

# MD-90 Motor Driver

## DUAL LINEAR AMPLIFIER FOR PIEZOELECTRIC MOTORS



## USER MANUAL

DYNAMIC STRUCTURES AND MATERIALS, LLC  
REV. 120427

## MD-90 PIEZOELECTRIC MOTOR DRIVER

*This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.*

Please review the following points for both personal and equipment safety while operating the linear piezoelectric amplifier.

### **HIGH ENERGY/VOLTAGE WARNINGS**

Exercise caution when using amplifiers. High energy level can be stored at the output voltage terminals on all amplifiers in normal operations. In addition, potentially lethal voltages exist in the power circuit and the motor connector. Filter capacitors store potentially dangerous energy for some time after power is removed.



### **AC SOURCE GROUNDING WARNING**

Ensure that the amplifier's power supply is connected to a grounded AC outlet with the recommended AC input connector configured for the available line voltage.


### **OPERATING AND SERVICES PRECAUTIONS**

Operate the amplifier in an environment free of flammable gases or fumes. Do not use substitute parts or make any unauthorized modifications to the amplifier to ensure that its safety features are not degraded. Contact DSM for service and repair assistance.

### **SPECIFICATIONS**

- Output Voltage: 2 Channels -30/+150V
- Maximum Continuous Current: 90mA (RMS current into a capacitive load)
- Maximum Peak Current: 90mA
- Dimensions: L x W x H Approx. 6.25" x 2" x 1"
- Operating Voltage: 24VDC input @ 3A
- Amplifier bandwidth: > 5kHz (-3dB)
- Electrical Noise on Output: ~2mVrms
- Short circuit, over-current, and over-temperature protection
- Connectors: Hirose DF13 series

## WARNING!

 This device is marked with the international caution symbol. It is important to read the Recommended Operation section of this manual before using this device as it contains important information related to product safety.

### *General Precautions*

- ◆ All insulation of leads connected to output terminals should have at least a 300V rating.
- ◆ Do not use clip leads in the connections. They are very dangerous for high-voltage work.
- ◆ Do not place objects on top of or close beside the amplifier during operation. Adequate airflow around the unit is encouraged to allow heat to dissipate.

### *Acceptable Load Types*

- ◆ This motor driver is designed to drive capacitive loads only. Do not use with resistive loads. The driver will only work properly when a capacitive load is connected to the output.
- ◆ Never connect an inductive or a resistive load to the unit. This would cause a short-lived high-current pulse at the output and would damage the unit.

### *Short Circuit Damage*

- ◆ Although the MD-90 motor driver is protected against a short circuit on the output, it is recommended that a short circuit condition be avoided.
- ◆ Never connect an "earth ground" lead (e.g., an oscilloscope ground lead) to the output terminal. This causes a short-lived high-current pulse and subsequent damage to the unit.
- ◆ If the user desires to observe the output signals using a voltage meter or an oscilloscope, the user must ensure that the meter or oscilloscope has an input impedance of at least 1 M $\Omega$ . Smaller input impedances could damage the unit.

## **RECOMMENDED OPERATION**

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### ***Intended Use***

DSM's MD-90 motor driver is intended to drive piezoelectric (capacitive) motors of the following types:

1. Low voltage piezoelectric materials rated for a maximum operating range of  $-30$  to  $+150V$  (piezo devices which have two lead wires: output voltage and ground)

### ***Instructions for Use***


#### **Start-Up / Shut-Down Procedure**

DSM recommends that the unit be connected to a load (capacitive, such as a piezoelectric device of the appropriate rating) during start-up and while the unit is running; operating without a load can be damaging to the unit's circuitry.

#### **Connecting the Load to the driver's Output**

The MD-90 motor driver will have been configured at the factory for an output voltage range corresponding to the specifications of the customer's motor (one of the types discussed in the "Intended Use" section).

Attach a standard load (i.e., a piezoelectric actuator with two lead wires for signal and ground) to the MD-90 motor driver to the connector labeled "motor out". Typically, the piezoelectric material manufacturer will designate the "live" or "hot" electrode with red lead wire and/or a visible mark on the piezo material to distinguish this electrode from the ground electrode.

 **CAUTION:** When the MD-90 motor driver is powered, the "motor output" connector can have voltages up to 150V.

#### **Power**

Power for the MD-90 motor driver is provided through the connector labeled "Power In".

Connect the ends of the power in lead wires to the +24V and ground on the connector "Power In".

#### **Operation**

Prior to completing the electrical connections outlined below, ensure that the work place is free of conductive objects that could pose electrical hazards to the user should the objects make contact with the high voltage output "motor out" connector.

- Connect the load to the MD-90 motor driver "motor out" connector with the supplied 4 pin DF13 connector.
- Connect 24Vdc to the "Power In" connector with the supplied 6 pin DF13 connector.

- Plug the AC/DC transformer into line power appropriate for the transformer’s ratings (see label on transformer)

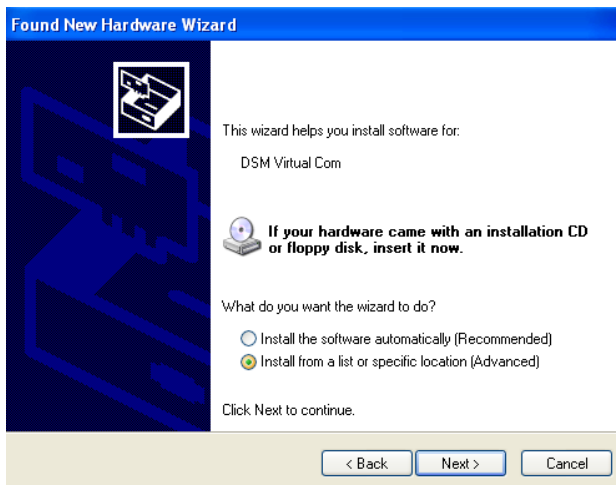
## Driver setup

### Windows XP install instructions:

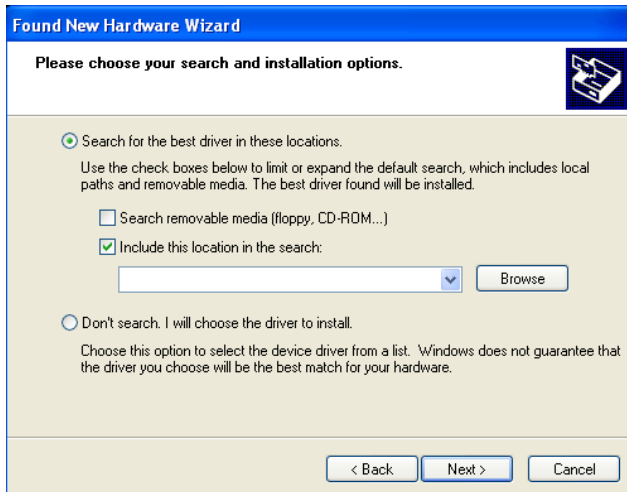
Connect the MD90 to an available USB port. The following window should appear.



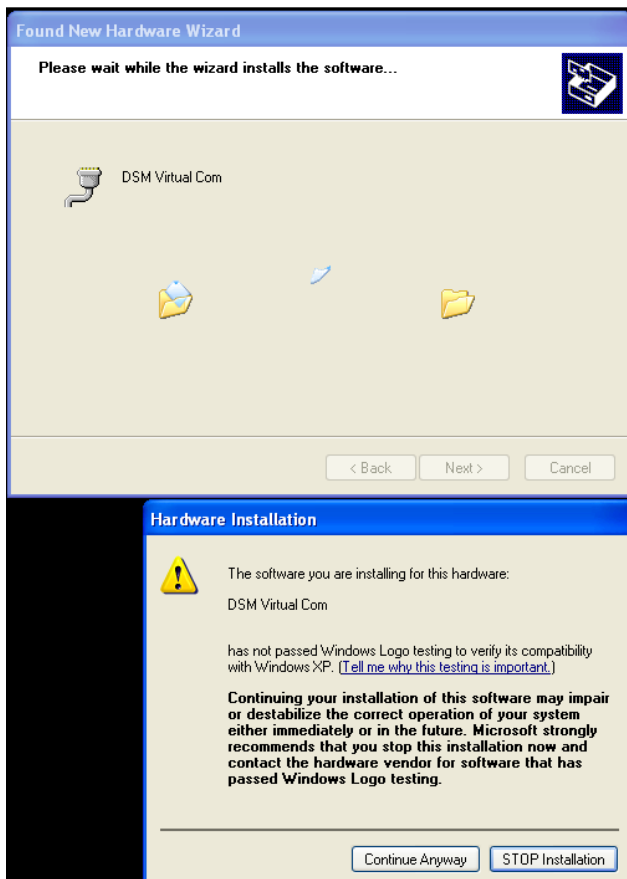
Click on “no not this time” and then click next.



Click on “Install from a list or specific location” and click next.



Browse to the location of the driver and click next. The following screen should appear.

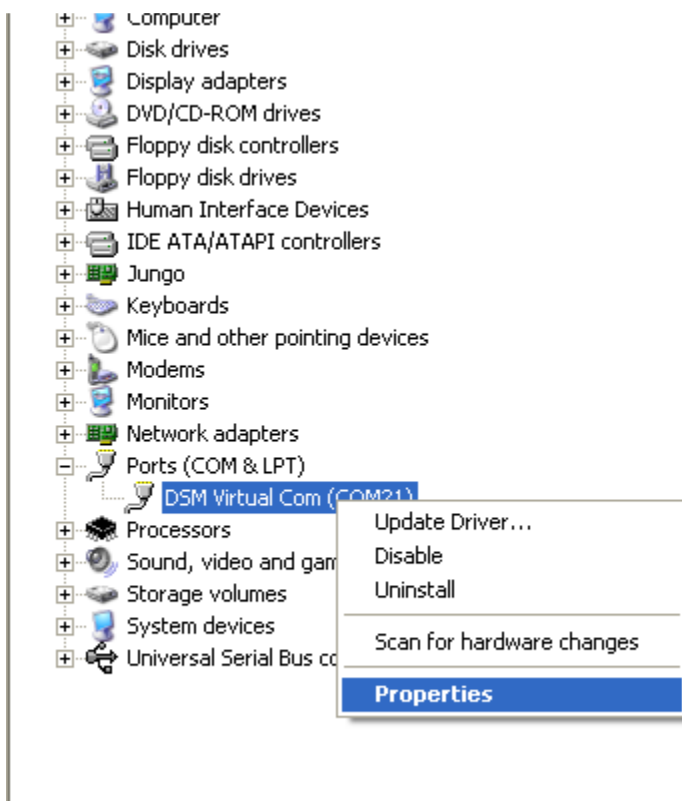


Click on “continue anyway” button.

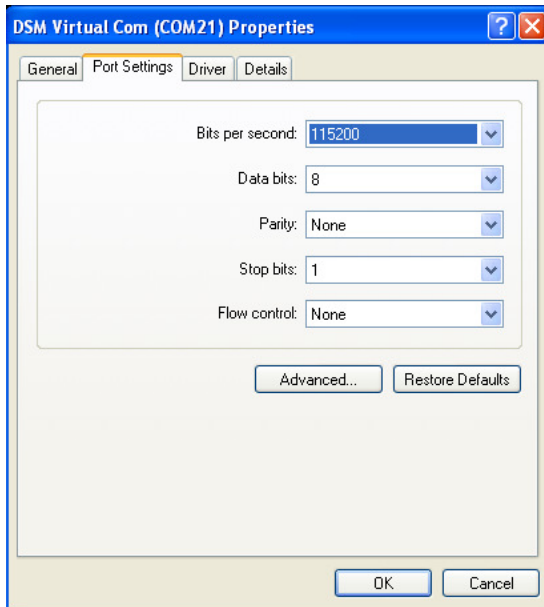
The driver will load and this screen should appear.



Click on “Finish” button to complete the installation. Open device manager and browse to Ports (COM & LPT) and right click on DSM Virtual Com and select properties.



Select settings to match the following.

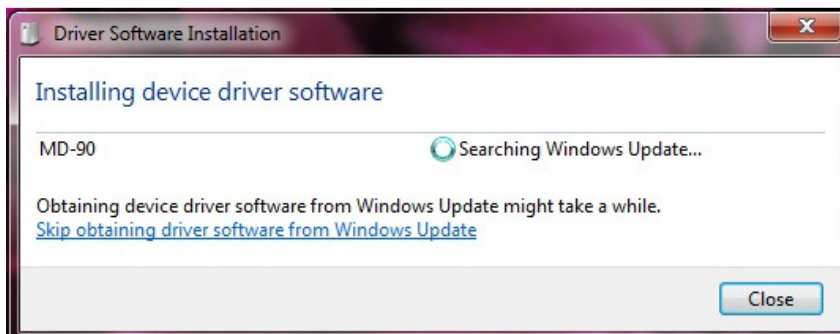


### Windows 7 install instructions:

Windows 7 does not include HyperTerminal or any type of terminal application. HyperTerminal for windows 7 can be purchased directly from Hillgrave.

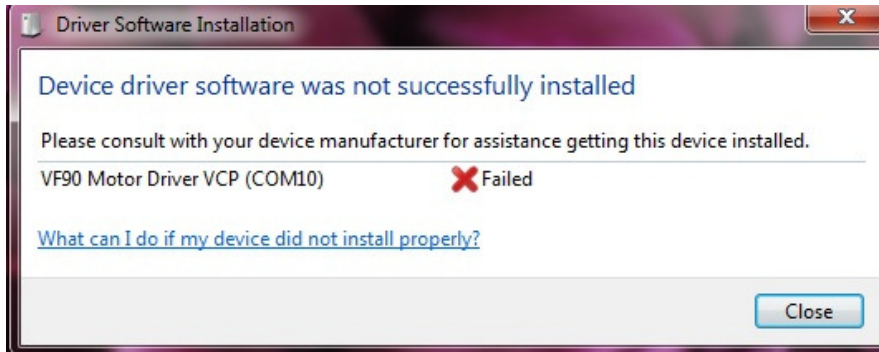
<http://www.hilgraeve.com/hyperterminal-trial/>. Also the driver for the USB to serial IC used in the MD90 does not have a digital signature for windows 7 64 bit. The user may temporarily disable digital signature enforcement from the command prompt or by hitting F8 during boot up. Disable at your own risk.

Connect the MD90 to an available USB port. The following should appear

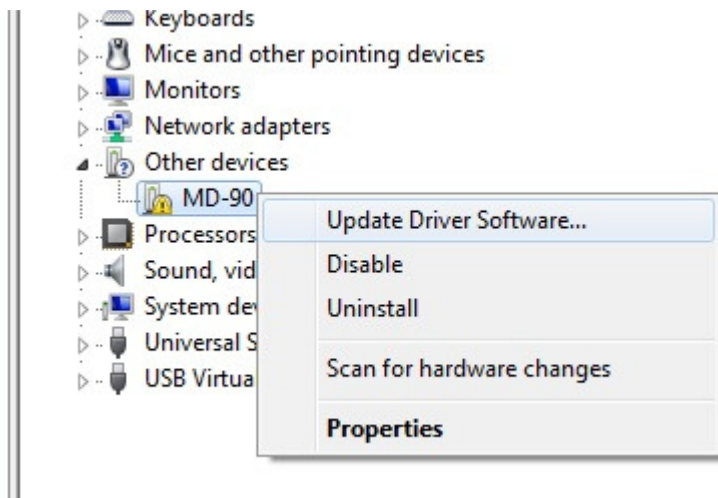


After the search completes the following will appear.

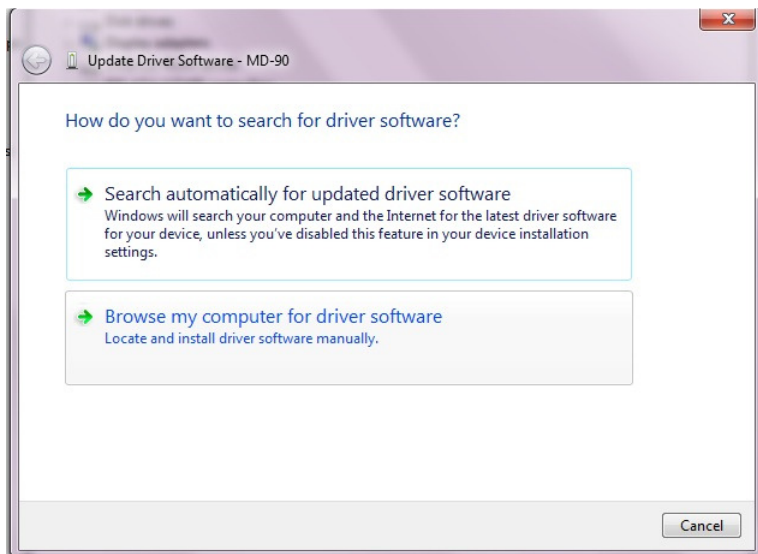




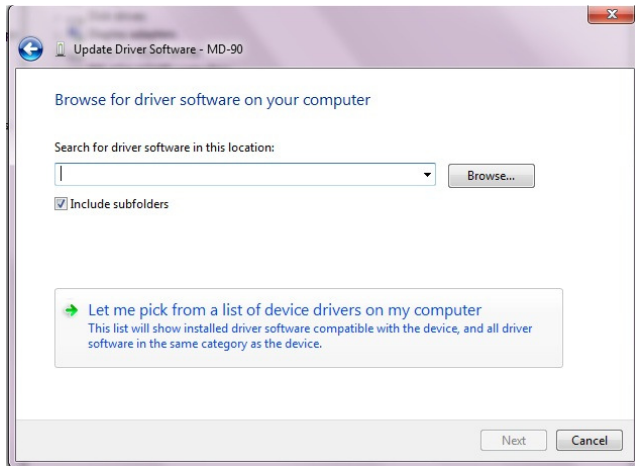
Click “Close” then open device manager and find the MD90 in “Other devices”. Right click on the device and select “Update Driver Software”



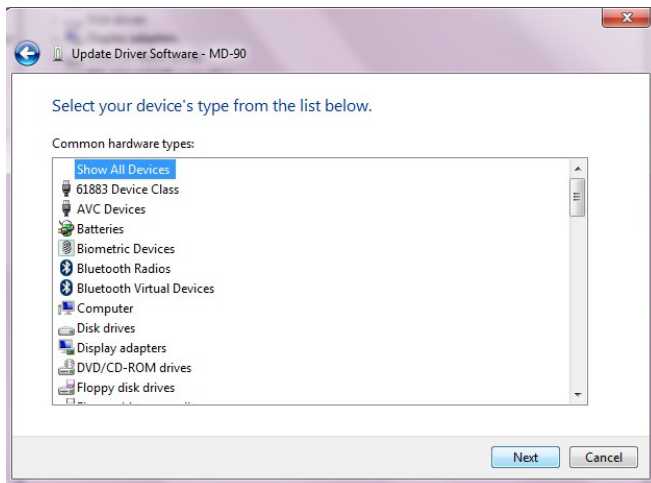
Click on “Browse my computer for driver software”



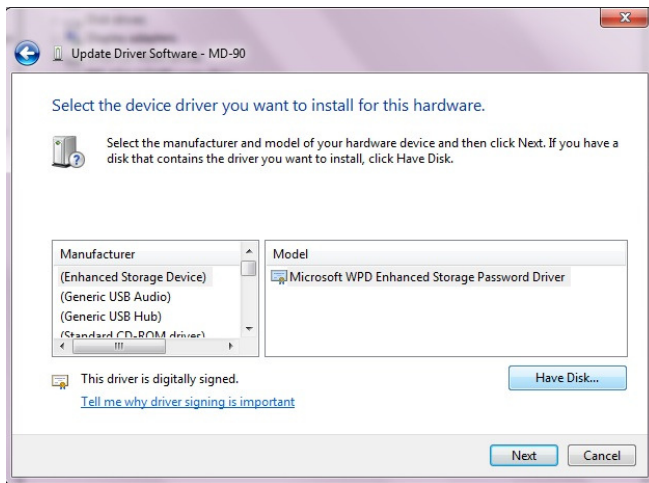
Click “Let me pick” and click next.



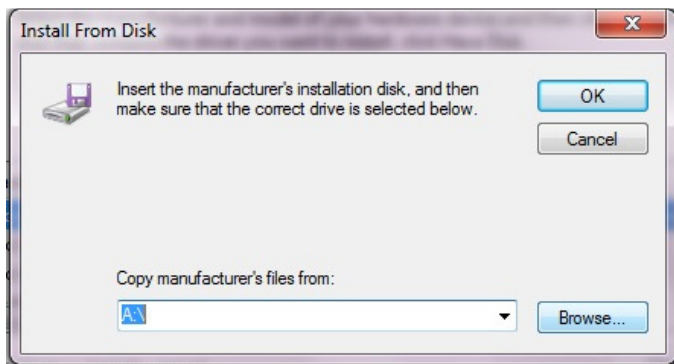
Click next to show all devices.



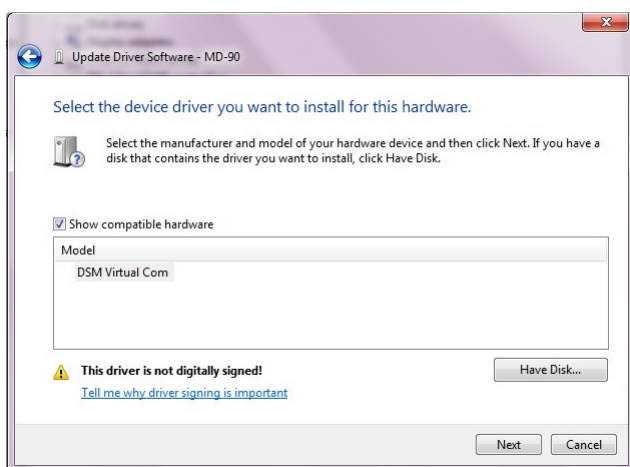
Click “Have Disk”



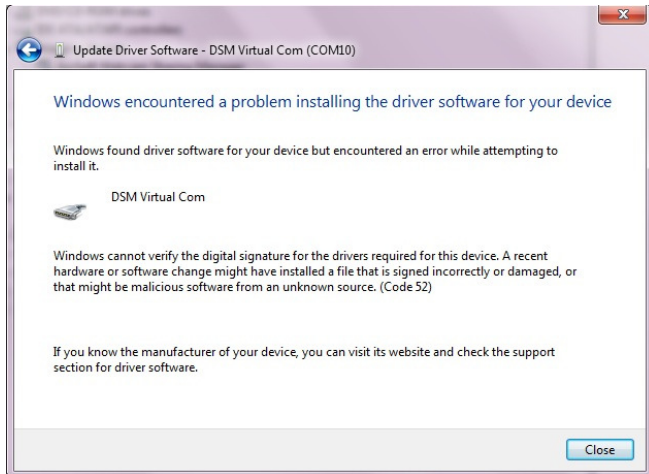
Click browse to select the location of the driver.



Click "OK". Select the driver and click "Next".



Click "Install the driver software anyway". The driver should load and the following should appear.



Click "Close". The driver should now be loaded. This example was for windows 7 64 bit. The digital signature will prevent the MD90 from operating unless the user temporarily disables digital signature enforcement.



**USB Serial commands:**

**Command structure:**

All commands should be followed by the Enter key when using HyperTerminal.

If using custom software, the command should be followed by a carriage return.

Example: enable power supply command. Both upper and lower case commands are valid.

Hex	ASCII
45 50 53 0D	EPS (Upper case)
65 70 73 0D	eps (Lower case)

Commands that include parameters such as SNS (set number of steps) should have the three letter command followed by the parameter then a carriage return.

Example:

Hex	ASCII
53 4E 53 20 31 30 30 0D	SNS 100 (Upper case)
73 6E 73 20 31 30 30 0D	sns 100 (Lower case)

The space between the command and parameter is optional.

**\*Spaces (Hex 20) are ignored by the command interpreter.\***

**Command list:**

**EOF** Echo off

This command disables the responses sent from the controller. **The response will now be a zero for valid command and a one for an invalid command.**

**Response:**

Hex	ASCII
0A 30 0D 0A	0

**Commands with a return value will return the value followed by a carriage return and line feed.**

Example (GD0) returns the following.

**Response:**

Hex	ASCII
0A 31 30 30 30 30 0D 0A	10000

**EON** Echo on (default mode)

This command enables the response from the controller. The default on power up is echo on.

**Response:**

Hex	ASCII
0A 45 63 68 6F 20 69 73 20 4F 4E 0D 0A	Echo is ON

**EPS** Enable Power Supply

This command enables the positive and negative rails. The voltages ramp in 1 second to keep peak currents low.

**Response:**

Hex ASCII  
0D 45 6E 61 62 6C 65 64 20 70 6F 77 65  
72 20 73 75 70 70 6C 79 0A 0D Enabled Power Supply

**DPS** Disable Power Supply  
This command disables the positive and negative rails.

**Response:**  
Hex ASCII  
0D 44 69 73 61 62 6C 65 64 20 70 6F 77  
65 72 20 73 75 70 70 6C 79 0A 0D Disabled power supply

**SNS** Set Number of Steps (parameter) maximum = 500  
This command sets the number of steps to take when step forward or backward is called. Setting the steps to anything greater than 500 is invalid.

**Example:** (SNS 500)  
**Response:**  
Hex ASCII  
0A 4E 75 6D 62 65 72 20 6F 66 20 73 74  
65 70 73 20 73 65 74 20 74 6F 20 35 30  
30 0D 0A Number of steps set to 500

**Example:** (SNS 800)  
**Response:** invalid command  
Hex ASCII  
0A 4E 6F 74 20 61 20 76 61 6C 69 64  
20 56 61 6C 75 65 0D 0A Not a valid Value

**SSF** Set Step Frequency (parameter) minimum 5, maximum 100. Units are Hz.  
This command sets the step frequency of the step move.

**Response:**  
Hex ASCII  
0A 53 74 65 70 20 66 72 65 71 75 65 6E  
63 79 20 28 48 7A 29 20 73 65 74 20 74  
6F 20 31 30 30 0D 0A Step frequency (Hz) set to 100

**Response:** Invalid command  
Hex ASCII  
0A 56 61 6C 75 65 20 6F 75 74 20 6F 66  
20 72 61 6E 67 65 0D 0A Value out of range

**ESF** Execute Step Forward  
This command starts the forward step sequence at the step frequency for the defined number of steps.

**Response:**  
Hex ASCII  
0A 53 74 61 72 74 65 64 20 66 6F 72 77  
61 72 64 20 6D 6F 76 65 0D 0A Started forward move

**ESB** Execute Step Backward

This command starts the backward step sequence at the step frequency for the defined number of steps.

**Response:**

Hex	ASCII
0A 53 74 61 72 74 65 64 20 62 61 63 6B	
77 61 72 64 20 6D 6F 76 65 0D 0A	Started backward move

**STP** Stops the motor

This command stops the step sequence. The motor will complete the current step then stop.

**Response:**

Hex	ASCII
0A 4D 6F 74 6F 72 20 73 74 6F 70 70 65	
64 0D 0A	Motor stopped

**STH** Stop and Hold

Unlike STP this command immediately stops the step sequence.

**Response:**

Hex	ASCII
0A 4D 6F 74 6F 72 20 73 74 6F 70 70 65	
64 20 61 6E 64 20 68 65 6C 64 0D 0A	Motor stopped and held

**SES** Set Extender Scale (parameter) minimum 1, Maximum 1000

Scales the extender channel to a portion of full scale. A value of 1000 is 100 percent and a value of 1 is 0.1 percent.

**Example:** (SES 500) sets scale to 50%.

**Response:**

Hex	ASCII
0A 52 65 73 63 61 6C 65 64 20 45 78 74	
65 6E 64 65 72 20 43 68 61 6E 6E 65 6C	
0D 0A	Rescaled Extender Channel

**Response** Invalid command

0A 53 63 61 6C 65 20 76 61 6C 75 65 20	
6F 75 74 20 6F 66 20 72 61 6E 67 65 20	
2D 20 76 61 6C 75 65 20 6E 6F 74 20 61	
63 63 65 70 74 65 64 0D 0A	Scale value out of range - value not accepted

**SD0** Set DAC 0 (parameter) minimum = 500, Maximum = 55,000

This command sends an analog voltage to amplifier 0 (the extender channel).

**SD1** Set DAC 1 (parameter) minimum = 500, Maximum = 55,000

This command sends an analog voltage to amplifier 1 (the clamper channel).

\* **The value is immediately sent to the amplifier with no ramping\***

**Response:**

Hex	ASCII
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0A 44 41 43 20 30 20 28 31 36 20 62 69  
74 29 20 73 65 74 20 74 6F 20 35 30 30  
0D 0A

**Response:** Invalid Command  
Hex

DAC 0 (16 bit) set to 500

ASCII

0A 44 41 43 20 76 61 6C 75 65 20 6F 75  
74 20 6F 66 20 72 61 6E 67 65 20 2D 20  
76 61 6C 75 65 20 6E 6F 74 20 61 63 63  
65 70 74 65 64 0D 0A

DAC value out of range - value not accepted

**RD0** Ramp DAC 0 (parameter) minimum = 500, Maximum = 55,000

This command Ramps the value of DAC 0 (the extender channel) to the selected value at a rate of 5.6kV/s.

**RD1** Ramp DAC 1 (parameter) minimum = 500, Maximum = 55,000

This command Ramps the value of DAC 1 (the clamper channel) to the selected value at a rate of 5.6kV/s.

**Response:**

Hex

ASCII

0A 44 41 43 20 30 20 28 31 36 20 62 69  
74 29 20 73 65 74 20 74 6F 20 35 30 30  
0D 0A

DAC 0 (16 bit) set to 500

**Response:** Invalid Command

Hex

ASCII

0A 44 41 43 20 76 61 6C 75 65 20 6F 75  
74 20 6F 66 20 72 61 6E 67 65 20 2D 20  
76 61 6C 75 65 20 6E 6F 74 20 61 63 63  
65 70 74 65 64 0D 0A

DAC value out of range - value not accepted

**GD0** Get DAC 0

This command gets the value of DAC 0 (the extender channel).

**GD1** Get DAC 1

This command gets the value of DAC 1 (the clamper channel).

**Response:**

Hex

ASCII

0A 44 41 43 20 30 20 28 31 36 20 62 69  
74 29 20 6C 61 73 74 20 73 65 74 20 74  
6F 20 35 30 30 0D 0A

DAC 0 (16 bit) last set to 500

**MA0** Measure Analog 0

This command gets the value of Analog input 0 in counts. The input range is +/- 10V.

**MA1** Measure Analog 1

This command gets the value of Analog 1 in counts.

**Response:**



Hex	ASCII
0A 41 44 43 30 20 76 61 6C 75 65 20 28	
63 6F 75 6E 74 73 29 20 3D 20 36 35 35	
33 35 0D 0A	ADC0 value (counts) = 65535

**CLE** Clear Errors

This command clears the counter error flag.

**Response:**

Hex	ASCII
0A 45 46 20 3D 20 30 0D 0A	EF = 0

**GIO** Get IO (parameter) 0 to 6

This command gets the status of the selected IO pin.

**SIO** Set IO (parameter) 0 to 6

This command sets the selected IO pin.

**CIO** clear IO (parameter) 0 to 6

This command clears the selected IO pin. (Setting it to 0)

Example (GIO 3)

**Response:**

Hex	ASCII
0A 49 4F 20 33 20 3D 20 31 0D 0A	IO 3 = 1

Example (SIO 3)

**Response:**

Hex	ASCII
0A 49 4F 20 33 20 3D 20 31 0D 0A	IO 3 = 1

Example (CIO 3)

**Response:**

Hex	ASCII
0A 49 4F 20 33 20 3D 20 30 0D 0A	IO 3 = 0

**\*(Note IO 4, 5, and 6 are Home, Lim+, and Lim- and cannot be set or cleared)\***

**\*(Currently all IO are set to input in hardware and software. IO 0 – 3 can be set up as output upon request.)\***

Example (CIO 5)

**Response:**

Hex	ASCII
0A 69 6E 76 61 6C 69 64 20 63 6F 6D	
6D 61 6E 64 0D 0A	invalid command



**GIN** Get all inputs

This command gets all 6 inputs

**Response:**

Hex ASCII  
0A 49 6E 3A 20 31 31 31 31 31 0D 0A In: 111111

**Unrecognized Command**

Any command that is not interpreted will result in the following response.

Echo On response

Hex ASCII  
0A 55 6E 72 65 63 6F 67 6E 69 7A 65 64  
20 43 6F 6D 6D 61 6E 64 07 0D 0A Unrecognized Command

Echo Off response

Hex ASCII  
0A 32 0D 0A 2

**Connections**

Power in:

Pins 1-3 = 24V DC (connect all leads to the power source)  
Pins 4-6 = Ground (connect all ground leads to power ground)

Motor Out:

Pin 1 = Motor 0 Positive (connect lead to the load)  
Pins 2-3 = no connection  
Pins 4 & 6 = Ground (connect both leads to load ground)  
Pin 5 = no connection  
Pins 7-8 = no connection  
Pin 9 = Motor 1 Positive (connect lead to the load)

Encoder (If using encoder option):

Pin 1 = 5V DC (from device to power encoder) Max current 500mA  
Pin 2 = A+  
Pin 3 = A-  
Pin 4 = B+  
Pin 5 = B-  
Pin 6 = I+  
Pin 7 = I-  
Pin 8 = Ground

The following Connections are reserved for future Firmware versions.

Digital IO:

Pin 1 = Limit+  
Pin 2 = Ground  
Pin 3 = Limit-  
Pin 4 = Ground  
Pin 5 = Home  
Pin 6 = Ground  
Pin 7 = IO 0  
Pin 8 = Ground  
Pin 9 = IO 1  
Pin 10 = Ground  
Pin 11 = IO 2  
Pin 12 = Ground  
Pin 13 = IO 3  
Pin 14 = Ground

Analog Input 1:

Pin 1 = Analog in 0 +  
Pin 2 = Ground  
Pin 3 = Analog in 0 –  
Pin 4 = Analog in 1 +  
Pin 5 = Ground  
Pin 6 = Analog in 1 –

Analog Input 2:

Pin 1 = Analog in 2 +  
Pin 2 = Ground  
Pin 3 = Analog in 2 –  
Pin 4 = Analog in 3 +  
Pin 5 = Ground  
Pin 6 = Analog in 3 –

Circuitry Protection

The MD-90 motor driver circuitry incorporates over-current, over-temperature, short-circuit, and over/under voltage (input power) protection.

When the protection circuitry is enabled as a result of excessive operating conditions or temperature, the amplifier will disconnect the output temporarily and will attempt to restart. During restart, the amplifier will recheck the operating conditions and will go into protection

mode again if the excessive conditions still exist. This protection thus protects both the amplifier and the load.

However, if the equipment is used in a manner not specified by DSM, the protection provided by the equipment may be impaired.


#### Recommended Environmental Conditions for Operation

The MD-90 motor driver is designed to operate in non-hazardous environments. Any deviation from the specified environment must be approved by DSM and may result in the voiding of any warranty. Any deviation not approved by DSM will be grounds for voiding of any warranty.

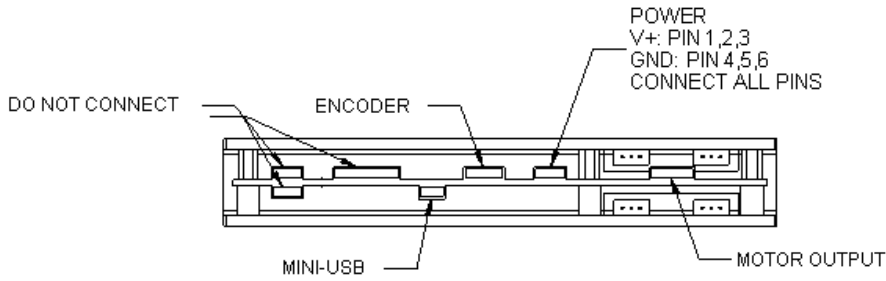
- Environmental Temperature: 0-50C
- Percent Relative Humidity: 0-80% non condensing
- Operating Supply Voltage: 24VDC input @ 3A

#### Cleaning

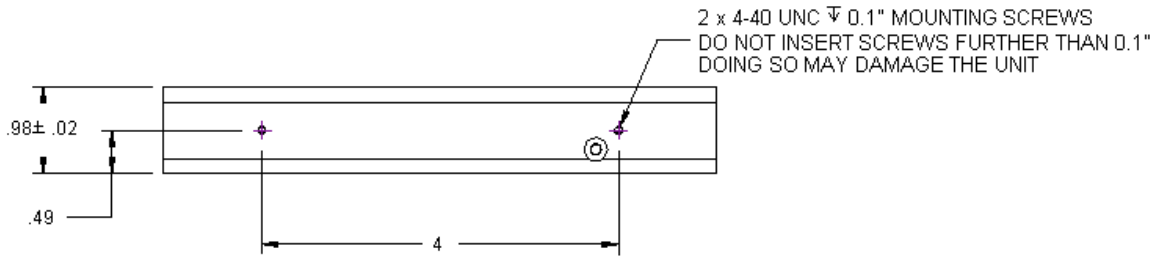
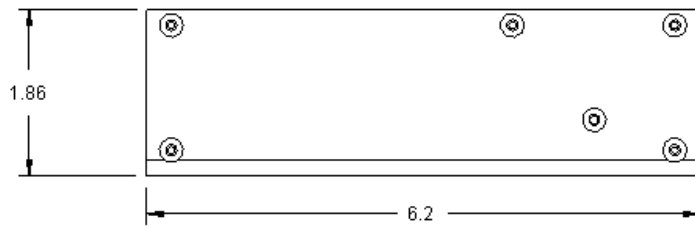
Prior to any cleaning, unplug the electrical power to the MD-90. Dust can be readily removed by wiping or by blowing with compressed dry air. Wiping the unit with a damp cloth is acceptable, but care must be taken not to leave any residual liquid at the electrical connections.

 **CAUTION:** In order to avoid electrical shock, do not spill or immerse the MD-90 motor driver in liquids.

### **MD-90 Motor Driver Mounting and Connection Diagram**



RIGHTMOST PIN IS PIN 1 ON ALL CONNECTORS



## **Warranty Information**

The DSM Warranty Period is a period of sixty (60) days beginning on the date that DSM ships the new, customer-purchased equipment or software. DSM warrants that its new equipment will be free from defects in materials and workmanship during the DSM Warranty Period.

DSM warrants that its software shall be fit for the particular uses described in DSM product literature and user's manuals available at the time of initial equipment shipment, and shall operate properly during the DSM Warranty Period.

In the event that DSM receives written notice of a claim under this Warranty within the DSM Warranty Period, DSM will repair or replace equipment or software, at its option, at no charge. These services shall be performed at DSM's factory or its designated repair facility.

Freight charges to return equipment or software to DSM are the customer's responsibility. DSM will pay freight charges to return the equipment to the customer.

### *Warranty Shipments Outside of North America:*

Warranty-repaired product is generally re-imported into the customer's country without duty; however the customer can most efficiently complete the administration of this duty exemption. Return freight to convey repaired or replaced parts or equipment from DSM to customer shall be "E.X.W." as such term is described by Incoterms 2000, with such expenses charged to customer's freight account for direct payment by customer to their freight service provider. All brokerage, freight, shipping, forwarding and handling charges, duties, customs and taxes applicable to warranty-repaired product shipments, if any, will be paid directly by the customer. DSM agrees to promptly reimburse customer for its actual freight cost incurred, *excluding* brokerage and handling charges, duties, customs and taxes, for warranty shipment from DSM to customer, using the same class of freight service selected to initially return the warranty claim equipment to DSM.

Reinstallation and recalibration of DSM equipment and software into a customer-specific application are not covered by this Warranty.

Equipment or software repaired or replaced under this Warranty is covered under the remaining DSM Warranty Period, if any, associated with the original new equipment or software.

### Exclusions

This Warranty does not cover:

1. Damage related to modification of DSM equipment or software after initial shipment by DSM.
2. Consequential or incidental damages such as property damage and incidental expenses.
3. Conditions caused by external factors such as abuse, misuse, inadequate power supply, or acts of God.

Owing to the wide range of experimental uses attempted by our customers, DSM does not warrant that its products are fit for a particular use.

Piezoelectric "stacks" (the elements within DSM's mechanical piezo devices) can bear high compressive load forces, but they are very sensitive to bending-, torsion-, shear- and especially to tensile forces. The design of any attached mechanics must apply only pure axial loading to the actuators. DSM's flexure-guided mechanical amplification frames are designed to provide a compressive preload force and to help prevent other bending or tensile forces that can damage the piezoelectric stacks. The user is advised to pay attention not only to the static force balances, but also to dynamic influences that can produce damaging acceleration forces resulting in bending motion or torque. Off-axis loading and/or dynamic operating conditions that induce resonant or near-resonant mechanical motion or undesirable dynamic modes resulting from physical impact of the actuator with its surroundings will void the terms of DSM's Warranty.

Opening of devices, machines, or electronics enclosures by anyone other than DSM voids this Warranty.