

MSD 25C

HARDWARE INSTALLATION
MANUAL



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1.0 Overview of MSD 25C

1.1 MSD 25C Definition

The MSD 25C is a two phase microstepping driver, which controls a two phase step motor. The output current of the MSD 25C is adjustable via an external resistor from 0.4 to 4.0 Amps peak (0.3 - 3.0 Amps RMS).

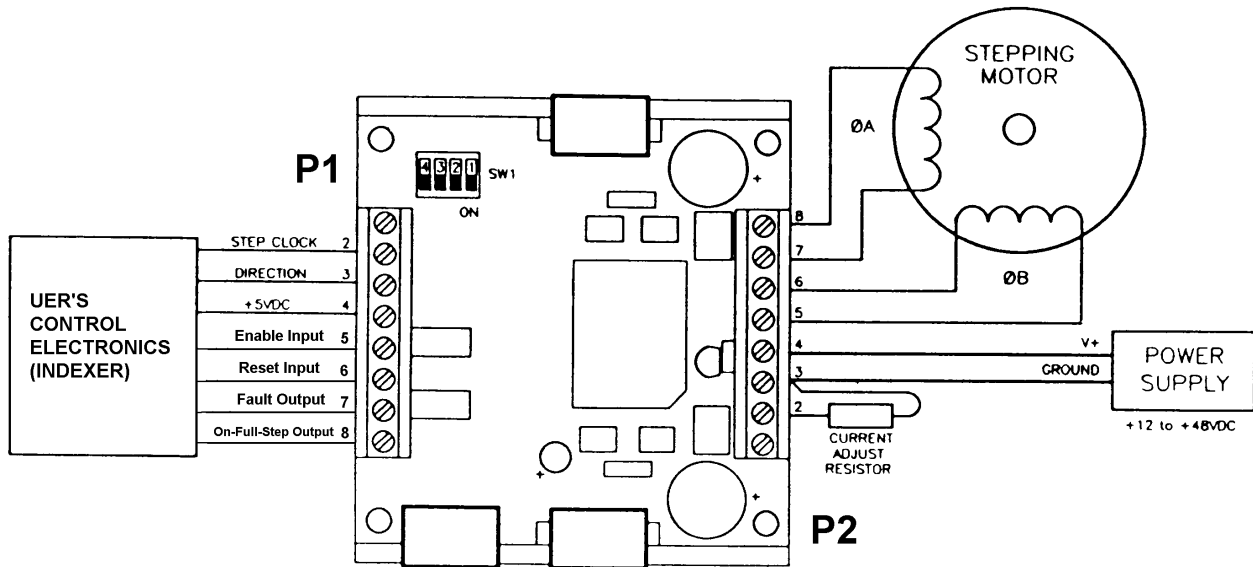
1.2 Drive Features

- Compact size - surface mount and ASIC technology
- Micro stepping - switch selectable, decimal 1/5, 1/10, 1/25, 1/50, 1/125, 1/250 and binary 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256
- Stepsize can be changes “on the fly”
- Single DC power supply, PWM chopper drive at 20 KHz
- Optically isolated signals, STEP, DIRECTION, ENABLE and RESET inputs
- FAULT and ON FULL STEP outputs
- Short circuit protection (the drive will disable if a short occurs on motor output)

1.3 General Specifications

Input Voltage	+12 to 48 Vdc
Phase output current	0.4 to 3 Amps (RMS), 4 Amps (Peak)
Output current setting	Via an external resistor
Idle current reduction setting	Via an external resistor
Idle current reduction	Automatic after 1 sec after the last step input
Isolated inputs	STEP, DIRECTION, ENABLE and RESET
Max. STEP frequency input	10 MHz
Step per revolution	400, 800, 1000, 1600, 2000, 3200, 5000, 6400, 1.8° - two phase step motor 10000, 12800, 25000, 25600, 50000 and 51200
Protection	Phase to Phase, Phase to ground, Phase to voltage and Thermal
Switching frequency (PWM)	20 kHz
Minimum load inductance	NONE
Operating temperature	0 to 50 °C providing the case will not exceed 70 °C
Storage temperature	-40 to + 125 °C
Maximum case temperature	+70 °C
Relative humidity range	10 to 90 %, non-condensing
Power Connectors	Screw terminal
Signal Connector	Screw terminal
Size	2.75" x 3.06" x 1.20"
Weight	0.25 lb

1.4 System Connections/Wiring Diagram



The above diagram shows an installation of the MSD 25C in a typical system. Your system may vary from this configuration. Typical components used with the MSD 25C microstepping driver include:

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

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 25C microstep driver. This manual is organized into chapters and appendices.

1.6 Warranty

The MCG MSD 25C has a two year warranty against defects in material and assembly. Products that have been modified by the customer, physically mishandled or otherwise abused through miswiring, incorrect switch settings and so on, are exempt from the warranty plan.

2.0 Installing the MSD 25C

This chapter explains how to install the MSD 25C microstep driver in your application.

2.1 Unpacking the MSD 25C

- Remove the MSD 25C driver from the shipping carton. The packaging material and the shipping carton may be retained for storage or shipment of the driver.
- Check all items against the packaging list. A label located on the side of the driver identifies:
 - model number
 - serial number
 - manufacturing 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 **Return Martial Authorization (RMA)** number. Do this as soon as possible after you have received the MSD 25C microstep driver.

2.2.1 Testing the MSD 25C Microstep Driver

This test can be used to confirm the MSD 25C microstep driver is functional and operational. The test requires a DC power source 12 - 48 Vdc, and a two phase step motor.

WARNING

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

1. Take note of the DIP switch settings before starting the test.
2. Ensure the power is OFF.
3. Refer to the section 1.4 “System Connection/Wiring Diagram”
4. Set the DIP switch to the following settings “positions” (Half Step setting):

SW1-1	SW1-2	SW1-3	SW1-4
ON	ON	ON	ON

5. Verify the current rating of the motor, refer to section 2.8.6 and 2.8.8.
6. Set the MSD 25C output current to be equal or less to the rating of the motor windings, refer to section 2.8.6 for the proper setting.

7. Connect the motor phases to the MSD 25C, PHASE A, A\ and PHASE B, B\ to connector P2 pins 8, 7, 6 and 5 respectively.
8. Connect the STEP CLOCK to P1-2.
9. Connect the OPTO POWER to P1-4, refer to section 2.8.4.2 for more information.
10. Check the DC voltage source output voltage and insure it is within specification by using an oscilloscope before connection to the MSD 25C is made.
11. Connect the DC power source to connector P2 pins 4 and 3.
12. Verify all the connections/wiring, then apply power.
13. Check the presence of holding torque on the motor shaft by trying to move the shaft.
14. Input a step command to P1-2, the motor should move.
15. Turn the DC power OFF.
16. Connect the P1-3 “DIRECTION”, apply power again.
17. Input a step command to P1-2, the motor should move in the opposite direction.
18. Turn the DC power OFF.
19. Connect the P1-5 “ENABLE”, apply power again.
20. Input a disable command, the motor shaft should be easier to move “free to move”.
21. Turn the DC power OFF, and remove all connections.

If the MSD 25C does not pass all the above steps, refer to section 4.0
“Maintenance / Troubleshooting”.

2.3 Storing the MSD 25C Driver

Return the MSD 25C to its shipping carton using the original packing materials. Store the drive in a clean, dry place that will not exceed the following conditions:

- Humidity: 10% to 90%, non-condensing.
- Storage temperature: -40 to +125 degrees C.

2.4 Selecting a Motor

The MSD 25C 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 25C 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 3.0 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 2.8.8 more information

2.5 Selecting a DC Power Supply

The MSD 25C 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 25C.

Refer to Section 2.8.7 and Appendix B for more information

2.6 Safety

Read the complete manual before attempting to install or operate the MSD 25C microstep driver. By reading the manual you will become familiar with practices and procedures that allow you to operate the MSD 25C 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 25C 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 (12 - 48 Vdc)

- Make sure motor case is tied 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 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 P1 and P2 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

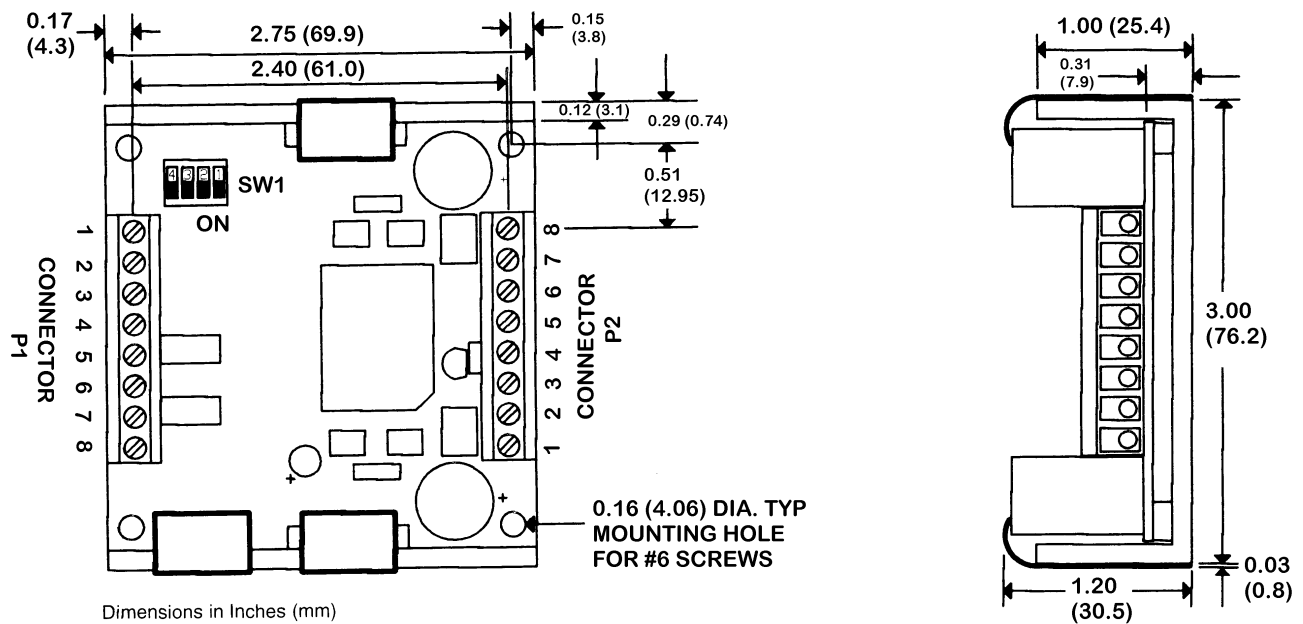
Mount the MSD 25C microstep driver in an enclosure providing protection to IP 54, protected against dust and splashing water, or IP 65, protected against water jets and dust free air. Manu NEMA type 4 cabinets provide this level of protection. Minimum cabinet requirements are:

- Depth 4 inches.
- Ventilation @ 25 °C to dissipate 12 watts @ I out 3 Amps RMS (4.2 amps peak).
- The air should be free of corrosive or electrically conductive contaminates.

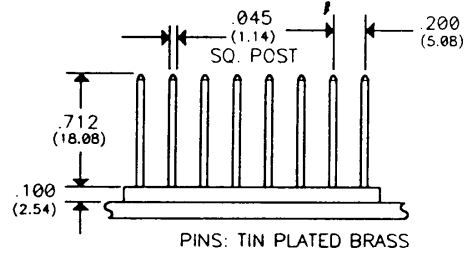
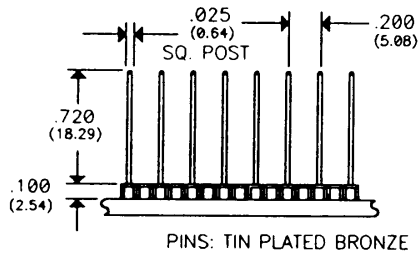
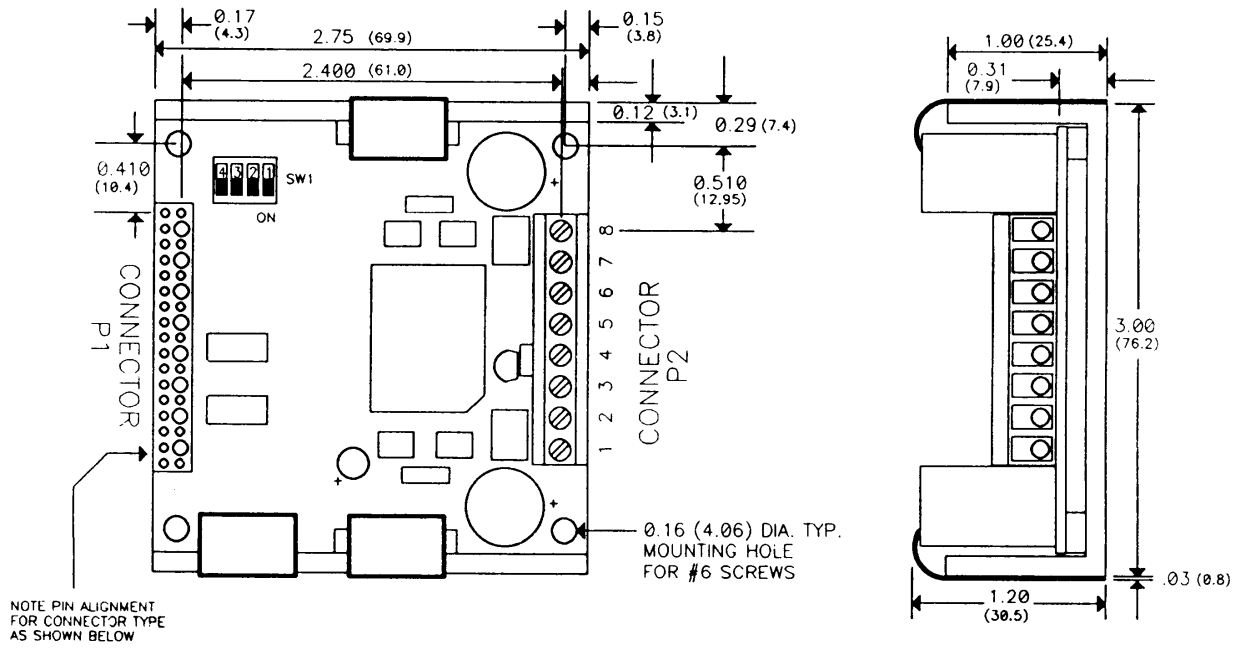
2.7.1 Cool plate mounting

- For optimal thermal performance and minimum panel usage, mount the MSD 25C to a cooling plate and the MSD 25C chassis should be maintained below 70 °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.
- If the MSD 25C is mounted to a panel with no cooling plate and no fan, a minimum unobstructed space of 2 inches above and below and 2 inches between side plate and any other objects must be provided.

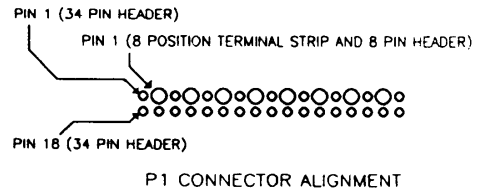
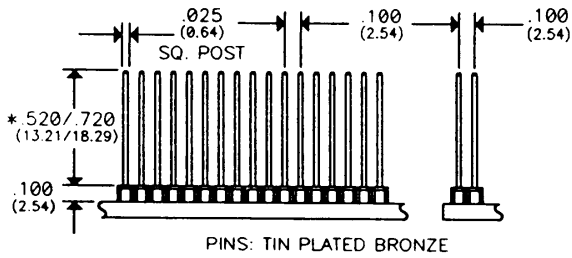
2.7.2 Mounting dimensions



MECHANICAL SPECIFICATIONS



OPTIONAL P2 CONNECTOR



OPTIONAL P1 CONNECTORS

* $.720$ HEIGHT PINS ARE USED IN CONJUNCTION WITH OPTIONAL $.045$ SQ. PINS ON P2

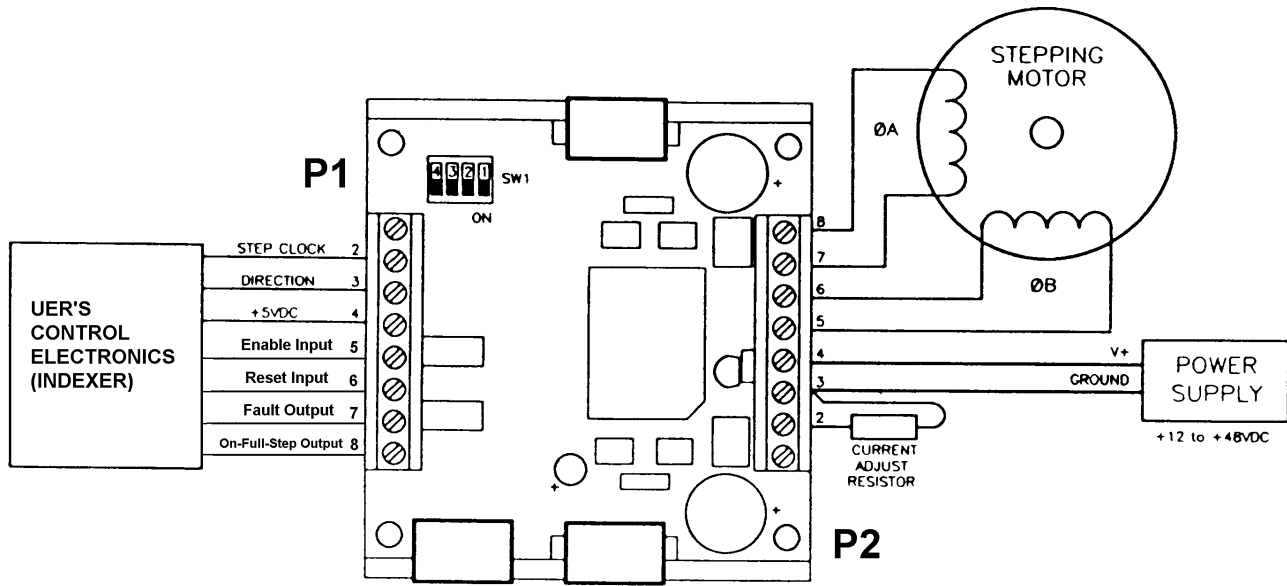
DIMENSIONS ARE INCHES (mm)

2.8 Electrical Interfacing and Connections

The MSD 25C has two I/O (input/output) Connectors.

- P1 - Signal connector, screw terminal type, 8 pin connector.
- P2 - Power and Motor connector, screw terminal, 8 pin connector.

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 wiring 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.

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 P1 - Signal Connector

This is an 8 pin screw terminal type I/O (input/output) connector. P1 signal interface accepts STEP, DIRECTION, ENABLE and RESET inputs, signals from the indexer and FAULT output signal (which indicates the MSD 25C is applying current to the motor windings) and ON-FULL-STEP output signal (this output can be used to count the number of full steps the motor has moved regardless of the microsteps in between).

Use shielded cable to reduce the chance of EMI induced noise. The shield needs to be grounded at the signal source to AC ground. The other end should be left unconnected (the shield will act like a drain).

Refer to Appendix A for more information

2.8.3.1 P1 Signal Table

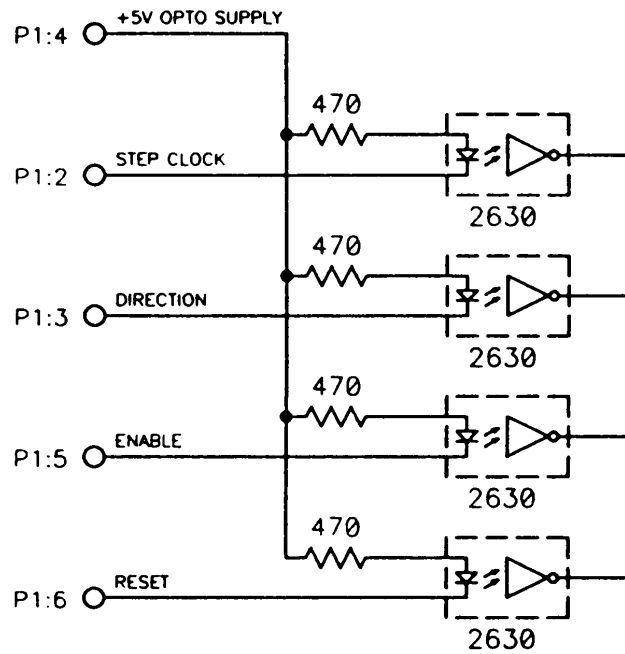
The following table shows the pin assignment and functionality along with a brief description of each pin.

8 pin PIN NO.	34 pin PIN NO.	Input/Output	Explanation Function / Description
	3	RESOLUTION SELECT 3 INPUT	Microstep resolution select 3 input. Used to select the number of microsteps per step. Refer to section 3.1.
2	4	STEP CLOCK INPUT	A positive going edge on this isolated input advances the motor one increment. The size of the increment is dependent on the microstep select input or switch S1. Refer to section 3.2.
3	6	DIRECTION INPUT	This isolated input is used to change the direction of the motor. Physical direction also depends on the connection of the motor windings. Refer to section 3.2.
4	8	OPTO SUPPLY INPUT	This +5 Vdc input is used to supply current to the isolated inputs. A higher voltage may be used (limit the current through the optocoupler). Refer to Appendix A.
5	10	ENABLE INPUT	This isolated input is used to enable/disable the output section of the driver. When HIGH (open) the outputs are enabled. However this input does not inhibit the step clock. Therefore when enabled the outputs will update by the number of clock pulses (IF ANY) applied to the driver while it had been disabled. Refer to section 3.2 and Appendix A.

6	12	RESET INPUT	When LOW, this isolated input will reset the driver (outputs will disable). When released, the driver will be initial state (phase A OFF, phase B ON). Refer to section 3.2 and Appendix A.
7	14	FAULT OUTPUT	This open collector output indicates the a short circuit has occurred. This output is active low. Refer to Appendix A.
8	16, 26	ON FULL STEP OUTPUT	This open collector output indicates when the driver is positioned at FULL STEP. This output can be used to count the number of FULL STEPs the motor has moved regardless of the number of microsteps in between. This output is active low. Refer to section 3.2 and 3.3.
	21	STEP CLOCK OUTPUT	Non isolated STEP CLOCK output.
	22	DIRECTION OUTPUT	Non isolated DIRECTION output.
	23	RESOLUTION SELECT 0	Microstep resolution select 0 input. Used to select the number of microsteps per step. Refer to section 3.1.
	24	RESOLUTION SELECT 2	Microstep resolution select 2 input. Used to select the number of microsteps per step. Refer to section 3.1.
	25	RESOLUTION SELECT 1	Microstep resolution select 1 input. Used to select the number of microsteps per step. Refer to section 3.1
	27	GROUND	Non isolated ground
1	1,2,5,7,9,111,3,1517,18,19,20,28-34	NC	No Connections should be made to these pins. This should be left floating.

2.8.3.2 Typical Interface

The following figure shows a typical interface between the user's electronics and the MSD 25C driver unit.

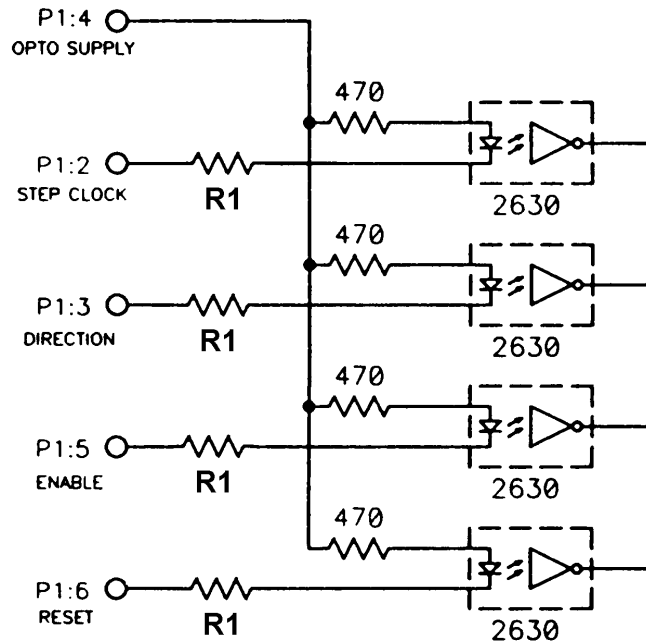


OPTICALLY ISOLATED INPUTS

2.8.3.3 Higher Voltage Interface

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 25C	R1
+12 Vdc	1400 ohms
+15 Vdc	1800 ohms
+30 Vdc	3800 ohms



OPTICALLY ISOLATED INPUTS

2.8.4 P2 - DC Power / Motor Connector

This is an 8 pin screw terminal type I/O (input/output) connector. P2 connects the DC power, motor phase and allows the user to set the current adjust along with idle current reduction to the MSD 25C microstep driver.

Input	Pin	Explanation
IDLE CURRENT REDUCTION	P2-1	Phase Current Adjustment input. A resistor between this pin and pin P2-2 (CURRENT ADJUSTMENT) will proportionally reduce the current in both windings approximately 1.0 second after the last positive edge of the step clock input. The amount of current reduction will depend on the resistor value used. Refer to section 3.4.
CURRENT ADJUSTMENT	P2-2	Phase Current Adjustment input. A resistor is connected between this input and P2-3 (GROUND supply input) to adjust the maximum phase current in the motor. A resistor MUST be connected to this input. Refer to section 2.8.6.
DC - (GROUND)	P2-3	+12 to +48 Vdc max.. The negative side (GROUND) of the power supply, connected to the DC-. Refer to section 2.8.7 and Appendix B.
DC +	P2-4	
Phase B	P2-5	Phase B of the stepping motor is connected between P2-5 and P2-6. Refer to section 2.8.8.
Phase B/	P2-6	
phase A	P2-7	Phase A of the stepping motor is connected between P2-7 and P2-8. Refer to section 2.8.8.
Phase A/	P2-8	

2.8.5 OUTPUT CURRENT

Output current of the motor used in microstepping is determined differently from FULL/HALF driver.

In the MSD 25C, a sine/cosine output function is used in rotating the motor. Therefore the output current of specified motor is equal to the RMS current driver.

The CURRENT ADJUSTMENT RESISTOR used to set the output current of the MSD 25C sets the PEAK output current of the sine/cosine waves. Therefore the specified motor current (**WHICH IS THE RMS VALUE**) should be multiplied by 1.4 in order to determine the PEAK value to which the MSD 25C will be set.

EXAMPLE : MCG step motor catalog number IH 23 002 , has a specified phase current of 2.2 amps (RMS), therefore the PEAK current is $2.2 \times 1.4 = 3.08$ amps

The RESISTOR value = OUTPUT CURRENT / 0.002, so for the above motor (IH 23 002) the resistor value is 1540 ohms (3.08/0.002).

The OUTPUT CURRENT on the MSD 25C is set by the an external resistor. This resistor is connected between P2-2 and P2-3 (**the resistor determines the per phase PEAK output current of the MSD 25C**). The relationship between the output current and the resistor value is as follows.

$$\text{OUTPUT PEAK CURRENT (AMPS)} = 0.002 * \text{RESISTOR VALUE (OHMS)}$$

The following table shows commercially available resistors for a given current for a given current setting.

PEAK OUTPUT CURRENT AMPS	STEP MOTOR RMS CURRENT RATINGS AMPS	RESISTOR VALUE (1%) (ohms)
0.4	0.29	200
0.6	0.43	301
0.8	0.57	392
1	0.7	499
1.2	0.86	590
1.4	1	698
1.6	1.14	787
1.8	1.29	887
2	1.43	1,000
2.2	1.57	1,100
2.4	1.7	1,210
2.6	1.86	1,300
2.8	2	1,400
3	2.14	1,500
3.2	2.29	1,580
3.4	2.43	1,690
3.6	2.57	1,780
3.8	2.7	1,910
4	2.86	2,000

WARNING

A CURRENT ADJUSTMENT RESISTOR IS ALWAYS NECESSARY TO KEEP THE MSD 25C IN A SAFE OPERATING REGION.

DO NOT OPERATE THE MSD 25C WITHOUT A CURRENT ADJUSTMENT RESISTOR.

NOTE

When connecting the CURRENT ADJUSTMENT resistor between P2-2 and P2-3 the leads should be as short as possible to help minimize the noise coupled into the driver.

2.8.6 Power connection

Power Supply specification

Recommended Type	Unregulated DC
Ripple Voltage	± 10%
output Voltage	+12 to +48 Vdc (max.)
Output Current	2 Amps typical, see note 6 below.

Use minimum #18 AWG twisted cable for the power supply cable, Heavier wire should be used for longer distances between the power supply and the driver. Twisted Pair (jacketed) Belden Part # 9740 or equivalent.

Connecting the MSD 25C and the power supply is shown in the following diagram. A simple non-regulated supply is for this example. The DC+ and DC- should run from the power supply's capacitor to the MSD 25C as a twisted pair no longer than 1 foot in length (shielding, with shield connected to AC ground, can reduce the EMI, noise emissions). A slow acting fuse should be included in the power supply between the rectifier and the capacitor as shown below.

NOTICE

1. It is extremely important that the supply voltage never exceed 48 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 48 Vdc because of the variation in the line voltage.

WARNING

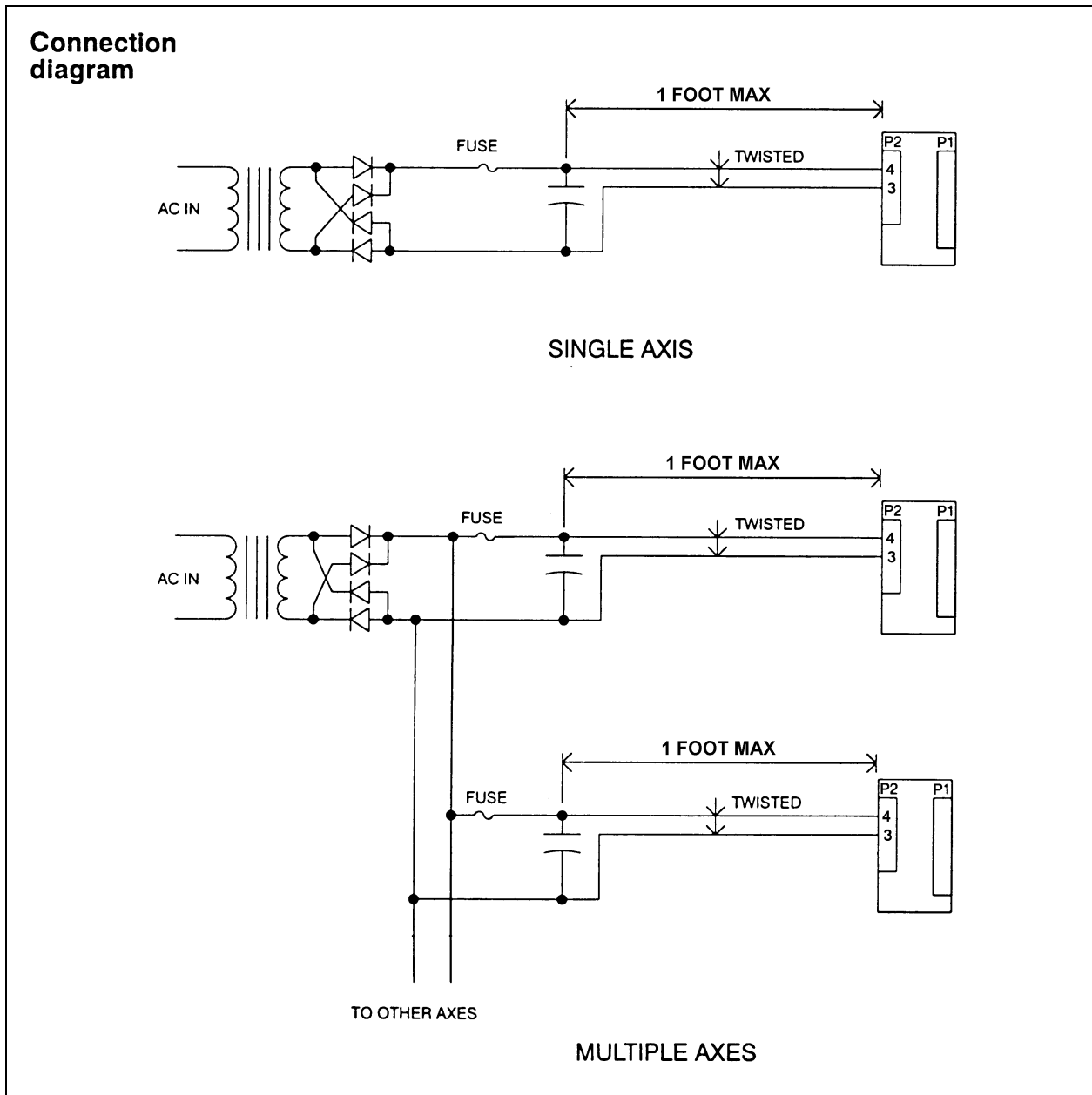
Under any operating conditions the power supply design must insure the bus voltage should not exceed 48 volts. Condition such as, high line voltage, transformer regulation effects, and voltage spiking due to current switching within the MSD 25C and regeneration.

2. Wiring inductance between the MSD 25C 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 1 foot in length.
3. If the distance is longer than 1 feet an electrolytic capacitor should be added across P2 pins 3 and 4 and located near the MSD 25C (3300 uF or 4700 uF @ 50 V). The capacitor required should handle 3.0 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 25Cs are to be run off of one power supply, each MSD 25C 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 25C.
7. The output current needed is dependent on the supply voltage, motor selection and load

WARNING

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

Refer to Appendix B for more information



2.8.7 Motor Connections

Twisted pair, over all shielded for motor cabling is recommended. Ground the shield end only at the AC ground at the 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).

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.

P2 connects the MSD 25C driver unit to the step motor. P2 utilizes a screw terminal type connector to simplify assembly.

Output	Pin	Explanation
Motor Phase A	P2-8	Motor phase A excitation.
Motor Phase A\	P2-7	Twisted Pair
Motor Phase B	P2-6	Motor phase B excitation.
Motor Phase B\	P2-5	Twisted Pair

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.***

WARNING

DO NOT CONNECT OR DISCONNECT MOTOR LEADS WITH POWER APPLIED

The MSD 25C is a bipolar driver 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 25C chops the voltage using a constant chopping frequency and a varying duty cycle. Duty cycles that exceeds 50% can cause unstable chopping. This characteristic is directly related to the motor's winding resistance. To avoid this situation, it is necessary to 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 25C 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 25C 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 25C.

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.

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

The following are the 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 25C microstepping driver.

Connections	4 - Lead	4 - Lead Color	4 - Lead	6 - Lead	Drive Connections
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	Color		Color	Color	
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	A\
	White/Black	White/Brown	
	Orange	Orange	B
	Red	Red	
	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 Operating / Configuration Selections

3.1 Step Size

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

BINARY

Resolution Microstep/step	Steps/Revolution 1.8° step motor	Switch 1 (MSEL 0 P1-23)	Switch 2 (MSEL 1 P1-25)	Switch 3 (MSEL 2 P1-24)	Switch 4 (MSEL 3 P1-3)
2	400	ON	ON	ON	ON
4	800	OFF	ON	ON	ON
8	1,600	ON	OFF	ON	ON
16	3,200	OFF	OFF	ON	ON
32	6,400	ON	ON	OFF	ON
64	12,800	OFF	ON	OFF	ON
128	25,600	ON	OFF	OFF	ON
256	51,200	OFF	OFF	OFF	ON

DECIMAL

Resolution Microstep/step	Steps/Revolution 1.8° step motor	Switch 1 (MSEL 0 P1-23)	Switch 2 (MSEL 1 P1-25)	Switch 3 (MSEL 2 P1-24)	Switch 4 (MSEL 3 P1-3)
5	1,000	ON	ON	ON	OFF
10	2,000	OFF	ON	ON	OFF
25	5,000	ON	OFF	ON	OFF
50	10,000	OFF	OFF	ON	OFF
125	25,000	ON	ON	OFF	OFF
250	50,000	OFF	ON	OFF	OFF

NOTE

1. ON in the above tables is ground and OFF is floating when the 34 pin option header is used.
2. When using the optional 34 pin header, the MSEL inputs are pulled up through 10 Kohms resistors to +5 Vdc.
3. These are non-isolated inputs and care should be taken when connecting the controller and drivers ground. An open collector interface is recommended.

When the number of microsteps per step are changed such that the MSD 25C does not fall on a full step (i.e. zero crossing of the sine/cosine waveforms) the MSD 25C will readjust itself at the next pulse that would overshoot the full step position to the full step position. This feature allows the MSD 25C to readjust the motor to common position no matter what resolution is chosen or when it is changed.

Selecting a microstep 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

3.2 Timing

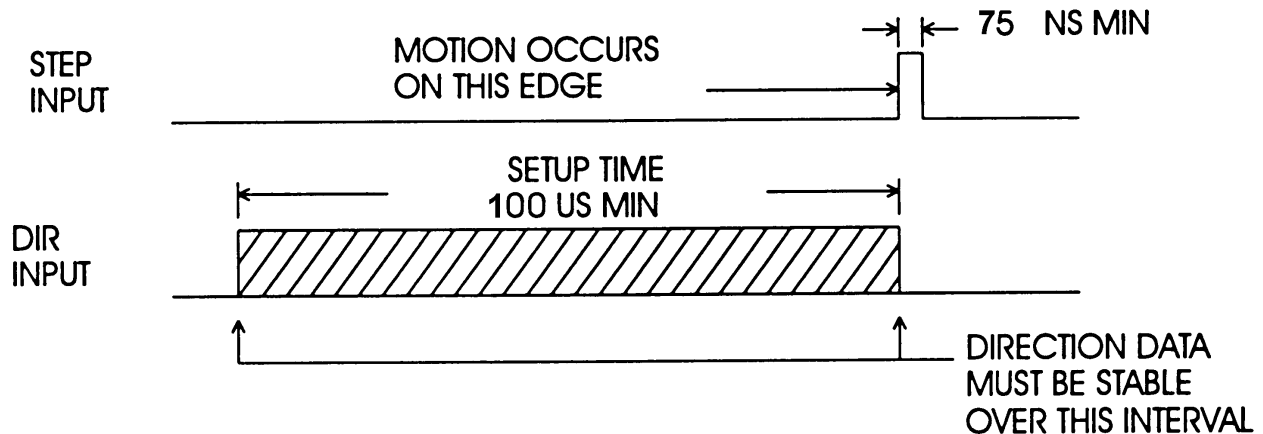
The direction and microstep resolution select inputs are synchronized with the positive going edge of the step clock input. When the step clock input goes high, the direction and microstep select inputs are latched and further changes to these inputs are ignored until the next rising edge of the step clock input.

After these inputs are latched, the MSD 25C looks to see if any changes occurred to the direction and microstep select inputs. If a change has occurred, the MSD 25C will execute the changes before taking the next step. Only after the change has been executed will the step be taken. If no change has occurred the MSD 25C will simply take the next step (this feature works as an automatic debounce for the direction and microstep select inputs).

- The minimum pulse width for STEP lock input is 75 nsec
- The typical execution time for STEP input, DIRECTION or Microstep select change is 100 nsec
- The RESET and ENABLE inputs are asynchronous to any input and can be changed at any time
- The reset requires a minimum pulse width of 500 nsec
- The FULL STEP output occurs 75 nsec after the positive edge of the step clock (excluding changes to the direction or the microstep select inputs)

3.3 Full Step Output Signal

- The MSD 25C has an active LOW open drain output at P1-8.



- A full step occurs when either the Phase A or Phase B cross through zero (i.e. full current in one winding and 0 current in the other winding).
- This output is TRUE for the duration of the full step.
- This full step position is a common position no matter what resolution is selected.
- This high speed MOSFET output is non-isolated and has the ability to sustain maximum driver voltage. It is capable of sinking up to 25 mAmps.
- This output can be used to count the number of mechanical full steps the motor has traveled without having to count the number of microsteps in between.
- A controller that utilizes this output can greatly reduce its position tracking overhead and substantially increasing its throughput.

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 1.0 second after the last positive going edge on the STEP clock input.
- The current to both motor windings is then revert back to the original current setting at the next positive going edge of the step clock input.
- To utilize this feature, a resistor must be connected between P2-1 and P2-2.
- The value of the resistor will determine the amount of current reduction. The amount of current per phase in the reduction mode is related to the value of the current adjust resistor and current reduction resistor.
- When current reduction circuit is activated, the current reduction resistor is paralleled with the current adjustment resistor. This lowers the total resistance value, and thus lowers the per phase output current.

The relationship between the output current and the resistor's values is as follows:

$$\text{Output Current Reduced (Amps)} = \frac{(0.002) * [R (\text{Current Adjust})] * [R (\text{Current Reduction})]}{R (\text{Current Adjust}) + R (\text{Current Reduction})}$$

$$R (\text{Current Reduction}) = \frac{\text{Output Current Reduced} * R (\text{Current Adjust})}{\{(0.002) * [R (\text{Current Adjust})]\} - \text{Output Current Reduced}}$$

NOTES

1. R values in the above equations are in ohms
2. When ICR is active, both the holding torque generated by the motor and the motor stiffness around the holding position are reduced.
3. The ICR function reduces the motor and drive heating during stand by operations.
4. When connecting the current reduction resistor between P2-1 and P2-2, the leads should be as short as possible to help minimize noise coupled into the MSD 25C driver.

4.0 Maintenance and Troubleshooting

The MSD 25C 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. The MSD 25C is internally protected against

4.1 Over temperature and short circuits

- The over temperature protection is built in into the power output bridge ICs.
- This circuit will disable the output if the junction temperature within the IC reaches 150 degrees C.
- When the temperature falls to a safe level the outputs will re-enable (***it is not a latched fault***).

4.2 Short circuit protection consist of

- Phase to phase
- Phase to ground and
- Bus voltage (DC+) to phase.
- If a short circuit is detected,
 - The MSD 25C outputs will be disabled and can not be re-enabled without resting or powering down the MSD 25C.
 - At the same time the open collector FAULT output is turned ON.
 - The FAULT output is non-isolated and has the ability to sustain the maximum driver voltage. It is capable of sinking up to 25 mAmps which can be used to drive a small relay or LED.

NOTE - *If you suspect that the MSD 25C 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 25C drivers. Refer to Appendix B for more information.*

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

Symptom	Corrective Action
Motor Produces NO	<ul style="list-style-type: none"> • Ensure power to MSD 25C is applied.

Torque	<ul style="list-style-type: none"> • Check that P2 power supply voltage is ≥ 12 and ≤ 48 Vdc. If possible, check with an oscilloscope to verify that this is true on transient basis. • Check for open fuses or open contactors • Ensure the drive is not disabled, check P1-5 (ENABLE) is not pulled LOW • Verify that current adjust resistor are set correctly • Check the motor connections for shorts across the windings or between the windings and the motor case. • 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 70 degrees C a heat sink or a cool fan is required. You might consider using the ICR function. • Check if the RESET input (P1-6) is not pulled LOW
Motor Produces Torque But Does Not Turn	<ul style="list-style-type: none"> • Make sure that the STEP input is switching and meets specified electrical and timing requirements • Check the phase current in both phases by placing an ammeter in series with each winding, if not present check the phase resistance, if one phase resistance is higher than the other phase you might consider replacing the motor. • Check the motor phasing (wiring if an 8 lead or 6 lead or even 4 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	<ul style="list-style-type: none"> • Check polarity of the DIRECTION (P1-3) input. • Check that the DIRECTION input satisfies the specified electrical and timing requirements. • Reverse the A and A/ motor phase (or reverse the B and B/ motor phase).
Motor Does Not Reach Expected Position	<ul style="list-style-type: none"> • Motor START/STOP (minimum) speed is too low the motor is starting in the low speed mechanical resonance (below 90 RPM) <ul style="list-style-type: none"> • Increase your START/STOP speed • Use finer resolution (microstep) setting. • Check that the step size setting of the driver is the same as the step size of the indexer. To check if you have the correct step size setting <ul style="list-style-type: none"> • Set your RUN speed to about 200 RPM • Apply (200 * step size) pulses to the driver • Motor should rotate one complete shaft rotation (1.8 degree motor only) • If it does not check your settings • Verify that the motor does not stall. If it does: <ul style="list-style-type: none"> • 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. • Change your motion profile, Incorrect ramp time, adjust the acceleration / deceleration ramp time. • Intermittent connection of the STEP CLOCK (P1-2) input.

	<ul style="list-style-type: none"> • Intermittent connection of the RESET (P1-6) input. • Intermittent connection of the OPTO SUPPLY (P1-4) input. • Incorrect STEP CLOCK magnitude. • Fault in the driver logic, to evaluate: <ul style="list-style-type: none"> • Set the MSD 25C to ½ 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.
Motor Operation is Rough or Erratic	<ul style="list-style-type: none"> • Operation is on resonance region of the torque/speed curve (low speed area). • Use finer step resolution. • Change frequency of applied logic pules. • Use higher bus voltage. • 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 25C 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	+12 to +48 Vdc @ 2.0 Amps (typical)	
Rated Drive Current (motor phase current settings)	0.3 - 3.0 Amps RMS (0.4 - 4.0 Amps PEAK)	
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
	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	Max. Forward Voltage
P1-2 STEP	7.0 mAmps	15.0 mAmps	5.0 volts	1.7 Volts
P1-3 DIR	7.0 mAmps	15.0 mAmps	5.0 volts	1.7 Volts
P1-5 ENABLE	7.0 mAmps	15.0 mAmps	5.0 volts	1.7 Volts
P1-6 RESET	7.0 mAmps	15.0 mAmps	5.0 volts	1.7 Volts

Signal output characteristics

P1-7, FAULT OUTPUT

Maximum Collector-Emitter Voltage	140 Vdc
Maximum Collector-Emitter Saturation Voltage	0.2 Vdc (Ics = 25 mA DC)
Maximum Output Current	25 mAmps

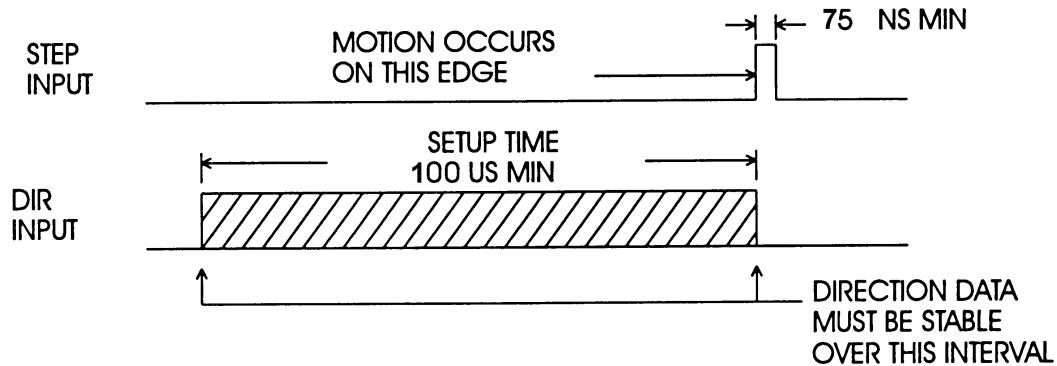
P1-8, FULL STEP OUTPUT

Maximum Output Current	25 mAmps
Maximum Drain-Source Voltage	100 Vdc
Typical Drain-Source Resistance	6.5 ohms (Ics = 25 mA DC)

Maximum step rate - 10 MHz

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

- The typical execution time for Step input, Direction or Microstep select change is 100



nsec

- The reset and enable inputs are asynchronous to any input and can be changed at any time
- The reset requires a minimum pulse width of 500 nsec
- The full step output occurs 75 nsec after the positive edge of the step clock (excluding changes to the direction or the microstep select inputs)

Storage Temperature - 40 °C to +125 °C

Operating Temperature - Full rated current 0 to 50 °C ambient provided chassis properly mounted so as not to exceed 70°C.

Humidity Range - 10 to 90%, non-condensing

Maximum chassis temperature - 70 °C. For optimal thermal performance, mount the MSD 25C chassis 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 70 °C.

Power Dissipation - Maximum 12 watts @ I out 3 amps RMS (4.2 amps peak).

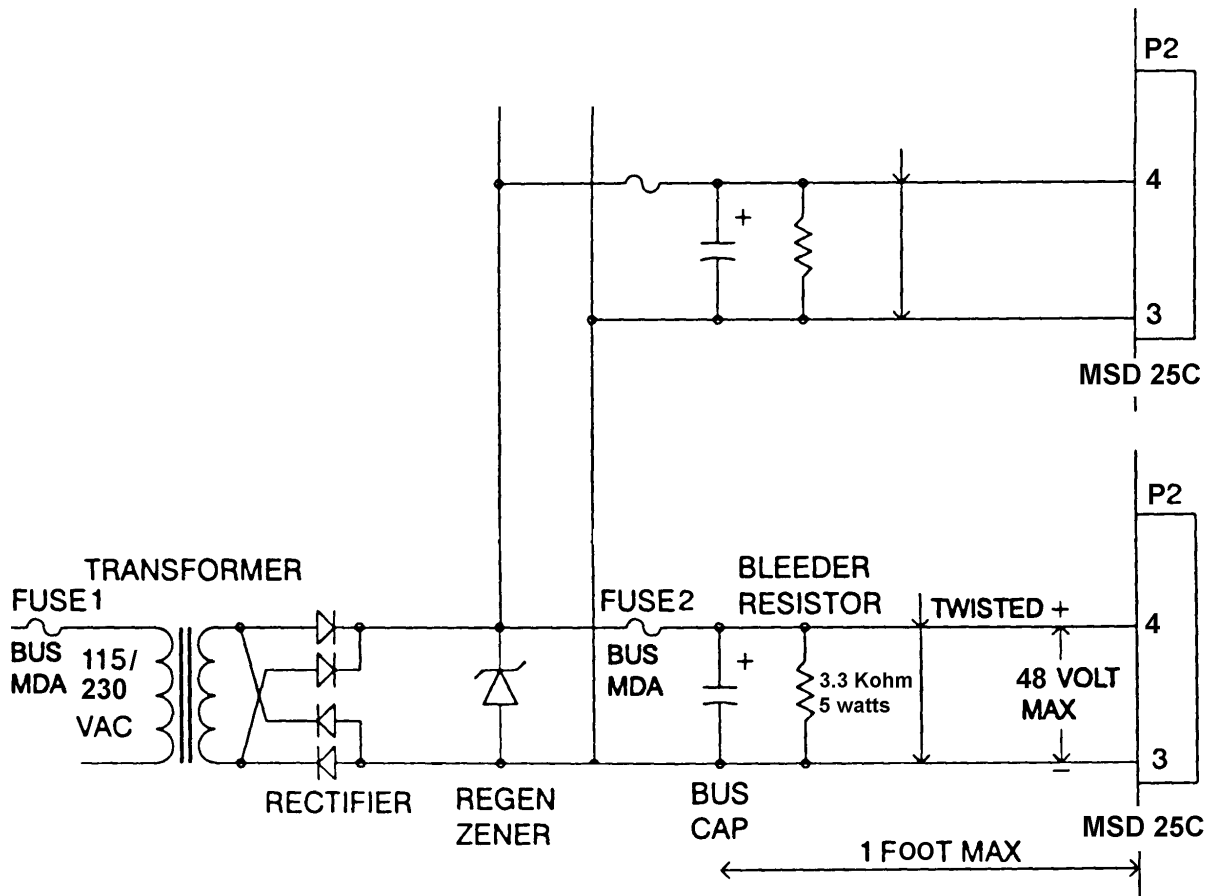
Weight - 0.25 lb..

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 25C micro-stepping 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 25C 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 25C(s) is sometimes required.

WARNING

Power supply design must insure that the voltage between P2-3 and P2-4 never exceeds volts 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 25C.

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 48 Volts DC. Of course lower voltage can be used, so long as the voltage is greater than the minimum specified motor value of 12 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 23 Vac, the peak bus voltage will be

$$(1.414 * 24) - 1.5 = 32.4 \text{ Vdc.}$$

A transformer with 115 Vac primary and 24 Vac secondary would produce 32.4 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

$$(1.414 * 1.1 * 24) - 1.5 = 35.8 \text{ Vdc}$$

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 24 Vac transformer with secondary rating current of 1 amp has a VA of 24.*

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	26.5 Vac
100 - 350	27.0 Vac
> 500	27.8 Vac

1.3 Current Rating - The average supply current into an MSD 25C 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 to the phase current.*

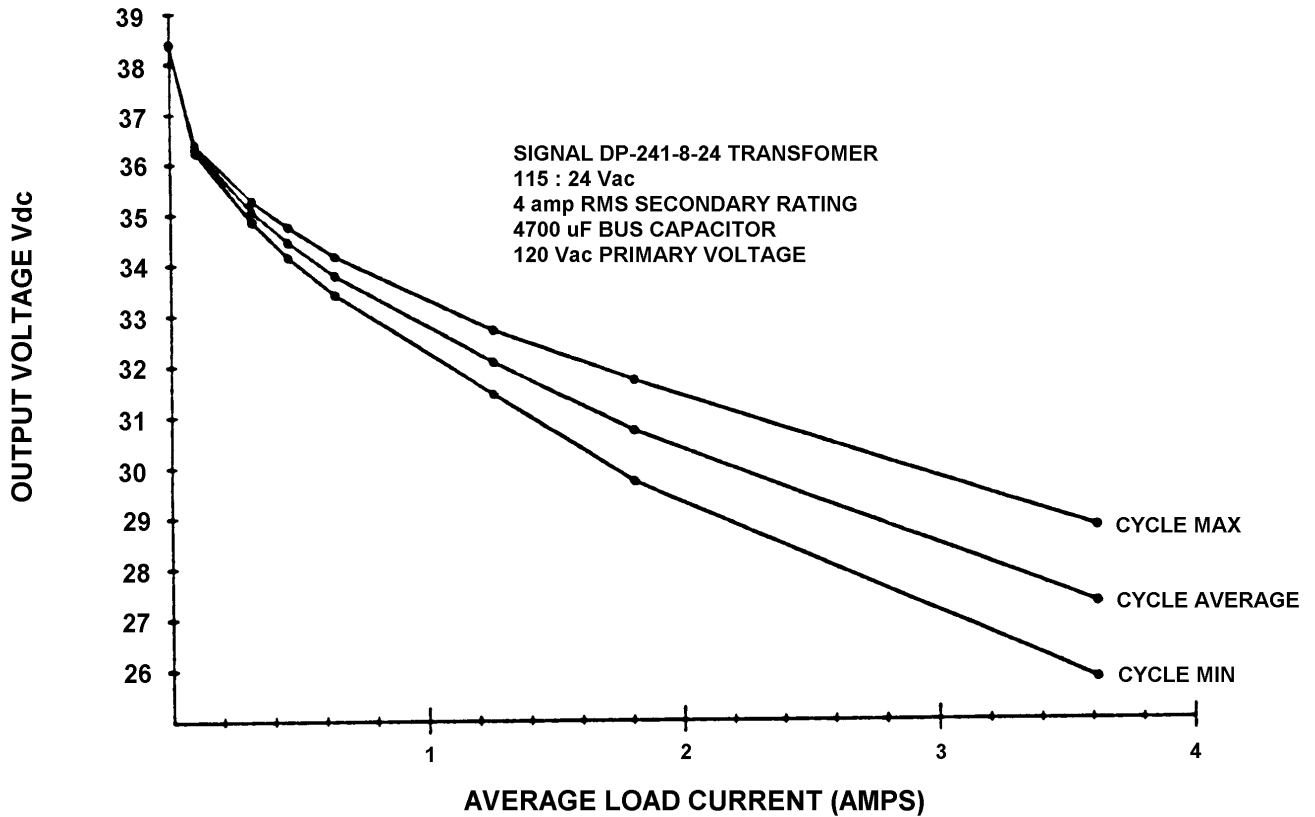
When the power is first applied to the MSD 25C, the supply current may briefly reach twice the phase current but it will drop when the input voltage reaches 12 Vdc, the minimum specified operating voltage. This brief surge does not affect the transformer sizing.

So if the output current setting of 2 amps RMS (2.8 amps peak) 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 25C drivers, each set for a phase current of 2 amps RMS should have a rated secondary RMS current of $1.8 * 3 * 2 = 10.8$ 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 25C using twisted pair and no longer than one foot in length.

The bus capacitance value for a single MSD 25C 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 25C’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 $1.3 * \text{desired DC bus voltage}$).

The 50 Volt, 60 Hz, 4700 micro-farad capacitor shown in the diagram 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 required, a correspondingly larger valued capacitor should be used.

The following table provides the minimum bus capacitance value for a single MSD 25C as function of current setting and bus voltage (increase the capacitance value by 20% if working with 50 Hz line)

Current setting (amps RMS)	24 Vdc Bus @ 60 Hz	36 Vdc Bus @ 60 Hz
2.5	6,900	4,700
2	6,000	4,200
1.5	5,200	3,700

4.0 Fusing

4.1 F1 Fuse - Good design practice to fuse each MSD 25C individually in a multi-axis configurations.

4.1.1 Current Rating - A minimum of 3.0 amps RMS slow acting fuse is appropriate (4.5 amps RMS is the maximum recommended fuse size)

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:

$$\text{Fuse Current Rating, amps RMS} = 3.6 * (\# \text{ of MSD 25Cs}) * (\text{MSD 25C RMS Phase Current Setting}) * \frac{\text{Transformer Secondary Voltage}}{\text{Transformer Primary Voltage}}$$

So, for example, if three MSD 25Cs with phase current set at 2 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 $3.6 * 3 * 2 * (24/115) = 4.5$ 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 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 follow:

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

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:

$$V = \sqrt{V_0^2 + \frac{2E}{C}}$$

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 V_{dc} of the drive, you should considering a shunt regulator circuit. **Be sure to the effect of high line voltage when evaluating this test.**

The MSD 25C 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 25C 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 V_{dc}.

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 48 Vdc. A 39 volts +/- 10% or 43 volts +/- 2% zener can be used.

Caution

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.

Appendix C Recommended Power Supply

The switch mode SPS 25D is 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 is capable of delivering 3 Amps continuous current and have the ability to absorb inductive current surges associated with the 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 General Specifications

AC input Voltage	120 Vac + 10 % , -15%
Input frequency	50 / 60 Hz
No load output voltage	45 Vdc nominal
Continuous output power	150 watts
Continuous DC output current	3 amps DC
Operating temperature	0 - 50 °C
Storage temperature	-40 - 125 °C
Max. heat sink temperature	70 °C
Connectors	Screw terminal
Weight	0.75 lb..
Size	3.90" x 4.00" x 1.50"

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:

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

where:

- $T_{\text{holding torque}}$ = 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-sec²

Example; the resonant frequency of an unloaded IS 23 027 MCG stepping motor having an inertia of 0.00274 oz-in-sec² provides a holding torque of 154 oz-in when connected in parallel with 2.24 amps RMS driver is

$$F_{\text{resonant}} \text{ (Hz)} = 1.1 \sqrt{\frac{154}{0.00274}} = 261 \text{ Hz}$$

So, if the motor were to run at 261 full steps per second or approximately 78 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 522 half-step per second which is still approximately 78 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 25C 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 size the less the torque disturbance the less the oscillation due to low speed resonance.

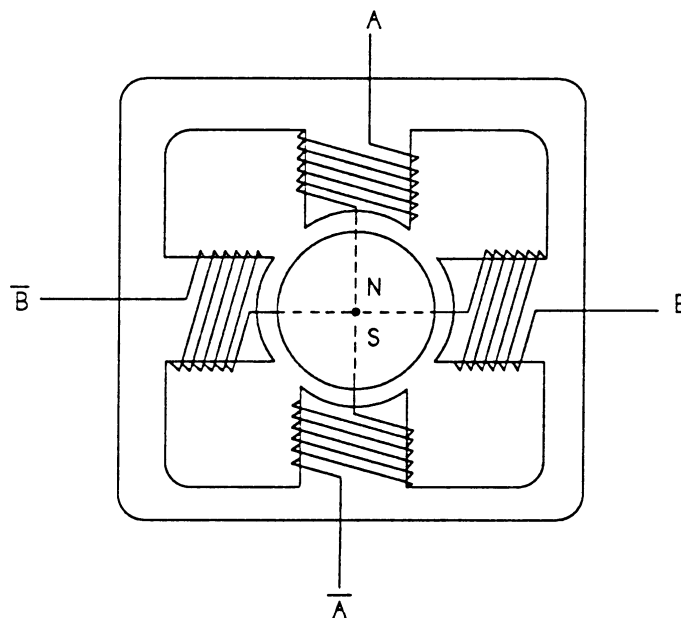
Appendix E Theory of Operation

The MCD 25C 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



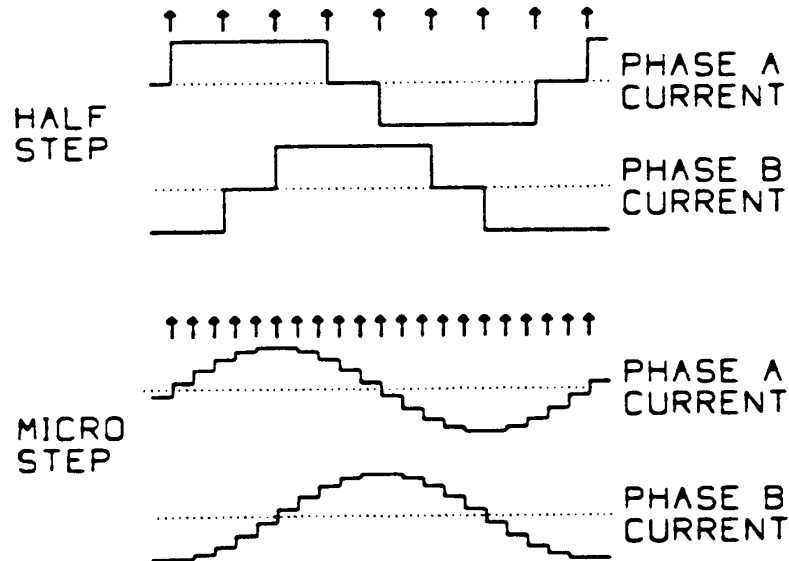
The stator consists of two windings and the rotor is a permanent magnet. The rotor aligns itself with the magnetic field created by the stator windings. By controlling the winding currents in the proper sequence, torque is produced and the rotor will rotate in the desired manner. The phase currents are bi-directional and sequencing of these phase currents is termed commutation. There are two basic types of stepping motor commutation possible with the MSD 25C driver module:

- 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 25C). Motor phase current wave forms for 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 waveforms encountered if full and sometimes in half step mode creates mechanical forces that may translate into mechanical resonance in a 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.

Chopper Circuit

An internal PWM (pulse width modulation) oscillator supplies pulses at a fixed 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.

Motor Current Regulation

Motor phase currents are controlled by two 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 by an external resistor up to 3.0 RMS (4.0 amps peak). To this purpose a resistor must be connected between P2-2 and P2-3, the resistor determines the peak current value of the MSD 25C (to determine the RMS value simply multiply the peak value by 0.7).

The phase current level is achieved by a chopping mode. The internal oscillator supplies pulses at the chopper frequency to both choppers. When the outputs are enabled, the current through the windings raises until a peak value set by the external resistor and the sense resistor is reached. At that moment the outputs are disabled and the current decays until the next oscillator pulse arrives. The amount of current decay during the fixed off time depends on the method used to recirculate the current: slow or fast.



*Contact your local distributor or call 1-888-624-3478 (US & Canada)
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