

DR-38M Driver - Revision Date: 02/17/09

***DR-38M
STEP MOTOR DRIVER
USERS GUIDE***

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Introduction

Congratulations on your purchase of an AMS model DR-38M Step Motor Driver. This product will provide years of reliable, accurate and cost-effective motion control. As with all AMS products, DR-38M is backed by over two decades of manufacturing excellence and a commitment to quality and support that guarantees your satisfaction.

This Technical Reference Guide will assist you in optimizing the performance of your step motor driver. Its purpose is to provide access to information that will facilitate a reliable and trouble-free installation. We recommend that each section be reviewed prior to installation.

Although the DR-38M and supporting documentation were designed to simplify the installation and on-going operation of your equipment, we recognize that the integration of motion control often requires answers to many complex issues. Please feel free to take advantage of our technical expertise in this area by calling one of our support personnel to discuss your application at 603-882-1447.

Thank You!

Your AMS Team

Product Overview



The **DR-38M** is a low cost, bipolar step motor driver designed to meet O.E.M. requirements for reliable, cost effective operation. The DR-38M operates in full, half or microstep mode at speeds up to 40k SPS. It uses a single power supply input voltage, between 12 and 40 Vdc, to generate a drive current output of 4.0 amps per phase. The DR-38M also implements a serial interface and non-volatile memory for configuration storage.

Features:

- *Low cost - small size*
- *Heat sinkable case*
- *Direction sensitive limit inputs, invert-able*
- *Speed sensing slow / fast decay selection*
- *12 to 40 Vdc power supply input*
- *4.0 amp output current (Peak)*
- *Output disable input*
- *Gentle power-up to reduce surge current*
- *Mating connectors included*
- *Full, half, quarter, and eighth microstep resolution*
- *Multi-speed jog inputs*
- *Auto current setback*
- *Serial interface for data entry*
- *Non-volatile memory configuration storage*
- *Optional encoder inputs for shuttle control*

Out of the Box

The standard driver package includes:

1. A DR-38M driver.
2. One 6-pin motor/power connector (P3) that mates with J3 on the driver (AMS# 82-1812-06).
3. One signal cable (P2) that mates with J2 on the driver (AMS# BLC-15).
4. Four option shunts.
5. One Users Manual (per shipment).

Required Accessories

1. Power supply-24 to 40Vdc.
2. A step pulse source with “low” going step pulses ranging from +5 to +24-volts (high) and 0 to 1-volt (low).
3. A four wire, two-phase, bi-polar step motor. Six and eight wire motors can also be configured.

Recommended/Optional Accessories

4. One SIN-20 serial adapter. While not absolutely necessary, the SIN-20 is recommended to simplify setup. Once the setup is complete, the SIN-20 can be removed and used for future applications.
5. Should additional cooling be required, a fan may be mounted to either draw or blow air across the heat-sink surface, depending on thermal conditions of the system.
6. Dual ammeter for more accurate current settings.

Power Supply Characteristics

For the best performance the power supply voltage should be as high as possible. It must be a minimum of two times the rated motor voltage; otherwise the motor will probably not function properly.

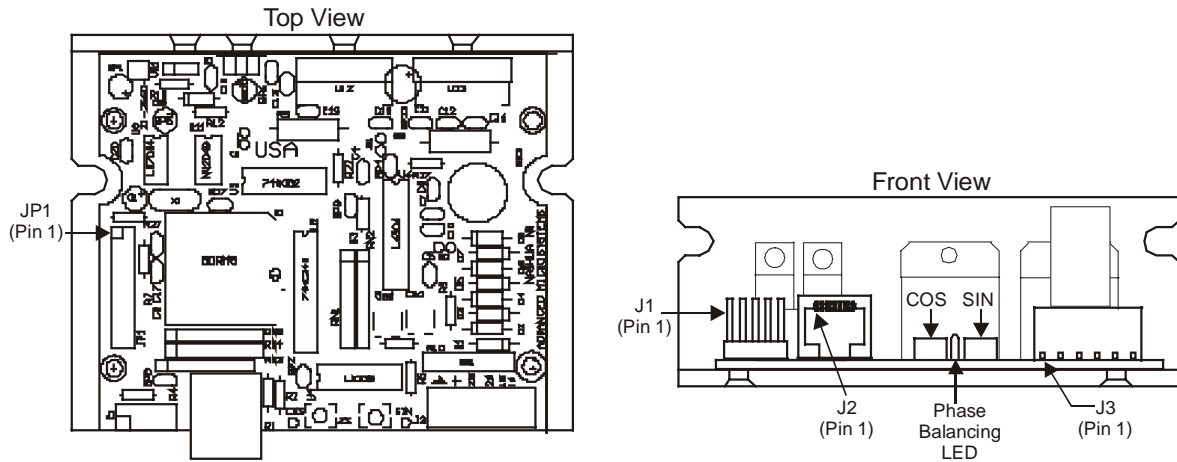
Be aware that exceeding the absolute maximum driver voltage rating (45 Vdc) for even the shortest time will cause (non warranty) destruction to the driver. An unregulated 36-volt power supply is preferred. If a regulated supply is used, it must be capable of withstanding any start-up surges. A switching regulated supply may not be suitable for use with this product. .

The power supply must be capable of providing sufficient current to meet the surge demands during turn-on. The power output (Volt-Amps) is probably the most important parameter. When V_{mm} is lower, more amperage is required. At higher voltages the chopping efficiency will reduce current demand. Generally, at 36 volts, a 3 to 4 amp power supply will operate most motors. Smaller motors require less Volt-Amps.

Note, frequently the best operation is obtained by using lower currents than the motor specification.

Quick Installation

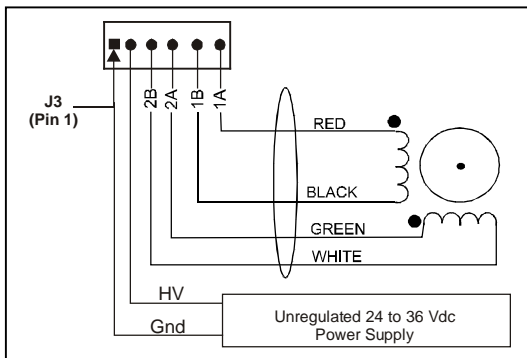
The following procedure will provide minimal setup to move a motor and ensure that the unit is operational:



Preparation

- Step 1.** Inspect for any damage as a result from shipment and handling.
- Step 2.** Insure both current controls (COS and SIN) are in the full counterclockwise (zero current) position.
- Step 3.** Connect power and motor wires to the mating connector for J3, per the table and diagram below.

J3 Pin	Signal	Description
1	Gnd (-)	Minus side of DC power supply
2	Vmm (+24 to 40-volts)	Positive side of DC power supply
3	PH-2B	Motor coil 2+
4	PH-2A	Motor coil 2-
5	PH-1B	Motor coil 1+
6	PH-1A	Motor coil 1-



Different motor manufactures use different nomenclature for winding designations. Coil 2 is connected between pins 3 and 4, and coil 1 between pins 5 and 6. These coils are separate and there must be no continuity between the two windings.

Note, driver outputs will be damaged if any PH output contacts Gnd or Vmm.

Setting the Current

The best method for setting the current is to use a dual ammeter circuit as described in the Addendum. Here, we will use the “meter-less” method.

The SIN and COS potentiometers each have ten equally spaced marks that can be used to set the output currents. The first mark, in the full CCW position, represents zero output current. Each incremental adjustment in the CW direction, adjusts the current approximately ¼ amp between 0 and 4 amps. Because most installations do not require the maximum torque, and motors usually have higher torque than the data sheets indicate, choose a lower current to start with; say ½ of the rated current.

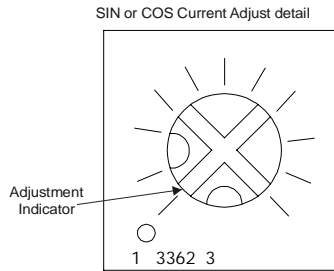
Step 4. Turn the power on.

Step 5. Carefully adjust the SIN potentiometer clockwise to the position corresponding to the desired current (see table below). At this point the phase balancing LED will be “off.”

Step 6. Adjust the COS potentiometer to an equal position.

The following table illustrates (approximate) current settings: Custom full-scale current range adjustments are also available (consult factory).

Adjustment Indicator	Current Value (Amps)
Full CCW	0
1	0.4
2	0.8
3	1.2
4	1.6
5	2.0
6	2.4
7	2.8
8	3.2
9	3.6
Full CW	4.0



Slight current imbalances will not affect performance significantly. Large imbalances can cause skipping steps and noisy operation or the symptoms of a stall condition.

Step 7. Step it.

If you’re using a SIN-20 (described in Hardware Connections Section), depress the jog switches to observe motion. Depending on motor characteristics, the jog parameters (B, K, and I commands) may have to be adjusted;

or

Apply step pulses from a pulse generator to verify motion.

If the motor refuses to turn, gradually increase or decrease current settings by rotating both trim pots equal amounts. Monitor motor heating with higher current settings. Heating is gradual depending on motor mass. The case should never exceed 100 degrees C.

In general, variations in step motor current settings are not critical. The value that provides reliable operation (sufficient torque), without motor over heating, is probably best.

“Do’s, Don’ts and Important Notes”

Do not connect or disconnect the motor when power is “ON.”

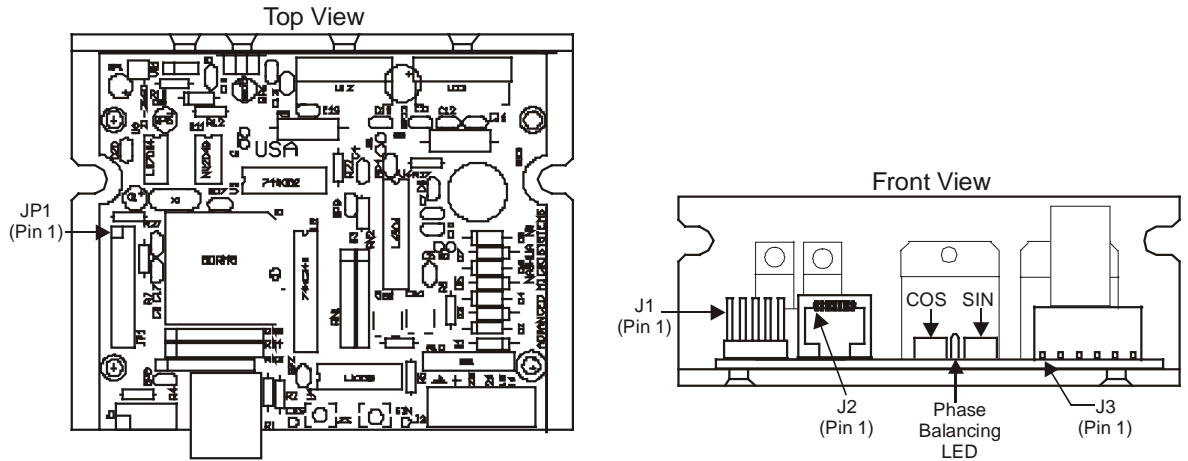
The module case is tied to the logic common and power pins internally. Do not tie your power supply to ground at another location.

The power supply voltage, including ripple and line voltage fluctuations must not exceed 45Vdc or be less than 12Vdc.

Make sure the motor to be used is compatible with the drive.

NEVER SHORT ANY MOTOR OUTPUT TO ANOTHER OUTPUT, GROUND or POWER SUPPLY. Permanent damage, not covered by warranty, will occur.

Hardware Connections



- J2: Step and Direction Input Connector
- JP1: Parameter Selection
- J3: Motor and Power Supply Connector

J1 and JP1 are both IDC connectors, capable of accepting suitable ribbon cable connections. JP1 has been designed primarily to accept shunts (jumpers).

Special Inputs (J1)

J1 is a 10-pin header that provides limit switch inputs, ground and a user defined +5 volt output. All inputs are 5 Vdc logic input, TTL/CMOS compatible. These signals connect DIRECTLY to the on-board microprocessor. It is highly recommended that external buffers be implemented to protect against inadvertent damage.

Caution: Exceeding the 5.5 volt maximum rating or below 0 volt minimum voltage will cause damage not covered by warranty.

Pin	Signal	Description
1	Vcc	+5 Vdc @ 100mA output (provided for user)
2	Lim A	Motion inhibited in CCW direction
3	Lim B	Motion inhibited in CW direction
4	Jog Sp	Selects one of two jog speeds
5	Jog 2	Move at selected jog speed CCW direction
6	Jog 1	Move at selected jog speed CW direction
7	Res.	Reserved input
8	GND	Power common
9	Res.	Reserved input
10	Res.	Reserved input

Vcc

The DR-38M contains a 5-volt regulator circuit that operates from Vmm input. This output is rated for 100 mA and may be used for external applications. Increased heating will result for higher input voltages (Vmm). Additional cooling may be necessary.

Limit Inputs, A and B

These are direction sensitive inputs that can be used to prevent hardware damage or used as a “home” stop. All motion is prevented in the specific direction. This includes jog as well as step pulse inputs.

Depending on system design, one input will prevent movement in the CCW direction, while the other will prevent movement in the CW direction. Asserting a low on both inputs will prevent movement in any direction.

The inputs can be inverted by installing jumper “I” (see JP1). In this case the inputs must be held at a low logic level to permit motion in the corresponding direction.

JOG Inputs

Dual speed “jog” is available on the DR-38M. Both speeds are programmable via the serial “B” command. These speeds are remembered in the on-board NV memory until modified. When changing jog speeds, acceleration and deceleration can be controlled to help prevent stalling. See the “K” and “I” serial commands in the Serial Interface section of this manual. Jog 1 and 2 initiate motion in opposite directions, while “Jog Sp” selects between the two preprogrammed speeds.

“Do’s, Don’ts and Important Notes”

When connecting from the J1 or J2 cable assembly to your controller, Do make sure that the pin-out is correct, as color codes may not be consistent from one cable assembly to the next. The wire size used with the J1 or J2 modular connectors may suffer voltage drops if more than several milliamps of current is attempted over any significant cable length.

Select (JP1)

JP1 is a 20-pin header that implements special features. All inputs are 5 Vdc logic input, TTL/CMOS compatible.

Caution: Exceeding the 5.5-volt maximum rating will cause damage not covered by warranty.

Pin	Signal	Description	Pin	Signal	Description
1	U0	Microstep Sel	2	Gnd	
3	U2	Microstep Sel	4	Gnd	
5	xx	No Function	6	Gnd	
7	H0	Hold Current	8	Gnd	
9	H1	Hold Current	10	Gnd	
11	IL	Invert Limits	12	Gnd	
13	S1	Fast Decay	14	Gnd	
15	S2	Slow Decay	16	Gnd	
17	S3	Stopped Out	18	Gnd	
19	RX	Data In	20	TXD	Data Out

(U0, U2) Microstep Resolution Select

The number of micro-steps per step is selected by U0 (pin 1), and U2 (pin 3) of connector JP1. A 1 (one) may be an open circuit or a value between 2 volts and the maximum input of 5 Vdc. A 0 (zero) or low is ground or less than 0.7 volts.

U0 (Pin 1)	U2 (Pin 3)	Resolution	Steps/Rev.
0	1	Full	200
1	1	1/2	400
1	0	1/4	800
0	0	1/8	1600

(H0, H1) Hold Current Select

The DR-38M will automatically increase the current in the motor windings to the Run current value on receipt of a step pulse. Approximately one (1) second after the last positive edge of the step clock input the current will decrease to the Hold current value. If the Hold current value is zero, the chopping will be disabled.

Jumpers installed on JP1, H0 and H1 are used to program the Hold current.

Hold Current Jumper Setting

Percentage of Run Current	Shunt Setting H0	Shunt Setting H1
100%	Out	Out
50%	In	Out
15%	Out	In
0%	In	In

The run current percentages are subject to high tolerances and therefore are approximate. In addition, the percentages can widely vary with step position and micro step.

The actual motor current will vary based on a number of factors including motor characteristics, cable length and shielding. The Rule of Thumb is to set the output current a little above the setting where reliable motion is achieved without excessive motor heating. Refer to the Addendum; “About Step Motor Current” for more information.

(I) Invert Limits

Installing a jumper here will “invert” the limit switch inputs, causing a high (5-volt) input to prevent motion. Both limits must be low (Gnd) to enable bi-directional motion.

(S1, S2) Fast and Slow Decay

The Decay feature is of particular importance. There are two methods of switching a bipolar chopper drive. The slow decay provides smoother operation at slow speeds, reducing mechanical resonance affects, while a fast decay mode enhances torque at higher speeds.

These settings can also be set using the serial “b 0 (fast) and b 255 (slow) commands. In automatic mode, the controller senses and selects fast or slow decay based on the shaft speed.

Jumpers Installed

S1	S2	Decay mode
No	No	Automatic (recommended)
Yes	No	Fast (best for higher speeds)
No	Yes	Slow (best for slow speed)

Some variation in winding current and heating will be observed, depending on the mode.

(S3) Stopped Output

A low output indicates motion, and a high (5-volt) when stopped. This logic output will sink a maximum of 1.6 milliamps with a 10k pull-up resistor to 5-volts.

(RXD) Input

This 5-volt logic input receives serial data from an external RS-232 receiver. Baud rate is 9600, 8 Data bits, no parity.

(TXD) Output

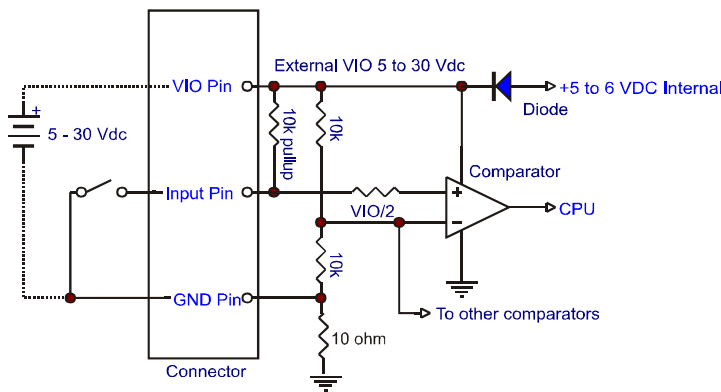
This 5-volt logic output can be used to supply a RS-232 line driver.

Never attempt to connect these TXD or RXD signals directly to any computer without a proper line receiver and driver.

Control (Step and Direction) Input (J2)

J2 is a miniature; 8-contact (RJ45) connector (similar to a phone plug) provided for interface of user control signals to the DR-38M. The essential input signals on J2 include a step pulse and direction control. The step resolution may also be selected as an alternative to JP1.

Typical Input Circuit



Pin #	Signal	Description
1	VIO	DC Reference (input)
2	Step*	Step pulse (input)
3	Dir*	Direction (Input) Set the shaft direction for STEP input.
4, 5, 6		Reserved
7	Dis*	Disable: Low input shuts off power drivers.
8	COM	Connect to power common (GND) through a 10-ohm resistor.

*Only these signals withstand 28-volt high input.

The DR-38M can be ordered with an optional encoder input. This is not “encoder feedback” but can be used to implement a shuttle or tracking design, where the motor position can move proportionally to some remote quadrature encoder. This input can withstand 28 volts.

VIO (Optional Supply Input) +5 to + 28 Vdc

This pin is used to define the threshold voltage for the Step pulse, Direction, and Enable inputs. Without an external supply, the logic threshold will be approximately 2.5-volts. If the logic signal input exceeds 5-volts an external VIO supply should be used. However, these 3 inputs will withstand in excess of 28-volts without damage. VIO output will measure about 4.5-volts.

Step/A (Input)

Each pulse applied causes a single step in the direction specified by the Direction Signal (pin 3). A low going pulse is preferred with a minimum width of 12 microseconds. Stepping occurs on the leading edge of the pulse.

Direction/B (Input)

This input specifies the shaft rotation direction on receipt of a step pulse. If the encoder input is ordered, encoder phase "B" is used here. This input can withstand 28-volts.

Disable (Input)

A low applied to this input disables stepping and reduces the current to zero. For applications that require holding current reduction, JP1, pins 7 and 9 can be used.

"Do's, Don'ts and Important Notes"

When connecting from the J1 or J2 cable assembly to your controller, Do make sure that the pin-out is correct, as color codes may not be consistent from one cable assembly to the next. The wire size used with the J1 or J2 modular connectors may suffer voltage drops if more than several milliamps of current is attempted over any significant cable length.

Motor Connection (J3)

The DR-38M is a bi-polar, chopper driver that works with both bi-polar and uni-polar motors, i.e. 8, 4 and 6 lead motors. It is also possible to half a 6 lead center tapped motor with the DR-38M, however the torque/speed performance may be reduced.

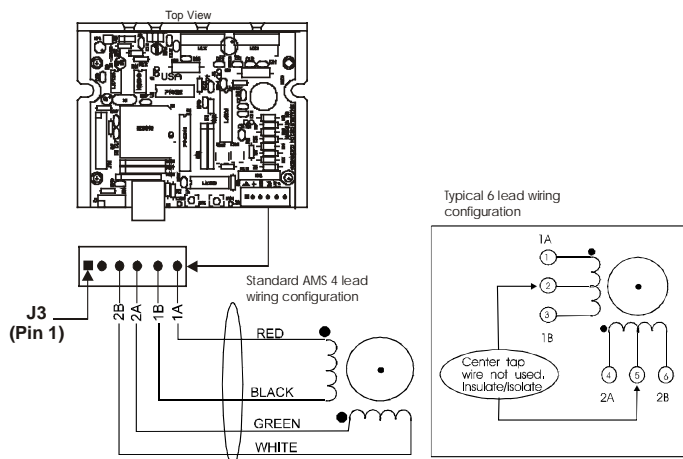
The DR-38M uses a constant chopping frequency and a varying duty cycle to sustain a given motor current. To avoid unstable chopping conditions and to provide a higher speed-performance ratio, a motor with a low winding inductance is preferred.

Drive Current

The ideal current for a given motor is based on the specific characteristics of the motor and the requirements of the application. As a result, establishing the correct current is often determined empirically. Insufficient current will result in inadequate torque and under utilization of the motor. Excessive current can cause high-speed torque ripple, resulting in stalling or pole slippage, over heating of the motor and general inefficiency of the system.

Additional information on motor winding characteristics is included in the Addendum under "About Step Motor Current."

Connecting a Stepping Motor (J3)



Pin #	Description	Function
3, 4	2B, 2A	Phase 2 of the stepping motor is connected between Pin 3 and Pin 4.
5, 6	1B, 1A	Phase 1 of the stepping motor is connected between Pin 5 and 6.

“Do’s, Don’ts and Important Notes”

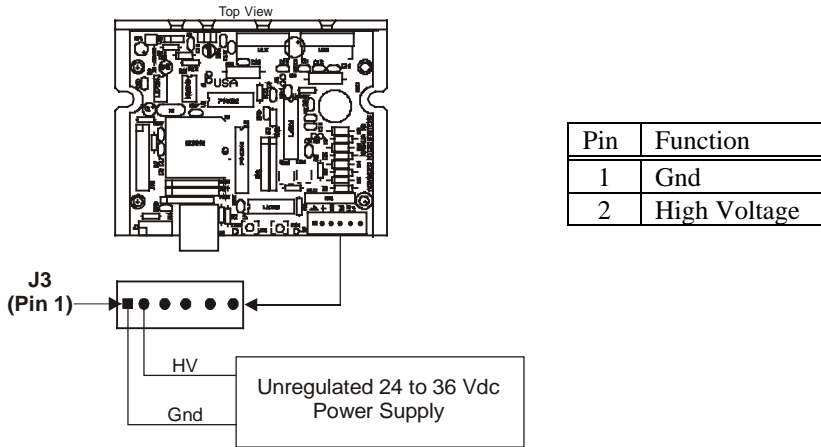
Do not connect or disconnect motor wires while power is supplied.

When using a 6 lead motor be sure to insulate/isolate unused wires.

The physical direction of the motor with respect to the direction input will depend on the connection of the motor windings. To reverse the direction of the motor with respect to the direction input, switch the wires on phase 1 or phase 2 of the outputs.

Power Supply Connection (J3)

The DR-38M can be operated from a single unregulated DC power supply. The 5-volt logic supply is derived from an internal 5-volt regulator.



Recommended Power Supply Circuit

AMS recommends using an unregulated DC (or linear regulated) power supply between 24 and 36-volts (12-40 volt actual operating range). The current rating of the power supply should be sufficient to operate the DR-38M, but not exceeding 6 amps. Switching power supplies are not recommended because of the inability to handle surge currents.

The single rectifier/filter can be used for single axis configurations, or multiple axes, provided component values are scaled accordingly. Alternatively, individual axes can be supported by their own rectifier/filter.

If multiple drivers are used with one power supply, each drive should have separate power and ground wires that connect directly to the output capacitor of the power supply.

“Do’s, Don’ts and Important Notes”

Individual axes should be independently fused for fault isolation.

The power supply voltage, including ripple and line voltage fluctuations must not exceed the peak rating of 40Vdc or be less than 12Vdc.

Do not connect or disconnect motor wires while power is applied.

Wire size used to connect the power source to the driver should be at least 18 gauge. Heavier wire should be used for longer distances between the power supply and the driver.

The power supply output current needed is dependent on the supply voltage, motor selection and load.

SIN-20 Configuration and I/O Buffer

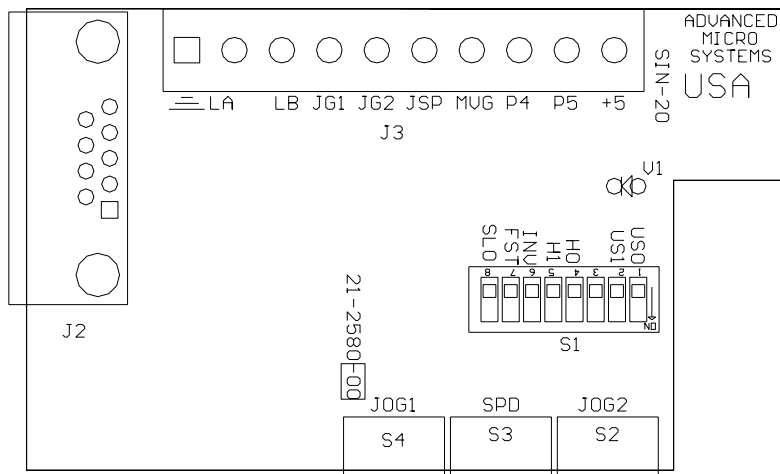
As an alternative to developing your own circuit, AMS offers a small PCB accessory for the DR-38M, called the SIN-20. This board may be mounted “piggy back” onto connectors J1 and JP1 of the DR-38M.

The SIN-20 contains RS-232 serial interface circuitry. Its primary purpose is to allow configuration and tests of the parameters stored in the DR-38M NV memory. It has a “DB9” connector that interfaces directly to any computer with “dumb terminal” software such as “Hyperterm.” See Serial Interface section for more information.

Features

- RS-232 TXD and RXD logic levels input
- Full duplex communication
- DB9 connector
- Powered from the DR-38M
- Stacking design allows configuration jumpers
- Seven protected inputs
- 5mm terminal blocks
- Jog push buttons
- Motion indicator
- Limit switch input buffers
- Jog switch input buffers
- Input threshold 2.5 or 5-volts

Once programmed the values will be retained in memory. The SIN-20 can be removed and saved for future use. The available commands are described further on in this manual.



SIN-20 (J3)

J3 is a 10-pin connector that provides limit switch inputs, ground and a user defined +5 volt output. All inputs are 5 Vdc logic input, TTL/CMOS compatible. These signals connect DIRECTLY to the on-board microprocessor. It is highly recommended that external buffers be implemented to protect against inadvertent damage.

Pin	Signal	Description
1	GND	Power common
2	LA	Motion inhibited in CCW direction
3	LB	Motion inhibited in CW direction
4	JG1	Move at selected jog speed CW direction
5	JG2	Move at selected jog speed CCW direction
6	JSP	Selects one of two jog speeds
7	MVG	5-volt logic output/led
8	P4	Reserved input
9	P5	Reserved input
10	+5	Vcc +5 Vdc Derived from DR-38M

+5-Volts (Vcc)

The DR-38M contains a 5-volt regulator circuit that operates from Vmm input. This output is rated for 100 mA and may be used for external applications. Increased heating will result for higher input voltages (Vmm). Additional cooling may be necessary.

Limit Inputs, A and B

These are direction sensitive inputs that can be used to prevent hardware damage or used as a “home” stop. All motion is prevented in the specific direction. This includes jog as well as step pulse inputs.

Depending on system design, one input will prevent movement in the CCW direction, while the other will prevent movement in the CW direction. Asserting a low on both inputs will prevent movement in any direction.

The inputs can be inverted (see Invert Limits S1-6). In this case the inputs must be held at a low logic level to permit motion in the corresponding direction.

JOG Inputs

Dual speed “jog” is available on the DR-38M. Both speeds are programmable via the serial “B” command. These speeds are remembered in the on-board NV memory until modified. When changing jog speeds, acceleration and deceleration can be controlled to help prevent stalling. See the “K” and “I” serial commands in the Serial Interface section of this manual. Jog 1 and 2 initiate motion in opposite directions, while “Jog Sp” selects between the two preprogrammed speeds.

SIN-20 (S1)

Switch	Signal	Description
1	US0	Microstep Select
2	US1	Microstep Select
3	NC	
4	H0	Hold Current
5	H1	Hold Current
6	INV	Invert Limits
7	FST	Fast Decay
8	SLO	Slow Decay

(US0, US1) Microstep Resolution Select

The number of micro-steps per step is selected by S1-1 and S1-2.

US0 (S1)	US1 (S2)	Resolution	Steps/Rev.
On	Off	Full	200
Off	Off	1/2	400
Off	On	1/4	800
On	On	1/8	1600

(H0, H1) Hold Current Select

The Hold current is selected by S1-4 and S1-5.

Percentage of Run Current	H0 (S4)	H1 (S5)
100%	Off	Off
50%	On	Off
15%	Off	On
0%	On	On

(INV) Invert Limits

S1-6 “On” will invert the limit switch inputs, causing a high (5-volt) input to prevent motion. Both limits must be low (Gnd) to enable bi-directional motion.

(FST, SLO) Fast and Slow Decay

The Decay feature is of particular importance. There are two methods of switching a bipolar chopper drive. The slow decay provides smoother operation at slow speeds, reducing mechanical resonance affects, while a fast decay mode enhances torque at higher speeds.

These settings can also be set using the serial “b 0 (fast) and b 255 (slow) commands. In automatic mode, the controller senses and selects fast or slow decay based on the shaft speed.

S1-7	S1-8	Decay mode
Off	Off	Automatic (recommended)
On	Off	Fast (best for higher speeds)
Off	On	Slow (best for slow speed)

Some variation in winding current and heating will be observed, depending on the mode.

JOG Inputs

Dual speed “jog” is available using the SIN-20. Both speeds are programmable via the serial “B” command. These speeds are remembered in the on-board NV memory until modified. When changing jog speeds, acceleration and deceleration can be controlled to help prevent stalling. See the “K” and “I” serial commands in the Serial Interface section of this manual. Jog 1 and 2 initiate motion in opposite directions, while “SPD” selects between the two preprogrammed speeds.

SIN-20 (S2, S3, S4)

Switch	Signal	Description
S2	Jog 2	Move at selected jog speed CCW direction
S3	SPD	Selects one of two jog speeds
S4	Jog 1	Move at selected jog speed CW direction

Serial Interface

Two contacts, pin 19 (RXD) and pin 20 (TXD), are provided on JP1 of the DR-38M and a 9 pin serial connector (J2) on the SIN-20 for serial communication. A limited set of commands permit the programming of parameters and storage in NV memory. Once stored, the “terminal” may be disconnected and the saved values can be used thereafter. The serial data (RXD and TXD) must be converted to EIA RS232 voltage levels with a converter IC such as a Maxim- MAX232.

Use any terminal program with the following settings: Baud- 9600 8 bits, Parity- none, Stop- 1.

On power-up, the DR-38M prints a sign-on message including the version and firmware date code.

Available Commands:

- B (Jog Speeds)
- b (Decay)
- ^C (Clear /Initialize)
- C1 (Clear and Restore NV Memory)
- D (Divider)
- I (Initial Velocity)
- K (Acceleration / Deceleration)
- M (Motion Test)
- S (Store)
- X (Examine Parameters)

Program Command Description

Command	ASCII Character (Keystroke)
Function	Functional description of command
Type	D= Default; initial parameter setting I= Immediate (direct execution) P= Program command; executable in stored program
NV	Non-volatile memory byte requirements in program
Mnemonic	Single character prefix used in multi-axis protocol; (prefixed by axis “Name” assignment in Party Line mode)
Data/Range 1	Affected parameters and valid numerical range of parameters
Data/Range 2	Same as Data Range 1 (as required)
Result	Information returned as a result of command execution or examination

Program Commands

Command	Function	Type	NV Bytes	
^C	Reset Controller	Immediate	N/A	
	Mnemonic	Data 1	Data 2	Result
		None	None	None

^C (Reset)

Resets controller to power-up condition, waiting for start sequence. It is analogous to “Ctrl-Alt-Delete” - reboot the computer. All outputs are set high, defaults are reloaded from NV memory, and position is set to zero.

B	Command	Function Set Jog Speeds	Type Default, Immediate, Program		NV Bytes 3
	Mnemonic (Name) B (speed)	Data 1 Speed (0±40,000)	Data 2 B(+) <i>xxx</i> = Slow B(-) <i>xxx</i> = Fast		Result None

B (Set Jog Speeds)

Two jog speeds are possible. When data 2 = plus the “slow” speed is specified. When data 2 =minus then the fast speed is programmed. These speeds are stored in NV memory.

Example: B 500 = slow speed, B -2000= fast speed. Speeds are divided by the “D” value.

b	Command	Function Set Slow or Fast Decay	Type Default, Immediate, Program		NV Bytes 2
	Mnemonic (Name) b (0, 255)	Data 1 Speed Threshold	Data 2		Result None

b (lower case B; Fast and Slow Decay)

When there is no motion (stopped), the decay will always be slow. The threshold defines a motor speed where slow decay changes from slow to fast decay during acceleration and switches back to slow decay during deceleration. The threshold will occur at an RPM where step resolution is taken into account.

Threshold Value:

Threshold	1/2 SPS	1/8 SPS
0	Fast (always)	
25	650	2400
50	1300	4800
100	2400	9600
150	3700	14000
200	5000	19200
255	Slow (always)	

Because the step rate is actually measured, the decay detection functions for external step pulse input. Slow decay provides smooth operation with reduced resonance’s at slow to medium speeds. Fast decay will generally enhance high-speed operation at speeds above 200-300 RPM. The actual settings usually must be determined empirically (see Addendum: “About Step Motor Current”) and tailored to the specific design.

Multiple variables that interact include:

- Operating step speed range
- Step resolution
- Motor size and characteristics
- Load inertia and load damping affects
- Supply voltage
- Motor current setting
- Acceleration and deceleration rates

Once the optimal settings are determined, they will apply to future production, provided all remains constant.

Command C1	Function Clear and Restore NV Memory	Type Immediate		NV Bytes N/A
	Mnemonic (Name) C (n)	Data 1 0-8	Data 2 None	Result Version

C1 (Initialize Memory)

Forces complete NV memory initialization with factory default values. This MUST be done when new NV memory is installed or existing memory is corrupted. Frequent use of this command should be avoided, as memory longevity may be affected.

Command D	Function Divide Speeds	Type Immediate, Program		NV Bytes 2
	Mnemonic (Name) D (n)	Data 1 Resolution (1-255)	Data 2 None	Result None

D (Divide Speeds)

All speeds during ramping and slewing are divided by the specified number (n). The pre-scale number may range between 1 and 255.

The power-up settings are stored in NV memory.

Command I	Function Set Initial Velocity	Type Default, Immediate, Program		NV Bytes 3
	Mnemonic (Name) I (n)	Data 1 SPS (40-36,000)	Data 2 None	Result None

I (Initial Velocity)

This parameter sets the initial velocity in steps per second. This is the first speed used at the beginning of jog acceleration. It must be slow enough that the motor can start without losing steps (stalling).

As with all velocity parameters, the initial velocity is divided by the divide factor (D). Using the examine (X) command displays updated velocities.

Command K	Function Set Ramp Slope Time	Type Default, Immediate, Program		NV Bytes 3
	Mnemonic (Name) H (n1, n2)	Data 1 Accel (0-255)	Data 2 Decel (0-255)	Result None

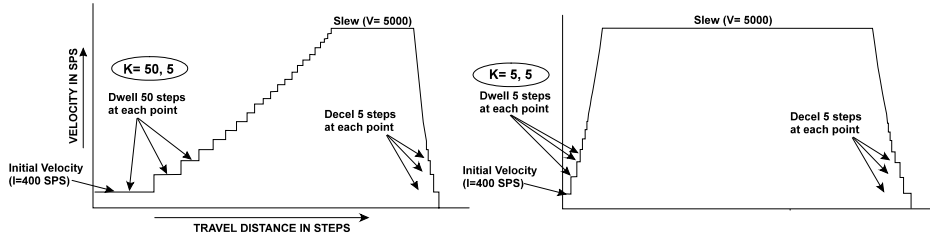
K (Ramp Slope)

Specify the ramp acceleration and deceleration time. The "K" command is used to adjust the ramp slope during the motor acceleration or deceleration. An internal lookup table defines the profile or shape of the acceleration/deceleration curve. Depending on the values of initial and slew velocities, a number of discrete velocities are used to define the acceleration or deceleration of the motor armature rotation.

The "K" value determines how many steps are made at each step rate point on the acceleration curve during ramping. Higher "K" values will increase the dwell time at each discrete point on the acceleration ramp. Lower values of "K" will increase the acceleration rate. A value of 0 will eliminate any ramping.

In practical applications, it is typically easier to decelerate a system, rather than accelerate a system. The separate decelerate parameter feature is a valuable time saver when compared to systems with fixed acceleration/deceleration times. Note, this command does not work with external step pulses.

The following two examples are of ramped indexes, each 2000 steps with I=400, V=5000, but different “K” values; K50 5 and K5 5:



M	Command		Function	Type	NV Bytes
			Move at Constant Velocity	(For Testing)	3
	Mnemonic	Data 1	Data 2	Result	
	(Name) M	SPS ($\pm 40,000$)	None		

M (Move at a Constant Velocity)

The “+” or “-” sign determines direction during the move at constant velocity function. The motor will ramp up, or down to a constant velocity. Motion will continue at the given speed until a new velocity is entered. The specified slew speed is in steps per second. Ramp parameters may be modified prior to each velocity command, allowing different ramp slopes. The direction is specified by the sign preceding the velocity. The DR-38M has the capability of decelerating and accelerating to full speed in either direction with a single command but motion must be halted with the “M0” command before the opposite direction can be initiated.

The default initial velocity is used at the first invocation of the command. The following commands and/or settings modify effective speeds and resolutions:

- D (Divide Command)
- K (Ramp Factor Command)
- Step Resolution (u0, u2 setting on JP1)

Command	Function	Type		NV Bytes
S	Save Parameters to NV Memory	Immediate		1
	Mnemonic	Data 1	Data 2	Result
	(Name) S	None	None	None

S (Save)

The following parameters are saved in the NV memory and will be recalled as defaults during power-on reset:

- D (Divider)
- I (Initial Velocity)
- K (Acceleration / Deceleration)
- B (Jog Speed)
- b (Decay)

Command	Function	Type		NV Bytes
X	Examine Settings	Immediate		N/A
	Mnemonic	Data 1	Data 2	Result
	X	None	None	Display Setting

X (Examine)

The Examine command displays parameters as follows:

X K= 5/5, I= 802, B= 400/1000, 1/8 b=60

Where:

- K= Ramp up/ramp down
- I= Initial velocity
- B= Slow/fast JOG
- 1/8= Resolution mode
- b= Decay setting

Electrical Specifications

Parameter	Min	Typ	Max	Unit
Supply voltage	12	24	40	Vdc
Peak output current per phase	0		4.0	Amp
Buffered inputs (Step, Direction, Enable)	-0.5	2.5 (Thresh)	28	Volt
VIO external ref. for buffered inputs	None	5	28	Volt
Pull-up resistor (VIO) for buffered inputs				
Un-buffered logic inputs (high)	2.0		5.5	Volt
Un-buffered logic inputs (low)	-0.5		0.8	Volt
Pull-up resistor logic inputs (5V)		10k		
Input step rate	0		40,000	Steps/Sec
Step Pulse Width	12			Microseconds
Steps / Revolution	200		1,600	1.8° Motor

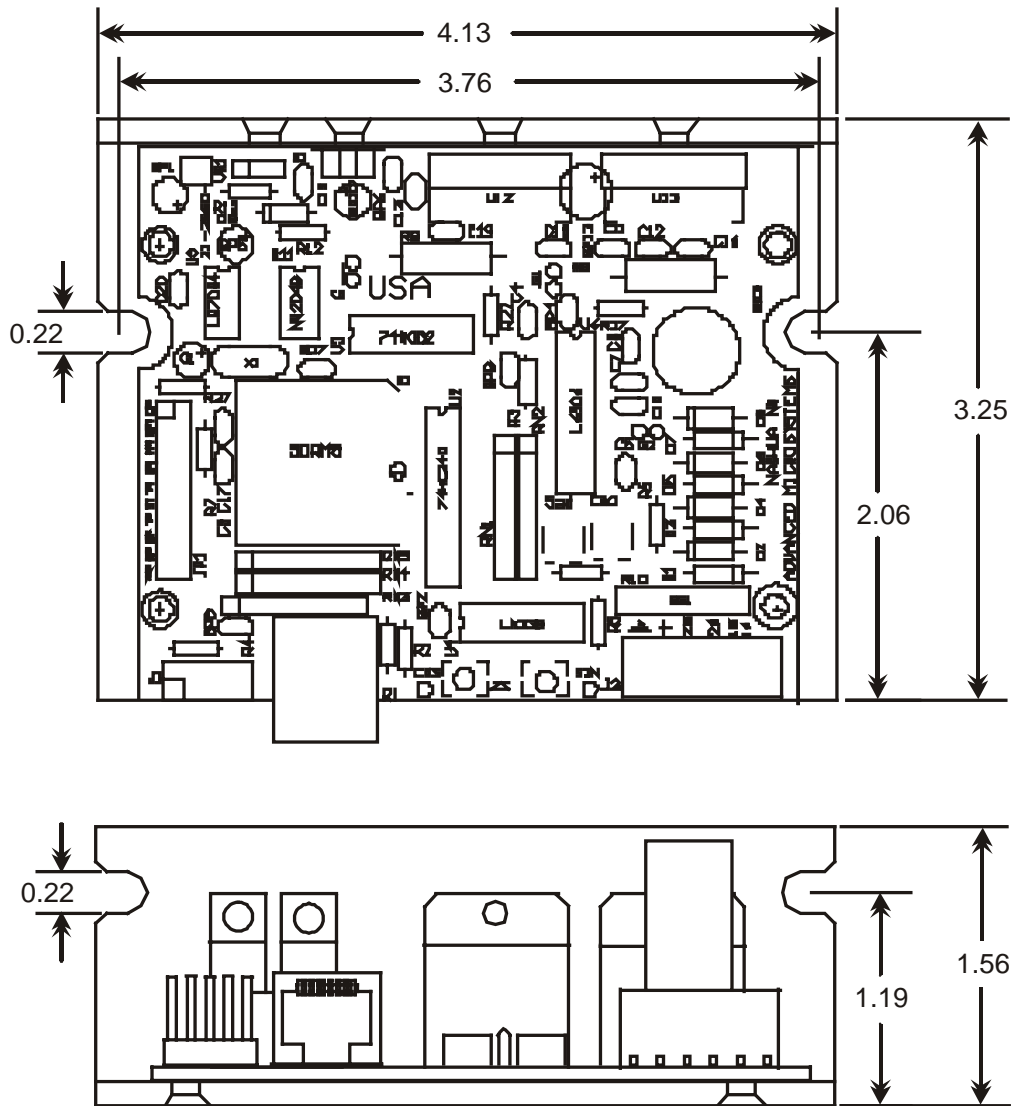
Output Current Load	12Vdc	24Vdc	40Vdc	Unit
No load	.05	.05	.06	Amps (Imm)
2.0 amps (both phases on)	2.4	1.0	0.7	Amps (Imm)
4.0 amps (both phases on)	7.0 *	3.3	2.0	Amps (Imm)

*This parameter exceeds the maximum rating of the DR-38M.

Thermal/Mechanical Specifications

Operating temperature.....0 to +50° C
 Storage temperature.....-40 to +125° C
 Size.....4.13" x 3.25" x 1.56"
 Weight.....12.8 oz.

Dimensional Drawing



Addendum

About Step Motor Current

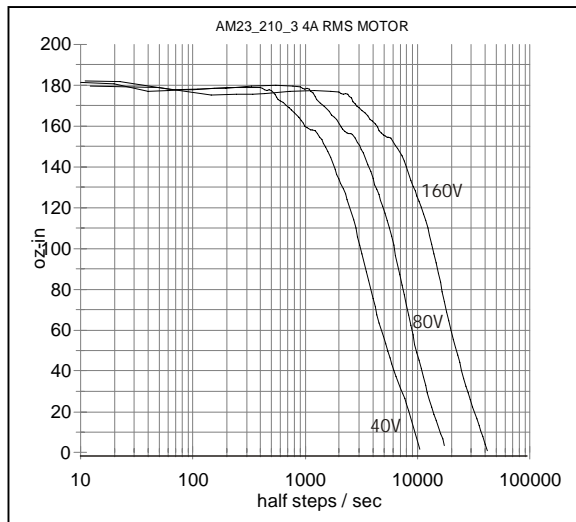
There is much confusion regarding the operation of step motors. Depending on your application, the step motor offers several advantages over servo motor designs, including lower cost and simplicity. The step (or stepper, or stepping) motor is a digital “synchronous” motor with a pre-designed number of “steps” per revolution. The most common motor has 200 full steps per revolution. Simple driver electronics can subdivide these steps into 1/2 step or more complex “microsteps.”

Step Motor Characteristics

- The positional repeatability of each full or half step is very close to exact.
- While microsteps are repeatable, they tend to be somewhat non-linear.
- The torque is maximum at zero speed.
- The motor shaft RPM exactly correlates with the steps-per-second.
- Torque decreases with speed, eventually to zero or a “stall” condition.
- Resonance at certain speeds can cause undesired stalls or erratic operation.

There is little difference between today’s step motor and the first generation of 60+ years ago. The magnetic materials and torque have been improved, yet it remains a simple, reliable workhorse of industrial motion control. Over time most improvements have been made to the drive and control electronics, i.e., microstep, solid-state components with higher voltage, current and switching speeds.

One insatiable hunger of a step motor is torque output at higher speeds. Winding inductance is the villain that limits speed. As the windings are switched on, the magnetic flux must be built up from current flow in the windings, producing mechanical torque. Higher step rates reduce the time available for flux to buildup and average current flow is reduced.



This reduced current results in reduced torque. The rate of current change depends on the voltage applied across it. High voltage applied across the coil will shorten the time constant.

Today’s systems strive for low inductance motors and high voltage supplies. The above curves show the increased speed that might be obtained with higher supply voltages, up to 160Vdc. At standstill the average motor voltage is regulated to approximately 3Vdc.

A current sense circuit is used to switch off the current when it reaches the set value; hence the motor power is regulated. These “chopper” circuits operate at speeds above 20khz, well above hearing limits.

The following is an abstract from “Control of Stepping Motors, a Tutorial” (linked from www.stepcontrol.com) by Douglas W. Jones, University of Iowa Department of Computer Science. <http://www.cs.uiowa.edu/~jones/step/index.html>.

“Small stepping motors, such as those used for head positioning on floppy disk drives, are usually driven at a low DC voltage, and the current through the motor windings is usually limited by the internal resistance of the winding. High torque motors, on the other hand, are frequently built with very low resistance windings; when driven by any reasonable supply voltage, these motors typically require external current limiting circuitry.”

“There is good reason to run a stepping motor at a supply voltage above that needed to push the maximum rated current through the motor windings. Running a motor at higher voltages leads to a faster rise in the current through the windings when they are turned on, and this, in turn, leads to a higher cutoff speed for the motor and higher torques at speeds above the cutoff.”

“Microstepping, where the control system positions the motor rotor between half steps, also requires external current limiting circuitry. For example, to position the rotor 1/4 of the way from one step to another, it might be necessary to run one motor winding at full current while the other is run at approximately 1/3 of that current.”

Motor Choice

The discussion here relates to bipolar chopper motors. Internally, standard motors have 4 windings, resulting in a total of 8 wire leads. Motor manufacturers supply various configurations:

Leads	Application Connection	Comment
8	Bipolar (series or parallel), unipolar	All 8 leads are available. External interconnect can be cumbersome and untidy.
6	Unipolar or bipolar series	Can be used with 50% copper reduced torque but increased speed possible.
4	Bipolar series or bipolar parallel	Series: higher torque but reduced speed capability. Parallel: higher speed with lowered torque.
5	Unipolar only	Not suitable for bipolar drives. See AMS model CCB-25 with programmable phase sequencing.

Determining the Current Value

Question: What is the right current value?

Answer: The minimum value to operate reliably.

As the step motor current is reduced below the rated current, the torque output is reduced and eventually the motor will stall. The ideal current setting minimizes heating of motor and electronics, increases reliability, and reduces power supply requirements. Motors run more quietly and resonance effects can be reduced. One drawback from low current operation is that some microstep size linearity may be reduced, but full or half step accuracy is not adversely affected.

AMPS and Wire Count and Power

The rated current is specified based on the rated power input (watts) of a given motor.

A. Basic 8 Wire Motor

While never actually used as 8 individual coils, virtually all permanent magnet motors have 4 internal coils. All common configurations can be constructed from the 8-wire motor.

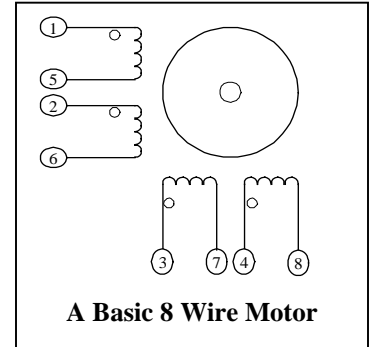
Let us assume that each winding of the 8-wire motor has the following specifications:

- Current = 1 amp
- Resistance = 4.0 ohm
- Voltage= 4.0 volts
- Inductance = 4.4 mH

The power per winding is:

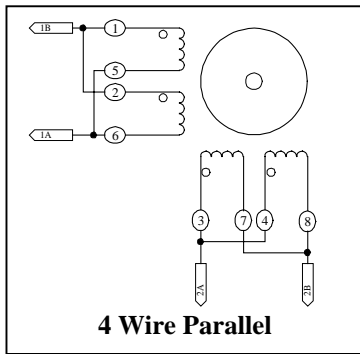
$$I^2R \text{ or } 1 \times 1 \times 4 = 4 \text{ watts,}$$

$$\times 4 \text{ coils} = 16 \text{ watts total for this motor.}$$



These values correspond closely with a NEMA size 23, 4 wire motor designs.

These following examples will configure the basic 8-wire motor into four real life connections:



4 Wire Parallel

The high-speed model implements parallel coil connection. Two coils connected in parallel result in the following for each of the two phases:

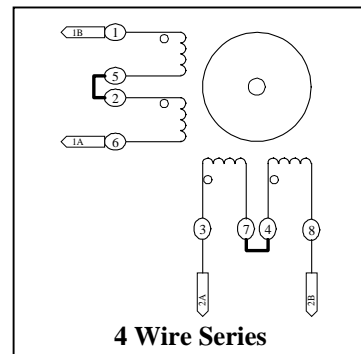
- Parallel Resistance= 2 ohms
- Parallel Inductance= 2.2 mH
- Current = 2 amps @4 volts or 8 VA
- Watts per phase= 8VA (x 2 phases) = 16 watts total

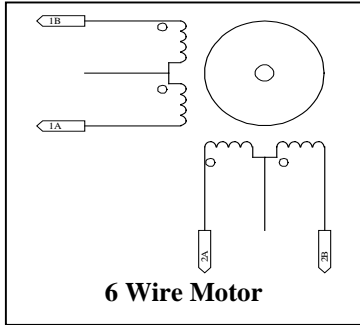
B. 4 Wire Series

Changing to a series design, we have two pairs of two coils connected in series. Each has:

- Series Resistance= 8 ohms
- Inductance= 17.5 mH
- The rated current is now 1 amp (8 Volts)
- Watts per phase=8 (x 2 phases) = 16 watts total

Note that the series inductance is FOUR times the parallel design. Inductance limits the obtainable speed, since the time constant limits the amount of flux (hence torque) when step-to-step time is short.





C: Adapting Available 6 Wire Motors

A 6-wire motor is equivalent to a 4-wire series motor.

Series Resistance= 4 ohms

Inductance= 17.5 mH

Rated current= 1 amp (8 volts)

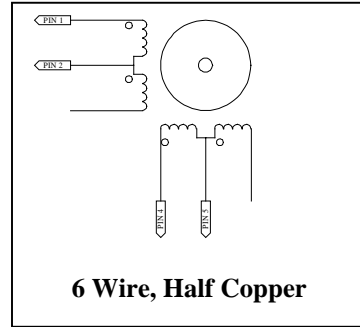
In practice the two coil ends are connected, while no connection is made to the center tap.

Half Copper or 50% Winding

The maximum speed can be increased by using 1/2 the coil. To do this, connect the driver between the center tap and one end of the winding.

The tradeoff is a loss of torque. The RMS current is the manufacturer’s unipolar amperage rating with the same wattage per phase.

Often a 6-wire design is being upgraded or the size, features, availability or cost dictate the 6-wire motor. Some characteristics can make the motor impossible to use. Many motors are rated at voltages in excess of 10 volts. This means that 20 volts is necessary in the series (100% copper) configuration.



Aside from having excessive inductance, proper chopper operation dictates operation from voltage sources much higher than the motor voltage rating. The minimum recommended value for Vmm (DC supply) is 3 times the winding rating (the higher the better, until excessive heating occurs or insulation breakdown).

Summary

# Leads	Winding Connection	Per Phase Bipolar Current	
		Full Step (Total)	Micro step (Peak)
4 wire	Parallel	2.0A (4.0A)	2.8A
4 wire	Series	1A (2.0A)	1.4
6 wire	Unipolar	1.4A per phase	NA
6 wire	Series	1A (2.8A)	1.4A
6 wire	50% Copper	1.4A (8A)	2

- Peak Current= One phase on and the other phase off.
- Peak Current =1.414 times RMS.
- RMS= Current per phase with both phases driven on (full step).
- RMS Microstep (or full step)= Both phases operating at equal currents.
- RMS = .707 times peak current.
- Total = Entire motor current.

HEAT: The Primary Enemy of Motor Damage

Advanced Micro Systems driver designs limit winding current to an adjustable value. Higher speeds are achieved from higher voltage DC supplies. In general, the only cause of motor damage is from excessive heating. Most step motors can withstand 100 degrees C.

A chopper drive regulates the motor current. Generally the “run” current is set at zero speed. If a hold mode is available the current will “set-back” when the motor is not moving. The voltage supplying the motor should be three or more times the rated motor voltage. If the supply were equal to the motor voltage, chopping would not function and performance would be very poor.

With higher voltages the regulation limits power and, hence heating. As the motor is rotated faster the chopper uses the available voltage to overcome a “back EMF” effect that takes place, thereby retaining more shaft torque.

More voltage applied to the motor equals more watts into the motor, resulting in additional heating. Motor heating can accumulate at continuous high stepping speeds, load torque and supply voltages of over 40 volts. Methods of reducing heating include motor heat sinking and short duty cycle (with a reduced holding current).

Design Tips

EMI (electromagnetic interference or electrical noise) can be a major source of problems when integrating power drivers with microprocessor based devices. EMI is typically generated through ground loops and AC power line disturbances. External devices such as, relays, coils, solenoids, arc welders, motors, drivers, and other computer-based equipment are also sources of EMI.

The following design tips will help to prevent EMI from interfering with the system operation:

- Shield the driver and wiring by mounting it in its own metal enclosure as far away from noise sources as possible.
- Ground motor shields only at the driver end.
- Make sure that all power wiring (motor, AC, etc.) is away from the signal wiring (I/O, communications lines, etc.).
- Mechanical grounds should all be tied to Earth at a single point. Chassis and motor grounds should be tied to the frame and the frame to Earth.
- Ground all signal wiring to one point.
- Use solid-state relays or opto isolators whenever possible to isolate remote signals. Suppress all mechanical relays with capacitors or MOV’s.
- Use shielded, twisted pair cables for the motor, I/O and communications wiring.

Microstep Verses Full Step Operating Current

The DR-38M can sequence winding currents to produce four different resolutions.

Resolution	Advantages	Disadvantages	Current Setup
Full Step	Highest torque	More resonance’s, noisy operation, large steps can be jumpy.	100%
Half Step	High torque	Less resonance and noise, smoother operation.	100%
Quarter Step	Very smooth, low resonance	Slightly less torque, micro step sizes have some accuracy variation.	140%
Eighth Step	Smoothest, low resonance	Same as Quarter Step.	140%

Motor output torque is proportional to the current settings. Many applications do not require full current for reliable operation. You should use lower currents (if possible) for quieter operation with less resonance.

If the application is full or half step, then you may adjust the winding current to the motor manufacturers "full step bipolar rating."

If the application is quarter or eighth step, then you may adjust the winding current to 1.4 times the motor manufacturers "full step bipolar rating." Be aware that if the motor is connected during this adjustment, that excessive heating can occur. Allowing most motors to temperatures above 100 degrees C. can cause internal melting and seizure. Short-term current overdrive will, in general, not harm these motors.

Current Setup for DR-38M Using a Dual Ammeter

The DR-38M incorporates two DMOS full-bridge power driver I.C.'s rated at 4 amps each. The chopper drive circuitry operates at approximately 20 KHz. Current sense resistors are used to regulate the current in each of the two windings. This feedback attempts to maintain a constant motor winding current, compensating for variations of power supply voltage, motor resistance, motor step rate, etc.

The basic setup technique involves the following steps:

1. Insert a current meter in series with one winding (the second winding is optional). Most AC amp-meters are designed to measure 60 Hz current and will produce reading errors in these 20 KHz + frequency-switching circuits, therefore, a separate bridge rectifier circuit is necessary.
2. Set both SIN and COS potentiometers to a safe, low (CCW) position, especially when using low current motors.
3. The output drive electronics must be set for peak current. The following conditions must be noted:
 - A. The drive outputs must be enabled, without any current reduction (100% holding).
 - B. The step controller must command equal currents for both winding.
 - C. Each product may have slight variations in their design.

The specific procedure to set both phases to 100% on the DR-38M uses the following setup for all current adjustment methods:

With a SIN-20

Depress JOG1, JOG2 and SPD buttons simultaneously, and then apply power. Both phases will be commanded to 100% current and adjustments may be made. The switch options will not be relevant. The power must be cycled off to reset this special mode.

Without a SIN-20

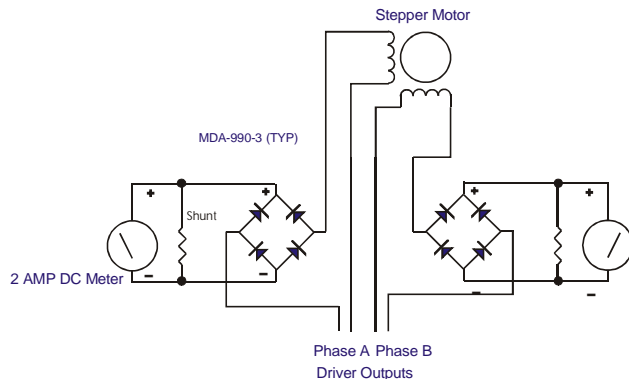
Remove any jumpers or connections from JP1 and J1. On power-up, both phases will be commanded to 100% current and adjustments may be made. The DR-38M will be in half step mode and can be stepped (any stepping can cause the current to vary from being equal).

Dual Meter Setup for Current Calibration (Best Method)

Using two meters is the best method because both phases can be observed at once. One can see the currents change, relative to one another, when stepping at a slow speed.

The following is the basic setup and diagram for two-phase current measurement:

1. The Amp meter can be digital or (preferably) analog.
2. The bridge rectifier must be rated above the maximum expected voltage and current.
3. A small capacitor (filter) may be needed across the meter.
4. Two meters will indicate proper operation.
5. Additional meter protection circuitry may be desired (not shown).



Here only one of the Amp meter circuits is used. After power is applied, (both windings at 100%) the metered phase is adjusted to the desired current. Next, the unmeasured phase is adjusted until the balance LED just changes ON/OFF. At this point both phases are equal.

******* WARNING *******

LIVE CONNECTING/DISCONNECTING MOTORS WILL CAUSE DAMAGE THAT IS NOT COVERED BY WARRANTY.