IBC-400

Hardware Manual

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Introduction

This manual is intended to provide information on the hardware setup, connections and specifications for the IBC-400, 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 IBC-400 intelligent step motion controller is a complete indexing "subsystem" in a very small package. Consuming less than 50mA it employs multiple embedded controllers, forming a distributed processing controller for operating step motors. In designs where more than one motor is required, up to 32 independent IBC-400 controllers, or combination of any AMS controller-driver products, can be connected from one COM port.

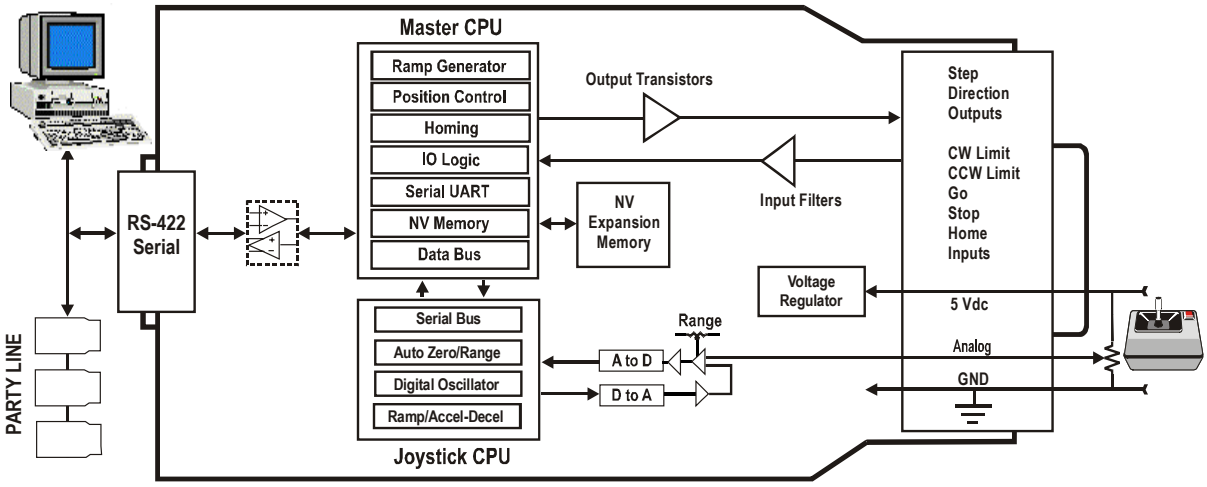
An RJ45 connector is used for communications with a "host" PC and is compatible with other AMS products. Commands from the host execute either as they are sent, or are directed into the non-volatile memory storage where pulsing the GO input triggers execution.

A 15 pin 'D' connector provides signals for use with any step motor or servo motor driver that accepts step and direction input. When interfaced to a COM port, using AMS' new intelligent serial adapter (SIN-11), total power consumption is still less than 75mA (typical). Step and direction signals can be sent to multiple drivers.

Features

- Non-volatile memory for stand alone operation
- Multiple control from a single COM port
- Speeds to over 60,000 steps/second
- Step, direction outputs
- Pulse or square wave step output
- 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
- Compact enclosure- 1.7 x 0.8 x 3.9 in.
- Industry standard connectors
- Optional analog "joystick" input
- Optional encoder feedback for closed-loop operation

Block Diagram



Intelligent Control

The IBC-400 has two integrated processors, a master CPU and an (optional) analog processor. The master CPU is the hub of the IBC-400 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

The master CPU also communicates with the optional analog processor for "joystick" control.

Serial Connections (J1)

An 8-pin RJ45 connector provides the serial interface used to communicate with a "host" computer, most commonly a PC. The communication is full duplex, 4-wire RS-422. The baud rate is 9600, 1start bit, 1stop bit, 8 data bits no parity.

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

If only one controller is used in the application, an RS-232 interface adapter (model SIN-9) can be used. However, RS-422/485, using serial converter, model SIN-11, is the preferred mode of operation. These devices can also be driven from a USB port.

Party Line
Party Line communication is an RS-422/485 full-duplex network capable of reliable data communication with to up to 32 units (controllers) over distances of 4,000 feet. In this application, each controller has a separate "name" assigned, permitting address by the host computer. With the IBC-400, party line mode can be enabled via software (Reference: ^N and ^P commands in the software section for more information).

Standard Input/Output Signals (J2)

A high density DB-15 connector (similar to a VGA monitor connection) provides all input and output functions. Inputs are buffered through comparators, capable of withstanding 28 volts. Buffered output signals can sink in excess of 0.5A @ 28 volts, non inductive.

Pin	Name	Function	Note
1	GND	Logic ground	Common Ground
2	VCC	5 volt logic power input	Regulated 5 Vdc
3	Step out	Output pulse	Programmable square wave
4	Direction out	Output level	
5	MVG out	Moving output status	Open drain, low when moving
6	SS in	Soft stop input halts program	Stops motions
7	GO in	GO input starts user program	Program starts sequence at 0
8	Home in	Input used by home command	Dual speed homing routine
9	Limit A	Stop motion in CW direction	Limit inputs invertible
10	Limit B	Stop motion in CCW direction	Limit inputs invertible
11	Port 1 in	User input port	Add ports with I/O option
12	Port 2 in	User input port	Add ports with I/O option
13	Port 3 in	User input port	Add ports with I/O option
14	Port 4 out	User output port	Add ports with I/O option
15	Analog	Input	Bi-directional 0 to ±2.5 volts or Uni-directional 0- adjustable (up to 24 volts)

All inputs (8) will withstand 0 to 28Vdc and all inputs have 10k pull-up to 4.7Vdc (VIO). The logic threshold is set at 2.5 volts.

GND (Pin 1)
Logic power and signal ground.

VCC (Pin 2)
External 5-volt power supply required to power the electronics. This is also used to power active serial adapters via the serial connector (J-1) at 50mA maximum.

Step Out (Pin 3)
This is a low going (sinking) pulse. The normal pulse width is approximately 10 microseconds. The l4 (lower case "L") command will produce wide pulses, equal to 1/SPS. In this mode the step rate is reduced by 50%. The step and direction can drive more than one driver where identical motion control (slaving) is desired.

Direction Out (Pin 4)
This signal responds to the specified direction as determined by the motion action.

Moving (Pin 5)
This output has the same characteristics as the other output ports. This signal, isolated by a diode, is also available on the serial connector. This or'ed version may be poled by the host as a "any controller moving" signal. The individual moving signal can be used to shut down the drive when motion stops.

Go, Soft Stop (Pins 6, 7)
A pulse 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.

The soft stop causes indexes and running programs to stop.

Home Input (Pin 8)
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 (Pins 9, 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).

Port 1, 2 and 3 (Pin 11, 12, 13)
The basic controller has one general purpose input. This input is rated for up to 28Vdc. Port 1 input 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 (commands "G" and "L").

Port 4 (Pin 14)
The basic controller provides one output port 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 this port on using the "A" command always asserts a "high current" sinking signal. This output is rated for up to 30Vdc.

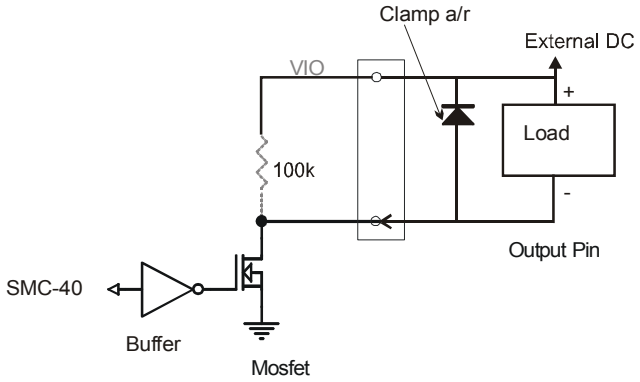
Analog Input (pin 15)
This signal is used with the joystick option. There are two modes of operation; uni-directional and bi-directional. Speed changes, controlled by varying the input voltage, is governed with speed ramp supervision, preventing motor stall conditions caused by abrupt changes in control 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.

Numerous commands can tailor the application to hardware. These include:

-Digital auto zero – calibrate stop voltage offset
-Digital dead zone – prevent drift
-Start speed
-Speed limit
-Acceleration, deceleration



Typical Output Circuit

Step, direction, moving and port 4 outputs use this circuit. An external, low value, pull up resistor (about 1k or less is suggested) should be used on the short step pulse output.

Open drain outputs will typically withstand 28 volts and drive ½ amp. Clamp diodes will be required when driving inductive loads. The 3 amp output FET's can drive higher currents for low duty cycle operations but use caution.

IBC-400 System Components and Accessories

Basic Step Motor Controller
Operates from 5 Vdc regulated supply.
Model: IBC-400
Options:
Analog processor – add "A" suffix
Encoder processor - add "E" suffix

Passive serial adapter. Connects RS-232 (DB9) to IBC-400 serial input.
No intelligence – use for single axis only.
Includes 7 foot cable.
Model: SIN-9

HD15M connector (solder cup contacts) and hood for connection without using the BLC-400 mounting base.
Model: BLC-405

Intelligent serial adapter. Recommended for applications with more than one axis (up to 32). It is especially suited for Windows applications. Includes cables shown here.
Model: SIN-11

USB converter for SIN-11.
Model: USB-1

"T" splitter for multi-axis applications. Includes serial "in" and serial "out" connections.
Model: BLC-45T

Mounting Options

The low cost BLC-405 is a high-density 15 pin male "D" connector, much like a standard VGA monitor connector. The solder cup contacts permit individual wires for signals (ports, limits, step, direction, home, +5, ground, etc.). Use of BLC-405 will require the designer to devise a mounting method. Possible techniques include Tie-wrap or Velcro in vibration prone environments. The case may be carefully opened, and then mounting holes added to the bottom (LED side). Attachment is achieved using screws and short spacers before electronics is installed and the cover is snapped back in place.

IBC-400A with analog input mounted to BLC-405 connector. This configuration requires a regulated +5V input (budget consumption 150mA).

An alternate method for mounting is use of the BLC-400 regulated base, which is designed to firmly attach to the signal connector. Two stand-offs allow bolting the assembly down. In low vibration environments vertical mounting with the friction fit of the DB15 connector will be adequate, while permanent environments will require use of the two captive screws and spacers (included).

Complete IBC-400AE with analog input and encoder feedback options mounted to BLC-400 regulated base.

Out of the Box – Quick Start

The IBC-400 operates from a single, regulated 5-volt or unregulated 9-volt DC power supply. A small interface board from AMS (BLC-400) is available as a convenient way to make connections to the input/output connector (J2), especially during product development.

Equipment Check List

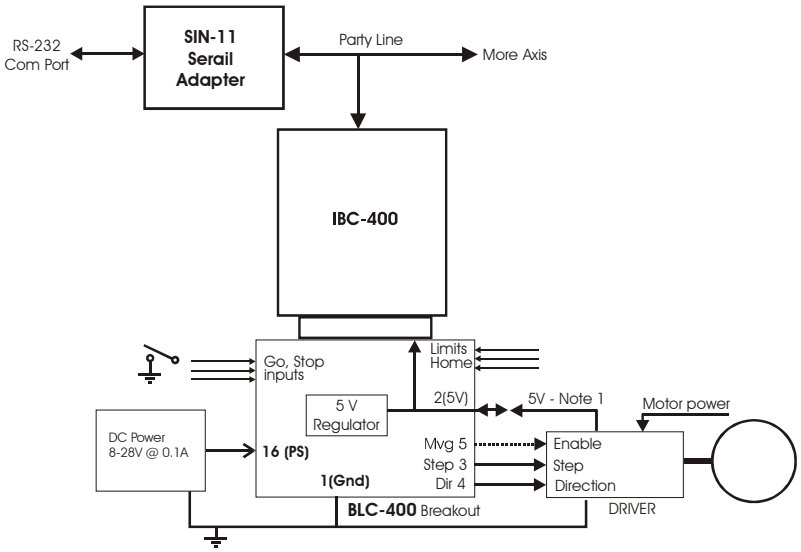
1. A computer with available serial port.
2. Installed serial communications software such as Hyper-term, EASI, ProComm, etc. (EASI works with DOS).
3. One IBC-400 controller.
4. One SIN-11serial adapter.
5. One power supply (see Power Supply Options, below).
6. One interface connector DB-15 high density male or one BLC-400.
7. A compatible stepper motor drive with motor.

Basic Set-up using a SIN-11

1. Connect the SIN-11 (RJ-45 end) adapter to serial input (J1) of the IBC-400.
2. Connect the SIN-11 (DB-9 end) adapter to the computer RS-232 serial port.
3. Connect your power supply as shown below.

BLC-400 Optional Breakout / Mounting Board

The IBC-400 is normally shipped with a 15 pin mating D-Sub connector (solder cups for wires). The optional BLC-400 however, simplifies construction.



The BLC-400 is a small (1.375 in. x 2.0 in.) interface board that provides both mounting and convenient wire connections. Two mounting holes permit attachment to a panel with screws. A vertical HD15 connector accepts the IBC-400 controller. Two 8 position terminal strips are available, labeled 1 through 16, to correspond to IBC-400 pins and signals. Note; pin 16 is an input to the 5-volt regulator.

Power Supply Options

The IBC-400 and accessories are powered from a regulated 5 volts. This supply powers various options and attached devices, including:

1. Main and analog processor
2. SIN-11 adapter
3. Encoder processor
4. Encoder(s)

1. With BLC-400: an unregulated 9 to 12V DC voltage is recommended, supplied to pin 16 (up to 24 volts may be used but a higher voltage may cause the over temperature regulator to shut-down). The generated 5 volts supplies the IBC-400 and is present as an output on pin 2, providing a low current supply for external use.
2. Without BLC-400: an external regulated 5-volt supply applied to pin 2 as an input: Some drivers have a 5-volt logic supply output. This is the preferred design in multiple axis designs, because multiple regulators connected in parallel may not have identical output, resulting in a load imbalance.

The attached SIN-11 is powered from the same 5-volts via the party line bus cable.

Configure Serial Communications
Make sure your host computer is configured as follows:
Full duplex, 9600 baud, no parity, 8 data bits, 1 stop bit.

Apply Power
The IBC-400 LED should blink green and the SIN-11 will sign on displaying version number, etc.

Sign-on
Depress the SPACE BAR key and the IBC-400 should sign-on.

During start up, several tests are made by the IBC-400 to verify proper communication and available hardware. This includes detecting and reporting the installed options with version numbers. The following information should appear on your screen:

Line 1- Master information
Date code – IBC-400 – SW version #

Line 2- Analog status
Not installed or SW version #

Line 3- Encoder status
Not installed or SW version #

Troubles
1. Nothing happens:
   1a. Check connections.
   1b. Check for correct COM port.
2. Garbage characters appear:
   2a. Verify baud rate and serial parameters.
   2b. Check serial connector(s)/cable ground continuity.

After Sign-on
1. Enter X<CR> (where <CR> is carriage return). The following parameters, set in non-volatile memory, will appear on your screen, where:
   K= Accel/Deccel Speed, I = Initial Speed/Divider, V= Run Speed/Divider, E= Current Setback Delay, n= Controller Name
2. Assign the IBC-400 a unique "name" character, for instance "A."
   2a. Enter a control "N" (^N).
   2b. The text "NAME?" is displayed.
   2c. Enter the name "A." The text responds with "Save (y)." Answer with a "y" (lower case). The response is "OK." Hit the spacebar key.
   2d. The name "A" is now stored directly to the non-volatile memory.
   2e. Verify using "X" command, where "n=A" is displayed as the last item.

Status LED
A two color LED provides status indications as follows:

When the 5-volt power supply is turned on, the LED blinks green at approximately once per second. Execution of programs either by power up trigger or go input trigger will cause execution indicators while running, then revert to a solid color.

After log-on (either terminal or party line), the LED will become solid green. When moving, the LED will alternate red/green, proportional to the step rate. At high step rates, both red and green will be present (with flicker). At the end of an index, the LED will revert to either color.

Single Controller Operation
Single controller (dumb terminal) operation is possible with any of AMS serial interface adapters. Functions available in single controller operation include:

1. Executing any single command
2. Programming sequences into nonvolatile (NV) memory
3. Renaming the controller
4. Clearing memory
5. Running stored programs

The following cautions apply:

1.Only one AMS controller is connected to a serial port. If more than one axis is attached, the name assignment will give all controllers the same name.
2. All commands are manually entered – "downloading" of files must be accomplished with party line software/hardware (explained later).

Single mode is useful for setup, test, debug, and programming using manual keyboard input from a computer or terminal. AMS supplies a free utility (EASI.EXE version 1.24 or higher) program that can operate in a dumb terminal mode.

Hyper-terminal, as supplied with all Windows operating systems, can also be used. The terminal program must not filter control characters. Setup should be full duplex, handshake none.

Some Rules

1. Data rate is standardized at 9600 Baud, 8 data bits, no parity, 1start and 1 stop bit.
2. Naming the controller is done with a single control character- ^N.
3. If using a SIN-8 or SIN-10 serial adapter the party line switch is not required.
4. Switching to party line mode is done using a single control character- ^P.

Any application (even single motor controller) where the computer "feeds" commands **MUST** use party line protocol. Observing the echoed character handshake is essential to avoid UART over-run errors.

Stand Alone Operation
Any controller can operate in a stand-alone operation. Go and stop inputs can trigger previously stored programs.

Example Index Command

Move motor 1000 steps in a + direction:
+1000 <CR>

Examine Command
The Examine command (X)<CR> will display a set of parameter values that were last stored into non-volatile memory. These (and other) parameters may be modified using the appropriate commands, then stored in non-volatile memory as the new "defaults."

X K= 5/3, I= 2001/4, V= 10014/4, E= 100, n=A

Where:
K= Ramp up/ramp down I= Initial velocity
V= Slew velocity/divider E= Current setback delay
n= Controller name

The values shown assume there are no input connections or special modes such as inverted limit switches.

Some dumb terminal mode rules:
1. The command line may be edited using backspace as characters are typed.
2. The line may be cancelled using <ESC>.
3. The command line is limited to 12 characters.
4. Only one command may be entered per line.
5. A space is optional between the command and first number.
6. A space or comma must be used to separate two parameter commands.

Although not necessary, it is desirable to have a motor connected to the driver. This provides gratifying feedback.

The motor characteristics should match the drive capability. If the motor refuses to move in response to an index like "+1000" steps, the control parameters may not be correct. This stalling manifests itself in partial movements of the motor shaft and audible sounds. Insure that the load is not too heavy. Tweaking parameters like motor current, velocities (I and V) and ramp slope (K) can usually coax the motor to action.

Controller Name Assignment
Whenever the application is controlled via a "host" computer the proper protocol (handshake) MUST be used. Either the programmer must write the necessary serial, echoed character-by-character software (driver), or implement a SIN-11 for the proper handshake.

In any case, a unique name must be assigned.
EVEN A SINGLE CONTROLLER APPLICATION REQUIRES PARTY LINE PROTOCOL.

AMS software searches for controller names starting with A, B, C, …. x, y, or z.

Recommended names are as follows:

Recommended Names: (Upper case A through Z) (Lower case a through z)		Non-valid Names:	
ASCII	HEX	ASCII	HEX
[	5B	^C	03
\	5C	CR	0D
]	5D	LF	0A
^	5E	@	40
-	5F		
‘	60		

Assign the controller name:

1. Enter control N (^N). – "name ?" is displayed.
2. Type the single (case sensitive) name character. "Save" is displayed.
3. Type "y" (lower case Y).
4. Hit the spacebar key.

Note: The controller will accept any character as a name, including control characters. Two common error characters show up as either a space ' ' or ♥ (heart symbol).

The unit is ready to operate in the current single controller mode or be switched over to party line mode. It is suggested that the operator use single mode first to become familiar with command input. The single controller mode can be used with any "dumb" terminal device and is not dependant on using the AMS software.

Analog Joystick Input Overview

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.

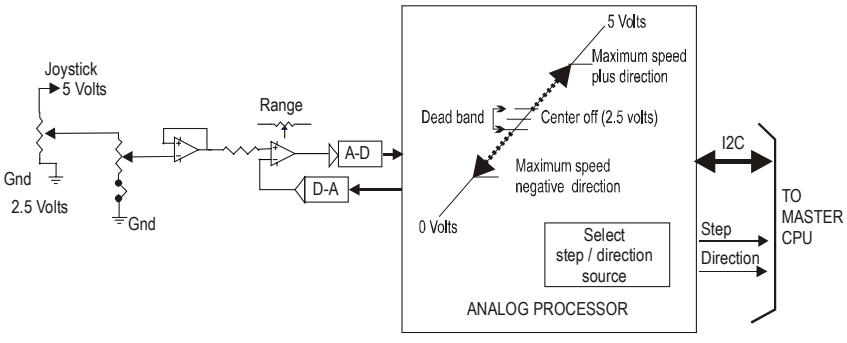
The analog joystick interface adds yet another dimension of motion control possibilities by providing the capability of speed that is proportional to the input voltage. Features include:

- 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 –5Vdc.

Input Voltage
The actual voltage applied to the input.

Joystick
The most popular design is a bi-directional 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 15).
3. Enter command "m3" (force uni-directional mode).
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 15).
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 DB15 connector as follows:
   2a. Wiper ……..Pin 15….. 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 '9 1.' The reading should be close to 2.5 volts.
6. If necessary, adjust joystick center for proper reading if a trim mechanism is provided or you have included it in your design.
7. Move joystick to travel extremes. Voltage should be symmetrical, slightly under 4.98 volts and slightly above zero.
8. Adjust gain to obtain a symmetrical voltage swing. The center voltages must remain 2.5 $\pm$ 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 15(+) of the DB15 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 bi-directional or zero volts for un-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
 0     *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 enable command is "1." The disable command is "m0."
2. Any index or motion command will disable joystick operation. Use the "1" command to re-enable.

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).

ENC- 400 Encoder Feedback Option for the IBC-400

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.

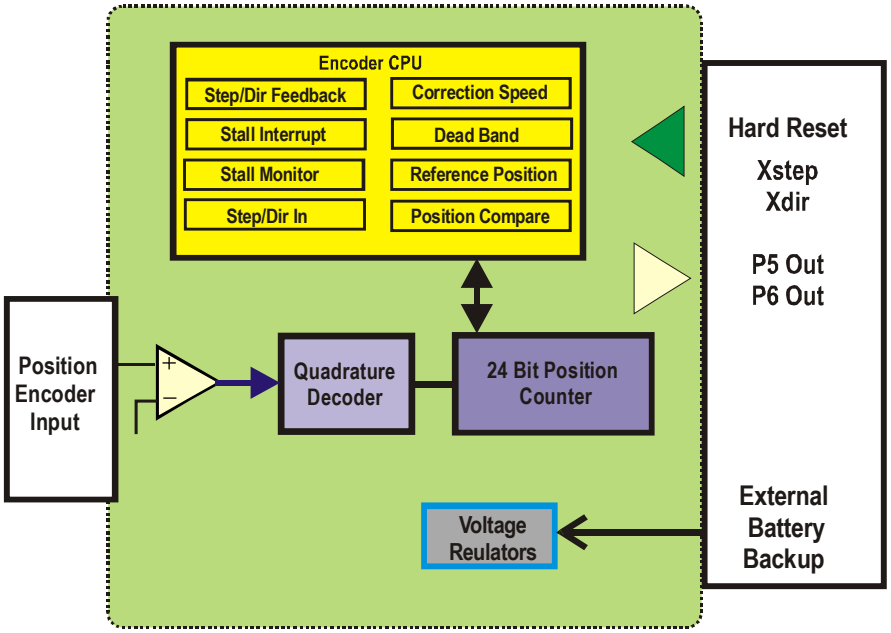
It is possible to mount the encoder to other parts of the system, for instance a linear (picket fence) encoder could be mounted to a slide. Attention must be paid to the encoder resolution vs. microstep resolution. We recommend microstep resolution of at least ¼ step or better. If full-step resolution 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. New features with the ENC-400 include provision for battery backup to prevent position loss and operation with almost any resolution encoder. The ENC-400 may co-exist with the analog option.

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

ENC-400 Block Diagram



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 (IBC-400) microcomputer via serial bus and step and direction signals to maintain/monitor target position and encoder counter position.

The processor communicates as a slave to the master IBC-400 processor.

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 (IBC-400) 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 IBC-400 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 IBC-400 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.

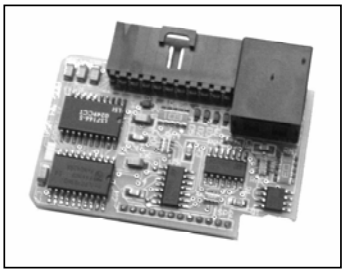
If the hunt mode is triggered because of an early stall exhaust, the step distance can be large. If the motor motion is obstructed, stepping attempt will be continuous, until an abort is executed. Whenever the position drifts outside the deadband, repositioning to the target position will be exact (as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

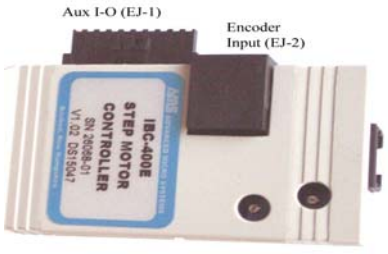
Battery Backup

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 Overview

The encoder option is a separate module that is fitted within the IBC-400 case. Two interface connectors, EJ-1 and EJ-2, provide additional signal connections.

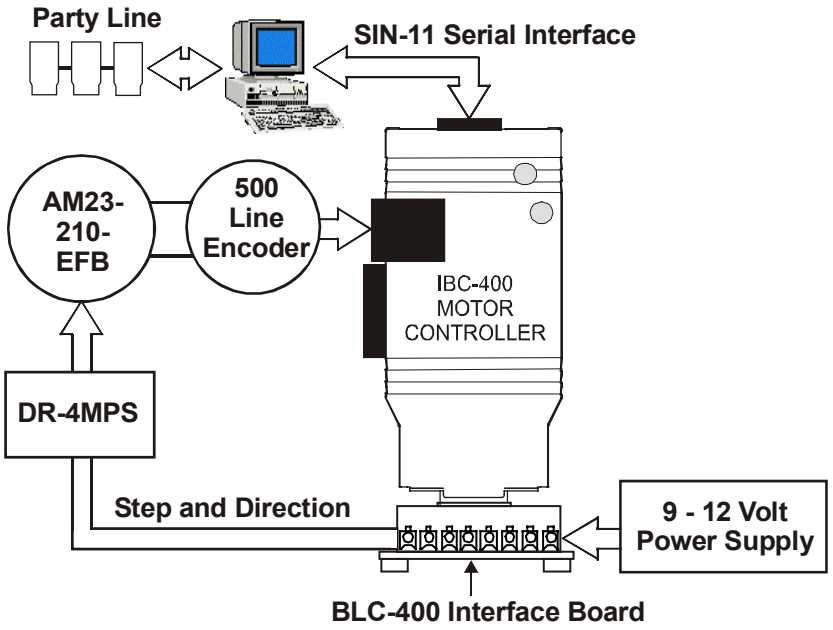




EJ-2 is an 8 contact RJ45 encoder input connector.
EJ-1 is a 12 contact signal connector (Molex SL Crimp series).

A typical setup from AMS is as follows:

1. IBC-400EA (with optional analog input)
2. BLC-400 interface board (simplifies connection and mounting)
3. Serial adapter SIN-11
4. DR-4MPS microstep driver with power supply
5. AM23-210-EFB500 (size 23 motor with 500 line encoder)
6. 9-12 Vdc logic power (Radio Shack model 273-1667 set for 9V can be used)



Note, any step motor driver with power supply can be used. Some models have a regulated +5 output that can power the IBC-400.

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 IBC-400. Do not allow excessive ground current to flow as it may cause damage not covered by warrantee.

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 under 50 Ma. 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.

Supplemental Signal Connector EJ-1

Pin	Name	Signal	Function	Type
1	BUB	Vbattery	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- 500Ma	Output
9	P6	Port 6	User Port 6- 500 Ma	Output
10	BU5	5 Volts	5 volt backup	Output

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 100 MA.

Pin 2- GND
This is the power common for the IBC-400 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.

Note, this is NOT encoder feedback. This feature requires the analog option. The electronics is physically located on the main IBC-400 board. The connections are made via the encoder board. Neither of these functions have any relation to encoder feedback. Any encoder feedback functions are disabled while in this mode.

Pin 7- Reserved for future use

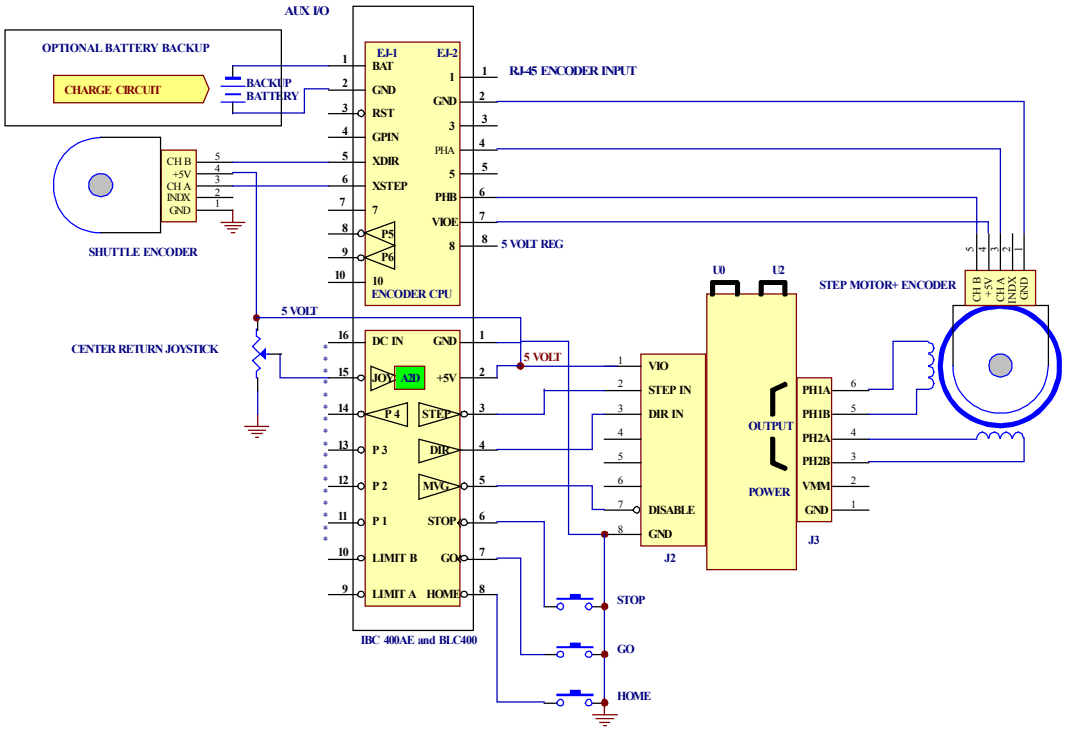
Pin 8, Pin 9- Output ports 5 and 6

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.

Pin 10- 5 volt output, reserved for future use

Note: The EJ-1 mating connector, Molex part number 50-57-941, and terminals, Molex part number 16-02-0103 (22-24 AWG) are supplied with the IBC-400E.

Encoder Schematic



Electrical Specifications

Power Supplies
Logic Supply ……. ….4.7 – 5.5Vdc

Controller
Step Rate Range…… ….56 to 65,535 Steps/Second
Minimum speed (D=255, square)…….. 6.6 Steps/Minute
Step low pulse width……...6 uS
Direction to first step setup ……150uS
Non-Volatile Memory…… 512 + 2048 Bytes
Communication……...Full Duplex RS-422, 9600 Baud
Maximum Networked……32 Axes - 4,000 Feet

Inputs (standard)
(3) User definable (ports 1, 2, 3)
(2) Limits
(1) Home
(1) Go
(1) Stop

Outputs (standard)
(1) User definable (port 4)
(1) Moving/Enable

Outputs (with encoder option)
(2) User definable (ports 5,6)

Joystick
Analog Joystick Input (1)……... 0-12Vdc or 2.5 ± 2.5Vdc
8 Bit A-D Inputs (1or 2)…… 0-5Vdc
Analog Speed Increments……...255 (Uni-directional), 128 (Bi-directional)

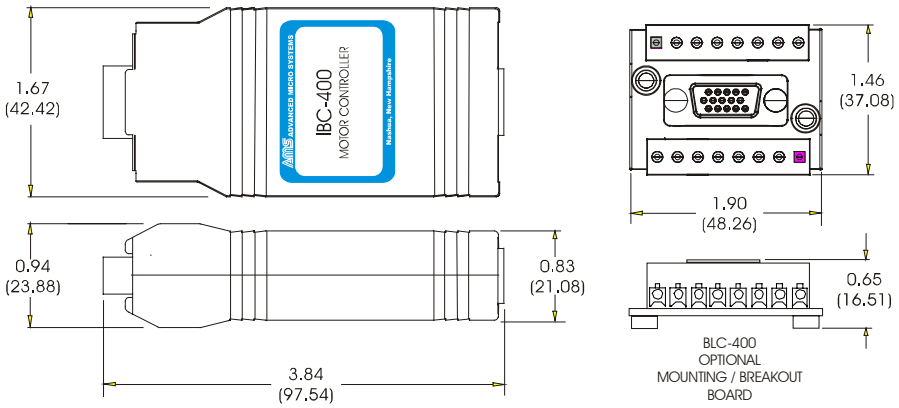
Signal Specifications
Input voltage may exceed VIO, but may increase VIO slightly. All inputs have 10k pull-up resistors to VIO (4.5 volts without external supply).

Standard	Min	Typ	Max	Units
I.O. Supply (VIO) internal		4.7		Vdc
Digital Threshold		1.6		Vdc
Digital Inputs (Vin)	-0.7		28	Vdc
Input Current (Sinking)		0.5	2.8	mA
Outputs (Ports 4, 5, 6, MVG)				
Output Voltage			28	Vdc
Output Current			0.5	Amp (cont.)

Environmental

Storage.....……..-45 to 85 Degrees C
Operating.....……... 0 to 50 Degrees C
Humidity.....……...0 to 95% (Non-condensing)

Dimensional

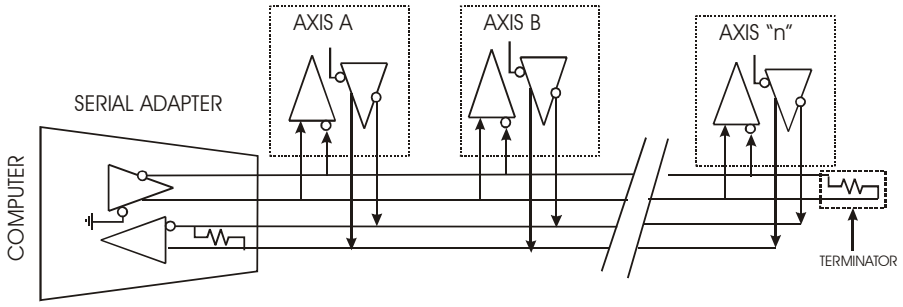


RS-422 Hardware

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



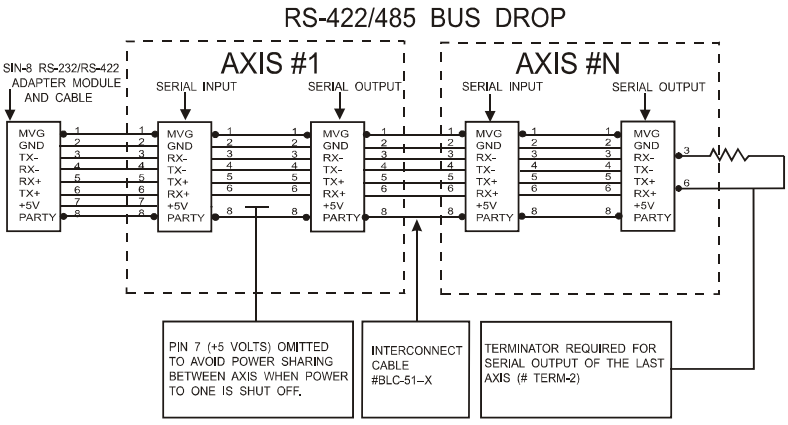
Communication hardware requires three components:

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-7 and SIN-9 Passive Adapters
The SIN-7 adapts RJ45 to DB-25 serial port and the SIN-9 adapts RJ45 to DB-9. 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-8 RS-232 to RS-422
This adapter contains RS-232 transmitter/receivers and RS-485 transmitter/receivers and can be used with party line network designs. Any number between one and thirty-two axes can be connected in a mini-drop network system using the SIN-8. Application software must implement special character-by-character handshake protocol. This model is not suitable for USB interface.

SIN-10
The SIN-10 is an intelligent serial line converter that simplifies application software development and improves overall performance. Dual, independent UARTS (COM ports) permit spooling commands at rates between 1200 and 115k baud. Communication between connected controllers and the SIN-10 is 9600, 38.4k or 470k baud. The SIN-10 will interface to a USB port.

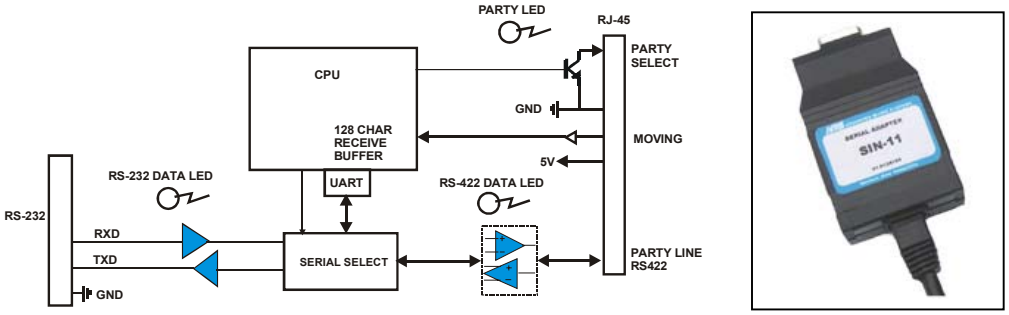
RECOMMENDED
SIN-11 Intelligent Serial Adapter
The SIN-11 is also an intelligent serial line converter but is designed as a smaller, lower cost replacement to the SIN-10 model. The primary difference is that it is fixed at 9600 baud.

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

The SIN-11 has a built-in microprocessor that offers a number of features:

- Operates as hardware RS-232 to RS-422 adapter
- Diagnostic LED's
- 9600 baud rate
- DB-9 serial input connector
- RJ-45 party line connector
- 5 volt powered from controller
- 128 character buffers for multiple commands per line

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.

IBC-400 Schematic