SENSITRON SEMICONDUCTOR

SMCS6G25-60
SMCS6G25-60-1

TECHNICAL DATA
DATA SHEET 5006, REV.ENG 1.1
Preliminary Data Sheet

SENSORLESS BRUSHLESS DC MOTOR CONTROLLER MODULE IN A POWER FLATPACK 25A, 600V

FEATURES:

- Two Quadrant Mode of Operation.
- Fully integrated 3-Phase Sensorless Brushless DC Motor Control Subsystem includes power stage, non-isolated driver stage, and controller stage
- IGBT Output Stage, with low saturation voltage.
- 20A peak Phase Current with up to400V Maximum DC Bus Voltage
- Internal Precision Current Sense Resistor
- Cycle by cycle current limiting.
- Fixed frequency PWM.
- Direction Input for Direction Reversal.
- Tacho output with frequency proportional to speed
- Analog or PWM command input.
- Hermetic or non-hermetic device (3.10" x 2.10" x 0.385")
- **Hermetic Device Part # (SMCS6G25-60)**
- **Non-Hermetic Device Part # (SMCS6G25-60-1)**

APPLICATIONS:

- Fans and Pumps

DESCRIPTION:

SMCS6G25-60 is an, integrated three-phase sensorless brushless DC motor controller/driver subsystems housed in a 43 Pin power flatpack. SMCS6G25-60 is a completely self-contained motor controller that converts an analog input command signal into a motor speed. SMCS6G25-60 is best used as a two quadrant speed controller for controlling/driving fans, pumps, and motors in applications which require small size.

SMCS6G25-60 is available with an IGBT power stage for DC bus voltage up to 400V. The small size of this complete motor control module makes it ideal for commercial aerospace and military applications.

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ABSOLUTE MAXIMUM RATINGS

(T_C=25 ^oC) unless otherwise noted

Characteristic	**Maximum**
Operating DC Bus Supply Voltage	400 V
Maximum Peak DC Bus Supply Voltage	600 V
Average Output Current	20 A
Peak Output Current	25 A
+15V Supply Voltage	+16.5 V
Logic Input Voltage	-0.3 V to +5.5 V
Operating & Storage Junction Temperature	-55 ^oC to +150 ^oC
IGBT Junction-to-Case Thermal Resistance R_{thjC} Diode Junction-to-Case Thermal Resistance R_{thjC}	1.0 $^oC/W$ 1.7 $^oC/W$
Pin-to-Case Voltage Isolation, at room conditions SMCS6G25-60 SMCS6G25-60-1	 600V DC 1000V DC
Lead Soldering Temperature, 10 seconds maximum, 0.125” from case * Tcase = 25° C	300°C

Recommended Operating Conditions

(T_C=25 ^oC) unless otherwise noted

Characteristic	**Maximum**
Operating Supply Voltage	300 V
Average Output Current T_C=80^oC	15 A
+15V Supply Voltage	+ 15 V +/-10%

Recommended Operating Conditions Conditions (T_C=25 ^oC)

PARAMETER SYMBOL CONDITIONS (NOTE 1)	MIN.	TYP.	MAX.	UNITS
Power Output Section				
Power Stage Leakage Current IDss at 480V			500	uA
Collector-to-Emitter Saturation Voltage) Ic =15 A		1.5	1.8	V
Diode Forward Voltage Vf IF = 15 A			1.8	V
Diode Reverse Recovery Time trr IF = 15A, di/dt = 500A/usec,		1.5	100	nsec
Control Section				
Control Supply Current Icc at +15V supply			30	mA
+15V Control Turn-On Threshold Tc over operating range	8.0	9.5	11.0	V
Current-Sense Amplifier Section				
Amplifier Voltage Gain	0.13	0.15	0.17	V/A
Slew Rate, rising and falling	0.70	1.5		V/usec
Logic Input Section				
LA1, LA2, Dir, PWM				
High Level Input Voltage Threshold	3.0	-	-	V
Low Level Input Voltage Threshold	-	-	1.0	V
Input Current, 0.0 < Vin <5.0V	-	30	-	uA
+5V Reference				
Output Voltage Vref	4.7	5.0	5.3	V
Output Current Io	-	-	30	mA
Load Regulation Iload = 0mA to –20mA	-	-	30	mV
Oscillator Section				
Oscillator Frequency Fo	18	20.0	22.0	kHz

SPECIFICATION NOTES:

1- All parameters specified for Ta = 2^{o}C, Vcc = +15Vdc, and all Phase Outputs unloaded. All negative currents shown are sourced by (flow from) the Pin under test.

2- Pulse Test: Pulse Width < 300 µSec, Duty Cycle < 2%.

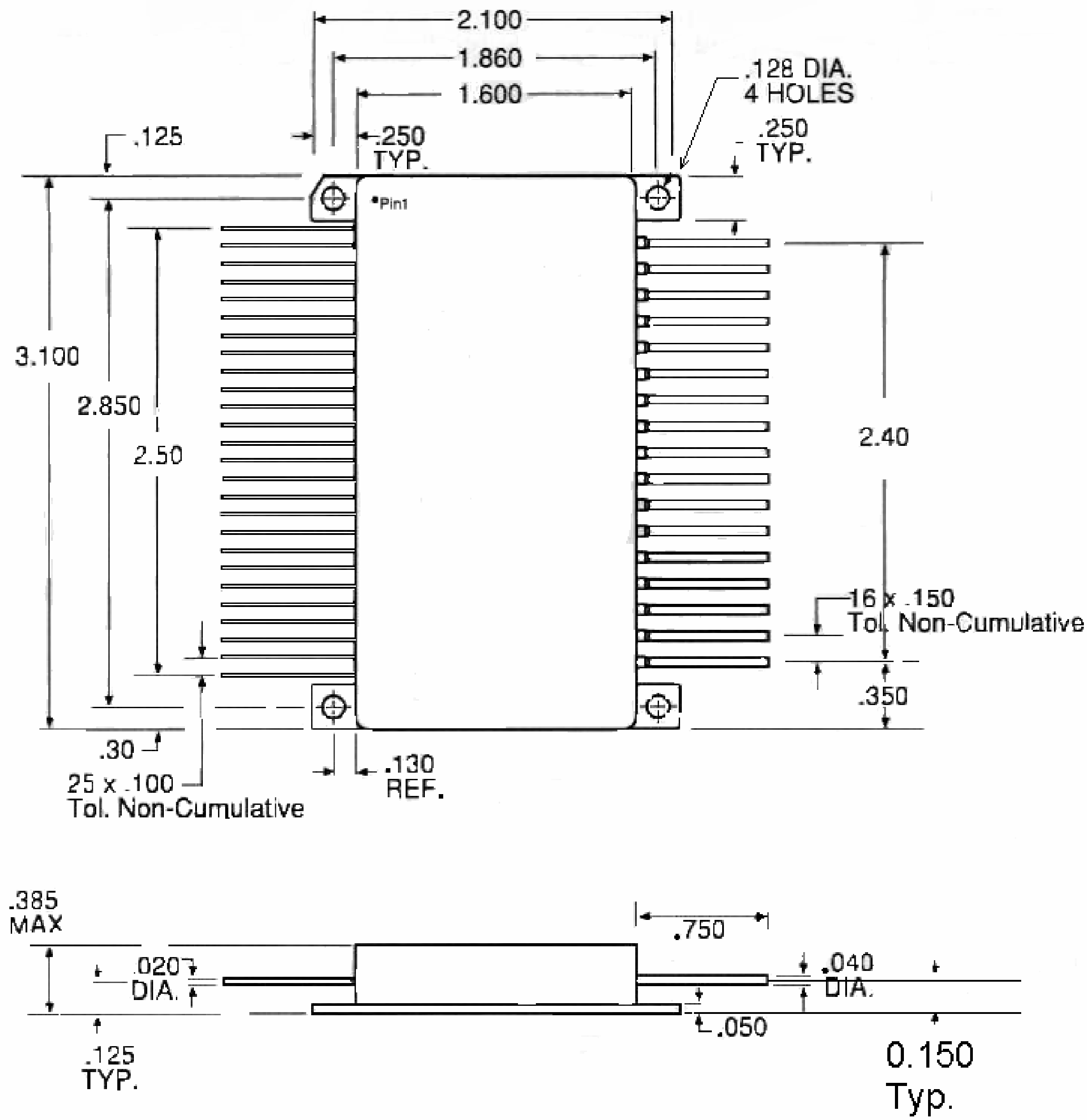

Fig. 2: Mechanical Outline For Hermetic Package, SMCS6G25-60

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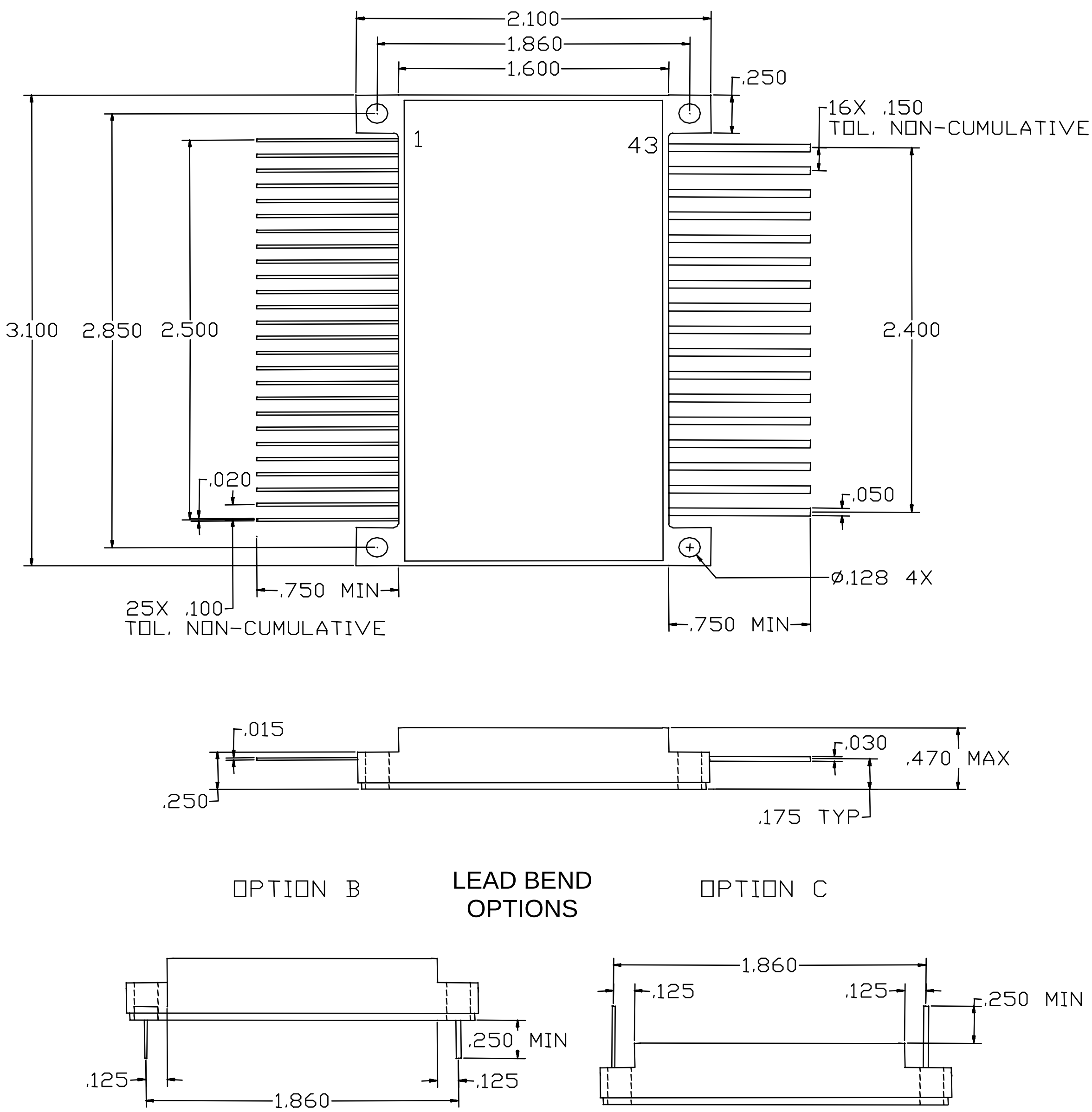

Fig. 3: Mechanical Outline For Plastic Case Package, SMCS6G25-60-1

PIN NUMBER	NAME	DESCRIPTION
1	+15V Input	The +15V power supply connection for the controller. Under-voltage lockout keeps all outputs off for Vcc below 10.5V. The return of +15V is Pin 2.
+15V supply should be an isolated power supply.		
2	Gnd	Return for +15V, and +5V supplies
3	NC	Not connected
4	Command	Analog input command. A voltage command proportional to the desired speed is applied at command input. This input is connected to an internal PWM comparator. Since the motor speed is proportional to the average phase voltage, the speed is controlled via duty cycle control. **The duty cycle is internally limited to 95% maximum.**
5	NC	Not connected
6	NC	Not connected
7	NC	Not connected
8	+5V Output	+5V output for external use. Maximum output current is 30mA. This pin should be bypassed to Signal Gnd with 1-5μF capacitor.
9	PWM	PWM command input. A variable duty cycle PWM input will override the analog command input at Pin4. The motor is directly proportional to the PWM duty cycle. Maximum duty cycle should be limited to 99%. **Outputs are disabled if duty cycle is zero or 100%. If not used, this Pin should be kept open.**
10	LA1	Lead angle control input. Pins are internally pulled down. See table on page 9 for lead angle as function of LA1 and LA2 settings.
11	LA2	
12, 13	Signal Gnd	Reference ground for all control signals of the device. All bypass capacitors and closed loop compensation components must be connected as close as possible to pins 12 and 13. These Pins **should not** be externally connected to the power ground Pins 27 and 28.
14	Dir	Motor direction input. This Pin is internally pulled down. If pulled high, motor will reverse rotation. **It is not safe to reverse the direction of rotation when the motor is running at high speed. First reduce the command input, then reverse direction when the motor speed is very low.**
15	NC	Not connected
16	NC	Not connected
17	Ph-FB	Motor back EMF feedback information. This input is used to optimize back EMF sensing together with the Ph-Ref input at **Pin 18**
18	Ph-Ref	Motor back EMF reference input
19	Tach-out	Variable frequency output proportional to the motor speed. This output frequency is three times, the motor back EMF frequency.

PIN OUT (continued)

20	NC	Not connected
21	Clock-Set	Adjustment input for an internal clock frequency. The default clock frequency is 10MHz
22	NC	Not connected
23	Ioc-Ref	User adjustable over-current limit reference input, depending on the motor and load requirements. This pin is internally connected to the over-current comparator for **cycle-by-cycle** current limiting. It is internally set to 2.50V by a resistor divider. The pull up to +5V is 20KΩ, and the pull down to Gnd is 20K . This internal setting corresponds to 16A peak with 10 mΩ current sense resistor and 33A peak with 5 m current sense resistor. This reference can be reduced by connecting a resistor between Ioc-Ref and Signal Gnd. Also, Ioc-Ref can be increased by connecting a resistor between Ioc Ref and the 5V reference. The over-current reference voltage is set according to the formula Ioc-Ref=Rs*Ip*15 volts (1) where Rs is the current sense resistor value in ohms and Ip is the peak current limit in amperes. The internal current sense resistor is 10mΩ . It can handle motor current up to 25A. For higher current, a 5mΩ should be used.
24	NC	Not connected
25	Iso	Output of the current sense amplifier for external monitoring. This output is feeding internally an over-current limit circuit.
26	NC	Not connected
27, 28	+VDC Return	Motor supply return. Pins 27 and 28 **should not** be connected to the signal Gnd Pins 2, 12, 13.
29, 30, 34, 35, 39, 40	Source Terminal	These pins are the source terminals of the three arms of the three-phase bridge. These Pins shall be shorted together externally using a low impedance bus to minimize power loss, as shown in Fig. 6.
31, 32	Phase C Output	Phase C terminals. Both terminals shall be used.
33, 38, 43	+VDC	These pins are the motor input power supply positive terminal. These Pins shall be shorted together externally using a low impedance bus. +VDC bus should be bypassed to +VDC Rtn with adequately voltage-rated low ESR capacitor, value is about 10μF per ampere of average motor current.
36, 37	Phase B Output	Phase B terminals. Both terminals shall be used.
41, 42	Phase A Output	Phase A terminals. Both terminals shall be used.
Case	NC	Not connected

Lead angle as function of LA1 and LA2 settings.

LA1 Setting	LA2 Setting		Lead Angle Electrical Degree
Low	Low		0.0
High	Low		7.5
Low	High		15
High	High		30

Operational Information

SMCS6G25-60 uses back EMF detection for rotor position detection. The position detection is done in synchronization with the PWM signal. Positional variation occurs in connection with the frequency of the PWM signal.

Fig. 5. illustrates the back EMF detection.

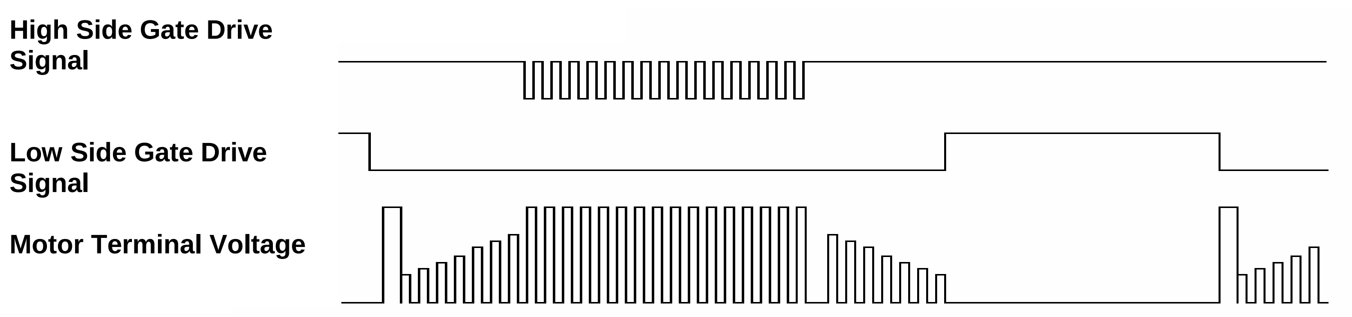

Fig. 4. High Side Gate drive, Low Side Gate drive, and Motor Terminal Voltage

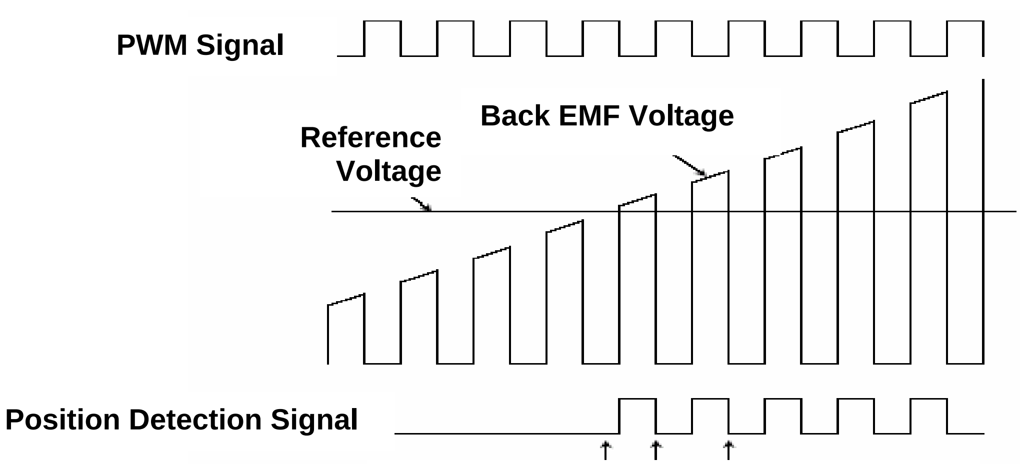

Fig. 5. Back EMF and Rotor Position Detection

Cycle-by-cycle

Current limiting is provided internally by an over-current comparator. A user adjustable over-current limit reference input is provided at Pin 23. Also, a current monitoring output is provided at Pin 25 for current monitoring and/or user current limiting.
The over-current reference adjustment procedure is described in the Pin Description section. The adjustment resistors, R4 and R5, are as shown in Fig. 6.

Closed Loop Speed Control

The motor speed is directly proportional to the input analog command at Pin 4 or a PWM signal duty cycle at Pin 9. However, speed regulation is poor in open loop systems. For tight speed regulation, a closed loop speed control can be implemented as shown in Fig. 6.
A tachometer can be used to provide speed feedback information, and an error amplifier to close the speed loop.

Motor Terminals Connection

Since the rotor position detection is done through the phases, the phase IDs are irrelevant. Any motor terminal connection to the controller with the sequence ABC, or BCA, or CAB will results in the same direction of rotation as long as the controller direction input is not changed. A motor terminal connection sequence of the opposite as CBA, or BAC, or ACB will result in a reversed rotation.

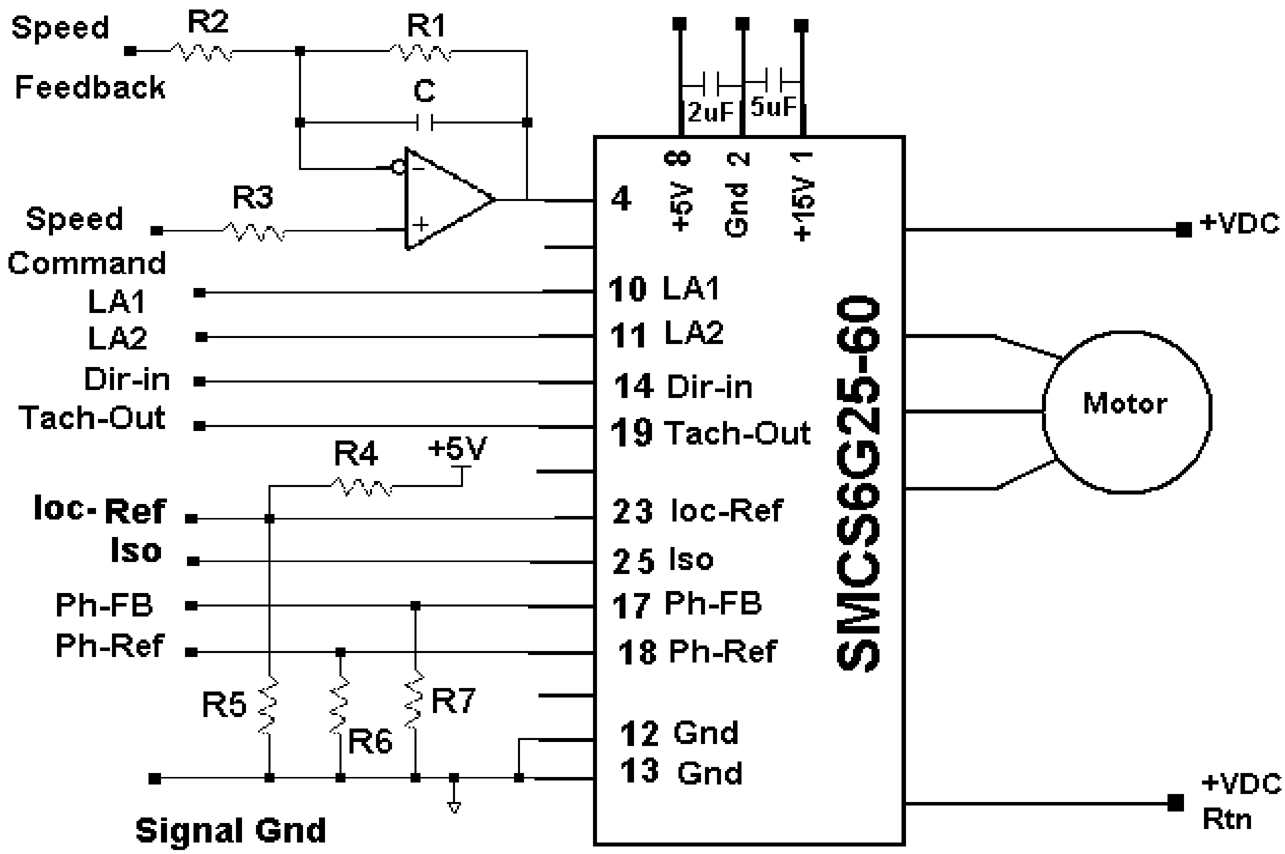

Fig. 6. Closed Loop Speed Control

DC Bus Filtering

To minimize the circuit parasitic inductance effect on the power stage, the layout of Fig. 7 is suggested. C1, C2, and C3 are 0.1μF to 0.5μF ceramic capacitors, connected across each leg of the three-phase bridge. Also, a bulk polarized capacitor C4 of about 10μF per ampere of average motor current should be connected across the DC bus.

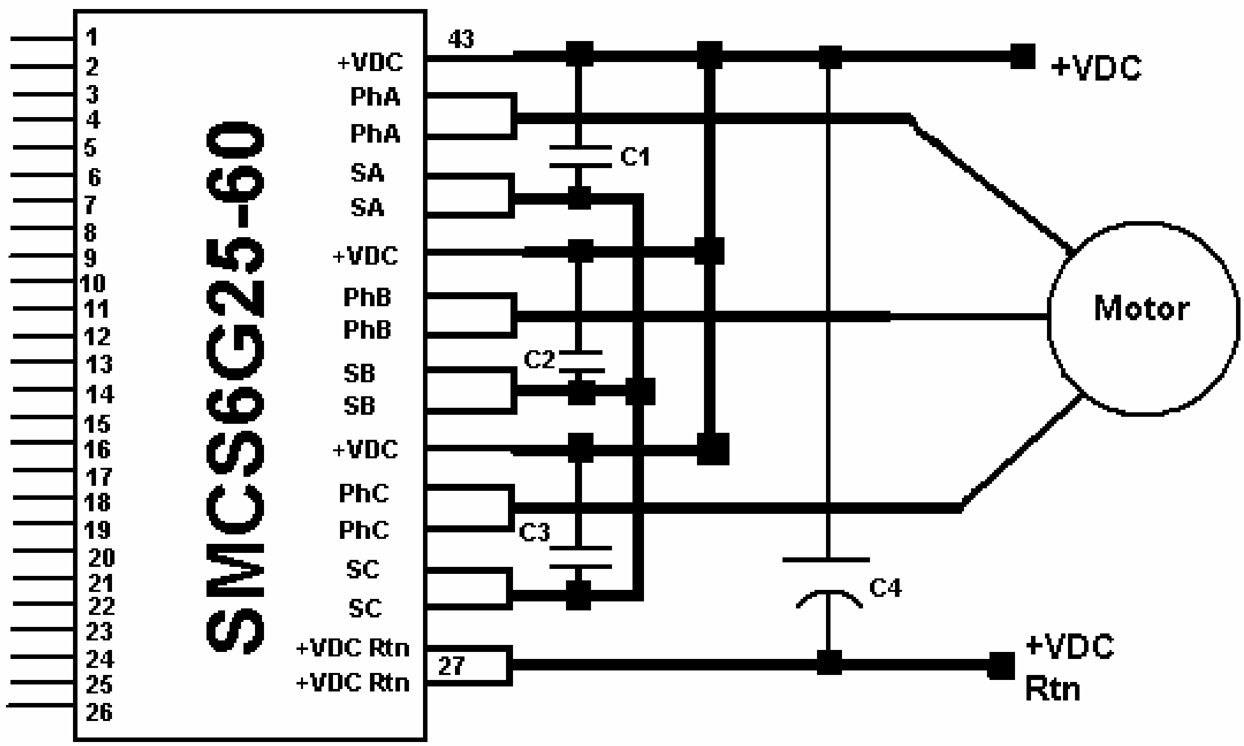

Fig. 7 DC Bus Bypass Capacitors

Application Information

Two Quadrant Mode Of Operation Of BDC Motor

Fig. 8 illustrates the four possible quadrants of operation for a BDC motor. Two-quadrant mode refers to a motor operating in quadrants I and III. With a two-quadrant BDC motor, friction is the only force to decelerate the load.

Two-quadrant mode, modulates only the high-side devices of the output power stage, as shown in FiG. 4. The current paths within the output stage during the PWM on and off times are illustrated in Fig. 9. During the on time, both switches S1 and S4 are on, the current flows through both switches and the motor winding. During the PWM cycle off time, the upper switch S1 is shut off, and the motor current circulates through the lower switch S4 and D2. The motor is assumed to be operated in quadrants I or III. During direction reversal in quadrants II and IV, the motor current path is as shown in Fig. 10.

Two-quadrant mode of operation is the **most efficient mode**, because the controller and motor switching losses are minimized. Also, EMI emission is minimum with two-quadrant mode of operation.

The limitation of two-quadrant mode of operation is, it is not safe to reverse motor direction at high speed.

In four-quadrant mode, both upper and lower switches are modulated. Motor current always decays during off time, eliminating any uncontrolled circulating current. In addition, the current always flows through the current sense resistor. **For servo system applications**, refer to SMCT6G20-60, or SMC6G25-60 motor controllers.

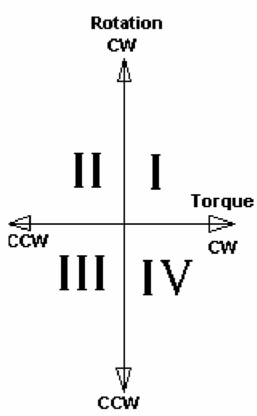

Fig. 8 Four Quadrants of Operation

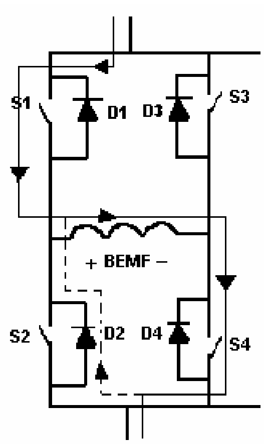

Fig. 9 Two-Quadrant Forward

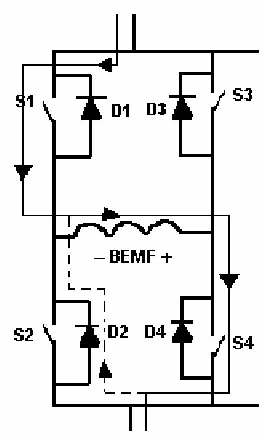

Fig. 10 Two-Quadrant Reverse

Cleaning Process:
Suggested precaution following cleaning procedure:
If the parts are to be cleaned in an aqueous based cleaning solution, it is recommended that the parts be baked immediately after cleaning. This is to remove any moisture that may have permeated into the device during the cleaning process. For aqueous based solutions, the recommended process is to bake for at least 2 hours at 125^{o}C.
Do not use solvents based cleaners.

Recommended Soldering Procedure:
Signal pins 1-26: 210C for 10 seconds max
Power pins 27 to 43: 260C for 10 seconds max.

ORDERING INFORMATION

PART NUMBER GUIDE

SMCS6G25-60 is a hermetic part. For non-hermetic add -1 to the end of the part number.

Typical current limit sense resistor values are 5, 10, 20, 30, 50, 60 mOhms. For operating current above 20A, a 5 mOhm resistor will be used. Contact the factory for other options.

Current Sense Resistor value and lead bend options shall be:

SMCS6G25-60-1-YYZ where **YY is the sense resistor value** and **Z is the lead bend option** if needed

Part number SMCS6G20-60-1-10B is non-hermetic, has a 10mOhm resistor, and option B lead bend.