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Part #: 903-010001-01

SC100 Servocontroller

Installation Manual

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SC100 INSTRUCTION MANUAL

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SECTION 1

INTRODUCTION

WARNING—DANGEROUS VOLTAGES

Voltage levels within this controller can exceed 400 VDC and/or 230 VAC. These voltage levels can cause serious injury or be fatal, therefore follow good electrical practices, applicable electric codes and the contents of this manual. The controller should not be opened since there are no user serviceable components except the externally mounted control board. Any attempt to open the controller can cause serious injury or be fatal. Defective units should be returned to the factory for repair.

1.1 General

This manual outlines Installation/Set-up, Troubleshooting, and Maintenance procedures for IMEC Corporation's SC100 Series of Brushless Servo Controllers. It also contains controller specifications and a general theory of operation.

These controllers are designed to operate Pacific Scientific Brushless Servo Motors or other 3-phase, Permanent Magnetic (PM) Brushless Servo motors. Each controller is an independent, stand-alone unit capable of four quadrant control of a single PM Brushless Servo motor. The controller can be configured with a Brushless Servo motor as either a torque block or, if the motor is equipped with a Tachsyn[®], as a velocity block. The controller employs high-frequency PWM current control to achieve high quality servo performance. Multiple protection circuits and careful design insure trouble-free operation.

1.2 Features

- Transformerless, direct 230 VAC line operation
- Built-in dynamic braking
- Magnetically isolated output stage to improve reliability and reduce crosstalk and ground loop disturbances
- MOV protected input circuitry
- Selectable commutation transducer phasing
- Integral fusing
- Built-in shunt regulator
- Wide velocity loop dynamic range adjustment
- Peak current limit adjustment
- Peak current limit programming inputs
- Multiple Protection Circuits
 - Output Fault
 - Protects against line-line and line-ground shorts.
 - Controller OT
 - Protects controller against thermal overload.
 - Tach Fault
 - Protects against motor runaway due to loss of tach signal or inversion of the tach polarity.
 - DC Bus Fault
 - Protects against overvoltage due to shunt regulator failure or undervoltage due to DC bus short.
 - Control Voltage OK
 - Protects against out of tolerance control voltages.
 - Motor OT
 - Input which allows connection to a motor mounted thermal overload sensor.
 - Enable Lockout
 - Requires that controller enable signal be applied after 230 VAC power has been applied. This prevents unexpected controller operation after a power outage.
 - I*t Circuit
 - Folds back output current to continuous current rating if the current is sustained at peak too long.
- 4 to 20mA Velocity Command input
- Protection Override Jumpers can override three of the protection features (I*t, Tach Fault, Enable Lockout) if it is necessary for a specific application. The controller is shipped from the factory with all protection circuits enabled.

1.3 Options

- External shunt regulator capability
- Ultra-Low Drift Velocity Loop
- Custom Compensation
- Noise reducing output toroid

SECTION 2
CONTROLLER SPECIFICATION

2.1 Electrical

Model	SC101	SC102	SC103	SC104	SC105
Input Voltage (See Note 1)		230 VAC (+10%, -15%), 47-63 Hz			
Input Phases	1	3	3	3	3
Bus Voltage (Nominal)		320 VDC			
Output Current					
Peak (5 Seconds)	15A	15A	30A	60A	60A
Continuous (Stall)	7.5A	12A	15A	20A	40A
Output Power					
Peak (5 Seconds)	4kW	4.5kW	9kW	17kW	17kW
Continuous (Stall)	1.5kW	3.6kW	4.5kW	6kW	9kW
Shunt Regulator Power					
Peak (300 ms)	8kW	8kW	8kW	15kW	15kW
Continuous	30W	30W	30W	30W	60W

The following specifications apply to all models:

Efficiency	>95%
(@ Rated Continuous Power)	
Form Factor	<1.01
Current Loop Bandwidth	800 Hz nominal
Velocity Offset	Adjustable to zero
Velocity Offset Drift	30 $\mu\text{V}/^\circ\text{C}$ typical (10 $\mu\text{V}/^\circ\text{C}$ optional)
(Referred to Input)	
Velocity Input Command	± 10 V bidirectional or 4–20 mA unidirectional (jumper selectable)
Switching Frequency	5 kHz
Torque (Current) Limit Adjustment	10% to 100% potentiometer
Torque (Current) Limit Inputs	0.5 V to 5 V corresponding to 10% to 100%, independent + and -
Torque (Current) Monitor	± 5 V corresponding to $\pm 100\%$
Voltage Monitor	± 7.5 V corresponding to \pm full output voltage
Fault Output	24 VDC, 250 mA relay contact, open on fault

Specifications subject to change without notice.

NOTE 1: For direct 230 VAC line operation, line rating must not exceed 100 KVA.

2.2 Environmental

This unit is of "open frame" design and is intended to be placed within a cabinet. The cabinet should be ventilated by filtered or conditioned air to prevent the accumulation of dust and dirt on the controller's electronic components. The air should also be free of corrosive or electrically conductive contaminants.

The controller is cooled by natural convection except the SC105 model which is fan cooled. To insure proper cooling, maintain the spacing recommendations outlined in Section 3.2. Also sufficient air flow must be maintained to keep the cabinet's internal ambient within the controller's rating given the power dissipation estimates listed in Section 2.4

The following specifications apply to all controllers:

Operating Temperature	
Full Ratings	0°C to 50°C
Derated (See Note 1)	50°C to 60°C
Humidity	5% to 95%, non-condensing
Altitude	1500 Meters (5000 Ft.)
Storage Temperature	-55°C to 70°C

NOTE 1: Linearly derate the continuous current and power ratings to 70% at 60°C.

2.3 Mechanical

Figure 2.1 gives a mechanical outline of the controller. Four slots are provided for mounting the unit on a cabinet wall or other vertical surface. The controller must be mounted vertically. The unit weighs approximately 16 lbs. and should be mounted accordingly.

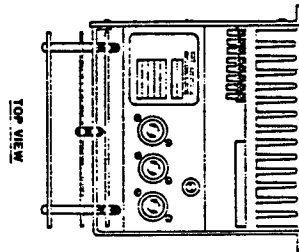
Controller signals are interfaced at the bottom of the controller using plug-in terminal blocks TB1 and TB2. Power connections to the motor and input power source are made on the screw terminal block, TB3, located at the top of the controller. Access to input fuses and the control supply fuse is at the top of the unit adjacent to TB3.

The front panel can be removed to make adjustments during set-up. It is recommended that the panel be replaced following set-up to provide protection for the Control Board and minimize the possibility of unauthorized adjustments.

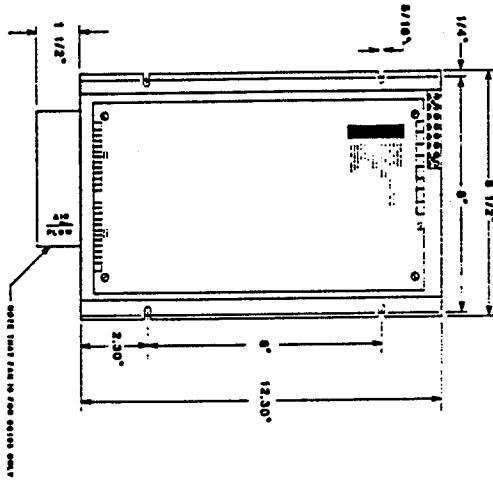
2.4 Power Dissipation

The table below lists the power dissipation (losses) of each controller model at various percentages of rated continuous output power. These numbers are approximate and do not include shunt regulator power (i.e. regenerated power).

% of Rated Continuous Output Power	Power Dissipation Watts				
	SC101	SC102	SC103	SC104	SC105
0%	30	30	30	30	30
25%	38	45	50	55	75
50%	45	60	68	80	120
75%	52	75	87	105	165
100%	60	90	105	130	205

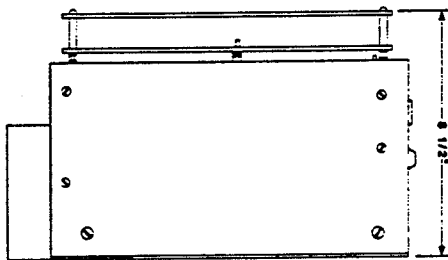


TOP VIEW



FRONT VIEW

FIGURE 2.1



SIDE VIEW

IMEC Corporation The Victor Company, 575 Main Street, Cambridge, Mass 02149 Tel. 617/743-0000	
MODEL BC100	PART CONTROLLER MECHANICAL OUTLINE
DATE 10-1-66	DRAWING NO. D-041000000
SHEET 1 OF 1	

DESIGNED BY CHECKED BY APPROVED BY	DATE SCALE TOLERANCES
--	-----------------------------

SECTION 3

INSTALLATION / SET-UP

Due to the wide variety of uses for this controller, it is the responsibility of the user or those applying the controller to determine the suitability of this product for any intended application. In no event will IMEC Corporation be responsible or liable for indirect or consequential damages resulting from the use of this controller.

The figures, tables and examples shown in this manual are intended solely to supplement the text. Because of the varied requirements of any particular application, IMEC Corporation cannot assume responsibility or liability for actual use based upon the illustrative uses and applications included in this manual.

WARNING

Dangerous voltages, currents, temperatures, torques, forces, and energy levels exist in this controller and its associated motor. Extreme caution and care should be exercised in the application of this equipment. Only qualified individuals should work on this controller and its application.

3.1 Unpacking and Inspection

Remove the controller from its shipping carton and check the items against the packing list. A nameplate located at the top of the controller next to the fuse holders identifies the unit by model number and serial number. Section 6.1 describes the model numbering system.

Inspect the controller for any physical damage that may have been sustained during shipment. All claims for damage whether concealed or obvious must be made to the shipper by the buyer as soon as possible after receipt of the unit.

Remove all packing materials from the unit. If the unit is to be stored, it should be stored in a clean, dry place. The storage temperature should be between -55°C and 70°C . To prevent damage during storage, it is recommended that the unit be stored in its original shipping carton after completing inspection for damage.

3.2 Mounting

Figure 2.1 illustrates the mechanical outline of the controller. Mounting is by four 5/16 inch slots located on an 8 inch square. The controller should be mounted on a flat, solid surface taking into consideration the approximate 16 lb. weight of the unit.

The controller should not be subjected to excessive vibration or shock. The environment should be free of corrosives, moisture and dust. Refer to Section 2.2 for the controller's environmental specifications. To insure proper cooling, there must be a minimum unobstructed space of 4 inches above and below the controller.

Since this controller is of "open frame" construction, it should be located within an enclosure to protect it from physical or environmental damage. The unit will fit in a standard 16" X 12" X 10" Hoffman enclosure.

3.3 I/O Definitions (Refer to Figure 3.1)

TB1-1 [+12 VDC]

-2 [-12 VDC]

-3 [12 VDC RTN]

These three terminals provide +12 VDC, -12 VDC and 12 VDC Return. The maximum allowable load on these supplies is 100 mA. These supplies are intended to power motor commutation transducers and/or an electronic brushless tachometer if present.

TB1-4 [MOTOR PTC]

-5 [MOTOR PTC RTN]

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. This input can also be interfaced to a thermostat (normally closed contact). This is a high impedance circuit and as such will require a thermostat intended for dry contact operation. See section 3.7.1 for contact current rating.

TB1-6 [KEY]

Connector keying.

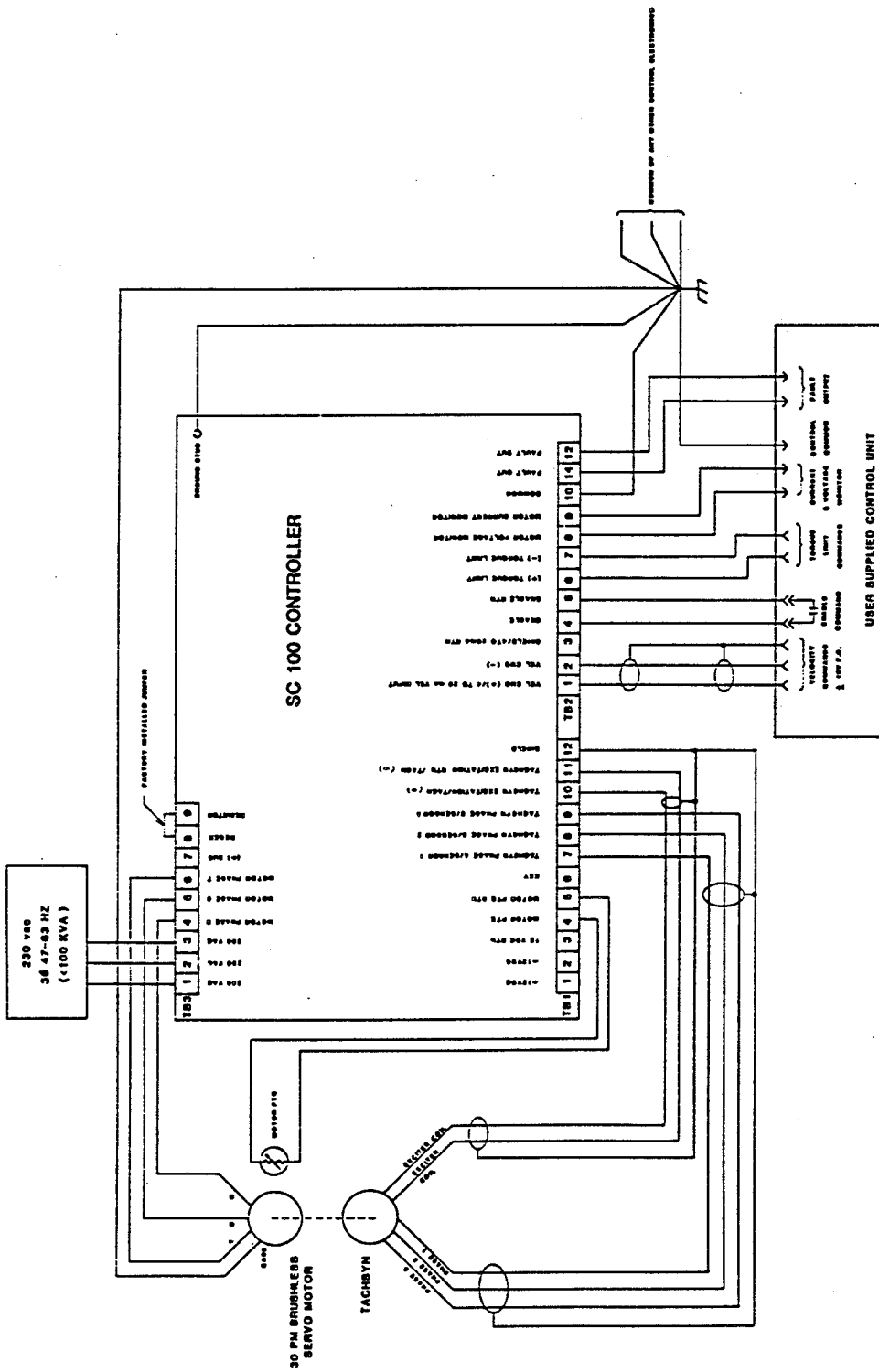
TB1-7 [TACHSYN[®] PHASE A/SENSOR 1]

-8 [TACHSYN[®] PHASE B/SENSOR 2]

-9 [TACHSYN[®] PHASE C/SENSOR 3]

These three terminals are the inputs for the three Tachsyn[®] output signals or for three digital commutation signals. A five position DIP switch selects whether the inputs are to be used for Tachsyn[®] interface or digital commutation signals. Set DIP switch S1-1,2,3 to OFF for use with the plug-in Tachsyn[®] Processor card. When S1-1,2,3 are ON, these inputs are each pulled-up to +12 VDC via a 22K ohm resistor and will accept +12 VDC CMOS compatible commutation signals.

REV	DATE	BY	CHKD	APPD
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				



NOTES:
1. IF THE USER SUPPLIED CONTROL UNIT IS NOT USED, THE TACHSYN UNIT MUST BE USED.
2. THE TACHSYN UNIT IS NOT USED IF THE USER SUPPLIED CONTROL UNIT IS USED.

FIG. 3.1

IMEC Corporation 5000 E. 1st Avenue Denver, CO 80231 (303) 751-1000	
MODEL	SC 100
SERIAL	804100010
CONTROLLER INTERCONNECTION DIAGRAM (WITH TACHSYN)	

- TB1-10 [TACHSYN® EXCITATION/TACH (+)]
-11 [TACHSYN® EXCITATION RTN/TACH (-)]
-12 [SHIELD]

These three terminals are outputs for the Tachsyn® excitation signals or inputs for a brushless tachometer signal. A five position DIP switch is used to select the desired function of these terminals. Set DIP switch S1-4,5 to OFF for use with the plug-in Tachsyn® Processor card. When S1-4,5 are ON, the terminals are a differential input for a brushless tachometer. The input will accept a ± 8 V Full Scale tachometer signal and has an input impedance of 10K ohm minimum. SHIELD is provided for connection of a cable shield.

- TB2-1 [VEL CMD (+)/4 to 20 mA VEL INPUT]
-2 [VEL CMD (-)]
-3 [SHIELD/4 to 20 mA RTN]

These three terminals are the Velocity Command inputs. The Velocity Command input can be either voltage mode or current mode. The user selects the desired input mode using the two S4 jumpers marked 20 mA and NORM. In NORM mode, VEL CMD (+) and VEL CMD (-) is a differential input which will accept a ± 10 V full scale Velocity Command signal and has a minimum input impedance of 10K ohm. In 20 mA mode, VEL CMD (+) is a 4 to 20 mA velocity Command input and SHIELD is the 4 to 20 mA return. Velocity control in this mode is unidirectional.

- TB2-4 [ENABLE]
-5 [ENABLE RTN]

The controller is enabled by closing a contact between these two terminals. An open collector transistor can also be used to enable the controller by connecting the collector to terminal 4 and the emitter to terminal 5. Terminal 4 input load is a 1K ohm pull-up to +12 VDC while terminal 5 is 12 VDC RTN. As such, the contact or transistor should have a rating exceeding 12 mA and 12 V.

- TB2-6 [(+) TORQUE LIMIT]

This terminal is (+) TORQUE LIMIT and is used to clamp the current (Torque) in one polarity. A 0.5 to 5 V signal can be used to limit the motor current at 10% to 100% of the controller's peak output current rating. Reducing the input below 0.5 V will not reduce the limit below 10%. This input is overridden by the I LIMIT potentiometer (see section 3.6) and hence if the pot is set to less than 100% this input will only be capable of pushing the current limit up to the potentiometer setting.

- TB2-7 [(-) TORQUE LIMIT]

This terminal is (-) TORQUE LIMIT and operates the same as TB2-6 but on current (Torque) of the opposite polarity. A symmetric torque limit can be achieved by wiring TB2-6 and TB2-7 together and driving them with a 0.5 to 5 V signal. Figure 3.3 illustrates the input structure of these TORQUE LIMIT inputs. If this input or the TB2-6 input is left unconnected, the current limit is set by I LIMIT.

- TB2-8 [MOTOR VOLTAGE MONITOR]

This terminal outputs a ± 7.5 V Full Scale signal which is proportional to the line-to-line controller output voltage. The scale factor of this output is 16 mV/V_{LL OUTPUT} nominal. The load on this output should be 20K ohm or greater.

- TB2-9 [MOTOR CURRENT MONITOR]

This terminal outputs a ± 5 V Full Scale DC signal which is proportional to the amplitude of the constant portion of the controller's six-step output current. The scale factor of this output is 0.33 V/A for the SC101/SC102, 0.167 V/A for the SC103, and 0.083 V/A for the SC104/SC105. The load on this output should be 20K ohm or greater. It may be necessary to low pass filter this signal (to attenuate residual high frequency carrier component) if it is to be used for instrumentation.

- TB2-10 [COMMON]

This is the controller common point and is at the same potential as 12 VDC RTN. This terminal provides a reference point for the TORQUE LIMIT signals and the monitor outputs.

- TB2-11 [FAULT OUT]
-12 [FAULT OUT]

These two terminals are attached to the fault relay contact. They are floating with respect to the Control Board common point. They should not exceed ± 50 V relative to COMMON. The contact is rated 24 VDC @ 250 mA. The contact is open if 230 VAC input power is not present, the controller is faulted or if an illegal power-up sequence has occurred i.e. 230 VAC power applied with an ENABLE signal present.

- TB3-1 [230 VAC]
-2 [230 VAC]
-3 [230 VAC]

These terminals are the 230 VAC, 3 phase inputs. No special phasing of the input is necessary. For the single phase input SC101 controller, TB3-2 is not used. The 230 VAC line rating must not exceed 100 KVA otherwise an isolation transformer (rating <100 KVA) must be used.

- TB3-4 [MOTOR PHASE R]
 -5 [MOTOR PHASE S]
 -6 [MOTOR PHASE T]

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 motor.

- TB3-7 [(+) BUS]
 -8 [REGEN]
 -9 [RESISTOR]

These terminals are used in applications requiring an external shunt regulator resistor. The standard controller has a factory installed jumper from TB3-8 to TB3-9 which connects the internal shunt regulator resistor. An external resistor can be added by removing the jumper and wiring the resistor between TB3-8 and TB3-7. Consult the factory regarding the use of an external shunt regulator resistor.

3.4 Controller Wiring

Figure 3.1 schematically illustrates the interconnection of the controller.

Wire sizes, wiring practices, and grounding/shielding techniques described in this manual are intended as a guideline only. Due to the variety of applications served by this controller, no single method of controller interconnection is universally applicable. The information included in this manual represents common servo controller wiring practices and should prove satisfactory in the majority of applications. However, local electrical codes, special operating conditions or system configurations should take precedence over the information provided herein.

Due to the switching nature of this or any other PWM controller, care should be exercised in routing power and signal wiring in the system. Noise radiated from nearby electrical or electronic equipment may cause undesired servo motor movement due to pickup by the controller's signal inputs. Likewise, the controller's power outputs can 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. Ideally the power and signal lines should be run in separate conduits or spaced at least 12" apart. Details of shielding are given later in this section.

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. Local electrical codes will usually outline the requirements regarding grounding of electronic equipment. The following suggestions and recommendations should be satisfactory in most applications.

A 14 AWG wire should be connected between an earth ground point and each of the following points:

- Controller ground stud
- Servo Motor case
- Input transformer ground stud, if applicable

Recommended wire sizes for the controller's 230 VAC input and motor output are given below. These recommendations are minimums i.e. a smaller wire gauge number (larger wire diameter) can also be used. The TB3 terminal strip will accept wire sizes from 12 AWG to 18 AWG.

230 VAC Input Wiring (TB3-1.2.3)

SC101	16 AWG
SC102	16 AWG
SC103	14 AWG
SC104	12 AWG
SC105	12 AWG

Motor Wiring (TB3-4.5.6)

SC101	16 AWG
SC102	16 AWG
SC103	14 AWG
SC104	12 AWG
SC105	12 AWG

To reduce radiated noise, the 3 motor leads should be twisted together. Additionally, the motor's ground wire should be twisted together with the 3 motor leads. To further reduce radiated noise, IMEC can supply a toroid through which the 3 motor leads are wrapped several times. This technique typically eliminates any noise problems.

The external Shunt Regulator resistor option is wired to TB3-7 and TB3-9. Wiring size for these connections is dependent upon the power rating of the specific application. Consult the factory for recommendations.

Controller signal connections are all made to plug-in terminal strips TB1 and TB2. Connections to these terminal strips must be made with the plug section removed from the controller to prevent damage to the Control Board. The terminal strips will accept 22 AWG to 16 AWG wire.

The TB1 plug-in terminal is keyed at position 6 to prevent exchanging the TB1 and TB2 plug sections. This keying will allow plug TB2 to be put in socket TB1 but TB1 will not go into socket TB2. Check the keying before inserting TB1 and TB2.

TB1 provides the interface to all motor related signal connections. Terminals TB1-1,2,3 provide +12 VDC, -12 VDC, and 12 VDC Return respectively to power commutation transducers and/or a brushless tachometer if used. These wires should be 20 AWG or larger and twisted together to minimize noise pickup.

A positive temperature coefficient thermistor (PTC) mounted on the motor windings can be used to protect the motor against thermal overload damage. The PTC should be wired to TB1-4 and TB1-5 using twisted pair 22 AWG wires or larger. The controller is set up to use a PTC which has a cold resistance of approximately 3K ohm that goes to 22K ohm at the desired trip-out temperature. This set-up will work with Pacific Scientific's standard motor PTC. Alternately, a thermostat can be used in place of the PTC. The thermostat contact should be normally closed and open at the desired trip-out temperature. The thermostat must be rated for dry contact operation since the sensing circuit is high impedance. See Section 3.7.1 for more information regarding the use of a thermostat or a PTC which has a different resistance versus temperature characteristic.

Terminals TB1-7,8 and 9 interface to a motor mounted Tachsyn® or digital commutation transducers such as Hall-Effect devices. Dip switch S1 selects the mode of these inputs. In either case these signals must be wired using a three conductor, shielded, 22 AWG or larger cable such as Belden 8771. The shield is connected to TB1-12. The other end of the shield is not connected and is insulated to prevent accidental connection.

Terminals TB1-10,11,12 also interface to the Tachsyn®, or to an electronic brushless tachometer. DIP switch S1 selects the mode of these terminals. In either case, these signals must be wired using a two conductor, shielded, 22 AWG or larger cable such as Belden 8761. The shield is connected to TB1-12. The other end of the shield is not connected and is insulated to prevent accidental connection.

TB2 provides the interface to the controller command signals, monitor signals and fault status signal. Terminals TB2-1,2,3 accept the Velocity Command from the user's equipment. These terminals will accept a voltage mode or current mode Velocity Command signal. The two S4 jumpers select the desired mode. The velocity command wiring should be done using a two conductor, shielded, 22 AWG or larger cable such as Belden 8761. It is recommended that the shield be wired at the user's equipment. Optionally, the shield can be wired at the controller, terminal TB2-3. **Under no circumstances should the shield be wired at both ends; only one end or the other should be connected.** The unconnected end of the shield should be insulated to prevent accidental connection.

The ENABLE command is interfaced at TB2-4 and 5. This signal should be wired using 22 AWG or larger wire in a twisted pair.

Terminals TB2-6 and 7 are the TORQUE LIMIT inputs. TB2-10 is the reference point for these two inputs which accept signals of 0 to 5 V. The two monitor signals on TB2-8 and 9 are also referenced to TB2-10. These outputs are analog signals and should have a load of 20K ohm or greater. All five of these signals should be wired using 22 AWG or larger wire. If a signal isn't being utilized, do not wire it since the unused lead will act as a noise pick-up. The leads from TB2-6,7,8,9 should be bundled with the lead from TB2-10.

The final two terminals are TB2-11 and 12. These terminals are the FAULT OUT signal which should be wired using a twisted pair of 22 AWG or larger wire. The FAULT OUT is a relay contact rated at 24 VDC, 250 mA. These two terminals must be kept within ± 50 V relative to TB2-10.

An important aspect of the controller wiring is the proper connection of the 3 motor terminals and the commutation signals. The controller will not properly drive the motor if these signals are not phased correctly.

The standard SC100 Servo Controller is designed for use with a Tachsyn® feedback transducer. This transducer provides all necessary commutation and velocity information for the controller. The Tachsyn® signals are interfaced via TB1 and processed by a plug-on Tachsyn® Processor card. Figure 3.1 shows the interconnection of the SC100 Servo Controller to a Pacific Scientific motor equipped with a Tachsyn®.

The SC100 can also be used with Hall-Effect sensors or other types of commutation transducers which produce +12 VDC CMOS compatible commutation signals. Jumpers CH1, CH2, and CH3 can provide an inversion to the respective SENSOR 1,2 and 3 signals to allow the use of 60° or 120° commutation signals. The SC100 can also accept velocity feedback information from a brushless tachometer or any other type of device which will produce an analog velocity signal.

3.5 Plug Jumper/DIP Switch Set-up

The controller has eight plug jumpers and one five position DIP switch which allow the user to select various controller modes. Remove the front panel by unscrewing the four nylon mounting screws to get to the Control Board. Location of the jumpers and DIP switch are shown in Figure 3.2. The controller is delivered with all eight plug jumpers installed.

CH1, CH2, CH3

These three jumpers are located at the center right portion of the Control Board and are used to provide an inversion on each of the respective SENSOR 1, SENSOR 2, SENSOR 3 commutation signal lines. Inversions of commutation signals are used to accommodate various versions of commutation signals.

PUR

The controller is designed to be powered-up with the ENABLE input inactive. If 230 VAC power is applied while the ENABLE input is active, the controller will not indicate a fault by an LED but the FAULT OUT contact will remain open and the output will not be enabled. This feature is intended to prevent unexpected motor operation after an interruption of 230 VAC power. A jumper labelled "PUR" is located in the lower center portion of the Control Board. If this PUR jumper plug is removed, this feature will be defeated. The controller will now power-up regardless of the ENABLE input status.

TACH

The TACH jumper, located next to the PUR jumper, will defeat the TACH FAULT circuit if it is removed. This jumper must be removed if the controller is used in a torque control mode without a tachometer. **This fault circuit can be extremely sensitive and cause nuisance faults in many applications. IMEC recommends that this fault circuit be enabled during controller installation to protect against accidental motor runaways. In actual operation, the use of this fault circuit will depend upon the application but typically the circuit will be disabled to prevent nuisance faults.**

DIS

The DIS jumper, also located next to the PUR jumper, will disable the I^t protection circuit if the jumper is installed. This will prevent the controller from folding back the current limit to the continuous current rating level if excessive time is spent at peak currents.

NORM/20 mA

There are two jumpers for this function selection located in the lower right corner of the control board. These jumpers are used to select the desired Velocity Command input mode. The two jumpers are factory installed in the NORM position which sets the controller up with a voltage mode Velocity Command. One jumper connects S4-1 to S4-2 and the other jumper connects S4-6 to S4-5. If the current mode (4 to 20 mA) Velocity Command is desired, the two jumpers should be moved to the 20 mA position i.e. one jumper connects S4-2 to S4-3 and the other jumper connects S4-5 to S4-4.

DIP Switch S1

A five position DIP switch is located just above connector TB1. This DIP switch is used to set the controller for the desired commutation and velocity feedback devices. In the standard configuration, a Tachsyn[®] Processor card is plugged into the J3/J4 connectors on the Control Board. **All five positions of DIP switch S1 must be set to OFF when using the Tachsyn[®] Processor.** If the controller is to be used with Hall-Effect devices and/or a brushless tachometer, all S1 positions must be set to ON and the Tachsyn[®] Processor card must be removed. The following table summarizes the operation of each S1 switch.

DIP Switch S1 Setting

Switch	Input Affected	Switch State/Function	
		OFF	ON
S1-1	TB1-7	Tachsyn [®] Phase A	Commutation Sensor 1
S1-2	TB1-8	Tachsyn [®] Phase B	Commutation Sensor 2
S1-3	TB1-9	Tachsyn [®] Phase C	Commutation Sensor 3
S1-4	TB1-10	Tachsyn [®] Excitation	Tach (+)
S1-5	TB1-11	Tachsyn [®] Excit. Rtn.	Tach (-)

3.6 Potentiometer Set-up

The controller has five user adjustments located on the Control Board. Figure 3.2 shows the location of these potentiometers and Figure 3.3 shows their function in the Velocity Loop circuit.

OFFSET, R83

This 20 turn potentiometer is used to adjust the Velocity Loop offset to zero. With a Velocity Command of zero applied to the controller's VEL CMD input, turn R83 until the motor stops turning.

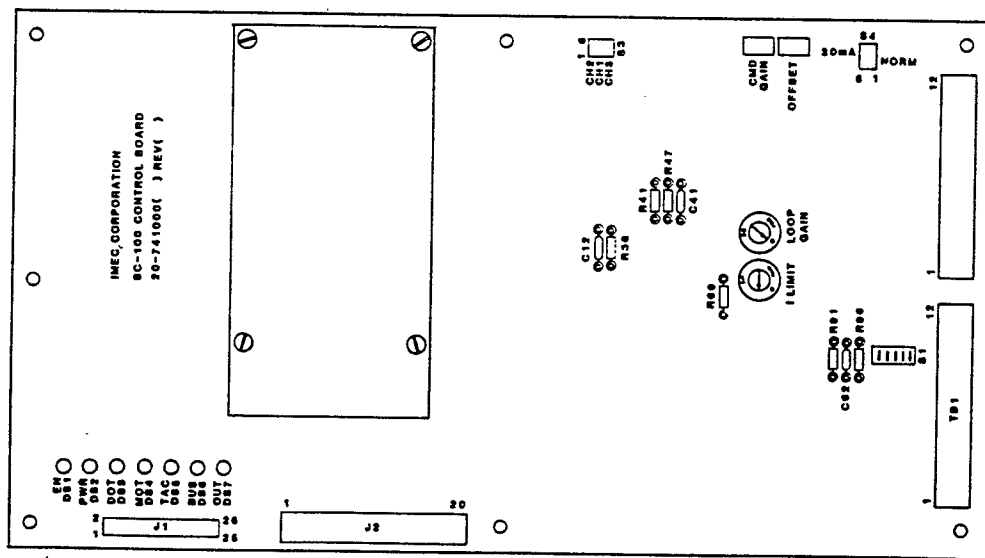


FIGURE 3.2

CMD GAIN, R76

Another 20 turn potentiometer, R76, is used to set the velocity command gain. This adjustment allows the user to vary the "RPM/Volt" scale factor of the command input. The potentiometer allows gain adjustment over a $\pm 40\%$ range about nominal. Clockwise rotation of R76 reduces the "RPM/Volt" input scale factor.

I LIMIT, R71

The graduated, single turn potentiometer, R71, adjusts the peak output current limit. The graduations are calibrated as percentage of peak output current rating, i.e. setting the adjustment to 50 will limit the peak output current to 50% of the controller's peak output rating. The adjustment operates in this manner over the 10% to 100% range. If the adjustment is turned below 10, the limit point remains at 10%. Note that this adjustment overrides the (+) TORQUE LIMIT and (-) TORQUE LIMIT inputs, i.e. these inputs cannot cause more output current than set by the I LIMIT potentiometer.

LOOP GAIN, R72

The adjustment, R72, is also a graduated, single turn potentiometer. This adjustment is used to vary the AC loop gain of the Velocity Loop. The adjustment has an 11 to 1 range and is graduated to allow the user to "calibrate" the controller set-up for the specific application, i.e. if the controller or Control Board is replaced, setting of this adjustment is simple. Velocity loop dynamics which are affected by the motor and load can be adjusted using this potentiometer. Information on its adjustment is contained in Section 3.8.

4 mA ADJ. R87

Adjustment, R87, is a single turn potentiometer. This adjustment is used to trim the 4 mA level for the 4 to 20 mA velocity command input.

3.7 Special Adjustments

Figures 3.2 and 3.3 show several resistors and capacitors mounted on solder posts. These components control the velocity loop dynamics, the current loop dynamics, and the Motor PTC input (TB1-4 and 5). The controller comes from the factory with standard component values installed in these solder posts. The remainder of this section describes how to change these values if necessary. If solder post mounted components are changed, the replacement components should be specified as below:

Resistors — 1%, 1/4 watt, metal film

Capacitors — 10%, 50 volt, X7R or BX monolithic ceramic

If the user wants special values installed to tailor the controller to a specific application, custom value components can be installed by the factory. Consult the factory or the local IMEC representative regarding the Custom Compensation Option.

3.7.1 Motor PTC Input Adjustment (R66)

Figure 3.4 shows the Motor PTC input structure and resistor R66 which is the input pull-up. Comparator U27 has 2.17 VDC applied to its non-inverting input as a reference. With R66 at the factory installed 100K ohm value, the Motor PTC should be selected to have an approximate 22K ohm resistance at the desired motor trip-out temperature. This value corresponds to the standard PTC used in Pacific Scientific Brushless Servo Motors. By changing R66, the user can tailor the Motor PTC input to match the PTC provided with the motor if it differs from the standard. The value of R66 is calculated by the formula:

$$R66 = (4.5) (R_{PTC} + 0.1)$$

where R66 = value of resistor R66 in Kohms.

R_{PTC} = value in Kohms of motor mounted PTC at the desired tripout temperature.

(Note: R66 has to be 1K ohm or larger).

A contact-type, normally closed thermostat can be used in place of a PTC. However, the contact must be rated for low current operation since the largest current available is 12 mA ($R66 = 1K$ ohm).

3.7.2 Current Loop Dynamics Adjustment (R36, C12)

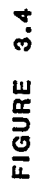
Resistor R36 and capacitor C12 control the proportional plus integral compensation of the controller current loops. These components are shown in Figure 3.2 but not in Figure 3.3 since they are not part of the Velocity Loop. They are used to adjust the current loop dynamics in situations where the motor inductance is too large for the nominal compensation installed at the factory. Custom current loop compensation to match the Pacific Scientific motor being used is available, consult the factory or the local IMEC representative. Since misadjustment of these components can cause possible damage to the controller's power section, extreme care should be exercised if changing these components. Consult the factory if in doubt.

For SC101/SC102, use the following formula to determine the value of resistor R36:

$$10 \text{ mH} < L_{LL} < 20 \text{ mH. } R36 = 68.1K \text{ ohm [standard value]}$$

$$L_{LL} > 20 \text{ mH. } R36 = 68.1K \text{ ohm} \times (L_{LL}/20 \text{ mH})$$

where R36 is in Kohms and L_{LL} is the line-to-line motor inductance in milliHenries.



1. 

DENOTES SOLDER POST



Hercules Corporation
A Subsidiary of Pacific Scientific

The Schrafft Center, 529 Main Street, Charlestown, MA 02129

DECIMAL	SC100	SCALE	DRAWN BY <i>Eric A. Ambrosio</i> APPROVED BY <i>W. E. Rye</i>	MOTOR PTC INPUT CIRCUIT	
FRACTIONAL	TITLE				
ANGULAR	DATE	DRAWING NUMBER			
	9 FEB 84	A04100007	1	1	1

For SC103, use the following formula to determine the value of resistor R36:

$$5 \text{ mH} < L_{LL} < 10 \text{ mH}, R_{36} = 68.1\text{K ohm [standard value]}$$

$$L_{LL} > 10 \text{ mH}, R_{36} = 68.1\text{K ohm} \times (L_{LL}/10 \text{ mH})$$

where R36 is in Kohms and L_{LL} is the line-to-line motor inductance in milliHenries.

For SC104/SC105, use the following formula to determine the value of resistor R36:

$$2.5 \text{ mH} < L_{LL} < 5 \text{ mH}, R_{36} = 68.1\text{K ohm [standard value]}$$

$$L_{LL} > 5 \text{ mH}, R_{36} = 68.1\text{K ohm} \times (L_{LL}/5 \text{ mH})$$

where R36 is in Kohms and L_{LL} is the line-to-line motor inductance in milliHenries.

NOTE: R36 must never be less than 68.1K ohm.

If the motor inductance is less than the values given above, consult the factory.

If resistor R36 is changed, capacitor C12 must be changed per the following formula:

$$C12 = 3.2/R36$$

where R36 is in Kohms and C12 is in μF .

3.7.3 Tachometer Lead Network Adjustment (R91, C62)

Resistor R91 and capacitor C62 provide a tachometer lead network. Since such a network is only used in certain applications, the controller is shipped from the factory without components installed in these locations. Component selection for these locations should be determined by the user according to the specific application.

3.7.4 Tachometer Gain Adjustment (R96)

Resistor R96 is the tach gain setting resistor. This resistor along with the "CMD GAIN" potentiometer R76 determines the gain of the "VEL CMD" input. The formula below defines the "VEL CMD" gain:

$$K_{CMD} = \frac{(R96)}{2 (R75 + R76)} \cdot \frac{1}{K_{TACH}}$$

where K_{CMD} = VEL CMD input gain in Krpm/Volt

K_{TACH} = Tachometer gain in Volt/Krpm.

Using the standard factory value of 10K ohm for R96 ($R75 = 6.81\text{K ohm}$ and $0 < R76 < 10\text{K ohm}$) gives the following range of "VEL CMD" gains:

$$\frac{0.30}{K_{TACH}} < K_{CMD} < \frac{0.73}{K_{TACH}}$$

or for other values of R96

$$\frac{R96}{33.62 K_{TACH}} < K_{CMD} < \frac{R96}{13.62 K_{TACH}} \quad \text{where R96 is in Kohms}$$

Exercise caution if changing the value of resistor R96. If a brushless tachometer is used in the system, note that it has an output saturation point at about $\pm 9 \text{ V}$ due to its internal op amp. If R96 is made too large and the "VEL CMD" input is not limited, the tachometer output can be saturated. At saturation, increases in tachometer speed will not be reflected in its output since it is voltage limited. This would lead to a runaway condition until the speed was brought back within the linear output range of the tach. The following formula defines the limits on R96 and the "VEL CMD" amplitude to insure linear tach operation:

$$(V_{CMD}) (R96) < 122$$

where V_{CMD} = VEL CMD maximum amplitude.

R96 = resistance of R96 in Kohms.

Note that with the standard value of $R96 = 10\text{K ohms}$ the "VEL CMD" input can be $\pm 12.2 \text{ V}$ maximum. Larger values of R96 can be used as long as the "VEL CMD" maximum amplitude is reduced.

3.7.5 Velocity Loop DC Gain Adjustment (R41)

R41 sets the DC gain of the velocity loop. In many positioning control applications, a well-defined, finite DC gain is desired to insure proper operation of the position loop. If desired, the DC gain limit can be eliminated by removing R41. This may be desirable in a speed control application. The DC gain is defined as the velocity error needed to produce full motor torque (current). From Figure 3.3 note that full current is produced by a 5 V current command. The formula below defines the velocity error voltage, V_E , necessary to produce full motor torque:

$$V_E = \frac{R96}{(20) (R41)}$$

For the standard values of $R96 = 10K \text{ ohm}$ and $R41 = 100K \text{ ohm}$, $V_e = 5 \text{ mV}$ hence a 5 mV velocity error voltage will produce full motor torque. Note that this DC gain is not affected by the "LOOP GAIN" adjustment R72.

3.7.6 Velocity Loop Dynamics Adjustment (R47, C41)

These two components along with the "LOOP GAIN" potentiometer R72 set the velocity loop dynamics. Resistor R47 and the potentiometer R72 set the dynamic gain of the velocity loop and hence control the velocity loop bandwidth. Capacitor C41 along with resistor R47 sets the frequency at which the velocity loop transitions from integral to proportional control.

The motor and mechanical load affect the velocity loop dynamics. Typically the motor torque constant, K_T , and the motor plus load inertia, J_L , are the main parameters of interest. These two parameters affect the dynamic velocity loop gain by K_T/J_L . "LOOP GAIN" adjustment may not have sufficient range. In this case, resistor R47 would have to be increased to bring the gain within the range of the R72 adjustment.

The transition frequency of the velocity loop from integral control to proportional control should be kept at least a factor of two below the bandwidth of the velocity loop to insure stable operation. With the standard values of R47 and C41, the transition frequency is 16 Hz , hence bandwidths down to approximately 30 Hz are no problem. If a lower bandwidth is needed, capacitor C41 should be increased to reduce the transition frequency. The transition frequency is defined by:

$$F_T = \frac{159}{(R47)(C41)}$$

where F_T in Hz , R47 in Kohms, and C41 in μF .

In some applications, torsional motor shaft resonances can be a problem, especially in cases with a large load inertia. These resonances usually manifest themselves as a high frequency ($> 300 \text{ Hz}$) oscillation. The simplest solution to such a resonance problem is to reduce the velocity loop bandwidth as low as system performance requirements will allow. If this does not solve the problem, contact the factory.

In most applications, the standard values of R47 and C41 will be sufficient. Section 3.8.1 outlines the procedure for selecting other values of R47 and C41 if necessary.

If the controller is to be used in a "torque block" mode, i.e without a tachometer or equivalent velocity feedback transducer, the following procedure should be followed. Remove R41, R47, and C41. Place a jumper wire in the C41 location. Set R72 to "0".

The following formula defines the value of resistor R47 necessary to obtain the desired "VEL CMD" gain for torque block operation:

$$(0.09)(R47) < K_{CMD} < (0.22)(R47) \text{ for SC101/SC102}$$

$$(0.18)(R47) < K_{CMD} < (0.44)(R47) \text{ for SC103}$$

$$(0.36)(R47) < K_{CMD} < (0.88)(R47) \text{ for SC104/SC105}$$

where K_{CMD} is "VEL CMD" input gain in Amps/Volt, R47 in Kohms.

The range of K_{CMD} is controlled by "CMD GAIN" potentiometer R76.

3.8 Initial Power Up

Every controller is burned-in and fully tested before leaving the factory. However, it is possible that damage has been sustained by the controller during shipping. This procedure should be followed to insure that the controller has not sustained shipping damage and has been installed properly. If problems are encountered during this procedure, refer to Section 4 or the appropriate section of this manual. Procedure A assumes that the controller is configured as a velocity block using a Tachsyn[®] and has a Tachsyn[®] Processor card installed. If the unit is configured as a torque block without velocity feedback refer to Procedure B. Procedure B assumes that Hall-Effect devices are used for commutation signals and there is no Tachsyn[®] Processor installed.

3.8.1 Procedure A

- (1) Check that the unit has been wired and mounted per instructions in Sections 3.2 and 3.4 of this manual. Be especially careful in checking the 230 VAC input and motor connections.
- (2) Set the adjustments and jumpers as follows:

Plug Jumpers

PUR	Insert if enable lockout desired.
TACH	Insert.
CH1	Insert.
CH2	Insert.
CH3	Insert.
DIS	Insert if I*t disable desired.

Potentiometers

LOOP GAIN	Set to "0"
I LIMIT	Set to "0"
CMD GAIN	Factory Set
OFFSET	Factory Set
4 mA ADJ	Factory Set

DIP Switch

S1-1	OFF
S1-2	OFF
S1-3	OFF
S1-4	OFF
S1-5	OFF

- (3) Insure that the ENABLE input is inactive.
- (4) Apply 230 VAC power to the controller.
- (5) Verify that only the "PWR" LED is lit.
- (6) ENABLE the controller.
The motor may rotate at this point. Be prepared to disable the controller or remove 230 VAC power if excessive motion occurs.
- (7) Command a small velocity.
- (8) The motor should be stable or rotate slowly in one direction.
- (9) Slowly rotate the "I LIMIT" adjustment clockwise toward "100". The motor should rotate slowly in a smooth, controlled manner. If operation appears normal, set the "I LIMIT" to the desired value. If the "TAC" LED lights, remove 230 VAC power, check Tachsyn[®] wiring and restart this procedure. If the motor rotates normally, but the direction opposite of that desired for the given "VEL CMD" input polarity, do the following: Remove 230 VAC power, reverse the Tachsyn[®] excitation leads TB1-10 and TB-11. Restart this procedure.
- (10) If the motor is rotating smoothly, slowly turn the "LOOP GAIN" adjustment clockwise until "100" has been reached or until the motor begins to oscillate. Turn the adjustment counterclockwise approximately 1/8 turn to achieve final setting. This is a simple, empirical way of setting the velocity loop dynamics. If a more exact response is desired, attach an oscilloscope to the tach output. Input small velocity steps and monitor the tach output. Adjust "LOOP GAIN" to obtain the desired step response.
- (11) If the motor oscillates at all settings of the "LOOP GAIN" adjustment, the compensation components R47 and C41 must be changed. Remove 230 VAC power and remove R47. Replace R47 with a resistor decade box set at 100K ohms (or at 100K ohm resistor). Place a capacitor decade box set at 1 μ F across C41. Restart this procedure at step (3). Insure that the "LOOP GAIN" adjustment is at "0". If the motor still oscillates contact the factory. Slowly rotate "LOOP GAIN" clockwise until the motor oscillates. Turn the adjustment 1/8 turn counterclockwise to achieve the final setting. As before if a more exact response is desired, monitor the velocity loop's step response. Decrease the value of C41 until overshoot occurs or increase it until the overshoot disappears. Next adjust R47 to further shape the step response.
- (12) After the response has been set, set the "VEL CMD" input to zero. Adjust "OFFSET" until motor rotation is zero.
- (13) Apply a known voltage to the "VEL CMD" input. Monitor the motor speed using the tach output voltage (TP4 on Control Board) or some other means. Adjust "CMD GAIN" to obtain the desired "VEL CMD" gain.

3.8.2 Procedure B

- (1) Check that the unit has been wired and mounted per instructions in this manual. Be especially careful in checking the 230 VAC input and motor connections.
- (2) Set the adjustments and jumpers as follows:

Plug Jumpers

PUR	Insert if enable lockout desired.
TACH	Remove.
CH1	Insert.*
CH2	Insert.*
CH3	Insert.*
DIS	Insert if I*t disable desired.
NORM/20 mA	Insert in NORM position.

* This is the correct jumper setting for a Pacific Scientific Brushless Servo Motor with Hall-Effect devices. Other motors may require a different setting.

Potentiometers

LOOP GAIN	Set to "0"
I LIMIT	Set to "0"
CMD GAIN	Factory Set
OFFSET	Factory Set
4 mA ADJ	Factory Set

DIP Switch

S1-1	ON
S1-2	ON
S1-3	ON
S1-4	ON
S1-5	ON

- (3) Insure that the ENABLE input is inactive.
- (4) Apply 230 VAC power to the controller.
- (5) Verify that only the "PWR" LED is lit.
- (6) ENABLE the controller.
Insure that the "VEL CMD" input is zero. The motor may rotate at this point. Be prepared to disable the controller or remove 230 VAC power if excessive motion occurs.
- (7) Command a small current (torque).
- (8) The motor should rotate in a smooth manner. If it rotates in the opposite direction of that desired for the given "VEL CMD" input polarity, do the following: Remove 230 VAC power, and complement the CH1, CH2, and CH3 jumpers. i.e. remove jumpers that are in place and install jumpers where there are none. Restart this procedure.
- (9) "I LIMIT", "CMD GAIN" and "OFFSET" adjust torque limit, torque command gain, and offset torque respectively when the controller is in this configuration. These adjustments are best made by using the Motor Current Monitor output. Attach a voltmeter between TB2-9 and TB2-10 and set it to read 5 V full scale. Set the "VEL CMD" input to zero. Adjust "OFFSET" until the voltmeter reads approximately zero. Lock the motor shaft in place. Turn the "I LIMIT" adjustment to "100". Apply a 1 VDC signal to the "VEL CMD" input. Adjust "CMD GAIN" to get the desired output current for a 1 volt command. The monitor output signal gain is 0.33 V/A for the SC101/SC102, 0.167 V/A for the SC103, and 0.083 V/A for the SC104/SC105. Finally set "I LIMIT" by the graduated markings on R71 or by applying a signal to the "VEL CMD" input to obtain full output current and then adjusting "I LIMIT" until the voltmeter indicates the desired current limit point.

SECTION 4

TROUBLESHOOTING

Controller faults are indicated by the five red and two green diagnostic LEDs mounted in the upper left corner of the Control Board. These LEDs are visible through the window in the Front Panel. Faults will also be indicated by an open FAULT OUT contact (TB2-11 and TB2-12).

The controller fault indicators can also be used to identify system faults since many times such faults will manifest themselves through the controller.

Before proceeding through the troubleshooting sequence verify that the input fuses and control voltage supply fuse are intact and that 230 VAC is present at the controller's input terminals.

WARNING

Dangerous voltages, currents, temperatures, torques, forces, and energy levels exist in this controller and its associated motor. Extreme caution and care should be exercised in the application of this equipment. Only qualified individuals should work on this controller and its application.

The only field serviceable component on the controller is the Control Board (See Section 5.2). It is recommended that in the event of a controller failure the entire unit be replaced and the defective unit returned to the factory for repair. **Verify that the controller is defective before replacing or returning for repair.**

During troubleshooting, the highest priority LED is DS2, PWR. If this LED is not lit, a fault has occurred on the ± 12 V supplies. In this case, ignore any other fault LEDs since they could be false indications due to the loss or interruption of the ± 12 V power.

An intermittent short on the ± 12 V supply may trip-out the controller but not indicate the fault. This would occur due to the ± 12 V being shorted long enough to clear the power-up reset circuit. Upon removal of the ± 12 V short circuit, a power-up reset would be generated which would clear all fault indicators. If the PUR jumper is installed, the controller would interpret this sequence of events as an illegal power-up sequence and would come up as described in Section 3.5. If the PUR jumper is not installed, the controller will cycle on and off with the ± 12 V short circuit which will result in erratic operation.

TROUBLESHOOTING GUIDE

Symptom	Possible Cause
Enabled LED not lit (DS1)	<ul style="list-style-type: none"> * Enable wire(s) to the controller open. * Enable command source defective. * Control Voltage(s) not present, see "PWR LED not lit". * Defective Control Board
PWR LED not lit (DS2)	<ul style="list-style-type: none"> * 230 VAC power not applied. * 230 VAC power out of tolerance (+10%, -15%). * Blown fuse. * Short circuit on the ± 12 V outputs, TB1-1, TB1-2 and TB1-3. * Defective Control Board or Control Voltage Transformer.
DOT LED lit (DS3) [Drive Overtemperature]	<ul style="list-style-type: none"> * Heatsink overtemperature due to excessive ambient temperature or excessive RMS output current. * Shunt Regulator resistor overtemperature due to excessive average regenerated power. * Heatsink airflow restricted. * Defective PTCs or Control Board. * Defective Shunt Regulator. * Fan clogged or stopped (SC105 only)

Symptom	Possible Cause
MOT LED lit (DS4) [Motor Overtemperature]	<ul style="list-style-type: none"> * Motor PTC connection(s) open. If a motor PTC is not being used place a jumper between TB1-4 and TB1-5. * Motor thermal overload due to excessive ambient temperature or excessive RMS motor current. * Defective Motor PTC, check resistance cold and hot. * Defective Control Board.
TAC LED lit (DS5) [Tachometer Fault]	<ul style="list-style-type: none"> * Tach connections open or shorted. If a tachometer is not being used, remove TACH jumper. (See Section 3.5). * Tach connections are reversed. This should only occur during installation/set-up or motor replacement. * Tachometer control supply connections TB1-1, TB1-2 and TB1-3 open circuit.
BUS LED lit (DS6) [Bus Fault]	<ul style="list-style-type: none"> * DC Bus overvoltage due to Shunt Regulator failure or excessively high 230 VAC input. Also can be due to excessive peak regenerated power. * DC bus undervoltage due to internal bus short circuit or a low 230 VAC input. Can also be caused by a 230 VAC dropout lasting longer than 20 milliseconds or less if the motor is at full power. * Incorrectly wired external dump resistor. Double check wiring.
OUT LED lit (DS7) [Output Fault]	<ul style="list-style-type: none"> * Motor power connections line-line short circuit. * Motor power connection(s) line-ground short circuit. * Motor internal winding short circuit. * Motor with insufficient inductance. * Output transistor or Base Driver failure. * Deadband circuit failure (Control Board).
Controller is enabled and no faults are indicated but motor does not respond.	<ul style="list-style-type: none"> * Check Fault Out contact, if it is open the controller has been improperly sequenced. Remove ENABLE signal, cycle 230 VAC power and then reapply the enable. (See Section 3.5). * Check for open motor connection(s). * Check for seized load or excessive load friction. * Verify that a velocity command is reaching the controller TB1-1 and TB2-2. * Verify that motor commutation signals are reaching the controller TB1-7, TB1-8, and TB1-9. * I LIMIT adjustment is turned down too low.

Symptom	Possible Cause
System unstable	<ul style="list-style-type: none"> * Velocity loop compensation or Loop Gain adjustment are incorrect. (See Section 3.6 and 3.7). * Check for excessive noise on the tachometer feedback signal or the velocity command signal. * User supplied position loop is improperly compensated.
System Runaway	<ul style="list-style-type: none"> * Tach Fault has occurred but "Tach" jumper is removed (See Section 3.5). * User supplied position loop has failed.
Erratic Motor Operation	<ul style="list-style-type: none"> * Improper motor connection(s). Incorrect phasing of motor, and/or commutation signals. * Noise, poor grounding, or poor shielding corrupting the velocity command and/or tachometer signal.
Peak current not achievable	<ul style="list-style-type: none"> * I^t circuit is operating and folding back the current limit point.

SECTION 5

MAINTENANCE

5.1 Routine Maintenance

The SC100 Series of Brushless Servo Controllers are designed for minimum maintenance. The following limited procedures performed on a regular basis should result in trouble-free controller operation if the unit has been installed and set-up in accordance with this manual.

WARNING

Dangerous voltages, currents, temperatures, torques, forces, and energy levels exist in this controller and it's associated motor. Extreme caution and care should be exercised in the application of this equipment. Only qualified individuals should work on this controller and its application.

- * Examine the controller for dust and dirt build-up. Insure that the heatsink fins and cooling slots are free of any build-up. The heatsink fins can be cleaned by clean, dry, low pressure air (<30 psi). For the SC105, check that the fan is clean and rotating properly.
- * Remove the Front Panel and remove any dust and dirt build-up from the Control Board. Use clean, dry, low pressure air (<30 psi). Replace the Front Panel.
- * If the controller has a significant build-up of dust, dirt or grease, or if it has been exposed to corrosive or electrically conductive contaminants, it should be removed from service and cleaned using agents suitable for use on printed wiring boards and electronic components.

5.2 Control Board Replacement

The only field serviceable component on the controller is the Control Board. Any other repairs should be performed by IMEC authorized repair personnel.

Replacement of the Control Board is straight forward. Follow the procedure listed below:

1. Remove the four nylon thumbscrews holding the front panel in place and remove the panel.
2. Unplug the TB1 and TB2 terminal strips.
3. Unplug the J1 ribbon connector.
4. Remove the four hex nylon spacers.
5. Remove the Control Board by disengaging the two locking board supports.
6. Place the replacement Control Board on the board supports and gently push until the two locking board supports engage.
7. Replace the connectors and Front Panel by following steps 1 through 4 in reverse.

The defective board should be packed in the shipping carton from the replacement board and returned to IMEC Corporation for repair.

Controllers returned for repair should be packed in the shipping carton from the replacement controller and returned to IMEC Corporation for repair.

The buyer is responsible for proper packing and shipment of controllers or Control Boards returned for repairs. In no event will IMEC Corporation be responsible or liable for damage resulting from shipment.

5.3 Fuse Replacement

The controller is fused for protection by four 230 VAC fuses which are located at the top right of the controller.

WARNING

Disconnect input voltage and allow at least 1 minute or more for internal voltages to decay before servicing the unit or replacing fuses.

The Control Voltage Supply fuse is a 1/4" X 1-1/4" Dual Element, 1/2 A, 250 V unit. Replace only with a Bussman MDL 1/2 or equivalent. The fuseholder for this fuse is bayonet-style, hence push and turn to remove the fuse.

The main input fuses are Time Delay, 20 A or 30 A, 300 V units. Replace only with Bussman fuses listed below or the equivalent. The fuseholders for these fuses are screw-type, hence unscrew counterclockwise to remove a fuse.

SC100 Model	Bussman Fuse
SC101	SC20
SC102	SC20
SC103	SC20
SC104	SC30
SC105	SC30

SECTION 6

PRODUCT NUMBERING

6.1 Product Numbers

The SC100 Series Brushless Servo Controllers are designated by the model numbering system shown below. The first field designates the Series member by power level. The second field is for a Customization Code. The standard product has a Customization Code of 001. For special orders, IMEC will assign a unique Customization Code to identify the special requirements. The final field is for Option Code. If this field is left blank, the controller will be set-up for use with digital commutation devices such as Hall-Effect transducers and a brushless tachometer (Tachsyn® Processor card is not installed).

The standard controller would have one of the four Tachsyn® Processor cards installed for use with the Tachsyn® transducer. The four processor cards are distinguished by different tachometer gradients. IMEC's MC500 Series Motion Control Card is also available as an option on the SC100 Series. This card adds various higher level motion control functions to the controller.

SC1XX-XXX-XX

Option Code

Blank = Hall sensor/Brushless tachometer Interface

T1 = Tachsyn® Processor, 0.5 V/Krpm tach gradient

T2 = Tachsyn® Processor, 1.0 V/Krpm tach gradient

T3 = Tachsyn® Processor 2.0 V/Krpm tach gradient

T4 = Tachsyn® Processor, 4.0 V/Krpm tach gradient

M = MC500 Series Motion Control Card

Customization Code

Factory assigned

001 = standard controller

Power Level

01 = 7.5 A cont., 15 A pk.

02 = 12 A cont., 15 A pk.

03 = 15 A cont., 30 A pk.

04 = 20 A cont., 60 A pk.

05 = 40 A cont., 60 A pk.

APPENDIX A

THEORY OF OPERATION

The SC100 Servo Controller is an independent, stand-alone PWM Servo drive capable of four quadrant control of a single Permanent Magnet Brushless Servo Motor. Each unit contains a DC Bus Supply; current controlled PWM output amplifier; control power supply; velocity control loop; shunt regulator; and protection circuits.

The Servo Controller is configured as a velocity control unit (velocity block) but can also be used as a torque control unit (torque block). This section describes the operation of the controller (Refer to Figure A.1).

A.1 DC Bus Supply

The DC Bus Supply is responsible for converting the 230 VAC, 3 phase (or single phase) line voltage into a high voltage source for use by the output inverter. The supply is protected by input fuses (F1, F2, F3) and line-to-line varistors (VR1, VR2, VR3). Fuses provide protection against overcurrents due to catastrophic failure in the high power sections of the controller. The varistors protect the supply against high voltage transients commonly found on power distribution lines.

The protected lines are fed to a 3 phase (or single phase) SCR/diode input bridge rectifier. Firing of the SCR's is provided by the Bus Control Circuit. This input configuration provides two advantages over a standard diode input bridge.

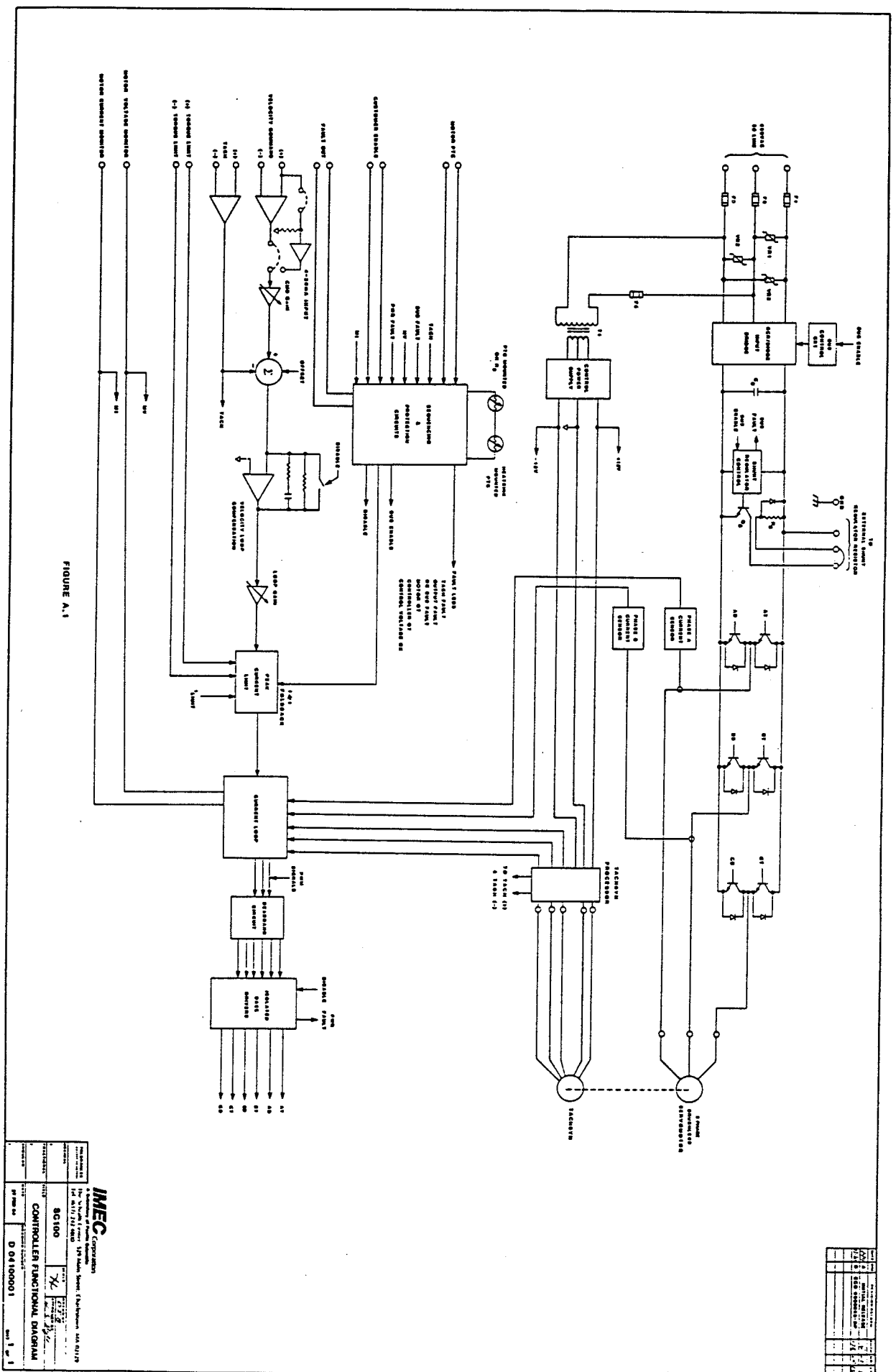
- 1) The first advantage is soft start capability. When the controller is initially connected to the line, the bus capacitor C_b is discharged. This initial condition causes a large inrush current spike when 230 VAC power is applied. This spike stresses all components in the circuit path including the input fuses and the input bridge. Any components in the 230 VAC distribution system can also be stressed, specifically contactors, fuses or breakers. In fact, the inrush current can trip breakers and/or blow fuses. The Bus Control Circuit controls the amplitude of the inrush current spike by turning on the bridge at an input voltage zero-crossing. This technique limits the inrush current spike to a width of 4 milliseconds and a peak amplitude of 80 A maximum for the SC102, 160 A for the SC101/SC103, and 270 A for the SC104/SC105. These current spikes are theoretical worst cases and typically will be less than half of these values. A standard diode input bridge structure could produce inrush current spikes of 1000 A or more on a stiff 230 VAC line.
- 2) The second advantage is the ability to turn the DC Bus voltage on and off. In conjunction with the Shunt Regulator Circuit, this capability adds an extra measure of protection in a fault situation and allows dynamic braking to be built into the controller. The Shunt Regulator Control Circuit is powered directly off the DC Bus as shown in Figure A.1. This allows the circuit to operate even if 230 VAC power is removed. The Shunt Regulator operates in either the regulation mode or bus decay mode depending upon the status of the Bus Enable input.

When Bus Enable is active, the DC Bus is powered and the Shunt Regulator operates in the regulation mode. In this mode, the circuit regulates the DC Bus voltage using transistor, Q_s , and series resistor, R_s . During motor braking, energy flows from the motor into the DC Bus i.e. opposite of normal motoring operation. If this regenerated energy is not dissipated, the DC Bus voltage will rise until a DC Bus overvoltage fault occurs. The Shunt Regulator dissipates the power by turning on transistor Q_s thereby dumping the regenerated energy into resistor R_s . Transistor Q_s "on" time is modulated by the Shunt Regulator Control Circuit to keep the DC Bus voltage below 390 V nominal.

Three external terminals are provided to allow connection of an external Shunt Regulator resistor. An external resistor would be used in applications requiring more power capability from the Shunt Regulator than is provided in the standard controller.

If Bus Enable is inactive, the DC Bus is turned off and the Shunt Regulator operates in the bus decay mode. In this mode, transistor Q_s is forced on continuously. This discharges the bus capacitor and dynamically brakes the motor.

Assume the motor is being driven at some speed when 230 VAC power is removed from the controller or a controller fault occurs. This puts the Shunt Regulator in the bus decay mode thereby placing resistor R_s across the DC Bus. Since the motor has a permanent magnetic rotor and is spinning, it works as a generator producing 3 phase voltages at its terminals. The voltage amplitude depends upon the motor speed and motor's voltage constant. These terminal voltages are 3 phase rectified back to the DC Bus by the flyback (freewheeling) diodes in parallel with the output transistors. Resistor R_s across the DC Bus appears as a load on the motor via these flyback diodes. This resistive load dissipates the kinetic energy stored in the motor thereby braking the motor. Since the load is a fixed resistor, the braking torque is proportional to motor speed, i.e. as the motor slows down the braking action decreases. This braking technique is analogous to braking a permanent magnetic DC brush-type motor with a dynamic braking resistor used to short the armature. The level of braking action is dependent upon the resistance of R_s and the motor/load characteristics.



A.2 Current Loops

When properly controlled, the output torque of a Brushless DC motor is proportional to the motor current. Maximum torque per Amp is achieved by proper phasing of the motor current relative to the rotor position. Rotor position information is provided to the controller via the three commutation transducer signals. These signals are usually generated by a Tachsyn[®], Hall-Effect sensors, or optical sensors mounted integral to the motor.

Figure A.2 illustrates the waveforms obtained when using a trapezoidal wound, 3 phase, wye connected Brushless Servo Motor. Motors can also be wound 3 phase delta and/or sinusoidal. The controller will operate these types of motors if the appropriate commutation signals are present. The theory of operation is similar for all motor types and hence only the configuration shown in Figure A.2 will be described.

The controller operates the motor by controlling the 3 phase currents to the motor. As shown in Figure A.2, the phase currents are classical six-step current waveforms I_R , I_S , and I_T . Note that at any instant in time one of the 3 phase currents is zero.

The commutation signals from the motor mounted Hall-Effect sensors are shown as signals SENSOR 1, SENSOR 2, and SENSOR 3. These signals are used by the controller to force the proper currents into the motor's 3 phase winding. Motor torque is optimized when the phase current is in-phase with its respective line-to-neutral back EMF voltage.

As an example consider motor phase R. The top three waveforms of Figure A.2 illustrate the three line-to-line voltages of a trapezoidally wound Brushless Servo motor. The voltages of importance however are the line-to-neutral voltages which are shown just below the line-to-line waveforms. Current I_R in-phase with line-to-neutral voltage V_{RN} produces torque. When V_{RN} is negative and constant, I_R is negative and constant and produces motoring torque. To obtain braking torque (generator action), the current I_R should be 180° out of phase with voltage V_{RN} . Hall-Effect signals SENSOR 3 and SENSOR 1 determine when current I_R is turned on and turned off.

At the same time phase R is producing torque, phase S or phase T is also producing torque. During the first half of V_{RN} 's constant positive section, V_{SN} and I_S are both negative and constant thereby producing constant motoring torque which aids the constant motoring torque produced by phase R.

As the motor rotates (Figure A.2 shows waveforms produced by a motor operating at a fixed speed), V_{SN} ramps toward zero, while V_{TN} ramps negative. As V_{SN} begins to ramp toward zero, V_{TN} has reached its constant negative value. At this point I_S goes to zero and I_T steps to a constant negative value. The motor current has "commutated" from phase S to phase T. Torque is now being produced by phase R and phase T. This commutation is caused by a transition of SENSOR 2 which informs the controller that the motor's rotor has rotated to an angular position where the current should be commutated from phase S to phase T to allow the proper generation of torque. As the motor rotates farther, the next commutation signal comes from a transition on SENSOR 1. This commutates the current from phase R to phase S while the current in phase T remains constant. Torque is now being produced by phase S and phase T.

This commutation sequence will continue as the motor rotates. The sequence will be reversed if the motor's rotation is reversed. Motor braking torque is produced by reversing the polarity of the current amplitude command. This does not affect the commutation sequencing but merely reverses the polarity of the phase currents. It forces the phase currents to be 180° out of phase with the line-to-neutral voltages thereby producing braking torque rather than motoring torque.

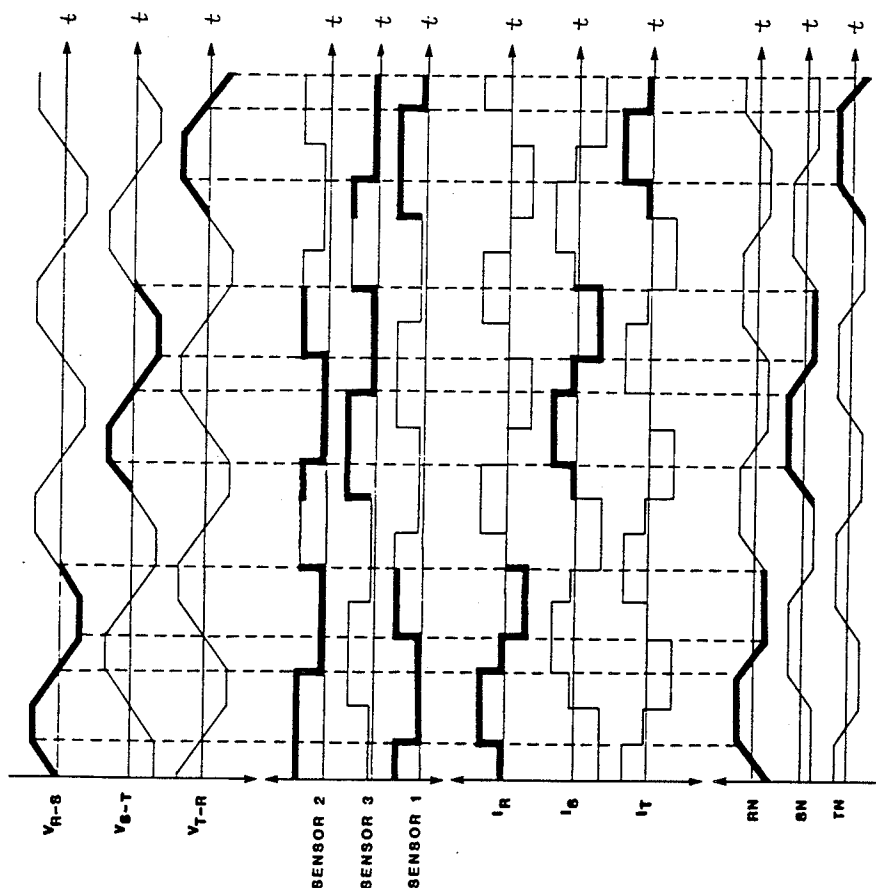
Phase currents are controlled by a Pulse Width Modulation (PWM) technique. A variable voltage is generated across the motor terminals by chopping the DC Bus Voltage (310 V nominal) with six transistor switches as shown in Figure A.1. Each phase voltage is controlled by two switches in a half-bridge configuration. By varying the duty cycle (percentage "on" time) of each switch, an average voltage is applied to each motor terminal. This voltage can be varied between plus and minus 310 V nominal line-to-line by proper control of the transistor switches.

Current control is accomplished by monitoring the motor phase currents and comparing these current feedback signals to the current command signal. The resulting error signal is conditioned by a proportional plus integral compensation network to obtain the desired current loop dynamics. This compensated signal is used as the voltage command to the PWM circuit. The PWM circuit outputs a fixed frequency pulse train which has a duty cycle proportional to this voltage command. A Deadband Circuit provides underlap which prevents two transistors in the same half-bridge (i.e. AT and AB) from being "on" simultaneously.

Each transistor has a Base Driver Circuit. The Base Driver Circuit provides voltage isolation between the Deadband Circuit's output signals, which are at earth ground, and the transistors' bases which are at a high voltage potential. The Base Driver Circuits also insure that the transistors have the proper base current applied for optimum turn-on and turn-off.

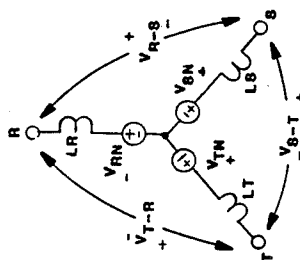
The Current Sensors detect the current in 2 of the 3 motor phases and provide an isolated voltage signal proportional to the measured current. As in the Base Driver Circuit, the current signals must be isolated since the currents are measured at high voltage potentials. Two signals from the current loops are brought out as user monitor points. One of these is a DC voltage proportional to the motor voltage while the other is a DC voltage proportional to the motor current. The current monitor signal is proportional to the current amplitude at the top of the six-step current waveform. The voltage monitor signal is proportional to the line-to-line (i.e. V_{RS}) voltage amplitude.

DATE	TIME	REVISION	RECORD	DATE	BY	CHK
1/27/84	10:00	A	INITIAL RELEASE	1/27/84	10:00	10:00
1/27/84	10:00	B	ECO 98000000-RP	1/27/84	10:00	10:00



NOTE: WAVEFORMS ARE FOR A FIXED MOTOR SPEED.

FIGURE A.2



TOLERANCES UNLESS OTHERWISE SPECIFIED		IMEC 93 MASSACHUSETTS AVENUE BOSTON, MA 02115 (617) 552-0400	
DECIMAL	FRACTIONAL	SCALE	DATE
		8C100	1/27/84
TOLERANCES UNLESS OTHERWISE SPECIFIED		BRUSHLESS DC MOTOR WAVEFORM	
DECIMAL	FRACTIONAL	DATE	DRAWING NUMBER
		27 JAN 84	B 04100002
		SHEET 1 OF 1	

A.3 Velocity Loop

The velocity loop as shown in Figure A.1 has two differential voltage mode inputs and one current mode (4 to 20 mA) input. One voltage mode input is the TACH feedback signal which corresponds to measured motor speed. The other voltage mode input is the VELOCITY COMMAND which corresponds to the motor speed command. The current mode input is also a VELOCITY COMMAND input. Using two jumpers, the user can select either the voltage mode or current mode VELOCITY COMMAND input. The VELOCITY COMMAND signal gain is adjustable by the CMD GAIN potentiometer.

The velocity error signal is conditioned by the VELOCITY LOOP COMPENSATION network. This network consists of proportional plus integral compensation with a fixed, finite DC gain. The DC gain and compensation parameters are adjustable by changing two resistors and a capacitor. In most applications, the standard compensation supplied with the controller will be adequate. A LOOP GAIN potentiometer allows the user to adjust the velocity loop's AC loop gain to compensate for various mechanical load inertias. This adjustment does not affect the DC gain.

The compensated velocity error signal is used as the current amplitude command signal. Since the motor's output torque is proportional to current, this current command is also a torque command. In fact, in applications requiring torque control rather than velocity control, the controller can be reconfigured easily. By eliminating the TACH feedback signal and replacing the VELOCITY LOOP COMPENSATION components to obtain a unity gain amplifier (replace two resistors and capacitor with a single resistor), the VELOCITY COMMAND input now functions as a torque command input.

The current command is processed by a PEAK CURRENT LIMIT circuit prior to reaching the CURRENT LOOP. This circuit has three inputs. The first is a potentiometer, I LIMIT, which allows the user to set a peak current limit between 10% and 100% of the controller's rated peak output current. The current limit is symmetric and operates in both current polarities. The other two inputs are (+) TORQUE LIMIT and (-) TORQUE LIMIT. These inputs allow the user to set the peak current limit between 10% and 100% of the controller's rated peak output current by applying a 0.5 V to 5 V analog signal. Unlike the I LIMIT adjustment, these inputs allow independent control of the positive and negative current limit points. This feature is useful for applications where the load has reached a travel limit in one direction and torque in that direction can be reduced to prevent mechanical damage. Torque in the other direction is left at its normal level so that the load can be driven off the travel limit. Symmetric current limiting can be realized with these inputs by wiring the two inputs together and driving them with a single command.

Note that the I LIMIT adjustment cannot be overridden on the high side by the TORQUE LIMIT inputs. For example, if the I LIMIT potentiometer is set at 50%, the output current will be limited to 50% even if the TORQUE LIMIT inputs are at 5 V. The current limit however can be reduced below 50% by dropping the TORQUE LIMIT inputs below 2.5 V.

The SC100 Servo Controller is designed to operate using a Tachsyn[®] transducer for commutation and velocity feedback. The Tachsyn[®] device is mounted on the Brushless Servo Motor and contains no electronics. The processing electronics are provided on a Tachsyn[®] Processor card which plugs on to the SC100 Control Board. This processor card converts the Tachsyn[®] signals into an analog velocity feedback signal and three digital signals which emulate Hall-Effect commutation signals. These commutation signals and analog velocity signal are routed to the correct circuits when the Tachsyn[®] Processor card is installed. If the user wishes to use other feedback devices, such as Hall-Effect sensors and a brushless tachometer, the SC100 can accept these signals by removing the Tachsyn[®] Processor card and changing the settings of a five position DIP switch.

A.4 Protection and Diagnostic Circuits

The controller incorporates several circuits to protect the controller and/or motor against damage due to abnormal operating conditions.

Several protection circuits prevent damage due to thermal overload situations. Internal to the controller are two positive temperature coefficient thermistors (PTC's) which monitor the heatsink temperature and the temperature of the shunt regulator resistor R_s .

The heatsink PTC faults the controller if the heatsink temperature rises above 95°C nominal. Such a situation could occur due to excessive ambient temperature (> 60°C), operation of the controller above its continuous rated output current, or improper ventilation.

The PTC mounted on R_s protects the resistor from damage and is set to trip at 120°C nominal. A resistor overtemperature condition would most likely be caused by excessive continuous regenerated power (> 30W). It could also be caused by a Shunt Regulator failure.

Either of these two overtemperature conditions will trip-out the controller and light the controller DOT LED, DS3.

Another section of the overtemperature protection circuits accepts information from an external PTC (or thermostat) via TB1-4 and TB1-5. This input is intended to be used with a PTC mounted internally on the motor windings. The PTC will protect the motor against thermal overload by tripping-out the controller if the motor reaches excessive temperatures. This overtemperature condition could be due to an excessive ambient temperature or excessive RMS motor current.

An overtemperature sensed by this external input will trip-out the controller and light the MOT LED, DS4. If the external MOTOR PTC input is not used, the input terminals TB1-4 and TB1-5 must be jumpered together otherwise the controller will always fault out on MOT at power-up.

The controller contains a circuit to protect against tachometer fault conditions. The controller will trip-out and indicate TACH FAULT if the tach is connected in the wrong polarity or if the tach feedback signal is lost due to a short or open circuit on the tach leads. This circuit prevents a motor runaway condition which would be caused by either of these conditions. The TAC LED, DS5, indicates this fault condition.

The circuit works by comparing the tach voltage to the motor voltage. If there is a predetermined level of motor voltage present and not a reasonable tach voltage of the same polarity, the controller assumes the tach signal is inconsistent and generates a TACH FAULT.

Removal of the jumper labeled TACH will disable this protection feature. This jumper must be removed if the controller is being used in a torque mode without a tach.

An I²t protection circuit is designed into the controller. This circuit will foldback the current limit to the continuous current rating level of the controller if the output current is kept at the peak rating level for longer than 5 seconds. If this automatic current foldback is undesirable in the user's application, it can be disabled by installing the DIS jumper.

As shown in Figure A.1, the Isolated Base Drivers generate a signal called PWR Fault. This signal indicates that a fault condition has occurred in the output inverter. Possible causes of this fault are (1) a line-to-line motor or motor lead short, (2) a line-to-neutral motor or motor lead short, (3) a motor of insufficient inductance, (4) an output transistor failure, (5) a Base Driver Failure, or (6) a failure in the Deadband Circuit.

This Fault condition is actually sensed by monitoring the voltage across each output transistor and determining if they are correct. For example an "on" transistor should have a low voltage emitter-to-collector. If a short circuit or one of the other conditions listed above exists, an "on" transistor could be pulled out of saturation, i.e. the emitter-to-collector voltage rises to a larger than normal value. This condition is detected and used to generate a PWR Fault signal. A PWR Fault signal will trip-out the controller and light the OUT LED, DS7.

The Shunt Regulator Control circuit monitors the DC Bus voltage. If the DC Bus voltage rises above 400 VDC nominal or drops below 200 VDC nominal a DC BUS FAULT signal is generated. This signal will trip-out the controller and illuminate the BUS LED, DS6.

A high bus voltage would most likely be caused by a failure in the Shunt Regulator. A low bus voltage condition would be due to either a 230 VAC line problem or a short across the bus (i.e. a shorted bus capacitor).

The green PWR LED, DS2 indicates that the ± 12 VDC control voltages are operating properly. This LED should be lit whenever 230 VAC power is applied. If it is not, it indicates an overvoltage or undervoltage condition on ± 12 VDC. The most likely cause of such a fault would be a short circuit on the ± 12 VDC output terminals TB1-1 and TB-2 or a blown control supply fuse. The circuit operates by comparing ± 12 VDC to a zener voltage reference.

The final LED, EN DS1, is green and is lit if an ENABLE signal is present (terminal TB2-4 connected to TB2-5).

Faults can only be cleared by cycling 230 VAC power. Also all faults which trip-out the controller will also open the FAULT OUT contact, turn off the DC bus and dynamically brake the motor by putting the Shunt Regulator into the bus decay mode.

A.5 Power Up/Down Sequencing

Assume ENABLE is inactive. Upon application of 230 VAC power the Control Voltage Power Supply will come up and generate a power-up reset pulse (PUR). The PUR signal will clear all the fault latches. During the PUR pulse, the Base Drive Circuits will be enabled and the FAULT OUT contact will be closed. Upon termination of the PUR pulse there is a check for any faults. If a fault is present, the Power Up sequence will be stopped, the FAULT OUT contact will be opened, the Base Drivers disabled, and the fault indicated by LED. If there are no faults present, the BUS Enable signal will be activated. This will power up the DC Bus via the Bus Control Circuit. It will also switch the Shunt Regulator from the bus decay mode to the regulation mode. After a nominal 500 ms delay (to allow the DC Bus voltage to come up), the controller is capable of accepting an ENABLE signal.

The previous sequence assumed that an ENABLE signal was not present during the sequence. If an ENABLE signal is present prior to application of 230 VAC power, the controller will trip-out. There will be no fault indication but the FAULT OUT contact will be open. 230 VAC power must be removed and reapplied with the ENABLE signal inactive to power up the controller. The sequencing is set up in this manner to prevent unexpected motor operation after a 230 VAC power outage. This feature can be defeated by removing the jumper labelled PUR. If this jumper is removed, the unit will power up with the application of 230 VAC power regardless of the status of the ENABLE input.

Removal of the ENABLE signal while the drive is operating normally will disable the controller and allow the motor to freewheel. There will be no dynamic braking action and the DC Bus will remain powered-up.

Removal of 230 VAC power regardless of the status of the ENABLE signal will cause the following sequence. The DC Bus voltage and control voltages will begin to collapse. Eventually one or the other will cause a fault due to an undervoltage condition. This will disable the controller, turn-off the DC Bus, open the FAULT OUT contact, put the Shunt Regulator in the bus decay mode and dynamically brake the motor.

APPENDIX B

BRUSHLESS SERVO MOTORS CONNECTIONS

The SC100 Series of brushless servo controllers are designed to drive 3 phase, permanent magnet, brushless servo motors. Pacific Scientific manufactures an extensive line of brushless servo motors for use with the SC100 Series.

Figure 3.1 illustrates the proper connection of an SC100 to a Pacific Scientific brushless servo motor equipped with a Tachsyn® feedback transducer. The table below summarizes the controller/motor connections.

<u>Motor Signal Name</u>	<u>SC100 Terminal</u>	<u>SC100 Terminal Name</u>
Phase R	TB3-4	Phase R
Phase S	TB3-5	Phase S
Phase T	TB3-6	Phase T
Case	Wired to common earth ground	
Exciter Coil	TB1-10	Tachsyn® Excitation
Exciter Coil	TB1-11	Tachsyn® Excit. Rtn.
Phase 1	TB1-7	Tachsyn® Phase A
Phase 2	TB1-8	Tachsyn® Phase B
Phase 3	TB1-9	Tachsyn® Phase C
Thermistor	TB1-4	Motor PTC
Thermistor	TB1-5	Motor PTC Rtn.

Note that these connections assume that the SC100 has a Tachsyn® processor card installed and that DIP switch S1 has all switches set to OFF. It also assumes that the CH1, CH2, CH3 jumpers are installed.

The SC100 Series can also operate Pacific Scientific brushless servo motors equipped with Hall-Effect devices and a brushless tachometer. The table below summarizes the connections when using a brushless tachometer and Hall-Effect devices.

<u>Motor Signal Name</u>	<u>SC100 Terminal</u>	<u>SC100 Terminal Name</u>
Phase R	TB3-4	Phase R
Phase S	TB3-5	Phase S
Phase T	TB3-6	Phase T
Case	Wired to common earth ground	
Tach Output	TB1-10	Tach (+)
Gnd	TB1-11	Tach (-)*
Sensor 1	TB1-7	Sensor 1
Sensor 2	TB1-8	Sensor 2
Sensor 3	TB1-9	Sensor 3
+ VDC	TB1-1	+12 VDC
- VDC	TB1-2	-12 VDC
Gnd	TB1-3	12 VDC Rtn.*
Thermistor	TB1-4	Motor PTC
Thermistor	TB1-5	Motor PTC Rtn.

*To improve noise rejection, 2 separate wires should be run from the "Gnd" back to TB1-3 and TB1-11.

This table assumes that there is no Tachsyn® processor card installed on the SC100 and that DIP switch S1 has all switches set to ON. It also assumes that the CH1, CH2, CH3 jumpers are installed.

For torque block operation, a brushless tachometer is not required. Controller/motor connections are identical to those above except that the Tach connections to TB1-10 and TB1-11 are not made and the velocity loop compensation is modified.

For use with motors other than Pacific Scientific motors, the wiring could vary from that described. Contact the factory regarding connection to brushless servo motors from other manufacturers.

