SMLC-*SA*

Installation & Operation Manual

SMLC-003a

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Chapter 1
Welcome

1 Welcome

This manual covers ORMEC's Single Axis ServoWire Motion & Logic Controller (SMLC-SA) and accessories used with it. It provides a detailed description of the SMLC-SA hardware and the necessary information for installing, operating and "getting started" with an SMLC-SA system.

The SMLC-SA is a single axis version of ORMEC's SMLC controller family. The SMLC-SA includes a built-in ServoWire SD servodrive. The programming capabilities of the SMLC-SA are completely identical to the multi-axis SMLC controllers. The drive capabilities are completely identical to the corresponding ServoWire SD servodrive.

The manual is divided into the following chapters:

Chapter 1	Welcome	Introduces you to this manual and its organization.
Chapter 2	General Description	Overview of the SMLC-SA product line.
Chapter 3	Installation	Provides instructions for installing the SMLC-SA .
Chapter 4	System Components	Provides a description of all of the components of an SMLC-SA, including pinouts of all of the interface connectors and terminal blocks.
Chapter 5	System Operation	Provides details on SMLC-SA operation.
Chapter 6	Specifications	Provides detailed environmental, mechanical and electrical specifications for the SMLC-SA.
Chapter 7	WAGO I/O installation	Provides instructions for installing and configuring the WAGO I/O and detailed descriptions of all the hardware interfaces, as well as an explanation of the LED status indicators.
Chapter 8	Getting Started	Provides detailed instructions on how to communicate with and run your SMLC-SA for the first time.
Chapter 9	Maintenance & Troubleshooting	Provides tips for maintaining and troubleshooting your SMLC-SA system
Chapter 10	Terms & Mnemonics	Provides definitions for term's specific to motion control

	and/or ORMEC's motion control products
Appendices	Contains detailed drawings documenting the SMLC-SA dimensions, system interface as well as associated interface cables and accessories.

This manual provides SMLC-SA hardware and cabling documentation. Detailed information on ORMEC's SMLC programming language is found in the on-line **SMLC Help**.

To obtain the latest version of the SMLC Help visit ORMEC's site on the World Wide Web at ***http://www.ormec.com***, or call the ORMEC Service Department at **1-(585) 385-3520**.

The functionality of certain portions of the SMLC-SA hardware is dependent on the firmware and options installed.

Chapter 2
General Description

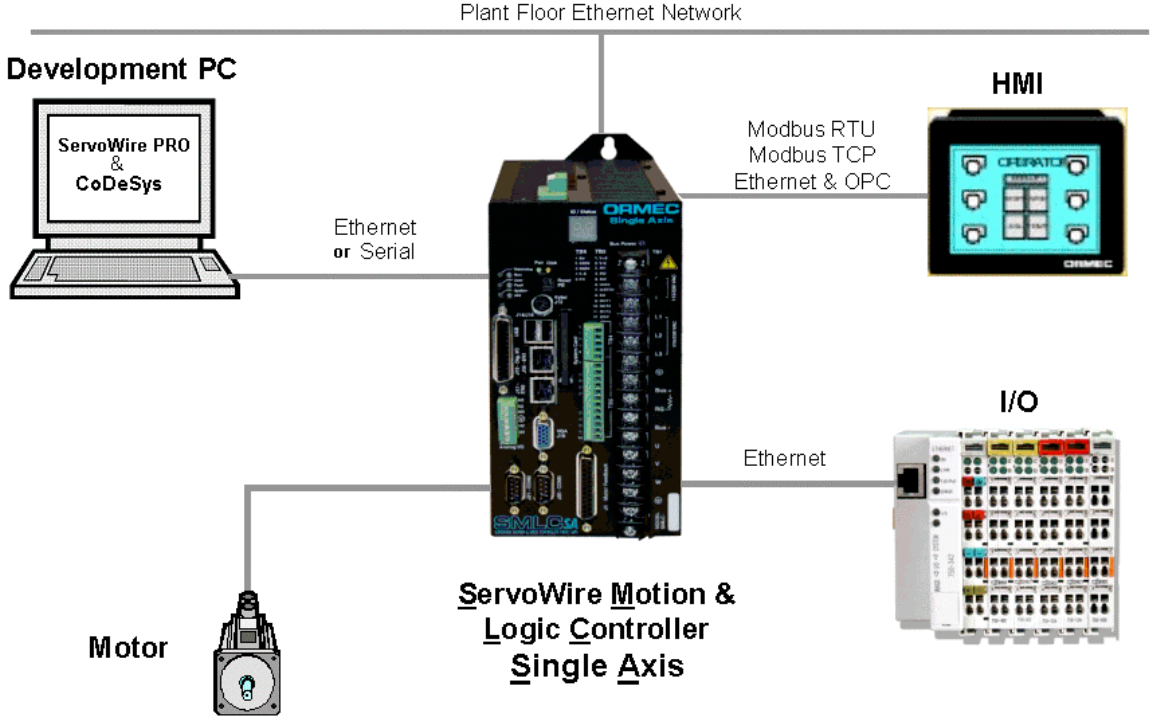


***Figure 1**, SMLC-SA System*

2 General Description

2.1 System Features

- **Application Development** - CoDeSys IEC 61131-3 Programming:
  IEC 61131-3 is an open standard developing application programs for motion and I/O control, running on a single processor. See: www.3s-software.com & www.PLCopen.org
- **Operating System** - QNX Neutrino Real Time Operating System (RTOS):
  In QNX Neutrino, only the most fundamental OS primitives (e.g. signals, timers, scheduling) are handled in the kernel itself. All other components – drivers, file systems, protocol stacks, user applications – run outside the kernel as separate, memory-protected processes. Fault resilience is built right in. See: www.QNX.com

- **System configuration & diagnostic's** - ServoWire Pro:
  ServoWire Pro provides an integrated suite of configuration, diagnostic and maintenance utilities that assist in the development and on-going support of ServoWire based SMLC systems.
- **ServoWire Drive I/O:**
  High speed ServoWire Drive I/O is used to capture axis position (example: registration) and control (start / stop) motion.
- **General Purpose I/O** - WAGO, Ethernet (MODBUS/TCP):
  Compact, highly reliable and cost effective, with a wide variety of Input / Output modules.

2.1.1 Hardware Features

SMLC-SA hardware includes:

- CPU – 400 MHz Celeron processor
- 2 Ethernet Ports – 10/100baseT (/1000baseT on model 160).
- 2 serial ports
- Development, HMI, Keyboard connectors.
- Built-in digital and analog I/O
- Built-in ServoWire SD drive with high speed sensors, additional digital and analog I/O

Figure 2, *SMLC-SA*

SMLC-SA memory includes:

- 128 Mb Dynamic RAM - Random Access Memory (volatile)
- 128Mb Removable Compact Flash memory for application program and data storage.
- 32 Kb Battery backed static RAM used for non-volatile data storage.

2.1.2 Drive Features

The all-digital ServoWire servodrive provides support for a variety of actuator technologies, including brushless rotary and linear motors, DC brush motors and voice coils. The drives are configured digitally, eliminating all manual configuration and offline configuration utilities, reducing the cost and complexity of maintaining the motion control system.

- **Simple Setup**: The drive's axis ID is fixed at 1; 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 loops for precise torque, velocity and position mode operation.

- **Standard Line Voltage Input**: SMLC-SA2__ models 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. SMLC-SA4__ models 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.

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

Motor short	Encoder open wire detection
Peak & RMS drive current limit	Hall sensor phasing error
Peak & RMS motor current limit	Motor over temperature
Missing phase detection (SMLC-SA225, 235, 260, 417, 425, 435 & 450 only)	Network communications errors

- **Diagnostics**: A 2-digit 7-segment display that shows the servodrive identification (ID) number, enabled status and fault status, 11 LEDs indicating I/O status and I/O power.

- **Software Configurable General Purpose I/O**: The drive has 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**: Software configurable 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 to reduce servodrive in-rush current.

- **Torque Mode Operation**: When combined with velocity and position loops in a high performance host 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 drive.

- **Position Mode Operation**: Position mode operation allows for precise motion by closing the velocity and position loops in the 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.

- **Shunt Regulation**: All Models except SMLC-SA203 and SMLC-SA205 have shunt regulation circuitry. If an application requires regenerative operation, regenerative discharge resistors can be mounted external to the servodrive.

- **Serial Encoder**: The motor encoder interface supports several serial encoder types. Yaskawa Sigma II 13 and 17-bit incremental and 16, 17 and 20-bit absolute encoders are supported. The Tamagawa TS56xx series of absolute encoders is also supported. The drive battery option is required to maintain multi-turn information for absolute encoders.

2.1.3 Software Features

ORMEC has selected the highly reliable QNX Neutrino as the SMLC-SA real time operating system (RTOS). The use of a RTOS in the SMLC-SA facilitates the integration of new functionality and eases product lifecycle maintenance by allowing for easy migration to new and more powerful hardware platforms, as they become available.

To implement the ServoWire Controller's programming, ORMEC has partnered with 3S to integrate high performance ServoWire Soft Motion technology with CoDeSys IEC 61131-3 software. CoDeSys covers all five IEC 61131-3 standard compliant languages, and is incorporated in over one hundred OEM partner products. All application motion and I/O control is implemented in a single program running on one processor, without the delays and timing issues associated with separate processor cards in PCs and PLC racks.

For motion control programming, ORMEC has implemented PLCopen Motion Control function blocks. Powerful features have been added to the open standard motion control function blocks, allowing motions to be loaded into a motion queue for sequential operation initiated independent of the I/O scan rate. Motions in the queue can be automatically repeated, simplifying application programming, and triggered by high-speed sensor inputs at the servo command Loop Rate (faster than the I/O scan rate). It is also possible to easily superimpose incremental time-based and geared motions on top of a constant motion gear ratio, without the need to develop cam profiles. For more details, read the help file **SMLCsoftware.chm** available from within CoDeSys and from the main menu of the SMLC-SA Installation CD.

2.2 Support Software

2.2.1 CoDeSys - Development Software

CoDeSys IEC 61131-3 programming with PLCopen motion function blocks provides open standard tools for developing application programs for motion and I/O control. General-purpose I/O options are fully supported using WAGO's 750 Series.

The IEC 61131-3 standard suite of programming languages provides an integrated set of software tools and graphical interfaces to meet a wide range of software development needs:

- Relay Ladder Logic (LD)
- Structured Text (ST)
- Sequential Function Chart (SFC)
- Function Block Diagram (FBD)
- Instruction List (IL) tools
- CoDeSys also includes a sixth language, Continuous Function Chart (CFC)

Development Software Part Numbers:

CDS-SDK/C - CoDeSys Developers Kit (one seat), CD-ROM, incl. ServoWire Pro, Wago BootP server, serial communication cable and one year of maintenance & support. The software in CDS-SDK supports development on all SMLC models, including the SMLC-SA

CDS-SDK-SA/C - CoDeSys Developers Kit (one seat), CD-ROM, incl. ServoWire Pro SA, Wago BootP server, serial communication cable and one year of maintenance & support. The software in CDS-SDK-SA can only be used to develop projects for SMLC-SA models.

Refer to the CoDeSys Online help for more information. There are also multiple programming tutorials available from the main menu of the SMLC-SA Installation CD.

2.2.2 ServoWire Pro - System Configuration Software

ServoWire Pro provides an integrated suite of configuration, diagnostic and maintenance utilities that assist in the development and on-going support of ServoWire systems. The software is designed to run on the development PC. ServoWire Pro is used to create a project file containing all of the motor and drive configuration information, which is then downloaded to the SMLC-SA.

There are two versions of ServoWire Pro: SW-PRO and SW-PRO-SA. SW-PRO can be used for commissioning all SMLC models, including SMLC-SA models. SW-PRO-SA can only be used for commissioning SMLC-SA models.

ServoWire Pro includes the following utilities:

• SwSetup	Forms and wizards to simplify drive configuration & set-up
• SwMonitor	Diagnostic utilities for monitoring drive and network performance
• SwTune	Tuning scope and software for optimizing motion performance
• SwUpgrade	Tools for upgrading the drive firmware
• SMLCUpgrade	Tool for upgrading SMLC firmware
• SMLC utilities	Manage files on an SMLC, configure the Ethernet ports, etc.

ServoWire Pro usage is covered in the ServoWire Pro tutorial available from the Help menu within ServoWire Pro. Basic ServoWire Pro operation is also covered in the SMLC Programming tutorials available from the main menu of the SMLC-SA Installation CD.

2.2.3 WAGO Ethernet I/O

The SMLC-SA supports Wago 750 Series Ethernet I/O. Refer to Chapter 7 - WAGO Installation & Operation for more information.

Wago BootP server is used to configure the IP address of Wago Ethernet bus couplers. Refer to section 7.1 - WAGO Installation for more details. Once the IP address has been set all of the remaining I/O configuration is done in the CoDeSys PLC Configuration utility. Refer to section 7.2 - WAGO Configuration for more details

2.3 Model Numbers

SMLC-SA 2 03 - S B A P 0

Pacer Support (optional)
P = adds incremental pacer support
0 = no pacer support

Analog I/O (optional)
A = Analog I/O included
0 = option not included

Absolute Encoder Support (optional)
B = adds backup battery for absolute enc.
0 = no battery added

Primary Feedback
S = Serial & Incremental Encoder support

Maximum Continuous Current
03 = 2.4 Arms/∅ (115/230 VAC 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/∅ (115/230 VAC model)
25 = 25 Arms/∅
35 = 35 Arms/∅
50 = 50 Arms/∅ (460 VAC model)
60 = 60 Arms/∅ (115/230 VAC model)

Bus Voltage
2 = 115/230 VAC
4 = 460 VAC

Chapter 3
SMLC-SA Installation

3 Installation

3.1 Safety Related Guidelines for Installation in the European Union

General: ORMEC product manuals are written to provide information required for the proper use of the equipment in the intended operation. They are written for technically qualified personnel such as engineers, programmers and maintenance specialists who have been trained in the application of automation control systems.

Proper Use: The equipment and/or system or components may only be used as described in the product manuals.

Guidelines: ORMEC motion control products generally form a part of a larger system or installation. These guidelines are intended to help integrate ORMEC products into the system.

- Since these products are component devices, overall automated system safety is beyond the scope of the product manuals and is the responsibility of the integrator.
- Compliance with EN292-1 and EN292-2 (Safety of Machinery) as well as EN60204 (Electrical Equipment of Industrial Machines) must be observed during the design phase.
- Only qualified personnel should be allowed access to the equipment.
- Opening the housing or protective covers may expose dangerous voltages.
- Emergency tripping devices in accordance with EN60204 must be effective in all operating modes of the automation equipment.
- Measures must be taken when interfacing the inputs and outputs of the automation equipment to prevent an undefined state from being assumed in the case of a wire break in the signal lines.
- The motion controller is a programmable device with the application program being written by the person integrating it into the machine. A qualified person should write this program. Measures must be taken to verify that the program written does not cause dangerous and unwanted machine operation.
- These systems are of rugged design and intended for general-purpose service. However, as with any equipment, reliability may be affected by more stressful operating conditions. Some benefit may be expected when actual operating conditions are better than the worst operating conditions specified in the product manual. Some applications may require consideration of special packaging, cooling, electrical noise protection, etc. for reliable operation.

3.2 Receiving and Inspection

ORMEC Single Axis ServoWire Motion & Logic Controller 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. Check the SMLC-SA and any of the accessories for bent or broken components, loose bolts or screws and any other physical damage before installing.

NOTE: Use the original SMLC-SA packaging material for shipping units.

Included with your SMLC-SA is a CD package, which contains installation disks, Users Guide, license agreement, and registration card. Please open this package, read the license agreement, and fill out and return the registration card. The SMLC-SA operates on the QNX operating system, with the runtime License pre-installed on your SMLC-SA.

3.3 Panel Mounting and Environment

Panel Mounting information including hole patterns and clearance requirements are available in Appendix C.

The controller's environment should be maintained as follows:

- Operating temperature should be between 0 and 50C (32ºF to 122ºF).
- The SMLC-SA should be mounted in a grounded metal enclosure
- If the electrical panel is subject to vibration, mount the unit 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 SMLC-SA is vertical on a panel using the mounting holes (3 or 4) provided on the base plate.

3.4 Drive Power Considerations

3.4.1 Supply Power for 115/230 VAC (SMLC-SA2__) Models

115/230 VAC Drives (SMLC-SA2__) 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 drive is 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 the drives used. Slow-blow circuit breakers or fuses should be used because the servodrive draws substantial inrush current at power up.

3.4.2 Supply Power for 460 VAC (SMLC-SA4__) Models

SMLC-SA4__ models have different limits for control power and motor power. This section deals with control power.

Control power (terminals r & t on TB2) for **SMLC-SA405 through SMLC-SA425** (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 drive is 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 **SMLC-SA435 and SMLC-SA450** (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 drive is 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) servodrives used. Slow-blow circuit breakers or fuses should be used because the servodrive draws substantial inrush current at power up.

3.4.3 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 DSP, 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.

3.4.4 Sizing Fuses, Line Filters, and Transformers

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

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

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

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 or 480 V maximum depending on drive and input.

3.4.5 Power Dissipation

Use the following table to determine cabinet cooling requirements:

	Dissipated Power (Watts)			
	Control Power			**External** Regen Resistor
	Max	Typical	Main Power	(if used)
SMLC-SA203	45	20	55	—
SMLC-SA205	45	20	90	—
SMLC-SA210	45	20	180	800 max.
SMLC-SA217	45	20	300	1200 max.
SMLC-SA220	55	30	350	2400 max.
SMLC-SA225	55	30	450	3000 max.
SMLC-SA235	55	30	600	4175 max.
SMLC-SA260	55	30	900	7100 max.
SMLC-SA405	45	20	120	1200 max.
SMLC-SA410	45	20	240	2400 max.
SMLC-SA417	55	30	405	4000 max.
SMLC-SA425	55	30	600	5970 max.
SMLC-SA435	60	35	835	8350 max.
SMLC-SA450	60	35	1200	12000 max.

Table 1, *Power Dissipation*

Main power dissipation is shown in **Table 1** 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 1**, column “External Regen Resistor” shows the rated regen capacity of the servodrive.

3.4.6 Line Filters

Once the incoming power service is determined, the appropriate main power line filter can be selected from **Table 2**. In the case of a system using multiple servodrives, they may share one line filter per cabinet.

Model	Main Power Input Voltage	Total Continuous Current	Main Power Line Filter
SMLC-SA203	Single phase	Up to 15 Amps	SAC-LF215U
SMLC-SA205		Up to 30 Amps	SAC-LF230U
SMLC-SA210 SMLC-SA217 SMLC-SA220 SMLC-SA225 SMLC-SA235 SMLC-SA260 SMLC-SA405 SMLC-SA410 SMLC-SA417 SMLC-SA425 SMLC-SA435 SMLC-SA450	Three-phase	Up to 30 Amps	SAC-LF30C
		30 – 55 Amps	SAC-LF55C
		55 – 100 Amps	SAC-LF100C

Table 2*, Line Filter Recommendations*

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

1. The filter must be mounted on the same panel as, and as close as possible to the drive.
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 drive.**
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.

3.4.7 Terminal Block Wiring Guidelines

All 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 3**. 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 drive are connected to the frame ground).

	Wire Gauge (AWG) [mm^2]	**Screw Torque** (in-lb) [N-m]
Terminal Block - **TB1 - Power**		
SMLC-SA203 to 220 SMLC-SA405 to 410	22 to 12 [0.64 to 2.1]	7.0 to 9.0 [0.8 to 1.0]
SMLC-SA225 to 260 SMLC-SA417 to 450	18 to 4 [1.0 to 5.2]	16 [1.8]
Terminal Block - **TB2 – Power**		
(SMLC-SA225 to 260 only)	24 to 10 [0.51 to 2.6]	4.4 to 5.3 [0.5 to 0.6]
Terminal Block – **TB3 – Analog I/O**		
All models	30 to 14 [0.14 to 1.5]	1.95 [.22]
Terminal Block – **TB4 – Drive I/O**		
All models	30 to 14 [0.14 to 1.5]	1.95 [.22]
Terminal Block – **TB5 – Drive I/O**		
All models	30 to 14 [0.14 to 1.5]	1.95 [.22]

***Table 3**, 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.

3.5 External Regen Resistor Wiring (RG)

Regenerative (regen) shunt circuitry, for use with external regen resistors, is provided on models SMLC-SA210, SMLC-SA217, SMLC-SA220, SMLC-SA225, SMLC-SA235, SMLC-SA260 and all 460 VAC drives, SMLC-SA4xx. Regen resistors are connected between the **Bus +** and **RG** terminals on TB1 (refer to **Figure 3**).

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

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

- Regen resistor, and other system, wiring should be routed so that it is not in contact with the regen resistors.
- **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.
- Mounting and wiring practices should be in accordance with NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.

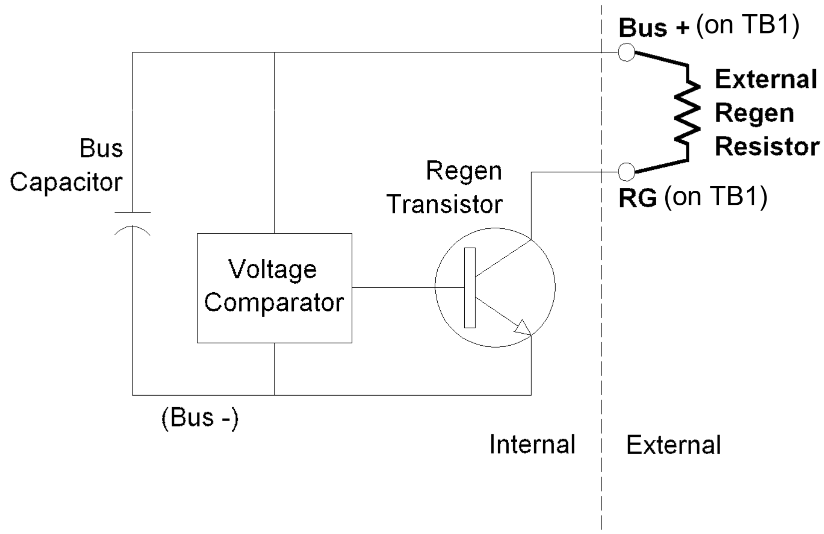


Figure 3, *Regen Resistor Connection*

For information on how the shunt circuitry operates, as well as information on sizing regen resistors, see Section **5.14**, **Regenerative Loads** (page 60).

3.6 Bus Sharing Wiring (230 V SMLC-SA225-260 and 460 V SMLC-SA405- 450)

Some 230 VAC ServoWire SD drives support DC Bus sharing and all 460 VAC ServoWire SD drives support DC Bus sharing. Since the SMLC-SA includes an integrated ServoWire SD drive this means that SMLC-SA models SMLC-SA225, SMLC-SA235, SMLC-SA260 and SMLC-SA405 to SMLC-SA450 support DC bus sharing. Bus sharing is not relevant in a single axis application but the information is included here for completeness.

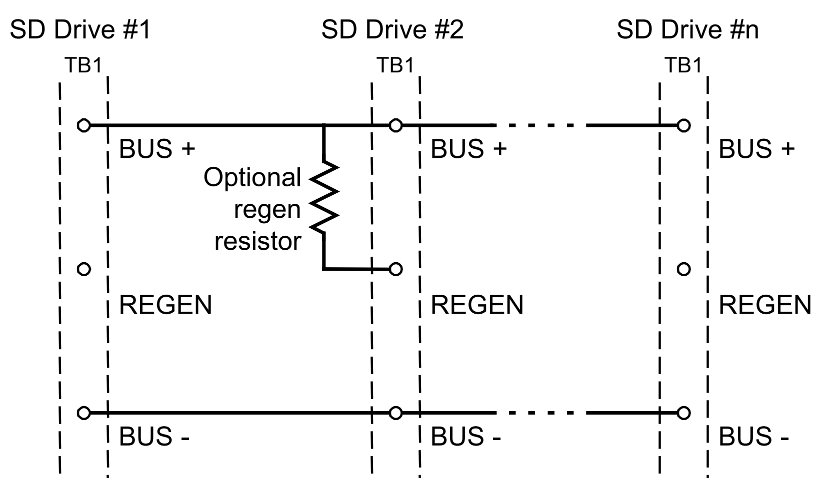
To configure these drives for bus sharing, the **Bus +** and **Bus –** terminals are connected as shown in **Figure 4**. Drives should be connected so that the highest power drives are in the center of the bus-sharing chain. Bus wiring between drives should be less than 12 inches in length to minimize 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 **5.14.7**, **Bus Sharing** (page 66).

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

- Wiring should have heat resistant, non-combustible insulation, rated at 600V or more.
- Switching voltages exceeding 400 VDC (230 V drives) and up to 800 VDC (460 V drives) may be present on the BUS+ and BUS- terminals. Use appropriate high voltage safety and noise suppression wiring methods.
- Mounting and wiring practices should be in accordance with NEC (National Electric Code) or UL (Underwriters Laboratories) specifications and in compliance with local ordinances.
- 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 page 14 for more information on regen resistor installation.

Figure 4, *Bus Sharing Connections*



3.7 Servomotor Installation

3.7.1 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 25ºC; for ambient temperatures above 25ºC, use the formula given below in Figure 5. Note that $°C_{Max}$ is 100ºC for all G-Series Servomotors except models G006, G011, G015, and G019; for these motors, $°C_{Max}$ is 85ºC. The motor current is de-rated by the same factor as the torque.

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

Figure 5, *G-Series Torque Derating for High Ambient Temperature*

3.7.2 Recommended Servomotor Wiring Methods

- When the motor is mounted to the machine and grounded through the machine frame, $^{dv}/_{dt}$ current flows from the servodrive through the floating capacity of the motor. To prevent the noise effects from this current, and also for safety, the motor housing (terminal D of the motor connector) should be connected to the frame of the servodrive (TB1 ground pin or pin 3 on J6), which should be directly grounded to the control panel frame using copper wire.
- When motor wiring is contained in metal conduits, the conduits and boxes must be grounded. For all SMLC-SA models, use wires of 12 AWG or heavier for grounding to the case (preferably flat woven silver-plated copper braid).
- If possible, route motor feedback and motor power cables in separate conduits or ductwork, separated by a minimum of 10 inches (25 cm).

3.7.3 Motors with Integral Fail-Safe Brakes

NOTE: The integral fail-safe brakes supplied on G-Series, H-Series and D-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 6** (page 20) for G-Series cable part numbers. Drawings for these cables are shown in Appendix E.. Figure 6 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 51) for further information.

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

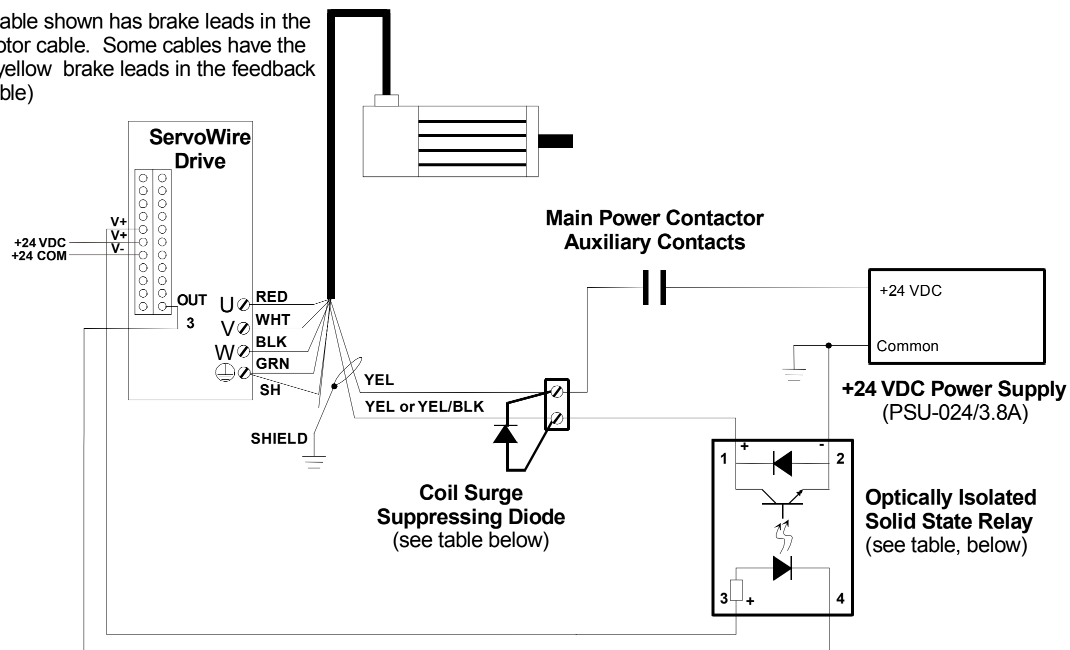


Figure 6, Fail-Safe Brake Interlock Circuit

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

3.7.4 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 5** (motors without brakes) and **Table 6** (motors with brakes).

MAC-G Motors Without Brakes	Motor Power Cable	Motor Encoder Cable
G005, G010, G006, G011, G015,G019 with SMLC-SA203 – 220	CBL-GMSW1 (p D-3)	
G016, G030, G040, G055, G080, G115 with SMLC-SA203 – 220	CBL-GMSW2 (p D-4)	CBL-GMSW (1-50 ft: p D-1) (51-150 ft: p D-2)
G080 & G115A2 with SMLC-SA225 & 235	CBL-GMSWT2 (p D-5)	
G130, G210 & G280 with SMLC-SA210 – 220	CBL-GMSW3 (p D-6)	
G130A2 with SMLC-SA225	CBL-GMSWT3 (p D-7)	CBL-GMSW (1-50 ft: p D-1) (51-150 ft: p D-2)
G210, G280A4 & G360A4 with SMLC-SA225 – 235	CBL-GMSWT5 (p D-7)	
G280A2 & G360A2 with SMLC-SA235 & 260	CBL-GMSWT6 (p D-7)	
G640A2 with SMLC-SA260	CBL-GMSWT9 (p D-7)	

Table 5, *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 SMLC-SA203 – 220</td><td colspan="2">CBL-GMSWB1 (p D-3)</td></tr>
<tr><td>G016, G030, G040, G055, G080, G115
with SMLC-SA203 – 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 SMLC-SA225 & 235</td><td>CBL-GMSWBT2 (p D-11)</td></tr>
<tr><td>G130, G210 & G280
with SMLC-SA210 – 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 SMLC-SA225</td><td>CBL-GMSWT3 (p D-7)</td></tr>
<tr><td>G210, G280A4 & G360A4
with SMLC-SA225 – 235</td><td>CBL-GMSWT5 (p D-7)</td></tr>
<tr><td>G280A2 & G360A2
with SMLC-SA235 & 260</td><td>CBL-GMSWT6 (p D-7)</td></tr>
<tr><td>G640A2
with SMLC-SA260</td><td>CBL-GMSWT9 (p D-7)</td></tr>
</table>

Table 6, *Cable Drawings for G-Series Motors* ***With*** *Brakes*

3.7.5 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 7** (motors without brakes) and **Table 8** (motors with brakes).

MAC-D Motors Without Brakes	Motor Power Cable	Motor Encoder Cable
DE003, DE006, DE008, DE011, DE021, DE042 with SAC- SD_203 – 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 SMLC-SA210 – 220	CBL-DMSW1 (p F-3)	
DA055 with SMLC-SA225	CBL-DMSWT1 (p F-4)	
DA090, DA110, DB200 with SMLC-SA225 – 260	CBL-DMSWT2 (p F-4)	
DA140, DB300 with SMLC-SA235 – 260	CBL-DMSWT3 (p F-4)	
DB100 with SMLC-SA220	CBL-DMSW4 (p F-3)	
DB100 with SMLC-SA225	CBL-DMSWT4 (p F-4)	
DB330 with SMLC-SA260	CBL-DMSWT5 (p F-4)	
DB465, DB700 with SMLC-SA235 – 260	CBL-DMSWT6 (p F-4)	

Table 7, *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- 203 – 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 SMLC-SA210 – 220	CBL-DMSWB1 (p F-5)	
DA055 with SMLC-SA225	CBL-DMSWBT1 (p F-6)	
DA090, DA110, DB200 with SMLC-SA225 – 260	CBL-DMSWBT2 (p F-6)	
DA140, DB300 with SMLC-SA235 – 260	CBL-DMSWBT3 (p F-6)	
DB100 with SMLC-SA220	CBL-DMSWB4 (p F-5)	
DB100 with SMLC-SA225	CBL-DMSWBT4 (p F-6)	
DB330 with SMLC-SA260	CBL-DMSWT5 (p F-4) & CBL-DMACB (p F-7)	
DB465, DB700 with SMLC-SA235 – 260	CBL-DMSWT6 (p F-4) & CBL-DMACB (p F-7)	

Table 8, *Cable Drawings for D-Series Motors* ***With*** *Brakes*

3.7.6 H-Series Servomotor Connections

Serial encoder support requires the "S" option.

MAC-H Motors Without Brakes	Motor Power Cable	Motor Encoder Cable
HA030, HA055, HB025, HB055, HB080	CBL-HMSW1	CBL-HMSW (1-50 ft: p G-1) (51-150 ft: p G-5)
HA110, HA090, HB200	CBL-HMSW2	
HA140, HB300	CBL-HMSW3	
HB100	CBL-HMSW4	
HB330	CBL-HMSW5	
HB465, 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 9, *Cable Drawings for H-Series Motors* ***Without*** *Brakes*

3.7.7 H-Series Motor Encoder Resolutions

Model number		Raw encoder resolution	Motor resolution
MAC-HE003A/	2.8 lb-in, 5000 RPM max, 115 VAC	**13-bit inc** **16-bit abs**	8,192 65,536
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**	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**	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		

3.7.8 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.

3.7.9 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.

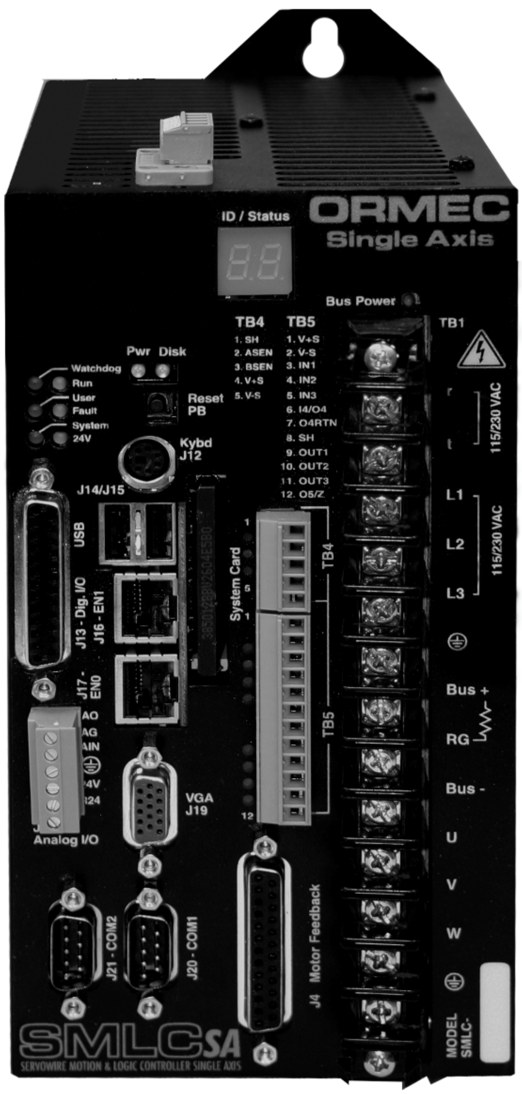
With a direct drive application a torsionally rigid flexible coupling should be used. Timing belts and gearboxes are also commonly used in servo applications. Shaft loading should be kept to a minimum. The allowable shaft bearing loading is listed in the Specifications Section.

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 key-way, 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, ringfeeder devices, etc.

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

Chapter 4 Components/Connections

4 Componen ts/Connections



ID/ Status	Drive ID and status 2-digit display
LEDs	Watchdog OK, Run, User, Fault, System, 24v power, 5v power, Disk activity, Bus power, Drive I/O and high speed sensor status
PB	Reset Pushbutton
System Card	Compact Flash **WARNING – Do not install or remove the system card with power applied to the SMLC-SA!**
J4	Motor feedback connector
J5	Auxiliary axis feedback connector (optional, on bottom, not shown in picture at left)
J12	Keyboard port (not supported by the software)
J13	Controller Digital I/O connector
J14/15	USB ports (not supported by the software)
J16/17	Ethernet ports EN1 and EN0
J18	Controller Analog I/O connector
J19	VGA connector (not supported by the software)
J20	Development Serial Port – COM1
J21	HMI /User Serial Port - COM2
TB1	Input AC Power, Bus Power, Motor and Regen connections
TB2	Control power (SA225-260, SA417-450 only)
TB3	Drive Analog I/O connector (optional, on top)
TB4	Drive I/O power and high speed sensors
TB5	Drive I/O power and inputs/outputs

This chapter provides descriptions of the SMLC-SA's components and connections. This includes pinouts of all connectors and terminal blocks.

4.1 Status/Miscellaneous

4.1.1 ID/Status display

The functioning of the ID/Status display is defined in section 5.2 - ID/Status display (page 43).

4.1.2 LEDs

The functioning of the LEDs is defined in section 5.3 - Status LED's (page 43). The state of the LEDs is indeterminate after a power cycle or reset. When the SMLC-SA firmware has finished loading the Watchdog OK LED will start flashing. This indicates that the boot process has completed.

4.1.3 Reset Pushbutton

The reset pushbutton is recessed on the front panel of the SMLC-SA. Pressing the reset pushbutton will reset the processor causing the motor to be disabled and the SMLC-SA to reboot. Resetting is a satisfactory alternative to power cycling the SMLC-SA after performing an SMLC firmware upgrade.

WARNING: Pressing the reset pushbutton does NOT automatically turn off the SMLC's local digital outputs and/or Drive outputs!

4.1.4 System Card

The System Card is a Compact Flash format storage device that contains the operating system, SMLC-SA firmware, SMLC-SA settings such as Ethernet IP addresses as well as the user application and data. The system card may be transferred from SMLC-SA to SMLC-SA or even pre-programmed and sent to a remote location.

4.2 Connectors

4.2.1 Motor Feedback Connector (J4)

*Refer to the **Table 54, Motor Encoder Specifications** (J4) 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 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 +5.3 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 servodrive: • 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 5.14.10 for a detailed explanation.
21	SHIELD	Motor encoder shield termination point
22 23	BAT+ BAT–	(Optional) Absolute encoder (3 VDC) backup power output.
14 15	SDATA SDATA'	Bi-directional differential signal pair for serial encoder communications.

Table 10, *Motor Feedback Connector (J4) Descriptions*

4.2.2 Pacer Feedback Connector (J5)

Note: The optional Pacer Feedback Connector is mounted on bottom of drive.

*Refer to the **Table 54, Motor Encoder Specifications** (J4) 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 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*

4.2.3 Keyboard/Mouse Interface Connector (J12)

The Keyboard Interface, standard on all SMLC-SA controllers, is a 6-pin mini-DIN connector. It is compatible with all IBM PC-AT compatible keyboards. The keyboard is only recognized at power-up.

The Keyboard interface is not supported by CoDeSys in the current release of SMLC-SA models.

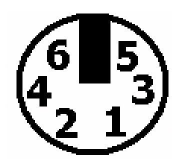


Figure 7, Keyboard Connector (J12) connector.

Pin	Signal	Description
1	KDAT	Bi-directional serial data line used to transfer data from or commands to the PC-AT keyboard.
2	MDAT	Bi-directional serial data line used to transfer data from or commands to the PS/2 mouse.
3	GND	Ground
4	VCC	Power
5	KCLK	Bi-directional clock signal used to strobe data/commands from/to the PC-AT keyboard.
6	MCLK	Bi-directional clock signal used to strobe data/commands from/to the PS/2 mouse.

Table 12, *Keyboard/Mouse Connector (J12) pin-out.*

4.2.4 Controller Digital I/O Connector (J13)

The SMLC-SA includes 8 digital inputs and 8 digital outputs via a 25 pin D-Sub female connector (J13). These I/O points are optically coupled and require an external voltage source via connector J18. The specifications for the I/O points are available in sections 6.1.2 and 6.1.3 beginning on page 75.

A functional schematic of the Inputs is shown in **Figure 8**. A functional schematic of the Outputs is shown in **Figure 9**.

Pin	Description
1	Chassis Frame
2	Digital Input 1
3	Digital Input 2
4	Digital Input 3
5	Digital Input 4
6	Digital Input 5
7	Digital Input 6
8	Digital Input 7
9	Digital Input 8
10	Digital Output 2
11	Digital Output 4
12	Digital Output 6
13	Digital Output 8
14	Ground
15	Ground
16	Ground
17	Ground
18	Ground
19	Ground
20	Ground
21	Ground
22	Digital Output 1
23	Digital Output 3
24	Digital Output 5
25	Digital Output 7

Table 13, Digital I/O connector (J13) pin-out.

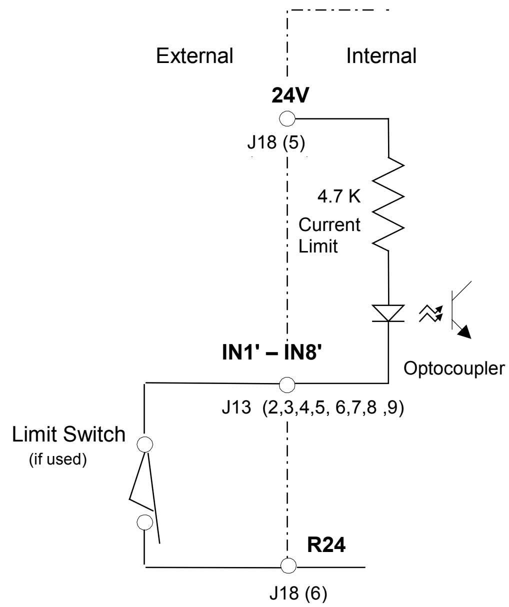


Figure 8, *Schematic of Discrete Inputs IN1'-IN8'*

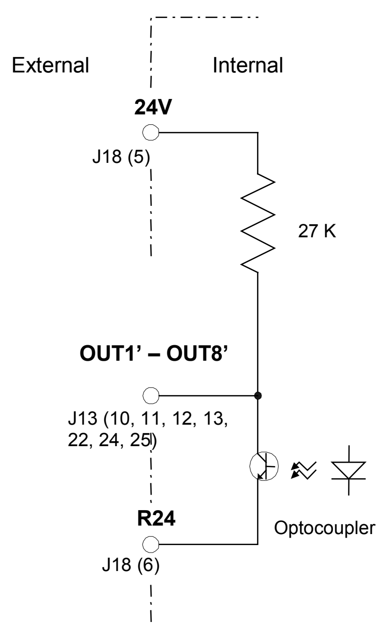


Figure 9, *Schematic of Discrete Outputs OUT1'-OUT8'*

4.2.5 USB Ports (J14/J15)

The USB ports are not supported by CoDeSys in the current release of the SMLC-SA.

4.2.6 Ethernet Ports EN1 and EN0 (J16/J17)

The Ethernet interface ports use an industry standard Intel 82551ER 10/100Base-Tx Ethernet chip. It can be used for networking with WAGO I/O, a MODBUS/TCP based HMI package or communications with the CoDeSys IDE or OPC Server.

Figure 10, Ethernet Connector (J16 & J17) connector

Pin	Signal	Description
8	*NC*	*NC* = No Connection
7	*NC*	
6	**RXD-**	Ethernet 10/100Base-Tx differential receiver inputs.
5	*NC*	
4	*NC*	
3	**RXD+**	Ethernet 10/100Base-Tx differential receiver inputs.
2	**TXD-**	Ethernet 10/100Base-Tx differential transmitter outputs.
1	**TXD+**	Ethernet 10/100Base-Tx differential transmitter outputs.

Table 14, Ethernet Port (J16 & J17) pin-out.

4.2.6.1 Ethernet Cables & Accessories

EISK5-100T	Ethernet Switch, 10BASE-T, 5 port, 24 VDC input, rail mount
CBL-ENET/3	Cable, Ethernet, RJ45, 3 ft.
CBL-ENET/7	Cable, Ethernet, RJ45, 7 ft.
CBL-ENET/10	Cable, Ethernet, RJ45, 10 ft.
CBL-ENET/25	Cable, Ethernet, RJ45, 25 ft.
CBL-ENET/50	Cable, Ethernet, RJ45, 50 ft.
CBL-ENET/75	Cable, Ethernet, RJ45, 75 ft.
CBL-ENET/100	Cable, Ethernet, RJ45, 100 ft.
	DO NOT USE CROSSOVER CABLES WITH A HUB. Crossover cables are used for connecting two devices directly together. Example: SMLC-SA to WAGO I/O without a hub.
CBL-ENET**X**/3	Cable, Ethernet **crossover**, RJ45, 3 ft.
CBL-ENET**X**/7	Cable, Ethernet **crossover**, RJ45, 7 ft.
CBL-ENET**X**/10	Cable, Ethernet **crossover**, RJ45, 10 ft.
CBL-ENET**X**/25	Cable, Ethernet **crossover**, RJ45, 25 ft.

Table 15, Ethernet Cables & Accessories part numbers.

4.2.7 Controller Analog I/O Connector (J18)

The SMLC-SA includes a 14-bit analog input and a 14-bit analog output on connector J18. This connector is also the location for supplying the power for the digital inputs and outputs. The 24V LED on the front of the SMLC-SA indicates the presence of the I/O supply voltage. The analog input and output specifications are found in sections 6.1.5 and 6.1.6 beginning on page 76. The specification for the I/O supply voltage is found in section 6.1.4 on page 75.

Pin	Signal	Description
1	AOUT	Analog output
2	AGND	Analog ground
3	AIN	Analog input
4		Chassis ground
5	24V	I/O supply voltage +
6	R24	I/O supply voltage -

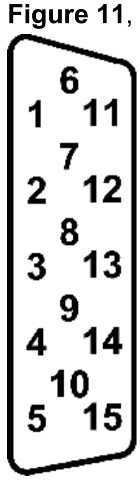
Table 16, Analog I/O connector (J18) pin-out.

4.2.8 VGA Connector (J19)

The VGA connector is capable of supporting a wide range of flat panel, CRT and LCD displays. There is no CoDeSys support for the VGA display in the initial release of these SMLC-SA models.

NOTE: *Beginning with SMLC firmware revision 2.0.0 the IP addresses assigned to the Ethernet ports are printed to the VGA port at power-up. If the IP address assignments of the Ethernet ports is unknown they may be determined by connecting a standard VGA monitor to this port and power cycling the SMLC.*

Figure 11, SMLC-SA - CRT Connector (J19) connector



Pin	Signal	Description
1	RED	Analog output carrying the red color signal to the CRT. For 75 ohm cable impedance.
2	GREEN	Analog output carrying the green color signal to the CRT. For 75 ohm cable impedance.
3	BLUE	Analog output carrying the blue color signal to the CRT. For 75 ohm cable impedance.
4	*NC*	No Connection
5	DIG-GND	Ground reference for HSYNC and VSYNC.
6	ANA-GND	Ground reference for RED, GREEN, and BLUE
7	ANA-GND	
8	ANA-GND	
9	NC	No Connection
10	DIG-GND	Ground reference for HSYNC and VSYNC.
11	*NC*	
12	DDCDAT	Display Data Channel Data. Used as data signal to/from monitors with DDC interface.
13	HSYNC	CRT horizontal synchronization output.
14	VSYNC	CRT vertical synchronization output.
15	DDCCLK	Display Data Channel Clock. Used as clock signal to/from monitors with DDC interface.

Table 17, CRT Connector (J19) pin-out

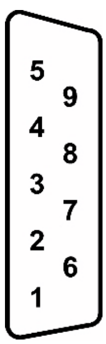
4.2.9 Development Serial Port COM1 - RS232 (J20)

SMLC-SA programming, system development, and system monitoring are accomplished by using a Microsoft Windows (NT/2000/XP) based PC attached to the RS-232 Development Serial Port connector (J20), which is located on the front of the SMLC. The Development Serial Port is an asynchronous RS-232 device. It is handled internally by a 16C550 compatible serial communications controller, and interfaced through a DB9 connector. Connection between the development computer and SMLC-SA Development Serial Port can be made while power is applied to the SMLC.

ORMEC can provide a coil-cord style communication cable (part number CBL-CDS-SER/10) for the Development Serial Port which are compatible with an IBM PC (DB9) style serial connector.

Configuration of the development computer communications is found in section 8.5 - Setting up Serial communications on page 100. The specifications for the COM1 serial port are found in section 6.1.7 - Development port COM1 Specifications (J20) on page 77.

Figure 12, RS-232 Serial Port Connector (J20,J21) Pinout



Pin	Signal	Description
1	DCD	Data Carrier Detect. This signal indicates that the modem or data set has detected the data carrier.
2	RxD	Serial input. This signal receives serial data from the communication link.
3	TxD	Serial output. This signal sends serial data to the communication link. The signal is set to a marking state on hardware reset when the transmitter is empty or when loop mode operation is initiated.
4	DTR	Data Terminal Ready. This signal indicates to the modem or data set that the on-board UART is ready to establish a communication link.
5	GND	Ground
6	DSR	Data Set Ready. This signal indicates that the modem or data set is ready to establish a communication link.
7	RTS	Request To Send. This signal indicates to the modem or data set that the on-board UART is ready to exchange data.
8	CTS	Clear To Send. This signal indicates that the modem or data set is ready to exchange data.
9	RI	Ring Indicator. This signal indicates that the modem has received a telephone ring signal.

Table 18, RS-232 Serial Port Connector (J20,J21) pin-out.

4.2.10 HMI Serial Port COM2 - RS232 (J21)

The SMLC-SA HMI serial port J21 uses a DB9 connector that provides access to asynchronous serial 232 communications. This port is commonly used to interface to the ORMEC HMI flat-panel touch-screen, but any serial MODBUS protocol master device can be used. It can alternately be used for general purpose serial communications with terminals, computers or programmable controllers by using the CoDeSys Library SysLibCom.lib.

Connections to the SMLC-SA HMI Serial Port is made through connector J21, which is located on the lower left side of the SMLC. The pin-out of the SMLC-SA HMI Serial Port is shown in **Figure 12**, RS-232

Serial Port Connector (J20,J21) Pinout. The specifications for the COM2 serial port are found in section 6.1.8 - HMI Serial Port COM2 Specifications (J21) on page 77.

The SMLC-SA User serial ports use a DB9 connector that provides access to asynchronous serial RS-232 communications. The ports can be used for general purpose serial communications with terminals, computers or programmable controllers by using the CoDeSys Library SysLibCom.lib.

4.3 Terminal Blocks

4.3.1 Drive Power Terminal Block (TB1)

4.3.1.1 SMLC-SA2__ Drive Power Terminal Block (TB1)

Terminal	Function	Description
r, t	Input Control Power (SMLC-SA203 – SMLC-SA220 only, for SMLC-SA225 – SMLC-SA260 see **Table 21**)	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power.
L1, L2, L3 – or – **L1, L2**	Input Main Bus Power	**(SMLC-SA210, 217, 220, 225, 235, 260):** Three phase 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz**.** **(SMLC-SA203, 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. (SMLC-SA225 – SMLC-SA260 only). See section 5.14.7 - Bus Sharing (page 66)
RG	Regen Resistor	If an external regen resistor is used (SMLC-SA210, 217, 220, 225, 235, 260 only), it is connected between **Bus +** and **RG**. See Section 3.5 - External Regen Resistor Wiring (RG) (page 41).
U,V,W	Motor Power	Single or Three-phase power to the motor. See: • G-Series Servomotor Connections (page 18) • D-Series Servomotor Connections (page 21) • H-Series Servomotor Connections (page 23) • DC Servomotor Connections (page 24). 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 (SMLC-SA225 – SMLC-SA260 only)

Table 19, *SMLC-SA2__ 115/230 VAC Drive Power Connections (TB1)*

4.3.1.2 SMLC-SA4__ Drive Power Terminal Block (TB1)

Terminal	Function	Description
r, t	Input Control Power (SMLC-SA405 – SMLC-SA410 only, for SMLC-SA417 – SMLC-SA450 see **Table 22**)	Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power.
L1, L2, L3 – or – **L1, L2**	Input Main Bus Power	**(SMLC-SA405, 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. See section 5.14.7 - Bus Sharing (page 66)
RG	Regen Resistor	If an external regen resistor is used, it is connected between **Bus +** and **RG**. See Section 3.5 - External Regen Resistor Wiring (RG) (page 41).
U,V,W	Motor Power	Single or Three-phase power to the motor. See: • G-Series Servomotor Connections (page 18) • D-Series Servomotor Connections (page 21) • H-Series Servomotor Connections (page 23) • DC Servomotor Connections (page 24). 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 (SMLC-SA417 – SMLC-SA450 only)

Table 20, *460 VAC Drive (SMLC-SA4__) Power Connections (TB1)*

4.3.2 Control Power Terminal Block (TB2)

4.3.2.1 SMLC-SA225 – SMLC-SA260 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 Drives in a network have control power applied, it is best to leave their control power on continuously.
⏚	Ground	Ground for control logic input power. **Must be connected to input power ground.**

Table 21, *SMLC-SA225 – SMLC-SA260 Control Power Connections (TB2)*

4.3.2.2 SMLC-SA417 – SMLC-SA450 Control Power Terminal Block (TB2)

Terminal	**Function**	**Description**
r, t	Input Control Power	**417 & 425** - Single phase 115 (-20%) to 230 (+15%) VAC, 50/60 Hz control logic input power. **435 & 450** - 230 (-20%, +15%) VAC, 50/60 Hz control logic input power. Generally, once the servodrives in a network have control power applied, it is best to leave their control power on continuously.
⏚	Ground	Ground for control logic input power. **Must be connected to input power ground.**

Table 22, *460VAC (SMLC-SA417 – SMLC-SA450) Control Power Connections (TB2)*

4.3.3 Drive Analog I/O Connections (TB3)

Refer to the **Table 55, Drive Analog I/O** Specifications (TB3) section (page 86) of the Specifications chapter for further information.

Pin	Signal	Function	Description
1	Shield	Cable shield connection	Connect the cable shield at one end only.
2	AOUT	Analog Output	Provides an analog output from the drive. The signal output is Software configurable. Torque command, Velocity Monitor, Position Error, Bus Voltage, Phase U, V or W current or a manual value can be selected.
3	AGND	Analog Ground	Ground reference for AOUT and AIN
4	AIN	Analog Input	Provides an analog input. This input can be used to close a feedback loop in the drive when in tension mode or can be used by the host controller. The input has a Software configurable low pass filter.

Table 23, *Drive Analog I/O (TB4) Connections*

4.3.4 Drive Sensor Connections (TB4)

Refer to the **Table 53, Drive I/O Specifications** (TB4 and TB5) section (page 84) of the Specifications chapter for further information.

Pin	Signal	Function	Description
1	Shield	Cable shield connection	Connect the cable shield at one end only.
2 3	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 13** (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.
4 5	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'

Table 24, *Drive Sensor (TB4) Connections*

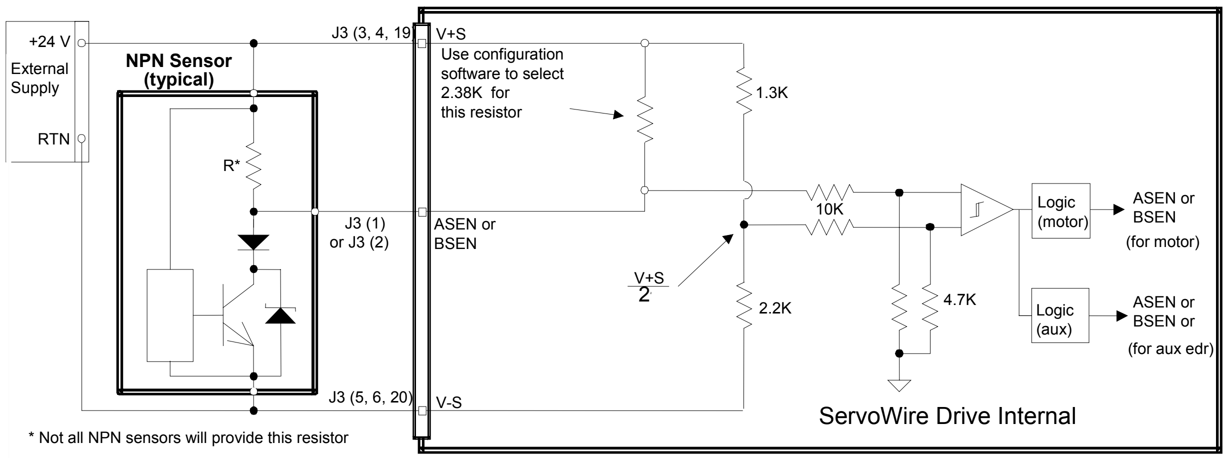
4.3.4.1 High Speed Sensor Inputs (ASEN, BSEN)

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 13 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



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

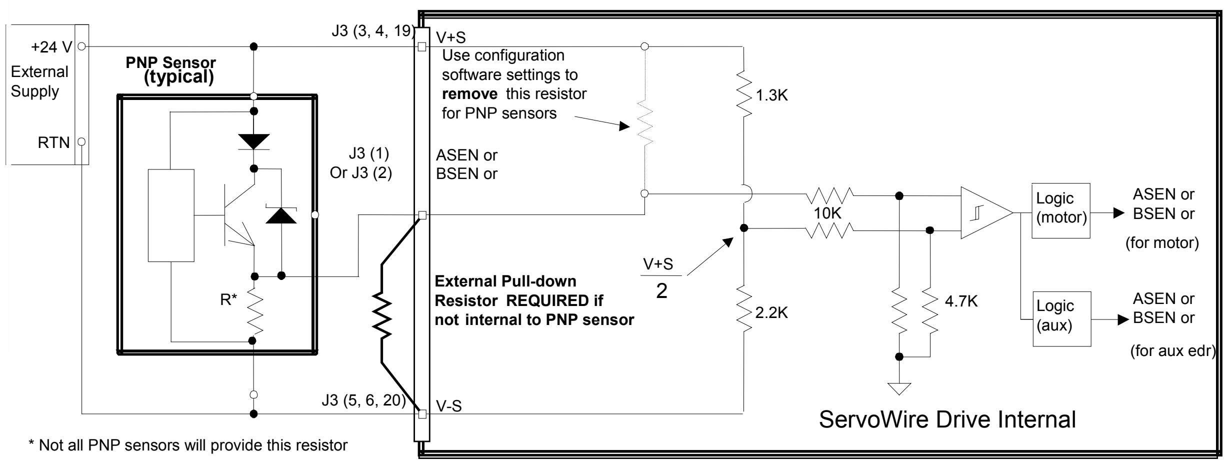


Figure 13, Schematic of ASEN and BSEN wiring for NPN and PNP sensors

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 drive frame ground (TB1, ground pin).

Configuration software such as ServoWire Pro or your application program are 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 servodrive outputs OUT1 and OUT2.

4.3.5 Drive Input / Output Connections (TB5)

Refer to the **Table 53, Drive I/O Specifications** (TB4 and TB5) section (page 84) of the Specifications chapter for further information.

Pin	Signal	Function	Description
1 2	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'
3 4 5	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 49) for further information. See **Figure 14** (page 40) 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.
6 7	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 50) for further information. See **Figure 14** (page 40) for a simplified schematic.
8	Shield	Cable shield connection	Connect the cable shield at one end only.
9 10 11 12	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 51) for further information. See (page 41) 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 25, *Drive Input / Output (TB5) Connections*

4.3.5.1 Drive 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 servodrive 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.

	SMLC-SA
Hardware Travel Limit Forward **Hardware Travel Limit Reverse** Refer to the **Hardware Travel Limits (IN1', IN2')** page 49	IN1' IN2'
E-Stop / Quick Stop Refer to the **Quick Stop Input (IN3')** page 49	IN3'

Figure 14 shows a simplified schematic of the Discrete Inputs, TB5 pins 3, 4, 5 and 6 (IN1' – IN4') connected to a limit switch. Refer to the Hardware Travel Limits on (page 49) and Quick Stop Input (page 50) 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.

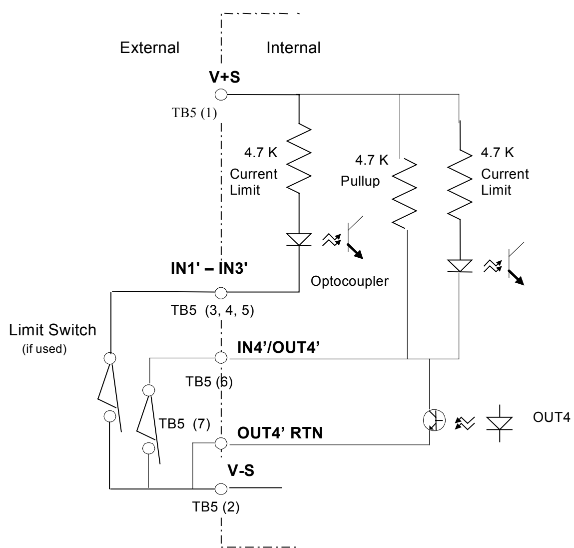


***Figure 14**, Schematic of IN1', IN2', IN3' and IN4'/OUT4' Inputs*

4.3.5.2 Drive Discrete Outputs (OUT1'-OUT5')

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

The servodrive 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.

	SMLC-SA
Brake control Refer to the **Brake Control Output (OUT3')** page 51	OUT3'
Drive Ready Refer to the **Drive Ready Output (OUT4')** page 51	OUT4'
Zero Reference Refer to the **Encoder Feedback Zero Reference Output** (OUT5') page 51	OUT5'

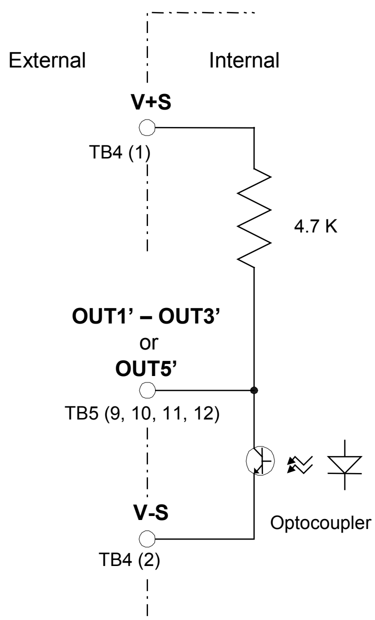


Figure 15, *Schematic of Discrete Outputs OUT1'-OUT5'*

Chapter 5
Operation

5 Operation

5.1 Power-up

The SMLC-SA is a user-programmable device and its operation is dependent on the ServoWire Pro configuration file & SMLC-SA application program present on the System Card.

Whenever AC power is applied to the SMLC-SA, it executes its power-up sequence, which can last up to 30 seconds. When the Watchdog OK LED starts flashing at its once per second rate the power-up sequence is complete. If a boot project is available on the System Card it is executed automatically. See the CoDeSys online help for assistance in creating a boot project.

NOTE: Until the SMLC-SA is initialized the state of the Status LED's on the SMLC-SA do not properly indicate the system status.

5.2 ID/Status display

At power-up and under normal operation the ID/Status display displays the servodrive ID which in an SMLC-SA is always 1. When a drive fault condition occurs the ID/Status display shows a two-digit fault code. The fault codes are listed in section 9.3.

5.3 Status LED's

Name	Color	Description
POWER	Green	There is 5V present on the main processor board
Disk	Yellow	The Compact Flash disk is being accessed
RUN	Green	The SMLC-SA is in run mode.
FAULT	Red	Internal error. The SMLC-SA must be power cycled to reset. A dump file will be generated and may be retrieved via ServoWire Pro's Dump utility. Contact ORMEC Service department for instructions.

Watchdog OK	Yellow	System Watchdog LED **MUST BE FLASHING**. This flashing yellow system Watchdog OK LED on the front of the controller will flash every second during normal operation. When CoDeSys is online with the SMLC-SA this LED will flash twice a second. When CoDeSys is logged out the flashing will resume at once per second. If the LED stops flashing the SMLC-SA operation is completely suspended and the Fault LED should come on. If you have disconnected CoDeSys and the LED is still flashing twice per second you will not be able to re-establish CoDeSys communications until you power cycle the SMLC-SA.
USER	Yellow	Under application program control via the MC_UserLED function block
24V	Green	The User supplied I/O voltage is present on J18.
SYSTEM	Yellow	Non-volatile memory batteries need to be replaced. Tested every 24 hours. The battery is not user replaceable. Contact ORMEC Service for repair.
Bus Power	Yellow	Indicates that bus voltage is present in the servodrive
Drive Inputs	Yellow	Indicates the status of the drives general purpose inputs IN1'-IN4'
Drive Sensors	Yellow	Indicates the status of the drives high-speed sensor inputs ASEN', BSEN' and ZREF'
Drive Outputs	Yellow	Indicates the status of the drives general purpose outputs OUT1'-OUT5'

Table 26, SMLC-SA Status LED's

5.4 Non-volatile memory

The CoDeSys Programming language supports non-volatile (NV) variables through the use of **RETAIN** and **PERSISTENT** keywords. Unlike normal CoDeSys variables, NV variable values are maintained through a loss of power or system reset, and are available to a user's application program when power is restored. 32 Kbytes of NV storage is available on the SMLC-SA Models covered in this manual

Retain variables are identified by the keyword **RETAIN**. These variables maintain their value even after an uncontrolled shutdown of the controller as well as after a normal switch off and on of the controller. When the program is run again, the stored values will be processed further.

Persistent variables are identified by the keyword **PERSISTENT**. Unlike Retain variables, these variables retain their value after a re-download or 'Online' 'Reset, but not at switching off and on of the controller (i.e. not at the command 'Online' 'Reset'), because they are not saved in the "retain area".

To reset the non-volatile variables to 0 use the command 'Online' 'Reset (original)'. Note that this will delete your boot project as well.

See: CoDeSys online help for further details.

5.5 System Power Wiring & Interlocks

The SMLC-SA provides integrated emergency stop and fault interlocks **through the servodrive**. System wiring diagrams for standard ORMEC servodrives, which include the recommended safety and fault interlocks for a typical system, are provided in the Appendix A. The primary features of these system-wiring diagrams are:

- The Main Power Contactor switches servomotor power, called Main Power.
- For the *Main Power Contactor* to be enabled, both the ServoWire Drive *E-Stop/Quick Stop* input and the Drive Ready output must be closed.
- For the *Drive Ready* output on the servodrive to be closed, five conditions must be satisfied:
- There must be no SMLC-SA diagnostic faults, including power-up diagnostics.

- There must be power (+5 to +24 referenced to RTN) applied to the drives V+S input and RTN must be connected to V-S.
- There must be current flow from the drives E-Stop/Quick-Stop input to V-S.
- There must be no drive faults from any standby or active servodrive and no open encoder signal wires on axes in pacer, standby, or active mode.
- Bus power must be applied to the drive.

There are many acceptable variations of these System Wiring Diagrams. If using a variation, it should incorporate the primary features as described above and as shown in the Appendix. Contact the ORMEC Service Department with any questions you may have in this area.

5.5.1 Emergency-Stop / Quick-Stop and Drive Ready Configuration

Located on the ServoWire drive is an Emergency-Stop / Quick -Stop input and Drive Ready output, allowing fail-safe control.

Emergency Stop Input:
A discrete input can be configured to operate as Emergency Stop input. When unasserted, this input causes the servo drive to generate a drive fault and disable output power to the motor, as well as generating an **OP_FAULT** condition in the application program.

Quick Stop Input:
A discrete input can be configured to operate as Quick Stop input. Unasserting the input in this mode generates an **OP_ALARM** condition in the application program and has the effects indicated below, which are dependent on the axis mode of operation (torque, velocity or position).

- **Torque mode -** Generates an OP_ALARM condition in the application program, output remains enabled and the drive continues to receive torque commands. This allows the application program to decelerate the load under control.

- **Velocity / Position mode -** Generates an OP_ALARM condition in the application program, output remains enabled, zero speed is commanded. Commanding zero speed may result in commanded current to bring the motor to a stop.

NOTE: **The SMLC-SA must be configured for E-Stop / Quick-Stop operation using ServoWire Pro.**

To configure the E-Stop/Quick-Stop operation right mouse click on the ServoWire Pro "Drive network \ Drive Icon" to display the drive properties form.

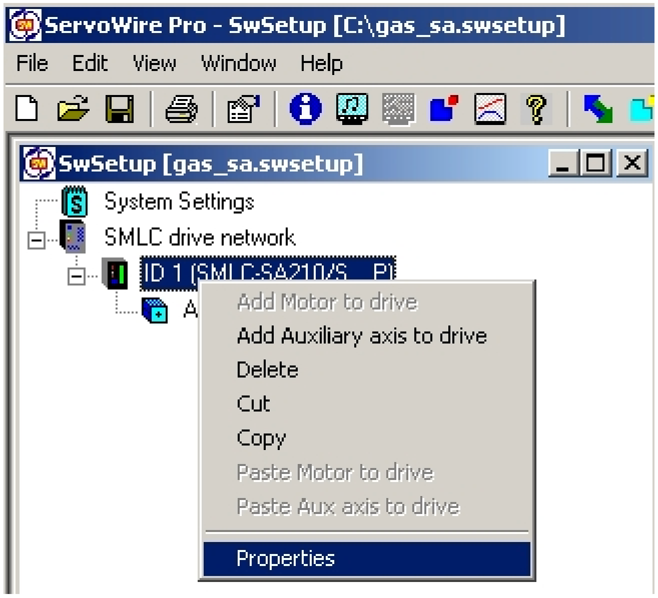


Figure 16, ServoWire Pro Drive Properties

5.5.2 Selecting the ServoWire drive input behavior

The ServoWire Pro, "Drive Properties / Inputs" Setup screen, allows a user-configurable input to be used to indicate when the drive is operating normally, without faults. This input is intended for use in the system E-Stop interlock circuit.

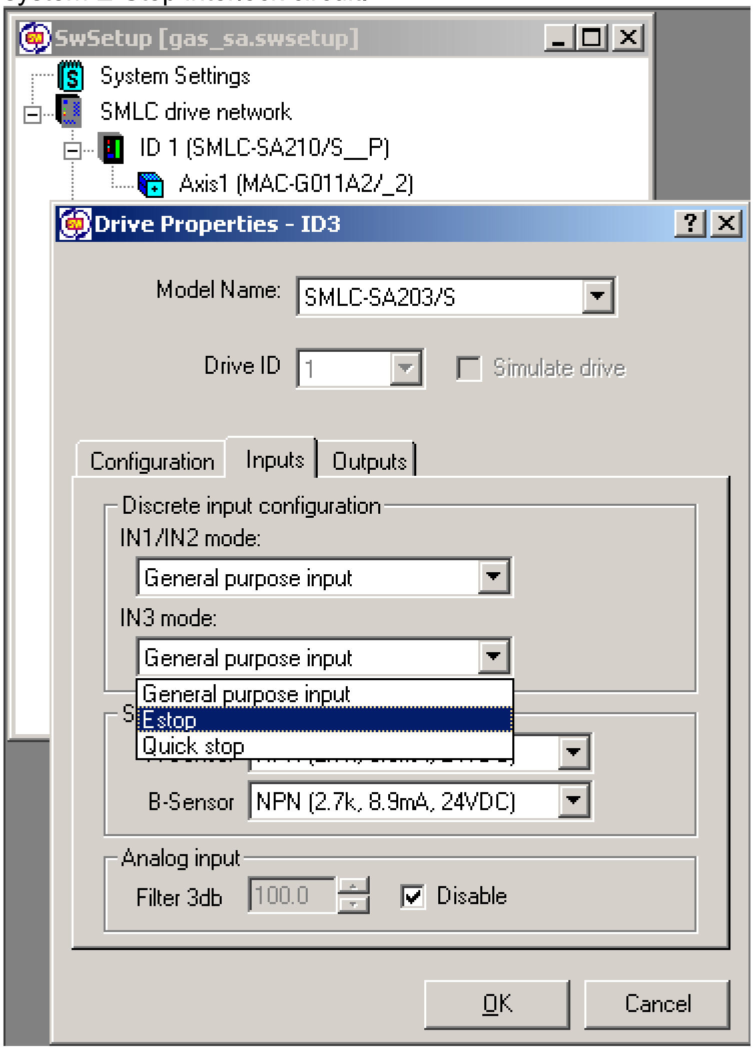


Figure 17, ServoWire Pro E-Stop / Quick Stop configuration

5.5.3 Selecting the ServoWire drive output behavior

The ServoWire Pro, "Drive Properties / Outputs" Setup screen, allows a user-configurable output to indicate when the drive is operating normally, without faults and the main bus is charged. This output is intended for use in the system Emergency-Stop interlock circuit.

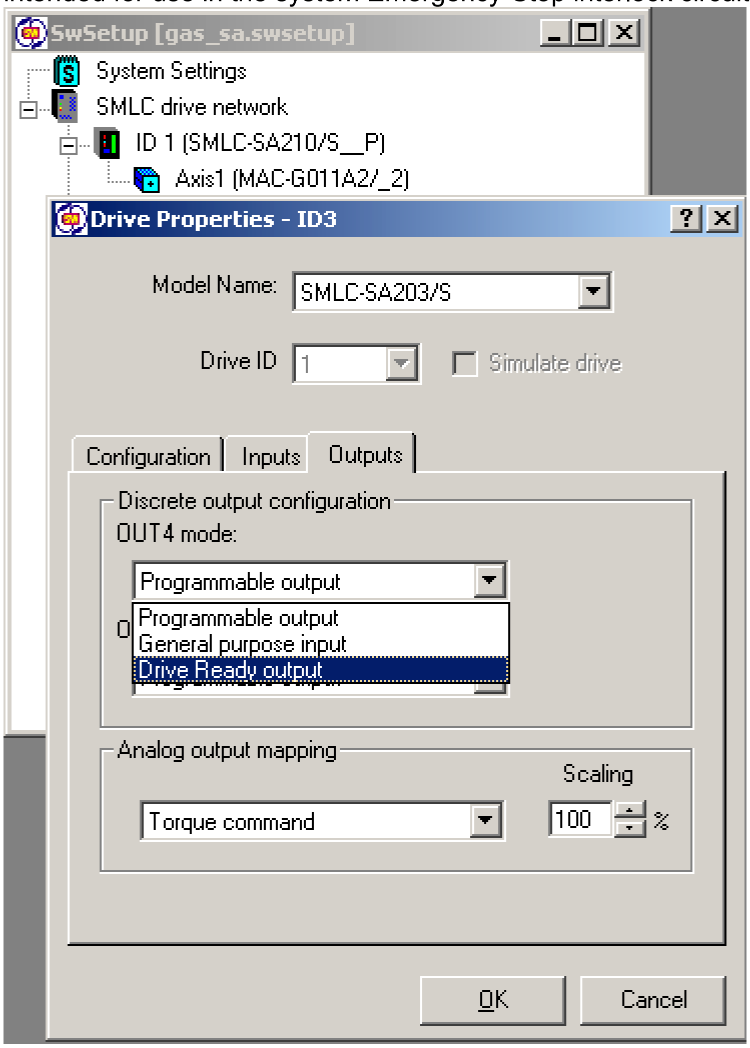


Figure 18, ServoWire Pro Drive Ready configuration

5.6 Drive Bus 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

- 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.

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

2) Drive faults

- If any fault condition occurs within the servodrive, 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 ID/Status display will indicate the fault code. **For the operation described above, OUT4 must be configured for operation as the Drive Ready output using ServoWire Pro.** 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.

- If the E-Stop switch is pressed 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 using ServoWire Pro.**

5.7 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 14** (Page 40).

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.

5.7.1 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.

5.7.2 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.

5.7.3 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 27**, 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 27, *Quick Stop Operation*

5.8 Discrete Outputs (OUT1' – OUT5')

* Note: Output # 4 is Bi-directional and shares the same pin with Input # 4.
See: I/O Schematic, **Figure 14** (Page 40).

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.

5.8.1 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 6** 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 19** for an explanation of the Brake Output sequence of operation and the configurable delay parameters.

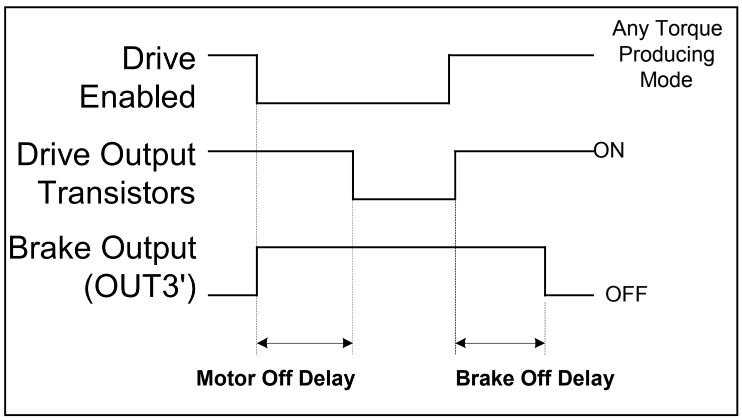


Figure 19, *Brake Output Sequence of Operation*

5.8.2 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.

5.8.3 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'.

5.9 Drive Status Indications

The servodrive status indication consists of a 2-digit 7-segment LED display (ID/Status), several individual LEDs indicating the status of the I/O points and a yellow LED indicating bus power.

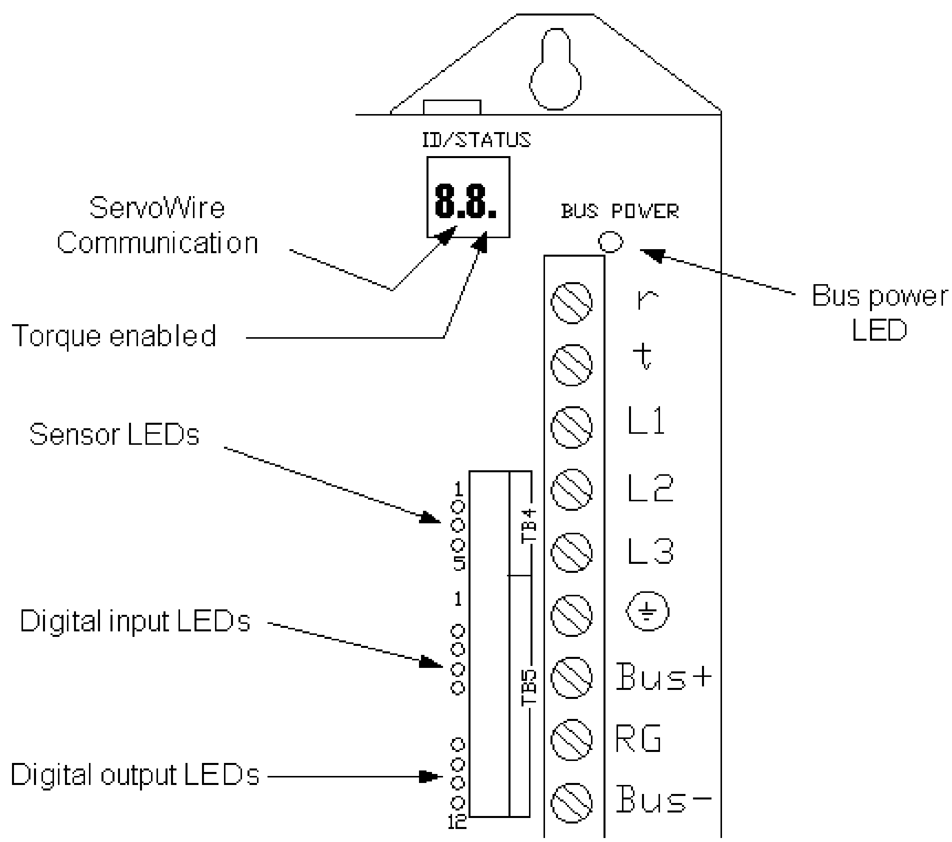
If a fault condition (except for auxiliary encoder open wire ***F2***) is present on the servodrive, the output transistors are disabled, and an appropriate fault code is displayed on the ID / Status display. The control power should be maintained in case of a servodrive fault, so that the status indicators 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:

- After the conditions causing a servodrive fault have been corrected, the application program must reset the drive fault.
- 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 20, *ID/Status Indications*



5.9.1 ServoWire Communications (Middle Dot of ID/Status Display)

During normal operation (e.g. when there are no faults), the middle dot of the ID/Status Display flashes to indicate the state of ServoWire Network.

Slow Flash: (on for 1 second, off for 1 second) indicates that the drive is functional, ServoWire power is detected on the ServoWire cable, but there is no ServoWire communications.

Moderate Flash: (on for ½ second, off for ½ second) indicates that 1394 (ServoWire) communications are beginning and the drive is seeing cycle start activity on the Network.

Rapid Flash: (on for 1/8 second, off for 1/8second) indicates that ServoWire communications is functioning normally and the drive is sending and receiving Isochronous communications..

Solid On or Off: indicates a drive failure that is recoverable only by cycling control power. This should be reported to the ORMEC Customer Service Dept. Solid On with an E6 fault indicates that there is no 1394 power.

5.9.2 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.

5.9.3 Bus Power (Yellow LED above TB1)

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

5.9.4 Sensor Status LED (to the side of TB4)

Illuminated to indicate that the sensor is sinking current. Note, in the case of a sensor configured for PNP operation illumination does not indicate that the sensor is active. The third LED in this section indicates that Sensor/IO power is applied (i.e. a voltage is applied between V+S and V-S).

5.9.5 Digital Input LEDs (to the side of TB5 INx positions)

Illuminated to indicate that there is current in the digital input. For most operation this indicates that the input is on.

5.9.6 Digital Output LEDs (to the side of TB5 OUTx positions)

Illuminated to indicate that the digital output is turned on.

5.9.7 Axis ID and Fault ID

When no drive alarms exist, the ID/Status will display the Drive ID, e.g. 1, 2, etc. When a drive alarm exists, the ID/Status display will alternate between the Drive ID and the alarm code (see **Table 28,** Servodrive Fault Codes.

There is a more detailed table of fault codes, which shows cause-and-effect for many of these faults in Section 9.3, Drive (page 106).

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 faults ***C0-CF*** are generated by the motion engine in the SMLC and then displayed on the drive. Refer to the online help file SMLCSoftware.chm for help in identifying and resolving these fault conditions.

Drive Fault Indicator[2]	Fault Code	Condition	Description
90-9F	144-159	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 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.
70	112	Axis offline	The drive has lost communications
71	113	Reference generation conflict	Internal error
72		*Not used*	
73		*Not used*	
74	116	Unsupported feedback device	The drive firmware does not support this feedback device type
75	117	Tension Max	Tension has reached the OP_TEN_MAX limit
76	118	Tension Min	Tension has reached the OP_TEN_MIN limit
77-7F		*Not used*	
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 (SMLC-SA225, 235, 260, and all 460v models 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 lesser 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 Drive , Fault Code ***A8***)
A9	169	Phase Loss	The drive detected the loss of a main power phase or a soft-start error.

[2] *Also see Section 9.3, ServoWire SD Drive Troubleshooting*

Drive Fault Indicator[2]	Fault Code	Condition	Description
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.	SMLC 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.
b4-bF		*Not used*	
C0	192	Lag Fault	The position following error exceeded the maximum amount configured using ServoWire Pro.
C1	193	Command Overspeed	The commanded speed exceeded the software configured axis speed limit.
C2	194	Actual Overspeed	The actual (feedback) speed exceeded the software configured axis speed limit.
C3	195	Hardware Travel Limit	Motion was commanded further into a hardware travel limit while the limit was still active.
C4		*Not used*	
C5	197	Loop Rate Exceeded	The available loop update time was insufficient to complete the loop processing
C6	198	Missing MotionData	The MotionData from the master axis is not available.
C7	199	Motion Segment overflow	
C8	200	Missing Motion table	
C9	201	Unexpected Offline	The SMLC is not receiving isochronous feedback from the drive.
CA	202	1394 Driver failure	The 1394 driver is no receiving its once-per-looprate update information from the 1394 bus driver.
Cb	203	Pacer Backup Overflow	The pacer axis backed up far enough to overflow the backup compensation.
CC	204	Invalid MotionData Config.	The MotionData is configured in a loop, which is not valid.
CD-CF		*Not used*	
D0-DF		*Not used*	
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.

Drive Fault Indicator[2]	Fault Code	Condition	Description
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. This should not happen on an SMLC-SA
E9-EF		*Not used*	
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 5.14.10
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 serial encoder.
F8	248	Unsupported Serial Encoder detected.	Unsupported encoder feedback type **- or -** Not supported by the drive firmware
F9-FF		*Not used*	

Table 28, *Servodrive Fault Codes (continued from previous page)*

5.10 Commutation Modes

By default, the servodrive is 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.

5.11 Commutation Feedback Signals

Commutation position signals are illustrated below.

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

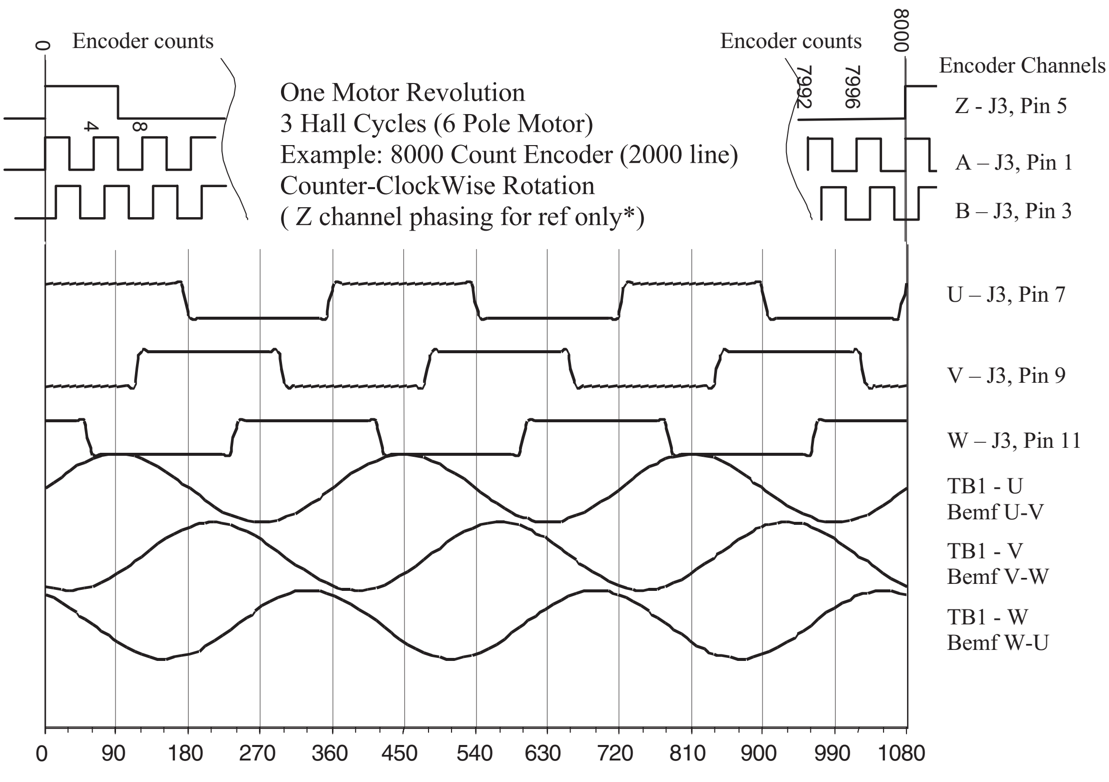


Figure 21, Hall signals and Motor Back EMF waveforms

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.

5.12 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.

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 29, Valid Hall Signal Sequences

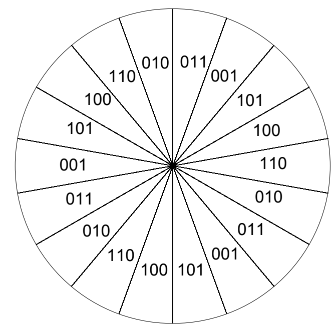


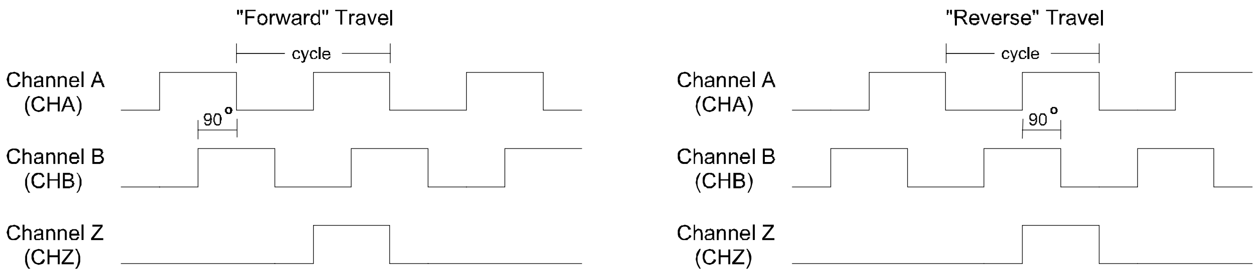
Figure 22, Valid Hall States (6 Pole Motor Example diagram)

5.13 Quadrature Feedback Signals

Quadrature position signals for "Forward" and "Reverse" travel are illustrated in **Figure 23**.

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 the servodrive yields a positioning resolution of 16,384 cnts/rev.

Optical Position Encoder Signals



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

Figure 23, *Quadrature Encoder Channel Description*

5.14 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:

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

5.14.1 Shunt Regulator

SMLC-SA models SMLC-SA210, SMLC-SA217, SMLC-SA220, SMLC-SA225, SMLC-SA235, SMLC-SA260, SMLC-SA405, SMLC-SA410, SMLC-SA417, SMLC-SA425, SMLC-SA435 and SMLC-SA450 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 servodrive controls the on-time duty cycle, so that the average current is appropriate for the regen resistor specified in the project software setting.

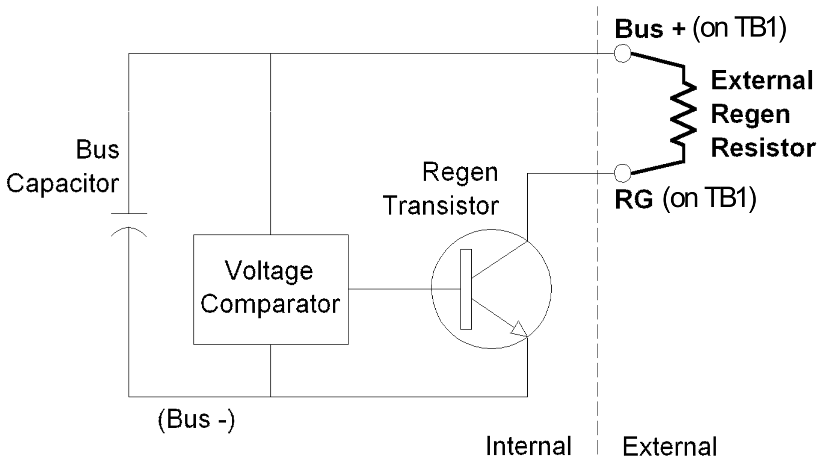


Figure 24, *Simplified Schematic of Shunt Regulator*

5.14.2 Sizing a Regen Resistor: Application-specific Formulas

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

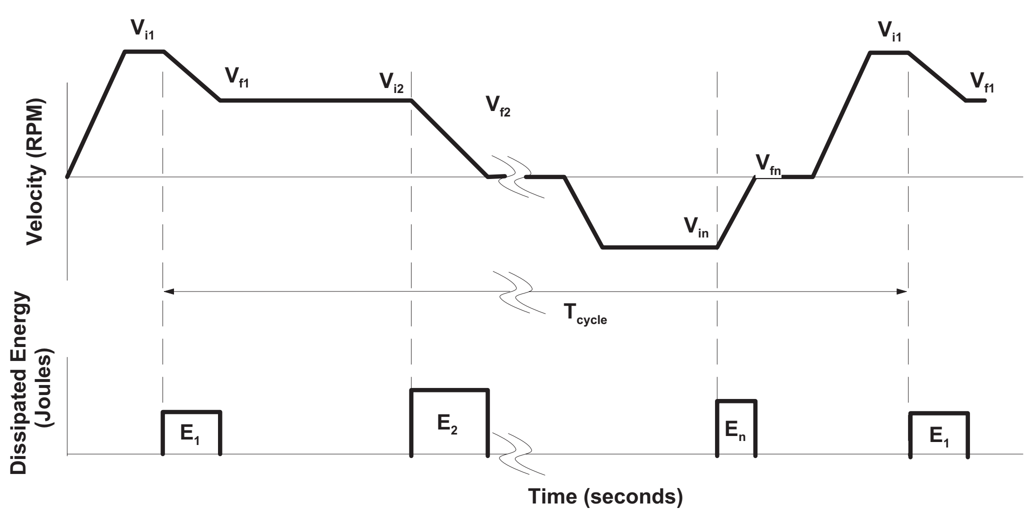


Figure 25, *Regeneration during deceleration.*

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

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

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

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

5.14.4.1 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 = Tω. Applying the appropriate units conversions:

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

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

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)

5.14.5 Sizing a Regen Resistor: Use Average Regenerative Power

Once Average Regenerative Power has been determined using one of the methods in section 5.14.2, the sizing of the resistor is nearly complete.

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

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

5.14.6 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 30** below shows 1) the minimum 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.

	Regen Resistor	**Drive Regen Power Output**	**Regen Transistor**	
ServoWire Drive	**Minimum Resistance**[1]	Maximum Average Power[3]	Peak Current[2]	Bus Capacitance
SMLC-SA203 SMLC-SA205	Regen Transistor not available.			540 µF
SMLC-SA210	50 Ω	800 W	8.5 A	1,170 µF
SMLC-SA217 SMLC-SA220	35 Ω	1200 W 1700 W	12 A	1,410 µF
SMLC-SA225	7.8 Ω	3000 W	50 A	3,360 µF
SMLC-SA235		4175 W		
SMLC-SA260	5.0 Ω	7100 W	75 A	
SMLC-SA405	70 Ω	1200 W	11.4 A	560 uF
SMLC-SA410	40 Ω	2400 W	20 A	
SMLC-SA417	40 Ω	4000 W	20 A	840 uF
SMLC-SA425	25 Ω	5970 W	32 A	
SMLC-SA435	20 Ω	8350 W	40 A	1120 uF
SMLC-SA450	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 30, *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 SMLC-SA425 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. Verifying 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 31**. 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 servodrive 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 31, *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 32** 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 SMLC-SA								
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 32, *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 33**.

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

5.14.7 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 26**). 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.

5.14.8 Bus Sharing Limitations

Most SMLC-SA models support bus sharing. 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 SMLC-SA Models ***SMLC-SA225, SMLC-SA235, and SMLC-SA260 only.***

On 460 VAC drives bus sharing is supported by all 460 V models, models SMLC-SA405, SMLC-SA410, SMLC-SA417, SMLC-SA425, SAC-SM435 and SMLC-SA450.

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 5.14, Regenerative Loads for more information on sizing regen resistors.

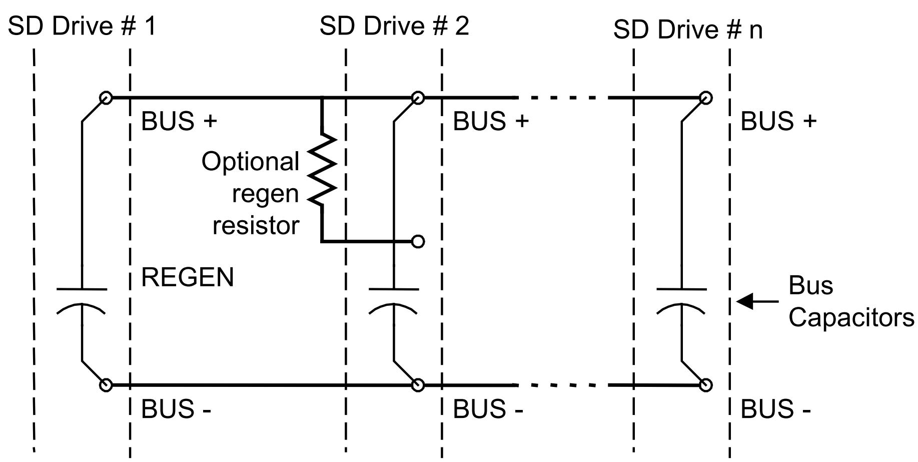


Figure 26, *Shared Bus Capacitors*

5.14.9 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 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).

5.14.10 Servomotor Temperature Protection

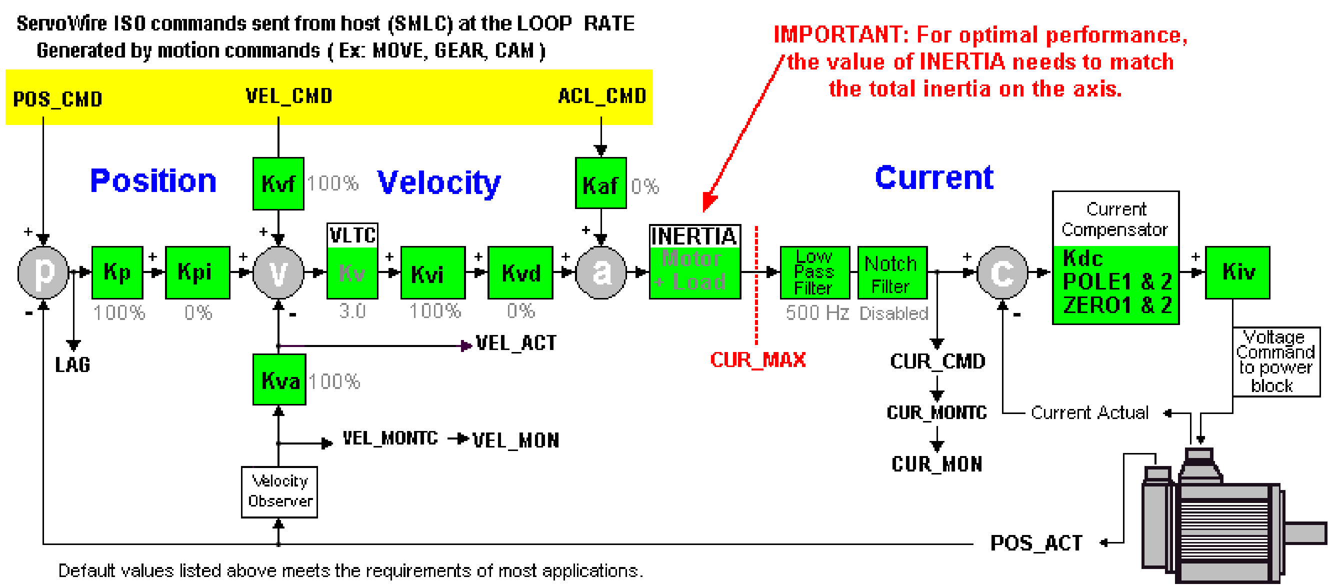
The thermostat contact wiring is part of the Motor Feedback Cable. When the thermal contact opens, the behavior of the servodrive will depend on the software configuration setting:

Table 34, Motor Over-Temperature Input

Motor Thermal Switch state.	ServoWire Pro configuration setting.	Behavior of Drive & SMLC.
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.

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

5.15 Tuning - Loop Diagram



5.15.1 Loop Rate

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

5.15.2 Position Actual

Position Actual 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.

5.15.3 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.)*

5.15.4 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%.

5.15.5 Velocity Observer

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

5.15.6 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%.

5.15.7 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%

5.15.8 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.

5.15.9 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.)*

5.15.10 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%

5.15.11 Velocity Monitor Time Constant

The Velocity Monitor Time Constant 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.

5.15.12 Velocity Monitor

Velocity Monitor 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.

5.15.13 Velocity Actual

Velocity Actual 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.

5.15.14 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%

5.15.15 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-sec²] >=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-sec²), range 0.000001 to 99 in-lb-sec²

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 ServoWire Pro's Inertia Calculator to accurately calculate total system Inertia by monitoring successive motor indexes.

5.15.16 Current Maximum

Current maximum 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

5.15.17 Current Command

Current command 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

5.15.18 Current Monitor Time Constant

Current Monitor Time Constant 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.

5.15.19 Current Monitor

Current Monitor 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

5.15.20 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. **WARNING** improper current loop gains can cause instability leading to damage of the motor and/or drive.
Default = 100%, range 0 to 3000%

5.15.21 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. **WARNING** improper current loop gains can cause instability leading to damage of the motor and/or drive.
Default = 100%, range 0 to 3000%

5.15.22 Poles & Zeros (Pole1, Zero1, Pole2, Zero2)

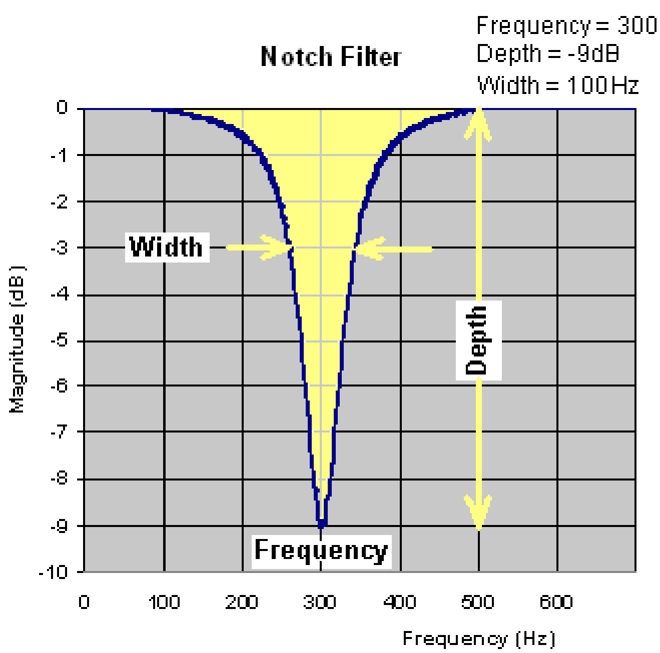
These values set the frequencies (in Hz) of the current loop compensation's poles and zeros. By default these parameters are set for a rapid current response with low ringing. In a few cases it is possible to improve current loop response by raising or lowering these values. **WARNING** improper current loop gains can cause instability leading to damage of the motor and/or drive.
Pole1 Default = 50 Hz, Pole2 Default = 2450 Hz, Zero1 Default = 800 Hz, Zero2 Default = 2450 Hz
Range 0 to 2500 Hz

5.16 Filter - Low-Pass Current Cutoff

The Current Filter sets the cutoff frequency (in 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)

5.16.1 Filter - Digital Notch

The Notch filter is used to reject (remove) one band of frequencies and passes both higher and lower frequencies.
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 6
Specifications

6 Specifications

6.1 Controller Specifications

CPU Processor	400 MHz Celeron
Total controller memory	128 M bytes DRAM
SMLC-SA program memory	128 M bytes Compact Flash
Non-volatile variable memory	32 K bytes Battery Backed SRAM

Table 35, *SMLC-SA Controller General Specifications*

6.1.1 Controller Battery Power Specifications

SMLC-SA Main processor - BIOS	One - lithium Battery
SMLC-SA Battery Backed SRAM	One - BR2032 lithium Battery (3 Volt, 190 mA Hr)
Data Retention	10 years of data retention powered. 1 year minimum, 5 year typical, unpowered.

Table 36, *SMLC-SA Battery Power*

6.1.2 Controller Digital I/O Power requirements (J13)

VIO+	4.5 volts to 27 volts
VIO-	not tied to SMLC-SA ground

Table 37, *Controller Digital I/O Power requirements*

6.1.3 Controller Digital Input Specifications (J13)

Current to turn on	0.7ma minimum 7.0ma maximum
Common VIO+	inputs sink to VIO-
Voltage max	VIO+ + 5vdc

Table 38, *Controller Digital input specifications*

6.1.4 Controller Digital Output Specifications (J13)

Open collector outputs with a common VIO-. Internal pullup on each output

Max sink current	33ma
low level voltage	1.2VDC
high level voltage	VIO+ - 0.5VDC
absolute maximum	27VDC

Table 39, *Controller Digital output specifications*

6.1.5 Controller Analog Input Specifications (J18)

12-bit resolution component. Return pin is shared with analog output. Note that analog ground is not isolated from the SMLC-SA ground.

Input range	+10VDC to –10VDC

Table 40, *Controller Analog input specifications*

6.1.6 Controller Analog Output Specifications (J18)

12-bit resolution component. Return pin is shared with analog input. Note that the analog ground is not isolated from the SMLC-SA ground

Output range	+10VDC to –10VDC
Max output rate	5kHz
Output settling time	20usec
Max output current	10mA

Table 41, *Controller Analog output specifications*

6.1.7 Development port COM1 Specifications (J20)

Connector	9 pin Male D Sub
Standards	EIA RS-232C
Default Config	8 data bits 1 stop bit no parity
Baud Rate	115.2K

Table 42*, SMLC-SA Development Serial Port*

6.1.8 HMI Serial Port COM2 Specifications (J21)

Connector	9 pin Male D Sub
Standards	EIA RS-232
Default Config.	8 data bits 1 stop bits no parity
Baud Rates	115.2K, 57.6K, 38.4K, 19.2K (Default), 9600, 4800, 2400, 1200

Table 43, SMLC-SA HMI Serial Port

6.2 Drive Specifications

6.2.1 Environmental Specifications

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

Table 44, *SMLC-SA Environmental Specifications*

6.2.2 Mechanical Specifications

Mounting Method: *Also see outline drawings in Appendix C*			Vertical panel mounting, two, three or four 10-32 (M5) screws			
Dimensions:						
SMLC-SA203, SMLC-SA205 and SMLC-SA210						
Height:		add 2” (51 mm) clearance top and bottom	9.0	inches	(229	mm)
Width:		add 1” (25 mm) clearance each side	4.2	inches	(107	mm)
Depth:		includes clearance for attached cables	10.5	inches	(267	mm)
Weight		SMLC-SA203 & SMLC-SA205	5.2	lbs.	(2.4	kg)
		SMLC-SA210	6.6	lbs.	(3.0	kg)
SMLC-SA405 and SMLC-SA410						
Height		add 2” (51 mm) clearance top and bottom	11.0	inches	(279	mm)
Width	SMLC-SA405	add 1” (25 mm) clearance each side	5.8	inches	(147	mm)
	SMLC-SA410	add 1” (25 mm) clearance each side	6.0	inches	(152	mm)
Depth		includes clearance for attached cables	10.5	inches	(267	mm)
Weight		SMLC-SA405	10.4	lbs.	(4.7	kg)
		SMLC-SA410	10.8	lbs.	(4.9	kg)
SMLC-SA217						
Height:		add 2”(51 mm) clearance top and bottom	9.0	inches	(229	mm)
Width:		add 1.2” (31 mm) clearance each side	5.4	inches	(137	mm)
Depth:		includes clearance for attached cables	10.5	inches	(267	mm)
Weight			8.3	lbs.	(3.8	kg)
SMLC-SA220						
Height:		add 2” (51 mm) clearance top and bottom	9.0	inches	(229	mm)
Width:		add 1” (25 mm) left side, 2” (51 mm) right-side clearance	5.6	inches	(142	mm)
Depth:		includes clearance for attached cables	10.5	inches	(267	mm)
Weight			9.1	lbs.	(4.1	kg)
SMLC-SA225, SMLC-SA235, SMLC-SA260, SMLC-SA417 and SMLC-SA425						
Height:		add 2” (51 mm) top , 4” (102 mm) bottom clearance	12.0	inches	(305	mm)
Width:		add 1” (25 mm) clearance each side	8.3	inches	(211	mm)
Depth:		includes clearance for attached cables	11.1	inches	(282	mm)
Weight			20.2	lbs.	(9.2	kg)
SMLC-SA435 and SMLC-SA450						
Height:		add 2”(51 mm) top , 4” (102 mm) bottom clearance	14.0	inches	(356	mm)
Width:		add 1” (25 mm) clearance each side	9.4	inches	(239	mm)
Depth:		includes clearance for attached cables	12.1	inches	(307	mm)
Weight			24.5	lbs.	(11.1	kg)

Table 45, *SMLC-SA Mechanical Specifications*

6.2.3 General Electrical Specifications for 115/230 VAC Drives (SMLC-SA2__)

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!	
SMLC-SA203, SMLC-SA205:	Single Phase, 50/60 Hz 115 (+15%, -20%) or 230 (+15%, -20%) VAC
SMLC-SA210, SMLC-SA217, SMLC-SA220, SMLC-SA235, SMLC-SA260:	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:	163 VDC nominal level
230 VAC nominal input power:	325 VDC nominal level
Shunt Regulator Activation DC Bus Voltage:	
115 VAC motors:	207 VDC
230 VAC motors:	395 VDC
High Bus Voltage Fault Activation DC Bus Voltage:	
115 VAC motors:	237 VDC
230 VAC motors:	425 VDC
Low Bus Voltage Fault Activation DC Bus Voltage:	
115 VAC nominal input power:	94 VDC
230 VAC nominal input power:	205 VDC

Table 46, *General Electrical Specifications for 115/230 VAC Drives (SMLC-SA2__)*

6.2.4 General Electrical Specifications for 460 VAC Drives (SMLC-SA4__)

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.**	
SMLC-SA405, SMLC-SA410, SMLC-SA417, SMLC-SA425, SMLC-SA435, SMLC-SA450	Three Phase, 50/60 Hz 230 (+15%, -20%) or 460 (+15%, -20%) VAC
Incoming Control Power Line Voltage – **TB1 or TB2** pins **r, t**	
SMLC-SA405, SMLC-SA410, SMLC-SA417, SMLC-SA425	Single Phase, 50/60 Hz 115 (-20%) to 230 (+15%) VAC
SMLC-SA435, SMLC-SA450	Single Phase, 50/60 Hz 230 (+15%) VAC only
Main DC Bus Voltage – **TB1** pins **BUS+, BUS-**	
230 VAC nominal input power:	325 VDC nominal level
460 VAC nominal input power:	650 VDC nominal level
Shunt Regulator Activation DC Bus Voltage:	
230 VAC motors:	395 VDC
460 VAC motors:	775 VDC
High Bus Voltage Fault Activation DC Bus Voltage:	
230 VAC motors:	450 VDC
460 VAC motors:	800 VDC
Low Bus Voltage Fault Activation DC Bus Voltage:	
230 VAC nominal input power:	205 VDC
460 VAC nominal input power:	325 VDC

Table 47, *General Electrical Specifications for 460 VAC Drives (SMLC-SA4__)*

6.2.5 Drive Performance Specifications

Drive Model	PWM Frequency	Torque Loop
SMLC-SA203 to SMLC-SA210	20 kHz	10 kHz
SMLC-SA217 to SMLC-SA260	10 kHz	10 kHz
SMLC-SA405 to SMLC-SA450	10 kHz	10 kHz

Table 48, *PWM Frequencies and Torque Loop Update Rates*

6.2.6 Command and Loop Update Rates

	SMLC Command Update Rate(s)[3]	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 49, *SMLC Command and Loop Update Rates*

[3] SMLC command updates are made at multiples of the 125 usec base network update rate, up to 2 kHz.

6.2.7 Output Specifications for 115/230 VAC Drives (SMLC-SA2__)

	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/∅)
SMLC-SA203	0.29	2.5	4.4	0.59	2.5	4.2
SMLC-SA205	0.49	4.2	7.4	0.98	4.1	7.1
SMLC-SA210	0.58	5.1	8.8	1.17	4.9	8.5
SMLC-SA217	0.98	8.6	14.8	1.97	8.2	14.3
SMLC-SA220	1.09	9.5	16.5	2.19	9.1	15.8
SMLC-SA225 **SMLC-SA235** **SMLC-SA260**	Single Phase Not Available			Single Phase Not Available		

Table 50, *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/∅)
SMLC-SA203	Three Phase Not Available		
SMLC-SA205			
SMLC-SA210	1.95	8.2	14.2
SMLC-SA217	3.32	13.9	24.1
SMLC-SA220	3.91	16.3	28.3
SMLC-SA225	5.98	25.0	50.0
SMLC-SA235	8.37	35.0	70.0
SMLC-SA260	15	60.0	120.0

Table 51, *Output (TB1 pins, U, V, W) Specifications with Three Phase Input Power*

6.2.8 Output Specifications for 460 VAC Drives (SMLC-SA4__)

	Three Phase 460 VAC Input		
Drive Model	**Rated Output Power** (KVA)	**Cont. Current** (Amps RMS/∅)	**Peak Current 2 sec** (Amps RMS/∅)
SMLC-SA405	2.4	5.0	10.0
SMLC-SA410	4.7	10.0	20.0
SMLC-SA417	8.1	17.0	34.0
SMLC-SA425	11.9	25.0	50.0
SMLC-SA435	16.7	35.0	70.0
SMLC-SA450	23.9	50.0	100.0

***Table 52**, Output (TB1 pins, U, V, W) Specifications with Three Phase Input Power*

6.2.9 Drive I/O Specification (TB4/TB5)

V+S, V-S **TB4 pin 4, TB5 pin 1 (V+S)** **TB4 pin 5, TB5 pin 2 (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 **TB4 pins 2, 3**	**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’ **TB5 pins 3, 4, 5, 6** Note: Input #4 (TB5 pin 6) 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’ **TB5 pins 9, 10, 11, 6, 12** Note: Output #4 (TB5 pin 6) 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 53**, Drive I/O Specifications (TB4 and TB5)*

6.2.10 Encoder Interface Specifications (J4/J5)

ENCA, ENCA', ENCB, ENCB' **J4 pins 1, 2, 3, 4** **J5 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** **J5 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')* Single-Ended Turn On Voltage $V_{IS} > 3$ V $2 V > V_{IS} > 3$ V $V_{IS} < 2$ V	Receiver Output H ? L Receiver Output H ? L

ENC PWR1, DGND **J4 pins 13, 24, 25 (Power)** **J4 pins 16, 17, 18 (Digital Ground)** **J5 Pacer pins 5, 6, 18 (Power)** **J5 Pacer pins 7, 19, 20 (Ground)**	**Encoder Power Supply** **Appendix B-1**
+5 VDC for 115/230 VAC Drives (SMLC-SA2__)	5.3 VDC, +/-5% 450 mA max.
+5 VDC for Low Power Drives (SMLC-SAA__)	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 54, *Motor Encoder Specifications (J4)*

6.2.11 Drive Analog I/O Specifications (TB3)

AIN **TB3 pin 4**	**Single Ended Analog Input**
Common Mode Input	-10 VDC to +10 VDC max.
Absolute Max. Input Voltage	+/-12 VDC
Native ADC resolution[4]	14 bits
Monotonic	
Sample rate	2500 Hz
Filter – hardware	1 kHz anti-aliasing
Filter – software	0-500 Hz software configurable

AOUT **TB3 pin 2**	**Single Ended Analog Output**
Common Mode Output	-10 VDC to +10 VDC max.
Output current drive	+/- 10 mA max
Native DAC resolution[4]	14 bits
Update rate	10,000 Hz

Table 55, *Drive Analog I/O Specifications (TB3)*

[4] The ADC and DAC have 14-bit resolution. The application quality of these I/O points is determined by the total system, not just the circuitry in the drive. Care should be taken routing signals to and from the drive.

6.3 Connector Part Numbers

		Mating Connector[5]			SMLC-SA Connector
Locator	**Signal**	**Description**	**Manufacturer & Part Number**	**Ormec P/N**	**Manufacturer & Part Number**
TB3	Drive Analog I/O (top of drive)	4-pin terminal block	Phoenix 1803594	CON889	Phoenix 1829361
TB4	Drive I/O	5-pin terminal block	Phoenix 1803604	CON887	Phoenix 1803303
TB5	Drive I/O	12-pin terminal block	Phoenix 1803675	CON888	Phoenix 1803374
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-B25SN
J5	Pacer Feedback (bottom of drive)	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
J12	Keyboard	mini DIN			
J13	Controller Digital I/O	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-B25SN
J16	EN1	RJ-45			
J17	EN0	RJ-45			
J18	Controller Analog I/O	6-pin terminal block	Phoenix 1827169	CON866	Phoenix 1803316
J19	VGA	15 pin male D-sub			
J20	COM1	9 pin female D-sub			
J21	COM2	9 pin female D-sub			

Table 56, *Connector Part Numbers*

[5] The mating D-sub connectors for J4 and J5 are not provided as part of the SMLC-SA.

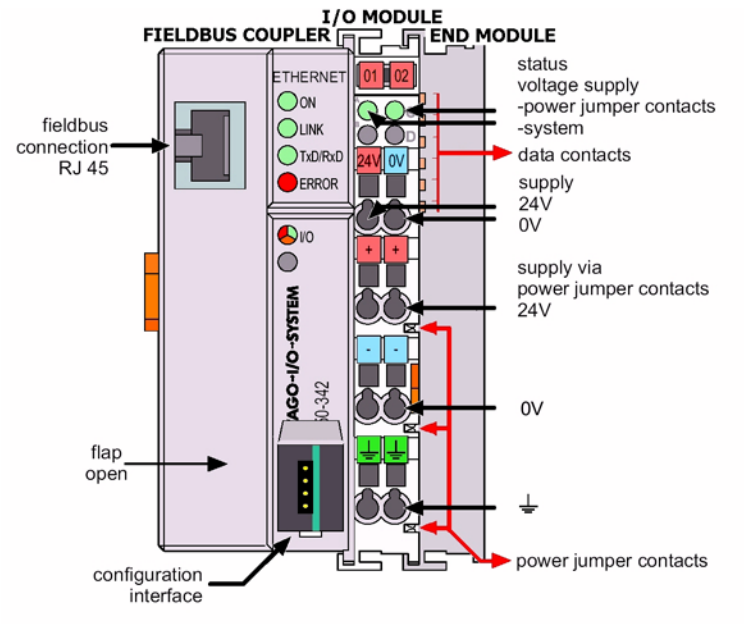
BLANK

Chapter 7
WAGO Installation & Operation

7 WAGO Installation & Operation

General-purpose I/O options are supported using WAGO Ethernet I/O (750 Series).

The I/O system offers a Fieldbus independent node design, even though the Fieldbus couplers utilizing different protocols. Cage clamp technology helps reduce installation time and provides gas-tight I/O connections that are maintenance-free and resistant to vibration.



The WAGO System consists of three components:

1. One Fieldbus Coupler (Left end)
2. A number of I/O modules (Middle)
3. One End Module (Right end).

The WAGO-ETH-KIT (fieldbus coupler) is a 10baseT, 64 I/O module (256 points max) that supports a wide selection of I/O module types and includes the end module. Your system can mix and match a wide variety of I/O modules including digital I/O with up to eight points each and analog I/O in several resolutions and signal types. A selection of specialty modules are also available – including a selection of thermocouples that can be used to implement PID control, up/down counters and an incremental encoder interface

7.1 WAGO Installation

The WAGO fieldbus coupler needs to be assigned an IP address. WAGO's BootP Server is used to assign an IP Address to the hardware MAC (Media Assess Code) ID of the fieldbus coupler.

- Launch the WAGO BootP server.

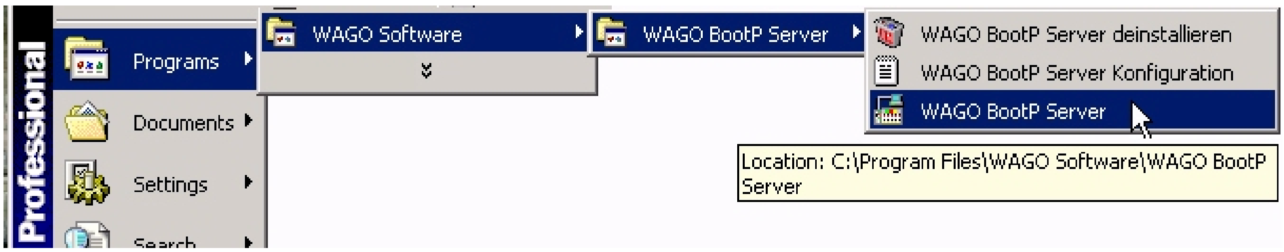


***Figure 27**, WAGO Launch BootP server:*

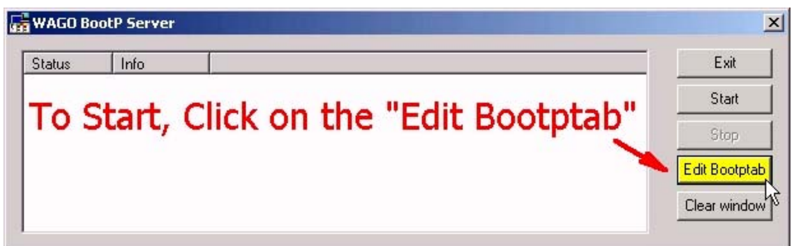


***Figure 28**, WAGO Launch Notepad*

- The file "**BootPtab.txt"** needs to be modified.

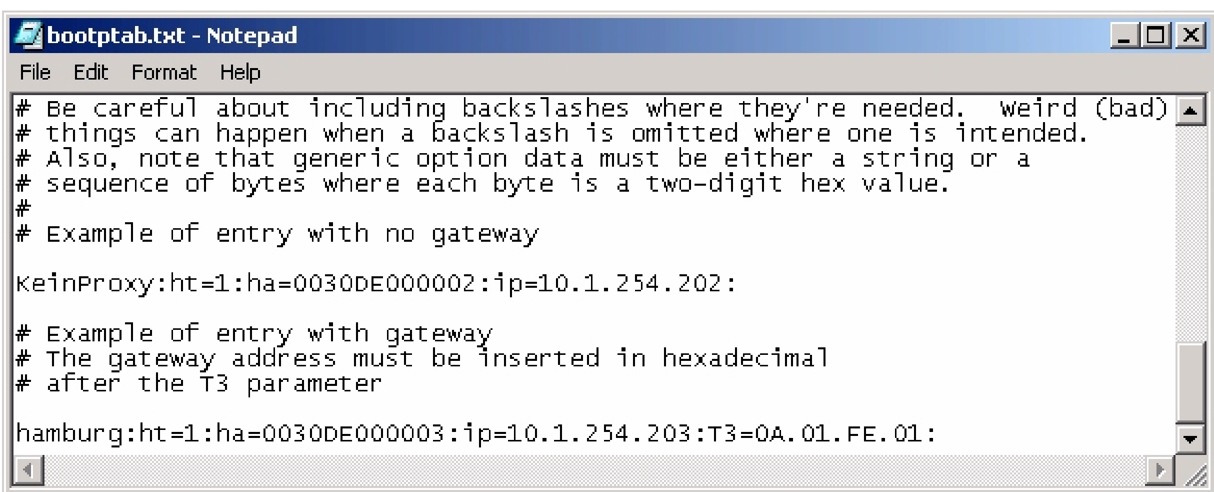


***Figure 29**, WAGO edit BootPtab.txt.*

The file "**BootPtab.txt"** has many lines that are commented by the "#" (pound symbol). Any line without a # will be processed so be careful when editing this file.

Look at the first line (near the bottom of the file) that does not have a pound symbol. (#)

KeinProxy:ht=1:ha=0030DE000002:ip=10.1.254.202:

- **KeinProxy** - is a label. German meaning "Node Name". It may be changed to any label or descriptor you like to identify the WAGO Ethernet I/O hardware. Example **MyWAGOconfig:**

- **ht** = hardware type.

- **ha** = is short for **H**ardware **A**ddress, also known as the MAC ID. It needs to match the MAC ID number that is located on the right side of the field coupler. Example **ha=0030DE000002:**

- **ip =** is short for **I**nternet **P**rotocol, the WAGO node address. Example **ip=192.168.0.123:**

MyWAGOconfig:ht=1**:ha=**0030DE000002**:ip=**192.168.0.123**:**

Look at the bottom (last) line in the file. This is a **second example** that demonstrates how to add the gateway address. If a gateway address is not going to be used, comment out this line by adding a #. Most applications typically do not use the gateway.

hamburg:ht=1:ha=0030DE000003:ip=10.1.254.203:**T3=0A.01.FE.01:**

- Now save the WAGO configuration file **BootPtab.txt** by clicking on the notepad - File/Save. Close the notepad editor.

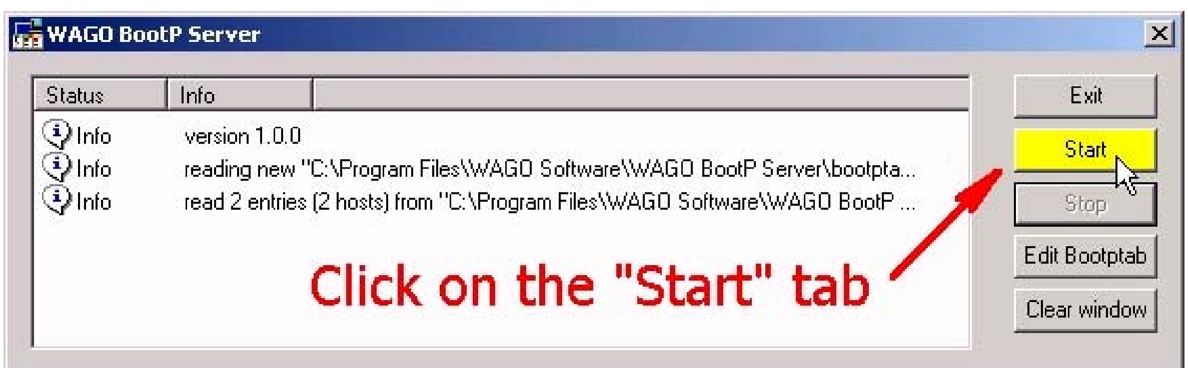


***Figure 30**, WAGO Start BootP Server*

- Now click on the start tab to display status messages.

- Turn the power off on the WAGO fieldbus coupler and wait for 5 seconds.

Now turn the power back on the WAGO fieldbus coupler. You should see additional status messages scrolling down the BootP Server screen.

Verify the status information displayed:

- Packets were received from an IP Address.
- The Ethernet Address is the same as the MAC ID of the Fieldbus coupler.
- The KeinProxy, or node identifier, and IP Address match what was entered in the text file using Notepad.

Verify the WAGO buscoupler or PFC is operating correctly. Its diagnostic LED's should be illuminated as follows:

On	Green
Link	Green
TxD/RxD	Flash as data is Sent/Received
Error	Should not be illuminated
I/O	Green

Your WAGO Fieldbus coupler is now ready for communications on an Ethernet network.

7.2 WAGO Configuration

Once the WAGO Fieldbus coupler IP address is set it is time to configure it in your CoDeSys program. Start up CoDeSys and proceed to the PLC Configuration utility on the Resources tab.

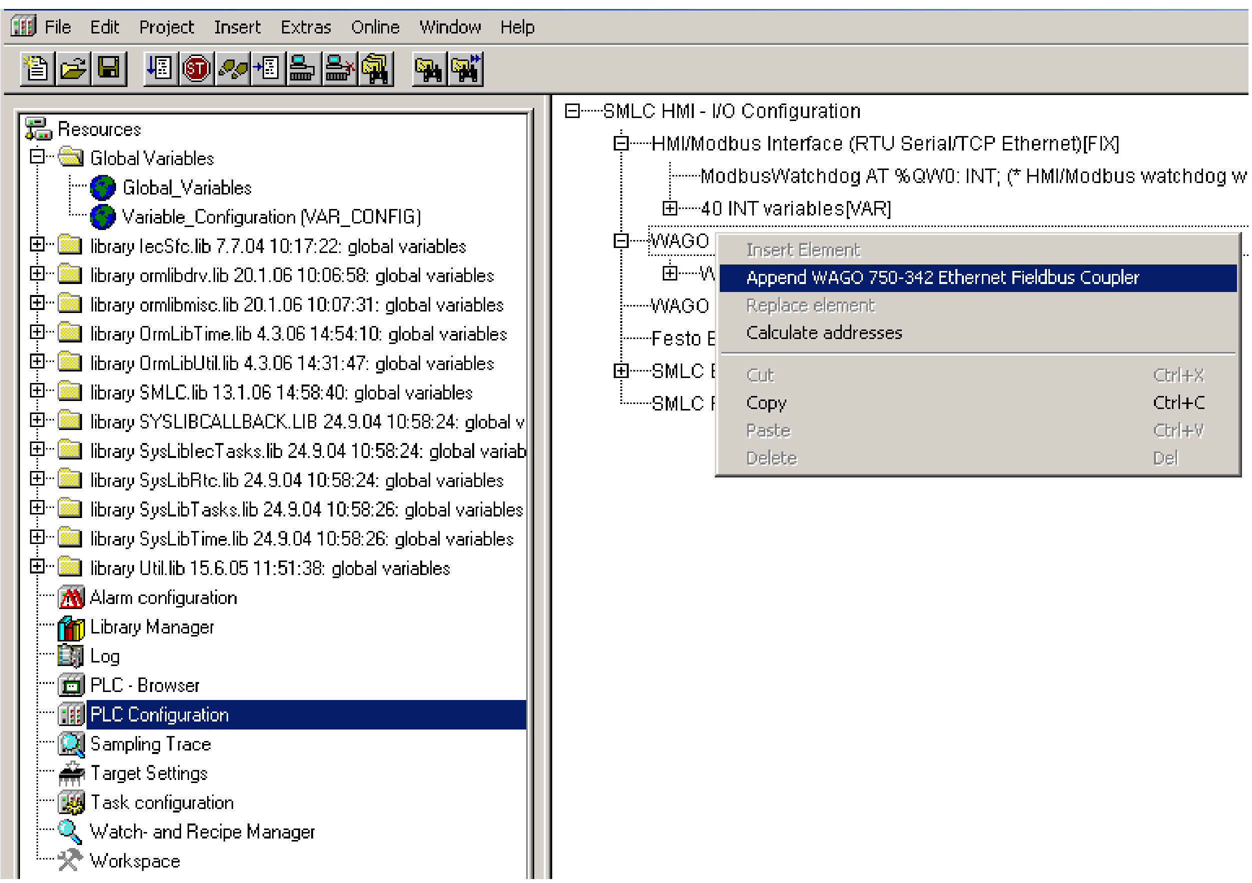


Figure 31 - Inserting a WAGO Fieldbus coupler

Now enter the IP address that was assigned to the Fieldbus coupler using the Bootp server.

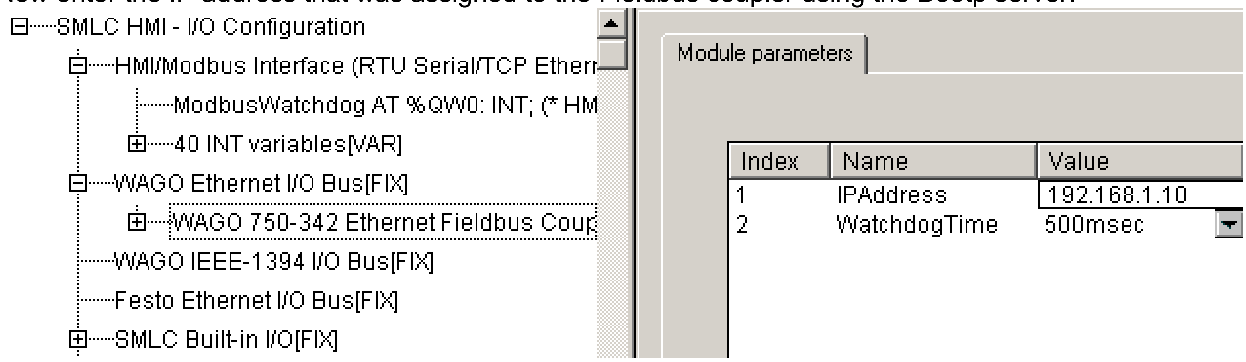


Figure 32 - Entering the WAGO Fieldbus coupler IP address

Right-click on the WAGO 750-342 Ethernet Fieldbus Coupler and insert the modules that are attached to the Fieldbus coupler. The order and module model numbers must match the physical assembly. After adding the modules variable names can be assigned to the individual I/O points by clicking on the AT in the module tree and typing in a variable name. All I/O variables assigned in the PLC configuration are automatically defined as global variables in the CoDeSys application program.

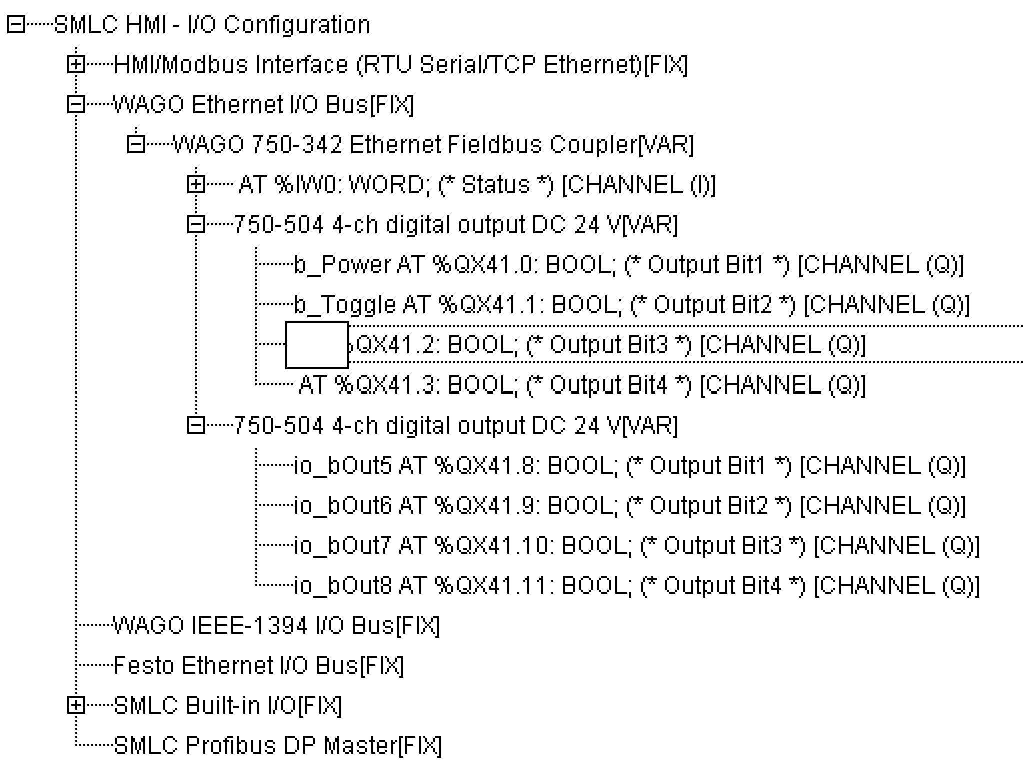


Figure 33 - Assigning variable names to WAGO I/O points

7.3 WAGO Part List

WAGO-ETH-KIT	Ethernet Fieldbus Coupler Kit, 10baseT, 64 I/O modules for 256 ins & 256 outs max. (incl. one End Module and two 10 mm End Stops) **NOTE 1:** WAGO Fieldbus couplers supply a limited amount of 24 VDC power to the I/O modules, which may not be sufficient for the application. A Power Supply and Supply Module may be required. Refer to the WAGO Ethernet or PROFIBUS I&O Manual or the WAGO Web Site for further information.
WAGO-750-342	Ethernet Fieldbus Coupler, 10BaseT, 64 I/O modules for 256 inputs & 256 outputs max.

WAGO Digital Input Modules

WAGO-750-400	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, 3.0 msec filter	
WAGO-750-401	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, 0.2 msec filter, high spd	
WAGO-750-410	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, 3.msec filter, 2-wire prox. switch	
WAGO-750-411	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, 0.msec filter, high spd, 2-wire prox. Switch.	
WAGO-750-418	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, 3.0 msec filter, diagnostics w/ ack	
WAGO-750-419	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, 3.0 msec filter, diagnostics	
WAGO-750-412	2-Ch DC Input, Sourcing (high-side switch), 48 VDC, 3.0 msec filter	(see note 2)
WAGO-750-424	2-Ch DC Input, Sourcing (high-side switch), 24 VDC, Intruder Detection	
WAGO-750-402	4-Ch DC Input, Sourcing (high-side switch), 24 VDC, 3.0 msec filter	
WAGO-750-403	4-Ch DC Input, Sourcing (high-side switch), 24 VDC, 0.2 msec filter, high spd	
WAGO-750-408	4-Ch DC Input, Sinking (low-side switch), 24 VDC, 3.0 msec filter	
WAGO-750-409	4-Ch DC Input, Sinking (low-side switch), 24 VDC, 0.2 msec filter, high spd	
WAGO-750-414	4-Ch DC Input, Sourcing (high-side switch), 5 VDC, 0.2 msec filter, high spd	(see note 2)
WAGO-750-422	4-Ch DC Input, Sourcing (high-side switch), 24 VDC, 1.0 msec filter, w/ 10 msec ext.	
WAGO-750-415	4-Ch AC/DC Input, 24VAC/VDC, 20 msec filter, 2-wire connection	(see note 2)
WAGO-750-423	4-Ch AC/DC Input, Sourcing (high-side switch), 24 VAC/VDC, 50 msec filter, w/ power jumper contacts (supply module req'd for 24 VAC operation)	(see note 2)
WAGO-750-430	8-Ch DC Input, Sourcing (high-side switch), 24 VDC, 3.0 msec filter	
WAGO-750-431	8-Ch DC Input, Sourcing (high-side switch), 24 VDC, 0.2 msec filter, high spd	
WAGO-750-435	1-Ch DC Input, 24 VDC, 3.0 msec filter, NAMUR	
WAGO-750-425	2-Ch DC Input, 24VDC, 3.0 msec filter, NAMUR	
WAGO-750-405	2-Ch AC Input, 230VAC	(see note 2)
WAGO-750-406	2-Ch AC Input, 120VAC	(see note 2)

WAGO Digital Output Modules

WAGO-750-501	2-Ch DC	Output, Sourcing (high-side switch), 24 VDC, 0.5 A	
WAGO-750-502	2-Ch DC	Output, Sourcing (high-side switch), 24 VDC, 2.0 A	
WAGO-750-504	4-Ch DC	Output, Sourcing (high-side switch), 24 VDC, 0.5 A	
WAGO-750-506	2-Ch DC	Output, Sourcing (high-side switch), 24 VDC, 0.5A, w/ diagnostics	
WAGO-750-507	2-Ch DC	Output, Sourcing (high-side switch), 24 VDC, 2.0 A, w/ diagnostics	
WAGO-750-509	2-Ch AC/DC	Output, SSR, 230 VAC/VDC, 300 mA	(see note 2)
WAGO-750-512	2-Ch Relay	Output, normally open, 230 VAC/30 VDC, 2.0 A	(see note 2)
WAGO-750-513	2-Ch AC/DC	Output, Isolated relay, 250 VAC/30VDC, 2.0A	(see note 2)
WAGO-750-514	2-Ch Relay	Output, changeover contacts (SPDT), 125 VDC/30 VDC, 0.5 A	(see note 2)
WAGO-750-516	4-Ch DC	Output, Sinking (low-side switch), 24 VDC, 0.5 A	
WAGO-750-517	2-Ch Relay	Output, changeover contacts (SPDT), 230 VDC/300 VDC, 1.0 A	(see note 2)
WAGO-750-519	4-Ch DC	Output, Sourcing (high-side switch), 5 VDC, 20 mA	(see note 2)
WAGO-750-522	2-Ch AC	Output, opto isolated, 35-230 VAC, 0.5 A, 3.0A for 30 sec once per hour	(note2)
WAGO-750-523	1-Ch AC	Output, opto isolated, 230 VAC, 16A, auto/manual operation	
WAGO-750-530	8-Ch DC	Output, Sourcing (high-side switch), 24 VDC, 0.5A	
WAGO-750-535	2-Ch DC	Output, Sourcing (high-side switch), 24 VDC Eex I	

Table 57 *Wago I/O Modules*

WAGO Analog Input Modules

WAGO-750-465	2-Ch Analog Input, 0-20 mA, 12-bit, single-ended	
WAGO-750-453	4-Ch Analog Input, 0-20 mA, 12-bit, single-ended	
WAGO-750-452	2-Ch Analog Input, 0-20 mA, 12-bit, differential	(see note 3)
WAGO-750-480	2-Ch Analog Input, 0-20 mA, 13-bit, differential	(see note 3)
WAGO-750-472	2-Ch Analog Input, 0-20 mA, 16-bit, single-ended	
WAGO-750-472/005-000	2-Ch Analog Input, 0-20 mA, 16-bit, single-ended, 60 Hz	
WAGO-750-466	2-Ch Analog Input, 4-20 mA, 12-bit, single-ended	
WAGO-750-455	4-Ch Analog Input, 4-20 mA, 12-bit, single-ended	
WAGO-750-485	2-Ch Analog Input, 4-20 mA, 12-bit single-ended, explosion protection	
WAGO-750-454	2-Ch Analog Input, 4-20 mA, 12-bit, differential	(see note 3)
WAGO-750-492	2-Ch Analog Input, 4-20 mA, 12-bit, differential, isolated	(see note 3)
WAGO-750-474	2-Ch Analog Input, 4-20 mA, 16-bit, single-ended	
WAGO-750-474/005-000	2-Ch Analog Input, 4-20 mA, 16-bit, single-ended, 60 Hz	
WAGO-750-456	2-Ch Analog Input, +/-10 V, 12-bit, differential	(see note 3)
WAGO-750-457	4-Ch Analog Input, +/-10 V, 12-bit, single-ended	
WAGO-750-479	2-Ch Analog Input, +/-10 V, 14-bit, differential	(see note 3)
WAGO-750-476	2-Ch Analog Input, +/-10 V, 16-bit, single-ended	
WAGO-750-467	2-Ch Analog Input, 0-10 V, 12-bit, single-ended	(see note 3)
WAGO-750-459	4-Ch Analog Input, 0-10 V, 12-bit, single-ended	
WAGO-750-468	4-Ch Analog Input, 0-10 V, 12-bit, single-ended	(see note 3)
WAGO-750-478	2-Ch Analog Input, 0-10 V, 16-bit, single-ended	
WAGO-750-460	4-Ch Analog Input for RTD, Pt100 resistance sensors	(see note 3)
WAGO-750-483	2-Ch Analog Input, 0-30 V14-bit, differential	
WAGO-750-469	2-Ch Analog Input for Thermocouple, Type K, w/ diagnostics	(see note 3)
WAGO-750-469/000-001	2-Ch Analog Input for Thermocouple, Type S, w/ diagnostics	(see note 3)
WAGO-750-469/000-002	2-Ch Analog Input for Thermocouple, Type T, w/ diagnostics	(see note 3)
WAGO-750-469/000-003	2-Ch Analog Input for Thermocouple, +/-120 mV, w/ diagnostics	(see note 3)
WAGO-750-469/000-006	2-Ch Analog Input for Thermocouple, Type J, w/ diagnostics	(see note 3)
WAGO-750-469/000-008	2-Ch Analog Input for Thermocouple, Type E, w/ diagnostics	(see note3)
WAGO-750-469/000-012	2-Ch Analog Input for Thermocouple, Type L, w/ diagnostics	(see note 3)
WAGO-750-461	2-Ch Analog Input for RTD, Pt100 resistance sensors	(see note 3)
WAGO-750-461/000-003	2-Ch Analog Input for RTD, Pt1000 resistance sensors	(see note 3)
WAGO-750-461/000-004	2-Ch Analog Input for RTD, Ni100 resistance sensors	(see note 3)
WAGO-750-461/000-005	2-Ch Analog Input for RTD, Ni1000 resistance sensors	(see note 3)
WAGO-750-461/000-002	2-Ch Analog Input for RTD, Resistor measurement, 10 - 1.2k ohms	(see note3)
WAGO-750-461/000-007	2-Ch Analog Input for RTD, Resistor measurement, 10 - 5.0k ohms	(see note3)
WAGO-750-491	1-Ch Analog Input for Resistor Bridges, 16-bits, 250 msec conversion time	(see note 3)
WAGO-750-491/000-001	1-Ch Analog Input for Resistor Bridges, 16-bits, 65 msec conversion time	(see note 3)

WAGO Analog Output Modules

WAGO-750-552	2-Ch Analog Output, 0-20 mA, 12-bit	
WAGO-750-585	2-Ch Analog Output, 0-20 mA, 12-bit, explosion protection	
WAGO-750-554	2-Ch Analog Output, 4-20 mA, 12-bit	
WAGO-750-556	2-Ch Analog Output, +/-10 V, 12-bit	(see note 3)
WAGO-750-557	4-Ch Analog Output, +/-10 V, 12-bit	
WAGO-750-550	2-Ch Analog Output, 0-10 V, 12-bit	(see note 3)
WAGO-750-559	4-Ch Analog Output, 0-10 V, 12-bit	

WAGO Specialty Modules

WAGO-750-404	1-Ch Up/Down Counter, 24 VDC, 32-bit, 100 kHz
WAGO-750-638	2-Ch Up/Down Counter, 24 VDC, 16-bit, 500 Hz
WAGO-750-511	2-Ch PWM Output, 24 VDC, 0.1A, 10-bit, 250 Hz, configurable duty cycle
WAGO-750-630/000-013	SSI Transmitter Interface, 29-bit, 125 kHz, binary
WAGO-750-630/000-008	SSI Transmitter Interface, 25 bit, 125 kHz, graycode
WAGO-750-630/000-011	SSI Transmitter Interface, 25-bit, 125 kHz, binary
WAGO-750-630/000-006	SSI Transmitter Interface, 24-bit, 250 kHz, graycode
WAGO-750-630/000-002	SSI Transmitter Interface, 24-bit, 250 kHz, binary
WAGO-750-630	SSI Transmitter Interface, 24-bit, 125 kHz, graycode
WAGO-750-630/000-004	SSI Transmitter Interface, 24-bit, 125 kHz, graycode w/ status
WAGO-750-630/000-001	SSI Transmitter Interface, 24-bit, 125 kHz, binary
WAGO-750-630/000-007	SSI Transmitter Interface, 24-bit, 83 kHz, graycode w/ status
WAGO-750-630/000-005	SSI Transmitter Interface, 15-bit, 125 kHz, graycode w/ status
WAGO-750-630/000-009	SSI Transmitter Interface, 13-bit, 250 kHz, binary
WAGO-750-630/000-012	SSI Transmitter Interface, 13-bit, 125 kHz, graycode
WAGO-750-631	Incremental Encoder Interface, 16-bit pos capture, 5 VDC edr power output (note 2)
WAGO-750-637	Incremental Encoder Interface, 32-bit pos capture, pos compare, 5 VDC edr power output (see note 2)
WAGO-750-635	Digital Impulse Interface, for magnetostrictive distance measurement sensors

WAGO Power Supplies and Accessories

WAGO-787-602	Power Supply 1.3A, 24 VDC output
WAGO-787-612	Power Supply 2.5A, 24 VDC output
WAGO-787-622	Power Supply 5.0A, 24 VDC output
WAGO-787-632	Power Supply 10A, 24 VDC output
WAGO-787-640	Power Supply 10A, 24 VDC output, 3-phase 230 VAC input
WAGO-750-601	Supply module with fuse, 24 VDC
WAGO-750-612	Supply module, 0 – 230 AC/DC (incl. 5 VDC modules)
WAGO-750-602	Supply module, 24 VDC
WAGO-750-615	Supply module with fuse, 120 VAC
WAGO-750-609	Supply module with fuse, 230 VAC
WAGO-750-622	Binary Spacer Module
WAGO-750-600	End Module
WAGO-249-117	End Stop
WAGO-247-PWR	Power and Ground Label Strip Pack blue “0V”, blue "-", red “24V”, red "+", light green ground symbol, light green “PE”, 100 each
WAGO-247-513/522	I/O Point Numbering Label Strip Pack, digits 00-99, 10 each

NOTE 2: Any WAGO Digital I/O modules operating at voltages other than 24 VDC require a Power Supply and Supply Module with the appropriate voltage rating for input power and isolation. Refer to the WAGO Ethernet I&O Manual included on the SMLC-SA installation CD or to the WAGO Web Site for further information.

NOTE 3: WAGO Analog Output and 2-Channel AC/DC Output Isolated Relay modules do not pass the power supply on to other modules in the rack. A supply module will be required for any I/O modules to the right of an Analog Output or Isolated Relay module in a WAGO I/O system. Refer to the WAGO Ethernet I&O Manual included on the SMLC-SA installation CD or to the WAGO Web Site for further information.

Chapter 8
Getting Started

8 Getting Started

8.1 Preparation for Test Run

For the test run, you need to:

1. Complete the appropriate System Wiring.
2. Create the configuration file “SwSetup” for your system by using ServoWire Pro.
3. Load the “SwSetup” file into the SMLC-SA.

DO NOT connect the motor shafts to the driven machine until after the test run is complete!

Before the test run, do the following checks of the servomotor and ServoWire Motion & Logic Controller and their installation. Correct any problems before proceeding.

8.2 ServoWire Motion & Logic Controller Checklist

Verify that the power is fused properly and that the system power wiring and grounding are correct. See Appendix B of this manual, as well as the *Servo Drive Manual*.

1) If a "lot system test" (integrated system test) was performed at ORMEC, the servo system **must be** installed the same as they were at the ORMEC factory. Servodrives and servomotors must be connected in the same order because the servo loop configuration parameters are stored in the ServoWire Pro configuration file “*filename.SwSetup*” by *Axis-ID*.

2) Verify that the system grounding is correct. Refer to Appendix B.

3) Check for compatible voltage ratings on all servodrives obtaining control power from terminals “ **r** ” and “ **t** ” on the servo drive.

4) Verify that all wiring leads are firmly connected to their terminals.

5) Verify SMLC-SA incoming line voltage. **CHECK POWER BEFORE APPLYING IT TO THE MOTION CONTROLLER!**

6) Attach an IBM-PC or compatible computer operating either the CoDeSys or ServoWire Pro communications utility to the SMLC-SA Serial Development Port (J6) or Ethernet port (J5).

8.3 Servomotor Checklist

1) Verify proper motor mounting and that the **shaft is not connected to the machine.**

2) Verify that the encoder cables and motor cables are properly installed.
   Note: ORMEC manufactured motor cables are color-coded.

Motor Cable Color	Servodrive Connection
RED	U
WHITE	V
BLACK	W
GREEN & SILVER	GROUND

3) Check that mounting bolts and nuts are tight.

4) Verify that motor shaft rotates freely by hand.
   NOTE: If your motor has an integral fail-safe brake you must apply power to the brake coil in order to allow the motor shaft to rotate.

5) For motors with oil seals, (standard on IP-67 rated motors) the seals should be in good condition and properly lubricated.

6) Verify that the metal key is removed from the motor shaft keyway, or that it is securely taped down, for test.

8.4 Applying System Control Power

1) After checking the items above, apply control power to the SMLC-SA.

2) The SMLC-SA will execute it's Power-up sequence as detailed in the section 5.1

3) After the Power-up sequence is complete, the Run light should be ON. At this point, the system is operating correctly and executing your application program.

8.4.1 Checklist for 115/230 VAC operation (SMLC-SA2__)

- 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 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.⏚
- Verify that the Motor wiring is correct.

- The main power interlock circuit disables main power under a drive fault condition.

8.4.2 Checklist for 460 VAC operation (SMLC-SA4__)

- The control power voltage should be 115 (+15%, -20%) or 230 (+15%, -20%) VAC, 50/60 Hz. except on the 35A and 50A models (SMLC-SA435 and SMLC-SA450) 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 motor.

- **CHECK POWER BEFORE APPLYING IT TO THE SERVODRIVE.**
- 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.⏚
- Verify that the Motor wiring is correct.
- The main power interlock circuit disables main power under a drive fault condition.

8.5 Setting up Serial communications

ServoWire Pro uses Dial-Up Networking (DUN) to communicate with the SMLC-SA Development port COM1 (J20). When your PC is properly configured and DUN is initialized (running), communications between ServoWire Pro and SMLC-SA is possible. The connection address is 200.200.200.200. The Development Port communication rate is 115K Baud.

NOTE: You must configure your Network Connections in Windows before you can communicate with an SMLC-SA. You must have Administrator rights to configure a new DUN connection! For more information see the "**Network Setup Help**" (NetSet2k.hlp) included on the SMLC-SA installation CD.

8.5.1 Initializing the Communications Connection

When ServoWire Pro needs to communicate with a SMLC-SA, it checks to see if a DUN connection has been established. If no connection exists, the "Connect To" dialog is displayed, allowing you to initialize the SMLC-SA connection. Thereafter, Windows handles all serial communications in the background.

Note: ServoWire Pro must know the correct Internet Protocol (IP) address of the SMLC-SA it is connecting with. The factory address for the RS-232 Serial Port is "200.200.200.200". This address refers to a Direct Cable Connection between ServoWire Pro and the SMLC-SA Serial Port (J6).

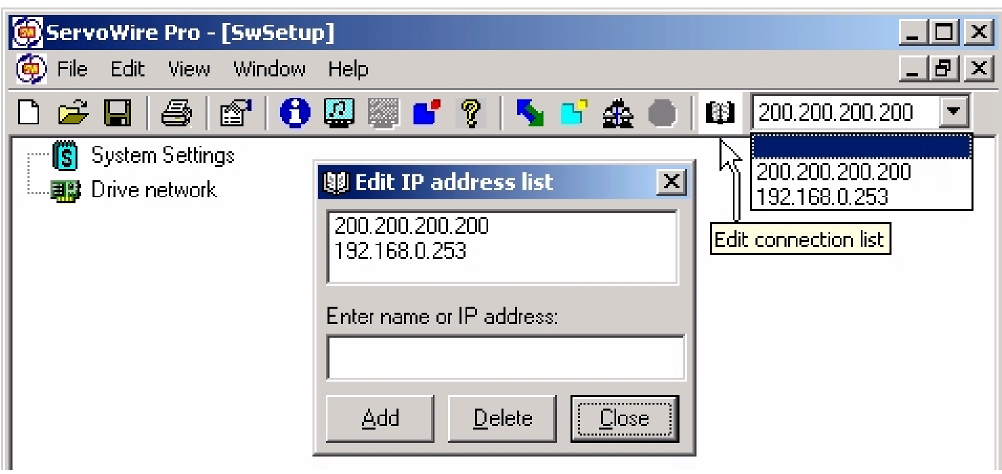


Figure 34, ServoWire Pro IP Address

8.5.2 Disconnecting serial communications from SMLC-SA and your PC.

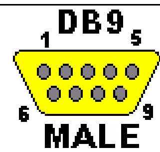
Chose the Close Project command, in the ServoWire Pro File menu, if you want to reconnect to a different SMLC-SA, or make changes to your network connections. To change your network connections, see Network Setup HELP.

8.5.3 Troubleshooting Connection Problems

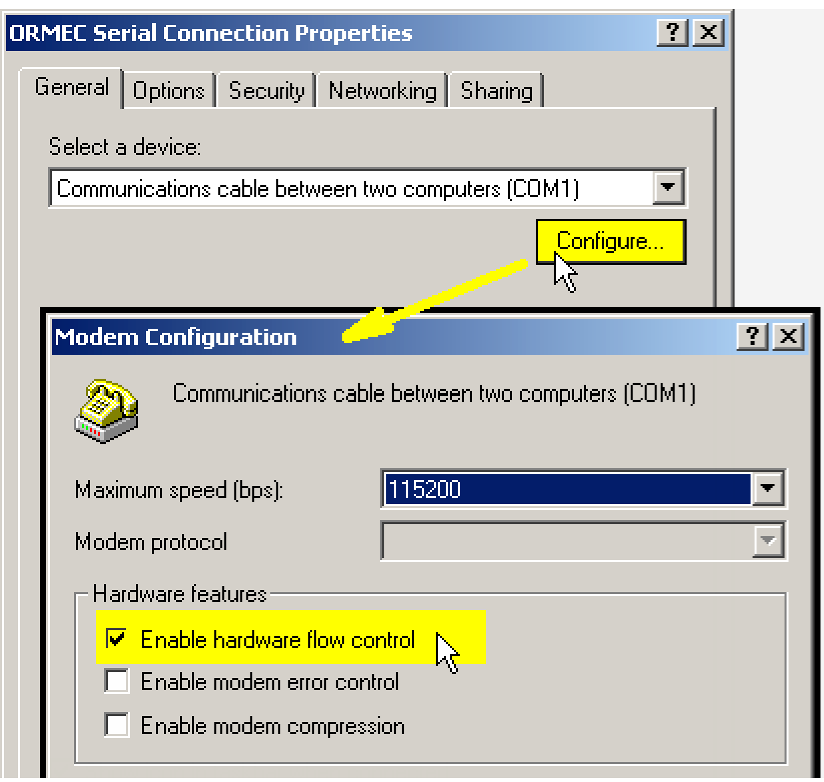
If you are having difficulty in establishing communications with SMLC-SA, see the ServoWire Pro Communications Troubleshooter.

8.5.4 Serial Communications Null Modem Cable to PC

This cable is used with the SMLC-SA RS-232 serial connector and Windows Dial-up connections.

SMLC-SA – J20		PC
Data Carrier Detect (DCD)		
Receive Data (RD)	2 - 3	(TD) Transmit Data
Transmit Data (TD)	3 - 2	(RD) Receive Data
Data Terminal Ready (DTR)	4 - 6	(DSR) Data Send Ready
Signal Ground (SG)	5 - 5	(SG) Signal Ground
Data Send Ready (DSR)	6 - 4	(DTR) Data Terminal Ready
Request To Send (RTS)	7 - 8	(CTS) Clear To Send
Clear To Send (CTS)	8 - 7	(RTS) Request To Send

The above pin-out will provide the best possible signaling between a SMLC-SA and a PC allowing you to use hardware flow control (RTS/CTS). This type of cable requires that you enable hardware flow control.



Note: Not all Null modem cables are alike. Some Null Modem Cables will bypass hardware flow control. This type of cable adds a short between pin 1 and 6 on the same connector to fool the communication program to thinking that they are online.

8.6 Ethernet Configuration

It is strongly recommended that the Ethernet port be used for development with the SMLC-SA because it supports a much faster communication rate of 10/100 M baud.

Default SMLC-SA Ethernet Port Addressing

- The SMLC-SA assigns the **default IP Address of 192.168.0.253** to EN0 (J17).
- The SMLC-SA assigns the **default IP Address of 192.168.1.253** to EN1 (J16).
- If you are going to use the default IP addresses you need to do nothing else.

8.6.1 Assigning Ethernet Port Addresses in ServoWire Pro.

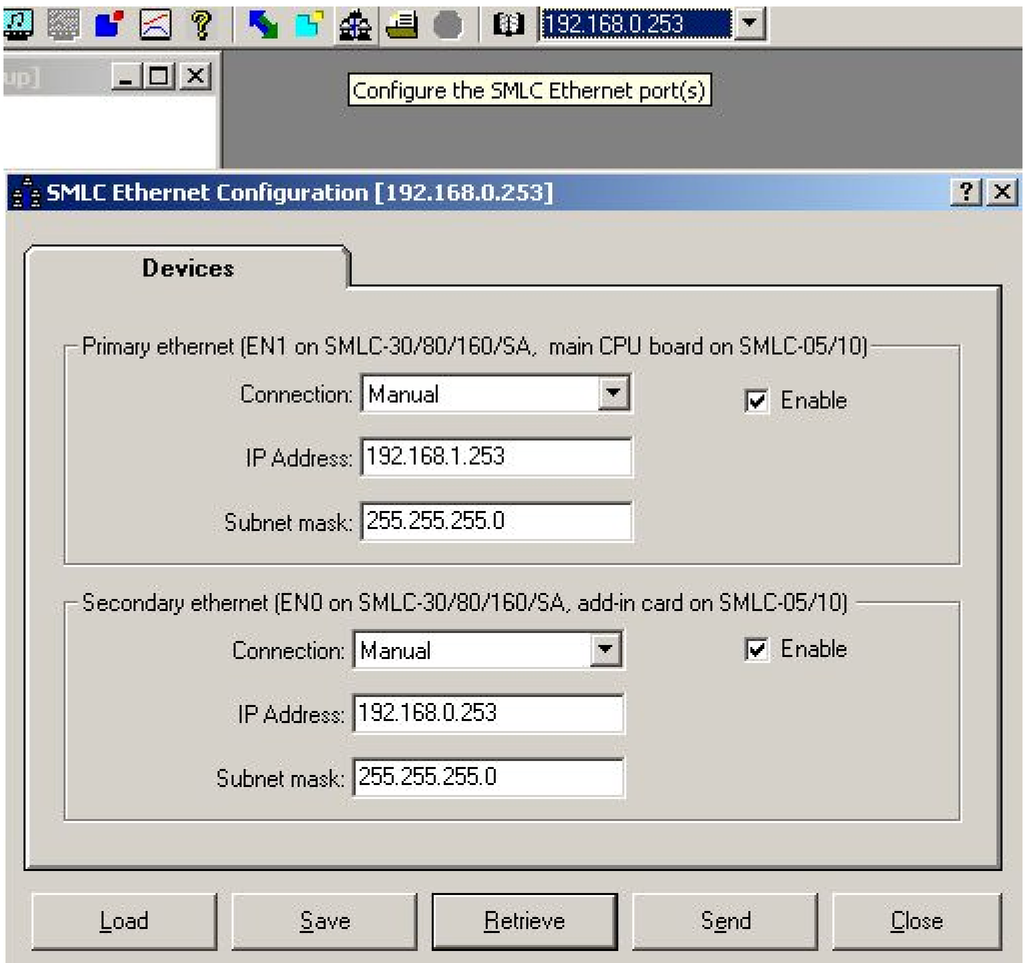


Figure 35, ServoWire Pro Ethernet Ports IP Address

If you are adding the SMLC-SA to an existing network, consult your Network Administrator to obtain an IP address and subnet mask that is compatible with your existing network.

Enter the desired Ethernet settings and Send them to the SMLC-SA. You must then cycle the power on the SMLC-SA for the new settings to take effect.

The SMLC-SA Ethernet configuration can also be load/saved in a file. This is provided as convenient way to keep a record of Ethernet settings for different projects.

8.7 ServoWire Pro Development Software

Once power has been applied to the system, you should run ServoWire Pro to communicate with the SMLC-SA unit. Consult the ServoWire Pro tutorial as appropriate for installation, startup, and communications details. The tutorial is available from the Help menu within ServoWire Pro.

8.7.1 Test Running Your SMLC-SA System

Once communications is established between the development computer and the SMLC-SA controller, ServoWire Pro can be used to configure the SMLC-SA hardware.
The ServoWire Pro provides the ability to:

- Configure the ServoWire drive analog and digital I/O.
- Select the appropriate motors and drives and configure the Servodrive I/O using the Axis Settings configurator.

After the SMLC-SA hardware has been configured for your application, the ServoWire Pro SwTune utility can be used to index and tune the axes.

The ServoWire Pro SwTune utility is a Windows based program that allows you to:

- Index all the motors, one at a time
- Interactively adjust servo loop parameters after the motors are connected to their respective loads, if required
- View graphical display of the commanded and actual motor velocity, commanded motor torque, and the position following error.

When the system hardware is configured for your application and the axes are tuned, you should proceed to develop your IEC 61131-3 application software.

Chapter 9
Maintenance & Troubleshooting

9 Maintenance & Troubleshooting

9.1 ORMEC Product Support

- ORMEC Product Support relates to the functionality and proper operation of ORMEC supplied software and equipment
- Product Service is provided by the ORMEC Service Department by phone at (585) 385-3520 or via e-mail at support@ormec.com
- Assistance installing and upgrading ORMEC supplied development software (e.g. CoDeSys), and ServoWire Drive firmware, including necessary third-party supporting files (i.e. Microsoft Windows Dial-Up Networking used for serial communication).
- Assistance configuring ORMEC development software communications.
- Explanation/clarification of the functionality and proper operation of ORMEC supplied hardware and software, as provided in the various documentation available for those products (e.g. Windows Help, Installation & Operation Manuals, Tech and App Notes, etc.)
- Troubleshooting assistance for ORMEC supplied hardware and firmware to insure the proper operation of ORMEC supplied equipment. Assistance troubleshooting third-party equipment connected to ORMEC equipment is not included.
- Providing return authorization (RA) numbers and replacement units (if appropriate) for defective products.

  Normal Product Support
  Phone and e-mail support, available from 8 AM to 5 PM EST.

  24-Hour Product Support
  Phone support, available 24-hours a day, 7 days a week, 365 days per year.
  There is an additional charge for this service.

9.2 Troubleshooting

No LEDs Lit on SMLC-SA

- Verify that there is AC power to the SMLC-SA. Verify that the AC voltage on the input power terminal block is the appropriate level (either 115 or 230 VAC).

SMLC-SA Does Not Complete the Power Up Sequence

If the SMLC-SA doesn't complete the power up sequence, gather the information listed below and call the ORMEC Service Department.

- Look at the " System" LED. If illuminated (ON) the battery for non-volatile memory needs to be replaced.
- SMLC-SA model number, version number & serial number.
- With the SMLC-SA in the incomplete power up sequence, note the status of the LED's located on the front of the controller: Power, Run, Fault, Watchdog OK, User, and System.
- The SMLC-SA version:
  If you are able to communicate with the SMLC-SA after resetting the unit or cycling power, the SMLC-SA version can be determined by using ServoWire Pro's SwMonitor.

9.3 Drive Fault Codes

Indication	Code	Status	Description
70	112	Axis off-line	

Indication	Code	Status	Description
71	113	Reference Generation Conflict	Internal error
Defective hardware or software ⇒ Report error to Ormec Customer Service.			

Indication	Code	Status	Description
74	116	Unsupported Feedback device	The drive firmware does not support this feedback type.
Upgrade the drive firmware to the latest versions			

Indication	Code	Status	Description
75	117	Tension Max	The actual measured tension is greater than OP_TEN_MAX and the application (OP_TEN_LIM_ACTION) is configured to generate a fault if this occurs.
• Check the machine for binding or jamming • Check the tension transducer for failure			

Indication	Code	Status	Description
76	118	Tension Min	The actual measured tension is less than OP_TEN_MIN and the application (OP_TEN_LIM_ACTION) is configured to generate a

			fault if this occurs.

- Check the machine for binding or jamming
- Check the tension transducer for failure

Indication	Code	Status	Description
90-99 ***9A-9F***	144-153 154-159	Internal Drive Error	An unexpected failure has occurred in the servodrive software or hardware.

Defective hardware or software ⇒ Report error to Ormec Customer Service.

Indication	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 3.4.7 (page 14) 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 (SMLC-SA225, 235, 260, 417, 425, 435 & 450 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 servodrive 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.

Indication	Code	Status	Description
A5	165	Configuration Mismatch	The drive type does not match the software configuration settings.
	The SMLC or 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 not configured for drive type SMLC-SA___ SMLC/MotionObjects may also indicate this by the exception # 1031, Error Message = Configured Drive type doesn't match actual drive hardware.		

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.

Indication	Code	Status	Description
A8	168	Invalid Commutation Position	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 SMLC documentation for further information regarding reading absolute encoder position.

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.	SMLC/MotionObjects fault: SMLC firmware 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
C0	192	Lag Fault	The position following error exceeded the maximum amount configured using ServoWire Pro.

Indication	Code	Status	Description
C1	193	Command Overspeed	The commanded speed exceeded the software configured axis speed limit.

Indication	Code	Status	Description
C2	194	Actual Overspeed	The actual (feedback) speed exceeded the software configured axis speed limit.

Indication	Code	Status	Description
C3	195	Hardware Travel Limit	Motion was commanded further into a hardware travel limit while the limit was still active.

Indication	Code	Status	Description
C5	197	Loop Rate Exceeded	The available loop update time was insufficient to complete the loop processing

Indication	Code	Status	Description
C6	198	Missing MotionData	The MotionData from the master axis is not available.

Indication	Code	Status	Description
C9	201	Unexpected Offline	The SMLC is not receiving isochronous feedback from the drive.

Indication	Code	Status	Description
CA	202	1394 Driver failure	The 1394 driver is no receiving its once-per-looprate update information from the 1394 bus driver.

Indication	Code	Status	Description
Cb	203	Pacer Backup Overflow	The pacer axis backed up far enough to overflow the backup compensation.

Indication	Code	Status	Description
CC	204	Invalid MotionData Configuration	The MotionData is configured in a loop, which is not valid.

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

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 SMLC 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 SMLC (8–40 VDC). The ServoWire cable is not connected to the drive and/or the SMLC.

Indication	Code	Status	Description
E8	232	Duplicate Drive ID	The SMLC has detected more than one drive with same Axis ID on the network. This should not occur on an SMLC-SA.

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.
F3_1	243	Invalid Hall State on Differential Inputs	Drive is configured for differential Hall inputs and an invalid value has been detected. 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
F3_2	243	Invalid Hall State on D-Series Motor interface	Drive is configured for a D-Series motor and an invalid Hall state has been detected.
F3_3	243	Invalid Hall State on H-Series Motor interface	Drive is configured for a H-Series motor with a serial encoder and an invalid Hall state has been detected.
When enabling axis		• Bad feedback cable ⇒ Check pins above (see cable diagrams in Appendix E) • Wrong axis feedback type selected in ServoWire or MotionDesk 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-SD-RES pins 10 & 23)
When the motor is hot		• Motor is overloaded ⇒ Reduce motor load • Excessive ambient temperature ⇒ Reduce ambient temperature to 25°C	
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 Configuration 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.
F7_1	247	Incremental encoder error	When using a H-Series motor with an incremental encoder the encoder has reported an error. The error can only be cleared by power cycling the motor, which can only be done by power cycling the drive.
F7_2	247	Absolute encoder overspeed error	When using a H-Series motor, the absolute encoder has reported an overspeed error. The error can only be cleared by power cycling the motor, which can only be done by power cycling the drive.
F7_3	247	Absolute encoder overspeed error	When using a H-Series motor, the absolute encoder has reported an absolute error. The error can only be cleared by power cycling the motor, which can only be done by power cycling the drive.
F7_4	247	Absolute encoder backup power error	When using a H-Series motor, the absolute encoder has reported a backup power error. Encoder backup power has failed and absolute

			position lost. The error can be cleared by issuing an Encoder Reset command either from the application program or within SwMonitor in ServoWire Pro. Operation can continue without the need for a power cycle, however, absolute position has been lost.
F7_5	247	Absolute encoder generic error	When using a H-Series motor, the absolute encoder has reported a generic error. The error can be cleared by issuing an Encoder Reset command either from the application program or within SwMonitor in ServoWire Pro. Operation can continue without the need for a power cycle.
F7_6	247	Absolute encoder over temperature error	When using a H-Series motor, the absolute encoder has reported an over temperature error. The error can be cleared by issuing an Encoder Reset command either from the application program or within SwMonitor in ServoWire Pro. However, it is recommended that the motor be allowed to cool down before continuing. This error is reported only once per power cycle of the motor.
F7_7	247	Absolute encoder battery low error	When using a H-Series motor, the absolute encoder has reported a battery low error. The error can be cleared by issuing an Encoder Reset command either from the application program or within SwMonitor in ServoWire Pro. Operation can continue without the need for a power cycle. This error is reported only once per power cycle of the motor.
F7_8	247	Unknown type of Sigma II encoder	

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.

9.4 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 40°C, or use a larger motor.
	Motor dirty	Clean motor surface
	Overload	Reduce load or use a larger motor.
Unusual Noise	Motor loosely mounted	Tighten mounting bolts
	Motor 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 (SMLC-SA210, SMLC-SA217, SMLC-SA220)	Use 3-phase power.
WARNING!!! **Turn off power before working on the Servomotor**		

Chapter 10
Terms & Mnemonics

10 Terms & Mnemonics

There are a number of terms or "buzzwords" which are often used in the Motion Control Industry, some of which have very specific meanings in ORMEC's products and systems. This section attempts to define many of these terms used in this document which may be unfamiliar.

***Absolute Encoder* -** a sensing device that provides the position of the motor shaft relative to a fixed reference point at power up without having move the motor shaft to determine that point. In the case of a multiple revolution absolute rotary encoder, the current position may be multiple turns away from the reference point.

Axis - In motion control, this term normally refers to one of the servomotors in the system, either by name or *Axis-ID* (Identification number) from 1 to 16. It is also used to refer to any *Master (Pacer) Encoders* in the system. Many ORMEC pre-defined variables in the SMLC-SA are defined for each axis in the system and are therefore indexed by Axis-ID name.

CoDeSys – **Co**ntroller **De**velopment **Sy**stem. The IEC-61131-3 runtime system developed by 3S Software used on the SMLC-SA.

CoDeSys IDE – The CoDeSys Integrated Development Environment is the Win32 based application that allows you to develop, download and debug SMLC-SA programs.

Current Source - The ability for a device to switch and provide current for a circuit.

Current Sink - The ability for a device to switch and accept the current in a circuit.

Electronic Gearing - A means of precisely coordinating the motion of a number of *servo axes* with a *pacer (master) axis.* The master axis can be an encoder or a servo axis.

Encoder - A digital position transducer used to determine the position of a motor, a rotating shaft on a machine or a linear position associated with a machine. It has two *quadrature* channels (A & B) which determine incremental movements and a single *encoder reference* channel (Z) which defines a unique position within its travel. Most, but not all, position encoders internally use optical gratings and sensors.

Encoder Zero Reference - A signal generated by the position *encoder* once per revolution, which may be used to determine the encoder's overall angular or linear orientation. Also sometimes called an *encoder marker pulse*.

Factory network adapters - A physical layer network interface which plugs into an SMLC and contains a co-processor for performing factory network communications (e.g. PROFIBUS requires a factory network adapter card). The SMLC-SA currently does not support any factory network adapters

Follower - A servo axis, which is controlling its motion as a function of MotionDATA, generated by a *pacer* axis. Follower motions are generated with the MC_GEAR statement in the SMLC-SA.

Home Position - A reference position for either a servo or an encoder *axis*.

Hardware Travel Limits HTL's - Inputs to ServoWire drive which must be asserted (sinking current), or disabled by software setting, for a servo axis to operate.

IEC-61131-3 - A global standard defining programming languages for industrial control.

Loop Update - *Servo Loops* in the SMLC-SA are updated at rates of between 500 and 2,000 times per second. At each *Loop Update*, the motion engine in the SMLC-SA performs housekeeping operations such as updating the axis position and the output signals in addition to performing the real-time control algorithm for that servomotor.

Machine Sensor - Any of a number of types of ON-OFF sensors, like proximity switches or mechanical switches mounted to a machine.

MODBUS – MODBUS® Protocol is a messaging structure developed by Modicon in 1979, used to establish master-slave/client-server communication between intelligent devices. It is a de facto standard, truly open and the most widely used network protocol in the industrial manufacturing environment.

MODBUS/TCP – Modbus/TCP is an implementation of the MODBUS Protocol, allowing MODBUS messages to be transferred via Ethernet.

OPC – OLE for Process Control. A set of open standards for connectivity and interoperability of industrial automation and enterprise systems.

Pacer - A *servo* or *encoder axis* which transmits either its actual or commanded motion to other servo axes through the MotionDATA communication channel to another servo axis.

Pacer Encoder - An incremental encoder or device that generates *quadrature* signals which are used by other servo axes when they operate as *followers*.

Quadrature - Quadrature or "phase quadrature" signals are the most commonly used method of electronically determining or transmitting bi-directional position information. The two-quadrature signals are digital square waves, which have their cycles displaced 90 degrees (of the 360 electrical degrees in the repeated waveform). All four edges of the two digital signals are normally used for the maximum possible position resolution ("4x").

RTOS - Real-Time Operating System.

Registration Control - The act of maintaining a fixed position relationship between machine tooling and a product in the machine. Registration is normally measured by capturing the tooling position with respect to the product using a registration sensor of some type. It is controlled by phasing the tooling ahead or behind based on the difference between the actual and desired positional orientation.

Resolver - A position transducer used to determine the position of a motor. Resolvers are rotary transformer devices with analog interfaces. However, in ORMEC Motion Control systems which use resolvers, the servodrive decodes the resolver position digitally.

Servo (or Servomotor) - A motor which is controlled by comparing its measured position with its desired position.

Servodrive - A power unit necessary to control a servomotor.

Servo Loop - The act of controlling a servo by repeatedly observing its speed and position and adjusting its torque creates a "servo loop". With ServoWire Motion & Logic Controller Manual, these digital loops are "closed" at *loop update* rates of 250 to 4,000 times per second.

ServoWire Pro – ORMEC's Win32 based commissioning software for SoftMotion platforms including the SMLC. ServoWire Pro contains tools for configuring, monitoring, tuning and upgrading the firmware of SoftMotion based drives and products.

SMLC - ServoWire Motion & Logic Controller (SMLC) is ORMEC's motion controller that integrates industry standard IEC 61131-3 programming with ORMEC's SoftMotion capabilities.

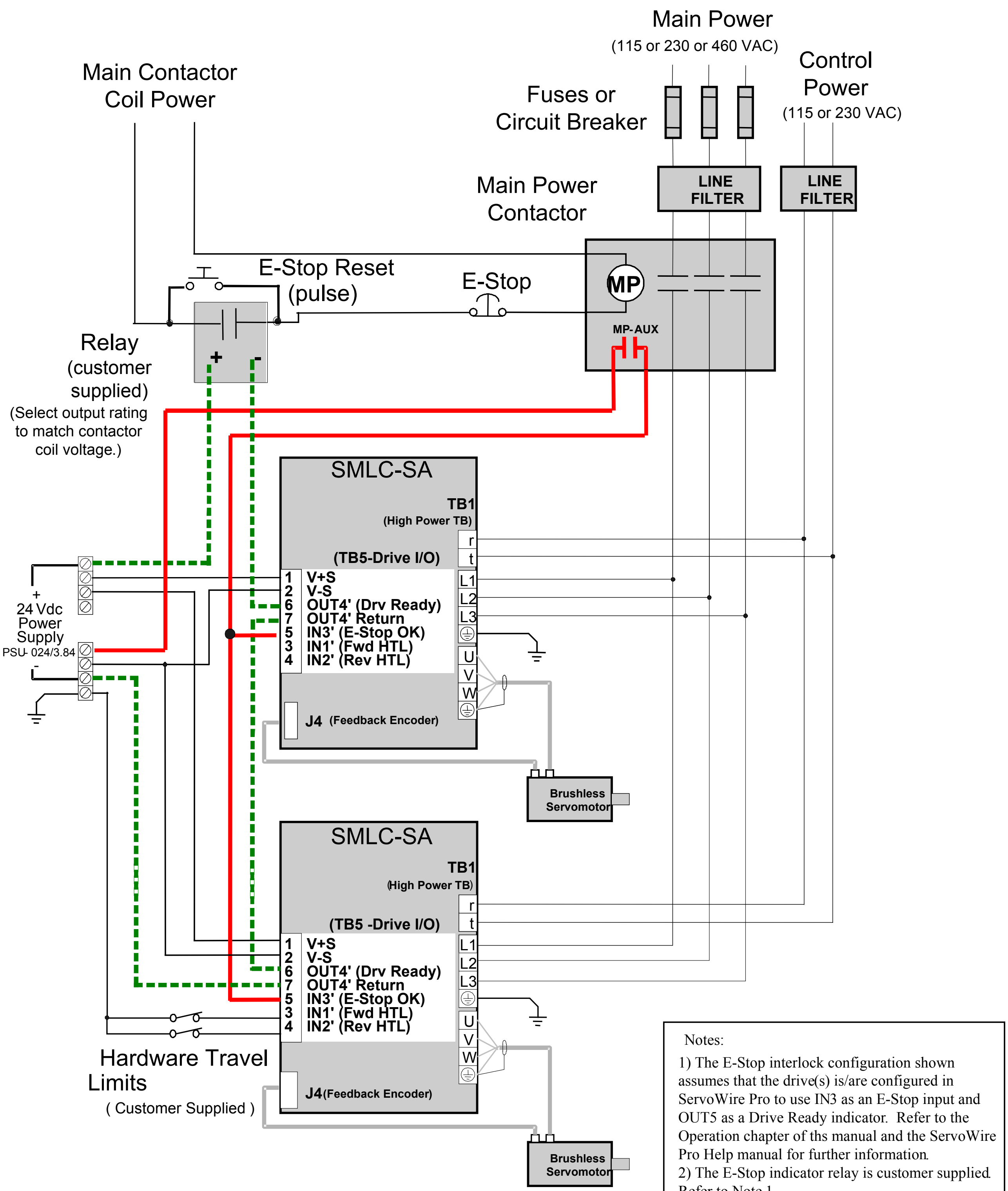
***SoftMotion* –** Open, PC-based software for controlling servodrives that eliminates the need for motion control boards or standalone motion controllers.

TCP/IP – Transmission Control Protocol over Internet protocol. The de facto standard Ethernet protocol.

Tension - the magnitude of force uniformly distributed through a material as a result an external force on that material which constrains movement.

Tension Control – using Tension feedback to control the velocity of a servomotor

Appendix A - System Wiring Diagram



Notes:

1) The E-Stop interlock configuration shown assumes that the drive(s) is/are 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 ths 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.**

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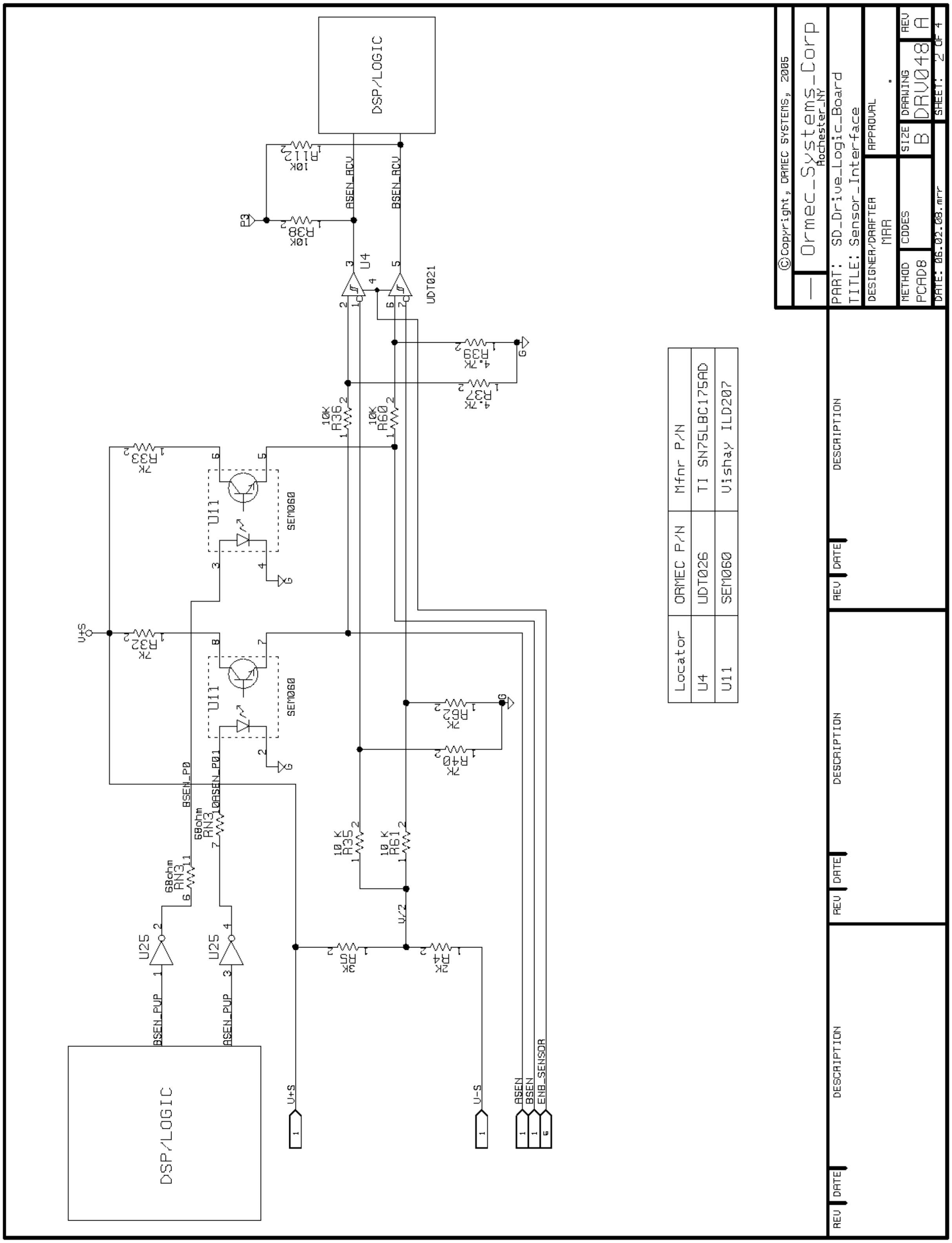
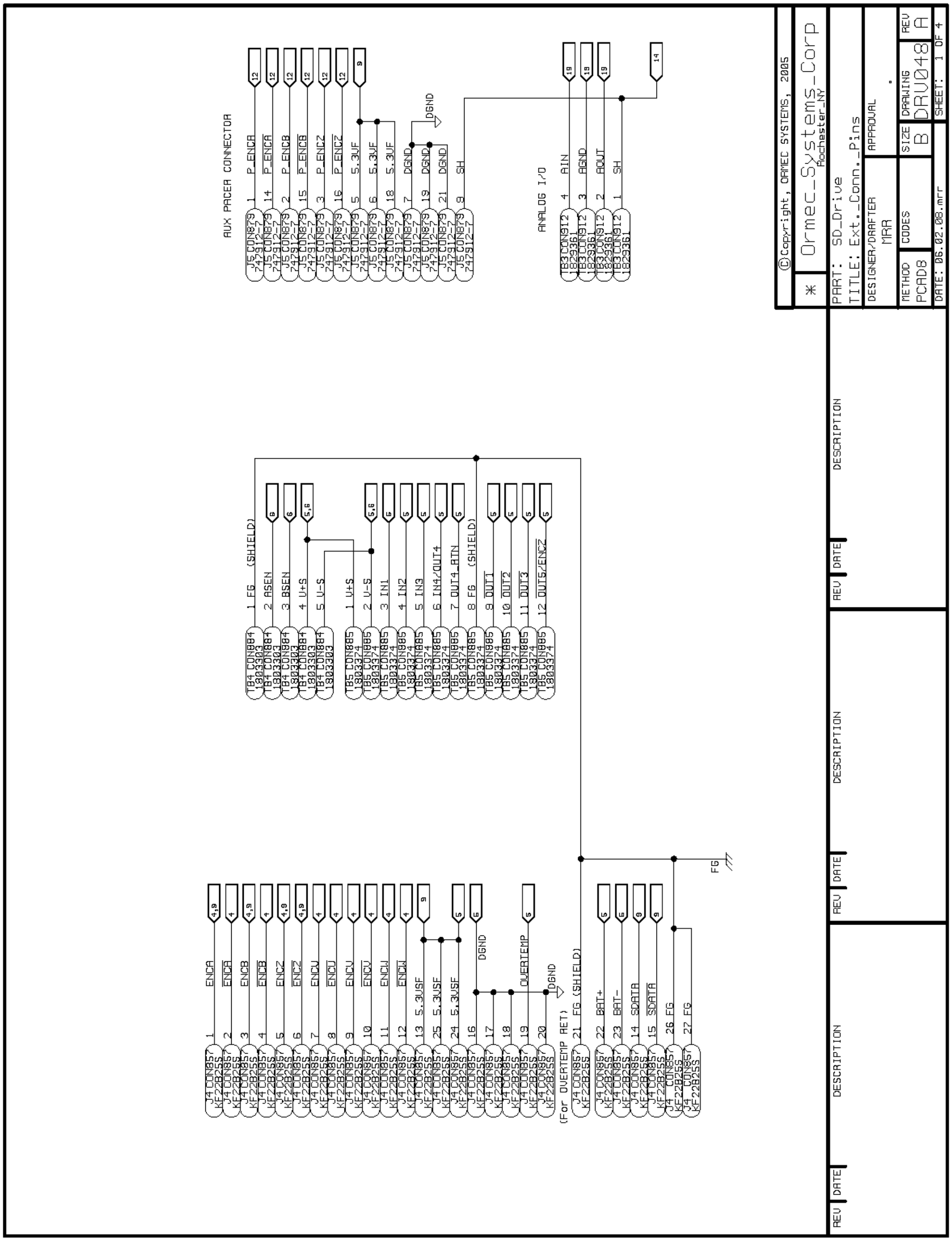
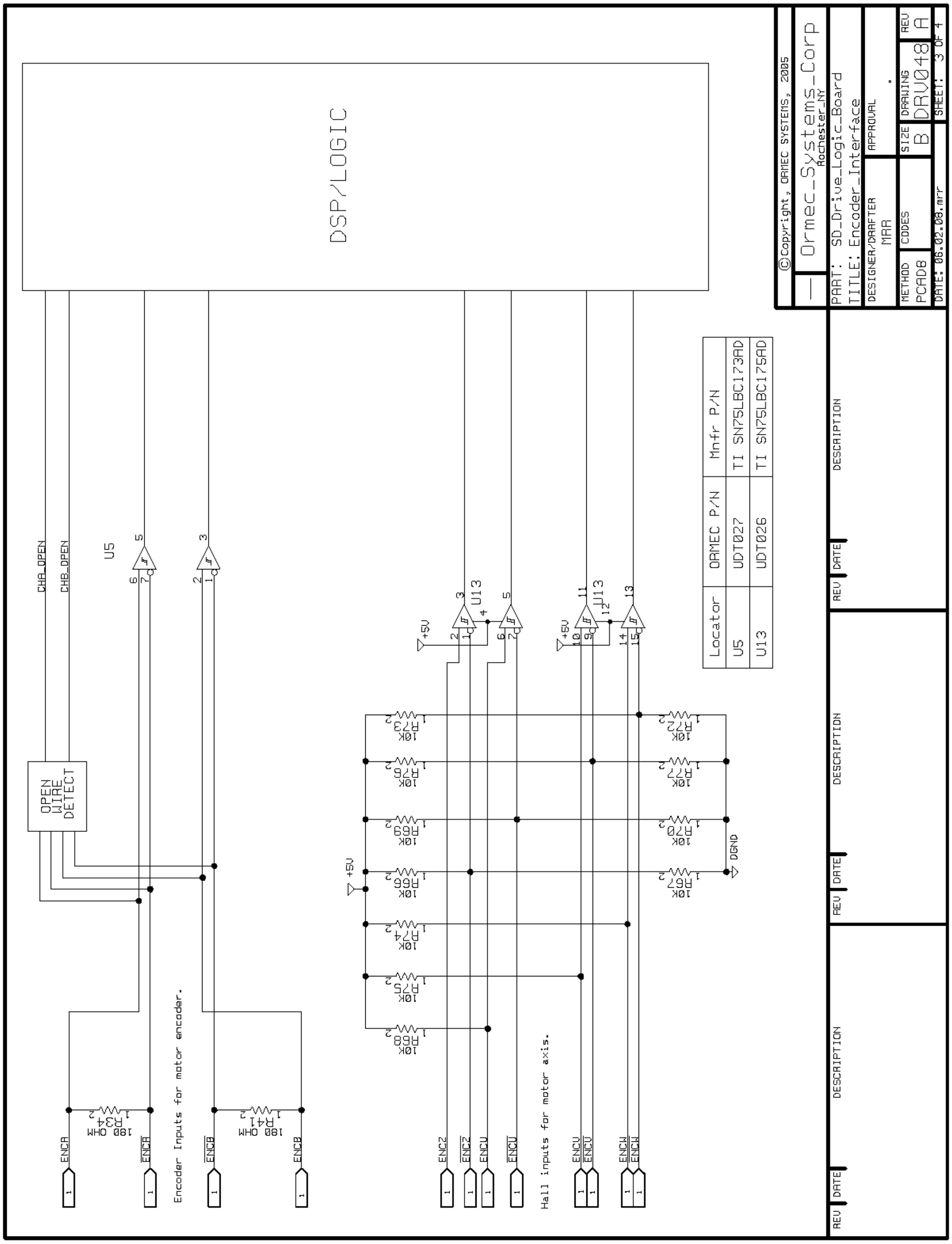
Appendix B – SMLC-SA Drive Logic Board - Sensor Interface



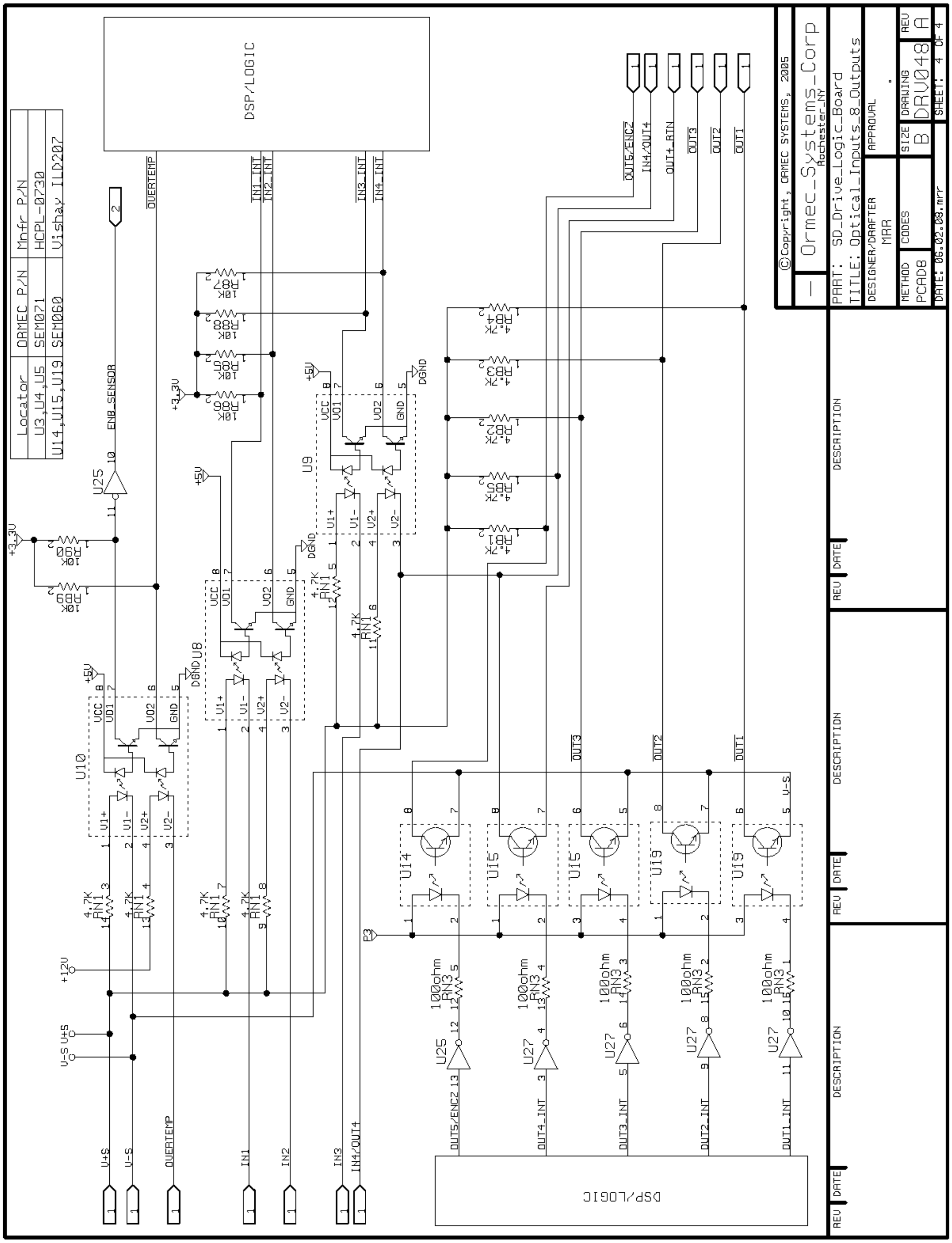
Appendix B – SMLC-SA Drive Logic Board - External Connection Pinout



Appendix B – SMLC-SA Drive Logic Board - Encoder Interface



Appendix B – SMLC-SA Drive Logic Board - Optical Inputs & Outputs



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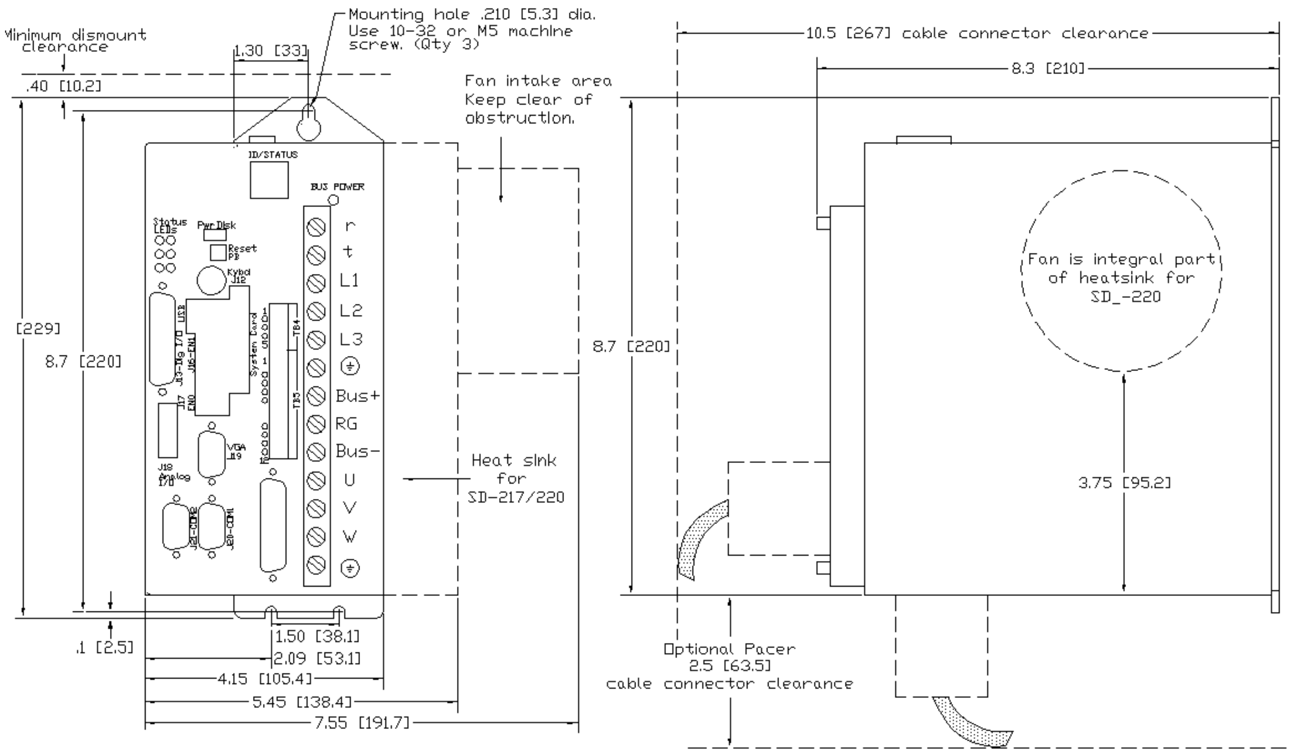
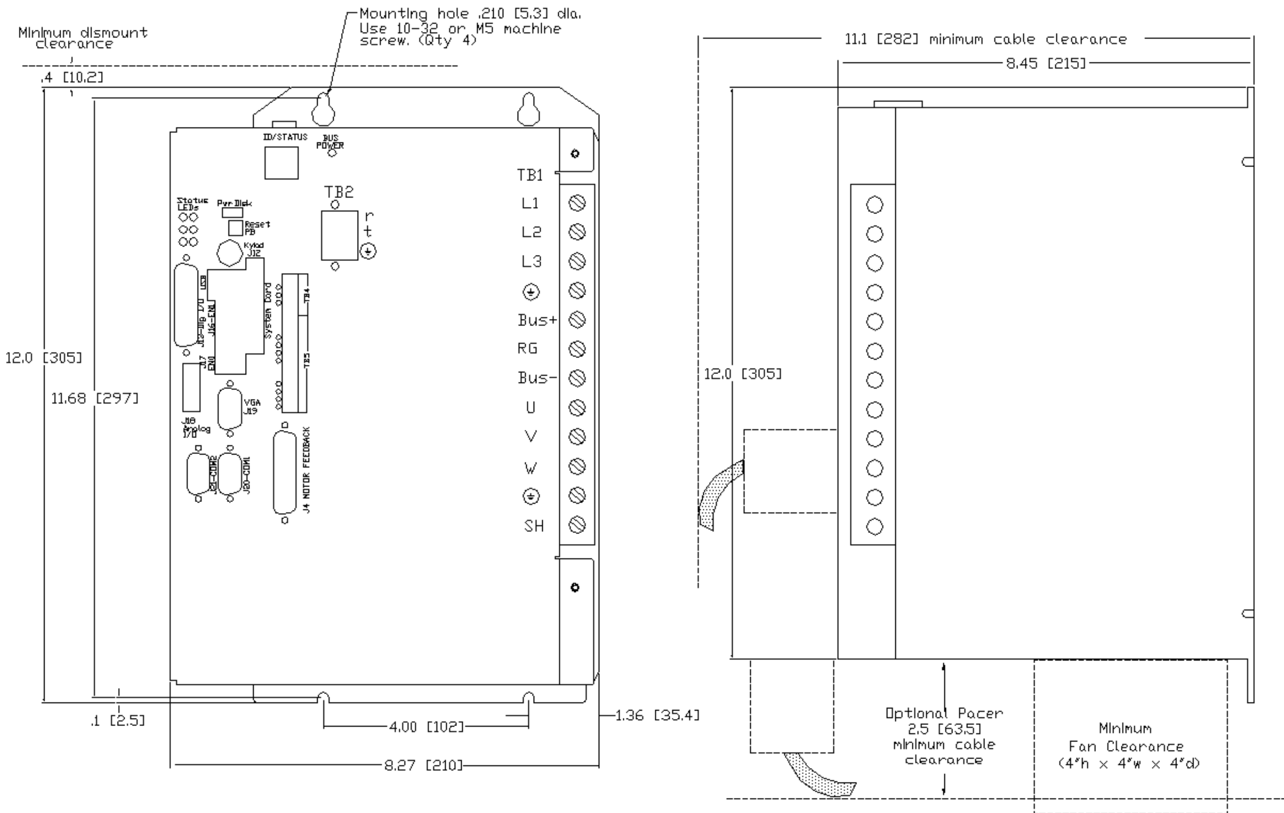
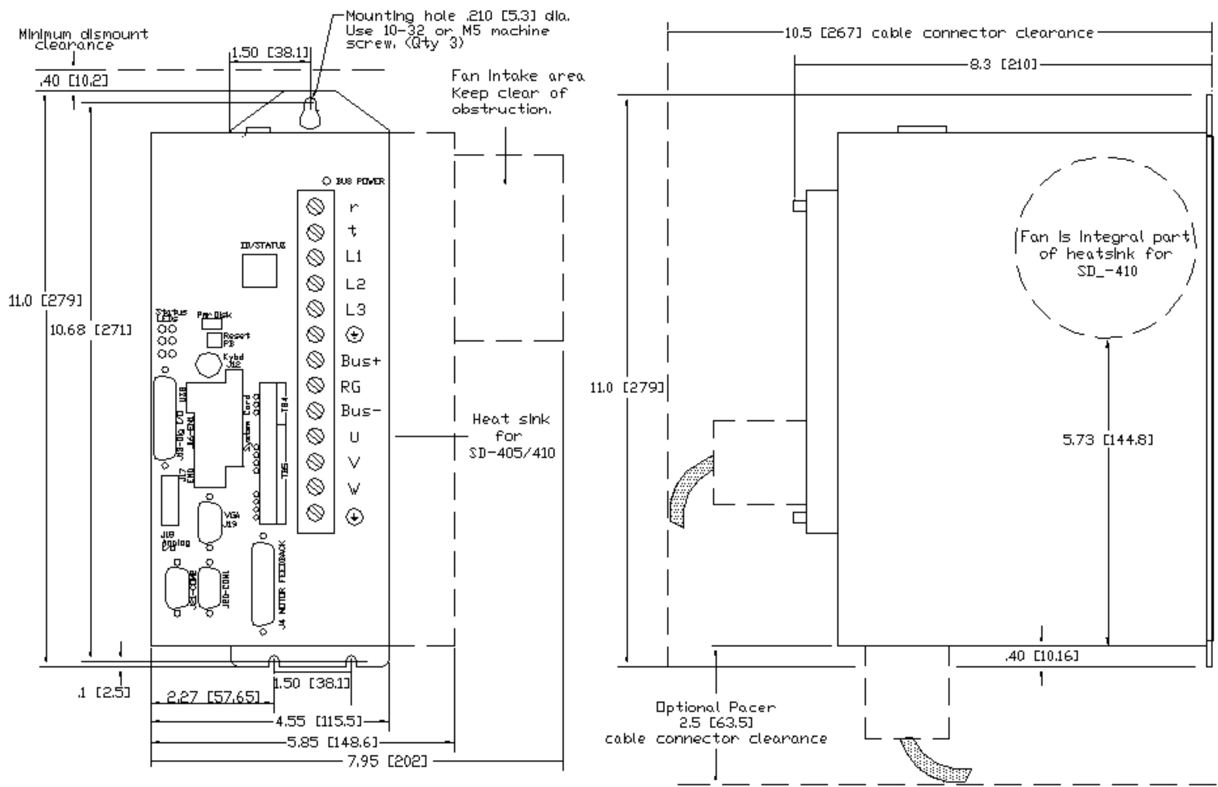
Appendix C - Mounting Information for SMLC-SA203, 205, 210, 217, 220



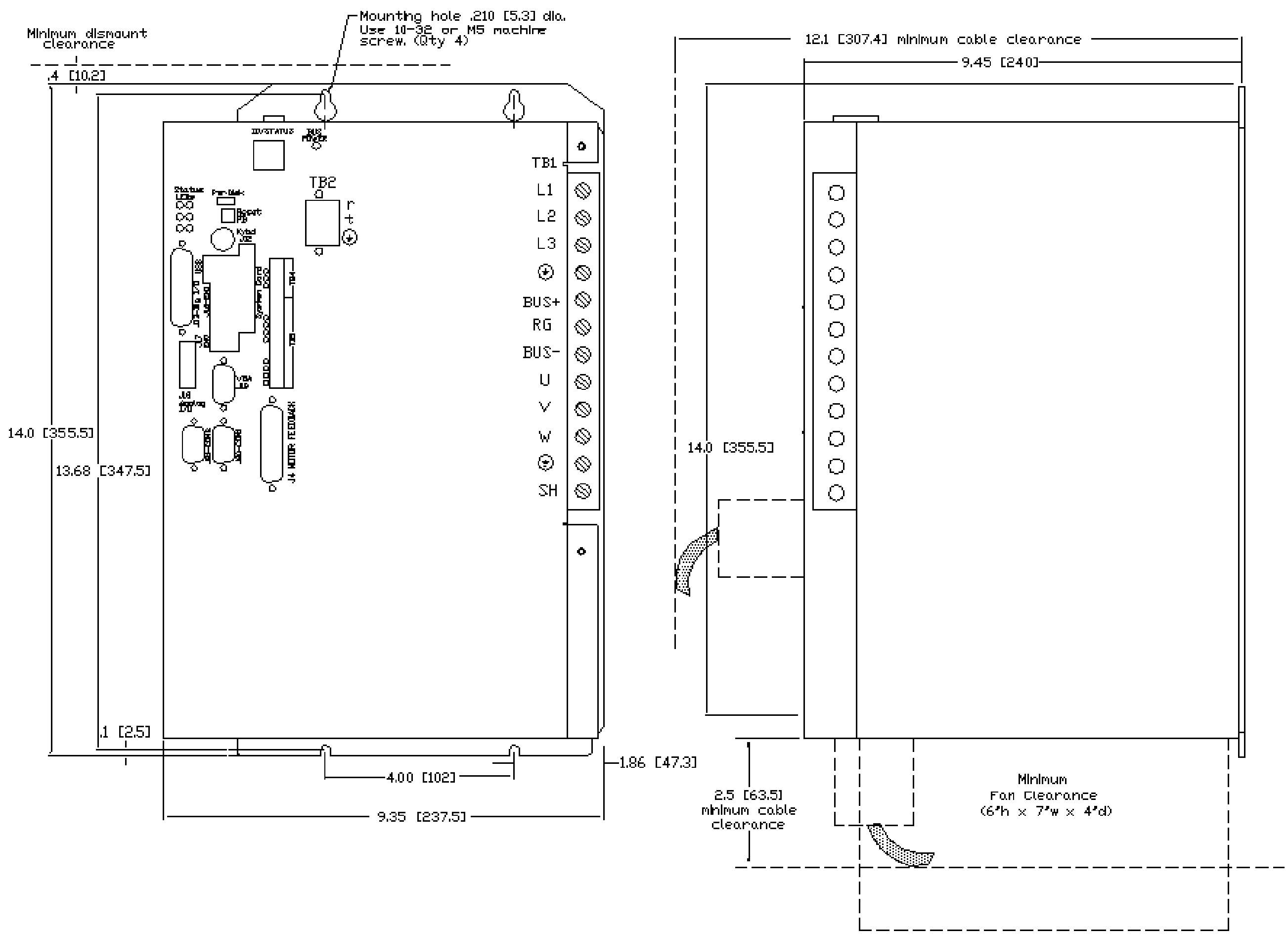
Appendix C - Mounting Information for SMLC-SA225, 235, 260, 417 & 425



Appendix C - Mounting Information for SMLC-SA405 & 410



Appendix C - Mounting Information for SMLC-SA435 & 450



Appendix C – Additional clearance requirements

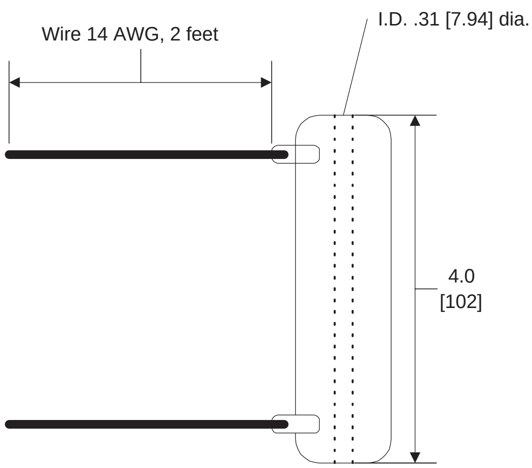
Additional clearance above, below and to the sides of the SMLC-SA is also required for heat dissipation:
SMLC-SA203, SMLC-SA205 and SMLC-SA210
Add 2” (51 mm) clearance top and bottom.
Add 1” (25 mm) clearance each side.

SMLC-SA217 and SMLC-SA405
Add 2” (51 mm) clearance top and bottom.
Add 1.2” (31 mm) clearance each side.

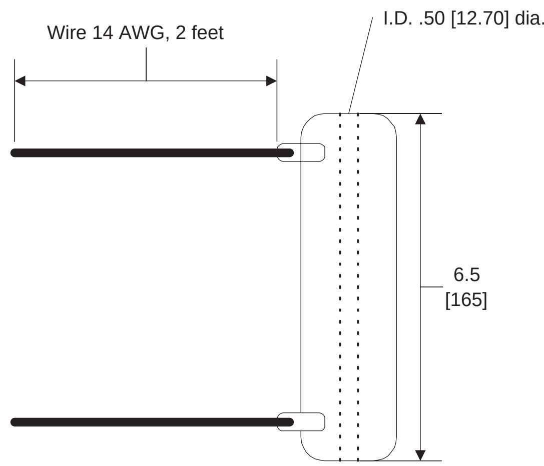
SMLC-SA220 and SMLC-SA410
Add 2” (51 mm) clearance top and bottom.
Add 1” left-side, 2” (51 mm) right-side clearance

SMLC-SA225, SMLC-SA235, SMLC-SA260, SMLC-SA417, SMLC-SA425, SMLC-SA435 and SMLC-SA450
Add 2” (51 mm) clearance.
Add 4” (102 mm) clearance bottom.
Add 1” (25 mm) clearance each side.

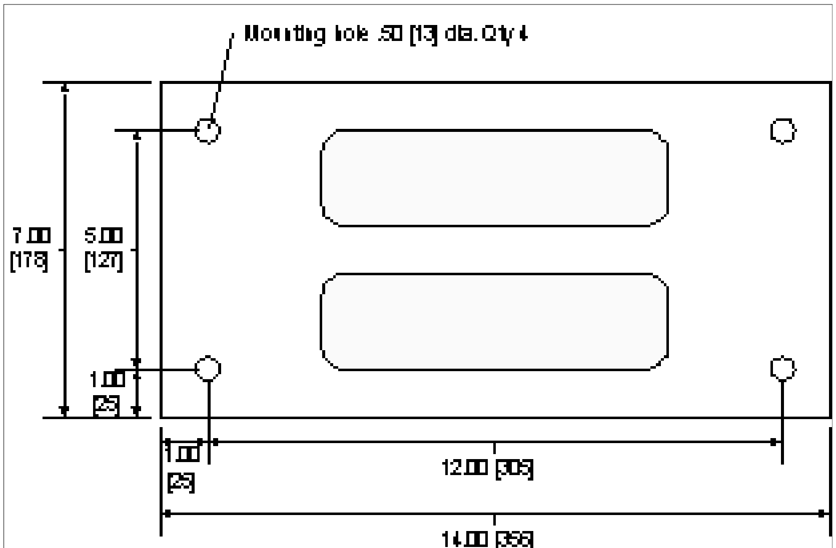
Appendix C - Regen Resistors



SAC-SWRR/0055

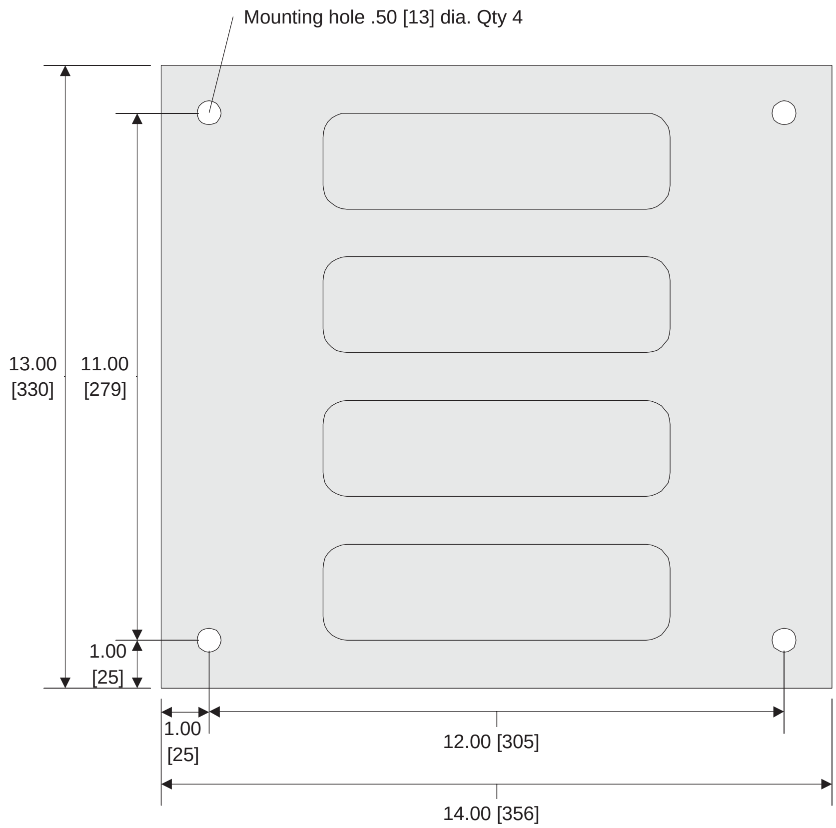


SAC-SWRR/0095



SAC-SWRR/0700, 0845, 0846

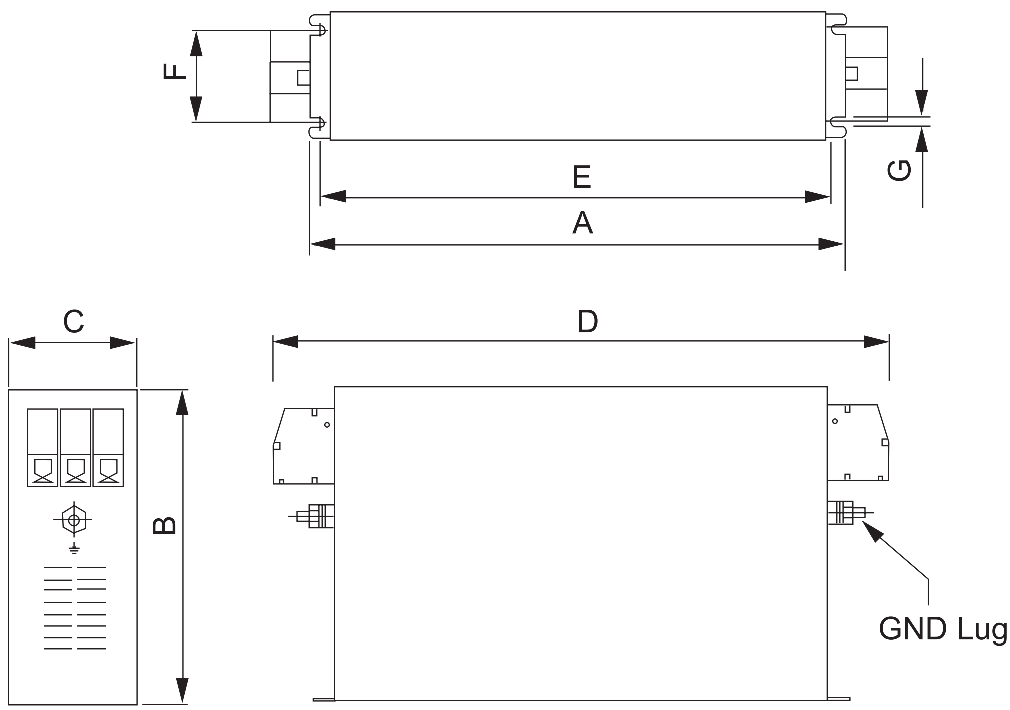
All dimensions in inches [mm]



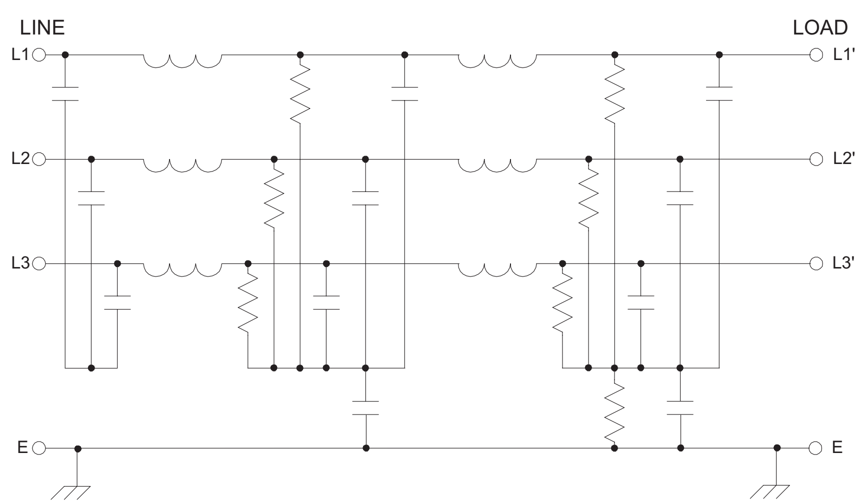
SAC-SWRR/1700

All dimensions in inches [mm]

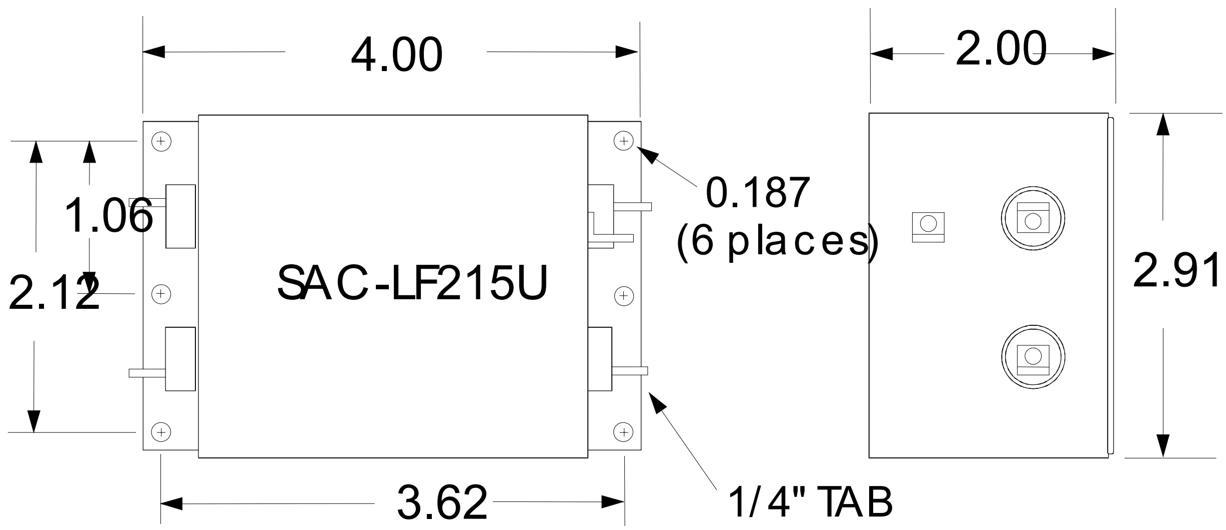
Appendix C - Line Filters: SAC-LF30C, 55C, & 100C



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

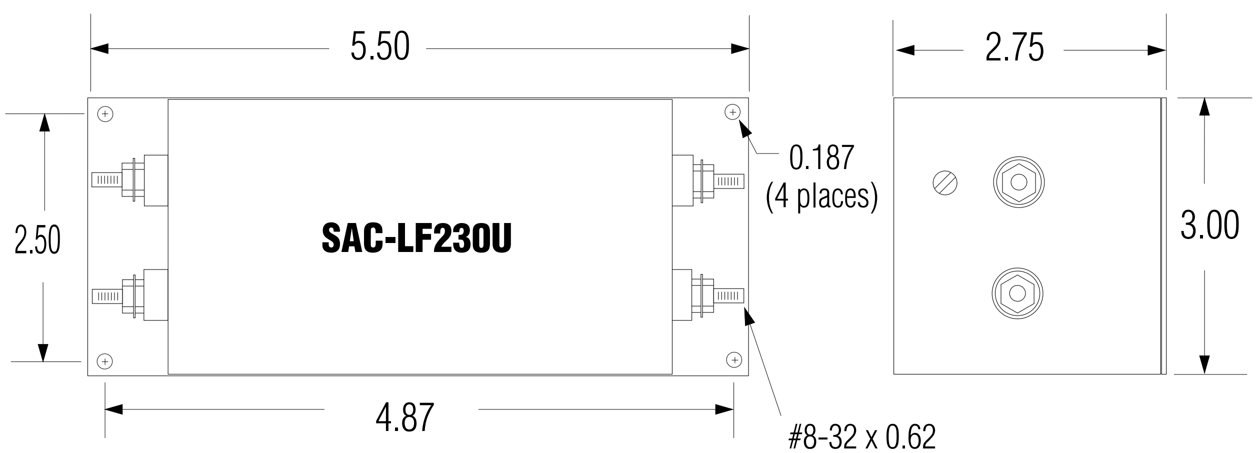


Appendix C - Line Filters: SAC-LF215U



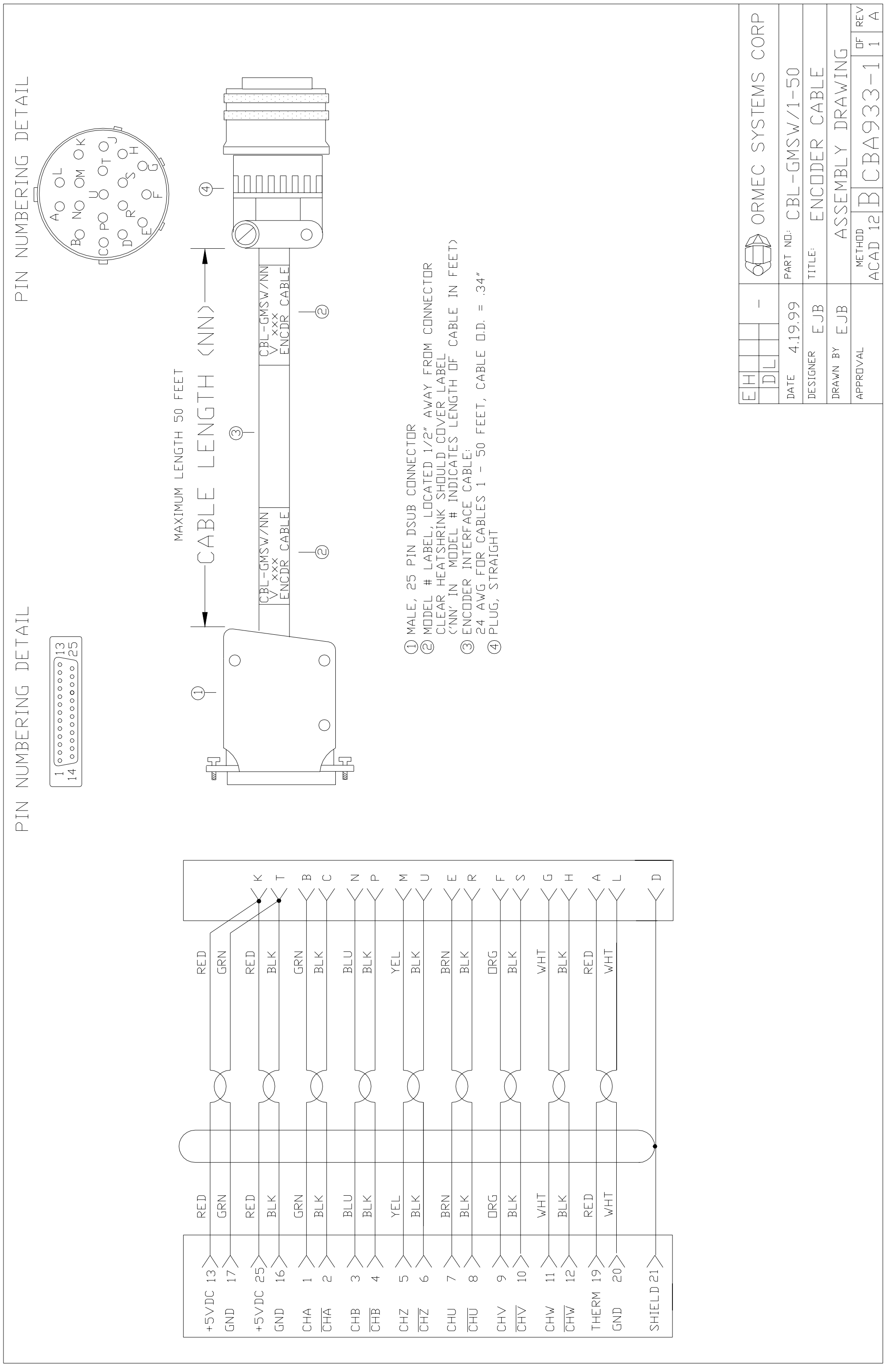
All dimensions in inches

Appendix C - Line Filters: SAC-LF230U

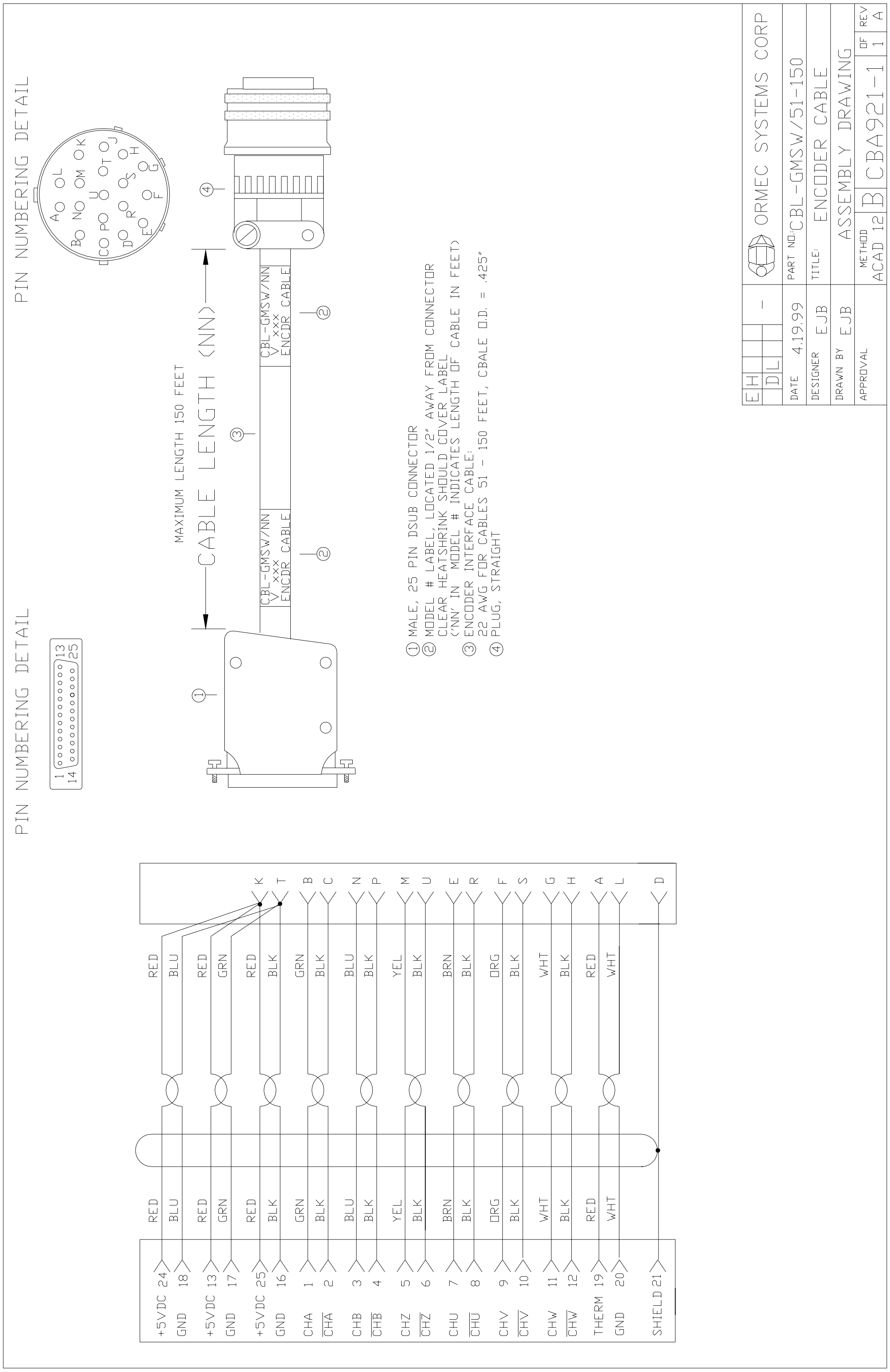


All dimensions in inches

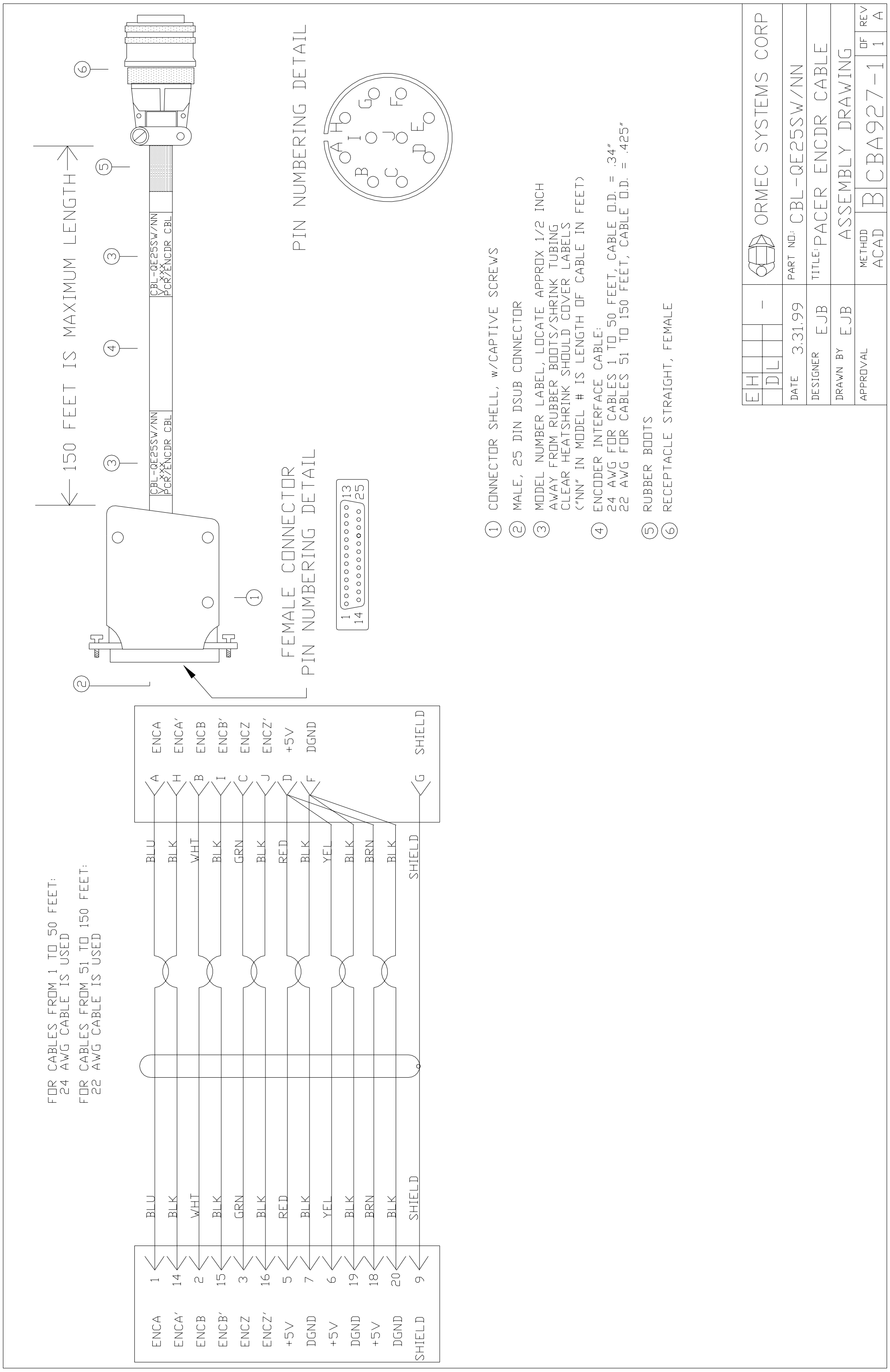
Appendix D - CBL-GMSW (1-50) Encoder Cable



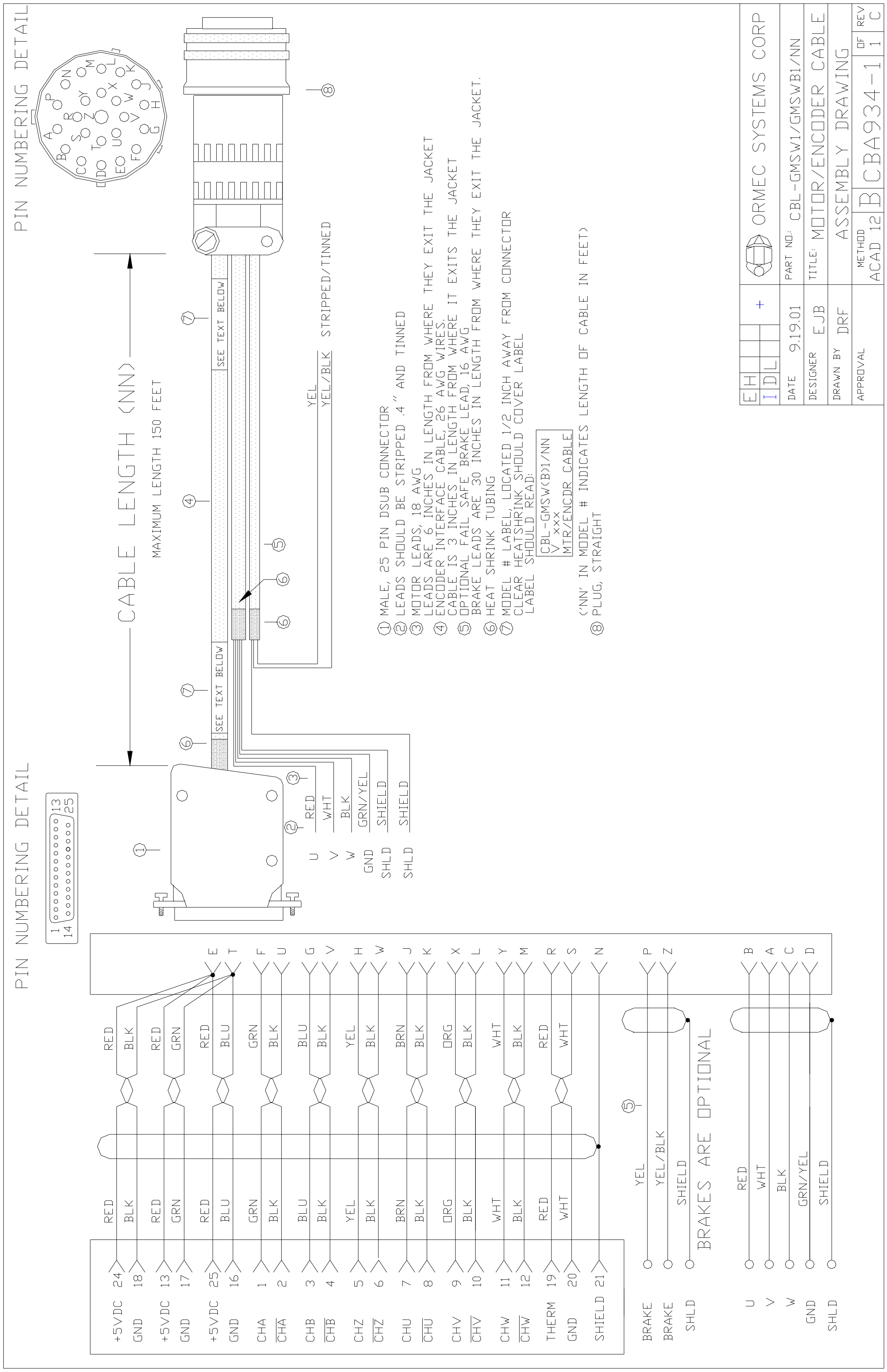
Appendix D - CBL-GMSW (51-150) Encoder Cable



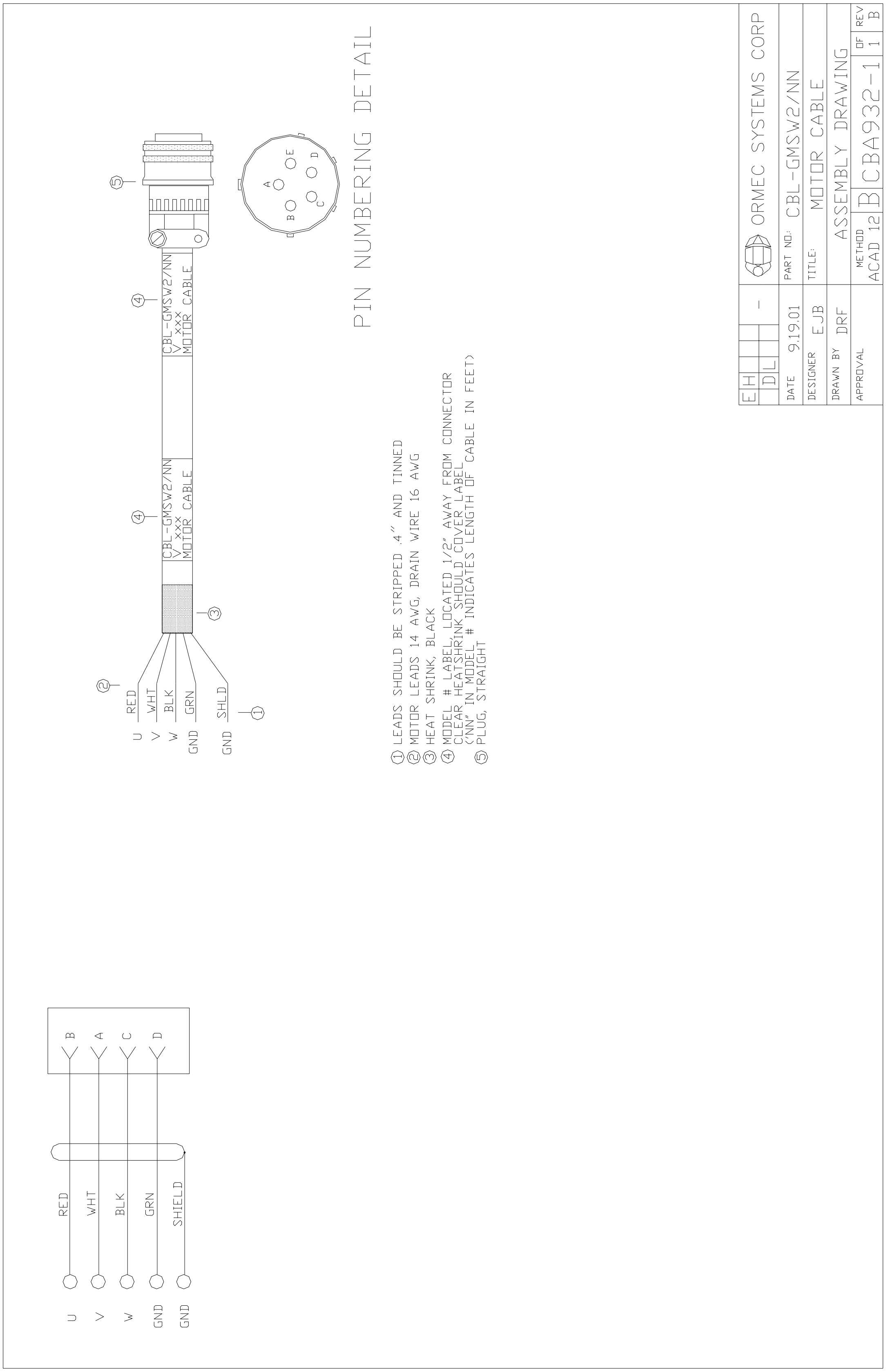
Appendix D - CBL-QE25SW Pacer Encoder Cable



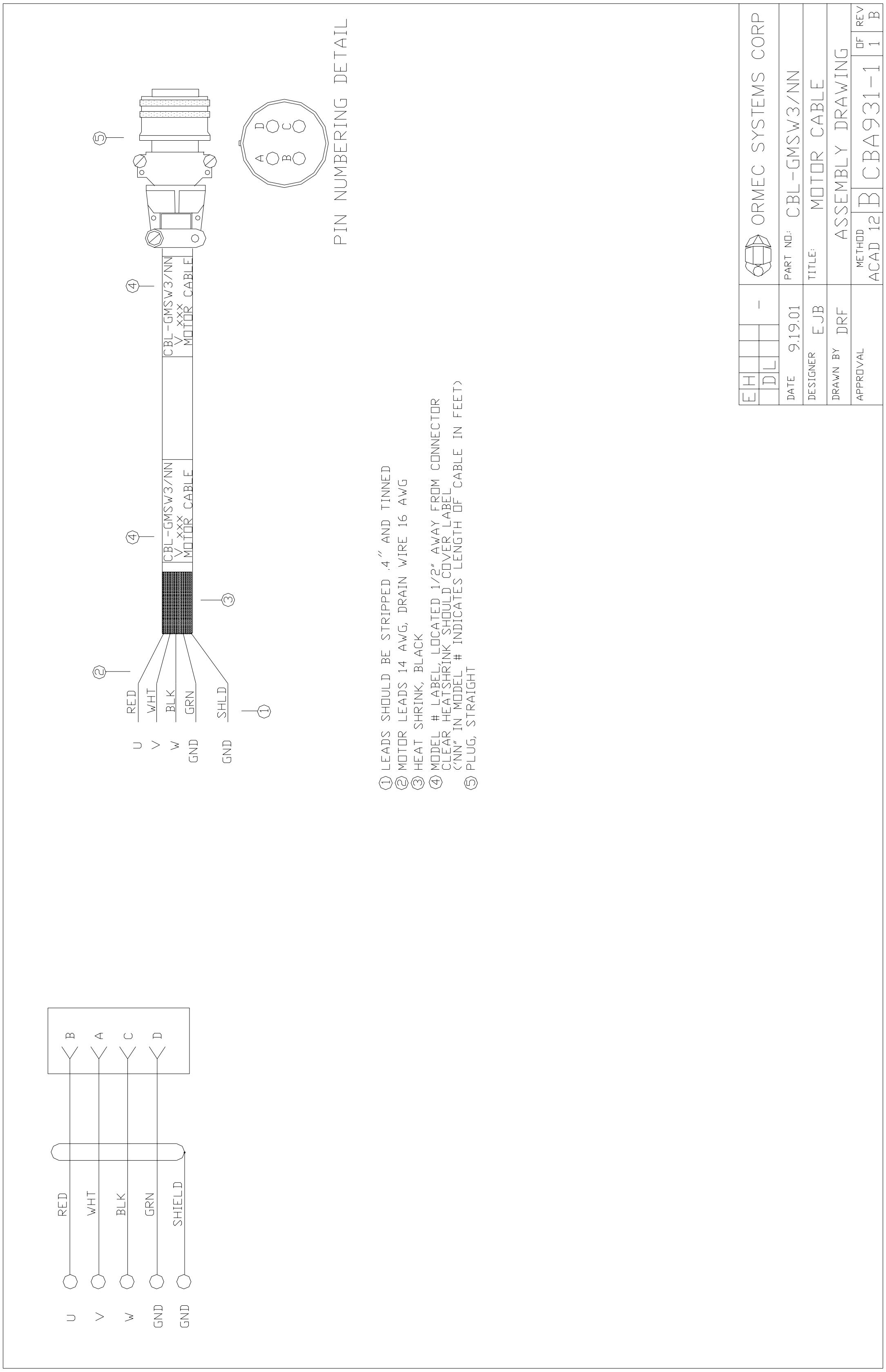
Appendix D - CBL-GMSW1 / GMSWB1 Motor/Encoder Cable



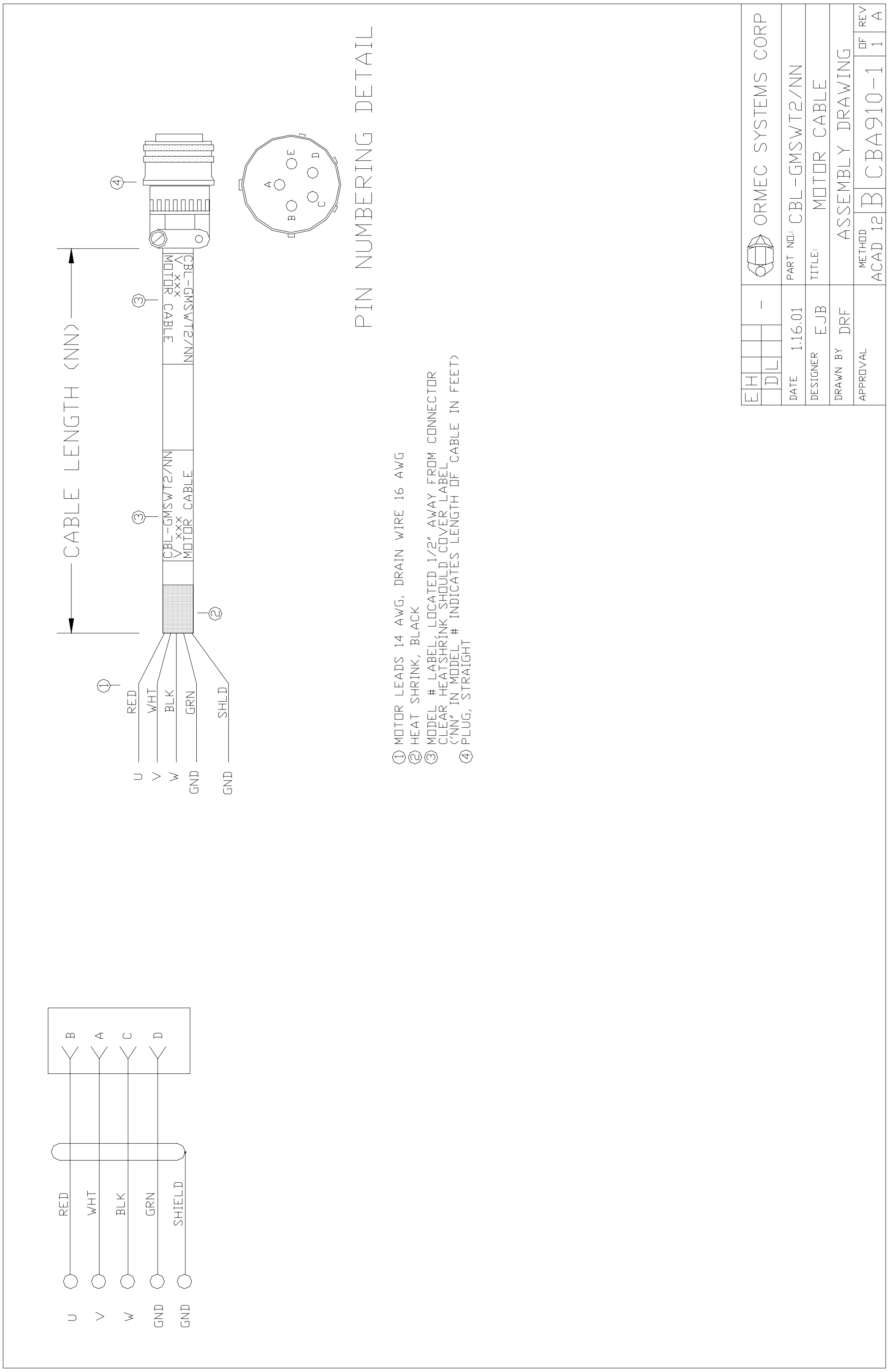
Appendix D - CBL-GMSW2 Motor Cable



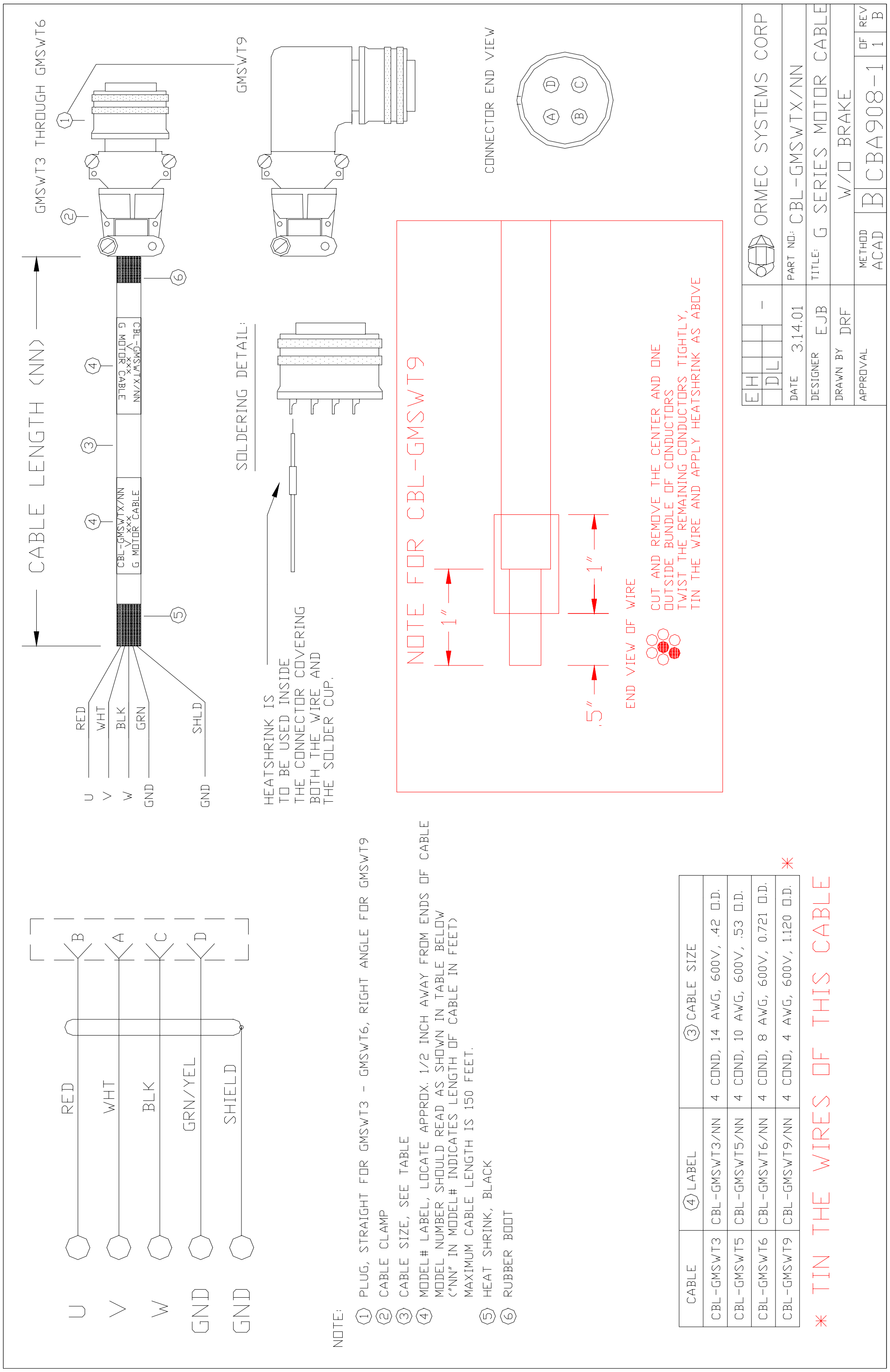
Appendix D - CBL-GMSW3 Motor Cable



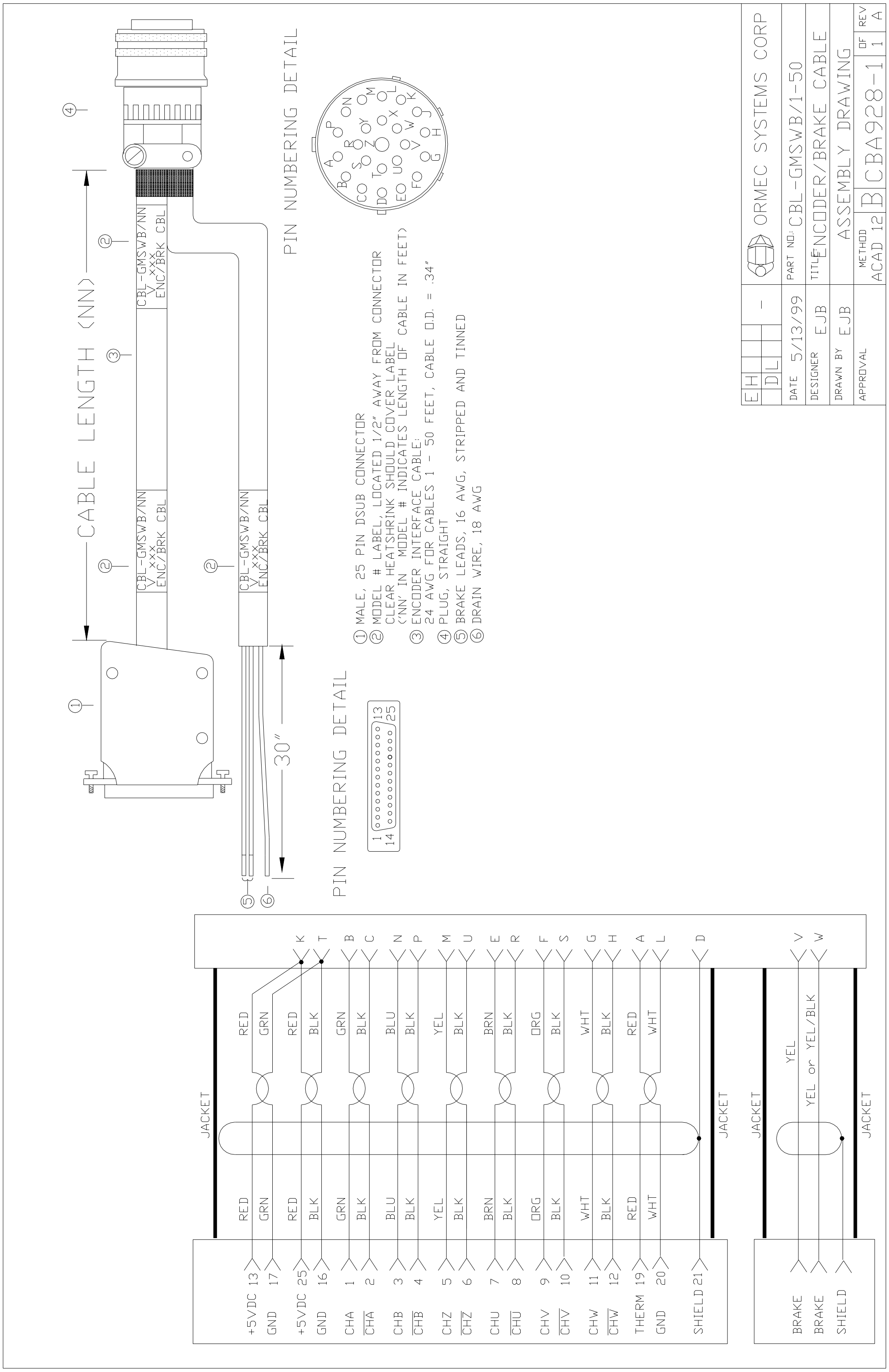
Appendix D - CBL-GMSWT2 Motor Cable



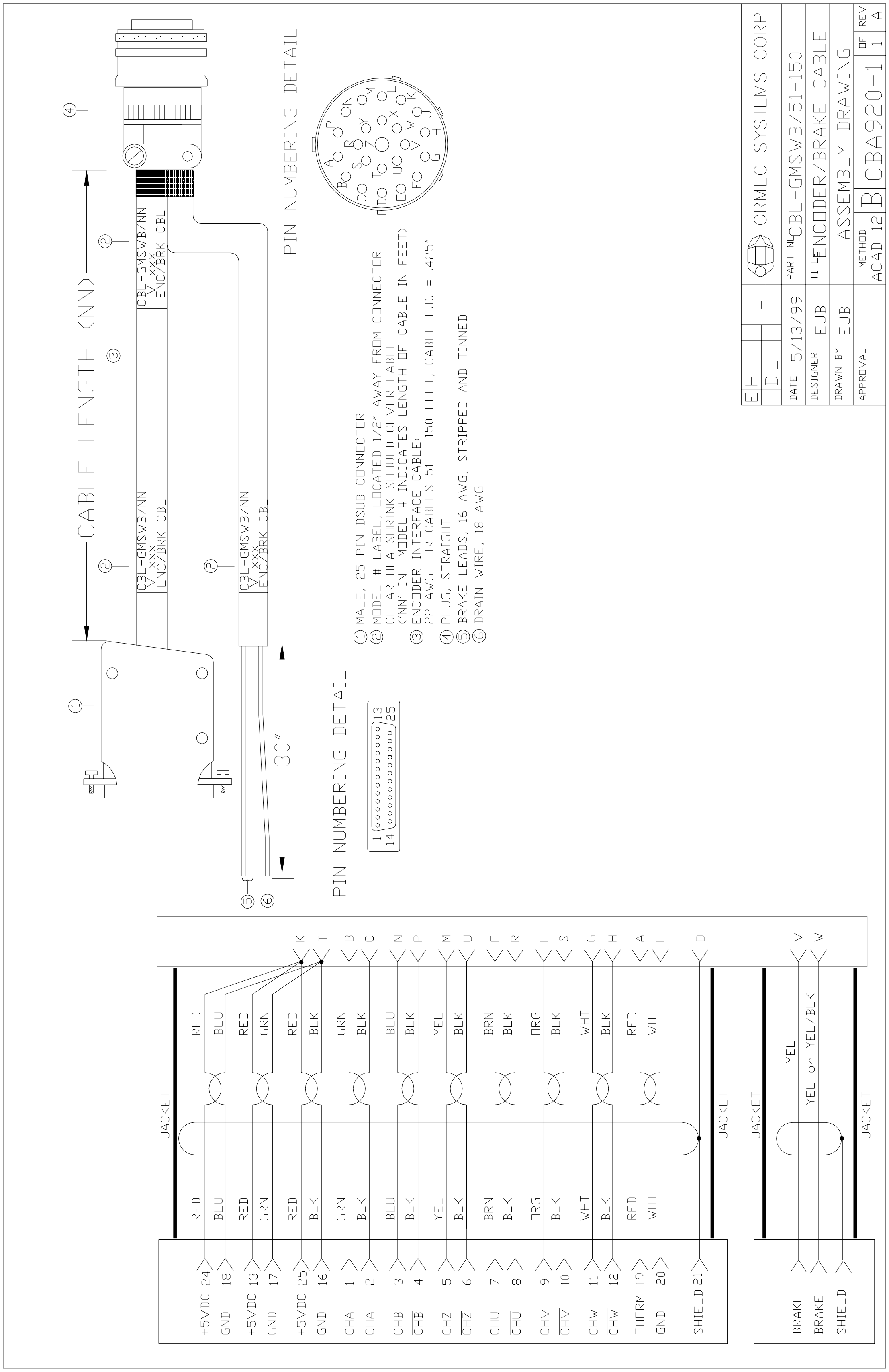
Appendix D - CBL-GMSWTX Motor Cable



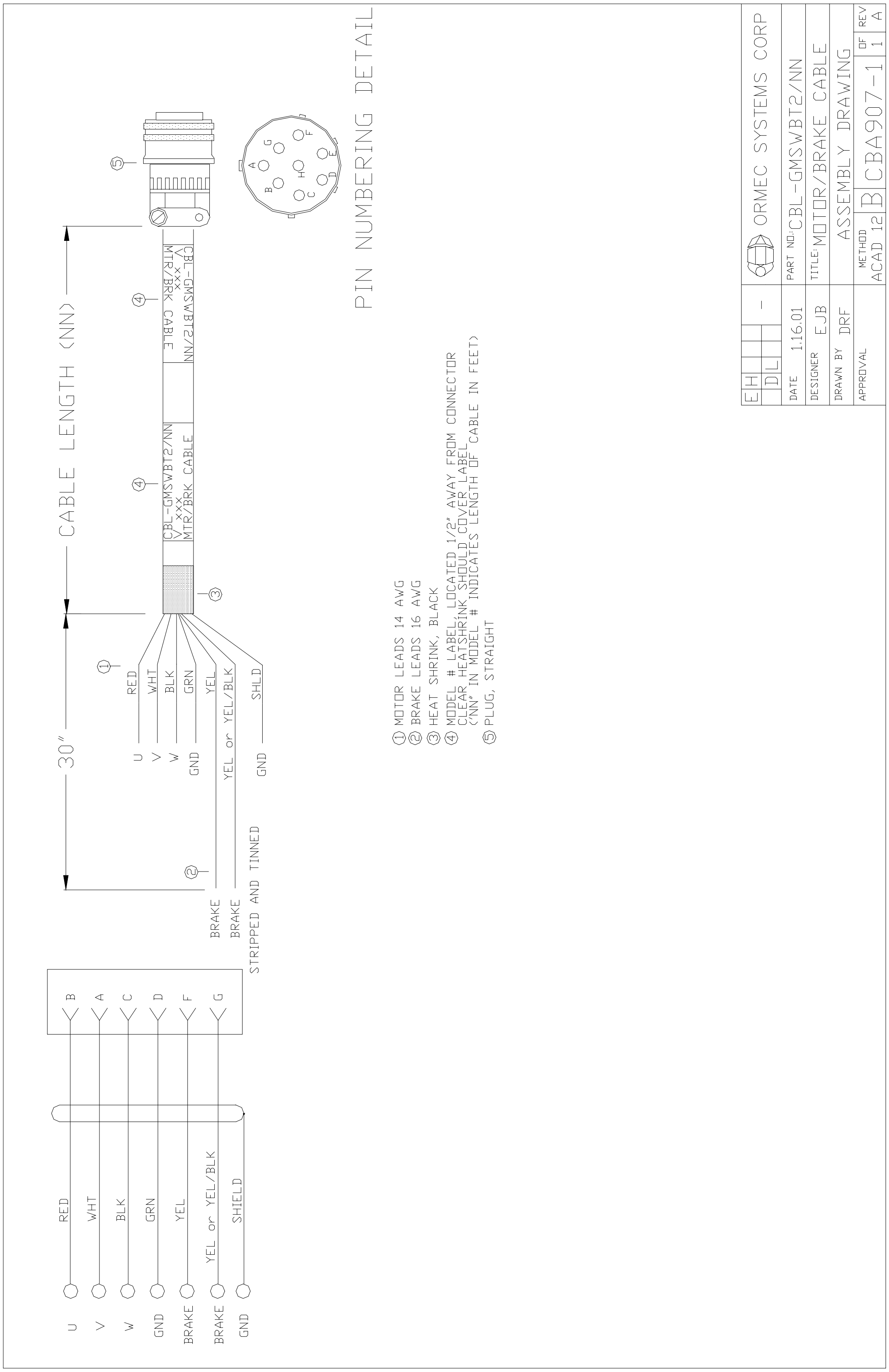
Appendix D - CBL-GMSWB Motor Cable



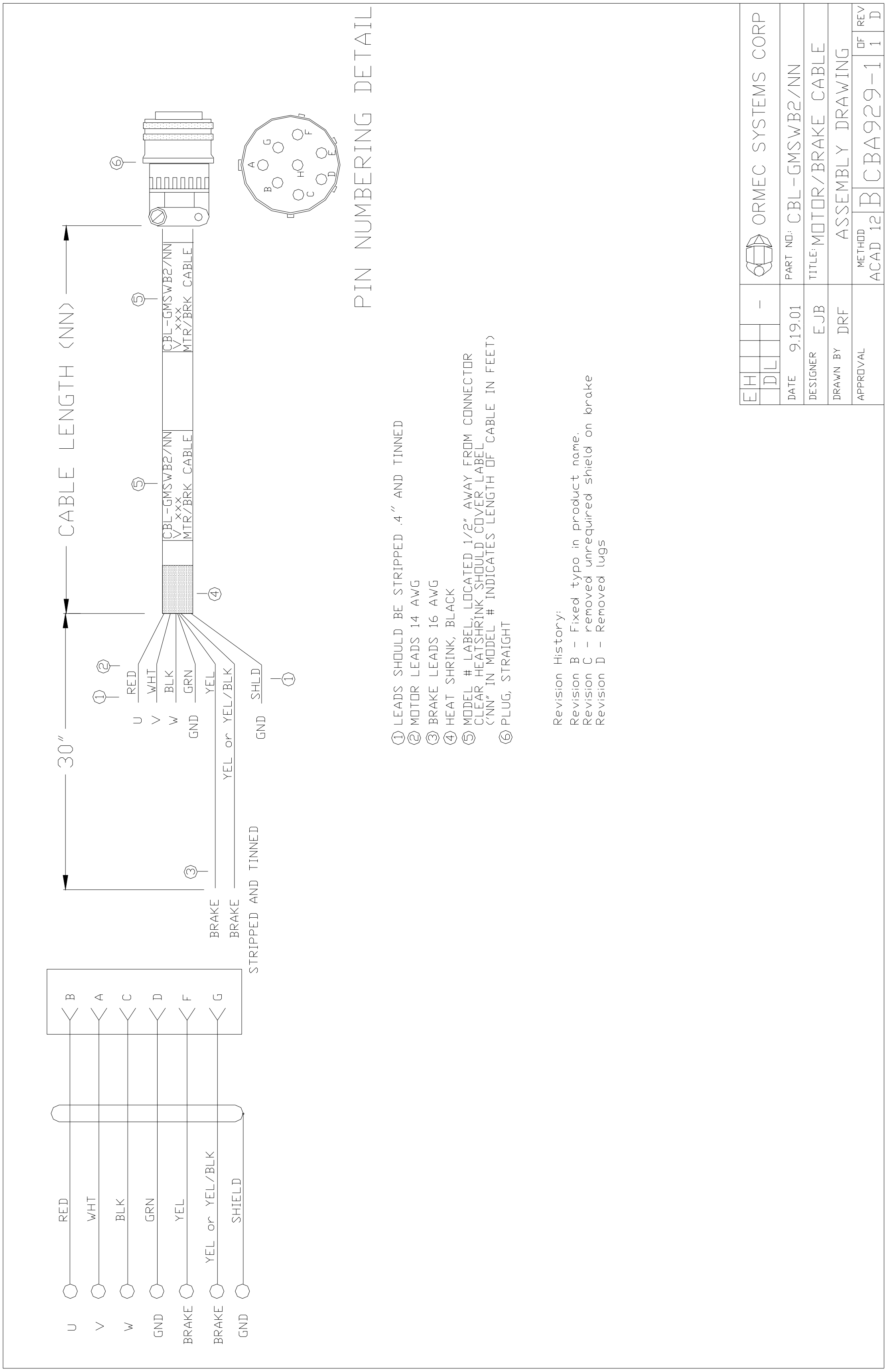
Appendix D - CBL-GMSWB



Appendix D - CBL-GMSWBT2 Motor / Brake Cable



Appendix D - CBL-GMSWB2 Motor / Brake Cable



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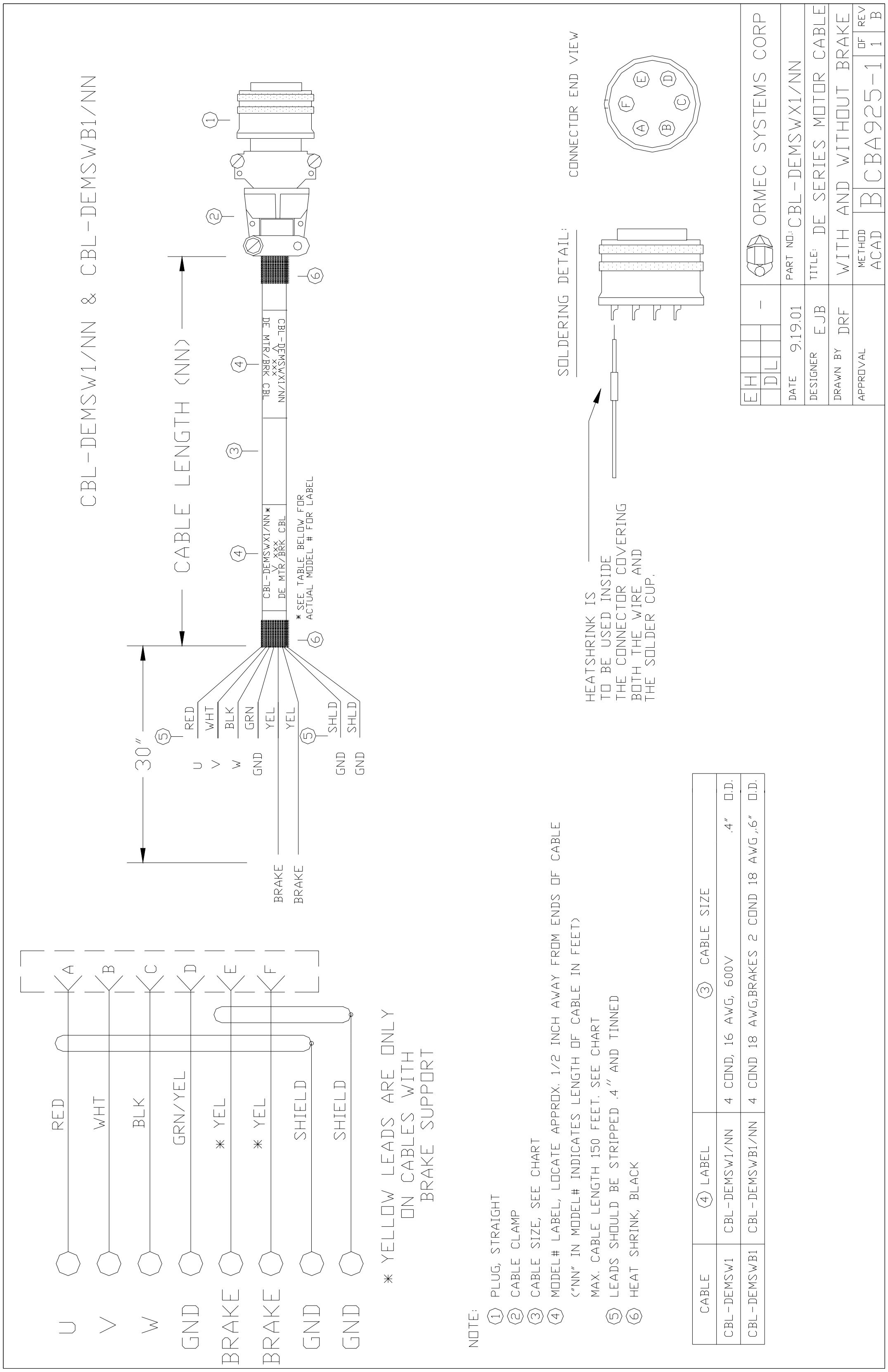
Appendix E - CBL-DEMSW1 Motor Cable



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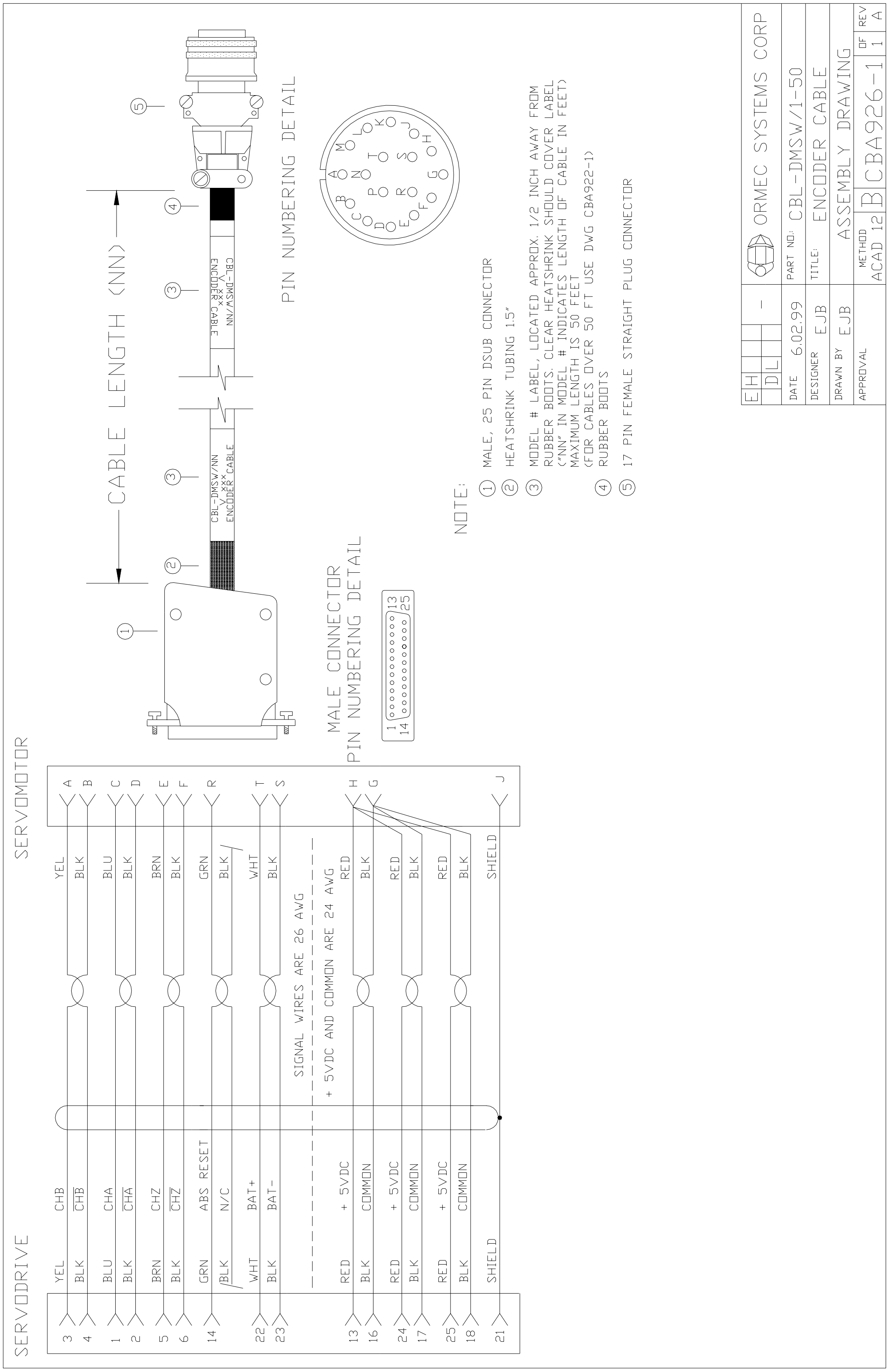
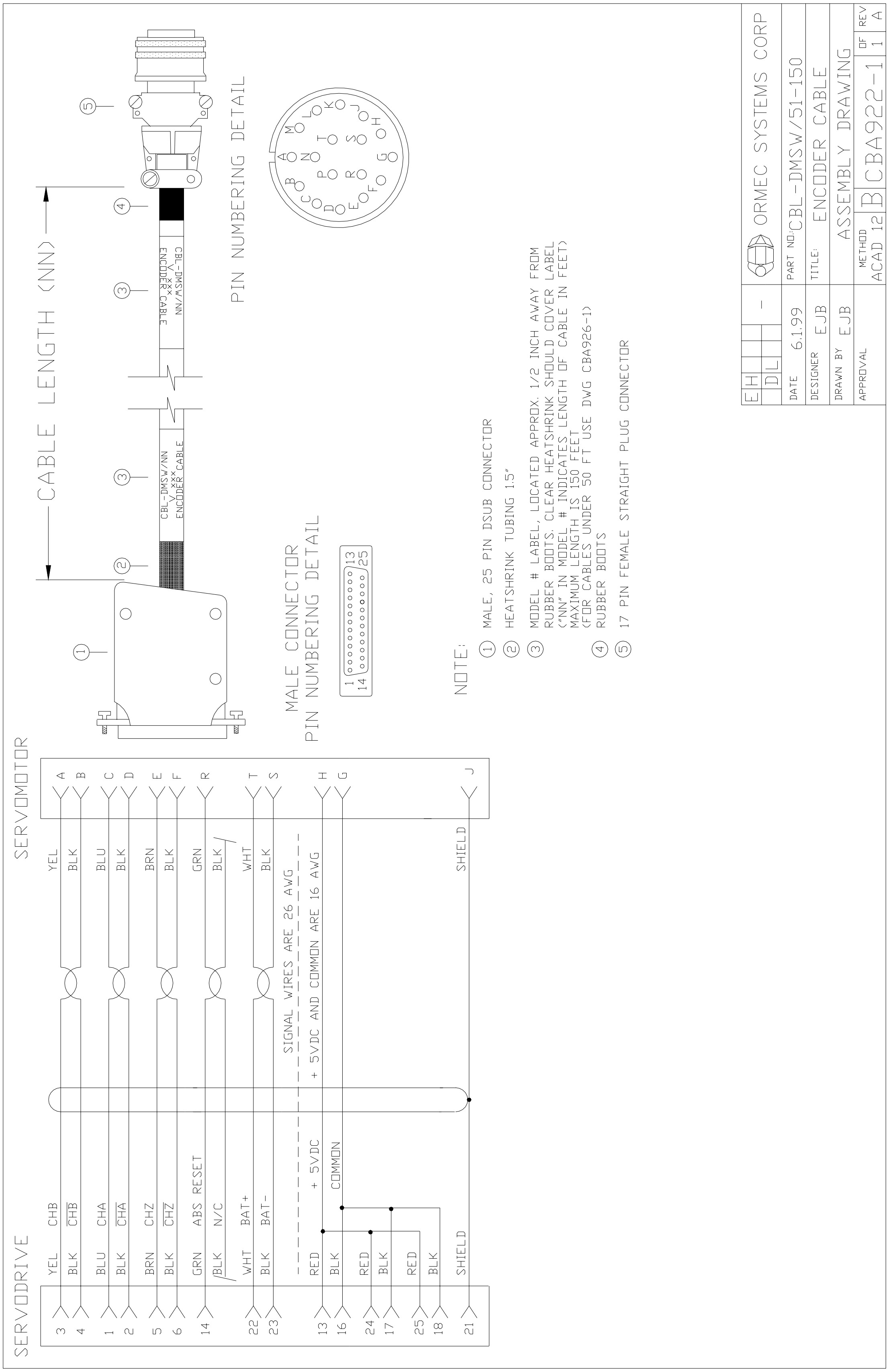
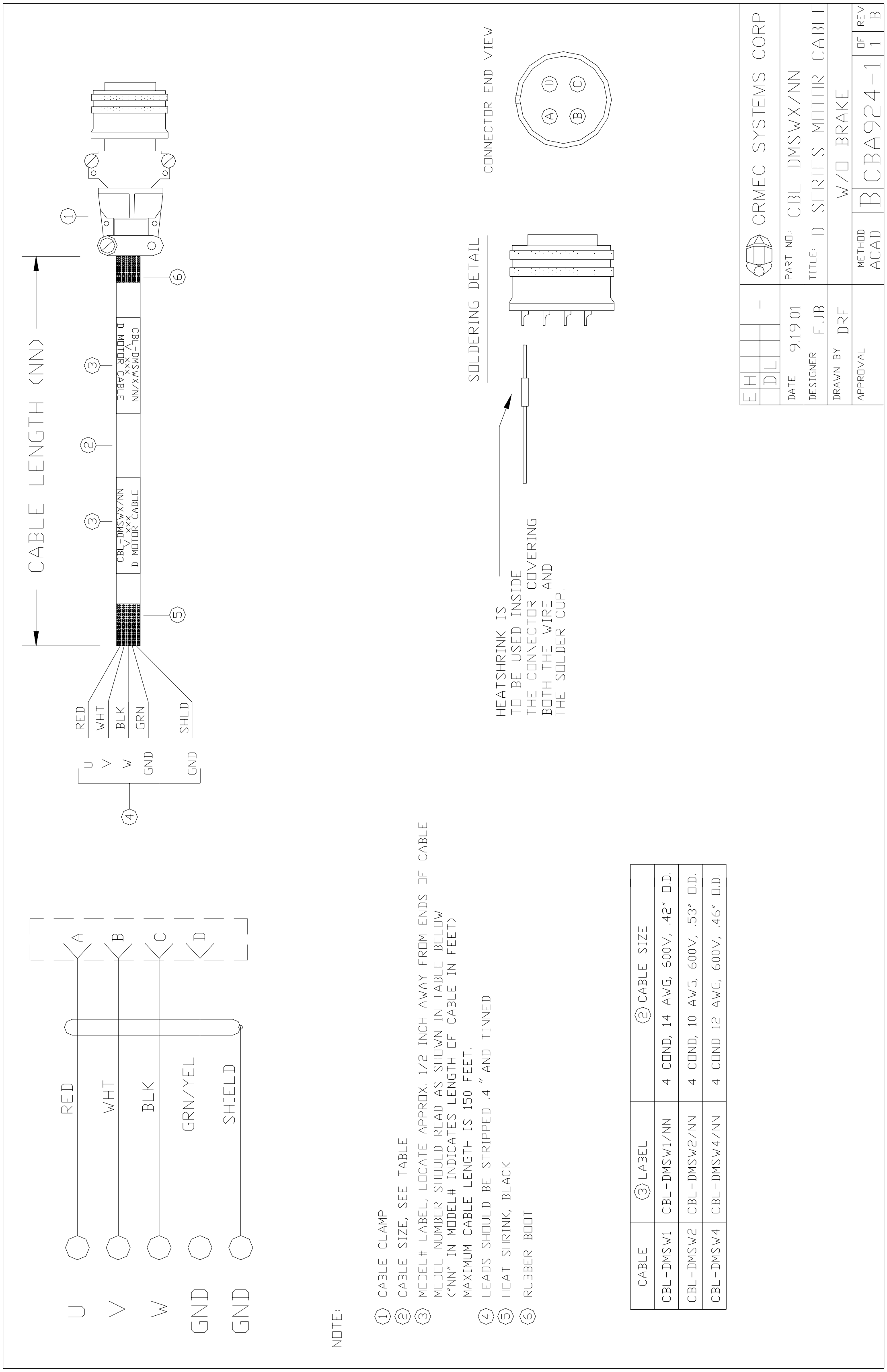
Appendix F - CBL- DMSW Encoder Cable



Appendix F - CBL-DMSW Encoder Cable

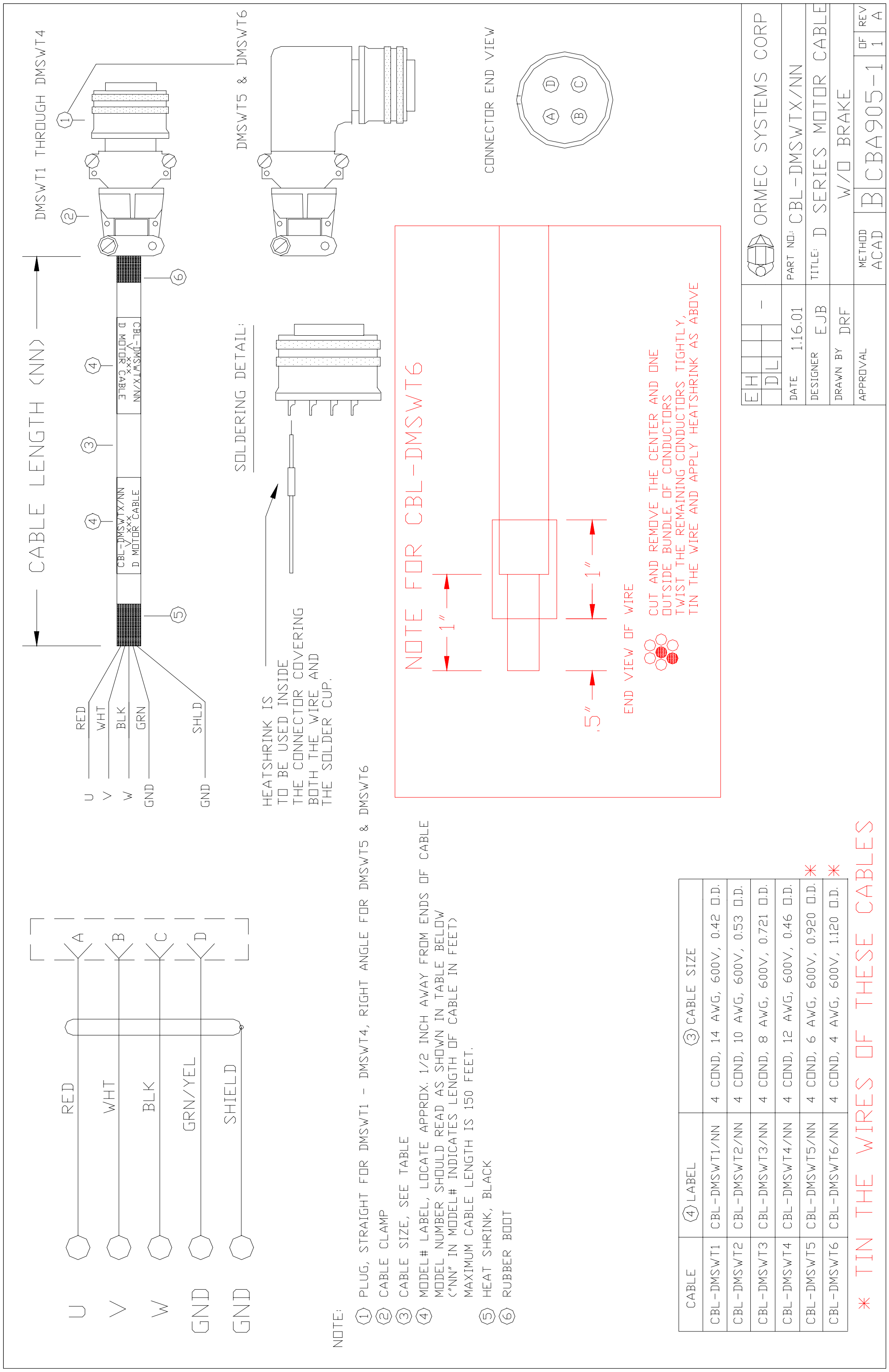


Appendix F - CBL-DMSWn Motor Cable



CABLE	(3) LABEL	(2) CABLE SIZE
CBL-DMSW1	CBL-DMSW1/NN	4 COND, 14 AWG, 600V, .42" O.D.
CBL-DMSW2	CBL-DMSW2/NN	4 COND, 10 AWG, 600V, .53" O.D.
CBL-DMSW4	CBL-DMSW4/NN	4 COND 12 AWG, 600V, .46" O.D.

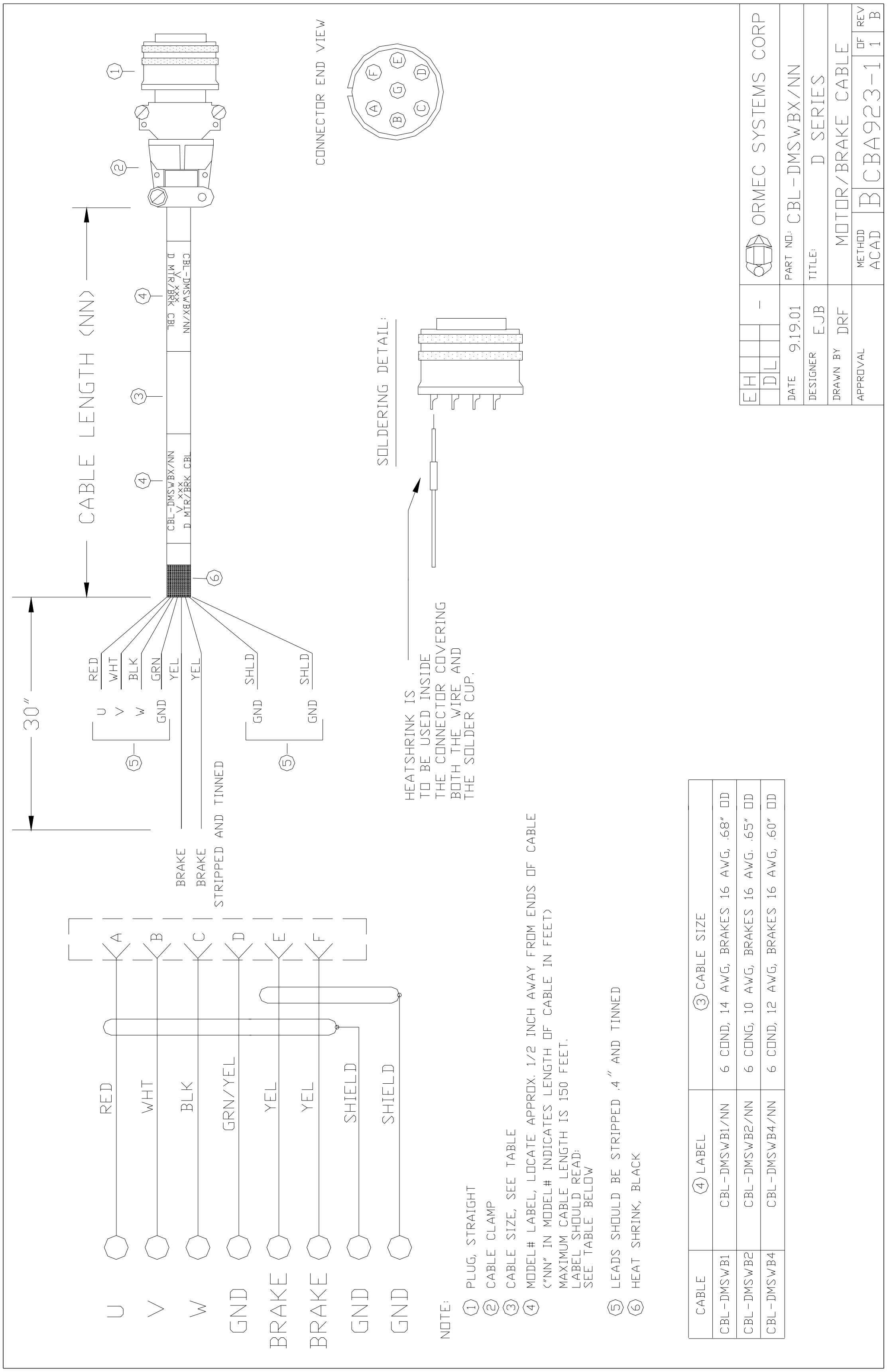
Appendix F - CBL-DMSWTx Motor Cable



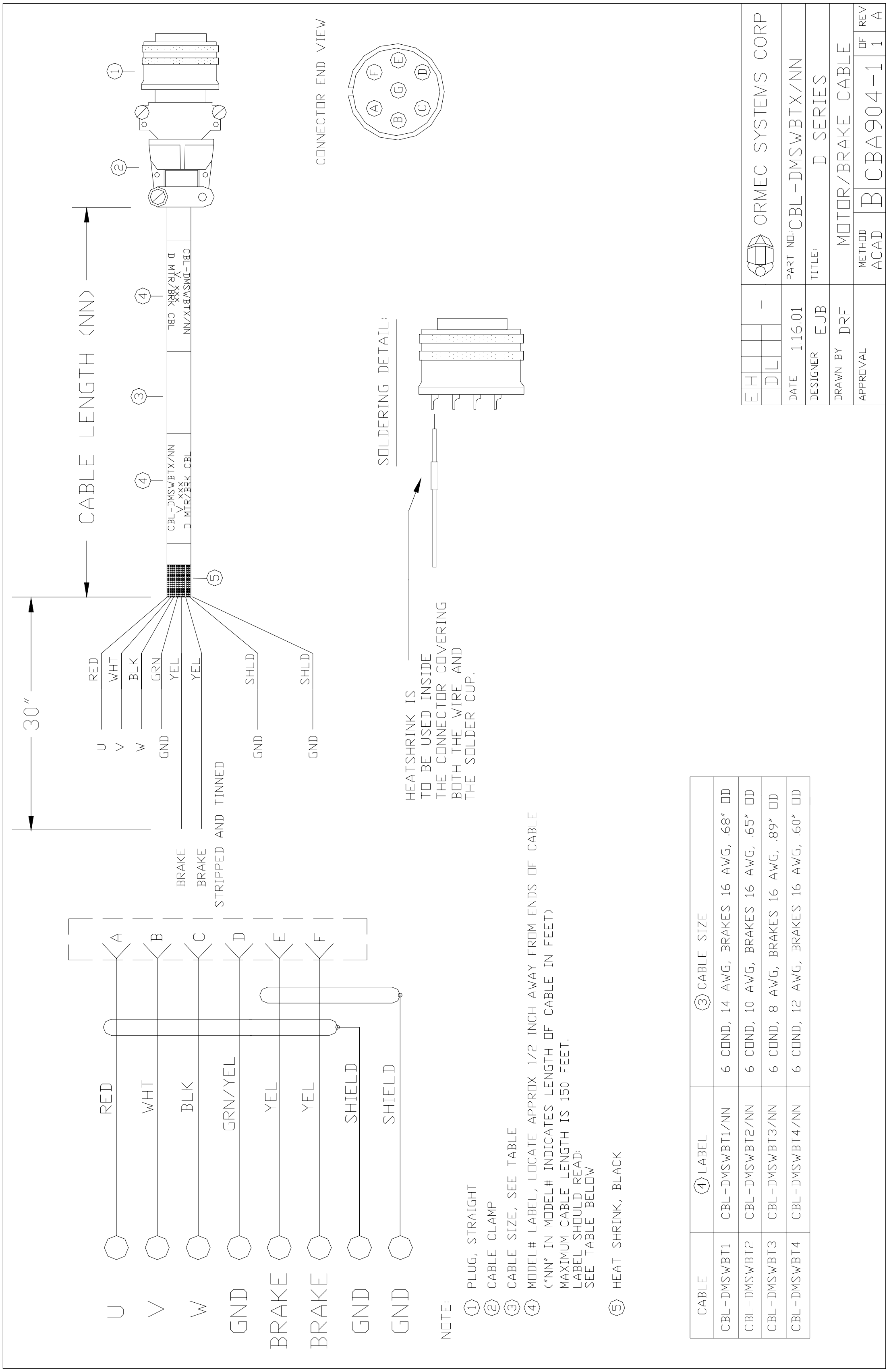
CABLE	④ LABEL	③ CABLE SIZE
CBL-DMSWT1	CBL-DMSWT1/NN	4 COND, 14 AWG, 600V, 0.42 O.D.
CBL-DMSWT2	CBL-DMSWT2/NN	4 COND, 10 AWG, 600V, 0.53 O.D.
CBL-DMSWT3	CBL-DMSWT3/NN	4 COND, 8 AWG, 600V, 0.721 O.D.
CBL-DMSWT4	CBL-DMSWT4/NN	4 COND, 12 AWG, 600V, 0.46 O.D.
CBL-DMSWT5	CBL-DMSWT5/NN	4 COND, 6 AWG, 600V, 0.920 O.D. *
CBL-DMSWT6	CBL-DMSWT6/NN	4 COND, 4 AWG, 600V, 1.120 O.D. *

* TIN THE WIRES OF THESE CABLES

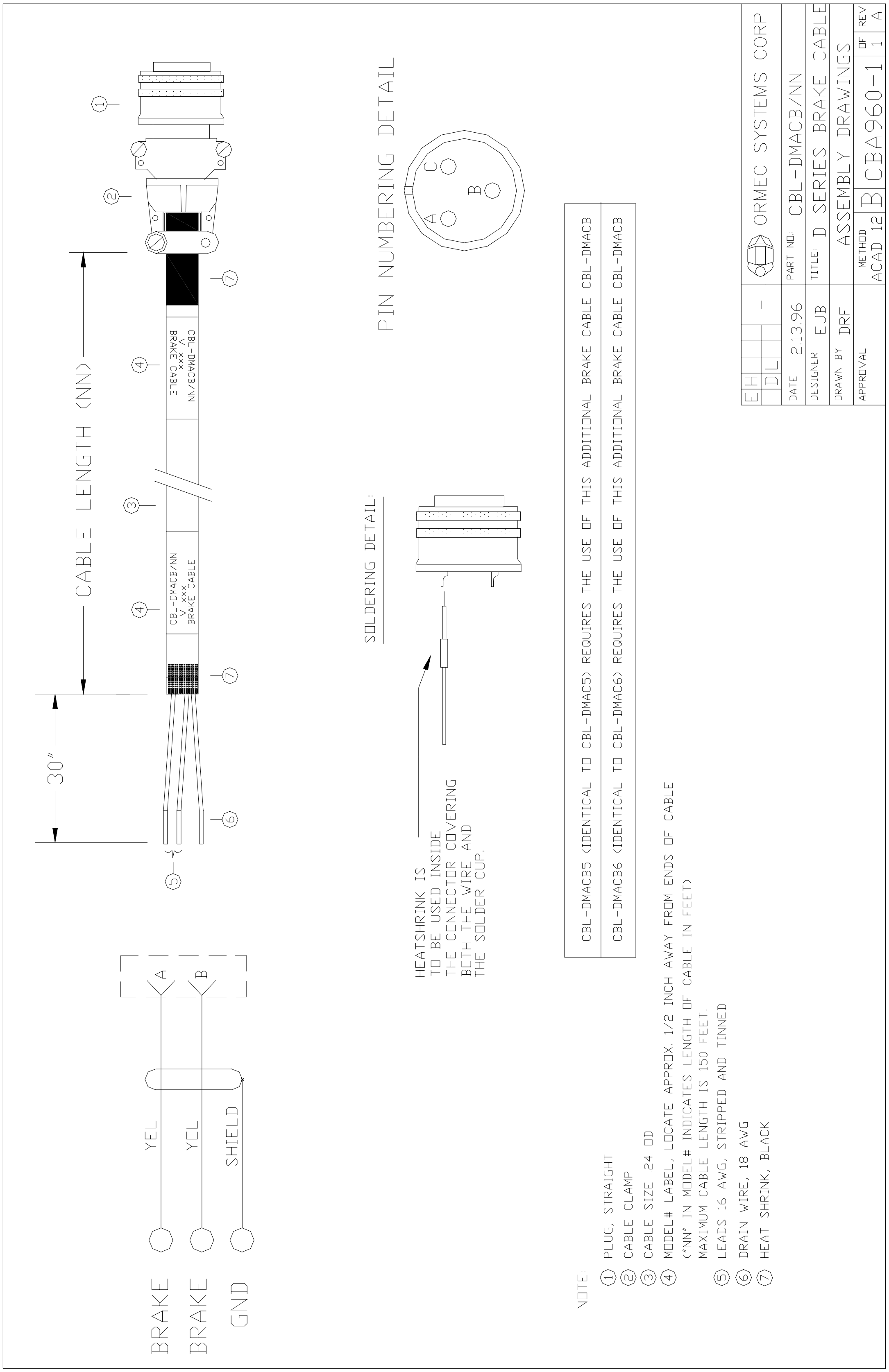
Appendix F - CBL-DMSWBn Motor / Brake Cable



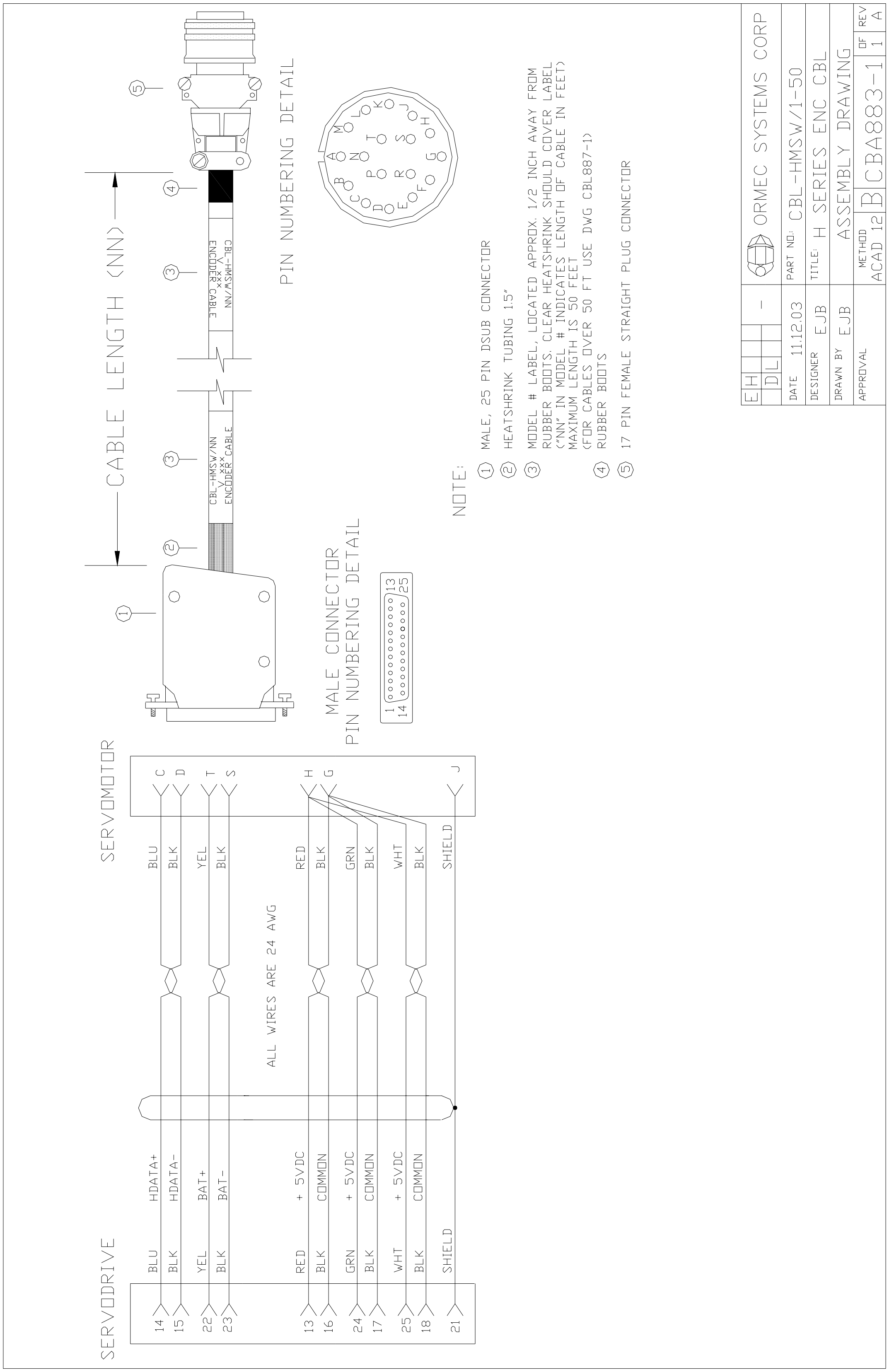
Appendix F - CBL-DMSWBTn Motor / Brake Cable



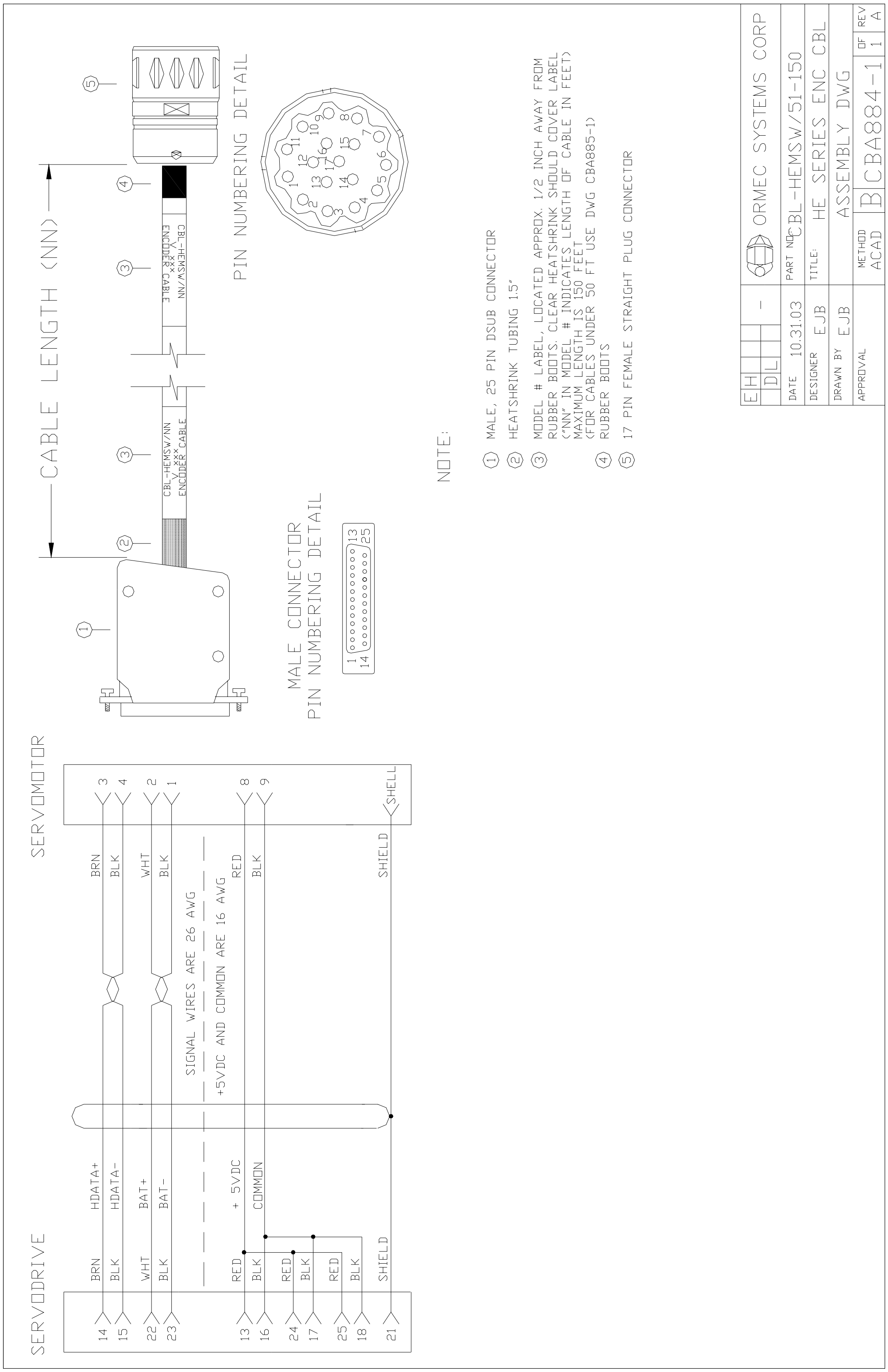
Appendix F - CBL-DMACB Brake Cable



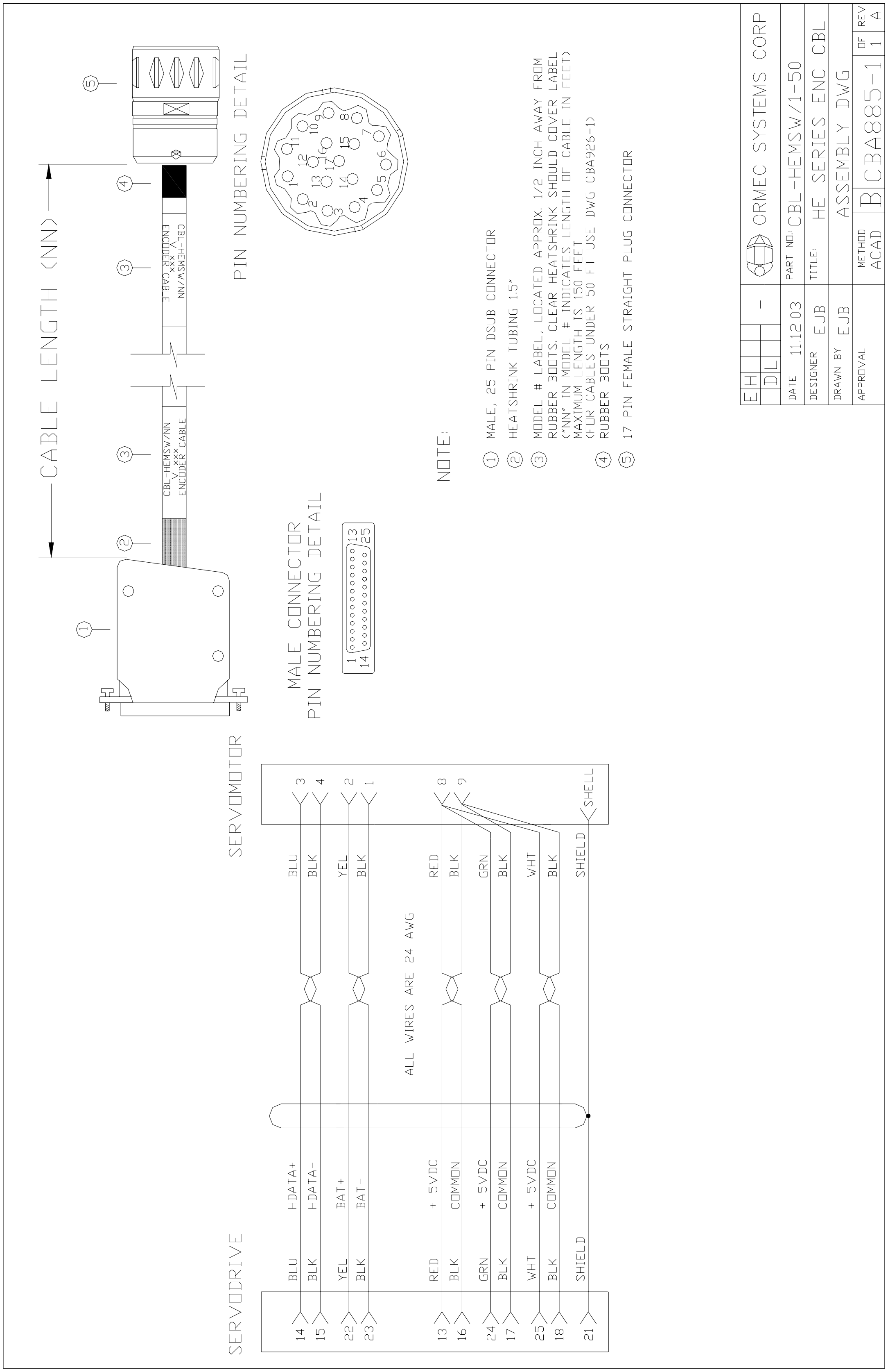
Appendix G - CBL-HMSW Encoder Cable



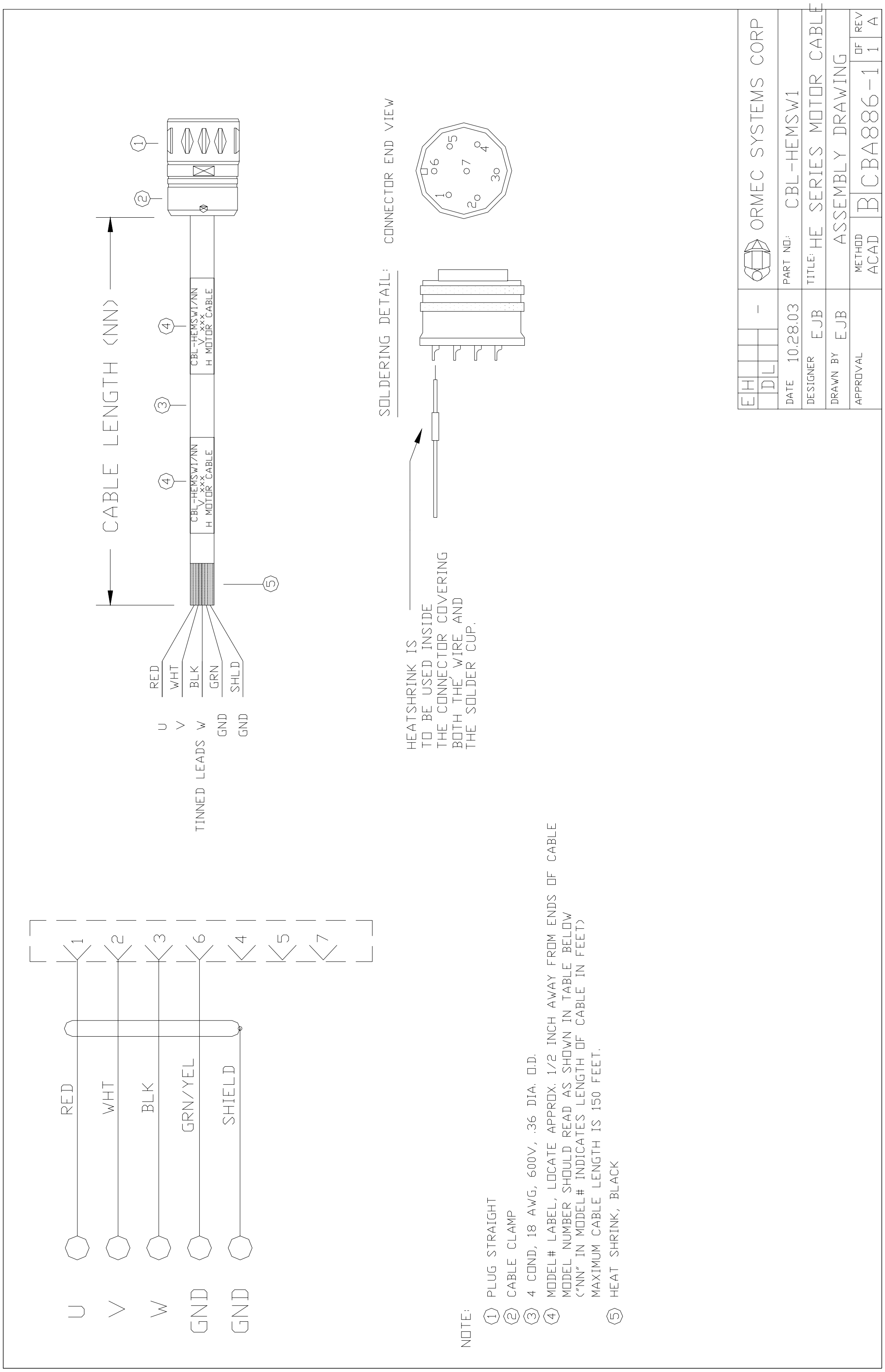
Appendix G - CBL-HEMSW Encoder Cable



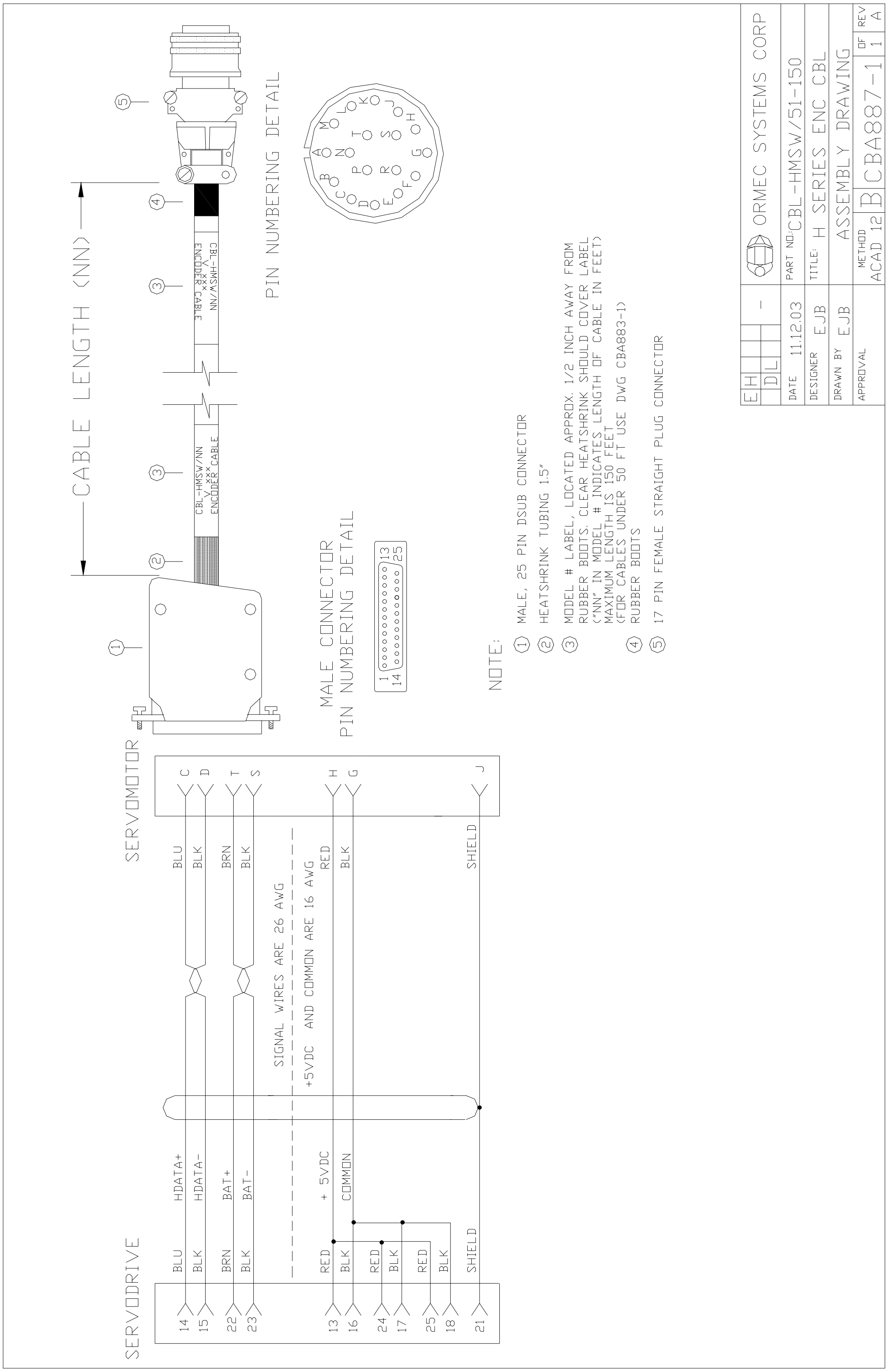
Appendix G - CBL-HEMSW Encoder Cable



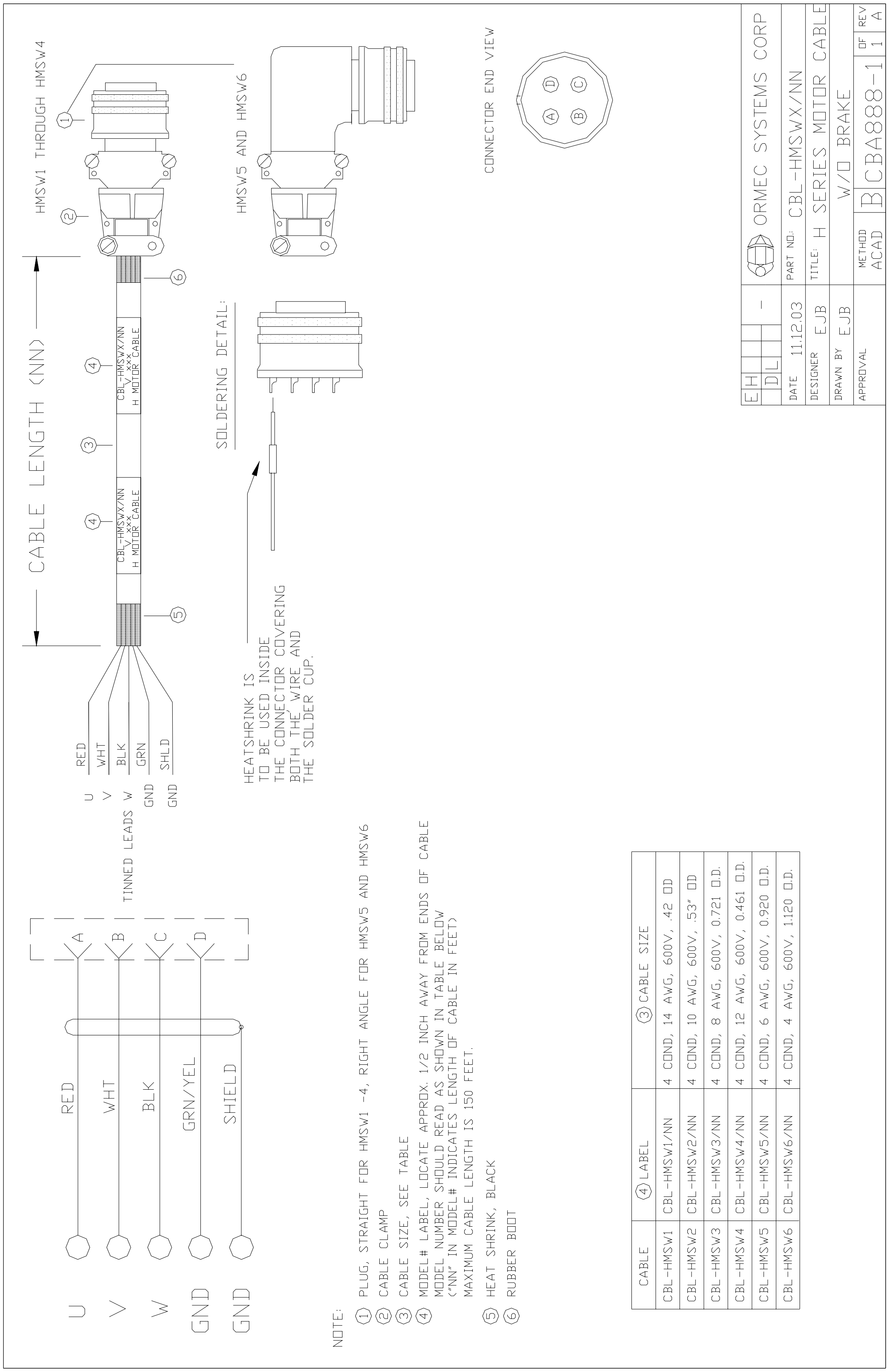
Appendix G - CBL-HEMSW1 Motor Cable



Appendix G - CBL-HMSW Encoder Cable



Appendix G - CBL-HMSWn Motor Cable



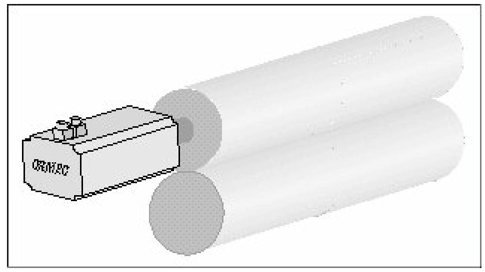
CABLE	④ LABEL	③ CABLE SIZE
CBL-HMSW1	CBL-HMSW1/NN	4 COND, 14 AWG, 600V, .42 OD
CBL-HMSW2	CBL-HMSW2/NN	4 COND, 10 AWG, 600V, .53" OD
CBL-HMSW3	CBL-HMSW3/NN	4 COND, 8 AWG, 600V, 0.721 O.D.
CBL-HMSW4	CBL-HMSW4/NN	4 COND, 12 AWG, 600V, 0.461 O.D.
CBL-HMSW5	CBL-HMSW5/NN	4 COND, 6 AWG, 600V, 0.920 O.D.
CBL-HMSW6	CBL-HMSW6/NN	4 COND, 4 AWG, 600V, 1.120 O.D.

Appendix H - Coupling High Performance Servos to Mechanical Loads

Application Note by Mick Oakley, Principle Applications Engineer, ORMEC Systems Corp.

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:

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

Shaft Stiffness:

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

Natural Frequency:

$f = \frac{1}{2\pi}\sqrt{S\frac{(J_M + J_L)}{(J_M \cdot J_L)}} Hz$	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 $72x10^3$ in-lb/rad. If we use this coupling on the load system described earlier, it will limit the system natural frequency to less than 197 Hz. Clearly this type of coupling would not be adequate. So instead, if we take a similarly rated bellows coupling[1], its stiffness will be $433x10^3$ in-lb/rad. This coupling would have a natural frequency of 480 Hz, which is much less likely to affect operation.

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

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

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

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

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

1. The filter will only work if the mechanism does not undergo significant changes overtime. As mechanisms wear or heat up, their natural frequencies can change. The natural frequency will also change as the load inertia changes. A once stable system may become unstable if the natural frequency shifts enough that the notch filter no longer cancels it out.
2. Many resonant loads have several natural frequencies. If you design a notch filter with a wide enough notch to cover all of the natural frequencies, you may end up with what is effectively a low pass filter which will reduce servo response considerably.

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

Timing Belts

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

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

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

Calculations to determine natural frequency of a timing belt system:

$M_1 = \frac{J_1}{R_1^2}, M_2 = \frac{J_2}{R_2^2}$	**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).
$S = \frac{EA \cdot width}{span}$	**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).
$F = \frac{1}{2\pi}\sqrt{S\frac{(M_1 + M_2)}{(M_1 \cdot M_2)}}Hz$	**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.
