ServoWire SM Drives

Installation and Operation Manual

SAC-SM 01e

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Chapter 1
Welcome

1 Welcome

This manual provides information about ORMEC's ServoWire SM servodrives, G-Series and D-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.
Chapter 2	**General Description** gives an overview of the ServoWire SM Drive product family.
Chapter 3	**Installation** provides instructions on how to install your ServoWire SM Drive(s), including a complete hardware description.
Chapter 4	**Operation** documents the power up and initial configuration approach for the ServoWire SM Drive.
Chapter 5	**Getting Started** provides detailed instructions on how to run your ServoWire SM Drive system for the first time.
Chapter 6	**Specifications** provides a detailed list of performance specifications for ServoWire SM Drives.
Chapter 7	**Maintenance and Troubleshooting** documents the various status and fault indicators.
Appendix	**Appendixes** contain a detailed drawing set **.**

Chapter 2
General Description

2 General Description

This manual covers ServoWire SM Drives, which operate with a Host PC or Orion Motion Controller that have Open HCI IEEE-1394 interfaces and control a wide variety of AC Servomotors, including ORMEC G-Series and D-Series Servomotors.

2.1 ServoWire SM Drive Capabilities and Features

- **ServoWire Interface**: The IEEE 1394 ServoWire interface to the Host PC or Orion Motion Controller that simplifies panel wiring and reduces cabling cost.
- **Simple Setup**: The drive's axis ID is programmed via a pushbutton on the top of the drive; all other drive configuration settings are set by the user's application software using the ServoWire interface, eliminating drive jumpers, address switches, and potentiometers.
- **All Digital**: High-speed DSP-controlled current loops for precise torque, velocity and position mode operation.
- **Standard Line Voltage Input**: ServoWire SM 115/230 VAC Drives (SAC-SM_**2**__) are available for operation directly on commercial power lines supplying either 115 (+15%, -20%) or 230 (+15%, -20%) VAC for the main power as well as the control power. ServoWire SM 460 VAC Drives (SAC-SM_**4**__) are available for operation directly on commercial power lines supplying either 230 (+15%, -20%) or 460 (+15%, -20%) VAC for the main power and either 115 (+15%, -20%) or 230 (+15%, -20%) VAC for the control power. Note the 35A and 50A control power is limited to 230 VAC.
- **DC Voltage Input**: The ServoWire SM Low Power Drives (SAC-SM_**A**__) can be operated on 24 – 96 (+/-10%) for the main power and 24 (+15%, -20%) for control power. *Note: ServoWire SM Low Power Drives are not for use with ORION Motion Controllers.*

- **Fault Detection and Protection**: Detection and protection against:

  Motor short
  Peak & RMS drive current limit
  Peak & RMS motor current limit
  Missing phase detection
  (SM_225, SM_235, SM_260 SM_417, SM_425, SM_435 & SM_450 only)
  Encoder open wire detection
  Hall sensor phasing error
  Motor over temperature
  ServoWire network communications errors

- **Diagnostics**: A 1-digit 7-segment display that shows the servodrive identification (ID) number, enabled status and fault status.

- **Software Configurable General Purpose I/O**: ServoWire SM Drives have general purpose I/O which can also be configured in software to provide an emergency stop or quick stop input and drive ready and fail-safe brake control outputs.

- **Variety of Commutation Options**: ServoWire SM Drives can be software configured for sinusoidal or trapezoidal commutation for AC brushless motors, as well as for DC operation to control DC motors, voice coils and other single phase actuators.

- **Soft Start**: Circuitry is provided on all 115/230 VAC ServoWire SM Drives (SAC-SM_2__) and all 460 VAC ServoWire SM Drives (SAC-SM_4__) to reduce servodrive in-rush current.

- **Torque Mode Operation**: When combined with velocity and position loops in high performance Host PC's or Orion Motion Controller, 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. The computing burden on the PC is reduced compared to torque mode operation by closing the velocity loop on the ServoWire SM Drive.

- **Position Mode Operation**: Position mode operation allows for precise motion control with the minimum computing burden on the PC by closing the velocity and position loops in the ServoWire SM Drive.

- **Wide Current Loop Bandwidth**: For high positioning accuracy and response.

- **Velocity and Torque Monitor**: High quality velocity monitor and torque monitor signals are provided to simplify system testing.

- **Small Package**: ServoWire SM Drives have a small footprint to conserve panel space.

- **Shunt Regulation**: All Models except SAC-SM_A03, SAC-SM_A05, SAC-SM_203 and SAC-SM_205 have shunt regulation circuitry. If an application requires regenerative operation, regenerative discharge resistors can be mounted external to the servodrive.

2.1.1 ServoWire SM Drive Model Number Description

SAC-SM S 2 03 / S A P

Pacer Support (optional)
P = adds incremental pacer support

Absolute Encoder Support (optional)
A = adds backup battery for encoder

Primary Feedback
E = Incremental Encoder
S = Serial & Incremental Encoder support

Maximum Continuous Current
03 = 2.4 Arms/∅ (115/230 VAC model)
3.0 Arms//∅ (24-96 VDC model)
05 = 4.2 Arms/∅ (115/230 VAC model)
05 = 5 Arms/∅ (460 VAC model)
10 = 8.2 Arms/∅ (115/230 VAC model)
10 = 10 Arms/∅ (460 VAC model)
17 = 13.9 Arms/∅ (115/230 VAC model)
17 = 17 Arms/∅ (460 VAC model)
20 = 16.3 Arms/∅
25 = 25 Arms/∅
35 = 35 Arms/∅
50 = 50 Arms/∅
60 = 60 Arms/∅

Input Bus Voltage
A = 24 to 96 VDC *(not for use with Orion M/C)*
2 = 115/230 VAC
4 = 460 VAC

Controller (Firmware)
S = SM RTX (customer supplied motion engine)
M = SMLC & MotionObjects applications.
Blank = Orion Motion Controller (MotionBASIC)

ServoWire Drive logo's	Model Number
Yellow Logo	**SM ....** Used with ORION Motion Controller. **MotionDESK** is used to upgrade the drive firmware.
Blue Logo	**SMM ...** Used with SMLC & MotionObjects applications. **SMS ....** SM RTX customer supplied motion engine. **ServoWire Pro** is used to upgrade the drive firmware.

2.1.2 Differences between SAC-SW / SAC-SM Drives that use MotionObjects.

The SM (Soft Motion) line of ServoWire drives has different features and functionality from the SW (ServoWire) drives, as shown in **Table 1**.

Feature		**SW Servodrive** **ServoWire**	**SM Servodrive** **Soft Motion**
1394 Comm. Speed		200 Mbit/sec maximum	400 Mbit/sec maximum
I/O Connectors		Pluggable terminal block	Pluggable header
Field Oriented Control		No	Yes, firmware 3.0.1 or later
High-Speed Sensors		3 – ASEN, BSEN & CSEN	2 – ASEN & BSEN
High-Speed Sensor Pull-up Resistor		3 choices – none (PNP), 2.38k (NPN) or 20k (NPN)	2 choices – none (PNP) or 2.7k (NPN)
Digital I/O (optically isolated)		2 Inputs, 6 Outputs	3 Inputs, 4 Outputs, 1 Bi-directional I/O.
Brake Output		OUT 6	OUT 3
Drive Ready Output		OUT 2	OUT 4
Hardware Travel Limits		IN1 & IN2	IN1 & IN2
Encoder Reference Z Output		Z Out	OUT 5
Delay Counter Output		DELAY	
Option Module Interfaces		None	Support for Feedback and I/O Option Modules
Analog I/O		2 Outputs	
ID/Status Displays		2-digit seven segment display, 6 I/O status LED's and Bus Power LED	Single digit seven segment display and Bus Power LED
Auxiliary Encoder Input		Drive Option (/ P)	Drive Option (/ P)

Feature		SW Servodrive ServoWire	SM Servodrive Soft Motion
Delay Counter		Drive Option (/ D)	
Yaskawa Absolute Encoder Support		Drive Option (/A)	Drive Option (/A) adds battery. Sigma II support always present on /S.
Resolver Feedback Option		None	Option Module SAC-SM-RES

***Table 1**, Differences between SAC-SW_ and SAC-SM_ Drives.*

2.2 ServoWire SM Drive Feedback Option Modules

ServoWire SM Drives support pluggable feedback option modules, which allow for the addition of feedback types other than the standard incremental quadrature or Yaskawa Sigma I & Sigma II (Serial) encoders.

When a feedback option module is installed on a ServoWire SM Drive, the quadrature encoder interface on the drive can be used for auxiliary feedback.

When the /P (pacer support) is selected the connector is mounted on the side of the drive and no other option modules can be installed.

Resolver Option Module Features

High Resolution – Software selectable 12, 14 or 16-bit resolution, providing 4096, 16,384 or 65,536 cnts/rev.

High Speed – 24,000 RPM maximum speed at 12 -bit resolution.
6,000 RPM maximum speed at 14 -bit resolution.
1,500 RPM maximum speed at 16 -bit resolution.

Configurable Excitation Frequency - Excitation frequencies of 2.5, 5 and 10 kHz available under software control

Configurable Excitation Voltage – Excitation voltages between 0 and 8V RMS available under software control.

Single Rev Absolute Feedback – Raw resolver feedback provides motor absolute position within one revolution.

Refer to Resolver Feedback Option Module section 3.9 of the Installation and Specifications chapters for further information.

2.2.1 ServoWire SM Drive Option Module Model Number Description

SAC-SM-LLL

LLL = RES (Resolver Feedback, 12 / 14 / 16-bit)

Chapter 3
Installation

3 Installation

3.1 Receiving and Inspection

ORMEC Servodrives 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 servodrive and any accessories for bent or broken components or any other physical damage before installation.

3.2 ServoWire SM Drive Panel and Environment Considerations

ServoWire SM Drives 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 included as an Appendix to this manual and can also be downloaded 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 above 0ºC & below 50ºC.
- 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 on the base plate.
  2 holes with SM_A03 and SM_A05
  3 holes with SM_203 through SM_220, and SM_405 through SM_410
  4 holes with SM_225 through SM_260, and SM_417 through SM_450

- Allow sufficient clearance around servodrive 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 ServoWire SM Drive enclosure, if possible. Regenerative discharge resistors can become extremely hot, so proper ventilation must be provided.

3.3 ServoWire SM Drives Outline Drawings

Note: Add 1-inch [25-mm] width the /P option and for each optional plug-in module.

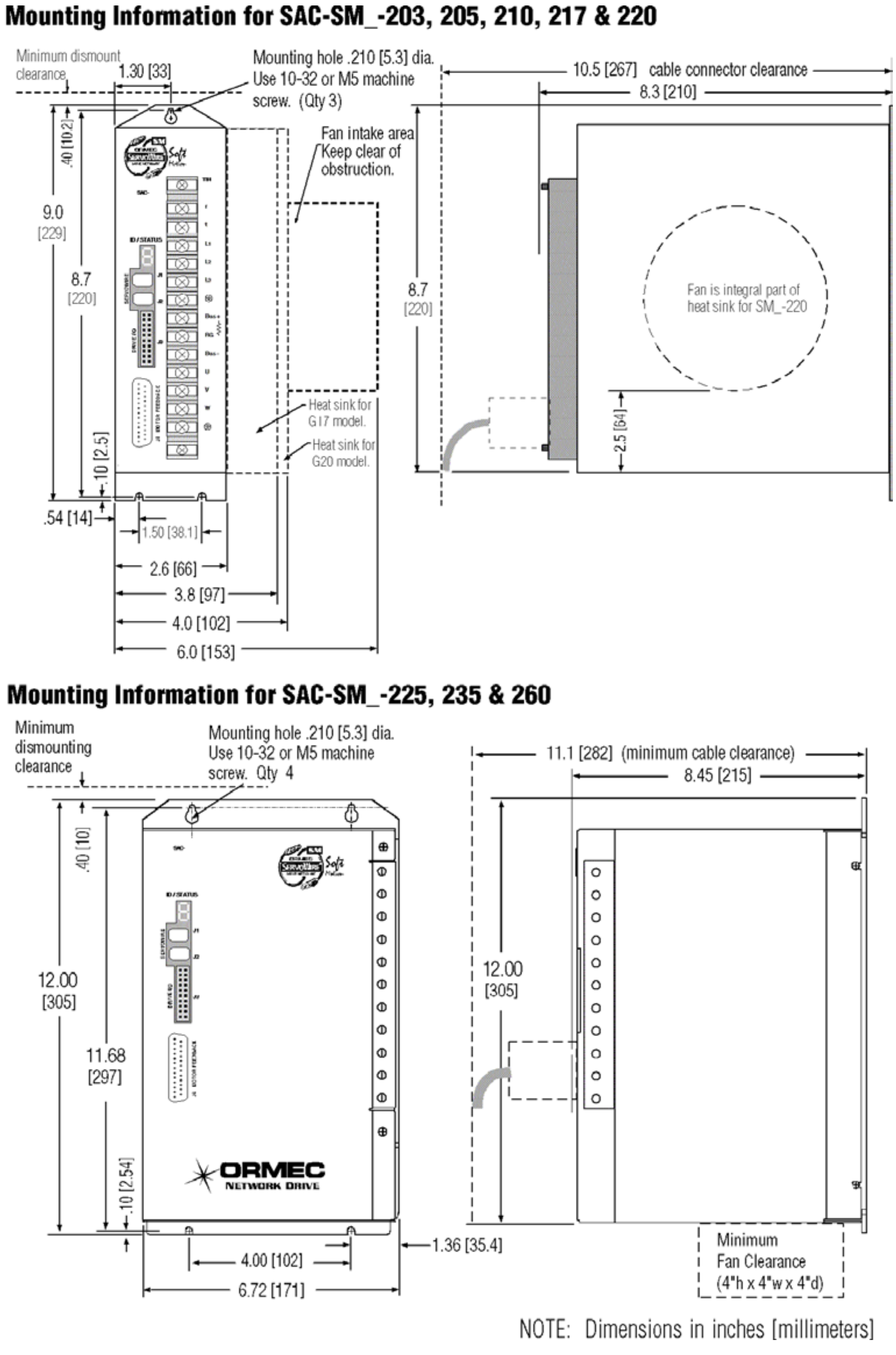
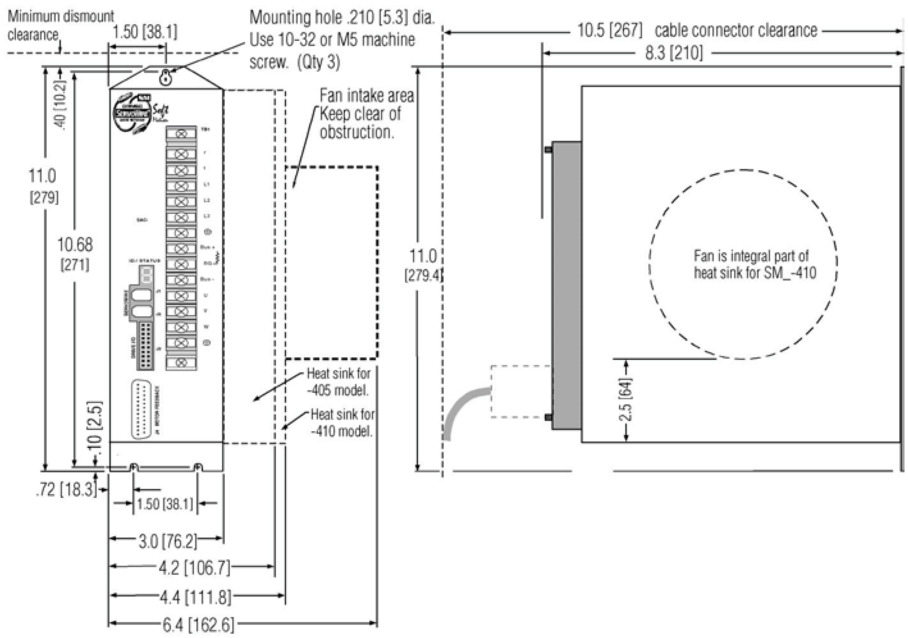


Figure 1,*ServoWire SM Drives (115/230 VAC input) Outline Drawings*

Mounting Information for SAC-SM_-405 & 410



Mounting Information for SAC-SM_-417 & -425

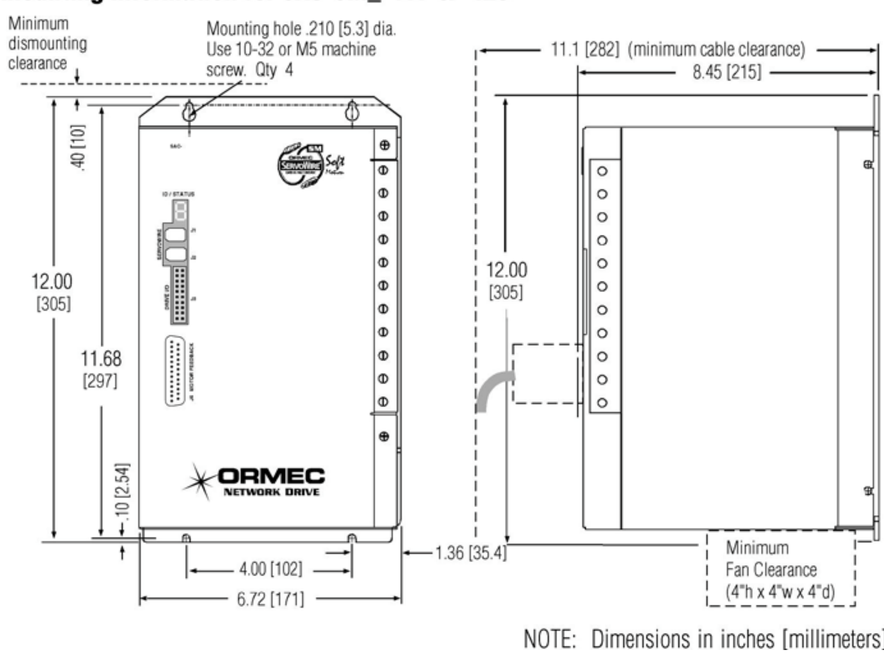


Figure 2, ServoWire SM Drives (460 VAC input) Outline Drawings (1 of 2)

Mounting Information for SAC-SM_- 435 & 450

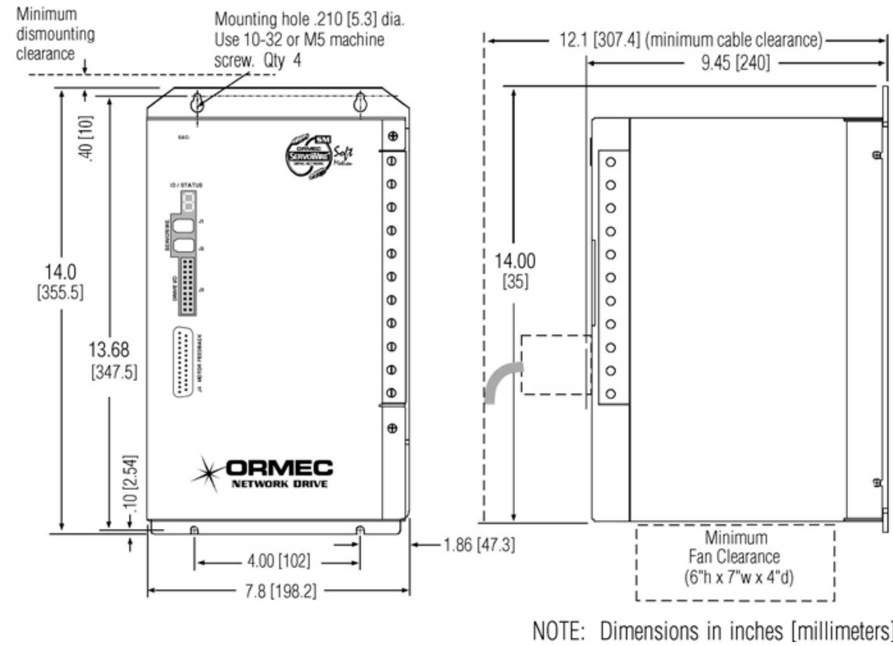


Figure 3,ServoWire SM Drives (460 VAC input) Outline Drawings (2 of 2)

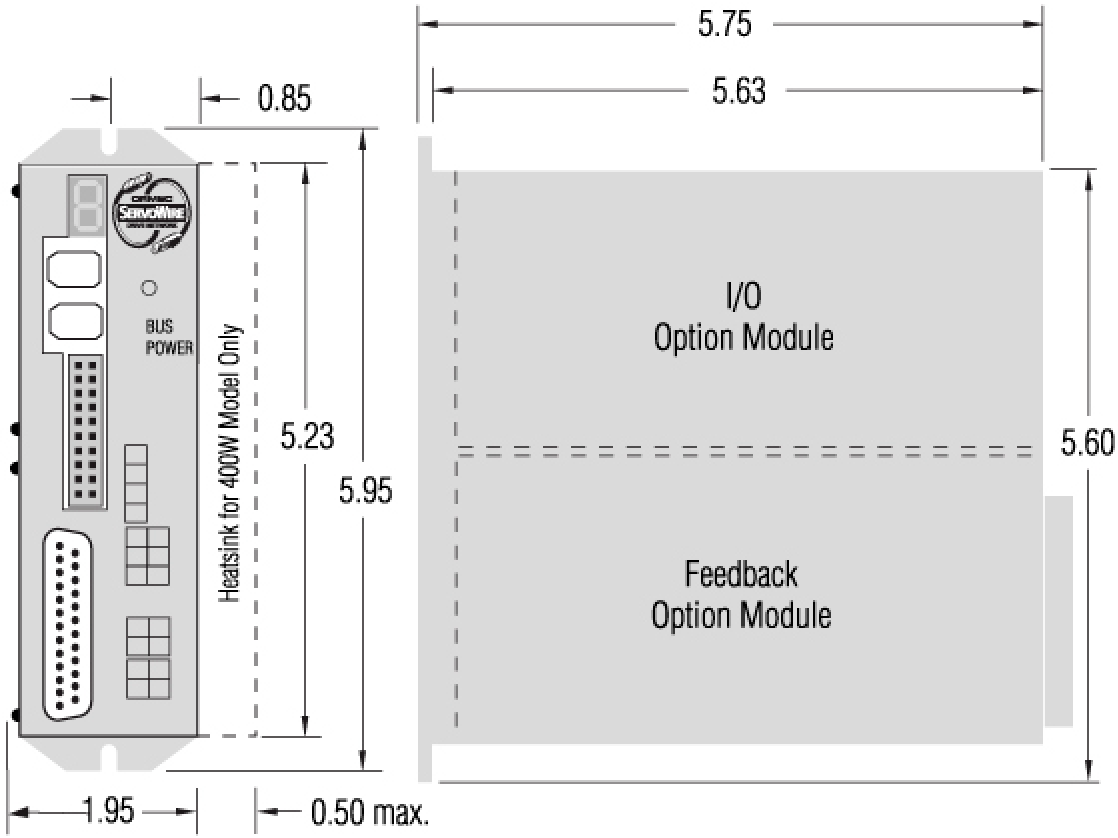


***Figure 4**, ServoWire SM Low Power Drives (24-96 VDC) Outline Drawing*

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

SAC-SM_A03 and SAC-SM_A05
Add 2” (51 mm) clearance top and bottom.
Add 0.5” (13 mm) clearance each side.

SAC-SM_203, SAC-SM_205 and SAC-SM_210
Add 2” (51 mm) clearance top and bottom.
Add 1” (25 mm) clearance each side.

SAC-SM_217 and SM_405
Add 2” (51 mm) clearance top and bottom.
Add 1.2” (31 mm) clearance each side.

SAC-SM_220 and SM_410
Add 2” (51 mm) clearance top and bottom.
Add 1” left-side, 2” (51 mm) right-side clearance.

SAC-SM_225, SAC-SM_235 , SAC-SM_260, SAC-SM_417, SAC-SM_425, SAC-SM_435 and SAC-SM_450
Add 2” (51 mm) clearance.
Add 4” (102 mm) clearance bottom.
Add 1” (25 mm) clearance each side.

3.4 Software Configuration Setup

The following motor parameters and drive settings are software configurable:

- **Motor Model Number / name**
- **Continuous Stall Current**
- **Peak Current**
- **Motor Torque** (Peak, Continuous, Rated)
- **Maximum Speed** of motor
- **Resistance** measured phase-to-phase
- **Inductance** measured phase-to-phase
- **Inertia** of rotor
- **Number of Poles** of motor
- **Hall Offset** in degrees
- **Maximum Drive Input Voltage** based on motor's rating
- **Commutation Type:** (Sine-Brushless/Trap-Brushless/DC-Brush)
- **Commutation Feedback Type:**
  Incremental encoder with separate U,V,W hall inputs -or-
  Yaskawa Sigma I incremental encoder -or-
  Yaskawa Sigma II Serial 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 Fault)
- **Hardware Travel Limit Inputs** (Enable/Disable)
- **Input Voltage for Drive** (115/230/460 VAC, 24-96 VDC)
- **Pull-up Resistors for ASEN & BSEN**:
  2.7 KΩ (8.9 mA at 24 VDC) for NPN sensor -or-
  No pull-up resistor for PNP sensor
- **ASEN & BSEN** gating (Enable/Disable)
- **ASEN, BSEN, ZREF** trigger (Rising/Falling/High/Low)
- **ZOUT** (primary or auxiliary axis)
- **Regen Resistor Resistance** (Ohms)
- **Regen Resistor Rated Power** (Watts)

The ServoWire icon, shown at the left, will be displayed in this manual wherever one of these drive parameters is discussed, to indicate that the functionality of the drive will depend on the Software Configuration setting.

SAC-SMM..............................used with **SMLC** or **MotionObjects** software.
SAC-SMS ....used with OEM provided software.

These configuration settings are stored as part of your ServoWire Pro software project file (*filename*.**SwSetup**), and are downloaded to the drive by the application program.

SAC-SM.................................used with **ORION** Motion Controller.

These configuration settings are stored as part of your MotionDESK software project file (*filename*.**MTD**), and are downloaded to the drive by the Orion MotionBASIC application program.

3.5 ServoWire SM Drives Power Considerations

3.5.1 Supply Power for Low Power (SAC-SM_A__) Drives

Low Power ServoWire SM Drives (SAC-SM_**A**__) can be operated by a power supply providing 24-96 VDC (+/-10%) main bus power and 24 VDC (+15%, -20%) logic power.

3.5.2 Supply Power for 115/230 VAC (SAC-SM_2__) Drives

ServoWire SM 115/230 VAC Drives (SAC-SM_**2**__) can be operated, through line filters or an isolation transformer, on commercial power lines supplying either 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz. The Drives are suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amperes, 240 VAC maximum.

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 ServoWire SM Drives used. Slow-blow circuit breakers or fuses should be used because the servodrive draws substantial inrush current at power up.

3.5.3 Supply Power for 460 VAC (SAC-SM_4__) Drives

ServoWire SM 460 VAC Drives (SAC-SM_4__) have different limits for control power and motor power. This section deals with control power.

Control power (terminals r & t on TB2) for **ServoWire SM 460 VAC Drives models 405 through 425** (5 A through 25 A) can be operated, through line filters or an isolation transformer, on commercial power lines supplying either 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz. The Drives are suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amperes, 240 VAC maximum.

Control power (terminals r & t on TB2) for **ServoWire SM 460 VAC Drives models 435 and 450** (35 A and 50 A) must be operated at 230 VAC ONLY. It can be operated, through line filters or an isolation transformer, on commercial power lines supplying 230 (+15%, -20%) VAC, 50/60 Hz. The Drives are suitable for use on a circuit capable of delivering not more than 5000 RMS symmetrical amperes, 240 VAC maximum.

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 ServoWire SM Drives used. Slow-blow circuit breakers or fuses should be used because the servodrive draws substantial inrush current at power up.

3.5.4 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 included as an Appendix to this manual and can also be, downloaded 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.

3.5.5 Sizing DC Power Supplies for Low Power ServoWire SM Drives (for SAC-SM_A__ only)

To determine the size power supply required for the main bus power, use the following conservative formulas:

Required Power (in watts) = 1.1 * **Rated Power of Motor** (in Watts)

Note: **Rated Power of Motor** can be found in motor manufacturer datasheets.

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.

3.5.6 Sizing Fuses, Line Filters, and Transformers for 115/230 VAC (SAC-SM_2__) and 460 VAC (SAC-SM_4) Drives

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

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

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

Note: **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.

Branch circuit short protection used should be suitable for use on a circuit capable of delivering not more than 5000 rms symmetrical amperes, 240 V maximum.

3.5.7 Power Dissipation

Use the following table to determine cabinet cooling requirements:

	Dissipated Power (Watts)			
	Control Power Max	Control Power Typical	Main Power	**External** Regen Resistor (if used)
SAC-SM_A03	14	5	10	—
SAC-SM_A05	14	5	10	—
SAC-SM_203	45	20	55	—
SAC-SM_205	45	20	90	—
SAC-SM_210	45	20	180	800 max.
SAC-SM_217	45	20	300	1200 max.
SAC-SM_220	55	30	350	2400 max.
SAC-SM_225	55	30	450	3000 max.
SAC-SM_235	55	30	600	4175 max.
SAC-SM_260	55	30	900	7100 max.
SAC-SM_405	45	20	120	1200 max.
SAC-SM_410	45	20	240	2400 max.
SAC-SM_417	55	30	405	4000 max.
SAC-SM_425	55	30	600	5970 max.
SAC-SM_435	60	35	835	8350 max.
SAC-SM_450	60	35	1200	12000 max.

***Table 2**, Power Dissipation*

Main power dissipation in shown in **Table 2** 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).

Actual power dissipated in the regen resistor is dependent on the application requirements. **Table 2**, column "External Regen Resistor" shows the rated regen capacity of the ServoWire SM Drive.

3.5.8 Line Filters

Once the incoming power service is determined, the appropriate main power line filter can be selected from **Table 3**. In the case of a system using multiple ServoWire SM Drives, they may share one line filter per cabinet.

ServoWire SM Drive	Main Power Input Voltage	Total Continuous Current	Main Power Line Filter
SAC-SM_203 SAC-SM_205	Single phase	Up to 15 Amps	SAC-LF215U
		Up to 30 Amps	SAC-LF230U
SAC-SM_210 SAC-SM_217 SAC-SM_220 SAC-SM_225 SAC-SM_235 SAC-SM_260 SAC-SM_405 SAC-SM_410 SAC-SM_417 SAC-SM_425 SAC-SM_435 SAC-SM_450	Three-phase	Up to 30 Amps	SAC-LF30C
		30 – 55 Amps	SAC-LF55C
		55 – 100 Amps	SAC-LF100C

***Table 3**, 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 ServoWire SM Drive(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 ServoWire SM Drives.**
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.

3.5.9 Terminal Block Wiring Guidelines

All ServoWire SM terminal block wiring should be UL listed copper wire with at least an 80C-temperature rating (wiring to regen resistors should be heat resistant, non-combustible insulation). The maximum wire gauge and screw terminal torque for each terminal block is indicated in **Table 4**. Wiring for TB1 should be twisted pair, shielded with the drain wire connected to earth ground (NOTE: the SHIELD connections at various points on the ServoWire SM Drive are connected to the frame ground).

	Wire Gauge (AWG) [mm^2]	**Screw Torque** (in-lb) [N-m]
J3 (all models)	24 to 12 [0.51 to 2.05]	na
J5 (SAC-SM_A__ Only)	20 to 16 [0.81 to 1.3]	na
J6 (SAC-SM_A__ Only)	20 to 16 [0.81 to 1.3]	na
J7 (SAC-SM_A__ Only)	20 to 16 [0.81 to 1.3]	na
J8 (SAC-SM_A__ Only)	20 to 16 [0.81 to 1.3]	na
Terminal Block - TB1		
SAC-SM_203 to SM_220 SAC-SM_405 to SM_410	22 to 12 [0.64 to 2.1]	7.0 to 9.0 [0.8 to 1.0]
SAC-SM_225 to SM_260 SAC-SM_417 to SM_450	18 to 4 [1.0 to 5.2]	16 [1.8]
Terminal Block - TB2		
(SAC-SM_225 to SM_260 only)	24 to 10 [0.51 to 2.6]	4.4 to 5.3 [0.5 to 0.6]

***Table 4**, Terminal Block Wiring Gauge and Screw Torque*

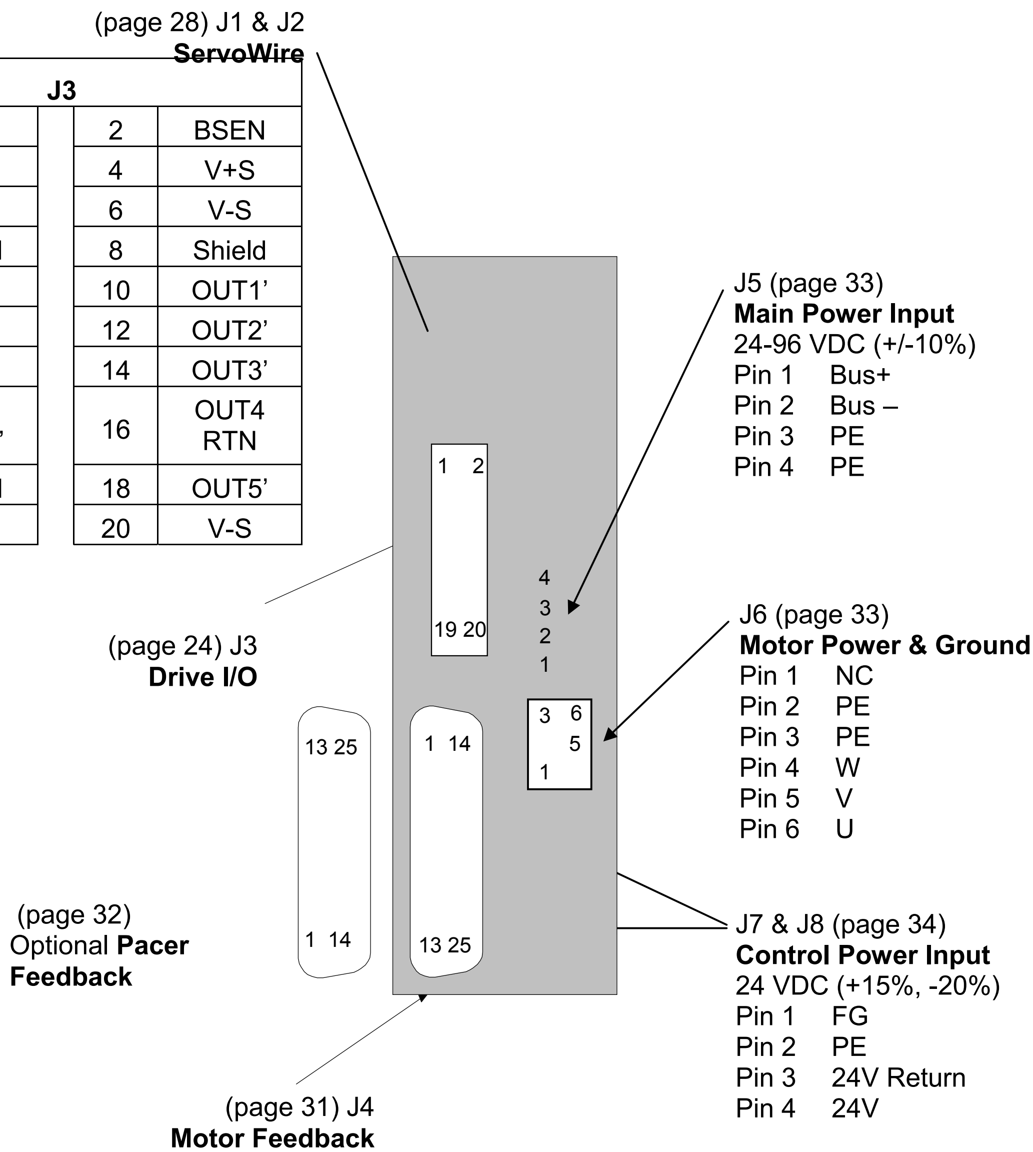
NOTE: **Install all power wiring (including ground wiring) according to NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.**

3.6 ServoWire SM Drive Connections

This section describes the ServoWire SM Drive. Signal descriptions are given in **Table 5** through **Table 10**. The remainder of Section 3.5.9 shows additional wiring information. Detailed electrical specs are in Section 6.1, ServoWire SM Drive Specifications. Part numbers for these and mating connectors are in Section 6.1.11 (page 86).

***Figure 5**, ServoWire SM Low Power Drive Connections overview (SM_A03 & SM-A05)*

J3			
1	ASEN	2	BSEN
3	V+S	4	V+S
5	V-S	6	V-S
7	Shield	8	Shield
9	IN1’	10	OUT1’
11	IN2’	12	OUT2’
13	IN3’	14	OUT3’
15	IN4’/ OUT4’	16	OUT4 RTN
17	Shield	18	OUT5’
19	V+S	20	V-S



J3			
1	ASEN	2	BSEN
3	V+S	4	V+S
5	V-S	6	V-S
7	Shield	8	Shield
9	IN1’	10	OUT1’
11	IN2’	12	OUT2’
13	IN3’	14	OUT3’
15	IN4’/ OUT4’	16	OUT4 RTN
17	Shield	18	OUT5’
19	V+S	20	V-S

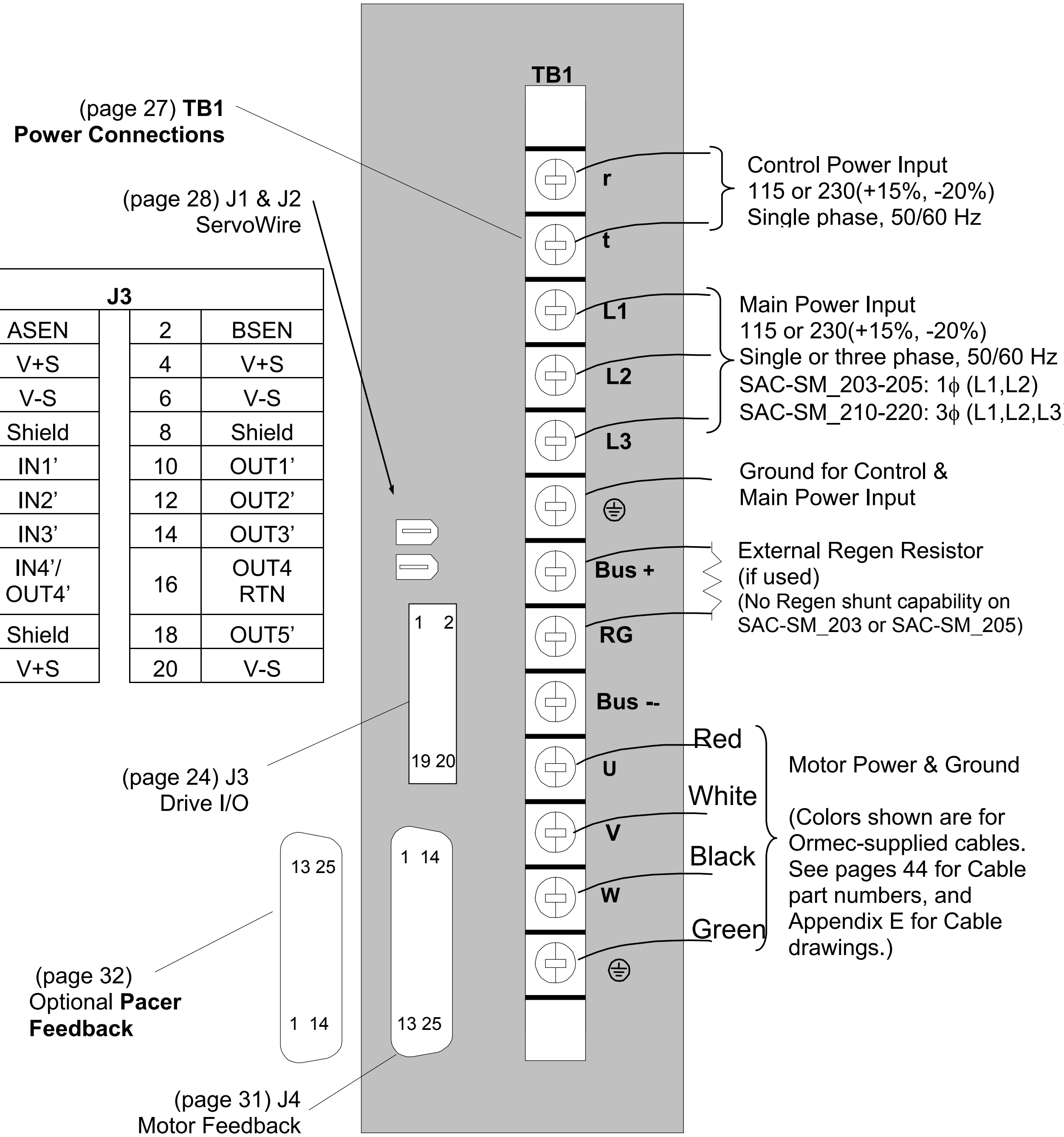


***Figure 6**, ServoWire SM Drive Connections Overview (SM_203 – SM_220)*

J3	
1	ASEN
3	V+S
5	V-S
7	Shield
9	IN1’
11	IN2’
13	IN3’
15	IN4’/ OUT4’
17	Shield
19	V+S

J3	
2	BSEN
4	V+S
6	V-S
8	Shield
10	OUT1’
12	OUT2’
14	OUT3’
16	OUT4 RTN
18	OUT5’
20	V-S

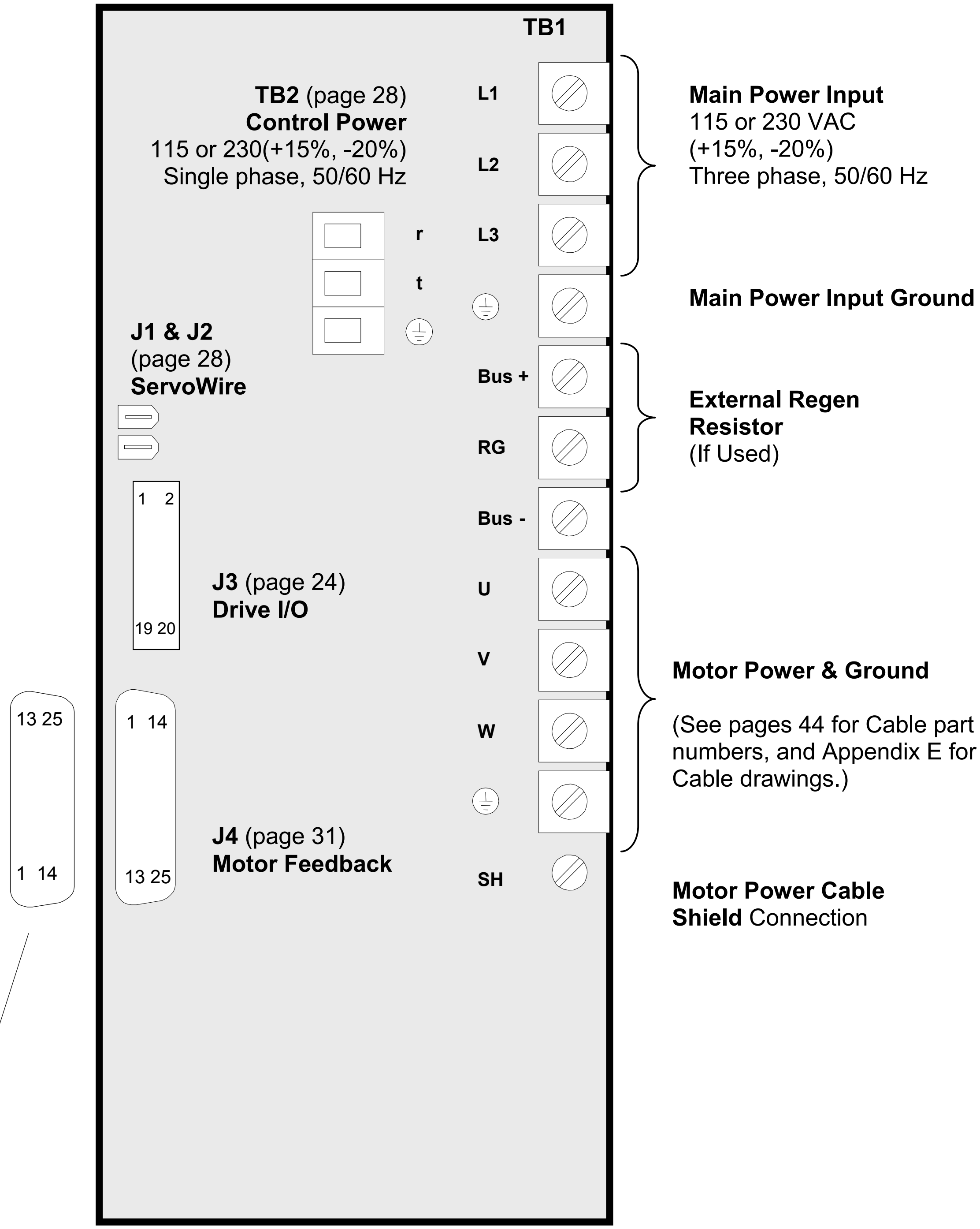
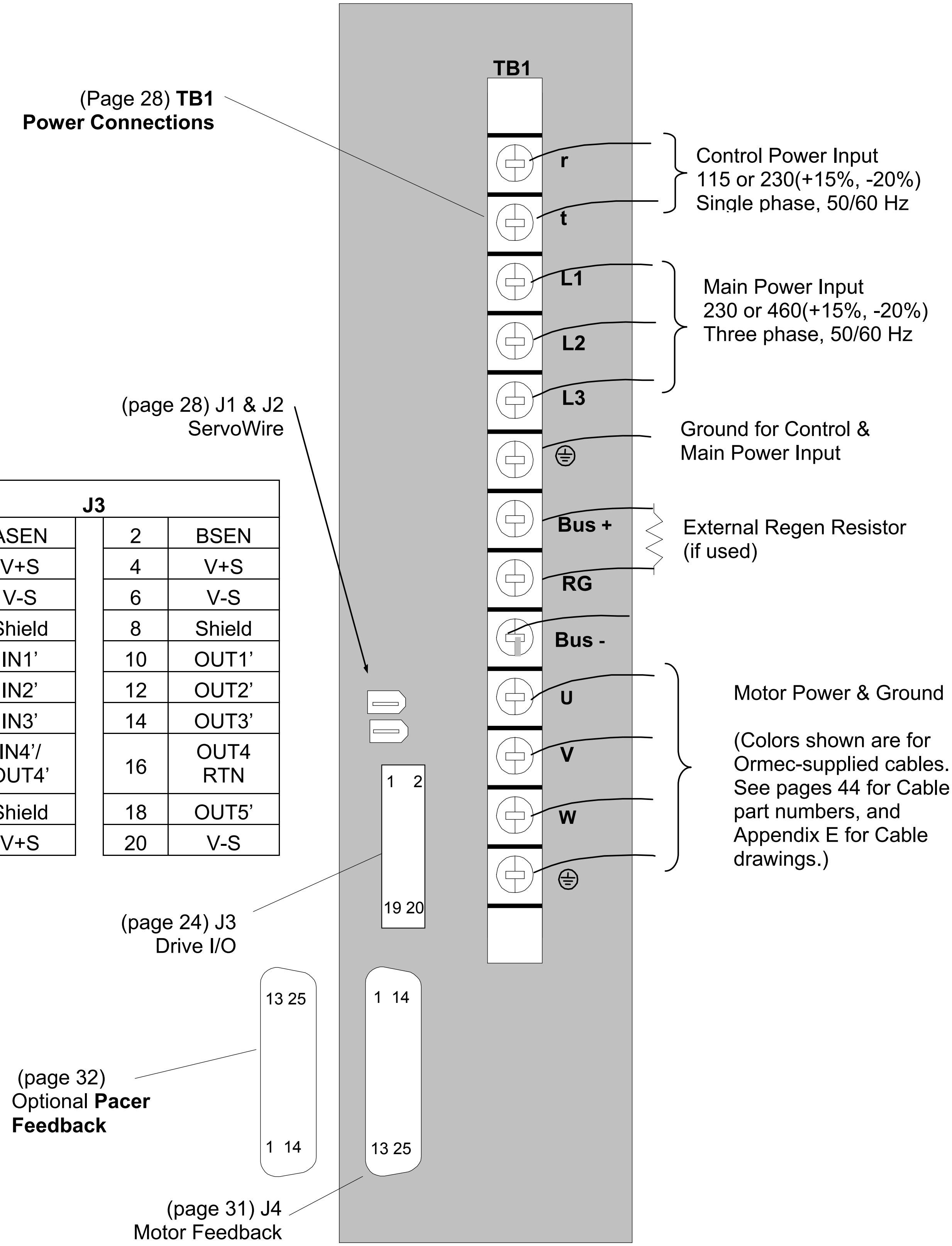


***Figure 7**, ServoWire SM Drive Connections Overview(SM_225 – SM_260)*



J3			
1	ASEN	2	BSEN
3	V+S	4	V+S
5	V-S	6	V-S
7	Shield	8	Shield
9	IN1'	10	OUT1'
11	IN2'	12	OUT2'
13	IN3'	14	OUT3'
15	IN4'/ OUT4'	16	OUT4 RTN
17	Shield	18	OUT5'
19	V+S	20	V-S

Figure 8, ServoWire SM Drive Connections Overview (SM_405 – SM_410)

J3	
1	ASEN
3	V+S
5	V-S
7	Shield
9	IN1’
11	IN2’
13	IN3’
15	IN4’/ OUT4’
17	Shield
19	V+S

J3	
2	BSEN
4	V+S
6	V-S
8	Shield
10	OUT1’
12	OUT2’
14	OUT3’
16	OUT4 RTN
18	OUT5’
20	V-S

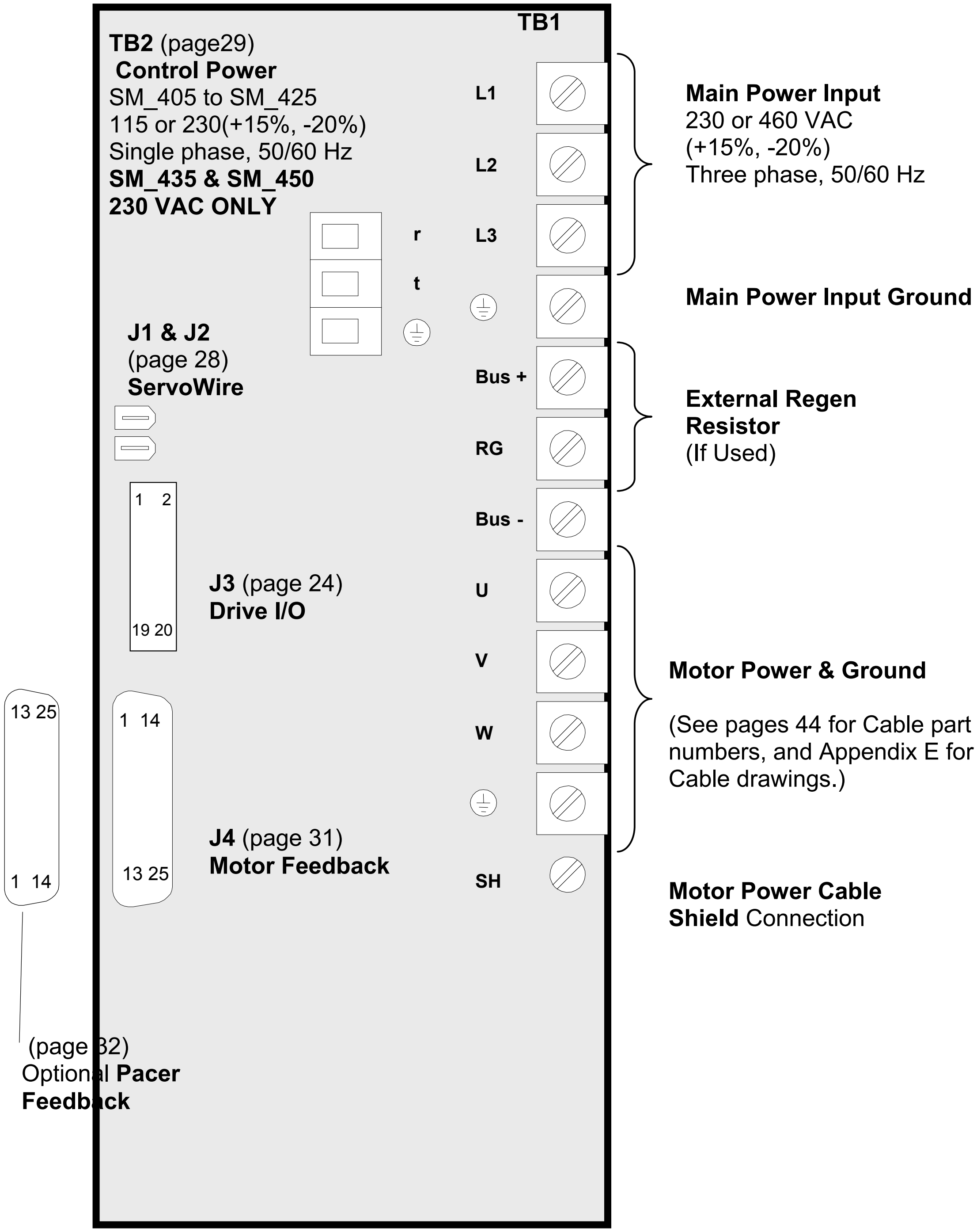


***Figure 9**, ServoWire SM Drive Connections Overview(SM_417 – SM_450)*

3.6.1 Drive Input / Output Connections for All Models (J3)

Refer to the Table **42,** Motor Encoder Specifications (J4)

Connector Part Numbers section (page 86) of the Specifications chapter for further information.

Pin	Signal	Function	Description
1 2	ASEN BSEN	High Speed Sensor Inputs	Software configurable for: • **2.7KΩ** pull-up resistor for NPN sensor (8.9 mA @ 24VDC) • **No** pull-up resistor for PNP sensor See **Figure 11** (page 35) for a simplified schematic. **V+S** and **V-S** must be connected to a DC Power Supply (5 – 24 VDC) in order to use these inputs.
3 4 19 5 6 20	V+S V+S V+S V-S V-S V-S	I/O Power Supply Input Common for I/O Power	Inputs for 5-24 VDC power supply used for: • High Speed Sensor inputs ASEN, BSEN • Discrete Inputs IN1' - IN4' • Discrete Outputs OUT1' – OUT5'
7 8 17	Shield	Cable shield connection	Connect the cable shield at one end only.
9 11 13	IN1' IN2' IN3'	General Purpose Input 1 General Purpose Input 2 General Purpose Input 3	Software configurable for operation as general-purpose inputs, or Hardware Travel Limit switch inputs, an E-Stop/Quick Stop input. Refer to the Discrete Inputs section of the Operation chapter (page 52) for further information. See **Figure 12** (page 37) for a simplified schematic. **V+S** and **V-S** must be connected to a DC Power Supply (5 – 24 VDC) in order to use these inputs.
15 16	IN4'/ OUT4' OUT4 RTN	General Purpose Input 4 or General Purpose Output 4 IN4/OUT4 Return	Usable as either a general purpose input or output and ServoWire Pro software-configurable for operation as a Drive Ready indicator. Refer to the Discrete Outputs section of the Operation chapter (page i) for further information. See **Figure 12** (page 37) for a simplified schematic.
10 12 14 18	OUT1' OUT2' OUT3' OUT5'	General Purpose Output 1 General Purpose Output 2 General Purpose Output 3 General Purpose Output 5	Software configurable for operation as general purpose outputs, as a Brake control output, isolated motor encoder reference or isolated feedback option module output. Refer to the Discrete Outputs section of the Operation chapter (page 54) for further information. See (page 38) for a simplified schematic. **V+S** and **V-S** must be connected to a DC Power Supply (5 – 24 VDC) in order to use these inputs.

***Table 5**, Drive Input / Output (J3) Connections*

3.6.2 ServoWire SM 115/230 VAC (SAC-SM_2__) Drive Power Terminal Block (TB1)

Terminal	**Function**	**Description**
r, t	Input Control Power (SM_203 – SM_220 only, for SM_225 – SM_260 see **Table 7**)	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power. Once the ServoWire SM Drives in a network have control power applied, it is best to leave their control power on continuously, while any of the drives is torque-producing. If one of the ServoWire Drives in a network loses control power, it will not adversely affect the other drives on the network. When control power is re-applied to that drive, all other ServoWire Drives on that network should not be effected.
L1, L2, L3 – or – **L1, L2**	Input Main Bus Power	**(SAC-SM_210, 217, 220, 225, 235, 260):** Three phase 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz**.** **(SAC-SM_203, 205):** Single phase 115 (+15%, -20%) to 230 (+15%, -20%) VAC, 50/60 Hz. The input voltage should match the configuration software setting, to ensure proper operation of low bus voltage faults and inrush current limiting.
⏚	Ground	Ground for input power. **Must be connected to input power ground.**
Bus + **Bus -**	DC Bus Power +	**Nominal bus voltage: 325 VDC for 230 VAC input** **163 VDC for 115 VAC input** These terminals can be used for connecting bus power between servodrives. (SM_225 – SM_260 only).
RG	Regen Resistor	If an external regen resistor is used (SAC-SM_210, 217, 220, 225, 235, 260 only), it is connected between **Bus +** and **RG**. See Section 3.6.16, External Regen Resistor Wiring (RG) (page 38).
U,V,W	Motor Power	Single or Three-phase power to the motor. See: • G-Series Servomotor Connections (page 43) • DE/DA/DB-Series Servomotor Connections (page 45) • DC Servomotor Connections (page 46). The motor type must match the configuration software setting, to ensure proper operation.
⏚	Ground	Ground connection for motor frame ground
SH	Shield Connection	Connection for motor shield drain (SM_225 – SM_260 only)

***Table 6**, ServoWire SM 115/230 VAC Drive (SAC-SM_2__) Power Connections (TB1)*

3.6.3 ServoWire SM Drive (SAC-SM_225 – SM_260) Control Power Terminal Block (TB2)

Terminal	Function	Description
r, t	Input Control Power	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power. Once the ServoWire SM Drives in a network have control power applied, it is best to leave their control power on continuously, while any of the drives is torque-producing. If one of the ServoWire Drives in a network loses control power, it will not adversely affect the other drives on the network. However, if control power is re-applied to that drive, all other ServoWire Drives on that network will respond with a drive alarm, ***E1***, and disable torque at their motors.
⏚	Ground	Ground for control logic input power. **Must be connected to input power ground.**

Table 7, *ServoWire SM Drive (SAC-SM_225 – SM_260) Control Power Connections (TB2)*

3.6.4 ServoWire SM 460 VAC (SAC-SM_4__) Drive Power Terminal Block (TB1)

Terminal	Function	Description
r, t	Input Control Power (SM_405 – SM_410 only, for SM_417 – SM_450 see **Table 9**)	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power. Generally, once the ServoWire SM Drives in a network have control power applied, it is best to leave their control power on continuously, while any of the drives is torque-producing. If one of the ServoWire Drives in a network loses control power, it will not adversely affect the other drives on the network. When control power is re-applied to that drive, all other ServoWire Drives on that network should not be effected.
L1, L2, L3 – or – **L1, L2**	Input Main Bus Power	**(SAC-SM_405, 410):** Three phase 230 (+15%, -20%) or 460 (+15%, -20%) VAC, 50/60 Hz**.** The input voltage should match the configuration software setting, to ensure proper operation of low bus voltage faults and inrush current limiting.
⏚	Ground	Ground for input power. **Must be connected to input power ground.**
Bus + **Bus -**	DC Bus Power +	**Nominal bus voltage: 325 VDC for 230 VAC input** **650 VDC for 460 VAC input** These terminals can be used for connecting bus power between servodrives.
RG	Regen Resistor	If an external regen resistor is used, it is connected between **Bus +** and **RG**. See Section 3.6.16, External Regen Resistor Wiring (RG) (page 38).
U,V,W	Motor Power	Single or Three-phase power to the motor. See: • G-Series Servomotor Connections (page 43) • DE/DA/DB-Series Servomotor Connections (page 45) • DC Servomotor Connections (page 46). The motor type must match the configuration software setting, to ensure proper operation.
⏚	Ground	Ground connection for motor frame ground

SH	Shield Connection	Connection for motor shield drain (SM_417 – SM_450 only)

***Table 8**, ServoWire SM 460 VAC Drive (SAC-SM_4__) Power Connections (TB1)*

3.6.5 ServoWire SM Drive (SAC-SM_417 – SM_450) Control Power Terminal Block (TB2)

Terminal	**Function**	**Description**
r, t	Input Control Power	**SM_417 & SM_425** - Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power. **SM_435 & SM_450** - 230 (-20%, +15%) VAC, 50/60 Hz control logic input power. Generally, once the ServoWire SM Drives in a network have control power applied, it is best to leave their control power on continuously, while any of the drives is torque-producing. If one of the ServoWire Drives in a network loses control power, it will not adversely affect the other drives on the network. However, if control power is re-applied to that drive, all other ServoWire Drives on that network will respond with a drive alarm, ***E1***, and disable torque at their motors.
⏚	Ground	Ground for control logic input power. **Must be connected to input power ground.**

***Table 9,** ServoWire SM Drive (SAC-SM_225 – SM_260) Control Power Connections (TB2)*

3.6.6 ServoWire Connectors for All Models (J1 & J2)

The ServoWire connector has six pins: two for power and four for communications. The connectors are available only as an integral part of an IEEE 1394 or ServoWire cable.

There is no 'in' or 'out' distinction between the J1 and J2 connectors. Each ServoWire network can be thought of as a bus.

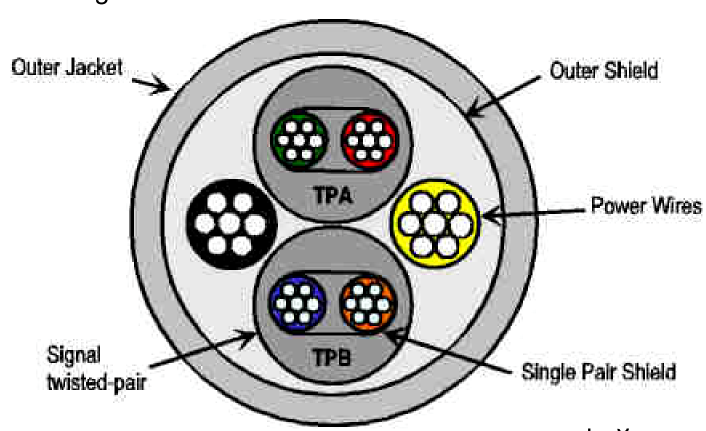
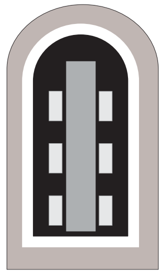


***Figure 10**, ServoWire Connector (J1 & J2) and Cable*

The following rules apply to connecting a ServoWire network:



- No loops are allowed.
- Only one PC or motion controller per network.
- No more than 16 defined drives per network.

3.6.7 Motor Feedback Connector for All Models (J4)

*Refer to the **Table 42**, Motor Encoder Specifications (J4)*
Connector Part Numbers section (page 86) of the Specifications chapter for further information
.

Pin	Signal	Description
1 2	ENCA ENCA'	Differential input, quadrature feedback channel A from the motor encoder.
3 4	ENCB ENCB'	Differential input, quadrature feedback channel B from the motor encoder.
5 6	ENCZ ENCZ'	Differential input, "once per revolution" marker signal from the motor encoder.
7 8 9 10 11 12	U U' V V' W W'	Differential or single-ended input, commutation feedback channels U, V and W from the motor encoder. The U, V and W (pins 7, 9 & 11) inputs are intended for use with differential commutation feedback. If the feedback signals are open collector outputs, external-biasing hardware may be required. The U', V' and W' (pins 8, 10 & 12) inputs are internally biased and no connection or external circuitry is required for use with single ended feedback. Refer to Appendix B-4 for further information.
13,24,25	ENC PWR1	+5.3 VDC (SAC-SM_2__ and SAC-SM_4__) or 5.0 VDC (SAC-SM_A__) power supply output for the motor encoder (450 mA max). This power is derived from the input control power.
16,17,18	DGND	Common for the +5 VDC supply (ENC PWR1).
19 20	TEMP' TEMP RET	Motor Over Temperature input. Configuration software settings determine the usage of this input. **Normally closed Contact** wired to the ServoWire SM Drive: • Open contact causes drive fault ***F4***. (Immediately disables motor torque). • or - Open contact causes application program error. • or - Open contact is ignored. No fault or error occurs. **No Sensor exists at motor**. Leave TEMP & TEMP RETURN unconnected. • Contact is normally open. (This setting will cause an application program configuration error if there is a closed contact). See Section 0 (page 72) for a detailed explanation.
21	SHIELD	Motor encoder shield termination point
22 23	BAT+ BAT–	(Optional) Absolute encoder (3 VDC) backup power output. *Available only if feedback option module supporting Yaskawa Sigma II Absolute Encoder is present on the ServoWire SM Drive.*
14 15	SDATA SDATA'	Bi-directional differential signal pair for serial encoder communications.

***Table 10**, Motor Feedback Connector (J4) Descriptions (also see cable drawings in Appendix E)*

3.6.8 Pacer Feedback Connector for All Models (mounted on side of drive)

*Refer to the**Table 42**, Motor Encoder Specifications (J4)*
Connector Part Numbers section (page 86) of the Specifications chapter for further information
.

Pin	Signal	Description
1 14	ENCA ENCA’	Differential input, quadrature feedback channel A from the pacer encoder.
2 15	ENCB ENCB’	Differential input, quadrature feedback channel B from the pacer encoder.
3 16	ENCZ ENCZ’	Differential input, “once per revolution” marker signal from the pacer encoder.
5, 6, 18	ENC PWR1	+5.3 VDC (SAC-SM_2__ and SAC-SM_4__) or 5.0 VDC (SAC-SM_A__) power supply output for the motor encoder (450 mA max). This power is derived from the input control power.
7, 19, 20	DGND	Common for the +5.3 VDC supply (ENC PWR1).
9	SHIELD	Motor encoder shield termination point

***Table 11**, Pacer Feedback Connector Descriptions (also see cable drawings in Appendix E)*

3.6.9 Low Power (SAC-SM_A__) Drive Main Power Connector (J5)

Refer to the **Figure 5**, ServoWire SM Low Power Drive Connections overview (SM_A03 & SM-A05) (page 21) for a diagram of the Main Power Connector (J5) location and pinout.

Pin	Signal	Function	Description
1 2	BUS+ BUS-	Main Power Input	24 – 96 VDC (+/-10%)
3 4	PE PE	Physical Earth	Chassis ground should be connected to the panel on which the drive is mounted. *Note: All PE signals are internally connected, only one connection to the panel is necessary.*

***Table 12**, Low Power Drive Main Power (J5) Connections*

3.6.10 Low Power (SAC-SM_A__) Drive Motor Power (J6)

Refer to the **Figure 5**, ServoWire SM Low Power Drive Connections overview (SM_A03 & SM-A05) (page 21) for a diagram of the Motor Power Connector (J6) location and pinout.

Pin	Signal	Function	Description
1	N/C	No Connect	Reserved for future use.
2	PE	Shield	Connection for motor shield drain
3	PE	Ground	Connection for motor frame ground
4 5 6	W V U	Motor Power	Single or Three-phase power to the motor.

***Table 13**, Low Power Drive Motor Power (J6) Connections*

3.6.11 Low Power (SAC-SM_A__) Drive Control Power (J7 & J8)

Refer to the **Figure 5**, ServoWire SM Low Power Drive Connections overview (SM_A03 & SM-A05) (page 21) for a diagram of the Control Power Connectors (J7, J8) location and pinout.

Pin	Signal	Function	Description
1	FG	Frame Ground	Must be connected to the same panel ground as the control power supply.
2	PE	Physical Earth	Chassis ground should be connected to the panel on which the drive is mounted. *Note: All PE signals are internally connected, only one connection to the panel is necessary.*
3 4	24V RET 24V	Return Control Power	Input for 24 VDC (+15%, -20%) control power supply, which provides all internal drive logic and feedback device power. *Note: This is not the same as V+S and V-S on connector J3.*

***Table 14**, Low Power Drive Control Power (J7, J8) Connections*

3.6.12 High Speed Sensor Inputs (ASEN, BSEN)

High speed sensor inputs ASEN and/or BSEN are individually software configurable for:

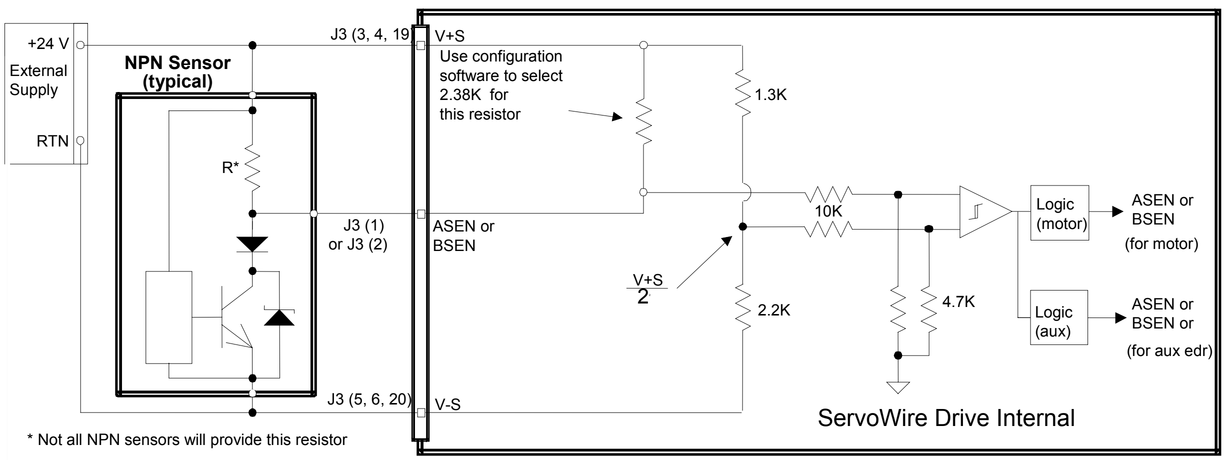
- NPN sensor: 2.7K pull-up resistor (8.9 mA @ 24 VDC)

PNP sensor: pull-up resistor removed from circuit.

Figure 11 on the following page shows sensor wiring for types NPN (top) and PNP (bottom).

NPN type Sensor Wiring

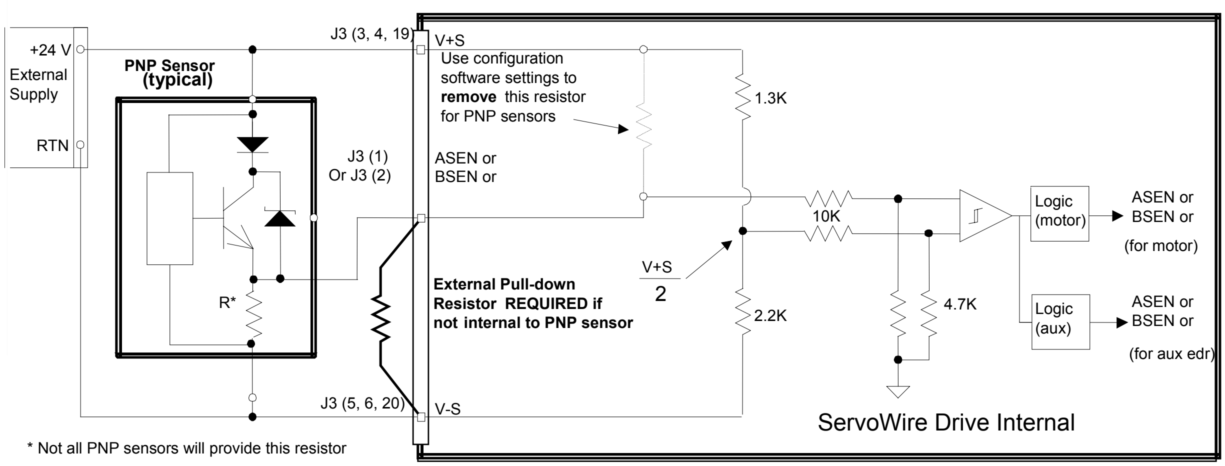
For ASEN, BSEN = true for sensor transistor ON (sinking current), set Axis Sensor Config = Falling Edge or Low Level
For ASEN, BSEN = true for sensor transistor OFF (floating), set Axis Sensor Config = Rising Edge or High Level



* Not all NPN sensors will provide this resistor

PNP type Sensor Wiring

For ASEN, BSEN = true for sensor transistor ON (sinking current), set Axis Sensor Config = Rising Edge or High Level
For ASEN, BSEN = true for sensor transistor OFF (floating), set Axis Sensor Config = Falling Edge or Low Level



* Not all PNP sensors will provide this resistor

Figure 11, Schematic of ASEN and BSEN wiring for NPN and PNP sensors

3.6.13 High Speed Sensor Inputs (ASEN, BSEN) (continued)

NOTE: **ASEN and BSEN wiring should be shielded twisted pair cable, with a foil shield. The DC Power Supply V-S connection should be connected to the same ground as the ServoWire SM Drive frame ground (TB1, ground pin or J7/J8 pin 1 on a Low Power Drive).**

Configuration software is used to configure ASEN and BSEN for edge- or level-sensitive triggering. **Using level-sensitive (high or low) triggering increases the susceptibility of your sensor inputs to noise.**

ASEN and/or BSEN inputs can be software configured to operate in a gated (masked) behavior by the ServoWire SM Drive outputs OUT1 and OUT2.

3.6.14 Discrete Inputs (IN1', IN2', IN3', IN4'/OUT4')

* Note: Input # 4 is Bi-directional & shares the same pin with Output # 4.

The four discrete inputs on the ServoWire SM Drive can be software configured as general purpose inputs for use by the application program, or as Hardware Travel Limits inputs and E-Stop/Quick Stop input.

	SAC-SMM or **SAC-SMS**	**SAC-SM** MotionBASIC required.
Hardware Travel Limit Forward **Hardware Travel Limit Reverse** Refer to the Hardware Travel Limits (IN1', IN2') page 52	IN1' IN2'	IN1' IN2'
E-Stop / Quick Stop Refer to the Quick Stop Input (IN3') page 52	IN3'	Not Available

Figure 12 shows a simplified schematic of the Discrete Inputs, J3 pins 9, 11, 13 and 15 (IN1' – IN4') connected to a limit switch. Refer to the Hardware Travel Limits on (page 52) and Quick Stop Input (page 53) sections of the Operation chapter for further information.

The IN4'/OUT4' pin is shared, with IN4' indicating the state of the I/O point. If OUT4' is disabled, then this pin can be used as an input. If OUT4' is enabled, then this pin cannot be used as an input, though the state of IN4' will still correctly indicate the state of the I/O point.

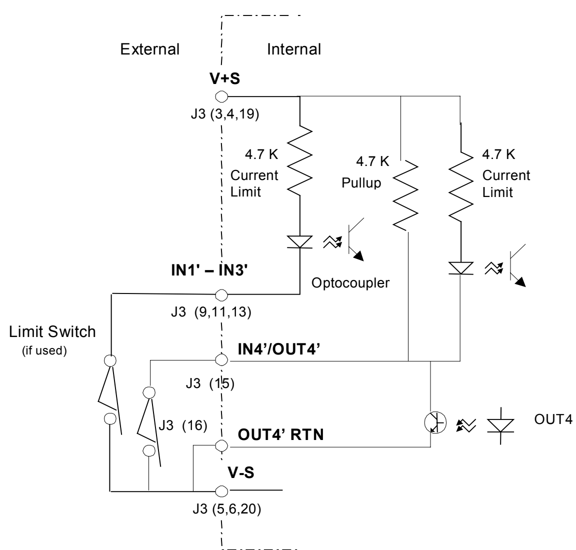


***Figure 12**, Schematic of IN1', IN2', IN3' and IN4'/OUT4' Inputs*

3.6.15 Discrete Outputs (OUT1'-OUT5')

* Note: Output # 4 is Bi-directional & shares the same pin with Input # 4.

A ServoWire SM Drive provides five optically isolated general-purpose digital outputs. By default these are controlled by the application program, but can be software configured as hardware status and control signals.

Software configurable, OUT1' through OUT5' can be configured as general purpose.

	SAC-SMM or **SAC-SMS**	**SAC-SM** MotionBASIC required.
Brake control Refer to the Brake Control Output (OUT3') page 54	OUT3'	OUT3'
Drive Ready Refer to the Drive Ready Output (OUT4') page 54	OUT4'	Not Available
Zero Reference Refer to the Encoder Feedback Zero Reference Output (OUT5') page 54	OUT5'	OUT5'

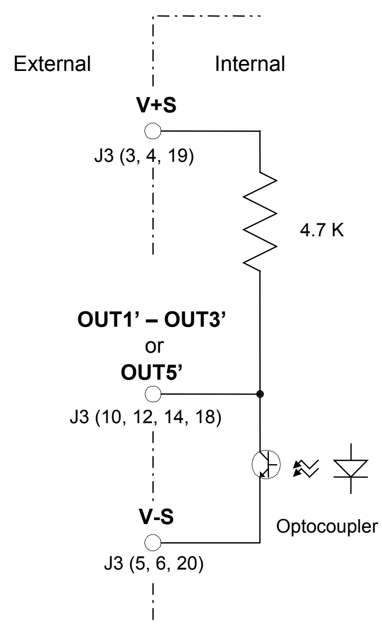


Figure 13, *Schematic of Discrete Outputs OUT1'-OUT5'*

3.6.16 External Regen Resistor Wiring (RG)

Regenerative (regen) shunt circuitry, for use with external regen resistors, is provided on ServoWire SM Drive models SAC-SM_210, SAC-SM_217, SAC-SM_220, SAC-SM_225, SAC-SM_235, SAC-SM_260 and all 460 VAC drives, SAC-SM_4xx. Regen resistors are connected between the **Bus +** and **RG** terminals on TB1 (refer to **Figure 14**).

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-SMRR/0700, SAC-SMRR/0845, SAC-SMRR/0846, and SAC-SMRR/1700 regen resistors are supplied with enclosures. Mounting enclosures for the SAC-SMRR/0055 and SAC-SMRR/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. **Switching voltages exceeding 400 VDC (230 V drives) or 800 VDC (460 V drives) may be present on the Bus+ and RG terminals (and across the regen resistor).** Use appropriate high voltage safety wiring methods.
5. Mounting and wiring practices should be in accordance with NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.

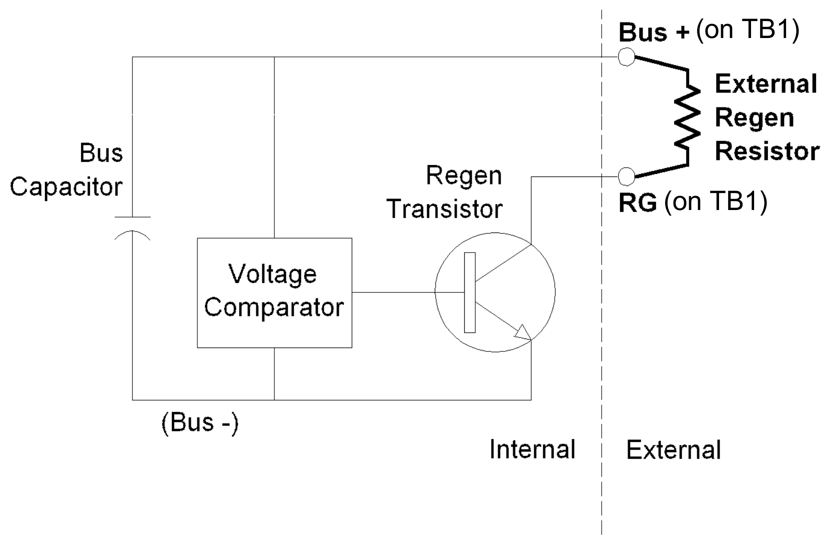


***Figure 14**, Regen Resistor Connection*

For information on how the shunt circuitry operates, as well as information on sizing regen resistors, see Section 4.9, Regenerative Loads (page 62).

3.6.17 Bus Sharing Wiring (230 V SM_225 – SM_260 and 460 V SM_405-SM_450)

DC Bus sharing is supported on 230 VAC ServoWire SM Drive models ***SAC-SM_225, SAC-SM_235, and SAC-SM_260 only***. DC Bus sharing is supported on all 460 VAC ServoWire SM Drives, models SM_405 to SM_450. To configure these drives for bus sharing, the **Bus +** and **Bus –** terminals are connected as shown in **Figure 15**. 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. NOTE: when bus sharing you CANNOT mix 230 VAC and 460 VAC drives on the shared bus at 460 VAC. Severe damage to the 230VAC drives will result.

For information on how the bus sharing operates, see Section 4.9.5, 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.
2. Switching voltages exceeding 400 VDC (230 V drives) and up to 800 VDC (460 V drives) maybe present on the Bus+ and BUS- terminals. Use appropriate high voltage safety and noise suppression wiring methods.
3. Mounting and wiring practices should be in accordance with NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.
4. 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 3.6.16 for more information on regen resistor installation.

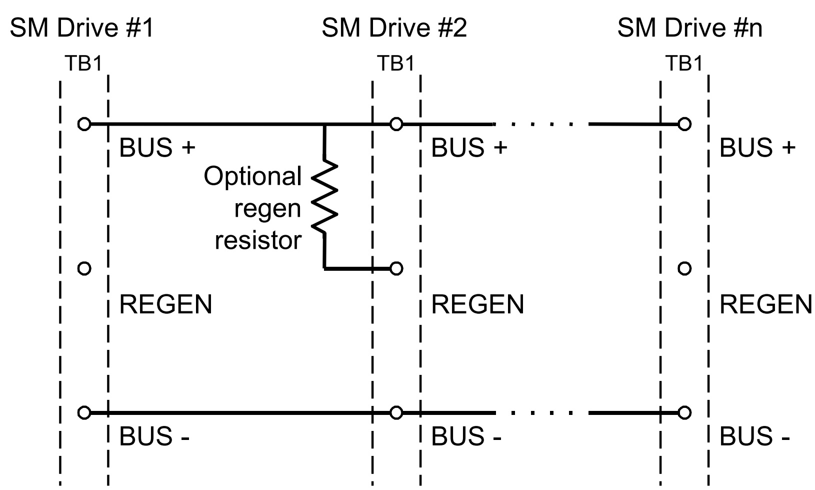


***Figure 15**, Bus Sharing Connections*

3.7 ServoWire SM Drive ID

Each ServoWire SM Drive has a Drive Identification (ID) number and letter, which is shown on the ID/Status LED display on the front of the unit. ServoWire SM Drives are shipped from the factory with Drive ID number set to 1.

The Drive ID is important because it establishes the axis ID of the motor being controlled by the ServoWire SM Drive, as well as the axis ID of the optional feedback module. The application program uses the axis ID.

A push-button on the top of the ServoWire SM Drive allows setting of the Drive ID. Pressing, or pressing and holding the push-button will display the Drive ID(s). This will be the numeric ID followed by a letter indicating which feedback devices are being used. An upper case “A” indicates the quadrature feedback interface (J4), a lower case “b” indicates the first feedback option module and a lower case “c” indicates the second feedback option module (far right). Only two feedback interfaces will be active at a time.

Once the Drive ID is being displayed, pressing the push-button will increment the Drive ID by 1 each time it is pushed, up to a maximum value. Pressing and holding down the push-button will cause the Drive ID to continue incrementing. After reaching its maximum value, it will roll over back to 1, and continue increasing again from there. While the Drive ID is incrementing, only the last digit is shown. To see the tens digit, the push-button must be released. This functionality is available after each power-up, before torque has been enabled at the motor.

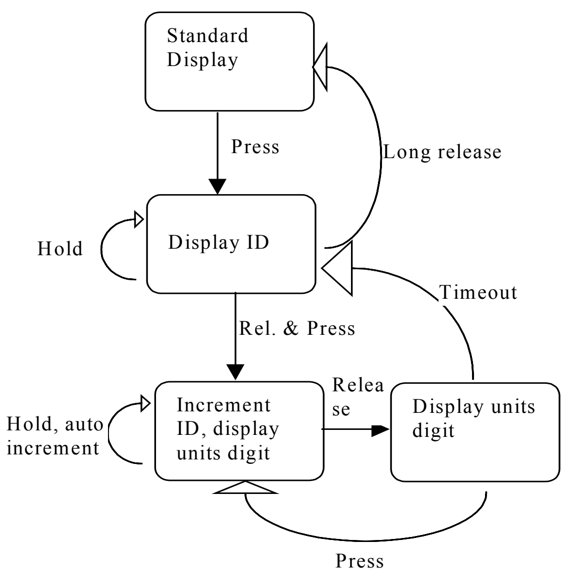


***Figure 16**, Drive ID Setup Flowchart*

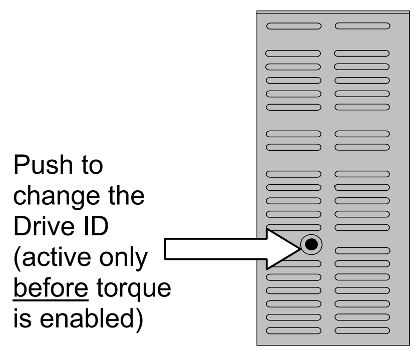


***Figure 17**, Top View of ServoWire SM Drive showing Drive ID Pushbutton*

3.8 Servomotor Installation

3.8.1 Motor Use and Environment

A *standard* G-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.
- G-Series Servomotors: Rated Torque's/Currents are for 25°C; for ambient temperatures above 25°C, use the formula given below in Figure 18. Note that $°C_{Max}$ is 100°C for all G-Series Servomotors except models G006, G011, G015, and G019; for these motors, $°C_{Max}$ is 85°C. The motor current is de-rated by the same factor as the torque.

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

***Figure 18**, G-Series Torque Derating for High Ambient Temperature*

3.8.2 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 ServoWire SM Drive 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 ServoWire SM Drive (TB1 pin or pin 3 on J6), which should be directly grounded to the control panel frame using copper wire.

2. When motor wiring is contained in metal conduits, the conduits and boxes must be grounded. For ServoWire SM 115/230 VAC or 460 VAC Drives (SAC-SM_2__, SAC-SM_4__), use wires of 12 AWG or heavier for grounding to the case (preferably flat woven silver-plated copper braid). For Low Power Drives (SAC-SM_A__), use wires of 16 to 18 AWG for grounding to the case.

3. If possible, route motor feedback and motor power cables in separate conduits or ductwork, separated by a minimum of 10 inches (25 cm).

3.8.3 Motors with Integral Fail-Safe Brakes

NOTE: **The integral fail-safe brakes supplied on 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 17** (page 44) for G-Series cable part numbers. Drawings for these cables are shown in Appendix E.

Figure 19 shows the recommended safety and fault interlock wiring for motors with fail-safe brakes.

- When the main power contactor opens, the brake engages.
- When OUT3’ is asserted, the brake disengages. OUT3’ can be software configured to automatically control the brake when it needs to be engaged and disengaged. OUT3’ can also be manually turned on and off to disengage or engage the brake under the control of the application program. Refer to the application software Help and the Brake Output section of the Operation chapter (page 54) for further information.

Use a separate +24 VDC power supply for coil power from the machine I/O power supply!

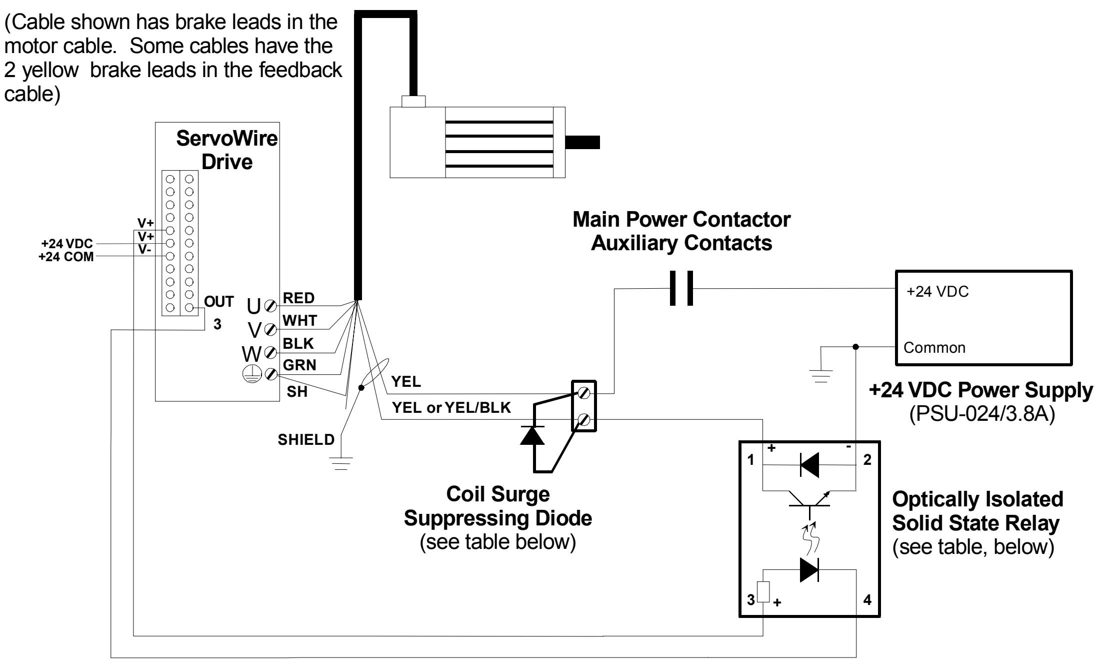


Figure 19, Fail-Safe Brake Interlock Circuit

	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 15**, Additional Components for use with Fail-Safe Brakes G-Series Servomotor Connections*

3.8.4 G-Series Servomotor Connections

For G-Series motors without brakes, refer to the appropriate cable drawing(s) in Appendix E. The motor and encoder cable part numbers and page numbers are shown in **Table 16** (motors without brakes) and **Table 17** (motors with brakes).

<table>
<tr><th>MAC-G Motors Without Brakes</th><th>Motor Power Cable</th><th>Motor Encoder Cable</th></tr>
<tr><td>G005, G010, G006, G011, G015,G019
with SAC- SM_203 – SM_220</td><td colspan="2">CBL-GMSW1 (p D-3)</td></tr>
<tr><td>G016, G030, G040, G055, G080, G115
with SAC-SM_203 – SM_220</td><td>CBL-GMSW2 (p D-4)</td><td rowspan="3">CBL-GMSW
(1-50 ft: p D-1)
(51-150 ft: p D-2)</td></tr>
<tr><td>G080 & G115A2
with SAC-SM_225 & SM_235</td><td>CBL-GMSWT2 (p D-5)</td></tr>
<tr><td>G130 & G210
with SAC-SM_210 – SM_220</td><td>CBL-GMSW3 (p D-6)</td></tr>
<tr><td>G130A2
with SAC-SM_225</td><td>CBL-GMSWT3 (p D-7)</td><td rowspan="4">CBL-GMSW
(1-50 ft: p D-1)
(51-150 ft: p D-2)</td></tr>
<tr><td>G210, G280A4 & G360A4
with SAC-SM_225 – SM_235</td><td>CBL-GMSWT5 (p D-7)</td></tr>
<tr><td>G280A2 & G360A2
with SAC-SM_235 & SM_260</td><td>CBL-GMSWT6 (p D-7)</td></tr>
<tr><td>G640A2
with SAC-SM_260</td><td>CBL-GMSWT9 (p D-7)</td></tr>
</table>

Table 16, *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.

<table>
<tr><th>MAC-G Motors With Brakes</th><th>Motor Power Cable</th><th>Motor Encoder Cable</th></tr>
<tr><td>G005, G010, G006, G011, G015,G019
with SAC-SM_203 – SM_220</td><td colspan="2">CBL-GMSWB1 (p D-3)</td></tr>
<tr><td>G016, G030, G040, G055, G080, G115
with SAC-SM_203 – SM_220</td><td>CBL-GMSWB2 (p D-10)</td><td rowspan="2">CBL-GMSW
(1-50 ft: p D-1)
(51-150 ft: p D-2)</td></tr>
<tr><td>G080 & G115A2
with SAC-SM_225 & SM_235</td><td>CBL-GMSWBT2 (p D-11)</td></tr>
<tr><td>G130 & G210
with SAC-SM_210 – SM_220</td><td>CBL-GMSW3 (p D-6)</td><td rowspan="5">CBL-GMSWB
(1-50 ft: p D-8)
(51-150 ft: p D-9)</td></tr>
<tr><td>G130A2
with SAC-SM_225</td><td>CBL-GMSWT3 (p D-7)</td></tr>
<tr><td>G210, G280A4 & G360A4
with SAC-SM_225 – SM_235</td><td>CBL-GMSWT5 (p D-7)</td></tr>
<tr><td>G280A2 & G360A2
with SAC-SM_235 & SM_260</td><td>CBL-GMSWT6 (p D-7)</td></tr>
<tr><td>G640A2
with SAC-SM_260</td><td>CBL-GMSWT9 (p D-7)</td></tr>
</table>

Table 17*, Cable Drawings for G-Series Motors* ***With*** *Brakes*

3.8.5 D-Series Servomotor Connections

For D-Series motors without brakes, refer to the appropriate cable drawing(s) in Appendix E. The motor and encoder cable part numbers and page numbers are shown in **Table 18** (motors without brakes) and **Table 19** (motors with brakes).

MAC-D Motors Without Brakes	Motor Power Cable	Motor Encoder Cable
DE003, DE006, DE008, DE011, DE021, DE042 with SAC- SM_203 – SM_220	CBL-DEMSW1 (p E-1)	CBL-DMSW (1-50 ft: p F-1) (51-150 ft: p F-12)
DA030, DA055, DB025, DB055, DB080 with SAC-SM_210 – SM_220	CBL-DMSW1 (p F-3)	
DA055 with SAC-SM_225	CBL-DMSWT1 (p F-4)	
DA090, DA110, DB200 with SAC-SM_225 – SM_260	CBL-DMSWT2 (p F-4)	
DA140, DB300 with SAC-SM_235 – SM_260	CBL-DMSWT3 (p F-4)	
DB100 with SAC-SM_220	CBL-GMSW4 (p F-3)	
DB100 with SAC-SM_225	CBL-GMSWT4 (p F-4)	
DB330 with SAC-SM_260	CBL-DMSWT5 (p F-4)	
DB465, DB700 with SAC-SM_235 – SM_260	CBL-DMSWT6 (p F-4)	

Table 18, *Cable Drawings for D-Series Motors* ***Without*** *Brakes*

MAC-D Motors With Brakes	Motor Power Cable	Motor Encoder Cable
DE003, DE006, DE008, DE011, DE021, DE042 with SAC- SM_203 – SM_220	CBL-DEMSWB1 (p E-1)	CBL-DMSW (1-50 ft: p F-1) (51-150 ft: p F-2)
DA030, DA055, DB025, DB055, DB080 with SAC-SM_210 – SM_220	CBL-DMSWB1 (p F-5)	
DA055 with SAC-SM_225	CBL-DMSWBT1 (p F-6)	
DA090, DA110, DB200 with SAC-SM_225 – SM_260	CBL-DMSWBT2 (p F-6)	
DA140, DB300 with SAC-SM_235 – SM_260	CBL-DMSWBT3 (p F-6)	
DB100 with SAC-SM_220	CBL-DMSWB4 (p F-5)	
DB100 with SAC-SM_225	CBL-DMSWBT4 (p F-6)	
DB330 with SAC-SM_260	CBL-DMSWT5 (p F-4) & CBL-DMACB (p F-7)	
DB465, DB700 with SAC-SM_235 – SM_260	CBL-DMSWT6 (p F-4) & CBL-DMACB (p F-7)	

Table 19*, Cable Drawings for D-Series Motors* ***With*** *Brakes*

3.8.6 H-Series Servomotor Connections

Serial encoder support requires SM Servo Drive with the "S" option.

MAC-D Motors Without Brakes	Motor Power Cable	Motor Encoder Cable
HA003, HA055, HB025, HB055, HB080, HB100	CBL-HMSW1	CBL-HMSW (1-50 ft: p G-1) (51-150 ft: p G-5)
HA110, HA140, HB200	CBL-HMSW2	
HB300	CBL-HMSW3	
HA90	CBL-HMSW4	
HB330, HB465	CBL-HMSW5	
HB700	CBL-HMSW6	
HE003, HE006, HE011, HE021, HE042	CBL-HEMSW1	CBL-HEMSW (1-50 ft: p G-3) (51-150 ft: p G-2)

Table 20, *Cable Drawings for H-Series Motors* ***Without*** *Brakes*

3.8.6.1 H-Series Motor Encoder Resolutions

			Motor Resolution using	
Model numder		**Raw encoder resolution**	**ORION**	**SMLC**
MAC-HE003A/	2.8 lb-in, 5000 RPM max, 115 VAC	**13-bit**	8,192	8,192
MAC-HE006A/	5.6 lb-in, 5000 RPM max, 115 VAC			
MAC-HE003B/	2.8 lb-in, 5000 RPM max, 230 VAC			
MAC-HE006B/	5.6 lb-in, 5000 RPM max, 230 VAC			
MAC-HE011B/	11 lb-in, 5000 RPM max, 230 VAC			
MAC-HE021B/	21 lb-in, 5000 RPM max, 230 VAC			
MAC-HE042B/	42 lb-in, 5000 RPM max, 230 VAC			
MAC-HA030B/	28 lb-in, 5000 RPM max, 230 VAC	**17-bit**	32,768 **	131,072 (17 bit)
MAC-HA055B/	56 lb-in, 5000 RPM max, 230 VAC			
MAC-HA090B/	87 lb-in, 5000 RPM max, 230 VAC			
MAC-HA110B/	112 lb-in, 5000 RPM max, 230 VAC			
MAC-HA140B/	140 lb-in, 5000 RPM max, 230 VAC			
MAC-HB025B/	25 lb-in, 3000 RPM max, 230 VAC	**17-bit**	32,768 **	131,072 (17 bit)
MAC-HB055B/	48 lb-in, 3000 RPM max, 230 VAC			
MAC-HB080B/	74 lb-in, 3000 RPM max, 230 VAC			
MAC-HB100B/	102 lb-in, 3000 RPM max, 230 VAC			
MAC-HB200B/	177 lb-in, 3000 RPM max, 230 VAC			
MAC-HB300B/	305 lb-in, 3000 RPM max, 230 VAC			
MAC-HB330B/	345 lb-in, 3000 RPM max, 230 VAC			
MAC-HB465B/	465 lb-in, 3000 RPM max, 230 VAC			
MAC-HB700B/	700 lb-in, 2000 RPM max, 230 VAC			

Note: ** Orion's MotionBASIC limits the counts per revolution to 32,768.
The full 17-bit resolution is unattainable when using an Orion Motion Controller.

3.8.7 DC Servomotor Connections

DC motors, voice coils and other actuators requiring single phase current output can be connected to pins U and V on the High Power Terminal Block (TB1). The Custom Motor editor can be used to configure the Drive for use with a DC motor or single phase actuator, as well as for configuring the Low Bus Voltage fault trip point.

3.8.8 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 torque, 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 from the ORMEC Web Site (www.ORMEC.com).

3.9 Resolver Feedback Option Module (SAC-SM-RES)

ServoWire SM Drives support up to two feedback option modules per drive, which can be used to provide resolver motor and/or auxiliary feedback. When only one feedback option module is installed, the quadrature encoder input is still available for use as either motor or auxiliary feedback.

The Resolver Feedback Option Module provides 12/14/16-bit resolution.

16 - Bit = 65536 cnts/rev. .... 1,500 RPM maximum.
14 - Bit = 16384 cnts/rev. .... 6,000 RPM maximum.
12 - Bit = 4096 cnts/rev. .... 24,000 RPM maximum.

It is configured for use with single speed resolver having a transformation ratio of 0.5. Refer to the Resolver Feedback Option Modules section 6.2 (page 87) of the Specifications chapter for further information.

3.9.1 Installation

To install a feedback option module:

1. Remove the access hole cover closest to the quadrature encoder feedback connector (J4), refer to **Figure 20**. Save this cover, as it will be replaced after the feedback option module is installed.
2. Install the shorter side of the 0.25”x0.41” header pins for the first level option module into the appropriate drive headers, as shown in **Figure 20**. Be sure the pins are properly aligned and firmly inserted into the drive headers.
3. Carefully install the first level option module on the header pins as shown in **Figure 20**. Be sure that the option module headers and the header pins are properly aligned before firmly inserting them. If only one feedback option module is being installed, you may skip ahead to step 6.

4. Install the shorter side of the 0.25"x0.31" header pins for the second level option module into the appropriate first level option module headers, as shown in **Figure 20**. Be sure the pins are properly aligned and firmly inserted into the first option module headers.
5. Carefully install the second level option module on the header pins as shown in **Figure 20**. Be sure that the option module headers and the header pins are properly aligned before firmly inserting them.
6. Replace the access hole cover and fasten the option module(s) to the drive with four screws, as shown in **Figure 20**.
   - If one option module is installed, use (4) 6-32 x 1" screws.
   - If two option modules are installed, use (4) 6-32 x 2" screws.

   If the screws are not easily inserted, or seem mis-aligned, this usually means the option module(s) is not properly installed.
7. Test the drive by applying control power and watching the STATUS/ID display for the following information:
   <Axis ID>A - indicates the main drive interface
   <Axis ID>B - indicates that the first option module is enabled
   <Axis ID>C - indicates that the second option module is enabled

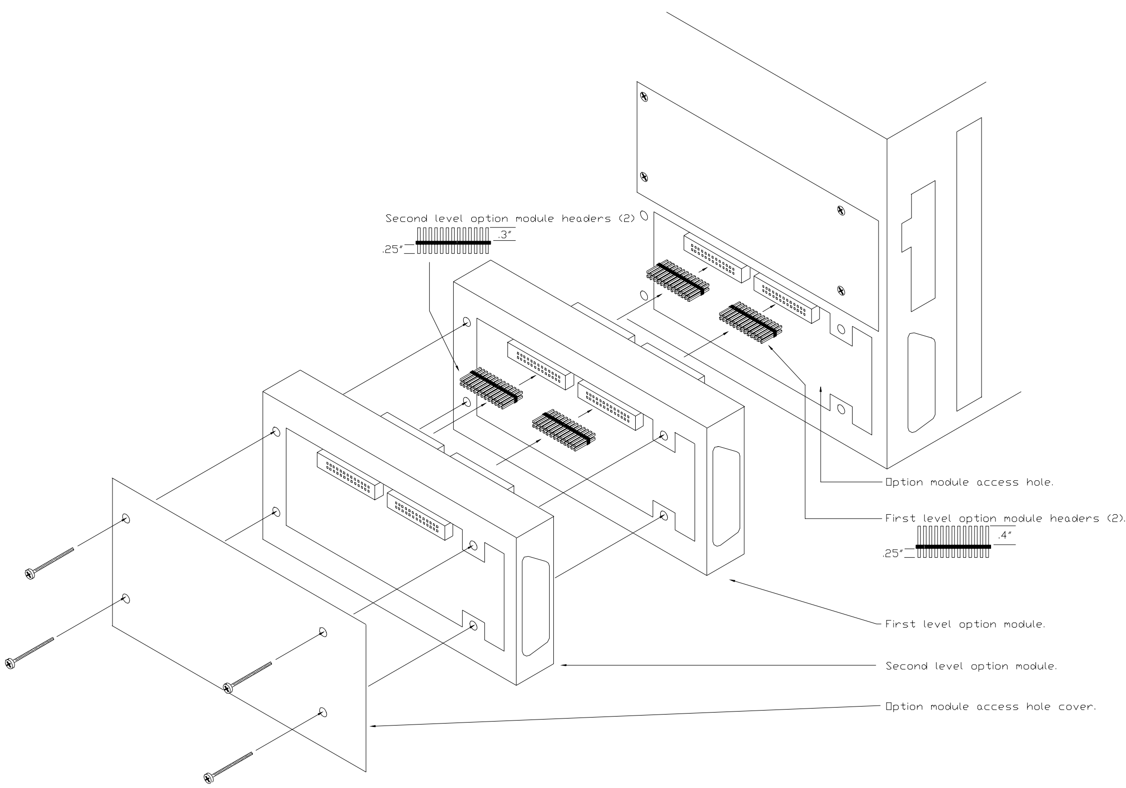


***Figure 20**, Feedback Option Module Installation 7*

3.9.2 Resolver Connector

Refer to the Resolver Feedback Option Modules section 6.2 (page 87) of the Specification chapter for further information.

Pin	Signal	Description
5, 7, 11	SHIELD	Resolver shield termination points.
10 23	TEMP' TEMP RET	Motor Over Temperature input. Software configuration settings determine the usage of this input. **Normally closed Contact** wired to the ServoWire SM Drive: • Open contact causes drive fault ***F4***. (Immediately disables motor torque). • **or –** Open contact causes application program error. • **or –** Open contact is ignored. No fault or error occurs. **No Sensor exists at motor**. Leave TEMP & TEMP RET unconnected. • Contact is normally open. (This setting will cause an application program configuration error if there is a closed contact). See Section 4.9.8 (page 72) for a detailed explanation.
17 18	REF- REF+	Differential output, resolver excitation frequency. The following resolver excitation parameters are specified in the configuration software settings: • Excitation Frequency: 2.5, 5.0 (default) & 10.0 kHz • Excitation Amplitude: 0 to 8V RMS, 4V RMS at 100% set in the configuration software. Due to variations in resolver transformation ratios, the excitation amplitude may require adjustment to meet the sine and cosine input voltage requirements.
19 20	COS- COS+	Differential Input, resolver feedback cosine channel from the motor resolver. • Feedback Amplitude: 2V RMS, +/-15%
21 22	SIN- SIN+	Differential Input, resolver feedback sine channel from the motor resolver. • Feedback Amplitude: 2V RMS, +/-15%
All Other Pins	N/C	No connection

***Table 21**, Resolver Feedback Option Module Pin Descriptions*

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) E-STOP 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.

b) 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 auxiliary contact (MP-AUX) to "pull-in", so that the main power contactor coil circuit is energized.

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

2) ServoWire Drive faults

a) If any fault condition occurs within a ServoWire SM Drive, the main circuit power is disconnected because the Drive Ready (OUT4') signal is unasserted and the customer supplied relay contact in the main power contactor coil circuit opens. In this case, the ServoWire SM Drive ID/Status display will indicate the fault code. **For the operation described above, OUT4 must be configured for operation as the Drive Ready output in the configuration software.** Refer to the Drive Ready Output section of this chapter for further information.

To reset a High Bus Voltage Fault, the main input power must be disabled long enough for the power capacitors to discharge to a level below the High Bus Voltage Fault limit.

To reset a Motor Over Temperature Fault, the motor must be sufficiently cool. The application program can clear all other fault conditions.

All fault conditions, including E-Stop, must be cleared before motor power can be restored. Also, the E-Stop Reset push-button must be

depressed long enough for all the drive power supplies to charge and the Drive Ready (OUT4') Relays to pull-up again.

b) If the E-Stop switch is pressed or another ServoWire SM Drive in the system experiences a fault, the drive discrete input IN3 will be unasserted. This will cause the drive to either disable the output or command zero output (hold position, zero velocity or zero torque), depending on how the drive is configured. **For the operation described above, IN3 must be software configured for E-Stop or Quick Stop operation.**

4.2 Discrete Inputs (IN1', IN2', IN3', IN4'/OUT4')

There are four optically isolated discrete inputs, IN1' through IN4'.

* Note: Input # 4 is Bi-directional and shares the same pin with Output # 4.
See: I/O Schematic, **Figure 12** (Page 37).

These inputs are available for use by the application program as general-purpose inputs, or can be configured as Hardware Travel Limits inputs and/or E-Stop/Quick Stop input. Refer to your application program documentation to determine how the Discrete Inputs are being used.

4.2.1 Hardware Travel Limits (IN1', IN2')

Discrete input IN1' and/or IN2' can be software configured to operate as Hardware Travel Limits (HTL). IN1' is assigned HTL Forward. IN2' is assigned HTL Reverse. If a servo is in position, velocity or output mode and it's Hardware Travel Limit is asserted, then it's commanded motion will be stopped, and a motion error will be generated. The HTL must be reset before any motion can be commanded to move off and away from the limit. Once the limit hardware has cleared and the HTL input is conducting current, then the software variable can be successfully cleared. Motion is again allowed in the direction of the HTL.

4.2.2 E-Stop Input (IN3')

Using ServoWire Pro, Discrete input IN3' can be software configured to operate as an E-Stop input. When unasserted, this input causes the servodrive to generate a drive fault and disable output power to the motor, as well as generating a fault callback in the application program. Refer to Appendix A-1 for a diagram of how this input is connected to the machine e-stop interlock circuit.

4.2.3 Quick Stop Input (IN3')

Using ServoWire Pro, Discrete input IN3' can be software configured to operate as a Quick Stop input. Unasserting IN3' in this mode generates an alarm callback in the application program and has the effects indicated in **Table 22**, which are dependent on the axis mode (torque, velocity or position), as configured in ServoWire Pro (Axis Settings, Drive Input). Refer to Appendix A-1 for diagram of how this input is connected to the machine e-stop interlock circuit.

Drive Input (Mode)	**Quick Stop Operation**
Torque	Generates an alarm callback in the application program, output remains enabled and the drive continues to receive torque commands. This allows the motion controller to decelerate the load under control.
Velocity/Position	Generates an alarm callback in the application program, output remains enabled, zero speed is commanded[1]. Commanding zero speed may result in commanded current to bring the motor to a stop. When the drive is configured to use IN3 as a Quick Stop input, missing phase detection is disabled when IN2 is unasserted.

***Table 22**, Quick Stop Operation*

4.3 Discrete Outputs (OUT1' – OUT5')

* Note: Output # 4 is Bi-directional and shares the same pin with Input # 4.
See: I/O Schematic, **Figure 12** (Page 37).

There are five optically isolated discrete outputs, OUT1' through OUT5'. These outputs are available for use by the application program as general-purpose outputs, or

(OUT3') can be configured as a Brake Control Output,

(OUT4') can be configured as a Drive Ready Output,

(OUT5') can be configured as a Feedback Encoder Reference Output.

Refer to your application program documentation to determine how the Discrete Outputs are being used.

[1] The drive may command current as necessary to maintain zero velocity.

4.3.1 Brake Control Output (OUT3')

Discrete output OUT3' can be software configured to operate as a Brake Output for controlling a motor fail-safe brake. When asserted, this output can be used to supply power to the coil of a motor fail-safe brake, keeping the brake disengaged and allowing motor motion. Refer to

Figure 19 for diagram of how this output is connected to a fail-safe brake interlock circuit.

The user can configure the delay time between enabling motor power and releasing the fail-safe brake, as well as the delay time between engaging the fail-safe brake and disabling motor power. This is a very useful feature when controlling vertical loads, it allows holding torque to be enabled before the brake is released and vice versa. Refer to the diagram in **Figure 21** for an explanation of the Brake Output sequence of operation and the configurable delay parameters.

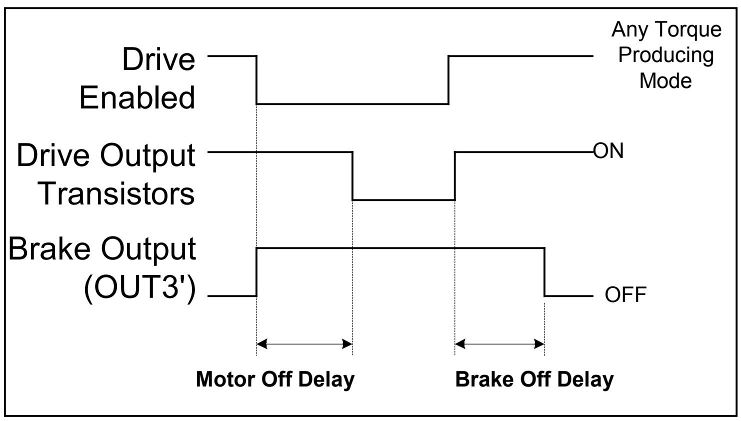


***Figure 21**, Brake Output Sequence of Operation*

4.3.2 Drive Ready Output (OUT4')

Discrete output OUT4' can be software configured to operate as a Drive Ready Output. When asserted, this output indicates that the servodrive is operating without any faults and the main bus is charged. Refer to Appendix A-1 for diagram of how this output is connected to the machine e-stop interlock circuit.

4.3.3 Encoder Feedback Zero Reference Output (OUT5')

Discrete output OUT5' can be software configured to operate as a buffered feedback encoder zero reference output. If no feedback option module is present on the drive, the state of this output corresponds to the state of the quadrature feedback (J4) encoder zero reference signal. If one or more feedback option modules is present, the configuration software can be used to specify which reference signal's state will be indicated by OUT5'.

4.4 Status Indications

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

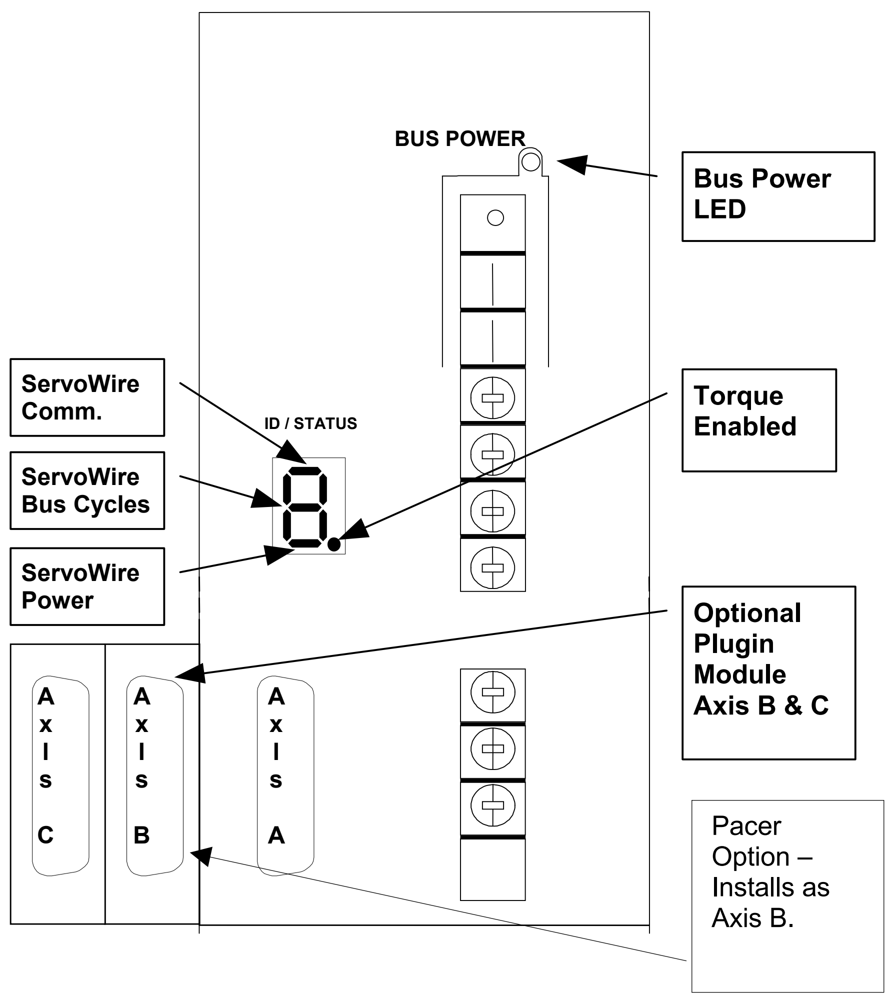
If a fault condition (except for auxiliary encoder open wire ***F2***) is present on the ServoWire SM Drive, the output transistors are disabled, and an appropriate fault code is displayed on the ID / Status display. The control power should be maintained in case of a servodrive fault, so that the status indicators can display 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 then 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, the application program must reset the drive fault.
2. If the fault is due to the motor or drive being over temperature, the servodrive fault will not reset until the component has cooled down.

***Figure 22**, ID/Status Indications*



4.4.1 ServoWire Communications (Status ID Display)

During normal operation (e.g. when there are no faults), the ID/Status Display flashes to indicate that the software is functioning. The particular segment of the ID/Status Display that is flashing is used to indicate the status of the ServoWire network.

The three segments will flash individually in the following order:

1st Bottom Status LED Segment (**ServoWire Power**):
Flashing indicates that the drive is functional and there is power supplied to the ServoWire interface. Note: An E6 error will be displayed if no power is supplied to the ServoWire interface from the ServoWire cable.

2nd Middle Status LED Segment (**ServoWire Bus Cycles**):
Flashing indicates that the drive is functional, there is power to the ServoWire interface and isochronous bus cycles are taking place.

3rd Top Status LED Segment (**ServoWire Iso. Communication**):
Flashing indicates that the drive is functional, there is power to the ServoWire interface, isochronous bus cycles are taking place and the drive is receiving isochronous commands. In general, this means that ServoWire communications are fully functional.

4.4.2 Torque Enabled (Right lower dot of ID/Status Display)

Off: indicates that torque is not enabled at the motor.
On: indicates that torque is enabled at the motor.

4.4.3 Bus Power (Yellow LED above TB1)

Illuminated to indicate that the bus power supply voltage is greater than approximately 24 VDC.

4.4.4 Axis ID and Fault ID

When no drive faults exist, the ID/Status will display the ServoWire network status as indicated in section 0. When a drive fault exists, the ID/Status display will sequence through showing the drive ID, axis ID and the fault code (shown on the next page in **Table 23**, ServoWire SM Drive Fault Codes) in order.

There is a more detailed table of fault codes, which shows cause-and-effect for many of these faults in Section 7.1, ServoWire SM Drive Troubleshooting Guide (page 89).

The format of the message will be the Drive ID number, followed by a letter indicating the axis on the drive and finally the two-digit error code. The axis ID letter indicates which feedback connector is associated with the error. The Encoder Feedback connector is A, the first feedback option module connector is B and the second feedback option module connector is C. For example, ***3A-F1*** indicates that the Drive ID is 3, the error is on the encoder feedback connector and the error is F1, an open encoder wire.

With one exception (fault ***F2***, Auxiliary Encoder Open Wire), all drive faults cause torque to be disabled at the motor.

Drive faults ***90 – 99*** and ***9A-9F*** may require cycling control power to clear the fault. The application program can clear all other faults (after the cause of the fault has been cleared).

Drive Fault Indicator[1]	Fault Code	Condition	Description
70-7F *90-9F*	112-159	Internal Drive Error	Internal errors may require cycling the drive control power to clear the fault. If the problem recurs or does not clear, contact ORMEC Application Support at **(585) 385-3520** or via e-mail at **support@ORMEC.com**. Please have your Support ID available when you call or reference it in your e-mail message.
90	144	Internal Drive Error	This fault is normal during ServoWire 1394 network cable pulls.
A0	160	Drive RMS Over Current	The actual RMS current has exceeded the drives 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 was exceeded.
A2	162	Power Module Fault	The Power Module's self-protection has detected a short circuit, over current, over temperature or control supply under voltage. **- or-** An SCR soft-start circuit error has been detected (SAC-SM_225, SM_235 & SM_260 only).
A3	163	Low Bus Voltage	The bus voltage is below the low voltage limit, which is calculated based on the Drive Input Voltage specified in the configuration software.
A4	164	High Bus Voltage	The bus voltage is above the high voltage limit, which is calculated based on the lessor of the motor rated voltage (as specified in software) and the drive maximum voltage.
A5	165	Drive hardware and configuration software mismatch.	The drive type or drive options does not match the software configuration settings. The application program has detected that the drive hardware does not match software configuration settings.
A6	166	Drive Not Configured	An attempt was made to enable torque before the drive's setup parameters have been configured. The drive setup parameters must be configured each time the drive's control power cycles on, before the drive can be enabled.
A7	167	Illegal While Drive Enabled	An attempt was made to configure a drive parameter while the drive was enabled.
A8	168	Invalid Commutation Position	An invalid commutation position was detected, possibly due to a discharged absolute encoder, or an encoder failure encoder. (See ServoWire SM Drive Troubleshooting Guide, Fault Code ***A8***)
A9	169	Phase Loss	The drive detected the loss of a main power phase or a soft-start error.
AA	170	Soft Start Error	Inrush current greater than 0.5 amps or a low bus voltage (<50 VDC) was detected when attempting to enable the drive (this is only checked when enabling a drive).
Ab		*Not Used.*	
AC	172	Drive Over Temperature	An over-temperature condition was detected in the drive powerblock, or a failure of the inrush current resistor.
Ad	173	E-Stop	A drive emergency stop was detected. This requires that the drive be configured to use one of the general-purpose inputs as E-Stop input.
AE	174	Software upgrade.	**SAC-SMM Drive**, MotionObjects fault: Host PC driver software upgrade is required.
AF		*Not Used.*	
b0	176	Checksum error	The checksum on the downloaded code was incorrect. The download has been aborted. Try again.
b1	177	Bad file	The download code was not recognized. The wrong file was used. The drive firmware may be too old to recognize this format.
b2	178	Firmware not compatible	The downloaded code is not designed for this drive hardware, but rather for different drive hardware. Obtain the correct file and try again.
b3	179	Firmware Checksum error	Internal firmware program checksum error. Reload drive firmware.

[1] *Also see Section 7.1, ServoWire SM Drive Troubleshooting*

Drive Fault Indicator[11]	Fault Code	Condition	Description
E0	224	ServoWire Protocol Incompatibility	The ServoWire communications protocol in the drive is not compatible with the one used by the motion controller or PC.
E1	225	ServoWire Timeout	1394 network power loss (Host PC power lost or PC re-booted) or Isochronous communications were lost. Example: Torque commands from the Orion Motion Controller or Host PC are missing.
E2	226	Isochronous Arbitration Failure	One possible cause is that the Loop Rate is set too high to allow all the drives on the 1394 network to send there isochronous data packets. Lower the Loop Rate.
E3	227	ServoWire Watchdog Timeout	The ServoWire Isochronous communications watchdog bit has not changed state within the allotted time.
E4	228	ServoWire Initialization Error	A hardware error was detected when initializing the IEEE 1394 communications controller circuitry.
E5	229	Drive Watchdog Timeout	The drive internal watchdog has timed out due to either the loss of ServoWire network power (usually due to loss of PC power) or an unexpected failure.
E6	230	No ServoWire Network Power	The drive is not detecting the 8-40 VDC on the ServoWire cable. No communication is possible until this is corrected. The error will automatically clear itself when ServoWire power is applied.
E7		*Not Used*	
E8	232	Duplicate Drive ID	The host has detected more than one drive with the same Axis ID. All the drives with duplicate IDs should be displaying this error.
F0	240	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. (Software configuration setting)
F1	241	Motor Encoder Open Wire	At least one motor encoder feedback channel (ENCA, ENCA', ENCB, ENCB') is not connected properly. (J4 pins 1,2,3,4)
F2	242	Auxiliary Encoder Open Wire	At least one channel (AUXENCA, AUX ENCA', AUXENCB, AUXENCB') is not connected properly.
F3	243	Invalid Hall State	The hall track feedback from the motor is improperly wired. This fault can also occur if the feedback type in the drive configuration software has been improperly identified.
F4	244	Motor Over Temperature	Open contact at J4 pins 19-20. See Section 0, page 72.
F5	245	Unknown Option Board	The drive has detected an option board installed, but does not recognize or support this board.
F6	246	Overtemp Config. Error.	The motor configuration indicates that there is no over temperature sensor, but an over temperature sensor was detected by the drive.
F7	247	Serial Encoder Alarm.	An alarm bit has been returned by the Sigma 2 encoder.
F8	248	Unsupported Serial Encoder detected.	Unsupported encoder feedback type **- or -** Not supported by the drive firmware

Table 23*, ServoWire SM Drive Fault Codes (continued from previous page)*

4.5 Commutation Modes

By default, ServoWire SM Drives are configured to control permanent magnet brushless DC servomotors using sine-wave commutation. The Drive can be configured for trapezoidal commutation of brushless motors or DC output for brush motors using the configuration software. This can be useful when integrating third party motors or when controlling motors other than DC brushless servomotors.

4.6 Commutation Feedback Signals

Commutation position signals are illustrated below.

The U, V and W signals are “on” for 180^{o} spaced 120^{o} 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.

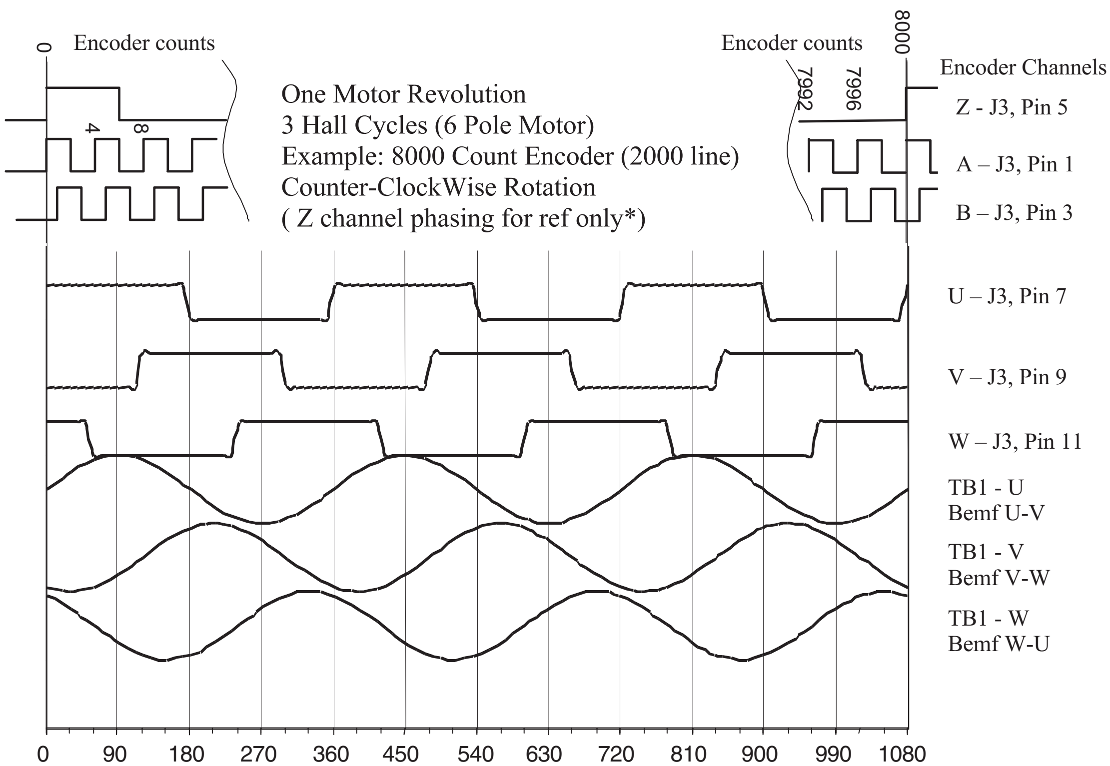


Figure 23, Hall signals and Motor Back EMF waveforms

If the motor’s back EMF and commutation signals are not directly in phase, the Hall Offset parameter can be used to compensate for the offset.

4.7 ServoWire Drive Commutation Feedback (Hall Signals)

NOTE: For the below procedure to work, the encoder must have hall support by providing integrated HALL data tracks. Resolver motors & Serial encoders (Sigma II) do not have hall support.

Using ServoWire Pro (SMLC)

The state of the commutation signals can be displayed using the Monitor utility in ServoWire Pro. To verify that the commutation feedback is correct, rotate the motor shaft clockwise or counter-clockwise and confirm that the Hall sensors proceed through the sequence indicated in this table.

Counter-Clockwise Rotation			Clockwise Rotation		
W	V	U	W	V	U
1	0	1	1	0	0
0	0	1	1	1	0
0	1	1	0	1	0
0	1	0	0	1	1
1	1	0	0	0	1
1	0	0	1	0	1

Note: Clockwise and Counter-Clockwise shaft rotation refers to rotation when viewing the end of the motor shaft

***Table 24**, Valid Hall Signal Sequences*

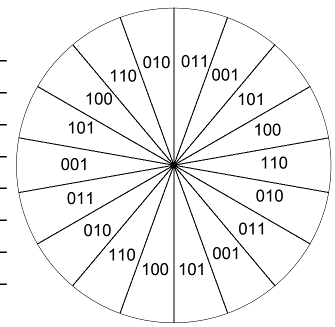


***Figure 24**, Valid Hall States (6 Pole Motor Example diagram)*

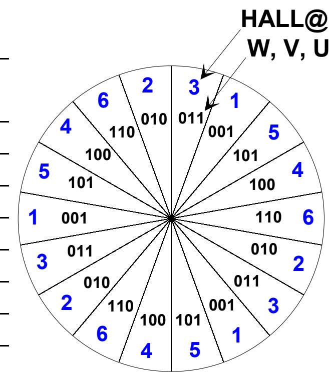
Using MotionDESK (Orion)

The state of the commutation signals can be displayed using the HALL@ MotionBASIC variable and the table below. To verify that the commutation feedback is correct, " **REPEAT PRINT HALL@(*AxisNumber~*)** ", rotate the motor shaft clockwise or counter-clockwise and confirm that the HALL@ value proceeds through the sequence indicated below. Refer to the MotionBASIC Help HALL@ variable section for further details.

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

Valid HALL@ Sequence



Valid Hall States (6 Pole Motor Example diagram)

4.8 Quadrature Feedback Signals

Quadrature position signals for "Forward" and "Reverse" travel are illustrated in **Figure 25**.

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 and servodrives, 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 a ServoWire SM drive yields a positioning resolution of 16,384 cnts/rev.

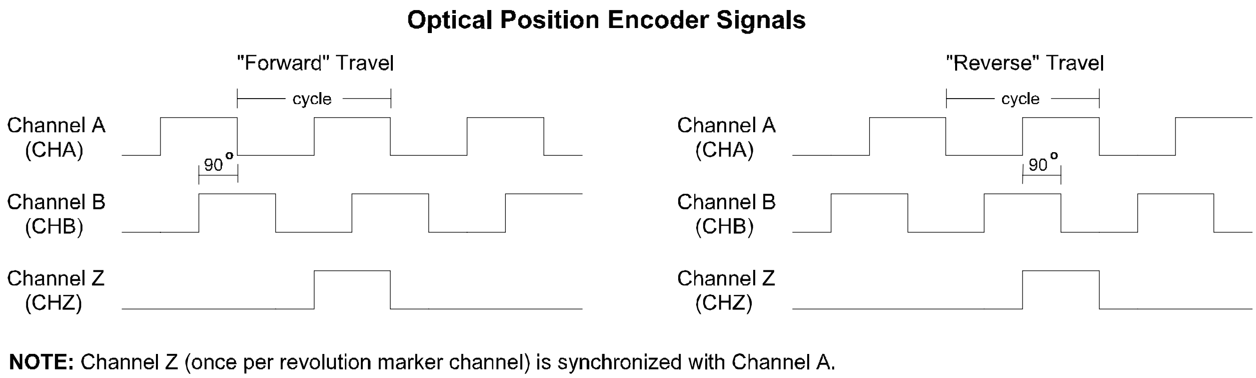


***Figure 25**, Quadrature Encoder Channel Description*

4.9 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; or
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.

4.9.1 Shunt Regulator

ServoWire SM Drive models SAC-SM_210, SAC-SM_217, SAC-SM_220, SAC-SM_225, SAC-SM_235, SAC-SM_260, SAC-SM_405, SAC-SM_410, SAC-SM_417, SAC-SM_425, SAC-SM_435 and SAC-SM_450 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 ServoWire SM Drive controls the on-time duty cycle, so that the average current is appropriate for the regen resistor specified in the project software setting.

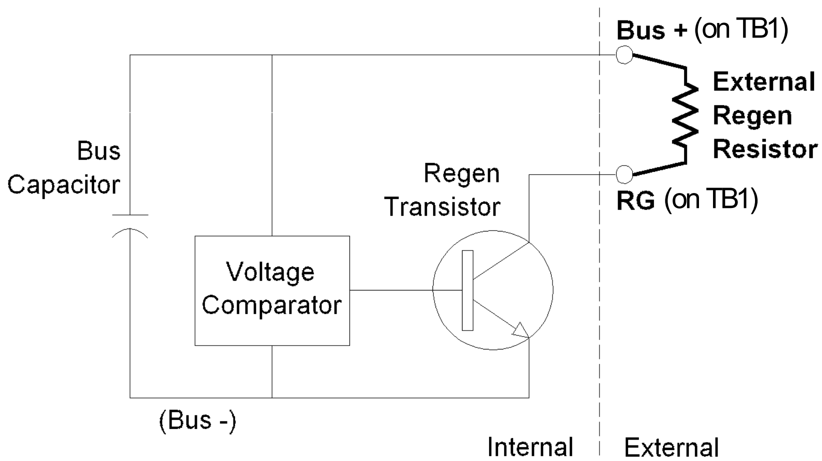


Figure 26, *Simplified Schematic of Shunt Regulator*

4.9.2 Sizing a Regen Resistor: Application-specific Formulas

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

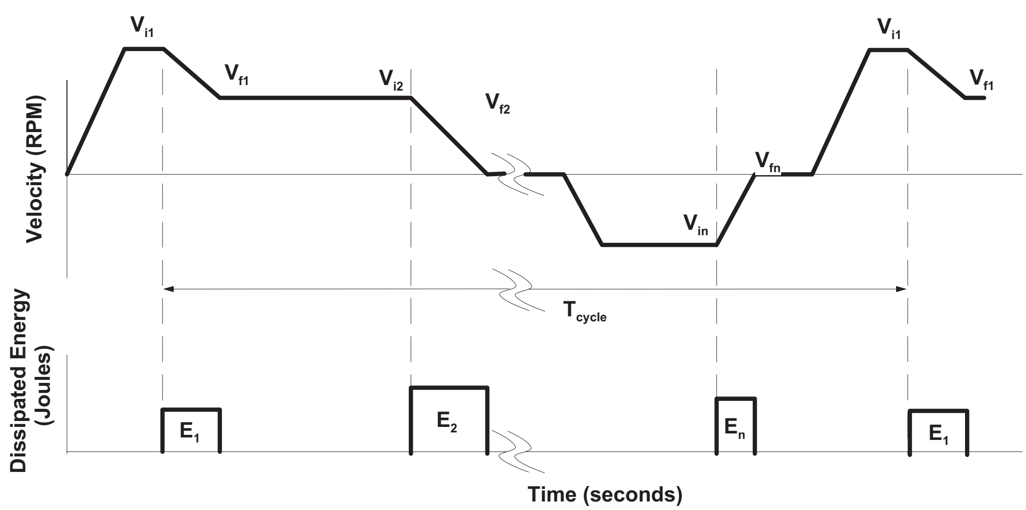


Figure 27*, Regeneration during deceleration.*

4.9.2.1 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:

$$E_{regen} = \tfrac{1}{2} I \cdot (V_i^{\,2} - V_f^2) \cdot (0.00124)$$ *(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 unit conversion: $\frac{(2\pi \text{rad} / \text{rev})^2 \cdot (4.448 \text{N} / \text{lb})(25.4 \text{mm} / \text{in})}{(60 \text{sec} / \text{min})^2 (1000 \text{mm} / \text{m})}$

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

$$P_{avg} = \frac{E_1 + E_2 + E_n}{T_{cycle}}$$ *(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)

4.9.2.2 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: $\frac{(2\pi rad/rev)(25.4mm/in)(4.448N/lb)}{(60sec/min)(1000mm/m)}$

4.9.2.3 Sizing a Regen Resistor: Regeneration Due to Vertical Load

In an application where the motor is supporting the weight of a poorly counterbalanced 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:

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

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 (Watts)
T_1 is the time spent in the cycle's 1^{st} downward move (seconds)
P_2 is the power dissipated by the cycle's 2nd downward move (Watts)
T_2 is the time spent in the cycle's 2^{nd} downward move (seconds)
…
P_n is the power dissipated by the cycle's Nth downward move(Watts)
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)

4.9.3 Sizing a Regen Resistor: Use Average Regenerative Power

Once Average Regenerative Power has been determined using one of the methods in section 4.9.2, 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 ServoWire SM Drive's shunt transistor.

4.9.4 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 25 below shows 1) the mimimum regen resistance allowed, 2) the resulting current at that resistance and 3) the maximum average regen power capability of the drive.

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.**

<table>
<tr><th></th><th>Regen Resistor</th><th>Drive Regen Power Output</th><th>Regen Transistor</th><th></th></tr>
<tr><th>ServoWire Drive</th><th>Minimum Resistance(1)</th><th>Maximum Average Power(3)</th><th>Peak Current(2)</th><th>Bus Capacitance</th></tr>
<tr><td>SAC-SM_A03
SAC-SM_A05</td><td colspan="3" rowspan="2">Regen Transistor not available.</td><td>47 uF</td></tr>
<tr><td>SAC-SM_203
SAC-SM_205</td><td>540 µF</td></tr>
<tr><td>SAC-SM_210</td><td>50 Ω</td><td>800 W</td><td>8.5 A</td><td>1,170 µF</td></tr>
<tr><td rowspan="2">SAC-SM_217
SAC-SM_220</td><td rowspan="2">35 Ω</td><td>1200 W</td><td rowspan="2">12 A</td><td rowspan="2">1,410 µF</td></tr>
<tr><td>1700 W</td></tr>
<tr><td>SAC-SM_225</td><td rowspan="2">7.8 Ω</td><td>3000 W</td><td rowspan="2">50 A</td><td rowspan="3">3,360 µF</td></tr>
<tr><td>SAC-SM_235</td><td>4175 W</td></tr>
<tr><td>SAC-SM_260</td><td>5.0 Ω</td><td>7100 W</td><td>75 A</td></tr>
</table>

SAC-SM_405	70 Ω	1200 W	11.4 A	560 uF
SAC-SM_410	40 Ω	2400 W	20 A	
SAC-SM_417	40 Ω	4000 W	20 A	840 uF
SAC-SM_425	25 Ω	5970 W	32 A	
SAC-SM_435	20 Ω	8350 W	40 A	1120 uF
SAC-SM_450	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 25*, 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-SM_425 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 26**. 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 ServoWire SM Drive using 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 26*, 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 27** 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-SM_**								
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 27**, 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 28**.

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

***Table 28**, Regen Transistor Turn-On and other Bus Voltage Levels*

4.9.5 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 28**). 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.

NOTE: All ServoWire SM Low Power Drives connected to the same main power supply have a shared-bus configuration.

4.9.6 Bus Sharing Limitations

Bus sharing is supported by most ServoWire SM drives. However, all drives connected to bus share must be operating off the same AC power supply. That is, connecting a 230 V drive to share the bus with a 460 V drive operating at 460 VAC will cause permanent damage to the 230 V drive.

On 230 VAC drives bus sharing is supported by ServoWire SM Drive models ***SAC-SM_225, SAC-SM_235, and SAC-SM_260 only.***

On 460 VAC drives bus sharing is supported by all 460 V models, ServoWire SM Drive models SAC-SM_405, SAC-SM_410, SAC-SM_417, SAC-SM_425, SAC-SM435 and SAC-SM_450.

In both cases the drive 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. The same source must be used for all drives connected together.
- 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 4.9, Regenerative Loads for more information on sizing regen resistors.

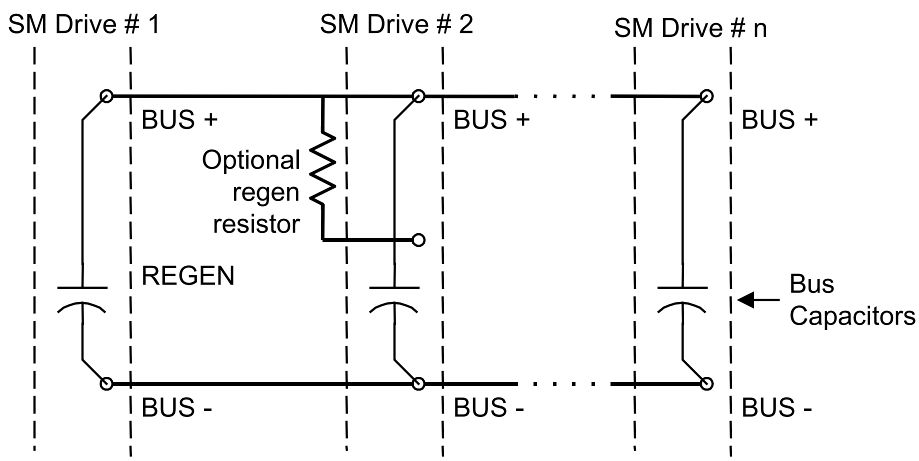


***Figure 28**, Shared Bus Capacitors*

4.9.7 Shunt Regulator Overload

If regenerated voltage is excessive, a High Bus Voltage fault (*A4*) 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 software**

configuration settings for the ServoWire SM Drive: 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).

4.9.8 Servomotor Temperature Protection

The thermostat contact wiring is part of the Motor Feedback Cable. When the thermal contact opens, the behavior of the ServoWire SM Drive will depend on the ServoWire SM Drive's software configuration setting:

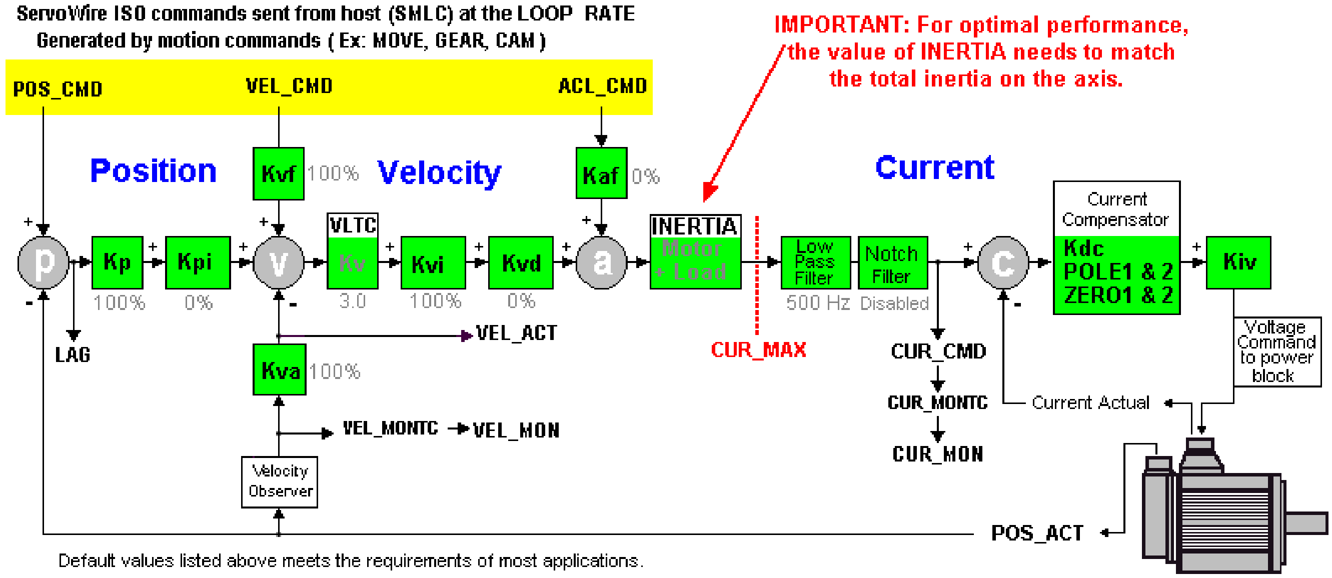
Host PC & MotionObjects		
Motor Thermal Switch state.	**ServoWire Pro configuration setting.**	**Behavior of ServoWire SMM Drive & MotionObjects.**
Open Closed	Ignore	An open contact will not cause any error or drive fault. A closed contact will cause an application program, temperature sensor configuration error.
Opens	Generate Alarm	An open contact will cause an OnAlarm callback. **NO Drive Fault will occur.** The motor can still have torque. It is up to the application's program to respond to the over temperature warning condition.
Opens	Generate Fault	An open contact will cause an OnFault callback. If the drive torque is enabled, a drive fault ***F4*** will immediately disable torque to the motor.
The status of the thermal contact can be monitored with MotionObjects member function **IsOverTemp**.		

Orion Motion Controller		
Motor Thermal Switch state.	**MotionDesk configuration setting.**	**Behavior of ServoWire SM Drive & MotionBASIC**
Open Closed	Ignore	An open contact will not cause any error or drive alarm. A closed contact will cause the MotionBASIC Configuration Error 1629 = Temperature sensor configuration error.
Opens	Generate Motion Error	An open contact will cause MotionBASIC ERR=1628 "Over temperature condition exists". **NO Drive Alarm will occur.** The motor can still have torque. It is up to the application's error handler to respond to the over temperature condition.
Opens	Generate Drive Alarm	When the motor is too hot, causing the contact to open, the SM Drive will generate an alarm. If the drive torque is enabled, a drive alarm ***F4*** will immediately disable torque to the motor. MotionBASIC generates an ALARM@=244 and ERR=1628 " Over temperature condition exists".
The status of the thermal contact can be monitored with MotionBASIC variable **OVER.TEMP@**.		

Table 29, *Motor Over-Temperature Input*

G-Series Servomotors have embedded thermostats, which open when the motor winding temperature exceeds 155°C.
DE/DA/DB-Series Servomotors do not have embedded thermostats.

4.10 Tuning - Loop Diagram



Loop Rate
Loop Rate defines the number of times per second (Hz) that the ISO commands will be sent to the drive.

Position Actual
Position Actual (POS_ACT) returns the value of, or assign a value to, the actual real-time position of an axis feedback device (encoder or resolver in axis position user units). See: Axis Position for more detail.

Position Gain Factor (Kp)
The position loop gain factor (**Kp**) is set by the motion controller as a function of the Velocity Loop Time Constant (VLTC) and Kp. With Kp set to the default 100%, the position loop is adjusted for a critically damped position response. Adjusting this factor higher, results in an under-damped response and adjusting it lower results in an over-damped response.
Default = 100%, range 1 to 500% *(Note: 100% meets the requirements of most applications.)*

Position Integral Factor (Kpi)
The Position Loop Integral gain factor (**Kpi**) is set by the motion controller as a function of the position loop characteristics. Position loop integral gain is normally required only in applications where position error during motion is critical, such as electronic gearing or in the control of continuous web systems. It may also be required to eliminate static position errors in applications with analog velocity loops, such as axes using distributed feedback or velocity mode servodrives. With Kpi = 100% and Position Gain Factor (Kp) properly adjusted, the servo axis is adjusted for critically damped position response. Adjusting this factor higher result in an under-damped response and adjusting it lower results in no improvement in response.
Default = 0%, range 0 to 500%.

Velocity Observer
The velocity observer is software running in the drive, which derives velocity information from the axis feedback signals (encoder or resolver)

Velocity Feedforward Factor (Kvf)
The Velocity Feedforward Factor (**Kvf**) allows the drive to directly command velocity as well as position in response to a motion command from the motion controller. This enhances servo response and accuracy because the velocity loop has significantly greater bandwidth than the position loop. The use of velocity feedforward is a major factor in the elimination of position following error while the axis is moving.
Default = 100%, range 0 to 200%.

Velocity Observer Sensitivity (Kva)
The Velocity Observer Sensitivity (**Kva**) determines how the velocity observer responds to changes in motor speed. Lower values will smooth low speed motion, but increase settling times on quick stops.
Default = 100%, range 40 to 200%

Velocity Loop Time Constant (VLTC)
The Velocity Loop Time Constant (**VLTC**) is used to indirectly set the velocity proportional gain Kv. The Velocity Loop Proportional Gain (Kv) is not available as a variable. The velocity proportional gain is set by the motion controller to achieve the velocity loop time constant objective established by VLTC.
The performance characteristics of the servo motion control system are highly dependent on Velocity Loop Time Constant (VLTC), should be set as small as the system dynamics allow. A realistic goal is 0.7 to 3 msec for loads, which are tightly coupled to the motor.
Default = 3 milliseconds, range 0.3 to 30 msecs.

Velocity Loop Integral Gain (Kvi)
The velocity loop integral gain factor (**Kvi**) is set by the motion controller as a function of the velocity loop characteristics. With Kvi set to the default 100%, the servo axis is adjusted for a critically damped velocity response. Adjusting this factor higher result in an under-damped response and adjusting it lower results in no improvement in response.
Default = 100%, range 0 to 1000% *(Note: 100% meets the requirements of most applications.)*

Velocity Derivative Gain (Kvd)
Velocity derivative gain (**Kvd**) sets the gain at which the velocity loop responds to feedback rate changes. Velocity derivative gain is inherently noisy and will increase step-input responsiveness. The default adjustment (0% of nominal) should be satisfactory for achieving stability.
Default = 0%, range 0 to 600%

Velocity Monitor Time Constant
The Velocity Monitor Time Constant (VEL_MONTC) sets the time constant of the filter on the velocity monitor. This filter affects reporting only, not motion performance. Velocity Monitor TC is a decimal value, with a higher value increasing filtering on the velocity-monitoring variable Velocity Monitor.
Default = 20.0 milliseconds, range 0.0 to 200.0 msecs.

Velocity Monitor
Velocity Monitor (VEL_MON) is a read only variable that returns the filtered observed (actual) velocity of the servo axis in user units. The Velocity Monitor TC controls the amount of filtering.

Velocity Actual
Velocity Actual (VEL_ACT) is a read only variable, which returns the current real-time instantaneous velocity of the servo axis, as determined by the velocity observer in user units. This filtered value is operating internally at the ServoWire Drive, and its resultant filtered value is returned to the velocity-summing junction.

Acceleration Feedforward Factor (Kaf)
Acceleration feedforward (**Kaf**) allows the drive to directly command acceleration (and therefore torque) as well as position in response to a motion command from the application program. This can enhance servo response and accuracy because the current (torque) loop has significantly greater bandwidth than the position and velocity loops. Acceleration feedforward has limited application, and is not used (disabled) in electronic gearing applications. Increasing its value will improve motions that command short, quick acceleration / decelerations.
Default = 0%, range 0 to 200%

Inertia
The total inertia of this axis is the combination of ***Motor and Load Inertia*** at the Motor Shaft, measured in in-lbs-sec². When an assignment is made to the INERTIA value, an additional range check is made to insure

that: Axis Peak Torque [in-lbs.] X Torque Gain [%] / OP_LOOP_INERTIA [in-lb-sec^2] >=12800.
If it is less than 12800, an error will be generated, and the parameters will not be changed in the drive.
Default = Motor Inertia only (in-lb-sec^2), range 0.000001 to 99 in-lb-sec^2

IMPORTANT:
For optimal performance, the value of INERTIA needs to match the total inertia on the axis as seen by the motor.
You can use MotionDESK's Axis Tune or ServoWire Pro's Inertia Calculator to accurately calculate total system Inertia by monitoring successive motor indexes.

Current Maximum
Current maximum (CUR_MAX) is the maximum drive current output that will limit the current command. It is expressed as a percent of Peak Current, multiplied by 1000.
Ex: Current Max = 67450 then its value is 67.45% of peak.
Range = 0 to 100,000

Current Command
Current command (CUR_CMD) returns the instantaneous real-time value for the current command output of an axis control loop. The valid range is from ± Current Max or responding to the desired servo drive current command output. The ±100,000 maximum range is expressed as a percent of Peak Current, multiplied by 1000, and is positive for "forward" output. Users desiring to limit output to values less than ± peak would lower current max.
Range = 0 to 100,000

Current Monitor Time Constant
Current Monitor Time Constant (CUR_MONTC) sets the time constant of the filter on the current command monitor. A higher value increases filtering on the current command monitoring variable. This filter affects reporting only, not motion performance.
Default = 4, range 0 to 200 milliseconds.

Current Monitor
Current Monitor (CUR_MON) returns a filtered current value for the current command output, of an axis current control loop. The amount of filtering is determined by the value of Current Command Time Constant. The value is positive for "forward" output.
Range -100,000 to 100,000

Current Loop DC Gain (Kdc)
This value is adjusted to the drive's current-loop DC gain. The DC Gain (Kdc) is a function of motor characteristics, impedance, drive bus-voltage, and drive size. This parameter is calculated for a rapid current response with low ringing. In a few cases it is possible to improve current loop response by raising or lowering this value. Doing so in conjunction with the Final Output Stage Gain may also provide an improvement in responsiveness.
Default = 100%, range 0 to 3000%

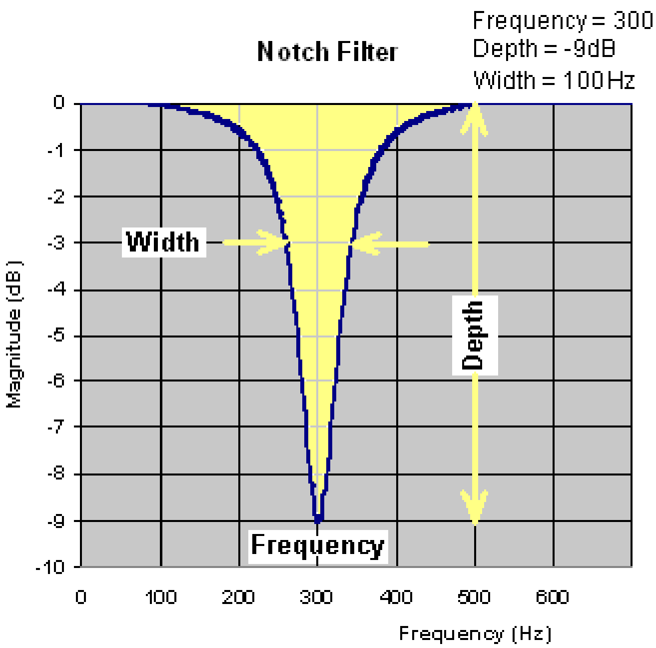
Current to Voltage Gain (Kiv)
This value is adjusted to the drive's final output stage gain. The final Output Stage Gain is a function of motor characteristics, impedance, drive bus-voltage, and drive size. This parameter is calculated for a rapid current response with low ringing. In a few cases it is possible to improve current loop response by raising or lowering this value. Doing so in conjunction with the Open-Loop DC Gain may also provide an improvement in responsiveness.
Default = 100%, range 0 to 3000%

4.11 Filter … Low-Pass Current Cutoff

The Current Filter sets the cutoff frequency (Hertz) of a recursive low-pass filter on the Current Command. This digital filter is operating internally at the ServoWire Drive, and its resultant filtered value is not returned to the motion controller current loop. A value of zero (0) will disable the filter.
Default = 500 Hz, range 20 to 2500 Hz (In 1 Hertz increments)

4.12 Filter … Digital Notch

The Notch filter is used to reject (remove) one band of frequencies and passes both higher and lower frequencies. This feature is only available in SAC-SM servo drives with firmware version 1.6.0 and later. You must enable the filter.
Default = Disabled



NOTCH FREQUENCY is the center frequency of the current loop's notch filter in Hertz. The center frequency of the notch measures the frequency at which the filter’s magnitude reaches it’s minimum value.
Default = 300, range 1 to 2500.

NOTCH DEPTH is the depth of the current loop's notch decibel's (dB). The depth of the notch measures the filter’s minimum magnitude.
Default = -4, range – 4 to – 40.

NOTCH WIDTH is the width of the notch (Hz). The width of the notch measures the distance between the two frequencies where the filter’s magnitude is –3dB.
Default = 50, range 1 to 1250 Hz

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 ServoWire SM 115/230 VAC Drive Check (SAC-SM_2__)

The control and main power voltage should be 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz. **The absolute maximum is 265 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 – not 230 VAC.

CHECK POWER BEFORE APPLYING IT TO THE SERVODRIVE.

- Check that feedback connector(s) J4 (and option modules) is/are firmly seated
- Check that Power terminal block connections r, t, L1, L2, L3, BUS+, RG, BUS-, U, V, W, and ground) are tight.
  Note: The Ormec standard motor cable is color-coded:
  RED= U, WHITE= V, BLACK= W, Green & Silver= GROUND. ⏚
- Motor wiring is correct.
- The main power interlock circuit disables main power under a ServoWire SM Drive fault condition.

5.1.3 ServoWire SM 460 VAC Drive Check (SAC-SM_4__)

The control power voltage should be 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz. except on the 35A and 50A models (SAC-SM_435 and SAC-SM_450) where the control power is limited to 230 (+15%, -20%) VAC only. **The absolute maximum is 265 VAC.**

The main power voltage is normally 460 (+15%, -20%) VAC, however, operation at 230 (+15%, -20%) VAC, 50/60 Hz. is acceptable. **The absolute maximum is 529 VAC.**

The main power voltage depends on the servomotor. Do not choose a main power voltage higher than that supported by the motorl.

CHECK POWER BEFORE APPLYING IT TO THE SERVODRIVE.

- Check that feedback connector(s) J4 (and option modules) is/are firmly seated
- Check that Power terminal block connections r, t, L1, L2, L3, BUS+, RG, BUS-, U, V, W, and ground) are tight.
  Note: The Ormec standard motor cable is color-coded:
  RED= U, WHITE= V, BLACK= W, Green & Silver= GROUND. ⏚
- Motor wiring is correct.
- The main power interlock circuit disables main power under a ServoWire SM Drive fault condition.

5.1.4 ServoWire SM Low Power Drive Check (SAC-SM_A__)

The control power voltage should be 24 VDC (+15%, -20%).

The main power voltage should be 24 – 96 VDC (+/-10%).

The minimum motor inductance should be 300 uH.

CHECK POWER BEFORE APPLYING IT TO THE SERVODRIVE.

- Check that feedback connector(s) J4 (and option modules) is/are firmly seated
- Check that the Main Power, Control Power and Motor Power connectors are firmly seated.
- The main power interlock circuit disables main power under a ServoWire SM Drive fault condition.

5.1.5 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.

Chapter 6
Specifications

6 Specifications

Ormec products covered by this manual:

ServoWire SM Drives				
SAC-SM_A03	SAC-SM_A05			
SAC-SM_203	SAC-SM_205	SAC-SM_210	SAC-SM_217	SAC-SM_220
SAC-SM_225	SAC-SM_235	SAC-SM_260		
SAC-SM_405	SAC-SM_410	SAC-SM_417	SAC-SM_425	SAC-SM_435
SAC-SM_450				

6.1 ServoWire SM Drive Specifications

6.1.1 Environmental Specifications

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

***Table 30**, Environmental Specifications*

6.1.2 Mechanical Specifications

Mounting Method: Also see outline drawings in **Figure 1,**ServoWire SM Drives (115/230 VAC input) Outline Drawings (page 10). **Figure 4**, ServoWire SM Low Power Drives (24-96 VDC) Outline Drawing (page 13).	Vertical panel mounting, two, three or four 10-32 (M5) screws.
Dimensions: *Note Add one inch (25 mm) width for each optional plug-in board.* **SAC-SM_A03 and SAC-SM_A205** Height: add 2” (51 mm) clearance top and bottom Width: add 0.5” (13 mm) clearance each side Depth: includes clearance for attached cables	 5.95 inches (151 mm) 1.95 inches (50 mm) 5.75 inches (146 mm) 1.8 lbs. (0.8 kg)

Weight:	SAC-SM_A03 & SAC-SM_A05		
SAC-SM_203, SAC-SM_205 and SAC-SM_210		9.0 inches	(229 mm)
Height:	add 2” (51 mm) clearance top and bottom	2.6 inches	(76 mm)
Width:	add 1” (25 mm) clearance each side	10.5 inches	(267 mm)
Depth:	includes clearance for attached cables	3.7 lbs.	(1.7 kg)
Weight:	SAC-SM_203 & SAC-SM_205	4.1 lbs.	(1.9 kg)
	SAC-SM_210		
SAC-SM_405 and SAC-SM_410		11.0 inches	(279 mm)
Height:	add 2” (51 mm) clearance top and bottom	4.2 inches	(107 mm)
Width: SM_405	add 1” (25 mm) clearance each side	4.4 inches	(112 mm)
SM_410	add 1” (25 mm) clearance each side	10.5 inches	(267 mm)
Depth:	includes clearance for attached cables	7.9 lbs.	(3.7 kg)
Weight:	SAC-SM_405	8.3 lbs.	(3.9 kg)
	SAC-SM_410		
SAC-SM_217		9.0 inches	(229 mm)
Height:	add 2” (51 mm) clearance top and bottom	3.8 inches	(97 mm)
Width:	add 1.2” (31 mm) clearance each side	10.5 inches	(267 mm)
Depth:	includes clearance for attached cables	5.8 lbs.	(2.7 kg)
Weight:			
SAC-SM_220		9.0 inches	(229 mm)
Height:	add 2” (51 mm) clearance top and bottom	4.0 inches	(112 mm)
Width:	add 1” left-side, 2” (51 mm) right-side clearance	10.5 inches	(267 mm)
Depth:	includes allowance for attached cables	6.6 lbs.	(3.1 kg)
Weight:			
SAC-SM_225, SAC-SM_235, SAC-SM_260, SAC-SM_417 and SAC-SM_425		12.0 inches	(305 mm)
Height:	add 2” (51 mm) top, 4” (102 mm) bottom clearance	6.72 inches	(187 mm)
Width:	add 1” (25 mm) clearance each side	11.1 inches	(282 mm)
Depth:	includes allowance for attached cables	17.7 lbs.	(8.1 kg)
Weight:			
SAC-SM_435 and SAC-SM_450		14.0 inches	(356 mm)
Height:	add 2” (51 mm) top, 4” (102 mm) bottom clearance	7.8 inches	(198 mm)
Width:	add 1” (25 mm) clearance each side	12.1 inches	(307 mm)
Depth:	includes allowance for attached cables	22.0 lbs.	(10. kg)
Weight:			1

***Table 31**, Mechanical Specifications*

6.1.3 General Electrical Specifications for Low Power Drives (SAC-SM_A__)

Control Power Voltage – **J7/J8** pins **3** (RTN)**, 4** (24V)	24 VDC (+15%, -20%)
Main DC Bus Voltage – **J5** pins **1** (BUS+)**, 2** (BUS-)	24 – 96 VDC (+/-10%)
High Bus Voltage Fault Activation DC Bus Voltage[1]:	120 VDC
Low Bus Voltage Fault Activation DC Bus Voltage[2]:	12 VDC
Minimum motor inductance:	300 uH

***Table 32**, General Electrical Specifications*

[1] Shunt regulator activation voltage and High Bus Voltage limits are calculated based on the lessor of the motor rated voltage, as entered in configuration software and the drive maximum voltage.

[2] The Low Bus Voltage limited is calculated based on the Drive Input Voltage specified in ServoWire Pro or MotionDesk.

6.1.4 General Electrical Specifications for 115/230 VAC Drives (SAC-SM_2__)

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!	
SAC-SM_203, SAC-SM_205:	Single Phase, 50/60 Hz 115 (+15%, -20%) or 230 (+15%, -20%) VAC
SAC-SM_210, SAC-SM_217, SAC-SM_220, SAC-SM_235, SAC-SM_260:	Three Phase, 50/60 Hz 115 (+15%, -20%) or 230 (+15%, -20%) VAC
Incoming Control Power Line Voltage – **TB1 or TB2** pins **r, t**	Single Phase, 50/60 Hz 115 (-20%) to 230 (+15%) VAC
Main DC Bus Voltage – **TB1** pins **BUS+, BUS-**	
115 VAC nominal input power: 230 VAC nominal input power:	163 VDC nominal level 325 VDC nominal level
Shunt Regulator Activation DC Bus Voltage[1]:	
115 VAC motors: 230 VAC motors:	207 VDC 395 VDC
High Bus Voltage Fault Activation DC Bus Voltage[1]:	
115 VAC motors: 230 VAC motors:	237 VDC 425 VDC
Low Bus Voltage Fault Activation DC Bus Voltage[2]:	
115 VAC nominal input power: 230 VAC nominal input power:	94 VDC 205 VDC

***Table 33**, General Electrical Specifications for 115/230 VAC Drives (SAC-SM_2__)*

6.1.5 General Electrical Specifications for 460 VAC Drives (SAC-SM_4__)

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.	
SAC-SM_405, SAC-SM_410, SAC-SM_417, SAC-SM_425, SAC-SM_435, SAC-SM_450	Three Phase, 50/60 Hz 230 (+15%, -20%) or 460 (+15%, -20%) VAC
Incoming Control Power Line Voltage – **TB1 or TB2** pins **r, t**	
SAC-SM_405, SAC-SM_410, SAC-SM_417, SAC-SM_425	Single Phase, 50/60 Hz 115 (-20%) to 230 (+15%) VAC
SAC-SM_435, SAC-SM_450	Single Phase, 50/60 Hz 230 (+15%) VAC only
Main DC Bus Voltage – **TB1** pins **BUS+, BUS-**	
230 VAC nominal input power: 460 VAC nominal input power:	325 VDC nominal level 650 VDC nominal level
Shunt Regulator Activation DC Bus Voltage[1]:	

	230 VAC motors: 460 VAC motors:	395 VDC 775 VDC
High Bus Voltage Fault Activation DC Bus Voltage[1]:	230 VAC motors: 460 VAC motors:	450 VDC 800 VDC
Low Bus Voltage Fault Activation DC Bus Voltage[2]:	230 VAC nominal input power: 460 VAC nominal input power:	205 VDC 325 VDC

***Table 34**, General Electrical Specifications for 460 VAC Drives (SAC-SM_4__)*

6.1.6 ServoWire SM Drives Performance Specifications

Drive Model	PWM Frequency	Torque Loop
SAC-SM_A03 and SAC-SM_A05	40 kHz	10 kHz
SAC-SM_203 to SAC-SM_210	20 kHz	10 kHz
SAC-SM_217 to SAC-SM_260	10 kHz	10 kHz
SAC-SM_405 to SAC-SM_450	10 kHz	10 kHz

***Table 35**, PWM Frequencies and Torque Loop Update Rates*

	MotionObjects Command Update Rate(s)[1]	Loop Update Rate
Position Loop	500 Hz - 2 kHz	Same as command update rate. H Series motors = 2.5kHz (same as Velocity Loop.)
Velocity Loop	500 Hz - 2 kHz	2.5 kHz
Torque Loop	500 Hz - 4 kHz	10 kHz

***Table 36**, MotionObjects Command and Loop Update Rates*

6.1.7 Output Specifications for Low Power Drives (SAC-SM_A__)

	24-96 VDC Input		
Drive Model	**Rated Output Power (KVA)**	**Cont. Current (Amps RMS/∅)**	**Peak Current 2 sec (Amps RMS/∅)**
SAC-SM_A03	0.200	3.0	5.0
SAC-SM_A05	0.400	5.0	10.0

***Table 37**, Output (J6 pins 4, 5, 6) Specifications for Low Power Drives (SAC-SM_A__)*

[1] ServoWire command updates are made at multiples of the 125 usec base network update rate, up to 4 kHz.

6.1.8 Output Specifications for 115/230 VAC Drives (SAC-SM_2__)

	Single Phase 115 VAC Input			Single Phase 230 VAC Input		
Drive Model	**Rated Output Power** (KVA)	**Cont. Current** (Amps RMS/∅)	**Peak Current 2 sec** (Amps RMS/∅)	**Rated Output Power** (KVA)	**Cont. Current** (Amps RMS/∅)	**Peak Current 2 sec** (Amps RMS/∅)
SAC-SM_203	0.29	2.5	4.4	0.59	2.5	4.2
SAC-SM_205	0.49	4.2	7.4	0.98	4.1	7.1
SAC-SM_210	0.58	5.1	8.8	1.17	4.9	8.5
SAC-SM_217	0.98	8.6	14.8	1.97	8.2	14.3
SAC-SM_220	1.09	9.5	16.5	2.19	9.1	15.8
SAC-SM_225 SAC-SM_235 SAC-SM_260	Single Phase Not Available			Single Phase Not Available		

Table 38, *Output (TB1 pins U, V, W) Specifications with Single Phase Input Power*

	Three Phase 230 VAC Input		
Drive Model	**Rated Output Power** (KVA)	**Cont. Current** (Amps RMS/∅)	**Peak Current 2 sec** (Amps RMS/∅)
SAC-SM_203	Three Phase Not Available		
SAC-SM_205			
SAC-SM_210	1.95	8.2	14.2
SAC-SM_217	3.32	13.9	24.1
SAC-SM_220	3.91	16.3	28.3
SAC-SM_225	5.98	25.0	50.0
SAC-SM_235	8.37	35.0	70.0
SAC-SM_260	15	60.0	120.0

Table 39, *Output (TB1 pins, U, V, W) Specifications with Three Phase Input Power*

	Three Phase 460 VAC Input		
Drive Model	**Rated Output Power** (KVA)	**Cont. Current** (Amps RMS/∅)	**Peak Current 2 sec** (Amps RMS/∅)
SAC-SM_405	2.4	5.0	10.0
SAC-SM_410	4.7	10.0	20.0
SAC-SM_417	8.1	17.0	34.0
SAC-SM_425	11.9	25.0	50.0
SAC-SM_435	16.7	35.0	70.0
SAC-SM_450	23.9	50.0	100.0

Table 40, *Output (TB1 pins, U, V, W) Specifications with Three Phase Input Power*

6.1.9 I/O Specification (J3)

V+S, V-S **J3 pins 3, 4, 19 (V+S)** **J3 pins 5, 6, 20 (V-S)**	**I/O Power Supply**
Externally supplied voltage used by: - High speed Sensor Inputs ASEN, BSEN - Discrete Inputs IN1', IN2', IN3', IN4' - Discrete Outputs OUT1'-OUT5'	
Max voltage between V+S and V-S	±27 VDC maximum

ASEN, BSEN **J3 pins 1, 2**	**High Speed Sensor Inputs**
Input Current depends on software configuration: NPN-type sensor with 2.7K pull-up resistor selected in drive: PNP-type sensor: current depends on pull-down resistance in sensor (or external pull-down).	 8.9 mA @ 24 VDC
Max. voltage	V+S
Minimum acceptance time	1 microsecond
Turn-on voltage V_{IN} > 0.5 * (V+S) + 0.4 VDC V_{IN} < 0.5 * (V+S) + 0.1 VDC	Receiver Output High Low

IN1', IN2', IN3', IN4' **J3 pins 9, 11, 13, 15** Note: Input #4 (J3 pin 15) is Bi-directional and shares the same pin with Output #4.	**Optically-coupled Digital Inputs**
Input should be normally sinking current to prevent an overtravel limit condition.	
Current to turn on	0.7 mA minimum 7.0 mA maximum
Voltage max.	5V + V+S maximum

OUT1'-OUT5' **J3 pins 10, 12, 14, 15, 18** Note: Output #4 (J3 pin 15) is Bi-directional and shares the same pin with Input #4.	**Optically-coupled Digital Outputs**
max. sink current	33 mA
low level voltage high level voltage	0.7 VDC maximum (Ic = 33 mA) V+S - 0.5 VDC
absolute maximum	27 VDC

***Table 41**, I/O Specifications (J3)*

6.1.10 Motor Encoder Interface Specifications (J4)

ENCA, ENCA', ENCB, ENCB' J4 pins 1, 2, 3, 4 Pacer pins 1, 2, 14, 15	**Differential Digital Inputs Appendix B-1, B-3**
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) Orion 1,000,000 (after 4x decode) SMLC & Softmotion
Maximum Encoder Data Rate:	4 MHz
Quadrature Specification	90^{o} +/-45^{o}
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' J4 pins 5, 6 Pacer pins 3, 16 U, U', V, V', W, W' J4 pins 7, 8, 9, 10, 11, 12	**Differential or Single-Ended Digital Input Appendix B-1, B-3**
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
Single-Ended Turn On Voltage V_{IS} > 3 V 2 V > V_{IS} > 3 V V_{IS} < 2 V	Receiver Output H ? L

END PWR1, DGND J4 pins 13, 24, 25 (Power) J4 pins 16, 17, 18 (Digital Ground) Pacer pins 5, 6, 18 (Power) Pacer pins 7, 19, 20 (Ground)	**Encoder Power Supply Appendix B-1**
+5 VDC for 115/230 VAC Drives (SAC-SM_2__)	5.3 VDC, +/-5% 450 mA max.
+5 VDC for Low Power Drives (SAC-SM_A__)	5.0 VDC, +/- 5% 450 mA max.

TEMP', TEMP RET **J4 pins 19, 20**	**Optically-isolated Digital Input** **Appendix B-1, B-4**
Should be normally sinking current to prevent an over-temperature condition.	
Current to turn on	2.5 mA
Voltage max.	+12 VDC maximum

***Table 42**, Motor Encoder Specifications (J4)*

6.1.11 Connector Part Numbers

		Mating Connector[1]			**Drive Connector**
Drive Label	**Signal**	**Description**	**Manufacturer & Part Number**	**Ormec P/N**	**Manufacturer & Part Number**
J1/J2	ServoWire	6 pin IEEE 1394	Available only as integral part of IEEE1394 (ServoWire) cable		Molex 53462-0611
J3	Drive I/O	20 pin header	Berg 65846-006 Amp 102398-8	CON-SM-J3 CON-SM-J3-IDC	Molex 70247-2001
J4	Encoder Feedback	25 pin male D-sub	Amp 207464-1 (conn.) Amp 745254-6 (pin) Amp 206478-3 (shell) Amp 90406-1 (tool)	CON638 CON640 CON641	Kycon K22L-B255N
Low Power Drives Only					
J5	Main Power	4 pin female connector	Molex 39-01-4040 (conn) Molex 44476-3112 (pins)[2] Molex 44476-1111 (pins)[3]	CON-SM-J5	Molex 39-30-1040
J6	Motor Power	6 pin female connector	Molex 39-01-2065 (conn) Molex 44476-3112 (pins)[2] Molex 44476-1111 (pins)[3]	CON-SM-J6	Molex 39-30-1060
J7/J8	Control Power	4 pin female connector	Molex 39-01-2045 (conn) Molex 44476-3112 (pins)[2] Molex 44476-1111 (pins)[3]	CON-SM-J7/J8	Molex 39-30-3045
	Pacer Feedback	25 pin female D-sub	Amp 207463-1 (conn.) Amp 745253-6 (pin) Amp 206478-3 (shell) Amp 90406-1 (tool)	CON650 CON649 CON641	Kycon K22B25PN

***Table 43**, Connector Part Numbers*

[1] The mating D-sub connectors for J3 and J4 are not provided as part of the ServoWire SM Drive.
[2] Pins for use with 16 AWG wires carrying up to 10 ADC.
[3] Pins for use with 18-20 AWG wires carrying up to ? ADC.

6.2 Resolver Feedback Option Modules

6.2.1 General Specifications

Feedback Resolution (Software configurable)	65536 cnt/rev .. @ 16-bit 16384 cnt/rev .. @ 14-bit 4096 cnt/rev .. @ 12-bit
Maximum Motor Speed	1,500 RPM .... @ 16-bit 6,000 RPM .... @ 14-bit 24,000 RPM .... @ 12-bit
Resolver Type	Single speed
Transformation Ratio	0.5

***Table 44**, Resolver Feedback Option Module General Specifications*

6.2.2 Resolver Interface Specifications

REF', REF SAC-SM-RES Connector pins 17, 18	**Differential Digital Output Appendix B**
Excitation Amplitude	0 to 8V RMS 4V RMS at 100% (default) in ServoWire Pro.
Excitation Frequency	2.5, 5 or 10 kHz Software Configurable.
COS', COS, SIN', SIN SAC-SM-RES Connector pins 19, 20, 21, 22	**Differential Digital Inputs Appendix B**
Feedback Amplitude	2V RMS, +/-15%
TEMP', TEMP RET SAC-SM-RES Connector pins 10, 23	**Optically-isolated Digital Input Appendix B**
Should be normally sinking current to prevent an over-temperature condition.	
Current to turn on	2.5 mA
Voltage max.	+12 VDC maximum

***Table 45**, Resolver Feedback Module Interface Specifications*

6.2.3 Resolver Connector Part Numbers

	Mating Connector[1]			Module Connector
Signal	**Description**	**Manufacturer & Part Number**	**Ormec P/N**	**Manufacturer & Part Number**
Resolver Feedback	25 pin female D-sub	Amp 207463-1 (conn.) Amp 745253-6 (pin) Amp 206478-3 (shell) Amp 90406-1 (tool)	CON650 CON649 CON641	Kycon K22B25PN
Module I/O	26 pin header pins	3M 929665-03-13-I[2] 3M 929665-08-13-I[3]	CON735 CON736	FCI Berg 68046-213 FCI Berg 68046-313

***Table 46**, Resolver Feedback Option Module Connector Part Numbers*

[1] The mating D-sub connector is not provided as part of the Resolver Feedback Option Module.
[2] Pins used between feedback module and drive logic board.
[3] Pins used between feedback modules.

Chapter 7
Maintenance and Troubleshooting

7 Maintenance and Troubleshooting

7.1 ServoWire SM Drive Troubleshooting Guide

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

Indication	Code	Status	Description
A0	160	Drive Over Current (RMS)	The maximum rating for the continuous current output of the drive has been exceeded.
When enabling axis with Servomotor connected	• Incorrect servomotor wiring ⇒ See Section 3.5.9 (page 20) 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	Code	Status	Description
A1	161	Drive Over Current (Peak)	The maximum rating for the peak current output of the drive has been exceeded.
When manually enabling axis.	The application program has not yet configured the drive ⇒ Configure the drives before changing to a torque-producing mode.		

Indication	Code	Status	Description
A2	162	Power Module Fault	The Power Module's self-protection has detected a short circuit, over current, over temperature, control supply under voltage. - or- An SCR soft-start circuit error has been detected (SAC-SM_225, SM_235 & SM_260 only). This fault is detected after the drive has been enabled.

Indication	Code	Status	Description
A3 Bus Power LED not on	163	Low Bus Voltage	The bus voltage is below the low voltage limit, which is calculated based on the Drive Input Voltage specified in the configuration software.
When the drive is being or has been enabled		• Input voltage does not match the 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	

Indication	Code	Status	Description
A4	164	High Bus Voltage	The bus voltage is above the high voltage limit, which is calculated based on the lessor of the motor rated voltage and the drive maximum voltage.
When power is applied to the main circuit		Applied voltage exceeds the Servomotor's rating ⇒ Reduce applied voltage. The configuration software settings for ServoWire SM Drive Input Voltage are lower than desired applied voltage ⇒ Increase setting in the configuration 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.	

<table>
<tr><th>Indication</th><th>Code</th><th>Status</th><th>Description</th></tr>
<tr><td>A5</td><td>165</td><td>Configuration Mismatch</td><td>The drive type does not match the software configuration settings.</td></tr>
<tr><td></td><td colspan="3">SAC-SMM Drives: MotionObjects has detected that the drive hardware does not match ServoWire Pro project settings. Either:
Auxiliary feedback encoder is created in the user program but drive does not have pacer (/P) hardware option. -OR-
Axis is configured for drive type SAC-SW_ but actual drive type is SAC-SM_. -OR-
Axis is configured for drive type SAC-SM_ but actual drive type is SAC-SW_.
MotionObjects may also indicate this by the exception # 1031,
Error Message = Configured Drive type doesn't match actual drive hardware.</td></tr>
</table>

Indication	Code	Status	Description
A6	166	Drive Not Configured	An attempt was made to enable torque before the drive's setup parameters have been configured. The drive setup parameters must be configured each time the drive's control power cycles on, before the drive can be enabled.

Indication	Code	Status	Description
A7	167	Illegal While Drive Enabled	An attempt was made to write parameters for the 'Number of Poles ' or 'Resolution' to the drive while the drive was enabled. The drive must be disabled before changing these parameters.

<table>
<tr><th>Indication</th><th>Code</th><th>Status</th><th>Description</th></tr>
<tr><td>A8</td><td>168</td><td>Invalid Commutation Position</td><td>A Drive configured for a motor with an absolute encoder was commanded to enable when the absolute encoder was discharged, or while the commutation position was invalid, or the ABS output was toggled on a Drive configured for an incremental encoder.

The commutation position is invalid on a drive configured for an absolute encoder motor when:
The Drive is powered up, prior to drive configuration
An open encoder line is detected
During trapezoidal commutation
'Number Of Poles' is written
'Resolution' is written
The commutation position becomes valid when the absolute encoder's position is read. Refer to the MotionObjects and ServoWire SM RTX documentation for further information regarding reading absolute encoder position.</td></tr>
</table>

Indication	Code	Status	Description
A9	169	Phase Loss	The drive detected the loss of a main power phase.

Indication	Code	Status	Description
AA	170	Soft Start Not Complete	The drive inrush current is greater than 0.5 amps or there is a low bus voltage (<50 VDC). Note: This is only checked when enabling the drive. The hardware switch from soft start mode to full power mode doesn't take place until after startup is complete, as evidenced by low inrush current and sufficient bus voltage. This error may be caused by: • Enabling too soon after applying AC bus power ⇒ Wait longer between disabling and reapplying AC bus power. • Low AC bus power input voltage so that BUS+ never reaches 50 VDC ⇒ Correct the AC bus power input voltage • The load on BUS+ and BUS- is drawing current as soon as AC bus power is applied ⇒ remove the load from BUS+ and BUS- (there should not be a load on BUS+ and BUS-, regen resistors are connected to BUS- and RG.

Indication	Code	Status	Description
AC	172	Drive Overtemp or Soft Start Error	An over-temperature condition was detected in the drive powerblock, or a failure of the inrush current resistor. This fault is detected when the drive is being enabled.

Indication	Code	Status	Description
Ad	173	E-Stop	A drive emergency stop was detected. This requires that the drive be configured to use one of the general purpose inputs as an E-Stop input

Indication	Code	Status	Description
AE	174	Software upgrade.	**SAC-SMM Drive**, MotionObjects fault: Host PC driver software upgrade is required.

Indication	Code	Status	Description
b0	176	Checksum error	The checksum on the downloaded code was incorrect. The download has been aborted. Try again.

Indication	Code	Status	Description
b1	177	Bad file	The download code was not recognized. The wrong file was used. The drive firmware may be too old to recognize this format.

Indication	Code	Status	Description
b2	178	Firmware not compatible	The downloaded code is not designed for this drive hardware, but rather for different drive hardware. Obtain the correct file and try again.

Indication	Code	Status	Description
b3	179	Firmware Checksum error	Internal firmware program checksum error, reload drive firmware.

Indication	Code	Status	Description
E0	224	ServoWire Protocol Incompatibility	The ServoWire communications protocol in the drive is not compatible with the one in ServoWire SM RTX.
Either the drive's firmware should be changed to a version that is compatible with ServoWire SM RTX, or ServoWire SM RTX must be changed to a version that is compatible with the ServoWire SM Drive.			

Indication	Code	Status	Description
E1	225	ServoWire Timeout	Isochronous communications (i.e. torque commands, velocity commands, etc.) from the motion controller or PC were lost (The ServoWire dot will indicate if communications has been re-established).
This normally occurs when the drive has control power, but the PC loses control power, or the IEEE 1394 interface card fails. In either case, once the cause has been corrected, the fault can be cleared by the application program (or by cycling power on the drive).			

Indication	Code	Status	Description
E3	227	ServoWire Watchdog Timeout	The ServoWire Isochronous communications watchdog bit has not changed state within the allotted time.

Indication	Code	Status	Description
E4	228	ServoWire Initialization Error	A hardware error was detected when initializing the IEEE 1394 communications controller circuitry.

Indication	Code	Status	Description
E5	229	Drive Watchdog Timeout	The drive internal watchdog has timed out due to either the loss of ServoWire network power (usually due to loss of PC power) or an unexpected failure.

Indication	Code	Status	Description
E6	230	No ServoWire Network Power	The drive is powered up and is not detecting ServoWire network power. Power for the ServoWire interface is supplied by the host PC or controller (8–40 VDC). Possible causes include: • The ServoWire cable is not connected to the drive and/or the host PC or controller. Be sure to verify that all the cables in the network are properly connected. • The host PC or controller is off and/or not supplying power to the ServoWire network.

Indication	Code	Status	Description
E8	232	Duplicate Drive ID	The host PC has detected more than one drive with same Axis ID on the network.

Indication	Code	Status	Description
F0	240	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	Code	Status	Description
F1	241	Motor Encoder Open Wire	At least one motor Encoder Feedback channel (ENCA, ENCA’, ENCB, ENCB’ is not connected properly. (J4 pins 1,2,3,4).

Indication	Code	Status	Description
F2	242	Auxiliary Encoder Open Wire	At least one auxiliary Encoder Feedback channel (ENCA, ENCA’, ENCB, ENCB’ is not connected properly. (J4 pins 1,2,3,4)

Indication	Code	Status	Description
F3	243	Invalid Hall State	An unexpected combination of Hall inputs has occurred. Invalid states detected: Encoder Feedback Connector: U,V,W (J4 pins 7, 9,11) all ON at the same time. U',V',W' (J4 pins 8,10,12) all ON at the same time. U,V,W (J4 pins 7, 9,11) all OFF at the same time. U',V',W' (J4 pins 8,10,12) all OFF at the same time.
When enabling axis		• Bad feedback cable ⇒ Check pins above (see cable diagrams in Appendix E) • Wrong axis feedback type selected in ServoWire Setup software settings ⇒ Correct software.	

Indication	Code	Status	Description
F4	244	Motor Over Temperature	The thermal contact has opened indicating that the motor is over temperature. This condition can not be reset until the motor has sufficiently cooled. Encoder connector (J4 pins 19 & 20) Resolver connector (SAC-SM-RES pins 10 & 23)
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 E). • Motor has no thermal switch, and ServoWire Setup software settings are configured to expect a closed contact. ⇒ Disable Thermal Contact in ServoWire Setup Axis Configuration • Defective Servodrive ⇒ Replace Servodrive	

Indication	Code	Status	Description
F5	245	Unknown Option Module	The drive has detected an installed option module, but does not recognize and/or support that module type. • Not supported by the drive firmware ⇒ Verify that the drive firmware revision supports the option module, and update as needed. • Improper option module installation ⇒ Reinstall the option module and verify it is properly connected to the drive. • Defective option module ⇒ Replace the option module

Indication	Code	Status	Description
F6	246	Overtemp Config. error.	The motor configuration indicates that there is no over temperature sensor, but an over temperature sensor was detected by the drive.

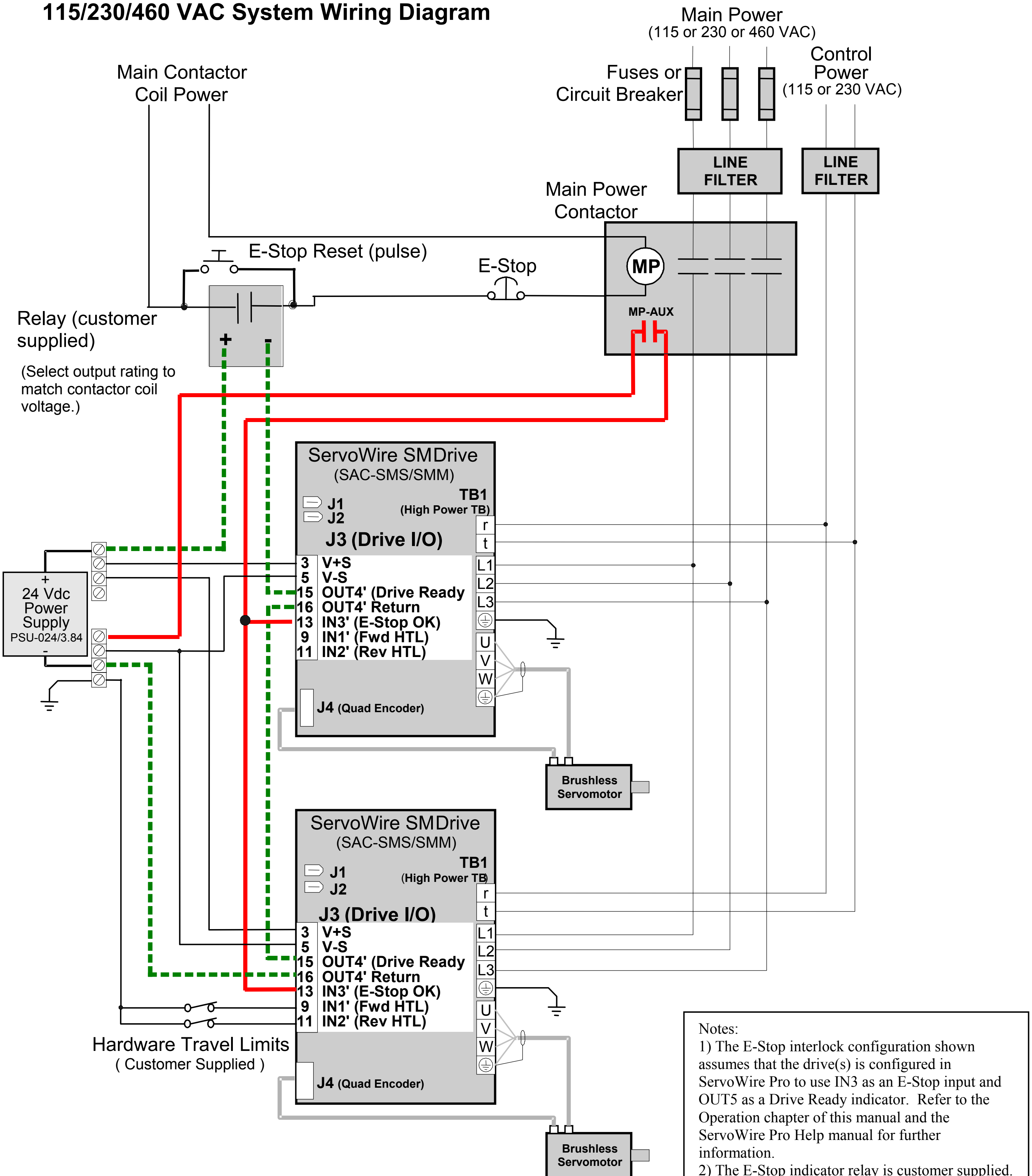
Indication	Code	Status	Description
F7	247	Serial Encoder Alarm.	When using a H-Series motors An alarm bit has been returned by the H-Series serial encoder. • Check connections & feedback cable for good electrical connection. • Try cycling the ServoWire Drive control power. • Defective encoder feedback - Replace Servomotor.

Indication	Code	Status	Description
F8	248	Unsupported Serial Encoder detected.	• Unsupported encoder feedback type detected - Replace servomotor to a supported type. • Not supported by the drive firmware - Verify that the drive firmware revision supports the Serial Encoder, and update as needed.

7.2 Servomotor Troubleshooting Guide

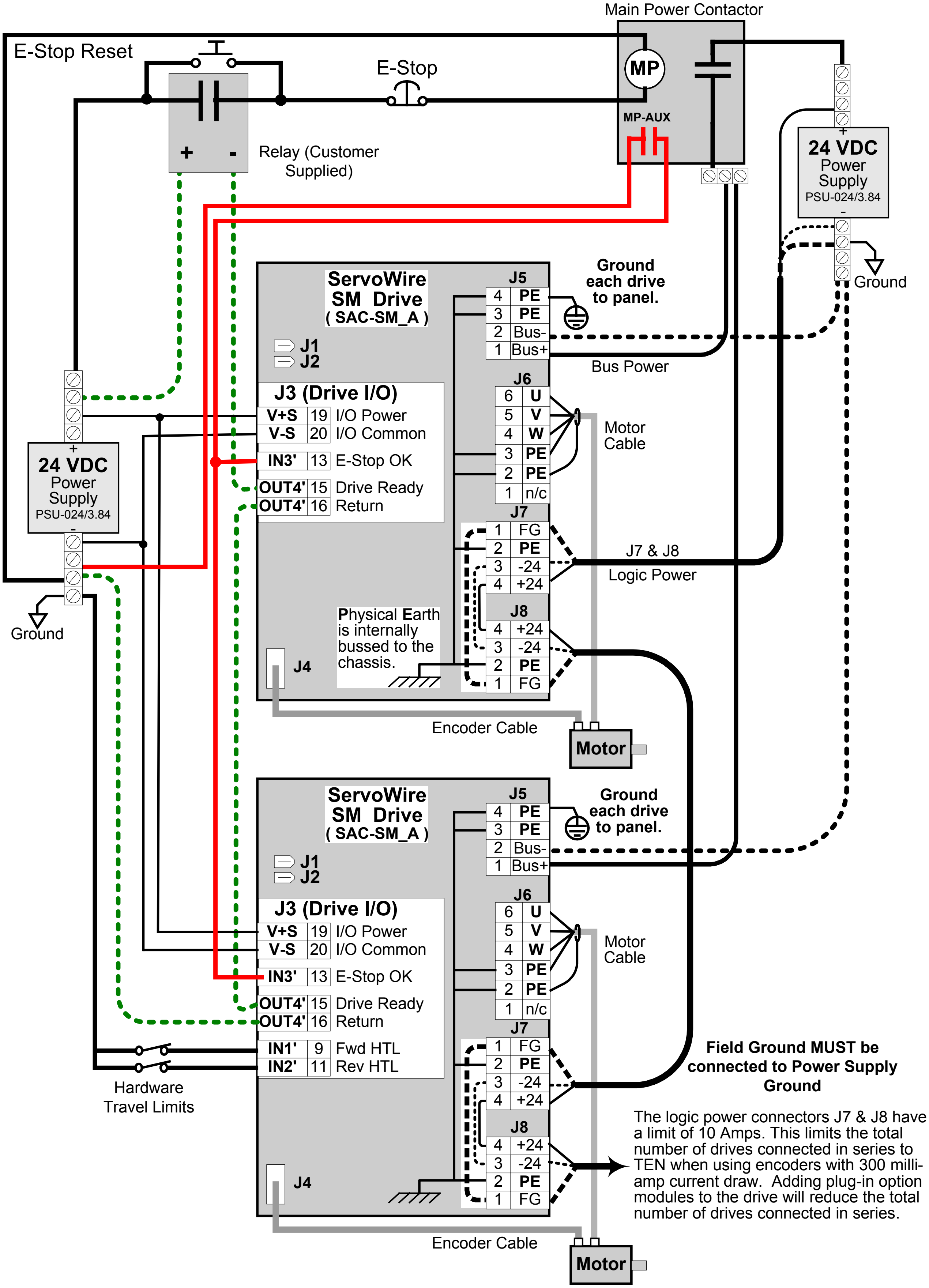
Problem	Cause	What to do
Motor does not start	Loose Connection ⇒ Tighten connection	
	Wrong wiring ⇒ Correct wiring	
	Overload ⇒ Reduce load or use a larger motor	
	Motor defective	Measure voltage across motor terminals U, V, & W on the Servodrive. If correct, replace motor, otherwise replace servodrive.
	Servodrive Defective	
Locked Rotor	Wrong order of U, V, W	Check cabling.
Unstable Operation	Wrong motor selected in the configuration software.	Check & correct that software matches motor.
	Improper Tuning	Check that Inertial load specified in the configuration software 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 40ºC, 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 is mis-aligned	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 (SAC-SM_210, SAC-SM_217, SAC-SM_220)	Use 3-phase power.
WARNING!!! Turn off power before working on the Servomotor		

115/230/460 VAC System Wiring Diagram

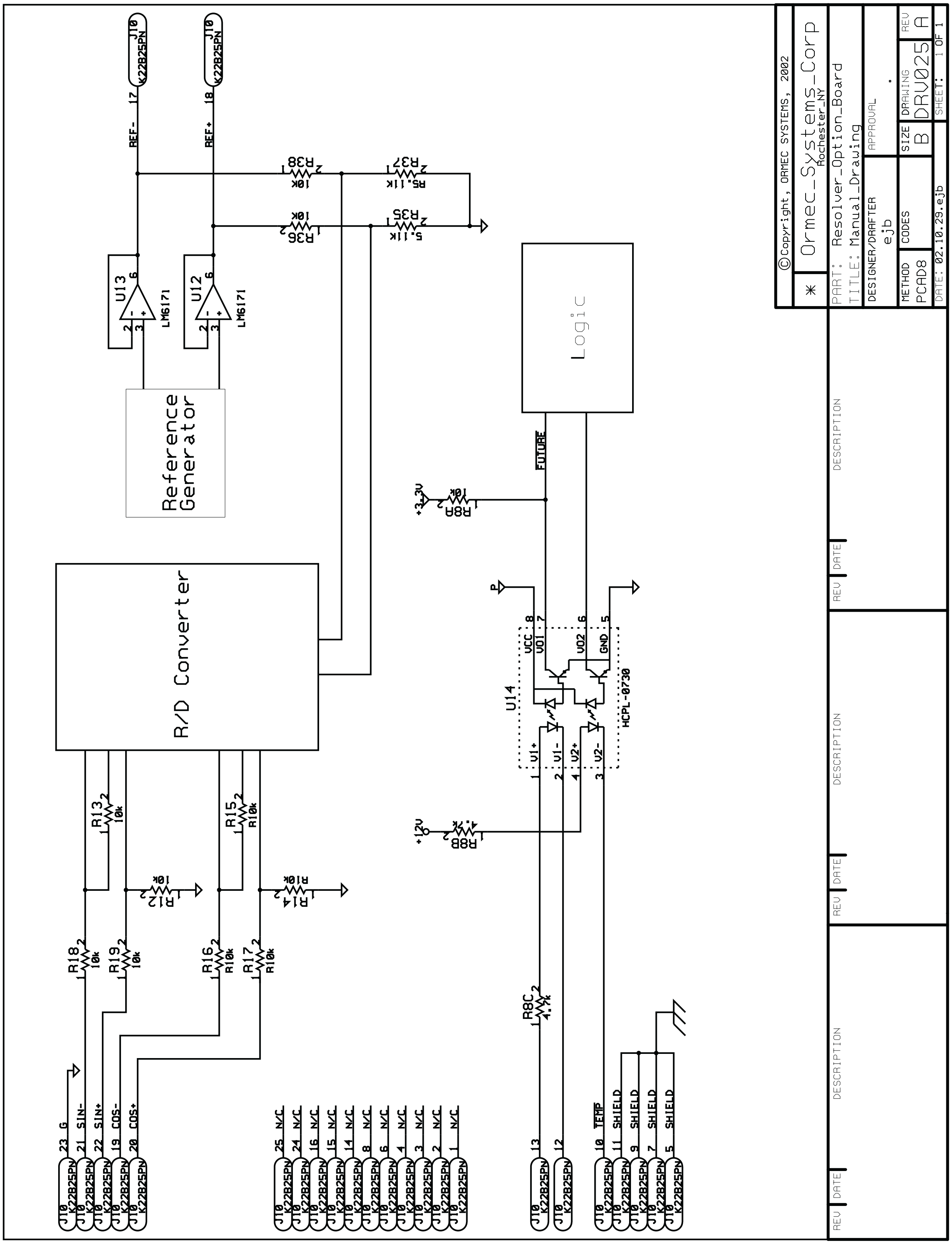


Notes:
1) The E-Stop interlock configuration shown assumes that the drive(s) is configured in ServoWire Pro to use IN3 as an E-Stop input and OUT5 as a Drive Ready indicator. Refer to the Operation chapter of this manual and the ServoWire Pro Help manual for further information.
2) The E-Stop indicator relay is customer supplied. Refer to Note 1.
3) The Drive Ready relay is customer supplied.
The Interlock and I/O power should be provided by separate power supplies to prevent inductive in-rush from the Drive Ready relay

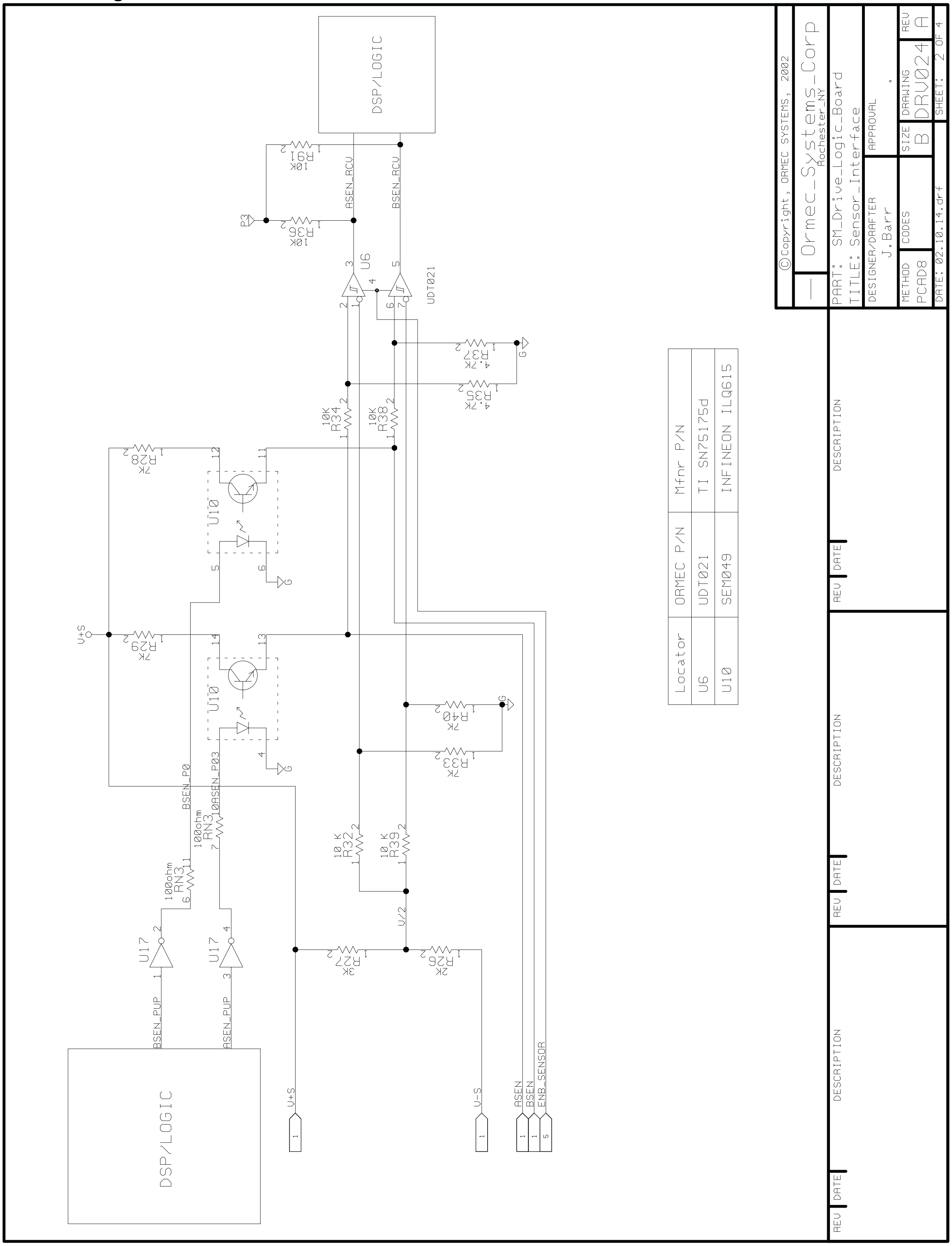
24-96 VDC System Wiring



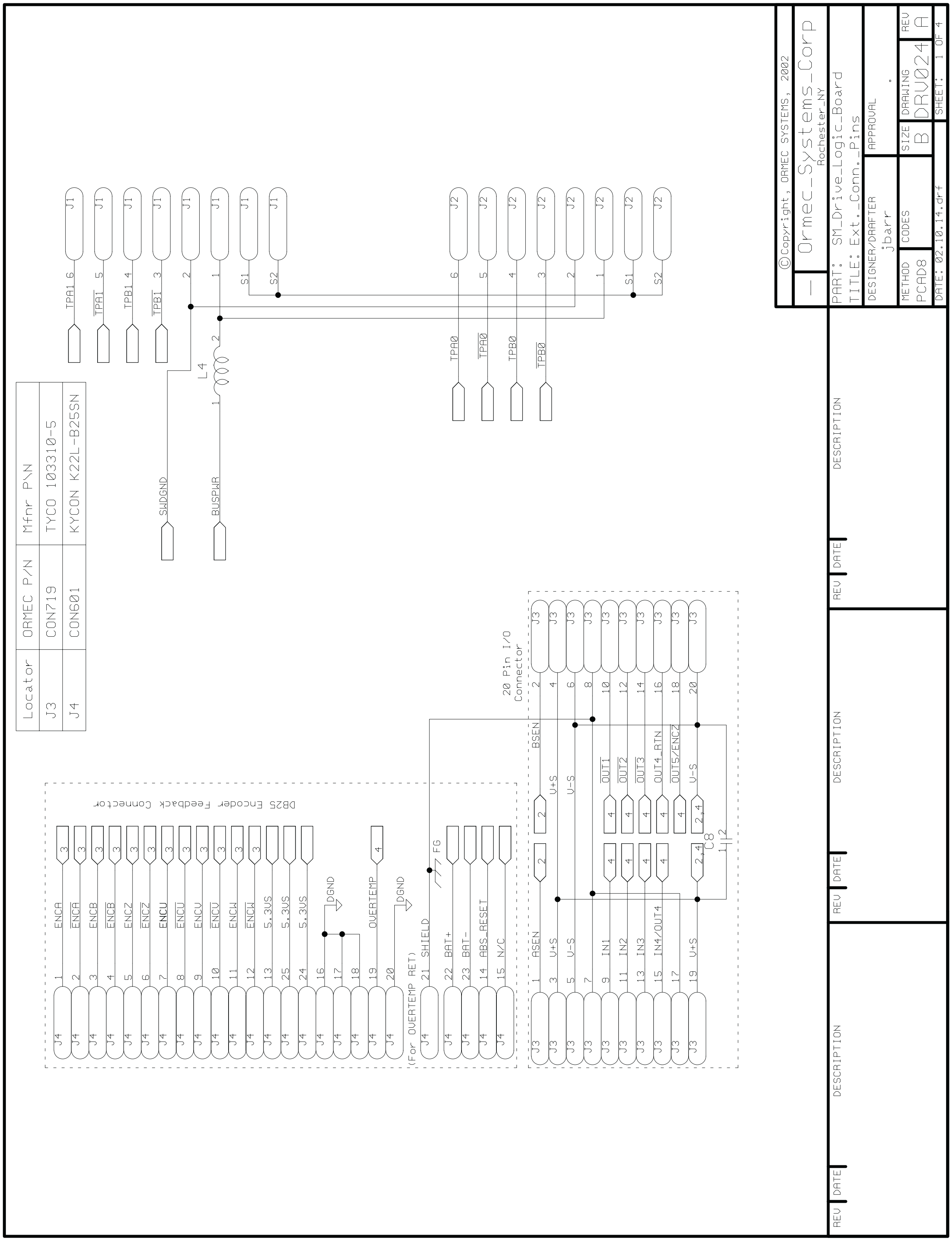
Resolver Option Board



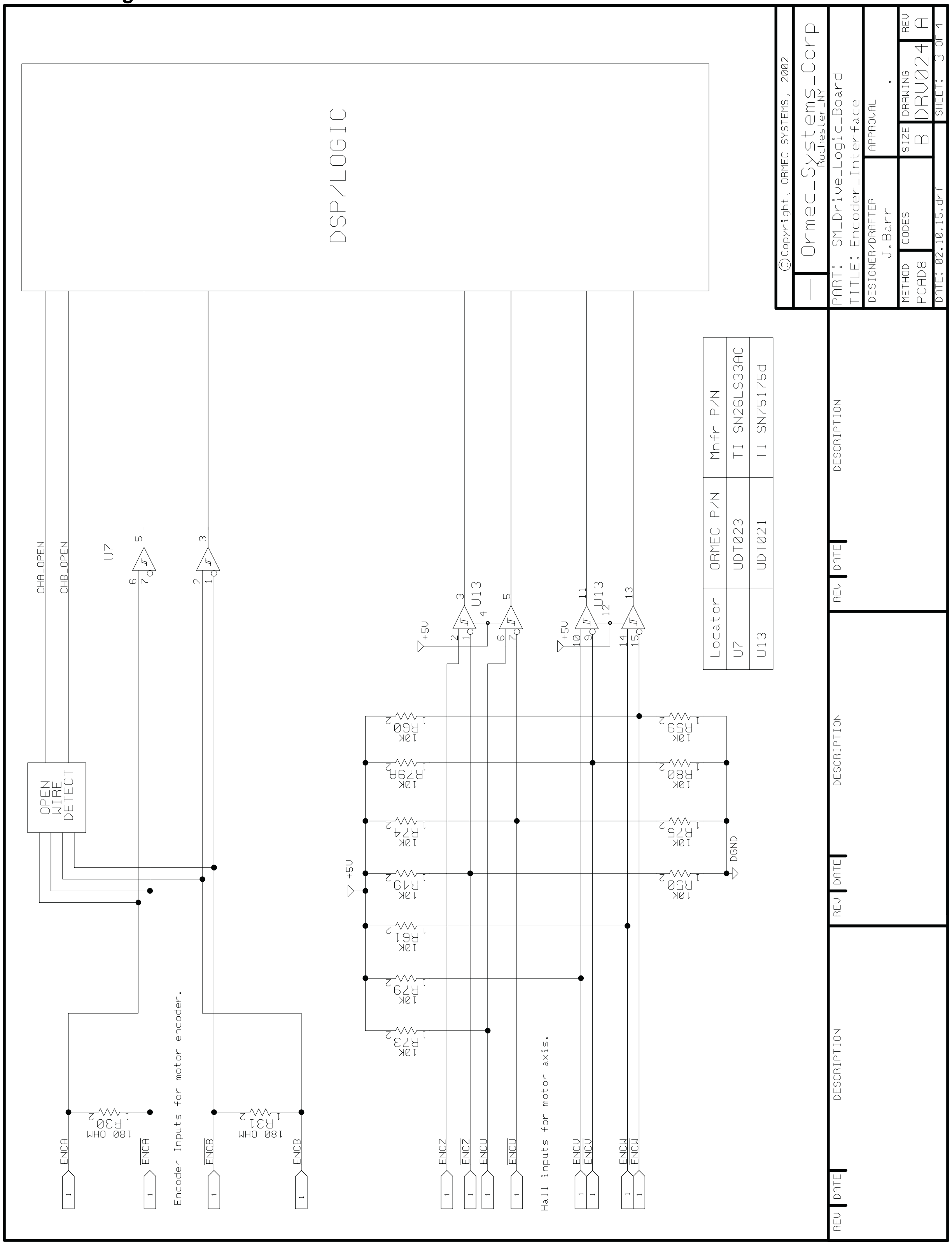
SM Drive Logic Board - Sensor Interface



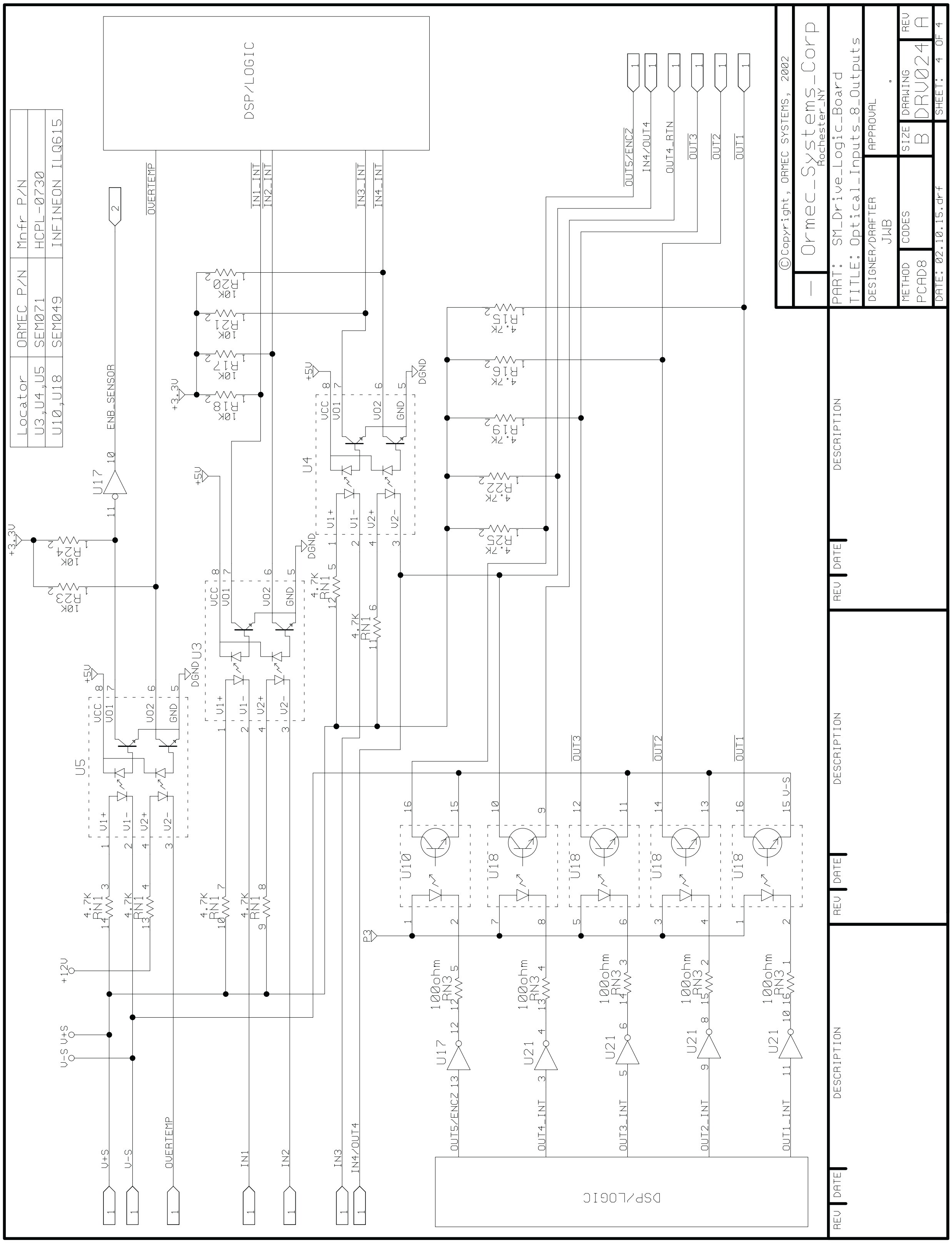
SM Drive Logic Board - External Connection Pinout



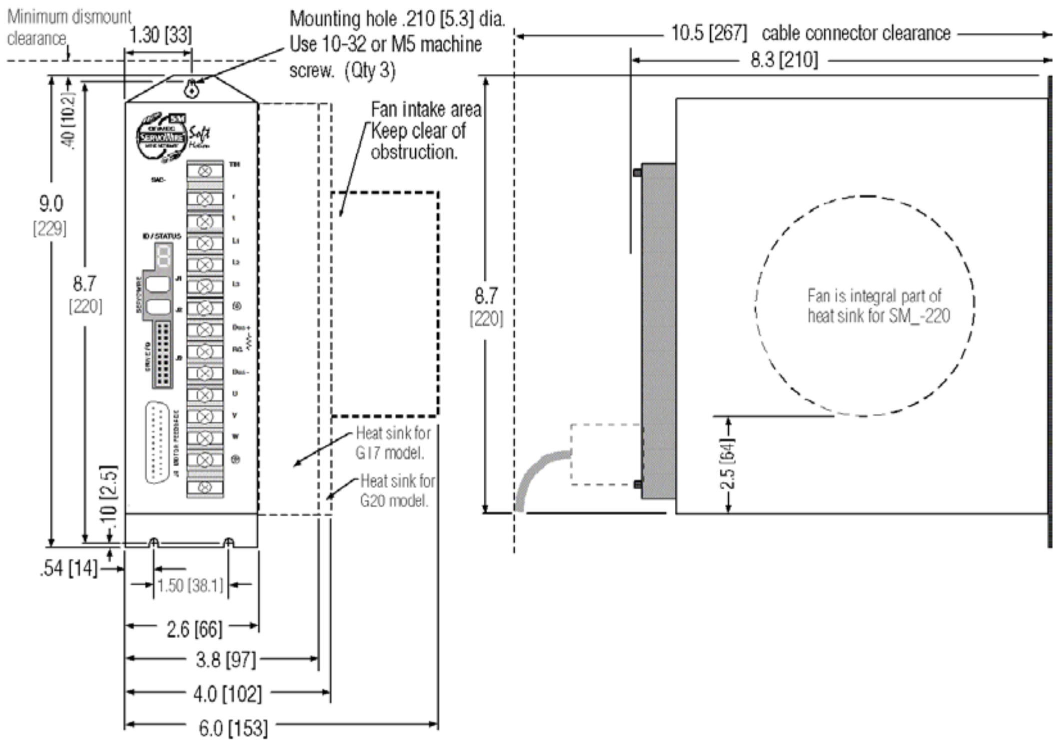
SM Drive Logic Board - Encoder Interface



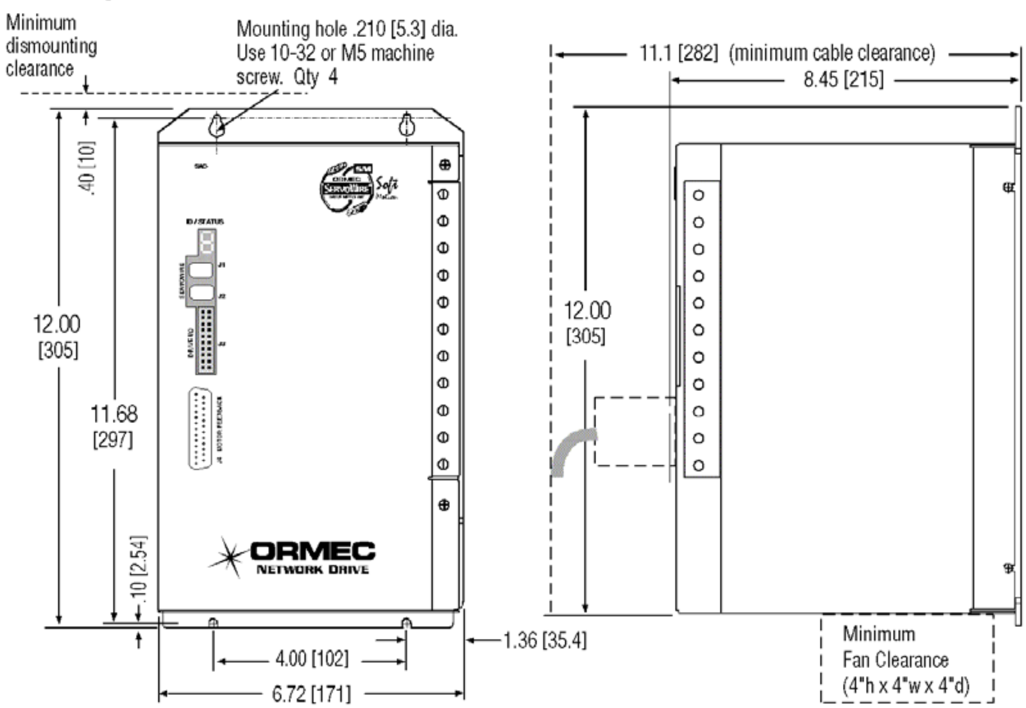
SM Drive Logic Board - Optical Inputs & Outputs



Mounting Information for SAC-SM_-203, 205, 210, 217 & 220



Mounting Information for SAC-SM_-225, 235 & 260



NOTE: Dimensions in inches [millimeters]

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

SAC-SM_203, SAC-SM_205 and SAC-SM_210

Add 2” (51 mm) clearance top and bottom.

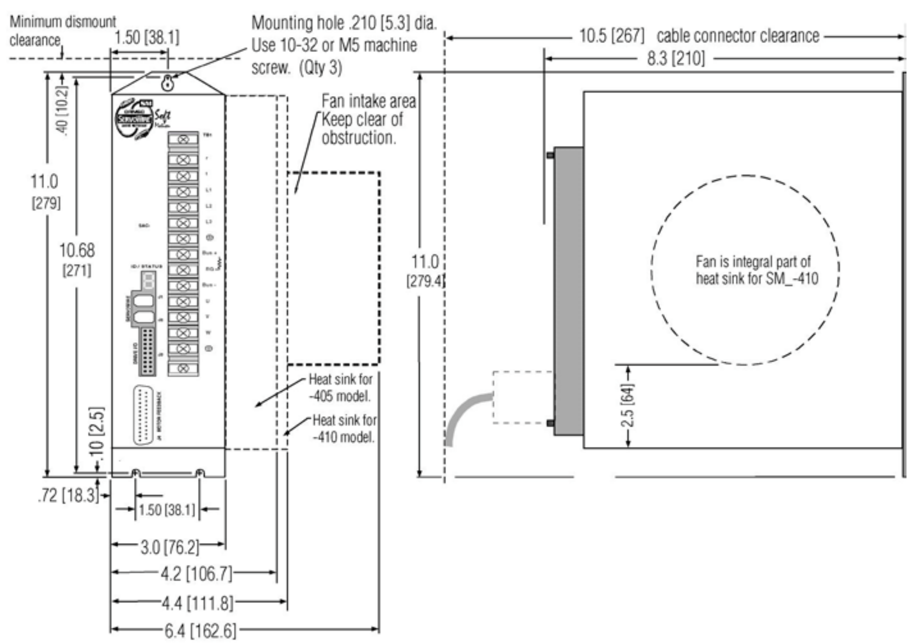
Add 1” (25 mm) clearance each side.

SAC-SM_217 and SAC-SM_405
Add 2" (51 mm) clearance top and bottom.
Add 1.2" (31 mm) clearance each side.

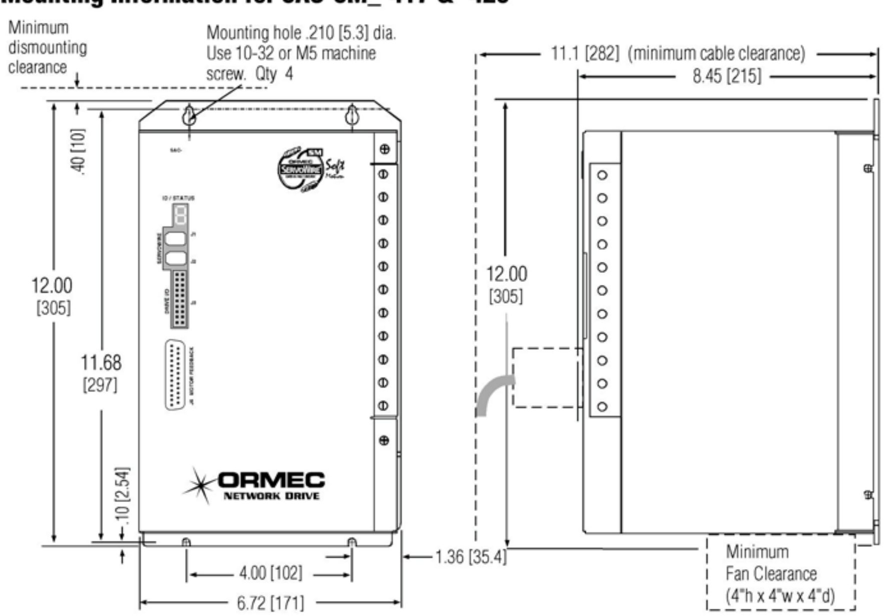
SAC-SM_220 and SAC-SM_410
Add 2" (51 mm) clearance top and bottom.
Add 1" left-side, 2" (51 mm) right-side clearance

SAC-SM_225, **SAC-SM_235, SAC-SM_260, SAC-SM_417, SAC-SM_425, SAC-SM_435 and SAC-SM_450**
Add 2" (51 mm) clearance.
Add 4" (102 mm) clearance bottom.
Add 1" (25 mm) clearance each side.

Mounting Information for SAC-SM_-405 & 410

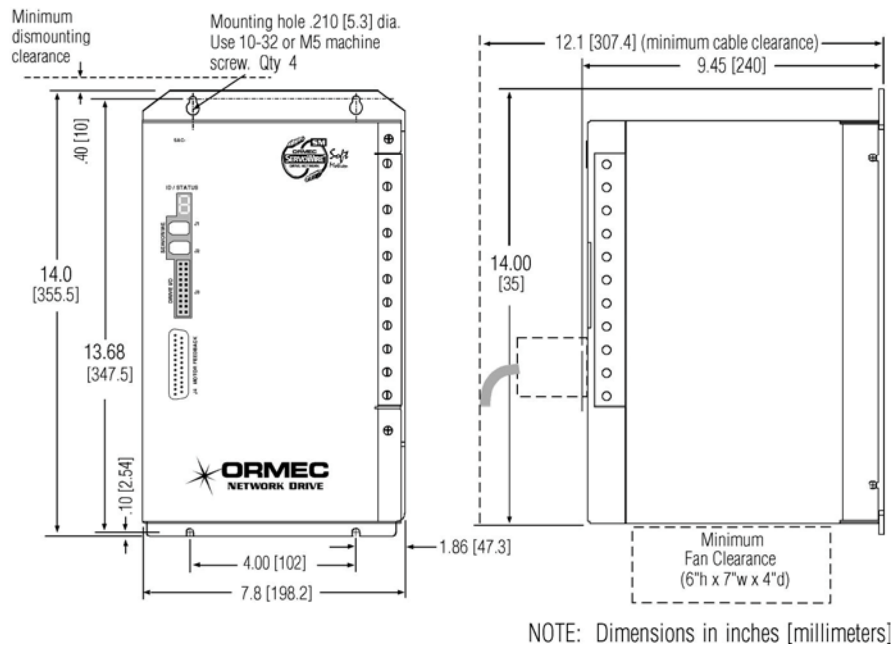


Mounting Information for SAC-SM_-417 & -425

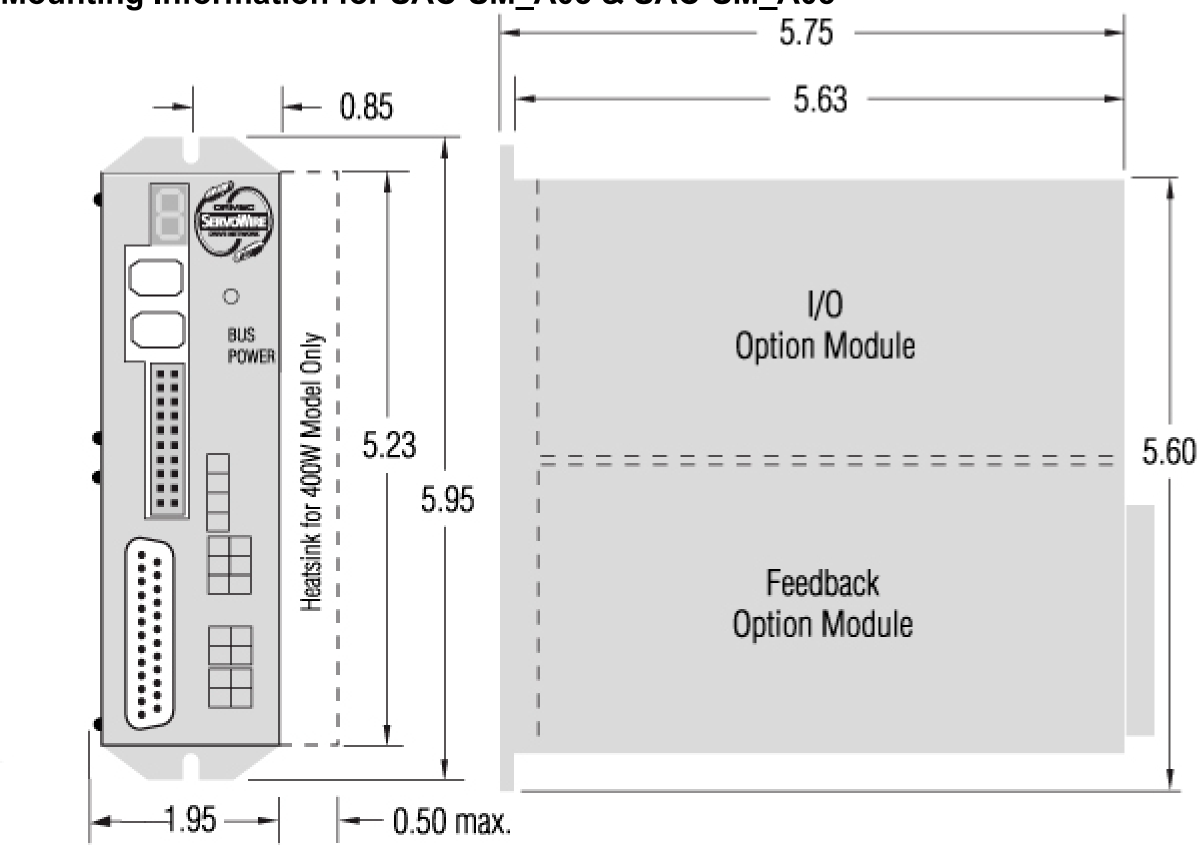


NOTE: Dimensions in inches [millimeters]

Mounting Information for SAC-SM_- 435 & 450

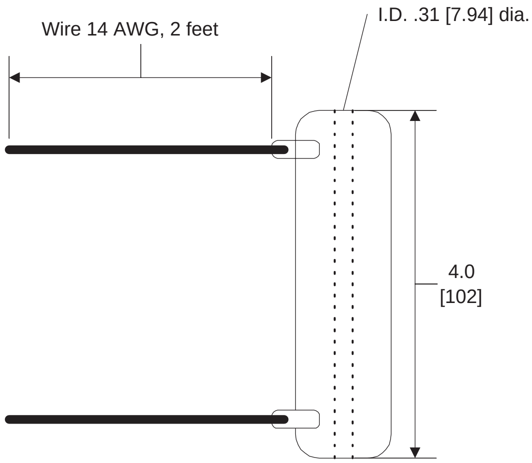


Mounting Information for SAC-SM_A03 & SAC-SM_A05

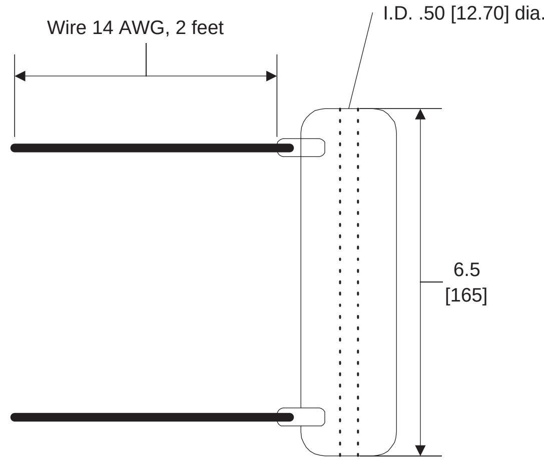


Additional clearance above, below and to the sides of the ServoWire Drives is also required for heat dissipation:
SAC-SM_A03 and SAC-SM_A05
Add 1” (25 mm) clearance top and bottom.
Add 0.5” (13 mm) clearance each side.

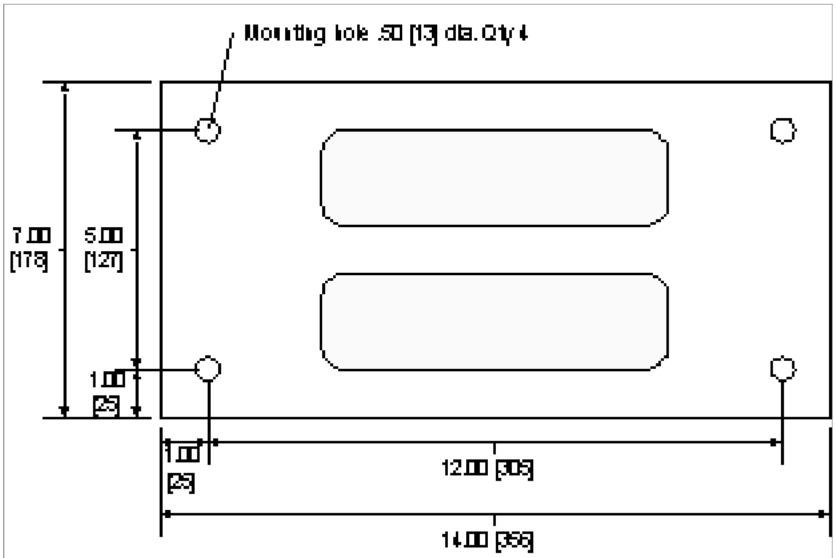
Regen Resistors



SAC-SWRR/0055

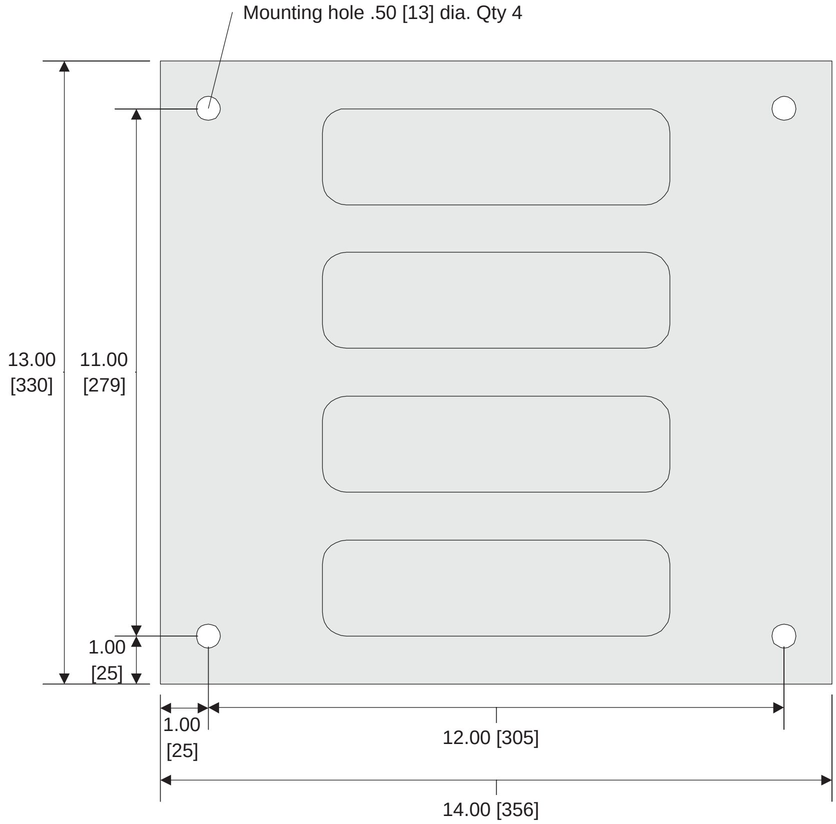


SAC-SWRR/0095



SAC-SWRR/0700, 0845, 0846

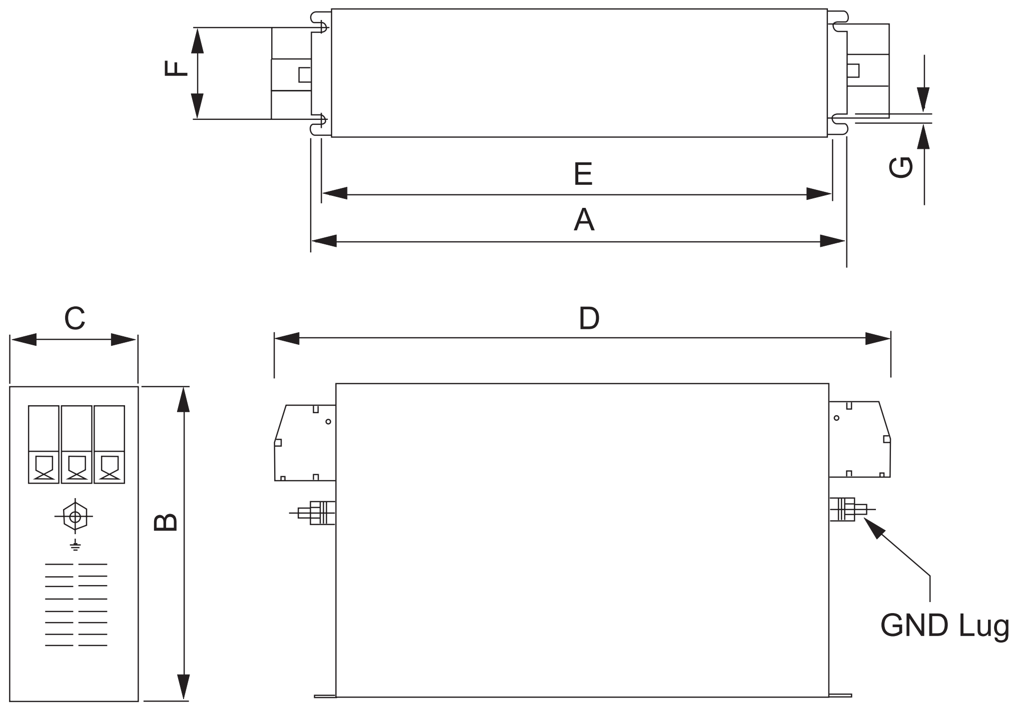
All dimensions in inches [mm]



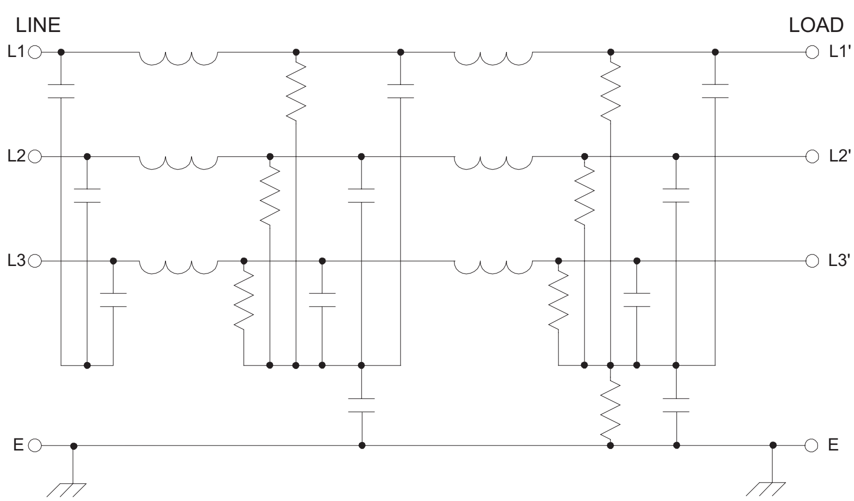
SAC-SWRR/1700

All dimensions in inches [mm]

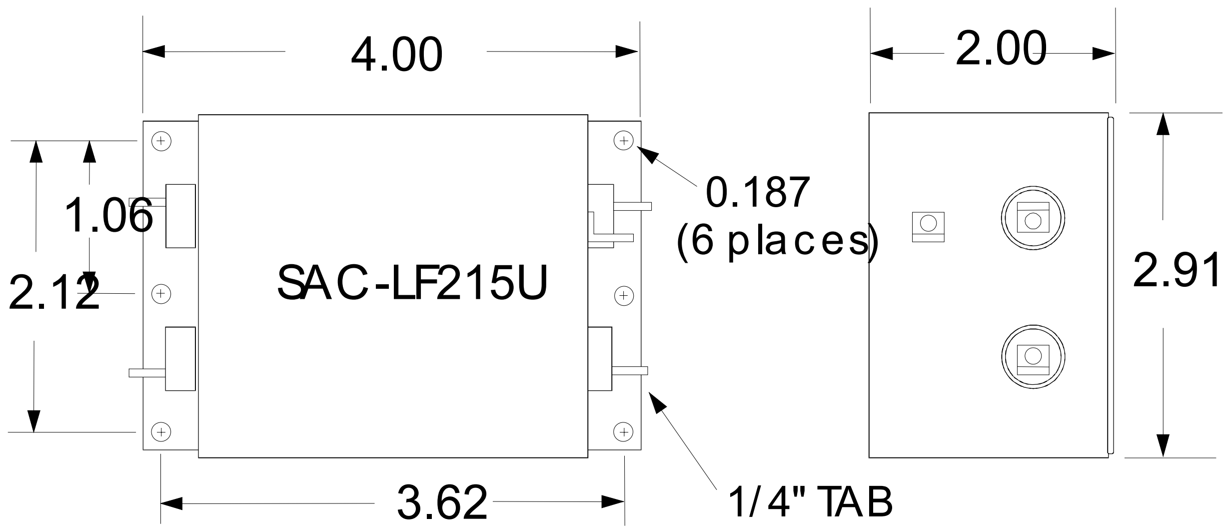
Line Filters: SAC-LF30C, 55C, & 100C



Line Filter	A	B	C	D	E	F	G	Units	GND Lug	Max. Wire Gauge
SAC-LF30C	13.2	5.9	2.4	13.9	12.6	1.4	0.3	inches	M5	6 AWG
	335	150	60	354	320	35	6.5	mm		10 mm2
SAC-LF55C	13.0	7.3	3.1	14.8	12.4	2.2	0.3	inches	M6	3 AWG
	329	185	80	377	314	55	6.5	mm		25 mm2
SAC-LF100C	14.9	8.7	3.5	17.2	14.3	2.6	0.3	inches	M10	1/0 AWG
	379	220	90	436	364	65	6.5	mm		50 mm2

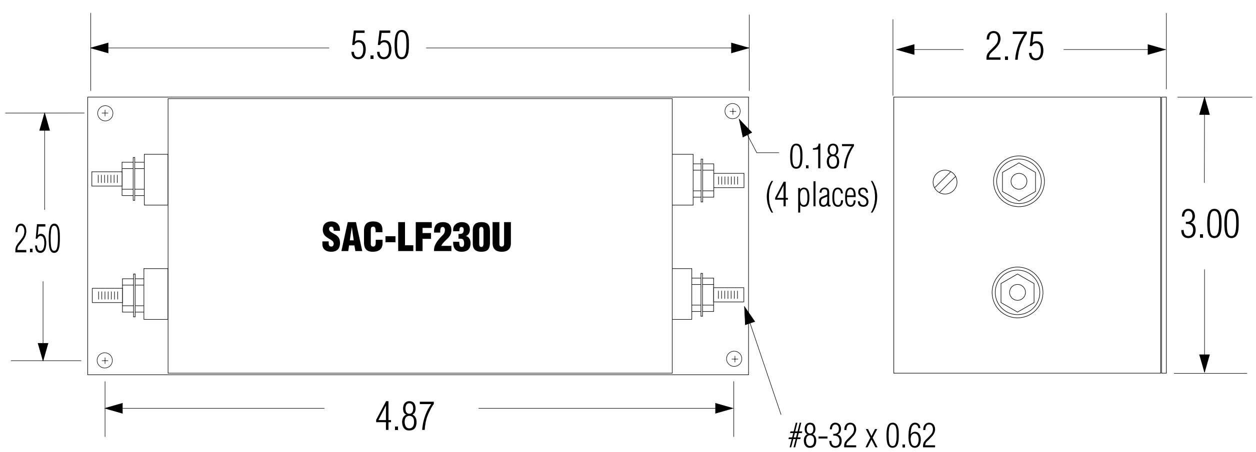


Line Filters: SAC-LF215U



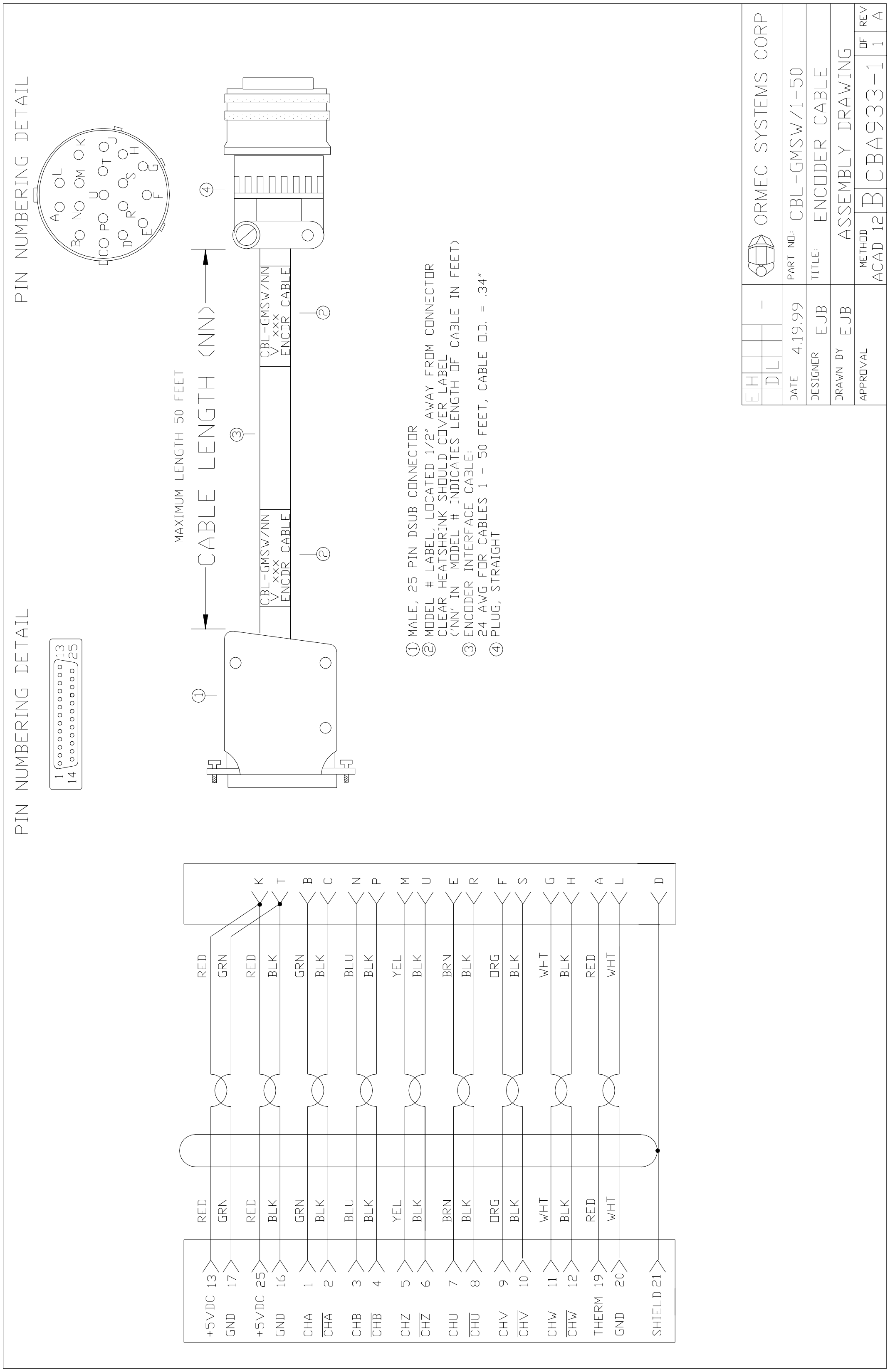
All dimensions in inches

Line Filters: SAC-LF230U

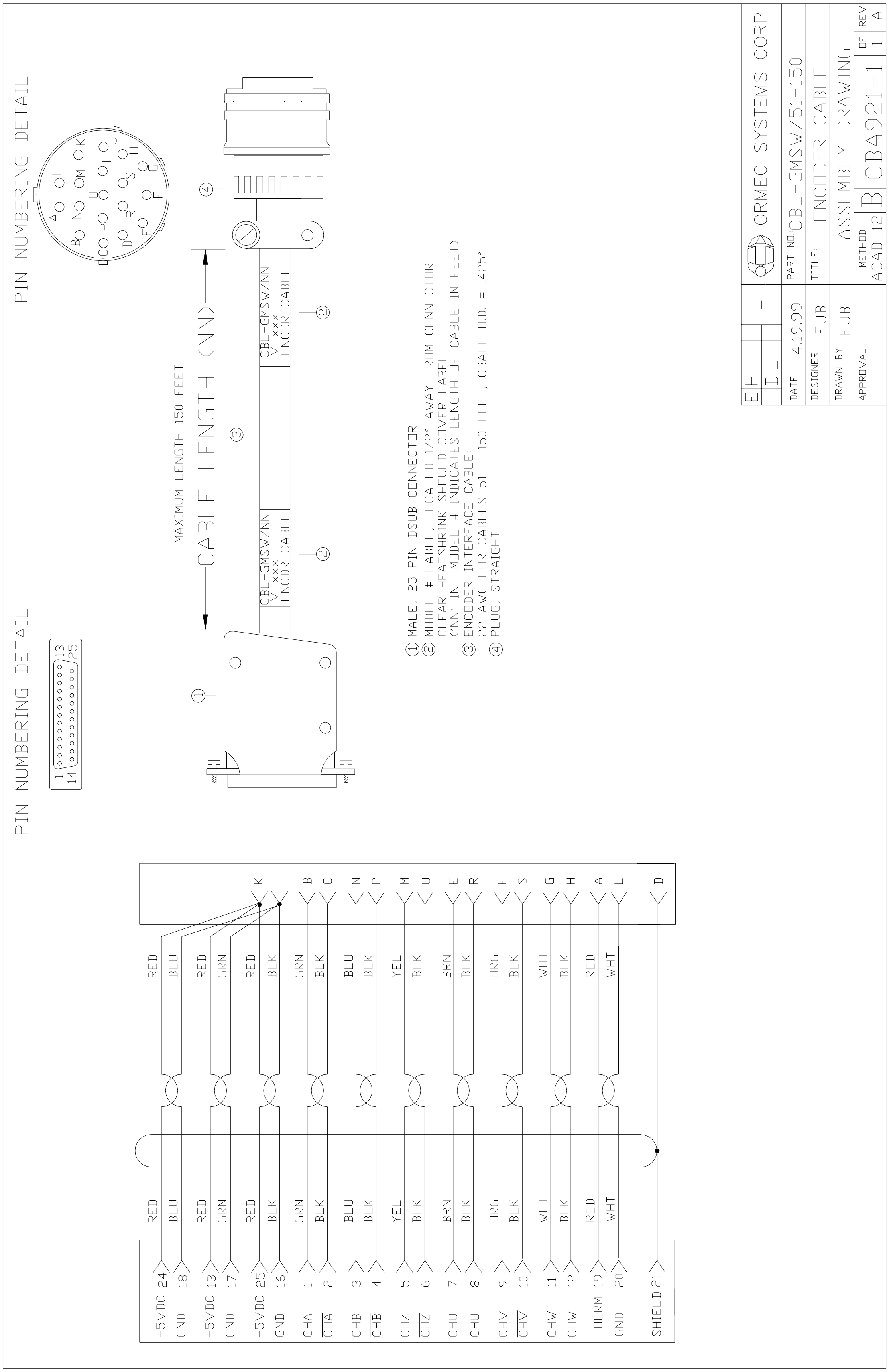


All dimensions in inches

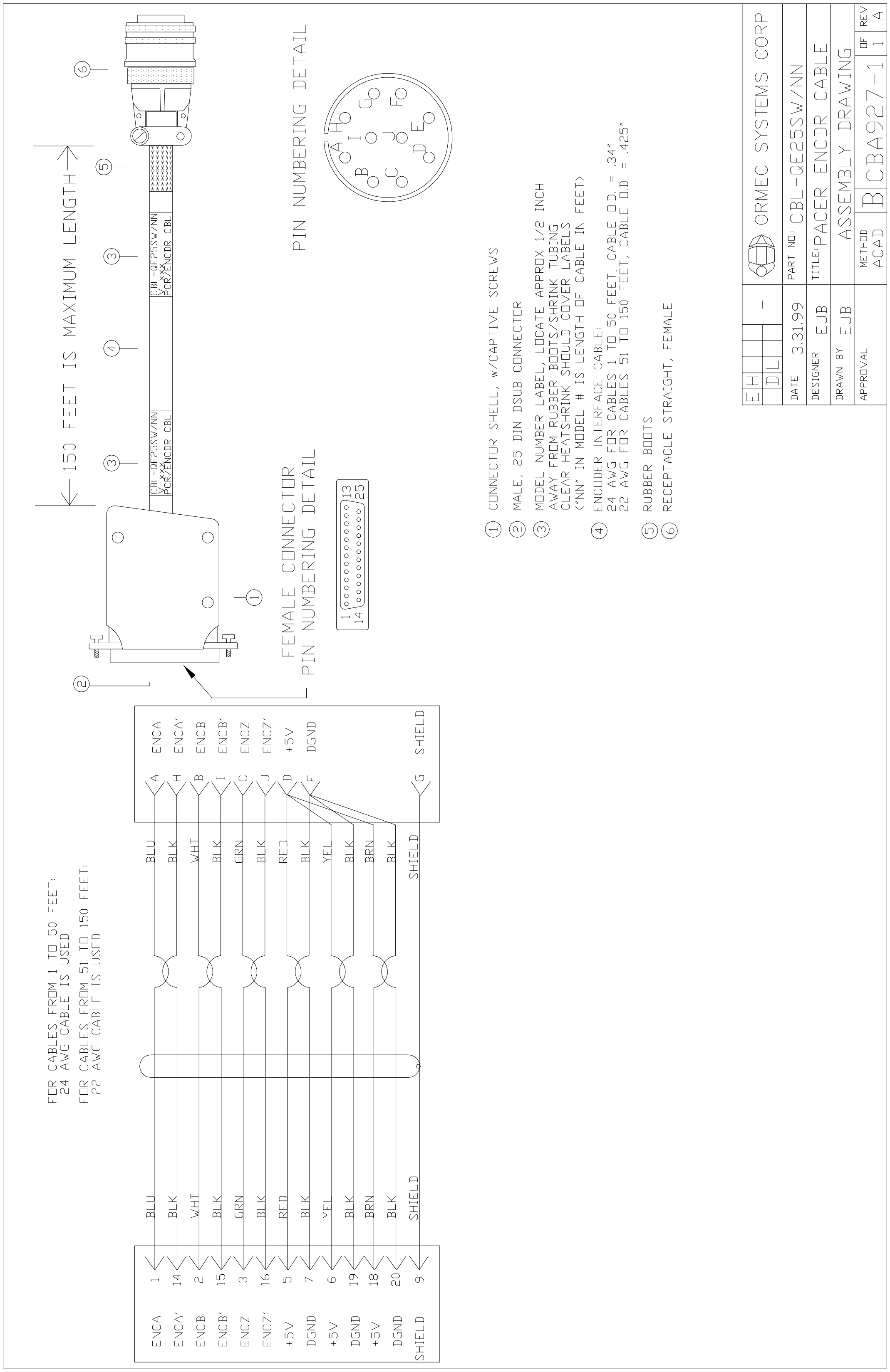
CBL-GMSW (1-50) Encoder Cable



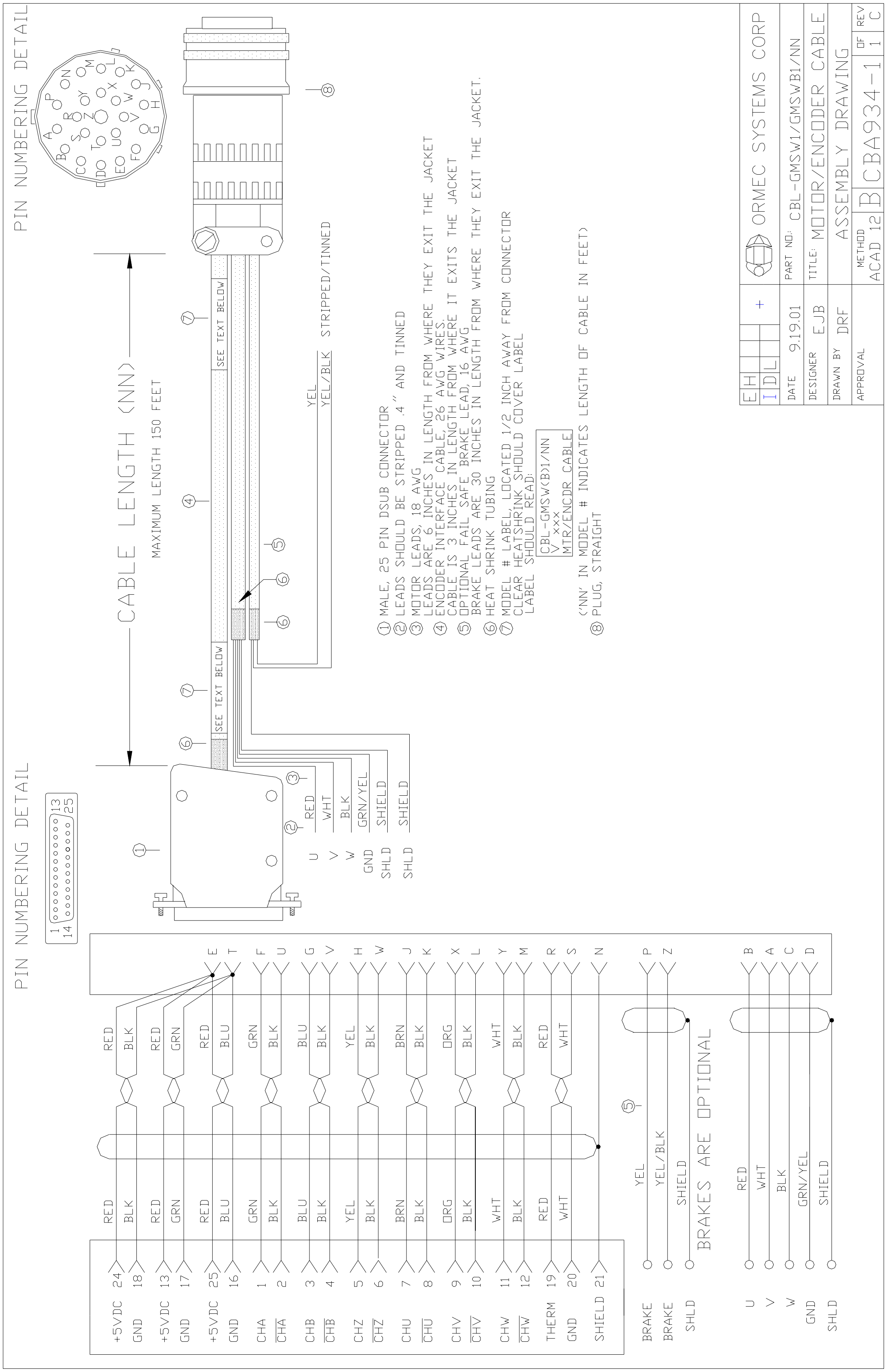
CBL-GMSW (51-150) Encoder Cable



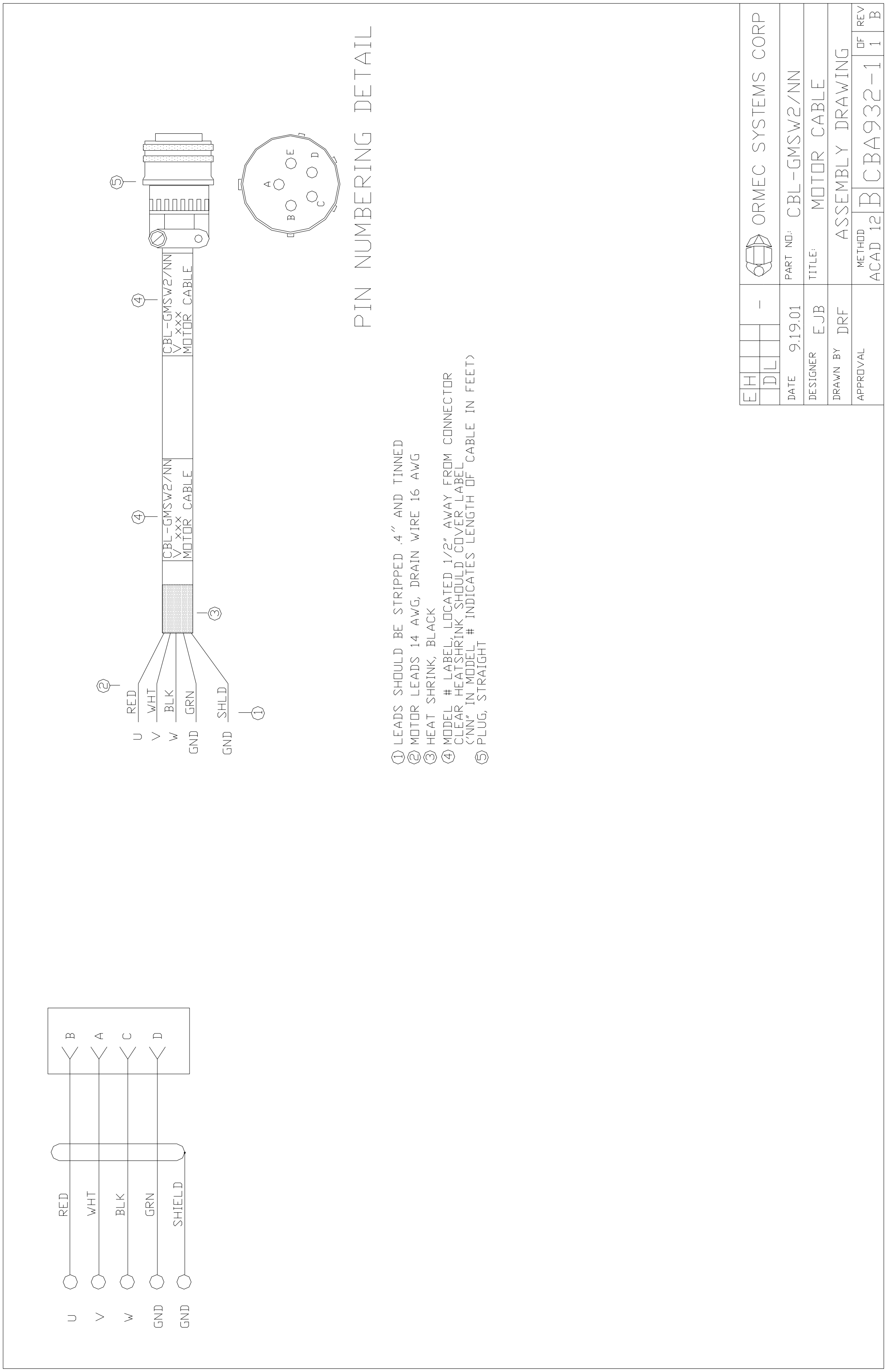
CBL-QE25SW Pacer Encoder Cable



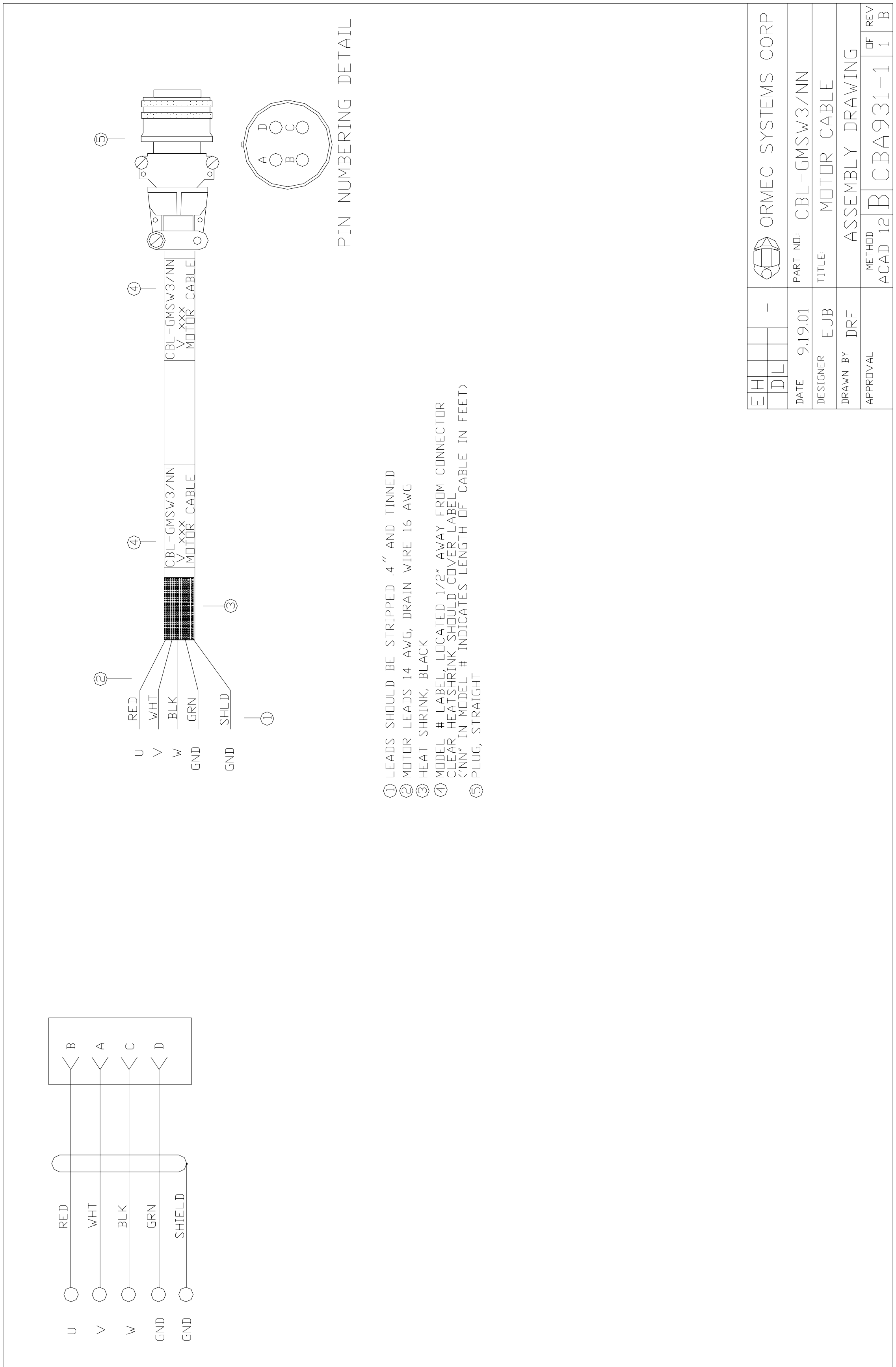
CBL-GMSW1 / GMSWB1 Motor/Encoder Cable



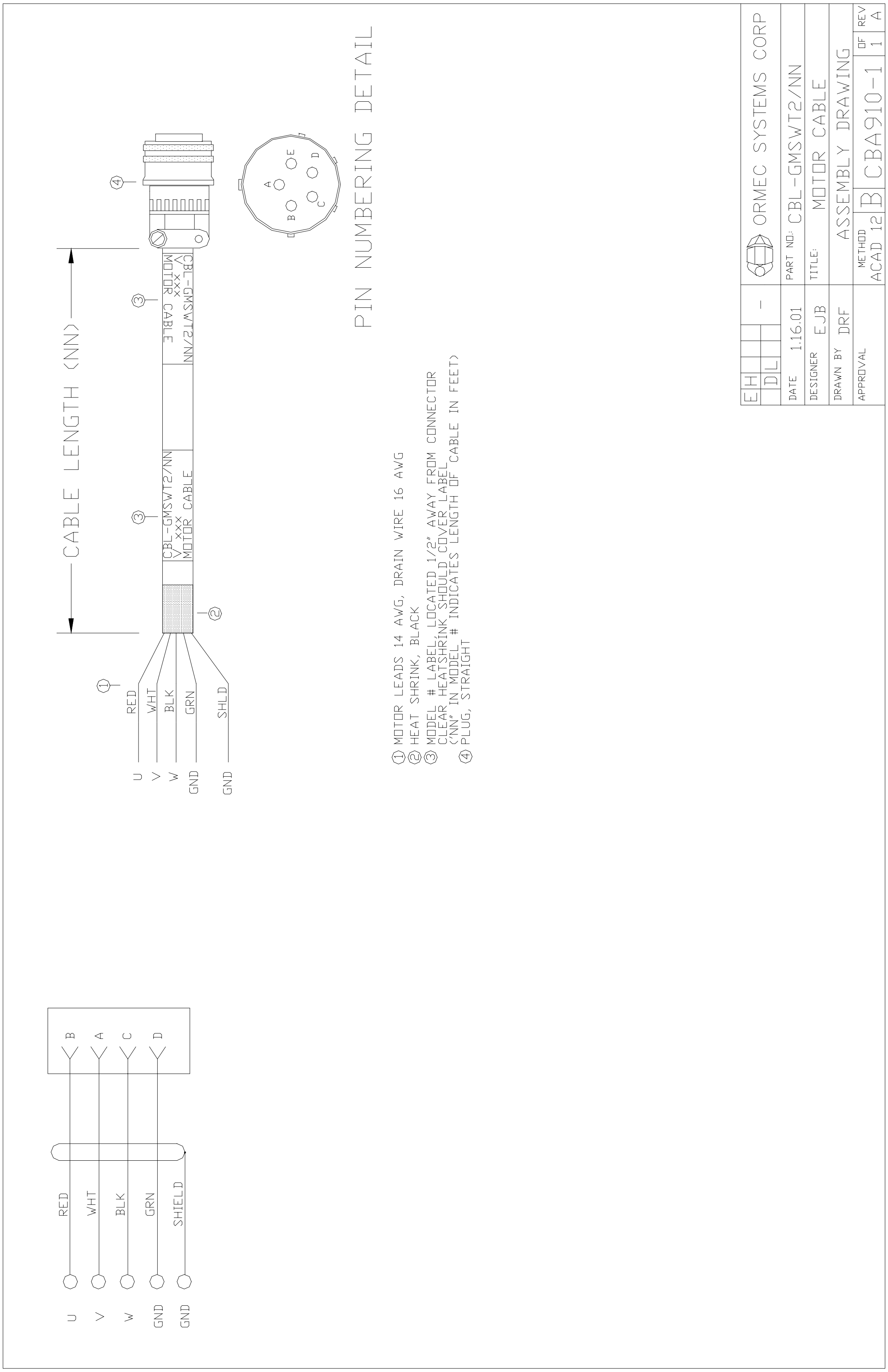
CBL-GMSW2 Motor Cable



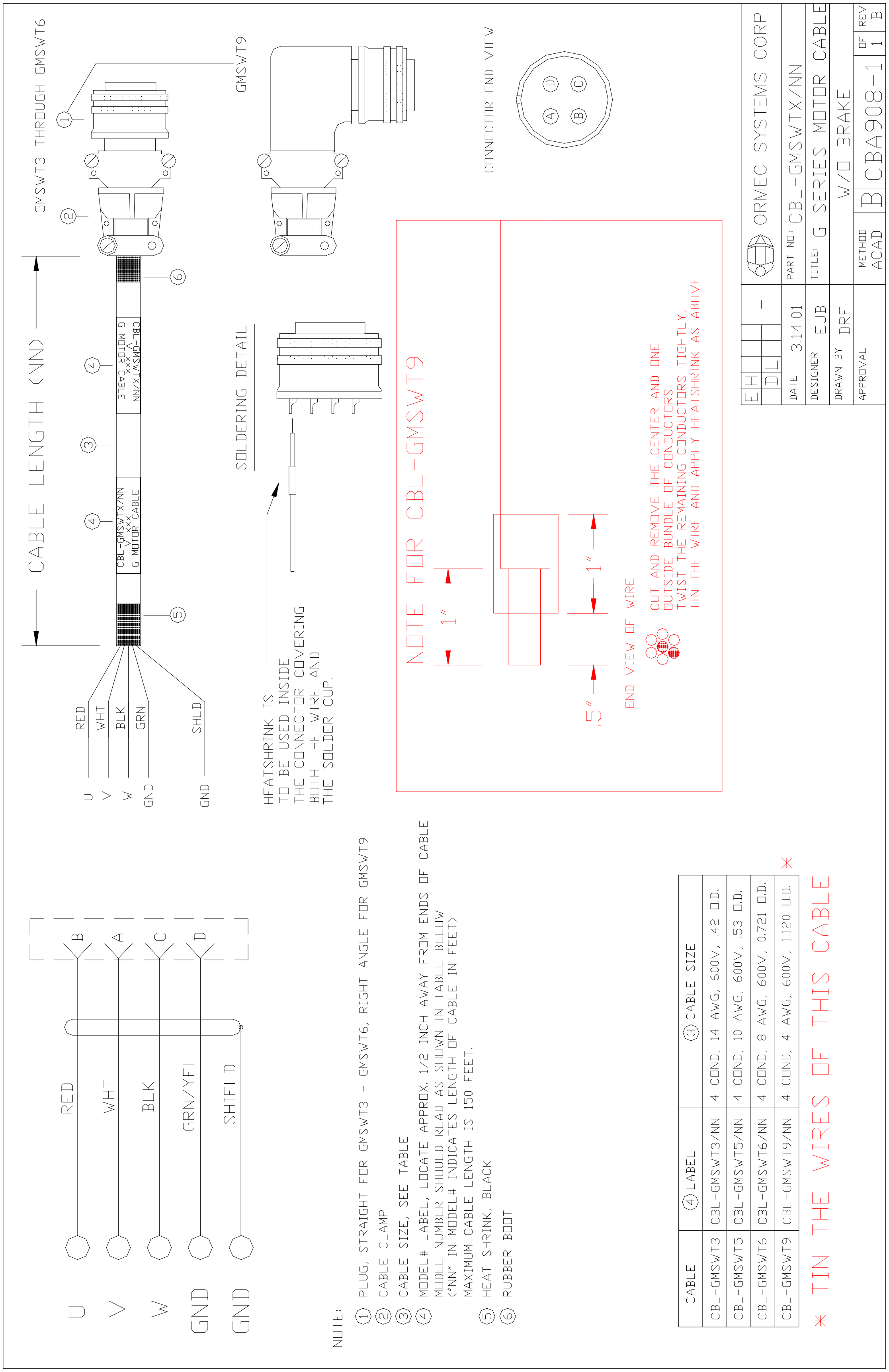
CBL-GMSW3 Motor Cable



CBL-GMSWT2 Motor Cable

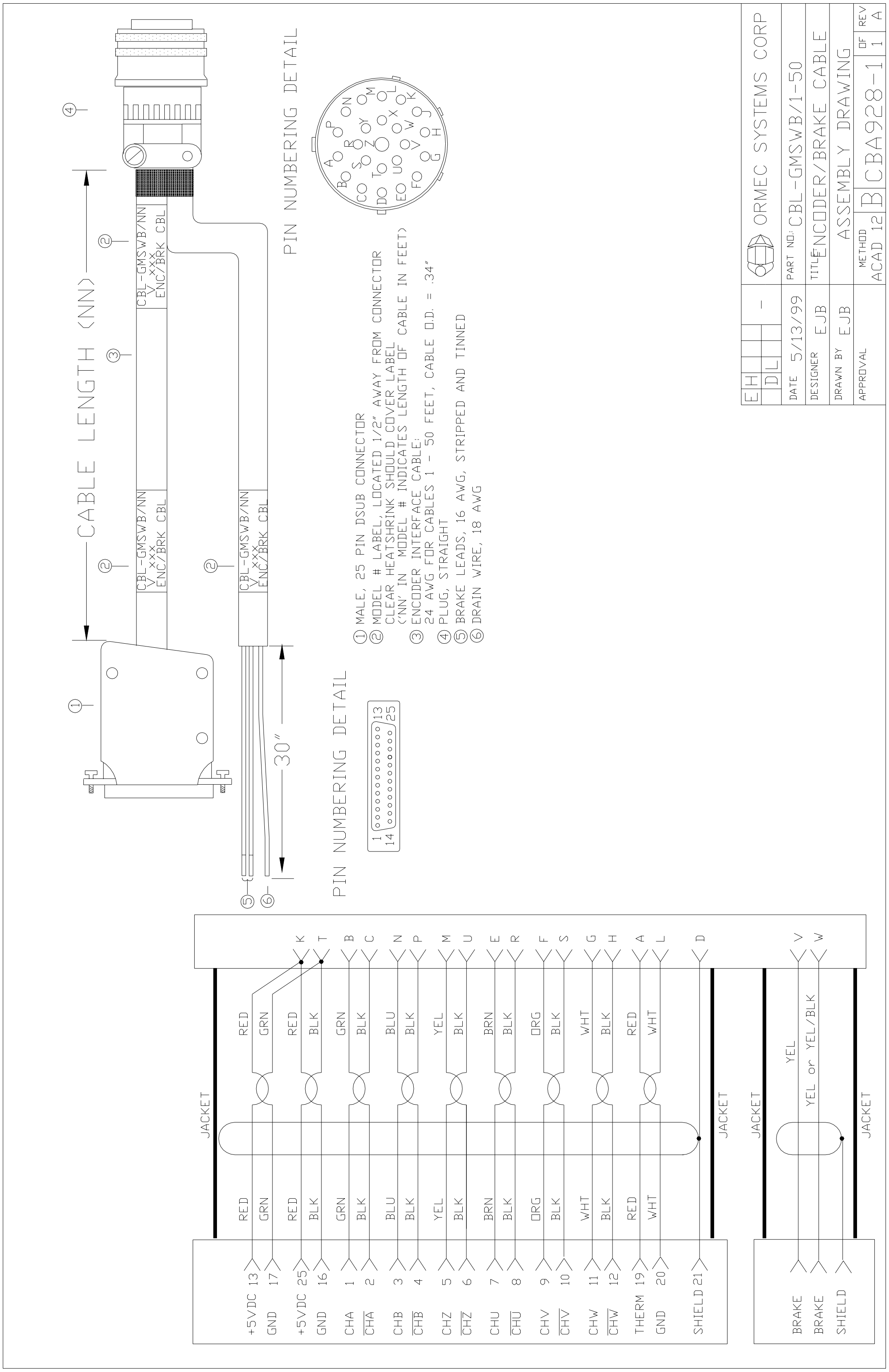


CBL-GMSWTX Motor Cable

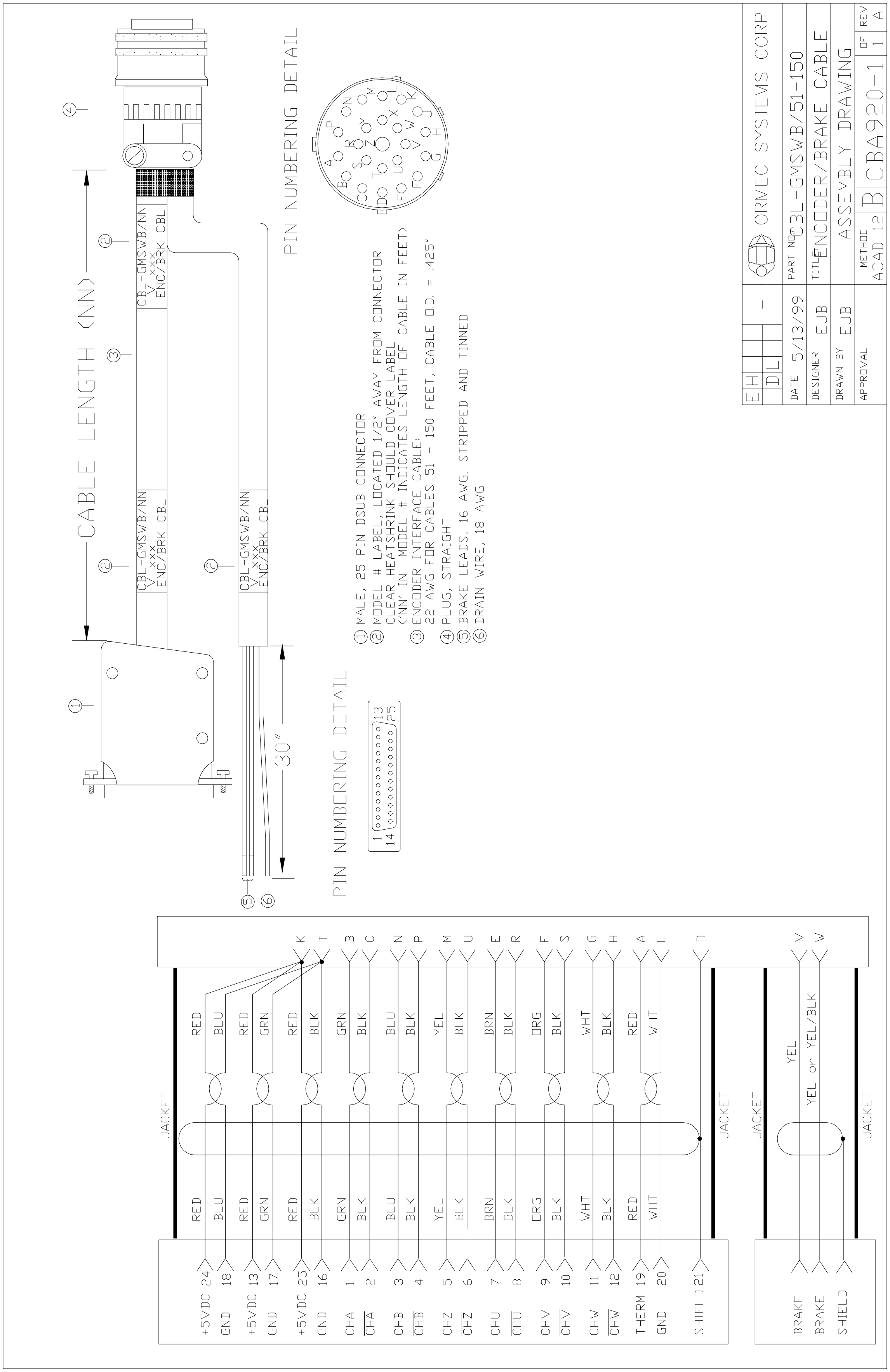


CABLE	(4) LABEL	(3) CABLE SIZE
CBL-GMSWT3	CBL-GMSWT3/NN	4 COND, 14 AWG, 600V, .42 O.D.
CBL-GMSWT5	CBL-GMSWT5/NN	4 COND, 10 AWG, 600V, .53 O.D.
CBL-GMSWT6	CBL-GMSWT6/NN	4 COND, 8 AWG, 600V, 0.721 O.D.
CBL-GMSWT9	CBL-GMSWT9/NN	4 COND, 4 AWG, 600V, 1.120 O.D.

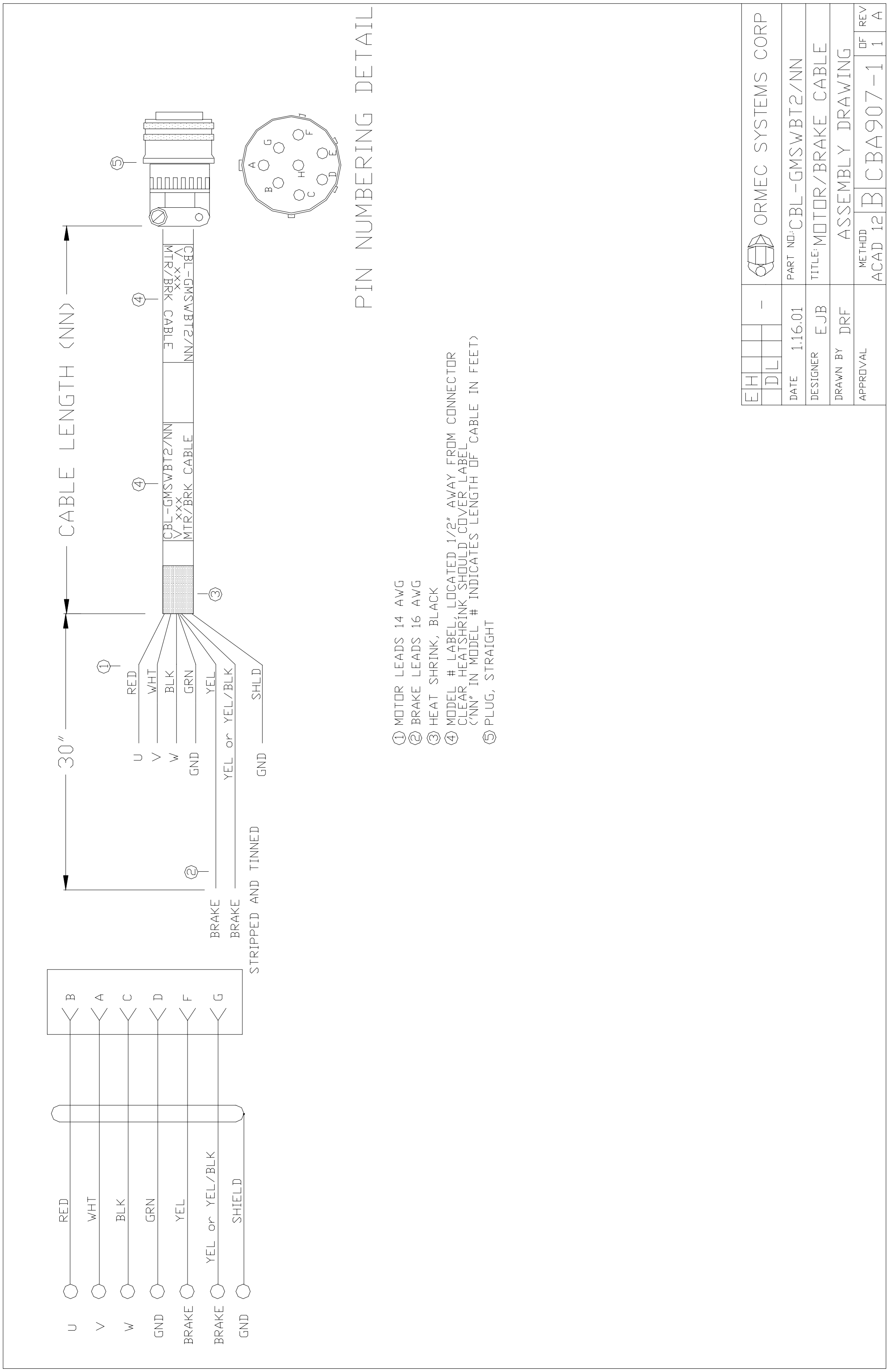
CBL-GMSWB Motor Cable



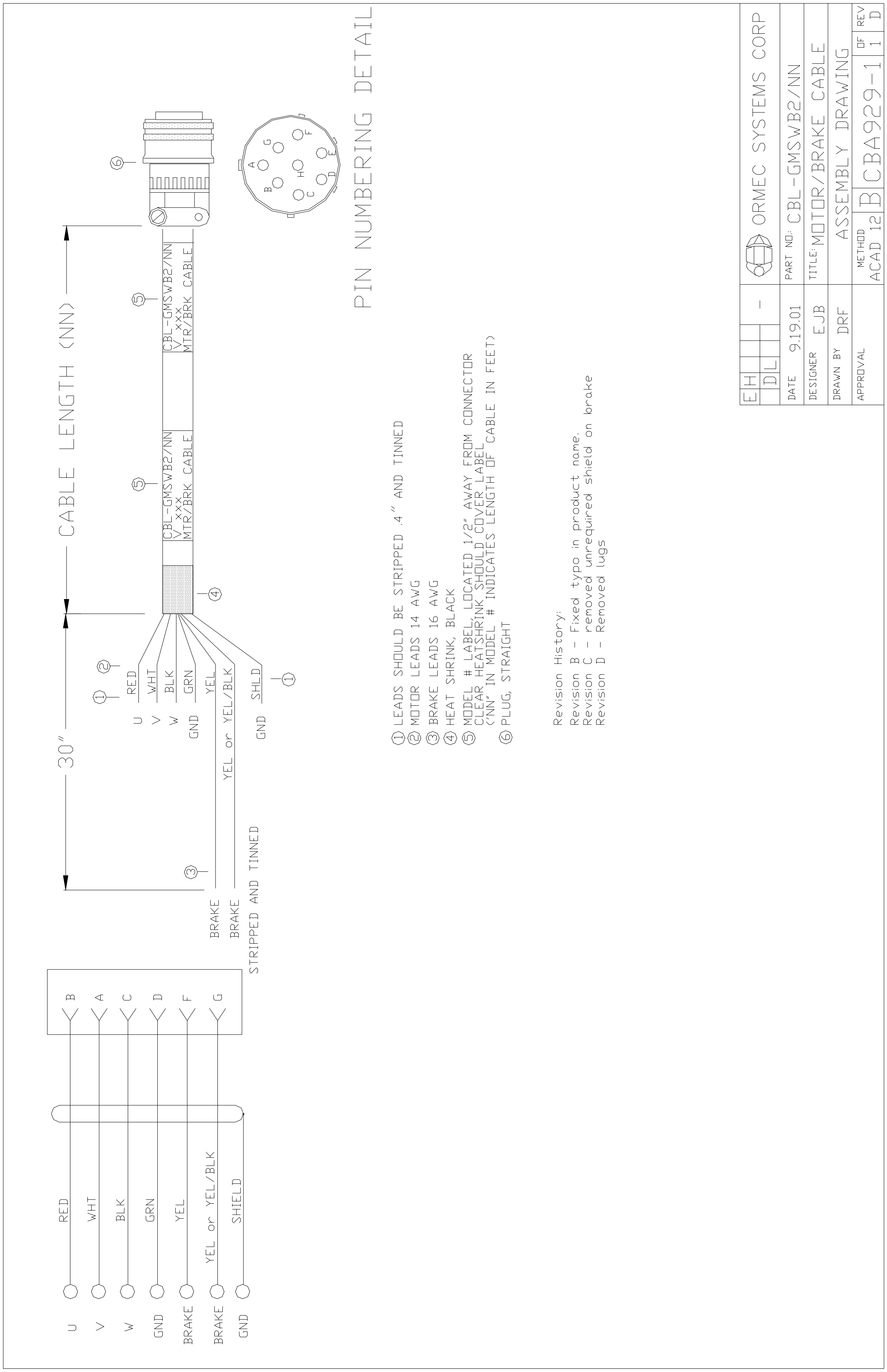
CBL-GMSWB


ORMEC SYSTEMS CORP
PART NO. CBL-GMSWB/51-150
TITLE ENCODER/BRAKE CABLE
ASSEMBLY DRAWING
METHOD ACAD 12
B
CBA920-1
OF 1 1
REV A
DATE 5/13/99
DESIGNER EJB
DRAWN BY EJB
APPROVAL
CABLE LENGTH (NN)
30"
PIN NUMBERING DETAIL
1 MALE, 25 PIN DSUB CONNECTOR
2 MODEL # LABEL, LOCATED 1/2" AWAY FROM CONNECTOR
CLEAR HEATSHRINK SHOULD COVER LABEL
('NN' IN MODEL # INDICATES LENGTH OF CABLE IN FEET)
3 ENCODER INTERFACE CABLE:
22 AWG FOR CABLES 51 - 150 FEET, CABLE O.D. = .425"
4 PLUG, STRAIGHT
5 BRAKE LEADS, 16 AWG, STRIPPED AND TINNED
6 DRAIN WIRE, 18 AWG
CBL-GMSWB/NN
ENC/BRK CBL
JACKET
+5VDC 24
GND 18
+5VDC 13
GND 17
+5VDC 25
GND 16
CHA 1
CHA 2
CHB 3
CHB 4
CHZ 5
CHZ 6
CHU 7
CHU 8
CHV 9
CHV 10
CHW 11
CHW 12
THERM 19
GND 20
SHIELD 21
BRAKE
BRAKE
SHIELD
YEL
YEL or YEL/BLK

CBL-GMSWBT2 Motor / Brake Cable



CBL-GMSWB2 Motor / Brake Cable



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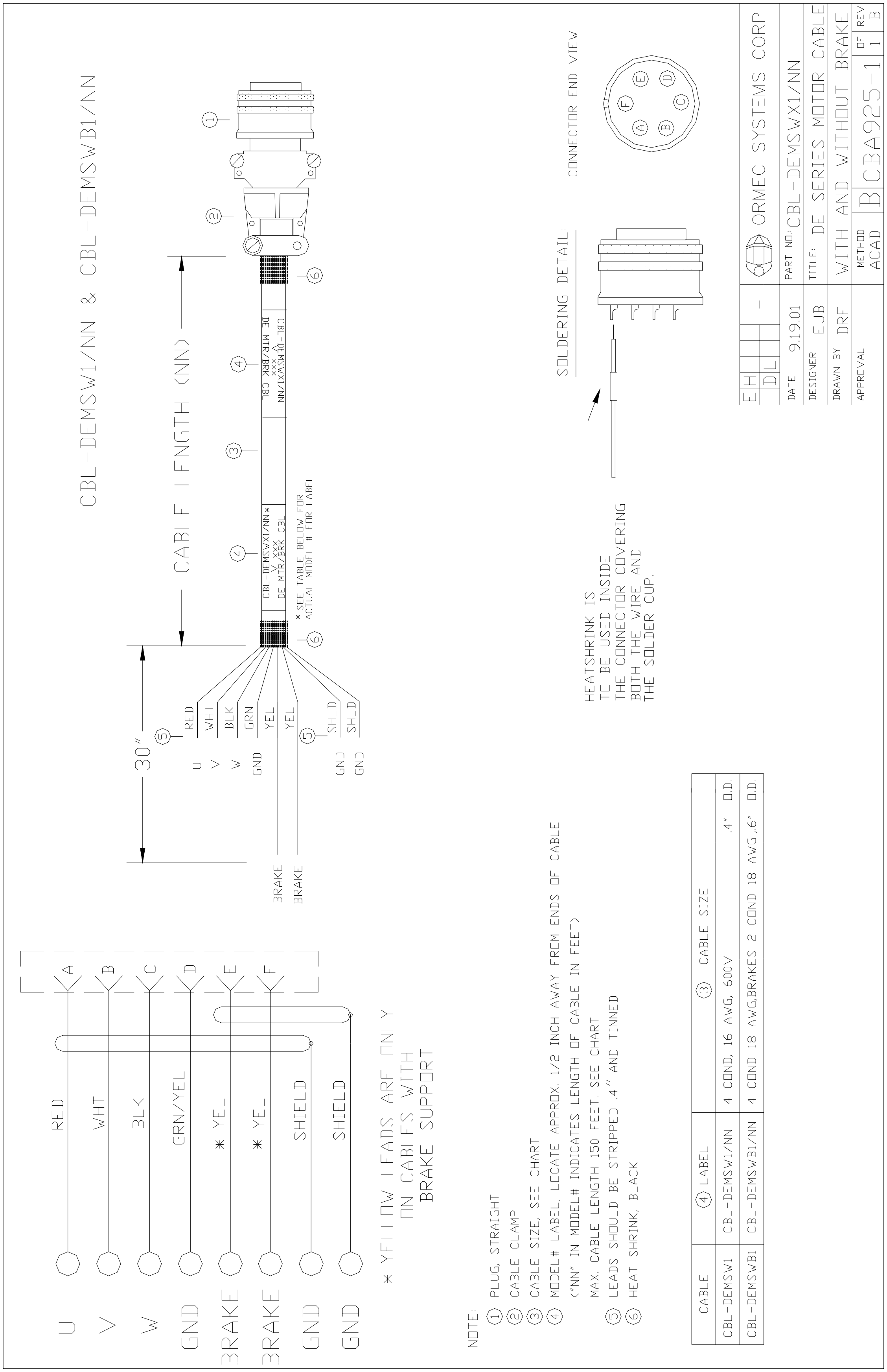
CBL-DEMSW1 Motor Cable



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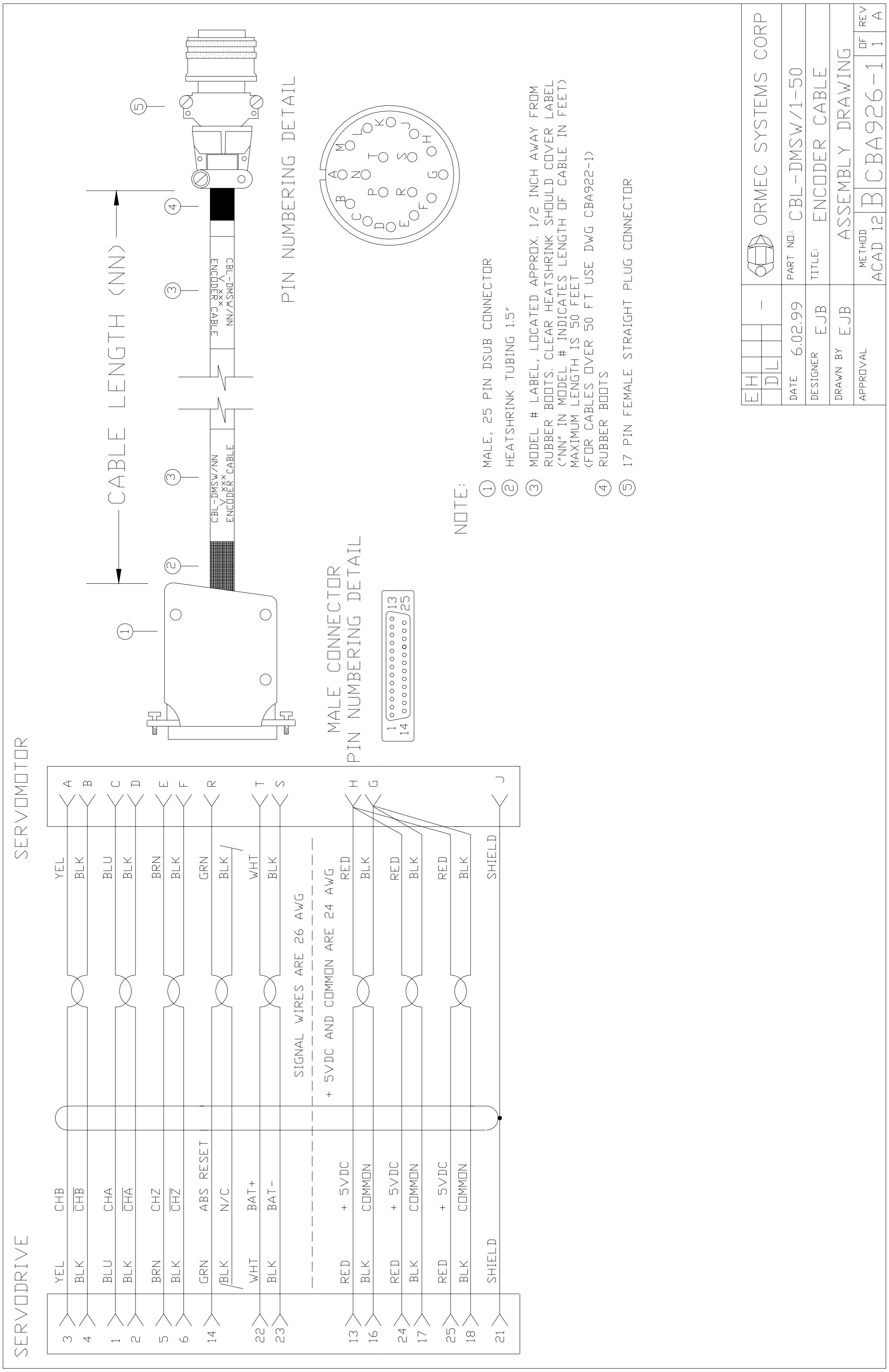
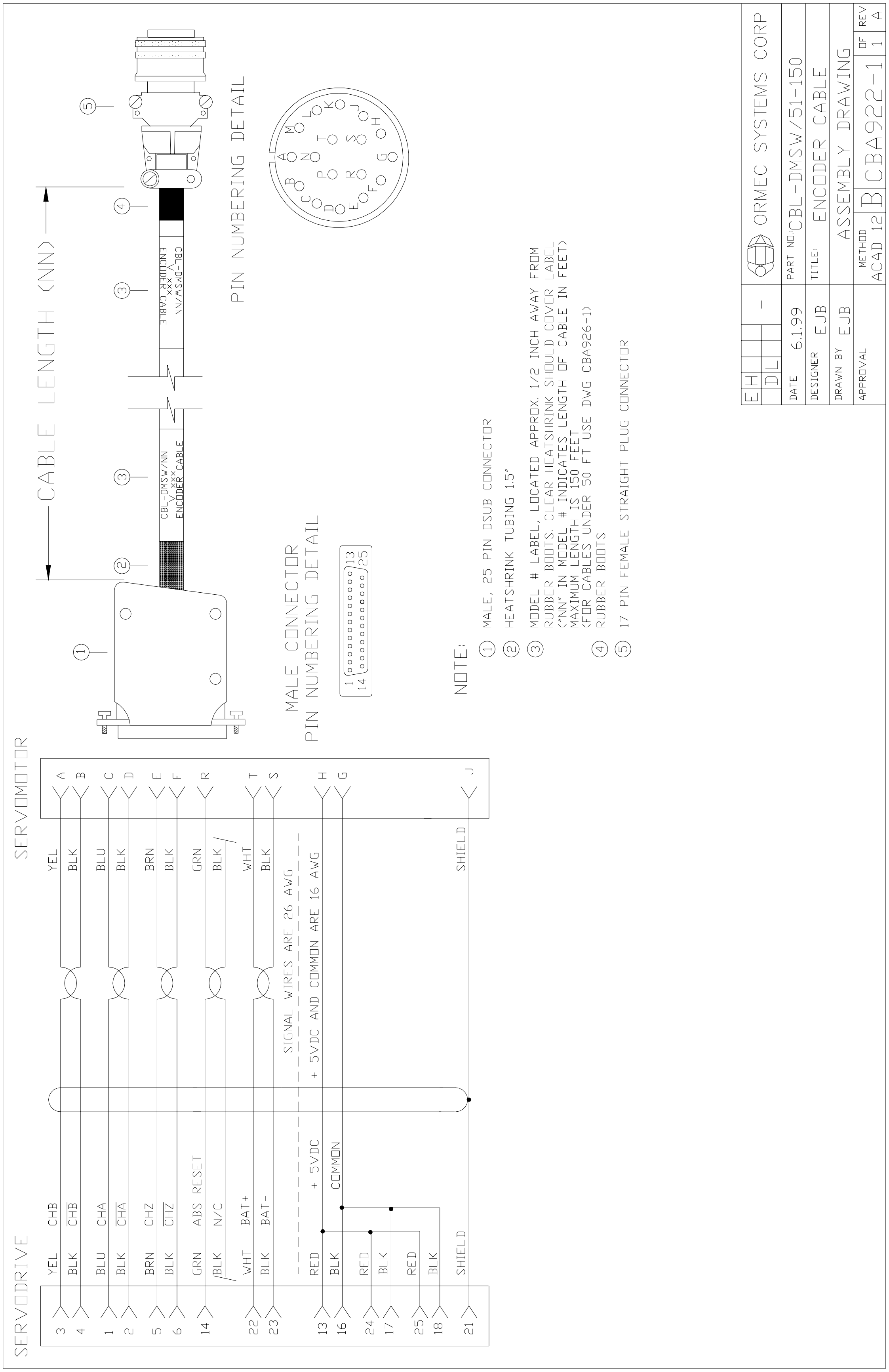
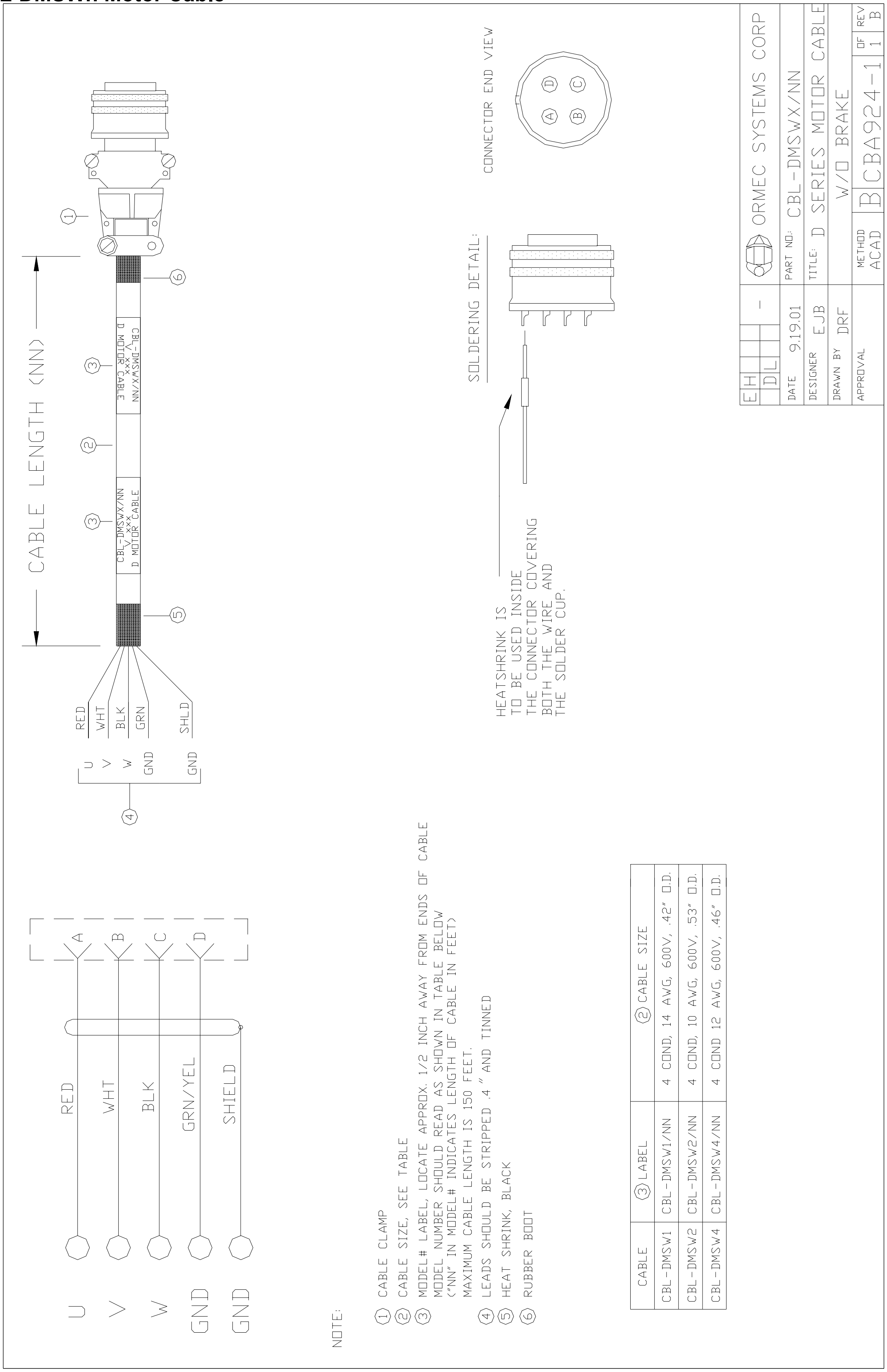
CBL- DMSW Encoder Cable



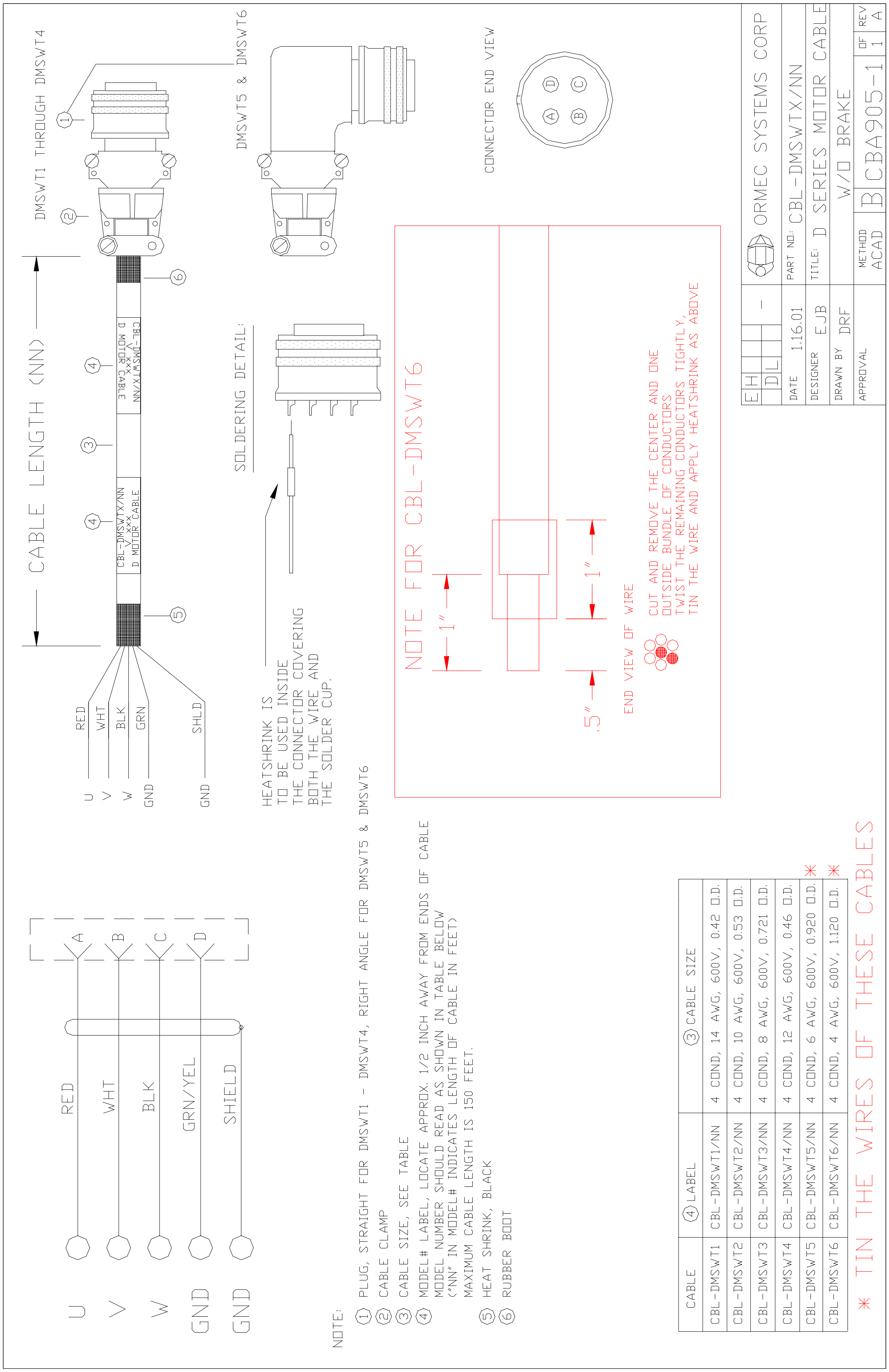
CBL-DMSW Encoder Cable



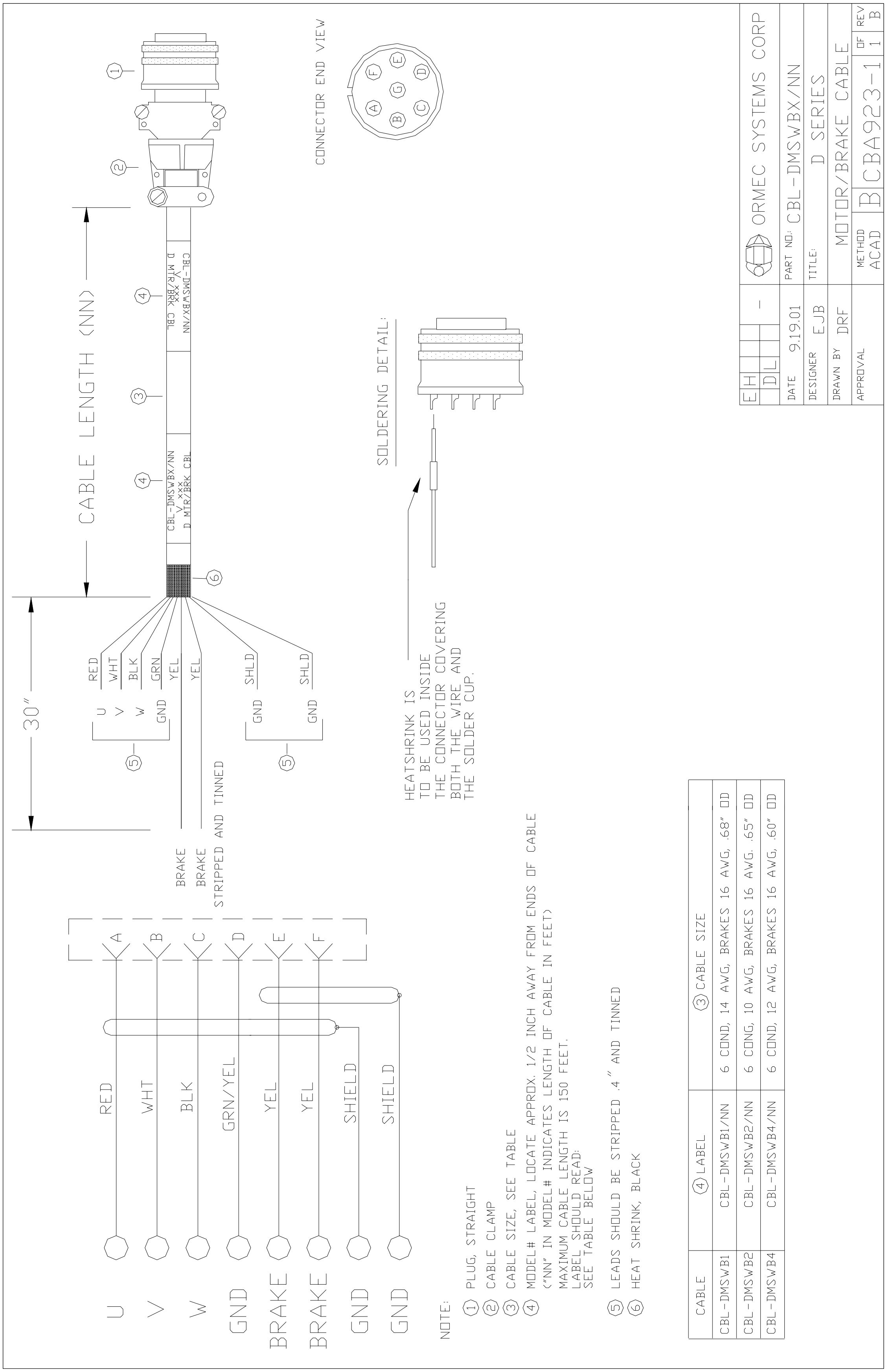
CBL-DMSWn Motor Cable



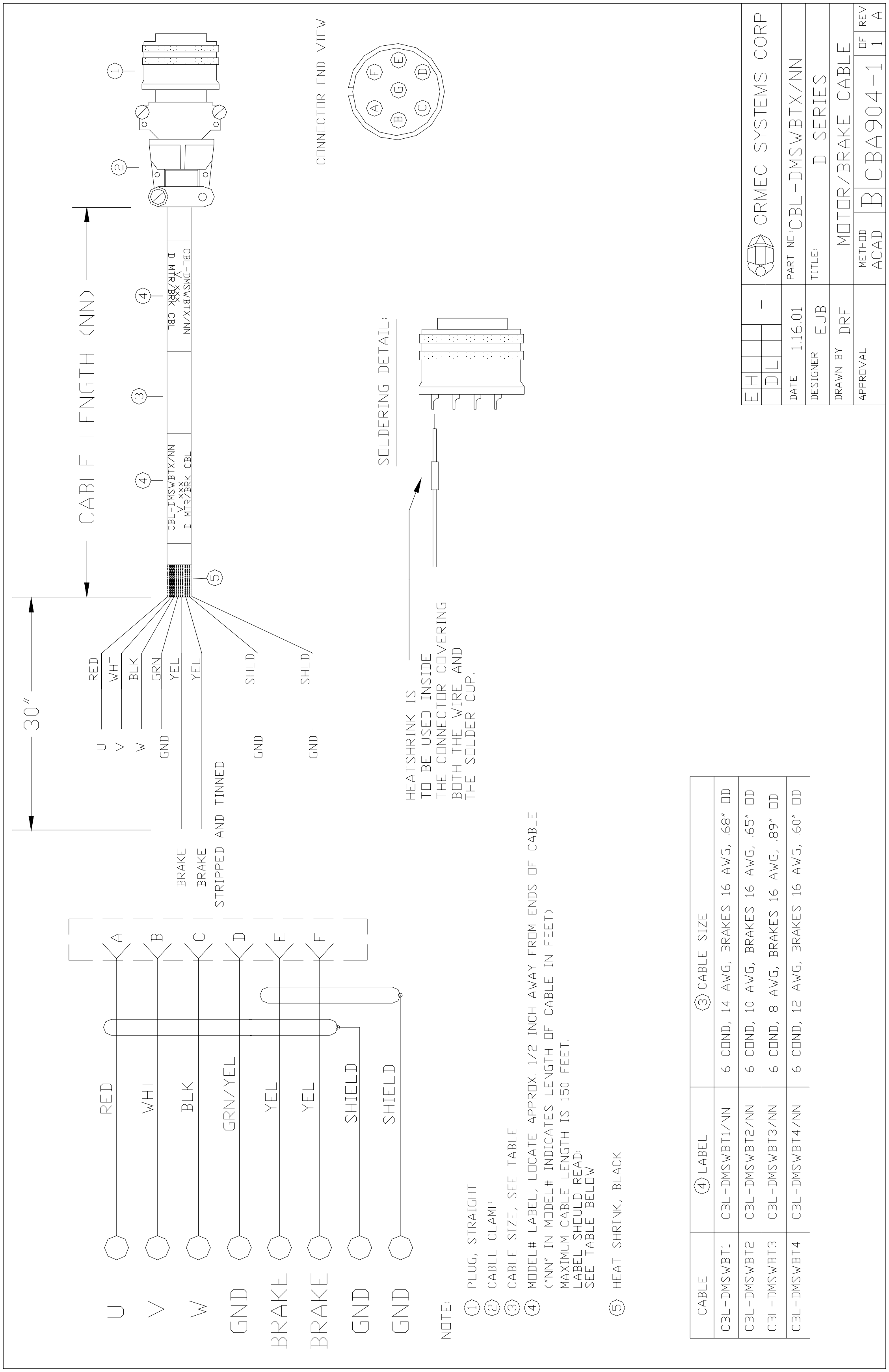
CBL-DMSWTx Motor Cable



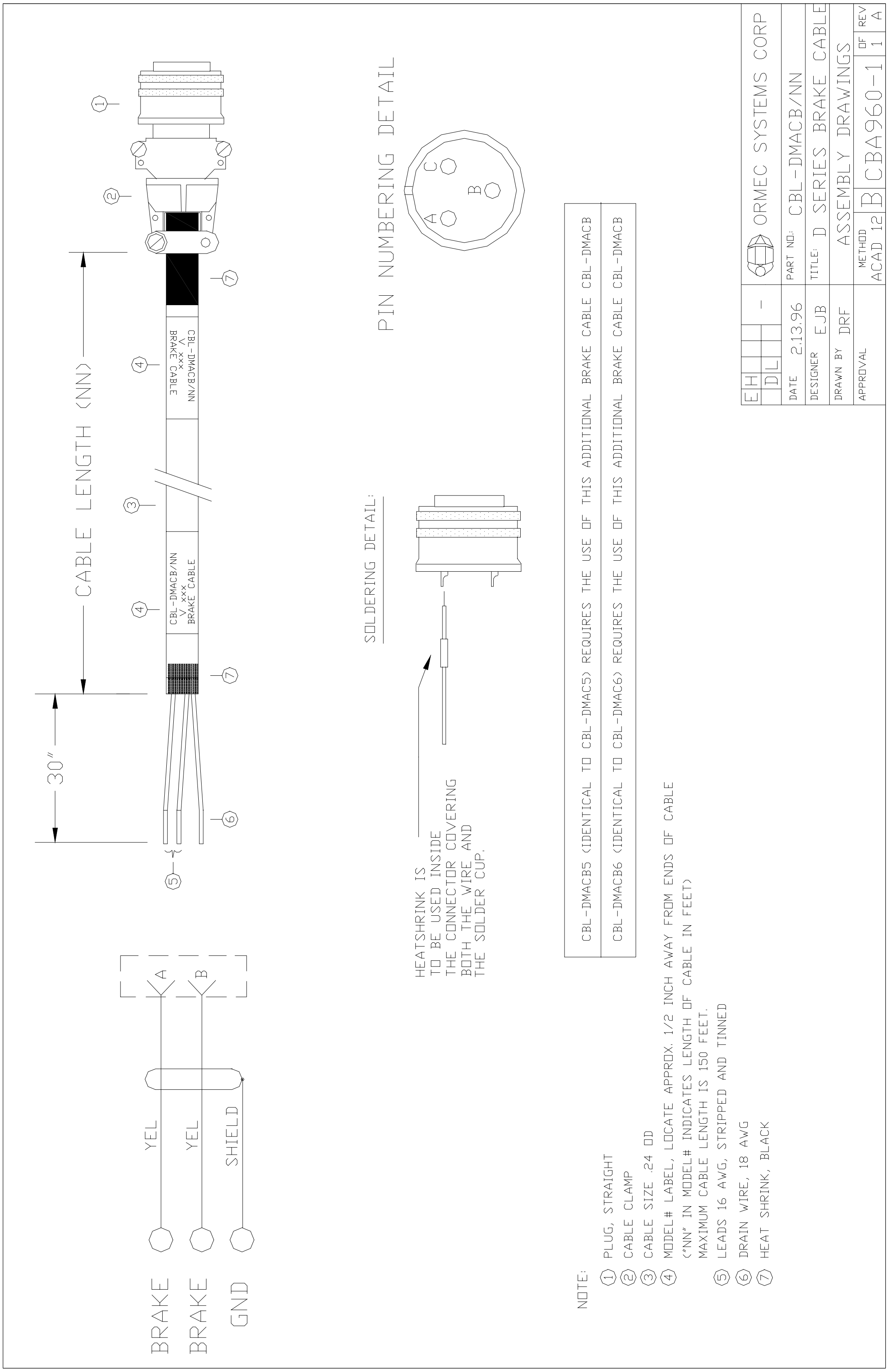
CBL-DMSWBn Motor / Brake Cable



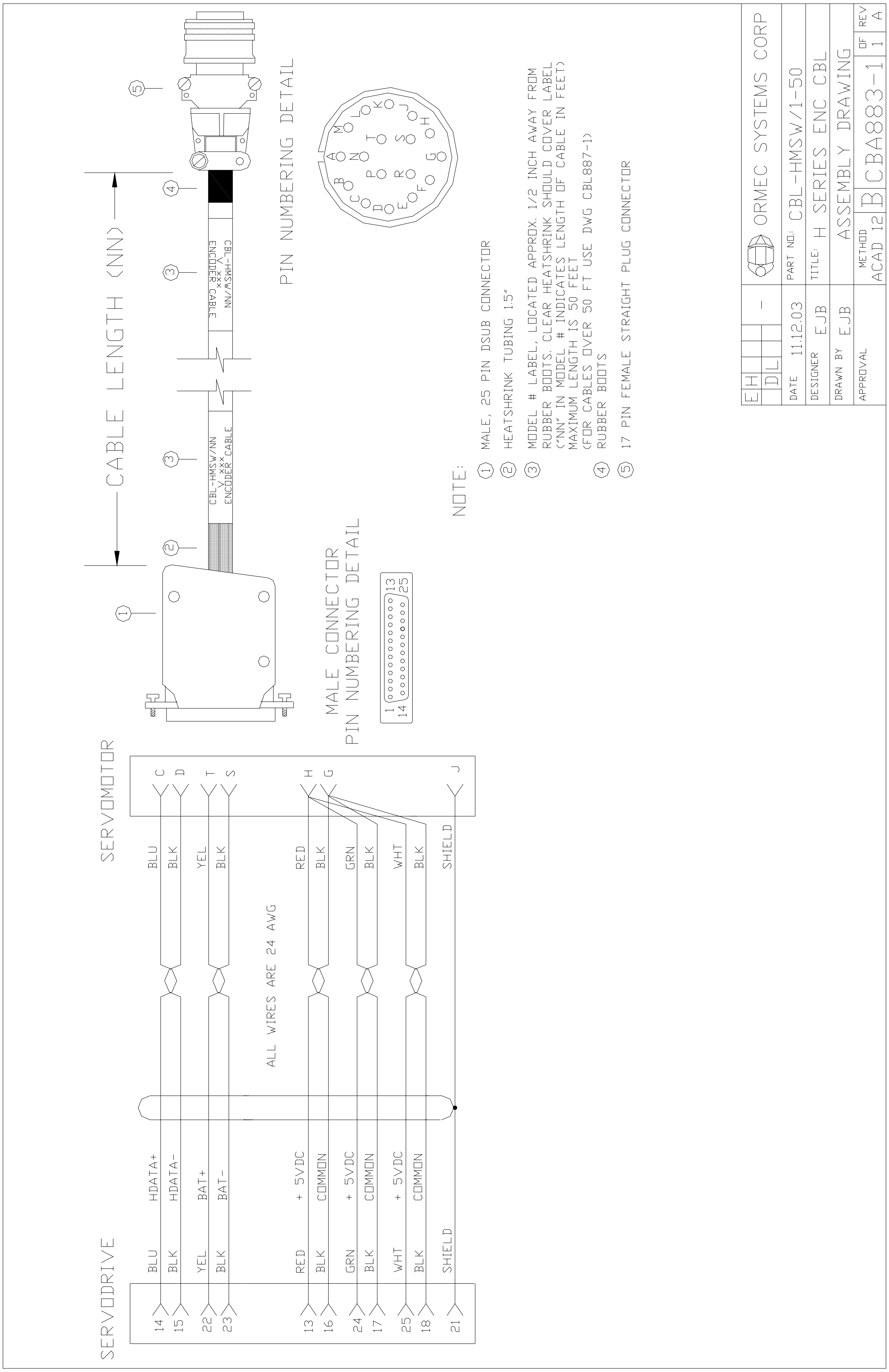
CBL-DMSWBTn Motor / Brake Cable



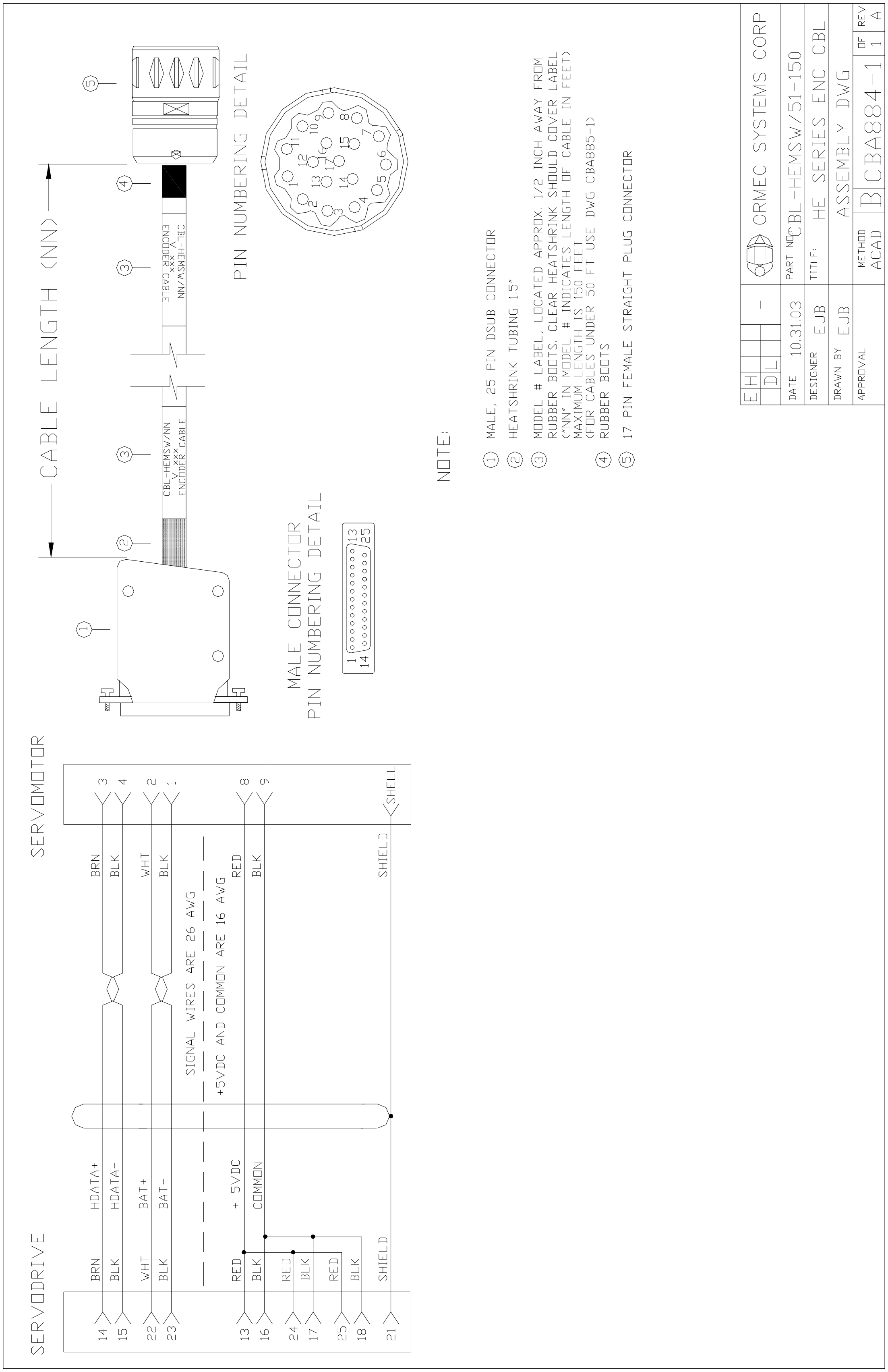
CBL-DMACB Brake Cable



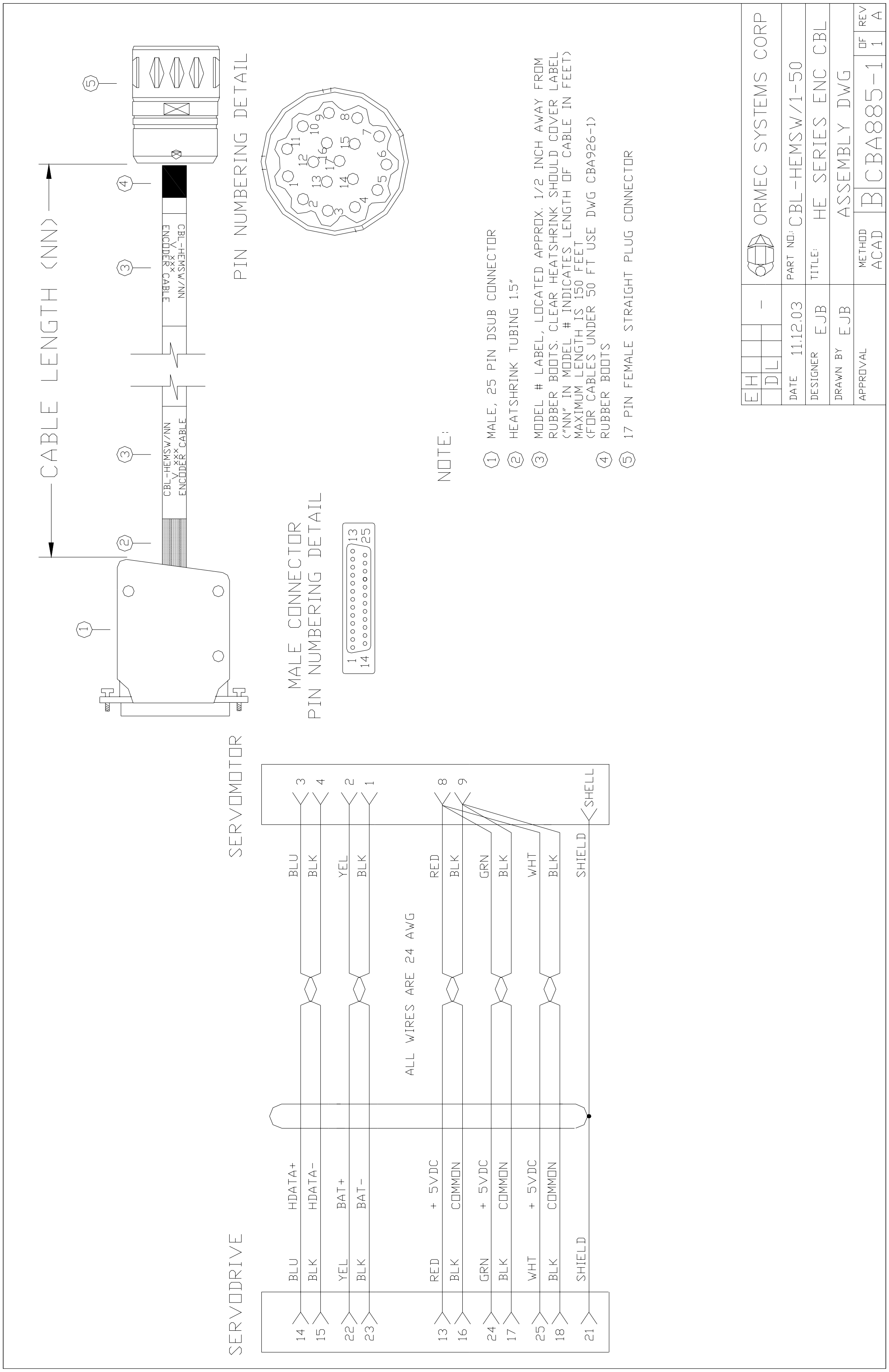
CBL-HMSW Encoder Cable



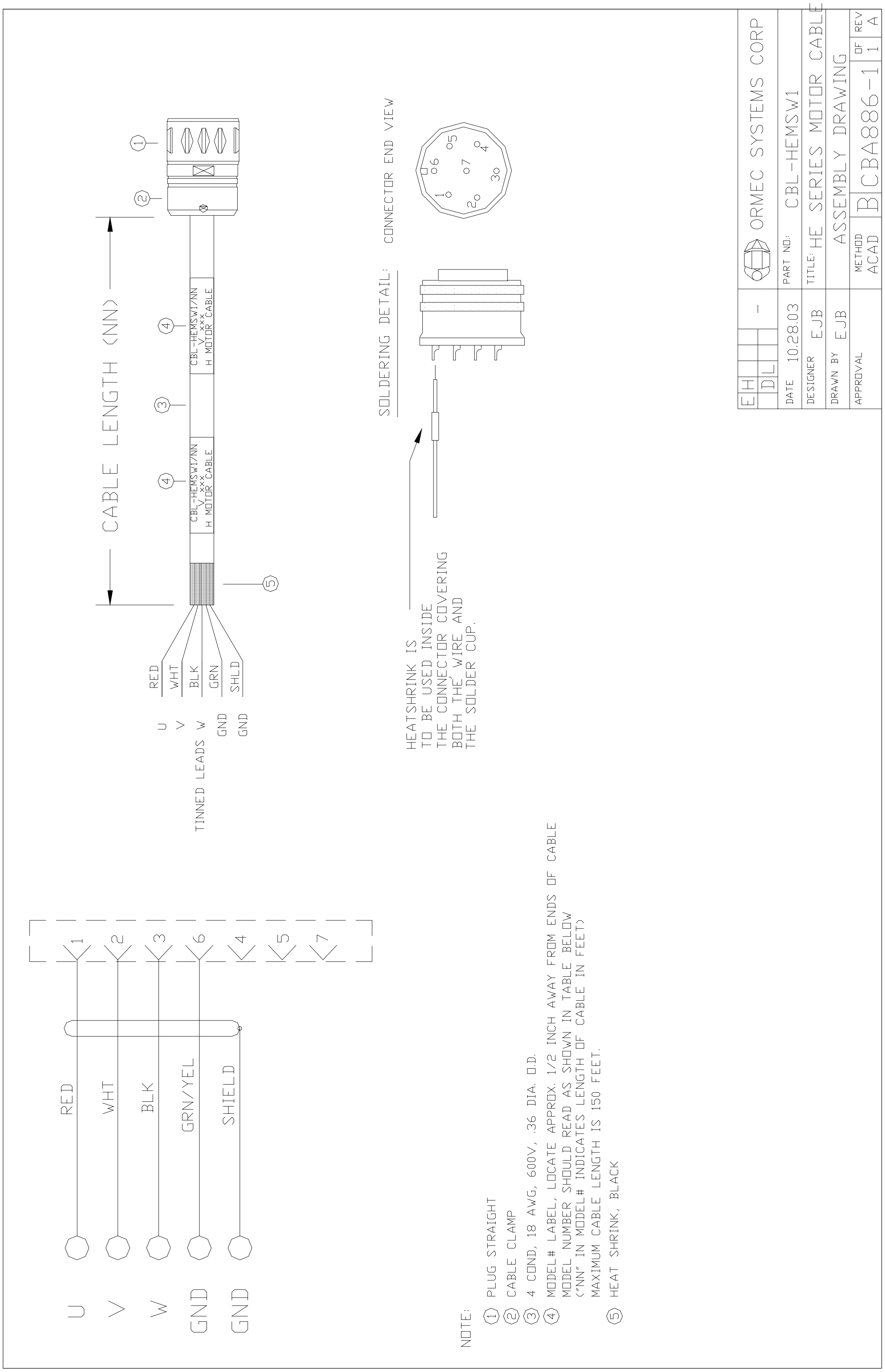
CBL-HEMSW Encoder Cable



CBL-HEMSW Encoder Cable



CBL-HEMSW1 Motor Cable



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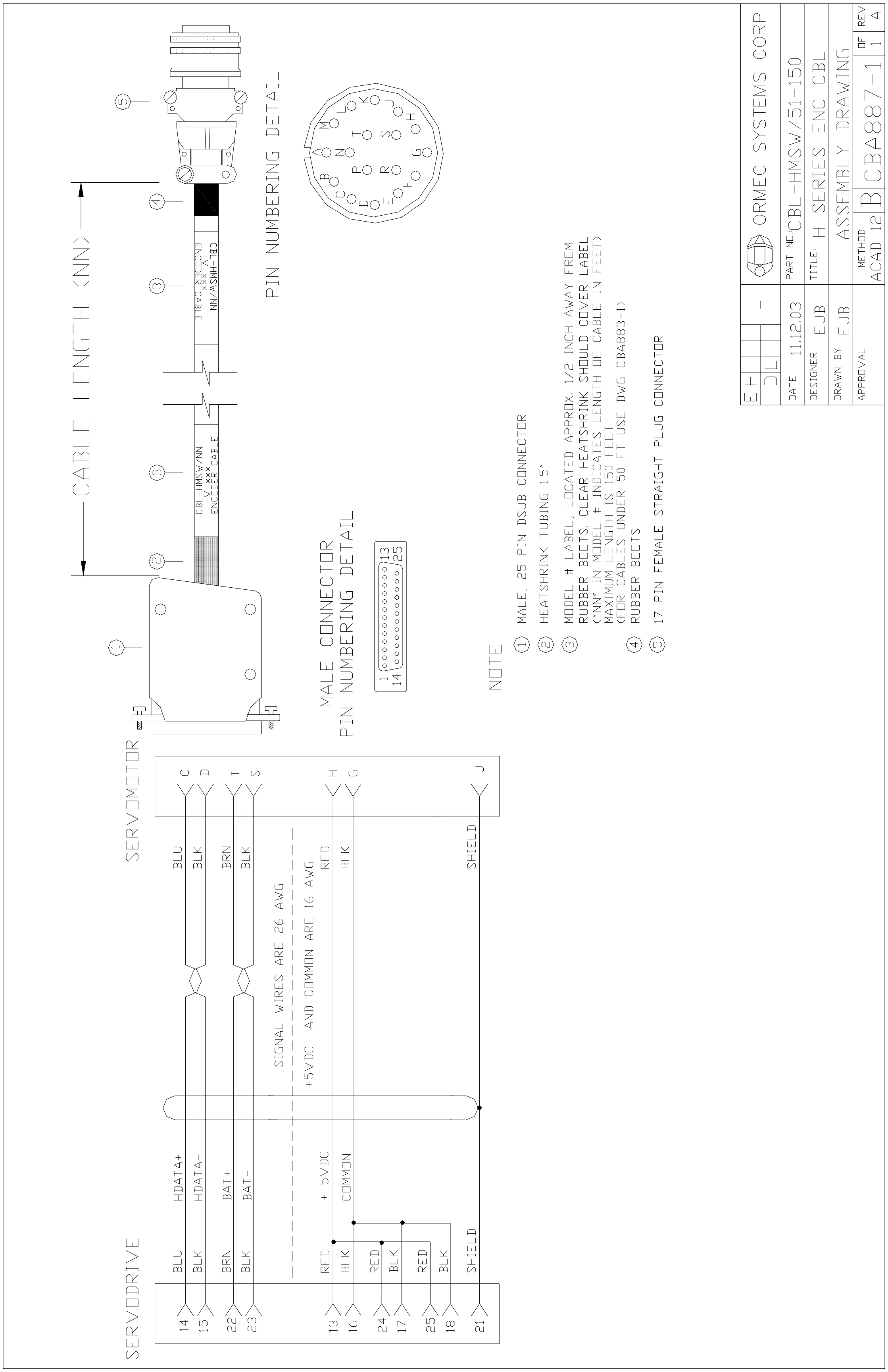
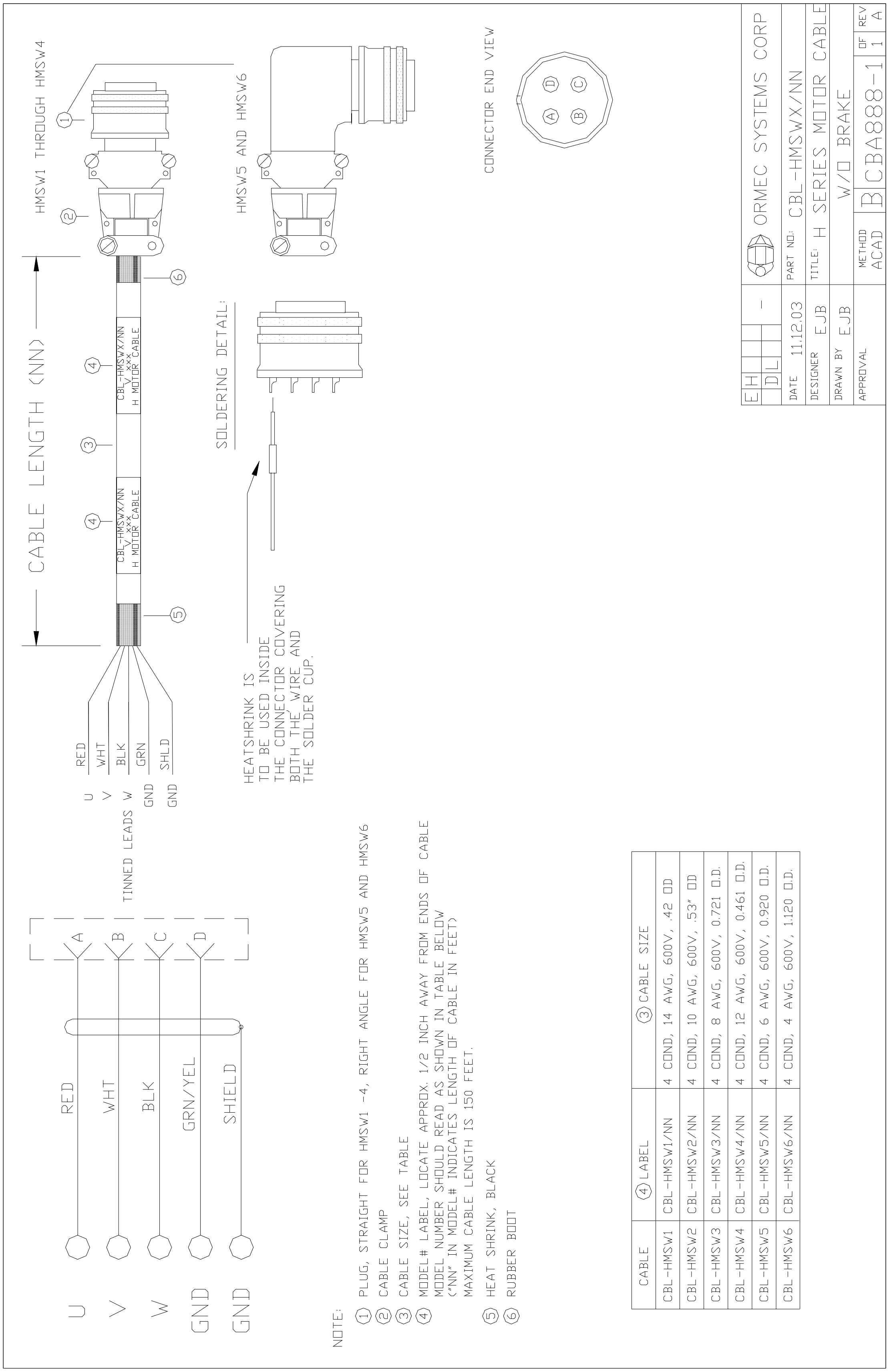


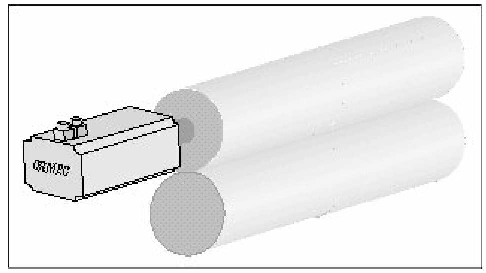
CBL-HMSWn Motor Cable



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:

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

Shaft Stiffness:

$S = \frac{\pi(OD^4)G}{32L} \text{in} - \text{lb/rad}$	**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:

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

If we take that same shaft and connect a MAC-DB200Q motor, with a moment of inertia of 0.0476 in-lb-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:

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

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 72×10^3 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 433×10^3 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:

$M_1 = \frac{J_1}{R_1^2}, M_2 = \frac{J_2}{R_2^2}$	**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.
	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.
	R_1 is the radius of the driving pulley (inches).
	R_2 is the radius of the driven pulley (inches).
$S = \frac{EA \cdot width}{span}$ $F = \frac{1}{2\pi}\sqrt{S\frac{(M_1 + M_2)}{(M_1 \cdot M_2)}}Hz$	**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).
	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).
	EA Belt spring rate in (lbs/inch width per unit strain).

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.
