DMC 6D & 12D

HARDWARE INSTALLATION

MANUAL

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1.0 Overview of DMC 6D & DMC 12D

1.1 DMC 6D & DMC 12D Definition

MCG DMC 6D & DMC 12D are PWM servo drives designed to drive brush type DC motors at a high switching frequency. Operating efficiencies approach 99 %.

1.2 Functional Block Diagram

Figure (1) Functional Block Diagram

1.3 Drive features

- Analog interface, ±10 volts analog interface.
- Single red/green LED indicates operating status.
- Over voltage protection.
- Over current protection.
- Over temperature protection.
- Short circuits protection across motor, ground and power leads.
- Designed to interface with digital controllers or could be used as stand-alone drives.
- Require a single DC unregulated power supply.
- Loop gain, current limit, command gain and offset can be adjusted using a 15 turn potentiometer.
- The offset adjusting potentiometer can also be used as an onboard input signal for testing purposes; when SW-4 is ON, position 4 of the DIP switch is ON.
- Agency approvals, UL recognized.

1.4 General Specifications

Specifications Table

1.5 System Connection/Wiring Diagram

The following diagram shows an installation of the DMC 6D or the DMC 12D in a typical system. Your system may vary from this configuration. Typical components used with these brushless servo drivers include:

- DC brush servo motor
- External switches
- Power supply

Figure (2) Wiring and connections diagram

1.6 How to Use This Manual

This manual provides and contains information, procedures and instruction on how to install, connect, set up, and test the servo drive. This manual is organized into chapters and appendixes.

1.7 Warranty

The MCG DMC 6D and DMC 12D have 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 DMC 6D & DMC 12D

This chapter explains how to install the DMC 6D & DMC 12D in your application.

2.1 Unpacking the Drive

1. Remove the drive from the shipping carton and remove all packing materials from the drive. The materials and the carton may be retained for storage or shipment of the drive.
2. Check all items against the packing list. A label located on the side of the drive identifies:
    - Model number
    - Serial number
    - Manufacturing date code

2.2 Inspection procedure

To protect your investment and ensure your rights under warranty, MCG recommends the following steps are performed upon receipt of the drive:

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

2.2.1 Testing the servo drive

The DMC 6D and DMC 12D are designed to operate in a self-test mode using POT 4, the "TEST / OFFSET," potentiometer to control an on board signal source. This test can be used to confirm that the servo drive is functional and operational. The test requires a DC power supply (20 - 80 Vdc), a DC voltmeter, and a DC brush motor.

1. Take note of the DIP switch setting before starting the test.
2. Always be prepared to turn the main power OFF.
3. Refer to Figure (2), "Wiring and Connection Diagram," on page XXX
4. Use sufficient capacitance with the power supply.
5. Set the DIP switch on the servo drive to the following settings, "positions":

SW-1	SW-2	SW-3	SW-4
ON	OFF	OFF	ON

6. Connect the DC bus voltage to P2-5 "+" and P2-4 "-." Do not reverse the power supply leads, as severe damage will result if you do.
7. Connect your ***DC voltmeter*** to P2-1 "MOTOR +" and P2-2 "MOTOR -."
8. Set your DC voltmeter to measure DC voltage.
9. Apply power by turning the DC power supply ON.
10. Check that the LED is GREEN (normal operation).
11. Turn POT 4, "TEST / OFFSET." At this moment, the DC voltmeter should read some voltage varying between ± bus voltage (the voltage applied to drive).
12. Set POT 4 "TEST / OFFSET" to output low DC voltage.
13. Turn the DC power supply OFF.
14. Wait about 10 seconds.
15. Remove the DC voltmeter connections.
16. Verify the motor inductance meets the drive requirement (200 µH minimum)
17. Connect the unloaded motor leads to P2-1 "MOTOR +" and P2-2 "MOTOR -"
18. Set the CURRENT LIMIT "POT 2" to the motor current specifications:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

19. Turn the DC power voltage ON.
20. Turn POT 4 "TEST / OFFSET" in both directions, the motor should vary speed in both directions if the motor does not rotate, turn POT 1, "LOOP GAIN," CW until the motor begins to rotate.
21. Using POT 4, adjust motor speed to 0 RPM (the motor should stop rotating).
22. Turn the DC power voltage OFF.
23. Wait 10 seconds, then remove all connections to the servo drive.
24. Set the DIP switch to the original drive settings.

If the drive passed the above test, proceed to the next section; if not refer to section 4.0 "Maintenance / Troubleshooting."

2.3 Storing the Drive

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

- Humidity: 5% to 95%, non-condensing.
- Storage temperature: -40 - 176 F (-40 to 80 degrees C).

2.4 Selecting a Motor

The DMC 6D and DMC 12D are compatible with many brush DC motors, both MCG brush DC motors and motors from other manufacturers. MCG brush DC motors that are compatible with the DMC 6D and DMC 12D drives include the ID15000, ID23000, ID34000 and ID42000 series.

The motor winding current rating must be equal to the output current setting of the drive. Refer to the torque speed curve in the ***CfD*** "Brush Servo Systems" catalog or contact your local MCG distributor for motor sizing and compatibility assistance.

Refer to Appendix A for more information

2.5 Selecting a DC Power Supply

The servo drive operates from a single unregulated DC power supply. It is recommended to select a power supply voltage which is does not exceed the maximum recommended voltage input on the drive or about 10 % higher than the maximum required for your motor terminal voltage.

This percentage is to count for the variation in Kt (torque constant) and Ke (voltage constant) and for losses in the system external to the drive.

Refer to Appendix A for more information.

2.6 Safety

Read the complete manual before attempting to install or operate the DMC 6D & DMC 12D drives. By reading the manual you will become familiar with practices and procedures that allow you to operate these drives 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 drives should be installed in an industrial cabinet such that access is restricted to suitable qualified personal.

- Electrical hazards can be avoided by disconnecting the drive from its power source and measuring the DC bus voltage to verify that it is within the safe level.
- Make sure motor case is tied to earth ground.
- DO NOT power the unit without the cover.
- DO NOT operate the unit without connecting the motor to the appropriate terminals; high voltage is present at the motor terminal even when motor is not connected and voltage bus is present.
- Always remove power before making any connection to the drive.
- Always turn OFF the main power before taking off the cover of the drive.
- DO NOT make any connections to the internal circuitry. Connections on the front panel are the only points where users should make connections.
- DO NOT use the ENABLE input as a safety shutdown. Always remove power to the drive for safety shutdown.
- Use power supply with sufficient capacitance.
- Make sure minimum inductance requirement is met.
- 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 drive but may damage the motor. If connection arcs or opens the motor is spinning rapidly, this 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 varies from 80 Volts above to 80 Volts below earth ground. All internal circuitry should be considered "hot" when power is present.

2.7 Mechanical Installation

Mount the drive in an enclosure providing protection to IP54, protected against dust and splashing water, or IP65, protected against water jets and dust free air. Many NEMA type 4 cabinets provide this type and level of protection. Minimum cabinet requirements are:

- Depth - 4 inches
- Ventilation to dissipate the heat generated by the drive:
  - DMC 6D - 4 watts
  - DMC 12D - 15 watts

- The air should also be free of corrosive or electrically conductive contaminants.
- Internal cabinet temperature should not exceed 122 F (50 degrees C). Operating temperature range: 32 - 122 F (0 - 50 degrees C).

2.7.1 Mounting Dimensions

Figure (3) Mechanical Dimensions

Position the drive in a vertical position on a flat, solid surface. This surface should be able to support 10.0 oz (0.3 Kg) the approximate weight of the drive.

- Bolt the drive in the cabinet using the mounting two slots in the rear side, or the four mounting slots in the side of the drive (cold plate mounting), using M4 or size 6-32 screw.
- Minimum unobstructed space of 4 inches (100 mm) at the drive top and bottom.
- Minimum of one inch on each side.
- Free of excessive vibration or shock.

2.8 Electrical Interfacing and Connections

The servo drive has two I/O (input/output) connectors.

- P1 - Signal connector, Molex type, 16 pin connector.
- P2 - Motor / Power connector, screw terminal, 5 pin connector.

2.8.1 Interface Connection Diagram

Figure (4) Wiring and Connections Diagram

2.8.2 Wiring

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

Warning

The user is responsible for conforming to 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.

Note

The grounding connections for the DC power, chassis, and motor must be connected as shown in the interface connection diagram.

Refer to Appendix B for more information

2.8.3 P2 - DC Power / Motor Connections

P2 is a five-pin screw terminal connector, which connects the drive to the motor armatures and the DC power to the drive.

P2 Pin NO	Signal	Description
1	MOTOR +	The + armature input from the drive.
2	MOTOR -	The - armature input from the drive.
3	POWER GND	Motor case input.
4	POWER GND	The negative terminal input of the DC bus voltage.
5	HIGH VOLTAGE	+20 to +80 Vdc max, input bus voltage.

P2 Power Interface Connection

Cable requirements: Use #14 to #18 AWG for cabling, use #16 AWG or heavier for the power supply. Obtain cable with each pair twisted.

NOTES

1. *The drive should be located **NO** further than 24 inches from the power supply.*
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.*
3. ***DO NOT** use wire shield to carry power, current or voltage.*

Refer to Appendix A, B and C for more information

2.8.4 Multiple Axis Power Wiring

The DC supply may be common to more than one drive. The power lead from each drive should terminate at the power supply terminals.

When multiple amplifiers are installed in a single application, caution regarding grounding loops must be taken. Any time there are two or more possible current paths to a ground connection, damage can occur or noise can be introduced in the system. The following rules apply to all multiple axis installations, regardless of the number of power supplies used.

- Never “daisy chain” any power or DC common connections.

- Use the “star” connection for each servo drive by running separate twisted power supply wires to each power connection on each drive.
- The upper limit on the DC supply can not exceed 80 Vdc.
- Use differential inputs to the servo drive to avoid common mode noise.
- To prevent noise, do not bundle the motor leads with the power supply leads.
- The DC power supply must be located as close as possible but no more than 2 feet from the drive.
- If the DC power supply must be located more than 2 feet from the drive, additional capacitance must be added across the DC power supply, but no more than 2 feet away; refer to Figure (5).
- Ideally separate capacitors would be located next to each drive, however, one may be used if twisted pairs, no longer than two feet, extended from the power supply capacitor to each drive.

Figure (5) Bypassing capacitors.

Refer to Appendix A, B and C for more information

2.8.5 Motor Wiring

Twisted shielded pair wire for motor cabling is recommended. Ground the shield end only at the drive end as shown in Figure (4). The motor power inputs are connected to the drive output.

Cable requirements: Use #14 to #18 AWG twisted pair wire for cabling. If the cable used is shielded, connect the shield to the drive end only; refer to Figure (4) “Wiring and Connections Diagram.”

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.*

Refer to Appendix A, B and C for more information

2.8.6 P1 - Signal Connector

This is a 16 pin Molex type I/O (input and output) connector. The Molex mating connector part numbers are:

Molex Plastic Body	22-01-3167
Insert Terminals	08-50-0114

The standard crimping hand tool is:

Molex part number	11-01-0185

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

P1 pin NO	Function	Function / Description
1	+5 Vdc @ 5 mA	• For customer use. • Internal DC-DC converter which generates the internal ± 12 Vdc from the high DC power supply input and also outputs regulated voltages of ± 5 Vdc @ 5 mA. • These outputs are short circuit protected.
2	Signal GND	
3	-5 Vdc @ 5 mA	
4	COMMAND -	• Analog command signal, a differential type signal to drive the servo drive. • If the drive is set for velocity mode, the differential COMMAND signal is the velocity command. • If the drive is set for torque (current) mode, the differential COMMAND signal is the torque or current command. • Separate scale and offset adjustments are used in conjunction with this input. • Input impedance of 50 kΩ. • Maximum input voltage ± 15 Volts
5	COMMAND +	
6	- TACH IN	• The tachometer input. • Input Impedance 60 kΩ • Maximum input voltage ± 60 Volts.
7	+ TACH IN / GND	
8	CURRENT MONITOR	• This is an output signal is proportional to the actual current in the motor leads. • Scaling is 2 Amps / 1 Volt for the DMC 6D • Scaling is 4 Amps / 1 Volt for the DMC 12D
9	CURRENT REFERENCE	• Command signal to the internal current loop. • The maximum peak current rating of the drive always equals 7.5 volts. ***SEE NOTE BELOW FOR MORE INFORMATION***
10	CONTINUOUS CURRENT LIMIT	• Can be used to reduce the factory preset maximum continuous current limit. • This is also a feature to separate peak and continuous current limit adjustments. ***SEE NOTE BELOW FOR MORE INFORMATION***.
11	$\overline{\text{ENABLE}}$	• The servo drive will be disabled if this pin is pulled to ground (pin 2 SIGNAL GND).
12	$\overline{\text{- INHIBIT IN}}$	• Inhibits the motor from rotating in the CCW direction if this pin is pulled to ground (pin 2 SIGNAL GND). • The CCW limit switch (over travel limits) input can be connected to this point.
13	$\overline{\text{+ INHIBIT IN}}$	• Inhibits the motor from rotating in the CW

		direction if this pin is pulled to ground (pin 2 SIGNAL GND). • The CW limit switch (over travel limits) input can be connected to this point.
14	FAULT	• TTL compatible output. • Under no fault condition this output is low • Under a fault condition this output is high • Faults are output short circuit, over voltage, over temperature, enable and during power on reset. • Fault condition indicated by red LED. ***Note*** Fault conditions are ***NOT LATCHED.*** When a fault condition is removed, the drive will be enabled and can resume motion if commanded.
15	NC	NOT CONNECTED
16		

Table (3) P1 Signal Interface Connector

For the internal circuit representations for the above connection points, refer to Figure (1), "Functional Block Diagram," for more details.

***NOTE:* PEAK & CONTINUOUS CURRENT LIMIT ADJUSTMENT**

It is critical to set the current limit so that the instantaneous motor current does not exceed the specified motor peak current ratings. Should this occur, the motor permanent magnets may become demagnetized. This would reduce both the torque constant and the torque rating of the motor and seriously affect the system performance.

MCG servo drives feature peak and continuous current limit adjustments. The maximum peak current is needed for fast acceleration and deceleration. These drives are capable of supplying the maximum peak current for 2 seconds and then the current limit is reduced gradually to the continuous value.

The purpose of this is to protect the motor in stalled condition, by reducing the current limit to the maximum continuous value. Current limiting is performed in the drive by reducing the output voltage to the motor.

The current limit adjustment potentiometer, "POT 2," has a 1 inactive turn in each end and is approximately linear. Thus, to adjust the current limit, turn POT 2 CCW to zero then turn it CW to the appropriate setting. Use the following table for approximated current settings:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

If the peak current reference does not reach the set peak current limit, the time for the peak current will be longer than 2 seconds. The actual time is a function of the RMS current.

Since the output current is proportional to P1-9, “CURRENT REFERENCE,” the adjusted current limit can be easily observed at this pin. The maximum peak current value equals 7.5 V at this pin with respect to P1-2, “SIGNAL GROUND.” The actual current can be monitored at pin P1-8, “CURRENT MONITOR,” with respect to P1-2, “SIGNAL GROUND.”

These drives feature separate peak and continuous current limiting adjustments. The continuous current can be reduced without affecting the peak current limit. This can be performed by connecting an external resistor between the CONTINUOUS CURRENT LIMIT (P1-10) and the SIGNAL GROUND (P1-2). Use the following table for resistor values,
(The table assumes that POT 2 is fully CW),

CURRENT LIMITING RESISTOR	20 kΩ	10 kΩ	2 kΩ	1 kΩ	200 Ω
CONTINUOUS CURRENT LIMIT	90 %	80 %	50 %	30 %	10 %
DMC 6D, Cont. Current	5.4 Amps	4.8 Amps	3.0 Amps	2.0 Amps	0.6 Amps
DMC 12D, Cont. Current	11.25 Amps	10.0 Amps	6.25 Amps	3.75 Amps	1.25 Amps

or you may use the following table for approximated current settings:

Number of turns from CCW (POT 2)	Resistor value (ohms)	DMC 6D		DMC 12D	
		I_{cont}	I_{peak}	I_{cont}	I_{peak}

5	200	±0.2	±4	±0.42	±8.33
	1.0 k	±0.6	±4	±1.25	±8.33
	2.0 k	±1	±4	±2.1	±8.33
	10 k	±1.6	±4	±3.33	±8.33
	20 k	±1.8	±4	±3.75	±8.33
10	200	±0.4	±8	±0.83	±16.67
	1.0 k	±1.2	±8	±2.5	±16.67
	2.0 k	±2	±8	±4.2	±16.67
	10 k	±3.2	±8	±6.67	±16.67
	20 k	±3.6	±8	±7.5	±16.67
15	200	±0.6	±12	±1.25	±25
	1.0 k	±2	±12	±3.75	±25
	2.0 k	±3	±12	±6.25	±25
	10 k	±4.8	±12	±10	±25
	20 k	±5.4	±12	±11.25	±25

2.8.7 Tachometer Wiring

Twisted 18 AWG shielded pair cable is the minimum requirement for tachometer cabling. Ground the shield at the drive end only; refer to Figure (4), “Wiring and Connections Diagram.”

Refer to Appendix B for more information

2.8.8 COMMAND Signal Wiring

- Twisted shielded pair wires for the COMMAND input signal is recommended. Connect the shield to the command signal source and not to the drive.
- If the command signal source is ungrounded, connect the shield to both the source and the drive ground.
- It is recommended that the input be connected directly to the drive differential input. Connect the signal command source “+” to the COMMAND + and the signal command source “-” to the COMMAND -.
- If the signal command source and the drive are grounded to the master chassis ground, leave the source end of the shield unconnected. The drive-input circuit will attenuate the common mode voltage between the signal command source and the drive power grounds.

- If the direction of motor rotation is not the desired one, reverse the polarity on the COMMAND input or reverse the motor leads (and the tachometer leads if in velocity mode).

Refer to Figure (4), and appendix B Figure ( ) for more information

3.0 Operating / Configuration Mode Selection

The drive can be configured into 4 different operating modes via a DIP switch. These modes are:

- Torque (current) Mode
- Velocity (Tachometer) Mode
- Voltage Mode
- IR Compensation Mode

3.1 Switch Functions

Switch	Function / Description	Setting	
		ON	OFF
1	Internal Voltage Feedback	ON	OFF
2	It is recommended to leave SW2 in the "OFF" position ***See section 3.1.1.***	Shorts (disables) the current loop integrator capacitor	Current loop integrator operating
3	This capacitor normally ensures "error free" operation by reducing the error signal (output of summing amplifier) to zero. ***See section 3.1.2***	Shorts (disables) the velocity loop integrator capacitor ***It is recommended to set it ON in Torque (current) mode***	Velocity / Voltage integrator operating. ***It is recommended to set it OFF in Velocity or voltage mode.***
4	TEST / OFFSET. Defines the function of Pot. 4.	On board reference signal in test mode.	Offset adjustment OFF.

DIP switch Functionality

3.1.1 Current Loop Integrator, SW2, R30 and C10

The current loop response (bandwidth) is determined by the current loop gain resistor, refer to Figure (1), "Functional Block Diagram." SW2, R30 and C10 control the PI (proportional and integral) gains of the current loop.

Current loop response is inversely proportional to motor inductance. Higher inductance motors require higher proportional gain to obtain the same response as lower inductance motors.

The greater the resistor value, the faster the response. If the resistor value is too high for the inductance, then overshoot or oscillation occurs in the current loop.

Typically the standard drive setting is recommended for load inductance less than 2 mH and the 100 kΩ setting is for load more than 2 mH. This may be accomplished by installing a through hole resistor in R30. For load inductors higher than 5 mH, a 200 kΩ or higher resistor can be placed in R30 for faster response. If the resistor value is too high for the inductance then overshoot or isolation occurs in the current loop.

In most applications, leaving SW2 in the OFF position is recommended.

By doing so, the signal is being integrated and the error signal is being reduced as well as the amount of signal overshoot. If the gain resistor value has been changed, C10 has to change.

Since adjustments of this component can cause possible damage to the drives power section, extreme care should be exercised if changing these components. Consult your local MCG distributor before attempting to change or add components.

3.1.2 Velocity Loop Integrator, SW3

The velocity loop integrator capacitor can be used to compensate for large load inertias. The greater the load inertia, the greater the capacitor value is required. This can be performed by switching SW3 OFF or by installing a larger through hole capacitor (C5); refer to Figure (1), “Functional Block Diagram.”

The need for a larger capacitor can be verified by shorting out the velocity integrator capacitor by turning SW3 ON. If the velocity loop is stable with the capacitor shorted out and unstable with the capacitor in the circuit then a greater capacitor value is needed.

If the capacitor is included in the circuit (SW3 OFF), it will force the motor velocity to precisely follow the commanded velocity (reducing the velocity error), this is assuming steady state operation were the velocity command or the load DOES NOT change.

The velocity loop integrator along with POT1, “LOOP GAIN,” control the stiffness and the ability to reject load torque disturbance. Too high of a capacitor value could cause an overshoot in the velocity loop and may cause the system to become unstable or break into oscillations.

The velocity loop response (bandwidth) is determined by POT 1, the “LOOP GAIN.” The greater the POT value (the more turns from CCW), the faster the response.

3.2 Potentiometer Functions

Potentiometer	Function	Description	Turning CW

Pot 1	Loop Gain	• Loop gain adjustments in voltage and velocity modes. • Voltage to current scaling factor adjustment in current mode. • If in ***TORQUE (CURRENT) MODE*** setting, this potentiometer should be set ***FULLY CCW***, otherwise a run away condition may occur.	Increases loop gain
Pot 2	Current Limit	• Adjusts both continuous and peak current limit by maintaining a ratio of 2:1 (peak : continuous)	Increase current limit
Pot 3	Command Gain	• Adjusts the ratio between the input COMMAND signal and the output variables (voltage, current, and velocity) • Turn this POT CW until the required output is obtained for a given input COMMAND signal. • If in ***TORQUE (CURRENT) MODE*** setting, this potentiometer should be set ***FULLY CW***.	Increase COMMAND input gain
Pot 4	Test / Offset	• When SW4 is OFF. This pot is used to adjust any imbalance in the input signal or in the drive. • When SW4 is ON, the sensitivity of this pot is greatly increased, so it can be used as an on board signal source for test purposes.	NA

Table (5) Potentiometer Functionality

3.2.1 LOOP GAIN, "POT 1," ADJUSTMENT

The velocity loop response (bandwidth) is determined by POT 1, the "LOOP GAIN." The greater the POT value (the more turns CCW) the faster the response.

POT 1, "LOOP GAIN," along with velocity loop integrator (SW 3) control the stiffness and the ability to reject load torque disturbance. Increasing resistance (turning POT 1 CW) causes an overshoot in the velocity loop and may cause the system to become unstable or break into oscillations.

NOTE

*If in **TORQUE (CURRENT) MODE**, this potentiometer should be set **FULLY CCW**; otherwise a run away condition may occur.*

3.2.2 CURRENT LIMIT, "POT 2," ADJUSTMENT

It is critical to set the current limit so that the instantaneous motor current does not exceed the specified motor peak current ratings. Should this occur, the motor permanent magnets may become demagnetized. This would reduce both the torque constant and the torque rating of the motor and seriously affect the system performance.

MCG servo drives feature peak and continuous current limit adjustments. The maximum peak current is needed for fast acceleration and deceleration. These drives are capable of supplying the maximum peak current for 2 seconds and then the current limit is reduced gradually to the continuous value.

The purpose of this is to protect the motor in stalled condition, by reducing the current limit to the maximum continuous value. Current limiting is performed in the drive by reducing the output voltage to the motor.

The current limit adjustment potentiometer "POT 2," has a 1 inactive turn in each end and is approximately linear. Thus, to adjust the current limit, turn POT 2 CCW to zero then turn it CW to the appropriate setting.

Use the following table for approximated current settings:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

If the peak current reference does not reach the set peak current limit, the time for the peak current will be longer than 2 seconds. The actual time is a function of the RMS. current.

Since the output current is proportional to P1-9 "CURRENT REFERENCE," the adjusted current limit can be easily observed at this pin. The maximum peak current value equals 7.5 V at this pin with respect to P1-2 "SIGNAL GROUND." The actual current can be monitored at pin P1-8 "CURRENT MONITOR" with respect to P1-2 "SIGNAL GROUND."

If the peak current reference does not reach the set peak current limit, the time for the peak current will be longer than 2 seconds. The actual time is a function of the RMS. current.

NOTE

If more peak current is needed, but continuous current needs to be limited, refer to section 2.8.6 "P1 - Signal Connector," specifically P1-10.

3.3 Torque (current) Mode

The torque (current) mode produces a torque output from the motor proportional to the COMMAND voltage input signal. The DC motor output torque is proportional to the motor current.
Torque (current) mode is especially important if the servo drive is used with a digital position controller. Under this condition, a movement of the motor shaft from the desired position causes a large correcting torque or "stiffness." Therefore this mode may produce a "run away" condition if operated without a controller.

3.3.1 Torque (current) mode setup procedure

Note
The following setup procedure should be performed with the motor unloaded (the load is uncoupled from the motor shaft)

1. Set the DIP switch to following setting:

SW-1	SW-2	SW-3	SW-4
OFF	OFF	ON	OFF

2. Set the potentiometer to the following settings:

Pot 1	Pot 2	Pot 3	Pot 4
Loop Gain	Current Limit	Command Gain	Test / Offset
Fully CCW	2 Turns from Fully CCW	Fully CW	Factory Settings

3. Ensure that the ENABLE input is inactive (P1-11 connected to P1-2).
4. Connect the Motor leads to P2-1 and P2-2
5. Tachometer does not have to connected in torque (current) mode
6. Check the DC voltage output from the power source before connecting it to the drive and make sure that it is within 80 Vdc maximum ***OR*** it does not exceed the motor maximum voltage terminal.
7. Connect the DC power to the drive (P2).
8. Check the unit wiring per Figure (4), "Wiring and Connection Diagram"
9. Ensure that the COMMAND input voltage signal is ZERO.
10. Apply power to the drive.
11. Verify that the LED is GREEN.
12. ENABLE the drive. *The motor may rotate at this point. Be prepared to disable the controller or remove the DC power if excessive motion occurs.* If the motor rotates, adjust POT 4 until the motor stops rotating.
13. Command a small torque (current) through the COMMAND input voltage signal.
14. The motor should rotate in a smooth manner. If the motor rotates in the opposite direction of that desired for a given COMMAND input polarity, check the polarity connection on the motor leads or the polarity connection to the COMMAND input.

15. Adjust POT 2, “CURRENT LIMIT,” to the motor maximum continuous current rating or to the desired maximum torque for the application. Use the following potentiometer approximation settings:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

NOTE

If more peak current is needed, but continuous current needs to be limited, refer to section 2.8.6 “P1 - Signal Connector,” specifically P1-10.

16. It is recommended to set POT 3 fully CW in this mode.

3.4 Velocity (tachometer) Mode

The addition of a DC tachometer to the motor shaft produces a voltage proportional to speed. With this addition, the tachometer output voltage replaces the motor terminal voltage as the controlled variable. Since this voltage is proportional to the motor speed, the operating mode is velocity mode.

3.4.1 Velocity (tachometer) mode setup procedure

NOTE

The following setup procedure should be performed with the motor unloaded (the load is uncoupled from the motor shaft)

1. Set the DIP switch to following settings:

SW-1	SW-2	SW-3	SW-4
OFF	OFF	OFF	OFF

2. Set the potentiometer to the following settings:

Pot 1	Pot 2	Pot 3	Pot 4
Loop Gain	Current Limit	Command Gain	Test / Offset
Fully CCW	2 Turns from Fully CCW	Fully CCW	Factory Settings

3. Ensure the ENABLE input is inactive (P1-11 connected to P1-2).
4. Connect the Motor leads to P2-1 and P2-2.
5. Connect the Tachometer leads to P1-6 and P1-7.
6. Check the DC voltage output from the power source before connecting it to the drive and make sure that it is within 80 Vdc maximum ***OR*** it does not exceed the motor maximum voltage terminal.
7. Connect the DC power to the drive (P2).
8. Check the unit wiring per Figure (4), “Wiring and Connection Diagram.”
9. Ensure that the COMMAND input voltage signal is ZERO.
10. Apply power to the drive.
11. Verify that the LED is GREEN.
12. ENABLE the drive. *The motor may rotate at this point. Be prepared to disable the controller or remove the DC power if excessive motion occurs.* If the motor rotates, adjust POT 4 until the motor stops rotating.
13. Command a small velocity command through the COMMAND input voltage signal.
14. The motor should rotate in a smooth manner. If the motor runs away or rotates in the opposite direction of that desired for a given COMMAND input polarity, check the polarity connection on the motor leads and the polarity for the tachometer or the polarity connection to the COMMAND input.
15. Adjust POT 2, the CURRENT LIMIT, to the motor maximum continuous current rating or to the desired maximum torque for the application. Use the following potentiometer approximation settings:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

NOTE

If more peak current is needed, but continuous current needs to be limited, refer to section 2.8.6 "P1 - Signal Connector," specifically P1-10.

16. While the motor is stationary (not rotating, by commanding zero volts through the COMMAND input, P1-4 and P1-5), begin turning POT 1 CW until the motor begins to oscillate. Once the motor begins to oscillate, turn the POT 1 until the motor stops oscillating.
17. Adjust POT 3, the COMMAND GAIN, to the desired scaling of the command input voltage. If the maximum input COMMAND voltage is 10 V and the drive/motor is maximum speed is 1000 rpm, then for 1 volt COMMAND input the drive should command 100 rpm. If the drive is not commanding 100 rpm per 1 volt applied through the COMMAND input voltage then you may adjust POT 4 until you reach 100 rpm per 1 volt applied. The commanded motor speed can be measured either by using a hand held tach or by measuring the motor tachometer voltage by placing a voltmeter across the tachometer leads (P1-6 and P1-7). So if the tachometer voltage gradient is 14 V/kRPM then you should measure 1.4 Volts if you are running at 100 RPM.

3.5 Voltage Mode

In the voltage mode, the COMMAND input signal commands a proportional motor voltage regardless of power supply voltage variations. This mode is recommended for velocity control when velocity feedback (tachometer) is unavailable.

3.5.1 Voltage mode setup procedure

NOTE

The following setup procedure should be performed with the motor unloaded (the load is uncoupled from the motor shaft)

1. Set the DIP switch to following settings:

SW-1	SW-2	SW-3	SW-4
ON	OFF	OFF	OFF

2. Set the potentiometer to the following settings:

Pot 1	Pot 2	Pot 3	Pot 4
Loop Gain	Current Limit	Command Gain	Test / Offset
Fully CCW	2 Turns from Fully CCW	Fully CCW	Factory Settings

3. Ensure that the ENABLE input is inactive (P1-11 connected to P1-2).
4. Connect the Motor leads to P2-1 and P2-2.
5. Tachometer leads do not have to be connected.
6. Check the DC voltage output from the power source before connecting it to the drive and make sure that it is within 80 Vdc maximum ***OR*** it does not exceed the motor maximum voltage at terminals.
7. Connect the DC power to the drive (P2).
8. Check the unit wiring per Figure (4), "Wiring and Connection Diagram."
9. Ensure that the COMMAND input voltage signal is ZERO.
10. Apply power to the drive.
11. Verify that the LED is GREEN.
12. ENABLE the drive. *The motor may rotate at this point. Be prepared to disable the controller or remove the DC power if excessive motion occurs.* If the motor rotates, adjust POT 4 until the motor stops rotating.
13. Command a small velocity command through the COMMAND input voltage signal.
14. The motor should rotate in a smooth manner. If the motor rotates in the opposite direction of that desired for a given COMMAND input polarity, check the polarity connection on the motor leads or the polarity connection to the COMMAND input.
15. Adjust POT 2, the CURRENT LIMIT, to the motor maximum continuous current rating or to the desired maximum torque for the application. Use the following potentiometer approximation settings:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

NOTE

If more peak current is needed, but continuous current needs to be limited, refer to section 2.8.6 "P1 - Signal Connector," specifically P1-10.

16. While the motor is stationary (not rotating, by commanding zero volts through the COMMAND input, P1-4 and P1-5), begin turning POT 1 CW until the motor begins to oscillate. Once the motor begins to oscillate turn the POT 1 CCW or until the motor stops oscillating.
17. Adjust POT 3, the COMMAND GAIN, to the desired scaling of the command input voltage. If the maximum input COMMAND voltage is 10 V and the drive/motor is maximum speed is 1000 rpm, then for 1 volt COMMAND input the drive should command 100 rpm. If the drive is not commanding 100 rpm per 1 volt applied through the COMMAND input voltage then you may adjust POT 4 until you reach 100 rpm per 1 volt applied. The commanded motor speed can be measured either by using a hand held tach or by measuring the motor. Placing a voltmeter across the motor leads (P2-1 and P2-2). So if the motor Ke (voltage constant) is 11 V/kRPM then you should measure 1.1 Volts if you running at 100 RPM.

3.6 IR Compensation Mode

If in voltage mode there is a load torque variation, the motor current will vary, as torque is proportional to motor current. Since the motor windings have resistance, the actual motor voltage is reduced by the product of motor current and resistance. Thus, motor speed, which is proportional to motor voltage (terminal voltage - IR drop), varies with the load torque.

In order to compensate for the internal motor voltage drop, a voltage proportional to motor current can be added to the command voltage. The amount of compensation is adjusted by an internal resistor. Be very careful when adjusting the IR compensation level.

If the feedback voltage is high enough to cause a rise in motor voltage with increased current, instability will occur. Such results are due to the fact that the increased voltage increases motor voltage.

If great a great deal of motor torque change is anticipated, it may be wise to consider the addition of a tachometer to the motor.

3.6.1 IR Compensation mode setup procedure

<u>NOTE</u>

The following setup procedure should be performed with the motor unloaded (the load is uncoupled from the motor shaft)

1. Set the DIP switch to following settings:

SW-1	SW-2	SW-3	SW-4
ON	OFF	OFF	OFF

2. Set the potentiometer to the following settings:

Pot 1	Pot 2	Pot 3	Pot 4
Loop Gain	Current Limit	Command Gain	Test / Offset
Fully CCW	2 Turns from Fully CCW	Fully CCW	Factory Settings

3. Ensure that the ENABLE input is inactive (P1-11 connected to P1-2).
4. Connect the Motor leads to P2-1 and P2-2
5. Tachometer leads do not have to be connected
6. Check the DC voltage output from the power source before connecting it to the drive and make sure that it is within 80 Vdc maximum ***<u>OR</u>*** it does not exceed the motor maximum voltage terminal.
7. Connect the DC power to the drive (P2).
8. Check the unit wiring per Figure (4), “Wiring and Connection Diagram.”
9. Ensure that the COMMAND input voltage signal is ZERO.
10. Apply power to the drive.
11. Verify that the LED is GREEN.

12. ENABLE the drive. *The motor may rotate at this point. Be prepared to disable the controller or remove the DC power if excessive motion occurs.* If the motor rotates slowly "drifts," adjust POT 4 until the motor stops rotating.
13. Command a small velocity command through the COMMAND input voltage signal (command low motor speed 20-200 RPM).
14. The motor should rotate in a smooth manner. If the motor rotates in the opposite direction of that desired for a given COMMAND input polarity, check the polarity connection on the motor leads or the polarity connection to the COMMAND input.
15. Adjust POT 2, the "CURRENT LIMIT," to the motor maximum continuous current rating or to the desired maximum torque for the application. Use the following potentiometer approximation settings:

Number of turns from CCW	DMC 6D		DMC 12D	
	I_{cont}	I_{peak}	I_{cont}	I_{peak}
5	± 2	± 4	± 4.2	± 8.3
10	± 4	± 8	± 8.3	± 16.6
15	± 6	± 12	± 12.5	± 25

NOTE

If more peak current is needed, but continuous current needs to be limited, refer to section 2.8.6 "P1 - Signal Connector," specifically P1-10.

16. While the motor is stationary (not rotating, by commanding zero volts through the COMMAND input, P1-4 and P1-5), begin turning POT 1 CW until the motor begins to oscillate. Once the motor begins to oscillate turn the POT 1 CCW or until the motor stops oscillating.
17. Adjust POT 3, the "COMMAND GAIN," to the desired scaling of the command input voltage. If the maximum input COMMAND voltage is 10 V and the drive/motor is maximum speed is 1000 rpm, then for 1 volt COMMAND input the drive should command 100 rpm. If the drive is not commanding 100 rpm per 1 volt applied through the COMMAND input voltage then you may adjust POT 4 until you reach 100 rpm per 1 volt applied. The commanded motor speed can be measured either by using a hand held tach or by measuring the motor by placing a voltmeter across the motor leads (P2-1 and P2-2). So if the motor Ke (voltage constant) is 11 V/kRPM then you should measure 1.1 Volts if you running at 100 RPM.
18. Adjusting the IR feedback (R8), begin with a very high (or open) IR feedback resistor (R8) with unloaded motor shaft.
19. Command a small velocity command through the COMMAND input voltage signal (command low motor speed 20-200 RPM).
20. Without the IR feedback, the motor shaft can be stalled easily. Decreasing the IR feedback resistor (R8) will make the motor shaft more difficult to stop. Too much IR feedback (too low resistor value) will cause motor run away when torque is applied to motor shaft.

4.0 Maintenance and Troubleshooting

- Normally the only maintenance required is to remove the dust and dirt from the drive, use low pressure air less than 15 psi.

- Drive status is indicated by the single LED located above the P2 connector.
- The Drive faults are indicated by the red LED.
- Faults are also indicated by the FAULT output on P1-14 output. The output will be high if the drive detects any fault.
- There are no field serviceable components in the drive.
- It is recommended that in the event of a drive failure, the entire drive be replaced and the defective drive returned to the factory for repair.
- Verify that the drive is defective before replacing or returning for repair.

The following table is a troubleshooting guide to diagnose and correct most problems. Follow the steps in section 4.1 to determine the functionality of the drive. If you are unable to achieve satisfactory operation contact our local MCG distributor.

IMPORTANT NOTE

If you suspect that the servo drive has been damaged, ***DO NOT*** *simply replace it with another servo drive and apply power. Recheck your power supply, motor and connections and verify that they meet all requirements. Improper power supply design is the most common cause for damaged drives.*

Problem or Symptom	Possible Cause	Action / Solution
LED not lit	NO DC power	• Verify that DC power is applied to drive (20 - 80 V) • Check for open circuit breakers
	Blown Fuses	• Check fuses • Check for short circuits
Green LED, but no motor response	Wiring	• Open motor connections • COMMAND not reaching P1-4, P1-5 • COMMAND is ZERO (or shorted) • + Inhibit or -Inhibit is active (P1-13 or P1-12 connected to signal GND P1-2)
	Electrical	• CURRENT LIMIT pot is turned fully CCW • P1-10 is shorted to GND • Under voltage, verify power supply is within minimum condition.
	Mechanical	• Seized load • Excessive frictional load • Verify that motor shaft turns freely with no power
Motor causes erratic operation	Loop Gain Pot set too high	• If the drive is in velocity mode, turn LOOP GAIN pot CCW until oscillations stops. • Controller gains are too high
	Noise	• Improper grounding, check the

		drive/system grounding (drive signal ground is not connected to source signal ground) • Noisy command signal • Excessive tachometer noise • Noisy INHIBIT inputs
	Mechanical	• Mechanical backlash, select a larger reduction ratio so the reflected inertia is equal to motor inertia. • Slippage.
	Electrical	• Excessive voltage spikes on the DC power input
	Feedback	• User supplied position and/or velocity loop is improperly compensated
System run away	Wiring	• If in velocity mode setting, check the polarity and wiring connection for both the motor leads and the tachometer • If in torque (current) mode, check that POT 1, "LOOP GAIN," is set fully CCW.
	Feedback	• User supplied position or velocity loop has failed • Check the polarity and wiring.
RED LED is lit	Drive disabled	• Check connection on P1-11, Enable the drive by opening the connection on P1-11
	Over temperature	• Excessive ambient temperature • Heatsink temperature above 65 degrees C • Restriction of cooling air due to insufficient spacing around the drive. • Add a fan or improve air circulation • Drive is being operated above its continuous power rating. • Change your motion profile.
	Output short circuit	• Check each motor lead for shorts with respect to motor housing and power ground. • Measure motor armature resistance between motor leads with the drive disconnected for shorts. • Insufficient motor inductance.
	Over voltage	• Check that the maximum input voltage is 80 Vdc. Check the AC line connected to the power supply for proper input value. • Check the regenerative energy absorbed during deceleration. This is performed with a voltmeter or scope and monitoring the power supply voltage. If the supply voltage increases above 86

		volts, additional power supply capacitance is necessary. Electrolytic type capacitors only should be used and located within 12 inches distance from the drive.
	Over Current	• Insufficient motor inductance • Seized load • Excessive frictional load. Verify that motor shaft turns freely with no power • Change motion profile • The system gains are too high

4.1 Testing the servo drive

The DMC 6D and DMC 12D are designed to operate in a self-test mode using POT 4, the "TEST / OFFSET" potentiometer, to control an onboard signal source. This test can be used to confirm that the servo drive is functional and operational and requires a DC power supply (not more than 80 Vdc), a DC voltmeter, and a DC brush motor.

1. Take note of the DIP switch setting before you begin the following test.
2. Always be prepared to turn the DC power voltage OFF.
3. Refer to Figure (2), "Wiring and Connection Diagram" on page XXX
4. Use sufficient capacitance with the power supply
5. Set the DIP switch on the servo drive to the following settings "positions":

SW-1	SW-2	SW-3	SW-4
ON	OFF	OFF	OFF

6. Connect the DC bus voltage to P2-5 "+" and P2-4 "-."Do not reverse the power supply leads, severe damage will result if you do.
7. Connect your DC voltmeter to P2-1 "MOTOR +" and P2-2 "MOTOR -."
8. Set your DC voltmeter to measure DC voltage.
9. Apply power by turning the DC power supply ON.
10. Check the LED is GREEN (normal operation).
11. Turn POT 4, "TEST / OFFSET," At this moment the DC voltmeter should read some voltage varying between ± bus voltage.
12. Set POT 4 "TEST / OFFSET" to output low DC voltage.
13. Turn the DC power supply OFF
14. Wait about 10 seconds
15. Remove the DC voltmeter connections.
16. Verify that the motor inductance meets the drive requirement (200 μH minimum)
17. Connect the motor leads to P2-1 "MOTOR +" and P2-2 "MOTOR -"
18. Set the "CURRENT LIMIT," POT 2 to the motor current specifications
19. Turn the DC power voltage ON
20. Turn POT 4 "TEST / OFFSET" in both directions, the motor should vary speed in both directions

21. Using POT 4, adjust motor speed to 0 RPM (the motor should stop rotating)
22. Turn the DC power voltage OFF
23. Wait 10 seconds then remove all connections to the servo drive
24. Set the DIP switch to the original drive settings

If the drive failed the above test, proceed to the next section. And if it passed the above test begin checking your system and wiring by the isolation method.

4.2 Defective Equipment

If you are unable to correct the problem and the drive is defective, you may return the drive to your local MCG distributor for repair or replacement. There are no field serviceable parts in the drive.

NOTE
To save unnecessary work and repair charges please write a note and attach to the defective drive explaining the problem.

4.3 Return Procedure

To ensure accurate processing and prompt return of any MCG products, the following procedure must be followed:

1. Call your local MCG distributor to obtain an RMA number.
2. Do not return any goods without an RMA number.
3. Goods received without any RMA number will ***NOT*** be accepted and will be returned to sender.
4. Pack the returned goods in the original shipping carton.
5. MCG is ***NOT*** responsible or liable for damage resulting from improper packaging or shipment.
6. Repaired units are shipped via UPS ground delivery. If another shipping method is desired, please indicate so on when requesting an RMA number and also indicate this information along with the return goods.

NOTE
Do not attempt to return the DMC 6D or DMC 12D 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.

14700 Martin Drive
Eden Prairie MN 55344
Attn.: Repair Department RMA# __________

Appendix A Power Supply, Motor and Drive Selections

Determine voltage and current requirements for the motor, based upon maximum velocity and torque.

Generally motor voltage is proportional to the motor speed and motor current is proportional to motor shaft torque. This relationship is described by the following equations:

$V_b = Ke * \omega_m$
$V_t = (I_m * R_m) + V_b$
$T = Kt * I_m$

Where:

V_b = Back EMF voltage	(volts)
Ke = Motor Voltage Constant	(V/KRPM)
ω_m = Motor Speed	(RPM)
Vt = Terminal voltage (DC power voltage)	(volts)
I_m = Motor current	(amps)
R_m = Motor terminal resistance (winding)	(ohms)
T = Motor load torque	(lb-in or Nm)
Kt = Motor Torque Constant	(lb-in/Amp or Nm/Amp)

Note: Usually the motor manufacture data sheet will contain the Kt and Ke values.

Determining the motor maximum speed and torque will determine maximum voltage and current.

$Vmax = (Ke * \omega_{max}) * 1.10$

For example, a motor with a Ke of 10 V/kRPM and required speed of 3000 RPM would require 33 Vdc minimum to operate successfully (the IR term was neglected in this calculation).

It is recommended to select a power supply voltage with a 10 % higher than the maximum required for the motor used in the application. This is a safety factor to account for the variances in the motor Ke, Kt and losses in the system external to the drive.

Maximum current required for your application and from your system (drive/motor) can be calculated as follow:

$I_{max} = T_{max} / (Kt * .95)$

For example, a motor with Kt = 1 lb-in/Amp and the maximum torque required is 4 lb-in would require minimum of 4.2 Amps. The term (Kt * .95) is called the effective Kt (effective torque constant) of the motor which assumes a hot value for the application. The average DC power supply current is not the same as the motor current, see the following figure.

Figure (A-1) Voltages and Currents relationships.

The power supply current is a pulsed DC current, when the MOSFET switch is ON, it equals the motor current and when it is OFF it is ZERO. Therefore, the power supply current is a function of the PWM duty cycle and the motor current.

For example, a 30 % duty cycle and 12 Amps motor current will result in approximately 4 Amps power supply current (the power supply may be a little over 4 Amps so it can drive the internal (logic) circuit inside the drive). A 30 % duty cycle also means the average motor voltage is 30 % of the DC bus voltage. Power supply power is approximately equals to the drive output power plus 3-5 %.

The drive voltage and current ratings are determined by the power supply voltage and the maximum motor current. It is recommended to select a servo drive with a voltage rating of at least 20 % higher than the maximum power supply voltage to allow for regenerative operations and power supply variations due to the AC input variation and transformer load regulations. The drive current rating should exceed the maximum motor current requirements, the reason behind that is to compensate for the hot values of the motor parameters (such as Kt, the Kt value decreases with temperature, so to maintain the same torque more current is needed).

Use sufficient capacitance for the power supply. Pulse width modulation (PWM) drives require a capacitance on the high voltage supply to store energy during PWM switching process. Therefore, a 1000 μF (minimum value) capacitor is needed within one foot of wire length to parallel the high voltage supply of the drive. This is not necessary when the DC bus power supply filter capacitor is within one foot of wire length from the drive.

Insufficient power supply capacitance problems occur particularly with high inductance motors. During motor braking, much of the stored kinetic energy is fed back into the power supply and charges its output capacitor to a higher voltage. If the charge reaches the drive over voltage shut down point, output current and braking will cease. At this time energy stored in motor inductance continuous to flow through the diodes in the drive to further charge the power supply capacitor. The value rise depends upon the power supply capacitance, motor speed, and inductance. A 2 mH motor at 20 Amps can charge 2000 μF up to 30 V. An appropriate capacitance is typically 2000 μF/Amp, maximum output current for a 50 V supply. Refer to appendix C “”Regenerative Operation and Consideration.”

Appendix B General Wiring Tips

Noise and System Grounding Considerations

Noise - in the form of interfacing signals can be coupled:

- Capacitively (electrostatic coupling) onto the signal wires in the circuit (the effect is more serious for high impedance points).
- Magnetically to closed loops in the signal circuit (independent of impedance levels).
- Electromagnetically to signal wires acting as small antennas for electromagnetic radiation.
- From one part of the circuit to other parts through voltage drops on ground lines.

Figure (B-1) Typical wiring diagram for noise consideration and system grounding.

Experience shows that the main source of noise is the high DV/DT (typically 1V/nanosecond) of drive's output power MOSFETs. The PWM output can be coupled back to the signal lines through straight capacitance "C1" between output and input wires. The best methods are to reduce capacitance between the offending points (move signal and motor leads apart), add shielding and use differential inputs at the drive.

Unfortunately, low frequency magnetic fields are not significantly reduced by metal enclosures. Typical sources are 50 or 60 Hz power transformers and low frequency current changes in the motor leads. The best solution in this case is to avoid large loop areas in signal, power supply and motor wires. Twisted pair wires are quite effective in reducing magnetic pick up because the enclosed area is small, and the signals induced in successive twist cancel.

Aside from overall shielding the best way to reduce radio frequency coupling is to keep leads short.

The voltage source between the drive and the controller grounds typically consists of some 60 Hz voltage, harmonics of the line frequency, some radio frequency signals, IR drops and other "ground noise." The differential COMMAND inputs of the drive will ignore the small amount of "ground signal."

Long signal wires (10 - 15 ft and up) can also be source of noise when driven from a typical OP-AMP output. Due to the inductance and capacitance of the wire, the OP-AMP output can oscillate. It is always recommended to set a fixed voltage at the controller and then check the signal at the drive with an oscilloscope to make sure that the signal is "clean."

Servo system wiring typically involves wiring the controller (digital or analog), servo drive, power supply and motor. Wiring these servo system components is fairly easy when the following few rules are observed.

1. Use shielded twisted pair wire for the COMMAND input signal and tie the shield at the controller end.
2. It is recommended that the signal, motor, tach, and power wire be routed in a separate cable harness.
3. All grounds are connected to a single chassis ground, normally the same as earth ground.
4. The grounding design is ultimately the responsibility of the system designer.

DC Power Supply Wiring

The PWM current spikes generated by the power output are supplied by the internal power supply capacitors. In order to keep the ripple current on these capacitors to an acceptable level it is necessary to use heavy power supply leads and keep them short (less than 2 feet). If the power supply leads exceed 2 feet then the amplifier must be by passed by a ceramic capacitor of 0.47 µF and an electrolytic capacitor of 3300 µF minimum within 3 feet of the servo drive (the closer the capacitor to the servo drive the better). Reduce the inductance of the of the power leads by twisting them.

Figure (B-2) Bypassing capacitors

Appendix C Regenerative Operation and 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 kinetic energy stored in the spinning motor and load inertias into electrical energy. If this kinetic energy is less than the losses in the drive and motor, the supply voltage does not increase. If the kinetic energy is greater than the losses, the supply voltage will increase.

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

The kinetic energy of a spinning inertia can be calculated as follow:

$E = 3.87 * 10 * J * \omega$

Where:

E = Kinetic energy	(joules)
J = Inertia	(oz-in-sec)
ω = 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 =

Where:

V = Final voltage	(volts)
V= 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 considering a shunt regulator circuit. ***Be sure to add the effect of high line voltage when evaluating this test.***

The DMC 6D and DMC 12D are 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 DMC 6D or DMC 12D over voltage shut down point, output current and braking will cease. 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 85 Vdc.

Appendix D: Recommended MCG Brush DC Servo Motors

The DMC 6D and DMC 12D can be used in conjunction with the following MCG brush DC servo motors.

Appendix E Recommended Power Supplies

The PL and PB series are unregulated DC power supplies offered by MCG to complement its brush DC servo drives and to provide a complete solution for single and multi-axis applications.

The PB series is a base plate mounting power supply, and the PL series is an L shape power supply.

PLXXXX

- Provides 2 second peak currents at 2 times nominal ratings with 20% duty cycles.
- L shape bracket mount, open chassis.

Model	Input AC Voltage	DC Output Voltage	DC Output Current	Weight (lb.)	Dimensions (inches)
PLL40B	120	40	40	21	5.7 x 10 x 4.94
PLL27C	120	60	27	21	5.7 x 10 x 4.94
PLL20D	120	80	20	21	5.7 x 10 x 4.94
PLH40C	240	40	40	21	5.7 x 10 x 4.94
PLH27C	240	60	27	21	5.7 x 10 x 4.94
PLH20D	240	80	20	21	5.7 x 10 x 4.94

PBXXXX

- Provides 2 second peak currents at 2 times nominal ratings with 20% duty cycles
- Base plate mount, open chassis.

Model	Input AC	DC Output	DC Output	Weight (lb.)	Dimensions

	Voltage	Voltage	Current		(inches)
PBL40B	120	40	40	21	13 x 10.5 x 6
PBL27C	120	60	27	21	13 x 10.5 x 6
PBL20D	120	80	20	21	13 x 10.5 x 6
PBH40B	240	40	40	21	13 x 10.5 x 6
PBH27C	240	60	27	21	13 x 10.5 x 6
PBH20D	240	80	20	21	13 x 10.5 x 6

Recommended MCG Brush DC Power Supply System Selections

Mechanical Mounting Dimensions

PLXXXX

PBXXXX

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