# *mSTEP-407 (Rev. B)*
# *Hardware Manual*

***Revision Date: 06/14/2010***

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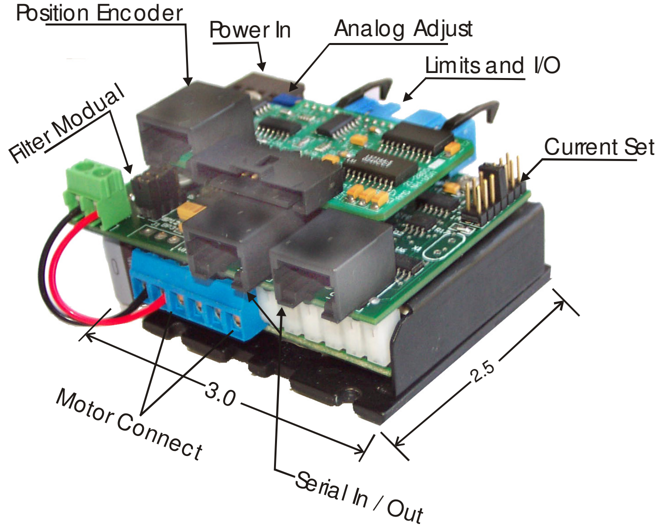
# 1) Hardware Overview

***Introduction***

This manual is intended to provide information on the hardware setup, connections and specifications for the *m*STEP-407, with analog input and encoder feedback options. Please refer to the SMC-40 (step motor control IC) Software Guide for non-volatile memory and program command instructions.

The *m*STEP-407 intelligent step motion controller is a complete indexing "subsystem" packaged and priced to save space and money. Employing the latest surface mount technology, the *m*STEP-407 includes multiple embedded controllers, forming a distributed processing system for operating the full-range (NEMA size 17 to 42) of step motors. In designs where more than one motor is required, up to 32 independent units can be connected from one COM port.

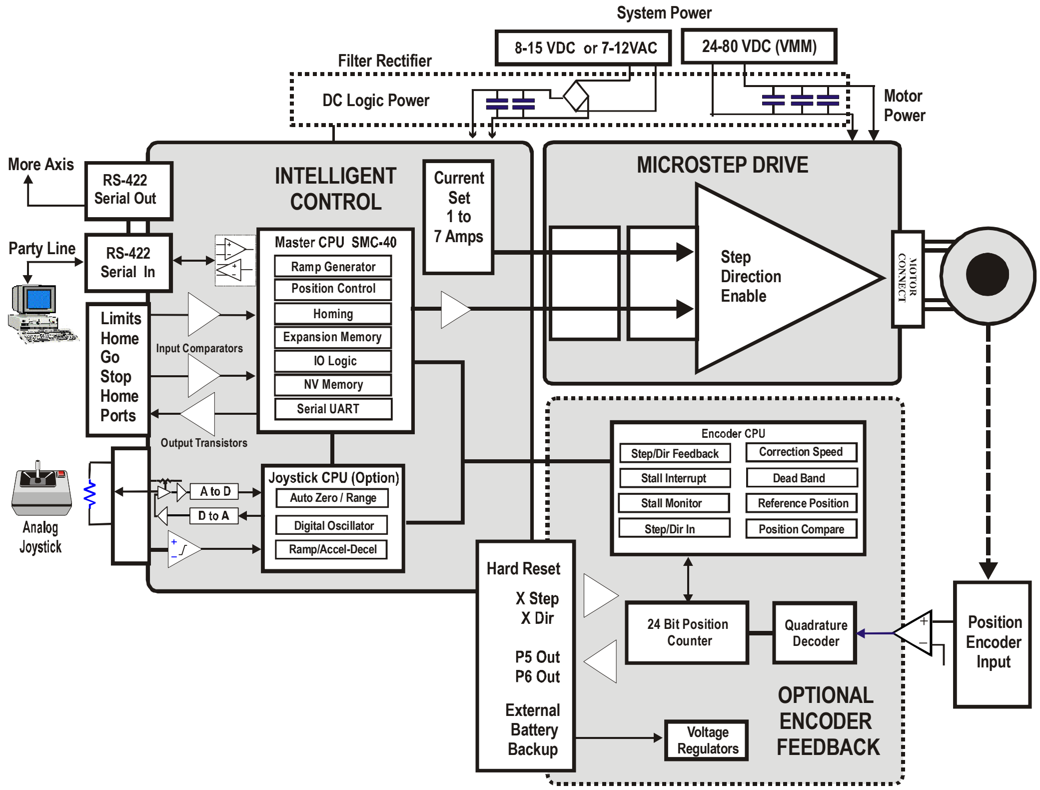
Serial communications with a "host" computer allows simple ASCII commands to be executed as they are sent, or directed into non-volatile memory storage where pulsing the GO input triggers execution. When interfaced to a COM port, using AMS' new intelligent serial adapter (SIN-11), total power consumption is low because of the CMOS design. Step and direction signals can be sent to multiple drivers.




***Features***

- Small Size- 3.0"W, 2.5"D, 1.5"H (76.2mm, 63.5mm, 38.1mm)
- Settable up to 7 Amps per phase at 24 to 80 VDC
- 10 microsteps per step
- Size 17 to 42 motors
- Non-volatile memory for stand alone operation
- Multiple control from a single COM port
- Speeds to over 60,000 steps/second
- Step, direction outputs
- Limit and Home inputs (range 5 to 28 volts)
- Go and soft stop inputs (range 5 to 28 volts)
- User import ports (range 5 to 28 volts)
- Outputs at ½ amp
- Power filter for added capacitance
- Industry standard connectors
- Options:
  Analog "joystick" input
  Encoder feedback for closed-loop operation

### *Block Diagram*




### *Intelligent Control*

The master CPU is the hub of the *m*STEP-407 operation. It performs numerous tasks, including:

1. Serial communication to the Party Line network.
2. Generating the ramped step and direction signals.
3. Application program storage and execution (stand alone or by command).
4. Parameter input, execute and storage.
5. User input, output, go and stop.

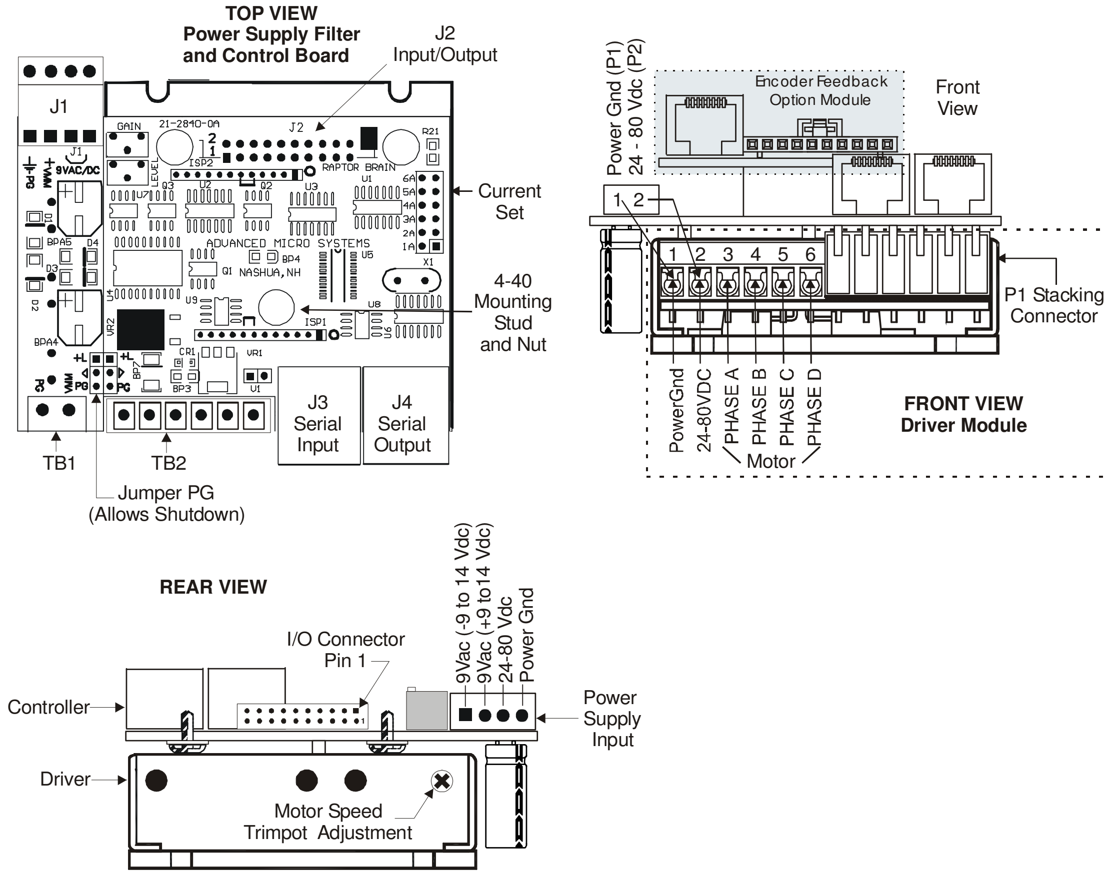
Available options include analog "joystick" control and encoder feedback for closed loop operation.

Model number configurations are as follows:

| Model | Option |
|---|---|
| *m*STEP-407 | Step Motor Control System |
| -50 | 50 VDC Power Filter (970uF) |
| -80 | 80 VDC Power Filter (300uF) |
| A | Analog Input |
| E | Encoder Feedback |

Example: *m*STEP-407-80E
Specifies a unit set for 80-volt power filter, and encoder feedback.

### *Top, Front and Rear View- mSTEP-407*




### *Installation Notes*

The *m*STEP-407 consists of two main components, the controller board and the driver. To mount the *m*STEP-407 to your heatsink, and/or to change the auto current reduction feature, the controller board must first be disconnected from the driver and the driver cover removed, as follows:

1. If you have the encoder option board, carefully disconnect it from the controller board by pulling up, with equal pressure from both sides, until the pins are separated from the sockets.
2. Remove the 4-40 mounting stud nut as indicated in the above drawing.
3. Carefully remove the controller board by pulling up on the P1 stacking connector and disengaging it from the driver. Be careful not to damage or disconnect the ground and power supply connect wires from pins 1 and 2 on the controller and driver.
4. Remove the power/motor connector (pins 1 – 6) by pulling the connector body upwards and off the mating header pins on the driver.
5. Remove the two screws from the bottom of the mounting plate. Slide the cover back and up to remove. This will allow clearance for securing the mounting plate to your heatsink.
6. Make any necessary changes to the auto current reduction option as described below.
7. Reinstall the cover. Before mounting to your heatsink, use heatsink compound on the bottom of the mounting plate. Heat sinking for current settings greater than 3 amps is required. The case temperature (measured on the bottom plate) should not exceed 70 degrees C and for best life should be kept to 50 degrees or less.
8. Once mounted, reverse steps 1 – 4 for final installation.

***Auto Current Reduction Option***

Often it is desirable to reduce motor current during periods when the motor is not in motion. Settings can be made to either the *m*STEP-407 controller board or the driver module (or a combination of both).

***m*STEP-407 Controller Board**
The "E" command sets a delay to shut off all current. An "E" value of 255 will prevent a timed shut-off and allow the setback current to be reduced to 50% of the run current, approximately one second after the motor has stopped.
.
**Driver Module**
In some designs, when encoder feedback is used or full hold torque is required, it may be necessary to disable the setback current. In this case, the driver must be opened, and the appropriate DIP switch re-configured for no standby current - see section "DIP switches inside the driver module". Note that the "E " command will still shut off the driver when a non-255 value is used.

***Note: The mSTEP-407 controller can also disable all current after motion stops (reference "E" command in the SMC-40 software manual).***

***DIP Switches inside the Driver Module***

Certain driver settings can be configured by the user based on DIP switches inside of the driver module. The table below summarizes the available options. To access the DIP switches please follow the procedure described in the section "Installation Notes" above.

DIP switch settings inside the driver module

| Switch # | Function |
|---|---|
| 9 | Auto Current Standby Enabled when in "on" position. "On" is the default when shipped. |
| 10 | NEMA-34/NEMA-42 size motor enabled when in "off" position. "On" is the default when shipped. |

For the auto current standby option please see the previous section.

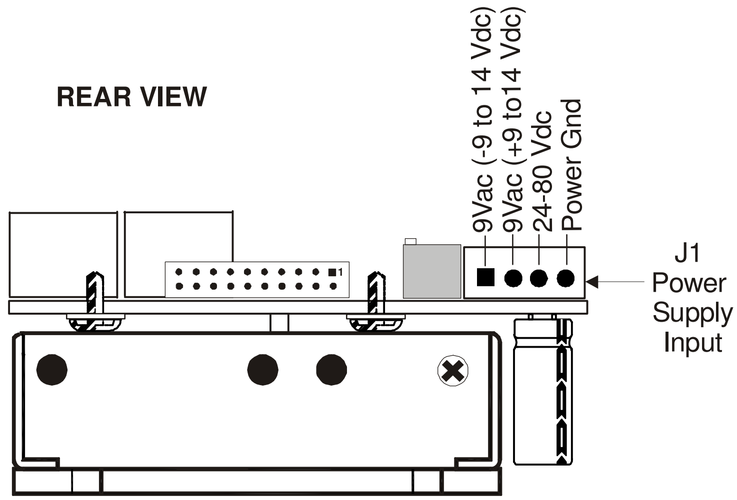
DIP switch number 10 when set to "off" adjusts mid band compensation for optimum performance when using NEMA34 or NEMA 42 motors.

***Power Supply Input (J1- 1, 2)***

The choice of power supply voltage depends on the high-speed performance required of the motor. Doubling the voltage doubles the motor's high-speed power. In all cases, the power supply voltage should be no less than 4 times or no more than 25 times the motor's rated voltage. The motor may not run as smoothly as possible if the power supply voltage is less than 4 times the motor's rated voltage. A power supply voltage greater than 25 times the motor's rated voltage may overheat and damage the motor, even if it is not turning. Motor winding inductance should be 500 uH or greater.

The connector at the rear of the power filter module provides power supply inputs. Power supplies need not be regulated, as long as the output voltages do not exceed the maximums specified (don't forget to consider high mains/AC line voltages). Switching power supplies are not recommended, as surge currents could trigger over current shutdown.

The high power motor supply may range between 24 and 80 VDC. Suggested power (volt-amp) ratings would range between 40 and 160 VA dependant on motor size. 80 VA will be adequate for most applications. The voltage choice governs high-speed performance. Please consult the motor speed-torque curves.




The controller is optically isolated from the motor driver

**Power Input**

| *m*STEP-407 | Signal | Description |
|---|---|---|
| J1-1 | POWER Ground | Motor power supply minus |
| J1-2 | POWER + | Motor power +24 to 80 VDC |
| J1-3 | Logic power | 10-15 Vdc or 7-11 VAC |
| J1-4 | Logic power | 10-15 Vdc or 7-11 VAC |

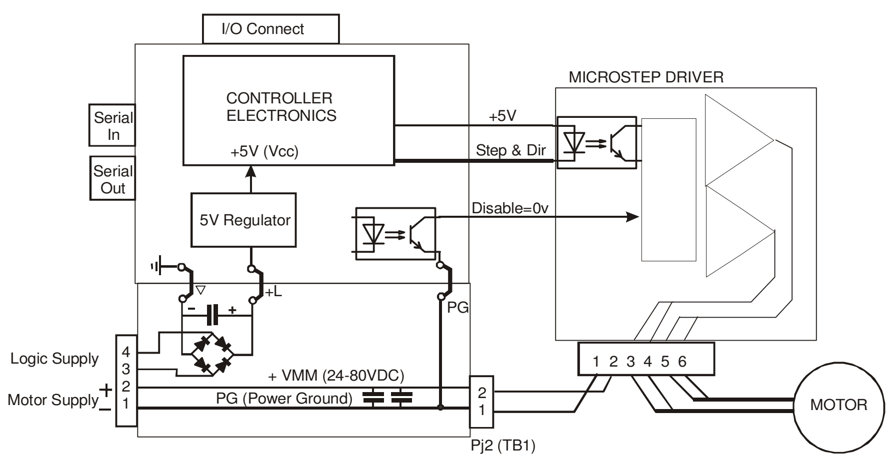
**Logic Power (J1- 3, 4)**

The power filter logic power circuit implements a bridge rectifier and filter capacitors, thus either AC or DC voltage may be applied. The logic power is regulated to 5 VDC on the *m*STEP-407. Maximum current with all options including an encoder and a SIN-11 serial adapter will not exceed 175mA. A small 9 VAC, 500mA modular supply is a good choice for the logic input. In designs with a regulated 5V DC available, you can alternately power the logic using the I/O connector.

**NEVER Apply AC voltage to any inputs, except J1-3and 4.**

### *Power Supply Specifications*

The *m*STEP-407 consists of two separate, fully opto-isolated, components. The power driver is a "chopper" design that regulates current into the motor windings, generating sine and cosine waveforms necessary for microstepping. The motor supply (Vmm) may range between 24 and 80 VDC. The choice is highly dependant on motor characteristics and performance requirements.



The logic "controller" section consists of microprocessors, a logic encoder and analog processing.

| Supply Voltage | Minimum | Suggested | Maximum | J1 Connection |
|---|---|---|---|---|
| Motor Supply Common (Vmm-) | | 0 VDC | | ,J1-1(-) |
| Motor Supply (Vmm+) | 24 VDC | 40 VDC | 85 VDC | ,J1-2(+) |
| *Logic (VL) Option 1 | 7.5 VAC | 9 VAC | 14 VAC | J1-3 and 4 |
| or | | | | |
| *Logic (VL) Option 2 | 10 VDC | 12 VDC | 20 VDC | J1-3 and 4 |
| or | | | | |
| *Logic (Reg. Vcc) Option 3 | 4.6 VDC | 5.0 VDC | 5.5 VDC | J2- 2(+) |
| *Logic (Return) Optional 3 | | 0 VDV | | J2-1(-) |

*Use only one of the three possible logic power source.

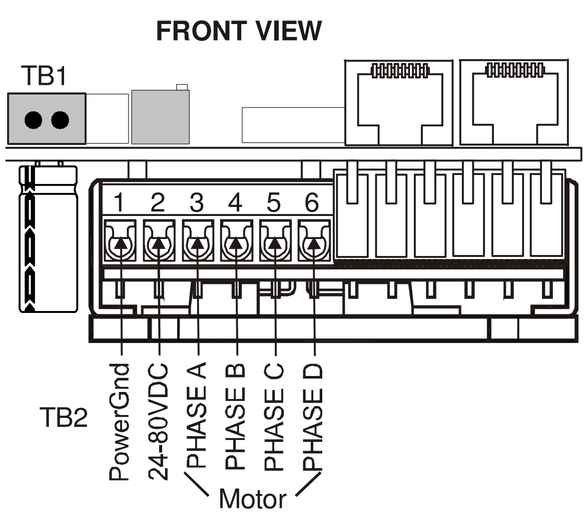
The supply inputs are located on a separate area called the filter or "conditioner."

**Motor Power Supply (Vmm)**
Multiple electrolytic capacitors across VMM provide additional drive stability. While the standard 80-volt model will generally work over the full Vmm voltage range, if VMM will be less than 50 VDC, then the 50-volt option should be chosen as it provides a higher capacitance.

**Logic Power Supply (VL)**
This input is applied to a low voltage bridge rectifier followed by filter capacitors and a 5-volt regulator. The bridge design allows either low voltage AC or DC voltage with protection against polarity reversal.

While it is possible to obtain the logic supply (VL) from the higher (Vmm) motor drive supply, it is discouraged because of the possibility of erratic operation or damage from ground voltage spikes.

***Motor Connection (TB2)***




**CAUTION! Damage to the *m*STEP-407 will occur if the motor leads are shorted to each other or to ground and/or the motor is plugged or unplugged when power is applied.**

**PHASE A** Connect one motor winding to terminal 3.
**PHASE B** Connect the other end of the winding to terminal 4.
**PHASE C** Connect the other motor winding to terminal 5.
**PHASE D** Connect the other end of the winding to terminal 6.

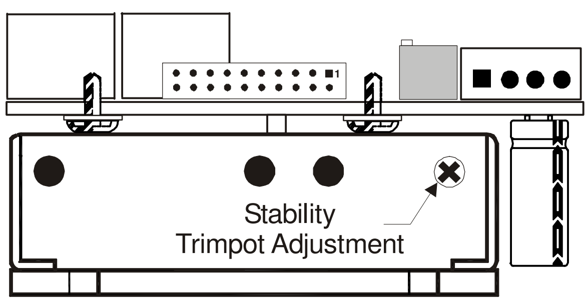
Turn the power supply off when connecting or disconnecting the motor. If the motor turns in the wrong direction, reverse the motor winding connections to terminals 3 and 4. Motor direction may also be reversed by using the "l" (lower case L) command.

A 4-wire, 6-wire or 8-wire motor may be used. When 6-wire motors are used, they may be connected in half winding or full winding. This is equivalent to an 8-wire motor connected in parallel or series. If a motor is connected in series or full winding, the motor's phase current rating is half of its parallel or unipolar rating. The choice depends on the high-speed performance required; a parallel-connected motor will provide twice the power of a series-connected motor at the same power supply voltage.

### *Stability Trimpot Adjustment*

This trimpot adjusts the motor for the smoothest possible low-speed operation. Set the motor speed to about 500 microsteps per second (1/10 microsteps), and then turn the trimpot until a distinct null is noted in the motor's vibration. This will result in the most even microstep placement for a given motor and power supply voltage.

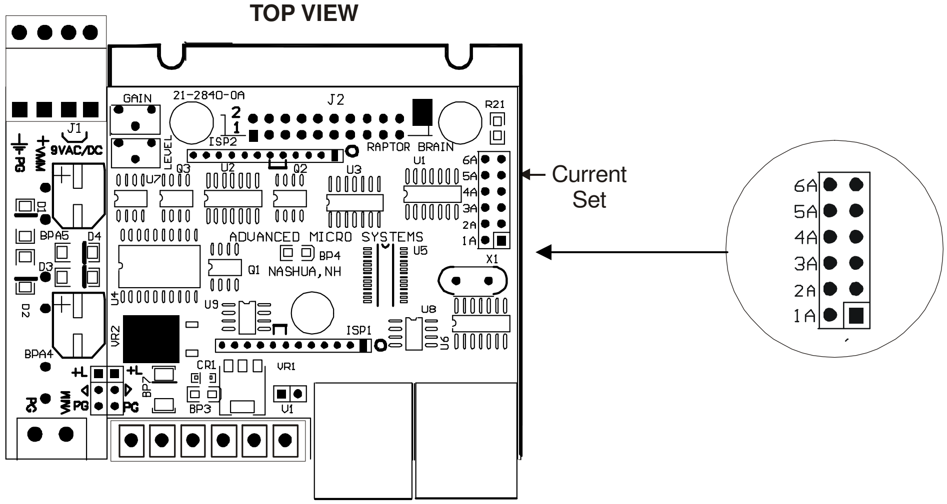
**REAR VIEW**




### *Current Setting*

The *m*STEP-407 can be set for 1 to 6 amps (peak) motor current by installing the current set jumper as indicated below. For 7 amps the jumper is removed.

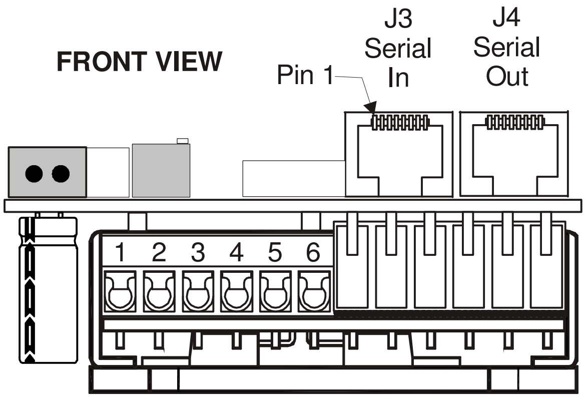
**TOP VIEW**




***Note: Damage to the motor can occur if the driver setting exceeds the motor rating.***

***Serial Connections In (J3), Out (J4)***

Two 8-pin RJ45 connectors provide the serial interface used to communicate with a “host” computer, most commonly a PC. The baud rate is 9600, 1start bit, 1stop bit, 8 data bits no parity.




The communication is full duplex, 4-wire RS-422.

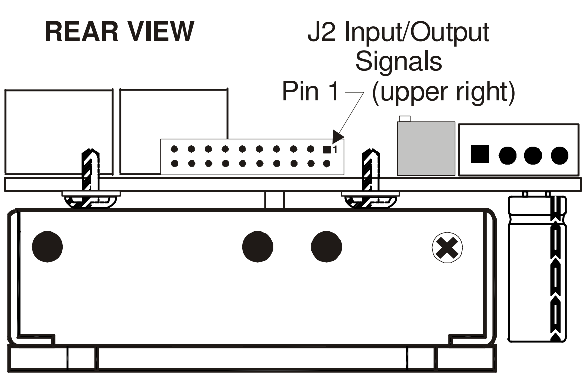
| Pin | Name | Function | Note | Pin | Name | Function | Note |
|---|---|---|---|---|---|---|---|
| 1 | MVG | Moving | Open drain | 5 | TX+ | Out | To party line |
| 2 | GND | Power | Logic common | 6 | RX+ | In | From party line |
| 3 | RX- | In | From party line | 7 | +5V | Power | Supply serial adapter |
| 4 | TX- | Out | To party line | 8 | PTY | None | Unused |

* +5V is not connected on the output (J4) connector.

If only one controller is used in the application, an RS-232 interface adapter (model SIN-9) may be used. The preferred interface however, is AMS model SIN-11 (RS-232 to RS-422). It’s internal microprocessor performs the necessary handshaking and has a number of useful functions for one or multi-axis applications. The SIN-11 also may be connected to a USB port, using a standard serial adaptor.

***Standard Input/Output Signals (J2)***

A 20 pin IDC connector provides all input and output functions. Inputs are buffered through comparators, capable of withstanding 28 volts. Buffered output signals, except step and direction, can sink in excess of 0.5A @ 28 volts, non inductive.



| J2 Pin | Name | Function | DB-25 Pin | | J2 Pin | Name | Function | DB-25 Pin |
|---|---|---|---|---|---|---|---|---|
| 1 | GND | Power | 1 | | 2 | VCC | +5V power | 14 |
| 3 | P1 | Input | 2 | | 4 | P2 | Input | 15 |
| 5 | P3 | Input | 3 | | 6 | P4 | Output | 16 |
| 7 | P5 | Output | 4 | | 8 | P6 | Output | 17 |
| 9 | LimA | CW stop | 5 | | 10 | LimB | CCW stop | 18 |
| 11 | Home | Input | 6 | | 12 | Stop | Input | 19 |
| 13 | Step | Output (5V) | 7 | | 14 | Dir | Output (5V) | 20 |
| 15 | MVG | Output | 8 | | 16 | VIO | In/Out | 21 |
| 17 | Go | Input | 9 | | 18 | Ana | Analog | 22 |
| 19 | VCC | +5Vpower | 10 | | 20 | Gnd | Power | 23 |
| X | | | 11 | | X | | | 24 |
| X | | | 12 | | X | | | 25 |
| X | | | 13 | | | | | |

“DB25” refers to an external ribbon cable connected via “D” connector

All inputs and outputs have 10k pull-up to 4.7 VDC (VIO). The logic threshold is set at 2.5 volts (VIO/2). VIO may be externally increased to a maximum of 24Vdc. The logic threshold will increase proportionately. Note, the inputs will withstand the higher voltage, even if VIO remains at the default 4.7 VDC.

**GND (J2-1 and 20)**
Logic ground. This common is isolated from the driver common. It is not available on other connectors, including J1- power input.

**VCC +5 Volts Power (J2-2 and 19)**
Produces 5-volt power used by the logic. This is also used to power active serial adapters via the serial connector (J3) at 50mA maximum. The logic power (9-12 volt) input is regulated to produce +5 volt logic power. Alternately a separate regulated +5 volts may be applied to as a substitute for the logic power input located on J1-2 and 3).

**Step Out (Step) (J2-13)**
Low going (sinking) pulses are applied to the driver. The driver has an intrinsic resolution of 1/10th microstep. Minimum pulse width is approximately 1.4 microseconds. The step and direction can drive more than one driver where identical motion control (slaving) is desired.

**Direction Out (DIR) (J2-14)**
This signal responds to the specified direction as determined by the motion action.

**Moving (MVG) (J2-15)**
This signal is low while moving and returns high after motion stops. On stopping motion, a timeout is triggered. The delay is specified by the “E” command. Please note that if automatic output shutdown is not desired, the “E 255” command will prevent shut down and the auto current reduction (setback) will be controlled in the driver.

When shutdown occurs, drive outputs will turn off and all holding current is lost. This signal, isolated by a diode, is also available on the serial connector. This or’ed version may be poled by the host as an “any controller moving” signal. The individual moving signal can be used to shut down the drive when motion stops.

**Go Input (J2-17)**
A pulse (>25 mS) into the go input causes a stored program to start executing at memory location 0 (zero). If the GO input is held on, program execution will restart again.

**Stop Input (J2-12)**
A pulse (>25 mS) into the stop causes indexes and running programs to stop.

**Home Input (J2-11)**
This input is used with the "F" command, to perform a find home function. The master moves in a direction based on the input level, finding the point where the input changes state. This is usually performed after power up to set a start "0" point.

**Limits (CW, CCW) (J2-9 and 10)**
The primary purpose of these inputs is to prevent motion in a given direction. These inputs are sampled on every step, regardless of the step pulse source. Any index in the corresponding direction will be halted. However, motion is still allowed in the non-limit direction (unless both limits are activated).

When a program is executing, limits still function and the program will "skip" the indexes in the limit direction. Some applications use a limit as the "home" location finder. The normal input is a sinking (low voltage) such as a switch to ground. The limits can be inverted through use of the "l" command and will invert both inputs via software. To permit motions the limits must then be held low (failsafe).

**Ports 1, 2 and 3 (Inputs) (J2-3, 4, 5)**
The controller has three general purpose inputs that are rated for up to 28 VDC. These ports can be used by several commands:

1. A host computer can read it via the "A" command.
2. Programs can execute based on the input state including "g" (branch) and "L"(loop).

**Ports 4, 5, 6 (Output) (J2-6, 7, 8)**
The basic controller provides three output ports for general-purpose use. The normal off condition (at power-up) is open drain with a weak pull-up resistor to the VIO voltage. Turning a port on using the "A" command always asserts a "high current" sinking signal. Outputs are rated for up to 30 VDC.

**Analog Input (J2-18)**
This signal is used with the joystick option. There are two modes of operation; uni-directional and bi-directional. Speed changes, controlled by varying the input voltage, are governed with speed ramp supervision, preventing motor stall conditions caused by abrupt changes in control voltages.

Uni-directional mode starts at zero speed at zero volts input. As the voltage increases so does the step rate (speed). An internal potentiometer allows full-scale range adjustment.

Bi-directional mode starts at zero speed with 2.5 volts (center off). Increasing voltage increases speed in the + (plus) direction, while decreasing voltage increases speed in the – (minus) direction.

*Specifications*

**Power Supplies**
- Logic Supply ........ 4.7 - 5.5VDC
- Supply Voltage ........ 24 to 80 VDC

**Controller**
- Step Rate Range ........ 56 - 65,535 SPS*
- Non-Volatile Memory ........ 512 + 2048 Bytes
- Communication ........ Full Duplex RS-422, 9600 Baud
- Maximum Networked ........ 32 Axes - 4,000 Feet

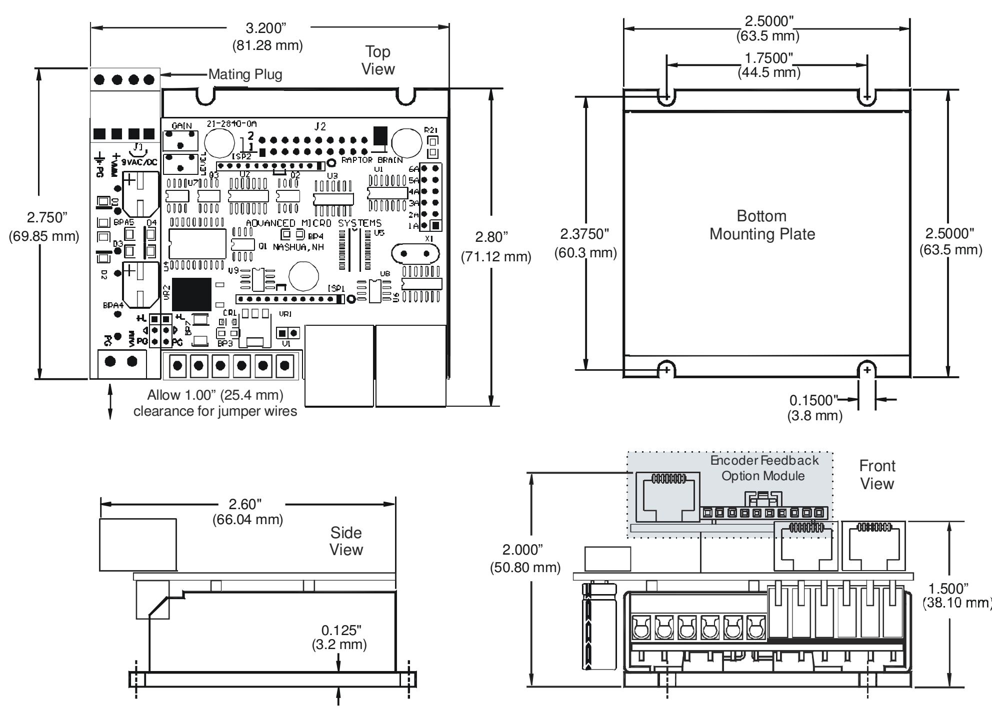
**I/O (Standard)**
- Digital Inputs (3) ........ Limits (2), Home, Go, Stop
- Outputs ........ Moving (1), User Defined (1)

**Joystick**
- Analog Joystick Input (1) ........ 0 -12V or 2.5 ± 5V
- Analog Speed Range ........ 56 - 65,535 SPS*

**Driver**
- Phase Current ........ 1 to 7 Amps and 0.3 to 2 Amps
- Auto Current Reduction ........ 33% of Set Current
- Quiescent Current ........ 15mA or Less
- Power Dissipation ........ 1 to 18 W (1 to 7 Amps)

**Physical**
- Size (*m*STEP-407) ........ 3.2"W, 2.8"D, 1.5"H (81.2mm, 71.1mm, 38.1mm)
- Size (*m*STEP-407-E) ........ 3.2"W, 2.8"D, 2.0"H (81.2mm, 71.1mm, 50.8mm)
- Mounting Pattern ........ 4 6-32 screws, 1.75" by 2.375" (44.5 mm, 60 mm)
- Weight ........ 5.5 oz. (156 gm)
- Temp ........ 0 to 70 C
- Humidity ........ 0 to 95 % (non-condensing)

*Divisible between 1 and 256



# 2) Analog “Joystick” Option

***Analog Joystick Overview (mSTEP-407-A)***

The newest products from Advanced Micro Systems are available with analog input. This input is used to generate a variable step rate frequency. The system is more than a simple voltage-to-frequency design. Input voltage is digitized with an Analog to Digital converter, and then digitally processed. The result is a stable, controlled step rate and direction function.

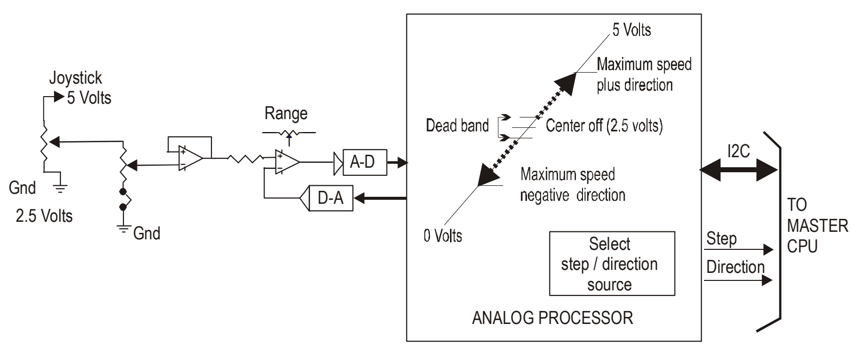
The analog joystick interface adds yet another dimension of motion control possibilities by providing the capability of speed that is proportional to the input voltage. Features include:

- A digitized analog input
- A "dead-zone" that is applied before stepping starts
- Stepping that starts at a specified rate
- Speed, governed by an acceleration setting, increases as voltage increases
- Speed, governed by a deceleration setting, decreases as voltage decreases
- A maximum speed setting
- An auto-zero function that can remove any offset
- The Auto-mode function selects uni-directional or bi-directional mode
- Two multi-turn potentiometers adjust range and gain

Probably the most advanced feature is the ability to constrain acceleration and deceleration rates. This function helps prevent step motor stall conditions that can occur when the step rate is changed abruptly. As the input voltage changes, the step rate is determined by a lookup table. The acceleration/deceleration profile is governed using the same algorithm as the standard "index" function used in the master CPU.

Input op-amps provide analog buffer and gain adjustment. As shipped, the analog circuit is preset for a 5 volt input range (unity gain) and bi-directional implementation.

The 8-bit analog to digital converter includes a voltage range of 0 to 5 volts. Assuming a joystick or potentiometer is attached and is centered, the wiper voltage should be 2.5 volts. The mode will be bi-directional with a dead-band, preventing unwanted drift to cause motion. Motion will start in the "plus" direction when the wiper voltage exceeds dead-band. Motion will be in the "minus" direction when the voltage goes below the dead-band. If the measured voltage is near zero the single direction mode is activated. The input voltage must be above the "dead-band" for motion to begin. The motor direction is controlled by the mode command. Integral ramping prevents motor "stalls" that could be caused by abrupt input changes.




**Analog Joystick Block Diagram**

Uni-directional operation always rotates in the same direction starting at zero volts input. The input voltage range and gain is adjustable by two potentiometers, allowing for a full-scale range up to 24 volts. The gain pot allows gain adjustment to accommodate joysticks with different full-scale ranges. Preferred joysticks have a 0-2.5-5.0 volt output, while others may have only ± 30% travel.

### *Definitions*

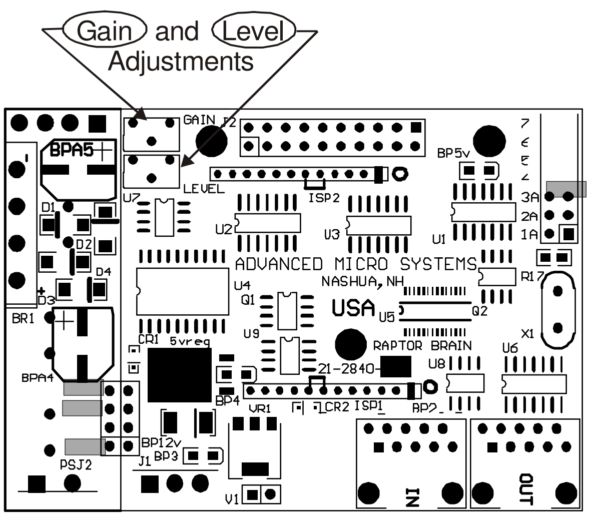
The following terms are used in the text that follows.

**Control Voltage**
This represents the internal voltage applied to the A to D converter, not the value applied to the input connector. The input voltage is buffered and amplified with op-amps gain and range adjustment potentiometers. This has a fixed range of 0 to 5Vdc.

**Input Voltage**
The actual voltage applied to the input.

**Joystick**
The most popular design is a bipolar joystick. These joysticks commonly use a potentiometer, piezoresistive, or Hall-effect sensor. The primary requirement is that the "center" position output is a voltage near 2.5 volts, ideally the full scale should be 0 to 5 volts.

### *Initial 5 Volt, Full-Scale Calibration*




This is the primary default calibration, performed at the factory.
1. Adjust the level potentiometer to maximum (full CW – 15 turns).
2. Apply 0 volts (ground) to the joystick input (pin 18).
4. Enter the command "9 1" (read out voltage). The reading should be zero or very close.
5. Apply +5.0 volts to the joystick input (pin 18).
6. Adjust the gain potentiometer CCW for a 4.98-volt reading. Insure that the adjustment is just high enough to read 4.98 or slightly less. Any reduction of voltage should result in a reading change.
7. Calibrate using the "1" command. The result should be 2.5Vdc.

***Setup Procedure, Bi-directional Joystick***

The following steps outline procedures for setting up an analog joystick system.

***Note: The joystick output must not exceed +5Vdc or be less than 0Vdc and the "Center " off must be close to the ideal 2.5 volts.***

1. Perform the "Initial 5 Volt Full-Scale Calibration" as described above.
2. Connect a center return joystick, 25k ohm or less, to the IDC connector (J2) as follows:
   2a. Wiper ……..Pin 18….. 2.5Vdc
   2b. High Side….Pin 2…….+5Vdc
   2c. Low Side…..Pin 1…….Gnd (common)
3. Turn on power and measure the wiper voltage with a meter. It should be close to 2.5 volts.
4. Sign on with space bar.
5. Enter the "m4" command to force bi-directional mode.
6. Enter '9 1.' The reading should be close to 2.5 volts.
7. If necessary, adjust joystick center for proper reading if a trim mechanism is provided or you have included it in your design.
8. Move joystick to travel extremes. Voltage should be symmetrical, slightly under 4.98 volts and slightly above zero.
9. Adjust gain to obtain a symmetrical voltage swing. The center voltages must remain 2.5 ± 0.5 volts. Note that this adjustment may modify the center (2.5) voltage. It is preferred that this offset should be less than 0.25 volts.
10. Enter "1" (calibrate command). A reasonable offset is corrected and the analog input is enabled.

***Setup Procedure, Uni-directional Joystick***

The positive control voltage is applied between pin 1(-) and pin 18(+) of the J2 connector. This mode allows for three voltage input ranges as follows:

***Note: For each situation, perform the "Initial 5 Volt Full-Scale Calibration" as described above, if necessary.***

**#1 Range: 0- 5 volt full-scale**
No additional adjustment is required.

**#2 Range: 0-1 to 0-4.9 volt full-scale**
1. Apply the full-scale voltage to the analog input.
2. Sign on with space bar.
3. Enter "m3" to force uni-directional mode.
4. Enter "9 1" readout.
5. Increase the gain potentiometer (CW) to obtain a 4.98-volt full-scale reading.

**#3 High voltage range – above 5 volts full-scale**
Voltage up to 24Vdc may be used to control speed. The input **must** be attenuated with the level control. Failure to do so can cause damage not covered by warranty.
1. Adjust the level potentiometer to minimum (15 turns CCW).
2. Apply the full-scale voltage to the analog input.
3. Sign on with space bar.
4. Enter "m3" to force uni-directional mode.
5. Enter "9 1" readout.
6. Increase the level potentiometer (CW) to obtain a 4.98-volt full-scale reading.

Once the setup is completed, the "1" auto calibrate command may be used at power up- provided that the analog voltage is within the auto calibrate range (2.5 volts for bipolar or zero volts for uni-directional). See the “go on power up” feature (G command) in the SMC-40 Software Guide for details.

Example:
P 192
G50 *Jump to address 50 to allow more commands.
P0

P 50
*Zero command, calibrate and enable analog.
P 0

S1 *Save

Notes
For both bi-directional and uni-directional operation, the following notes apply:
1. The disable command is “m0.”
2. The enable command is “m3” uni-directional and “m4” for bi-directional.
3. The m command does not effect calibration.
4. Any index or motion command will disable joystick operation. Use the “m3 or m4” command to re-enable.

# *3)* Encoder Feedback Option

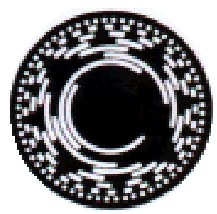
***Introduction to Encoders***

An encoder is an electro-mechanical “sensor” that is useful in any system that requires position measurement or tracking. The primary use is to track and read the position of a system component such as a robotic arm, radar antenna, or slide driven by a motor.

The most common design is the rotary slotted disk where a series of slots open and close the light source with movement. Photo detectors then produce digital signals.

There are two basic types of encoders, Absolute and Incremental.

**Absolute Encoders**



Absolute encoders output a unique digital numeric for any given position of the encoder's rotation. They are used in applications where a device is inactive for long periods of time or moves at a slow rate, such as flood gate control, telescopes, cranes, valves, etc.

The rotary absolute encoder design uses a precision wheel with a number of concentric tracks, with each track representing one bit of accuracy. Typically, the optical wheel is encoded with gray code rather than binary. Since computers operate in binary the advantage of this design is that the position can never be lost. Disadvantages are higher cost, wiring is more complex and power consumption is higher.

**Incremental Encoders**

The more common encoder is the incremental design. An incremental encoder produces a series of square waves as it rotates. The number of square wave cycles produced per one turn of the shaft is called the encoder resolution.

Incremental encoders work by rotating a code disc in the path of a light source, with the code disc acting like a shutter to alternately shut off or transmit the light to a photo detector. Thus, the resolution of the encoder is the same as the number of lines on the code disc. A resolution of 500 means that the encoder code disc will have 500 lines on it and one turn of the encoder shaft will produce 500 complete square wave cycles, each cycle indicating one degree of shaft rotation.

Since the resolution is "hard coded" on the code disc, optical encoders are inherently very repeatable and, when well constructed, very accurate. They also have no error accumulation as you might experience with analog sensors, and the square wave output is inherently easy for digital signal processing techniques to handle.

Generally, incremental encoders provide more resolution at a lower cost than their absolute encoder cousins do. They also have a simpler interface because they have fewer output lines. Typically, an incremental encoder would have 4 lines; 2 quadrature (A and B) signals, a power and a ground line.

A 12 bit absolute encoder, by contrast, would use 12 output wires plus a power and ground line. Incremental encoders are usually supplied with two channels (A and B) that are offset from one another by 1/4 of a cycle (90 degrees). This type of signal is referred to as “quadrature” and allows the user to determine not only the speed of rotation but its direction as well. By examining the phase relationship between the A and B channels, one can determine if the encoder is turning clockwise (B leads A) or counterclockwise (A leads B).

### *Encoder Feedback Option (mSTEP-407-E)*

Advanced Micro Systems designs include a quadrature decoder circuit with filtering. This design produces a 4X output. With a quality disc and properly phased encoder, this 4X signal will be accurate to better than 1/2 count. A 500-line encoder mounted to the rear of a stepper motor will generate 2,000 counts per revolution.

**Mounting Design**
The preferred attachment is a 1:1 mechanical mount on the step motor shaft. This eliminates effects from system backlash and because AMS can supply the motor/encoder combination, the need for special brackets or couplings is eliminated.

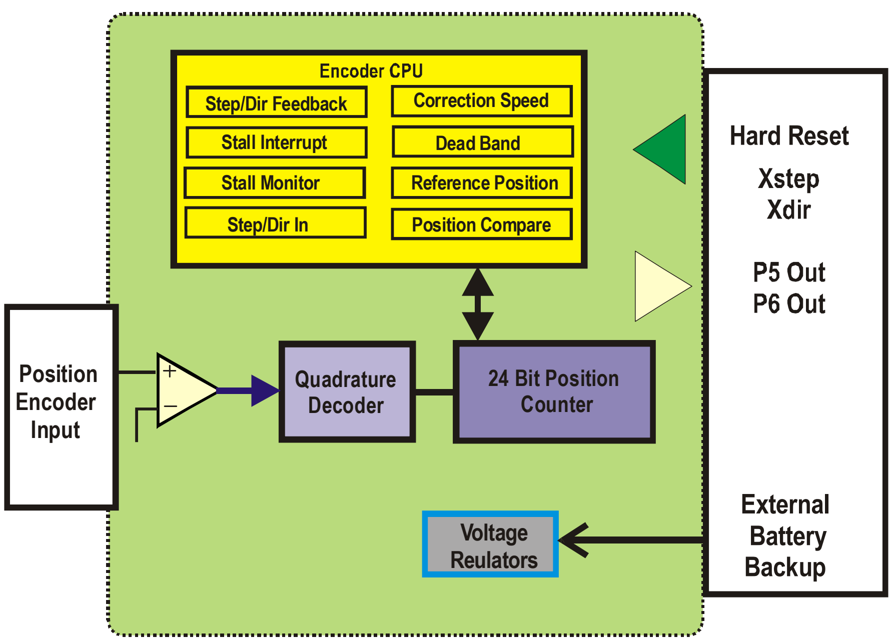
It is possible to mount the encoder to other parts of the system, for instance a linear (picket fence) encoder could be mounted to a slide. Attention must be paid to the encoder resolution vs. microstep resolution. We recommend microstep resolution of at least ¼ step or better. If full-step resolution is used, each motor step would represent 10 encoder (2000/rev) counts. This would require an increased deadband to prevent "servo" oscillating effects.

In addition to the two channel inputs, index pulse homing is possible. A feature with the *m*STEP-407-E includes provision for battery backup to prevent position loss and operation with almost any resolution encoder. The encoder option (E) may co-exist with the analog option (A).

Features include:

- Use with 50-1024 line (CPR) encoders
- Monitor for stall condition during index
- Retry index "n" times upon stall detect
- Position maintenance mode with deadband
- Battery backup input to keep position registers

### *Block Diagram (mSTEP-407-E Option)*




ENCODER MODULE

***Operation***

The encoder system is composed of the following components:

1. Input buffers receive encoder signals A-B, and optional index pulse. While designed to operate with 5-volt signals, the inputs will also work with 24-volt signals.
2. Quadrature input that decodes encoder A-B signal to obtain 4X resolution. For instance, a 500 "line" encoder will produce 2,000 counts per revolution.
3. A 24 bit bi-directional counter that tracks incremental encoder position at count rates to 1 MHZ.
4. A Control Microprocessor (CPU) that provides stall detection, and re-position outside dead zone control and math functions to convert encoder motion commands into step motor index distance. The CPU communicates with the master (*m*STEP-407) microcomputer via serial bus and step and direction signals to maintain/monitor target position and encoder counter position.

The encoder CPU receives the parameter information: encoder resolution, microstep resolution, deadband size, allowed lag, and hunt speeds. On receipt of an index command, the CPU calculates a number for the "step index" and stall monitoring is started by loading the retry counter. The CPU counts the master (*m*STEP-407) step motor steps and samples the actual encoder position periodically. If the distance traveled is less than the specified lag distance, then a stall condition is triggered. The CPU decrements the stall-retry counter and notifies the *m*STEP-407 of the stall event. One of two operations are triggered:

1. If the retry count is not zero, a new index is computed from the actual position and target position. The *m*STEP-407-E will initiate a new (hopefully shorter) index. If subsequent stall detects occur, the retries continue until the retry counter reaches zero. The position maintenance mode is then started.
2. Hunt (position maintenance) is used when the encoder position wanders outside of the specified deadband (encoder count) distance. The encoder CPU generates step and direction signals to force the position to be equal the target position. The "hunt" speed is specified with the "v" (lower case V) command. The step-rate is without ramp and is RPM compensated for the specified microstep resolution.

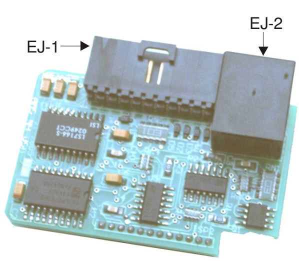
If the hunt mode is triggered because of an early stall exhaust, the step distance can be large. If the motor motion is obstructed, stepping attempt will be continuous, until an abort is executed. Whenever the position drifts outside the deadband, repositioning to the target position will be exact (as opposed to just within the deadband).

**Battery Backup**

The battery backup input implements a 5-volt low dropout regulator that will maintain a power supply to the counters and encoder. The electronics consume less than 10mA. Typical encoders require between 20 and 100mA, dependant on model and features.

***Encoder Hardware***

The encoder option is a separate module that plugs into the *m*STEP-407. Two interface connectors, EJ-1 and EJ-2, provide additional signal connections.




EJ-1 is a 12 contact signal connector (Molex SL Crimp series). EJ-2 is an 8 contact RJ45 encoder input connector.

***Supplemental Signal Connector EJ-1***

| Pin | Name | Signal | Function | Type |
|---|---|---|---|---|
| 1 | BUB | Battery | Backup input 8-15 VDC | 10mA |
| 2 | GND | GND | Power common | Earth |
| 3 | RST | Reset | Hard reset | Input |
| 4 | GPI | GP Input | Currently undefined | Input |
| 5 | DIR | Dir/Phase A | External direction / Shuttle Encoder A | Input |
| 6 | STP | Step/Phase B | External step pulse/ Shuttle Encoder B | Input |
| 7 | | Reserved | | |
| 8 | P5 | Port 5 | User port 5 | Output 500mA |
| 9 | P6 | Port 6 | Fault output /User Port 6 | Output 500mA |
| 10 | BU5 | BU5 | Back-up 5 volt | |

**Pin 1- BUB (Back up battery input)**
This provides a keep-alive power of the encoder and related circuitry. When the main power supply is off, the battery is used to provide an absolute like encoder and position will not be lost as long as the battery voltage is above 7 VDC. Under normal powered-up conditions, consumption from a 9-volt source is about 10mA. During a power-fail situation, the encoder's requirements determine current consumption. Typically, encoders consume between 30 and 100mA.

**Pin 2- GND**
This is the power common for the *m*STEP-407-E logic power supply.

**Pin 3- Hard Reset**
When implemented, a low on this input will cause a complete system reset.

**Pin 4- GP Input**
This input is not defined yet.

**Pin 5- DIR/Phase A**
**Pin 6- Step/Phase B**
These two inputs are used for motor positioning by either a step pulse with direction input (mode "m5" command) or A-B encoder input (mode "m6" command). This feature allows a rotary, typical panel mounted encoder, to be used to tweak motor positions. Motor position and speed change will be directly proportional to changes in the encoder. Hence, it is commonly referred to as a shuttle or follower encoder.

Again, this is NOT encoder feedback. This feature requires the analog option. The electronics is physically located on the main *m*STEP-407 board. The connections are made via the encoder board. Neither of these functions have any relation to encoder feedback. In fact, any encoder feedback functions are disabled while in this mode.

**Pin 7- Reserved for future use**

**Pin 8, Pin 9- Output ports 5 and Port 6***
These are two additional general-purpose output ports controlled by the "A" command. These open drain outputs can sink a minimum of ½ amp and have weak (10k) pull-up resistors to VIOE. Higher voltage devices may be driven but a stronger external pull-up resistor may be required if the outputs must be at a higher potential than VIOE.

*** Port 6 may also be used as a hardware "Fault" output. Reference the following description.**

**Pin 9- Fault Output (Port 6)**
This is an alternate function available when encoder feedback is implemented. A FAULT condition is signaled when one of two possible events occurs:

**1. Hunt Time Fault**
Upon failure to reach the target position (hunting) within the specified time, the fault output will be turned on (low voltage sinking output). The “w nnn” (lower case) command is used to specify this condition. If hunt distance is enabled, it will be disabled.

**2. Hunt Distance Fault**
This fault detection limits the number of steps that will be supplied to the driver after entering the hunt mode. The “x nnn” (lower case) command is used to specify this condition. If hunt timeout was enabled, it will be disabled.

The “q nnn” (lower case) command is used to read and reset the fault flags. See the SME-40 software section of the SMC-40 Software Guide.

**Pin 10- BU5**
5 volts from battery, VCC, or regulated 5 volts.

***Encoder Input Connector EJ-2***

| Pin | Name | Function | Type |
|---|---|---|---|
| 1 | | Reserved | |
| 2 | GND | Gnd | Power supply COMMON |
| 3 | | N/C | |
| 4 | QA | Phase A | Quadrature signal from encoder, typically 5V (withstand 15V) |
| 5 | | N/C | |
| 6 | QB | Phase B | Quadrature signal from encoder, typically 5V (withstand 15V) |
| 7 | VIOE | VIOE* | Output to encoder (75mA max) maintained if battery backup is implemented |
| 8 | | 5V Reg. | Regulated battery voltage, may be useful for test |

*Encoders requiring high supply current should be powered externally.

**Pin 2- Gnd**
Power Ground (return) is common to all electronics within the *m*STEP-407-E. Do not allow excessive ground current to flow as it may cause damage not covered by warranty.

**Pin 4 and 6- Quadrature Signals**
The AB quadrature signals are processed to obtain count and direction. The 24-bit position counter tracks changes of position.

**Pin 7- VIOE “Voltage Input-Output for Encoder”**
Most applications will use this to power the position encoder. Recommended encoders consume less than 50mA. Special applications may use higher voltage power and/or logic levels. In these designs, this pin can be used as a power input.

The following signal characteristics are determined by VIOE:
1. Logic threshold for all inputs on this module (QA, QB, RST, GPI, DIR, STP).
2. The threshold equals 0.3*VIOE (default 1.5 volts when VIOE= 5 volts).
3. Port 5 and 6 outputs have 10k pull up resistors to VIOE.

***Calibration in Application***

Where there are several “variables” that may be unknown or not readily available (including step resolution, picket fence encoders, encoder resolution and/or mechanical “gear” ratio) the following technique may be used to “measure” the unknown parameters.

You must be able to determine when the motor shaft has made one revolution (several full revolutions can be used if the results are scaled appropriately.

After power up and sign-on, in single axis terminal mode, perform these steps:

| Step | Command | Remark | Note |
|---|---|---|---|
| 1 | e 0 | Turn off encoder | |
| 2 | O 0 | Reset position | |
| 2 | Z 1 | Display both positions | Upper case Z |
| 3 | +nnn | Determine steps for full revolution of motor | See “h” command |
| 4 | | Read and note encoder value (must be positive) | + yyy |
| 5 | R 0 | Return to zero position | |
| 6 | | Repeat steps 3 to 5 to verify | |

Enter the values:

“h nnn” – micro steps per revolution

“e yyy/4)” - line count is ¼ readout

All numbers must be integers.

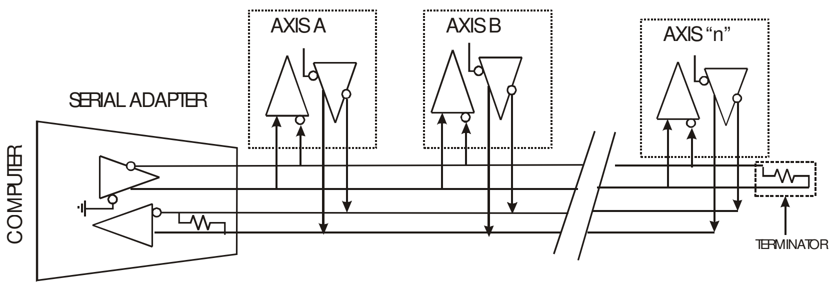
# 4) Addendum

### *RS-422 Hardware*

AMS communication protocol is an RS-422 design that uses RS-485 rated circuits. This interconnect is comparable to a LAN configuration. The hybrid design merges the best of both EIA specifications and maintains compatibility with EIA RS-422 and features:

- Multi drop serial bus
- Full duplex connection; receive data is one pair of wires and transmitted data a second pair
- Zero to five-volt differential signals for high speed and robust noise rejection over long distances
- Data speeds to 100K baud
- Up to 32 controllers from one COM port
- Cable network length to 1200 meters (4000 ft)
- Use for single controller “dumb terminal” mode

**RS-422 Connect**



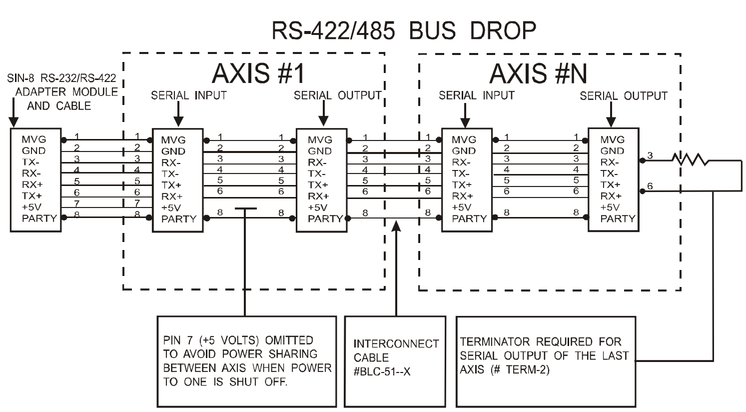

Communication hardware requires three components:

1. A serial adapter (RS-232 to RS-422).
2. A cable(s) (supplied with adapter).
3. A terminator (supplied with adapter).

### *Other Party Line Signals*

In addition to the 4 serial data bus wires, several other signals exist in the AMS party line interconnect.

1. **GND** (pin 2) is common for all devices (controller). All power supply commons are connected to prevent high common mode voltages. Please note that the power common is generally connected to the case return.
2. **+5 Volts** (pin 7) is available to power the serial adapter from the first controller.
3. **Party Select** (pin 8) is used for other products that require this input.




***Note: Pin 8- Party is not used in products utilizing the ^N and ^P commands.***

### *Serial Adapters*

AMS offers several adapters suitable for a variety of applications and budgets as follows:

**SIN-9 Passive Adapter**
The SIN-9 adapts RJ45 to DB-9 serial port. They are wired directly through with RS-232 levels passing to the appropriate RJ-45 pins. These will only interface to one controller. Application software must implement special character-by-character handshake protocol. This model is not suitable for USB interface.

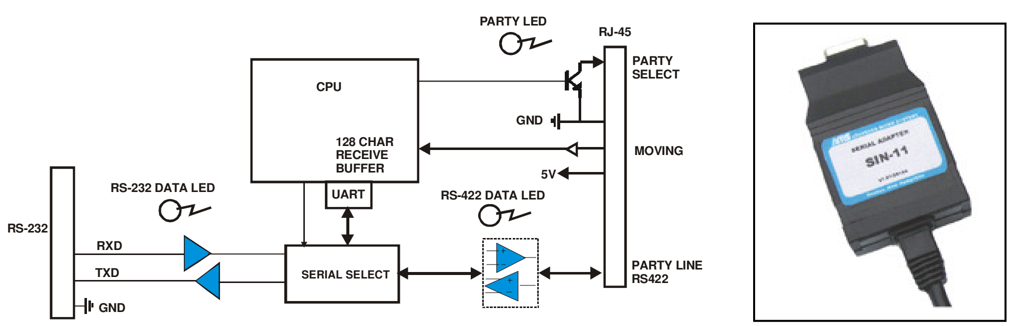
**SIN-11 Intelligent Adapter (Recommended)**
The SIN-11 is an intelligent serial line converter. The SIN-11 has a built-in microprocessor that offers a number of features:

- Converts RS232 to RS-422
- Diagnostic LED's
- 9600 baud rate
- RJ-45 party line connector
- 5 volt powered from controller
- 128 character buffers for multiple commands per line

Specific operating instructions are contained in the SIN-11 Users Guide.

The SIN-11 is also available with a USB interface instead of an RS-232 interface. The respective model name is SIN-11-USB.

Because the SIN-11 eliminates the need for special echoed character software it can be used in Windows applications where either the machine or software is slow and/or the operating system prevents direct programming of input or output instructions.




**SIN-11, Intelligent Serial Line Converter**

There are several commands that the SIN-11 can execute including: "Scan for controller present" (required initialization) and "Wait until motion complete" (one or all controllers).

On power up the IBC-400 and SIN-11 all start in the Single Controller mode where characters pass directly between the RS-232 and RS-422 bus. However, the SIN-11 monitors the ASCII stream for the presence of the special "&" character (several other trigger characters are also available).

When the "&" is detected, the CPU awakens and performs several actions:

1. Isolates input (RS232) from output (RS422).
2. Asserts the party select signal (pin 8) to the "on" condition –used by many.
3. Emits a software reset (^C) to the controllers.
4. Emits a ^P (control P) to the controllers which places the IBC-400 in party line mode.
5. Scans and maps party line controller into memory.
6. Reports the named controller as found.

The SIN-11 is now configured as a "line input" device, that is, the host computer can print a complete text line containing multiple commands. Once the line is received, it is processed starting with the first character received.

Assuming that there are two controllers named "A" and "B." A typical command string to a system could be:

A+1000;B+1000;&W*;AZ;BZ

This would cause both axes to move the specified number of steps; wait until motion is stopped, then read back the two positions.