MSD 50D

HARDWARE INSTALLATION

MANUAL

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1.0 Overview of MSD 50D

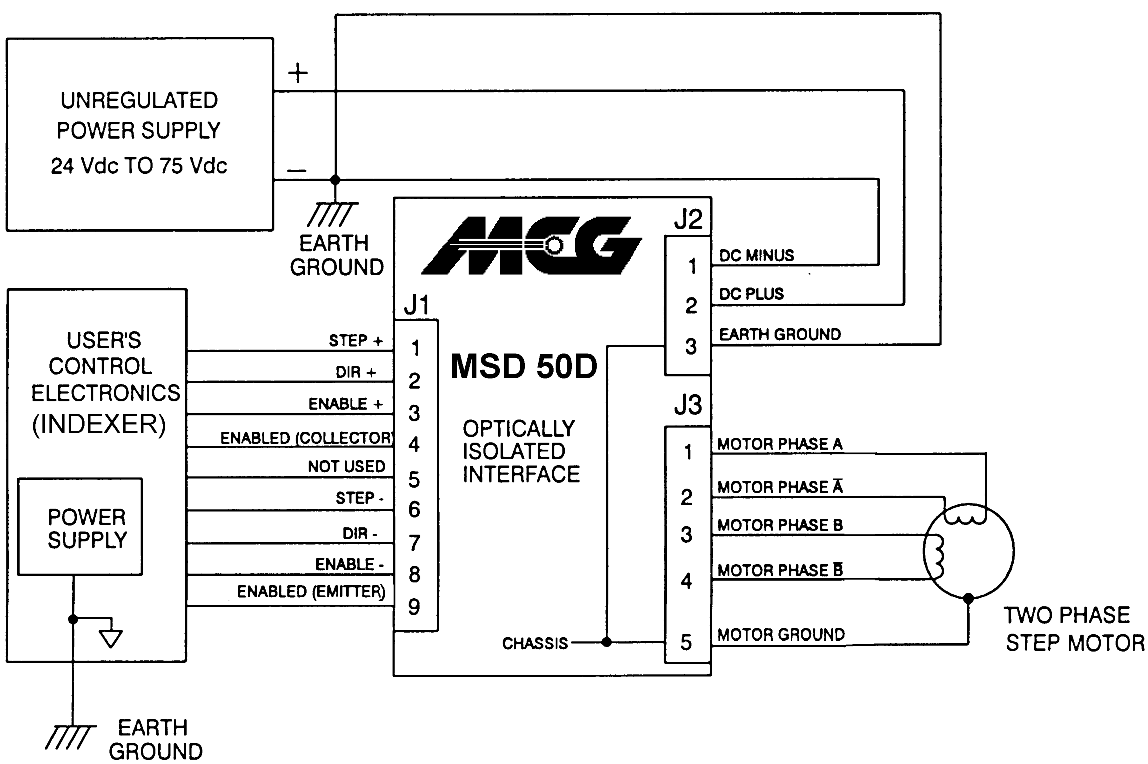
1.1 MSD 50D Definition

The MSD 50D is a two phase microstepping driver, which controls a two phase step motor. The output current of the MSD 50D is dip switch selectable from 5 to 0.625 Amps RMS.

1.2 Drive Features

- PWM Bipolar chopper drive at 20 KHz with MOSFET power devices.
- Micro stepping - switch selectable, with decimal jumper installed Full, ½, 1/5, 1/10, 1/25, 1/50,1/125, with decimal jumper removed ½, ¼, 1/8, 1/16, 1/32,1/64, 1/128, 1/256
- Midrange instability circuit which reduces the instability of step motors at high speeds
- Short circuit protection- the drive will disable if a short circuit occurs on motor outputs
- Optically isolated signal interface for the STEP, DIRECTION and ENABLE inputs and additionally the ENABLED output
- UL- Recognized, - 508C (type R) - File E176751(N)

1.3 System Connection/Wiring Diagram



The above diagram shows an installation of the MSD 50D in a typical system. Your system may vary from this configuration. Typical components used with the MSD 50D microstepping driver include:

- Two phase step motor
- External switches
- DC power supply

1.4 General Specifications

Input Voltage	+24 to 75 Vdc
Phase output current	0.625 to 5 Amps (RMS), 7.1 Amps (Peak)
Output current setting	Via 3 dip switch setting, increment of 0.625 Amps
Idle current reduction setting	Via a dip switch setting, 50% of current setting
Idle current reduction	Automatic after 0.1 sec from the last step input default (0.05 and 1.0 sec can be selected via a switch and a jumper)
Isolated inputs	STEP, DIRECTION, and ENABLE
Isolated outputs	ENABLED output
Max. STEP frequency input	2 MHz with step filter disable (500 KHz with step filter enable)
Step per revolution 1.8° - two phase step motor	200, 400, 800, 1000, 1600, 2000, 3200, 5000, 6400, 10000, 12800, 25000, 25600, 50000 and 51200
Protection	Phase to Phase, Phase to ground, Phase to voltage, internal under voltage and bus overvoltage
Switching frequency (PWM)	20 kHz
Minimum load inductance	NONE
Operating temperature	0 to 50 °C providing the case will not exceed 60 °C
Storage temperature	-55 to + 70 °C
Maximum case temperature	+60 °C
Relative humidity range	10 to 90 %, non-condensing
Motor connectors	5 contact plug in screw terminal
Power Connectors	3 contact plug in screw terminal
Signal Connector	9 socket D connector
Size	5.00" x 1.5" x 4.30"
Weight	1 lb. nominal

1.5 How to Use This Manual

This manual provides and contains information, procedures and instructions on how to install, connect, setup and test the MSD 50D microstep driver. This manual is organized into chapters and appendices.

1.6 Warranty

The MCG MSD 50D has a two year warranty against defects in material and assembly. Products that have been modified by the customer, physically mishandled or other wise abused through miswiring, incorrect switch settings and so on, are exempt form the warranty plan.

2.0 Installing the MSD 50D

This chapter explains how install the MSD 50D microstep driver in your application.

2.1 Unpacking the MSD 50D

- Remove the MSD 50D driver from the shipping carton. The packaging material and shipping carton may be retained for storage or shipment of the driver.
- Check all items of the driver against the packaging list. A label located on the bottom of the driver identifies:
    - model number
    - serial number
    - manufacture date code

2.2 Inspection Procedure

To protect your investment and insure your rights under warranty, MCG recommends the following steps be performed upon receipt of the driver:

- Inspect the driver for any physical damage that may have been sustained during shipment.
- Perform procedures described in section 2.2.1 before storing or installing the driver
- If you find damage, either concealed or obvious, contact your buyer to make claim with the shipper. Contact your distributor to obtain **R**eturn **M**artial **A**uthorization (RMA) number. Do this as soon as possible after you have received the MSD 50D driver.

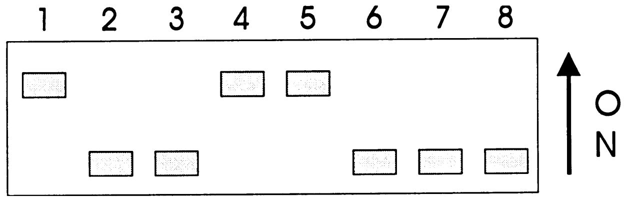
2.2.1 Testing the MSD 50D Microstep Driver

This test can be used to confirm the MSD 50D microstep driver is functional and operational. The test requires a DC power source 24 - 75 Vdc, and a two phase step motor.

WARNING

Perform this initial power up with the motor shaft disconnect form the load. Improper wiring or undiscovered damaged could result in undesired motor motion. Be prepared to remove power if excessive motion occurs.

1. Ensure the power is OFF.
2. Take note of the DIP switch settings before starting the test.



These setting reflect the following:

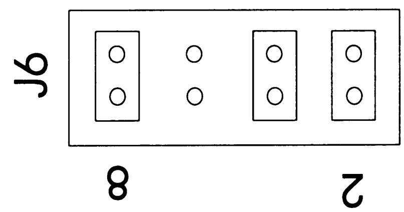
- Step size of 1/25 (5000 steps/revolution)
- Mid-range instability enabled
- Idle Current Reduction enabled
- 5 Amps RMS motor current

WARNING

If the motor is rated at less than 5 Amps RMS winding current, set position 5, 6 and 8 accordingly. Refer to section 3.0.

Make sure power is removed before proceeding.

3. Check that jumper J6 is set as follows, refer to section 3.0 “Power Up the MSD 50D”



These settings reflect the following:
- Idle Current Reduction Enabled (0.1 second delay)
- MSD 50D enabled with the enable input driven
- Decimal step size selected
- Step input filter enabled

4. Refer to the section 1.3 “System Connection/Wiring Diagram”
5. Verify the current rating of the motor, refer to section 2.8.5
6. Set the MSD 50D output current to be equal or less to the rating of the motor windings, refer to section 3.0.
7. Connect the motor phases to the MSD 50D, PHASE A, A\ and PHASE B, B\ to J3 pins 1, 2, 3 and 4 respectively.
8. Connect the indexer to J1, refer to section 2.8.3
9. Check the DC voltage level to insure it is within specification by using an oscilloscope before connection to the MSD 50D (J2), refer to section 2.8.4.
10. Switch ON power
11. Verify that the motor has holding torque by attempting to rotate the motor shaft. The energized motor shaft is either immovable or resistant to rotation.
12. Input a disable command, the motor shaft should easier to move “free to move”
13. Input an enable command, holding torque should be present at the motor shaft.
14. Input a step command and verify the motor moves.
15. Reverse the polarity of the DIRECTION signal and step the motor. The direction of rotation should change.
16. Turn the DC power OFF and remove all connections.

If the MSD 50D does not pass the above test, refer to section 4.0 “Maintenance /Troubleshooting”.

2.3 Storing the MSD 50D Driver

Return the MSD 50D to its shipping carton using the original packaging materials. Store the driver in a clean, dry place that will not exceed the following conditions:

- Humidity: 10 - 90 %, non-condensing
- Storage temperature: -55 to 70 degrees C.

2.4 Selecting a Motor

The MSD 50D microstep driver is compatible with many two phase step motors, both MCG step motors and motors from other manufacturers. MCG step motors that are compatible with the MSD 50D microstep driver includes the IS 16, IS 17, IS 23, IH 23 and IS 34 series.

The motor winding current rating must equal to the output current setting of the driver (up to 5.0 Amps RMS). Refer to the torque speed curves in the ***CfD*** "Microstepping Components" or "Stepping Motors" catalogs or contact your local MCG distributor for motor sizing and compatibility assistance.

Refer to Section 2.8.5 more information

2.5 Selecting a DC Power Supply

The MSD 50D operates from a single power unregulated DC power supply. It is recommended to select a power supply voltage which does not exceed the maximum recommended voltage input to the MSD 50D.

Refer to Section 2.8.4, Appendix B and Appendix C for more information

2.6 Safety

Read the complete manual before attempting to install or operate the MSD 50D microstep driver. By reading the manual you will become familiar with practices and procedures that allow you to operate the MSD 50D microstep driver safely and effectively.

As a user or person installing these drives, you are responsible for determining the suitability of this product for the intended application. MCG is neither responsible for nor liable for indirect or consequential damage resulting from the inappropriate use of this product.

2.6.1 Safety Guidelines

Electrical shock and hazards are avoided by using normal installation procedures for electrical power equipment in an industrial environment. The MSD 50D microstep driver should be installed in an industrial cabinet such that access is restricted to suitable qualified personnel.
Electrical hazards can be avoided by disconnecting the drive from its power source and measuring the DC voltage to verify it is the safe level (24 - 75 Vdc)

- Make sure motor case is tied to earth ground. This normally done by connecting the motor case to J3-5 and connecting J2-3 to earth ground.
- ***DO NOT*** operate the unit without connecting the step motor phases to the appropriate terminals. High voltage is present at the motor terminal when the motor is not connected and DC power is present.
- Always remove power before making any connection to the driver.
- ***DO NOT*** make any connections to the internal circuitry. Connections to J1, J2 and J3 are the only points where users should make connections.

- ***DO NOT*** use the ENABLE input as a safety shutdown. Always remove power to the driver for safety shutdown.
- ***DO NOT*** spin the motor without power. The motor acts like a generator and will charge up the power capacitor through the drive. Excessive speed may cause over voltage breakdown in the power MOSFETs. Note the driver having an internal power converter that operates from the high voltage will become operative.
- ***DO NOT*** short the motor at high speed. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the drive peak current. The short itself should not damage the driver but may damage the motor. If the motor is spinning rapidly and motor connections arc or open, a high voltage pulse flows back into the drive (due to stored energy in the motor inductance) and may damage the drive.

WARNING

Voltage potential inside the drive vary from +Vbus Volts above to -Vbus Volts below earth ground. All internal circuit should be considered "hot" when power is present.

2.7 Mechanical Installation

Mount the MSD 50D microstep driver in an enclosure providing protection to IP 54, protected against dust and splashing water, or IP 65, protected against water jets and dust free air. Many NEMA type 4 cabinets provide this level of protection. Minimum cabinet requirements are:

- Depth 7 inches.
- Ventilation to dissipate power, see the following plot for power vs.. RMS current.
- The air should be free of corrosive or electrically conductive contaminates.

2.7.1 Cool plate mounting

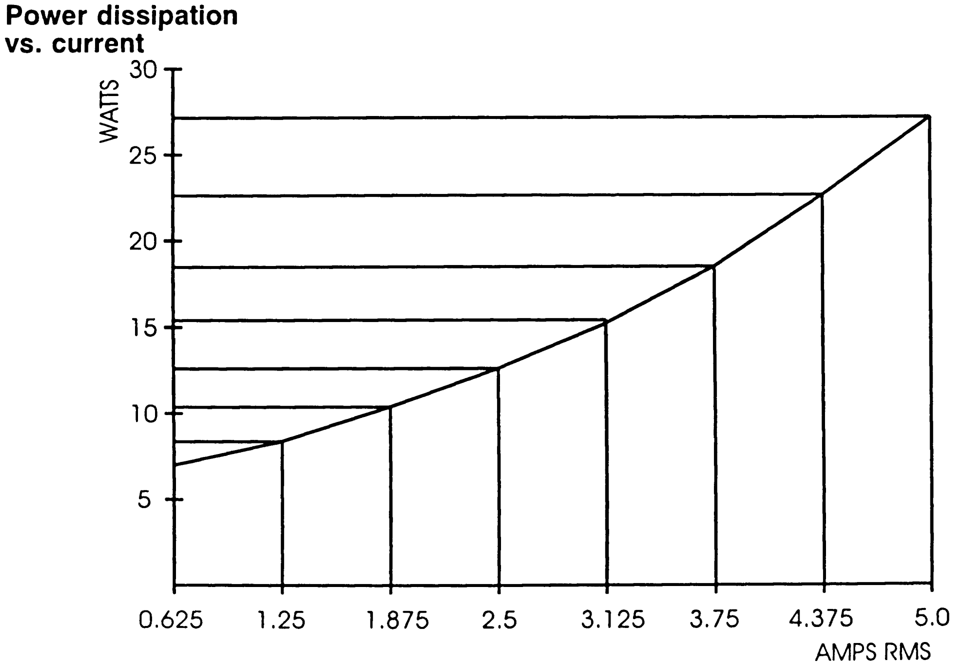
For optimal thermal performance and minimum panel usage, mount the MSD 50D bookcase style to a cooling plate and the MSD 50D chassis should be maintained below 60 °C. Using M4 or 6-32 screws inserted through the mounting slots on the back of the unit. For a better heat transfer if the surface is irregular use thermal grease.

The following graph of the MSD 50D power dissipation vs.. current setting may be used to design a cooling plate or direct measurement may be taken during normal operations and adjustments is made to plate area or air flow.

2.7.2 Heat sink mounting

If a cooling plate is not provided, the optional heat sink available for MCG can be mounted to the side of the MSD 50D and the combined unit mounted to a panel using slots on the back of the MSD 50D.

With minimum unobstructed space of 4 inches above and below the unit and cooling is accomplished solely on the through convention, the MSD 50D can be run at 5 Amps RMS maximum for ambient temperature of 25 °C and 2.5 amps RMS maximum for ambient temperature of 45 °C. Using the fan to blow air past the heat sink will increase the allowable current significantly. It is always required that the MSD 50D chassis temperature not to exceed 60 °C.



2.7.3 Panel mounting

If the MSD 50D is mounted to a panel with no cooling plate and no heat sink, a minimum unobstructed space of 4 inches above and below and 1 inch between side plate and any other objects must be provided. If cooling is accomplished solely through convection air flow (no fan), the unit can run at 2.5 amps RMS maximum if the ambient is 25 °C and 1.25 amps RMS if the ambient is 45 °C.

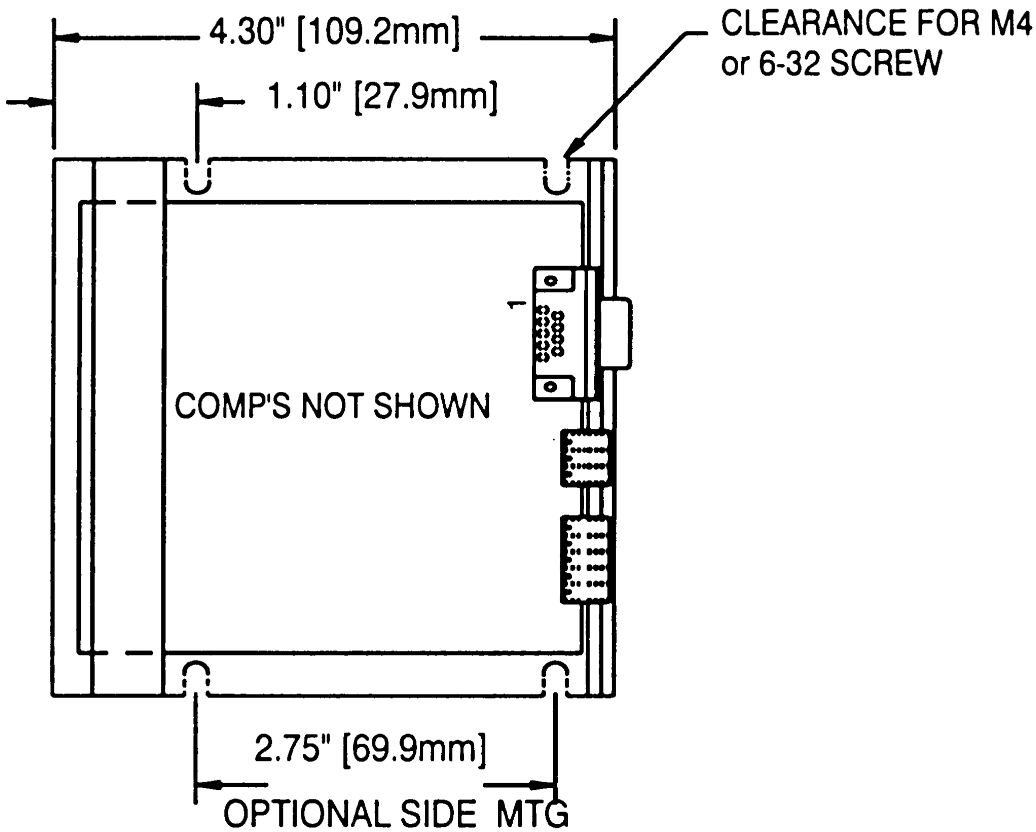
Again the use of a fan to blow air past the side plate of the MSD 50D driver will increase the allowable current.

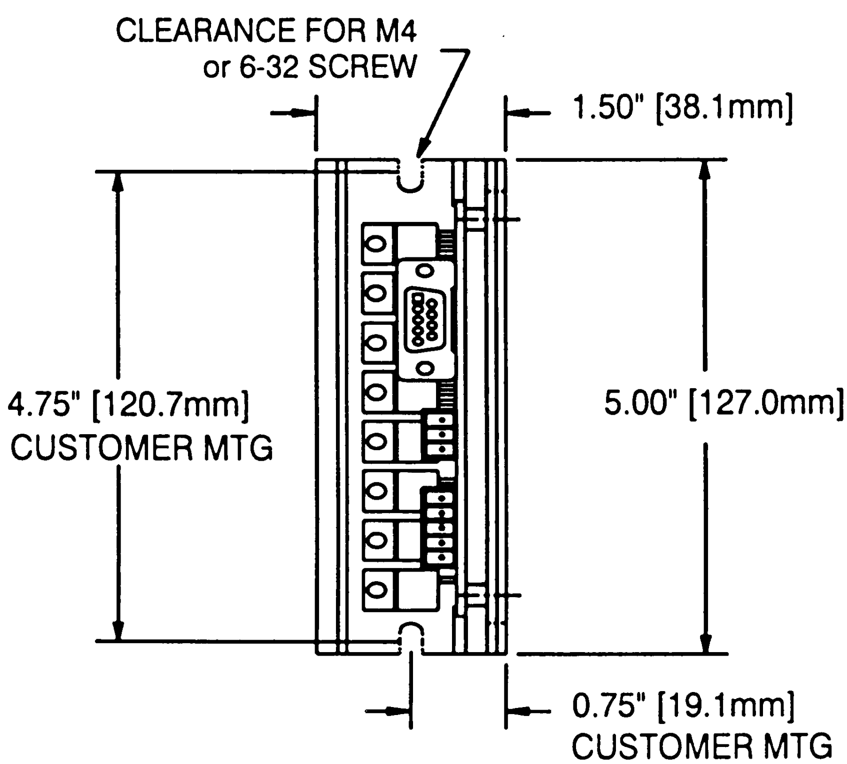
MCG offers an optional side mount heat sink (part number MSD 5HS) which adds only 1.0 inch to the width (total width would be 2.5 inches).

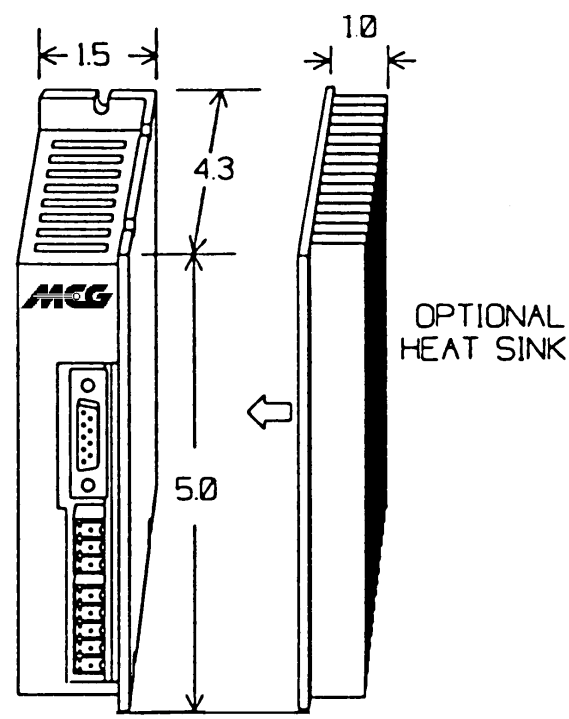
2.7.4 Mounting dimensions

Refer to the following dimensions for mounting the MSD 50 D. Your installation should met the following guidelines:

- Vertical orientation for the unit
- Flat, solid surface capable of supporting 1.0 lb. weight (0.5 KG mass) of the unit
- Free of excessive vibration or shock
- Minimum unobstructed space of 4 inches (10 cm) above and below the unit
- Maximum ambient temperature of 50°C and chassis maximum temperature of 60°C


4.30" [109.2mm]
CLEARANCE FOR M4
or 6-32 SCREW
1.10" [27.9mm]
1
COMP'S NOT SHOWN
2.75" [69.9mm]
OPTIONAL SIDE MTG


CLEARANCE FOR M4
or 6-32 SCREW
1.50" [38.1mm]
4.75" [120.7mm]
CUSTOMER MTG
5.00" [127.0mm]
0.75" [19.1mm]
CUSTOMER MTG

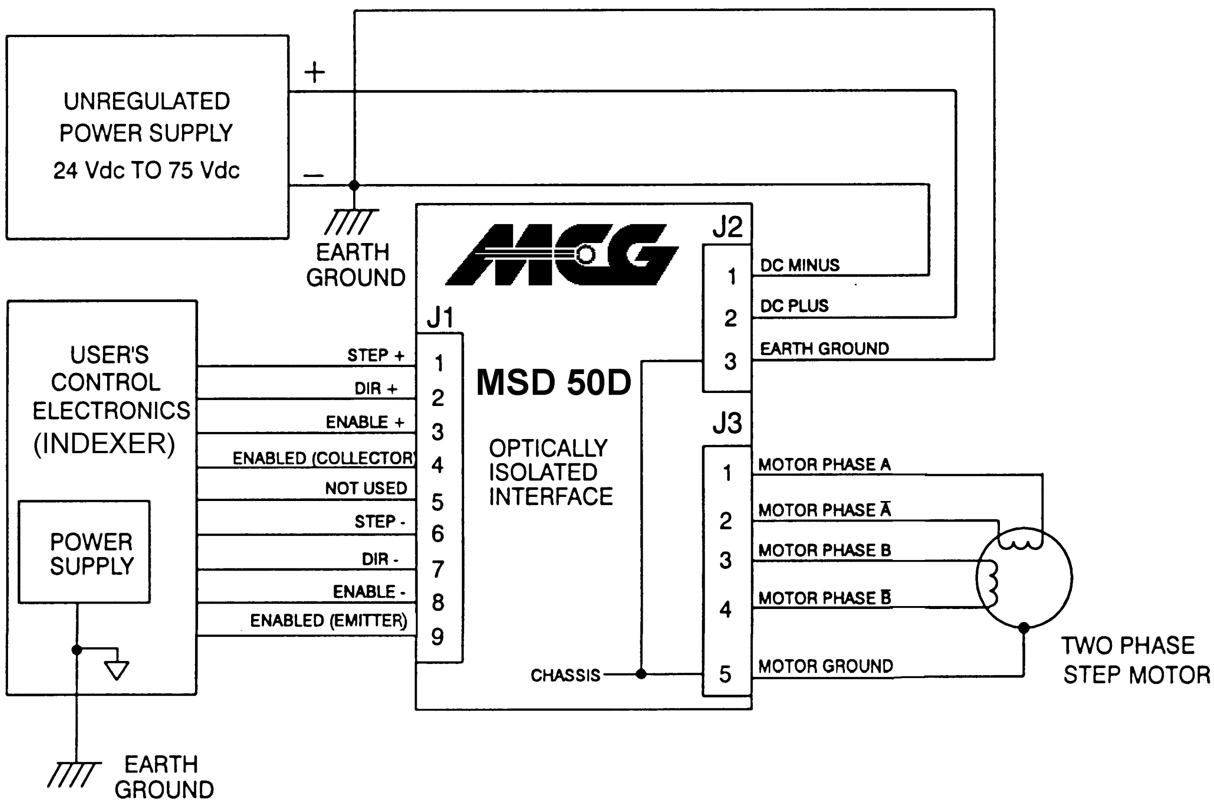

1.5
1.0
4.3
MCG
5.0
OPTIONAL
HEAT SINK

2.8 Electrical Interfacing and Connections

The MSD 50D has three I/O (input/output) connectors.

- J1 - Control Signal, 9 pin D connector
- J2 - DC power input, mating connector - PCD ELVP03100
- J3 - Motor phases, mating connector - PCD ELVP05100

2.8.1 Interface Connection Diagram



2.8.2 Wiring

Wiring sizes and practices as well as grounding and shielding techniques described in this section represents the common wring practices and prove satisfactory in majority of applications.

Due to the switching nature of this PWM driver, care should be exercised in routing power and signal wiring in the system. Noise radiated from nearby electrical or electronic equipment may cause undesired motor movement due to pickup by the driver signal inputs.

Likewise, the driver power outputs can generate noise which could be picked up by the driver's signal inputs or by other electronic equipment located 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 signal lines should run in a separate conduits or spaced at least 12” apart.

NOTE

In multi-axis applications, it is preferable to run each power connection from the supply to the each MSD 50D and not daisy chain the power connections.

WARNING

The user is responsible for conforming with all applicable local, national and international codes. Wiring practices, grounding disconnects and over current protection are of particular importance. Nonstandard applications and special operating conditions and system configurations may differ than what's described in this section.

2.8.3 J1 - Signal Connector

J1 signal interface accepts STEP, DIRECTION and ENABLE signals form the indexer and outputs and enabled signal which indicates the MSD 50D is applying current to the motor windings. The mating cable connector is an ITT CANNON DE-9P with ITT CANNON DE110963 hood and D20419 clamp kit.

2.8.3.1 J1 Signal Table

Input/Output	Pin	Explanation - Function/Description
STEP +	J1-1	• Input. Used to command motor rotation.
DIR +	J1-2	• Input. Determines the direction of motor rotation. If standard motor wiring is followed, the motor will turn CW if the Opto current is ZERO. • The sense of the DIR+ input can be reversed by reversing the connections of either A& A\ **OR** B&B\.
ENABLE +	J1-3	• Input. Used to enable or disable the MSD 50D’s power stage. • With the J6, 5-6 jumper out (factory default) the power stage is enabled if the output current is ZERO and disabled if the Opto is driven. • Inserting the jumper reverses this functionality. • There is a delay of approximately 500 micro sec after enabling the drive and the power stage becoming active.
ENABLE Collector	J1-4	• Output. Collector of transistor that is on when the MSD 50D’s power stage is active.
	J1-5	**NOT USED**
STEP -	J1-6	• Input. Used to command the motor rotation
DIR -	J1-7	• Input. Determines the direction of motor rotation. If standard motor wiring is followed, the motor will turn CW if the Opto current is ZERO. • The sense of the DIR+ input can be reversed by reversing the connections of either A& A/ **OR** B&B/.
ENABLE -	J1-8	• Input. Used to enable or disable the MSD 50D’s power stage. With the J6 5-6 jumper

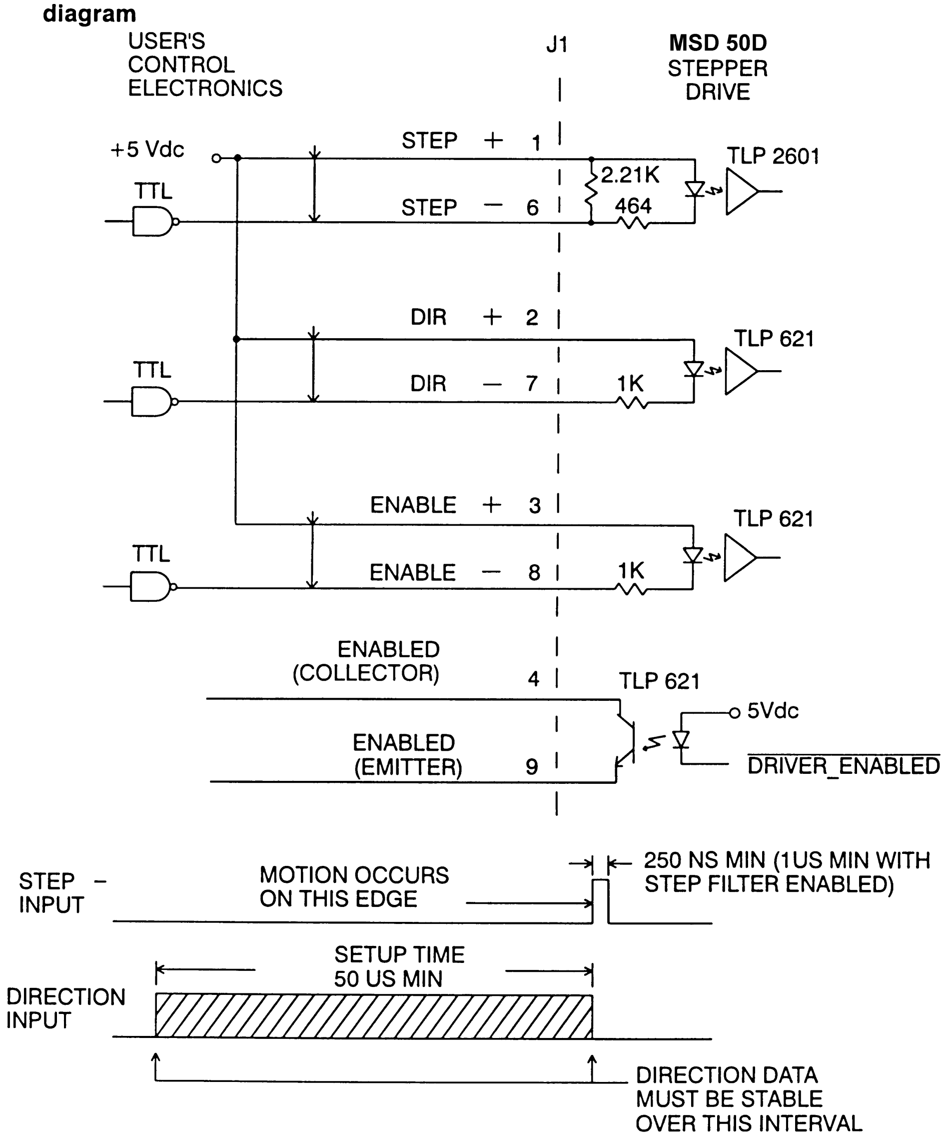
		out (factory default) the power stage is enabled if the output current is ZERO and disabled if the Opto is driven. Inserting the jumper reverses this functionality. • There is a delay of approximately 500 micro sec after enabling the drive and the power stage becoming active.
ENABLED EMITTER	J1-9	• Output. • Emitter of transistor that is on when the MSD 50's power stage is active.

2.8.3.2 Typical Interface

The following figure shows a typical interface between the user's electronics and the MSD 50D driver unit. **The TTL gates should have totem pole output and capable of sinking at least 10.0 mAmp at 0.4 volts.**

Refer to Appendix A for more specifications.

Interface diagram

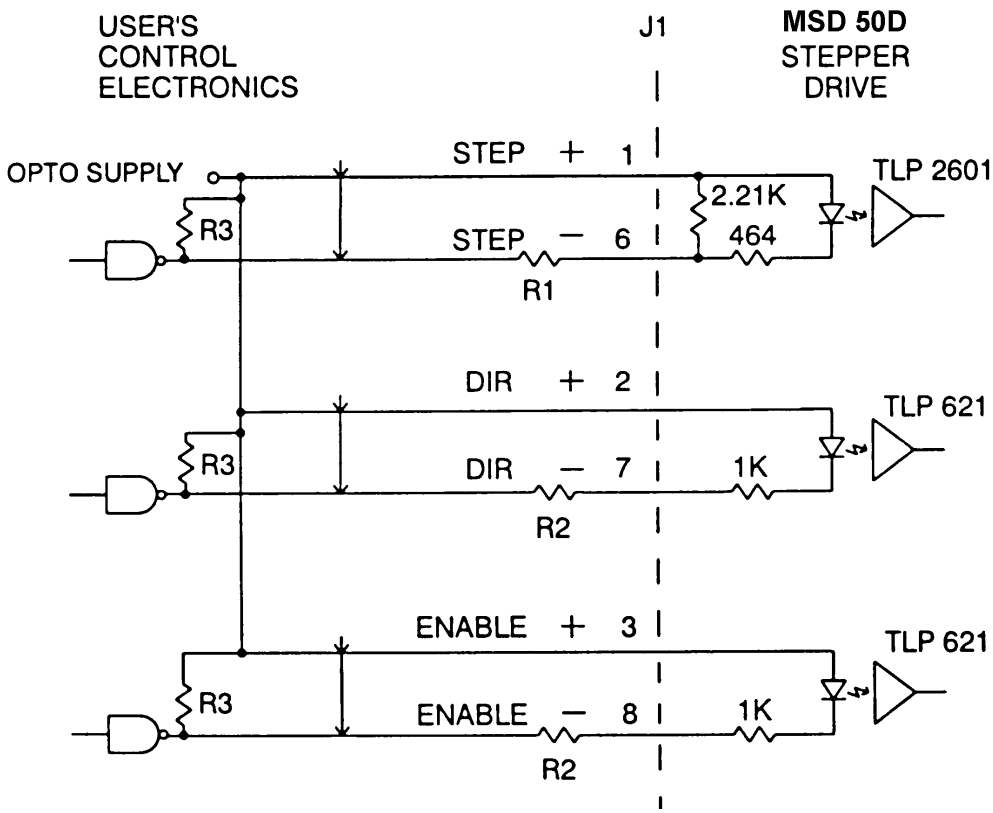


2.8.3.3 Higher voltage interface

Voltages up to 30 volts can be used for the Opto power input to the MSD 50D driver. However, a resistor must be put in series with the command inputs as shown below. Values of several common supply voltages are given in the following table

Opto Supply to MSD 50D	R1	R2
+12 Vdc	1 Kohm	1.5 Kohm
+15 Vdc	1.5 Kohm	2.2 Kohm
+30 Vdc	3.3 Kohm	6.8 Kohm

If the drivers have open collector outputs, pull up resistors (R3) should be added as shown. Atypical value for R3 is 2.7 Kohm.



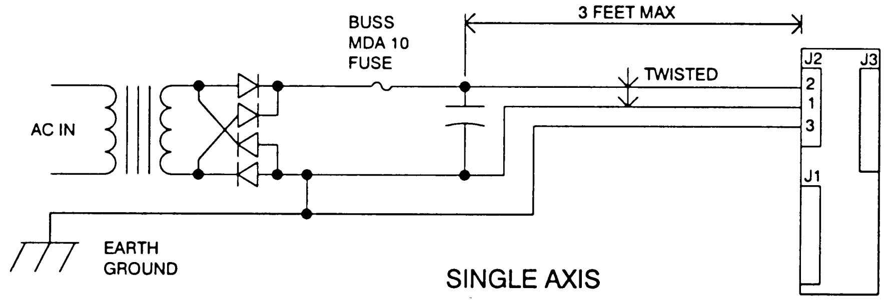
2.8.4 J2 Power Connector

J2 connects the DC power to the MSD 50D driver unit.

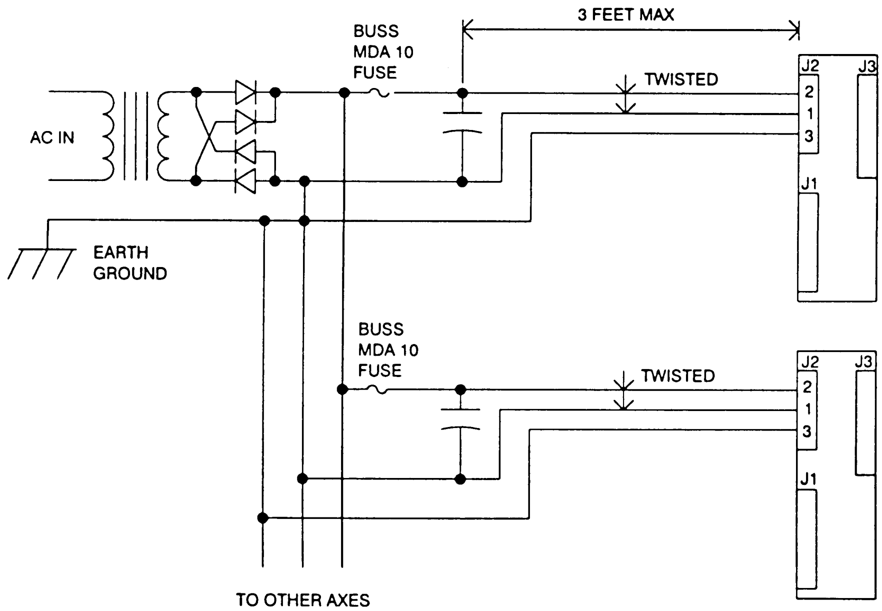
Input	Pin	Explanation
DC -	J2-1	• +24 to +75 Vdc max.. at 5 amps. • Ripple voltage ± 10%. • The negative side of the power supply, connected to the DC-, should be connected to the Earth ground. • No connections is made within the MSD 50D driver unit between J21- and J2-3.
DC +	J2-2	
Earth Ground	J2-3	Connected to the MSD 50D case and J3-5 , motor ground.

Connecting the MSD 50D and the power supply is shown in the following diagram. A simple non-regulated supply is for this example.

Connection diagram



SINGLE AXIS



MULTIPLE AXES

The DC+ and DC- should run from the power supply's capacitor to the MSD 50D as a **<u>twisted pair no longer than 3 feet</u>** in length (shielding, with shield connected to earth ground, can reduce the noise emissions).

A buss MDA 10 A, slow acting fuse (or equivalent) should be included in the power supply between the rectifier and the capacitor as shown below.

Use minimum #18 AWG twisted cable for the power supply cable. Twisted Pair (jacketed) Belden Part # 9740 or equivalent.

Heavier wire (#16 AWG, Belden Part # 8471 or equivalent) should be used for longer distances between the power supply and the driver

NOTICE

1. It is extremely important that the supply voltage never exceed 75 volt DC even on a transient basis. This is one of the most common causes of driver failures. Care should be taken specially when using an unregulated DC power sources, insure that the output voltage does not exceed 75 Vdc because of the variation in the line voltage.

WARNING

Under any operating conditions the power supply design must insure the bus voltage should not exceed 75 volts. Condition such as, high line voltage, transformer regulation effects, and voltage spiking due to current switching within the MSD 50D and regeneration.

2. Wiring inductance between the MSD 50D power input and the external capacitor is significant because the PWM chopper driver requires pulse currents. Therefore, it is extremely important that the two be connected by twisted pair no longer than 3 feet in length.
3. If the distance is longer than 3 feet an electrolytic capacitor should be added across J2 pins 1 and 2 and located near the MSD 50D. The capacitor required should handle 5.0 amps RMS ripple @ 120 Hz or greater.
4. Switching power supplies and regulated linear with overcurrent protection are not recommended because of their inability to handle surge currents.
5. If multiple MSD 50D's are to be run off of one power supply, each MSD 50D should have sperate power and ground wires that connected directly to the output capacitor of the power supply.
6. It is recommended that a input line filter be used on the power supply to limit voltage spikes to the MSD 50D.
7. The output current needed is dependent on the supply voltage, motor selection and load

WARRING

DO NOT CONNECT OR DISCOUNT THE MOTOR LEADS WITH POWER APPLIED.

Refer to Appendix B for more information

2.8.5 J3 Motor connections

J3 connects the 50D driver unit to the step motor. J3 utilizes a plug in screw terminal type connector to simplify assembly and allow quick connect and disconnect.

Output	Pin	Explanation
Motor Phase A	J3-1	Motor phase A excitation. Twisted Pair
Motor Phase A\	J32	
Motor Phase B	J3-3	Motor phase B excitation. Twisted Pair
Motor Phase B\	J3-4	
Drive Case (Earth) Ground	J3-5	Connected to the motor case ground.

Twisted pair, over all shielded for motor cabling is recommended. Ground the shield end only at the J3-5 of the MSD 50D driver, the other end of the shield should remain unconnected. The motor power inputs are connected to the drive output.

Use minimum #18 AWG twisted for cabling (Belden Part # 9368 or equivalent) for motors with current ratings less than 2.5 amps RMS and #16 AWG twisted pair (Belden Part #1492A or equivalent) for motors with current rating above 2.5 amps RMS.

NOTES

1. ***DO NOT*** *use wire shield to carry motor current.*
2. ***DO NOT*** *solder or pre-tin the tips of the cable going into the screw terminal connector, solder will contract and will result in loose connections over time.*

NOTE

1. *The physical direction of the motor with respect to the direction input depends on the connections of the motor windings.*
2. *To reverse the motor direction with respect to the motor direction input, switch the wires on PHASE A* **OR** *PHASE B.*

WARRING

DO NOT CONNECT OR DISCONNECT MOTOR LEADS WITH POWER APPLIED

The MSD 50D is a bipolar drivers which works equally well with both BIPOLAR and UNIPOLAR motors, (i.e. 4, 6 center taped and 8 lead motors). To maintain a given set motor current, the MSD 50D chops the voltage using a constant chopping frequency and a varying duty cycle. Choose a motor with a low winding resistance, the lower the winding resistance (hence lower winding inductance) the higher the step rate.

Since the MSD 50D is a constant current source, it is necessary to use a motor that is rated at the same voltage as the supply voltage. What is important is that the MSD 50D is set to the motor's rated current. The higher the voltage used the faster the current flow through the motor coils (windings). This in turn means a higher step rate. Care should be taken not to exceed the maximum voltage of the MSD 50D.

Therefore choosing a motor for a system design, the best performance for a specified torque is a motor with lowest possible winding resistance used in conjunction with the highest possible driver voltage.

Stepper Motors can be configured as 4, 6 and 8 leads. Each configuration requires different currents.

The following are different lead configurations and the procedures to determine their output current. ***Keeping in mind that the stepping motor current ratings are published in RMS values (the peak current value can be obtained by multiplying the RMS value by 1.4).***

4 Lead Motors:
Use specified motor current to determine their output.

6 Lead Motors:
1. "Parallel", when configuring a 6 lead motor half coil configuration (i.e. connected from one end of the coil to the center tap, higher speed configuration) use the specified current per phase (or unipolar) current to determine the current adjustment resistor value.
2. "Series", when configuring the motor so the entire coil is used (i.e. connected from end to end with center tap floating, high torque configuration) multiply the phase (or unipolar) current rating by 0.7. Use this result to determine the current adjustment resistor value.

8 Lead Motors:
1. Series Connections, when configuring the motor windings in series, multiply the per phase (or unipolar) current rating by 0.7. Use this result to determine the current adjustment resistor value. The series connections will increase the inductance by a factor of 4 and this will cause the torque to drop off at higher speeds and that why the series mode is only useful at low speeds.
2. Parallel Connections, when configuring the motor windings in parallel, multiply the per phase (or unipolar) current rating by 1.4. Use this result to determine the current adjustments resistor value. The parallel connections does not effect the motor inductance but the motor resistance drops in half so for the same motor power dissipation the current can be increased by 40% and this will provide a significant torque increase.

It is preferable to connect an 8 lead stepping motor in parallel connections. The parallel connections produces a greater shaft power (flatter torque curve over a higher speed range).

Series connections is useful when torque is required at low speeds (it allows the motor to produce high torque at low speeds from lower current drivers). Series connections carries a greater likelihood of resonance due its high torque in the low speed region.

WARNING

Although stepping motors will run hot when configured correctly, damage may occur to the motor if a higher than specified current is used. Most specified motor currents are maximum values. Care should be taken when exceeding these ratings. The current rating of a step motor is determined by the allowable temperature rise. Unless the motor manufacturer's data state otherwise, the rating is a "unipolar" value and assumes both phases ON "energized" simultaneously and it is an RMS value NOT the Peak value.

The following tables shows different MCG stepping motor based upon the number of leads, colors, possible configurations and connectivity to the MSD 50D microstepping driver.

Connections	4 - Lead Color	4 - Lead Color	4 - Lead Color	6 - Lead Color	Drive Connections
4 - Lead Bipolar	White	Brown	Black	Green	A
	Yellow	White/Brown	Orange	White/Green	A\
	Red	Red	Red	Red	B
	Blue	White/Red	Yellow	White/Red	B\
				White	No Connections is made to driver
				Black	

Connections	8 - Lead Color	8 - Lead Color	Drive Connections
4 - Lead Bipolar Parallel Connections	Black	Brown	A
	White/Orange	White/Orange	
	White/Black	White/Brown	A\
	Orange	Orange	
	Red	Red	B
	White/Yellow	White/Yellow	
	White/Red	White/Red	B\
	Yellow	Yellow	

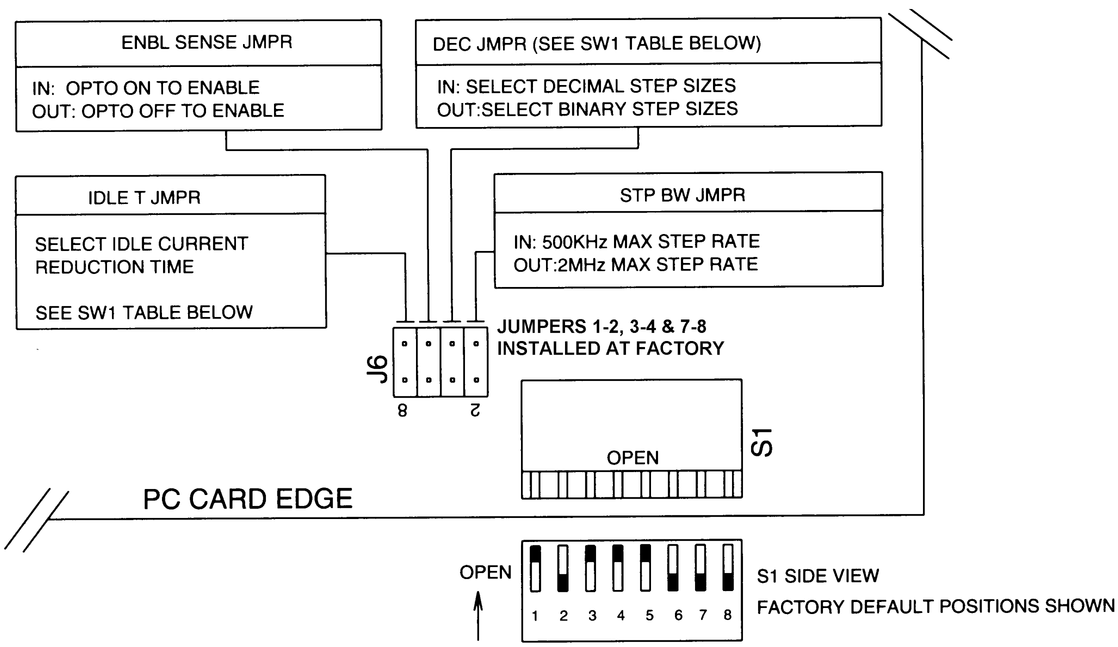
Connections	8 - Lead Color	8 - Lead Color	Drive Connections
4 - Lead Bipolar Series Connections	Black	Brown	A
	White/Orange	White/Orange	Connected together but no connections is made to the driver
	White/Black	White/Brown	
	Orange	Orange	A\
	Red	Red	B
	White/Yellow	White/Yellow	Connected together but no connections is made to the driver
	White/Red	White/Red	
	Yellow	Yellow	B\

3.0 Powering Up the MSD 50D Driver

3.1 Setting Switch S1 & Jumper J6

Dip switch S1 and Jumper J6 set the following:

- Step Size
- Motor Current Level
- Mid-range instability ON/OFF
- Idle Current Reduction
- Enable Sense
- Step Filter response time



SW1 POSITION 1	SW1 POSITION 2	SW1 POSITION 3	STEP SIZE DEC JMPR IN	STEP SIZE DEC JMPR OUT
CLOSED	CLOSED	CLOSED	FULL	HALF
CLOSED	CLOSED	OPEN	HALF	1/4
CLOSED	OPEN	CLOSED	1/5	1/8
CLOSED	OPEN	OPEN	1/10	1/16
OPEN	CLOSED	CLOSED	1/25	1/32
OPEN	CLOSED	OPEN	1/50	1/64
OPEN	OPEN	CLOSED	1/125	1/128
OPEN	OPEN	OPEN	1/250	1/256

SW1 POSITION 6	SW1 POSITION 7	SW1 POSITION 8	MOTOR CURRENT AMPS RMS
CLOSED	CLOSED	CLOSED	5.0
CLOSED	CLOSED	OPEN	4.375
CLOSED	OPEN	CLOSED	3.750
CLOSED	OPEN	OPEN	3.125
OPEN	CLOSED	CLOSED	2.5
OPEN	CLOSED	OPEN	1.875
OPEN	OPEN	CLOSED	1.25
OPEN	OPEN	OPEN	0.625

SW1 POSITION 4	MID-BAND INSTABILITY CONTROL
CLOSED	DISABLED
OPEN	ENABLED

IDLE_T JUMPER	SW1 POSITION 5	IDLE CURRENT REDUCTION
IN	CLOSED	DISABLED
IN	OPEN	0.1 SEC DELAY
OUT	CLOSED	0.05 SEC DELAY
OUT	OPEN	1.0 SEC DELAY

3.2 Step Size

The step size sets the amount of rotation per input step. Fifteen set sizes are available using jumper J6 position 3-4 and DIP switch S1 positions 1-3 as shown in the above figure. For all MCG stepping motors and all 1.8° step motors, step size can be converted to steps per rotation using the following table:

Decimal		Binary	
Full	200	Half	400
Half	400	1/4	800
1/5	1,000	1/8	1,600
1/10	2,000	1/16	3,200
1/25	5,000	1/32	6,400
1/50	10,000	1/64	12,800
1/125	25,000	1/128	25,600
1/250	50,000	1/256	51,200

Selecting a micro step size ¼ or smaller results in

- High resolution
- Smoother low speed operation
- Ability to operate in low-speed resonance regions

Refer to Appendix D for more information

3.3 Mid-Range Instability Control

Mid -range frequency instability and the resulting loss of torque occurs in any step motor/driver system due to motor back EMF modulating the motor winding currents at certain speeds.

Mid-range instability can be explained as a result of the electronic, magnetic, and mechanical characteristics of any stepping motor system. The circuitry used to control this phenomenon does so by advancing or delaying the switching of the output current with respect to the incoming pulse train.

Enable the mid-range instability control function by placing DIP switch S1 position 4 in the open position as shown previously. This is the default position and should be used for most applications if your application is affected by loss torque at mid-range speeds.

This feature controls torque loss at mid-rang speeds. When enabled, the motor maintains torque at mid-range operations, provided the torque load does not exceed the motor torque ratings.

3.4 Idle Current Reduction (ICR)

The Idle Current Reduction (ICR) function reduces the phase current at times when no motion is commanded. Motor current is reduced when no step commands are received for a given time.

This time can be set to 0.05 seconds, 0.1 seconds or 1.0 seconds. Current to both motor windings is reduced by ½.

The ICR function can be enabled/disabled and the time delay between the last step command and current reduction can be set to 50 msec, 0.1 seconds or 1.0 second using the DIP switch S1 position 5 and jumper J6 position 7-8.

With the jumper installed (factory default), ICR is disabled when DIP swicth S1 position 5 is in the closed position and enabled with a delay of 0.1 second (current is reduced to 50% when no command is received for 0.1 second when the switch is open).

With the jumper removed, ICR is enabled and the delay can be set to 0.05 second or 1.0 second by placing DIP switch S1 position 5 in the closed or open position respectively.

The ICR function reduces the motor and drive heating during stand by operations.

When ICR is active, both the holding torque generated by the motor and the motor stiffness around the holding position are reduced by approximately 50%.

3.5 Setting Motor Current

Motor current can be set using the DIP switch S1 position 6, 7, and 8 as shown previously. Current should be compatible with the motor current ratings.

Power dissipation in the MSD 50D drive increases as the output current is increased, so that more cooling is required at higher motor current settings, refer to section 3.1 and 2.5.

3.6 Enable Sense Control

The polarity of the enable input can be changed using jumper J6 position 5-6.

With the jumper removed (factory default), the drive is enabled when the enable input is not driven and disabled when the enable input is driven (current flows in enable Opto). This allows the MSD 50D driver to be used with no connections to the enable input.

With the J6 position 5-6 jumper installed, the enable input must be driven (current flowing in the Opto) for the MSD 50D power stage to be enabled.

3.7 Step Bandwidth Adjustment

A digital filter can be enabled which reduces susceptibility to noise on the step input at the expense of a lower limit on maximum step frequency.

With the jumper J6 position 1-2 installed (factory default) the filter is enabled and step pulses must have a minimum width of 1 microsecond. Pulses less than 0.5 microsecond in width will be rejected.

With the filter disabled, jumper 6 position 1-2 removed, step pulses must be a minimum of 0.25 microseconds wide.

Therefore, the maximum step frequency is 500 KHz with the filter enabled and 2 MHz with the filter disabled.

4.0 Maintenance and Troubleshooting

The MSD 50D is designed for minimum maintenance. The only maintenance is remove the superficial dust and dirt from the driver using a clean, dry and low pressure air.

MSD 50D has an “ENABLED” output

- ON when the driver is enabled and
- OFF when the driver is disabled or faulted due to any of the following faults:
  - Output over current (line to line or line to neutral short)
  - Bus over voltage
  - Low voltage supply out of tolerance.

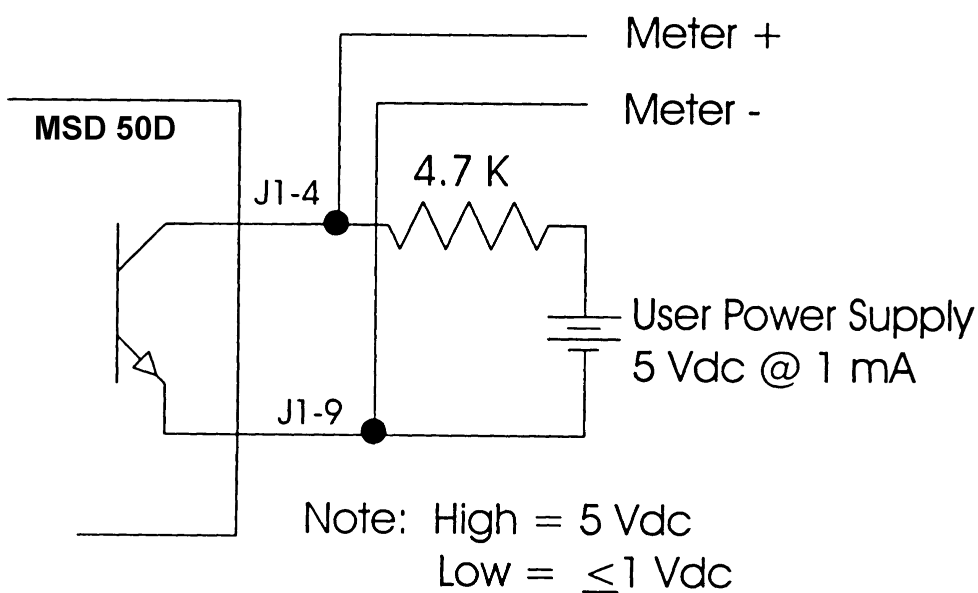
In case of a fault

- *Any fault will disable the MSD 50D driver.*
- *The ENABLED output - opto transistor OFF*
- *The MSD 50D driver input power has be cycled to clear and reset the driver (turn power OFF then ON).*

Simple circuit

NOTE *- If you suspect that the MSD 50D driver unit has been damaged,*

- *DO NOT simply replace it with another and apply power.*



- *Recheck the power supply design and verify that it meets all requirements.*
- *Improper power supply design is the most common cause for damaged MSD 50D drivers. Refer to Appendix B for more information*

Use the following troubleshooting table and the following simple circuit to diagnose and correct most problems. If you are unable to achieve satisfactory operations contact your local MCG distributor.

Symptom	Corrective Action
Motor	• Ensure the drive is not disabled.

Produces NO Torque	• Check for open fuses or open contactors • Ensure power to MSD 50D is applied. • Check that P2 power supply voltage is >= 24 and <= 75 Vdc. If possible, check with an oscilloscope to verify that this is true on transient basis. • Check the motor connections for shorts across the windings or between the windings and the motor case. • Verify that current setting is set correctly • Recheck that the motor connections are wired correctly (motor phases are not crossed wired). • Check the driver case temperature. If the case temperature is above 60 degrees C a heat sink or a cool fan is required. You might consider using the ICR function.
Motor Produces Torque But Does Not Turn	• Make sure that the STEP input is switching and meets specified electrical and timing requirements • Check the opto power to J1 • Check the phase current in both phases by placing an ammeter is series with each winding, if not preset check that phase resistance. • Check the motor phasing (wiring if an 8 lead motor or 6 lead motor). • Check the input frequency if it is too high, lower the input frequency by adding a ramp frequency.
Motor Rotates In The Wrong Direction	• Check polarity of the DIRECTION input. • Also, check that the DIRECTION input satisfies the specified electrical and timing requirements. • Reverse the A and A/ motor phase (**<u>or</u>** reverse the B and B/ motor phase).

Motor Does Not Reach Expected Position	• Check that the step size setting of the driver is the same as the step size of the indexer.
	• Verify that the motor does not stall. If it does:
	    • Recheck sizing calculations. Be sure that the power supply voltage is high enough for the required torque vs.. speed curve.
	    • Use finer step size to avoid low speed resonance problems
	    • Check that the STEP and DIRECTION inputs satisfy all electrical timing requirements.
	• Fault in the driver logic, to evaluate:
	    • Set the MSD 50D to FULL step
	    • Pulse the motor 1 step (motor should move one step)
	    • Repeat this procedure for 16 steps in both direction
	    • If the driver fails this test replace the driver
	• Incorrect ramp time, adjust the acceleration / deceleration ramp time.
	• Intermittent connection of the STEP CLOCK input or incorrect STEP magnitude.

Motor Operation is Rough or Erratic	• Operation is on resonance region of the torque/speed curve. • Change frequency of applied logic pules • Use higher bus voltage • Use finer step resolution • Improper phase sequencing (faulty driver), replace driver.

If you can not correct the driver problem, or if it is defective, return it to MCG Inc. for repair or replacement.

Call MCG Inc. or your local distributor to get an RMA # (Return Material Authorization Number)

NOTE

Do not attempt to return the MSD 50D or any other equipment without a valid RMA#. Returns received without a valid RMA# will not be accepted and will be returned to the sender.

Pack the drive in its original shipping carton. MCG Inc. is not responsible or liable for damage resulting from improper packaging shipment.

Ship the drive to

MCG Inc.
1500 North Front Street
New Ulm MN 56073-0637
Attn.: Repair Department RMA# __________

Appendix A Specifications

Electrical

Input Power Supply	+24 to +75 Vdc @ 5.0 Amps	
Rated Drive Current (motor phase current settings)	5.000 +/- 0.25 Amps RMS 4.375 +/- 0.2 Amps RMS 3.750 +/- 0.2 Amps RMS 3.125 +/- 0.15 Amps RMS 2.500 +/- 0.15 Amps RMS 1.875 +/- 0.125 Amps RMS 1.250 +/- 0.125 Amps RMS 0.625 +/- 0.100 Amps RMS	
Drive Circuit	Two phase bipolar, chopper current regulated	
Chopper Frequency	20 KHz, nominal	
Step size, Switch Selectable (1.8 degrees two phase step motor)	Step size	Steps/Revolution
	Full	200
	1/2	400
	1/4	800
	1/5	1,000
	1/8	1,600
	1/10	2,000
	1/16	3,200
	1/25	5,000
	1/32	6,400
	1/50	10,000
	1/64	12,800
	1/125	25,000
	1/128	25,600
	1/250	50,000
	1/256	51,200

Signal Input Requirements (optically isolated inputs)

Input	Min Input Current (Opto ON)	Max.. Input Current	Max. Reverse Voltage (input to J1-9)
J1-1, J1-6 STEP	5.5 mAmps	10.0 mApms	5.0 volts
J1-2, J1-7 DIR	3.0 mAmps	4.5 mAmps	5.0 volts
J1-3, J1-7 ENABLE	3.0 mAmps	4.5 mAmps	5.0 volts

Signal Output Characteristics

J1-4, J1-9, ENABLED -
Optically isolated NPN transistor with open collector and open emitter.

Maximum low level voltage while sinking 2 mAmps @ 0.5 Volts

Maximum STEP Rate

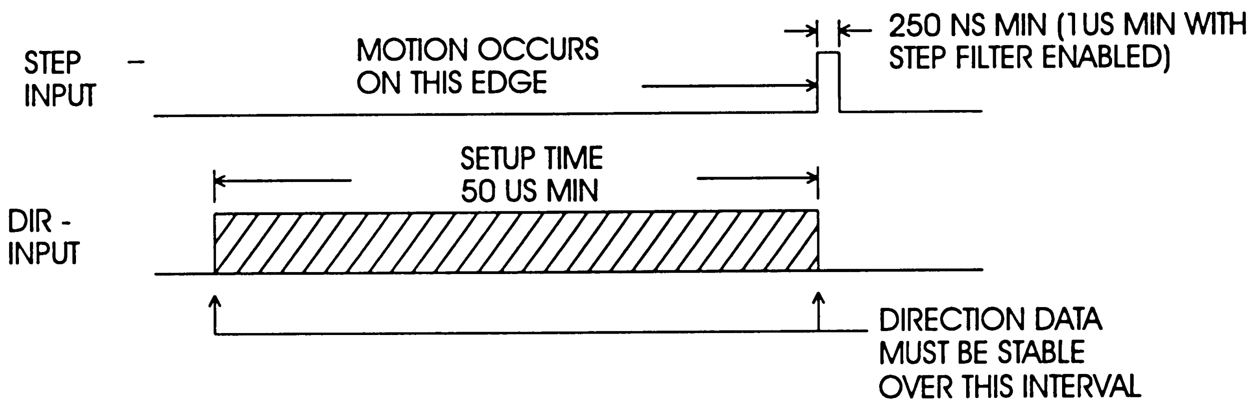
- 2 MHz with step filter disabled
- 500 KHz with step filter enabled

STEP/DIRECTION Timing Requirements

The figure below show the required timing relationship between the STEP and DIRECTION inputs.

Minimum Ramp Time For STEP Rate (Accel/Decel)

50 mseconds, this restriction only applies with the mid-range instability control circuit



enabled.

Drive State Generator Transition Delay Relative To Input STEP

With mid-range instability circuit enabled, at pulse frequencies less than 500 full steps/sec, delay is less than 500 microseconds. At frequencies greater than 500 full steps/sec, delay is less than 270 ° of full input pulse period.

With mid-range stability control circuit disabled, delay is less than 10 microseconds at all step frequencies.

Operating Temperature

Full rated current 0 to 50 °C ambient provided chassis properly mounted so as not to exceed 60 °C.

Storage Temperature - 55 °C to +70 °C

Maximum Chassis Temperature 60 °C

For optimal thermal performance, mount the MSD 50D chassis (back or side) to a cooling plate or heat sink. Use a thermal pad or grease if the surface is irregular. A fan or idle current reduction may be employed to keep chassis below 60 °C.

Humidity Range - 10 to 90%, non-condensing

Convection Cooling - MSD 50D mounted on cooling plate

With optional heat sink (MCG part number MSD 5HS) -

- Full rating (5 Amps RMS) at 25 °C
- 2.5 Amps RMS at 45 °C

Without heat sink -

- 2.5 Amps RMS at 25 °C
- 1.25 Amps RMS at 45 °C

Weight - 1.0 lb..

Connectors

Power Supply - PCD ELVH0310 connector.
Mating connector: PCD ELVP03100

Motor - PCD ELVH0510 connector.
Mating connector: PCD ELVP05100

Signal - 9 contact female D connector.
Mating Connector: ITT Cannon DE-9P with ITT Cannon DE110963 and D20419 Clamp Kit.

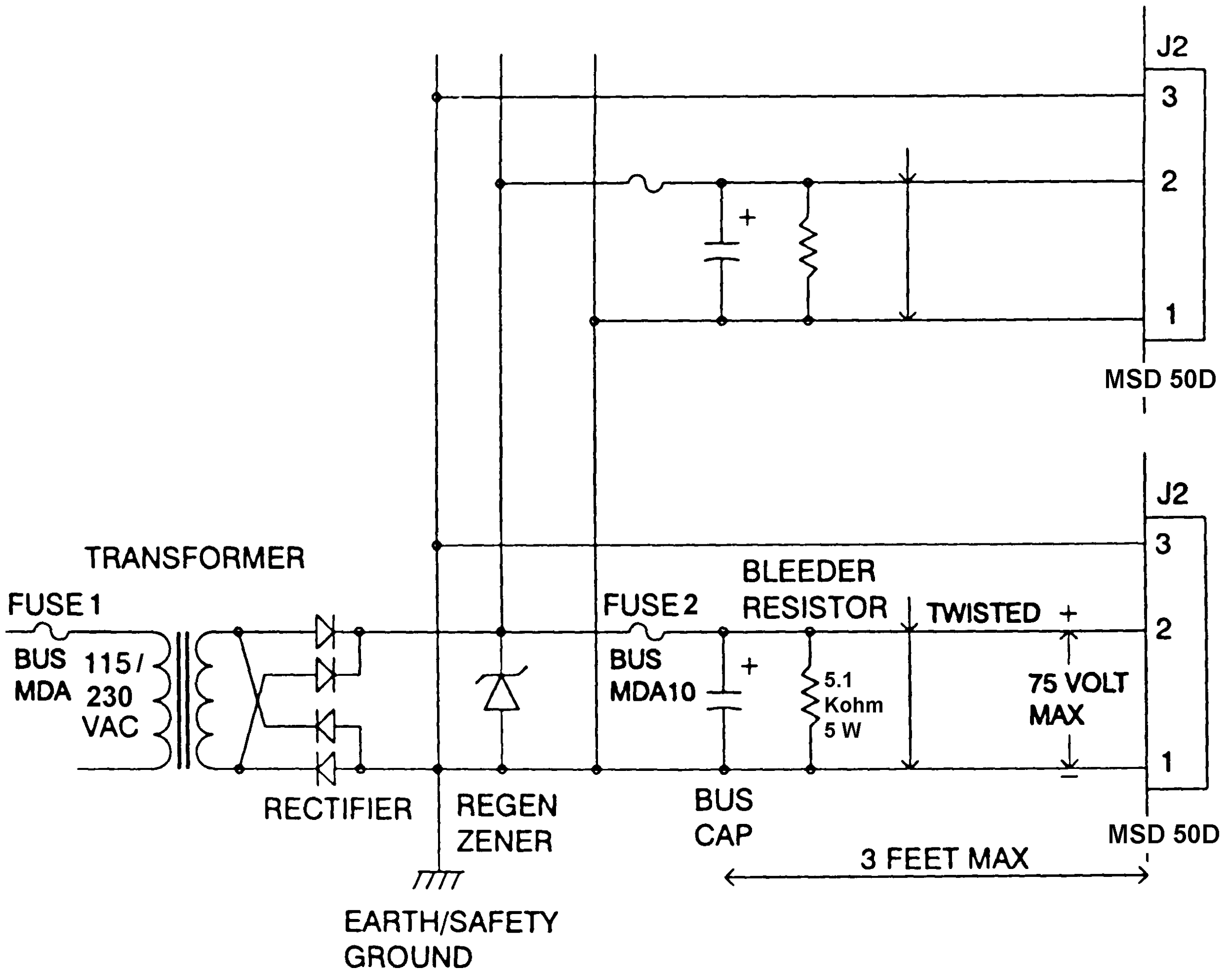
Appendix B Power Supply and Regenerative Power Considerations

This section provides selection guidelines for the power supply components.

The figure below shows a full wave bridge, capacitor input configuration most commonly used to power one or more MSD 50D microstepping driver modules.

A single transformer provides isolation and transforms the AC input voltage to a level that, when rectified, provides the desired DC bus voltage.

Fusing should be between the rectifier and the individual bus capacitors. This allows fuse size based upon the current requirements of a single module to provide the greatest protection.



The capacitors must be connected to the MSD 50D DC+ and DC- inputs using twisted pairs no longer than one foot in length as shown below to control winding inductive effects.

A regen clamp to absorb power transferred from the motor to the MSD 50D(s) is sometimes required.

<u>WARNING</u>

Power supply design must insure that the voltage between J2-2 and J2-1 never exceeds maximum recommended voltage under any operating conditions. These conditions include high line voltage, transformer regulation effects, voltage spiking due to current switching within the module and regeneration. Failure to do this can result in permanent damage to the MSD 50D.

1.0 Line Transformer Selection

1.1 Primary Voltage and Frequency Rating - Make sure that the transformer is guaranteed at the highest line voltage combined with the lowest line frequency that will ever be used to power your system. Failure to do so can result in saturation, large current increases and winding failure.

1.2 Secondary Voltage Rating - Maximum motor speed performance will be achieved by using as high a motor supply voltage as possible without ever exceeding 75 Volts DC. Of course lower voltage can be used, so long as the voltage is greater than the minimum specified motor value of 24 volts DC, but motor torque will drop more rapidly as speed increases.

The peak bus voltage, excluding any spiking due to current switching in the driver module or any generation effects, is approximately equal to

$$(1.414 * \text{Actual Secondary RMS Voltage}) - 1.5$$

This assumes a 0.75 volts drop across each rectifier diode. To insure this, as well as to discharge the bus capacitor when AC power is removed, it is recommended that the bleed resistor be placed across the capacitor's output as shown above.

If for example, the RMS voltage is 40 Vac, the peak bus voltage will be

$$(1.414 * 40) - 1.5 = 55 \text{ Vdc.}$$

A transformer with 115 Vac primary and 40 Vac secondary would produce 55 volts peak bus voltage under nominal line conditions and at rated loading.

However, if the line voltage increases by 10% the peak bus voltage increases to

$$(1.414 * 1.1 * 40) - 1.5 = 60.7 \text{ Vdc}$$

at rated transformer loading.

Loading regulation must also be accounted for when selecting the transformer. Transformers are designed to produce their specified secondary voltage when loaded by their rated current. ***For currents less than rated, the secondary voltage will increase.***

Signal Transformer gives the following load regulation data for its line rectifier transformer:

VA Rating	Load Regulation
1 - 100	10 %
100 - 350	8 %
> 500	5 % or less

NOTE:

- *The VA product is obtained by multiplying the specified secondary voltage, Volts RMS, by the secondary current, Amps RMS.*
- *For example a 40 Vac transformer with secondary rating current of 2.5 amp has a VA of 100.*

This means that the secondary voltage of 100 VA transformer will increase 10% over the specified voltage if the load current is reduced from rated current to zero.

Since the stepping driver(s) might sometimes be disabled, the full regulation effect as well as maximum line voltage should be considered when selecting the transformer.

Based upon these considerations, the table below gives the highest allowable rated secondary voltage when using a line with +10% voltage tolerance:

Transformer VA Rating	Maximum Rated
1 - 100	44.7 Vac
100 - 350	45.5 Vac
> 500	46.8 Vac

1.3 Current Rating - The average supply current into an MSD 50D is approximately equal to the output phase current.

NOTES

- *The supply current is a function of the motor used as well as motor speed and torque.*
- *The actual supply current may be less than the phase current.*
- *To optimize the design, the supply current can be measured when the motor is producing highest shaft power. Otherwise, assume it equals the phase current.*

When the power is first applied to the MSD 50D, the supply current may briefly reach twice the phase current but it will drop when the input voltage reaches 24 Vdc, the minimum specified operating voltage. This brief surge does not affect the transformer sizing.

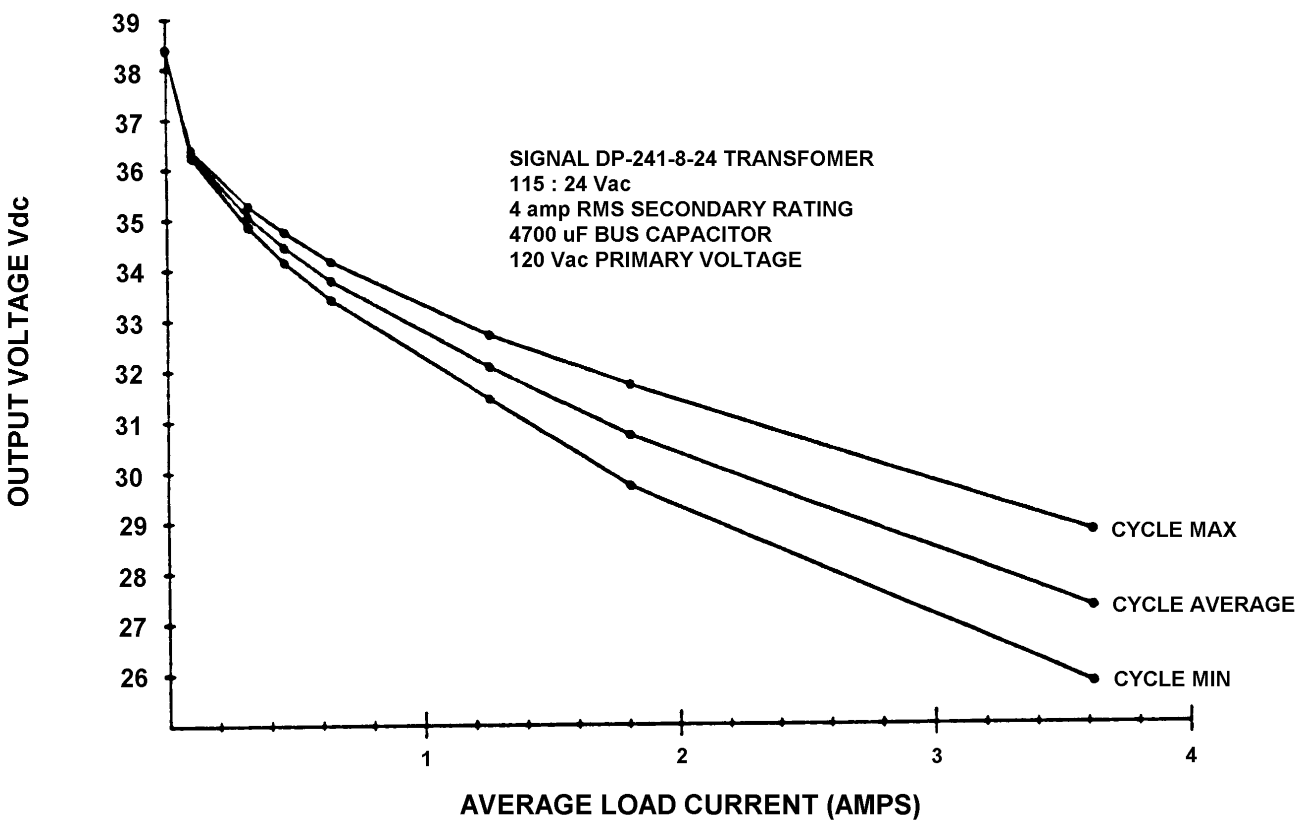
So if the output current setting of 5 amps RMS (7.1 amps peak while microstepping) is selected, then the average transformer secondary current equals the sum of the average driver currents. Because the transformer supplies pulses of current to charge the “bus” capacitor(s) on the other side of the diode bridge, the RMS current is higher than the average current. The transformer should have rated secondary RMS current of 1.8 times the average current or higher.

For example, the transformer used to supply three MSD 50D drivers, each set for a phase current of 5 amps RMS should have a rated secondary RMS current of 1.8 * 3 * 5 = 27 amps RMS or greater.

It is NOT advisable to significantly oversize the transformer because this will increase rectifier surge current during turn on, rectifier RMS current (for a given average current) during normal operation, and capacitor ripple current.

1.4 Typical Performance Curve - The following graph shows the measured output voltage vs. load current of the supply built using 100 VA transformer.
The transformer is rated at 24 Vac secondary voltage at 4 amps RMS with 115 Vac primary voltage. The curve shows the average voltage as well as the minimum and maximum voltages occurring over a 1/120 second which is a charging cycle.

The drop in average voltage with increasing load is due to poor regulation typical of such small transformer as well as voltage ripple which increases with load. The voltage drop will be smaller for larger transformer with higher VA ratings.



2.0 Rectifier Diode Selection

2.1 Voltage rating - for the bridge rectifier configuration shown, the peak inverse voltage "PIV" equals 1.414 times the secondary RMS voltage.

So, for example, a 24 Vac RMS secondary transformer will develop 1.414 * 24 = 33.9 Vdc "PIV" across the rectifier diodes.

To allow line variation and spiking, allow at least 50% safety factor in the diode rating.

Therefore, the PIV rating of the rectifier diodes should be at least twice the rated secondary RMS voltage.

2.2 Current rating - Since each diode conducts only in on alternate cycles, the average diode current will be half the supply average DC current load on the supply.

When power is first applied, there is a surge of current to charge the capacitor(s) which must be less than the diode's peak on cycle surge current "I_{FSM}" rating.

Typically diodes are chosen with average current rating at least twice the average current load of the supply.

It is advisable to select diodes with an even greater average current rating because they have lower thermal resistance between the junction and case and hence ease heat sinking requirements.

It is a good design practice to limit the junction temperature to 125 degrees C. Testing should be done to insure power ON surge current is within the diode's "I_{FSM}" rating.

3.0 Capacitor Selection

The bus capacitor should be connected to the MSD 50D using twisted pair and no longer than one foot in length.

The bus capacitance value for a single MSD 50D is a function of the working bus voltage and current setting for the module.

3.1 Current Rating - The bus capacitor's 120 Hz ripple current rating should equal or exceed the MSD 50D's current setting (or ripple current must be at least three amps RMS at 120 Hz as a default)

3.2 Voltage Rating - The capacitor voltage rating should be at least twice the transformer's rated secondary RMS voltage (or minimum of 1.3 * desired DC bus voltage).

If a 50 Volt, 60 Hz, 4700 micro-farad capacitor is to be used in the previous diagram it will result in approximately 3 volts peak to peak voltage ripple at the input to the module when the operational bus voltage is set at 36 Vdc and the driver output current is at 2.5 amps RMS.

If less ripple is required, a correspondingly larger valued capacitor should be used.

The following table provides the minimum bus capacitance value in microfarad for a single MSD 50D as function of current setting and bus voltage (increase the capacitance value by 20% if working with 50 Hz line)

Current setting (amps RMS)	30 Vdc Bus @ 60 Hz	50 Vdc Bus @ 60 Hz	70 Vdc Bus @ 60 Hz
5	14,000	8,300	6,000
4.37	12,000	7,300	5,200
3.75	10,000	6,300	4,500
3.12	8,700	5,200	3,700
2.5	6,900	4,200	3,000
1.87	5,200	3,100	2,200
1.25	3,500	2,100	1,500
0.62	1,700	1,000	740

4.0 Fusing

4.1 F1 Fuse - Good design practice to fuse each MSD 50D individually in a multi-axis configurations.

4.1.1 Current Rating - A minimum of 5.0 amps RMS slow acting fuse is appropriate (10 amps RMS is the recommended fuse size when the MSD 50D is set for 5 amps RMS)

4.1.2 Voltage Rating - A voltage rating of 115 is the minimum requirements

4.2 F2 Fuse - A line fuse should be included in series with the transformer primarily to protect against short circuits.

4.2.1 Current rating - The fuse RMS current rating should be approximately twice the transformer's primary RMS current during normal operation. Based upon the foregoing:

Fuse Current Rating, amps RMS =

3.6 * (# of MSD 50Ds) * (MSD 50D RMS Phase Current Setting) * $\frac{\text{Transformer Secondary Voltage}}{\text{Transformer Primary Voltage}}$

So, for example, if three MSD 50Ds with phase current set at 2.5 amps RMS are driven by a transformer with primary voltage of 115 Vac and secondary of 24 Vac, the fuse should have an RMS rating of 3.6 * 3 * 2.5 * (24/115) = 5.6 amps RMS

4.2.2 Voltage rating - a voltage rating of 250 Volts is suitable for use with both 115 Vac and 230 Vac Lines.

The fuse must handle the high inrush current when power is first applied. The BUSS MDA line of fuses or equivalent is recommended for FUSE 1 and FUSE 2

5.0 Regeneration Considerations

During braking (when the motor and load are decelerated by the drive), the drive returns the motor's kinetic energy to the power supply capacitor and this process can charge the capacitor to potentially dangerous voltages.

In this case, the motor becomes a generator converting a mechanical energy stored in the spinning motor and load inertias into electrical energy. If this mechanical energy is less than the losses in the drive and motor, the supply voltage does not increase. If the mechanical energy is greater than the losses, the supply voltage will increase.

Consequently, power supplies should have sufficient capacitance to absorb this energy without over voltaging the drive or the power supply.

The mechanical energy of a spinning inertia can be calculated as follows:

$$E = 3.87 * 10^{-5} * J * W^{2}$$

where

E = Kinetic energy	(joules)
J = Inertia	(oz.in.sec^{2})
W= Motor speed	(RPM)

If all or part of this energy is converted to electrical energy in the form of charge on the bus capacitor, the final voltage will be:

$$V = \sqrt{V_o^2 + \frac{2E}{C}}$$

where:

V = Final voltage	(volts)
V_0= Initial voltage	(volts)
C = Total capacitance	(farads)
E = Initial kinetic energy	(joules)

To find out if the regenerative energy is a problem, run the system while monitoring the supply voltage with a storage oscilloscope. Start your system with slow deceleration rates (shorten the deceleration time) while monitoring the DC bus voltage. If regeneration causes the bus voltage to exceed peak input Vdc of the drive, you should be considering a shunt regulator circuit. ***Be sure to include the effect of high line voltage when evaluating this test.***

The MSD 50D is not equipped with a built in shunt regulator circuit. During braking, the DC bus capacitor will charged up to higher voltage. If this higher voltage reaches the MSD 50D it will damage the driver. To ensure smooth braking for large inertial loads, a shunt circuit has to be added so it will switch on the shunt resistor when the DC bus reaches 45 Vdc.

6.0 Clamping Circuit

If a clamp circuit is required, a power zener diode can be used as shown in the figure. The maximum zener clamp voltage must not exceed 75 Vdc.

<u>Caution</u>

If a clamp is required , the transformer secondary voltage must be rechecked to insure that the minimum clamp voltage is not exceeded under high line and low load conditions when there is no regeneration. Otherwise, the zener might overheat and fail.

To determine the required zener diode rating, start with 5 watt device and monitor the zener current with a current probe. Power in watts is the average current in amps times the zener voltage. Estimate the average current from the oscilloscope trace and compute the power. Select the zener rated slightly higher than the measure power.

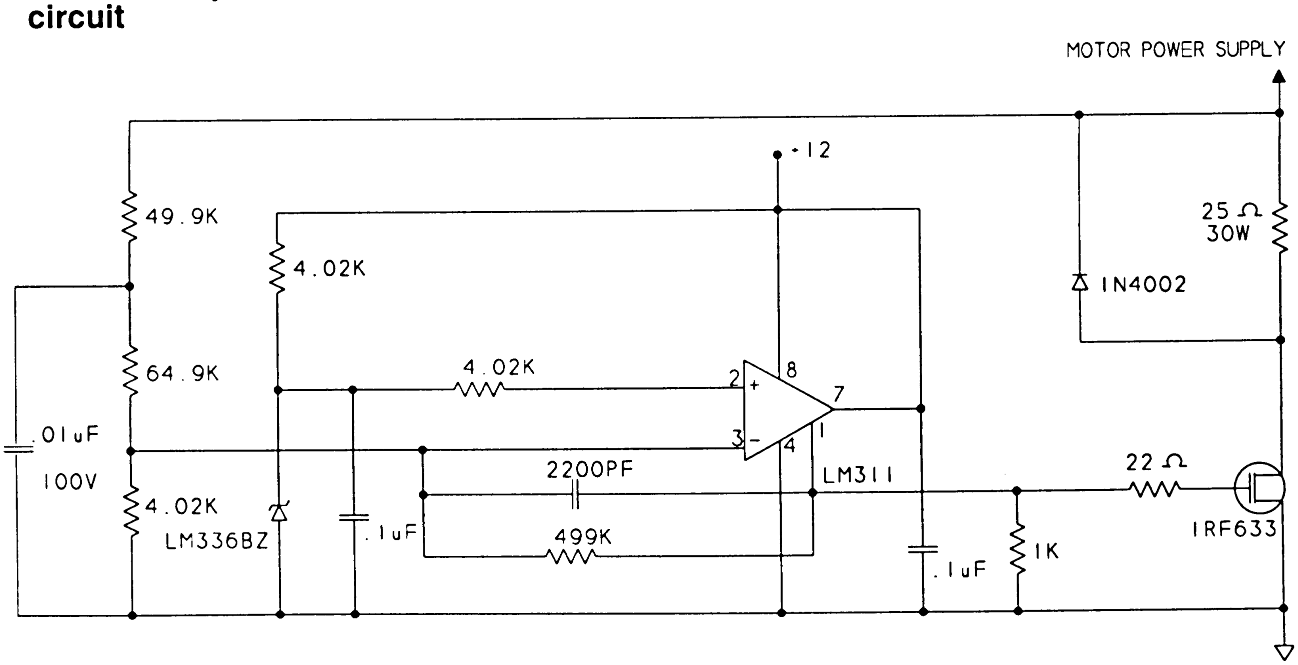
If the average power is too high to be conveniently dissipated in a zener diode, the active voltage clamp circuit shown below can be used instead. Power is dissipated in the 25 ohms, 30 watt resistor if the bus voltage exceeds 75 Vdc.

Appendix C Recommended Power Supply

The switch mode SPS 25D and SPS 50D are designed specifically for supplying power to stepping drivers. Regular switching power supplies are designed for constant, unvarying loads and are not tolerant of current surges produced by rapid changes in power demand and the inductance of motor coils.

The SPS 25D and SPS 50D are capable of delivering 3 and 4 Amps continuous current respectively and have the ability to absorb inductive current surges associated with the

Active clamp circuit



stepping motors. This produces controlled output power which enables the stepping motors to operate at higher performance levels.

Features

- Compact size
- Efficient switching design
- High output power
- Power LED

Protection

- Short circuit
- Thermal (over temperature)
- Fault LED

	SPS 25D	SPS 50D
AC input Voltage	120 Vac + 10 % , -15%	120 Vac + 10 % , -15%
Input frequency	50 / 60 Hz	50 / 60 Hz
No load output voltage	45 Vdc nominal	75 Vdc nominal
Continuous output power	150 watts	250 watts (300 watts peak)
Continuous DC output current	3 amps DC	4 amps DC
Operating temperature	0 - 50 °C	0 - 50 °C
Storage temperature	-40 - 125 °C	-40 - 125 °C
Max. heat sink temperature	70 °C	70 °C
Connectors	Screw terminal	Screw terminal
Weight	0.75 lb..	1.00 lb..
Size	3.90” x 4.00” x 1.50”	4.40” x 4.00” x 1.60”

MCG also offers linear power supplies for single and multi-axis configurations. The linear power supplies can operate from 120 or 240 Vac @ 50 or 60 Hz. Refer to the *CfD* “Microstepping Components” catalog or contact your local MCG distributor for assistance.

Appendix D Low Speed Resonance

A stepping motor is a rotary spring mass system where:

- The motor’s inertia plus any load inertia is the “mass”.
- The torque produced by the motor which, for small deflections, is proportional to the angle between the actual and the commanded positions is the “spring”.

If the shaft of the motor is displaced from its holding position by small angle and then suddenly released, it will swing back and forth around the holding position in a gradually decaying oscillation before eventually coming to a rest.

As with any lightly damped resonant system, a stepping motor can be made to oscillate at its natural (resonant) frequency if it is excited by torque pulses occurring at this rate. This will happen if the step rate equals the resonant frequency.

The resonant frequency of a stepping motor having 200 full steps per revolution is given by:

$$F_{resonant}\ (Hz) = 1.1\sqrt{\frac{T_{holding\,torque}}{J_{total}}}$$

where:

- $T_{holding\,torque}$ = is the holding torque of the step motor expressed in oz-in
- J_{total} = is the total inertia of the system (motor inertia plus load inertia) expressed in oz-in-sec^2

Example; the resonant frequency of an unloaded IS 34 008 MCG stepping motor having an inertia of 0.0183 oz-in-sec^2 provides a holding torque of 424 oz-in when connected in parallel with 5.00 amps RMS driver is

$$F_{resonant}\ (Hz) = 1.1\sqrt{\frac{424}{0.0183}} = 167\ Hz$$

So, if the motor were to run at 167 full steps per second or approximately 50 RPM the resonant will excited. If the oscillations become large enough, the motor will drop out of synch and stall.

NOTE: Resonance might be present at 334 half-step per second which is still approximately 50 RPM and if it did, it will not be as severe as the full step running mode.

Two solutions to the resonance issues when using the MSD 50D are:

- Avoid running the motor near the speed that will excite the resonance frequency. This accomplished by setting the START/STOP (minimum) speed in the associated indexer (controller) above the speed that excites the resonance.
- Use finer step size (microstepping). The finer (smaller) the step the less torque disturbance the less oscillation due to low speed resonance.

Appendix E Theory of Operation

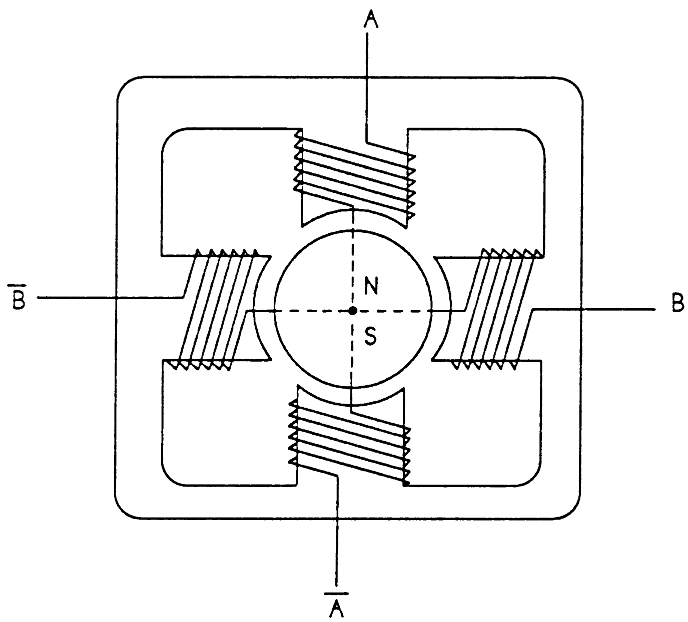
The MCD 50D driver module contains an ASIC which contains a translator circuit that translates STEP and DIRECTION signal inputs into current command signals sent to phase A and phase B power amplifiers. The driver also contains a logic power supply that provides regulated voltage to various logic circuits within the driver module and phase A and phase B amplifiers that drive phase A and phase B step motor windings.

Step Motor Operation

A hybrid stepping motor can be simplified to the diagram shown below:

Commutation

The stator consists of two windings and the rotor is a permanent magnet. The rotor aligns itself with the magnetic field created by the stator windings. By controlling the winding currents in the proper sequence, torque is produced and the rotor will rotate in the desired manner. The phase currents are bi-directional and sequencing of these phase currents is termed commutation. There are three basic types of stepping motor commutation possible with the MSD 50D driver module:



- Full Step
- Half Step
- Microstep

Motor Current Wave Forms

Each step input causes the phase of the motor current excitations to advance or retard by an amount determined by the selected step size setting (S1 - switch setting of the MSD 50D). Motor phase current wave forms for full step, half step and microstepping (step size 5 which 1/5 microstep per step) are shown below, the arrows in the diagram represent step low to high transition.

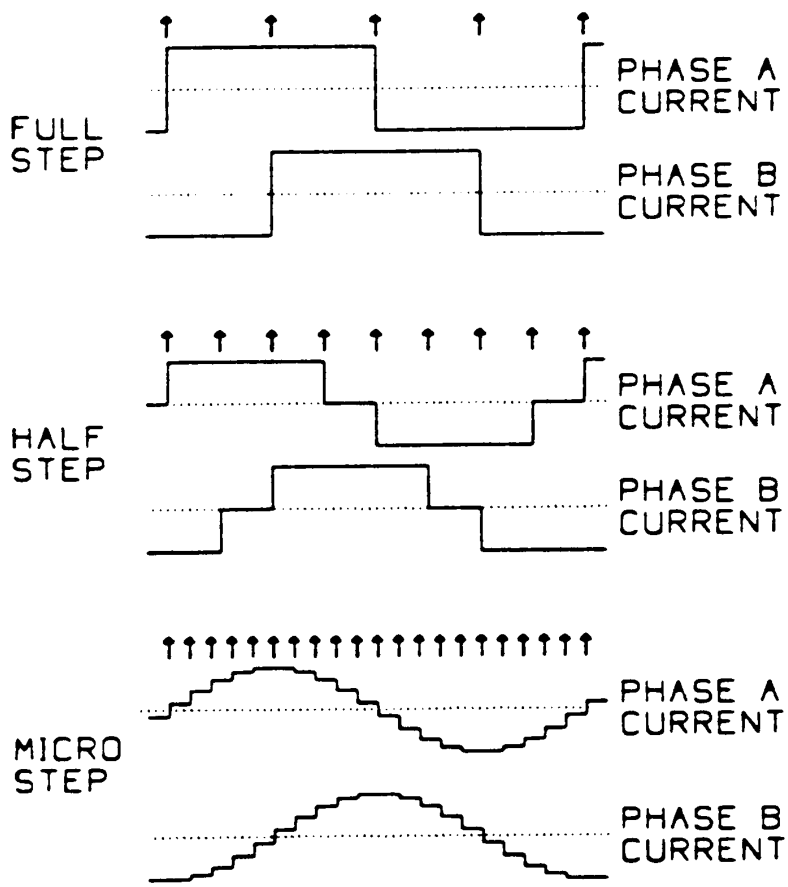
The magnetic field rotates through a smaller angle per input step for microstepping than for half stepping. This results in finer resolution and smoother operation.

Advantages and Disadvantages of Microstepping

Disadvantages

- Increased pulse rate required for the same velocity

Advantages



- Finer position resolution is achieved
- Torque ripple can be reduced
- Low speed motor resonance can be reduced. Microstepping can help smooth out the mechanical motion of a step motor. Large pulse drive wave forms encountered if full and sometimes in half step mode creates mechanical forces that may translate into mechanical resonance in positioning system. These resonance are also dependent on the load characteristics and they are difficult to control because of the low damping characteristics of the stepping motors. Resonance may cause loss of synchronization and the motor may skip or gain a step. Microstepping reduces large current transients and it is beneficial in reducing or eliminating the resonance problem.

Step Operation

The translator accepts STEP input pulses of 250 nsec (or 1 usec with step filter enabled) or greater duration from an indexer or other pulse source. It then outputs current commands signals that control the power circuits in phase A and phase B power amplifiers. Selection of full step, half step, or microstep mode is done by means of a DIP switch and jumper J6 in the translator circuit. Setting the switches and J6 to the proper positions selects either full, ½, ¼, 1/5, 1/8, 1/10, 1/16, 1/25, 1/32, 1/50, 1/64, 1/125, 1/128, 1/250, or 1/256 step mode. The motor will step on low to high transition of the step input pulse.

Direction Operation

For a given set of motor phase winding connections, the DIRECTION input to the translator determines the direction of rotation of the stepping motor. Reversing the connections to one phase winding reverses the effect of the Direction input. The DIRECTION input must be present a minimum of 50 usec before the low to high transition of the STEP input.

Chopper Circuit

Each MSD 50D contains a chopper circuit whose function it to sense the magnitude of current in its associated phase winding and to momentarily cut off the power to its winding when this current exceeds the commanded value. An internal PWM (pulse width modulation) oscillator supplies a stable chopper frequency of 20 kHz (independent of phase winding inductance) to a logic circuitry which in return turn on a pair of transistors in each bridge. The mid-range stability control circuit, when enabled, controls the timing of the step output with the respect to the input pulse command in order to maintain synchronous motor speed.

Motor Current Regulation

Motor phase currents are controlled by four switch mode (chopper), MOSFET, full bridges. PWM switching provides efficient and precise current control to obtain good torque speed characteristics from the stepping motor. The peak current delivered by the H bridge can be set through the dip switch (S1) up to 5.0 RMS (7.1 amps peak). Each current command is summed into a current feedback control circuit that regulates the motor phase current independent of voltage, temperature, or winding impedance variations.

Contact your local distributor or call 1-888-624-3478 (US & Canada)
for Customer Service & Technical Support
Internet: www.mcg-net.com
Email: sales@mcg-net.com