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Danaher Motion Pacific Scientific

Programmable Brushless Servocontroller

SC450 Installation & Hardware Reference Manual

Document Number: 04500102
Rev C
List Price: $30 US

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Record of Manual Revisions

ISSUE NO.	DATE	BRIEF DESCRIPTION OF REVISION
C	11/27/02	Updated contact information

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1. INTRODUCTION

The Danaher Motion Pacific Scientific SC450 Series Servocontrollers are designed to operate Danaher Motion Pacific Scientific brushless servomotors or other 3-phase, permanent magnetic (PM) brushless servomotors. Each controller is an independent, stand-alone unit capable of four quadrant control of a single PM brushless servomotor. There are three models in the series:

- The SC451 with peak power output capability of 1000 Watts
- The SC452 with peak power output capability of 2000 Watts
- The SC453 with peak power output capability of 4500 Watts

All models are functionally equivalent, however the SC453 is 1.7 inches wider and has some minor differences in wiring and location.

1.1. Features

- **Micro-processor based design** — provides added reliability and flexability.
- **Danaher Motion Pacific Scientific's ServoBASIC** — combines the ease of BASIC language programming in conjunction with sophisticated motion control features.
- **Non-volatile memory** — provides storage of parameters and motion profiles.
- **RS-232 or RS-485 serial communications port** —provided for programming and host controllers. A range of programmable discrete I/O are also provided.
- **Resolver control** — requires only a single resolver mounted on the motor for complete feedback information for motor commutation and for all digital velocity and position servo feedback signals.
- **Proprietary circuitry** — uses a proprietary integrated circuit for motor commutation and drive protection.
- Transformerless direct 115/230 VAC line operation
- **Magnetically/optically isolated output stage** — improves reliability and reduces crosstalk and ground loop disturbances.
- **Watchdog timer circuit** — monitors microprocessor operation.
- **Electronic gearing** — allows you to control the movement of the motor shaft with an external encoder.

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1.2. Options

Standard motor power and feedback cables.

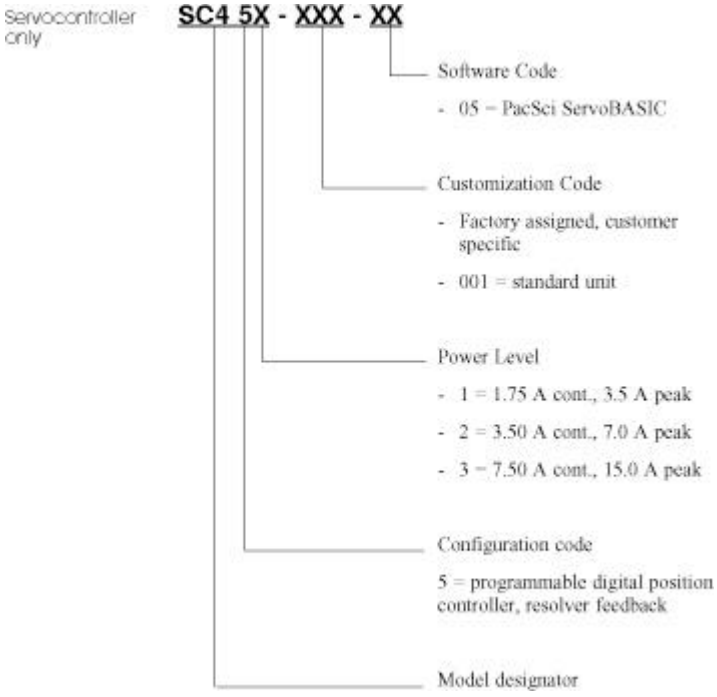
1.3. Typical Applications

Typical applications for SC450 servocontrollers include:

- Labelling machines
- X-Y tables
- Machine tools
- Packaging machinery
- Microcircuit wafer spinners
- Robotics

1.4. Ordering Information

1.4.1. Ordering Servocontroller

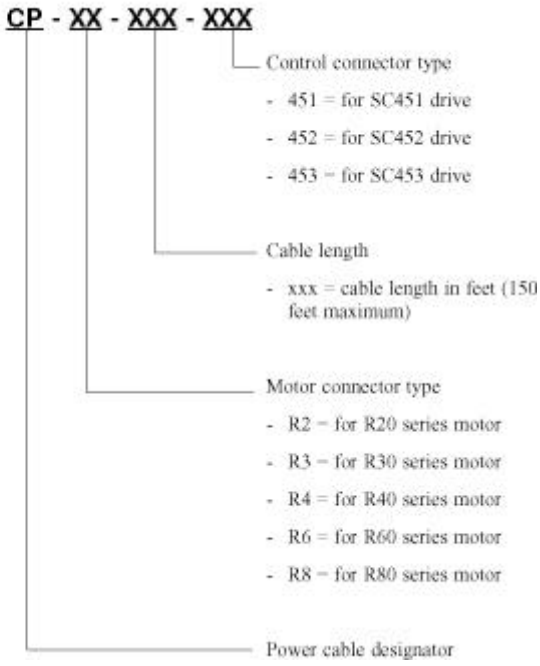


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1.4.2. Ordering Cables

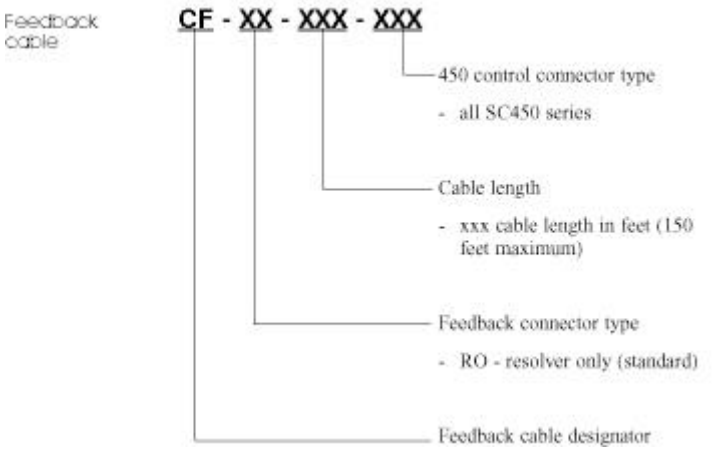
Cable order codes

Each system requires one power cable and one feedback cable.



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1.4.3. Ordering Feedback



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2. INSTALLATION

This section covers how to install the SC450 series unit.

2.1. Unpacking and Inspecting

1. Remove the SC450 series controller from the shipping carton. Make sure all packing materials are removed from the unit.
2. Check the items against the packing list. A label located on the side of the unit identifies the unit by model number, serial number and date code.

Inspect the unit for any physical damage that may have been sustained during shipment.

If you find damage, either concealed or obvious, contact your buyer to make a claim with the shipper. Do this **within 10 days of receipt of the unit**.

After inspection, store the controller in a clean, dry place. The storage temperature must be between -25 and 85 °C. To prevent damage during storage, replace the unit in the original shipping carton.

2.2. Installation and Use

As the user or person installing and using this unit, you are responsible for determining the suitability of this product for any application you intend. In no event will Danaher Motion Pacific Scientific be held responsible or liable for indirect or consequential damage resulting from the use of this product.



Read this manual completely to effectively and safely operate the SC450 series unit.

2.2.1. Safety

Voltage levels within this controller can exceed 400 VDC and/or 230 VAC.



The circuits in the SC450 series controller are a potential source of severe electrical shock. Follow the safety guidelines to avoid shock.

To avoid possible personal injury whenyou are working with the SC450 series controller:

- Do not power up the controller without the cover on and the chassis tied to earth ground.
- Do not operate the controller without the motor case tied to earth ground.
- Do not make any connections to internal circuitry.
- Do not connect or disconnect the motor with power applied to the unit. Always remove power before making any connections to the unit.
- Before removing the cover of the unit, shut off power and allow the unit to sit for five (5) minutes to discharge the internal voltages.

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- Be careful of the motor terminals of the drive when disconnected from the motor. With the motor disconnected and power applied to the controller, the motor terminals of the drive have high voltage present.
- Do not use the enable input as a safety shutdown. Always remove power to the controller for a safety shutdown.

2.3. Selecting Other System Components

Match your SC450 series unit to your other components:

- The SC450 series unit requires a variable + 5 to + 12 VDC external analog signal capable of driving the servocontroller 50 kW input impedance for velocity command control. Choose a source such as a PLC, the DAC of a computer or a motion controller.
- The SC450 series unit is designed for use with Danaher Motion Pacific Scientific's line of brushless servo motors including the R (rare earth) and F (ferrite) series motors. Refer either to the Danaher Motion product catalog or contact Danaher Motion Customer Support (815-226-2222) for system torque-speed curve information.

2.4. Mounting

Select a standard deep NEMA (National Electrical Manufacturer's Association) cabinet appropriate for industrial applications.

The SC450 series servocontrollers require a 12 inch (30.5 cm) deep cabinet.

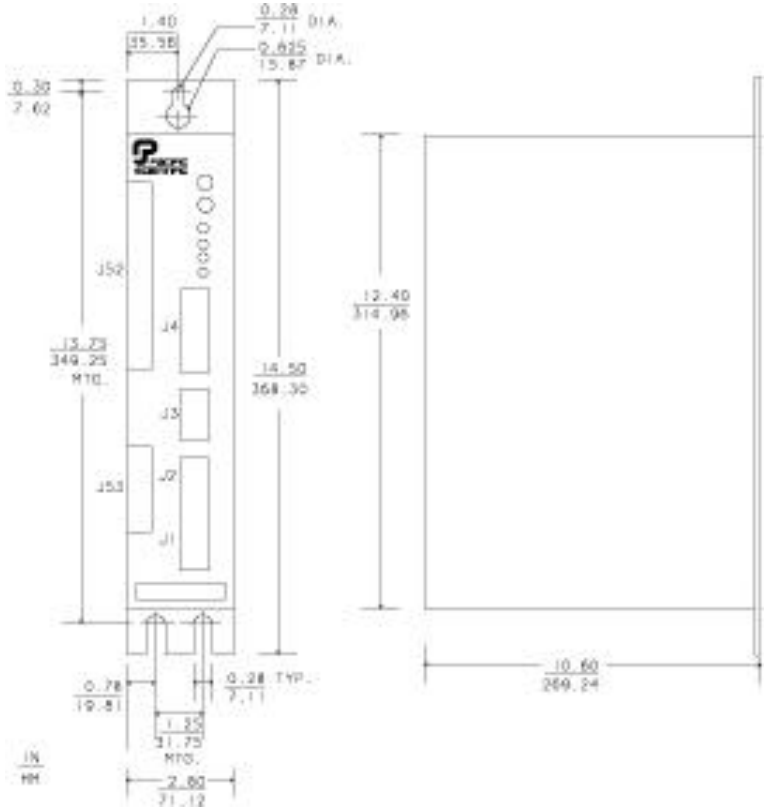


If the cabinet is ventilated, use filtered or conditioned air to prevent the accumulation of dust and dirt on the electronic components. The air should also be free of corrosive or electrically conductive contaminants.

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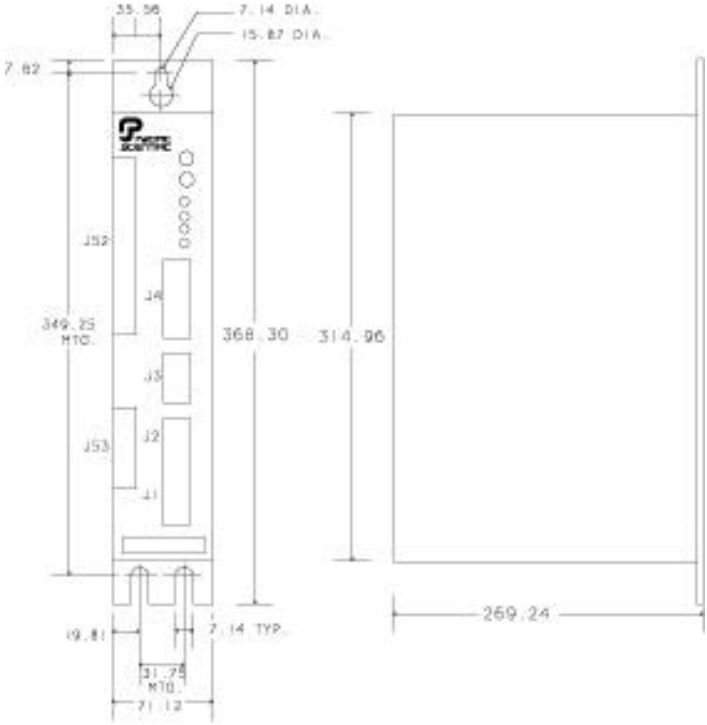
2.4.1. Outline Dimensions

2.4.1.1. SC451/452 (IN INCHES)



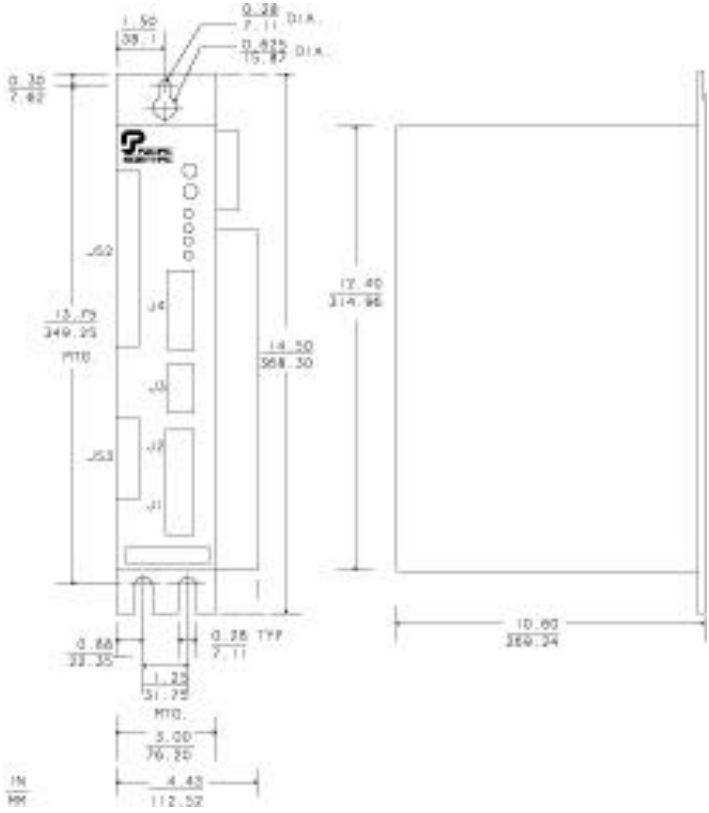
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2.4.1.2. SC451/452 (IN MILLIMETERS)



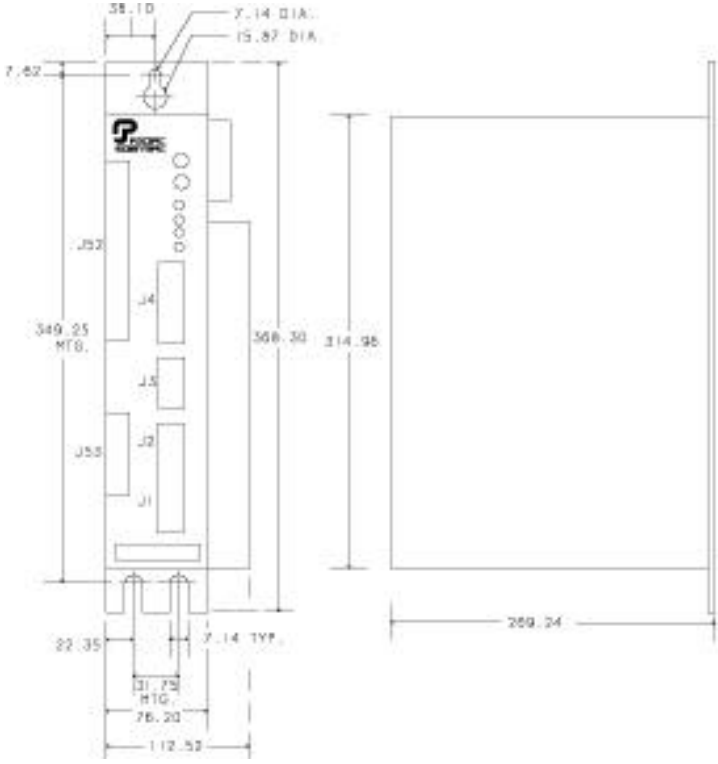
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2.4.1.3. SC453 (IN INCHES)



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2.4.1.4. SC453 (IN MILLIMETERS)



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2.4.2. Guidelines

The SC450 series controller is designed for installation in a cabinet. Your installation should meet the following guidelines:

- Vertical orientation for the controller
- Flat, solid surface capable of supporting the approximate weight of the units as follows:
  SC451 - 6 lbs (2.7 kg)
  SC452 - 6 lbs (2.7 kg)
  SC453 - 11 lbs (5.0 kg)



An optional safety cover is available to provide added protection for the controller.

- Free of excessive vibration or shock.
- Minimum unobstructed space of 4 inches (10 cm) above and below the controller and 1 inch (2.5 cm) on either side.
- Operating temperature of:
  0 to 50 °C at full rated output current.
  0 to 60 °C at 70% full rated output current. Derate linearly from 100% to 70% of full rating at 60 °C.

Bolt the unit to the cabinet using the mounting slots (refer to dimensions figure) with 1/4-20 (M6 metric equivalent) or # 10 bolts.

2.5. I/O Definitions

The eight input/output connectors are:

J1 - Power
J2 - Motor
J3 - Command I/O
J4 - Monitor
J52 - Discrete I/O
J53 - Encoder interface
J54 - Resolver
J55 - Serial link



For further information on connector cabling, see Connection Diagrams.

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2.5.1. Inputs/Outputs

The table below provides a summary of the connectors.

Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J1 Connector [Power] - SC452		
J1-1,2	230 VAC Line 3	These are the three power input lines. No special phasing is necessary. For single phase 115/230 VAC operation, use lines 1 and 2. For 3-phase 230 VAC operation, use all three input lines.
J1-4,5	115/230 VAC Line 2	
J1-7,8	115/230 VAC Line 1	
J1-3,6,9	N/C	These terminals are not used but are provided for voltage isolation between the AC lines.
J1-10	Chassis Ground	This terminal is provided as the safety grounding point for the controller and must be connected to earth ground to prevent shock hazard.
J1 Connector [Power] - SC453		
J1-1	230 VAC Line	These are the three power input lines. No special phasing is necessary. For single phase 115/230 VAC operation, use lines 1 and 2. For 3-phase 230 VAC operation, use all three input lines.
J1-2	115/230 VAC Line	
J1-3	115/230 VAC Line	
J1-4	Chassis Ground	This terminal is provided as the safety grounding point for the controller and must be connected to earth ground to prevent shock hazard.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J2 Connector [Motor] - SC452		
J2-1,2	Motor phase R	These terminals are the controller output phases R, S and T. Proper phasing of these outputs relative to the motor terminals is important. Double check these connections when wiring the motor.
J2-4,5	Motor phase S	
J2-7,8	Motor phase T	
J2-3,6,9	N/C	These terminals are not used but are provided for voltage isolation between the motor output phases.
J2-10	Motor Ground	This terminal must be connected to the ground lead on the cable coming from the motor.
J2 Connector [Motor] - SC453		
J2-1	Motor phase R	These terminals are the controller output phases R, S and T. Proper phasing of these outputs relative to the motor terminals is important.
J2-2	Motor phase S	
J2-3	Motor phase T	
J2-4	Motor Ground	This terminal must be connected to the ground lead on the cable coming from the motor.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J3 Connector [Command I/O]		
J3-1,2,4,5	N/C	These terminals are not used.
J3-3,7	Common	This is the controller common point and is at the same potential as 12 VDC RTN.
J3-6	Fault Out	This terminal is an open collector output. The output is pulled low if there is power applied to the controller and no faults are present. The output is rated at 25 mA sink. 30 VDC maximum.
J3-8	Motor Current Monitor	This terminal puts out a + 4.4 V full scale DC signal which is proportional to the amplitude of the constant portion of the controller's 6-step output current. The scale factor of this output is 1.26 V/A for the Model SC451, 0.63 V/A for the Model SC452, and 0.32 V/A for the Model SC453. This output has a 1 KΩ output impedance and should have a load impedance of 20 KΩ or greater.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J4 Connector [Monitor]		
J4-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14	Reserved	These terminals are not used in this controller configuration.
J4-13	Common	Reference for + 12 VDC.
J4-15	Tach Monitor	This terminal puts out a DC voltage that is proportional to the motor speed. The scale factor for this output is 0.56 V/Krpm. This output has a 1 KΩ output impedance and should have a load impedance of 20 KΩ or greater.
J52 Connector [Discrete I/O]		
J52-1, 49	I/0 +5 VDC	These two pins provide +5 VDC power for use in interfacing to the Discrete I/O. The maximum allowable load on this pin plus pin J55-14 is 50 mA. There is a 30 Ω resistor in series with these outputs
J52-all even pins	I/O RTN	All the even numbered pins on the J52 connector are return pins for use in interfacing to the Discrete I/O.
J52-3, 5, 7, 9, 13	N/C	These pins are not used
J52-11	I/O +12 VDC	This pin provides +12 VDC power for use in interfacing to the Discrete I/O. The maximum allowable load on this pin is 10 mA. There is a 160 Ω resistor in series with this output.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J52 Connector [Discrete I/O] (*Continued)*		
J52-15	Stop when PREDEF.INP=1 Input 8 when PREDEF.INP=0	When this pin is connected to I/O RTN (any even pin on J52) the program will stop executing. Any motion in progress will be stopped immediately. RMT.START = 1 Program starts executing as if RUN<return> has been typed. RMT.START = 0 GO.FUNC = 0, GO.VEL is executed. GO.FUNC = 1, GO.INCR is executed. GO.FUNC = 2, GO.ABS is executed. **This pin is only active in IMMEDIATE mode. When a program is running, this pin is treated as a programmable input pin.**
J52-17	Start when PREDEF.INP=1 Input 7 when PREDEF.INP=0	When this pin is connected to I/O RTN (any even pin on J52) the REMOTE START input is activated. This can cause one of five things to occur depending upon the current state of the variable RMT.START and GO.FUNC.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J52 Connector [Discrete I/O] (*Continued*)		
J52-19	Jog when PREDEF.INP=1 Input 6 when PREDEF.INP=0	When this pin is connected to I/O RTN (any even pin on J52) the motor will start turning counter-clockwise at the speed determined by the variable JOG.SPEED. The jog function does not operate when a program is running. This input is overridden by the Jog + input. When a program is executing, this pin can be used as a general purpose input.
J52-21	Jog + when PREDEF.INP=1 Input 5 when PREDEF.INP=0	When this pin is connected to I/O RTN (any even pin on J52) the motor will start turning clockwise at the speed determined by the variable JOG.SPEED. The jog function does not operate when a program is running. This input overrides the Jog - input. When a program is executing, this pin can be used as a general purpose input.
J52-23	Fault when PREDEF.INP=1 Input 8 when PREDEF.INP=0	This pin is an open collector, programmable output pin. This output is turned OFF whenever the controller has encountered a fault. The variable, FAULTCODE, tells you what fault has occurred. The controller must be turned off to clear a fault.
J52-25	Motor moving when PREDEF.INP=1 Output 7 when PREDEF.INP=0	This pin is an open collector, programmable output pin. This output is turned OFF whenever the motor shaft is turning faster than 5 rpm. Otherwise, this output is turned ON. For information on how to connect to open-collector outputs, refer to J52 Discrete I/O.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J52 Connector [Discrete I/O] (*Continued*)		
J52-27	Output 6	This pin is an open collector, programmable output pin. To turn this output ON, set the variable OUT6 to 0. To turn this output OFF, set the variable OUT6 to 1. For information on how to connect to open collector outputs, refer to J52 Discrete I/O.
J52-29	Output 5	This pin is an open collector, programmable output pin. To turn this output ON, set the variable OUT5 to 0. To turn this output OFF, set the variable OUT5 to 1. For information on how to connect to open collector outputs, refer to J52 Discrete I/O.
J52-31	Output 4	This pin is an open collector, programmable output pin. To turn this output ON, set the variable OUT4 to 0. To turn this output OFF, set the variable OUT4 to 1. For information on how to connect to open collector outputs, refer to J52 Discrete I/O.
J52-33	Output 3	This pin is an open collector, programmable output pin. To turn this output ON, set the variable OUT3 to 0. To turn this output OFF, set the variable OUT3 to 1. For information on how to connect to open collector outputs, refer to J52 Discrete I/O.
J52-35	Output 2	This pin is an open collector, programmable output pin. To turn this output ON, set the variable OUT2 to 0. To turn this output OFF, set the variable OUT2 to 1. For information on how to connect to open collector outputs, refer to J52 Discrete I/O.
J52-37	Output 1	This pin is an open collector, programmable output pin. To turn this output ON, set the variable OUT1 to 0. To turn this output OFF, set the variable OUT1 to 1. For information on how to connect outputs, refer to J52 Discrete I/O.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J52 Connector [Discrete I/O] (*Continued*)		
J52-39	Input 4	This pin is a programmable input pin that can be used within your Danaher Motion Pacific Scientific ServoBASIC program. The state of this input is shown by the variable INP4. If this input pin is connected to I/O RTN (any even pin on J52), INP4 = 0. If this input pin is not connected, INP4 = 1.
J52-41	Input 3	This pin is a programmable input pin that can be used within your ServoBASIC program. The state of this input is shown by INP3. If this input pin is connected to I/O RTN (any even pin on J52) then INP3 = 0. If this input pin is not connected, then INP3 = 1.
J52-43	Input 2	This pin is a programmable input pin that can be used within a ServoBASIC program. The state of this input is shown by INP2. If this pin is connected to I/O RTN (any even pin on J52), INP2 = 0. If not connected, INP2 = 1.
J52-45	Mechanical home switch (Input 1)	This input pin is used when the SEEK.HOME function is called. It is used to establish the home position for the system. This pin can also be used as a general purpose programmable input.
J52-47	Enable	This input must be connected to I/O RTN (any even pin on J52) to enable the controller. If this input is disconnected, no current flows to the motor.
J52-49	I/O +5 VDC	This input provide s+5 VDC power for use in interfacing to the Discrete I/O. The maximum allowable load on this pin plus pin J55-14 is 50 mA. There is a 30 Ω resistor in series.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J53 Connector [Encoder Interface]		
J53-1, 4, 7, 10, 11, 14, 17	Common	These seven pins are signal common.
J53-2	Ref A	These two pins are differential input ports for the electronic gearing encoder.
J53-3	/Ref A	
J53-5	Ref B	These two pins provide differential input ports for the electronic gearing encoder.
J53-6	/Ref B	
J53-8, 9, 12, 13, 15, 16, 18, 19, 20	N/A	These terminals are not used.
J54 Connector [Resolver Interface]		
J54-1	Resolver S1 (+Sin)	These two differential input pins accept the Sine output from the motor resolver feedback transducer
J54-2	Resolver S3 (-Sin)	
J54-3	Resolver S2 (+Cos)	These two differential input pins accept the cosine output from the motor resolver feedback transducer.
J54-4	Resolver S4 (-Cos)	
J54-5	Shield	This pin is the connection point for the shields for the resolver cables.
J54-6	Resolver R1 (+Excit)	These pins are outputs for the excitation to the resolver feedback transducer.
J54-7	Resolver R2 (-Excit)	
J54-8	Ref Z	These two pins are the encoder mark pulse input signals.
J54-9	/Ref Z	
J54-10	Motor PTC	These two terminals provide an interface for a motor mounted positive temperature coefficient thermistor (PTC). The PTC acts as thermal overload protection for the motor. These inputs must be connected to each other with a jumper if a PTC is not used.
J54-11	Motor PTC RTN	
J54-12	N/A	This terminal is not used.

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Summary of I/O Definitions and Pinouts		
Pin Number	**I/O Signal Name**	**Explanation**
J55 Connector [Serial Link]		
J55-1	Shield +5 VDC RTN	This pin is the connection point for the RS-232 cable shield. It also serves as a +5 VDC return point.
J55-2	RXD 232	This pin is the RS-232 serial port receive point.
J55-3	TXD 232	This pin is the RS-232 serial port transmission point.
J55-7	Common	This pin is the signal common for the RS-232 serial port.
J55-14	+5 VDC	This pin is a +5 VDC supply point. The pin puts out +5 VDC. The maximum allowable load on this pin is 500 mA
J55-22	-RXD 485	These pins are for the RS-485 serial port differential input.
J55-23	+RXD 485	
J55-24	-TXD 485	These pins are for the RS-485 serial port differential output.
J55-25	+TXD 485	
J55-4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21	N/A	These pins are not used.

2.6. Controller Wiring

The figure on the following page is an SC450 connection diagram. The information in this manual represents common servocontroller wiring practice which should prove satisfactory for many applications. However, because of the variety of applications served by this controller, no single method of controller connection applies to all situations.

Wiring, wire sizes and grounding and shielding instructions in this manual are intended as guidelines.



Local electrical codes, special operating conditions or system configurations should take precedence over the information in the manual. If you have any problems or questions, please contact your local Danaher Motion distributor.

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2.6.1. Noise

Because of the switching nature of PWM controllers, care should be exercised in routing power and signal wiring in the system. Noise radiated from nearby electrical or electronic equipment may cause undesired servomotor movement due to pickup by the controller's signal inputs. The controller's power outputs can also generate noise which could be picked up by the controller's signal inputs or by other electronic equipment where lines run near the controller's output wiring.

To reduce the possibility of noise pickup, power and signal lines should be twisted, shielded and routed separately by running in separate conduits or spacing at least 12 inches apart.

2.6.2. Grounding

To minimize shock hazards to personnel and damage to equipment, all components of the servo system should have their chassis connected to a common earth ground point. Please follow local electrical codes regarding the requirements for grounding of electronic equipment.

2.6.3. Wiring and Tools

2.6.3.1. J1 AND J2 CONNECTORS

18 AWG wire and Panduit hand insertion tool MRT-156F or Panduit automatic tool MCT with CTD-156 head should be used for making the following connections:

- An earth ground point and the controller chassis ground terminal (J1-10)
- An earth ground point and the input transformer ground stud, if applicable
- The motor wiring and AC input wiring (J1 and J2 on SC451/SC452)



The SC453 uses screw terminal connectors for J1 and J2 and does not require the insertion tool.

2.6.3.2. J3 AND J4 CONNECTORS

22 AWG wire and Panduit hand insertion tool MRT-100F or Panduit automatic tool MCT with CTD-100F head should be used for controller signal connections made to plug-in connectors J3 and J4.



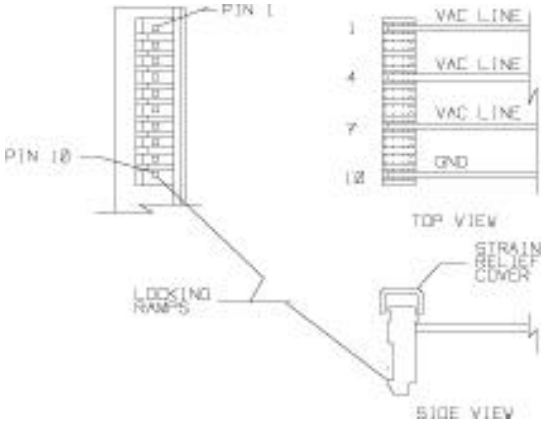
Refer to Connection Diagrams for detailed information on connectors and wiring.

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2.7. Connection Diagrams

2.7.1. J1 AC Power - SC451, SC452

2.7.1.1. MATING CONNECTOR DIAGRAM



Mating Connector	Panduit CE156F18-10 (supplied)
Mating Connector Strain Relief Cap	Panduit MSCC156F10 (supplied)
Connector Assembly Tool	Panduit MRT-156F (Recommended for prototype only) Panduit MCT with CTD-156F Panduit PPHT-156F with PPHT-156FE
Wire Specification	
Gage	18 AWG
Insulation OD	0.04" to 0.09"
Types	
PVC	UL Style 1061 or 1095 (7, 10, 16 or 19 strand) MIL-W-16878 (7, 16, or 19 strand)
Teflon (0.01" or less insulation thickness)	MIL-W-16878E/48, Type G MIL-W-16878E, Type E MIL-W-16878E/6, Type ET MIL-W-16878, Type KT (7 or 19 strand) MIL-W-16878, Type K (7 or 19 strand)

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2.7.1.2. CONNECTOR PINOUT

Pin Number	Signal Name
J1-1	230 VAC Line
J1-2	230 VAC Line
J1-3	Not used
J1-4	115/230 VAC Line
J1-5	115/230 VAC Line
J1-6	Not used
J1-7	115/230 VAC Line 3
J1-8	115/230 VAC Line 3
J1-9	Not used
J1-10	Chassis Ground

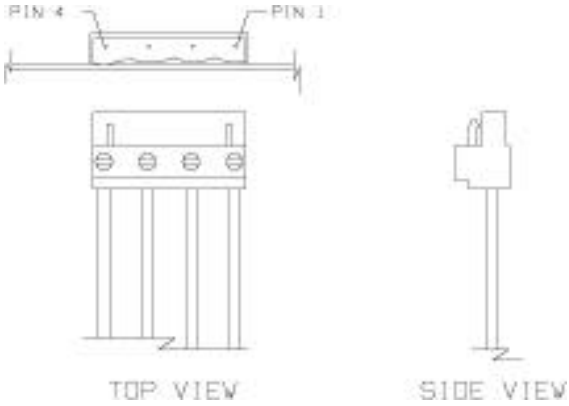
For a reliable quality connection:

1. Use correct assembly tool and follow instructions supplied with tool.
2. Use correct wire gage and wire type.
3. Use strain relief cap.

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2.7.2. J1 AC Power - SC453

2.7.2.1. Mating Connector Diagram



Mating Connector	Phoenix Type GMSTB1, 5/4-ST-7, 62 (supplied)
Connector Assembly Tool	Standard straight blade screwdriver
Wire Specification	
Gage	14 to 22 AWG
Type	PVC or Teflon Insulation
Insulation Strip Length	0.28"

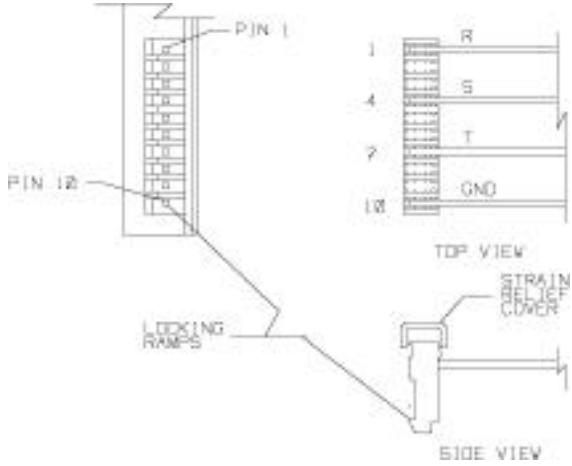
2.7.2.2. Connector Pinout

Pin Number	Signal Name
J1-1	230 VAC Line
J1-2	230/115 VAC Line
J1-3	230/115 VAC Line
J1-4	Chassis Ground

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2.7.3. J2 Motor power - SC451, SC452

2.7.3.1. MATING CONNECTOR DIAGRAM



Mating Connector	Panduit CE156F18-10 (supplied)
Mating Connector Strain Relief Cap	Panduit MSCC156F10 (supplied)
Connector Assembly Tool	Panduit MRT-156 (Recommended for Prototype only) Panduit MCT with CTD-156F Panduit PPHT-156F with PPHT-156FE
Wire Specification	
Gage	18 AWG
Insulation OD	0.04" to 0.09"
Types	
PVC	UL Style 1061 or 1095 (7, 10, 16 or 19 strand) MIL-W-16878 (7, 16 or 19 strand)
Teflon (0.01" or less insulation thickness)	MIL-W-16878E/48, Type G MIL-W-16878E, Type E MIL-W-16878E/6, Type ET MIL-W-16878, Type KT (7 or 19 strand) MIL-W-16878, TYpe K (7 or 19 strand)

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2.7.3.2. CONNECTOR PINOUT

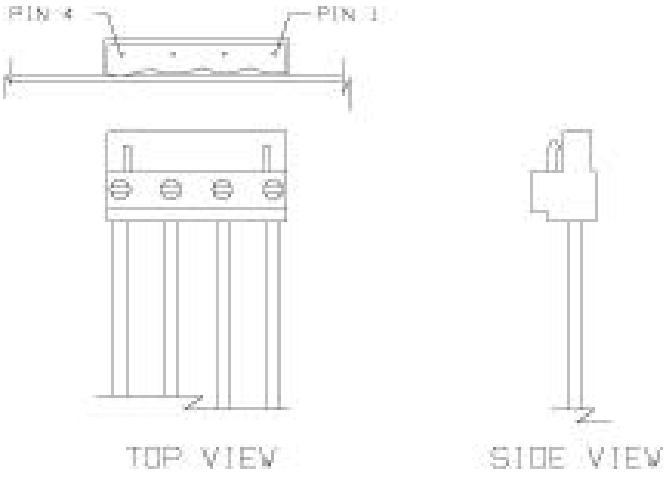
Pin Number	Signal Name
J2-1	Motor Phase R
J2-2	Motor Phase R
J2-3	Not used
J2-4	Motor Phase S
J2-5	Motor Phase S
J2-6	Not used
J2-7	Motor Phase T
J2-8	Motor Phase T
J2-9	Not used
J2-10	Motor ground

For reliable quality connection:

1. Use correct assembly tool and follow instructions supplied with tool.
2. Use correct wire gage and wire type.
3. Use strain relief cap.

2.7.4. J2 Motor power - SC453

2.7.4.1. MATING CONNECTOR DIAGRAM



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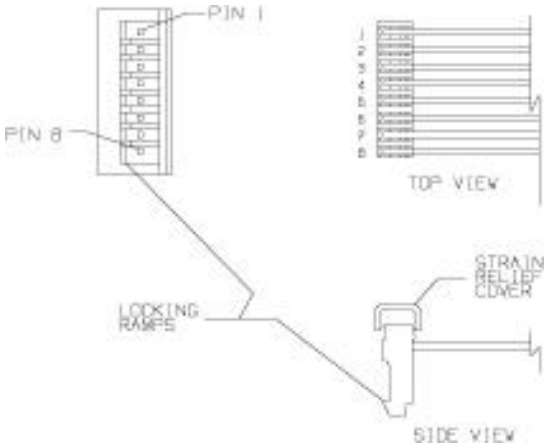
Mating Connector	Phoenix Type GMSTB1, 5/4-ST-7,62 (supplied)
Connector Assembly Tool	Standard straight blade screwdriver
Wire Specification	
Gage	14 to 22 AWG
Type	PVC or Teflon Insulation
Insulation Strip Length	0.28"

2.7.4.2. CONNECTOR PINOUT

Pin Number	Signal Name
J2-1	Motor Phase R
J2-2	Motor Phase S
J2-3	Motor Phase T
J2-4	Motor Ground

2.7.5. J3 Connector - Command I/O

2.7.5.1. MATING CONNECTOR DIAGRAM



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Mating Connector	Panduit CE100F22-8 (supplied)
Mating Connector Strain Relief Cap	Panduit MSCC100F08 (supplied)
Connector Assembly Tool	Panduit MRT-100F (Recommended for Prototype only)
	Panduit MCT with CTD-100F
	Panduit PPHT-100F with PPHT-100E
Wire Specification	
Gage	22 AWG
Insulation OD	0.03" to 0.055"
Types	
PVC	UL Style 1061 or 1095 (7, 10, 16 or 19 strand)
	MIL-W-16878 (7, 16 or 19 strand)
Teflon (0.01" or less insulation thickness)	MIL-W-16878E/48, Type G
	MIL-W-16878E, Type E
	MIL-W-16878E/6, Type ET
	MIL-W-16878, Type KT (7 or 19 strand)
	MIL-W-16878, Type K (7 or 19 strand)

2.7.5.2. CONNECTOR PINOUT

Pin Number	Signal Name
J3-1	Not used
J3-2	Not used
J3-3	Common
J3-4	Not used
J3-5	Not used
J3-6	Fault Out
J3-7	Common
J3-8	Motor Current Monitor

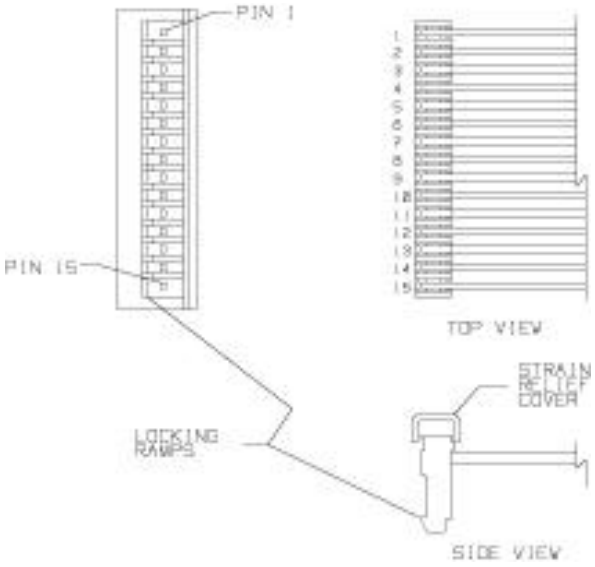
For a reliable quality connection:

1. Use correct assembly tool and follow instructions supplied with the tool.
2. Use correct wire gage and wire type.
3. Use strain relief cap.

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2.7.6. J4 Connector - Monitor

2.7.6.1. MATING CONNECTOR DIAGRAM



Mating Connector	Panduit CE100F22-15 (supplied)
Mating Connector Strain Relief Cap	Panduit MSCC100F15 (supplied)
Connector Assembly Tool	Panduit MRT-100F (Recommended for Prototype only)
	Panduit MCT with CTD-100F
	Panduit PPHT-100F with PPHT-100FE
Wire Specification	
Gage	22 AWG
Insulation OD	0.03" to 0.055"
Types	
PVC	UL Style 1061 or 1095 (7, 10, 16 or 19 strand)
	MIL-W-16878 (7, 16 or 19 strand)
Teflon (0.01" or less insulation thickness)	MIL-W-16878E/48, Type G
	MIL-W-16878E, Type E
	MIL-W-16878E/6, Type ET
	MIL-W-16878, Type KT (7 or 10 strand)
	MIL-W-16878, Type K (7 or 19 strand)

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2.7.6.2. CONNECTOR PINOUT

Pin Number	Signal Name
J4-1	Reserved
J4-2	Reserved
J4-3	Reserved
J4-4	Reserved
J4-5	Reserved
J4-6	Reserved
J4-7	Reserved
J4-8	Reserved
J4-9	Reserved
J4-10	Reserved
J4-11	Reserved
J4-12	Reserved
J4-13	Common
J4-14	Reserved
J4-15	Tachometer Monitor

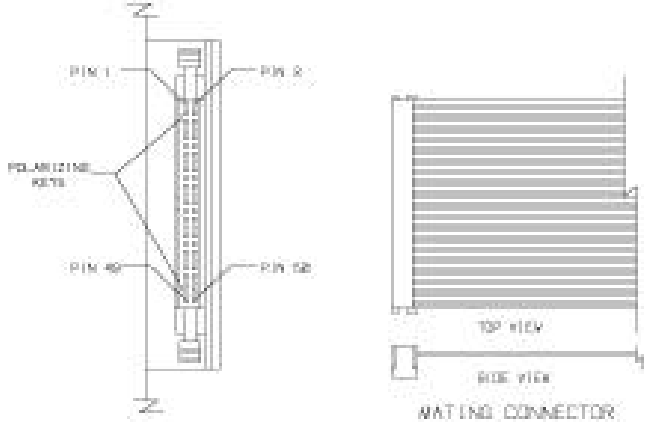
For a reliable quality connection:

1. Use correct assembly tool and follow instructions supplied with tool.
2. Use correct wire gage and wire type.
3. Use strain relief cap.

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2.7.7. J52 Discrete I/O

2.7.7.1. MATING CONNECTOR DIAGRAM



Mating Connector	3M 3425-6050 (supplied)
Connector Assembly Tool	Press and tooling, contact 3M
Wire Specification	
Gage	26 or 28 AWG
Type	
PVC	UL rated VW-1, UL Style 2651 round conductor, flat cable, 50 conductor, 0.05 center spacing, solid or stranded conductors
Examples	3M 3801/50 (26 AWG stranded) 3365 3M/50 (28 AWG stranded)

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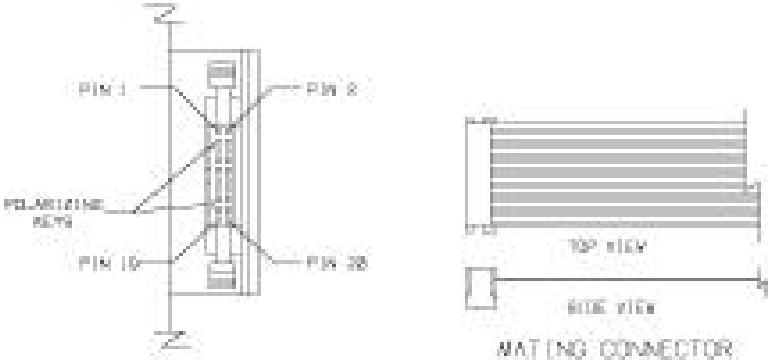
2.7.7.2. CONNECTOR PINOUT

Pin Number	Signal Name	Pin Number	Signal Name
J52-1	+5 VDC	J52-2	I/O Common
J52-3	Not used	J52-4	I/O Common
J52-5	Not used	J52-6	I/O Common
J52-7	Not used	J52-8	I/O Common
J52-9	Not used	J52-10	I/O Common
J52-11	I/O +12 VDC	J52-12	I/O Common
J52-13	Not used	J52-14	I/O Common
J52-15	Stop/Input 8	J52-16	I/O Common
J52-17	Start/Input 7	J52-18	I/O Common
J52-19	Jog -/Input 6	J52-20	I/O Common
J52-21	Jog +/Input 5	J52-22	I/O Common
J52-23	Fault/Output8	J52-24	I/O Common
J52-25	Motor Moving/ Output7	J52-26	I/O Common
J52-27	Fault/Out6	J52-28	I/O Common
J52-29	Output 5	J52-30	I/O Common
J52-31	Output 4	J52-32	I/O Common
J52-33	Output 3	J52-34	I/O Common
J52-35	Output 2	J52-36	I/O Common
J52-37	Output 1	J52-38	I/O Common
J52-39	Input 4	J52-40	I/O Common
J52-41	Input 3	J52-42	I/O Common
J52-43	Input 2	J52-44	I/O Common
J52-45	Mechanical Home Switch (Input 1)	J52-46	I/O Common
J52-47	Enable	J52-48	I/O Common
J52-49	I/O +5 VDC	J52-50	I/O Common

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2.7.8. J53 Encoder Interface

2.7.8.1. MATING CONNECTOR DIAGRAM



Mating Connector	3M 3421-6020
Connector Assembly Tool	Press and Tooling, contact 3M
Wire Specification	
Gage	26 or 28 AWG
Type	PVC, UL rated VW-1, UL style 2651, round conductor flat cable, 20 conductor, 0.05 center spacing, solid or stranded conductors
Examples	3M 3801/20 (26 AWG stranded) 3M 3365/20 (28 AWG stranded)

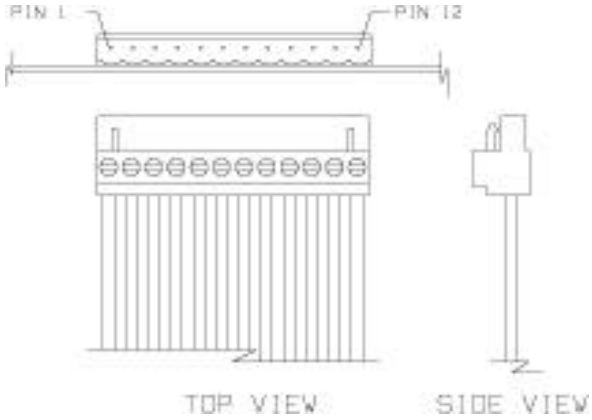
2.7.8.2. CONNECTOR PINOUT

Pin Number	Signal Name	Pin Number	Signal Name
J53-1	Common	J53-2	Ref A
J53-3	/Ref A	J53-4	Common
J53-5	Ref B	J53-6	/Ref B
J53-7	Common	J53-8	Not used
J53-9	Not used	J53-10	Common
J53-11	Common	J53-12	Not used
J53-13	Not used	J53-14	Common
J53-15	Not used	J53-16	Not used
J53-17	Common	J53-18	Not used
J53-19	Not used	J53-20	Not used

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2.7.9. J54 Resolver

2.7.9.1. MATING CONNECTOR DIAGRAM



Mating Connector	Weidmuller BL12-2279.6 (supplied)
Connector Assembly Tool	Standard straight blade screwdriver
Wire Specification	
Gage	14 to 22 AWG
Types	PVC or Teflon insulation
Insulation Strip Length	0.25"

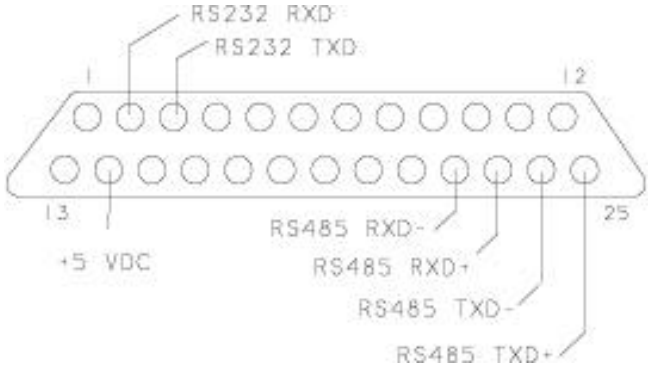
2.7.9.2. CONNECTOR PINOUT

Pin Number	Signal Name
J54-1	Resolver S1 (+ Sin)
J54-2	Resolver S3 (-Sin)
J54-3	Resolver S2 (+ Cos)
J54-4	Resolver S4 (-Cos)
J54-5	Shield
J54-6	Resolver R1 (+ Excit)
J54-7	Resolver R2 (-Excit)
J54-8	Ref Z
J54-9	/Ref Z
J54-10	Motor PTC
J54-11	Motor PTC Rtn
J54-12	Not used

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2.7.10. J55 Serial Link

2.7.10.1. MATING CONNECTOR DIAGRAM



Mating Connector	DB-25S
Connector Assembly Tool	Solder, crimp, or ribbon depending upon the style of connector chosen
Wire Specification	Depends upon style of connector chosen

2.7.10.2. CONNECTOR PINOUT

Pin Number	Signal Name	Pin Number	Signal Name
J55-1	Shield, +5 Rtn	J55-2	RS232 RXD
J55-3	RS232 TXD	J55-4	Not used
J55-5	Not used	J55-6	Not used
J55-7	Common	J55-8	Not used
J55-9	Not used	J55-10	Not used
J55-11	Not used	J55-12	Not used
J55-13	Not used	J55-14	+5 VDC
J55-15	Not used	J55-16	Not used
J55-17	Not used	J55-18	Not used
J55-19	Not used	J55-20	Not used
J55-21	Not used	J55-22	RS485 RXD -
J55-23	RS485 RXD +	J55-24	RS485 TXD -
J55-25	RS485 TXD +		

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3. POWERING UP THE SC450 SERIES

3.1. Controller Modes

The controller has several jumpers/switches to allow the user to select various controller modes. These include:

- One plug jumper
- One 5-position DIP switch
- One voltage selector switch

3.1.1. Voltage Selector Switch

A two-position switch, located in the lower left corner of the "lower" controller PC board, sets the controller for 115 or 230 VAC operation.



Improper setting of this switch can cause severe damage to the controller.



The factory default setting is 230 VAC.

3.1.2. Jumper Block E1

The jumper block is located in the upper right corner of the "lower" controller PC board and is used to select velocity loop compensation. There are four jumper positions available:

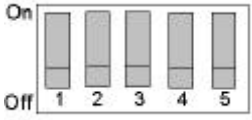
Jumper Position	Function
1-2	Not used
3-4	Custom Velocity Loop Compensation
5-6	Standard Velocity Loop Compensation #2 (for high gain systems)
7-8*	Standard Velocity Loop Compensation #1 (for low gain systems)

* Factory default setting.

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3.1.3. DIP Switch S1

A five-position DIP switch located in the center of the "Upper" controller PC board is used to set the controller serial link configuration. Refer to the table located on the following page for the correct switch settings.



The diagram above shows all the switches off.

3.1.3.1. S1 SWITCHES 1 THROUGH 3

These switches select either RS-232 or RS-485 operation. They are also used to select the RS-485 address setting.

3.1.3.2. S1 SWITCHES 4 AND 5

These switches select the baud rate for the serial link (RS-232 or RS-485) between the SC450 controller and the customer's terminal or host computer.

Serial Address	Switch Position		
	1	2	3
RS-232 operation (address 7)	Off	Off	Off
RS-485 operation address			
0	On	On	On
1	Off	On	On
2	On	Off	On
3	Off	Off	On
4	On	On	Off
5	Off	On	Off
6	On	Off	Off

Baud Rate*	Switch Position	
	4	**5**
1200	On	On
2400	Off	On
4800	On	Off
9600	Off	Off

Factory default setting is all switches Off, which corresponds to RS-232 operation and 9600 baud rate.

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3.2. Potentiometer Set Up

The controller has four 15-turn potentiometers (A through D) on the front panel to permit user adjustments.

Potentiometer	Description
A - Velocity Offset	The velocity loop offset has been adjusted to zero at the factory. Do not change this setting.
B - Command Gain	The velocity command gain should be in the full clockwise position (factory default setting).
C - Velocity Loop Gain	The AC loop gain of the controller's velocity loop can be increased over a 20 to 1 range by rotating the screw of this potentiometer clockwise. Because velocity loop dynamics are affected by the motor and the load on the motor, this potentiometer must be adjusted by the user, for a given set of conditions.
D - Current Limit	To adjust the peak output current, rotate this potentiometer knob clockwise. At full counter-clockwise, there is no output current. At full clockwise, 100% of the peak rated output current of the controller is obtained.

3.3. Special Adjustments

Several resistors and capacitors control the velocity and current loop dynamics as well as the motor PTC solder posts.



Consult with your local Danaher Motion distributor regarding factory installation of custom value components with specified values to tailor the controller to a specific application (Custom Compensation Option).

3.4. Servocontroller Tuning

The SC450 servocontroller requires hardware and software adjustments in order to provide the best tradeoff of transient response and system stability. The tuning procedure outlined in this section pertains to a specific mechanical load. It is recommended that this procedure initially be performed with the motor shaft disconnected from external loads. However, the procedure must also be repeated with the motor coupled to the external load.

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3.4.1. Control Loops

The SC450 servocontrollers have three primary control loops:

- Motor current
- Motor velocity
- Position

The innermost loop is the current control loop which is commanded by the velocity control loop. The velocity loop is commanded by the position control loop. On SC450 controllers, the current and velocity control loops are implemented with analog electronics, while the position control loop is controlled digitally via a microprocessor.

The current loop maintains motor current, hence torque and acceleration. For a specific motor and controller model, the recommended configuration of the current loop has been pre-assigned via the controller customization code and requires no adjustment.

The velocity loop subtracts the sensed motor velocity from the commanded value to generate an error signal. This signal is amplified and filtered to provide the command signal to the current control loop. Adjustments to the velocity loop are performed via the velocity loop gain potentiometer in conjunction with the E1 jumper setting located near the green power LED on the lower circuit card. The velocity control loop must be tuned independently of the position loop by preconfiguring the appropriate software parameters.

The position servo generates an error signal between the desired and measured positions. It then amplifies and filters this signal using the software parameters PLGAIN (Position Loop Proportional GAIN) and PLIGAIN (Position Loop Integral GAIN).

Another function of the position controller is to generate a velocity servo feedforward signal by multiplying the desired motor velocity by the FFGAIN scale factor. The sum of the filtered position error and velocity feedforward signals is then multiplied by the variable DACGAIN and output to a digital-to-analog converter. This analog signal is scaled by the command gain potentiometer to form the velocity command signal.

3.4.2. Tuning Procedure

The tuning procedure consists of adjusting the velocity servo loop first, then adjusting the positioning servo control loop.

The velocity servo loop is controlled with analog electronics. However, the velocity loop receives its command signal from the microprocessor via a digital-to-analog convertor. The positioning servo loop is closed and controlled within the microprocessor.



DO NOT enable the controller yet. The controller is enabled by connecting J52-47 to I/O Common (any even pin on J52).

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1. Connect the motor, feedback, power and serial communications cabling. Use a terminal or a PC (using terminal emulation software, such as PACCOM) to communicate with the servocontroller.
2. 2. Power up the controller. If communications are configured correctly, a sign on message will be displayed.
3. Insure the controller is in immediate mode and none of the pre-defined inputs are asserted (JOG+, JOG-, START, STOP). You must be able to enter immediate mode commands such as LIST, QRY, AUTO, RUN, etc.



Software servo parameters can be determined using the QRY command. You can temporarily (until the controller power is removed) change them as many times as desired. However, the SAVEVAR command saves them permanently in non-volatile memory.

4. Insure the software parameter DACGAIN is set equal to 120 (use the QRY command). If not, type DACGAIN = 120 <return>. **Never** change this variable.
5. Insure the command gain potentiometer (labelled COMMAND GAIN) is turned fully clockwise. **Never** change this setting.
6. Set the current limit potentiometer (labelled CURRENT LIMIT) to the desired level. Typically this is 100% (when the current limit potentiometer is fully clockwise).



If powering up for the very first time, you may want to initially set the current limit to a low value to insure cabling is correct or to limit peak motor torque. This may prevent damage if there are any loose fittings in the drive train mechanics.

7. Preset the velocity loop gain potentiometer (labelled VEL LOOP GAIN) by turning it fully counterclockwise. This is the minimum electronic gain setting.
8. Insure the E1 jumper, located near the green POWER LED of the lower PC board, is set to 7-8 (the factory default setting).

3.4.2.1. VELOCITY LOOP TUNING PROCEDURE

To configure the controller to test the velocity loop, the position servo loop must be turned off or “defeated”. This is done by setting the position loop gain and the position loop integral gain to zero by entering:

1. PLGAIN = 0 <return>
2. PLIGAIN = 0 <return>

To permit issuing a velocity command via the feedforward gain path, set the velocity feedforward gain to its maximum value (100%) by entering:

3. FFGAIN = 255 <return>
4. Enable the controller by connecting J52-47 to I/O Common (any even pin on J52). The motor may begin rotating slowly at this point.



Be prepared to disable the controller at any time during the tuning procedure. Do so whenever excessive oscillation occurs. Excessive oscillation may cause damage to the system.

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5. If the motor oscillates (rotates back and forth) or is unstable:
   - — First attempt to increase the electronic gain by turning the velocity loop gain potentiometer (labelled VEL LOOP GAIN) slowly in the clockwise direction.
   - — If the oscillation becomes worse, disable the controller.
   - — Insure the velocity loop gain potentiometer is fully counterclockwise (this is a 15-turn pot).
   - — Move the E1 jumper from position E1-5 to position E1-6.
   - — Enable the controller as outlined in Step 4 of this section.
   - — If the motor still appears to be unstable, check all connections between the motor and controller. Insure there are no intermittent connections.

6. Velocity Offset Adjustment.

   If the motor is rotating slowly in the clockwise direction, turn the velocity offset potentiometer (labelled VEL OFFSET) slowly in the counterclockwise direction until motion ceases. If the motor is rotating slowly in the counterclockwise direction, turn the velocity offset potentiometer slowly in the clockwise direction until motion ceases.

7. Enter the following ServoBASIC program to aid in velocity loop tuning.



If another program is in memory use the SAVE command if you wish to store it in non-volatile memory, then enter the NEW command to erase the temporary program memory.

```
10  PLGAIN = 0                  'Defeat
20  PLIGAIN = 0                 'Position loop
30  ENABLE = 1                  'Insure software enable set
40  FFGAIN = 255                '100% feedforward gain
50  ACCEL.RATE = 1000000        'Full acceleration
60  FLT1 = 1000                 'Test velocity Ä1000 RPM
                                save in FLT1

70  RUN.SPEED = FLT1
80  DIR = 0
90  GO.VEL                      'Run 1000 RPM clockwise
100 PAUSE                       'Wait one second
110 RUN.SPEED = 0
120 GO.VEL                      'Command zero velocity
130 PAUSE                       'Wait one second
140 RUN.SPEED = FLT1
150 DIR = 1
160 GO.VEL                      'Run 1000 RPM counter-clockwise
170 PAUSE                       'Wait
180 RUN.SPEED = 0
190 GO.VEL                      'Command zero velocity
200 PAUSE
210 GOTO 70                     'Loop endlessly until
                                program is aborted
```


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The remaining portion of this procedure is the most critical adjustment to the controller. There are two simple, empirical methods of adjusting the velocity loop gain. If using the basic method, which does not require an oscilloscope, proceed to Basic Velocity Loop Tuning. If an oscilloscope is available, it will provide more precise, less subjective controller tuning. For the oscilloscope method, proceed to Velocity Loop Tuning Using an Oscilloscope.

3.4.2.2. BASIC VELOCITY LOOP TUNING

1. After typing in the program defined in the previous step, enter the RUN command to begin execution. The program performs an endless sequence of velocity steps between 0 and 1000 RPM in both clockwise and counter-clockwise directions, remaining at each speed for one second.



The program performs an endless sequence of velocity steps between 0 and 1000 RPM in both the clockwise and counterclockwise directions.

2. Slowly turn the velocity loop gain potentiometer (labelled VEL LOOP GAIN) clockwise (to increase gain) or as far as it will go, until the motor begins to oscillate. Then, immediately turn the loop gain potentiometer counterclockwise (decrease gain) until the oscillation stops. Oscillations are most likely to occur when a transition in velocity is made.

3. Turn the velocity loop gain potentiometer an additional two turns in the counter-clockwise direction.

4. Type in Control C (press control and C simultaneously) to stop the program from executing. The motor should stop or it should rotate very slowly.

   Repeat Step 6 of Velocity Loop Tuning Procedure to eliminate any velocity offset.

This concludes potentiometer adjustments.

Proceed to Step 1 of Position Loop Tuning Procedure.

3.4.2.3. VELOCITY LOOP TUNING WITH AN OSCILLOSCOPE

1. Connect an oscilloscope to the tachometer monitor signal on J4 pin 15. The ground reference of the oscilloscope should be made to J4 pin 13.



The scale factor of the tachometer test point is approximately 0.56 volts/krpm.

2. After typing in the program defined in the previous section, enter the RUN command to commence execution.



The program performs an endless sequence of velocity steps between 0 and 1000 rpm in both the clockwise and counter-clockwise directions.

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3. Monitor the tachometer signal using the oscilloscope. Slowly turn the velocity loop gain potentiometer (labelled VEL LOOP GAIN) until the waveform resembles the critically damped response as illustrated.



4. High frequency resonance situations.

   If the response appears to be overdamped and a small increase in the velocity loop gain causes the controller to suddenly break into high frequency oscillations, the system is probably experiencing a high frequency mechanical resonance. A potential solution involves the addition of a second anti-resonant filter. This entails soldering a capacitor connected in parallel across the feedback resistor.



If this modification is attempted, insure the control power is off prior to soldering.

   — If the E1 jumper is set to 7-8, a 0.015 microfarad, 10%, 50V, X7R or BX monolithic ceramic capacitor should be soldered across R153.

   — If the E1 jumper is set to 5-6, a 0.15 microfarad, 10%, 50V, X7R or BX monolithic ceramic capacitor should be soldered across R154.

   After a satisfactory response has been obtained, abort the test program by typing ^C. This will stop commanded motion.

   To eliminate any velocity offset, repeat Step 6 of Velocity Loop Tuning Procedure.

3.4.2.4. Position Loop Tuning Procedure

1. First, reset the velocity feedforward gain to its minimum value by entering:

   FFGAIN = 0 <return>

2. PLGAIN sets the proportional gain of the position loop. This parameter controls the bandwidth of the position control loop. The greater the bandwidth that can be obtained, the quicker the settling time the positioning system is in response to motion commands. If the gain is too high the system becomes unstable and results in sustained oscillation. The objective is to achieve as high a gain as possible while still maintaining adequate stability.

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PLIGAIN specifies the amount of integral gain used in the controller. The integrating function will assure that the actual position will servo to the commanded value during steady state conditions. The integrator is turned on only when approaching the completion of a commanded move. This eliminates any offset residing in the velocity control. Any non-zero value for PLIGAIN results in overshoot of the commanded position.

To aid in the position loop tuning, enter the following program at this time.

```
30  ENABLE = 1                  'Insure software enable set
40  FFGAIN = 255                '100% feedforward gain
50  ACCEL.RATE = 1000000        'Full acceleration
60  FLT1 = 1000                 'Test velocity Ä1000 RPM
                                save in FLT1
70  RUN.SPEED = FLT1
80  DIR = 0
90  GO.VEL                      'Run 1000 RPM clockwise
100 PAUSE                       'Wait one second
110 RUN.SPEED = 0
120 GO.VEL                      'Command zero velocity
130 PAUSE                       'Wait one second
140 RUN.SPEED = FLT1
150 DIR = 1
160 GO.VEL                      'Run 1000 RPM counter-clockwise
170 PAUSE                       'wait
180 RUN.SPEED = 0
190 GO.VEL                      'Command zero velocity
200 PAUSE
210 GOTO 70                     'Loop endlessly until
                                program is aborted
```

As was the case with velocity loop tuning, adjustments can be supplemented with an oscilloscope or can be performed without one. If an oscilloscope is used, proceed to Oscilloscope Position Loop Tuning Method. Otherwise, go to Basic Position Loop Tuning Method.



Both of these methods are outlined below.

3.4.2.4.1. Basic Position Loop Tuning Method

1. Set PLGAIN = 1 in the immediate mode. Then run the program defined in the previous section and observe the motor shaft when starting and stopping.
2. If no overshoot occurs, stop (using Control C).
3. RUN the program (RUN command) and increase PLGAIN until a position overshoot is detected. Then decrease PLGAIN to the highest value possible with no overshoot.

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3.4.2.4.2. Oscilloscope Position Loop Tuning Method

1. Connect an oscilloscope from the buffered tachometer test point as indicated in Step 1 of Velocity Loop Tuning Using an Oscilloscope.
2. Command motion control by RUNing the ServoBASIC program defined in the previous section.

   This program commands velocity from 0 to 1000 RPM in the clockwise direction, waits one second, commands velocity back to 0 RPM, waits one second, performs the sequence in the counterclockwise direction, then repeats the process.

   Change PLGAIN in the immediate mode to modify gain settings. Then, enter the RUN command to commence program execution. Note that the program loop is performed endlessly. Type in Control C to stop the program and modify PLGAIN.
3. Monitor the tachometer signal using the oscilloscope. Select a value for PLGAIN that produces the velocity waveform that resembles the critically damped response as illustrated below.



3.4.2.5. SPECIAL ADJUSTMENTS

3.4.2.5.1. Position Loop Integral Gain Adjustment

PLIGAIN should now be set. PLIGAIN's function is to overcome the velocity offset with minimal overshoot. This ensures the controller will servo the actual motor position (POSITION) to the commanded value (POS.COMMAND) to drive the position error (POS.ERROR) to zero Use as small a value as possible (a value of one is recommended). Increasing PLIGAIN to too high a value may cause instability.



Any non-zero value for PLIGAIN results in some position overshoot.

3.4.2.5.2. Velocity Feedforward Gain Adjustment

Feedforward gain helps eliminate large positioning following errors by adding a signal to the position servo's output, which is proportional to commanded velocity. This generally helps reduce position following error and servo settling time.

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Feedforward gain is specified by the parameter FFGAIN and can be set from 0 (no feedforward) to 255 (100% feedforward). Too high a value for FFGAIN will result in significant overshoot of the commanded position.

If an oscilloscope is available, monitor the velocity waveform while commanding a test profile as indicated in the Oscilloscope Position Loop Tuning Method.



Only FFGAIN (not PLGAIN) values should be varied for different test cases.

If the feedforward gain is set too high, position overshoot occurs. To avoid position loop overshoot, it is generally not recommended to set feedforward past 70% or a value of 179. One exception to this may be an electronic gearing application where no steady state following error can be tolerated. In this case setting FFGAIN to 255 may be necessary.

This concludes special adjustments.

3.4.2.6. TUNING SUMMARY

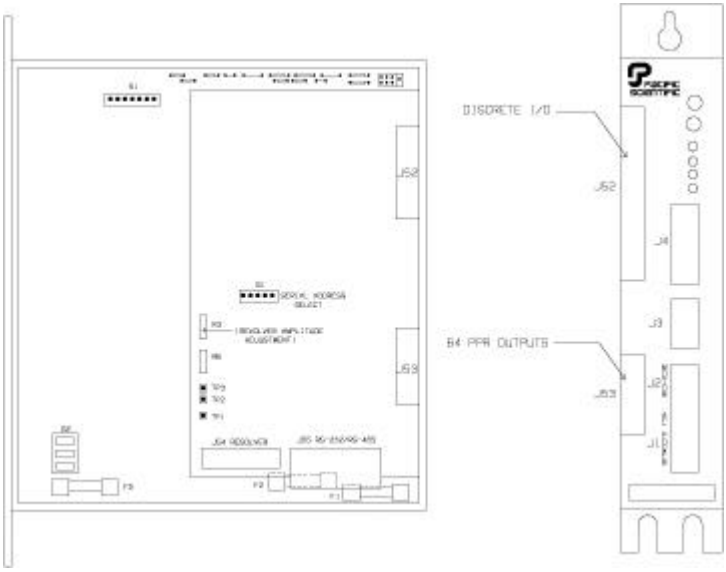
If you have followed the steps outlined in the previous sections, the tuning procedure is now complete. Please ensure that the following adjustments have been performed or verified.

- E1 Jumper Setting (For proper tuning)
- Potentiometer Adjustments
  - COMMAND GAIN (Full clockwise)
  - CURRENT LIMIT (As required)
  - VEL LOOP GAIN (For proper tuning)
  - VEL OFFSET (Nullify velocity drift)
- Software Adjustments
  - DACGAIN (Set equal to 120)
  - PLGAIN (For proper tuning)
  - PLIGAIN (Nullify velocity offset)
  - FFGAIN (Minimize following error)

Be sure to use the SAVEVAR command to permanently store the software parameters in non-volatile memory. Unless changed within the program, these are the values the controller will use.

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3.4.3. Location Adjustments



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4. TROUBLESHOOTING

4.1. Maintenance

Remove superficial dust and dirt from the unit using clean, dry, low-pressure air.

4.2. Faults

Controller faults are indicated by the red and green diagnostic LEDs located at the top of the front panel. Faults are also indicated by FAULT OUT (J52-27) ceasing to sink current. This output is the collector of an NPN transistor having its emitter connected to ground. The transistor is On when no faults are present and Off when a fault occurs.

The fault output transistor is turned off to indicate a composite fault, which is asserted when one of seven fault protection circuits trips. These are:

Fault Outputs	***Description***
Motor Over-temperature	Sensed by means of PTC thermistor on motor armature. Trips when resistance exceeds approximately 41kΩ. This corresponds to 150°C for sensor mounted on Danaher Motion Pacific Scientific motors.
Drive Over-temperature	Sensed via PTC thermistor on power stage heatsink.
Motor Over-current (I*T) SC453 only 	Sensed using an absolute value and a filtering circuit which is processing the motor current sensor's output. This circuit will trip if the controller senses a peak current flow of 15 amperes, continuously, for over 5 seconds (with zero current flow prior to the 5 seconds of peak current). ***If the controller is supplying current at or near the continuous rating (7.5 amperes), and the current increases to the peak value (15 amperes), the circuit triggers much faster. (The circuit's objective is to ensure current is within the drive's continuous rating to protect the power switching electronics from thermal overload.)***
Line-Neutral Fault	Sensed when the sum of currents flowing through the armature (R, S and T nodes) is non-zero. This fault implies external shoft circuit to chassis ground in either power stage, cabling or motor.
Control Logic Supply Under-voltage	Triggered when the internal +12 VDC logic supply is under permitted tolerance.
Bus Over-voltage	High voltage DC bus is monitored and trips where voltage exceeds approximately 400 volts.

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Fault Outputs	*Description*
Bus Over-current	Triggers when motor current exceeds 11 amps for a SC452 (rated for 7.0 amps peak) and 22 amps for an SC453 (rated for 15.0 amps peak).

Before proceeding through this troubleshooting section, check to ensure the following:

- 115/230 VAC is present at the controller's input terminals
- Voltage selector switch is set to the proper position
- Input fuses and control voltage supply fuse are intact

If the green POWER LED is not lit, a fault has occurred on the + 12 V supply, a fuse is blown or AC power is not being applied. In this case, ignore the red FAULT LED because interruption of the + 12 V power may give a false indication.

There are no field serviceable components in the controller. In the event of a controller failure, the entire defective unit should be returned to the factory for repair or replacement. Verify that the controller is defective before returning it for repair.

4.2.1. Consistent/Recurrent Fault Identification

To identify faults, perform the following procedure.

1. Apply AC power to the controller with the drive disabled.
2. Check for bad connections on the AC power wire and the feedback wire.
   - If the Green Power LED is On and the Red Fault LED is Off, the drive has powered up properly, proceed to step 3.
   - If the above conditions are not true, refer to the following table for a set of problems and possible solutions.

Fault	Problem	Possible Solution
Red fault LED On and Green Power LED Off	When the Green Power LED is Off, the control circuitry supply voltages are not what they should be.	Check the 115/230 switch and the AC input line for proper settings. Check fuses F1 to F3. Check the + V supply voltages by measuring J4-11 and J4-12 with respect to return (J4-13) for +12V and +12V = 0.5V respectively. Check for shorts in the wiring.

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Fault	Problem	Possible Solution
Red Fault LED On and Green Power LED On	Improper connection of the motor over-temperature circuit.	Check wiring to the motor thermal overload sensor, J4-9 and J4-10. Proper connection of the motor PTC can be directly checked by measuring the voltage of the pull-up resistor R123. Measure the voltage of the resistor with respect to the ground solder post. The side of the resistor nearest the front panel should have 0 to 0.5V on it and the other side should have a +12 V supply.
		Check that motor is not over-heated.
	Excessive input line voltage.	Check for excessive line voltage by measuring the AC power input line-to-line voltages on J1.

3. Enable the controller with motion command set to approximate zero. If the controller does not fault, proceed to step 4. If the controller does fault, refer to the table below for possible problems and solutions.

Fault	Problem	Possible Solution
Red Fault LED turns On and Green Power LED stays On	Short in motor wiring.	Power down the controller and unplug the motor power connector. Now, power up the controller, enable the controller and rotate the motor shaft by hand (at least one revolution) while the controller is enabled. If the controller does not fault, there has to be a problem in the motor cabling or in the motor.
	Controller output stage problem.	
	Line-Neutral fault	Check to see if the motor power wires are shorted to ground.
		Cabling capacitance is too high.
	Excessive time at peak current controller overcurrent (I*T) **SC453 only**	Reduce acceleration rates, duty cycle (on/off) of commanded motion, increase time permitted for motion.
	Controller low level power supply low.	Use larger drive and motor.
		Correct the undervoltage condition or intermittent AC power.
Red Fault LED does not turn On but the motor runs roughly	Servo compensation not properly set up.	If the controller is running a bare motor but the controller was left set up for a machine, the servo parameters must be reset.
	Feedback wiring not set up properly.	Check that the controller part number goes with the motor to which it is connected.

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4. Run the controller through normal motion cycles. Since the controller can rotate the shaft through at least one complete revolution, the fault must be occurring during normal operation. If a fault still occurs, refer to the table below for possible problems and solutions.

Problem	Possible Solution
Marginal wiring - momentary open circuits in the AC power or shorts in the motor power wiring.	Check cable and connector wiring.
Insufficient or missing regeneration capability.	If the servo is driven by some external mechanical power source during part of its cycle, it is possible to regenerate too much peak energy to the controller's power supply and the system will fault to save itself from overload. It is also possible to order controllers without the regeneration module to save money. In those cases, it is possible that a change in machine inertia or motion cycle could bring the regeneration high enough to pump the internal bus power supply to cause a bus over voltage fault.
Input AC power line glitch - If the input power drops away for more than 33 ms, the drive faults on insufficient control voltage.	If the power outage lasts for more than 2 seconds, the controller will automatically test itself through a power up reset.
Motor or controller is actually overheating. 	Check the motor's surface temperature by hand. ***If the motor is over-heating, the surface temperature will be over 100 °C.***
Mismatched controller and motor.	To prevent this problem, make sure the controller model number goes with the motor you are using. Refer to Current Loop Dynamics Adjustment (R103, C50), to check that the drive is set up for the motor in use.

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4.2.2. Common Problems and Solutions

Problem	Cause	Possible Solution
Motor runs at constant velocity after power up or while in immediate mode	Software variable PREDEF.INP is set to 1 and Jog inputs (INP5 and INP6) are asserted.	Set PREDEF.INP equal to 0 or insure Jog controls are not asserted.
POWER LED not lit FAULT LED lit	115/230 VAC power not applied.	Check for open circuit breakers in AC line.
	Voltage selector switch improperly set.	Be sure voltage selector switch matches line voltage.
	115/230 VAC power out of tolerance (+10%, -15%).	Check that line voltage meets drive's voltage and current requirements.
	Blown control voltage fuse or input fuse.	Check fuses (F1 through F4).
	Short circuit on 12 VDC outputs.	Check for short circuit in cabling.
	Controller temperature too high.	Check that the ambient temperature is not too high.
		Be sure cooling is not restricted by insufficient space around input.
	Motor over-temperature.	Be sure that unit is not being operated above its continuous power rating.
		Be sure that motor PTC connection(s) are not open. If a motor PTC is not being used, place a jumper between J54-10 and J54-11. Ensure that motor RMS torque output is within rating for ambient temperature.
	Output short circuit.	Check if motor power wires are shorted together.
		Short circuit in motor windings.
		Insufficient motor inductance.
	Bus over-voltage.	Check if AC voltage is excessive (>253 VAC). Excessive regenerated power.

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Problem	Cause	Possible Solution
Controller is enabled, green Power LED is lit, red Fault LED is off, but the motor does not respond	Open motor connection(s). Seized load or excessive load friction. Controller is not enabled, ENABLE command input is not reaching J52-47. Software ENABLE is not set. There is an open or misconnection of the resolver. The CURRENT LIMIT potentiometer is turned full counter-clockwise.	Check controller wiring. With drive disabled, check freedom of motion of load. Check controller wiring. ENABLE command must be low (< 0.5 volts). Check wiring between resolver and controller. Be sure that the CURRENT LIMIT potentiometer is at least two full turns clockwise from full counter-clockwise.
Motor oscillates	Velocity loop compensation or velocity loop gain adjustment is incorrect. Improper shielding and grounding. Position loop improperly compensated.	Refer to Velocity Loop Tuning Procedure and Basic Velocity Loop Tuning. Check wiring. The motor case must be grounded and the resolver wiring must be shielded as shown in the connection diagram. Refer to PLGAIN, PLIGAIN in the ServoBASIC Programming Manual.
Motor accelerates to high speed regardless of command input	Resolver and/or motor are wired incorrectly.	Check resolver and motor wiring.
Motor operates erratically (excessive growling, quivering or sudden jumps)	Improper motor and/or resolver wiring. Improper shielding and grounding.	Check resolver and motor wiring. Check wiring diagrams in this manual. Check that motor case is grounded and the resolver wiring is shielded as shown in the connection diagram.

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4.3. Replacing Solder Post Mounted Components

If solder post mounted components are changed, the replacement components should be:

Resistors — + 1%, 1/4 Watt, metal film
Capacitors — + 10%, 50 Volt, X7R or BX monolithic ceramic

4.3.1. Current Loop Dynamics Adjustment (R103, C50)

Resistor R103 (factory installed value = 100 kΩ) and capacitor C50 (factory installed value = 0.015 microfarads (µf)) control the proportional plus integral compensation of the controller current loops. These components are used to adjust the current loop dynamics when the motor inductance is out of the range of the nominal compensation installed at the factory. For custom current loop compensation to match the Danaher Motion Pacific Scientific motor being used, consult your local Danaher Motion distributor.



Misadjustments of these components can damage the controller's power section. Please exercise extreme care if you change these components.

Use the following tables to determine the value of Resistor R103 in kΩ and Capacitor C50 in microfarads (µf):

Operation Voltage = 230 VAC (Line-to-line inductance; range in mH)				
SC451	**SC452**	**SC453**	**R103 in kW**	**C50 in µf**
< 9	< 4	< 2	Consult factory	
9 - 12	4 - 6	2 - 3	51	0.033
12 - 36	6 - 18	3 - 9	100	0.015
36 - 100	18 -54	9 - 27	Consult factory	
> 100	> 54	> 27	Consult factory	

Operation Voltage = 115 VAC (Line-to-line inductance; range in mH)				
SC451	**SC452**	**SC453**	**R103 in kW**	**C50 in µf**
< 9	< 4	< 2	Consult factory	
9 - 12	4 - 6	2 - 3	51	0.033
12 - 36	6 - 18	3 - 9	100	0.015
36 - 100	18 -54	9 - 27	Consult factory	
> 100	> 54	> 27	Consult factory	

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4.3.2. Velocity Loop Dynamics Adjustment

Jumper block E1 and the velocity loop gain potentiometer are used to set the velocity loop dynamics.
The E1-7,8 position provides proportional and integral (PI) compensation for systems with lower torque/inertia ratios.
The E1-5,6 position, the velocity loop gain potentiometer, allows the gain to be adjusted over a 20 to 1 range.

4.4. Customer Support/Contact Information

Danaher Motion Pacific Scientific technical documentation is updated periodically and may be changed without notice. The latest documentation can be found on our website. For information on this product or where to purchase near you, contact: your local distributor.

Danaher Motion Customer Support
Phone: (815) 226-2222
Fax: (815) 226-3080
Email: customer.service@danahermotion.com
Website: www.danahermotion.com

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5. SPECIFICATIONS

5.1. General

Position Control

Range	0 to + 100,000,000 steps
Resolution	4096 steps per rev (5.3 arcmin/step)
Accuracy	15 arcmin

Speed Control

Range	0 to + 10,000 rpm (Actual maximum speed depends upon motor/controller combination used)
Resolution	0.01 rpm

Non-volatile Memory

Write cycles	10,000 operations Refer to SAVE, SAVEVAR in the *ServoBASIC Programming Reference Manual* for further information.

Acceleration/ Deceleration

Range	3 to 1,000,000 rpm/second
Resolution	3 rpm/second

Torque (Current)

Limit Control Range	0% to 100% of peak rating (Potentiometer control)

Discrete Input Sampling Period Jog+, Jog- = Start, Stop

Mechanical Home Switch	1.024 millseconds

Position Loop Update

Period	1.024 milliseconds

Serial Interface

Type	RS-232 or RS-485 (switch selectable)
Baud Rate	1200, 2400, 4800, 9600 (switch selectable)
Parity	none
Data Word	10 bit (8 data, 1 start, 1 stop)

5.2. Mechanical

	SC451	SC452	SC453
Weight (lbs/kg)	6 / 2.7	6 / 2.7	11 / 5

5.3. Environmental

Full ratings (°C)	0 to 50
Derated (°C)	50 to 60 (linearly derate the continuous current and power ratings to 70% at 60°C)
Humidity (%, non-condensing)	10 to 90
Altitude (ft/meters)	5000/1500
Storage Temperature (°C)	-55 to 70

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5.4. Electrical

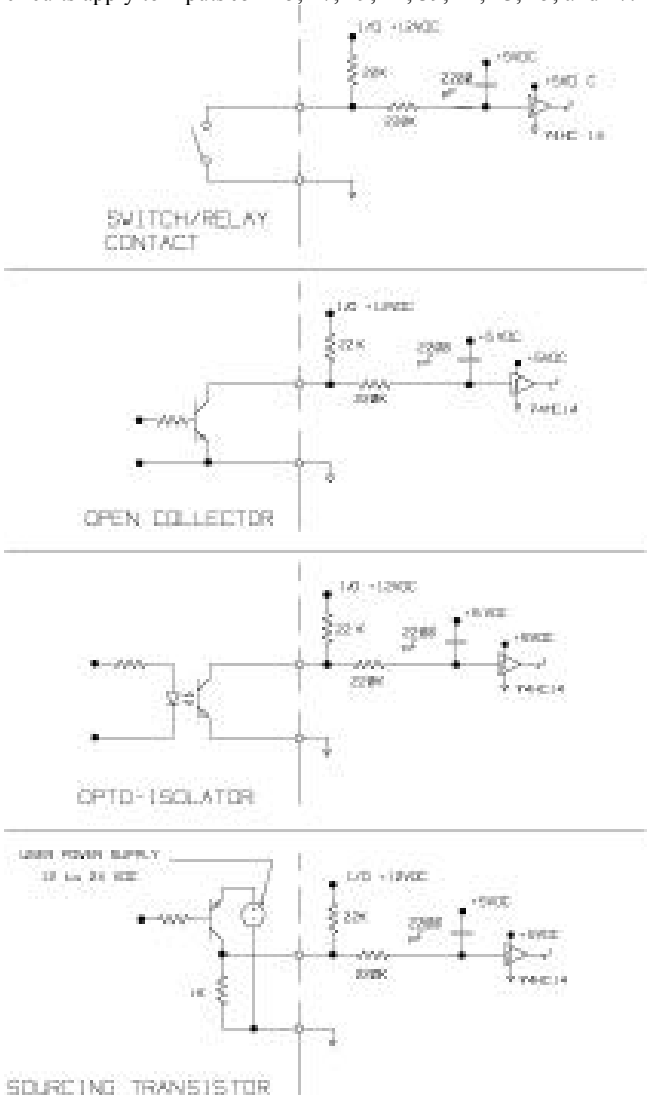
Parameter	SC451	SC452	SC453
Input voltage	115/230 VAC (+ 10, - 15%) 1 or 3 phase, 47-63 Hz		
Bus voltage (nominal)			
230 VAC Input (VDC)	320		
115 VAC Input (VDC)	160		
Output Current			
Peak (A)	3.5	7.0	15.0
Continuous (stall)			
230 VAC Input (A)	1.75	3.5	7.5
115 VAC Input (A)	2.1	4.2	7.5
Output Power			
Peak			
230 VAC Input (W)	1000	2000	4500
115 VAC input (W)	500	1000	2250
Continuous (stall)			
230 VAC, 3-Phase Input (W)	500	1000	2250
230 VAC, 1-Phase Input (W)	350	700	1575
115 VAC, 1-Phase Input (W)	175	350	800
Shunt Regulator			
Peak Power (0.3 seconds) (W)	1500	1500	6000
Continuous Power (W)	20	20	40
Efficiency (at rated continuous power) (%)	> 90		
Form Factor	< 1.01		
Current Loop Bandwidth (kHz)	3 max.		
Velocity Offset	Adjustable to zero		
Velocity Offset Drift (referred to input)	50 µV/°C typical		
Output Ripple Frequency (kHz)	20	20	15
Fault Output	Open collector, 30 VDC, 25 mA sink		

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6. INTERFACING INFORMATION

6.1. Discrete Input Wiring Examples

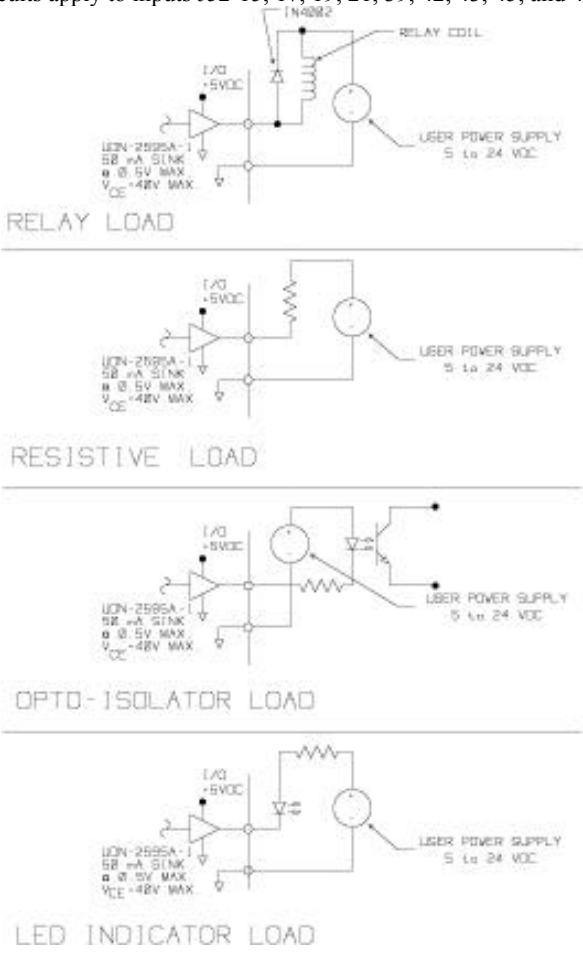
These circuits apply to inputs J52-15, 17, 19, 21, 39, 42, 43, 45, and 47.



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6.2. Discrete Output Wiring Examples

These circuits apply to inputs J52-15, 17, 19, 21, 39, 42, 43, 45, and 47.

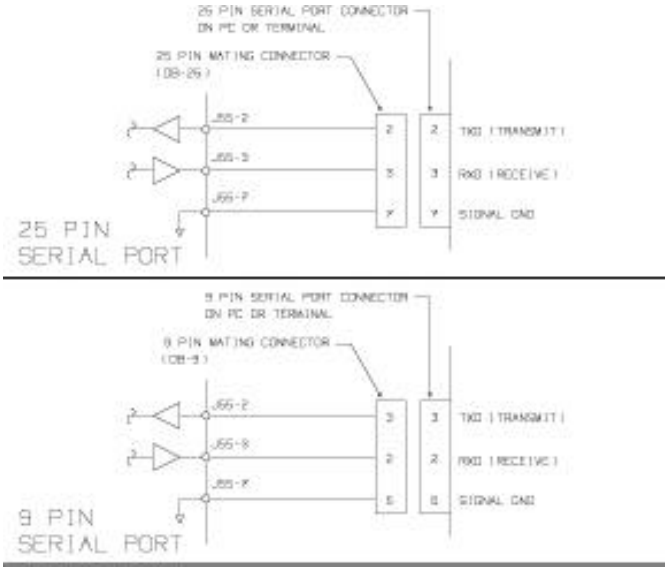


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6.3. RS-232 Port Wiring Examples

These are standard RS-232 serial port pinouts for IBM compatible personal computers. Pinouts vary among computer manufacturers.

Check the hardware reference manual for your machine before wiring the serial port.



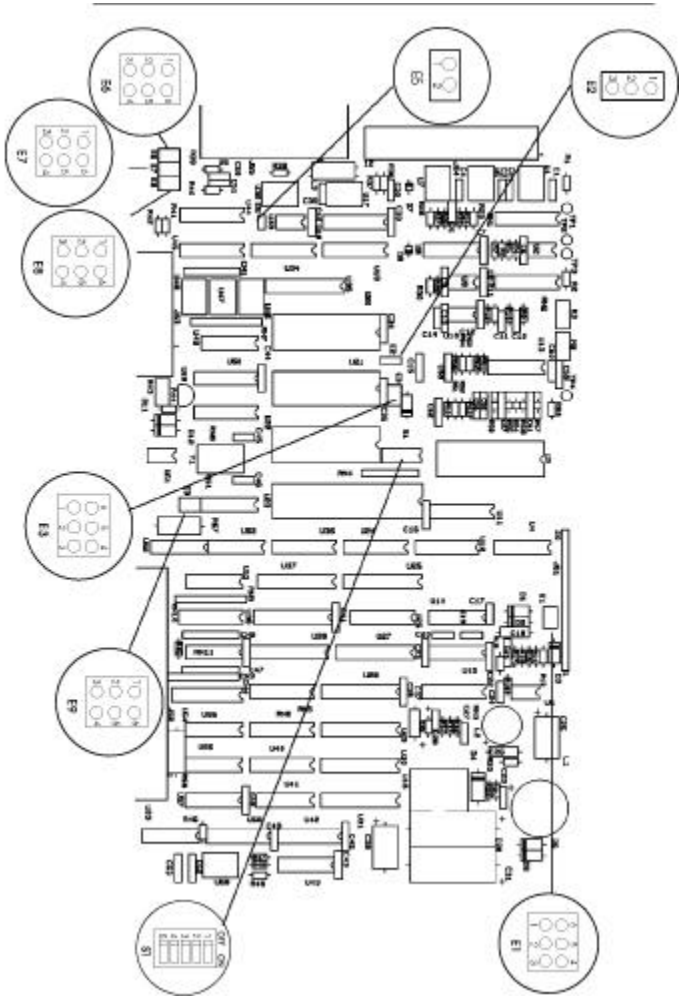
6.4. MC500 Control Board

The table below shows the default jumper settings for the MC500 Digital Control Board. Be aware that -05 firmware is used with standard 2K memory and -15 firmware is used with 8K expanded memory.

Jumper Block	Purpose	Default Setting -05 Firmware	Default Setting -15 Firmware
E1	Tach Signal	2-3, 5-6	2-3, 5-6
E2	NV Memory Size	1-2	2-3
E3	Static RAM Size	2-3, 5-6	2-3, 4-5
E4	Not Used	N/A	N/A
E5	Encoder Output Disable	1-2	1-2
E6	Registration Input	1-2	1-2
E7	RS-485	2-3, 4-5	2-3, 4-5
E8	RS-485	2-3, 4-5	2-3, 4-5
E9	Discrete I/O	1-2, 5-6	1-2, 5-6

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6.4.1. Jumper Locations



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