24V power connection. Requires Molex Crimp Tools for proper installation.
CABKIT2B	Includes Molex mating connectors pre-crimped for dual axis drives (double width) up to 15 amp continuous rated (GxH102xx, Gxx152xx). • 3 ft. AC Input Cable • 3 ft. 24VDC Power Cable • 10 ft. shielded Motor Cables
CONKIT2C	Mating Connector Kit for single axis drives, up to 15 amp continuous rating (Gxx101xx, Gxx151xx): Includes Molex Connectors kits for one motor, AC input connection, and 24V power connection. Requires Molex Crimp tools for proper installation.
CABKIT2D	Includes Molex mating connectors pre-crimped for single axis drives up to 15 amp continuous rated (Gxx101xx, Gxx151xx). • 3 ft. AC Input Cable • 3 ft. 24VDC Power Cable 10 ft. shielded Motor Cables
CONKIT4A	Mating Connector Kit for single axis drives up to 30 amp continuous rating (Gxx201xx, Gxx301xx): Includes Molex Connectors kits for one motor (4pin), AC input connection (4 pin), and 24V power connection. Requires Molex Crimp Tools for proper installation.
CABKIT4B	Includes Molex mating connectors pre-crimped for single axis drives up to 30 amp continuous rated (Gxx201xx, Gxx301xx). • 3 ft. AC Input Cable (4pin) • 3 ft. 24VDC Power Cable 10 ft. shielded Motor Cables (4 pin)
G14AWG	Motor Power Cables. Extended cable length. Per foot per cable for the CABKITs. Customer must specify length. For drives up to 15 amp continuous rating.(Gxx051xx, Gxx101xx, Gxx151xx, Gxx012xx, Gxx032xx, Gxx052xx, Gxx102xx, Gxx152xx)

Connector and pins Part numbers

CONKIT1A

Connector	D/T part number	D/T part number individuals	Molex part number
24VDC & Shunt Resistor	200-000F02-HSG	Housing: 014-000F02-HSG Pins: 014-043375-001	44441-2002 43375-0001
Motor (x2) 3pins	200-000F03-HSG	Housing: 014-000F03-HSG Pins: 014-043375-001	44441-2003 43375-0001
AC Input	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031

CONKIT1C

Connector	D/T part number	D/T part number individuals	Molex part number
24VDC & Shunt Resistor	200-000F02-HSG	Housing: 014-000F02-HSG Pins: 014-043375-001	44441-2002 43375-0001
Motor (x1) 3pins	200-000F03-HSG	Housing: 014-000F03-HSG Pins: 014-043375-001	44441-2003 43375-0001
AC Input	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031

CONKIT2A

Connector	D/T part number	D/T part number individuals	Molex part number
24VDC & Shunt Resistor	200-000F02-HSG	Housing: 014-000F02-HSG Pins: 014-043375-001	44441-2002 43375-0001
Motor (x2) 3pins	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031
AC Input	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031

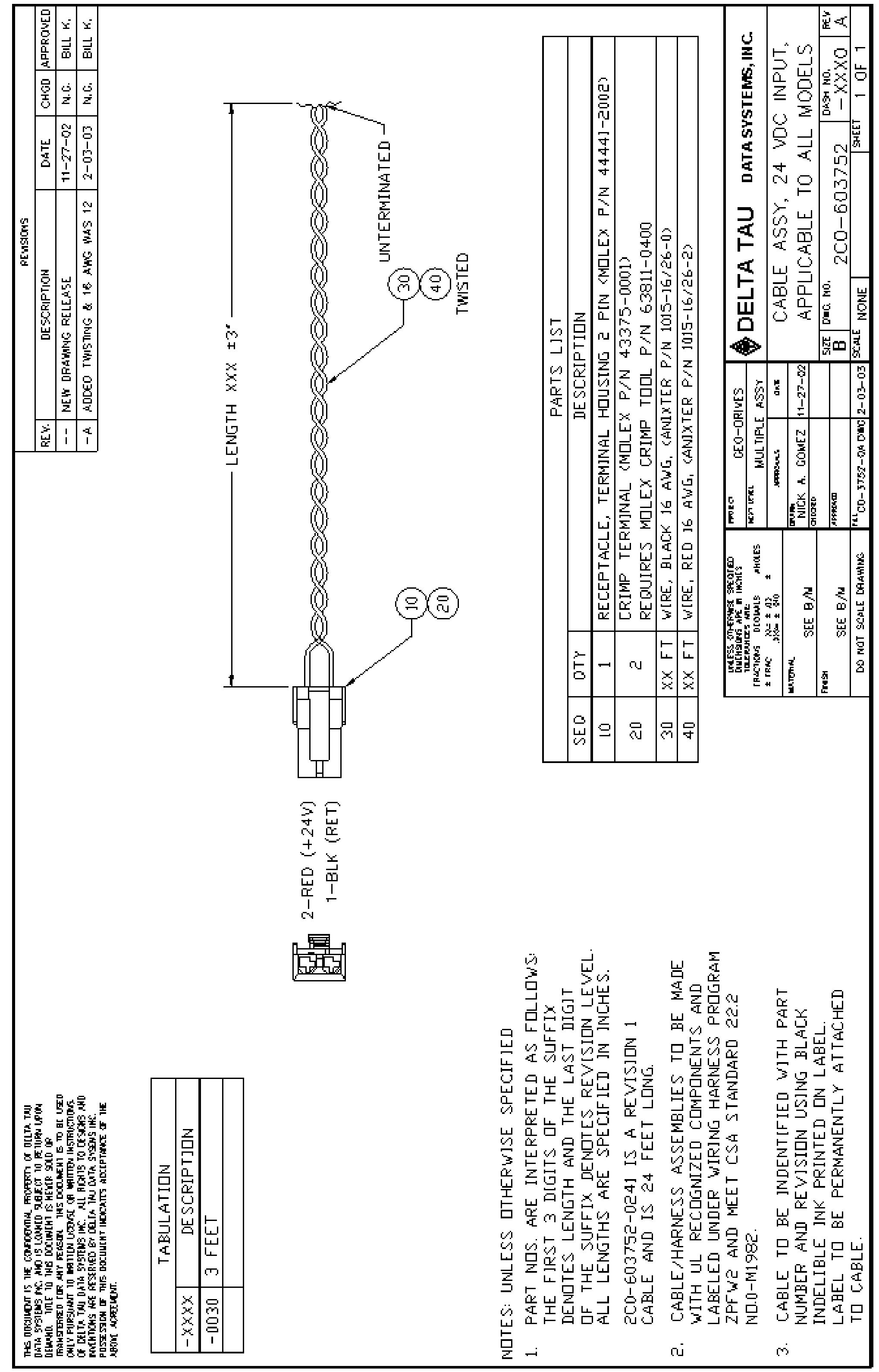
CONKIT2C

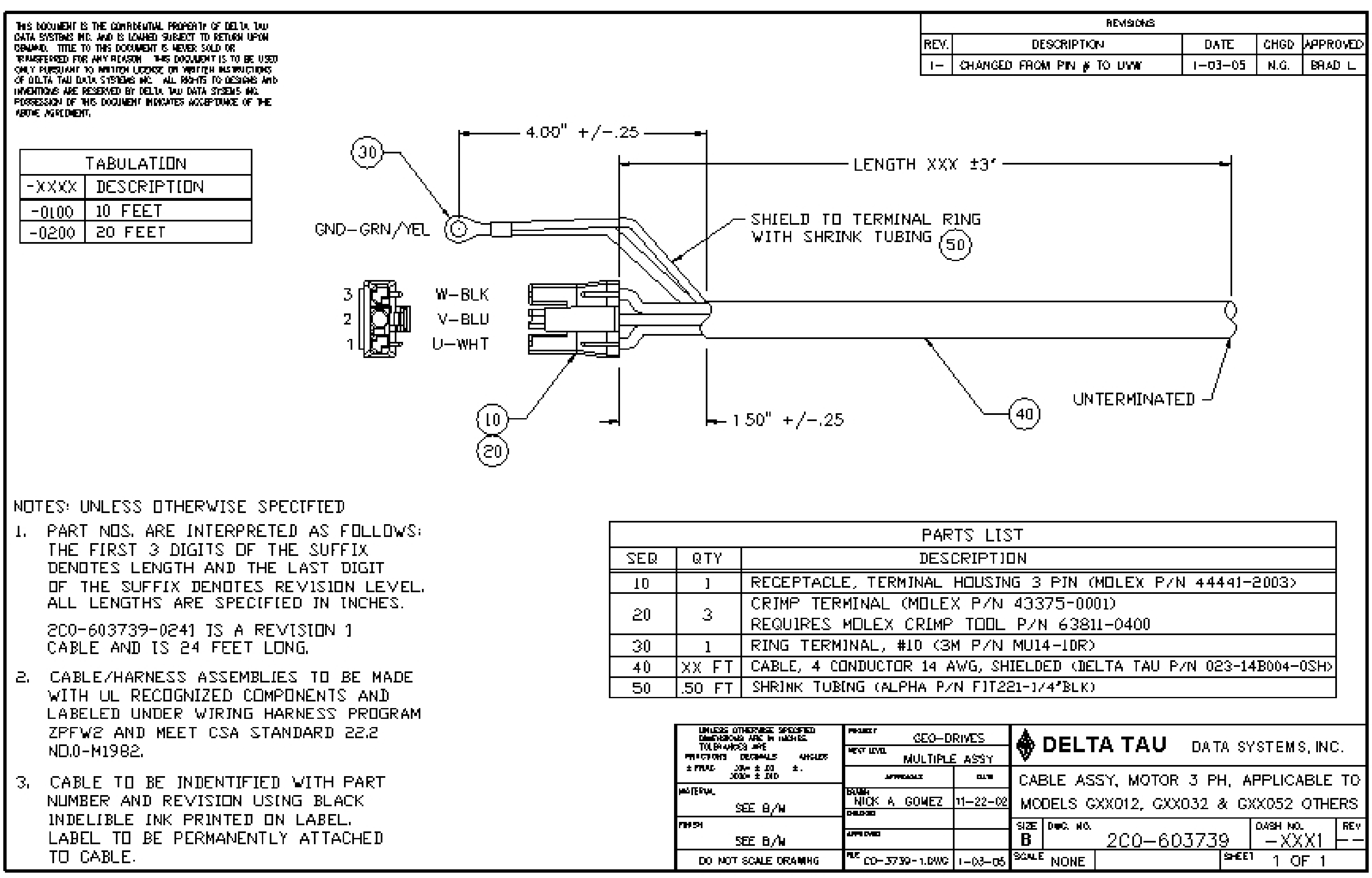
Connector	D/T part number	D/T part number individuals	Molex part number
24VDC & Shunt Resistor	200-000F02-HSG	Housing: 014-000F02-HSG Pins: 014-043375-001	44441-2002 43375-0001
Motor (x1) 3pins	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031
AC Input	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031

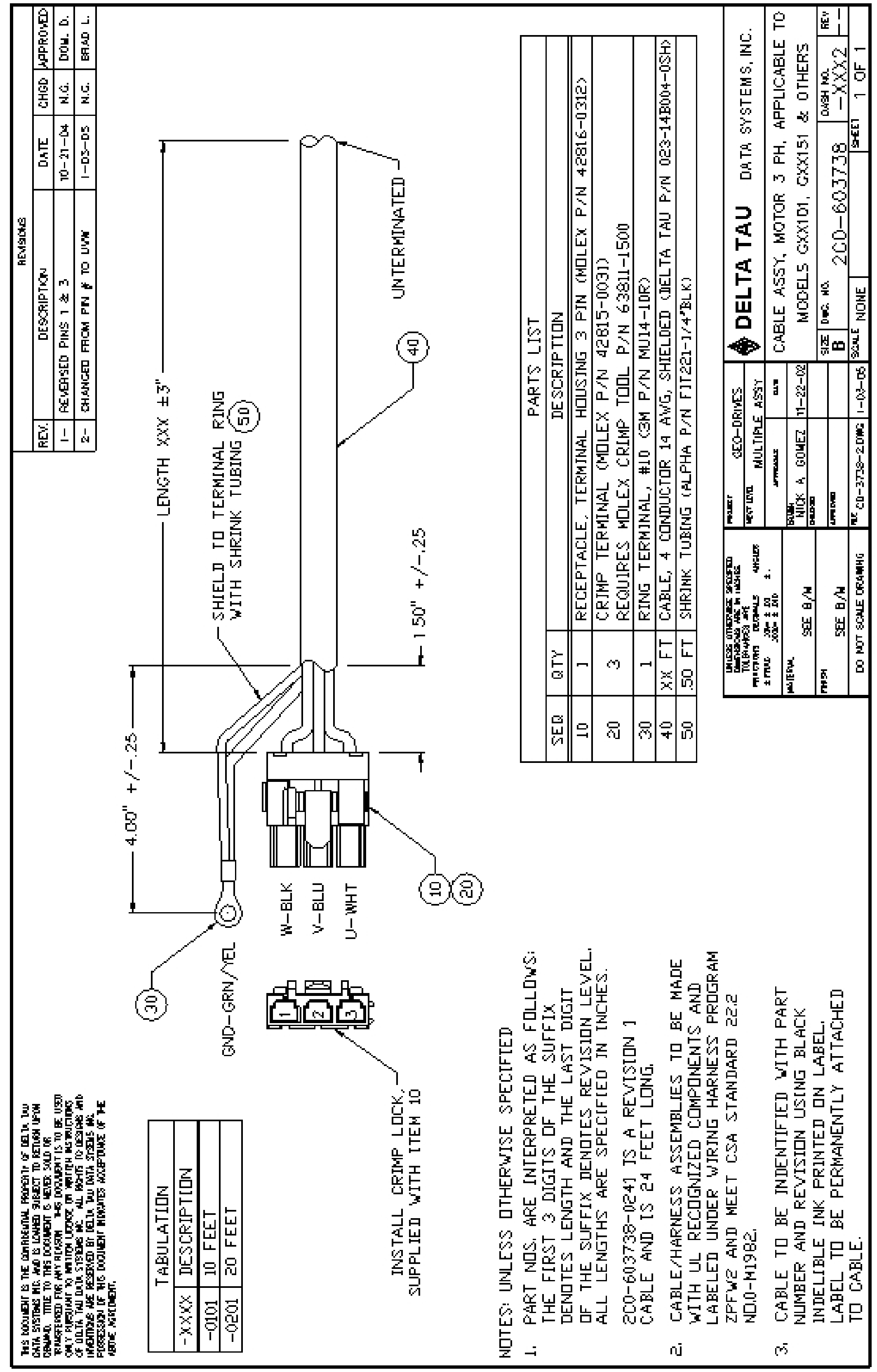
CONKIT4A

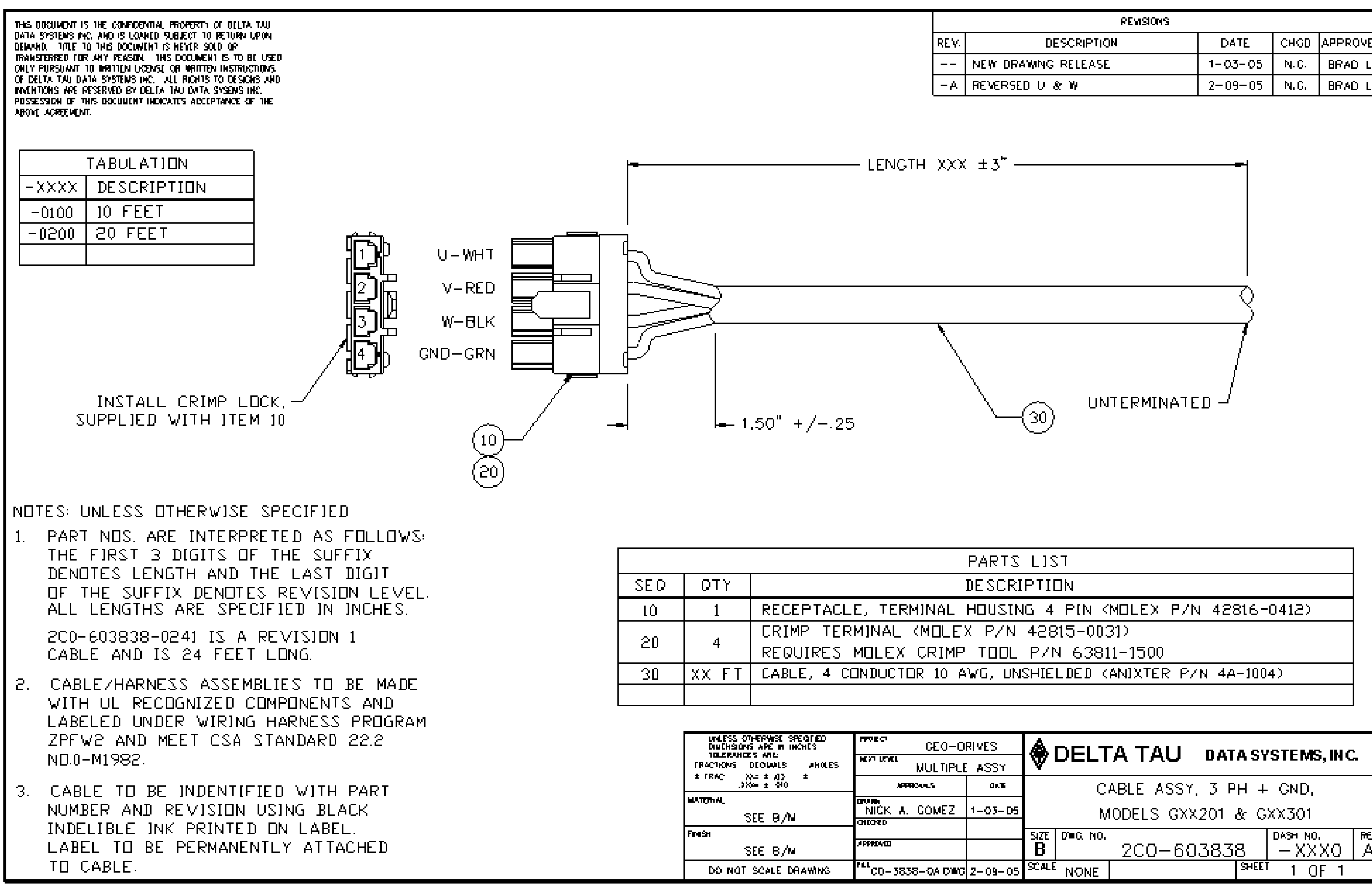
Connector	D/T part number	D/T part number individuals	Molex part number
24VDC	200-000F02-HSG	Housing: 014-000F02-HSG Pins: 014-043375-001	44441-2002 43375-0001
Shunt Resistor	200-H00F03-049	Housing: 014-H00F03-049 Pins: 014-042815-0031	42816-0312 42815-0031
Motor (x1) 4pins	200-H00F04-049	Housing: 014-H00F04-049 Pins: 014-042815-0031	42816-0412 42815-0031
AC Input	200-H00F04-049	Housing: 014-H00F04-049 Pins: 014-042815-0031	42816-0412 42815-0031

APPENDIX B - CABLE DRAWINGS




REVISIONS
REV. | DESCRIPTION | DATE | CHGD | APPROVED
1- | CHANGED FROM PIN # TO UVW | 1-03-05 | N.G. | BRAD L.
TABULATION
-XXXX | DESCRIPTION
-0100 | 10 FEET
-0200 | 20 FEET
4.00" +/-.25
LENGTH XXX ±3'
GND-GRN/YEL
SHIELD TO TERMINAL RING WITH SHRINK TUBING (50)
3 W-BLK
2 V-BLU
1 U-WHT
1.50" +/-.25
UNTERMINATED
(10) (20) (30) (40)
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.
2C0-603739-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
PARTS LIST
SEQ | QTY | DESCRIPTION
10 | 1 | RECEPTACLE, TERMINAL HOUSING 3 PIN (MOLEX P/N 44441-2003)
20 | 3 | CRIMP TERMINAL (MOLEX P/N 43375-0001) REQUIRES MOLEX CRIMP TOOL P/N 63811-0400
30 | 1 | RING TERMINAL, #10 (3M P/N MU14-10R)
40 | XX FT | CABLE, 4 CONDUCTOR 14 AWG, SHIELDED (DELTA TAU P/N 023-14B004-0SH)
50 | .50 FT | SHRINK TUBING (ALPHA P/N FIT221-1/4"BLK)
MATERIAL SEE B/M
FINISH SEE B/M
DO NOT SCALE DRAWING
PROJECT GEO-DRIVES
NEXT LEVEL MULTIPLE ASSY
DRAWN NICK A. GOMEZ 11-22-02
FILE C0-3739-1.DWG 1-03-05
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, MOTOR 3 PH, APPLICABLE TO MODELS GXX012, GXX032 & GXX052 OTHERS
SIZE B
DWG. NO. 2C0-603739
DASH NO. -XXX1
REV --
SCALE NONE
SHEET 1 OF 1


REVISIONS
REV. | DESCRIPTION | DATE | CHGD | APPROVED
1- | REVERSED PINS 1 & 3 | 10-21-04 | N.G. | DOW. D.
2- | CHANGED FROM PIN # TO UVW | 1-03-05 | N.G. | BRAD L.
TABULATION
-XXXX | DESCRIPTION
-0101 | 10 FEET
-0201 | 20 FEET
4.00" +/-.25
LENGTH XXX ±3"
30
GND-GRN/YEL
SHIELD TO TERMINAL RING WITH SHRINK TUBING 50
W-BLK
V-BLU
U-WHT
INSTALL CRIMP LOCK, SUPPLIED WITH ITEM 10
1.50" +/-.25
10
20
40
UNTERMINATED
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.
2C0-603738-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
PARTS LIST
SEQ | QTY | DESCRIPTION
10 | 1 | RECEPTACLE, TERMINAL HOUSING 3 PIN (MOLEX P/N 42816-0312)
20 | 3 | CRIMP TERMINAL (MOLEX P/N 42815-0031) REQUIRES MOLEX CRIMP TOOL P/N 63811-1500
30 | 1 | RING TERMINAL, #10 (3M P/N MU14-10R)
40 | XX FT | CABLE, 4 CONDUCTOR 14 AWG, SHIELDED (DELTA TAU P/N 023-14B004-0SH)
50 | .50 FT | SHRINK TUBING (ALPHA P/N FIT221-1/4"BLK)
PROJECT GEO-DRIVES
NEXT LEVEL MULTIPLE ASSY
MATERIAL SEE B/M
FINISH SEE B/M
DO NOT SCALE DRAWING
DRAWN NICK A. GOMEZ 11-22-02
CD-3738-2.DWG 1-03-05
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, MOTOR 3 PH, APPLICABLE TO MODELS GXX1D1, GXX151 & OTHERS
SIZE B
DWG. NO. 2C0-603738
DASH NO. -XXX2
REV --
SCALE NONE
SHEET 1 OF 1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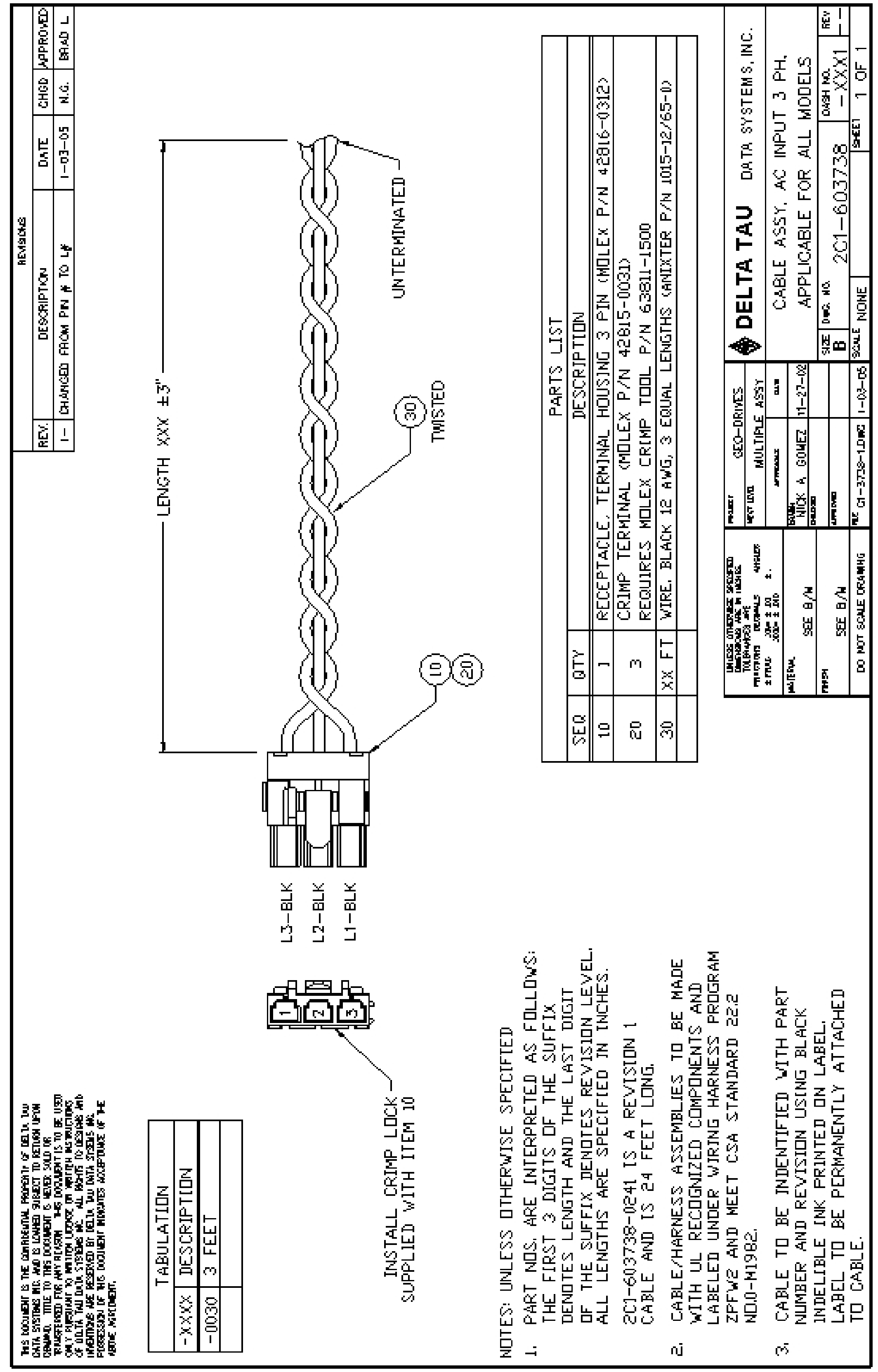
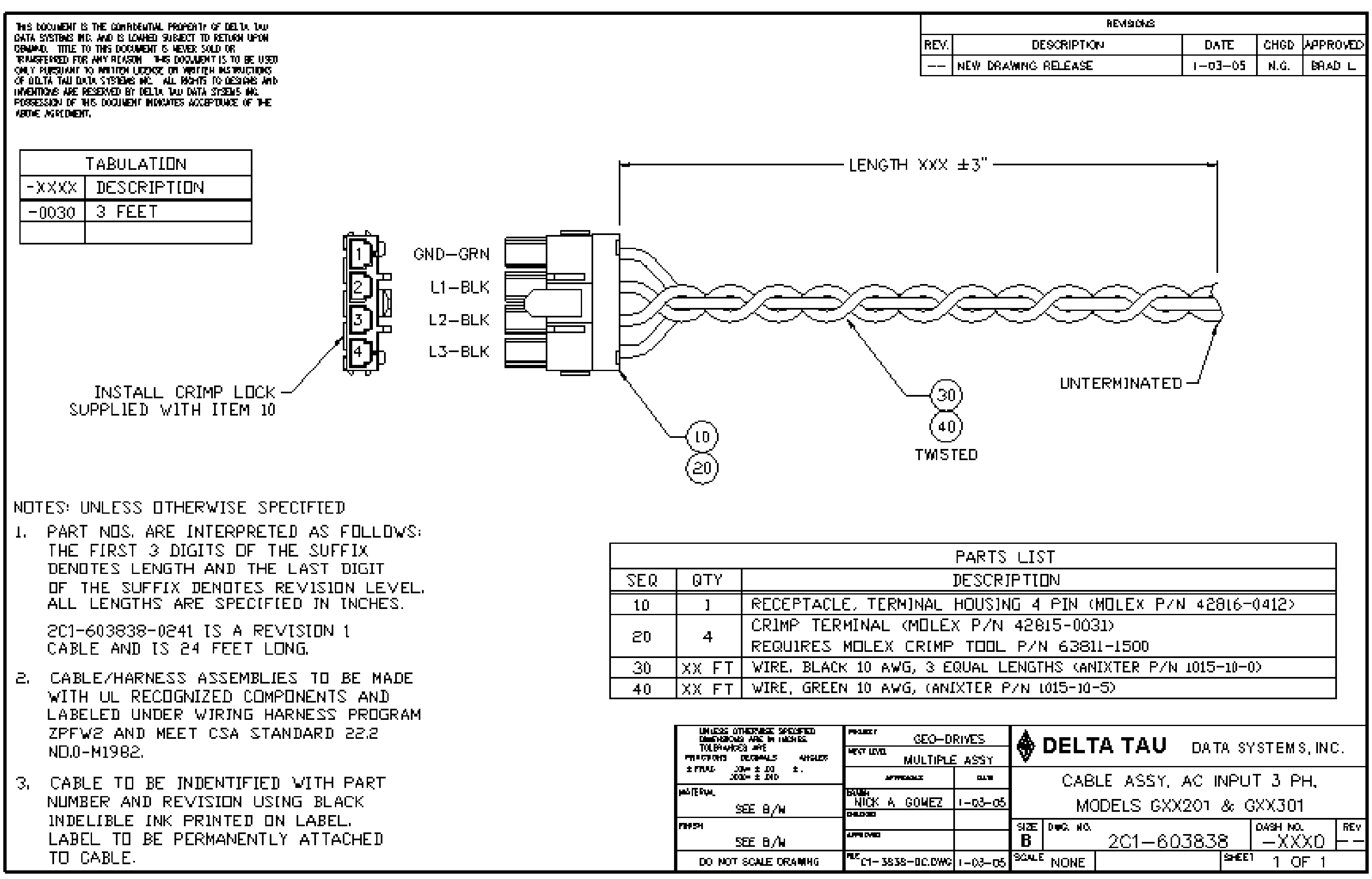
REVISIONS
REV. | DESCRIPTION | DATE | CHGD | APPROVED
-- | NEW DRAWING RELEASE | 1-03-05 | N.G. | BRAD L.
-A | REVERSED U & W | 2-09-05 | N.G. | BRAD L.
TABULATION
-XXXX | DESCRIPTION
-0100 | 10 FEET
-0200 | 20 FEET
LENGTH XXX ±3"
U-WHT
V-RED
W-BLK
GND-GRN
1
2
3
4
INSTALL CRIMP LOCK, SUPPLIED WITH ITEM 10
1.50" +/-.25
UNTERMINATED
10
20
30
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.
2C0-603838-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
PARTS LIST
SEQ | QTY | DESCRIPTION
10 | 1 | RECEPTACLE, TERMINAL HOUSING 4 PIN (MOLEX P/N 42816-0412)
20 | 4 | CRIMP TERMINAL (MOLEX P/N 42815-0031) REQUIRES MOLEX CRIMP TOOL P/N 63811-1500
30 | XX FT | CABLE, 4 CONDUCTOR 10 AWG, UNSHIELDED (ANIXTER P/N 4A-1004)
MATERIAL SEE B/M
FINISH SEE B/M
DO NOT SCALE DRAWING
GEO-DRIVES
MULTIPLE ASSY
NICK A. GOMEZ 1-03-05
CD-3838-0A DWG 2-09-05
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, 3 PH + GND, MODELS GXX201 & GXX301
SIZE B
DWG. NO. 2C0-603838
DASH NO. -XXX0
REV A
SCALE NONE
SHEET 1 OF 1


REVISIONS
REV. DESCRIPTION DATE CHGD APPROVED
1- CHANGED FROM PIN # TO L# 1-03-05 N.G. BRAD L.
TABULATION
-XXXX DESCRIPTION
-0030 3 FEET
LENGTH XXX ±3"
L3-BLK
L2-BLK
L1-BLK
INSTALL CRIMP LOCK SUPPLIED WITH ITEM 10
UNTERMINATED
30 TWISTED
10
20
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.
2C1-603738-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
PARTS LIST
SEQ QTY DESCRIPTION
10 1 RECEPTACLE, TERMINAL HOUSING 3 PIN (MOLEX P/N 42816-0312)
20 3 CRIMP TERMINAL (MOLEX P/N 42815-0031) REQUIRES MOLEX CRIMP TOOL P/N 63811-1500
30 XX FT WIRE, BLACK 12 AWG, 3 EQUAL LENGTHS (ANIXTER P/N 1015-12/65-0)
PROJECT GEO-DRIVES
NEXT LEVEL MULTIPLE ASSY
DRAWN NICK A. GOMEZ 11-27-02
MATERIAL SEE B/W
FINISH SEE B/W
DO NOT SCALE DRAWING
FILE C1-3738-1.DWG 1-03-05
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, AC INPUT 3 PH, APPLICABLE FOR ALL MODELS
SIZE B DWG. NO. 2C1-603738 DASH NO. -XXX1 REV --
SCALE NONE SHEET 1 OF 1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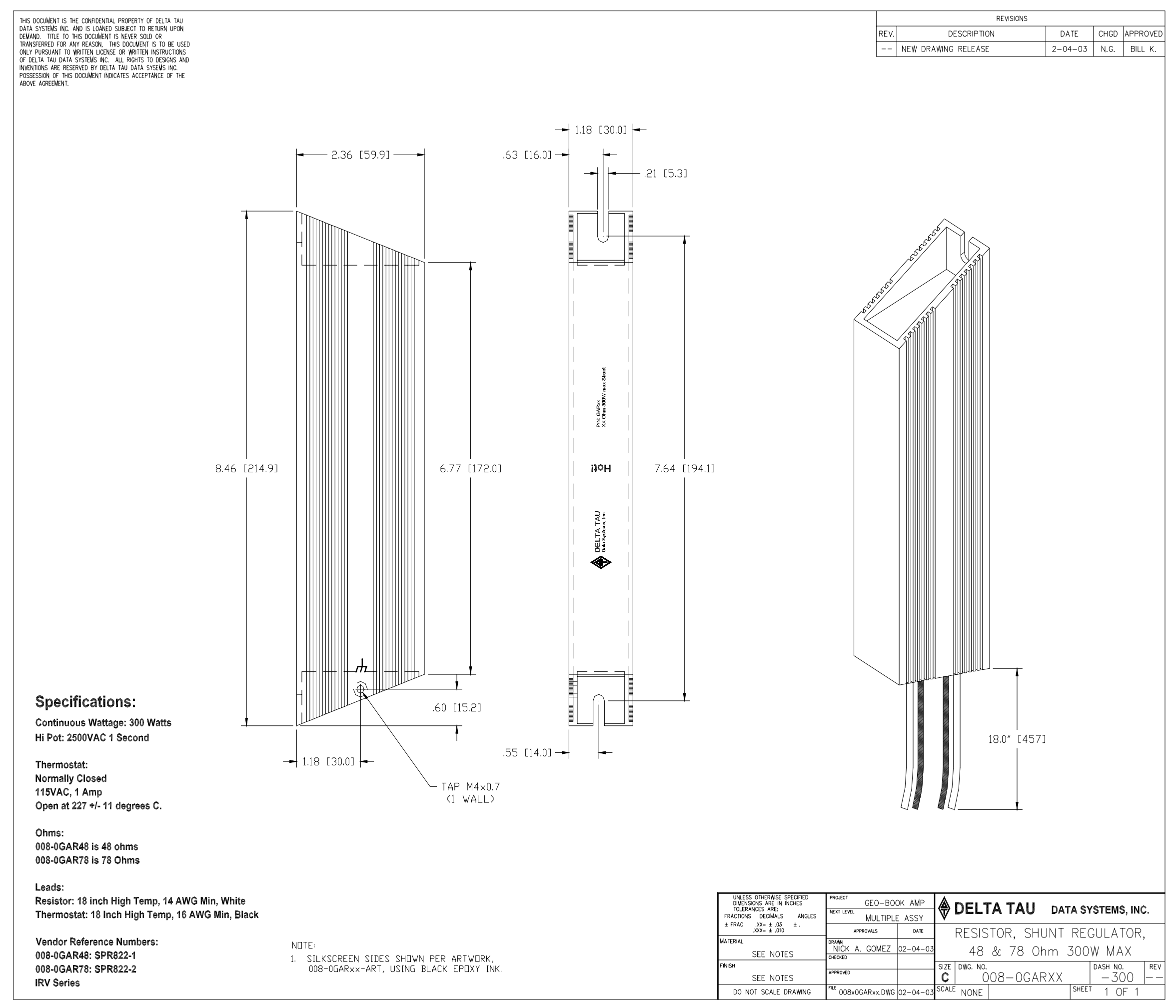
REVISIONS
REV. DESCRIPTION DATE CHGD APPROVED
-- NEW DRAWING RELEASE 1-03-05 N.G. BRAD L.
TABULATION
-XXXX DESCRIPTION
-0030 3 FEET
LENGTH XXX ±3"
GND-GRN
L1-BLK
L2-BLK
L3-BLK
INSTALL CRIMP LOCK SUPPLIED WITH ITEM 10
UNTERMINATED
10
20
30
40
TWISTED
NOTES: UNLESS OTHERWISE SPECIFIED
1. PART NOS. ARE INTERPRETED AS FOLLOWS: THE FIRST 3 DIGITS OF THE SUFFIX DENOTES LENGTH AND THE LAST DIGIT OF THE SUFFIX DENOTES REVISION LEVEL. ALL LENGTHS ARE SPECIFIED IN INCHES.
2C1-603838-0241 IS A REVISION 1 CABLE AND IS 24 FEET LONG.
2. CABLE/HARNESS ASSEMBLIES TO BE MADE WITH UL RECOGNIZED COMPONENTS AND LABELED UNDER WIRING HARNESS PROGRAM ZPFW2 AND MEET CSA STANDARD 22.2 NO.0-M1982.
3. CABLE TO BE INDENTIFIED WITH PART NUMBER AND REVISION USING BLACK INDELIBLE INK PRINTED ON LABEL. LABEL TO BE PERMANENTLY ATTACHED TO CABLE.
PARTS LIST
SEQ QTY DESCRIPTION
10 1 RECEPTACLE, TERMINAL HOUSING 4 PIN (MOLEX P/N 42816-0412)
20 4 CRIMP TERMINAL (MOLEX P/N 42815-0031) REQUIRES MOLEX CRIMP TOOL P/N 63811-1500
30 XX FT WIRE, BLACK 10 AWG, 3 EQUAL LENGTHS (ANIXTER P/N 1015-10-0)
40 XX FT WIRE, GREEN 10 AWG, (ANIXTER P/N 1015-10-5)
PROJECT GEO-DRIVES
NEXT LEVEL MULTIPLE ASSY
MATERIAL SEE B/W
FINISH SEE B/W
DRAWN NICK A. GOMEZ 1-03-05
DO NOT SCALE DRAWING
FILE C1-3838-0C.DWG 1-03-05
DELTA TAU DATA SYSTEMS, INC.
CABLE ASSY, AC INPUT 3 PH. MODELS GXX201 & GXX301
SIZE B
DWG. NO. 2C1-603838
DASH NO. -XXX0
REV --
SCALE NONE
SHEET 1 OF 1

Regenerative Resistor: GAR78/48

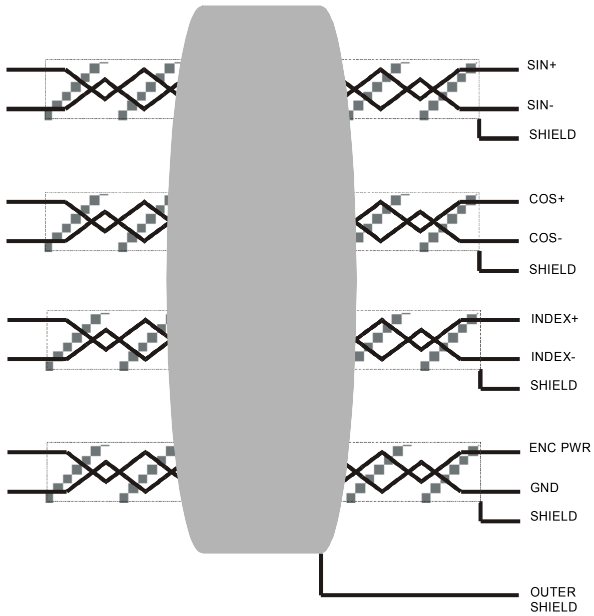
Model	Description	1.5/4.5A	3/9A	5/10A	10/20A	15/30A	20/40A	30/60A
GAR78	300W 78 OHM regenerative resistor with Thermostat protection. Includes 18 inch wire cable. Single or Dual Axis.	√	√	√				
GAR48	300W 48 OHM regenerative resistor with Thermostat protection. Includes 18 inch wire cable. Single or Dual Axis.				√	√		
GAR48-3	300W 48 OHM regenerative resistor with Thermostat protection. Includes 18 inch wire cable.						√	√



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.