G Series
Digital ServoDrive

Installation and Operation Manual
G-MAN01g

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ORMEC Systems Corp.

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CE Mark

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Chapter 1
Welcome

1 Welcome

This manual provides information about ORMEC's G Series Servodrives and G-Series, DE-Series, DA-Series and DB-Series Servomotors --- providing both technical descriptions and information required for their installation, operation and maintenance.

The manual is divided into the following chapters:

Chapter 1	**Welcome** introduces you to this manual and how it is organized.
Chapter 2	**General Description** gives an overview of the G Series Servodrive product family.
Chapter 3	**Installation** provides instructions on how to install your G Series Servodrives. It also provides a complete hardware description of the G Series Servodrives.
Chapter 4	**Operation** documents the power up and initial configuration approach for the G Series Servodrive.
Chapter 5	**Getting Started** provides detailed instructions on how to run your G Series Servodrive system for the first time.
Chapter 6	**Specifications** provides a detailed list of performance specifications for G Series Drives and G-Series and DE/DA/DB-Series brushless servomotors.
Chapter 7	**Maintenance and Troubleshooting** documents the various status and alarm indicators.
Appendixes	**Appendixes** contain a detailed drawing set **.**

Chapter 2
General Description

2 General Description

This manual covers G Series Servodrives, which control a wide variety of AC Servomotors, including G-Series and D/DE Series Servomotors.

2.1 G Series Servodrive Capabilities and Features

- **Simple Setup:** All drive configuration settings are set by the user's application software using the RS-232 interface, eliminating drive jumpers, address switches, and potentiometers.
- **All Digital:** High speed DSP-controlled current loops for precise torque mode and velocity mode operation.
- **Standard Line Voltage Input:** G Series 230 VAC Drives can be operated directly on commercial power lines which supply at either 115 (+15%, -20%) or 230 (+15%, -20%) VAC for the main power as well as the control power. G Series 460 VAC Drives have control power operated directly on commercial power lines which supply at either 115 (+15%, -20%) or 230 (+15%, -20%) VAC and main power operated directly on commercial power lines which supply at 460 (+15%, -20%) VAC.
- **Fault Detection and Protection:** Detection and protection against:

  Motor short
  Peak & RMS drive current limit
  Peak & RMS motor current limit
  Missing phase detection (G225, G235, G260, G417, 425, 435 & 450 only)
  Encoder open wire detection
  Hall sensor phasing error
  Motor over temperature

- **Diagnostics:** A 7-segment display shows alarm status. Individual LEDs indicating bus power, once per rev marker and commanded torque.
- **Variety of Commutation Options:** G Series Drives can be configured for sinusoidal or trapezoidal commutation for AC brushless motors, as

well as for DC motor operation to control DC motors, voice coils and other single phase actuators.

- **Soft Start:** Circuitry is provided to reduce Servodrive in-rush current.
- **Torque Mode Operation:** Torque mode operation allows extremely high load inertia to motor inertia ratios.
- **Velocity Mode Operation:** Velocity mode operation allows for fast and precise velocity control.
- **Position Mode Operation:** Position mode operation allows for precise position control.
- **Positioner Mode Operation**: In this mode the drive will interpret the input command as a position set point. When the set point changes a controlled motion is generated to move to the new position. The positions are treated as absolute positions within the system. Documentation for this mode is not yet integrated into this manual. It is attached at the end of this pdf file.
- **Wide Current Loop Bandwidth:** For high positioning accuracy and response.
- **Small Package:** G Series Drives have a small footprint to conserve panel space.
- **Shunt Regulation:** All Models except G203 and G205 have shunt regulation circuitry. If an application requires regenerative operation, regenerative discharge resistors can be mounted external to the servodrive.

2.1.1 G Series Drive Model Number Description

In July 2004 Ormec improved the G series servodrives by adding a resolver version and making the quadrature version more configurable, thereby allowing fewer models to cover more feedback types, reducing spare part variations. At that time the Model Numbers were changed to reflect this simpler approach. While the old Model Numbers can still be used, orders for new equipment should use the new format. Both formats are shown.

New Model Number Description

SAC-Gv##-if

Voltage
v = main power voltage rating, 230 or 460 VAC, using 2 or 4

Current
= continuous rated current, amps
(03, 05, 10, 17, 20, 25, 35, 60 – 230 V drives)
(05, 10, 17, 25, 35, 50 – 460 V drives)

Inputs – i opton
A = Analog

Motor Feedback – f option
Q = Quadrature Commutation encoder
R = Resolver

Old Model Number Description

G##-xYx-00

Current
= continuous rated current, amps (03, 05, 10, 17, 20, 25, 35, 60)

Inputs
A = Analog (required option)

Motor Feedback
E = Commutation encoder
Y = Multiplexing encoder

Communications
B = RS-232

2.2 G-Series Servomotor Capabilities and Features

- **Wide Power Range:** Output power ratings from 0.20 to 13 HP.
- **Wide Torque Range:** Continuous stall torques from 5 to 640 in-lb.
- **Low to High Speed:** Maximum motor speeds from 1700 to 7,000 RPM.
- **High Torque-to-Inertia Ratios:** Motors with high *Torque-to-Inertia* ratios deliver a higher percentage of rated power to the load in applications that require high acceleration and deceleration rates.
- **English and Metric Frames:** All motors are available with metric mounting flanges; some models are also available with NEMA frames.
- **Durable Construction:** Service life is maximized by the brushless motor construction, high thermal efficiency frame and rugged sealed bearings. Standard IP-65 motor sealing permits operation in harsh industrial environments.
- **Industrial Internal Position Transducer - Quadrature** The standard rugged internal position encoder measures 8,000 precise increments of position, or counts, per revolution. Optional motor encoders provide 6,000, 8192, 12,000, 16,384, or 24,000 counts per revolution.
- **Industrial Internal Position Transducer - Resolver** The G Series drives support a standard resolver as a feedback device. The drive can be configured for resolutions of 4096 (12-bit) or 16384 (14-bit) counts per revolution of the encoder. To support various types of resolvers adjustment can be made to vary the frequency (2500, 5000 or 10,000 Hz) of the reference signal as well as the amplitude to account for transformation ratios from 0.25 to 2.0. The drive provides quadrature outputs derived from the resolver signals for use by the host controller.
- **Low Torque Ripple:** Sinusoidal construction combined with precise sinusoidal electronic commutation provide low motor output torque ripple.

- **Fail-Safe Brake:** An optional fail-safe brake is available integral to the motor.

2.2.1 G-Series Servomotor Model Number Description

MAC-G###*WV/FTO*$_1$

Torque
= Continuous Stall Torque (in-lb)

Winding Identifier
W = A (high speed)
= B (medium speed)

Input Voltage
V = 1 (115 VAC input power)
= 2 (230 VAC input power)
= 4[1] (230 VAC input power)

Feedback Type
F = 1[2] (1500 linecount encoder – 6000 cts/rev)
= 2 (2000 linecount encoder – 8000 cts/rev)
= 3 (3000 linecount encoder – 8192 cts/rev)
= B[2] (2048 linecount encoder – 12000 cts/rev)
= C[2] (4092 linecount encoder – 16384 cts/rev)
= 6 (6000 linecount encoder – 24000 cts/rev)

Mounting Flange Type
T = M (metric frame dimensions)
= E (NEMA frame dimensions)

Fail-Safe Brake *(specified only if option is desired)*
O$_1$ = B (fail-safe brake with 24 VDC coil)

[1] 460 VAC motor operated at 230 VAC.

[2] Not available for some servomotors. Refer to **Table 33** for motor-encoder compatibility.

2.3 DE/DA/DB Series Capabilities and Features

- **Wide Power Range:** Output power ratings from 0.13 to 15 HP.
- **Wide Torque Range:** Continuous stall torques from 2.8 to 665 in-lb.
- **High Speed:** Maximum motor speeds from 2,000 to 4,500 RPM.
- **High Torque-to-Inertia Ratios:** Motors with high *Torque-to-Inertia* ratios deliver a higher percentage of rated power to the load in applications which require high acceleration and deceleration rates.
- **Durable Construction:** Service life is maximized by the brushless motor construction, high thermal efficiency frame and rugged sealed bearings. Standard IP-65 motor sealing with optional IP-67 sealing permits motor operation in harsh industrial environments.
- **Industrial Internal Position Transducer:** The rugged internal position transducer measures 4096 to 32,768 (depending on selected motor) precise increments of position, or counts, per revolution.
- **Low Torque Ripple:** Sinusoidal construction combined with precise sinusoidal electronic commutation provide low motor output torque ripple.
- **Fail-Safe Brake:** An optional fail-safe brake is available integral to the motor. (See 3.7.3 Motors with Integral Fail-Safe Brakes)

2.3.1 DE/DA/DB Series Servomotor Model Number Description

MAC-DA####$M_1/O_1O_2O_3$
MAC-DB####$M_1/O_1O_2O_3$
MAC-DE###$M_1V_1/O_1O_2O_3$

Torque
= Continuous Stall Torque (in-lb)

Motor Identifier
M_1 = A – U (motor matching reference letter)

Input Voltage (MAC-DE only)
V_1 = 1 (115 VAC input power)
= 2 (230 VAC input power)

Feedback Type
O_1 = I (incremental encoder)

Sealing *(specified only if option is desired)*
O_2 = V (shaft oil seal)

Fail-Safe Brake *(specified only if option is desired)*
O_3 = B (fail-safe brake with 24 VDC coil)

Chapter 3
Installation

3 Installation

3.1 Receiving and Inspection

ORMEC Servodrives, Servomotors, and their associated accessories are put through rigorous tests at the factory before shipment. After unpacking, however, check for damage, which may have been sustained in transit. The bolts and screws should all be tight, and motor output shafts should rotate freely by hand. Check the Servodrives and any accessories for bent or broken components or any other physical damage before installation.

3.2 ServoDrive Panel and Environment Considerations

ServoDrives are designed for panel mounting, with the panel in turn mounted in a metallic enclosure (supplied by the machine builder). For optimal EMC (ElectroMagnetic Compatibility) shielding, the enclosure should have continuous ground continuity maintained between all metal panels.

For high quality servo performance, proper wiring, grounding and shielding techniques must be considered. Refer to the “Shielding and Grounding Electrical Panels” Application Note, which is available from ORMEC's site on the World Wide Web at http://www.ormec.com.

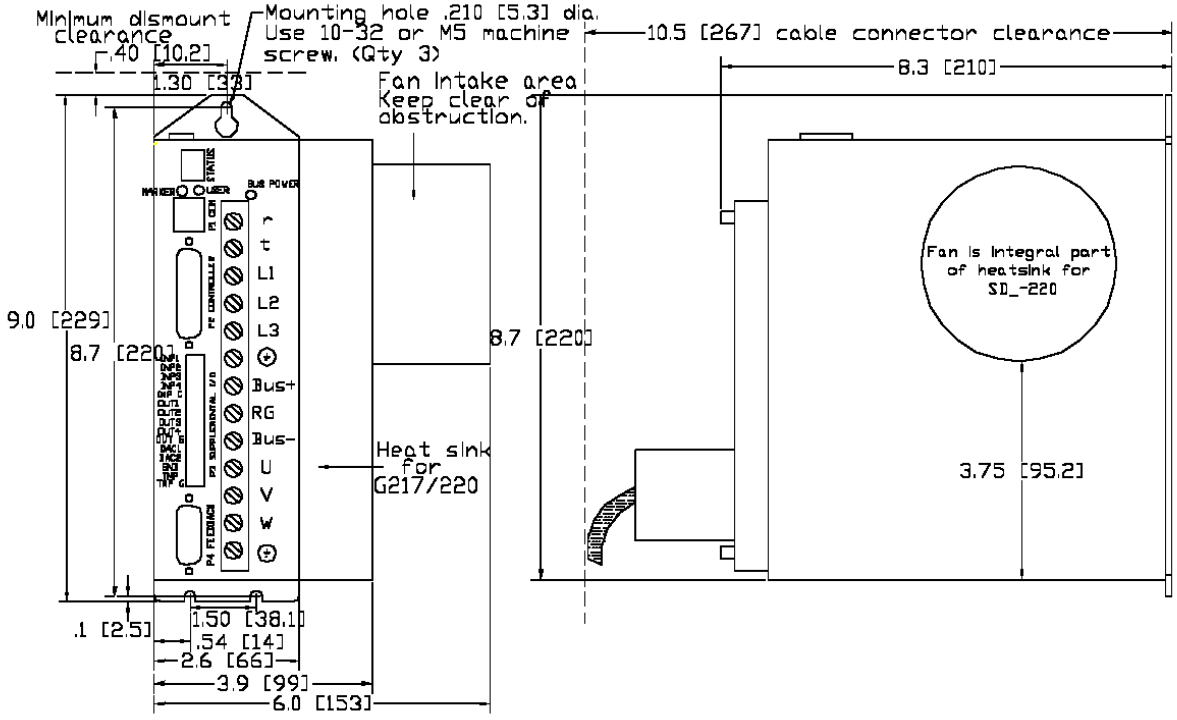
The servodrive environment should be maintained as follows:

- Ambient operating temperature should be at or below 50°C.
- If the electrical panel is subjected to vibration, mount the units on shock absorbing material.
- Avoid use in corrosive atmospheres which may cause damage over time.
- Select a location with minimum exposure to oil, water, hot air, high humidity, excessive dust, or metallic particles.

- The proper mounting orientation for the Servodrive is vertical on a panel using the mounting holes holes (5 with G203 through G220 and G405 through G410, 4 with G225 through G260 and G417 through G450) on the base plate.
- Allow sufficient clearance around Servodrives for airflow, and provide proper ventilation. Section 3.3 shows the minimum clearance between drives.
- External regenerative discharge resistors should be mounted in an enclosure separate from the servodrive enclosure, if possible. Regenerative discharge resistors can become extremely hot, so proper ventilation must be provided.

3.3 Servodrive Outline Drawings

3.3.1 Mounting Information for SAC-G203, 205, 210, 217, 220



All dimensions are in inches [mm].

Figure 1, *Drives 203 - 220 Outline Drawings*

3.3.2 Mounting Information for SAC-G225, 235, 260, 417 & 425

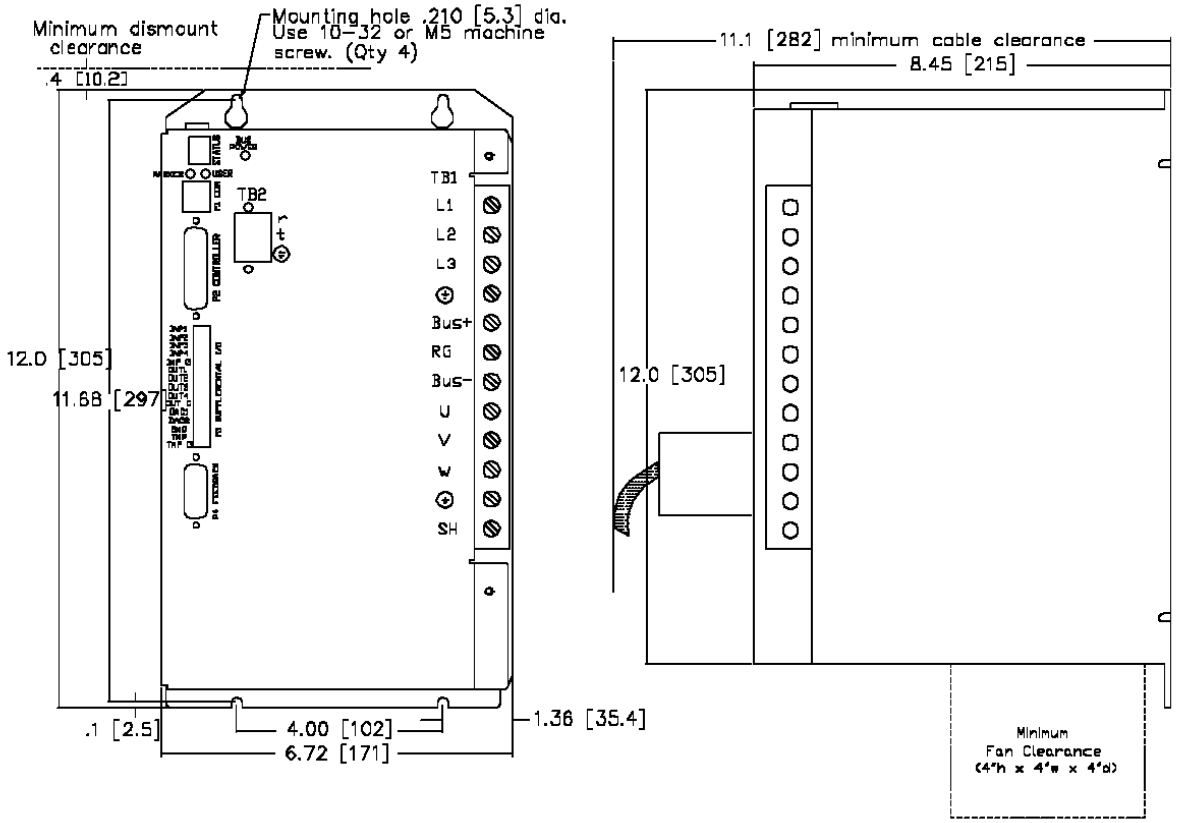


Figure 2, *Drives 225-260 & 417-425 Outline Drawings*

3.3.3 Mounting Information for SAC-G405 & 410

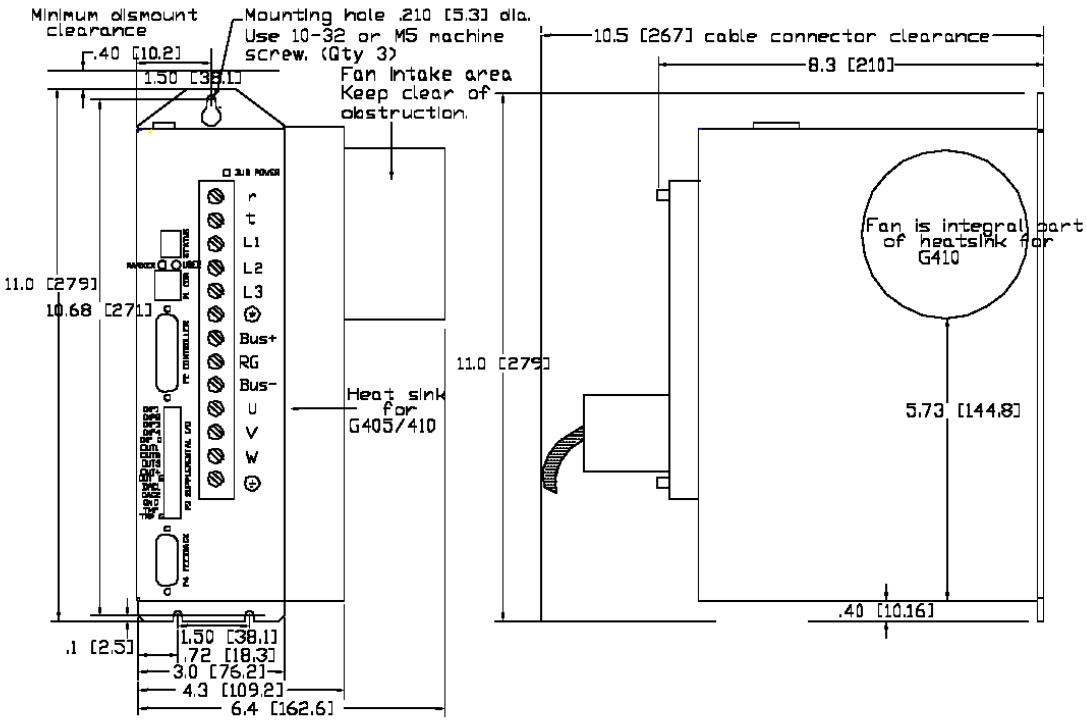


Figure 3, Drives 405 & 410 Outline Drawings

3.3.4 Mounting Information for SAC-G435 & 450

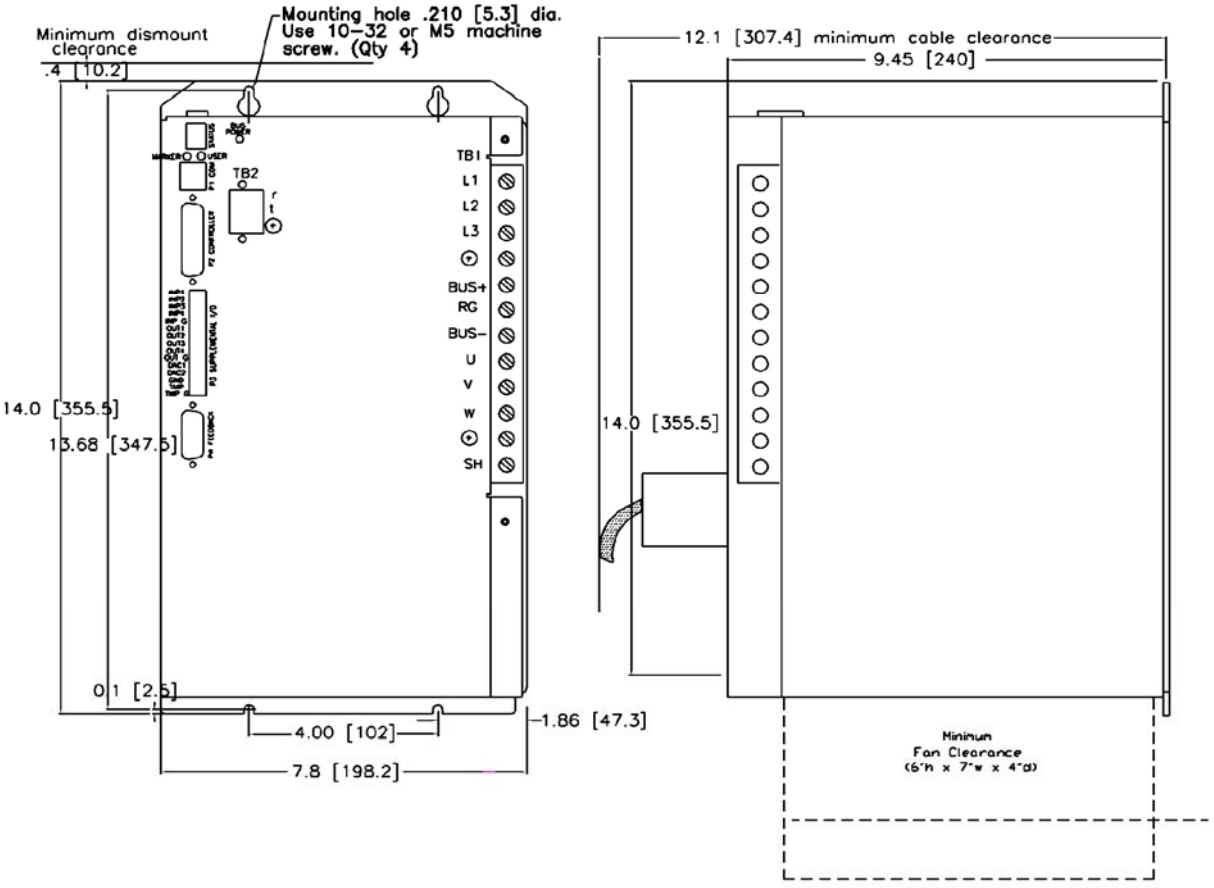


Figure 4, Drives 435 & 460 Outline Drawings

Additional clearance above, below and to the sides of the ServoDrives is also required for heat dissipation:

G203, G205, G210 and G405
Add 2” (51 mm) clearance top and bottom.
Add 1” (25 mm) clearance each side.

G217, G410
Add 2” (51 mm) clearance top and bottom.
Add 1.2” (31 mm) clearance each side.

G220
Add 2” (51 mm) clearance top and bottom.
Add 1” left-side, 2” (51 mm) right-side clearance.

G225, G235, G260, G417, G425, G435 and G450
Add 2” (51 mm) clearance top.

Add 4" (102 mm) clearance bottom.
Add 1" (25 mm) clearance each side.

.

3.4 UltraTools Software Configuration

UltraTools is a special software program for the G Series digital servodrive that provides the power to make setting up the G Series servodrive as easy and as flexible as possible, all through the use of a comfortable graphical user interface. UltraTools will run on any desktop or laptop computer running Windows 95, Windows 98, Windows NT, or Windows XP. Complete details can be found in Appendix F.

The following drive settings are configured with UltraTools:

- **Motor Model Number**
  - **Continuous Stall Current**
  - **Peak Current**
  - **Maximum Speed** of motor
  - **Resistance** measured phase-to-phase
  - **Inductance** measured phase-to-phase
  - **Number of Poles**
  - **Hall/Resolver Offset**
  - **Maximum Drive Input Voltage** based on motor's rating
  - **Commutation Feedback Type**:
    Incremental encoder with separate U,V,W hall inputs -or-
    Incremental encoder with encoded U,V,W hall information -or-
    U,V,W hall inputs without incremental encoder -or-
    Resolver
  - **Feedback Resolution** (Counts per revolution)
  - **Thermal Switch** in motor is present/not present
  - **Thermal Time Constant** of motor.
- **Motor Over Temperature Handling** (Ignore/Error/Drive Alarm)
- **Hardware Travel Limit Inputs** (Enable/Disable)
- **Input Voltage for Drive** (115/230/460)
- **Regen Resistor Resistance** (Ohms)
- **Regen Resistor Rated Power** (Watts)
- **Control Mode**
- **Command Source**
- **Host feedback Resolution** (Counts per rev – can be different from motor feedback resolution)

These settings can be stored in a (.udp) file, downloaded to the G Series drive, and stored in the drive's EEPROM.

3.5 ServoDrive Power Considerations

3.5.1 Supply Power

230 VAC Drives - G Series Drives can be operated, through line filters or an isolation transformer, on commercial power lines which supply either 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz. Suitable for use on a circuit capable of delivering not more than 5000 rms symmetrical amperes, 240 V maximum.

460 VAC drives - G Series Drives can be operated, through line filters or an isolation transformer, on commercial power lines which supply either 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz.for control. Suitable for use on a circuit capable of delivering not more than 5000 rms symmetrical amperes, 240 V maximum. For main power G Series Drives can be operated, through line filters or an isolation transformer, on commercial power lines which supply 460 (+15%, -20%) VAC, 50/60 Hz. Suitable for use on a circuit capable of delivering not more than 5000 rms symmetrical amperes, 480 V maximum.

Both - To prevent power line accidents due to grounding error, contact error, or to protect the system from a fire, circuit breakers or fuses must be installed according to the number and size (current capacity) of G Series Drives used. Slow-blow circuit breakers or fuses should be used because the servodrives draw substantial inrush current at power up.

3.5.2 Shielding, Power Line Filtering & Noise Suppression

The Servodrive uses high voltage switching power transistors in the main DC Bus circuit. When these transistors are switched, the di/dt or dv/dt switching noise may sometimes prove objectionable depending on the wiring and/or grounding method. The Servodrive also utilizes a microprocessor, which can be susceptible to power line interference caused either by the output switching transistors or other equipment on the power line, such as welders, electrical discharge machines, induction heating equipment, etc. Careful layout of wiring and power line filtering will help prevent noise interference. Recommendations with respect to wiring and grounding are described later in this section. Further information is available in the "Shielding & Grounding Electrical Panels" Application Note, which is available at ORMEC's Web Site (http://www.ormec.com).

It is recommended that line filters be installed to eliminate electro-magnetic interference coming into the system from the power line, as well as block switching noise from being transmitted back out to the power line from the Servodrives.

3.5.3 Sizing Fuses, Line Filters, and Transformers

To determine current requirements for fuses, line filters and transformers for main power, use the following conservative formulas:

$$\textbf{Required Power} \text{ (in KVA)} = \frac{1.1 * \textbf{Rated Power of Motor} \text{ (in Watts)}}{1000}$$

$$\textbf{Required Current} \text{ (in Amps)} = \frac{1.1 * \textbf{RatedPower of Motor} \text{ (in Watts)}}{\textbf{Incoming Line Voltage} \text{ (in Volts AC)}}$$

where **Rated Power of Motor** can be found in Chapter 6, Specifications.

In cases where the motor is substantially over-sized for an application, consider substituting the actual power required by the application into the above formulas, instead of the motor's rated power.

3.5.4 Power Dissipation

Use the following table to determine cabinet cooling requirements:

	Dissipated Power (Watts)			
	Control Power			**External** Regen Resistor (if used)
	Max	Typical	Main Power	
SAC-G203	45	20	55	
SAC-G205	45	20	90	
SAC-G210	45	20	180	800 max.
SAC-G217	45	20	300	1200 max.
SAC-G220	55	30	350	2400 max.
SAC-G225	55	30	450	3000 max.
SAC-G235	55	30	600	4175 max.
SAC-G260	55	30	900	7100 max.
SAC-G405	45	20	120	1200 max.
SAC-G410	45	20	240	2400 max.
SAC-G417	55	30	405	4000 max.
SAC-G425	55	30	600	5970 max.
SAC-G435	60	35	835	8350 max.
SAC-G450	60	35	1200	12000 max.

***Table 1**, Power Dissipation*

Main power dissipation shown in the table is for the rated output power of the drive. The actual dissipated main power may be lower, depending on the motor and/or application requirements. To more closely estimate main power

dissipation, use the conservative formula: 0.1*(rated power of the motor). In cases where the motor is substantially oversized for the application, use 0.1*(the power required by the application).

Power dissipated in the regen resistor is dependent on the regen resistor connected to the drive, as well as the application requirements. The table shows the rated capability of the regen transistor in the servodrive.

3.5.5 Line Filters

Once the incoming power service is determined, the appropriate main power line filter can be selected from the following chart. In the case of a system using multiple Servodrives, only one line filter is required per cabinet.

Servo Drive	Main Power Input Voltage	Total Continuous Current	Main Power Line Filter
G203 G205	Single phase	Up to 15 Amps	SAC-LF215U
		Up to 30 Amps	SAC-LF230U
G210 G217 G220 G225 G235 G260 G405 G410 G417 G425 G435 G450	Three-phase	Up to 30 Amps	SAC-LF30C
		30 – 55 Amps	SAC-LF55C
		55 – 100 Amps	SAC-LF100C

***Table 2**, Line Filter Recommendations*

The following methods are recommended for proper installation of line filters:

1) The filter must be mounted on the same panel as, and as close as possible to the servodrive(s).

2) Paint or other panel covering material should be removed before mounting the filter.

3) All SAC-LF___C line filter ground connections should be tied to earth ground with a single wire (preferably braid), and **the filter must be grounded before connecting the servodrives.**

4) Line filters should not be touched for a minimum of 10 seconds after removal of the supply power.

5) Separate the input and output leads by a minimum of 10 inches (250 mm). Do not bundle them or run them in the same duct or wireway.

Do not bundle the ground lead with the filter output lines or other signal lines, and do not run them in the same duct.

3.6 Servo Drive Connections

This section describes the servodrive connections at TB1, TB2 (G225 – G260, G417 – G450 only), and P1, P2, P3, and P4. Signal descriptions are given in **Table 3** through **Table 8**. The remainder of Section 3.6 shows additional wiring information. Detailed electrical specs are in Section 6.1, Servodrive Specifications. Part numbers for these and mating connectors are in Section 6.1.9 (page 81).

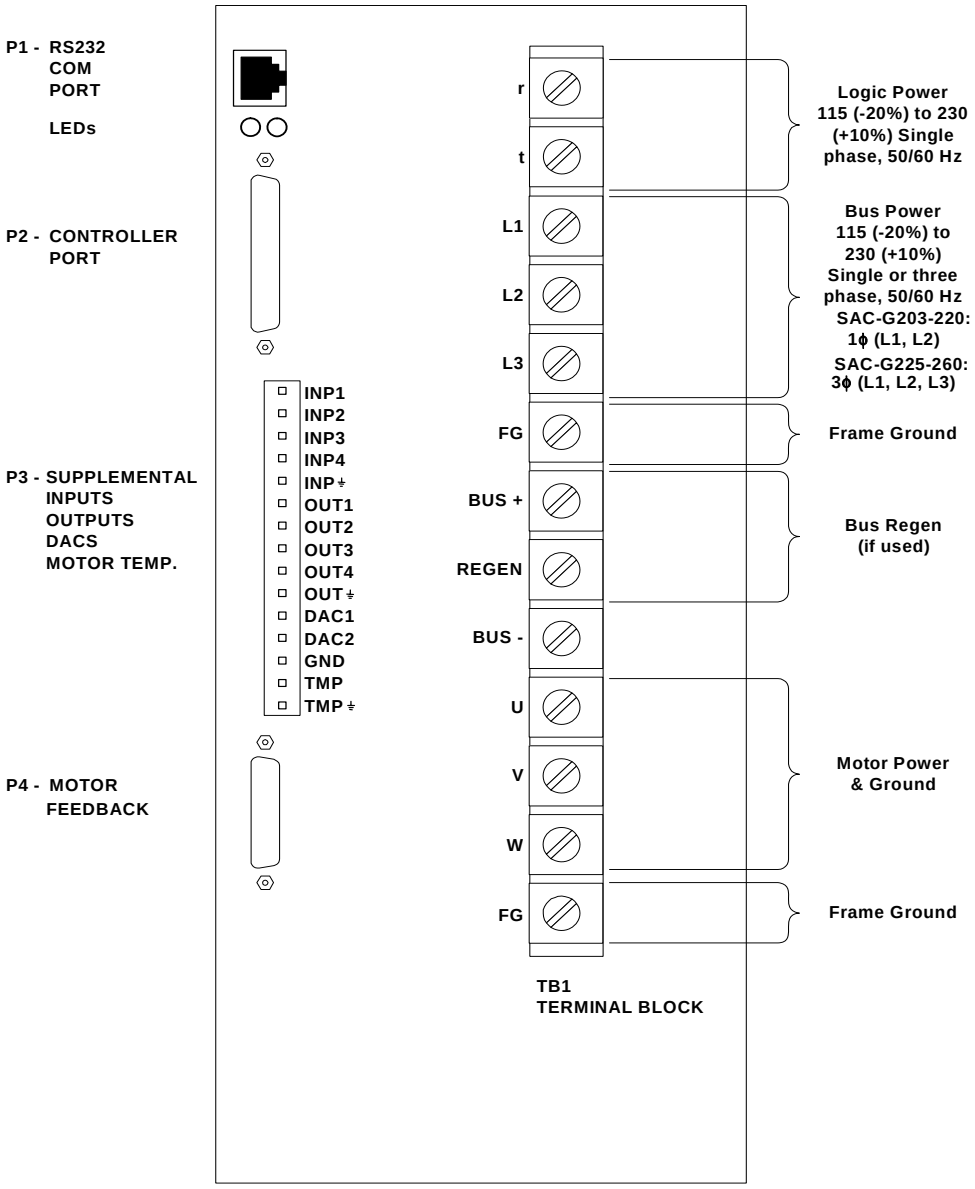


***Figure 5**, G Series Drive Connections Overview* (G203 – G220)

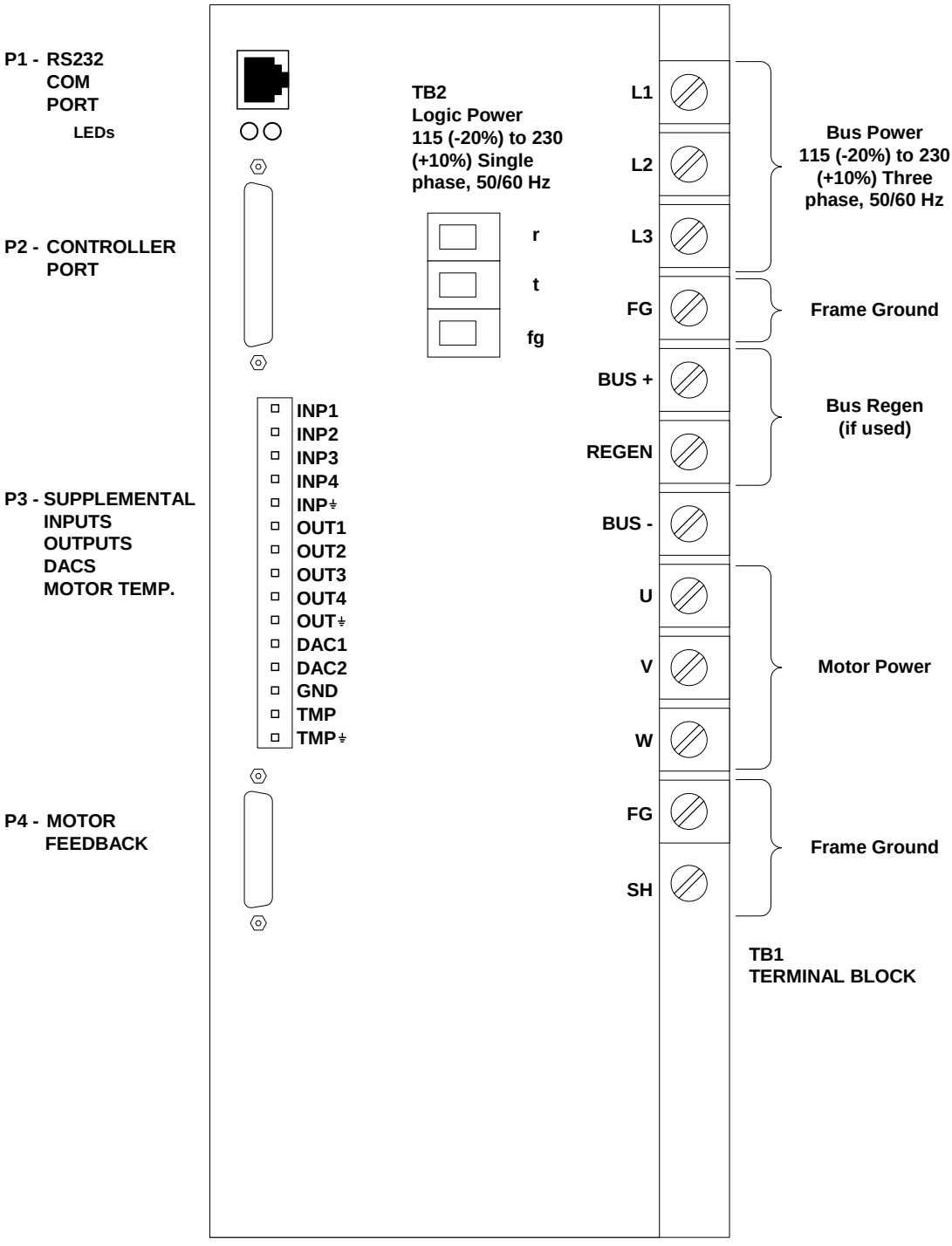


***Figure 6**, G Series Drive Connections Overview* (G225 – G260)

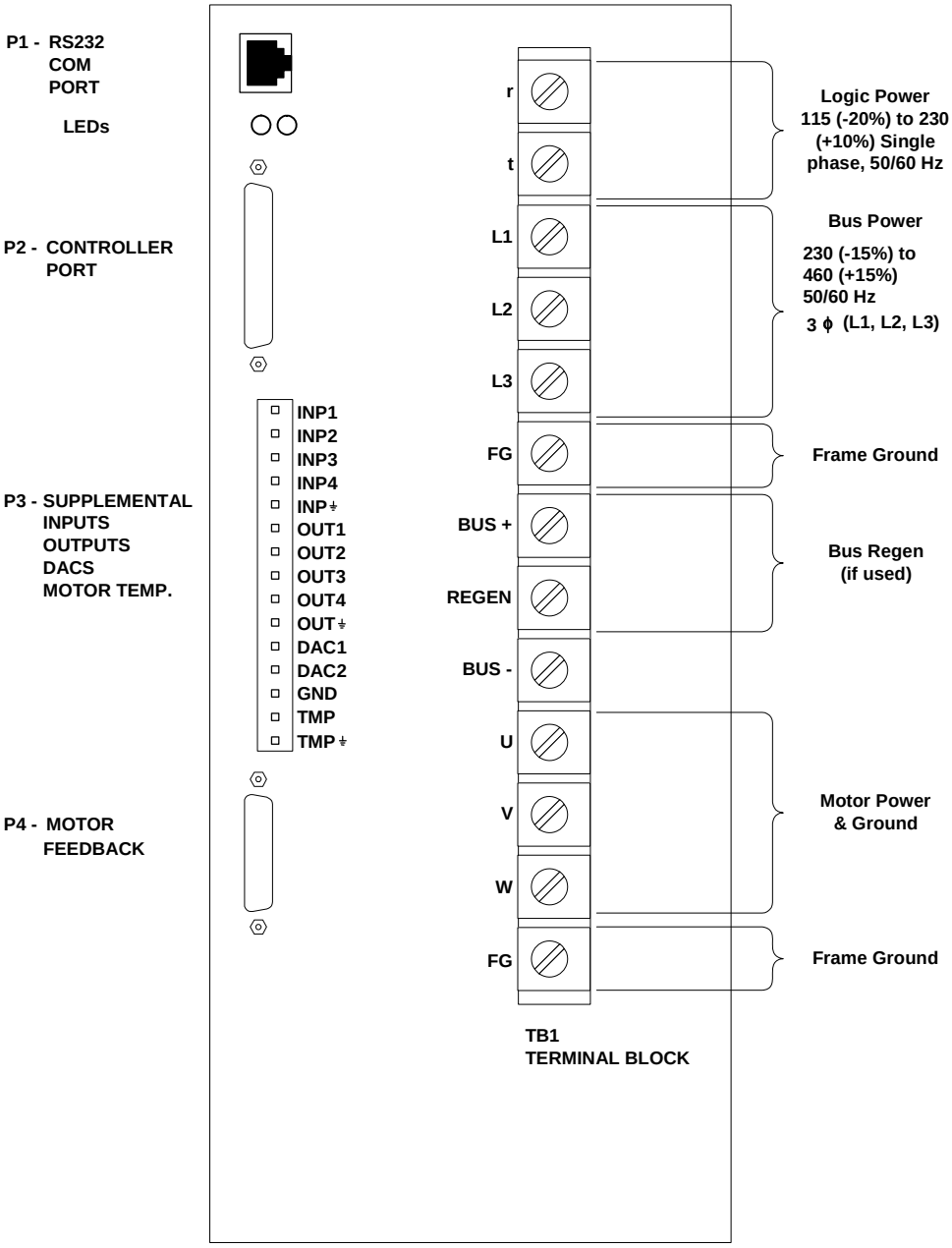


***Figure 7**, G Series Drive Connections Overview* (G405 – G410)

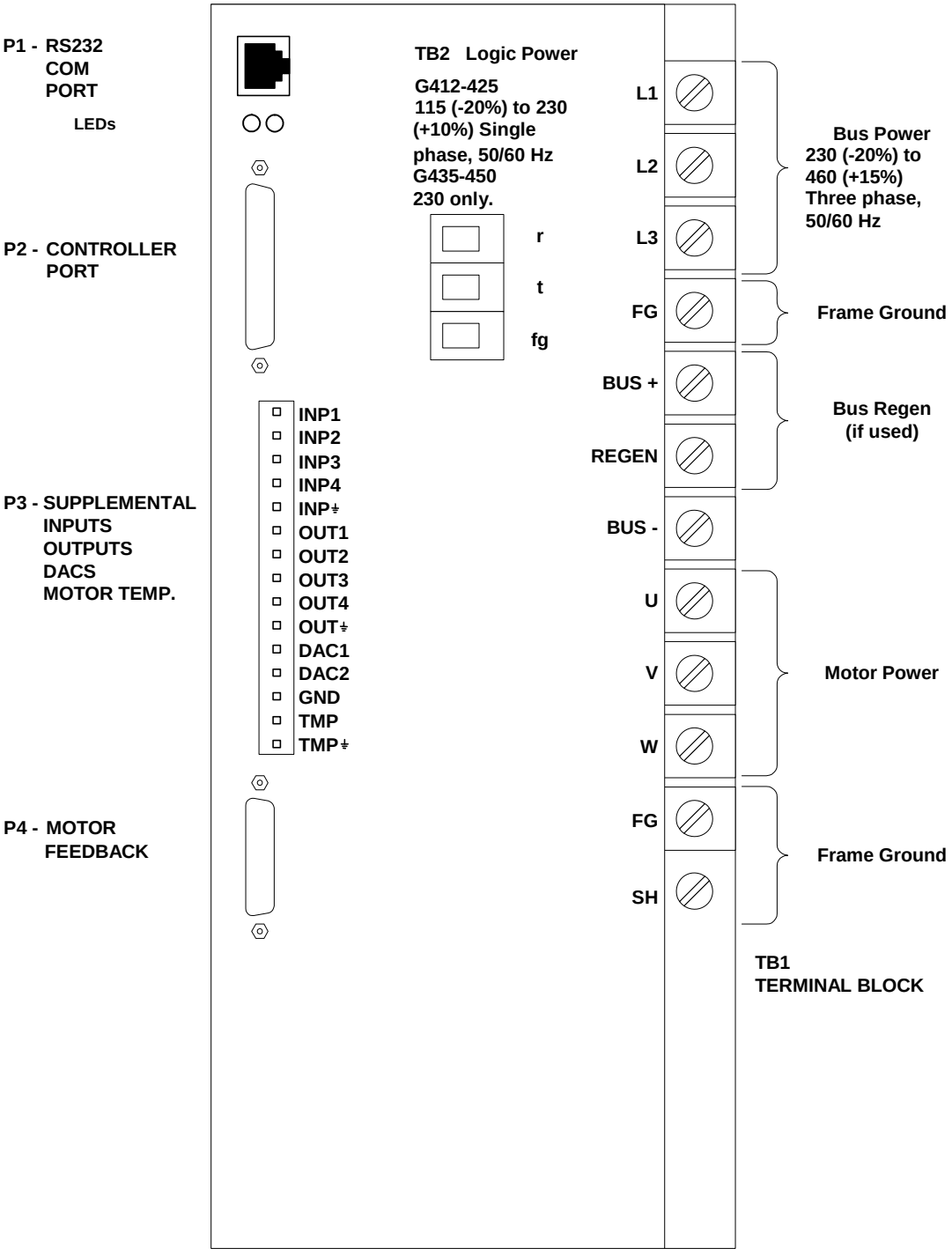


***Figure 8**, G Series Drive Connections Overview* (G417 – G450)

3.6.1 Power Terminal Block (TB1)

Refer to the Servodrive Connector Part Numbers section (page 81) of the Specifications chapter for further information.

Signal	Function	Description
r, t	Logic Power (G203 – G220 only)	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power.
L1, L2, L3 – or – **L1, L2**	Bus Power	**(G210, G217, G220, G225, G235, G260):** Three phase 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz**.** **(G405, G410, G417, G425, G435, G450):** Three phase 230 (+15%, -20%) or 460 (+15%, -20%) VAC, 50/60 Hz**.** **(G203, G205):** Single phase 115 (+15%, -20%) to 230 (+15%, -20%) VAC, 50/60 Hz. The input voltage should match the UltraTools software setting, to ensure proper operation of low bus voltage faults and inrush current limiting.
FG	Ground	Ground for input power. This terminal should be connected to the panel near the drive. The panel should be grounded at some point.
Bus + **Bus -**	Bus Regen	**Nominal bus voltage:** **650 VDC for 460 VAC input** **325 VDC for 230 VAC input** **163 VDC for 115 VAC input** These terminals can be used for connecting bus power between servodrives. If an external regen resistor is used (G210-G260, G4xx only), it is connected between Bus + and REGEN. See Section 3.6.7 External Regen Resistor Wiring (RG) (page 33).
REGEN	Regen Resistor	If an external regen resistor is used (only on G210 - G260 and all G4xx), it is connected between **Bus +** and **REGEN.** See Section 3.6.7 External Regen Resistor Wiring (RG) (page 33).
U,V,W	Motor Power	Single or Three-phase power to the motor. See: • G-Series Servomotor Connections (page 38) • DE/DA/DB-Series Servomotor Connections (page 40). The motor type must match the UltraTools software setting, to ensure proper operation.
FG	Ground	Ground connection for motor frame ground
SH	Shield Ground	Connection for motor shield ground (G225 – G260, G417 - G450 only). On other sizes use the motor frame ground pin to terminate the shield.

Table 3, *Power Terminal Block (TB1) Description*

3.6.2 Logic Power Terminal Block (TB2) (G225, G235, G260, G417, G425, G435, G450 only)

Refer to the Servodrive Connector Part Numbers section (page 81) of the Specifications chapter for further information.

Signal	Function	Description
r, t	Logic Power	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power. For G435 and G450 use 230 (+/-15%) VAC only.
FG	Ground	Ground for input logic power. This terminal must be connected to a ground reference, preferably to the panel near the drive. Do not use the same panel connection as used from TB1. The panel must be grounded at some point.

Table 4, *Logic Power Terminal Block (TB2) Description (G225, G235, G260, G417, G425, G435, G450)*

3.6.3 RS232 or RS485 Communications Port (P1)

The P1 connector is used to communicate with external system communications devices, such as a PC running the UltraTools setup and diagnostic program. The port is capable of either RS232 or RS485 communications using a single RJ-11 connector. The internal port includes an auto baud rate detect feature which detects the baud rate of incoming data after receiving two successive carriage return / line feeds. The standard protocol of 8 data bits, parity none, and 1 stop bit is supported, as well as others, in speeds ranging from 1200 baud to 38400 baud. The standard Xon/Xoff communication protocol is used for handshaking. The only connections necessary for RS232 communication are GND, TX, and RXA (pins 1, 2, and 3). The remaining lines (pins 4, 5, and 6) are used for RS485 communications. When connecting between the G Series servodrive and an external PC, etc., in RS232 mode, the TX transmit line must connect to the PC serial communications receive line, and the RXA receive line must connect to the PC transmit line.

Standard cables are available from Ormec Systems Corporation to facilitate connection between the G Series servodrive and an external desktop or laptop PC in RS232 mode. Refer to the Servodrive Connector Part Numbers section (page 81) of the Specifications chapter for further information.

Additional information and details on RS485 operation can be found in the Operation chapter. Additional detail can be found in appendix B.

Pin	Signal	Description
1	GND	Ground
2	TX	Transmit
3	RXA	RS-232 (single ended) receive input or RS-485 (differential) positive side of differential receiver
4	/RXA	RS-485 – inverted side of differential receiver
5	TXA	RS-485 – positive side of differential transmiter
6	/TXA	RS-485 – inverted side of differential transmitter

Table 5, *RS232 RS485 Communications Port (P1) Description*

3.6.4 Controller Port (P2)

The DB25 connector at P2 is designed to connect an external controller to the G Series servodrive. The signals present on this connector should provide all that is needed to permit an external controller to control the operation of the power output section of the servodrive. Additional detail can be found in appendix B.

Pin	Signal	Description
1	**Velocity/Torque Analog Command Signal Input (+)**	This input is the positive input of the analog command signal for velocity or torque. **Note**: In order for the G Series servodrive to control motor motion through this analog signal, the servodrive must be operating in ANALOG mode, not SERIAL mode. ANALOG is the default startup mode for the servodrive when it first powers up. Please refer to the software commands later in this manual. **Differential Input**: For differential input, the analog command signal is applied between P2 pin 1 (positive input) and P2 pin 2 (negative input). **Single-ended Non-inverted Input**: For single-ended non-inverted input, the signal is applied to P2 pin 1 with respect to common, which is analog ground, pin 4. To achieve single-ended input, P2 pin 2 must be jumpered to pin 3.
2	**Velocity/Torque Analog Command Signal Inverted Input (–)**	When using differential inputs, this input is the negative input of the analog command signal for velocity or torque. When using single-ended non-inverted input mode, pin 2 must be jumpered to pin 3. When using single-ended inverted input mode, pin 1 must be jumpered to pin 3, and the command signal is applied to this pin (pin 2). See pin 1 above.
3	**Analog Ground**	Single-ended jumper reference. This ground is provided to facilitate operation with single-ended input.
4	**Analog Ground**	Shield for differential input, or single-ended common.
5	**+ 5 volts**	For external use (10 ma max.)
6	**Encoder Reference Output Z –**	Index or marker channel compliment reference
7	**Encoder Reference Output Z +**	Index or marker channel reference

Table 6, *Controller Port (P2) Description (continued on next page)*

Pin	Signal	Description
8	**Encoder Reference Output B +**	Encoder data channel B reference. See Section 4.5, Commutation Feedback.
9	**Encoder Reference Output B –**	Encoder data channel B compliment reference
10	**Encoder Reference Output A +**	Encoder data channel A reference. See Section 4.5, Commutation Feedback
11	**Encoder Reference Output A –**	Encoder data channel A compliment reference
12*	**Dedicated Fault Output Common**	This pin provides a common for **Fault Output** (pin 13). This is an isolated output.
13*	**Dedicated Fault Output**	This output will normally be closed if no fault condition exists. If a fault condition occurs, this output will be opened until the fault condition causing it is cleared. Cycling P2 pin 24 will not clear this fault output by itself. The fault can only be cleared by first correcting the condition causing the fault, and then by performing a Fault reset using pin 24 or sending the FAULT 0 command via the RS232 port or completely resetting or repowering the servodrive.
14*	**Digital Input 1 (INP1)**	This input provides a convenient means for sending an input signal from the controller to a user selectable input. This isolated input is identical to **INP1** on P3. See 3.6.4.1, Shared Digital Inputs & Outputs.
15*	**Digital Input 2 (INP2)**	This input provides a convenient means for sending a second input signal from the controller to a user selectable input. This isolated input is identical to **INP2** on P3. See 3.6.4.1, Shared Digital Inputs & Outputs.
16*	**Digital Input Common**	This pin provides a common for both of the digital input connections. These are all isolated inputs.
17*	**Digital Output 1 (OUT1)**	This output provides a convenient means for sending an output signal from the servodrive back to the controller. This isolated output is identical to **OUT1** on P3. See 3.6.4.1, Shared Digital Inputs & Outputs.
18*	**Digital Output 2 (OUT2)**	This output provides a convenient means for sending a second output signal from the servodrive back to the controller. This isolated output is identical to **OUT2** on P3. See 3.6.4.1, Shared Digital Inputs & Outputs.
* All of the inputs and outputs noted for P2 above follow the hardware setup described in **Figure 10, Making Digital I/O Connections**, later in this chapter.		

Table 6, *Controller Port (P2) Description (continued on next page)*

Pin	Signal	Description
19*	**Digital Output 3 (OUT3)**	This output provides a convenient means for sending a third output signal from the servodrive back to the controller. This isolated output is identical to **OUT3** on P3. See 3.6.4.1, Shared Digital Inputs & Outputs, below.
20	**Digital Output Common**	This pin provides a common for all three of the digital output connections. These are all isolated outputs.
21	**Reserved**	Do not connect to this terminal.
22	**Reserved**	Do not connect to this terminal.
23*	**Dedicated Drive Enable Input**	By default, this input must be pulled high in order to enable the servodrive. If this input is held open, output to the motor will be disabled. This default setting can be reversed by changing the INPFN98 setting in the command mode, or by changing the drive enable input setting in UltraTools.
24*	**Dedicated Fault Reset Input**	In the event that a servodrive fault occurs, it can be cleared and reset by closing this input for a minimum of 4 milliseconds and then reopening it. This default setting can be reversed by changing the INPFN99 setting in the command mode, or by changing the drive reset input setting in UltraTools.
25*	**Dedicated Drive Enable / Fault Reset Common**	This pin provides a common for the Drive Enable and Fault Reset Inputs. These are both isolated outputs.
* All of the inputs and outputs noted for P2 above follow the hardware setup described in **Figure 10, Making Digital I/O Connections**, later in this chapter.		

Table 6, *Controller Port (P2) Description (continued from previous page)*

3.6.4.1 Shared Digital Inputs & Outputs

Please note that the two digital inputs (**INP1** & **INP2**) and three digital outputs (**OUT1** – **OUT3**) brought out by this P2 connector to the controller are identical to the I/O of the same name on the P3 connector. They are included on P2 for convenience in connecting with the controller. The digital outputs can be monitored at both P2 and P3 without confusion or harmful results. However, the digital inputs must be controlled at only one location, either P2 or P3. If the inputs (**INP1** & **INP2**) are actually controlled at P2, then no connection should be made to these inputs on the P3 connector. If the inputs are controlled at P3, then no connection should be made to them at the P2 connector. See **Figure 9**. Additional detail can be found in appendix B.

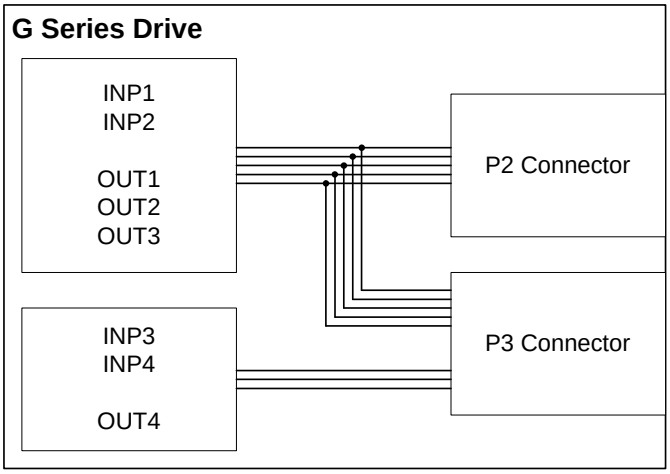


***Figure 9**, Shared Digital Inputs & Outputs*

3.6.5 Supplemental Input Port (P3)

This quick-disconnecting Phoenix style header provides connections for the digital I/O, the DACs, and the motor temperature input. The digital inputs and outputs are user definable as to function and provide flexibility in handling such things as servodrive faults, etc. The two DAC outputs can help monitor signal levels and other items of interest. The motor temperature condition tracked on this connector provides protection against damaging the motor. Please note that the motor temperature wiring hookup must agree with the MOTMODE software command of the servodrive. That is, if 'Overtemp:' in the motor setup in UltraTools indicates to IGNORE the motor temperature sensor (MOTMODE 0), then no connection should be made to the TMP terminals on P3, or an 'F4' motor temperature error will occur. Likewise, if the choice is to indicate a fault (MOTMODE 1 and 2), then a valid motor temperature connection MUST be made, or an 'F4' motor temperature error will occur.

Pin	Signal	Description
1*	**Digital Input 1 (INP1)**	Fully isolated digital input. See 3.6.4.1, Shared Digital Inputs & Outputs.
2*	**Digital Input 2 (INP2)**	Fully isolated digital input. See 3.6.4.1, Shared Digital Inputs & Outputs.
3*	**Digital Input 3 (INP3)**	Fully isolated digital input.
4*	**Digital Input 4 (INP4)**	Fully isolated digital input.
* All of the inputs and outputs noted for P2 above follow the hardware setup described in **Figure 10, Making Digital I/O Connections**, later in this chapter.		

***Table 7,** Supplemental I/O Port (P3) Description(continued from previous page)*

Pin	Signal	Description
5*	**Digital Input Common**	This pin provides a common for all of the digital input connections. These are all isolated inputs.
6*	**Digital Output 1 (OUT1)**	Fully isolated, user definable digital output. See 3.6.4.1, Shared Digital Inputs & Outputs.
7*	**Digital Output 2 (OUT2)**	Fully isolated, user definable digital output. See 3.6.4.1, Shared Digital Inputs & Outputs.
8*	**Digital Output 3 (OUT3)**	Fully isolated, user definable digital output. See 3.6.4.1, Shared Digital Inputs & Outputs.
9*	**Digital Output 4 (OUT4)**	Fully isolated, user definable digital output.
10*	**Digital Output Common**	This pin provides a common ground for all of the digital output connections. These are all isolated outputs.
11	**Digital – to - Analog Output 1 (DAC1)**	Torque Monitor ±10 VDC analog signal. 3 VDC = rated torque.
12	**Digital – to - Analog Output 2 (DAC2)**	Velocity Monitor ±10 VDC analog signal. The scaling depends on the maximum speed of the motor: Max speed 5000 rpm or higher: 1 VDC = 1000 rpm. Max speed between 2000-4999 rpm: 2 VDC = 1000 rpm. Max speed 1999 rpm or lower: 5 VDC = 1000 rpm. The maximum speed normally defaults to the maximum speed printed on the side of the motor, but for G-Series motors rated for 460 VAC (MAC-Gxxxx**4**), but operated at 230 VAC, it is limited to half of the maximum speed printed on the side of the motor.
13	**DAC Signal Common**	This pin provides a common for the two digital to analog outputs.
14*	**Motor Temperature Input**	This is the input pin for the normally closed motor thermal switch. These motor temperature pins are located close to the feedback connector, the normal source for the motor temperature input wires. The MOTMODE command defines how the drive will react to this input. **Note**: Failure to monitor the motor temperature outputs could result in damage to the motor and could void your warranty.
15*	**Motor Temperature Common**	This pin provides a common for the Motor Temperature Input.
* All of the inputs and outputs noted for P2 above follow the hardware setup described in **Figure 10, Making Digital I/O Connections**, later in this chapter.		

Table 7, *Supplemental I/O Port (P3) Description(continued from previous page)*

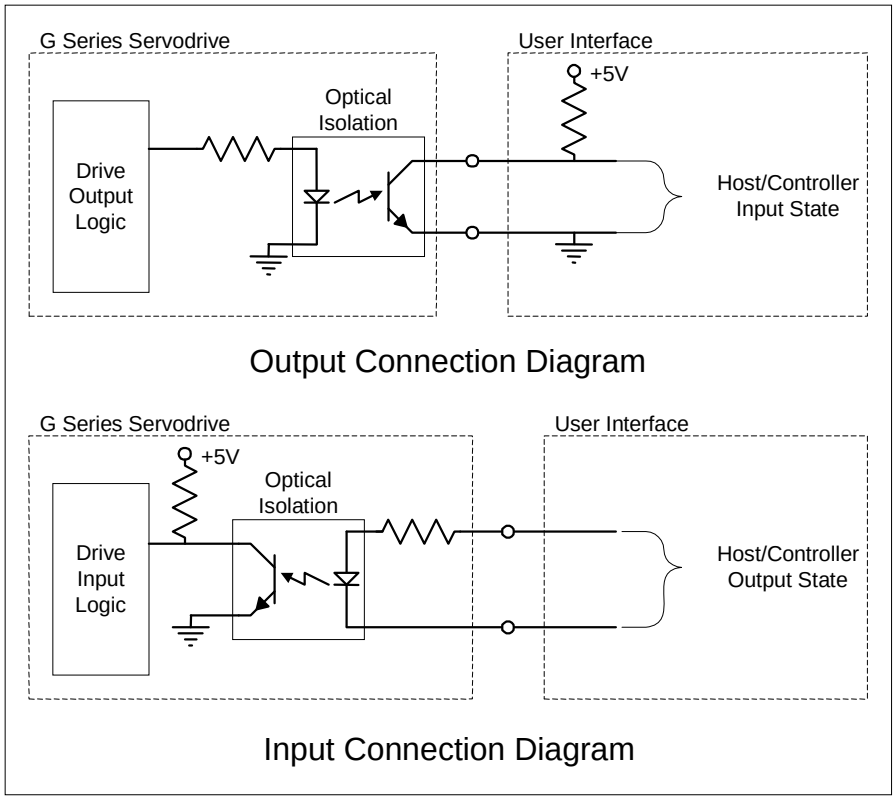


***Figure 10**, Making Digital I/O Connections*

Additional detail can be found in appendix B.

3.6.6 Feedback Port (P4)

The DB15 connector at P4 provides a simple and effective method for connecting the servomotor feedback to the G Series servodrive. This supplies the necessary encoder and Hall or resolver information to the DSP which allow it to track velocity and also provide commutation control to the servomotor.

Note, the quadrature and resolver feedback versions use different connector genders to prevent accidentally connecting the wrong feedback type.

Feedback Type	**Connector on Drive**	**Connector on cable**
Quadrature	Female DB15	Male DB15
Resolver	Male DB15	Female DB15

Refer to the Servodrive Connector Part Numbers section (page 81) of the Specifications chapter for further information. Additional detail can be found in appendix B.

Pin	Signal	Description
1	ENC PWR	+5 VDC power supply output for the motor encoder (450 mA max). This power is derived from the input control power at pins **r,t**.
2	DGND	Common for the +5 VDC supply (ENC PWR).
3 4	ENCZ' ENCZ	Differential input, "once per revolution" marker signal from the motor encoder.
5 6	ENCB' ENCB	Differential input, quadrature feedback channel B from the motor encoder.
7 8	ENCA' ENCA	Differential input, quadrature feedback channel A from the motor encoder.
9	SHIELD	Motor encoder shield termination point
10 11 12 13 14 15	W' W V' V U' U	Differential or single-ended input, commutation feedback channels U, V and W from the motor encoder. The U, V and W (pins 15, 13 & 11) inputs are intended for use with single ended commutation feedback. If the feedback signals are open collector outputs, external biasing hardware may be required. The U', V' and W' (pins 14, 12 & 10) inputs are internally biased and no connection or external circuitry is required for use with single ended feedback.

***Table 8**, Feedback Port (P4) Connections – Quadrature interface*

Pin	Signal	Description
1 2	Ref + Ref -	Differential analog reference output from the drive to the resolver.
3 4	Sin - Sin +	Differential analog input from the resolver. Note that the names Sin and Cos as labeled on the resolver may not always provide the phasing as required by the drive. It may be necessary to reverse the Sin and Cos pairs to get proper control. The drive expects feedback position to increase with counter clockwise rotation of the motor shaft as viewed from the shaft end of the motor.
5 6	Cos + Cos -	Differential analog input from the resolver.
7	DGND	Common for the +5 VDC supply (+5 V).
8	+5 V	+5 VDC power supply output (450 mA max). This power is derived from the input control power at pins **r,t**.
9	SHIELD	Motor resolver shield termination point. It is recommended that the cable to the resolver use separate shields around the 3 signal pairs (Ref, Sin, Cos) and that each shield be terminated in one of the shield pins.
10	Motor Temp input	Duplicate of the P3 pin 14 Motor Temperature Input.
11	SHIELD	Motor resolver shield termination point.
12	N/C	Do not connect any wire to this terminal.
13	SHIELD	Motor resolver shield termination point.
14	N/C	Do not connect any wire to this terminal.
15	SHIELD	Motor resolver shield termination point.

***Table 9**, Feedback Port (P4) Connections – Resolver interface*

3.6.7 External Regen Resistor Wiring (RG)

Regenerative (regen) shunt circuitry, for use with external regen resistors, is provided on Servodrive models G210, G217, G220, G225, G235, G260, and G4xx only. Regen resistors are connected between the **Bus +** and **REGEN** terminals on TB1 (refer to **Figure 11**).

The following methods are recommended for proper installation of regen resistors:

1. **Regen resistors can become very hot as part of normal operation and should be mounted in a ventilated, "touch safe" enclosure.** ORMEC SAC-SWRR/0700, SAC-SWRR/0845, SAC-SWRR/0846, and SAC-SWRR/1700 regen resistors are supplied with enclosures. Mounting enclosures for the SAC-SWRR/0055 and SAC-SWRR/0095 regen resistors are not included and must be supplied by the user.
2. Regen resistor wiring should have heat resistant, non-combustible insulation.

3. Regen resistor, and other system, wiring should be routed so that it is not in contact with the regen resistors.
4. **On 230 VAC drives Switching voltages exceeding 400 VDC may be present on the Bus+ and REGEN terminals (and across the regen resistor).** Use appropriate high voltage safety and noise suppression wiring methods.
5. **On 460 VAC drives Switching voltages exceeding 800 VDC may be present on the Bus+ and REGEN terminals (and across the regen resistor).** Use appropriate high voltage safety and noise suppression wiring methods.
6. Mounting and wiring practices should be in accordance with NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.

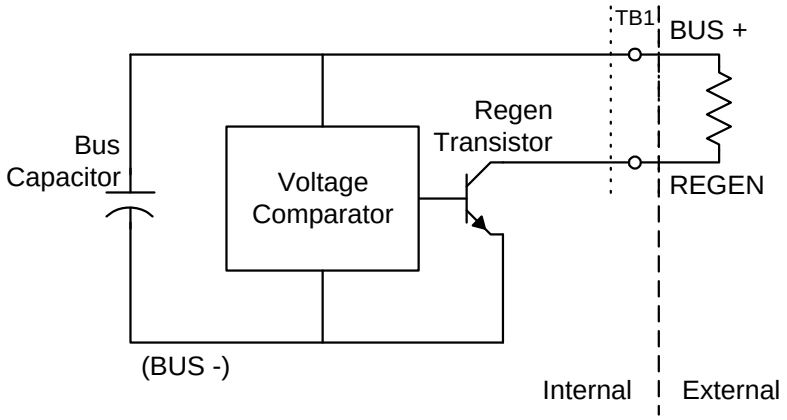


***Figure 11**, Regen Resistor Connection*

For information on how the shunt circuitry operates, as well as information on sizing regen resistors, see Section 4.8, Regenerative Loads (page 57).

3.6.8 Bus Sharing Wiring (G225 – G260 and G4xx)

DC Bus sharing is supported on Servodrive models ***G225, G235, G260 and all G4xx only***. To configure these drives for bus sharing, the **Bus +** and **Bus –** terminals are connected as shown in **Figure 12**. Drives should be connected so that the highest power drives are in the center of the bus-sharing chain. Bus wiring between drives should be less than 12 inches in length to minimize oscillatory effects. As long as the total system regenerative load can be dissipated, there is no limit to the number of drives that can share the DC bus.

For information on how the bus sharing operates, see Section 4.8.5, Bus Sharing.

The following methods are recommended for proper configuration of bus sharing:

1. Wiring should have heat resistant, non-combustible insulation, rated at 600V or more for G2xx (230 V drives) and rated at 1000V or more for G4xx (460 V drives)..
2. **On 230 VAC drives (G2xx) Switching voltages exceeding 400 VDC maybe present on the Bus+ and BUS- terminals.** Use appropriate high voltage safety and noise suppression wiring methods.
3. **On 460 VAC drives (G4xx) Switching voltages exceeding 800 VDC maybe present on the Bus+ and BUS- terminals.** Use appropriate high voltage safety and noise suppression wiring methods.
4. Mounting and wiring practices should be in accordance with NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.
5. If an external regen resistor is to be used in conjunction with bus sharing, it should be connected to the largest servodrive in the bus-shared network. **No more than one regen resistor may be used in any bus sharing configuration**. See 0 for more information on regen resistor installation.

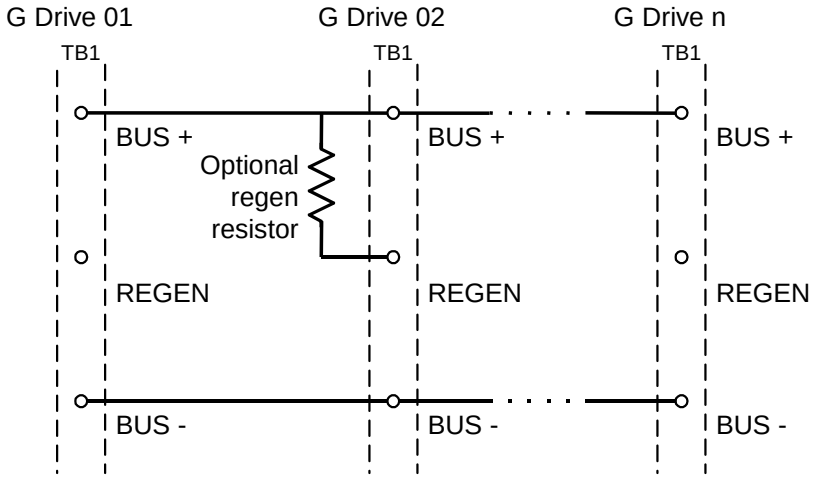


***Figure 12**, Bus Sharing Connections*

3.7 Servomotor Installation

3.7.1 Motor Use and Environment

A standard G-Series or DE/DA/DB-Series Servomotor (IP65) is designed for use as described below:

- Either horizontal or vertical mounting orientation

- Indoors, clean and dry
- Free from corrosive and/or explosive gases or liquids
- If the location is subject to excessive water or oil, protect the motor with a cover. The motor can withstand a small amount of splashed water or oil.
- Accessible for inspection and cleaning
- Face mounting: the structural integrity of the mounting can be critical to obtaining the maximum performance from your Servomotor application.
- DE/DA/DB-Series Servomotors: Ambient Temperature: 0ºC to +40ºC.
- G-Series Servomotors: Rated Torques/Currents are for 25ºC; for ambient temperatures above 25ºC, use the formula given below in **Figure 13**. Note that $°C_{Max}$ is 100ºC for all G-Series Servomotors except models G006, G011, G015, and G019; for these motors, $°C_{Max}$ is 85ºC. The motor current is derated by the same factor as the torque.

$$\text{Torque}_{\text{Derated}} = \text{Torque}_{\text{Rated}} * \frac{(^{o}C_{\text{Max}} - {}^{o}C_{\text{Ambient}})}{(^{o}C_{\text{Max}} - 25^{o}C)}$$

***Figure 13**, G-Series Torque Derating for High Ambient Temperature*

3.7.2 Recommended Servomotor Wiring Methods

1) When the motor is mounted to the machine and grounded through the machine frame, $^{dv}/_{dt}$ current flows from the Servodrive through the floating capacity of the motor. To prevent the noise effects from this current, and also for safety, the motor housing (terminal D of the motor connector) should be connected to the frame of the Servodrive (TB2 pin FG), which should be directly grounded to the control panel frame using braided copper wire.
2) When motor wiring is contained in metal conduits, the conduits and boxes must be grounded. Use wires of 12 AWG or heavier for grounding to the case (preferably flat woven silver-plated copper braid).
3) If possible, route motor feedback and motor power cables in separate conduits or ductwork, separated by a minimum of 10 inches (25 cm).

3.7.3 Motors with Integral Fail-Safe Brakes

NOTE: **The integral fail-safe brakes supplied on DA/DB/DE-Series and G-Series motors are intended for holding purposes (preventing the movement of a stopped motor) only and should not be used for braking a motor in motion. Using an integral fail-safe brake to stop a motor in motion may result in damage to the motor-brake unit.** An external brake should be used for fail-safe stopping a motor in motion.

Motors with brakes require special cables; see **Table 12** (page 39) for G-Series cable part numbers; see **Table 14** (page 41) for DE/DA/DB-Series cable part numbers. Drawings for these cables are shown in Appendix D.

Figure 14 shows the recommended safety and fault interlock wiring for motors with fail-safe brakes.

- When the main power contactor opens, the brake engages.
- When /DRIVE ENABLE is asserted, the brake disengages.

Use a separate +24 VDC power supply for coil power! Most motion controller power and I/O supplies should **not** be used for switching inductive loads.

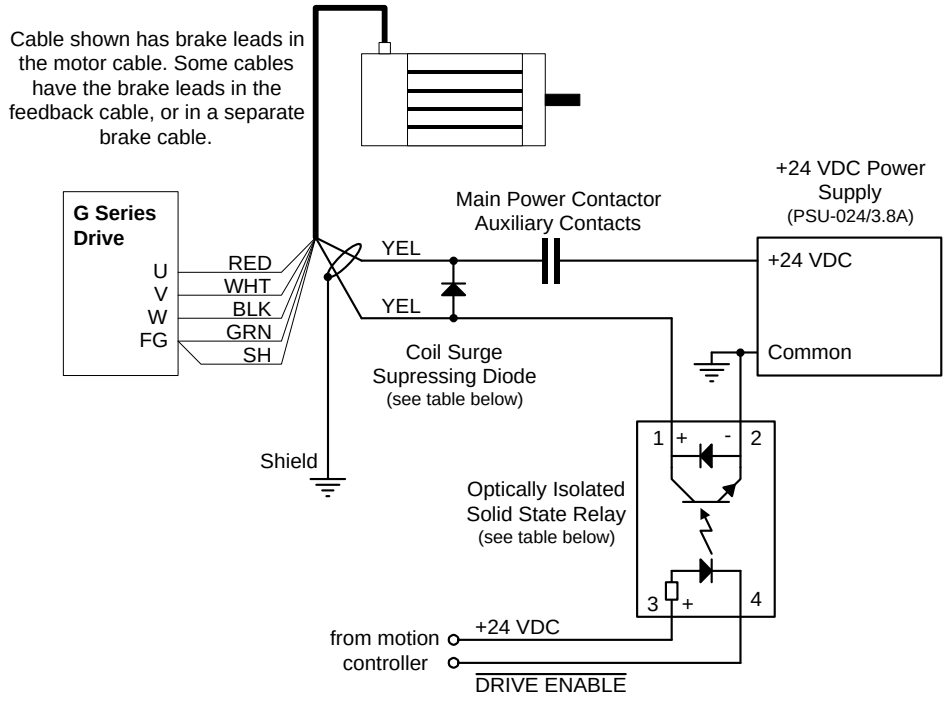


***Figure 14**, Fail-Safe Brake Interlock Circuit*

	Ormec P/N	**Manufacturer, P/N**
Optically-Isolated Solid State Relay	MIO-DC60S-3	Opto-22, DC60S-3
Coil Surge Suppressing Diode	SEM029	Motorola, MUR410

***Table 10**, Additional Components for use with Fail-Safe Brakes*

3.7.4 G-Series Servomotor Connections

For G-Series motors without brakes, refer to the appropriate cable drawing(s) in Appendix D. The motor and encoder cable part numbers and page numbers are shown in **Table 11** (motors without brakes) and **Table 12** (motors with brakes).

MAC-G Motors Without Brakes	Motor Power Cable	Motor Encoder Cable
G005, G010, G006, G011, G015,G019 with Servodrives G203 – G220	CBL-GBRFP (p E-2)	
G016, G030, G040, G055, G080, G115 with Servodrives G203 – G220	CBL- GMSW2 (p E-4)	CBL-GBRFC (p E-1)
G080 & G115A2 with Servodrives G225 & G235	CBL-GMSWT2 (p E-5)	
G130 & G210 with Servodrives G210 – G220	CBL-GMSW3 (p E-6)	
G130A2 with Servodrive G225	CBL-GMSWT3 (p E-8)	CBL-GBRFC (p E-1)
G210, G280A4 & G360A4 with Servodrives G225 – G235	CBL-GMSWT5 (p E-8)	
G280A2 & G360A2 with Servodrives G235 & G260	CBL-GMSWT6 (p E-8)	
G640A2 with Servodrive G260	CBL-GMSWT9 (p E-8)	

Table 11, *Cable Drawings for G-Series Motors* ***Without*** *Brakes*

For G005, G006, G010, G011, G015, G019 motors, the brake leads are in the combined power/feedback cable.

For G016, G030, G040, G055, G080, and G115 motors, the brake leads are in the motor power cable.

For G130, G210, G280, G400 and G640 motors, the brake leads are in the motor feedback cable.

MAC-G Motors With Brakes	Motor Power Cable	Motor Encoder Cable
G005, G010, G006, G011, G015,G019 with Servodrives G203 – G220	CBL-GBRFPB (p E-3)	
G016, G030, G040, G055, G080, G115 with Servodrives G203 – G220	CBL-GMSWB2 (p E-9)	CBL-GBRFC (p E-1)
G080 & G115A2 with Servodrives G225 & G235	CBL-GMSWBT2 (p E-10)	
G130 & G210 with Servodrives G210 – G220	CBL-GMSW3 (p E-6)	CBL-GBRFCB
G130A2 with Servodrive G225	CBL-GMSWT3 (p E-8)	
G210, G280A4 & G360A4 with Servodrives G225 – G235	CBL-GMSWT5 (p E-8)	
G280A2 & G360A2 with Servodrives G235 & G260	CBL-GMSWT6 (p E-8)	
G640A2 with Servodrive G260	CBL-GMSWT9 (p E-8)	

***Table 12**, Cable Drawings for G-Series Motors **With** Brakes*

3.7.5 DE/DA/DB-Series Servomotor Connections

For DE/DA/DB-Series motors without brakes, refer to the appropriate cable drawing(s) in Appendix D. The motor and encoder cable part numbers are shown in **Table 13** (motors without brakes) and **Table 14** (motors with brakes).

MAC-D_ Motors Without Brakes	**Motor Power Cable**	**Motor Encoder Cable**
DE003, DE006, DE008, DE011, DE021, DE042 with Servodrives G203 – G220	CBL-DEMSW1 (p E-11)	CBL-DMG (1-50 ft: p E-12) (51-150 ft: p E-13)
DA030, DA055, DB025, DB055, DB080 with Servodrives G210 - G220	CBL-DMSW1 (p E-14)	
DA055 with Servodrive G225	CBL-DMSWT1 (p E-15)	
DA090, DA110, DB200 with Servodrives G225 – G260	CBL-DMSWT2 (p E-15)	
DA140 & DB300 with Servodrives G235 – G260	CBL-DMSWT3 (p E-15)	
DB100 with Servodrive G220	CBL-DMSW4 (p E-14)	
DB100 with Servodrive G225	CBL-DMSWT4 (p E-15)	
DB330 with Servodrive G260	CBL-DMSWT5 (p E-15)	
DB465 & DB700 with Servodrives G235 – G260	CBL-DMSWT6 (p E-15)	

***Table 13**, Cable Drawings for DE/DA/DB-Series Motors **Without** Brakes*

MAC-D_ Motors With Brakes	Motor Power Cable	Motor Encoder Cable
DE003, DE006, DE008, DE011, DE021, DE042 with Servodrives G203 – G220	CBL-DEMSWB1 (p E-11)	CBL-DMG (1-50 ft: p E-12) (51-150 ft: p E-13)
DA030, DA055, DB025, DB055, DB080 with Servodrives G210 – G220	CBL-DMSWB1 (p E-16)	
DA055 with Servodrive G225	CBL-DMSWBT1 (p E-17)	
DA090, DA110, DB200 with Servodrives G225 – G260	CBL-DMSWBT2 (p E-17)	
DA140 & DB300 with Servodrives G235 – G260	CBL-DMSWBT3 (p E-17)	
DB100 with Servodrive G220	CBL-DMSWB4 (p E-16)	CBL-DMG (1-50 ft: p E-12) (51-150 ft: p E-13)
DB100 with Servodrive G225	CBL-DMSWBT4 (p E-17)	
DB330 with Servodrive G260	CBL-DMSWT5 (p E-15) & CBL-DMACB (p E-18)	
DB465 & DB700 with Servodrives G235 – G260	CBL-DMSWT6 (p E-15) & CBL-DMACB (p E-18)	

***Table 14**, Cable Drawings for DE/DA/DB-Series Motors **With** Brakes*

3.7.6 Coupling the Servomotor to the Load

Good alignment of motor and the driven machine is essential to prevent vibration, increase bearing and coupling life, and to prevent shaft and bearing failures.

With a direct drive application a torsionally rigid flexible coupling should be used. Timing belts and gearboxes are also commonly used in servo applications. Shaft loading should be kept to a minimum. The allowable shaft bearing loading is listed in the Specifications Section.

In either case, it is preferable to attach the coupling or pulley to the shaft with a clamping arrangement rather than transmit torque through the keyway, because of the reversing shock torques, which the Servomotor can generate. A number of mechanical approaches afford this type of attachment including tapered hubs, split hubs, ringfeder devices, etc.

Further information is available in Ormec Tech Note #27 - Coupling High Performance Servos to Mechanical Loads, which is available in Appendix E of this manual.

Chapter 4
Operation

4 Operation

4.1 Power On and Off Sequencing

Appendix A shows the recommended interlock approaches for both single and multiple axes. Note its features:

1) ESTOP interlocks

a) The recommended E-Stop switch is a maintained-contact red mushroom head push-button, which must be manually pulled out (reset) after it has been pressed (asserted). It should be powered by 115 or 230 VAC, and must conduct current for the Servomotor to provide output torque.

c) The E-Stop Reset should be a momentary contact pushbutton. It must be asserted after all power is applied and the E-Stop switch is closed. It must be closed long enough for the main power contactor coil circuit to be energized, and the main power auxiliary relay to "pull-in".

e) If the E-Stop switch is pressed (asserted), the main circuit power is disconnected, and torque is prevented at the motor(s).

2) Servodrive faults

a) If any fault condition occurs within a Servodrive, the Servodrive Status display will indicate the fault code.

To reset a High Bus Voltage Fault, the main input power must be disabled long enough to discharge the power capacitors. This will be indicated by the BUS POWER LED on the Servodrive no longer being illuminated.

To reset a Motor Over Temperature Fault, the motor must be sufficiently cool.

Not only must any alarm condition, including E-Stop, be cleared before motor power can be restored, but the E-Stop Reset push-button must then be depressed long enough for all the relays to pull-up again.

4.2 Servodrive Status Indications

The servodrive status indication consists of a 1-digit 7-segment LED display (Status) and a yellow LED indicating bus power.

If an alarm condition is present on the Servodrive, the output transistors are disabled, and an appropriate error code is displayed on the Status display. The control power should be maintained in case of a Servodrive fault, so that the status indicators can indicate the unit's status until the cause of the fault is determined.

If any wiring changes are necessary, **turn off the control and main power circuits and wait for the BUS POWER LED to go completely off to avoid possible electrical shock.**

Notes:

1) After the conditions causing a servodrive fault have been corrected, reset the drive.

2) If the fault is due to the motor or drive being over temperature, the servodrive will not reset until the component has cooled down.

4.2.1 Bus Power LED Status Indicator

The Bus Power LED is an amber colored LED located near terminal R of the Logic Power input on TB1. This LED provides an indication of the state of the bus power on the terminals of TB1 and internal to the G Series servodrive. If the LED is lit, there is voltage on the bus. If it is not lit, any voltage on the bus has decayed to very low levels.

WARNING: If the BUS POWER LED is lit, high voltages may be present on the BUS POWER and BUS/REGEN terminals of TB1 on the servodrive. These voltages may be LETHAL. Appropriate precautions must be taken when working with or near these terminals to avoid personal INJURY or DEATH!

LED Label	Color	Illuminated when...
BUS POWER	Yellow	Main DC Bus Power is on.

***Table 15**, Bus Power LED Status Indicator*

4.2.2 Marker LED

The Marker LED is located just below the Status ID and to the left of the Torque LED. This LED is on when the once per revolution marker is active. On quadrature feedback drives (SAC-x-AQ) the LED tracks activity on the ENCZ and ENCZ' inputs. When the differential pair is high the LED is on.

On resolver feedback drives (SAC-x-AR) the LED is on when the resolver is within 1 count of the 0 position of the resolver.

In both cases the time the LED is on (i.e. the width of the pulse) is a function of speed of the motor. If the motor travels quickly through the marker region the LED may not be on long enough to be visible.

4.2.3 Torque LED

The torque monitor LED is located just below the Status ID to the right of the Marker LED. This LED is used as an indication of the torque command activity. The intensity is proportional to the level of the torque command and the color varies from Red for positive torque command to Green for negative torque command.

4.2.4 Status ID

The segmented STATUS LED located above the RS232 connector P1 provides valuable information on any fault condition that may occur in the servodrive.

If the Status LED is a rapidly rotating segment display, the servodrive is alive and operating, and no fault condition exists. When a drive alarm exists, the Status display will show the alarm code (shown on the next page in **Table 16**, Servodrive Alarm Codes). There is a more detailed table of alarm codes which shows cause-and-effect for many of these alarms in Section 7.1, Servodrive Troubleshooting Guide (page 115).

All drive alarms cause torque to be disabled at the motor. Drive alarms ***90 – 99*** and ***9A-9F*** may require cycling control power to clear the alarm. All other alarms can be cleared by setting FAULT=0 (after the cause of the alarm has been cleared).

Alarm Code[1]	FAULT	Condition	Description
90-99 9A-9F	144-159	Internal Drive Error	Should be reported to Ormec Customer Service Internal error ***98*** indicates that the manufacturing calibration of the drive has not been done.
A0	160	Drive RMS Over Current	The actual RMS current has exceeded the drive's rated continuous current longer than the allowed time (2 seconds at peak current).
A1	161	Peak Over Current	The peak current rating for the drive or motor was exceeded. The motor's peak current rating is an UltraTools setting.
A3	163	Low Bus Voltage	The bus voltage is below 90 VDC (usually due to disabled main power).
A6	166	Drive Not Configured	An attempt was made to enable torque before the drive's setup parameters have been configured.
A8	168	Invalid Commutation Position	An invalid commutation position was detected, possibly due to an encoder failure.
A9	169	Phase Loss	Loss of a main power phase.
AA	170	No Bus Voltage	No bus voltage was detected. The SCR has not been commanded ON when trying to enable the drive
AC	171	Soft Start Error	An overtemperature condition was detected in the drive powerblock, or a failure of the inrush current resistor.
B0	176	Download checksum error	A checksum error was detected in the FlexROM2 upgrade file sent to the drive. No upgrade was performed.
B1	177	Incompatible file	The drive does not recognize the file (data) sent as an upgrade as being a valid upgrade file. Check the file and try again.
B2	178	Incompatible version	The upgrade file sent to the drive will not work on this drive. A version 1 file was sent but a version 2 (FlexROM2) file is needed.
B3	179	Internal checksum error	The drive firmware stored in non-volatile memory has been corrupted.
C1	193	Hardware Disable	Analog (Ext Ctrllr) Mode. Drive disabled by hardware enable input (Check hardware enable input).
C2	194	Software Disable	Serial (Utools) Mode. Drive disabled by software enable command (Check DRVENA command).

[1] *Also see Section 7.1, Servodrive Troubleshooting*

Table 16, *Servodrive Alarm Codes (continued on next page)*

Alarm Code[1]	FAULT	Condition	Description
F1	241	Motor RMS Over Current	The motor's rating for continuous current has been exceeded by the actual RMS current for longer than allowed by the thermal time constant of the motor. (UltraTools software setting)
F2	242	Power Module Fault	The Power Module's self-protection has detected a short circuit, over current, over temperature or control supply under voltage.
F3	243	High Bus Voltage	The bus voltage is excessive. The trip point depends on the rated voltage of the motor, an UltraTools software setting: • Motor rated for 115 VAC: trip point = 237 VDC • Motor rated for 230 VAC or above: trip point = 425 VDC
F4	244	Motor Over Temperature	Open contact at P3 pins 14-15. See Section 4.9, page 65.
F7	247	Motor Feedback Open Wire	At least one motor feedback channel is not connected properly. On quadrature feedback drives check ENCA, ENCA', ENCB, ENCB' (P4 pins 5,6,7,8). For resolver feedback drives check SIN+, SIN-, COS +, COS – (P4 pins 3, 4, 5, 6).
F8	248	Watchdog Timeout	DSP Watchdog timeout error.

[1] *Also see Section 7.1, Servodrive Troubleshooting*

Table 16*, Servodrive Alarm Codes (continued from previous page)*

4.3 RS-485 Communication Mode

All current SAC-Gxx and older G-Series servodrives with part numbers Gxx-AEC-xxx support an RS485 multi-drop network. Servodrives with this feature enabled use RS485/422 differential signals and addressing protocol to determine which drive responds to commands on the communications bus.

Documentation for electrical connections can be found in Appendix B. Detailed documentation on the software commands can be found in Appendix G.

This section describes the operation of the drive when in RS485 mode.

NOTE: If more than 4 G-Series drives are connected together on the same RS485 communications bus, the terminating resistors for all the drives *except the first and last* on the network must be removed. Refer to section 4.3.4 RS485 Terminating Resistors for further information.

4.3.1 RS-485 Overview

Two commands, RS-485 and RS-485EN are added to support operation in RS485 mode. The 1st command sets the node ID for the drive. The 2nd command is used to select the active node on the bus. Further details can be found in Appendix G.

RS-485 operation requires the following steps:

1. Enable RS-485 operation using the RS-485 command. The drive can be configured to use a software set ID or a hardware ID. Enabling RS-485 mode and setting the ID is done using the RS-485 command.
2. Issue a STORE command after the RS-485 command to make the selection non-volatile.
3. Reset or power cycle the drive. Upon power up it will enter RS-485 mode.
4. Be sure to use a cable wired to the 485 differential pins. Note that RS232 and RS485 communications use the same connector, P1. However, the pinout is different for each mode, with some dual use pins. Reference **Table 5** for details.
5. After power up send carriage returns to autobaud the drive.
6. Use the RS-485EN command to select which drive is active on the network.

4.3.2 RS-485 Node address

Every drive on the 485 bus must have a different node ID. This allows selection of only one drive to "talk" on the bus. Only one drive at a time should electrically drive the bussed transmit lines.

Valid addresses are 1 to 16, allowing up to 16 drives on one bus. Using command RS-485 a value of 1 to 16 provides a software set address of 1 to 16. A value of 100 indicates that the Digital Inputs should be sampled at power up and used to set the node ID to a value of 1 to 15. Note, setting the ID using the software command allows access to address 16, while using the hardware method 16 is not available.

4.3.2.1 Software Node ID and power up

When using a software set node ID the drive will:

1. Display a flashing P on the 7-segment display during the first 30 seconds after power up.
2. During those 30 seconds the drive is communicating in RS232 mode. This approach provides a method to disable RS-485 mode on a drive when you don't know the address or don't have 485 capable hardware in the host. During the 30 seconds, using the RS232 pinout on P1 you may query the address using command RS-485 or disable 485 operation by entering command RS-485 0 followed by a STORE, followed by a RESET.
3. At the completion of power up processing the P will stop flashing and the drive will be communicating in RS-485 mode. Autobaud and RS-485EN command will be needed to communicate with the drive

4.3.2.2 Hardware Node ID and power up

When using a hardware set node ID the drive will:

1. Display a lower case r during a one second wait at power up.
2. At the end of the 1 second delay sample Digital Inputs INP1, INP2, INP3 and INP4.
3. The ID found is displayed on the 7-segment display. This serves as a visual verification that the ID was found and a debug aid during development.
4. The drive will delay approximately 1 second, then continue with power up processing.
5. At the completion of power up processing the drive will be communicating in RS-485 mode. Autobaud and RS-485EN command will be needed to communicate with the drive. The Digital Inputs will then function as Digital Inputs.
6. When setting the hardware node ID, IN_COM will need to be grounded and a voltage is applied to INP1 to INP4. Pin outs can be found at 3.6.5 Supplemental Input Port (P3), page 29 or 3.6.4 Controller Port (P2), page 25. Mapping of inputs to RS-485 ID is as follows:

INP4	INP3	INP2	INP1		RS-485 ID
open	open	open	open		0 – unused. Enter RS-232 mode.
open	open	open	+V		1
open	open	+V	open		2
open	open	+V	+V		3
open	+V	open	open		4
open	+V	open	+V		5
open	+V	+V	open		6
open	+V	+V	+V		7
+V	open	open	open		8
+V	open	open	+V		9
+V	open	+V	open		10
+V	open	+V	+V		11
+V	+V	open	open		12
+V	+V	open	+V		13
+V	+V	+V	open		14
+V	+V	+V	+V		15

Open indicates no current in the input optocoupler. This can be accomplished by leaving the input open or by shorting the input to IN_GND.

+V indicates a voltage is applied to turn on the input. Valid voltages are 5 – 24 VDC.

4.3.3 RS-485 Operation

When the drive is operating in RS-485 communication mode a few changes take place. These changes are provided to assist in recognizing which drive is the active drive on the 485 bus.

The drive uses the 7-segment display to indicate when the drive is not enabled by displaying a C1 or C2. In 485 mode:

If drive is not the active RS485 drive

C1 Drive disabled by hardware enable input (Check hardware enable input)

C2 Drive disabled by software enable command (Check DRVENA command)

If drive is using RS485 and is the active RS485 drive (RS-485EN <node> received with this node addressed)

c1 Drive disabled by hardware enable input (Check hardware enable input)

c2 Drive disabled by software enable command (Check DRVENA command)

notice that the c is lower case.

When the servodrive is enabled the display is a rapidly rotating figure 8 pattern. When the drive is the active RS485 drive then this pattern will rotate half as fast.

4.3.4 RS485 Terminating Resistors

An RS485 communications bus requires signal line terminating resistors on the first and last nodes (drives) on the network. All G-Series drives are shipped with the terminating resistors installed.

For networks consisting of four drives or less, simply connect the drives together on the network. The total impedance of the terminating resistors should be high enough to allow proper operation.

For Networks with more than four drives, the terminating resistors in all the drives *except the first and last* in the network must be removed as per the following instructions.

1) Locate a small access hole on the top of the drive. Inside you will see a 2-pin jumper.
2) With a small pliers remove the jumper. Removal will disconnect the termination resistor.

4.3.5 Debugging RS485 Communications

Setting up a RS485 communication network can be frustrating when a problem develops and it's not clear what the problem is. A number of features are available to assist with this process.

1) In RS485 mode, just as in RS232 mode, initial carriage returns are needed to autobaud the drive so that it configures for the correct baud rate. Wait until the drive enters RS485 mode before issuing the carriage returns.
2) For software set node IDs, during the 1st 30 seconds after power up (while the P is flashing) the drive is in RS232 mode and the RS485 address can be queried (RS-485?) or RS485 operation can be disabled (RS-485 0).
3) For hardware set node IDs you may enter RS232 mode by simply disconnecting all signals from the digital inputs. This will be identified as invalid address 0 and cause the drive to remain in RS232 mode. Also remember that the INP1 and INP2 are connected in parallel on P2 and P3. Be sure to disconnect from both.
4) While RS485 mode is enabled the display changes when the drive is the active drive on the network. This aids in determining that the address communications are working.

4.4 Servodrive Commutation Modes

By default, Servodrives are configured to control permanent magnet brushless DC servomotors using sine-wave commutation. The Drive can be configured for trapezoidal commutation using the SIXSTEP command. (Quadrature version only.) This can be useful when integrating third-party motors.

4.5 Commutation Feedback

In order to control the motor it is necessary for the drive to know the rotary position of motor relative to the physical windings. This information is provided by the commutation feedback device.

The Servodrives support two different styles of feedback devices, quadrature and resolver. The quadrature signals are provided by an encoder, which typically uses an optical disk to produce a pair of square waves. These provide a high resolution position of the motor. These devices also include 3 hall channels which provide the needed relation to the physical windings.

A resolver uses a different technology to provide position feedback. The resolver is basically a rotating transformer with two windings wound 90 degrees apart. A reference sine wave is sent to the resolver and two sine waves are returned 90 degrees apart. Based on the amplitude of the two return signals it is possible to determine the angular position of the motor. In this case no "hall" information is needed.

The G-Series servodrives are capable of using either type of feedback device. Interfacing to quadrature feedback devices requires drive version SAC-

GxxxxQ (Q for quadrature) and interfacing to resolver feedback devices requires drive version SAC-GxxxxR (R for resolver). Details about these feedback signals can be found in the next sections.

4.5.1 Commutation Feedback Signals – Quadrature Feedback drive

Commutation position signals are illustrated in **Figure 15** for drives configured for quadrature feedback, SAC-GxxxAQ versions.

The Hall U, V and W signals are "on" for 180° spaced 120° apart and allow the Drive to determine motor position for commanding current. These signals are used to determine rotor position whenever the Drive is operating in trapezoidal commutation mode (SIXSTEP).

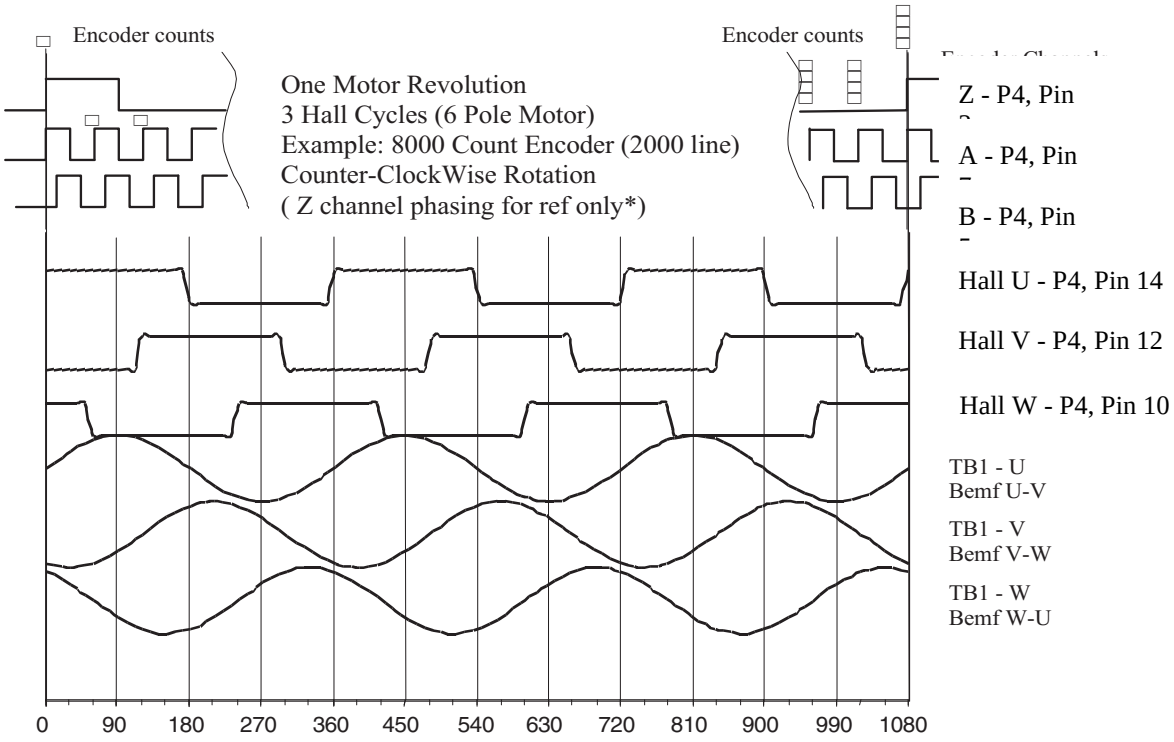


***Figure 15**, Hall signals and Motor Back EMF waveforms*

If the the motor's back emf and commutation signals are not directly in phase, the HOFFSET parameter can be used to compensate for the offset.

The state of the commutation signals can be displayed using the HALL variable and **Table 17**. To verify that the commutation feedback is correct, rotate the motor shaft clockwise or counter-clockwise and confirm that the HALL value proceeds through the sequence indicated in **Table 17**.

Counter-Clockwise Rotation		Clockwise Rotation	
W, V, U	**HALL**	**W, V, U**	**HALL**
101	5	100	4
001	1	110	6
011	3	010	2
010	2	011	3
110	6	001	1
100	4	101	5
Note: Clockwise and Counter-Clockwise shaft rotation refers to rotation when viewing the end of the motor shaft			

***Table 17**, HALL Sequence*

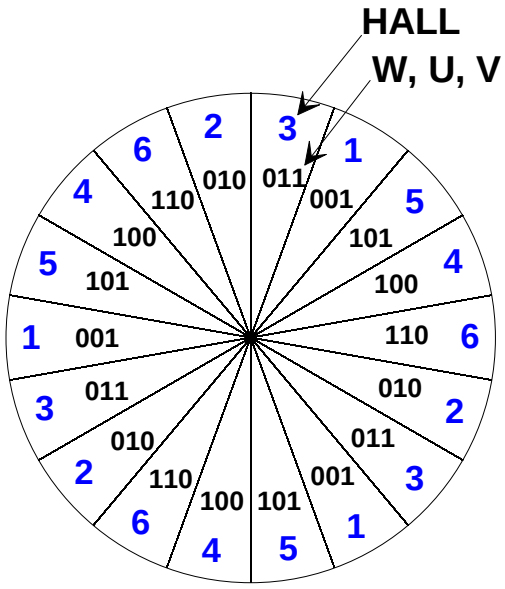
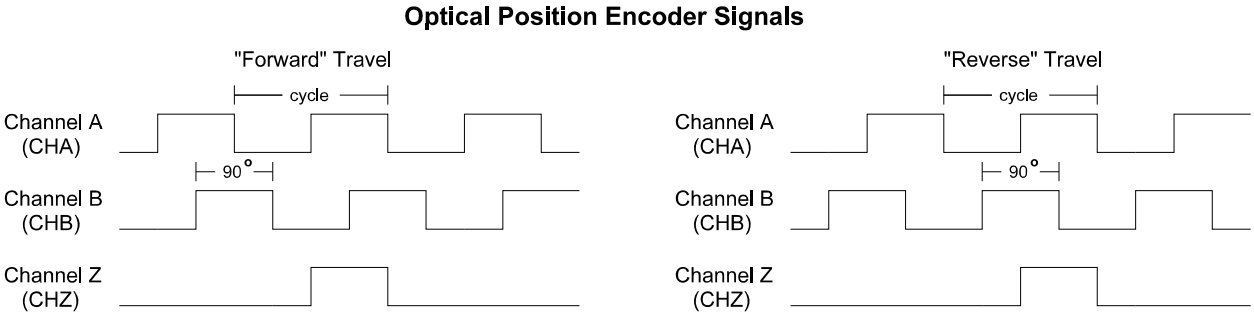


***Figure 16**, Valid Hall States (6 Pole Motor Example diagram)*

4.5.2 Quadrature Feedback Signals –Quadrature Drives

Quadrature position signals for "Forward" and "Reverse" travel are illustrated in **Figure 17**.

Channel A and Channel B are phase quadrature signals, which allow the Servodrive and associated digital positioning electronics to determine both travel distance and direction. Programmable motion controllers, such as ORMEC's, typically decode each transition of both encoder channels, yielding a resolution of four times the linecount specification per revolution e.g. A position encoder with 4096 linecount, when decoded by an ORMEC Controller yields a positioning resolution of 16,384 cts/rev.



NOTE: Channel Z (once per revolution marker channel) is synchronized with Channel A.

***Figure 17**, Quadrature Encoder Channel Description*

4.6 Commutation Feedback Signals – Resolver Feedback drive

A resolver works by receiving a reference sine wave of a given frequency and amplitude. The resolver on the motor then couples this like a transformer into two other windings, SIN and COS, which are 90 degrees apart. The SIN and COS signals are returned to the drive where they are decoded and the position determined.

There are design variations in resolver which may need to be compensated. The UltraTools development system will help you configure the servodrive for your specific resolver. Direct commands can also be used. The servodrive has adjustments for:

- Excitation frequency – the frequency of the reference signal. Some resolvers won't handle high freqencies. As the frequency changes, the impedance of the resolver changes and the ability of the resolver to couple the signal to the output windings changes. In some cases getting low enough that the resolver does not operate. Also, as the impedance goes down the current in the reference signal will go up. With higher current comes higher voltage drop. As long as it is within the limits of the drive the system will work. See command R.RFREQ for directly setting this value.

- Transformation Ratio – the gain of the resolver reference in to SIN and COS out can vary, typically ranging from 0.5 to 2. The servodrive expects SIN and COS to be 2 Vrms. The servodrive can be configured to meet this requirement for transformation ratios of 0.25 to 2. See command R.TRATIO for directly setting this value.

The REF signal is provided by the drive and sent to the resolver. The SIN and COS signals are returned and are spaced 90^{o} apart and allow the Drive to determine motor position for commanding current.

If the motor's back emf and commutation signals (SIN & COS) are not directly in phase, the ROFFSET parameter can be used to compensate for the offset.

The drive requires that the SIN and COS signals be phased such that the POS command returns an increasing value when the motor is rotated counter-clockwise as viewed from the shaft end. If the POS value is decreasing, reversing the SIN and COS pairs will usually help. The signals labeled SIN and COS by the motor manufacturer do not always have the same phasing from manufacturer to manufacturer.

Position controllers also need motor position feedback. Most controllers do not accept resolver signals for that feedback. The G-Series Servodrive generates a quadrature equivalent which is provided for use by the controller, available on connector P2. The resolution of the quadrature feedback is set independent of the resolver commutation resolution using the R.QRES command. This resolution cannot be set higher than the resolution of the commutation resolution (see R.RESOL).

4.7 Control Architecture

The G-Series servodrive is capable of operating in one of 3 control modes, torque, velocity and position. The command input for the control mode can come from one of 4 input paths. The input path and the control mode can be set independently.

4.7.1 Control Modes

4.7.1.1 Torque Mode Control

In torque control mode the input command is interpreted as a torque command. This is sometimes referred to as current mode. The servodrive controls the current to the motor which produces the desired torque.

Only the current loop is operational in the servodrive. Gains for this loop are based on motor characteristics and are set using the Current tab of the motor setup in Ultratools.

4.7.1.2 Velocity Mode Control

In velocity control mode the input command is interpreted as a velocity command. The servodrive controls the current to the motor to keep the motor running at the desired velocity. The drive uses the motor feedback, encoder or resolver, to measure the velocity of the motor.

Both the velocity loop and the current loop are operational. Gains for these loops are found in Ultratools on the Velocity and Current tabs of the motor setup..

4.7.1.3 Position Mode Control

In position control mode the input command is interpreted as a posiiton command. The servodrive controls the current to the motor to keep the motor positioned at the desired position. Changing the position causes the motor to move. To move at a desired velocity while maintaining position accuracy requires that the input change so as to produce the desired velocity, which is the change in position per time. The drive uses the motor feedback, encoder or resolver, to measure the position and velocity of the motor.

The position, velocity and current loops are all operational. Gains for these loops are found in Ultratools on the Position, Velocity and Current tabs of the motor setup..

4.7.2 Command Inputs

4.7.2.1 Analog control input

The G-Series servodrive has an analog command input port. It is found on connector P2. The input accepts analog inputs from -10 v to +10 v.

This input is selected by executing the ANALOG command.

4.7.2.2 Serial control input

The G-Series servodrive can accept command inputs via the serial port. When in this mode the other control inputs are ignored. When in this mode the control input is set using the command CMD.

This input is selected by executing the SERIAL command.

4.7.2.3 Profile generator control input

The G-Series servodrive has an on board profile generator which can be used for the control input. This profile generator is primarily designed to allow tuning of the control loops in the drive.

The profile generator is automatically configured and operated when using the tuning controls in UltraTools.

This input is selected by executing the PRFENA 1 command.

4.8 Regenerative Loads

Regenerative loading occurs when the direction of power flow is from the machine to the motor: the motor is acting as a generator. Another way of describing this is that the load torque is acting in a direction to 'help' the motor to move in the commanded direction of motion. This can occur for a variety of reasons including:

1) Decelerating the machine faster than it would coast, especially from high speeds and with large inertial loads;

2) Using the motor to act as a brake on an unwind stand for a roll of material, where the tension in the web causes the motor to brake while moving forward; and

3) Using the motor to lower a vertical load that is not counterbalanced.

In many cases, this extra energy is dissipated by machine friction, or stored temporarily in the drive's power capacitors. However, if the amount of regenerative energy is excessive, it must be shunted to an external regenerative resistor, in order to prevent a high bus voltage condition. For assistance determining if your application has a regenerative load component, contact your ORMEC Sales and Applications Engineer.

4.8.1 Shunt Regulator

Servodrive models G210 through G260 and all G4xx models have shunt regulator circuitry for dissipating excessive regenerative voltage.

The shunt regulator consists of a voltage comparator and a switching transistor. When the voltage comparator detects excess bus voltage, it turns on the shunt regulator transistor, dissipating energy from the servodrive capacitors to the external regen resistor. The on-time duty cycle is controlled by the Servodrive, so that the average current is appropriate for the regen resistor specified in the UltraTools project software setting.

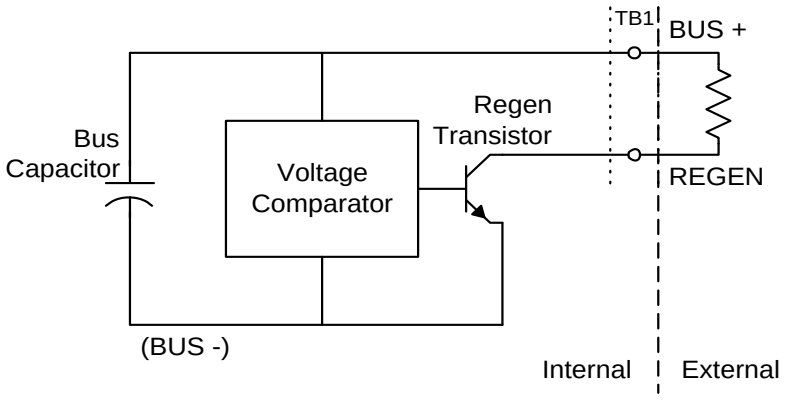


Figure 18, *Simplified Schematic of Shunt Regulator*

4.8.2 Sizing a Regen Resistor: Application-specific Formulas

Regardless of the type of application, the value of interest is **Average Regenerative Power**.

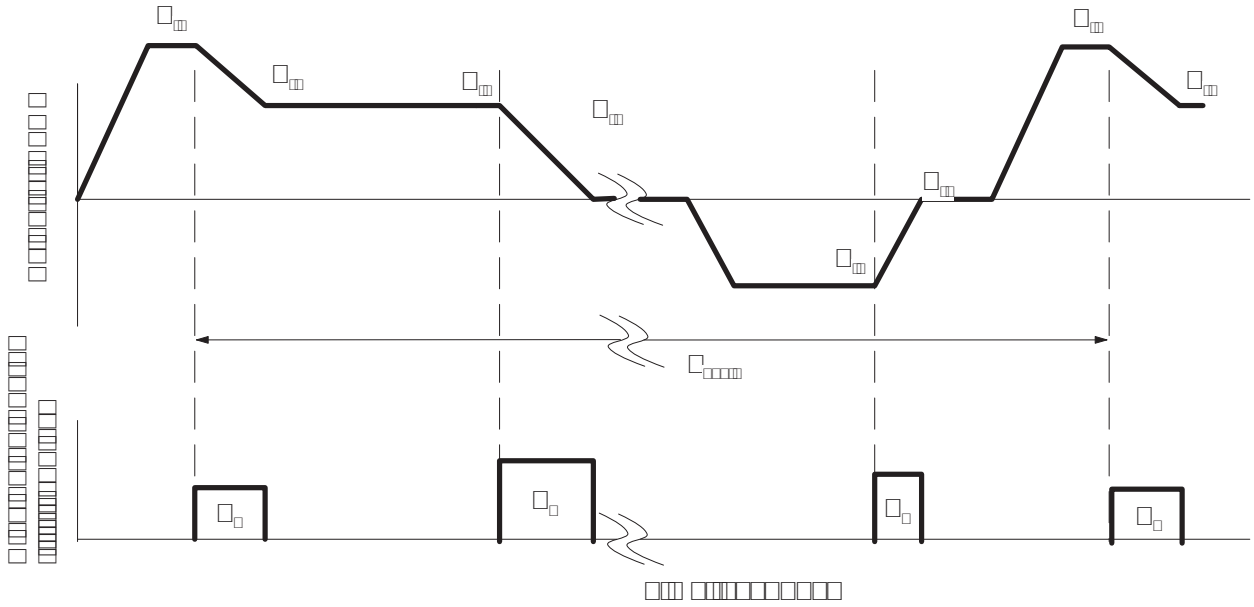


Figure 19*, Regeneration During Deceleration*

4.8.2.1 Sizing a Regen Resistor: Regeneration Due To Decleration

Regeneration during a motor's deceleration is due to the decreasing kinetic energy of the rotating inertia. Not all of this energy will make it back to the DC bus; some or all of it may be absorbed by machine friction and motor losses. In the case of sizing regen resistors, neglecting frictional losses is a conservative approach to sizing a regen resistor.

Each deceleration in a cycle results in a loss of kinetic energy at the motor. Depending on frictional losses, some or all of this energy may make it back to the drive as **Regenerative Energy**. Rotational kinetic energy at any velocity can be calculated with the general equation $E = \frac{1}{2} I\omega^2$. Applying the appropriate units conversions:

$$E_{regen} = \tfrac{1}{2} I \cdot (V_i^{\,2} - V_f^{\,2}) \cdot (0.00124) \qquad \textit{(Equation 1)}$$

where: E_{regen} is the loss of kinetic energy during a deceleration (Joules)
I is the total system inertia (motor + load) (in-lb-sec^2)
V_i is the initial speed of the motor before deceleration (RPM)
V_f is the final speed of the motor after deceleration (RPM)
(0.00124) is a units conversion: $\frac{(2\pi \text{rad/rev})^2 \cdot (4.448 \text{N/lb})(25.4 \text{mm/in})}{(60 \text{sec/min})^2 (1000 \text{mm/m})}$

Average Regenerative Power for the total cycle can be calculated as:

$$P_{avg} = \frac{E_1 + E_2 + \cdots + E_n}{T_{cycle}} \qquad \textit{(Equation 2)}$$

where P_{avg} is the average dissipated power over the entire cycle (Watts)
E_1 is the energy dissipated by the 1st decel in the cycle (Joules)
E_2 is the energy dissipated by the 2nd decel in the cycle (Joules)
…
E_n is the energy dissipated by the Nth decel in the cycle (Joules)
N is the number of decelerations in the cycle
T_{cycle} is the total repetitive cycle time (seconds)

4.8.2.2 Sizing a Regen Resistor: Regeneration Due To Web Tension (motor acting as brake)

The regeneration in a tensioned-web application is due to the web tension pulling the braking motor along in the same direction that it is moving.

Average Regenerative Power is calculated with the general formula: $P = T\omega$. Applying the appropriate units conversions:

$$P_{avg} = (0.0118) * T \cdot V \qquad \textit{(Equation 3)}$$

where P_{avg} is the continuous regenerated power (Watts)
T is the torque at the motor due to web tension (in-lb)
V is the velocity of the motor shaft (RPM)
(0.0118) is a conversion: $\frac{(2\pi \text{rad/rev})(25.4 \text{mm/in})(4.448 \text{N/lb})}{(60 \text{sec/min})(1000 \text{mm/m})}$

4.8.2.3 Sizing a Regen Resistor: Regeneration Due to Vertical Load

In an application where the motor is supporting the weight of an uncounterbalanced load, regeneration may occur when the load is being lowered. This is due to gravity 'helping' the motor lower the load.

Instantaneous Regenerative Power can be calculated with the formula $P = T\omega$. Applying the appropriate units conversions:

$P_{instant} = (0.0118) * T * V$ *(Equation 4)*

where $P_{instant}$ is the instantaneous regenerated power (Watts)
T is the torque at the motor due to load weight (in-lb)
V is the speed of the motor during downward motion (RPM)
(0.0118) is a conversion: $\frac{(2\pi rad/rev)(25.4mm/in)(4.448N/lb)}{(60sec/min)(1000mm/m)}$

Average Regenerative Power for the total cycle can be calculated as:

$$P_{avg} = \frac{P_1 \cdot T_1 + P_2 \cdot T_2 + \cdots + P_n \cdot T_n}{T_{cycle}}$$ *(Equation 5)*

where P_{avg} is the average dissipated power over the entire cycle (Watts)
P_1 is the power dissipated by the cycle's 1st downward move (Joules)
T_1 is the time spent in the cycle's 1st downward move (seconds)
P_2 is the power dissipated by the cycle's 2nd downward move (Joules)
T_2 is the time spent in the cycle's 2nd downward move (seconds)
…
P_n is the energy dissipated by the cycle's Nth downward move(Joules)
T_n is the time spent in the cycles Nth downward move (seconds)
N is the total number of downward moves in the cycle
T_{cycle} is the total repetitive cycle time (seconds)

4.8.3 Sizing a Regen Resistor: Use Average Regenerative Power

Once Average Regenerative Power has been determined using one of the methods in section 4.8.2, the sizing of the resistor is nearly complete.

The wattage of the regenerative resistor should be greater than or equal to the application's calculated Average Regenerative Power.

The next section shows the minimum resistance requirements, as well additional limitations on the regen power that can be shunted, based on the Servodrive's shunt transistor.

4.8.4 Sizing a Regen Resistor: Regen Transistor and Resistor Limitations

The amount of energy that can be dissipated by an external regen resistor may be limited by the current capability of the switching transistor.

Table 18 below shows the rated maximum continuous current of the Servodrive's regen transistor circuitry, as well as the minimum resistance for any external regen resistor.

NOTE: **Do not use a lower resistance than shown in the table below! Too low a resistance may result in peak currents that are too high for the regen transistor, and could result in damage to the transistor.**

	Regen Resistor	**Drive Regen Power Output**	**Regen Transistor**	
ServoWire Drive	**Minimum Resistance**(1)	Maximum Average Power(3)	Peak Current(2)	Bus Capacitance
SAC-G203 SAC-G205	Regen Transistor not available.			540 µF
SAC-G210	50 Ω	800 W	8.5 A	1,170 µF
SAC-G217 SAC-G220	35 Ω	1200 W 1700 W	12 A	1,410 µF
SAC-G225	7.8 Ω	3000 W	50 A	3,360 µF
SAC-G235		4175 W		
SAC-G260	5.0 Ω	7100 W	75 A	
SAC-G405	70 Ω	1200 W	11.4 A	560 uF
SAC-G410	40 Ω	2400 W	20 A	
SAC-G417	40 Ω	4000 W	20 A	840 uF
SAC-G425	25 Ω	5970 W	32 A	
SAC-G435	20 Ω	8350 W	40 A	1120 uF
SAC-G450	15 Ω	12000 W	53.3 A	

1 Minimum resistance – limited by drive transistor.

2 Calculated using minimum resistance at maximum voltage.

3 Average Regen Output Power which the drive can sustain over time without failure

***Table 18**, Regen Resistor Selection Requirements*

The actual resistance of the regen resistor determines the current in the resistor. Using Ohms law the current when the regen transistor turns on will

be I = V/R. V will be 395 V or 775 V depending on the drive bus voltage setting. The table shows what the current will be for the minimum resistance allowed.

When using the minimum resistance value the power output (dissipated in the resistor) will be much higher than the drive and usually the resistor can sustain. Having this peak capability allows the drive to remove a large amount of energy quickly. For example, using the SAC-G425 values: $P = V^2/R$. With V = 775 V and R = 25 ohms the instantaneous power is $775^2/25$ = 24,025 W. For a short time the drive and resistor (properly sized) can tolerate this power. The column "Maximum Average Power" shows how much average regen power the drive can sustain without damage. Verfying that the Average Power requirements are met is accomplished by analysis of the application.

The resistors current and power ratings may also limit the amount of energy that can be dissipated by a regen resistor. The peak current that will be seen by the resistor is shown in **Table 19**. This current is limited by the regen resistor's resistance value, so if a higher resistance is used, the peak current will be lower.

The G-Series Drive uses an on-off duty cycle limits the average current that will be seen by the resistor. This limits the average current so that neither the wattage of the resistor (configuration software setting) nor the continuous current of the regen transistor is exceeded on a continuous basis.

Regen Resistor	Resistance	Wattage	Peak Current on 230 V drive (425 VDC max)	Peak Current on 460 V drive (800 VDC max)
SAC-SMRR/0055	50 Ω	55 W	8.5 A	16 A
SAC-SMRR/0095	40 Ω	95 W	11 A	20 A
SAC-SMRR/0700	54 Ω	700 W	7.9 A	14.8 A
SAC-SMRR/0845	40 Ω	845 W	11 A	20 A
SAC-SMRR/0846	10 Ω	846 W	43 A	Not supported on 460 V drives
SAC-SMRR/1700	6.5 Ω	1,700 W	65 A	

***Table 19**, Standard Regen Resistor Specifications*

The regen resistors are voltage rated for up to 1000 VDC allowing them to be used on both the 230 VAC and 460 VAC drives. When applying the resistor the minimum resistance supported by the drive must not be exceeded. **Table 20** shows which regen resistors are compatible with which drives. Entries with a Pk indicate that the combination provides regen output at or near the peak regen capacity of the drive, however, the power rating of the resistor is not rated for continuous operation at that output level.

Regen Resistor			Drive Model SAC-G								
Model Number SAC-	**Resis-tance**	**Power Rating**	**210**	**217, 220**	**225, 235**	**260**	**405**	**410, 417**	**425**	**435**	**450**
SMRR/0055	50 Ω	55 W	Pk	Y	Y	Y		Y	Y	Y	Y
SMRR/0095	40 Ω	95 W		Pk	Y	Y		Pk	Y	Y	Y
SMRR/0230	81 Ω	230 W	Y	Y	Y	Y	Y	Y	Y	Y	Y
SMRR/0650	72 Ω	648 W	Y	Y	Y	Y	Pk	Y	Y	Y	Y
SMRR/0700	54 Ω	700 W	Pk	Y	Y	Y		Y	Y	Y	Y
SMRR/0825	26 Ω	825 W			Y	Y			Pk	Pk	Y
SMRR/0845	40 Ω	845 W		Pk	Y	Y		Pk	Y	Y	Y
SMRR/0846	10 Ω	846 W			Pk	Y					
SMRR/1650	15 Ω	1650 W			Y	Y					Pk
SMRR/1700	6.5 Ω	1,700 W				Pk					
Y = combination acceptable, Pk = acceptable and at or near peak regen output capacity of the drive											

Table 20, Standard Regen Resistor Drive Compatibility

The voltage seen by the resistor will range between the Turn-On level and the High-Bus level, as shown below in **Table 21**.

Nominal Input Voltage (VAC)	Nominal Bus Voltage (VDC)	Turn On Regen Transistor (VDC)	High Bus Voltage Alarm (VDC)
230	325	395	425
460	650	775	800

***Table 21**, Regen Transistor Turn-On and other Bus Voltage Levels*

4.8.5 Bus Sharing

The extra energy generated by regenerative loads can also be dissipated through bus sharing. In a shared-bus configuration, the bus capacitors are all connected in parallel, magnifying the total bus capacitance by the number of drives present (see **Figure 20**). Also, the regenerative energy generated by one drive can be used to reduce the input power requirements of any other active drives on the shared bus. However, if the amount of regenerative

energy available is excessive, it must be still be shunted to an external regenerative resistor, in order to prevent a high bus voltage condition. For assistance in determining how to use bus sharing in your application, contact your ORMEC Sales and Applications Engineer.

4.8.5.1 Bus Sharing Limitations

Bus sharing is supported by Servodrive models ***G225, G235, G260 and G4xx only***, and is subject to the following restrictions:

- Drives that are sharing the DC bus must also be connected to a main input power source and a control input power source.
- Main input power should be applied to all shared-bus drives within 0.1 seconds to prevent possible damage to internal drive control circuits.
- Bus wiring between drives should be less than 12 inches in length to minimize oscillatory effects.
- **Only one regen resistor may be used in a bus sharing network.** That regen resistor must be sized to handle the regenerative power produced by all of the drives in a shared bus configuration. See Section 4.8, Regenerative Loads for more information on sizing regen resistors.

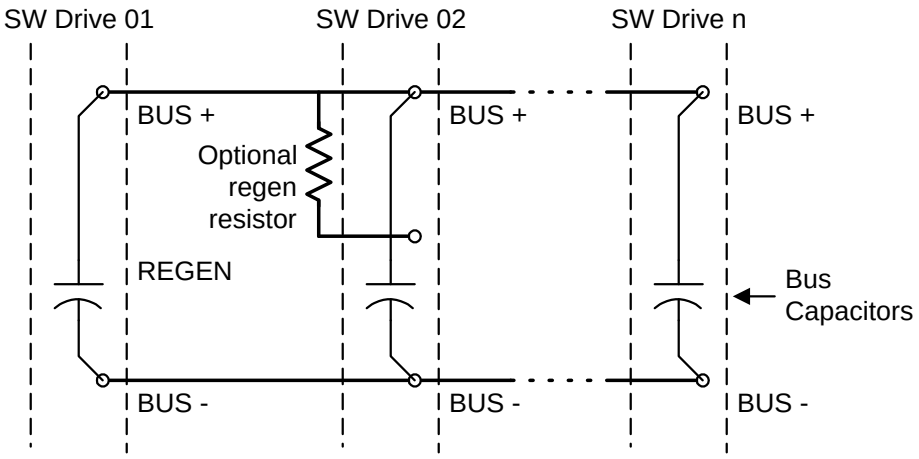


***Figure 20**, Shared Bus Capacitors*

4.8.6 Shunt Regulator Overload

If regenerated voltage is excessive, a High Bus Voltage fault (***F3***) may occur. A High Bus Voltage fault will not reset until the voltage level has dropped to an acceptable level. This will occur faster if you disable main power.

If High Bus Voltage faults recur, one of the following actions may resolve the problem:

- Increase the wattage of the external regenerative discharge resistor. **For this change to be effective, you must also change the**

UltraTools software settings for the Servodrive:
Regen Resistor Power.

- Reduce the commanded current limit for the Controller.
- Reduce the commanded deceleration.
- Decrease the maximum motor speed.
- Reduce the inertial load seen by the motor, either by removing part of the load, or by increasing the gear ratio (motor-to-load).

4.9 Servomotor Temperature Protection

The thermostat contact wiring is part of the Motor Feedback Cable (P3 connector on the Servodrive). When the thermal contact opens, the behavior of the Servodrive will depend on the Servodrive's software configuration in UltraTools:

UltraTools Configurations		
Thermal Switch Exists on Motor	**Motor OverTemp Handling**	**Behavior of Servodrive**
No	No Connection	A closed contact will cause a drive alarm ***F4***. The drive will not be disabled.
Yes	Fault, no disable	If the drive torque is enabled with open OverTemp contacts, a drive alarm ***F4*** will immediately occur. The drive will not be disabled.
Yes	Fault, disable	If the drive torque is enabled with open OverTemp contacts, a drive alarm ***F4*** will immediately disable torque to the motor.

Table 22, *Motor Over-Temperature Input (P3 pins 14-15)*

G-Series Servomotors have embedded thermostats, which open when the motor winding temperature exceeds 155ºC.

DE/DA/DB-Series Servomotors do not have embedded thermostats.

Chapter 5
Getting Started

5 Getting Started

5.1 Test Run

Before doing a test run, check the following points listed in this section. Correct any problems before proceeding.

5.1.1 Servomotor Check

Before test run, check the following.

- Motor mounting and grounding are correct.
- Bolts and nuts are tight.
- For motors with oil seals (IP67), the seals are not damaged and are properly lubricated.
- Motor Power and Feedback Cables are properly attached.

5.1.2 Servodrive Check

- The control and main power voltage should be:

Drive	Control Power – Drive capability	Main Power –Drive capability
SAC-G2xx	115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz **The absolute maximum is 265 VAC.**	115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz **The absolute maximum is 265 VAC.**
SAC-G405, G410, G417, G425	115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz **The absolute maximum is**	230 -20%) to 460 (+15%) VAC, 50/60 Hz **The absolute maximum is 529**

	265 VAC.	**VAC.**
SAC-G435, G450	Only 230 (+15%, -20%) VAC, 50/60 Hz **The absolute maximum is 265 VAC.**	230 -20%) to 460 (+15%) VAC, 50/60 Hz **The absolute maximum is 529 VAC.**

- The main power voltage depends on the servomotor: **MAC-G005A1, G006A1, G010A1, G010B1, G011A1, G015A1, DE003A1, DE-006B1 and DE008C1 servomotors are rated for 115 VAC – <u>not 230 VAC</u>.**
- **CHECK POWER <u>BEFORE</u> APPLYING IT TO THE SERVODRIVE.**
- Check that feedback connector P4 is firmly seated.
- Check that Power terminal block connections (r,t,L1,L2,L3, FG, BUS+,REGEN,BUS-,U,V,W, and FG) are tight.
- Motor wiring is correct.
- The main power interlock circuit disables main power under a Servodrive alarm condition.

5.1.3 Preparation for Test Run

During test run, the driven machine should not be attached to the Servomotor. If it is necessary to start with the driven machine connected to the motor, proceed with great care.

- After checking items above, turn on the control power.
- Enable the main power circuit and measure main DC Bus voltage.
- The front of the Servodrive provides important status indications, described in Section 4.2, Servodrive Status Indications (page 44).

5.2 Establishing Communications

5.2.1 Apply Logic Power

Apply Logic Power to the servodrive. The 7-segment display should indicate a “C2” status code. This code indicates that the drive is software disabled, which is the factory default mode. If the display indicates anything other than “C2”, see Section 7.1, Servodrive Troubleshooting Guide to determine the nature of the code.

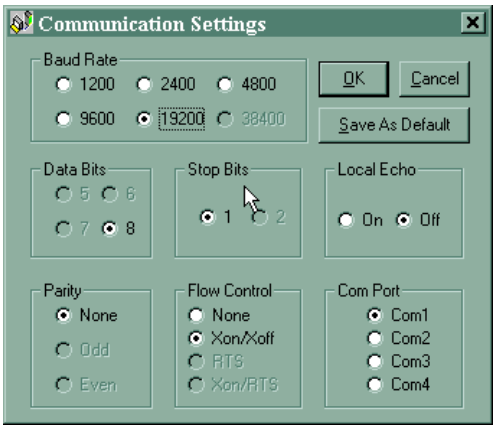
5.2.2 Connect Communication Cable

Plug the communication cable that came with UltraTools into the drive and the Windows-based PC on which you installed UltraTools.

5.2.3 Check Communication Parameters

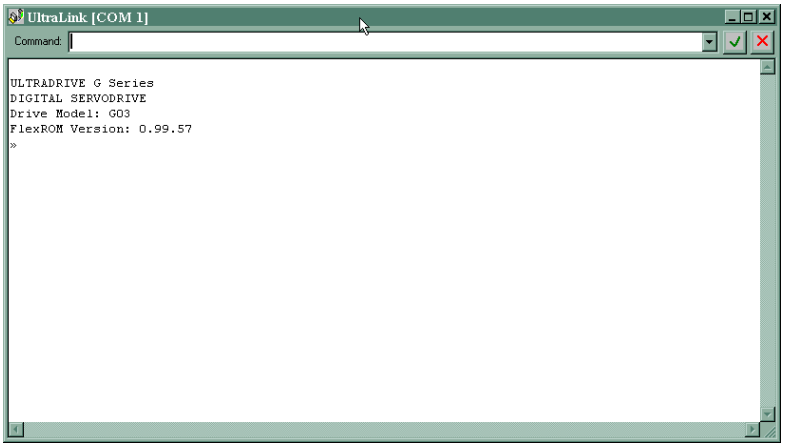
Launch UltraTools, and click the **Com Set Up** toolbar button to edit the communication parameters.

Set the communication parameters to match your hardware configuration in the **Communication Setup** dialog.



5.2.4 Connect to the Drive

Click the **Connect/Disconnect** toolbar button to establish a connection with the servodrive. The following should be observed in the UltraLink Window.



You are now connected to the G Series servodrive and may enter commands directly.

5.2.5 Defining a Servomotor to Use with the Servodrive

Click the Motor Setup toolbar button.

- In the Drive Configuration dialog, select the Motor/Drive tab.
- If you were connected and communicating with a G Series drive, the Drive Selection field is “grayed out” indicating that UltraTools has

already "talked" with the drive and knows what the drive model number is.

- If you have an ORMEC motor or a custom (non-ORMEC) motor, select the ORMEC motor series. (You will use Edit or Add later to define your custom motor.)
- Select your specific ORMEC motor using the Motor Selection pulldown menu. If using a custom motor, you may select any motor similar to the one you're using.
- If you are using a custom (non-ORMEC) motor, click on the Add button to begin definition of a new motor or Edit button now to redefine the motor parameters per your motor, using another motor as a starting point.
- For custom motors, fill in all motor and drive configuration and operational mode fields. Remember to give this motor configuration file a descriptive name in the Model Name entry
- Save your custom motor configuration file by clicking the Save Setup to Disk button at the bottom of the dialog.
- Send your ORMEC or custom motor configuration data to the servodrive by clicking on the Send Setup to Servodrive button. This tells the G Series servodrive all it needs to know to drive the motor you're using.
- Make sure you save the configuration data in the servodrive by clicking the Store Servo in EEPROM button. This will save the setup configuration in EEPROM for use after the servodrive is restarted.

5.2.6 Checking your Configuration

Check your configuration by commanding some amount of current to check rotation. Use the following commands to produce current in the servodrive:

- Type Serial and press enter
- Type INPFN98 +
  or
  Select the N.O. Drive Enable Input option on the Inputs tab in the Motor Config window, to allow the UltraTools Drive Enable/Disable icons to work in Serial Mode.
- Type CMD 1000 and press enter [1000 may be replaced with any number between +/- 32767 appropriate to produce current and rotation]. It should be noted that an unloaded motor should require relatively small command values to produce adequate current for rotation.
- If you are unable to produce rotation in both directions with small current commands, check your setup, particularly the motor pole count and encoder counts per rev values found in the Electrical/Thermal tab called by the Edit button in the Motor/Drive Setup Dialog. If these values are correct, check the motor feedback and power wiring to ensure proper phasing of the motor.

Chapter 6
Specifications

6 Specifications

Ormec products covered by this manual:

Servodrives – 230 V Versions				
SAC-G203	SAC-G205	SAC-G210	SAC-G217	SAC-G220
SAC-G225	SAC-G235	SAC-G260		
Note: Model number format changed in July 2004 to include voltage and the SAC- prefix. For compatibility a drive may be reordered using the previous part number. This manual also covers those drives. To convert from the old number add a SAC- prefix and an 2 after the G, for example from G05 becomes SAC-G205. This only applies to 230 V drives.				
Servodrives – 460 V Versions				
SAC-G405	SAC-G410	SAC-G417	SAC-G425	SAC-G435
SAC-G450				

G-Series Servomotors	**DE/DA/DB-Series Servomotors**
MAC-G005A1	DE003A1, DE003A2
MAC-G006A1, G006A2	DE006B1, DE006B2
MAC-G010A1, G010B1	DE008C1
MAC-G011A1, G011A2, G011B2	DE011C2
MAC-G015A1, G015A2, G015B2	DE021D2
MAC-G016A2, G016B2	DE042E2
MAC-G019A1, G019A2, G019B2	DA030F
MAC-G030A2, G030B2	DA055G
MAC-G040A2, G040B2	DA090H
MAC-G055A2, G055A4	DA110J
MAC-G080A2, G080A4	DA140K
MAC-G115A2, G115A4	DB025L

MAC-G130A2, G130A4	DB055M
MAC-G210A2, G210A4	DB080N
MAC-G280A2, G280A4	DB100P
MAC-G360A2, G360A4	DB200Q
MAC-G640A2	DB300R
	DB330S
	DB465T
	DB700U

6.1 Servodrive Specifications

6.1.1 Servodrive Environmental Specifications

Operating Temperature:	0 to +50°C
Storage Temperature:	-20 to +70 °C
Operating and Storage Humidity	10 to 90%, non-condensing

***Table 23**, Servodrive Environmental Specifications*

6.1.2 Servodrive Mechanical Specifications

Mounting Method: Also see outline drawings in **Figure 1,** Drives 203 - 220 Outline Drawings (page 11).		Vertical panel mounting, three 10-32 (M5) screws (four screws for G225, G235, & G260).	
Dimensions:			
G203, G205 and G210			
Height:	add 2" (51 mm) clearance top and bottom	9.38 inches	(238 mm)
Width:	add 1" (25 mm) clearance each side	3.04 inches	(76 mm)
Depth:	includes clearance for attached cables	10.5 inches	(267 mm)
Weight:	G203 & G205	3.8 lbs	(1.7 kg)
	G210	4.2 lbs	(1.9 kg)
G217			
Height:	add 2" (51 mm) clearance top and bottom	9.38 inches	(238 mm)
Width:	add 1.2" (31 mm) clearance each side	4.25 inches	(97 mm)
Depth:	includes clearance for attached cables	10.5 inches	(267 mm)
Weight:		5.9 lbs	(2.7 kg)
G220			
Height:	add 2" (51 mm) clearance top and bottom	9.38 inches	(238 mm)
Width:	add 1" left-side, 2" (51 mm) right-side clearance	4.4 inches	(112 mm)
Depth:	includes allowance for attached cables	10.5 inches	(267 mm)
Weight:		6.7 lbs	(3.1 kg)
G225, G235 and G260			
Height:	add 2" (51 mm) top, 4" (102 mm) bottom clearance	12.00 inches	(305 mm)

Width:		add 1" (25 mm) clearance each side	7.35	inches	(187 mm)
Depth:		includes allowance for attached cables	11.1	inches	(282 mm)
Weight:			17.8	lbs	(8.1 kg)
G405 and G410					
Height:	add 2" (51 mm) top, 4" (102 mm) bottom clearance		11.0	inches	(279 mm)
Width:	G405	add 1" (25 mm) clearance each side	4.2	inches	(107 mm)
	G410	add 1" (25 mm) clearance each side	4.4	inches	(112 mm)
Depth:		includes allowance for attached cables	10.5	inches	(267 mm)
Weight:	G405		7.9	lbs	(3.7 kg)
	G410		8.3	lbs	(3.9 kg)
G417 and G425					
Height:	add 2" (51 mm) top, 4" (102 mm) bottom clearance		12.00	inches	(305 mm)
Width:		add 1" (25 mm) clearance each side	7.35	inches	(187 mm)
Depth:		includes allowance for attached cables	11.1	inches	(282 mm)
Weight:			17.8	lbs	(8.1 kg)
G435 and G450					
Height:	add 2" (51 mm) top, 4" (102 mm) bottom clearance			inches	(356 mm)
Width:		add 1" (25 mm) clearance each side	14.0	inches	(198 mm)
Depth:		includes allowance for attached cables	7.8	inches	(307 mm)
Weight:				lbs	(8.1 kg)
			12.1		
			22.0		

***Table 24**, Servodrive Mechanical Specifications*

6.1.3 Servodrives General Electrical Specifications

Incoming Main Power Line Voltage – **TB1** pins **L1, L2, L3**	
WARNING: Use the servomotor's voltage rating to determine the maximum input voltage for the servodrive. MAC-G005A1, MAC-G006A1, MAC-G010A1, MAC-DE003A1, MAC-DE006B1, and MAC-DE008C1 are rated for 115 VAC, not 230 VAC! Be sure to check for 230 VAC or 460 VAC motors when using a G4xx servodrive.	
G203, G205:	Single Phase, 50/60 Hz 115 (+15%, -20%) or 230 (+15%, -20%) VAC
G210, G217, G220, G235, G260:	Three Phase, 50/60 Hz 115 (+15%, -20%) or 230 (+15%, -20%) VAC
G405, G410, G417, G425, G435, G450:	Three Phase, 50/60 Hz 230 (+15%, -20%) or 460 (+15%, -20%) VAC
Incoming Control Power Line Voltage –	
G203 – G220: **TB1** pins **r, t** G225 – G260: **TB2** pins **r, t**	Single Phase, 50/60 Hz 115 (-20%) to 230 (+15%) VAC
G405 – G410: **TB1** pins **r, t** G417 – G425: **TB2** pins **r, t**	Single Phase, 50/60 Hz 115 (-20%) to 230 (+15%) VAC
G435 – G450: **TB2** pins **r, t**	Single Phase, 50/60 Hz 230 (+/- 15%) VAC **only**
Main DC Bus Voltage – **TB1** pins **BUS+, BUS-**	
115 VAC nominal input power: 230 VAC nominal input power: 460 VAC nominal input power:	163 VDC nominal level 325 VDC nominal level 650 VDC nominal level
Shunt Regulator Activation DC Bus Voltage:	
115 VAC motors: 230 VAC motors: 460 VAC motors:	207 VDC 395 VDC 775 VDC
High Bus Voltage Fault Activation DC Bus Voltage:	
115 VAC motors: 230 VAC motors: 460 VAC motors:	237 VDC 425 VDC 800 VDC
Low Bus Voltage Fault Activation DC Bus Voltage:	
115 VAC nominal input power: 230 VAC nominal input power: 460 VAC nominal input power:	94 VDC 205 VDC 410 VDC

***Table 25**, Servodrive General Electrical Specifications*

6.1.4 Servodrive Output (**TB1** pins **U, V, W**) Specifications

	Single Phase 115 VAC Input			Single Phase 230 VAC Input		
Drive Model	**Rated Output Power (KVA)**	**Cont Current (Amps RMS/Ø)**	**Peak Current 2 sec (Amps RMS/Ø)**	**Rated Output Power (KVA)**	**Cont Current (Amps RMS/Ø)**	**Peak Current 2 sec (Amps RMS/Ø)**
G203	0.29	2.5	4.4	0.59	2.5	4.2
G205	0.49	4.2	7.4	0.98	4.1	7.1
G210	0.58	5.1	8.8	1.17	4.9	8.5
G217	0.98	8.6	14.8	1.97	8.2	14.3
G220	1.09	9.5	16.5	2.19	9.1	15.8
G225 G235 G260	Not Available			Not Available		

***Table 26**, Servodrive Output (**TB1** pins **U, V, W**) Specifications for Single Phase Input Power*

	Three Phase 230 VAC Input		
Drive Model	**Rated Output Power (KVA)**	**Cont Current (Amps RMS/Ø)**	**Peak Current 2 sec (Amps RMS/Ø)**
G203	Not Available		
G205			
G210	1.95	8.2	14.2
G217	3.32	13.9	24.1
G220	3.91	16.3	28.3
G225	5.98	25.0	50.0
G235	8.37	35.0	70.0
G260	15	60.0	120.0
G405	2.4	5.0	10.0
G410	4.7	10.0	20.0
G417	8.1	17.0	34.0
G425	11.9	25.0	50.0
G435	16.7	35.0	70.0
G450	23.9	50.0	100.0

***Table 27**, Servodrive Output (**TB1** pins, **U ,V, W**) Specifications for Three Phase Input Power*

6.1.5 Servodrive Controller Port Specification (P2)

Analog Input, Analog GND **P2 pins 1,2,3,4**	**Analog Control Input**
V input	+/- 10 VDC typical
Voltage max.	15 VDC
Input Impedance	10 K ohm typical

+5 V **P2 pin 5**	**+5 V Output**
Output Voltage	+5 VDC +/- 7%
Current	15 mA maximum

ENCZ, ENCZ' **P2 pins 7, 6**	**Index/Marker Differential Output**
V low level output V high level output	0.7 VDC max 2.3 VDC min.
V differential	2 V min.
Differential Driver	RS422

ENCA, ENCA', ENCB, ENCB' **P2 pins 10, 11, 8, 9**	**Quadrature Encoder Differential Output**
V low level output V high level output	0.7 VDC max 2.3 VDC min.
V differential	2 V min.
Differential Driver	RS422

NF+, NF- **P2 pins 13, 12**	**Fault Optically-coupled Output**
Max. sink current	30 mA
Low level voltage High level voltage	0.7 VDC maximum (Ic = 20 mA) open collector, no pullup
Absolute maximum	27 VDC

INP1, INP2 & GND P2 pins 14, 15, 16	**Optically-coupled Digital Inputs**
Current to turn on	0.7 mA minimum 7.0 mA maximum
Voltage max.	27 VDC maximum

OUT1-OUT3 & GND P2 pins 17, 18, 19, 20	**Optically-coupled Digital Outputs**
Max. sink current	33 mA
Low level voltage High level voltage	0.7 VDC maximum (Ic = 20 mA) open collector, no pullup
Absolute maximum	27 VDC

ENABLE, FAULT_RESET, RETURN P2 pins 23, 24, 25	**Optically-coupled Inputs**
Current to turn on	0.7 mA minimum 7.0 mA maximum
Voltage max.	20 VDC maximum

Table 28, Servodrive Controller Port Specifications (P2)

6.1.6 Servodrive Supplemental I/O Specification (P3)

INP1-INP4 & GND P3 pins 1-5	**Optically-coupled Digital Inputs**
Current to turn on	0.7 mA minimum 7.0 mA maximum
Voltage max.	27 VDC maximum

OUT1-OUT4 & GND (pins 6-10	**Optically-coupled Digital Outputs**
Max. sink current	33 mA
Low level voltage High level voltage	0.7 VDC maximum (Ic = 20 mA) open collector, no pullup
Absolute maximum	27 VDC

DAC1, DAC2 & GND (pins 11-13)	**Analog Outputs & Analog Ground**
Voltage output range	+/- 10 VDC
Current Output	5 mA maximum
Load Resistance	2K ohms minimum
DAC1: Velocity Monitor (default selection, software configurable)	
DAC2: Current Monitor (default selection, software configurable)	

TMP, TMP GND (pins 14-15)	**Temperature**
Should be normally sinking current to prevent an overtemperature condition.	
Current to turn on	2.5 mA
Voltage max.	+12 VDC maximum

***Table 29**, Servodrive Supplemental I/O Specifications (P3) (continued from previous page)*

6.1.7 Servodrive Motor **Quadrature** Encoder Feedback Specifications (P4)

Use this table for servodrives built for **quadrature** encoder feedback, SAC-Gxxx-x**Q** versions. The quadrature interface uses a female connector on the drive at P4. (The specifications and pinout for the resolver version differ, be sure to use the correct table.)

Quadrature Encoder Drive

ENC PWR, GND (pins 1, 2)	**Encoder Power Supply**
+5 VDC	5 VDC, +/-5% 450 mA max.

ENCA, ENCA', ENCB, ENCB' (pins 5, 6, 7, 8)	**Differntial Digital Inputs**
Common Mode Input	-15 VDC to +15 VDC max.
Absolute Max. Input Voltage	+/-25 VDC
Maximum Encoder Counts per Electrical Cycle	32,768 (after 4x decode)
Maximum Encoder Data Rate:	2 MHz
Quadrature Specification	90° +/-45 °
Differential Turn On Voltage $V_{ID} > 0.7$ V -0.7 V $> V_{ID} > 0.7$ V $V_{ID} < -0.7$ V *Where V_{ID} = (ENCx) – (ENCx')*	Receiver Output H ? L

ENCZ, ENCZ', U, U', V, V', W, W' (pins 3, 4, 10, 11, 12, 13 , 14, 15)	**Differential or Single-Ended Digital Input**
Common Mode Input	-12 VDC to +12 VDC max.
Absolute Max. Input Voltage	+/-25 VDC
Differential Turn On Voltage $V_{ID} > 0.2$ V -0.2 V $> V_{ID} > 0.2$ V $V_{ID} < -0.2$ V *Where V_{ID} = (ENCx) – (ENCx')*	Receiver Output H ? L

***Table 30**, Servodrive Motor Quadrature Encoder Feedback Specifications (P4)*

6.1.8 Servodrive Motor **Resolver** Feedback Specifications (P4)

Use this table for servodrives built for **resolver** feedback, SAC-Gxxx-x**R** versions. The resolver interface uses a male connector on the drive at P4. (The specifications and pinout for the quadrature encoder version differ, be sure to use the correct table.)

Resolver Encoder Drive

Resolver REF+, REF- (pins 1, 2)	**Resolver Differential Reference Signal**
Maximum Output Voltage (software configurable)	7 Vrms - differential
Maximum Output Current	60 mA

COS+, COS-, SIN+, SIN- (pins 5, 6, 4, 3)	**Differntial Resolver Inputs**
Operating Input Voltage	2 Vrms +/- 15%
Absolute Max. Input Voltage	3 Vrms

+5v, GND (pins 8, 7)	**5V output power**
+5 VDC	5 VDC, +/-5% 450 mA max.

TMP (pin 10)	**Overtemperature Input (Parallel connection with P3 TMP)**
Should be normally sinking current to prevent an overtemperature condition.	
Current to turn on	2.5 mA
Voltage max.	+12 VDC maximum

Table 31*, Servodrive Motor Resolver Feedback Specifications (P4)*

6.1.9 Servodrive Connector Part Numbers

		Mating Connector		
Label	**Signal**	**Description**	**Manufacturer & Part Number**	**Ormec P/N**
P1	RS232 Com Port	RJ11 Modular Jack	Ormec P/N CBL-SER-AT	
P2	Controller Port	25 pin male D-sub	Amp 207464-1 (conn.) Amp 745254-6 (pin) Amp 206478-3 (shell) Amp 90406-1 (tool)	CON638 CON640 CON641
P3	Supplemental I/O	15 pos TB plug	Phoenix 1803701	CON5011
P4	Motor Feedback Quadrature Encoder	15 pin male D-sub	Amp 205206-1 (conn.) Amp 745254-6 (pin) Amp 749915-2 (shell) Amp 90406-1 (tool)	CON5499 CON640 CON5491
	Motor Feedback Resolver	15 pin female D-sub	Amp 205205-2 (conn.) Amp 66504-9 (pin) Amp 749915-2 (shell) Amp 58448-2 (tool)	CON805 CON806 CON5491
TB2	Logic Power (G225-G260 only)	3 pos TB plug	Phoenix 1804917	CON5512

***Table 32**, Servodrive Connector Part Numbers*

6.2 MAC-G Servo Motors

6.2.1 MAC-G Series Overview

Maximum Speeds:	600 to 7,000 RPM
Continuous stall torques:	5 to 640 lb-in
Peak Torques:	10 to 1,239 lb-in
Peak Acceleration:	up to 72,993 rad/sec^2
Rated Power:	0.20 to 13 HP
Position Encoder Resolution:	8,000 counts/rev after four times quadrature decode (up to 24,000 counts/rev optional)
Ambient Temperature:	0 - 40C
Enclosure Rating:	IP65 (Viton shaft seal standard)
Insulation:	Class F

Servomotor	Recommended Servodrive	Compatible Servodrives	
MAC-G005A1	**G203**	G205	G210
MAC-G006A1	**G205**	G210	
MAC-G006A2	**G203**	G205	G210
MAC-G010A1	**G205**	G210	G217
MAC-G010B1	**G203**	G205	G210
MAC-G011A1	**G210**	G217	G220
MAC-G011A2	**G205**	G210	
MAC-G011B2	**G203**	G205	G210
MAC-G015A1	**G210**	G217	G220
MAC-G015A2	**G205**	G210	G217
MAC-G015B2	**G203**	G205	G210
MAC-G016A2	**G205**	G210	
MAC-G016B2	**G203**	G205	G210

***Table 33**, G-Series Servomotor and Servodrive Compatibility (continued on next page)*

Servomotor	Recommended Servodrive	Compatible Servodrives	
MAC-G019A1	**G217**	G220	
MAC-G019A2	**G210**	G217	G220
MAC-G019B2	**G203**	G205	G210
MAC-G030A2	**G210**	G217	G220
MAC-G030B2	**G205**	G210	
MAC-G040A2	**G210**	G217	G220
MAC-G040B2	**G203**	G205	G210
MAC-G055A2	**G210**	G217	G220
MAC-G055A4	**G205**	G210	
MAC-G080A2	**G217**	G220	G225
MAC-G080A4	**G210**	G217	G220
MAC-G115A2	**G220**	G225	G235
MAC-G115A4	**G210**	G217	G220
MAC-G130A2	**G217**	G220	G225
MAC-G130A4	**G210**	G217	G220
MAC-G210A2	**G220**	G225	G235
MAC-G210A4	**G217**	G220	G225
MAC-G280A2	**G235**	G260	
MAC-G280A4	**G225**	G235	G260
MAC-G360A2	**G235**	G260	
MAC-G360A4	**G225**	G235	
MAC-G640A2	**G260**		

***Table 33**, G-Series Servomotor and Servodrive Compatibility (continued from previous page)*

	Maximum Speed					
	Standard Position Encoder	Optional Position Encoders				
Servomotor	**8,000* counts/rev**	**6,000* counts/rev**	**8,192* counts/rev**	**12,000* counts/rev**	**16,384* counts/rev**	**24,000* counts/rev**
G005A1	**5,000**	5,000	5,000	4,000	**N/A**	2,000
G006A1	**6,000**	6,800	5,859	4,000		2,000
G006A2	**4,600**	4,600	4,600	4,000		2,000
G010A1	**5,500**	5,500	5,500	4,000		2,000
G010B1	**3,500**	3,500	3,500	3,500		2,000
G011A1	**6,000**	7,000	5,859	4,000		2,000
G011A2	**5,600**	5,600	5,600	4,000		2,000
G011B2	**3,800**	3,800	3,800	3,800		2,000
G015A1	**6,000**	6,300	5,859	4,000		2,000
G015A2	**5,600**	5,600	5,600	4,000		2,000
G015B2	**3,700**	3,700	3,700	3,700		2,000
G016A2	**5,000**	5,000	5,000	4,000		2,000
G016B2	**2,500**	2,500	2,500	2,500		2,000
G019A1	**5,625**	5,625	5,625	4,000		2,000
G019A2	**5,000**	5,000	5,000	4,000		2,000
G019B2	**3,700**	3,700	3,700	3,700		2,000
G030A2	**5,000**	5,000	5,000	4,000	2,929	2,000
G030B2	**2,600**	2,600	2,600	2,600	2,600	2,000
G040A2	**3,500**	3,500	3,500	3,500	2,929	2,000
G040B2	**1,700**	1,700	1,700	1,700	1,700	1,700
G055A2	**3,500**	3,500	3,500	3,500	2,929	2,000
G055A4	**3,700**	3,700	3,700	3,700	2,929	2,000

* Resolution after four times quadrature decode.

***Table 34**, G-Series Servomotor Encoder Resolutions and Speeds (continued on next page)*

	Maximum Speed					
	Standard Position Encoder	Optional Position Encoders				
Servomotor	**8,000* counts/rev**	**6,000* counts/rev**	**8,192* counts/rev**	**12,000* counts/rev**	**16,384* counts/rev**	**24,000* counts/rev**
G080A2	**3,500**	3,500		3,500	2,929	2,000
G080A4	**3,700**	3,700		3,700	2,929	2,000
G115A2	**3,500**	3,500		3,500	2,929	2,000
G115A4	**3,700**	3,700		3,700	2,929	2,000
G130A2	**2,700**			2,700	2,700	2,000
G130A4	**3,500**			3,500	2,929	2,000
G210A2	**2,700**			2,700		2,000
G210A4	**3,500**			3,500		2,000
G210B4	**1,800**		**N/A**	1,800		1,800
G280A2	**2,700**			2,700		2,000
G280A4	**3,500**	**N/A**		3,500		2,000
G360A2	**2,000**			2,000	**N/A**	2,000
G360A4	**3,500**			3,500		2,000
G400B4	**1,300**			1,300		1,300
G640A2	**2,400**			2,400		2,000
G640B4	**1,300**			1,300		1,300

* Resolution after four times quadrature decode.

***Table 34**, G-Series Servomotor Encoder Resolutions and Speeds (continued from previous page)*

6.2.2 MAC-G Motor Specifications (for motors **without** brakes)

PERFORMANCE	**Units**	**G005A1**	**G006A1**	**G006A2**
Maximum Speed(7)	RPM	5,000	6,800	4,600
Continuous Stall Torque	lb-in (N-m)	5.0(1) (0.56)(1)	5.8(2) (0.66)(2)	5.8(2) (0.66)(2)
Rated Speed	RPM	3,700	4,800	4,000
Rated Torque	lb-in (N-m)	3.5(1) (0.40)(1)	4.8(2) (0.55)(2)	5.0(2) (0.56)(2)
Rated Power	HP watts	0.20 150	0.36 270	0.31 230
Peak Torque(5)	lb-in (N-m)	10 (1.1)	12 (1.4)	14 (1.6)
Continuous Stall Torque/Inertia	radians/sec^2	67,568	45,669	45,669
MECHANICAL				
Moment of Inertia(3)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	0.0740 (0.084)	0.127 (0.143)	0.127 (0.143)
Friction Torque, Static	lb-in (N-m)	0.50 (0.056)	0.60 (0.068)	0.60 (0.068)
Servomotor Weight(3)	lbs (kg)	3.0 (1.4)	3.5 (1.6)	3.5 (1.6)
Maximum Radial Shaft Load(4)	lbs (N)	20 (89)	35 (156)	35 (156)
Maximum Axial Shaft Load	lbs (N)	15 (67)	20 (89)	20 (89)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G203	G205	G203
Servodrive Input Power	VAC	115	115	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	2.4 (0.28)	1.8 (0.21)	3.6 (0.4)
Continuous Motor Current	amps$_{RMS/Ø}$	2.0	3.1	1.6
Peak Motor Current(6)	amps$_{RMS/Ø}$	6.2	9.8	4.9
Thermal Time Constant(6)	minutes	4	8	7

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/4" aluminum heatsink. Maximum case temperature is 100C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 6" x 6" x 1/4" aluminum heatsink. Maximum case temperature is 85C.

3 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

4 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

5 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

6 Motor current specifications independent of the drive selected.

7 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G010A1	G010B1	G011A1
Maximum Speed(8)	RPM	5,500	3,500	7,000
Continuous Stall Torque	lb-in (N-m)	10(1) (1.1)	9.4(1) (1.1)	11(2) (1.3)
Rated Speed	RPM	3,800	2,100	4,900
Rated Torque	lb-in (N-m)	7.0(1) (0.79)	8.4(1) (0.95)	9.4(2) (1.1)
Rated Power	HP watts	0.42 310	0.27 200	0.72 540
Peak Torque(6)	lb-in (N-m)	17(3) (1.9)(3)	16(3) (1.8)(3)	26(3) (3.0)(3)
Continuous Stall Torque/Inertia	radians/sec^2	72,993	68,613	44,534
MECHANICAL				
Moment of Inertia(4)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	0.137 (0.155)	0.137 (0.155)	0.247 (0.279)
Friction Torque, Static	lb-in (N-m)	0.80 (0.090)	0.80 (0.090)	0.80 (0.090)
Servomotor Weight(4)	lbs (kg)	4.0 (1.8)	4.0 (1.8)	4.4 (2.0)
Maximum Radial Shaft Load(5)	lbs (N)	20 (89)	20 (89)	35 (156)
Maximum Axial Shaft Load	lbs (N)	15 (67)	15 (67)	15 (67)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G205	G203	G210
Servodrive Input Power	VAC	115	115	115
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	2.5 (0.28)	3.9 (0.44)	2.0 (0.22)
Continuous Motor Current(7)	amps$_{RMS/Ø}$	4.1	2.5	5.8
Peak Motor Current(7)	amps$_{RMS/Ø}$	12	7.7	17
Thermal Time Constant	minutes	8	8	9

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/4" aluminum heatsink. Maximum case temperature is 100C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 6" x 6" x 1/4" aluminum heatsink. Maximum case temperature is 85C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G011A2	G011B2	G015A1
Maximum Speed(7)	RPM	5,600	3,800	6,300
Continuous Stall Torque	lb-in (N-m)	11(1) (1.3)(1)	11(1) (1.3)(1)	15(1) (1.7)(1)
Rated Speed	RPM	4,000	2,400	4,500
Rated Torque	lb-in (N-m)	9.8(1) (1.1)(1)	10(1) (1.2)(1)	13(1) (1.4)(1)
Rated Power	HP watts	0.62 460	0.39 290	0.91 680
Peak Torque(5)	lb-in (N-m)	24(2) (2.7)(2)	28 (3.2)	25(2) (2.9)(2)
Continuous Stall Torque/Inertia	radians/sec^2	44,534	44,534	42,017
MECHANICAL				
Moment of Inertia(3)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	0.247 (0.279)	0.247 (0.279)	0.357 (0.403)
Friction Torque, Static	lb-in (N-m)	0.80 (0.090)	0.80 (0.090)	1.0 (0.11)
Servomotor Weight(3)	lbs (kg)	4.4 (2.0)	4.4 (2.0)	5.3 (2.4)
Maximum Radial Shaft Load(4)	lbs (N)	35 (156)	35 (156)	35 (156)
Maximum Axial Shaft Load	lbs (N)	15 (67)	15 (67)	15 (67)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G205	G203	G210
Servodrive Input Power	VAC	230	230	115
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	3.6 (0.40)	7.0 (0.79)	1.9 (0.21)
Continuous Motor Current(6)	amps$_{RMS/Ø}$	3.2	1.6	8.0
Peak Motor Current(6)	amps$_{RMS/Ø}$	9.8	4.8	24
Thermal Time Constant	minutes	8	8	9

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 6" x 6" x 1/4" aluminum heatsink. Maximum case temperature is 85C.

2 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

3 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

4 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

5 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

6 Motor current specifications independent of the drive selected.

7 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G015A2	G015B2	G016A2
Maximum Speed(8)	RPM	5,600	3,700	5,000
Continuous Stall Torque	lb-in (N-m)	15(1) (1.7)(1)	15(1) (1.7)(1)	16(2) (1.8)(2)
Rated Speed	RPM	4,000	2,400	3,600
Rated Torque	lb-in (N-m)	13(1) (1.5)(1)	14(1) (1.6)(1)	13(2) (1.5)(2)
Rated Power	HP watts	0.82 610	0.52 390	0.75 560
Peak Torque(6)	lb-in (N-m)	24(3) (2.8)(3)	29 (3.2)	35(3) (4.0)(3)
Continuous Stall Torque/Inertia	radians/sec^2	42,017	42,017	48,780
MECHANICAL				
Moment of Inertia(4)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	0.357 (0.403)	0.357 (0.403)	0.328 (0.371)
Friction Torque, Static	lb-in (N-m)	1.0 (0.11)	1.0 (0.11)	0.4 (0.045)
Servomotor Weight(4)	lbs (kg)	5.3 (2.4)	5.3 (2.4)	8.3 (3.8)
Maximum Radial Shaft Load(5)	lbs (N)	35 (156)	35 (156)	40 (178)
Maximum Axial Shaft Load	lbs (N)	15 (67)	15 (67)	25 (111)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G205	G203	G205
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	3.6 (0.41)	7.1 (0.80)	5.2 (0.59)
Continuous Motor Current(7)	amps$_{RMS/Ø}$	4.2	2.1	3.1
Peak Motor Current(7)	amps$_{RMS/Ø}$	12	6.4	11
Thermal Time Constant	minutes	8	8	8

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 6" x 6" x 1/4" aluminum heatsink. Maximum case temperature is 85C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/4" aluminum heatsink. Maximum case temperature is 100C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G016B2	G019A1	G019A2
Maximum Speed(8)	RPM	2,500	5,625	5,000
Continuous Stall Torque	lb-in (N-m)	16(1) (1.8)(1)	19(2) (2.1)(2)	19(2) (2.1)(2)
Rated Speed	RPM	1,600	4,500	4,000
Rated Torque	lb-in (N-m)	15(1) (1.7)(1)	16(2) (1.8)(2)	16(2) (1.8)(2)
Rated Power	HP watts	0.38 280	1.1 850	1.0 770
Peak Torque(6)	lb-in (N-m)	42 (4.7)	41(3) (4.7)(3)	50 (5.6)
Continuous Stall Torque/Inertia	radians/sec^2	48,780	40,685	40,685
MECHANICAL				
Moment of Inertia(4)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	0.328 (0.371)	0.467 (0.528)	0.467 (0.528)
Friction Torque, Static	lb-in (N-m)	0.40 (0.045)	1.2 (0.14)	1.2 (0.14)
Servomotor Weight(4)	lbs (kg)	8.3 (3.8)	6.2 (2.8)	6.2 (2.8)
Maximum Radial Shaft Load(5)	lbs (N)	40 (178)	35 (156)	35 (156)
Maximum Axial Shaft Load	lbs (N)	25 (111)	15 (67)	15 (67)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G203	G217	G210
Servodrive Input Power	VAC	230	115	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	10 (1.2)	1.8 (0.21)	3.7 (0.42)
Continuous Motor Current(7)	amps$_{RMS/Ø}$	1.6	11	5.1
Peak Motor Current(7)	amps$_{RMS/Ø}$	5.7	31	16
Thermal Time Constant	minutes	8	8	8

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/4" aluminum heatsink. Maximum case temperature is 100C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 6" x 6" x 1/4" aluminum heatsink. Maximum case temperature is 85C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G019B2	G030A2	G030B2
Maximum Speed(8)	RPM	3,700	5,000	2,600
Continuous Stall Torque	lb-in (N-m)	17(1) (2.0)(1)	30(2) (3.4)(2)	30(2) (3.4)(2)
Rated Speed	RPM	2,500	3,700	1,700
Rated Torque	lb-in (N-m)	17(1) (1.9)(1)	26(2) (2.9)(2)	28(2) (3.2)(2)
Rated Power	HP watts	0.67 500	1.5 1,100	0.75 560
Peak Torque(6)	lb-in (N-m)	29(3) (3.2)(3)	68(3) (7.7)(3)	67(3) (7.6)(3)
Continuous Stall Torque/Inertia	radians/sec^2	36,403	36,232	36,232
MECHANICAL				
Moment of Inertia(4)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	0.467 (0.53)	0.828 (0.936)	0.828 (0.936)
Friction Torque, Static	lb-in (N-m)	1.2 (0.14)	0.50 (0.056)	0.50 (0.056)
Servomotor Weight(4)	lbs (kg)	6.2 (2.8)	12.0 (5.4)	12.0 (5.4)
Maximum Radial Shaft Load(5)	lbs (N)	35 (156)	40 (178)	40 (178)
Maximum Axial Shaft Load	lbs (N)	15 (67)	25 (111)	25 (111)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G203	G210	G205
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	7.1 (0.81)	5.1 (0.58)	10 (1.1)
Continuous Motor Current(7)	amps$_{RMS/Ø}$	2.6	6.0	3.0
Peak Motor Current(7)	amps$_{RMS/Ø}$	7.9	22	11
Thermal Time Constant	minutes	8	10	10

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 6" x 6" x 1/4" aluminum heatsink. Maximum case temperature is 85C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/4" aluminum heatsink. Maximum case temperature is 100C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G040A2	G040B2	G055A2
Maximum Speed[8]	RPM	3,500	1,700	3,500
Continuous Stall Torque	lb-in (N-m)	39[1] (4.4)[1]	39[1] (4.42)[1]	54[2] (6.1)[2]
Rated Speed	RPM	2,500	1,000	2,500
Rated Torque	lb-in (N-m)	36[1] (4.0)[1]	37[1] (4.2)[1]	47[2] (5.3)[2]
Rated Power	HP watts	1.3 1,000	0.58 430	1.7 1,300
Peak Torque[6]	lb-in (N-m)	102[3] (11)[3]	61[3] (6.9)[3]	102[3] (11)[3]
Continuous Stall Torque/Inertia	radians/sec^2	31,707	31,707	22,222
MECHANICAL				
Moment of Inertia[4]	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	1.23 (1.39)	1.23 (1.39)	2.43 (2.74)
Friction Torque, Static	lb-in (N-m)	0.60 (0.068)	0.60 (0.068)	1.0 (0.11)
Servomotor Weight[4]	lbs (kg)	15 (6.6)	15 (6.6)	20 (9.1)
Maximum Radial Shaft Load[5]	lbs (N)	40 (178)	40 (178)	100 (445)
Maximum Axial Shaft Load	lbs (N)	25 (111)	25 (111)	50 (222)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G210	G203	G210
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	7.6 (0.86)	15 (1.7)	7.6 (0.86)
Continuous Motor Current[7]	amps$_{RMS/Ø}$	5.1	2.4	7.1
Peak Motor Current[7]	amps$_{RMS/Ø}$	19	9.1	25
Thermal Time Constant	minutes	10	10	12

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/4" aluminum heatsink. Maximum case temperature is 100C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G055A4	G080A2	G080A4
Maximum Speed[8]	RPM	1,850	3,500	1,850
Continuous Stall Torque	lb-in (N-m)	54[1] (6.1)[1]	83[2] (9.4)[2]	83[2] (9.4)[2]
Rated Speed	RPM	1,300	2,600	1,400
Rated Torque	lb-in (N-m)	50[1] (5.7)[1]	71[2] (8.0)[2]	76[2] (8.6)[2]
Rated Power	HP watts	1.1 770	2.8 2,100	1.6 1,200
Peak Torque[6]	lb-in (N-m)	102[3] (11)[3]	203[3] (23)[3]	203[3] (23)[3]
Continuous Stall Torque/Inertia	radians/sec^2	22,222	16,836	16,836
MECHANICAL				
Moment of Inertia[4]	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	2.43 (2.74)	4.93 (5.57)	4.93 (5.57)
Friction Torque, Static	lb-in (N-m)	1.0 (0.11)	1.4 (0.16)	1.4 (0.16)
Servomotor Weight[4]	lbs (kg)	20 (9.1)	29 (13)	29 (13)
Maximum Radial Shaft Load[5]	lbs (N)	100 (445)	100 (445)	100 (445)
Maximum Axial Shaft Load	lbs (N)	50 (222)	50 (222)	50 (222)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G205	G217	G210
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	15 (1.7)	7.6 (0.86)	15 (1.7)
Continuous Motor Current[6]	amps$_{RMS/Ø}$	3.6	11	5.5
Peak Motor Current[7]	amps$_{RMS/Ø}$	12	38	19
Thermal Time Constant	minutes	22	16	16

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 10" x 10" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 12" x 12" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G115A2	G115A4	G130A2
Maximum Speed(7)	RPM	3,500	1,850	2,700
Continuous Stall Torque	lb-in (N-m)	116(1) (13)(1)	116(1) (13)(1)	130(1) (15)(1)
Rated Speed	RPM	2,600	1,400	1,800
Rated Torque	lb-in (N-m)	100(1) (11)(1)	107(1) (12)(1)	119(1) (13)(1)
Rated Power	HP watts	4.0 3,000	2.3 1,700	3.4 2,500
Peak Torque(5)	lb-in (N-m)	203(2) (23)(2)	203(2) (23)(2)	220(2) (25)(2)
Continuous Stall Torque/Inertia	radians/sec^2	16,044	16,044	13,786
MECHANICAL				
Moment of Inertia(3)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	7.23 (8.17)	7.23 (8.17)	9.43 (10.7)
Friction Torque, Static	lb-in (N-m)	1.8 (0.20)	1.8 (0.20)	2.4 (0.27)
Servomotor Weight(3)	lbs (kg)	37 (17)	37 (17)	36 (16)
Maximum Radial Shaft Load(4)	lbs (N)	100 (445)	100 (445)	150 (667)
Maximum Axial Shaft Load	lbs (N)	50 (222)	50 (222)	50 (222)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G220	G210	G217
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	7.6 (0.86)	15 (1.7)	9.6 (1.1)
Continuous Motor Current(6)	amps$_{RMS/Ø}$	15	7.7	13
Peak Motor Current(6)	amps$_{RMS/Ø}$	54	27	39
Thermal Time Constant	minutes	16	16	16

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 12" x 12" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

2 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

3 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

4 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

5 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

6 Motor current specifications independent of the drive selected.

7 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G130A4	G210A2	G210A4
Maximum Speed(7)	RPM	1,750	2,700	1,750
Continuous Stall Torque	lb-in (N-m)	130(1) (15)(1)	210(1) (24)(1)	210(1) (24)(1)
Rated Speed	RPM	1,200	2,000	1,300
Rated Torque	lb-in (N-m)	121(1) (14)(1)	184(1) (21)(1)	191(1) (22)(1)
Rated Power	HP Watts	2.3 1,700	5.8 4,300	3.9 2,900
Peak Torque(5)	lb-in (N-m)	213(2) (24)(2)	458(2) (52)(2)	361(2) (41)(2)
Continuous Stall Torque/Inertia	radians/sec^2	13,786	11,053	11,053
MECHANICAL				
Moment of Inertia(3)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	9.43 (10.7)	19.0 (21.5)	19.0 (21.5)
Friction Torque, Static	lb-in (N-m)	2.4 (0.27)	3.0 (0.34)	3.0 (0.34)
Servomotor Weight(3)	lbs (kg)	36 (16)	51 (23)	51 (23)
Maximum Radial Shaft Load(4)	lbs (N)	150 (667)	150 (667)	150 (667)
Maximum Axial Shaft Load	lbs (N)	50 (222)	50 (222)	50 (222)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G210	G225	G217
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	16 (1.8)	9.6 (1.1)	16 (1.8)
Continuous Motor Current(6)	amps$_{RMS/Ø}$	8.2	22	13
Peak Motor Current(6)	amps$_{RMS/Ø}$	24	65	38
Thermal Time Constant	minutes	16	20	20

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 12" x 12" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

2 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

3 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

4 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

5 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

6 Motor current specifications independent of the drive selected.

7 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G280A2	G280A4	G360A2
Maximum Speed(7)	RPM	2,700	1,750	2,000
Continuous Stall Torque	lb-in (N-m)	280(1) (32)(1)	280(1) (32)(1)	360(1) (41)(1)
Rated Speed	RPM	2,000	1,300	1,500
Rated Torque	lb-in (N-m)	245(1) (28)(1)	252(1) (28)(1)	321(1) (36)(1)
Rated Power	HP watts	7.6 5,700	5.1 3,800	7.6 5,700
Peak Torque(5)	lb-in (N-m)	641(2) (72)	752(2) (85)	851(2) (96)
Continuous Stall Torque/Inertia	radians/sec^2	9,790	9,790	10,286
MECHANICAL				
Moment of Inertia(3)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	28.6 (32.3)	28.6 (32.3)	35.0 (39.6)
Friction Torque, Static	lb-in (N-m)	3.6 (0.41)	3.6 (0.41)	4.2 (0.47)
Servomotor Weight(3)	lbs (kg)	66 (30)	66 (30)	83 (38)
Maximum Radial Shaft Load(4)	lbs (N)	150 (667)	150 (667)	150 (667)
Maximum Axial Shaft Load	lbs (N)	50 (222)	50 (222)	50 (222)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G235	G225	G235
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	9.6 (1.1)	16 (1.8)	13 (1.4)
Continuous Motor Current(6)	amps$_{RMS/Ø}$	29	17	28
Peak Motor Current(6)	amps$_{RMS/Ø}$	87	51	83
Thermal Time Constant	minutes	22	22	23

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 12" x 12" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

2 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

3 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

4 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

5 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

6 Motor current specifications independent of the drive selected.

7 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

PERFORMANCE	Units	G360A4	G640A2
Maximum Speed(8)	RPM	1,750	2,400
Continuous Stall Torque	lb-in (N-m)	360(1) (41)(1)	640(2) (72)(2)
Rated Speed	RPM	1,300	1,600
Rated Torque	lb-in (N-m)	323(1) (36)(1)	580(2) (66)(2)
Rated Power	HP watts	6.6 4,900	13 10,000
Peak Torque(6)	lb-in (N-m)	752(3) (85)(3)	1,239(3) (140)(3)
Continuous Stall Torque/Inertia	radians/sec^2	10,286	8,989
MECHANICAL			
Moment of Inertia(4)	in-lb-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	35.0 (39.6)	71.2 (80.5)
Friction Torque, Static	lb-in (N-m)	4.2 (0.47)	9.8 (1.1)
Servomotor Weight(4)	lbs (kg)	83 (38)	98 (44)
Maximum Radial Shaft Load(5)	lbs (N)	150 (667)	250 (1,112)
Maximum Axial Shaft Load	lbs (N)	50 (222)	100 (445)
ELECTRICAL & THERMAL			
Servodrive Model Number	SAC-	G225	G260
Servodrive Input Power	VAC	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/Ø}$ (N-m/amp$_{RMS/Ø}$)	16 (1.8)	11 (1.2)
Continuous Motor Current(76)	amps$_{RMS/Ø}$	22	59
Peak Motor Current(7)	amps$_{RMS/Ø}$	66	163
Thermal Time Constant	minutes	23	25

1 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 12" x 12" x 1/2" aluminum heatsink. Maximum case temperature is 100C.

2 Performance ratings are obtained with servomotor ambient temperature of 25C and with motor mounted to a 14" x 14" x 3/4" aluminum heatsink. Maximum case temperature is 100C.

3 Peak motor torque is limited by the peak current of the Servodrive. The next larger drive may be used to increase the amount of peak torque available.

4 Specifications for servomotors without brakes. Refer to the appropriate sections for servomotor specifications with brakes.

5 Maximum radial shaft load specification is for a load centered 1 inch (25.4 mm) from the face of the motor.

6 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

7 Motor current specifications independent of the drive selected.

8 Actual maximum speed dependent on motor encoder resolution. Refer to Table 34.

6.2.3 Specifications for G-Series Servomotors **With** Brakes

Motor	**Brake Holding Torque** lb-in (N-m)	**Motor Moment of Inertia** lb-in-sec^2 (kg-m^2)	**Motor Length** in (mm)	**Motor Weight** lb (kg)	**Brake Current @24VDC** (Amps)
MAC-G005	10.0 (1.13)	$0.099x10^{-3}$ ($0.112x10^{-4}$)	6.8 (173)	3.8 (1.7)	0.21
MAC-G006	24.0 (2.71)	$0.197x10^{-3}$ ($0.222x10^{-4}$)	6.55 (167)	6.5 (2.9)	0.60
MAC-G010	10.0 (1.13)	$0.162x10^{-3}$ ($0.183x10^{-4}$)	8.00 (203)	4.8 (2.2)	0.21
MAC-G011	24.0 (2.71)	$0.317x10^{-3}$ ($0.358x10^{-4}$)	7.45 (186)	7.4 (3.4)	0.60
MAC-G015		$0.427x10^{-3}$ ($0.482x10^{-4}$)	8.05 (207)	8.3 (3.8)	
MAC-G016	60.0 (6.77)	$0.478x10^{-3}$ ($0.540x10^{-4}$)	8.74 (222)	10.5 (4.8)	0.52
MAC-G019	24.0 (2.71)	$0.537x10^{-3}$ ($0.607x10^{-4}$)	8.80 (224)	9.2 (4.2)	0.60
MAC-G030	60.0 (6.77)	$0.978x10^{-3}$ ($1.11x10^{-4}$)	10.3 (261)	10.5 (4.8)	0.52
MAC-G040		$1.38x10^{-3}$ ($1.56x10^{-4}$)	11.8 (299)	16.8 (7.6)	
MAC-G055	240 (27.1)	$3.33x10^{-3}$ ($3.76x10^{-4}$)	10.6 (270)	26 (11.8)	0.88
MAC-G080		$5.83x10^{-3}$ ($6.59x10^{-4}$)	13.1 (333)	34.6 (15.7)	
MAC-G115		$8.13x10^{-3}$ ($9.18x10^{-4}$)	15.6 (397)	43 (19.5)	
MAC-G130	360 (40.7)	$11.7x10^{-3}$ ($13.2x10^{-4}$)	14.0 (356)	48 (21.8)	1.13
MAC-G210		$21.3x10^{-3}$ ($24.1x10^{-4}$)	16.7 (424)	63 (28.6)	
MAC-G280		$30.9x10^{-3}$ ($34.9x10^{-4}$)	19.4 (492)	78 (35.4)	
MAC-G360		$37.3x10^{-3}$ ($42.1x10^{-4}$)	22.1 (561)	93 (42.2)	
MAC-G640	1080 (122)	$79.7x10^{-4}$ ($90.1x10^{-4}$)	18.7 (494)	122 (55.3)	1.4

***Table 35**,Specifications for G-Series Motors **With** Brakes*

6.2.4 MAC-G Motor Mating Connectors

	Mating Connectors (used in cables)	
Motors Without Brakes	**Motor Power Connector**	**Motor Feedback Connector**
G005, G010, G006, G011, G015, G019	Bendix PT06E16-23S(SR) (Motor Power and Feedback are in a single connector)	
G016, G030, G040, G055, G080, G115	Bendix PT06E14-5S(SR)	Bendix PT06E14-18S(SR)
G130, G210, G280, G360	MS3106F-22-22S	
G640	MS3106F-32-17S	

***Table 36**, MAC-G Motor Mating Connectors for Motors **Without** Brakes*

For G005, G006, G010, G011, G015, G019 motors, the brake leads are in the combined power/feedback cable.

For G016, G030, G040, G055, G080, and G115 motors, the brake leads are in the motor power cable.

For G130, G210, G280, G360 and G640 motors, the brake leads are in the motor feedback cable.

	Mating Connectors (used in cables)	
Motors With Brake	**Motor Power Connector**	**Motor Feedback Connector**
G005, G006, G010, G011, G015,G019	Bendix PT06E16-23S(SR) (Motor Power and Feedback are in a single connector)	
G016, G030, G040, G055, G080, G115	Bendix PT06E16-8S(SR)	Bendix PT06E14-18S(SR)
G130, G210, G280, G360	MS3106F-22-22S	Bendix PT06E16-23S(SR)
G640	MS3106F-32-17S	

***Table 37**, MAC-G Motor Mating Connectors for Motors **With** Brakes*

6.3 MAC-DE/DA/DB Servo Motors

6.3.1 MAC-DE Series Overview

Maximum Speed:	4,300 TO 4,500 RPM
Continuous stall torques:	2.8 to 42 lb-in
Peak Torques:	5.1 to 73 lb-in
Peak Acceleration:	up to 49,123 rad/sec^2
Rated Power:	0.13 to 2.0 HP
Position Encoder Resolution:	8,192 cts/rev (after quadrature decode)
Ambient Temp:	0 – 40C
Ambient Humidity:	20% to 80% (non-condensing)
Enclosure Rating	IP55
Insulation	Class B

Servomotor	Recommended Servodrive	Compatible Servodrives	
MAC-DE003A1	**G203**	G205	G210
MAC-DE003A2	**G203**	G205	G210
MAC-DE006B1	**G205**	G210	G217
MAC-DE006B2	**G203**	G205	G210
MAC-DE008C1	**G210**	G217	
MAC-DE011C2	**G205**	G210	G217
MAC-DE021D2	**G205**	G210	
MAC-DE042E2	**G210**	G217	G220

Table 38, DE-Series Servomotor and Servodrive Compatibility

6.3.2 MAC-DA Series Overview

Maximum Speed:	4,500 RPM
Continuous stall torques:	28 to 140 lb-in
Peak Torques:	68 to 321 lb-in
Peak Acceleration:	up to 19,858 rad/sec^2
Rated Power:	1.3 to 6.6 HP
Position Encoder Resolution:	16,384 cts/rev (after quadrature decode)
Ambient Temp:	0 – 40C
Ambient Humidity:	20% to 80% (non-condensing)
Enclosure Rating	IP65 standard (optional shaft oil seal)
Insulation	Calss F

Servomotor	Recommended Servodrive	Compatible Servodrives	
MAC-DA030F	**G210**	G217	G220
MAC-DA055G	**G217**	G220	G225
MAC-DA090H	**G225**	G235	
MAC-DA110J	**G225**	G235	G260
MAC-DA140K	**G235**	G260	

Table 39, DA-Series Servomotor and Servodrive Compatibility

6.3.3 MAC-DB Series Overview

Maximum Speed:	3,000 RPM
Continuous stall torques:	25 to 665 lb-in
Peak Torques:	44 to 1000 lb-in
Peak Acceleration:	up to 5,017 rad/sec^2
Rated Power:	0.6 to 2.8 HP
Position Encoder Resolution:	32,768 cts/rev (after quadrature decode)
Ambient Temp:	0 – 40C
Ambient Humidity:	20% to 80% (non-condensing)
Enclosure Rating	IP65 standard (optional shaft oil seal)
Insulation	Class F

Servomotor	Recommended Servodrive	Compatible Servodrives	
MAC-DB025L	**G205**	G210	
MAC-DB055M	**G210**	G217	G220
MAC-DB080N	**G217**	G220	
MAC-DB100P	**G220**	G225	
MAC-DB200Q	**G220**	G225	G235
MAC-DB300R	**G235**	G260	
MAC-DB330S	**G260**		
MAC-DB465T	**G260**		
MAC-DB700U	**G260**		

Table 40, DB-Series Servomotor and Servodrive Compatibility

6.3.4 MAC-DE/DA/DB Specifications

PERFORMANCE(1)	**Units**	**DE003A1/I**	**DE003A2/I**	**DE006B1/I**
Maximum Speed	RPM	4,500	4,500	4,500
Continuous Stall Torque	lb-in (N-m)	2.8 (0.32)	2.8 (0.32)	5.6 (0.64)
Rated Speed	RPM	3,000	3,000	3,000
Rated Torque	lb-in (N-m)	2.8 (0.32)	2.8 (0.32)	5.6 (0.64)
Rated Power	HP watts	0.13 100	0.13 100	0.25 190
Peak Torque(4)	lb-in (N-m)	5.1 (0.58)	8.2 (0.93)	14 (1.5)
Continuous Stall Torque/Inertia	radians/sec^2	49,123	49,123	30,270
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	0.057 (0.065)	0.057 (0.065)	0.185 (0.209)
Friction Torque, Static	lb-in (N-m)	0.048 (0.0054)	0.048 (0.0054)	0.11 (0.012)
Servomotor Weight(2)	lbs (kg)	1.5 (0.7)	1.5 (0.7)	3.1 (1.4)
Maximum Radial Shaft Load(2)	lbs (N)	17 (78)	17 (78)	55 (245)
Maximum Axial Shaft Load	lbs (N)	11 (49)	11 (49)	15 (68)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G203	G203	G205
Servodrive Input Power	VAC	115	230	115
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	1.4 (0.16)	3.5 (0.39)	2.3 (0.26)
Continuous Motor Current(5)	amps$_{RMS/ø}$	2.2	0.89	2.7
Peak Motor Current(5)	amps$_{RMS/ø}$	7.1	2.8	8.4
Thermal Time Constant	minutes	8	8	14
Insulation Class		B	B	B

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DE006B2/I**	**DE008C1/I**	**DE011C2/I**
Maximum Speed	RPM	4,500	4,500	4,500
Continuous Stall Torque	lb-in (N-m)	5.6 (0.64)	8.4 (0.95)	11 (1.3)
Rated Speed	RPM	3,000	3,000	3,000
Rated Torque	lb-in (N-m)	5.6 (0.64)	8.4 (0.95)	11 (1.3)
Rated Power	HP watts	0.25 190	0.39 290	0.54 400
Peak Torque(4)	lb-in (N-m)	11 (1.3)	25 (2.8)	28 (3.2)
Continuous Stall Torque/Inertia	radians/sec^2	30,270	27,273	35,714
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	0.185 (0.209)	0.308 (0.347)	0.308 (0.347)
Friction Torque, Static	lb-in (N-m)	0.11 (0.012)	0.20 (0.022)	0.20 (0.022)
Servomotor Weight(2)	lbs (kg)	3.1 (1.4)	4.6 (2.1)	4.6 (2.1)
Maximum Radial Shaft Load(2)	lbs (N)	55 (245)	55 (245)	55 (245)
Maximum Axial Shaft Load	lbs (N)	15 (68)	15 (68)	15 (68)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G203	G210	G205
Servodrive Input Power	VAC	230	115	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	3.1 (0.35)	2.2 (0.25)	4.7 (0.54)
Continuous Motor Current(5)	amps$_{RMS/ø}$	2.0	4.3	2.6
Peak Motor Current(5)	amps$_{RMS/ø}$	6.0	14	8.0
Thermal Time Constant	minutes	14	16	16
Insulation Class		B	B	B

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DE021D2/I**	**DE042E2/I**	**DA030F/I**
Maximum Speed	RPM	4,500	4,300	4,500
Continuous Stall Torque	lb-in (N-m)	21 (2.4)	42 (4.8)	28 (3.2)
Rated Speed	RPM	3,000	3,000	3,000
Rated Torque	lb-in (N-m)	21 (2.4)	42 (4.8)	28 (3.2)
Rated Power	HP watts	1.0 750	2.0 1,500	1.3 1,000
Peak Torque(4)	lb-in (N-m)	34 (3.9)	73 (8.3)	68 (7.7)
Continuous Stall Torque/Inertia	radians/sec^2	11,230	11,765	18,182
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	1.87 (2.11)	3.57 (4.03)	1.54 (1.74)
Friction Torque, Static	lb-in (N-m)	0.32 (0.036)	0.53 (0.060)	0.43 (0.049)
Servomotor Weight(2)	lbs (kg)	10 (4.6)	15 (6.6)	10 (4.6)
Maximum Radial Shaft Load(2)	lbs (N)	88 (392)	110 (490)	154 (686)
Maximum Axial Shaft Load	lbs (N)	33 (147)	33 (147)	44 (196)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G205	G210	G210
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	5.7 (0.64)	6.1 (0.69)	5.7 (0.64)
Continuous Motor Current(5)	amps$_{RMS/ø}$	4.1	7.5	6.0
Peak Motor Current(5)	amps$_{RMS/ø}$	13	28	17
Thermal Time Constant	minutes	18	18	12
Insulation Class		B	B	F

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft load specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DA055G/I**	**DA090H/I**	**DA110J/I**
Maximum Speed	RPM	4,500	4,500	4,500
Continuous Stall Torque	lb-in (N-m)	56 (6.3)	87 (9.8)	112 (13)
Rated Speed	RPM	3,000	3,000	3,000
Rated Torque	lb-in (N-m)	56 (6.3)	87 (9.8)	112 (13)
Rated Power	HP watts	2.5 1,900	4.0 3,000	5.2 3,900
Peak Torque(4)	lb-in (N-m)	101 (11)	217 (24)	207 (23)
Continuous Stall Torque/Inertia	radians/sec^2	19,858	14,032	13,176
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	2.82 (3.19)	6.20 (7.01)	8.50 (9.60)
Friction Torque, Static	lb-in (N-m)	0.62 (0.070)	0.74 (0.083)	0.95 (0.11)
Servomotor Weight(2)	lbs (kg)	15 (7.0)	24 (11)	31 (14)
Maximum Radial Shaft Load(2)	lbs (N)	154 (686)	221 (980)	265 (1,176)
Maximum Axial Shaft Load	lbs (N)	44 (196)	88 (392)	88 (392)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G217	G225	G225
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	5.0 (0.56)	5.1 (0.58)	4.9 (0.55)
Continuous Motor Current(5)	amps$_{RMS/ø}$	12	19	24
Peak Motor Current(5)	amps$_{RMS/ø}$	42	56	77
Thermal Time Constant	minutes	23	33	36
Insulation Class		F	F	F

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DA140K/I**	**DB025L/I**	**DB055M/I**
Maximum Speed	RPM	4,500	3,000	3,000
Continuous Stall Torque	lb-in (N-m)	140 (16)	25 (2.8)	53 (6.0)
Rated Speed	RPM	3,000	1,500	1,500
Rated Torque	lb-in (N-m)	140 (16)	25 (2.8)	48 (5.4)
Rated Power	HP watts	6.6 4,900	0.59 440	1.1 850
Peak Torque(4)	lb-in (N-m)	321 (36)	44 (4.9)	88 (10)
Continuous Stall Torque/Inertia	radians/sec^2	12,844	3,900	4,309
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	10.9 (12.3)	6.41 (7.24)	12.3 (13.9)
Friction Torque, Static	lb-in (N-m)	1.1 (0.13)	0.43 (0.049)	0.65 (0.074)
Servomotor Weight(2)	lbs (kg)	37 (17)	12 (5.5)	17 (7.6)
Maximum Radial Shaft Load(2)	lbs (N)	265 (1,176)	110 (490)	110 (490)
Maximum Axial Shaft Load	lbs (N)	88 (392)	22 (98)	22 (98)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G235	G205	G210
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	5.4 (0.61)	7.3 (0.82)	7.3 (0.83)
Continuous Motor Current(5)	amps$_{RMS/ø}$	28	3.8	7.1
Peak Motor Current(5)	amps$_{RMS/ø}$	84	11	17
Thermal Time Constant	minutes	40	12	17
Insulation Class		F	F	F

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DB080N/I**	**DB100P/I**	**DB200Q/I**
Maximum Speed	RPM	3,000	3,000	3,000
Continuous Stall Torque	lb-in (N-m)	74 (8.4)	102 (12)	196 (22)
Rated Speed	RPM	1,500	1,500	1,500
Rated Torque	lb-in (N-m)	74 (8.4)	102 (12)	165 (19)
Rated Power(4)	HP watts	1.7 1,300	2.4 1,800	3.9 2,900
Peak Torque	lb-in (N-m)	152 (17)	155 (18)	312 (35)
Continuous Stall Torque/Inertia	radians/sec^2	4,066	3,630	4,816
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	18.2 (20.6)	28.1 (31.8)	40.7 (46.0)
Friction Torque, Static	lb-in (N-m)	0.87 (0.098)	1.0 (0.12)	1.4 (0.16)
Servomotor Weight(2)	lbs (kg)	21 (9.6)	31 (14)	40 (18)
Maximum Radial Shaft Load(2)	lbs (N)	154 (686)	265 (1,176)	331 (1,470)
Maximum Axial Shaft Load	lbs (N)	77 (343)	110 (490)	110 (490)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G217	G220	G225
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	7.4 (0.84)	6.5 (0.73)	7.3 (0.83)
Continuous Motor Current(5)	amps$_{RMS/ø}$	11	17	24
Peak Motor Current(5)	amps$_{RMS/ø}$	28	42	56
Thermal Time Constant	minutes	25	34	35
Insulation Class		F	F	F

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

9 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

4 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DB300R/I**	**DB330S/I**	**DB465T/I**
Maximum Speed	RPM	3,000	3,000	3,000
Continuous Stall Torque	lb-in (N-m)	300 (34)	345 (39)	450 (51)
Rated Speed	RPM	1,500	1,500	1,500
Rated Torque	lb-in (N-m)	252 (28)	310 (35)	425 (48)
Rated Power(4)	HP watts	5.9 4,400	7.4 5,500	10 7,500
Peak Torque	lb-in (N-m)	479 (54)	728 (82)	839 (95)
Continuous Stall Torque/Inertia	radians/sec^2	5,017	4,378	4,054
MECHANICAL				
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	59.8 (67.6)	78.8 (89.0)	111.0 (125.4)
Friction Torque, Static	lb-in (N-m)	2.3 (0.25)	3.0 (0.33)	4.2 (0.47)
Servomotor Weight(2)	lbs (kg)	51 (23)	66 (30)	88 (40)
Maximum Radial Shaft Load(2)	lbs (N)	331 (1,470)	397 (1,764)	397 (1,764)
Maximum Axial Shaft Load	lbs (N)	110 (490)	132 (588)	132 (588)
ELECTRICAL & THERMAL				
Servodrive Model Number	SAC-	G235	G260	G260
Servodrive Input Power	VAC	230	230	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	8.1 (0.91)	7.8 (0.88)	8.2 (0.93)
Continuous Motor Current(5)	amps$_{RMS/ø}$	33	42	55
Peak Motor Current(5)	amps$_{RMS/ø}$	84	110	130
Thermal Time Constant	minutes	36	44	46
Insulation Class		F	F	F

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

PERFORMANCE(1)	**Units**	**DB700U/I**
Maximum Speed	RPM	2,000
Continuous Stall Torque	lb-in (N-m)	665 (75)
Rated Speed	RPM	1,500
Rated Torque	lb-in (N-m)	620 (70)
Rated Power(4)	HP watts	14.75 11,000
Peak Torque	lb-in (N-m)	1000 (113)
Continuous Stall Torque/Inertia	radians/sec^2	2,671
MECHANICAL		
Moment of Inertia(2)	in-lb-sec^{2}x10^{-3} (kg-m2x10-4)	249.0 (281.4)
Friction Torque, Static	lb-in (N-m)	7.2 (0.81)
Servomotor Weight(2)	lbs (kg)	127 (58)
Maximum Radial Shaft Load(2)	lbs (N)	397 (1,764)
Maximum Axial Shaft Load	lbs (N)	132 (588)
ELECTRICAL & THERMAL		
Servodrive Model Number	SAC-	G260
Servodrive Input Power	VAC	230
Torque Sensitivity, K_t	lb-in/amp$_{RMS/ø}$ (N-m/amp$_{RMS/ø}$)	11 (1.2)
Continuous Motor Current(5)	amps$_{RMS/ø}$	59
Peak Motor Current(5)	amps$_{RMS/ø}$	140
Thermal Time Constant	minutes	68
Insulation Class		F

1 Performance ratings are obtained with servomotor ambient temperature at 40C.

2 Specification for incremental encoder motor only. Refer to the Brake Options Servomotor Performance Specifications section for specification of servomotor with absolute encoder and/or brake options.

3 Maximum radial shaft losd specification is for a load centered 0.2 inches (5 mm) from the end of the motor shaft.

4 Motor's peak torque is limited by the peak current of the servodrive. The Next larger drive may be used to increase the amount of peak torque available. Consult an ORMEC Applications Engineer for details.

5 Motor current specifications independent of the drive selected.

6.3.5 Specifications for DE/DA/DB-Series Motors with Incremental Encoders and Fail-Safe Brakes

The brake's holding torque is equivalent to the motor's rated torque. Also see **Table 42**, Specifications for Fail-Safe Brakes for DE/DA/DB-Series Motors (page 112).

Servomotor	**Servodrive**	**Inertia** lb-in-sec^{2}x10^{-3} (kg-m^{2}x10^{-4})	**Servomotor Length** inches (mm)	**Servomotor Weight** lbs (kg)	**Quadrature Output Res.** counts/rev
MAC-DE003A1/I_B	G203	0.091 (0.103)	3.39 (86)	2.0 (0.9)	8,192
MAC-DE006B1/I_B	G205	0.272 (0.307)	3.68 (94)	4.2 (1.9)	8,192
MAC-DE008C1/I_B	G210	0.394 (0.446)	4.47 (114)	5.7 (2.6)	8,192
MAC-DE003A2/I_B	G203	0.091 (0.103)	3.39 (86)	2.0 (0.9)	8,192
MAC-DE006B2/I_B	G203	0.272 (0.307)	3.68 (94)	4.2 (1.9)	8,192
MAC-DE011C2/I_B	G205	0.394 (0.446)	4.47 (114)	5.7 (2.6)	8,192
MAC-DE021D2/I_B	G205	2.23 (2.52)	4.65 (118)	13 (5.9)	8,192
MAC-DE042E2/I_B	G210	4.34 (4.91)	5.75 (146)	18 (8.2)	8,192
MAC-DA030F/I_B	G210	1.73 (1.95)	7.60 (193)	13 (5.9)	16,384
MAC-DA055G/I_B	G217	3.01 (3.40)	9.53 (242)	19 (8.6)	16,384
MAC-DA090H/I_B	G225	7.84 (8.86)	9.33 (237)	31 (14)	16,384
MAC-DA110J/I_B	G225	10.1 (11.5)	10.8 (274)	38 (17)	16,384
MAC-DA140K/I_B	G235	12.5 (14.2)	12.4 (314)	44 (20)	16,384
MAC-DB025L/I_B	G205	8.05 (9.10)	6.93 (176)	17 (7.7)	32,768
MAC-DB055M/I_B	G210	13.9 (15.8)	7.83 (199)	21 (9.5)	32,768
MAC-DB080N/I_B	G217	19.8 (22.4)	8.78 (223)	26 (12)	32,768
MAC-DB100P/I_B	G217	35.0 (39.5)	8.54 (217)	42 (19)	32,768
MAC-DB200Q/I_B	G225	47.6 (53.7)	9.57 (243)	52 (24)	32,768
MAC-DB300R/I_B	G235	66.7 (75.3)	10.9 (277)	63 (29)	32,768
MAC-DB330S/I_B	G260	85.7 (96.8)	12.2 (311)	77 (35)	32,768
MAC-DB465T/I_B	G260	118 (133)	15.2 (385)	100 (45)	32,768
MAC-DB700U/I_B	G260	261 (295)	15.1 (383)	143 (65)	32,768

Table 41**, Specifications for DE/DA/DB-Series Motors with **Incremental Encoders** and **Brakes

6.3.6 Specifications for Fail-Safe Brakes for DE/DA/DB-Series Motors

Servomotor	Servodrive	Holding Torque	Coil Resistance	Coil Voltage	Coil Current
		lb-in (N-m)	ohms (at 20C)	VDC	Amps (at 20C)
MAC-DE003A1/__B	G203	4.3 (0.49)	114	24	0.23
MAC-DE006B1/__B	G205	8.7 (0.98)	116	24	0.21
MAC-DE008C1/__B	G210	17 (1.9)	89	24	0.29
MAC-DE003A2/__B	G203	4.3 (0.49)	114	24	0.23
MAC-DE006B2/__B	G203	8.7 (0.98)	116	24	0.21
MAC-DE011C2/__B	G205	17 (1.9)	89	24	0.29
MAC-DE021D2/__B	G205	32 (3.6)	77	24	0.31
MAC-DE042E2/__B	G210	63 (7.1)	58	24	0.42
MAC-DA030F/__B	G210	66 (7.8)	82	24	0.29
MAC-DA055G/__B	G217	66 (7.8)	82	24	0.29
MAC-DA090H/__B	G225	177 (20)	59	24	0.41
MAC-DA110J/__B	G225	177 (20)	59	24	0.41
MAC-DA140K/__B	G235	177 (20)	59	24	0.41
MAC-DB025L/__B	G205	39 (4.4)	59	24	0.41
MAC-DB055M/__B	G210	112 (13)	59	24	0.41
MAC-DB080N/__B	G217	112 (13)	59	24	0.41
MAC-DB100P/__B	G217	380 (43)	31	24	0.77
MAC-DB200Q/__B	G220	380 (43)	31	24	0.77
MAC-DB300R/__B	G220	380 (43)	31	24	0.98
MAC-DB330S/__B	G220	646 (73)	25	24	0.98
MAC-DB465T/__B	G220	646 (73)	25	24	0.77
MAC-DB700U/__B	G220	744 (84)	18	24	1.33

***Table 42**, Specifications for Fail-Safe Brakes for DE/DA/DB-Series Motors*

6.3.7 Mating Connectors for DE/DA/DB-Series Motors Without Brakes

	Mating Connectors (used in cables)	
Motors Without Brakes	**Motor Power Connector**	**Motor Feedback Connector**
DE-Series	MS-3106F18-12S	MS3106F20-29S
DA030F, DA055G, DB025L, DB055M, DB080N	MS-3106F18-10S	MS3106F20-29S
DA090H, DA110J, DA140K, DB100P, DB200Q, DB300R	MS-3106F22-22S	
DB330S, DB465T, DB700U	MS-3106F32-17S	

***Table 43**, MAC-D_ Motor Mating Connectors for Motors **Without** Brakes*

	Mating Connectors (used in cables)	
Motors With Brakes	**Motor Power Connector**	**Motor Feedback Connector**
DE-Series	MS-3106F18-12S	MS3106F20-29S
DA030F, DA055G, DB025L, DB055M, DB080N	MS3106F20-15S	MS3106F20-29S
DA090H, DA110J, DA140K, DB100P, DB200Q, DB300R	MS-3106F24-10S	
DB330S, DB465T, DB700U	MS-3106F32-17S MS-3106F10SL-3S*	

* Brake option requires separate brake cable. Same motor cable is used for motors with and without brake.

***Table 44**, MAC-D_ Motor Mating Connectors for Motors **With** Brakes*

Chapter 7
Maintenance and Troubleshooting

7 Maintenance and Troubleshooting

7.1 Servodrive Troubleshooting Guide

Indication	FAULT	Status	Description
90-99 9A-9F	144-153 154-159	Internal Drive Error	An unexpected failure has occurred in the Servodrive software or hardware.
Defective hardware or software ⇒ Report error to Ormec Customer Service.			

Indication	FAULT	Status	Description
A0	160	Drive Over Current (RMS)	The maximum rating for the continuous current output of the drive has been exceeded for more than 2 seconds at peak current.
When enabling axis with Servomotor connected		• Incorrect servomotor wiring ⇒ See Section 3.7 (page 35) for correct wiring. • Defective Servomotor ⇒ Replace Servomotor	
After applying control power with Servomotor disconnected		• Defective Servodrive ⇒ Replace Servodrive	
Under load or during acceleration.		• Drive and/or motor may be undersized for the application.	

Indication	FAULT	Status	Description
A1	161	Over Current (Peak)	The maximum rating for the peak current output of the drive or the motor has been exceeded.
When enabling axis		UltraTools has not yet configured the drive.	

Indication	FAULT	Status	Description
A3 Bus Power LED not on	163	Low Bus Voltage	The bus voltage is too low. The trip point depends on the nominal input voltage, an UltraTools software setting: • 115 VAC nominal input: trip point = 94 VDC • 230 VAC nominal input: trip point = 205 VDC • 460 VAC nominal input: trip point = 410 VDC
When the AC input voltage applied to L1 and L2 is at least 88 VAC			• Input voltage does not match UltraTools software setting ⇒ Decrease software setting or increase applied AC input voltage.
			• Main fuses blown or circuit breaker tripped ⇒ Correct main input power problem, and replace fuses or reset circuit breaker.
			• Defective Servodrive ⇒ Replace Servodrive
When the AC input voltage applied to L1 and L2 is at least 88 VAC or 166 VAC, depending on UltraTools software setting			• Main fuses blown or circuit breaker tripped ⇒ Correct main input power problem, and replace fuses or reset circuit breaker
			• Defective Servodrive ⇒ Replace Servodrive

Indication	FAULT	Status	Description
A6	166	Drive Not Configured	An attempt was made to enable torque before the drive's setup parameters have been configured.

Indication	FAULT	Status	Description
A8	168	Invalid Commutation Position	A Drive was commanded to enable when the commutation position was invalid.

A9	169	Phase Loss	Loss of a main power phase was detected.

AA	170	No Bus Voltage	No bus voltage was detected. The SCR has not been commanded ON when trying to enable the drive.

AC	172	Soft Start Error	An overtemperature condition was detected in the drive powerblock, or a failure of the inrush current resistor.

Indication	FAULT	Status	Description
B0	176	Download checksum error	A checksum error was detected in the FlexROM2 upgrade file sent to the drive. No upgrade was performed.
At completion of download		• Communications error causing corrupt transmission. Try again. • Corrupt file on disk. Replace file and try again. • Version of UltraTools too old for file format. Versions before 2.0 will not work correctly with FlexROM2 files. Upgrade UltraTools.	

B1	177	Incompatible file	The drive does not recognize the file (data) sent as an upgrade as being a valid upgrade file. Check the file and try again.

B2	178	Incompatible version	The upgrade file sent to the drive will not work on this drive. The data is coded to indicate which hardware platforms are supported. The code indicates that this file will not work on this hardware platform. Check the file and try again or change the hardware to the correct platform.

B3	179	Internal checksum error	The drive firmware stored in non-volatile memory has been corrupted.
At power up		• If present at every power cycle then return drive immediately. • If intermittent then there is a problem and the drive needs to be replaced.	

Indication	FAULT	Status	Description
C1	193	Hardware Disable	Drive disabled by the hardware enable input.
Check the hardware enable input (P2-23).			

Indication	FAULT	Status	Description
C2	194	Software Disable	Drive disabled by a software enable command.
Check the DRVENA command setting.			

Indication	FAULT	Status	Description
F1	241	Motor Over Current (RMS)	The motor's rating for continuous current has been exceeded by the actual RMS current for longer than allowed by the thermal time constant of the motor.

Indication	FAULT	Status	Description
F2	242	Power Module Fault	The Power Module's self-protection has detected a short circuit, over current, over temperature or control supply under voltage.

Indication	FAULT	Status	Description
F3	243	High Bus Voltage	The bus voltage is excessive. The trip point depends on the rated voltage of the motor, a UltraTools software setting: • Motor rated for 115 VAC: trip point = 237 VDC • Motor rated for 230 VAC (or above): trip point = 425 VDC • Motor rated for 460 VAC (or above): trip point = 800 VDC

When power is applied to the main circuit	• Applied voltage exceeds the Servomotor's rating ⇒ Reduce applied voltage. • UltraTools software settings for Servodrive Input Voltage are lower than desired applied voltage ⇒ Increase setting in UltraTools software. Defective Servodrive ⇒ Replace Servodrive
While motor is in regeneration, or when drives share bus power, if any of the motors is in regeneration. Regeneration may exist during deceleration, or during downward motion in a non-counterbalanced vertical application, or in a tensioned unwind application.	• A regenerative discharge resistor is required by the application but is not present ⇒ Install regen resistor, reduce inertial load, or reduce max speed and/or acceleration. • The regenerative resistor installed has been damaged and is no longer fully functional ⇒ Install higher-wattage regenerative resistor, and reduce inertial load, or reduce max speed and/or acceleration.

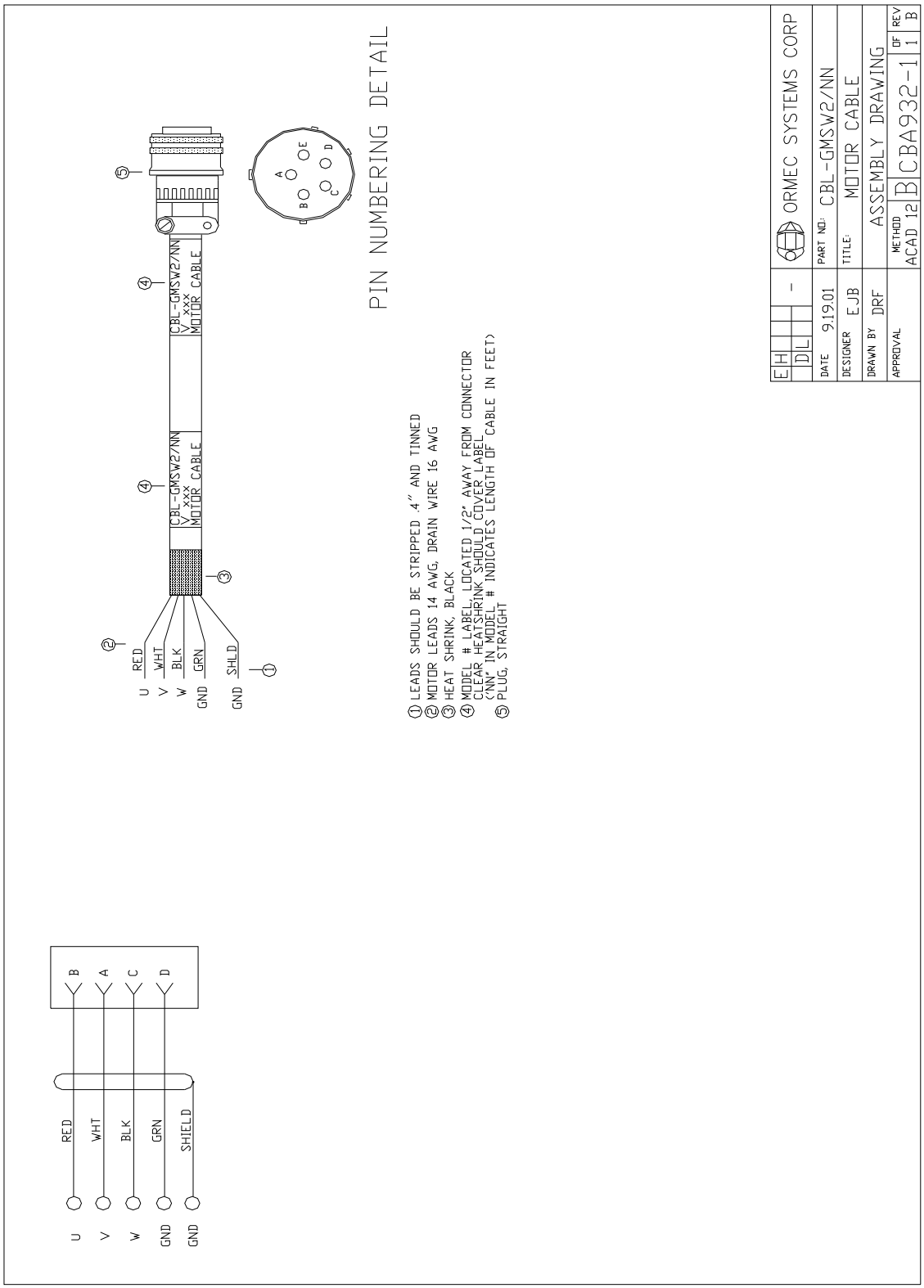
Indication	FAULT	Status	Description
F4 HITEMP LED is on	244	Motor Over Temperature	The thermal contact has opened (P3 pins 14 & 15, or P4 pins 10 and 7 on Resolver versions) indicating that the motor is over temperature. This condition can not be reset until the motor has sufficiently cooled.
When the motor is hot		• Motor is overloaded ⇒ Reduce motor load • Excessive ambient temperature ⇒ Reduce ambient temperature to 25ºC	
When the motor is cool to the touch		• Faulty motor feedback wiring ⇒ Check cable and all termination points. • Defective thermal switch in motor ⇒ Disconnect motor and test for continuity at motor pins. (See motor pinouts in Appendix D). • Motor has no thermal switch, and UltraTools software settings are configured to expect a closed contact. ⇒ Disable Thermal Contact in UltraTools • Defective Servodrive ⇒ Replace Servodrive	

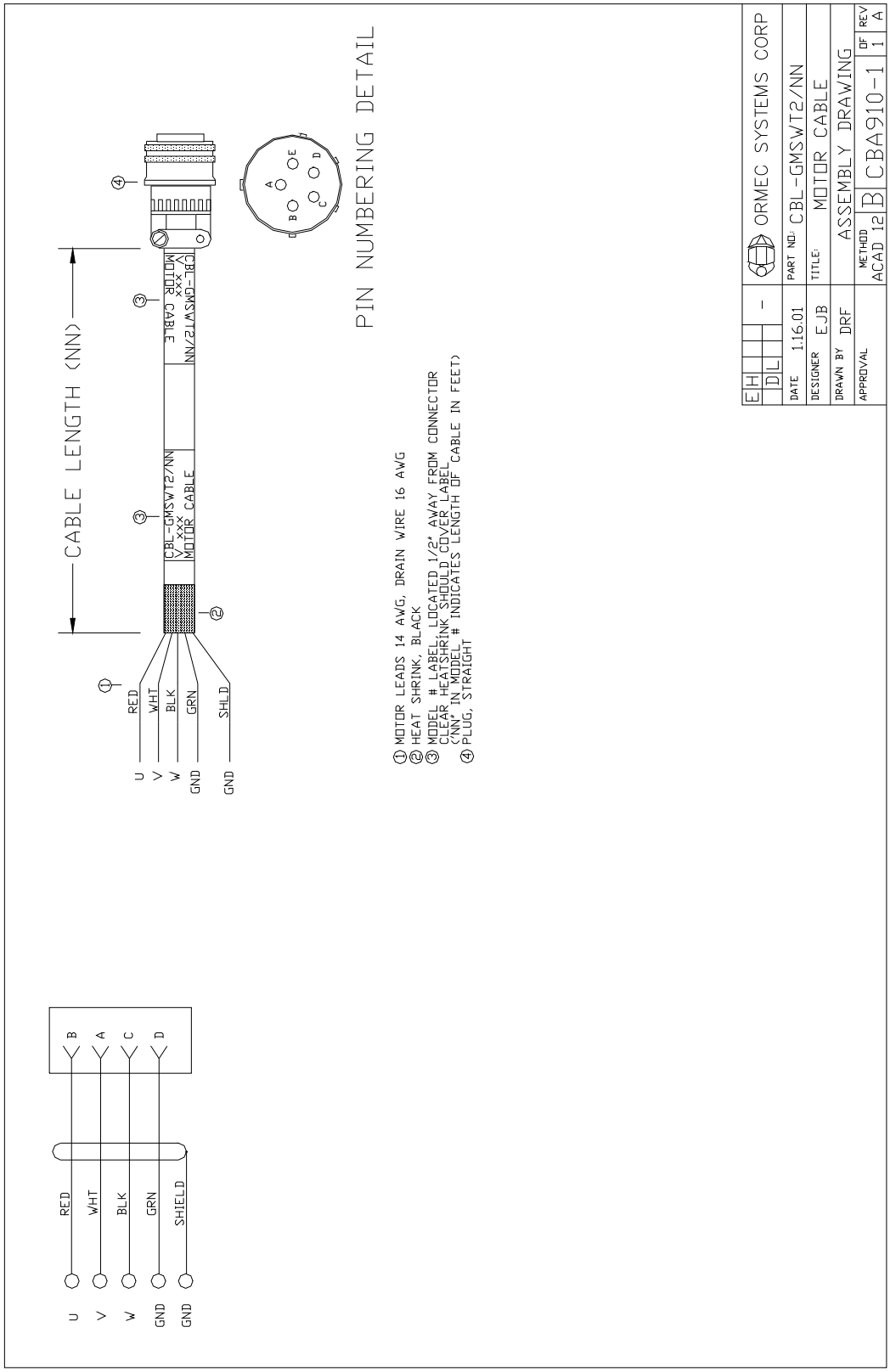
Indication	FAULT	Status	Description
F7	247	Motor Feedback Open Wire	At least one motor feedback channel is not connected properly. On quadrature feedback drives check ENCA, ENCA', ENCB, ENCB' (P4 pins 5,6,7,8). For resolver feedback drives check SIN+, SIN-, COS +, COS – (P4 pins 3, 4, 5, 6).
During acceleration or deceleration of resolver motor		• Temporary resolver tracking error. Reduce acceleration or deceleration rate or increase R.DEB value to compensate. During high rates of acceleration or deceleration the Resolver-to-Digital converter may temporarily fall behind in tracking the motor position. This is reported as an error using the same signal as the open wire and goes away as soon as the converter catches up. The R.DEB value debounces that error signal. A larger value will cause the drive to ignore a longer temporary error signal. If the application can tolerate ignoring this error then increasing R.DEB may help.	

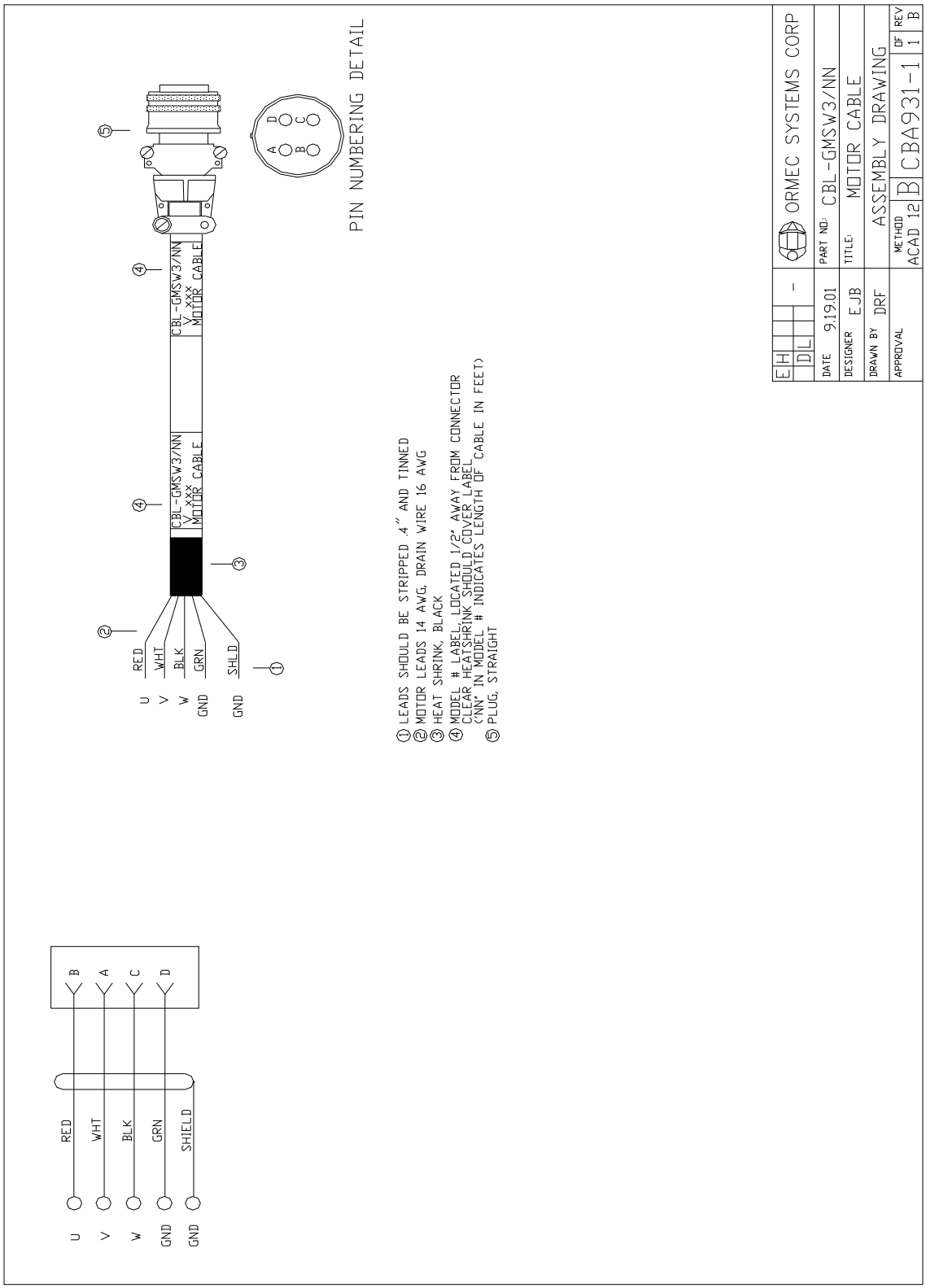
Indication	FAULT	Status	Description
F8	248	Watchdog Timeout	DSP Watchdog timeout error.

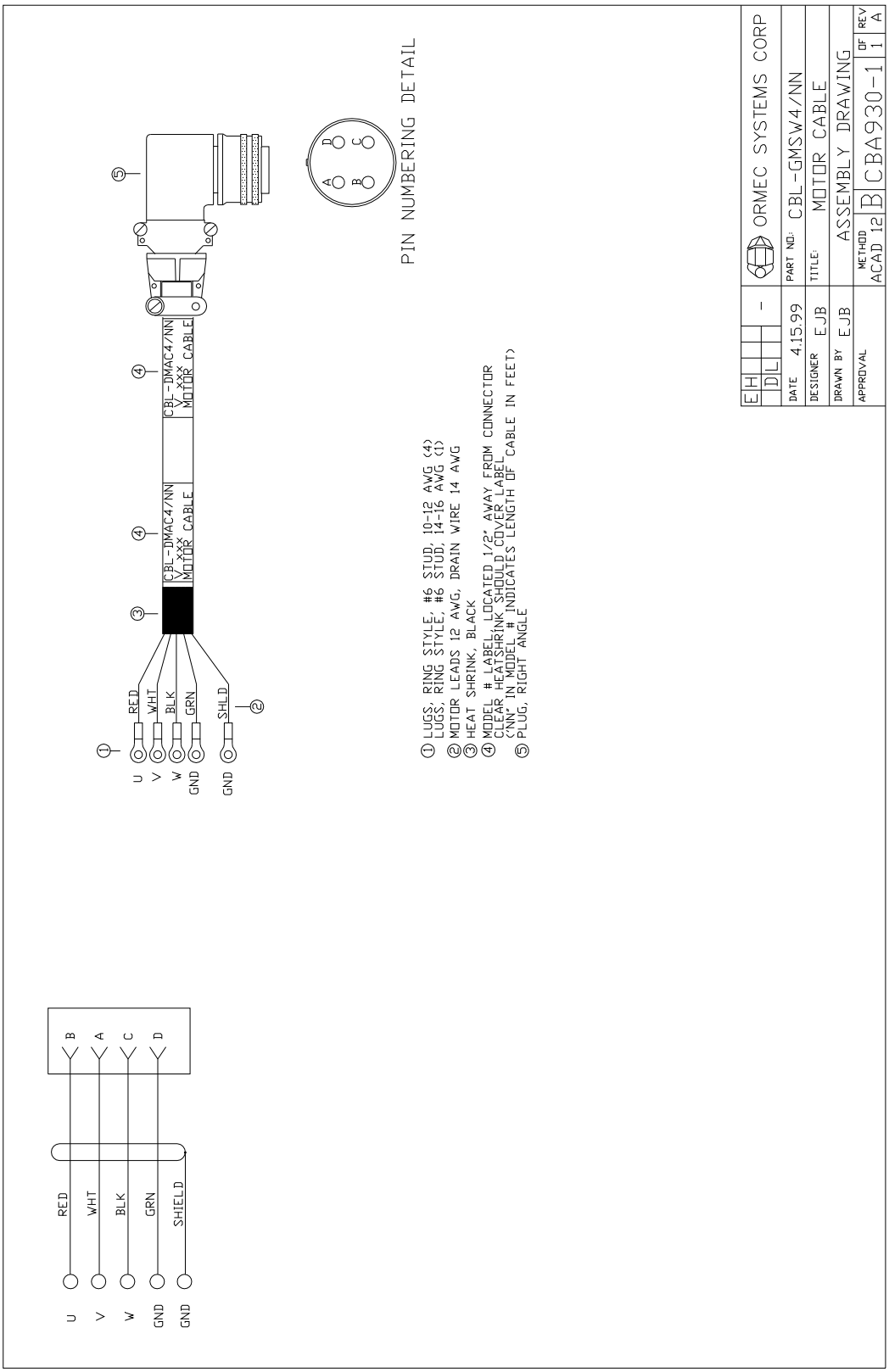
7.2 Servomotor Troubleshooting Guide

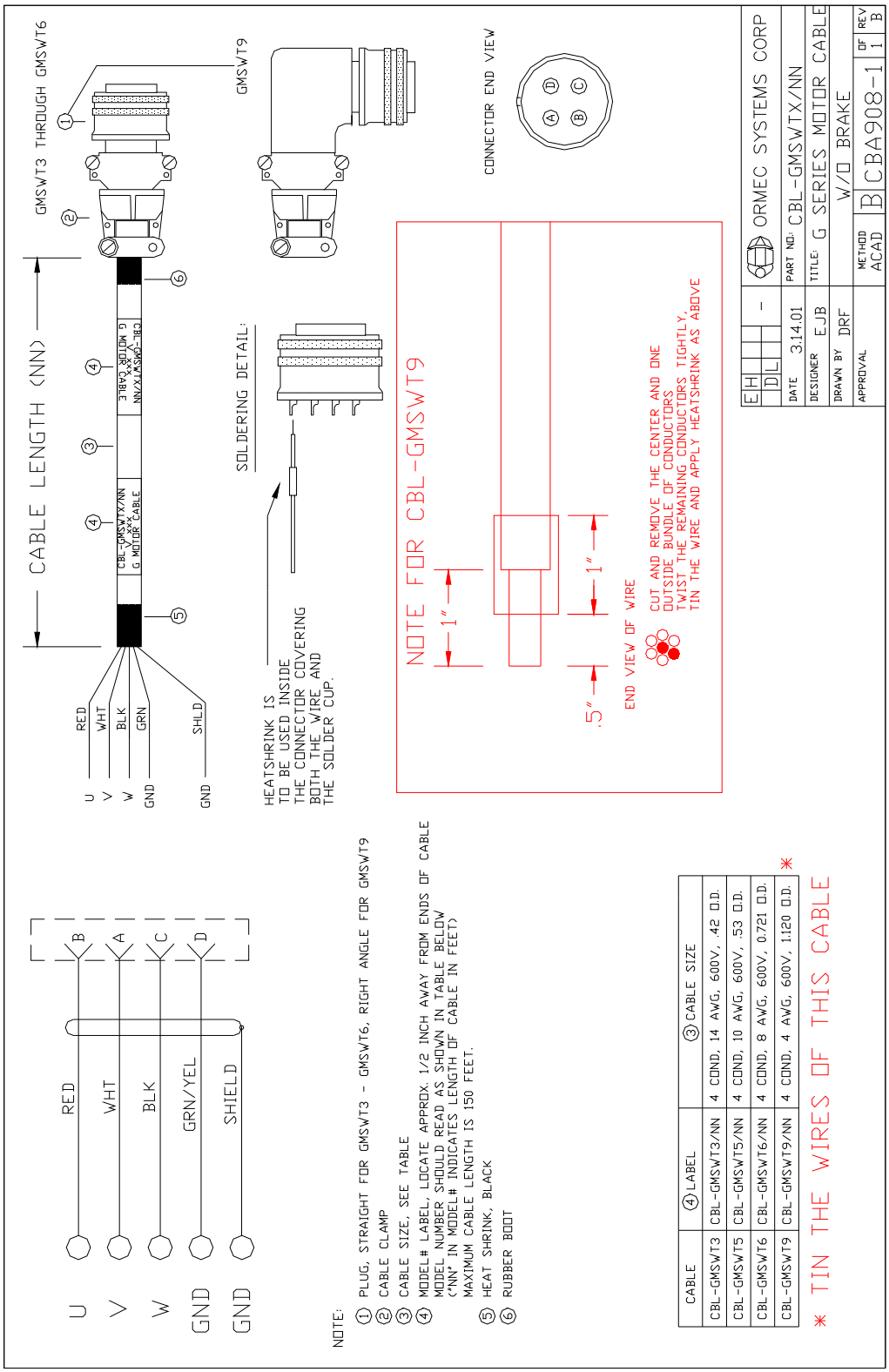
Problem	Cause	What to do
Motor does not start	Loose Connection ⇒ Tighten connection	
	Wrong wiring ⇒ Correct wiring	
	Overload ⇒ Reduce load or use a larger motor	
	Motor defective	Measure voltage across motor terminals U, V, & W on the Servodrive. If correct, replace motor, otherwise replace servodrive.
	Servodrive Defective	
Locked Rotor	Wrong order of U, V, W	Check cabling.
Unstable Operation	Wrong motor selected in UltraTools	Check & correct that software matches motor.
	Improper Tuning	Check that Inertial load specified in UltraTools is less than or equal to the actual load seen by the motor. Check other tuning parameters.
	Wrong Wiring	Inspect and correct wiring of motor terminals U, V, & W and/or the encoder.
Motor Overheats	Excessive ambient temperature	Reduce ambient temperature below 40°C, or use a larger motor.
	Motor dirty	Clean motor surface
	Overload	Reduce load or use a larger motor.
Unusual Noise	Motor loosely mounted	Tighten mounting bolts
	Motor misaligned	Realign
	Coupling out of balance	Balance coupling
	Noisy bearing	Check alignment, loading of bearing, lubrication.
	Vibration of driven machine	Check the machine's mechanical operation.
	Improper grounding and/or shielding	Check the servomotor, servodrive, and power supply grounding and shielding.
	Incorrect servo control loop tuning	Check the servo control loop tuning parameters.
Poor Velocity Regulation	Single phase main power (L1 & L2 only) on a drive expecting 3-phase power (G210, G217, G220)	Use 3-phase power.
WARNING!!! **Turn off power before working on the Servomotor**		

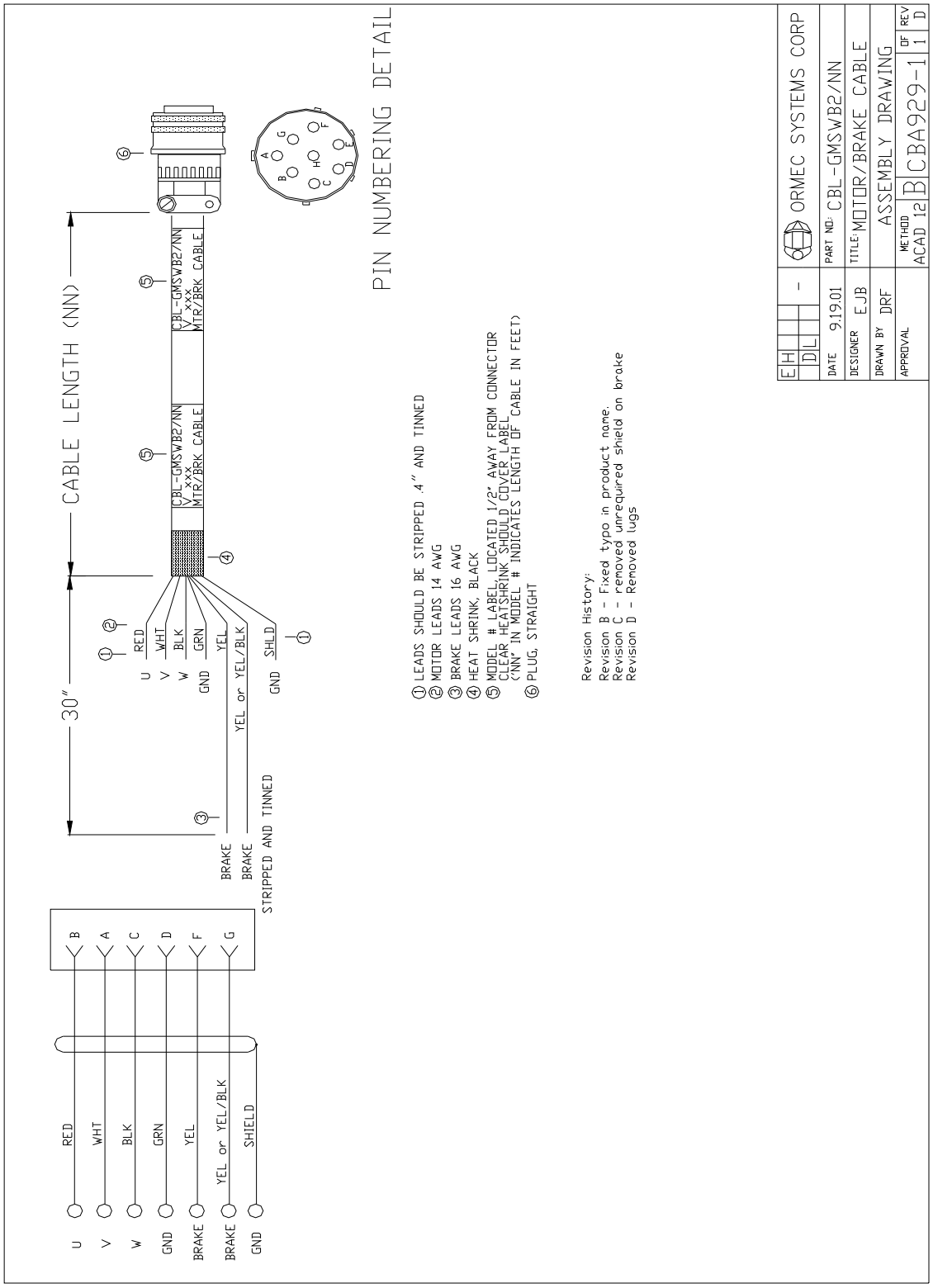

PIN NUMBERING DETAIL
CBL-GMSW2/NN
-XXX
MOTOR CABLE
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
A
B
C
D
E
① LEADS SHOULD BE STRIPPED .4" AND TINNED
② MOTOR LEADS 14 AWG, DRAIN WIRE 16 AWG
③ HEAT SHRINK, BLACK
④ MODEL # LABEL, LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
("NN" IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
⑤ PLUG, STRAIGHT
ORMEC SYSTEMS CORP
PART NO: CBL-GMSW2/NN
TITLE: MOTOR CABLE
ASSEMBLY DRAWING
DATE 9.19.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL
METHOD ACAD 12
CBA932-11
REV B

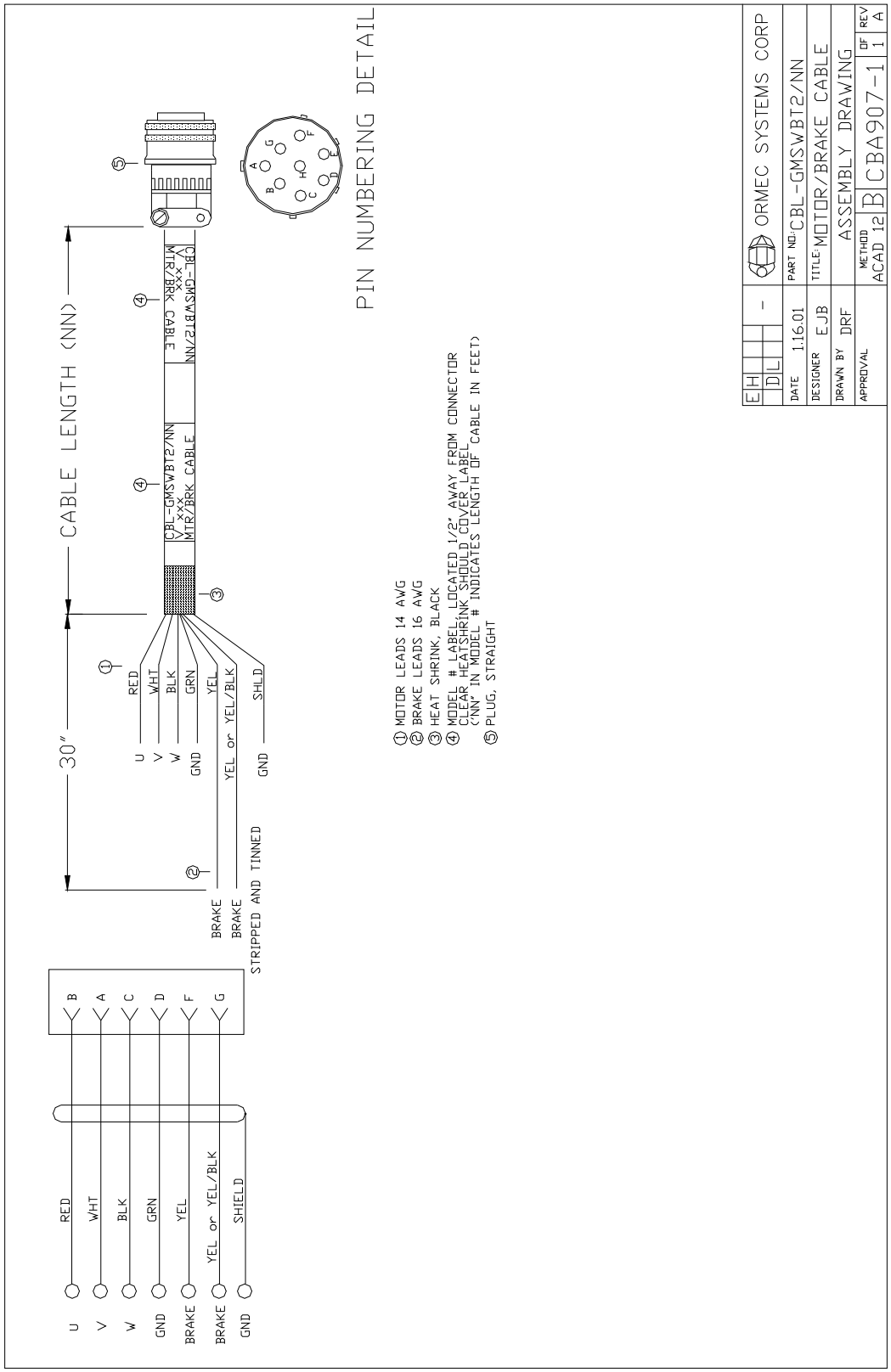

CABLE LENGTH (NN)
CBL-GMSWT2/NN
V xxx
MOTOR CABLE
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
PIN NUMBERING DETAIL
① MOTOR LEADS 14 AWG, DRAIN WIRE 16 AWG
② HEAT SHRINK, BLACK
③ MODEL # LABEL, LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
("NN" IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
④ PLUG, STRAIGHT
ORMEC SYSTEMS CORP
PART NO: CBL-GMSWT2/NN
TITLE: MOTOR CABLE
ASSEMBLY DRAWING
METHOD ACAD 12
B CBA910-1
DF 1
REV A
DATE 1.16.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL

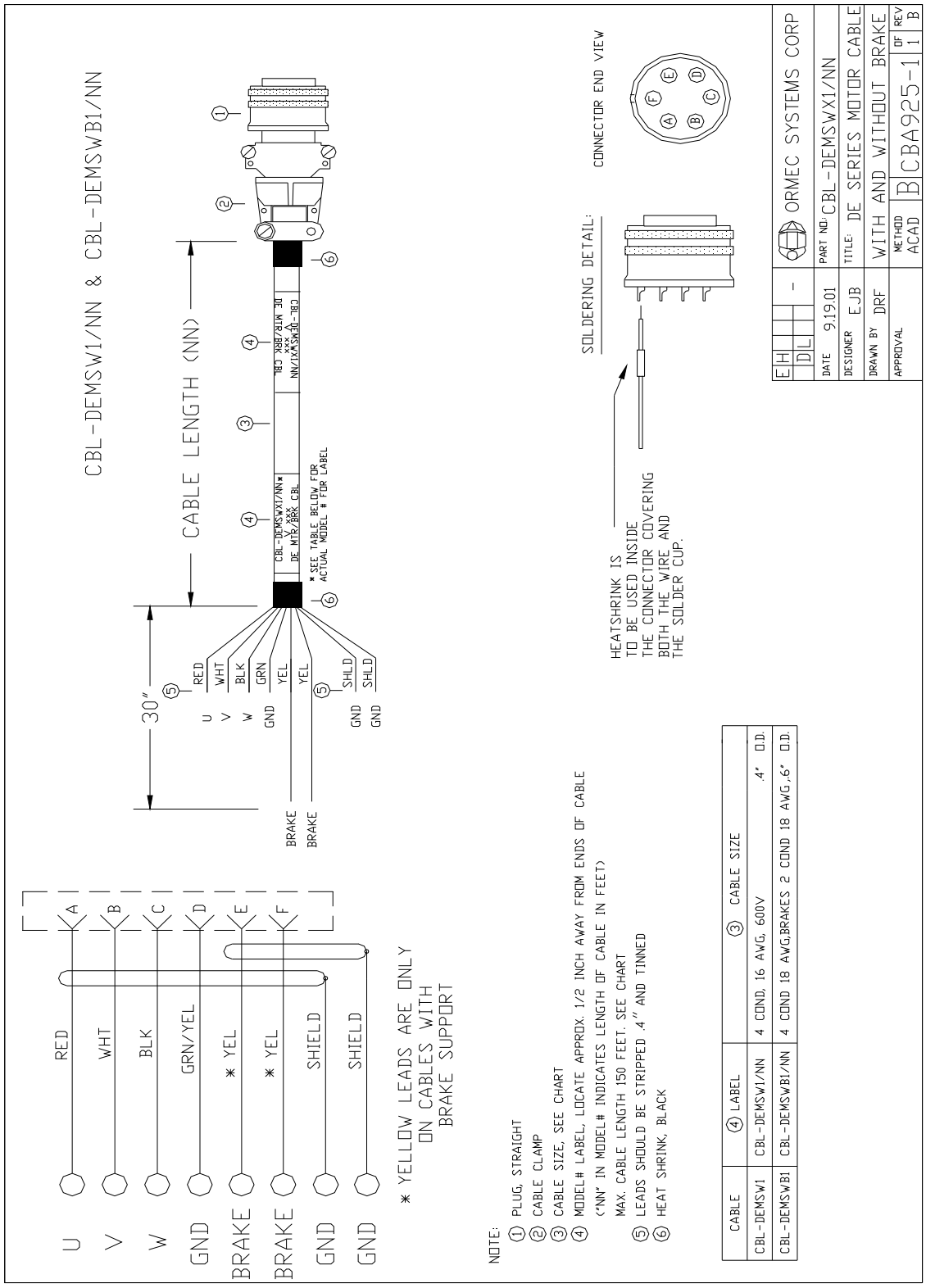

PIN NUMBERING DETAIL
A
B
C
D
CBL-GMSW3/NN
V.XXX
MOTOR CABLE
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
① LEADS SHOULD BE STRIPPED .4" AND TINNED
② MOTOR LEADS 14 AWG, DRAIN WIRE 16 AWG
③ HEAT SHRINK, BLACK
④ MODEL # LABEL, LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
("NN" IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
⑤ PLUG, STRAIGHT
ORMEC SYSTEMS CORP
PART NO: CBL-GMSW3/NN
TITLE: MOTOR CABLE
ASSEMBLY DRAWING
DATE 9.19.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL
METHOD ACAD 12
B CBA931-1
SIZE B
DF 1
REV B

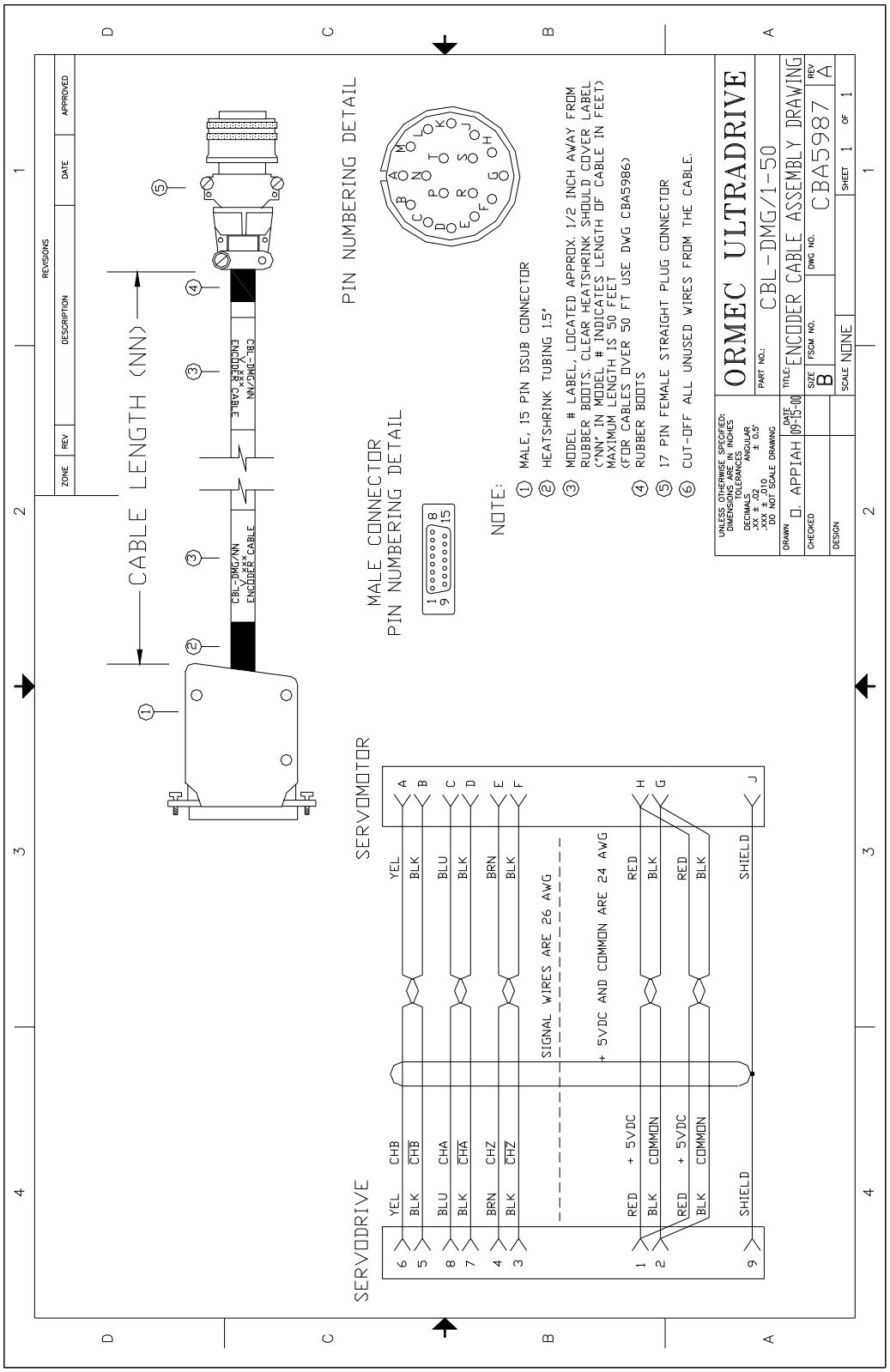

PIN NUMBERING DETAIL
A
B
C
D
CBL-DMAC4/NN
MOTOR CABLE
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
① LUGS, RING STYLE, #6 STUD, 10-12 AWG (4)
LUGS, RING STYLE, #6 STUD, 14-16 AWG (1)
② MOTOR LEADS 12 AWG, DRAIN WIRE 14 AWG
③ HEAT SHRINK, BLACK
④ MODEL # LABEL LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
CNVY IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
⑤ PLUG, RIGHT ANGLE
ORMEC SYSTEMS CORP
PART NO: CBL-GMSW4/NN
TITLE: MOTOR CABLE
ASSEMBLY DRAWING
DATE 4.15.99
DESIGNER EJB
DRAWN BY EJB
APPROVAL
METHOD ACAD 12
B CBA930-1
DF 1
REV A

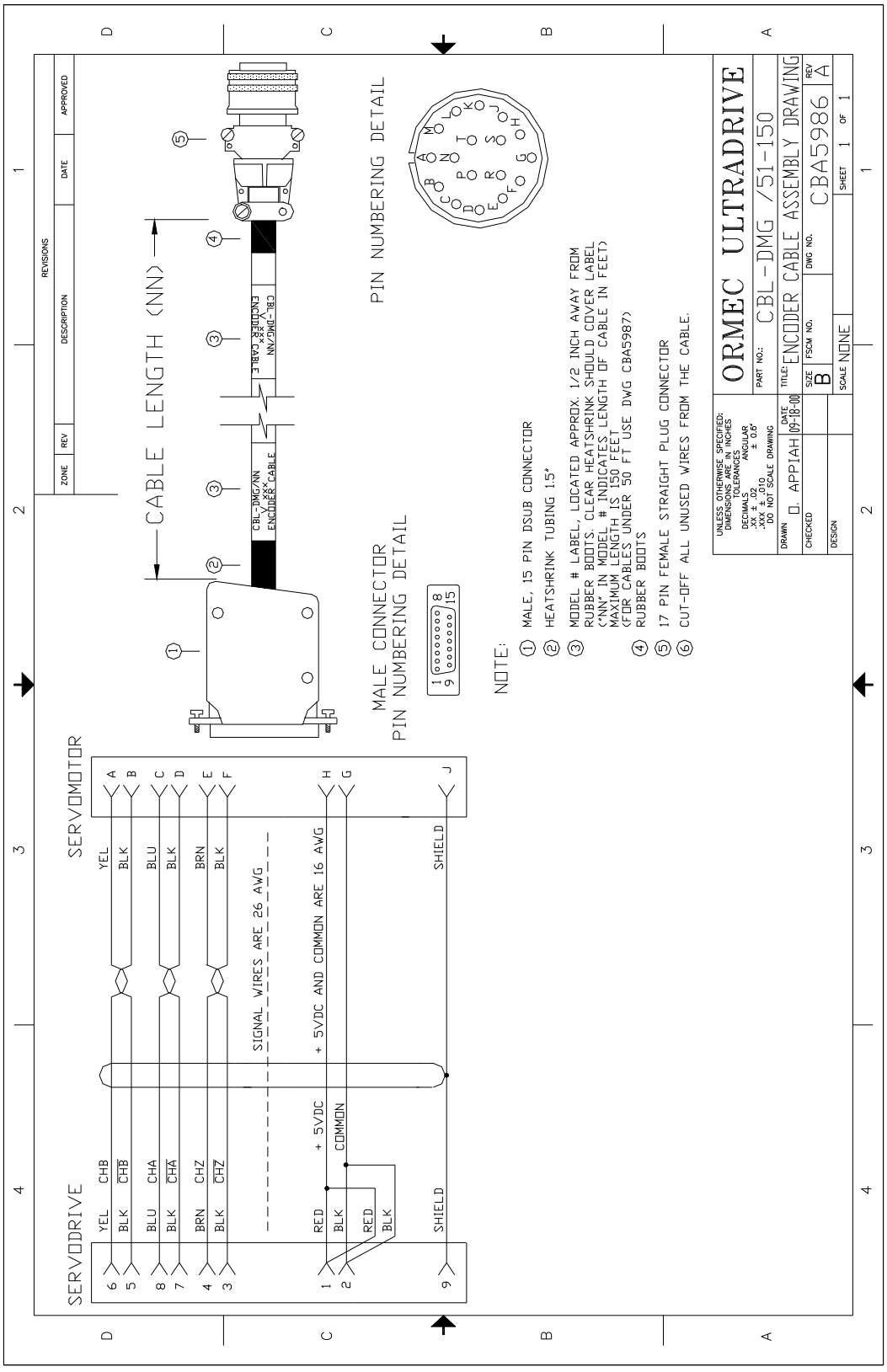

GMSWT3 THROUGH GMSWT6
GMSWT9
CABLE LENGTH (NN)
SOLDERING DETAIL:
CONNECTOR END VIEW
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
HEATSHRINK IS TO BE USED INSIDE THE CONNECTOR COVERING BOTH THE WIRE AND THE SOLDER CUP.
NOTE FOR CBL-GMSWT9
1"
.5"
1"
END VIEW OF WIRE
CUT AND REMOVE THE CENTER AND ONE OUTSIDE BUNDLE OF CONDUCTORS. TWIST THE REMAINING CONDUCTORS TIGHTLY. TIN THE WIRE AND APPLY HEATSHRINK AS ABOVE
ORMEC SYSTEMS CORP
PART NO: CBL-GMSWTX/NN
TITLE: G SERIES MOTOR CABLE W/O BRAKE
DATE 3.14.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL
METHOD ACAD
CBA908-1
REV B
SHEET 1 OF 1
NOTE:
① PLUG, STRAIGHT FOR GMSWT3 - GMSWT6, RIGHT ANGLE FOR GMSWT9
② CABLE CLAMP
③ CABLE SIZE, SEE TABLE
④ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE
MODEL NUMBER SHOULD READ AS SHOWN IN TABLE BELOW
("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET)
MAXIMUM CABLE LENGTH IS 150 FEET.
⑤ HEAT SHRINK, BLACK
⑥ RUBBER BOOT
CABLE | ④LABEL | ③CABLE SIZE
CBL-GMSWT3 | CBL-GMSWT3/NN | 4 COND, 14 AWG, 600V, .42 O.D.
CBL-GMSWT5 | CBL-GMSWT5/NN | 4 COND, 10 AWG, 600V, .53 O.D.
CBL-GMSWT6 | CBL-GMSWT6/NN | 4 COND, 8 AWG, 600V, 0.721 O.D.
CBL-GMSWT9 | CBL-GMSWT9/NN | 4 COND, 4 AWG, 600V, 1.120 O.D. *
* TIN THE WIRES OF THIS CABLE

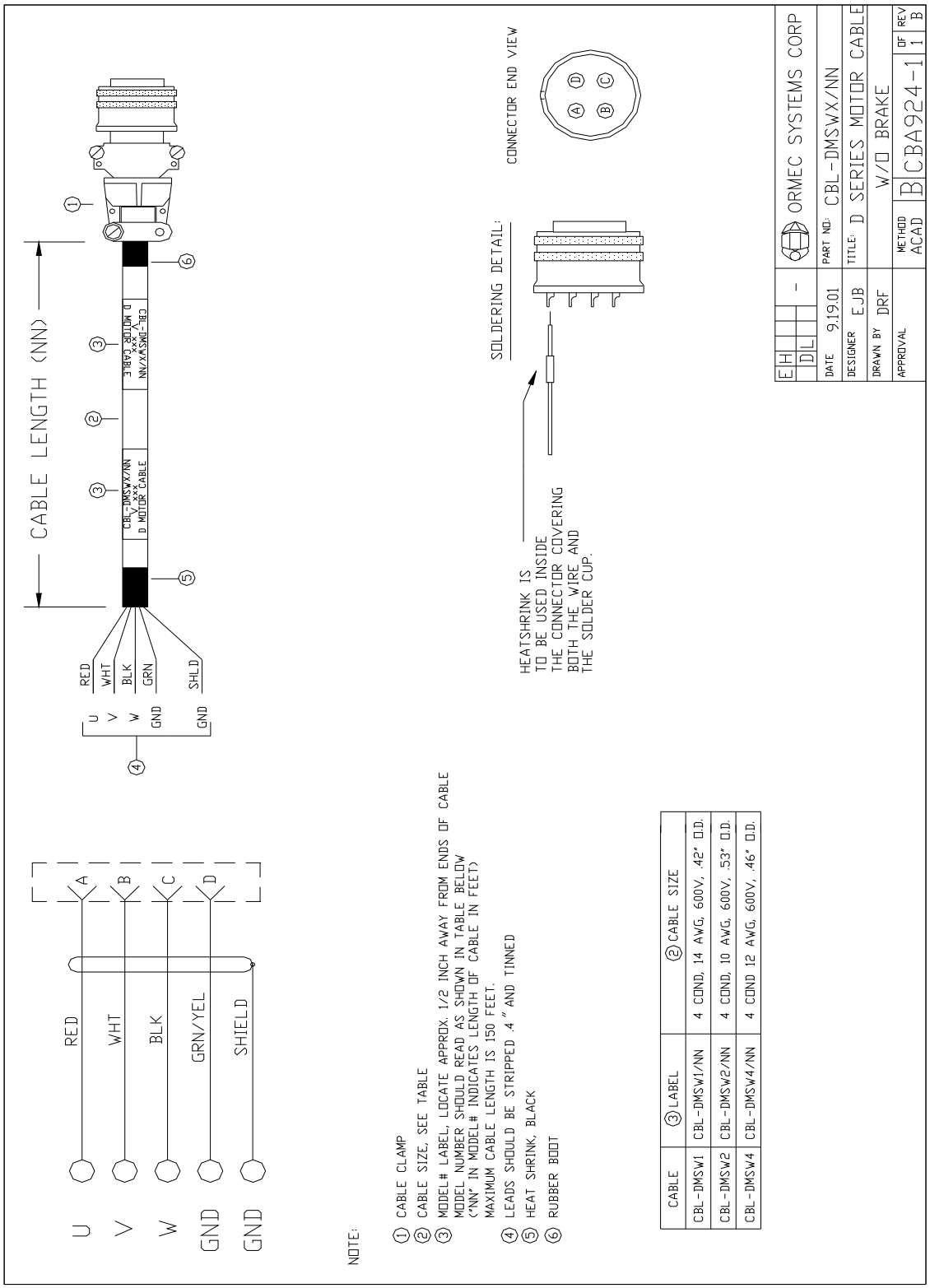

PIN NUMBERING DETAIL
CABLE LENGTH (NN)
30"
CBL-GMSWB2/NN
V xxx
MTR/BRK CABLE
RED
WHT
BLK
GRN
YEL
YEL or YEL/BLK
SHLD
U
V
W
GND
BRAKE
BRAKE
GND
STRIPPED AND TINNED
① LEADS SHOULD BE STRIPPED .4" AND TINNED
② MOTOR LEADS 14 AWG
③ BRAKE LEADS 16 AWG
④ HEAT SHRINK, BLACK
⑤ MODEL # LABEL, LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
('NN' IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
⑥ PLUG, STRAIGHT
Revision History:
Revision B - Fixed typo in product name.
Revision C - removed unrequired shield on brake
Revision D - Removed lugs
ORMEC SYSTEMS CORP
PART NO: CBL-GMSWB2/NN
TITLE: MOTOR/BRAKE CABLE
ASSEMBLY DRAWING
DATE 9.19.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL
METHOD ACAD 12
CBA929-1
REV D
DF 1

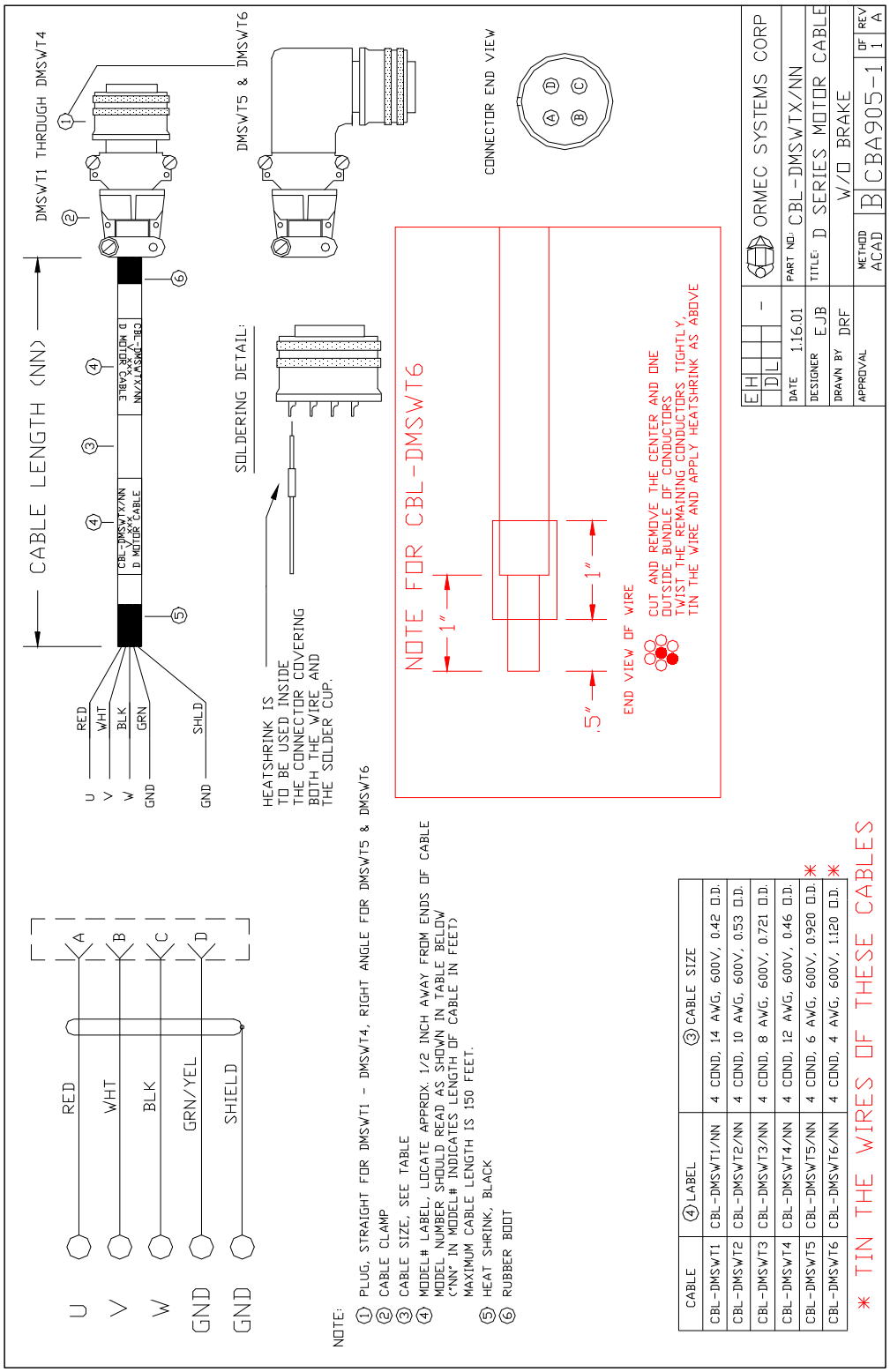

PIN NUMBERING DETAIL
CABLE LENGTH (NN)
30"
CBL-GMSWBT2/NN
MTR/BRK CABLE
① MOTOR LEADS 14 AWG
② BRAKE LEADS 16 AWG
③ HEAT SHRINK, BLACK
④ MODEL # LABEL, LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
("NN" IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
⑤ PLUG, STRAIGHT
RED
WHT
BLK
GRN
YEL
YEL or YEL/BLK
SHLD
U
V
W
GND
BRAKE
BRAKE
GND
STRIPPED AND TINNED
ORMEC SYSTEMS CORP
PART NO: CBL-GMSWBT2/NN
TITLE: MOTOR/BRAKE CABLE
ASSEMBLY DRAWING
METHOD ACAD 12
B CBA907-1
REV A
DF 1
DRAWN BY DRF
DESIGNER EJB
DATE 1.16.01
APPROVAL

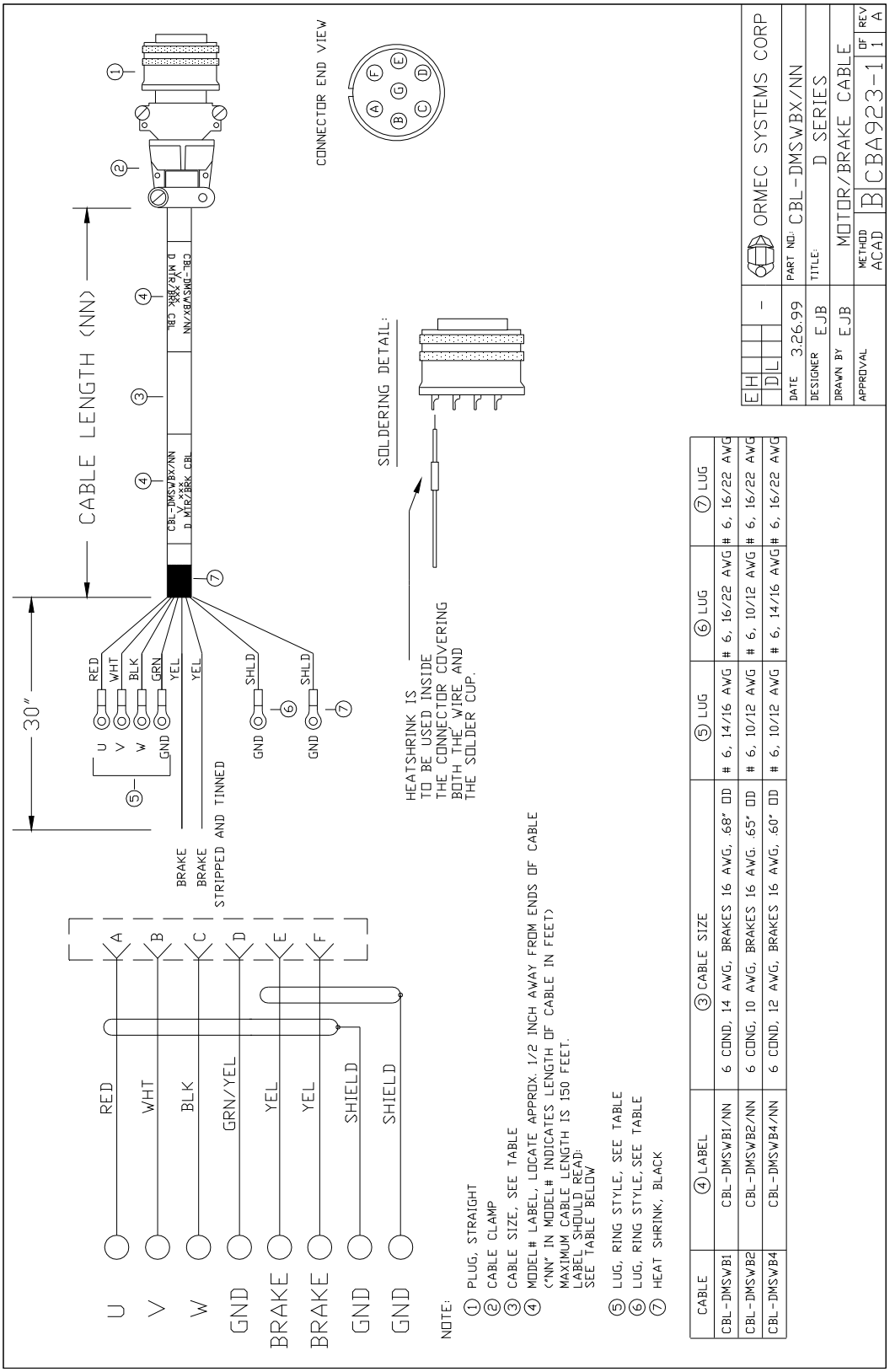

CBL-DEMSW1/NN & CBL-DEMSWB1/NN
CABLE LENGTH (NN)
30"
RED
WHT
BLK
GRN
YEL
YEL
SHLD
SHLD
U
V
W
GND
BRAKE
BRAKE
GND
GND
* SEE TABLE BELOW FOR ACTUAL MODEL # FOR LABEL
CBL-DEMSWX1/NN*
DE MTR/BRK CBL
CBL-DEMSWX1/NN
DE MTR/BRK CBL
SOLDERING DETAIL:
CONNECTOR END VIEW
HEATSHRINK IS TO BE USED INSIDE THE CONNECTOR COVERING BOTH THE WIRE AND THE SOLDER CUP.
* YELLOW LEADS ARE ONLY ON CABLES WITH BRAKE SUPPORT
NOTE:
① PLUG, STRAIGHT
② CABLE CLAMP
③ CABLE SIZE, SEE CHART
④ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE ("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET) MAX. CABLE LENGTH 150 FEET. SEE CHART
⑤ LEADS SHOULD BE STRIPPED .4" AND TINNED
⑥ HEAT SHRINK, BLACK
CABLE | ④ LABEL | ③ CABLE SIZE
CBL-DEMSW1 | CBL-DEMSW1/NN | 4 COND, 16 AWG, 600V .4" O.D.
CBL-DEMSWB1 | CBL-DEMSWB1/NN | 4 COND 18 AWG,BRAKES 2 COND 18 AWG,.6" O.D.
ECN | DL | - | ORMEC SYSTEMS CORP
DATE 9.19.01
PART NO: CBL-DEMSWX1/NN
DESIGNER EJB
TITLE: DE SERIES MOTOR CABLE WITH AND WITHOUT BRAKE
DRAWN BY DRF
APPROVAL
METHOD ACAD
B CBA925-1 DF 1 REV B


ORMEC ULTRADRIVE
PART NO.: CBL-DMG/1-50
TITLE: ENCODER CABLE ASSEMBLY DRAWING
DWG NO. CBA5987
REV A
SIZE B
SCALE NONE
SHEET 1 OF 1
DRAWN D. APPIAH 09-15-00
CHECKED
DESIGN
REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
CABLE LENGTH (NN)
CBL-DMG/NN
ENCODER CABLE
PIN NUMBERING DETAIL
MALE CONNECTOR
PIN NUMBERING DETAIL
NOTE:
1 MALE, 15 PIN DSUB CONNECTOR
2 HEATSHRINK TUBING 1.5"
3 MODEL # LABEL, LOCATED APPROX. 1/2 INCH AWAY FROM RUBBER BOOTS. CLEAR HEATSHRINK SHOULD COVER LABEL ("NN" IN MODEL # INDICATES LENGTH OF CABLE IN FEET) MAXIMUM LENGTH IS 50 FEET (FOR CABLES OVER 50 FT USE DWG CBA5986)
4 RUBBER BOOTS
5 17 PIN FEMALE STRAIGHT PLUG CONNECTOR
6 CUT-OFF ALL UNUSED WIRES FROM THE CABLE.
SERVOMOTOR
SERVODRIVE
SIGNAL WIRES ARE 26 AWG
+ 5VDC AND COMMON ARE 24 AWG
SHIELD


ORMEC ULTRADRIVE
PART NO.: CBL-DMG /51-150
TITLE: ENCODER CABLE ASSEMBLY DRAWING
DWG NO. CBA5986
REV A
SIZE B
SCALE NONE
SHEET 1 OF 1
DRAWN D. APPIAH 09-18-00
CHECKED
DESIGN
REVISIONS
ZONE REV DESCRIPTION DATE APPROVED
CABLE LENGTH (NN)
CBL-DMG/NN ENCODER CABLE
PIN NUMBERING DETAIL
MALE CONNECTOR
PIN NUMBERING DETAIL
NOTE:
① MALE, 15 PIN DSUB CONNECTOR
② HEATSHRINK TUBING 1.5"
③ MODEL # LABEL, LOCATED APPROX. 1/2 INCH AWAY FROM RUBBER BOOTS. CLEAR HEATSHRINK SHOULD COVER LABEL ("NN" IN MODEL # INDICATES LENGTH OF CABLE IN FEET) MAXIMUM LENGTH IS 150 FEET (FOR CABLES UNDER 50 FT USE DWG CBA5987)
④ RUBBER BOOTS
⑤ 17 PIN FEMALE STRAIGHT PLUG CONNECTOR
⑥ CUT-OFF ALL UNUSED WIRES FROM THE CABLE.
SERVOMOTOR
SERVODRIVE
SIGNAL WIRES ARE 26 AWG
+5VDC AND COMMON ARE 16 AWG
YEL CHB
BLK CHB
BLU CHA
BLK CHA
BRN CHZ
BLK CHZ
RED +5VDC
BLK COMMON
RED
BLK
SHIELD

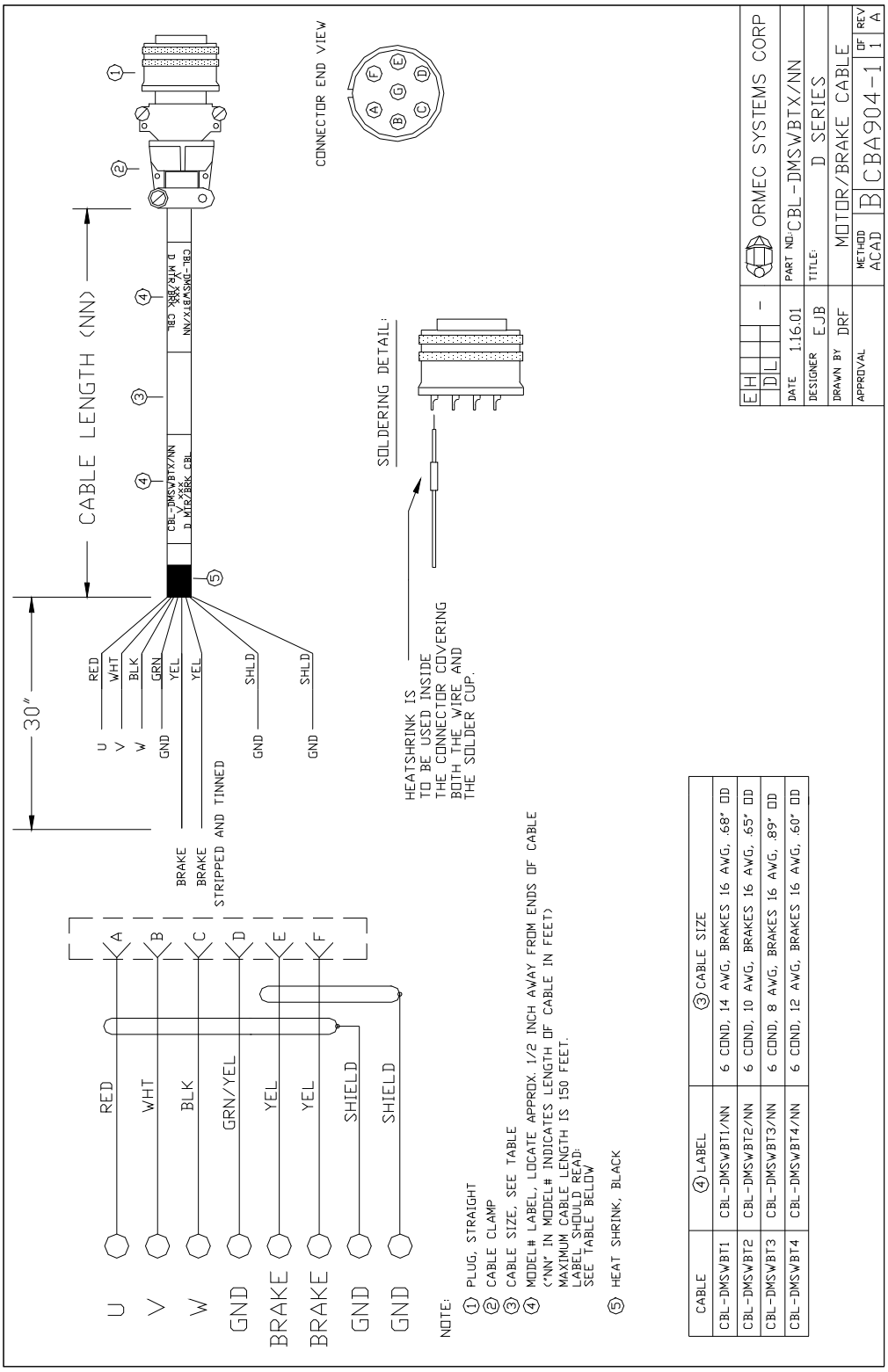

CABLE LENGTH (NN)
CBL-DMSWX/NN
D MOTOR CABLE
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
SOLDERING DETAIL:
HEATSHRINK IS TO BE USED INSIDE THE CONNECTOR COVERING BOTH THE WIRE AND THE SOLDER CUP.
CONNECTOR END VIEW
A
B
C
D
RED
WHT
BLK
GRN/YEL
SHIELD
U
V
W
GND
GND
NOTE:
① CABLE CLAMP
② CABLE SIZE, SEE TABLE
③ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE
MODEL NUMBER SHOULD READ AS SHOWN IN TABLE BELOW
("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET)
MAXIMUM CABLE LENGTH IS 150 FEET.
④ LEADS SHOULD BE STRIPPED .4" AND TINNED
⑤ HEAT SHRINK, BLACK
⑥ RUBBER BOOT
CABLE | ③ LABEL | ② CABLE SIZE
CBL-DMSW1 | CBL-DMSW1/NN | 4 COND, 14 AWG, 600V, .42" O.D.
CBL-DMSW2 | CBL-DMSW2/NN | 4 COND, 10 AWG, 600V, .53" O.D.
CBL-DMSW4 | CBL-DMSW4/NN | 4 COND 12 AWG, 600V, .46" O.D.
E H
D L
-
ORMEC SYSTEMS CORP
DATE 9.19.01
PART NO: CBL-DMSWX/NN
DESIGNER EJB
TITLE: D SERIES MOTOR CABLE
DRAWN BY DRF
W/O BRAKE
APPROVAL
METHOD ACAD
B CBA924-1
DF 1 1
REV B

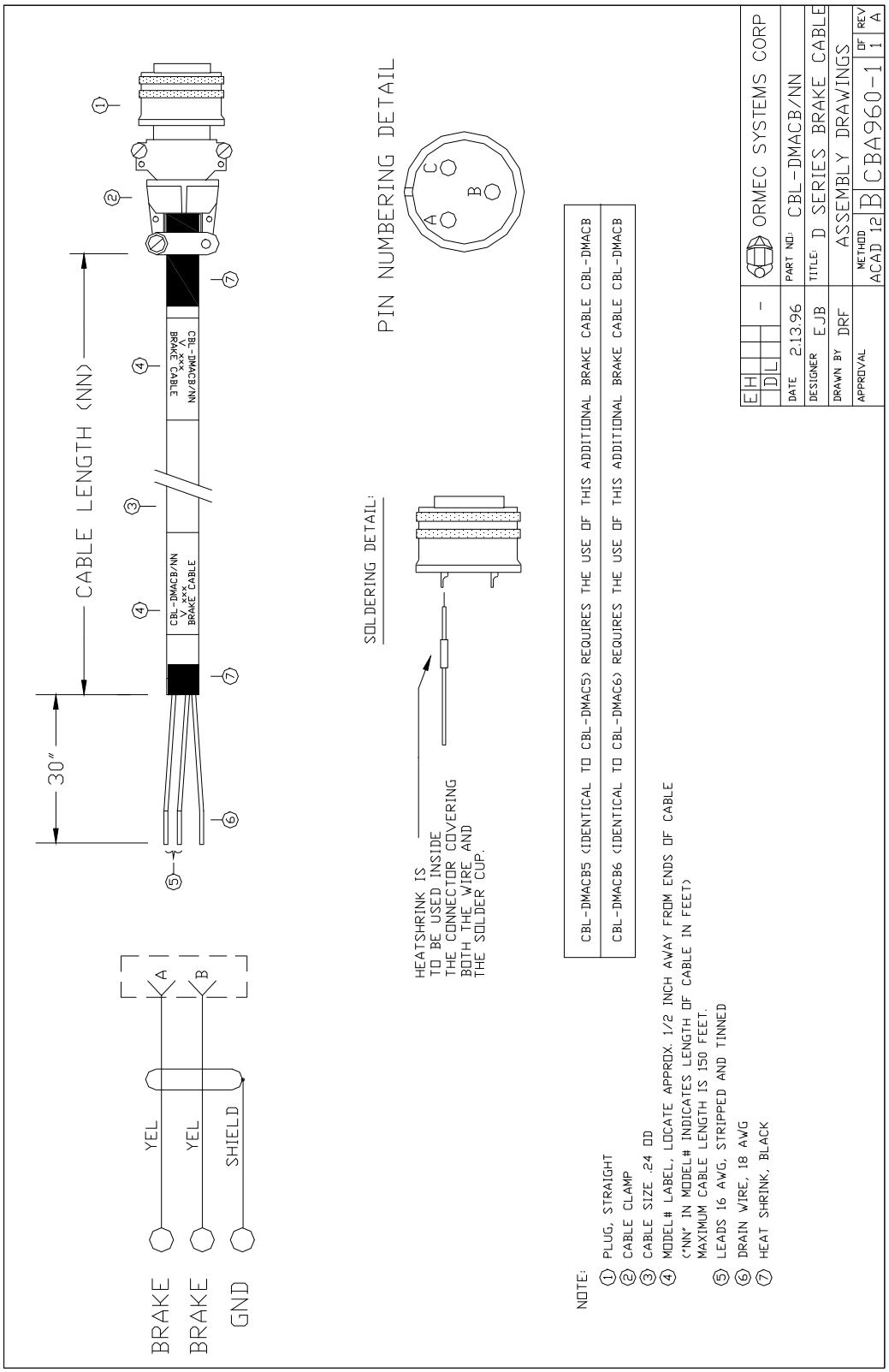

DMSWT1 THROUGH DMSWT4
DMSWT5 & DMSWT6
CABLE LENGTH (NN)
CBL-DMSWTX/NN
D MOTOR CABLE
RED
WHT
BLK
GRN
SHLD
U
V
W
GND
GND
SOLDERING DETAIL:
HEATSHRINK IS TO BE USED INSIDE THE CONNECTOR COVERING BOTH THE WIRE AND THE SOLDER CUP.
CONNECTOR END VIEW
A
B
C
D
NOTE FOR CBL-DMSWT6
1"
1"
.5"
END VIEW OF WIRE
CUT AND REMOVE THE CENTER AND ONE OUTSIDE BUNDLE OF CONDUCTORS
TWIST THE REMAINING CONDUCTORS TIGHTLY, TIN THE WIRE AND APPLY HEATSHRINK AS ABOVE
RED
WHT
BLK
GRN/YEL
SHIELD
U
V
W
GND
GND
NOTE:
① PLUG, STRAIGHT FOR DMSWT1 - DMSWT4, RIGHT ANGLE FOR DMSWT5 & DMSWT6
② CABLE CLAMP
③ CABLE SIZE, SEE TABLE
④ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE
MODEL NUMBER SHOULD READ AS SHOWN IN TABLE BELOW
("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET)
MAXIMUM CABLE LENGTH IS 150 FEET.
⑤ HEAT SHRINK, BLACK
⑥ RUBBER BOOT
CABLE | ④LABEL | ③CABLE SIZE
CBL-DMSWT1 | CBL-DMSWT1/NN | 4 COND, 14 AWG, 600V, 0.42 O.D.
CBL-DMSWT2 | CBL-DMSWT2/NN | 4 COND, 10 AWG, 600V, 0.53 O.D.
CBL-DMSWT3 | CBL-DMSWT3/NN | 4 COND, 8 AWG, 600V, 0.721 O.D.
CBL-DMSWT4 | CBL-DMSWT4/NN | 4 COND, 12 AWG, 600V, 0.46 O.D.
CBL-DMSWT5 | CBL-DMSWT5/NN | 4 COND, 6 AWG, 600V, 0.920 O.D. *
CBL-DMSWT6 | CBL-DMSWT6/NN | 4 COND, 4 AWG, 600V, 1.120 O.D. *
* TIN THE WIRES OF THESE CABLES
E H D L
DATE 1.16.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL
ORMEC SYSTEMS CORP
PART NO: CBL-DMSWTX/NN
TITLE: D SERIES MOTOR CABLE W/O BRAKE
METHOD ACAD
B CBA905-1
DF 1 1
REV A



NOTE:
① PLUG, STRAIGHT
② CABLE CLAMP
③ CABLE SIZE, SEE TABLE
④ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE ("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET)
MAXIMUM CABLE LENGTH IS 150 FEET.
LABEL SHOULD READ:
SEE TABLE BELOW
⑤ LUG, RING STYLE, SEE TABLE
⑥ LUG, RING STYLE, SEE TABLE
⑦ HEAT SHRINK, BLACK

CABLE	④ LABEL	③ CABLE SIZE	⑤ LUG	⑥ LUG	⑦ LUG
CBL-DMSWB1	CBL-DMSWB1/NN	6 COND, 14 AWG, BRAKES 16 AWG, .68" OD	# 6, 14/16 AWG	# 6, 16/22 AWG	# 6, 16/22 AWG
CBL-DMSWB2	CBL-DMSWB2/NN	6 COND, 10 AWG, BRAKES 16 AWG, .65" OD	# 6, 10/12 AWG	# 6, 10/12 AWG	# 6, 16/22 AWG
CBL-DMSWB4	CBL-DMSWB4/NN	6 COND, 12 AWG, BRAKES 16 AWG, .60" OD	# 6, 10/12 AWG	# 6, 14/16 AWG	# 6, 16/22 AWG


CABLE LENGTH (NN)
30"
CONNECTOR END VIEW
SOLDERING DETAIL:
HEATSHRINK IS TO BE USED INSIDE THE CONNECTOR COVERING BOTH THE WIRE AND THE SOLDER CUP.
RED
WHT
BLK
GRN
YEL
YEL
SHLD
SHLD
U
V
W
GND
BRAKE
BRAKE
GND
GND
STRIPPED AND TINNED
A
B
C
D
E
F
RED
WHT
BLK
GRN/YEL
YEL
YEL
SHIELD
SHIELD
U
V
W
GND
BRAKE
BRAKE
GND
GND
NOTE:
① PLUG, STRAIGHT
② CABLE CLAMP
③ CABLE SIZE, SEE TABLE
④ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE ("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET)
MAXIMUM CABLE LENGTH IS 150 FEET.
LABEL SHOULD READ:
SEE TABLE BELOW
⑤ HEAT SHRINK, BLACK
CABLE
④ LABEL
③ CABLE SIZE
CBL-DMSWBT1
CBL-DMSWBT1/NN
6 COND, 14 AWG, BRAKES 16 AWG, .68" OD
CBL-DMSWBT2
CBL-DMSWBT2/NN
6 COND, 10 AWG, BRAKES 16 AWG, .65" OD
CBL-DMSWBT3
CBL-DMSWBT3/NN
6 COND, 8 AWG, BRAKES 16 AWG, .89" OD
CBL-DMSWBT4
CBL-DMSWBT4/NN
6 COND, 12 AWG, BRAKES 16 AWG, .60" OD
E
H
D
L
-
DATE 1.16.01
DESIGNER EJB
DRAWN BY DRF
APPROVAL
ORMEC SYSTEMS CORP
PART NO: CBL-DMSWBTX/NN
TITLE: D SERIES
MOTOR/BRAKE CABLE
METHOD ACAD
B CBA904-1
DF 1
REV A

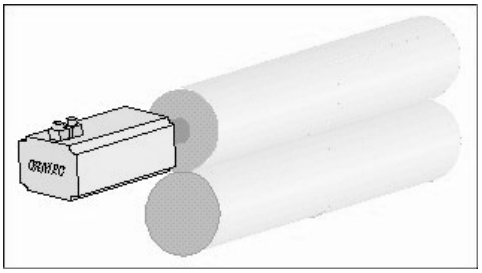

CABLE LENGTH (NN)
30"
CBL-DMACB/NN
X.XXX
BRAKE CABLE
PIN NUMBERING DETAIL
A
B
C
SOLDERING DETAIL:
HEATSHRINK IS
TO BE USED INSIDE
THE CONNECTOR COVERING
BOTH THE WIRE AND
THE SOLDER CUP.
BRAKE
BRAKE
GND
YEL
YEL
SHIELD
A
B
CBL-DMACB5 (IDENTICAL TO CBL-DMAC5) REQUIRES THE USE OF THIS ADDITIONAL BRAKE CABLE CBL-DMACB
CBL-DMACB6 (IDENTICAL TO CBL-DMAC6) REQUIRES THE USE OF THIS ADDITIONAL BRAKE CABLE CBL-DMACB
NOTE:
① PLUG, STRAIGHT
② CABLE CLAMP
③ CABLE SIZE .24 OD
④ MODEL# LABEL, LOCATE APPROX. 1/2 INCH AWAY FROM ENDS OF CABLE
("NN" IN MODEL# INDICATES LENGTH OF CABLE IN FEET)
MAXIMUM CABLE LENGTH IS 150 FEET.
⑤ LEADS 16 AWG, STRIPPED AND TINNED
⑥ DRAIN WIRE, 18 AWG
⑦ HEAT SHRINK, BLACK
EH
DL
-
ORMEC SYSTEMS CORP
DATE 2.13.96
PART NO: CBL-DMACB/NN
DESIGNER EJB
TITLE: D SERIES BRAKE CABLE
DRAWN BY DRF
ASSEMBLY DRAWINGS
APPROVAL
METHOD ACAD 12
B CBA960-1
DF 1
REV A

Coupling High Performance Servos to Mechanical Loads

Application Note by Mick Oakley, Vice President, Customer Support Engineering

Introduction

Mechanical design for servos adds an additional set of constraints to the design rules normally used for power transmission design. These added constraints relate primarily to the stiffness of the system and inertial matching. Decisions on speed reducers, couplings, shaft configurations and many other critical aspects of the mechanical design are often made very early in the design process. Once made, these decisions can be very expensive and time consuming to change.



The intent of this Application Note is to communicate some design information and "rules of thumb" that we at ORMEC have found important in our many years of applying servos to industrial automation. Are these guidelines universal truths? Obviously any set of design rules will from time to time collide with a special case. However, the following guidelines will apply in the vast majority of cases and the prudent designer will only violate them after careful analysis and with a thorough understanding of the risks involved.

Why Be Concerned About The Load?

Knowledgeable servo designers are wary of using a servomotor to drive mechanisms whose moment of inertia is many times that of the motor itself. However, economic pressures and other technical advantages often cause engineers to want to direct drive high inertia loads. The main advantages they seek are to eliminate the cost, maintenance and inaccuracy of a reducer. While it is usually easier to avoid large inertia mismatches, with appropriate attention to detail, they can be made to work. One reason many designers lean towards direct drive, is to avoid the cyclical inaccuracies that gear reducers can introduce. The closed loop servo can monitor its actual speed and position and rapidly adjust for load disturbances. When the load inertia is many times the motor inertia, the motor has only a very small amount of kinetic energy compared to the load. To compensate for a sudden change in load, the servo amplifier must inject a large amount of energy into the servomotor very quickly. This demands a high gain, high bandwidth system. When you combine high gain, high bandwidth and large inertia mismatches, alarm bells should start to sound.

What constitutes a large inertia mismatch? At one time designers strove to achieve a 1:1 inertia match. They considered anything above 5:1 to be a potential problem. The application of digital technology to servo control, digital signal processors in particular, has relaxed that constraint. These days, mismatches of 100:1 or even 1000:1 can be made to work with careful mechanical design.

While good mechanical design is always important, inertia mismatches of 10:1 and above, can only work if the mechanical designer has paid careful attention to minimizing backlash and compliance in the design.

Backlash Effects

Backlash, sometimes called "lost motion", is a mechanical effect that allows you to turn the motor shaft without causing any motion at the load. Generally, you can rotate the motor shaft back and forth over a limited range. If you release the shaft, it will stay where it is.

Backlash, has the effect of temporarily uncoupling and re-coupling the load and the motor with changing speed and direction. When stopped, if there are insufficient external forces acting on the load, the motor may for all intents and purposes be disconnected from the load completely. If the servo is tuned to work well when the load is disconnected, it will have extremely poor performance when the load is connected. Likewise, if the servo is tuned for adequate performance, it will be unstable when the backlash disconnects the load.

The most common symptom of backlash is a "buzz" , often very loud, which occurs primarily when the motor is stopped. Often you can eliminate the buzz by applying a torque at the load. If you tune the servo to eliminate the "buzz", the system becomes very "soft". Sometimes the gain is so low that it cannot stabilize the position loop and the system may oscillate wildly at a low frequency (1-5 Hz)

The only way to solve the problem is to mechanically eliminate the backlash. If you do not eliminate the buzz, over time it may overheat the motor or ruin the mechanical system.

A common source of backlash is using a key-way or set screw to couple to the motor shaft. While key-ways are fine for lawnmowers, they are inadequate for high performance servos! A clamp style coupling, preferably a taper lock bushing, is the only acceptable way to couple to a servomotor shaft.

Another common cause of backlash is improperly adjusted spur gears or using gear reducers that are not designed for servo applications. Properly selected precision planetary gearheads, such as those manufactured by Bayside Controls Inc., Micron Instrument Corp. or Neugardt are generally quite good for servo applications. However, you must make sure the gearhead and primary pinion are mounted and adjusted properly. If you are not careful, improper mounting will introduce backlash into the system and it will deteriorate over time.

Compliance Effects

Compliance also allows you to rotate the input shaft without the load moving. However, with compliance you are actually "winding up" the mechanical system like a spring. When you release the input shaft, it will spring back close to its original position.

Compliance, or wind up, effects show up as a torsional resonant frequency which in turn causes the servo to be unstable. The instability generally shows up as a medium to high frequency oscillation in the order of 100 to 500 Hz. Unlike the "buzz" caused by backlash the sound is often a pure note and does not go away when the motor moves. The frequency does not change as you manipulate the servo tuning however the amplitude may change. Applying a friction load may also reduce the amplitude of the oscillation. As with the buzz caused by backlash, left uncorrected, this resonance will overheat the motor and possibly damage the mechanism.

Long drive shafts, where the bulk of the load inertia is some distance from the motor, are a common cause of this type of problem. It is often surprising how much windup can exist in what appears to be a rather substantial shaft. Take for example a 1 inch diameter stainless steel shaft about 18 inches long. When you apply a 500 in-lb. load the shaft will wind up almost 0.5 degrees.

Shaft Windup:

$\theta = \frac{360T}{2\pi S} \text{deg rees}$	T is applied torque (in-lb.)
	S is the stiffness (in/rad)

Shaft Stiffness:

$S = \frac{\pi(OD^4)G}{32L} in-lb/rad$	**OD** is the inside diameter and **ID** is the outside diameter in inches.
	G is the shaft shear modulus (lb/in^2) *for a stainless steel shaft it is* ($11x10^6$).
	L is the length of the shaft in inches.

Natural Frequency:

$f = \frac{1}{2\pi}\sqrt{S\frac{(J_M + J_L)}{(J_M \cdot J_L)}} Hz$	$\mathbf{J_M}$ is the motor inertia ($in\text{-}lb\text{-}sec^2$)
	$\mathbf{J_L}$ is the load inertia ($in\text{-}lb\text{-}sec^2$)

If we take that same shaft and connect a MAC-DB200Q motor, with a moment of inertia of 0.0476 $in\text{-}lb\text{-}s^2$, on one end and a load inertia of 100 times the motor inertia on the other end, the natural frequency of the system will be about 184 Hz.

Generally, if the natural frequency of the system is less than about 500 Hz, you may encounter resonance problems in high performance systems. There is no magic about the number 500, it is simply a rule of thumb. With a mechanical natural frequency above 500 Hz, you are unlikely to have a resonance problem. At frequencies below 500 Hz, the probability of resonance problems increases. In the above example, to achieve a natural frequency of 500 Hz, you would have to increase the shaft diameter to 1.6875 inches or decrease the shaft length to 2.5 inches.

The natural frequency will usually be determined by the least stiff portion of the drive train which is often the shaft coupling. Be sure to obtain stiffness specifications for any coupling you expect to use and complete the necessary calculations. If you have more than one "un-stiff" component in your drive train, the effects are additive in that the resulting overall stiffness is given by:

Stiffness for 'n' components:

$$S_T = \frac{1}{\frac{1}{S_1} + \frac{1}{S_2} + \frac{1}{S_3} + ... \frac{1}{S_n}}$$

If the moment of inertia of components located between these couplings is significant compared to the overall load inertia, the calculations become a lot more complex and usually result in multiple resonant frequencies.

Often times, choice of couplings, shaft dimensions and attachment methods have surprising effects. No designer should approach the design of a servo driven mechanism, especially one with a significant inertial mismatch, without doing a careful analysis of the natural frequency of the mechanical system. "Seat of the pants" engineering is almost guaranteed to result in problems.

Coupling Selection

In any servo mechanism, selection of mechanical couplings is critical. When there is a large inertia mismatch it is doubly so. Many times it is the choice of coupling that causes the system to have a low resonant frequency. Helical style couplings are almost never stiff enough to avoid problems unless the load inertia is so low as to be insignificant. The best choice is a bellows style coupling with taper lock bushings.

If we take a typical inexpensive helical coupling rated for 500 in-lbs of torque, the stiffness will be approximately $72x10^3$ in-lb/rad. If we use this coupling on the load system described earlier, it will limit the system natural frequency to less than 197 Hz. Clearly this type of coupling would not be adequate. So instead, if we take a similarly rated bellows coupling[1], its stiffness will be $433x10^3$ in-lb/rad. This coupling would have a natural frequency of 480 Hz, which is much less likely to affect operation.

Generally, it is best to avoid helical, disc, oldham, split beam and jaw type couplers. Metal bellows will usually provide the best results. In addition to the coupling type you must also pay careful attention to how it is attached to the shafts. A clamping or taper lock is the best way to go. Always avoid keyways and set screws.

How to Tame Mechanical Load Problems

As said earlier, most mechanical load problems are really backlash and/or compliance problems. The solutions involve changing the mechanical design to eliminate any backlash and to raise the natural frequency above 500 Hz. Increasing the natural frequency can often be accomplished by selecting a stiffer coupling, increasing the diameter of shafts or decreasing the lengths of shafts.

Another way to increase reduce the possibility of instability is to add a speed reducer. This step can reduce the reflected inertia by the square of the reduction ratio. Adding speed reduction also increases resolution at the motor and improves performance at low load speeds. It also allows the motor to run at a higher speed which gives it more kinetic energy to overcome load disturbances. This in turn can reduce the gain and bandwidth requirements for the servo.

Obviously, adding a speed reducer adds the reducer's efficiency losses, in accuracy and compliance to the system so careful selection of the reducer type is critical.

Another helpful technique, although one with its own disadvantages, is to add notch filtering in the servodrive command. Ideally, a notch filter exactly counters the effect of the mechanical resonance and eliminates the system's ability to respond at that frequency. When properly designed and implemented, they work well without requiring mechanical changes. The disadvantages of notch filters are:

1) The filter will only work if the mechanism does not undergo significant changes overtime. As mechanisms wear or heat up, their natural frequencies can change. The natural frequency will also change as the load inertia changes. A once stable system may become unstable if the natural frequency shifts enough that the notch filter no longer cancels it out.

2) Many resonant loads have several natural frequencies. If you design a notch filter with a wide enough notch to cover all of the natural frequencies, you may end up with what is effectively a low pass filter which will reduce servo response considerably.

While many mechanical problems can be resolved using notch filters, they don't address the root cause of the problem and therefore are not a universal cure all.

Timing Belts

Timing belts are a very economical and surprisingly accurate way to provide modest speed reductions. For servo applications, you should choose a belt with a high tensile stiffness and low backlash. Belts that use an aramid tensile member and a modified curvilinear tooth profile are good in both qualities. Belt selection and design is a fairly specialized process and the reader would be well advised to consult one of the many excellent application guides published by belt manufacturers for assistance in this area. Another advantage of timing belts over other types of reducer is their very high efficiency, 95% or better. A disadvantage of timing belts is the added inertia of the pulleys.

However, the added inertia can be minimized by modifying standard pulleys to reduce their mass. Custom pulleys can be made from light weight materials such as aluminum and are available from most belt manufacturers.

Timing belts designed for precise positioning have a tensile member that uses fibers with a very high tensile strength. These fibers are set at a diameter that is much larger than a typical direct drive shaft. If the belt system has been properly sized the stiffness of the system can be better than a solid steel shaft. In the example shown on page 3, the system had a shaft windup of 0.5 degrees with a 500 in-lb load. If you substitute a 37mm wide timing belt[2] using 6 inch pulleys[3] on 18 inch centers, the windup will be less than 0.25 degrees. When a speed reduction is used rather than 1:1, the windup decreases further.

To calculate the natural frequency of a timing belt system, you need to know the spring rate of the belt. This is available from the belt manufacturer and is normally called the EA factor. The EA factor for a belt varies with the tension of the belt and is usually shown on a chart that plots EA (lbs per inch width per unit strain) against belt load (lbs per inch width).

Calculations to determine natural frequency of a timing belt system:

<table>
<tr><td rowspan="4">$$M_1 = \frac{J_1}{R_1^2}, M_2 = \frac{J_2}{R_2^2}$$</td><td>$\mathbf{J_1}$ is the total moment of inertia at the driving pulley (in-lb-s^2). It includes the inertia of the pulley and everything connected to it.</td></tr>
<tr><td>$\mathbf{J_2}$ is the total moment of inertia at the load pulley(in-lb-s^2). It includes the inertia of the pulley and everything connected to it.</td></tr>
<tr><td>$\mathbf{R_1}$ is the radius of the driving pulley (inches).</td></tr>
<tr><td>$\mathbf{R_2}$ is the radius of the driven pulley (inches).</td></tr>
<tr><td rowspan="4">$$S = \frac{EA \cdot width}{span}$$
$$F = \frac{1}{2\pi}\sqrt{S\frac{(M_1 + M_2)}{(M_1 \cdot M_2)}}Hz$$</td><td>**S** is the belt stiffness (lb/inch). span is the belt span, which is the distance the belt spans between the initial contact points on the pulleys on the tension side of the belt (inches). width is the belt width (inches).</td></tr>
<tr><td>**span** is the belt span, which is the distance the belt spans between the initial contact points on the pulleys on the tension side of the belt (inches).</td></tr>
<tr><td>**width** is the belt width (inches).</td></tr>
<tr><td>**EA** Belt spring rate in (lbs/inch width per unit strain).</td></tr>
</table>

The calculations for windup and resonant frequency of a timing belt system can get quite tricky since you must take belt tension and load forces into account when deciding what EA value to use[4] . Unless you are already familiar with the techniques, you should seek the assistance of your belt supplier. For the purpose of this Tech Note it is sufficient to say that it is not difficult to design a timing belt drive that is as stiff or stiffer than a typical direct coupled load. The main advantage of a timing belt system is not that it significantly increases the natural frequency but rather it changes the *amplitude of the resonance*. A timing belt system adds considerable damping to the system and for a given natural frequency, *will allow higher gain settings* before resonance becomes a problem. Another advantage is that it allows you to run the motor at a higher speed which, if the motor inertia is small compared to the load, will provide better operation.

One thing to remember is that resonances are usually a greater problem when the system is stopped that when it is moving under load. By reducing belt tension slightly, you can provide a measure of decoupling between the motor and load. This decoupling and the damping provided by the belt will often reduce resonance problems. Be careful not to reduce the tension too much or accuracy will suffer. A good rule of thumb is to make sure the "slack" side of the belt is always under some tension.

Another thing to remember is that too much belt tension can easily generate a radial load on the motor shaft which will drastically reduce bearing life. When belt tension must be high, always use a jack shaft with its own bearings to isolate the motor shaft from the radial load.

Summary

In summary, if you have a load to motor inertia mismatch greater than 10:1, or have a significant portion of the load inertia coupled through long shafts, you will need to carefully analyze your mechanical design. You will need to make sure there is no backlash and that the natural frequency is higher than 500 Hz. If you cannot achieve that, gear or belt reduction are the best alternatives for making it work. As a last resort, notch filtering may be practical in some special cases.

References

1. Rimtec, type ADK 60.

2. Gates Rubber Co. Poly Chain GT (Part # 14M-1400-37) http://www.gates.com/polychain.html).

3. Gates Rubber Co. (Part # 14M-34S-37).

4. Selecting Synchronous Belts for Precise Positioning, A.W. Wallin - Applications Engineer, Synchronous Drives Div., The Gates Rubber Co., Denver CO.

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Appendix G: Software Commands

Chapter 1 Software Overview

Description

This chapter provides an overview of the software features and commands used with the G Series Digital Servodrives. The G Series Digital Servodrive has an onboard RS232 COM connector, which uses an RJ-11 port. A desktop or laptop computer can be connected to the G Series servodrive through this port and can use it to set up the servodrive, communicate with the servodrive, and otherwise direct the operation of the G Series servodrive. This RS232 serial connection uses the simple Xon/Xoff protocol for controlling communication at baud rates up to 38,400 baud. The G Series servodrive includes the ability to 'auto-sense' the baud rate, meaning that at power up, it will watch for a carriage return to be sent to it from the PC (the Enter or Return key). From that character, it can detect the baud rate of the source PC and will set its own baud rate to match it. At that point, the G Series servodrive will answer back with its identification and the version number of the internal Flashram program code. The PC program available to provide this communication capability is UltraTools for the G Series.

About UltraTools for the G Series

UltraTools is a special software program for the G Series digital servodrive that provides the power to make setting up the G Series servodrive as easy and as flexible as possible, all through the use of a comfortable graphical user interface. UltraTools will run on any desktop or laptop computer running Windows 95, Windows 98, or Windows NT. The program takes about five megabytes of storage space on the hard drive. Included on the distribution CD are the program and its associated help files. In addition, the CD also contains PDF files that supply valuable reference materials on the total G Series family of products.

UltraTools consists of three major components: UltraLink, UltraEditor, and UltraScope. Each fills a separate and distinct function within the tools environment. Each of these components works individually or in concert with the others to provide the power needed to set up the G Series servodrive.

UltraLink

UltraLink is a communications environment that allows the user to talk directly to the G Series servodrive through its RS-232 serial port. A wide variety of communication speeds and setup parameters are supported. All of the G Series servodrive commands can be entered in this mode. Examination of the internal motor or servodrive parameter values is an easy matter. In addition, UltraLink allows for the easy downloading of a series of commands or other setup parameter sets that have been prepared for entry into the servodrive. UltraLink provides the foundation for all communication that occurs between the UltraTools and the servodrive. Also, UltraScope can talk to the G Series servodrive only if a communication port has been opened in UltraLink.

UltraEditor

The UltraEditor is a competent text editing environment that can be used to edit any of the various text files that are used with the G Series servodrive, which includes the commands or setup parameters in an UltraTools Parameter (udp) file. The editor provides the basic tools to

modify text, like cut, copy, paste, find and replace, as well as simple formatting tools like tab settings.

UltraScope

UltraScope is, in effect, a digital scope that can take advantage of the sampling abilities of the G Series servodrive to provide a visual picture of the motion that is occurring with a system. It gives the user a method for defining the test motion that is to be used to set up the servodrive system. It also provides an easy way to set up the tuning parameters. It also allows the user to view (plot) all the standard motion items like current loop and velocity loop commands and the actual output that may be of interest in setting up a motion system, as well as most other parameters that you may wish to see. Defining the motion profile, the items to be plotted, the color of the plotted lines, the thickness and type of plotted lines, all these things are easy to do with UltraScope. The sample data can be saved to disk, as can the plot. The plot can be printed easily for future reference. UltraScope provides an in depth view of what is happening in the motion being examined.

Setting Manually versus Using Windows Interface

Almost all of the parameters that control the setup of the motor or the G Series Digital Servodrive can be set manually in the UltraLink window using special commands. Any of the valid software commands can be sent to the servodrive to set it up and make motion. This is done by typing the command name, followed by a space, followed by the value to set for that command if it requires one. Parameters can also be set, usually more easily, using the Windows interface through the selection of the appropriate pull down menu.

When using the immediate mode in UltraLink to set parameters, a general rule applies on how the commands that require parameters work. For those commands that set parameter values, if a command is typed and is followed by a valid argument, usually a numeric value between 0 and 32767, that command or mode will be given the value you have sent to it. If the command is entered with a question mark following it, then the current value or condition for that item will be returned from the G Series Servodrive. Some commands do not have specific parameter values, like the servo mode commands (TMODE and VMODE) and the other mode commands. In this case, typing the TMODE command will set its state to on. To find the state of the mode commands, enter the MODE command, and they will be displayed. This provides a simple technique for setting or querying the value of the internal parameters in the servodrive. Entering an invalid command name will cause an ERROR message to be returned. .

Before software commands can be used to actually move a motor, the servodrive input channel must be placed into serial command mode. The input command (torque or velocity) can come from one of two sources, either the analog control signal on connector P2 or the serial commands. At power up, the G Series Digital Servodrive automatically comes up in analog command input mode, such that a signal on the analog input line would control the servodrive. To switch the servodrive command input to come from the serial channel it is necessary to send the following command to it: SERIAL. This causes the servodrive to use the serial channel, specifically the command CMD, to provide the input command (torque or velocity). Switching back to analog input is done using the command ANALOG or by cycling the power.

G Series DSP Software Command List

Most G Series functions can be set up in one of two ways, either by selecting the appropriate menu item in the Windows interface, or by typing in a command in the UltraLink window. The available commands are listed below. Commands follow the general format of: *Command* {*argument*} where

the argument is optional. Some commands, like GO, do not require an argument. Entering commands with an argument will set the command to that value. Entering the command with a question mark will cause the present value of the command to be displayed.

Motor Parameters:

ENCCNTS	Encoder counts per revolution of the motor (after 4x quadrature encoding)
FEEDBACK	Sets the type of feedback to use for the attached motor
HOFFSET	Set the Hall offset in electrical degrees
IMTRPK	Motor's Peak Rated Current Limit, where 1000 represents 10.00 amps
IMTRRMS	Motor's RMS Continuous Rated Current Limit, where 500 means 5.00 amps
MTRVMAX	Motor maximum speed in kHz
POLES	Total motor poles per revolution
QRES	Sets the resolution of the quadrature output
R.DEB	Sets the debounce time on the resolver error signal
ROFFSET	Set the resolver offset in electrical degrees
R.QRES	Sets the resolution of the quadrature output when using a resolver
R.RESOL	Resolver resolution, counts per revolution, of the motor
R.RFREQ	Sets the frequency of the resolver reference
R.TRATIO	Sets the transformation ratio of the resolver

Modes:

ANALOG	Select Analog ref input, hardware signal on P2, as the command input
MODE?	Report existing states for the Servo Control, Commutation, and Command modes
PMODE	Set Position Control Mode
SERIAL	Select serial command, CMD, as the command input
SINE	Set Sine Commutation Mode
SIXSTEP	Set Six Step Commutation Mode
TMODE	Set Torque Control Mode
VMODE	Set Velocity Control Mode
MOTMODE	Sets the motor overtemperature fault mode

Servodrive:

ACCEL	Acceleration of the velocity or torque signal, depending on mode (32767 max)
ADC.3DB	Analog input Bessel filter to minimize noise on the analog input line
AOFFSET	Used to adjust for the analog offset found in the Velocity/Torque command input
BUSLOW	Sets voltage at which SCR turns on, below which a 'Low Bus Voltage' error occurs
CMD	Set the RS232 torque or velocity command signal, depending on mode

DACFN1	Set source function for DAC1 output, (DACFN1 defaults to Velocity monitor)
DACFN2	Set source function for DAC2 output, (DACFN2 defaults to Current monitor)
DECEL	Deceleration of the velocity or torque signal, depending on mode (32767 max)
DRVENA	Enable/Disable servodrive output (in software) by setting to 1 (enable) or 0 (disable)
FAULT	Report or Clear any existing faults in the drive
HALL?	Get the Hall state for the current position of the motor (1, 3, 2, 6, 4, or 5)
HOME	Sets up a routine to reset the drive's POS register at first instance of encoder Index
ICLAMP	User settable current limit. The current command of the drive will not be allowed to exceed this.
INPx	Show existing state for digital input (x = 1…4 for INP1 to INP4), state = 1 or 0
INPFNx	Set target function for digital input (x = 1…4 for INP1 to INP4)
MINFO?	Gets a list of version, ID's, and drive component serial numbers
OUTFAULT	Set up OUT1, OUT2 and OUT3 for binary fault data output
OUTx	Show existing state for digital output (x = 1…4 for OUT1 to OUT4), state = 1 or 0
OUTFNx	Set source function for digital output (x = 1…4 for OUT1 to OUT4)
POS	Ask for or set the encoder position information
POSHOME?	Ask for the encoder position at the completion of the last HOME command
PWMFREQ?	Ask for the current PWM frequency in Kilohertz (read only parameter)
RAMTEST	Perform a continous test of the DSP static ram memory until powered down
REM or **;**	Allow the inclusion of 'remarks' in a command file being sent to the servodrive
RESET	Does a DSP software reboot (faults cleared, parameters restored from EPROM)
RESTORE	Restore servodrive parameters from previously stored values inside the EPROM
RS-485	Enables RS-485 communication mode and sets the node ID for this drive
RS-485EN	Commands the active drive ID on the RS-485 network
STATUS?	Return drive status, including inputs, outputs, enabled condition, and fault code
STORE	Store nonvolative servodrive parameters into the EPROM for use during power up
VBUS?	Check the condition of the bus output voltage
VER?	Query for the Version Number of the G Series Flash ROM

Shunt Regulation (Regen) Parameters:

RGCLIM	Shunt Resistor Current Limit (based on ohms/watts/voltage of shunt resistor)
RGTRIP	Shunt Regulation Trip Voltage (set to 0 to disable shunt regulation) (G10 and up)

Tuning:

ICMD.3DB	Specifies a Bessel low-pass filter corner frequency for use in current loop tuning
KIS	Torque command scaling factor, where KIS = 10000 results in scale factor of 1.0

KIV	Set the current loop's current-to-voltage conversion constant
KPI	Position Loop Integral Gain
KPP	Position Loop Proportional Gain
KVD	Velocity Loop Derivative Gain Constant
KVI	Velocity Loop Integral Gain Constant
KVP	Velocity Loop Proportional Gain Constant
VELOBS	Set velocity observer filter sensitivity for smoother response in velocity mode

Profile Commands:

GO	Command to begin motion in Profile mode after defining a motion profile
PRFCYCL	When PRFMODE is 3, this defines the number of cycles to run the current Profile
PRFENA	Enable/Disable profiling mode by setting to 1 (enable) or 0 (disable)
PRFHILV	High command signal level for Profile
PRFHIT	Defines how long to run the Profile at top Current/Velocity level (1 = 400 µsecs)
PRFLOLV	Low command signal level for Profile (often 0)
PRFLOT	Defines how long to run the Profile at low Current/Velocity level (1 = 400 µsecs)
PRFMODE	Profiling mode, either 1 or 2 or 3, defining the type of Profile cycle to run
STOP	Command to stop any Profile motion that is taking place

Data Gathering Commands:

DGABORT	Causes the data gathering function to be stopped or aborted
DGLOGx	Defines data gathering log source, where x = 1 to 4 for four possible channels
DGPOINTS	Number of points to log per data item
DGSTAT	Data gathering status (0 – Not set, 1 – Ready to start, 2 – Collecting, 3 – Done)
DGTRIG	Defines the type of trigger to start the data gathering, 1 = GO, or 2 = Start Now
DGUPDATE	Data Gathering update interval, where 1 = 400 µsec, 2 is 800 µsec, etc.
DGUPLD	Ask the G Series servodrive to upload the recently gathered data

Command Set

ACCEL

Acceleration Command

Format1: ACCEL { value }
Format2: ACCEL?
Type Direct Mode Command
Units: CMD units per interrupt cycle (400 µsec)
Argument Type: Unsigned Integer, 1 to 32767

See Also: CMD, DECEL, SERIAL

The ACCEL command sets the value of the desired torque or velocity command acceleration through the use of the RS232 serial port for use in Profile motion. ACCEL will cause motion to ramp up to the specified CMD signal at the rate given by ACCEL. An ACCEL of 2 would ramp up to a CMD of 5000 in 1 second.

If the ACCEL? command is entered, the existing value for this parameter will be returned.

Examples:

» ACCEL 65 ;Sets acceleration to 65 CMD units per interrupt

ADC.3DB

Specify a Bessel filter corner frequency for the analog input signal

Format1: ADC.3DB { value }
Format2: ADC.3DB?
Type Nonvolatile Parameters
Units: Corner Frequency in Hertz: 0, or 5 to 625 Hz

The ADC.3DB parameter specifies a Bessel filter corner frequency (3db or 45 degree phase shift point) that is applied to the ADC for the analog input signal. This filter can help reduce the effect of noise on the analog input signal. The default for the corner frequency is 0, which means no filtering is done normally. The corner frequency can range from 5 to 625 Hz. Specifying a value of '0' will turn the filter off.

If the ADC.3DB? command is entered, then the drive returns the existing value for ADC.3DB.

Examples:

» ADC.3DB 20 ; Sets the Bessel filter corner frequency to 20 Hz.

ANALOG

Analog Command Mode

Format: ANALOG
Type Nonvolatile Parameters
Argument Type: none

See Also: SERIAL, MODE?, AOFFSET

The ANALOG command sets up the drive to use the analog signal for the input command. In this mode, the desired command signal must be applied to the analog input pins at P2, and the analog-to-digital converter converts this signal for use digitally inside the servodrive. The SERIAL command provides the means to switch from analog control back to serial control through the RS-232 port.

Use the MODE? Command to determine the existing state of the command mode.

The startup mode for the G series servodrive is always ANALOG.

Examples:

» ANALOG (This command puts the servodrive in analog mode)
» SERIAL (This command puts the servodrive in serial mode)
» ANALOG (This command puts the servodrive back in analog mode)

AOFFSET

Analog Offset Command

Format1: AOFFSET { value }
Format2: AOFFSET?
Type Non volatile parameter
Argument Type: Signed integer +/- 32767

See Also: ANALOG

The AOFFSET command sets the parameter that is used to adjust for the analog offset found in the Velocity/Torque command input at pins 1-2 of Controller connector P2. The units for AOFFSET are such that 3277 represents an offset of 1 volt.

If the AOFFSET? command is entered, then the drive returns the existing value for AOFFSET.

Examples:

» AOFFSET 244 : 244 would give 244/3277 = +0.0745 millivolt offset

BUSLOW

Bus Low Voltage Check Value

Format1: BUSLOW { value }
Format2: BUSLOW?
Type: Nonvolatile Parameter
Units: DC Volts
Argument Type: Unsigned Integer, 0 to 32767

See Also: VBUS

The BUSLOW parameter represents the minimum voltage below which a 'Low Bus Voltage' fault (A3) will be generated by the drive. BUSLOW is also used as the threshold below which the SCR will be turned off as part of the soft start logic.

If the BUSLOW? command is entered, the existing value for it is returned.

NOTE: A setting of 0 for BUSLOW will cause the servodrive to use the default, which is 90 DC volts, for the BUSLOW value

Example:

» BUSLOW?
90 ; The existing setting for BUSLOW is 90 volts

CMD

Current Command / Velocity Command

Format1: CMD { value }
Format2: CMD?
Type: Direct Mode Command
Units: +/-32767 equals full scale input
Argument Type: Signed Integer, +/-32767

See Also: SERIAL

The CMD command sets the value of the desired velocity (in velocity mode) or current (in torque mode) through the use of the R232 serial port. The SERIAL command must previously be set to 'ON' for the CMD command to work. Commands applied to the drive via the CMD command are executed within the velocity loop interrupt rate of 400 microseconds. If the CMD? command is entered, the existing value for this parameter will be returned.

The units for CMD are equivalent to the gain of the ADC input. The argument used with CMD is equivalent to the voltage input that would be applied to the ADC to achieve that number. The gain of the ADC input defaults to +/-10 = +/-32767 (full scale).

Examples:

```
» CMD  2000          ;Sets output current command immediately
» CMD?          ;Returns the output current command
2000
» CMD  –2000         ;Output direction changes immediately
```

DACFNx

Digital to Analog Output Function Command

Format1: DACFN1 { value }
Format2: DACFN2 { value }
Format3: DACFN1?
Format4: DACFN2?
Type Nonvolatile Parameter
Argument Type: Unsigned Integer (See table below)

The DACFNx command sets the source function for the output of the specified DACx. DACFN1 refers to DAC1 as defined by the markings on the G Series servodrive. DACFN2 refers to DAC2. Outputs for these are updated every 400 microseconds.

If either of the DACs is entered followed by a question mark (DACFN1?) the existing value for this parameter will be returned.

Following is a table indicating what values refer to what internal functions:

VALUE	FUNCTION THAT OUTPUT REFLECTS:
1	Velocity term
2	Output current term (current command term before multiplying by the commutation terms)
3	U output current term
4	V output current term
5	W output current term
6	Drive's current integrator term
7	Motor's continuous current integrator term
8	Shunt integrator term

Examples:

```
» DACFN1  2          ;DAC1 will now report the drive current
» DACFN1  1          ;DAC1 will now report the drive velocity
```

DECEL

Deceleration Command

Format1: DECEL { value }
Format2: DECEL?
Type Direct Mode Command
Units CMD units per interrupt cycle (400 µsec)
Argument Type: Unsigned Integer, 1 to 32767

See Also: CMD, ACCEL, SERIAL

The DECEL command sets the value of the desired torque or velocity command deceleration through the use of the RS232 serial port during Profile motion. DECEL will cause motion to ramp down to the specified CMD signal at the rate given by DECEL. A DECEL of 1 would ramp down from a CMD velocity of 2500 in 1 second.

If the DECEL? command is entered, the existing value for this parameter will be returned.

Example:

» DECEL 10 ;Sets deceleration to 10 CMD units per interrupt (400 µsec)

Data Gathering

Data Gathering is a feature of the G-Series servodrive in which the drive will perform real time capture of some data, buffer it and then upload it to the host. The purpose is to be able to store up to 4 related values, all synchronized, and then be able to plot them (using UltraTools), effectively making a digital scope.

Operation of data gathering is made simple with the commands defined below. The drive will store up to 4 channels of information. There are 4 buffers of 4000 points each available. The user selects which channels will be used and the information to be stored in that channels log (command DGLOGx), how many points to actually store, up to 4000 (command DGPOINTS). The logging can occur as fast as the velocity loop, 2.5kHz, or at integer multiples below using the DGUPDATE command. Once the rate is set each channel is logged at the same rate and at the same time so that all of the information is synchronized.

Logging of the data is controlled by the DGTRIG command. This command determines when the logging takes place, immediately or triggered by an event such as PROFILE generation. For each trigger command one set of data is collected. To log another set of data another DGTRIG command must be executed. Once the data is logged the DGUPLD command allows the data to be uploaded to a host computer.

Example:

```
; (Profile Example)      ;Set up or define a Profile before coming here
» DGLOG1 1               ;log Actual Velocity
» DGLOG2 6               ;log Velocity Error term
» DGLOG3 2               ;log Velocity Command term
» DGPOINTS 400           ;capture 400 points
» DGUPDATE 2             ;update every 2nd velocity loop update (every 800 µsecs)
» DGTRIG 1               ;start data gathering on GO
» GO                     ;start the profile and the data gathering
» DGSTAT                 ;see if the data gathering is done yet
» 2
» DGSTAT                 ;see if the data gathering is done yet
» 3
» DGUPLD                 ;upload the gathered data
»

; (Capture Example -No Profile)      ;No Profile is needed for a pure capture
» DGLOG1 1               ;log Actual Velocity
» DGLOG2 6               ;log Velocity Error term
» DGLOG3 2               ;log Velocity Command term
» DGPOINTS 400           ;capture 400 points
» DGUPDATE 2             ;update every 2nd velocity loop update (every 800 µsecs)
» DGTRIG 2               ;start data gathering immediately
» DGSTAT                 ;see if the data gathering is done yet
» 2
» DGSTAT                 ;see if the data gathering is done yet
» 3
» DGUPLD                 ;upload the gathered data
```

DGABORT

Data Gathering Abort

Format: DGABORT
Type Direct Mode Command
Argument Type: none

See Also: GO, DGTRIG, DGUPLD, DGSTAT

The DGABORT command allows the user to stop or abort the collecting and sending back of the collected data points. It gives the user the power to stop the process rather than wait for it to get done by finishing normally.

Example:

» DGABORT ;Stop the G Series from sending back the remaining data points

DGLOGx

Log source

Format1:	DGLOG1	<source>
Format2:	DGLOG2	<source>
Format3:	DGLOG3	<source>
Format4:	DGLOG4	<source>
Format5:	DGLOGx?	
Type	Direct Mode Command	
Argument Type:	Unsigned integer, 0 to 8	

See Also: GO, DGTRIG, DGPOINTS, DGUPDATE

The DGLOGx commands define the source of the information to be logged in the given log. The servodrive can log up to four items at a time. Each item is stored in a different log, numbered 1 to 4. This command defines the item to go into each log using the table below. DGLOG1 defines the source for log #1, DGLOG2 is used for log #2, etc.

<source>	**Information logged**
0	no logging in this log
1	Actual velocity
2	Velocity Command
3	I(u) actual current phase U
4	I(v) actual current phase V
5	I(w) actual current phase W
6	Velocity Error Term
7	DC Current (same as current command prior to summing with commutation)
8	Bus Voltage (in volts)

Examples:

```
DGLOG1    1    ; select Actual velocity to be logged on Log #1
DGLOG2    0    ; turn off Log #2
```

DGPOINTS

Data Points Logged

Format1: DGPOINTS { size }<# of points logged>
Format2: DGPOINTS?
Type Direct Mode Command
Argument Type: Unsigned Integer, 1 to 4000

See Also: DGLOGx, DGUPDATE, DGTRIG, DGSTART, GO

The DGPOINTS command defines how many points (samples) should be logged at the next trigger. This number of points will be logged in each active channel. Up to four data items can be sampled in a given data gathering.

If the DGPOINTS? command is entered, the existing value for this parameter will be returned.

Examples:

```
» DGPOINTS  2500     ; Log 2500 samples.  (If DGUPDATE is 1, log 1 sec of information.)
» DGPOINTS  4000     ; Log 4000 samples.  (If DGUPDATE is 2, log 3.2 sec of information.)
```

DGSTAT

Data Gathering Status

Format: DGSTAT?
Type Direct Mode Command
Argument Type: none (0, 1, 2, or 3 can be returned)

See Also: GO, DGTRIG

This command returns status information about the data gathering operation. 1 = trigger enabled and waiting for trigger, 2 = collecting data, 3 = data in buffer (collecting complete flag), 0 = no activity (i.e. Not triggered and not collecting data).

The function of this command is to allow a host to determine when a trigger has occurred and that all of the data has been logged before beginning the upload via DGUPLD.

Examples:

```
» DGSTAT?            ; Check the status of the data gathering
3                    ; Data is in buffer, ready for the DGUPLD command
```

DGTRIG

Data Gathering Trigger

Format1: DGTRIG { mode }
Format2: DGTRIG?
Type Direct Mode Command
Argument Type: 1 or 2

See Also: GO, DGSTAT

The DGTRIG command defines the trigger source for starting the data gathering and enables and begins gathering . A 1 denotes that data gathering should begin when the GO command is issued. A 2 means that data gathering should begin immediately. After data has been gathered another DGTRIG is required to perform another data gathering.

If the DGTRIG? command is entered, the existing value for this parameter will be returned.

Examples:

» DGTRIG 1 ; Begin taking samples when the GO command is given.

DGUPDATE

Update rate

Format1: DGUPDATE {# of updates}
Format2: DGUPDATE?
Type Direct Mode Command
Argument Type: Unsigned Integer, 1 to 500

See Also: DGPOINTS, DGTRIG, DGSTART, GO

The DGUPDATE command defines the ticks between data samples, that is, how often the drive will capture the desired data samples. Data gathering is based on the velocity loop update rate, 2.5 kHz (400 µsec). Samples can be logged on every loop update or some number of updates can be skipped between samples. This parameter sets the sampling rate using the formula:

$$\text{sampling rate} = \frac{\text{velocity loop update (2.5 kHz)}}{\text{<\# of updates>}}.$$

If the DGUPDATE? command is entered, the existing value for this parameter will be returned.

Examples:

```
» DGUPDATE 1      ; Takes samples every 0.4 milliseconds, 2.5 kHz rate (2500/1)
» DGUPDATE 2      ; Takes samples every 0.8 milliseconds, 1.25 kHz  (2500/2)
» DGUPDATE 5      ; Takes samples every 2 milliseconds, 500 Hz  (2500/5)
```

DGUPLD

Data Gathering Upload Data

Format: DGUPLD
Type Direct Mode Command
Argument Type: none

See Also: GO, DGABORT, DGTRIG, DGPOINTS, DGSTAT, DGLOGx

The DGUPLD command is used to tell the G Series servodrive to begin sending back the data that it has just collected from a test move of some type. The data is sent back in groups of four hexadecimal characters per each data item requested by the user. Each data record (between 1 and 4 items of data as requested by the user via DGLOGx) is terminated with a carriage return and line feed. After the last data record is sent by the G Series servodrive, a # character is sent to signal the end of the data.

Example:

```
                    ;Before coming here, set up your desired Profile
» DGLOG1  1         ;log actual velocity in log #1
» DGLOG2  8         ;log bus voltage in log #2
» DGLOG3  0         ;turn off data log #3
» DGLOG4  0         ;turn off data log #4
» DGPOINTS 5        ;capture 5 points
» DGUPDATE 10       ;10 updates apart
» DGTRIG 1          ;Begin taking samples when the GO command is given.
» GO                ;When ready, we issue the GO command to get data
»
» DGUPLD            ;Once the motion is done (DGSTAT?), we upload data
FFFF0123            ;here come's the data….
FFF30124
FFFE0119
00030123
FFFF0119
#                   ;'#' signifies the end of the data log
»
```

DRVENA

Enables or Disables Servodrive Output

Format1: DRVENA { mode }
Format2: DRVENA?
Type Nonvolatile Parameter
Argument Type: 0 or 1

See Also: STATUS?, STORE

The DRVENA command is used to enable or disable the servodrive output IGBT transistors. A "0" argument disables the servodrive output, while a "1" argument enables the servodrive output. Note that the hardware enable input (Controller connector P2) must be asserted (or set for normally open operation) for this command to have any effect.

This command is used both in direct mode, to enable and disable the drive, and as a nonvolatile parameter. Setting the DRVENA mode followed by the ***STORE*** command will set the drive's startup mode to the setting of the DRVENA command when the ***STORE*** command was invoked. Entering the DRVENA? command will return either an 'ENABLED' or 'DISABLED' to indicate its present state.

Examples:

» DRVENA 1 (This command enables the servodrive)

ENCCNTS

Encoder Counts per Revolution (with quadrature)

Format1: ENCCNTS { counts }
Format2: ENCCNTS?
Type Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-65535

See Also: POLES, SIXSTEP, SINE

The EncCnts command sets the encoder line counts (multiplied) per revolution of the motor. Since this is a 16-bit value and the G Series employs quadrature multiplication, the maximum setting is 65535. Setting a value greater than 65535 will generate a "value out of range" error.

Examples:

The following example sets the encoder count to 8000 counts per revolution for a motor with a 2000 line per revolution encoder:

```
»ENCCNTS  8000     ; 2000 lines * 4 = 8000 counts
```

FAULT

Queries/Resets drive faults

Format1: FAULT?
Format2: FAULT 0
Type Direct Mode Command
Argument Type: 0 (optional)

See Also: STATUS, DRVENA, Appendix A – Fault Codes

The FAULT command will cause the drive to either clear faults (FAULT 0) or report the existing fault value in decimal (FAULT?). If the drive is enabled, the outputs will be turned on. The FAULT 0 command will not enable a drive that is either hardware or software disabled, or if the condition causing the fault has not been corrected. Note, for some faults it may appear that the FAULT 0 command did not clear the fault. This is generally not the case. Usually the fault was cleared, but was then reasserted because the fault condition was still true making it appear as though it was not cleared.

Examples:

```
»FAULT?     ; Return the current fault code decimal value
»FAULT 0    ; Clears fault
```

FEEDBACK

Feedback Selection Command

Format1: FEEDBACK { value }
Format2: FEEDBACK?
Type Nonvolatile Parameter
Argument Type: Unsigned Integer, 0 to 5

See Also:

The FEEDBACK command selects the type of feedback provided by the motor and configures the drive for proper operation. The choices are:

0 = Yaskawa digital multiplexed encoder
1 = Reserved
2 = Quadrature feedback with divide by 4 (resolution is encoder line count)
3 = Quadrature feedback (resolution is encoder line count times 4)
4 = Reserved
5 = Resolver

If the FEEDBACK? command is entered, the existing value for this parameter will be returned.

Example:

```
» FEEDBACK 3          ; Selects a quadrature encoder as the feedback device
```

GO

Profile Go

Format: GO
Type Direct Mode Command
Argument Type: none

See Also: PRFENA, STOP

The GO command allows the user to start in motion the Profile that has been defined by all of the PRF type commands. The SERIAL command must previously be set to 'ON' for this command to work.

Examples:

```
»PRFENA  1          ; Enable profile mode
»TMODE              ; Set Torque mode on (to move using Torque mode)
»PRFHILV 8000       ; Set value for the high level profile command
»PRFHIT 1000        ; Set time to run 'at Current', in 400 µsecs units
»PRFLOLV 0          ; Set the low level command to 0
»PRFLOT 1000        ; Set time to run 'at low level', also in 400 µsecs units
»PRFMODE 3          ; Set PRFMODE to 3 for fixed cycles
»PRFCYCL 1          ; Set PRFCYCL so we do only a single cycle in our move
»GO                 ; GO causes our profile motion to begin
```

HALL

Hall state at existing motor position

Format: HALL?
Type Direct Mode Command
Argument Type: none

The HALL command provides a method for checking the Hall state inputs at the existing position of the motor. The commutation signals for W, V, and U are respectively indicated in bits 3, 2, and 1 (LSB) of the integer value returned by HALL. When the input is ON, the bit is set to 1, and when it's OFF, the bit is set to 0. The HALL value returned will normally be a single digit from 1 to 6. It should never be a 0 or a 7, which would indicate an electrical or wiring problem concerning the motor. When a motor is hooked up properly, the Hall states will normally progress in the order 1 3 2 6 4 5... when the motor is turned in a counter-clockwise motion as seen when facing the shaft of the motor (encoder counting in a positive direction). This HALL command will be fully functional when operating in SIXSTEP mode (trap mode) with the drive enabled or disabled. When operating in SINE mode, the HALL command will only update the Hall state information when the drive is disabled. Nevertheless, in SINE mode, after disabling the drive with DRVENA 0, rotating the motor shaft will provide the Hall state information normally desired. This parameter provides a means to troubleshoot the wiring of motors to the G series servodrive.

CounterClockWise Motion

W,V,U state	HALL value
101	5
001	1
011	3
010	2
110	6
100	4

Example:

```
» HALL?      ;Ask for the Hall state
3
```

HOFFSET

Sets the Hall Offset

Format1: HOFFSET { value }
Format2: HOFFSET?
Type Nonvolatile Parameters
Argument Type: Signed Integer, +/-360

The HOFFSET parameter is used to set the offset between the positive portion of the back emf observed from the motor leads that will connect to the drive's U and V outputs (U with respect to V) and the +5 volt portion of the Hall signal that will connect to the drive's U Hall input when rotating the motor counter-clockwise from the face of the motor. The argument is in electrical degrees.

Examples:

» HOFFSET 30 ; Sets the Hall offset to +30 electrical degrees, i.e. the back emf leads the Hall signal by 30 electrical degrees.

HOME

Set or Query Home Status

Format1: HOME
Format2: HOME?
Type: Direct Mode Command
Argument Type: None

The HOME? command returns status of the home function. The home function zeros the position after seeing the index marker of the encoder. The HOME command enables this mode. A "0" is returned if the index marker has not yet been seen, and a "1" is returned when the index marker has been seen and the position register (POS?) has been reset.

Examples:

```
»POS?          ; Check where we are at to begin with
12345678
»HOME          ; Sets the HOMEing mode
»CMD 150       ; Set velocity and direction
»HOME?         ; Query for the Home Complete flag
0
»HOME?         ; Query for the Home Complete flag again
1              ; Home is complete
»POS?          ; Now, see where we are at after rezeroing position
23
```

ICLAMP

Set Peak Current Clamp Level As a Percentage of Peak Current

Format1:	ICLAMP { value }
Format2:	ICLAMP?
Type	Nonvolatile Parameters
Units:	Percent of Peak
Argument Type:	Unsigned Integer, 0-100
See Also:	IMTRPK, IMTRRMS

The ICLAMP parameter sets the peak current as a percentage of the IMTRPK value. The factory default value is 100, which represents 100%. Setting this limit simply clamps the input current command so that it will not be allowed to exceed this ICLAMP value. It will not generate a fault on the drive. This parameter is dynamic and may be changed on-the-fly.

This limit, ICLAMP, prevents a command of too large a value from being entered, and is an indirect limit on the output. A poorly tuned current loop may have overshoots which exceed the limit.

Examples:

» ICLAMP 50 ; Sets the input current limit to 50% of the IMTRPK value.

ICMD.3DB

Specify a Bessel corner frequency

Format1:	ICMD.3DB { value }
Format2:	ICMD.3DB?
Type	Nonvolatile Parameters
Units:	Corner Frequency in Hertz, 0 to 2500 Hz

The ICMD.3DB parameter specifies a Bessel low-pass filter corner frequency (3db or 45 degree phase shift point) that is applied to the command for current before it is applied to the current loops. This filter helps stabilize some systems due to the G Series' highly responsive current loops. The default for the corner frequency is 500 Hz and is suitable for most systems. The maximum corner frequency that can be specified is 2500 Hz. Specifying a value of '0' will turn the filter off.

If the ICMD.3DB? command is entered, then the drive returns the existing value for ICMD.3DB.

Examples:

» ICMD.3DB 1000 ; Sets the Bessel filter corner frequency to 1000 Hz.

IMTRPK

Set Peak Current Clamp Level

Format1:	IMTRPK { value }
Format2:	IMTRPK?
Type	Nonvolatile Parameters
Units:	Hundredths of amperes
Argument Type:	Unsigned Integer, 0 to 32767
See Also:	IMTRRMS, ICLAMP

The IMTRPK parameter sets the peak current (in Amps DC) by clamping the current command of the servodrive. The factory default is equal to the drive's peak current and will change based on the motor. UltraTools sets this value based on the motor data.

Examples:

» IMTRPK 500 ; Sets the peak current limit to 5 amperes.

IMTRRMS

Sets the motor RMS Current Limit

Format1:	IMTRRMS { value }
Format2:	IMTRRMS?
Type	Nonvolatile Parameter
Units:	Hundredths of amperes DC
Argument Type:	Unsigned Integer, 0 to 32767

The IMTRRMS command sets the RMS motor current-limit for the motor to the given value in hundredths of amperes. The continuous current term is integrated over a specific period of time. If the resultant RMS value is exceeded by the drive output, a servodrive fault will occur, disabling the drive.

If the IMTRRMS? command is entered, the existing value for this parameter will be returned.

Examples:

» IMTRRMS 750 ; Sets the motor RMS current limit to 7.5 amperes

INPx?

Digital Input State Command

Format1: INP1 ?
Format2: INP2 ?
Format3: INP3 ?
Format4: INP4 ?
Format5: INP? – Returns a 4 character binary string indicating the status of all four inputs.
Type Direct Mode Query
Argument Type: none
See Also: INPFNx , OUTFAULT

The INPx command allows the user to query the state of the given digital input. INP1 to INP4 refer to the digital inputs as defined by the markings at connector P3 on the servodrive. Note that INP1 and INP2 are also present on the Controller connector, P2. The value returned by the query can be either a 0 or a 1, indicating an OFF or ON condition for the input. The ON condition is defined as current flowing in the optocoupler at the input. Note that INP1 can be used in conjunction with OUTFAULT 1 to assist in querying bits 1-3 or 4-6 of the existing fault code value. See OUTFAULT.

The fifth format (INP?) returns a 4 character binary string indicating the status of all four inputs, INP1 to INP4, from left to right.

Examples:

```
»INP1?          ; Query the existing state of INP1
0               ; State of INP1 is 0 or OFF
»INP2?          ; Query the existing state of INP2
1               ; State of INP2 is 1 or ON
»INP?           ; Query the existing state of all INP's
0 1 0 0         ; INP1 is OFF, INP2 is ON, INP3 is OFF, INP4 is OFF
```

INPFNx

Digital Input Function Command

Format1:	INPFN1 { [-]value } for future use (See also OUTFAULT)
Format2:	INPFN2 { 0, 1 or –1 } [for Clockwise inhibit]
Format3:	INPFN3 { 0, 1 or –1 } [for Counter-Clockwise inhibit]
Format4:	INPFN4 { [-]value } for future use
Format5:	INPFN98 { + | - } [Dedicated drive enable setting]
Format6:	INPFN99 { + | - } [Dedicated fault reset setting]
Type	Nonvolatile Parameter
Argument Type:	Signed integer, OR + or – sign (for INPFN98 or INPFN99)

The INPFNx command sets the target function that the input defined in x is to be directed to in the G Series servodrive. INPFN1 refers to INP1 as defined by the markings on the servodrive. INPFN2 refers to INP2, INPFN3 refers to INP3, and INPFN4 refers to INP4. Placing the optional minus sign in front of the *value* inverts the assertion of the input, making it a normally closed input. Setting an INPFNx to a value of 0 will disable that INPx from going to any internal function. Following is a table indicating what values refer to what internal functions:

INPFN	Function That Input Is Directed to:
1	Reserved for future use (See OUTFAULT for special use of INP1)
2	Clockwise rotation inhibit
3	Counter-clockwise rotation inhibit
4	Reserved for future use

INPFN98 and INPFN99 are special parameters for inverting the dedicated hardware Enable and Reset inputs (P2, pins 23 and 24. Pin 25 is common for these inputs). In the factory default mode (–), the enable input is normally closed, in that it takes current in the opto-coupler associated with the enable for the drive to operate. The factory default mode for the reset input (+) is that it takes momentary current to reset the drive and clear faults. By using the INPFN98 + command, the enable input functionality is changed to normally open, in that it takes a lack of current in the opto-coupler to enable the drive. By using the INPFN99 – command, the reset functionality is changed to normally open, in that it takes momentary loss of current to reset the drive and clear faults.

Entering the INPFNxx command followed by a question mark (INPFNxx?) will return the sign and value for that input.

Examples:

```
»INPFN2 -1    ; NOT asserting INP2 will disable clockwise motor rotation
»INPFN3  1    ; Asserting INP3 will disable counter-clockwise motor rotation
»INPFN4  0    ; INP4 will be unused
»INPFN98 -    ; Current must now flow through the opto-coupler to enable the drive.
»INPFN99 -    ; Current must momentarily decay in reset opto-coupler to reset the drive.
»INPFN2?      ; Return the current settings for input 2
-1
```

KIS

Sets the torque-mode command scaling

Format1:	KIS { value }
Format2:	KIS?
Type:	Nonvolatile Parameter
Argument Type:	Unsigned Integer 0-32767
See Also:	TMODE

In torque mode, the KIS parameter is used to scale the torque command. A KIS setting of 10000 equates to a gain that will achieve plus or minus peak current when the input voltage is at plus or minus 10 volts. This is considered a gain of 1.

Entering the KIS command with an argument value will set the scaling factor per that value immediately.

Entering KIS? will cause the current value to be returned.

Example:

```
» KIS  10000          ; This enters the a scaling factor of 100%
» KIS?
10000
```

KIV

Sets the Current Loop's Current-to-Voltage Conversion

Format1:	KIV { value }
Format2:	KIV?
Type:	Nonvolatile Parameter
Argument Type:	Unsigned Integer 0-32767
See Also:	RGCLIM

The Kiv parameter sets the current loop's current-to-voltage conversion constant.

Examples:

```
»KIV 4000
»KIV?
4000
```

KPI

Position Loop Integral Gain

Format1: KPI { gain }
Format2: KPI?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-65535

See Also: KPP

The KPI command sets the integral gain for the position loop. The default value is off, 0. Integral gain 'integrates' (adds up) the error over time, and thereby increases amplifier output to eliminate or minimize position error. Entering the KPI command with an argument value will set the integral gain per that value.

Entering the KPI? command will cause the existing value for this parameter to be returned from the servodrive.

Example:

```
» KPI  402          ; This enters the position loop integral gain
» KPI?              ; This returns the current position loop integral gain
402.
```

KPP

Position Loop Proportional Gain

Format1: KPP { gain }
Format2: KPP?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-32767

See Also: KPI

The KPP command sets the proportional gain of the position loop. Proportional gain is a linear component that provides a constant correction for a given amount of error. The default gain should be satisfactory to achieve stability. Entering the KPP command with an argument value will set the proportional gain per that value immediately.

Entering the KPP? command will cause the existing value for this parameter to be returned from the servodrive.

Example:

```
» KPP  402          ; This enters the position loop proportional gain as 402.
```

KVD

Velocity Loop Derivative Gain

Format1: KVD { gain }
Format2: KVD?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-65535

See Also: KVP, KVI

The KVD command sets the derivative gain of the velocity loop. The default gain should be satisfactory to achieve stability. Derivative gain sets the gain at which the velocity loop responds to feedback rate changes. Derivative gain is inherently noisy and will increase step input responsiveness. Entering the KVD command with an argument value will set the derivative gain per that value.

Entering the KVD? command will result in the existing value for this parameter being returned from the servodrive.

Example:

» KVD 2100 ; This enters the velocity loop derivative gain.

KVI

Velocity Loop Integral Gain

Format1: KVI { gain }
Format2: KVI?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-65535

See Also: KVD, KVP

The KVI command sets the integral gain for the velocity loop. The default gain should be satisfactory to achieve stability. Integral gain 'integrates' (adds up) the error over time, and thereby increases amplifier output to eliminate or minimize velocity error. Entering the KVI command with an argument value will set the integral gain per that value.

Entering the KVI? command will cause the existing value for this parameter to be returned from the servodrive.

Example:

» KVI 4022 ; This enters the velocity loop integral gain
» KVI? ; This enters the velocity loop integral gain
4022.

KVP

Velocity Loop Proportional Gain

Format1: KVP { gain }
Format2: KVP?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-32767

See Also: KVD, KVI

The KVP command sets the proportional gain of the velocity loop. Proportional gain is a linear component that provides a constant correction for a given amount of error. The default gain should be satisfactory to achieve stability. Entering the KVP command with an argument value will set the proportional gain per that value immediately.

Entering the KVP? command will cause the existing value for this parameter to be returned from the servodrive.

Example:

» KVP 4024 ; This enters the velocity loop proportional gain.

MINFO?

Manufacturing information and serial numbers of the drive hardware

Format: MINFO?
Type: Direct Mode Command
Argument Type: none

See Also: MODE?, STATUS?, VER?

The MINFO? command will cause the drive to return a list of information about this drive, including the hardware version, powerboard ID (drive size), and the serial numbers of the drive components. Following is a sample output:

Examples:

»MINFO? ;Ask for the manufacturing information
Hardware version: 1.0.0
Powerboard ID: 261
Drive Serial#: 23
Logic Board Serial#: 206-132
Power Board Serial#: 69-211

MODE?

Display Current Servodrive Modes

Format: MODE?
Type Direct Mode Query
Argument Type: none

See Also: TMODE, VMODE, ANALOG, SERIAL, SINE, SIXSTEP, STATUS?

The MODE? command is used to determine the state of the various operation modes inside the G Series servodrive, including Servo Control Mode (Torque/Velocity), Commutation Mode (Sine/Sixstep), and Command Mode (Analog/Serial). The response from the servodrive will define these in a three-line answer. Each line is independent of the other, so eight possible permutations can be returned.

Examples:

```
»MODE?                          (This query displays the servodrive modes)
SERVO MODE: TORQUE CONTROL
COMMUTATION MODE: SIXSTEP
COMMAND MODE: SERIAL
```

MOTMODE

Set Motor Over-Temperature Mode

Format1: MOTMODE { value }
Format2: MOTMODE?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0-2

The MOTMODE parameter determines how the drive will process **M**otor **O**ver-**T**emperature faults. Valid values and their definitions follow:

Value	Definition
0	The state of motor over-temperature input must be open, no connection, or a fault is generated. However, the drive will not be disabled by this fault.
1	Eight-segment LED displays fault code and asserts the internal flag associated with the motor over-temperature fault so any output mapped to it will be asserted. Also, the status of OUT1-OUT3 will be changed to indicate a motor over-temperature fault has occurred if the OUTFAULT mode is enabled. However, the drive will continue to operate.
2	Drive output is disabled. Eight-segment LED displays fault code and asserts the internal flag associated with the motor over-temperature fault so any output mapped to it will be asserted. Also, the status of OUT1-OUT3 will be changed to indicate a motor over-temperature fault has occurred if the OUTFAULT mode is enabled.

Examples:

```
»MOTMODE 2      ; Drive will disable output when a motor over-temperature fault occurs
»MOTMODE?       ; Displays current mode
2
```

MTRVMAX

Maximum Motor Velocity

Format1: MTRVMAX{ value }
Format2: MTRVMAX?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 0 to 32767
Units: kHz

See Also: ENCCNTS

The MTRVMAX parameter is the maximum speed at which the motor can operate in kHz. UltraTools will use this to set up internal scaling parameters the DSP uses to control the servodrive. The MTRVMAX value should be set in UltraTools by setting the Speed input values in Motor Setup. The equivalent speed of the motor in RPM will be dependent on the setting for ENCCNTS. The relationship is: RPM = MTRVMAX * 60 / ENCCNTS

Examples:

```
»MTRVMAX?
 800          ; The existing speed limit is 800 kHz, or 6000 RPM (ENCCNTS=8000)
```

OUTFAULT

Sets up OUT1, OUT2 and OUT3 for outputting binary fault data

Format1: OUTFAULT { 0 or 1 }
Format2: OUTFAULT?
Type Nonvolatile Parameter
Argument Type: Unsigned Integer, 0 or 1

See Also: INPFNx

The OUTFAULT parameter, when set to 1, is used to dedicate outputs OUT1 to OUT3 for use in querying the lower 6 bits of the current fault code for the drive. If INP1 is 0, bits 1 to 3 will be placed in OUT1 to OUT3, respectively. If INP1 is 1 (ON), then bits 4 to 6 will be used. The OUT1, OUT2 and OUT3 outputs are located on the P3 Supplemental I/O Connector and are duplicated on the P2 Controller Connector. Valid fault codes are identical to those outlined in the Status Display section of this manual. In this manner, 2^6 or 64 fault and status codes can be decoded.

If the OUTFAULT mode is enabled, use of the OUTFNx command with output 1-3 will generate an “in use by OUTFAULT” error.

Examples:

```
» OUTFAULT  1     ; A binary representation of the faults will now occupy OUT1-OUT3
```

Fault Code Displayed	FAULT	Data on OUT3..OUT2..OUT1 (1=asserted, 0=unasserted)		Description
		When INP1 = 1	When INP1 = 0	
A0	160	100	000	Drive over current
A1	161	100	001	Over Current
A3	163	100	011	Low bus voltage
A6	166	100	110	Drive not configured
A8	168	101	000	Invalid Commutation Position
A9	169	101	001	Phase Loss
AA	170	101	010	No bus voltage
AC	172	101	100	Soft start error
F1	241	110	001	Motor over current
F2	242	110	010	Power module fault
F3	243	110	011	High bus voltage
F4	244	110	100	Motor over temperature
F7	247	110	111	Motor feedback open
F8	248	111	000	Watchdog Timeout
		Note: asserted outputs sink current, unasserted outputs have a weak pullup		

OUTx

Digital Output State Command

Format1: OUT1? { value }
Format2: OUT2? { value }
Format3: OUT3? { value }
Format4: OUT4? { value }
Format5: OUT? Returns a binary representation of the inputs in a character string indicating the state of all 4 bits.
Type: Direct Mode Query
Argument Type: none

The OUTx command allows the user to query the state of the given digital output. OUT1 to OUT4 refer to the digital outputs as defined by the markings at the P3 Supplemental I/O connector on the servodrive. The value returned by the query can be either a 0 or a 1, indicating an OFF or ON condition for the output.

Use of the fifth format (OUT?) will return a binary representation of the outputs in a character string indicating the state of all 4 bits, OUT1 to OUT4, from left to right.

Examples:

```
»OUT1?          ; Query the existing state of OUT1
0               ; State of OUT1 is 0 or OFF
»OUT4?          ; Query the existing state of OUT4
1               ; State of OUT4 is 1 or ON
»OUT?           ; Query the existing state of all OUT's
0 0 0 1         ; OUT1 is OFF, OUT2 is OFF, OUT3 is OFF, OUT4 is ON
```

OUTFNx

Digital Output Function Command

Format1: OUTFN1 {[-] value)
Format2: OUTFN2 {[-] value)
Format3: OUTFN3 {[-] value)
Format4: OUTFN4 {[-] value)
Format5: OUTFNx?
Type: Nonvolatile Parameter
Argument Type: value – selects Boolean value per table

The OUTFNx command sets the boolean fault state that OUTx is to be drawn from inside the G Series servodrive. OUTFN1 refers to OUT1 as defined by the markings on the servodrive. OUTFN2 refers to OUT2, OUTFN3 refers to OUT3, and OUTFN4 refers to OUT4. The OUTx are updated every 400 msec. If the optional minus [-] sign is placed in front of the value, then the function inverts the output. Setting an OUTFNx to a value of 0 will disable that OUTx. The following table indicates what values refer to what internal functions that can be output.

Value	Boolean selected
0	none
1	Motor RMS Overcurrent Fault
2	Drive RMS Overcurrent Fault
3	Bus Voltage Too High Fault
4	Bus Voltage Too Low Fault
5	Encoder Feedback Fault
6	IPM Fault
7	Invalid Hall State Fault
8	Motor Temperature Fault
9	Power block enabled – true if drive is controlling current
10	Motor Motion – true if motor speed greater than 1% of max speed

If the optional minus [-] sign is placed in front of the *value* then the function inverts the output. Setting an OUTFNx to a value of 0 will disable that OUTx.

Examples:

```
»OUTFN1 -1   ; OUT1 will be asserted when a motor RMS overcurrent fault does NOT exist
»OUTFN2  5   ; OUT2 will be asserted when an encoder feedback fault exists
»OUTFN3 -3   ; OUT3 will be asserted when a bus over-voltage fault does NOT exist
»OUTFN4  0   ; OUT4 will be unused and will have no output
```

PMODE

Set Position Mode

Format: PMODE
Type: Nonvolatile Parameter
Argument Type: none

See Also: TMODE, VMODE, ANALOG, SERIAL, MODE?

The PMODE command sets the servodrive control mode to position mode. In position mode both the position loop and velocity loops are closed in the servodrive. The position loop provides the necessary control signals to cause the motor to move to keep the actual motor position (POS) at the commanded position (POSSTEP). The accuracy and speed of response are affected by the mechanical system and the tuning of the position and velocity loops in the drive.

The position loop command input can come from many sources.

1) Positioner Mode
2) Serial value set via CMD – when SERIAL is 1 the value set using the CMD command sets the commanded position, the POSSTEP value. Care should be exercised when changing the commanded position using CMD. The change in commanded position is an instantaneous command with no acceleration, deceleration or profile.
3) Analog input – when ANALOG is 1 the +/- 10v analog input sets the commanded position proportionally between +/- 32768.
4) Profile generator – when the profile mode is enabled, PRFENA is 1, the output of the profile generator sets the commanded position.
5) Setting POS, current position – when the POS command is executed with a value it sets the current actual position and also the commanded position.

Use the MODE? command to determine the existing state of the servodrive mode.

Example:

```
PMODE      ;Set for Position mode
```

POLES

Sets the number of motor poles

Format1: POLES { value }
Format2: POLES?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 2-and up

See Also: SIXSTEP, SINE, ENCCNTS

The POLES command sets the servodrive up for the number of poles in the servomotor.

Entering the POLES? command will cause the existing value for this parameter to be returned from the servodrive.

Example:

The following example sets the motor poles to 4 for a four-pole motor:

» POLES 4

POS

Query or Set of encoder position

Format1: POS?
Format2: POS { value }
Type: Direct Mode Command
Argument Type: Signed integer

The POS? query returns the current 32-bit position of the drive's feedback encoder. The second Format(2) provides a means for setting the value of the encoder position.

Examples:

```
»POS 1234     ; Sets encoder position to 1234
»POS 0        ; Sets encoder position to  0
»POS?         ; Query for position
32189
```

POSERR

Query position error when in PMODE

Format1: POSERR?
Type: Direct Mode Query
Argument Type: none

See Also: POS, POSSTEP

The POSERR? query returns the current 32-bit position error value. This is the difference between the commanded position, POSSTEP and the actual position of the motor, POS. Though a value can be returned when the drive is in any mode the value is meaningful in PMODE.

Examples:

»POSERR? ; Query for position error
32189

POSHOME

Position when last HOME occurred

Format: POSHOME?
Type Direct Mode Command
Argument Type: none

The POSHOME parameter provides a means for determining the encoder counts per rev of a motor. It is the value of POS when the encoder reference (ZREF or Zero pulse) occurred, during a HOME command. After the value of POS is saved in POSHOME, POS is cleared, as documented in HOME. This can be used to get a relatively accurate measurement of the distance between encoder reference signals. Step 1: Execute a HOME command and slowly move the motor through the encoder reference, watching for the HOME to be completed. HOME? will return a 1 after completion. At the reference point, POSHOME will be set to the value in POS, whatever its value is, and POS will be set to 0. Step 2: Issue another HOME command and continue to slowly move the motor through the encoder reference again, in the same direction of motion and at the same speed. At this second reference, POSHOME will be set to the value of POS, and then POS will again be set to 0. Now POSHOME contains the distance between encoder reference marks.

A word about the accuracy of POSHOME. POSHOME is NOT hardware latched. It is software latched in an interrupt routine. Therefore there is some latency from the reference mark to the interrupt routine and the storing of the value. The slower the speed, the more accurate will be the value. Secondly, the value stored is the value in POS, which is updated at the control interrupt rate. Since the reference interrupt routine is asynchronous to the control interrupt, there will be a small amount of error there. Again, the slower the motor moves, the more accurate will be the reading. And if the same direction and speed is used for this entire process, the tendency will be for the latencies mentioned above to be equal and

cancel out one another. There are other uses that POSHOME could be applied to, but this is one of the handier ones, particularly when setting up a new motor with the drive.

Example:

```
» HOME          ;Call for a HOME
CMD 30          ;Move slowly to completion of the HOME
» HOME?         ;Is it done HOMEing?
0               ;Not yet
» HOME?         ;Is it done HOMEing?
1               ;Now it is (POS will be zeroed at this point, too)
» HOME          ;Immediately do another HOME
» HOME?         ;Is it done HOMEing?
0               ;Not yet
» HOME?         ;Is it done HOMEing?
1               ;Now it is


» POSHOME?      ;Ask for the existing value in POSHOME
8000            ;Zref to Zref counts!
```

POSSTEP

Query commanded position when in PMODE

Format1: POSSTEP?
Type: Direct Mode Query
Argument Type: none

See Also: POS, POSERR

The POSSTEP? query returns the current 32-bit commanded position value. The commanded position value is set by Step and Direction input, CMD command or the analog input, depending on the mode.

Whenever the motor position is redefined using the POS command POSSTEP is set to the same value.

Though a value can be returned when the drive is in any mode the value is only meaningful in PMODE.

Examples:

```
»POSERR?        ; Query for position error
32189
```

PRFCYCL

Profile Cycles (when Profile Mode = 3)

Format: PRFCYCL { value }
Format2: PRFCYCL?
Type: Direct Mode Command
Argument Type: Unsigned Integer, 1 to 32767

See Also: SERIAL, PRFLOT, PRFHIT

The PRFCYCL command in conjunction with the PRFMODE command (when set to 3) will cause the existing Profile definition to be repeated according to the value of the PRFCYCL parameter. Setting PRFMODE to 3 and setting PRFCYCL to 1 will cause a single cycle of the Profile to be done at the next GO command. The SERIAL command must previously be set to 'ON' for this command to work. If PRFCYCL? is entered without a parameter, the current value for this parameter will be returned.

Examples:

```
» PRFMODE 3        ;Sets the Profile mode to do a fixed number of cycles
» PRFCYCL  1       ;This calls for only one cycle to be done
```

PRFENA

Enables or Disables Profile Mode

Format1: PRFENA { mode }
Format2: PRFENA?
Type: Direct Mode Command
Argument Type: 0 or 1

See Also: SERIAL, PRFMODE, PRFCYCL

The PRFENA command enables or disables profiling mode, which allows the servodrive to define and use simple profiling commands through the serial port. A "1" argument enables the profiling mode, while a "0" argument disables profiling mode. The SERIAL command must be 'ON' for this PRFENA command to work. After first enabling the profiling mode with PRFENA 1, and then defining certain profiling parameters, simple profile moves can be done.

Entering the PRFENA? command will cause the existing value for this parameter to be returned from the servodrive.

Examples:

```
»PRFENA  1          ;Enable profile mode
»TMODE              ;Set Torque mode on (to move using Torque mode)
»PRFHILV 8000       ;Set value for the high signal command for the current
»PRFHIT 1000        ;Set time to run 'at Current', in 400 µsecs units
»PRFLOLV 0          ;Set the low level command to 0
»PRFLOT 1000        ;Set time to run 'at low level', also in 400 µsecs units
»PRFMODE 3          ;Set PRFMODE to 3 for fixed cycles
»PRFCYCL 1          ;Set PRFCYCL so we do only a single cycle in our move
»GO                 ;GO causes our profile motion to begin
```

PRFHILV

Profile High Level Signal

Format1: PRFHILV { value }
Format2: PRFHILV?
Type: Direct Mode Command
Argument Type: Signed Integer, +/-32767

See Also: SERIAL, PRFLOT, PRFHIT, PRFLOLV

The PRFHILV command sets the Profile definition for the actual signal level for the high velocity or high current signal level, depending on whether the profile is being run in Velocity or Torque mode. The PRFHILV signal will be on for the length of time as defined by PRFHIT. PRFHILV can be used to provide great flexibility in the Profile that is to be run, allowing for 'back and forth' movements and other variations.

Entering the PRFHILV? command will cause the existing value for this parameter to be returned from the servodrive..

Examples:

» PRFHILV 3000 ;Sets the 'high command' level to 3000

PRFHIT

Profile High Level Time

Format1: PRFHIT { time }
Format2: PRFHIT?
Type: Direct Mode Command
Argument Type: Unsigned Integer, 0 to 65535

See Also: CMD, SERIAL, PRFLOT, PRFHILV

The PRFHIT command sets the Profile definition of the time to remain at the commanded velocity or current signal level (which is given by PRFHILV) depending on whether the Profile is run in Torque mode or Velocity mode. The SERIAL command must previously be set to 'ON' for this command to work. PRFHIT is given in 400 µsec units, e.g. 2500 = 1 second. Values higher than 65535 will be truncated to 65535.

Entering the PRFHIT? command will cause the existing value for this parameter to be returned from the servodrive.

Examples:

» PRFHIT 1000 ;Sets high command time for CMD to be 0.4 seconds

PRFLOLV

Profile Low Level Signal

Format1: PRFLOLV { value }
Format2: PRFLOLV?
Type: Direct Mode Command
Argument Type: Signed Integer, +/-32767

See Also: SERIAL, PRFLOT, PRFHILV

The PRFLOLV command sets the Profile definition for the actual signal level for the low velocity or low current signal level, depending on whether the Profile is being run in Velocity or Torque mode. PRFLOLV is often set to 0. The PRFLOLV signal will be on for the length of time as defined by PRFLOT. PRFLOLV can be used to provide greater flexibility in the Profile that is to be run, allowing for 'back and forth' movements and other variations. The SERIAL command must previously be set to 'ON' for this command to work.

Entering the PRFLOLV? command will cause the existing value for this parameter to be returned from the servodrive.

Examples:

» PRFLOLV 1000 ; Sets the 'low command' level for the existing test mode to 1000

PRFLOT

Profile Low Level Time

Format1: PRFLOT { time }
Format2: PRFLOT?
Type: Direct Mode Command
Argument Type: Unsigned Integer, 0 to 65535

See Also: PRFLOLV, SERIAL, PRFHIT

The PRFLOT command sets the Profile definition for the time to remain at the low velocity or current signal level, which is defined by PRFLOLV. (PRFLOLV is often set to 0.) The SERIAL command must previously be set to 'ON' for this command to work. PRFLOT is given in 400 microsecond units, e.g. 2500 = 1 second. Values higher than 65535 will be truncated to 65535.

Entering the PRFLOT? command will cause the existing value for this parameter to be returned from the servodrive.

Examples:

» PRFLOT 2500 ; Sets low command time for PRFLOLV to be 1.0 seconds.

PRFMODE

Profile Mode

Format1:	PRFMODE { mode }
Format2:	PRFMODE?
Type:	Direct Mode Command
Argument Type:	Unsigned Integer, 1 or 2 or 3
See Also:	SERIAL, PRFLOT, PRFHIT, PRFHILV , PRFLOLV, GO, STOP

The PRFMODE command sets the Profile mode that is to be used for the next Profile motion. Profiling is a feature of the G-Series servodrive in which the drive will perform predefined profile moves in one of three different, settable modes: (1) Dynamic, (2) Repetitive, and (3) Set Cycle, as defined below. The original purpose was to provide a simple method to create and plot motion using UltraTools, effectively making a digital scope. But the overall profiling capability can provide tools for specific applications, as well as being helpful debugging tools. Entering the PRFMODE? command will cause the existing value for this parameter to be returned from the servodrive.

PRFMODE 1 (Dynamic)

In the Dynamic mode (1), the ACCEL and PRFHILV values are used to accelerate or decelerate to the commanded PRFHILV command value and hold that value. If the PRFHIT timeout value is set to 0, the profiler will continue at the commanded value until either a STOP command or a GO command is entered. If PRFHIT contains a value, it will represent a timeout value for the 'at speed' motion, given in 400 µsec units. This feature provides a safety factor for PRFMODE 1. By using PRFHIT, the PRFMODE 1 motion will not continue forever without controller intervention. The minimum intervention is to send a GO command. No other parameters need to be resent. Or new settings for the PRFMODE 1 parameters can be sent, followed by the GO command. Note that the slowest setting for controller intervention is 65535/2500 = 26.2 sec. Setting PRFHIT to 2500 would require controller intervention every 1 sec. (Remember, the timeout starts after the end of the acceleration ramp.) If a STOP command is issued, the profiler will decelerate using the current DECEL value. If a new PRFHILV value is set and another GO command is issued during Profile motion, the profiler will accelerate or decelerate to the new PRFHILV value using the current ACCEL value. Following is an example of the setup:

```
VMODE           ; Set velocity mode
PRFENA 1        ; Enable profiling mode
PRFHILV 4000    ; Set high signal level for the profile
PRFHIT 0        ; Set timeout to 0 so motion goes on until STOP is issued
ACCEL 400       ; The ACCEL defines how fast we come up to speed
DECEL 400       ; The DECEL defines how fast we come to a stop
PRFMODE 1       ; Select the 'Dynamic' mode for profiling
GO              ; Now the Profile is defined, GO do it, STOP when done
```

Once the GO command is issued, the dynamic profile continues until a STOP command is issued or until a timeout occurs, if PRFHIT has a setting other than 0.

PRFMODE 2 (Repetitive)

In the Repetitive mode (2), a profile is defined using a high signal level and time, and then a low signal level and time. Acceleration and deceleration function as described above. Once profile motion is begun with a GO command, motion will accelerate to the high signal level and hold there for the high signal time. Then motion will decelerate to the low signal level and hold there for the low signal time (both of which can be 0, if desired). Then motion decelerates to 0, and the whole process begins again. This repetitive motion will continue until the STOP command is issued. Following is an example of this setup:

```
VMODE           ; Set velocity mode
PRFENA 1        ; Enable profiling mode
PRFHILV 4000    ; Set high signal level for first part of the profile
PRFHIT 1000     ; Set the time duration for the high level signal, 0.4 seconds
PRFLOLV -4000   ; Set low signal level for the second part of the profile
PRFLOT 1000     ; Set the time duration for the low level signal, 0.4 seconds
ACCEL 400       ; The ACCEL defines how fast we come up to speed
DECEL 400       ; The DECEL defines how fast we come to a stop
PRFMODE 2       ; Select the 'Repetitive' mode for repeat profiling
GO              ; Now the Profile is defined, GO do it, STOP when done
```

Once the GO command is issued, the repetitive profile continues until a STOP command is issued.

PRFMODE 3 (Set Cycle)

In the Set Cycle mode, the profiler uses all of the same parameters as in mode 2, except that PRFCYCL is used to set the number of cycles to run.

```
VMODE           ; Set velocity mode
PRFENA 1        ; Enable profiling mode
PRFHILV 4000    ; Set high signal level for first part of the profile
PRFHIT 1000     ; Set the time duration for the high level signal, 0.4 seconds
PRFLOLV –4000   ; Set low signal level for the second part of the profile
PRFLOT 1000     ; Set the time duration for the low level signal, 0.4 seconds
ACCEL 400       ; The ACCEL defines how fast we come up to speed

DECEL 400       ; The DECEL defines how fast we come to a stop
PRFMODE 3       ; Select the 'Set Cycle' mode for fixed cycle profiling
PRFCYCL 1       ; We tell PRFCYCL we wish to do only one cycle of motion
GO              ; Now the Profile is defined, GO do it.  It stops itself when done
```

Once the GO command is issued, the Set Cycle profile continues until the PRFCYCL number of cycles has been completed, and then it stops. If the user enters the STOP command, this will also stop the profile.

NOTE: In all modes, ACCEL is used when changing to the PRFHILV value, and DECEL is used when changing to PRFLOLV or when stopping.

The combination of these various Profiling commands allows complete flexibility in defining almost any Profile desired. The SERIAL command must previously be set to 'ON' for this command to work. And Profiling must be enabled using PRFENA 1.

PWMFREQ?

PWM Frequency

Format: PWMFREQ?
Type: Direct Mode Query
Argument Type: None (Read Only Value)

See Also:

The PWMFREQ? query allows the user to find out the period of the PWM signal. The delivered answer is in kHz units. This is a 'Read Only' type of value.

Examples:

```
» PWMFREQ?      ;Ask for the PWM period information
16              ;16 corresponds to 16 kHz
```

RAMTEST

Perform a continuous test of the DSP static ram memory

Format: RAMTEST
Type: Direct Mode Command
Argument Type: None

This command will immediately disable the drive and then execute a continuous test of the DSP static ram memory. Once begun, the only way to stop this test is to cycle the logic power to the drive. The test writes a sequential pattern to the SRAM and verifies it. However, with each pass the sequence is moved one location. While running, the seven segment display will be changing with each pass through the RAM. If an error occurs at any time during the testing, the display will flash, with the pattern alternating between two vertical bars and three horizontal bars, until the power is cycled.

During a normal power-up, a single cycle of this test is performed to verify that the DSP dynamic ram is operating properly.

Example:

```
» RAMTEST          ;Perform continuous ram test until powered down
```

R.DEB

Sets the Resolver Error Debounce Time

Format1: R.DEB { value }
Format2: R.DEB?
Type Nonvolatile Parameters
Units: tenths of msec
Argument Type: Unsigned Integer. Default 500 (50 msec).

The R.DEB parameter is used to set the debounce time for the resolver error signal. This value determines how long the signal must be active before being reported. When reported it will be reported as an F7 error. The argument is in msec.

The resolver interface is capable of detecting and reporting 2 types of errors. The first is a low or missing resolver signal. If the reference signal to the resolver or either the SIN or COS signal returned do not have sufficient amplitude then an error is reported. The second error involves the ability to track resolver position. The interface uses a standard tracking resolver to digital converter. It is possible during high acceleration and decelerations for the tracking to fall behind, meaning the reported position as an error. When this tracking error reaches +/- 100 LSBs then the error is set. It automatically clears when the tracking catches up. In most applications this brief tracking error during acceleration/deceleration is not noticed or a problem.

This command allows adjustment of the debounce time of the error signal. This allows the drive to pass through short pulses of the error signal without stopping operation while still catching significant problems. Setting the time higher requires a longer pulse before reporting an error.

Examples:

```
» R.DEB 300          ; Sets the error debounce time to 30 msec.
» R.DEB 1000         ; Sets the error debounce time to 100 msec.
```

REM or ;

Remarks

Format1: REM
Format2: ; (semicolon)
Type: Direct Mode Command
Argument Type: none

See Also:

The REM or semicolon character ";" may be followed by comments up to the max command length. The drive will ignore all text following the REM or semicolon until after the next carriage return and line feed is received. A space character must follow either the REM or the semicolon character, or a syntax error will occur.

Examples:

```
»REM This is a comment that will be completely ignored by the drive
»; This too will be completely ignored by the drive
»RESET               ; Reset the drive here
»KVP 400             ; Set the velocity loop proportional gain
»TMODE               ; Turn on torque mode
```

RESET

Software DSP Reset

Format: RESET
Type: Direct Mode Command
Argument Type: none

See Also:

The RESET command resets the DSP and performs a software reboot. All faults are cleared and all setup and tuning variables are zeroed and restored automatically from EEPROM. This command is equivalent to cycling the power to the DSP.

Examples:

```
»RESET          ;Reset the drive immediately
```

RESTORE

Restore Parameters from EEPROM

Format: RESTORE
Type: Direct Mode Command
Argument Type: none

See Also: STORE

The RESTORE command restores certain servomotor and servodrive parameters from EPROM into the servodrive, providing the desired startup conditions for a particular application and hardware configuration. When the servodrive is first powered up, these parameters will also be restored from the EPROM into the servodrive. The parameters restored include the servo control mode (TMODE/VMODE), the commutation mode (SINE/SIXSTEP), the command mode (ANALOG/SERIAL), the motor parameters (POLES, ENCCNTS, HOFFSET, IMTRPK, IMTRRMS, ICLAMP, MOTMODE, MTRVMAX), the current loop tuning constants, the velocity loop tuning constants, the digital input function definitions (INPFNx), the digital output function definitions (OUTFNx), the DAC function definitions (DACFNx), the Regen settings (RGTRIP, RGCLIM), and the condition of the DRVENA parameter (allows drive to start up enabled).

Examples:

```
»RESTORE        ;Restore setup parameters from EPROM
```

RGCLIM

Shunt Resistor Regen Current Limit

Format1: RGCLIM { value }
Format2: RGCLIM?
Type: Nonvolatile Parameter
Argument Type: Unsigned Integer, 1 to 32767

See Also: RGTRIP

The RGCLIM command sets the maximum current limit for dissipating regenerative energy in the shunt resistor(s). Note that only G Series drives G10 and higher can make use of the shunt commands. The G3 and G5 drives are not capable of providing shunting capability.

Examples:

```
» RGCLIM 4315          ; Set shunt resistor current limit
```

RGTRIP

Shunt Resistor Regen Trip Voltage

Format1:	RGTRIP { value }
Format2:	RGTRIP?
Type:	Nonvolatile Parameter
Argument Type:	Unsigned Integer (volts)
See Also:	RGCLIM

The RGTRIP command sets the voltage at which the drive's internal shunt regulator will begin to operate by shunting excess regeneration voltage across the shunt resistor. If this parameter is set to 0, then the shunt regulation function of the servodrive will be disabled. Note that only G Series drives G10 and higher can make use of the shunt commands. The G3 and G5 drives are not capable of providing shunting capability.

Warning: Setting this value lower than the nominal bus voltage (155 VDC, 325 VDC or 650 VDC) will cause the shunt output to be on at all times.

Examples:

» RGTRIP 395 ; Set shunt regulation to begin at 395 volts

ROFFSET

Sets the Resolver Offset

Format1:	ROFFSET { value }
Format2:	ROFFSET?
Type	Nonvolatile Parameters
Argument Type:	Signed Integer, 0 to 360

The ROFFSET parameter is used to set the offset between the positive portion of the back emf observed from the motor leads that will connect to the drive's U and V outputs (U with respect to V) and the resolver 0 position when rotating the motor counter-clockwise from the face of the motor. The argument is in electrical degrees.

Note that ROFFSET and HOFFSET are synonymous and either can be used to set or display the offset value.

Examples:

» ROFFSET 30 ; Sets the resolver offset to +30 electrical degrees, i.e. the back emf leads the resolver 0 point by 30 electrical degrees.

R.QRES

Resolver Output Quadrature Resolution Command

Format1:	R.QRES { value }
Format2:	R.QRES?
Type	Nonvolatile Parameter
Argument Type:	Unsigned Integer, 4096 or 2048 or 1024
See Also:	FEEDBACK, R.RESOL

The R.QRES command sets the resolution of the synthesized encoder output.

If the R.QRES? command is entered, the existing value for this parameter will be returned.

Most controllers connected to the drive require motor feedback provided in a quadrature format. The drive will create this quadrature output from the resolver feedback. The resolution of this quadrature output can be adjusted and is independent of the resolver resolution. It is possible, and acceptable, to have the resolver resolution higher than the Output Quadrature resolution.

R.RESOL

Resolver Resolution Command

Format1:	R.RESOL { value }
Format2:	R.RESOL?
Type	Nonvolatile Parameter
Argument Type:	Unsigned Integer, 4096 or 16384
See Also:	ENCCNTS, FEEDBACK, POLES, SIXSTEP, SINE, R.QRES

The R.Resol command sets the resolver resolution in counts per revolution of the motor. The drive is designed for proper operation and optimization at two resolutions, 4096 and 16384.

This command sets the resolution, it does not change the feedback type. Command FEEDBACK must be used for that.

Note that R.RESOL and ENCCNTS are synonymous and either can be used to set or display the drive feedback resolution.

If the R.RESOL? command is entered, the existing value for this parameter will be returned.

Examples:

The following example sets the resolver resolution to 4096 counts per revolution for a motor using a resolver for feedback.

```
»R.RESOL 4096 ;
```

R.RFREQ

Resolver Reference Frequency Command

Format1:	R.RFREQ{ value }
Format2:	R.RFREQ?
Type	Nonvolatile Parameter
Argument Type:	Unsigned Integer, 2500, 5000, 10000
See Also:	R.TRATIO

The R.RFREQ command sets the resolver reference signal frequency. Three frequencies are currently supported. In general, the higher the frequency supported by the resolver the better the performance.

If the R.RFREQ? command is entered, the existing value for this parameter will be returned.

A resolver works by receiving a reference sine wave of a given frequency and amplitude. The resolver on the motor then couples this like a transformer into two other windings, SIN and COS, which are 90 degrees apart. The SIN and COS signals are returned to the drive where they are decoded and the position determined. The ratio of the amplitude of the reference signal to the amplitude of the signal returned is the transformation ratio. In a 1.0 ratio the return has the same amplitude as the reference. In a 0.5 ratio the return signal is only ½ the amplitude of the reference.

The hardware on the drive will support a wide range of frequencies. However, not all resolvers will. As the frequency changes the impedance of the resolver changes and the ability of the resolver to couple the signal to the output windings changes. As the impedance goes down the current in the reference signal will go up. With higher current comes higher voltage drop. As long as it is within the limits of the drive the system will work.

Also, some resolvers, especially some older ones, are designed such that they do not couple high frequency signals well. In some cases getting low enough that the resolver does not operate sufficiently.

Examples:

```
»R.RFREQ 2500          ; set resolver reference frequency to 2500 Hz
»R.RFREQ 5000          ; set resolver reference frequency to 5000 Hz
»R.RFREQ 10000  ; set resolver reference frequency to 10000 Hz
```

R.TRATIO

Resolver Transformation Ratio Command

Format1:	R.TRATIO{ value }
Format2:	R.TRATIO?
Type	Nonvolatile Parameter
Units:	Hundredths of ratio
Argument Type:	Unsigned Integer, 25 to 200 (ratios of 0.25 to 2.00)

See Also: R.RFREQ

The R.TRatio command sets the resolver transformation ratio. Setting a higher value will reduce the amplitude of the resolver reference signal. Setting a lower value will increase the amplitude of the reference signal. The units are in hundredths to allow fractional ratios. For a transformation ratio of 0.25 enter value 0.25 * 100 = 25.

If the R.RESOL? command is entered, the existing value for this parameter will be returned.

A resolver works by receiving a reference sine wave of a given frequency and amplitude. The resolver on the motor then couples this like a transformer into two other windings, SIN and COS, which are 90 degrees apart. The SIN and COS signals are returned to the drive where they are decoded and the position determined. The ratio of the amplitude of the reference signal to the amplitude of the signal returned is the transformation ratio. In a 1.0 ratio the return has the same amplitude as the reference. In a 0.5 ratio the return signal is only ½ the amplitude of the reference.

The hardware on the drive requires a return signal with an amplitude of 2 V rms. In order to get the correct return signal and support various transformation ratios the drive is capable of adjusting the amplitude of the reference signal to compensate for the transformation ratio of the resolver. A resolver with a transformation ratio of 1.0 requires a reference signal with an amplitude of 2 V rms. A resolver with a transformation ratio of 0.5 requires a reference signal with an amplitude of 4 V rms. The resolver output will be half of that or 2 V rms.

Examples:

»R.TRATIO 25 ; set transformation ratio to .25, raising the output amplitude to compensate for the signal level reduction in the resolver

»R.TRATIO 150 ; set transformation ratio to 1.50, lowing the output amplitude

RS-485

RS-485 Node ID

Format1:	RS-485 {node ID}
Format2:	RS-485?
Type	Direct Mode Command
Argument Type:	Unsigned Integer, 0 to 16 and 100

See Also: RS-485EN, STORE

The RS-485 command sets the node ID for the current drive. The STORE command must be used to save the drive node ID in flash, otherwise, the drive ID will revert to the last value saved in flash the next time the logic power is cycled. A value of 0 will disable RS485 communications, the drive will operate in RS232 mode. A value of 100 will configure the drive to use the Digital inputs at power up to set the node ID and to switch to RS-485 communications immediately.

Note, it is best to cycle power or issue a reset command after the STORE command. RS485 address changes become effective immediately, however, hardware configuration changes are only done at power up or reset. Thus, changing between RS232 and RS485 with the RS-485 command will change the interface from single ended RS232 to differential RS485 after the next reset, not immediately.

If the node ID is set between 1 and 16 then hardware configuration to RS485 is delayed for 30 seconds after power up. The drive will power up configured for RS232. If RS485 has been selected by storing a non-zero address then a P will flash on the display during this initial mode. While in this mode you are able to use RS232 communications and query the drives node address and disable RS485 mode if desired. Also while in this mode RS485 communications will not work. This feature provides a method to reset a servodrive with an unknown RS485 address while the differential RS485 drivers are not available.

If the node ID is set to 100 then the drive will use the Digital input states at power up to determine the node ID. The inputs will be sampled approximately 1 second after power up. If a valid address is found the drive will immediately enter RS485 mode, skipping the 30 second delay defined in the previous paragraph. Additional details can be found in the main body of the Installation and Operation Manual.

If the RS-485? command is entered, the node ID for the current drive will be returned.

Examples:

```
» RS-485 1      ; sets current drive node ID to 1
» RS-485?       ; returns the current node ID
» STORE         ; saves the current drive node ID in flash memory
» RESET         ; resets the drive which configures for RS485 mode
```

RS-485EN

Enable RS-485 Node

Format1: RS-485EN {node ID}
Format2: RS-485EN?
Type Direct Mode Command
Argument Type: Unsigned Integer, 0 to 16

See Also: RS-485

The RS-485EN command sets the active node ID for the RS-485 communications. If node ID matches this servodrives address, then it will become the active drive. If there is no match then the command is ignored. When a servodrive is not the RS485 active drive all commands except RS-485EN are ignored.

If the RS-485EN? command is entered, the node ID for the current drive will be returned.

Examples:

```
» RS-485EN 1        ; enable communications with drive node ID 1
» RS-485EN?         ; returns the current node ID
» RS-485EN 2        ; enable communications with drive node ID 2
```

SERIAL

Serial Command Input

Format: SERIAL
Type: Direct Mode Command
Argument Type: none

See Also: ANALOG, SDINPUT, MODE? , PMODE, VMODE, TMODE

The SERIAL command sets the servodrive command source to be the serial interface, via command CMD. In this mode, the desired command signal must be sent to the servodrive as an ASCII command, CMD. Executing this command effectively disables the analog and step and direction command inputs.

This command only changes the command source. The serial interface is always functional, regardless of the command source.

To switch to another command source use the appropriate command to select that channel, ANALOG or SDINPUT.

Use the MODE? Command to determine the current state of the command mode.

Examples:

```
» SERIAL     (This command puts the servodrive in serial command mode)
» ANALOG     (This command puts the servodrive in analog command mode)
» SERIAL     (This command puts the servodrive back in serial command mode)
```

SINE

Set Sine Commutation Mode

Format: SINE
Type: Nonvolatile Parameter
Argument Type: none

See Also: POLES, ENCCNTS, SIXSTEP, MODE?

The SINE command sets the servodrive's electronic commutation method to sinusoidal commutation. Your motor must utilize both an encoder and Hall sensors (or commutation

tracks) in order to use sinusoidal mode. In sinusoidal mode, the POLES and ENCCNTS values must be set prior to setting this parameter.

Use the MODE? command to determine the existing state of the commutation mode.

Examples:

The example below sets the commutation mode to sinusoidal.

» SINE

SIXSTEP

Set SixStep Commutation Mode

Format: SIXSTEP
Type: Nonvolatile Parameter
Argument Type: none

See Also: POLES, ENCCNTS, SINE, MODE?

The SIXSTEP command sets the servodrive's commutation mode to six-step (trapezoidal) commutation. The servodrive's velocity term is derived from the encoder attached to the drive.

Use the MODE? command to determine the existing state of the commutation mode.

Note: if the SIXSTEP command is given with a resolver selected as feedback it will be ignored. It is invalid but no error will be generated.

Examples:

The example below sets the commutation mode to sixstep.

» SIXSTEP

STATUS?

Return Drive Status

Format: STATUS?
Type: Direct Mode Query
Argument Type: none

See Also: MODE?, VER?

The STATUS command displays the status of inputs, outputs, drive enable/disable settings and faults.

Examples:

```
»STATUS?
» INPUTS: 1 0 1 0 ; Input 1 is on, input 2 is off, input 3 is on, input 4 is off
»OUTPUTS: 0 1 0 1 ; Output 1 is off, output 2 is on, output 3 is off, output 4 is on
»  DRIVE: ENABLED or HARDWARE DISABLED or DISABLED
»FAULT CODE: 0     ; Fault codes as they would appear on 8-segment LED display
```

STOP

Profile Stop

Format: STOP
Type: Direct Mode Command
Argument Type: none

See Also: PRFENA, GO

The STOP command allows the user to stop any motion that was initiated by the Profile GO command. The SERIAL command must previously be set to 'ON' for this command to work.

Examples:

```
»STOP      ;Stop the Profile motion
```

STORE

Store Parameters into EPROM

Format: STORE
Type: Direct Mode Command
Argument Type: none

See Also: RESTORE

The STORE command stores certain servomotor and servodrive parameters into EPROM. When the servodrive is first powered up, these parameters will be restored from the EPROM into the servodrive, providing the desired startup conditions for a particular application and hardware configuration. The parameters STOREd include the servo control mode (TMODE/VMODE), the commutation mode (SINE/SIXSTEP), the command mode (ANALOG/SERIAL), the motor parameters (POLES, ENCCNTS, HOFFSET, IMTRPK, IMTRRMS, ICLAMP, MOTMODE, MTRVMAX), the current loop tuning constants, the velocity loop tuning constants, the digital input function definitions (INPFNx), the digital output function definitions (OUTFNx), the DAC function definitions (DACFNx), the Regen settings (RGTRIP, RGCLIM), and the condition of the DRVENA parameter (allows drive to start up enabled).

Examples:

```
»STORE          ; Store setup parameters into EPROM
```

TMODE

Set Torque Command Mode

Format: TMODE
Type: Nonvolatile Parameter
Argument Type: none

See Also: VMODE, PMODE, CMD, ANALOG, SERIAL, MODE?

The TMODE command sets the servodrive's control mode to torque control. This effectively changes the drive's transfer function from volts output/volt input (a voltage source or velocity mode drive) to amperes output/volt input (a current source or torque mode drive). The Kis command is used for scaling the current command in torque mode. The velocity term remains available for use by one of the drive's DACs.

The accuracy and speed of response are affected by the mechanical system and the tuning of the current loop in the drive.

The torque command input can come from many sources. Note that a torque command is effectively a force command and not a velocity command. If there is no resistance to the motor rotation it will run at maximum velocity.

1) Serial value set via CMD – when SERIAL is 1 the value set using the CMD command sets the commanded torque.
2) Analog input – when ANALOG is 1 the +/- 10v analog input sets the commanded torque.
3) Profile generator – when the profile mode is enabled, PRFENA is 1, the output of the profile generator sets the commanded torque.

If the MODE command is entered, followed by a question mark (MODE?), then the drive returns the state of all the modes of operation.

Example:

```
» TMODE      ;Set for Torque mode
» MODE?
SERVO MODE:  TORQUE CONTROL
COMMUTATION MODE:  SIXSTEP
COMMAND MODE:  SERIAL
```

VBUS

Voltage on the Bus

Format: VBUS?
Type Direct Mode Command
Argument Type: none

The VBUS command provides an easy method for checking the bus voltage output level, as measured and indicated by the DSP firmware. This command can be a helpful diagnostic tool when trying to find the cause or condition of an anomaly occurring in the drive.

Example:

```
» VBUS?      ;Ask for the bus output voltage
161
```

VELOBS

Specify a sensitivity value for the velocity observer

Format1: VELOBS { value }
Format2: VELOBS?
Type Nonvolatile Parameters
Units: Sensitivity in units ranging from 20 to 200, where 100 is normal

The velocity observer parameter controls a filter relating to the velocity feedback that helps control the velocity loop. Input values can range from 20 to 200, where 100 is considered a normal setting. This command changes the velocity observer coefficients. Lower values will smooth low speed motion, but increase settling times on quick stops. Higher values will increase velocity response at the expense of smoothness.

If the VELOBS? command is entered, then the drive returns the existing value for VELOBS.

Examples:

```
» VELOBS 90          ; Sets VELOBS to 90 for slightly smoother low speed motion
```

VER?

Version of the G Series Internal Software

Format: VER?
Type: Direct Mode Command
Argument Type: none

See Also: MODE?, STATUS?

The VER? command allows the user to find out the version of the software in the DSP for the G Series servodrive.

Examples:

```
»VER?                          ;Ask for the version information
ULTRADRIVE G Series
DIGITAL SERVODRIVE
Drive Model:  G205
Feedback: Quadrature
FlexROM2 Version:  2.0.0
```

VMODE

Set Velocity Control Mode

Format: VMODE
Type: Nonvolatile Parameter
Argument Type: none

See Also: TMODE, PMODE, ANALOG, SERIAL, MODE?

The VMODE command sets the servodrive control mode to velocity mode. In velocity mode only the velocity loop is closed in the servodrive. The servodrive will interpret the command signal as a velocity command and automatically adjust the motor current to cause the motor to turn at the commanded velocity.

The accuracy and speed of response are affected by the mechanical system and the tuning of the velocity loop in the drive.

The velocity loop command input can come from many sources.

4) Serial value set via CMD – when SERIAL is 1 the value set using the CMD command sets the commanded velocity. Care should be exercised when changing the commanded velocity using CMD. The change in commanded velocity is an instantaneous command with no acceleration, deceleration or profile.
5) Analog input – when ANALOG is 1 the +/- 10v analog input sets the commanded velocity.
6) Profile generator – when the profile mode is enabled, PRFENA is 1, the output of the profile generator sets the commanded velocity.

An analog or serial command applied to the servodrive would then act to control the servomotor's velocity.

Use the MODE? command to determine the existing state of the servodrive mode.

Example:

```
VMODE      ;Set for Velocity mode
```