

**R356 Controller**  
with built-in 256x Microstepping Driver  
and encoder feedback for position correction



**User Manual**  
Version 1.06

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Thank you for purchasing the R356 Controller with Microstepping Driver. This product is warranted to be free of manufacturing defects for one year from the date of purchase.

## PLEASE READ BEFORE USING

Before you begin, ensure there is a suitable DC Power Supply. **Do not disconnect the DB-15 cable while power is still being applied to the controller.** This will damage the board. Under any circumstances, do not exceed +40 VDC.

## DISCLAIMER

The information provided in this document is believed to be reliable. However, no responsibility is assumed for any possible inaccuracies or omissions. Specifications are subject to change without notice.

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### Special Symbols



Indicates a **WARNING** and that this information could prevent injury, loss of property, or even death (in extreme cases).

## R356 User Manual

Product: R356  
Version: 1.06  
Date: 2/17/2010

Version History		
Version	Date	Description of Changes
1.00	7/01/2008	New User Manual
1.01	4/3/2009	Added new RS485-232 converter card info and color code for opto sensor connection page 18.
1.02	8/11/09	Added max surface temperature. Updated encoder cable image.
1.03	9/16/09	Updated image for LED connection.
1.04	9/18/09	Updated pinouts and Appendix for step/dir mode.
1.05	10/29/2009	Added full step as a resolution option.
1.06	2/17/2010	Updated typo on page 6 for max step pulse rate.

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## 1. FEATURES

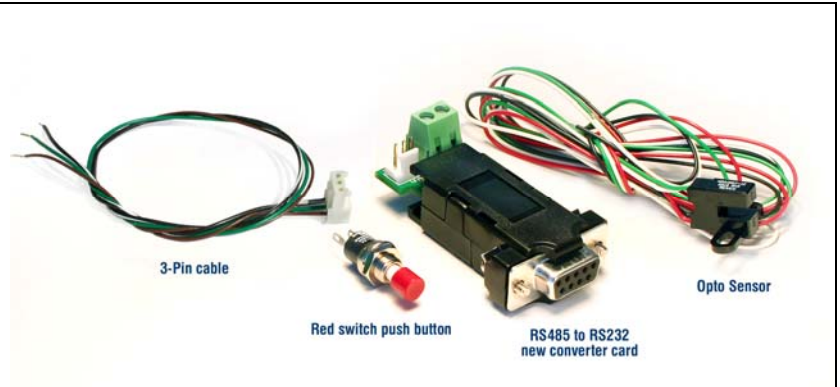
- Operates from +12V to 40V
- Single 2 wire bus linking up to 16 drive/controls ( on RS485 bus)
- 3.0 Amp Peak Chopper (PWM) Driver (2.14 A/Ph)
- Full step, 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256 step resolution
- Stand alone operation with no connection to a PC
- Execution Halt pending switch push button
- Pre-wired internally for Opto Switch inputs
- Homes to an Opto or Switch closure with a single command
- Fully programmable ramps and speeds
- Four digital I/O and two fixed input channels
- Switch selectable address
- Software selectable "Move" and "Hold" currents
- Two inputs can be used for left and right limit switches
- Option to use unit as a driver only and accept TTL step pulses
- Takes in single-ended optical encoder input for position correction
- Hold Current automatically selected upon move completion

### Designer's Kit with RS232 communication

Here is the list of components if you have purchased the optional Designer's Kit:

- RS485 to RS232 converter card
- A switch push button
- Opto Sensor
- 3-Pin cable (optional usage)

RMS part number: KIT-RS232



### Designer's Kit with USB communication

Here is the list of components if you have purchased the optional Designer's Kit:

- USB to RS232 converter card
- A switch push button
- Opto Sensor
- A USB 6 foot long cable

Lin part number: KIT-USB



### R356's Encoder Option

A single-ended optical encoder must be installed on your motor in order to have encoder feedback. Position correction mode can be turned on such that it will continually send step pulses until the true desired position and actual position equals each other. The option of simply sending an error report is also possible. The R356 must first be set up to work with the encoder by understanding the CPR and calculating an encoder ratio. See the Appendix of this user manual.

## Default Settings

Function (command)	Description
Running Current (m)	25% of 3.0 Amps
Holding Current (h)	10% of the run current
Step Resolution (j)	256x
Top Velocity (V)	305175 pps (microsteps/sec)
Acceleration (L)	L=1000, 6103500 $\mu$ steps/sec <sup>2</sup>
Position	0
Microstep smoothness (o)	1500
Outputs (J)	Both are turned off, J0, inputs 1 & 2
Baud Rate	9600 bps

Table 1: Default Settings

## **2. ELECTRICAL SPECIFICATIONS**

Supply Voltage: +12 to +40 VDC  
Peak Current: 0.3 to 3.0 Amps

### **Digital I/O Specifications**

Number of I/O 4  
Number of Inputs 2  
Input Voltage +0 VDC to +5 VDC (0 to 24V tolerant, but 5V recommended)  
Input Current 700 mA  
Pull-up Resistors 20k  $\Omega$   
Protection Static Protection to the microprocessor

For a 1.8° stepper:

Steps per Revolution: 200, 400, 800, 1600, 3200, 6400, 12800, 25600, 51200

## **3. OPERATING SPECIFICATIONS**

Maximum Step Frequency 2<sup>^</sup>31 (pps) or 2.147GHz  
Operating Temperature Range 0° to 50° C  
Storage Temperature Range -20° to 70° C  
Maximum surface temperature 70°C

### **Communication Specifications**

Interface Type RS485 (RS232 or USB with a converter card)  
Baud Rate 9600\*, 19200, or 38400 bps  
# Bits per character 8 Data  
Parity None  
Stop Bit 1  
Flow Control None

\*default

## 4. MECHANICAL SPECIFICATIONS

### Dimensions

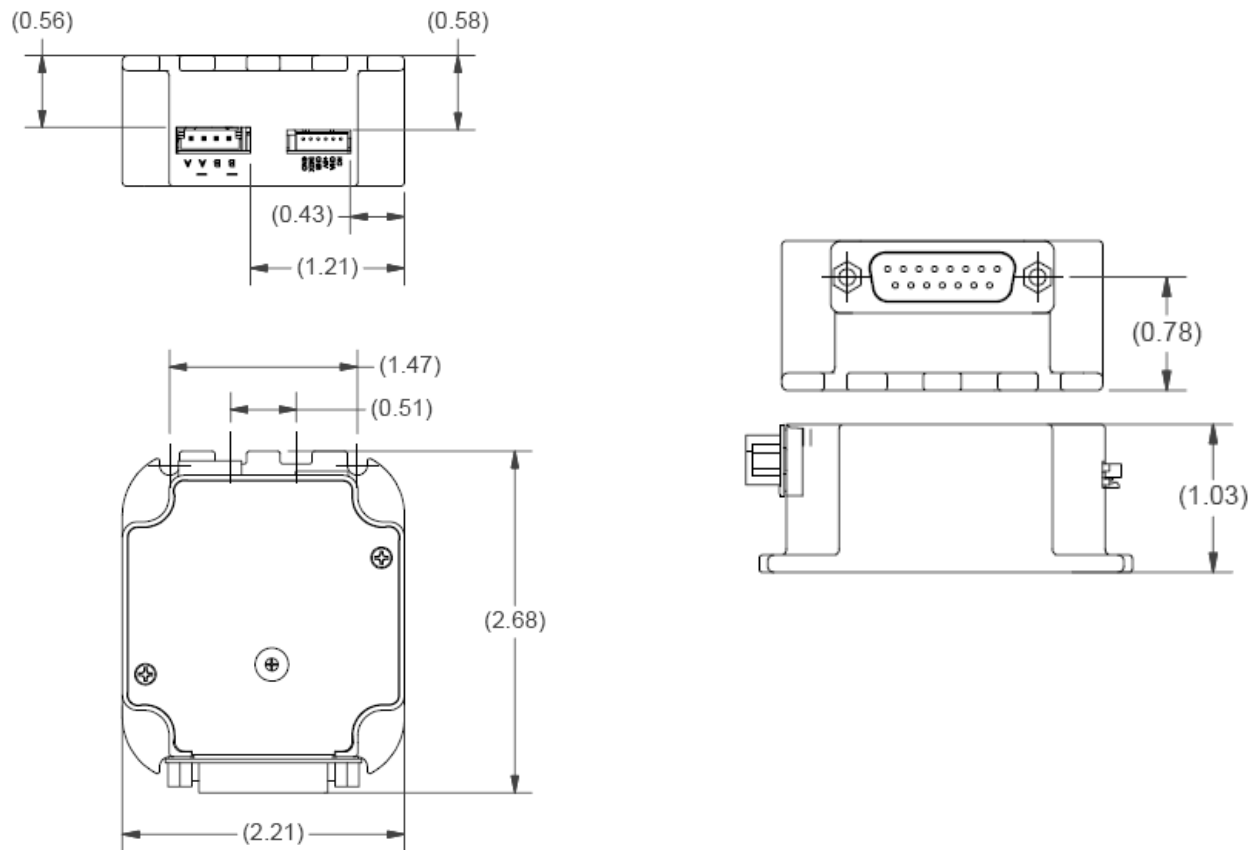


Figure 1: Dimensions

## 5. PIN ASSIGNMENTS

A DB-15 female connector cable comes with every R356 unit. It receives power and provides the control connections for the R356 Unit. On the opposite end of the DB-15 female connector cable, there is a 3 pin connector provided for the converter card in order for the R356 to communicate with the PC. The four I/O wires are colored Orange, Orange/White, White and Red/White. This will allow for options such as solenoids, relays, opto isolators, LED's and many other input and output connections.

PIN #	COLOR	FUNCTION	I/O # or Function
1	Green	Power Ground	
2	Black	1A On/Off Output	
3	White/Green	Direction Input (see Appendix)	
4	Yellow	+5VDC Input for Opto Isolated STEP and DIR (see Appendix)	
5	Orange	Input	2/Jog2 Input
6	Yellow/White	Internal Power for Opto Sensor	
7	Orange/White	Input (Opto Input)	3/Opto1 Input
8	Black/White	RS485 A	
9	Red	+12V TO +40V POWER	
10	Blue	1A ON/OFF Output	
11	Blue/White	Step Input (see Appendix)	
12	Green/White	Signal Ground	
13	White	Input	1/Jog1 Input
14	Red/White	Input	4/Opto2 Input
15	Brown	RS485 B	

Table 2: Pin assignments

\*Inputs are labeled 1, 2, 3 and 4 for programming the 'Halt', 'Skip', and special mode 'n' commands.

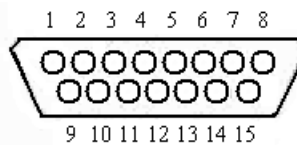
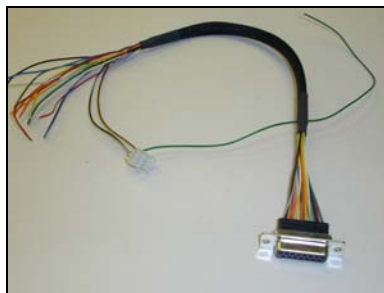


Figure 2: DB-15 Female Cable Connector (Rear View of R356 unit)



Cable 90-096 (connects with either RS485-232 or USB Card)

### Connecting to the new RoHS version RS232 card

R356 pin#	R356 color	*USB pin#
8	Black/white	1 (RS485A)
1	Green	2 (GND connect to Power Supply Ground)
15	Brown	3 (RS485B)

Table 3: Pinouts for using RS232

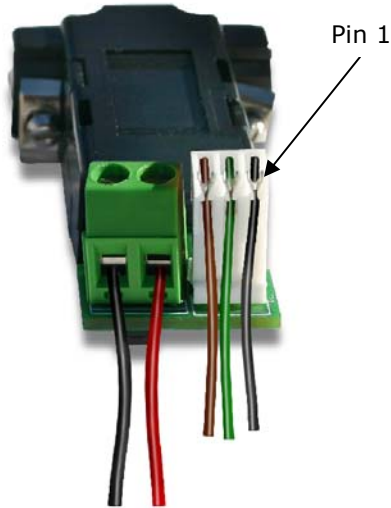


Figure 3: RS232 to RS485 converter card, p/n 083-00050  
The RS232 card requires power (7-40VDC).

### Connecting to the USB card

R356 pin#	R356 color	*USB pin#
8	Black/white	1 (RS485A)
1	Green	2 (GND connect to Power Supply Ground)
15	Brown	3 (RS485B)

Table 4: Pinouts for using USB

\*Where Pin #1 is located here:



RS485 Connection View

Figure 4: USB to RS485 converter card, p/n USB485

The USB converter card does not require power (it receives power from the PC). Power is still needed for the R356 controller/driver.

## 6. CONNECTION SPECIFICATIONS



**DO NOT PLUG IN POWER UNTIL EVERYTHING IS CONNECTED.**

Quick Start  
RS232-485 converter card

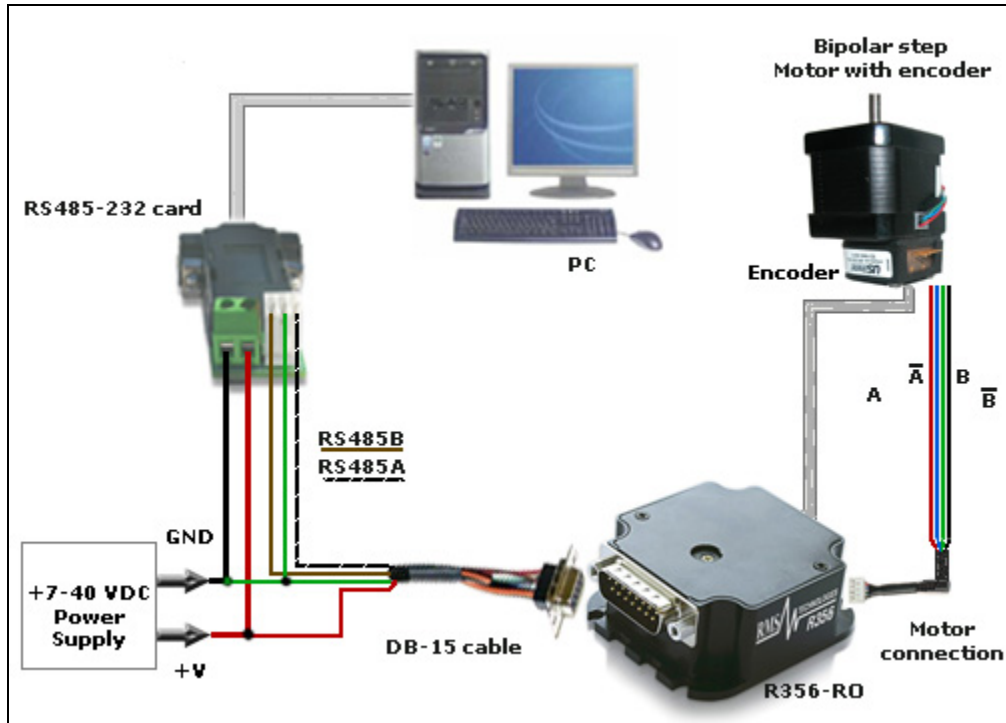


Figure 5: Connection using RS232

1. The RS232 converter card connects to the R356 using the DB-15 cable that is provided to you. The 3-Pin connector is placed onto the converter card. **R356's pin 9, Red wire is +12-40VDC, pin 1, Green wire is Ground. The converter card's green wire needs to also connect to the Power supply ground.**
2. Your power supply will be connected to the RS232 card where the green header is located. **+ is for +12-40VDC, - is for the Power Supply Ground.**
3. Connect the motor and optional encoder to the R356.
4. Connect the RS232 card to your PC with a male to female DB-9 cable.
5. Turn your power supply on and follow instructions for using HyperTerminal.



## Mating Connectors

The following cables are provided with the R356 unit:  
**DB-15 cable:**



**4-Pin cable for step motor:**  
 One 4-pin cable is for the motor windings.



The table to the right depicts the function  
 Part # 90-018

Color	Function
Red	A+ Phase
Blue	A- Phase
Green	B+ Phase
Black	B- Phase

*Table 5: Pin description for Motor*

### Encoder cable:

This is ideally for a US Digital E2, E5, or E3 encoder. One side plugs into the R356. The opposite side have flying leads for you to use.



Pin #	Color	Function
1	Green	Ground
2	White	Index
3	Yellow	Ch B
4	Red	+5VDC
5	Blue	Ch A
6	--	--

*Table 6: Pinouts for encoder cable*

## 7. CONFIGURING AND CONTROLLING THE R356

### HyperTerminal Setup

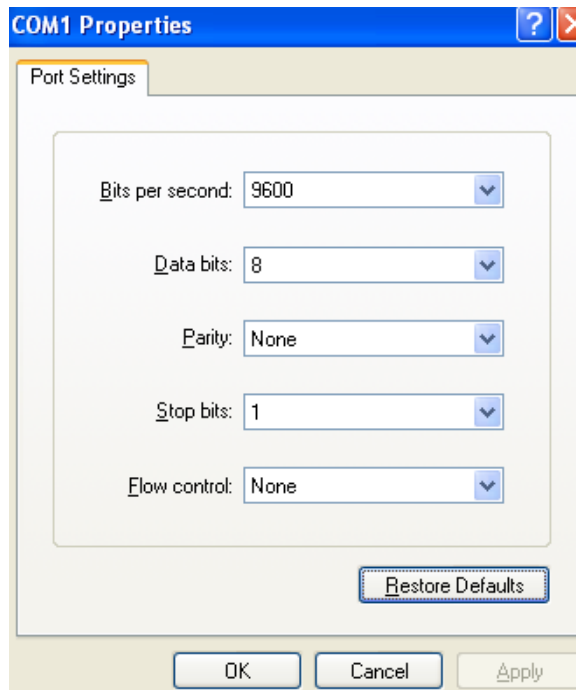
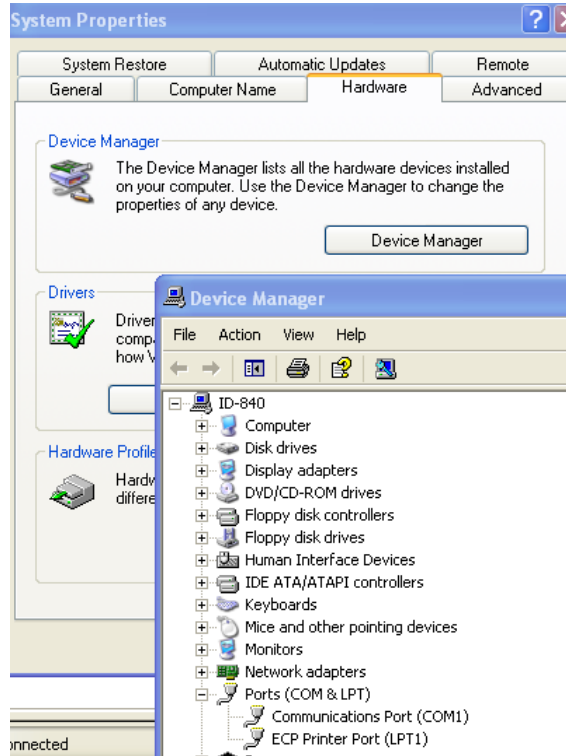
Please follow these steps in order to properly set up HyperTerminal:

1. Open a terminal from your PC by following these steps: Start Menu → Programs → Accessories → Communications → HyperTerminal
2. Assign a name for your New Connection
3. Determine the correct COM port # by right clicking on "My Computer" and selecting "Properties". Select the "Hardware Tab" and click on "Device Manager".

Note: if you are using the USB485 converter card, first download driver files (found online: [www.rmsmotion.com](http://www.rmsmotion.com)).

You should then see the RMS USB 485 converter card in the "Ports (COM & LPT)" area.

If you are connecting via RS232, most likely it is COM1, "Communications Port".

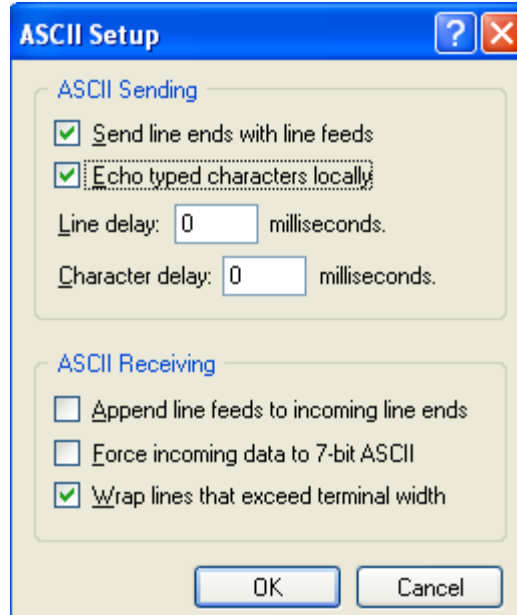


4. Under 'Connect using', select the COM connection that corresponds to your PC serial port (i.e. COM 1, COM 2, etc.) then click 'OK'
5. Set your Port Settings to default (i.e. 9600 baud, 8 data, no parity, 1 stop bit, no flow control)

6. Turn on local echo by going to:

File → Properties → Settings tab → ASCII Setup: Click on the box for "Echo Typed Characters Locally" and click on the box for "Send Line ends with line feeds". Click "OK".

7. Now you can type your commands



Example command: /1A1000R

- This will run unit #1 to the Absolute position 10000
- You can check the address of your driver by checking the dial at the top of the driver. (See the following page for Changing the Address)
- A full list of commands is available in the Silverpak 23C / R356 Command List
- Hint: Most common commands to change are:
  - Step resolution (/1j2R sets it to half stepping)
  - Velocity in pulses/sec (/1V1000R sets the speed to 1000 pps)
  - Run current (/1m50R sets the run current to 50%)
  - Hold current (/1h20R sets the hold current to 20%)
  - Move the motor (/1P800R moves the motor 2 revs if half stepping)

HyperTerminal Responses:

/0@□ indicates good command and that it was received correctly

/0b□ indicates bad command

/0C□ indicates that the command is out of range

/0'□ indicates that the command is terminated

/0'a□ Overflow

### Setting the Current



**CAUTION! DO NOT SET THE CURRENT ABOVE THE MOTOR'S RATED CURRENT.**

In order to set the correct current for your motor, you must program the specified amount in HyperTerminal

Current is set based on the Maximum amount of current the controller board can output, which is 3.0 Amps Peak. Below is a table of how much current will be applied to your motor for each setting.

Percent	=	Motor's Current Rating (Amps)	Driver's Equivalent Current (Amps)
10%	=	0.21	0.30
20%	=	0.43	0.60
30%	=	0.64	0.90
40%	=	0.86	1.20
50%	=	1.07	1.50
60%	=	1.29	1.80
70%	=	1.50	2.10
80%	=	1.71	2.40
90%	=	1.93	2.70
100%	=	2.14	3.00

Table 5: Desired Current

To achieve the equivalent Driver Current (Amps), multiply your motor's rated current by 1.4. Follow these examples:

**Example One:**

You have a motor that is rated at **0.85** Amps,  $0.85 \text{ Amps} \times 1.4 = \sim 1.2 \text{ Amps}$ . Using *Table 5* we would see that 1.2 Amps is 40% of the driver's maximum output current.

Assuming the R356 is addressed to Number 1, this is what you'd program: **/1m40R**

**Example Two:**

You have a motor that is rated at **1.0** Amps, and your Controller is addressed to Number 1, this is what you'd program: **/1m46R**

This will set the controller to 1.4 Amps Peak. How did we get 1.4 Amps?  $\rightarrow 1.0 \text{ Amps} \times 1.4 = 1.4 \text{ A Peak}$ .

**WARNING!: Setting the Current to a value greater than the Motor's rated current will damage your motor, and may overheat the controller.**

## Connecting Multiple R356 Units

Connect multiple units by using the Converter card, shown below. If using the RS232-to-RS485 converter card, daisy chain all four wires: power, ground, RS485+ and RS485- prior to plugging into the converter card.

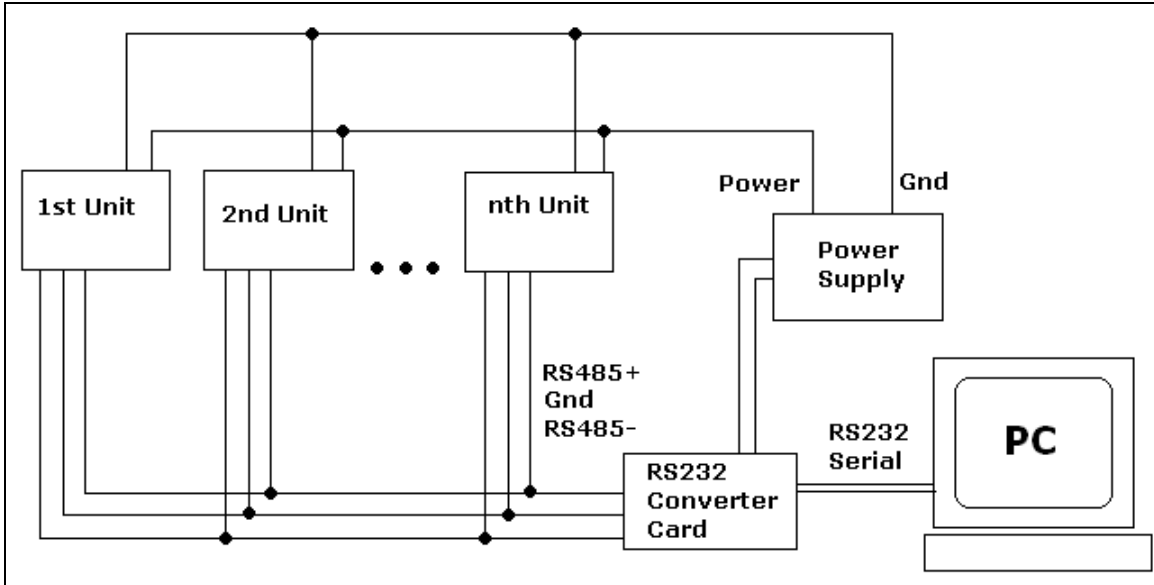


Figure 7: Connection using RS232 Converter Card

If using the USB485 converter card, connect all the power and ground lines on the units to the main power supply. Then daisy chain the RS485+ and RS485- lines prior to plugging into the USB485 card.

Be sure to also ground the USB485 card with Pin 2, ground.

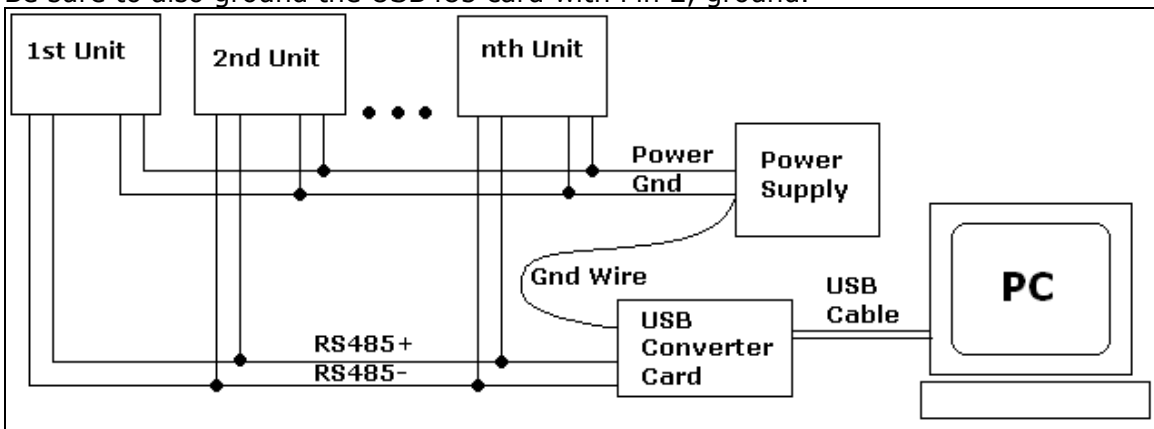


Figure 8: Connection using USB485Converter Card

## Changing the Address of the Controller

Use a screwdriver to turn the dial so the arrow points to the desired Address. Use this number when programming commands. For example, /1P1000R



Figure 9: Address Dial

Note: New RoHS compliant boards have a **Black** dial instead of a Red one.

## Connecting Accessories

If you have purchased the Designer's Kit, there is a Red Push Button and an Optical Sensor included. Follow the schematics below in order to properly assemble accessory pieces.

### Push Button

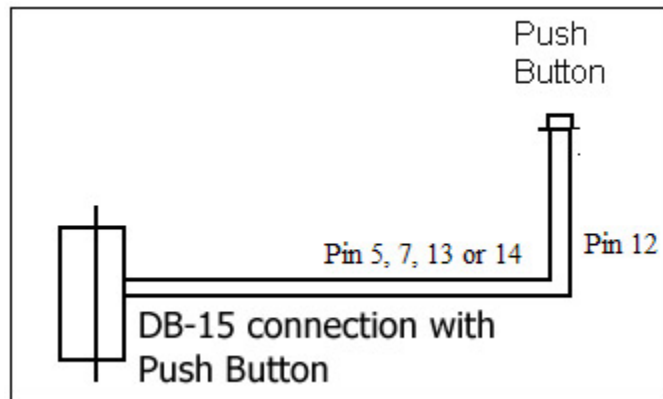


Figure 10: Push Button Schematic

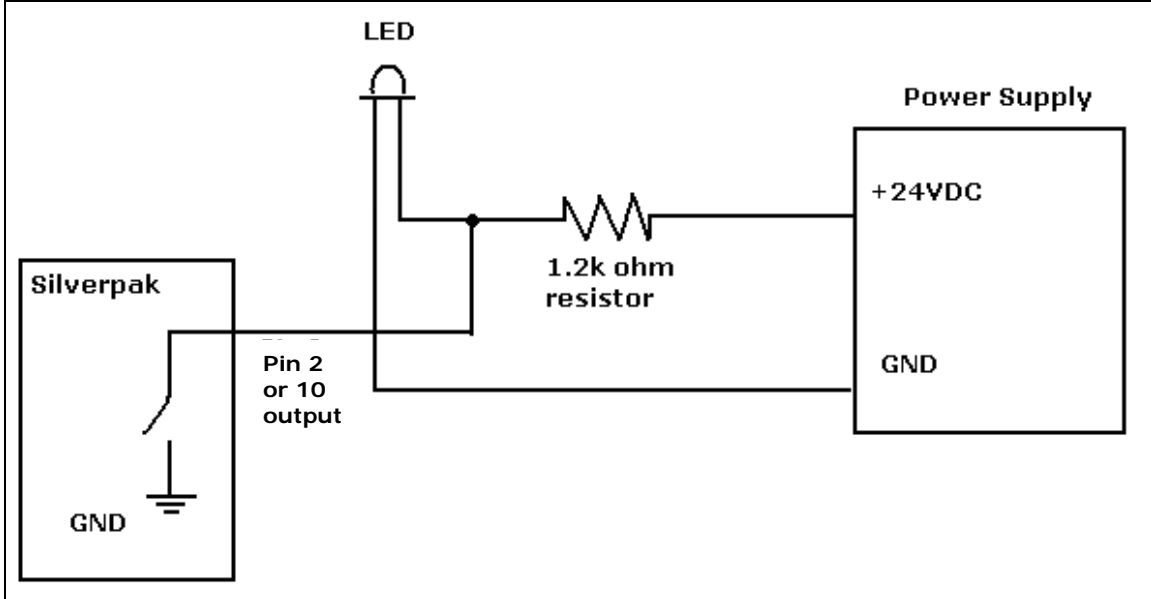
Pins 5, 7, 13 and 14 can all be used with push buttons. Below shows the corresponding input numbers for these pins.

Input 1	Pin 13
Input 2	Pin 5
Input 3	Pin 7
Input 4	Pin 14

Table 7

**LED or other output**

The two I/O lines, pins 2 & 10, can drive an external device such as solenoids, LED's, or switches. The bidirectional I/O's are switches to ground internally, and therefore need to be connected to the +V of the power supply. Below is a recommended connection for lighting an LED with 20 mAmps:



Upon entering command /1J0R, both pins 2 & 10 will output 1 Amps. The 1.2k ohm resistor will limit the current to 20 mAmps into the LED. Select any ohm value to limit your current based on the device that is connected to the output. I/O's are 24VDC tolerant.

**Optical Sensor**

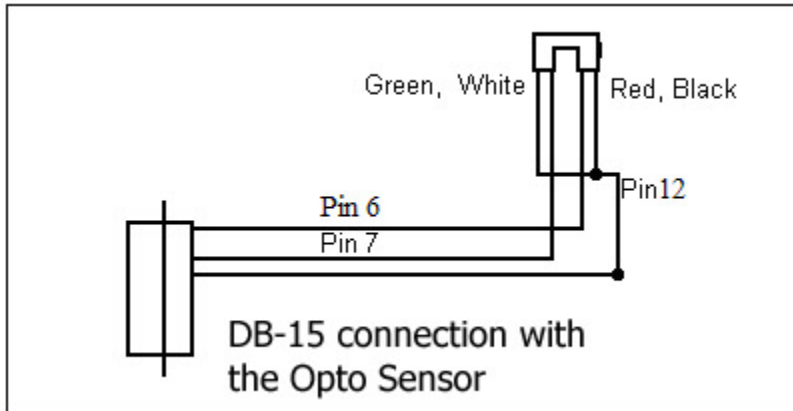


Figure 11: Opto Sensor Connection Schematic

Use the following table to solder the corresponding wires.

Optical Sensor	DB15 Cable	Pin #
Green →	Green/white	12
Black →	Green/white	12
Red →	Yellow/white	6
White →	Orange/white	7

Table 8

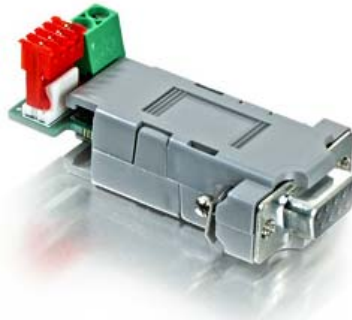
## 8. APPENDIX

### Connecting to the non-RoHS RS232 card (with Red 4-Pin)

If using the old non-RoHS converter card, here are the connection specifications for this converter card:

R356 pin#	R356 color	RS232 card pin#
8	Black/white	A (RS485A)
15	Brown	B (RS485B)
1	Green	- (GND)
9	Red	+ (PWR)

Table 9: Pinouts for using RS232

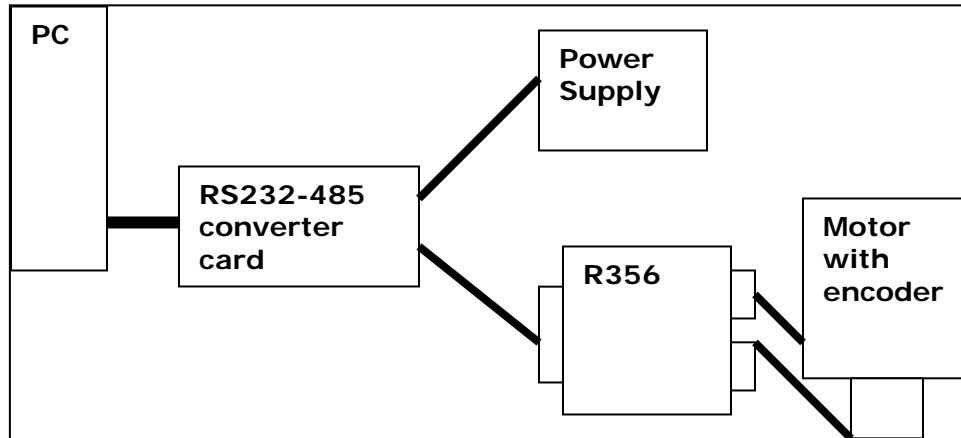


RS232 to RS485 converter card, p/n ACC-01

The RS232 card requires power (7-40VDC). Power is then sent to the motor via the Red 4-Pin connector.

### Quick Start

#### RS232-485 converter card



Connection using RS232

6. The RS232 converter card connects to the R356 using the DB-15 cable that is provided to you. The red 4-Pin connector is placed onto the converter card.
7. Your power supply will be connected to the RS232 card where the green header is located. **+ is for +12-40VDC, - is for the Power Supply Ground.**
8. Connect the motor and optional encoder to the R356.
9. Connect the RS232 card to your PC with a male to female DB-9 cable.
10. Turn your power supply on and follow instructions for using HyperTerminal.

### How to connect with old cable:

If you have a cable with a Red 4-Pin connector, simply cut off this connector, strip the wires and reconnect to a 3-Pin connector in the following manner:

Old 4-Pin cable		Connect to	New 3-Pin cable	
Pin #	Color/function		Color/function	Pin #
Pin 1	Red (PWR)	→	Connect to main power supply	--
Pin 2	Green (GND)	→	Green (GND)	Pin 2
Pin 3	Brown RS485 B (+)	→	Brown RS485 B (+)	Pin 3
Pin 4	Black/white RS485 A (-)	→	Black/white RS485 A (-)	Pin 1

### Encoder Usage

The R356 can do closed loop position correction. The encoder connects to the board internally.

### Position Correction Mode

Position correction mode, when enabled will issue steps to the motor until the encoder reads the correct position. Once enabled, **positions are given in Quadrature encoder counts of the encoder – not in microsteps**. If the motor stalls during a move then this mode will reattempt the move until the encoder reads the correct number, or until it has tried a certain number of times and times out.

#### First: Set The Encoder Ratio:

Encoder ratio = [(Microstep \* 200 steps/rev) / (CPR \*4)]\*1000

This must be a whole number after you multiply by 1000.

For example: a 1.8° motor set to 256x microstepping with a 1000 count encoder:

Encoder ratio = ((200 \* 256)/(1000\*4))\*1000 = 12800

Set encoder ratio: /1aE12800R

#### If Encoder Ratio is Unknown:

Follow these steps:

1. Issue a /1n0R to clear any special modes
2. Issue a /1z0R to set position of encoder and controller to zero
3. Issue a /1A100000R and ensure the move completes at a velocity that does not stall.
4. Issue a /1?0 to read current position. This should be 100000.
5. Issue a /1?8 to read the encoder position
6. Issue a /1aE0R which auto divides these two numbers
7. Issue a /1?aE which read backs the encoder ratio computed
8. This value is a rough guide and may be a few counts off due to inaccuracies in the motor position and run-out of the encoder, but use the EXACT number that was returned and set it with a /1aEXXXR. Or, please contact RMS Technologies and provide us with your motor part number and we can look up the encoder CPR for you.

#### Second: Set the Error in Quadrature Encoder Ticks allowed before correction begins:

/1aC50R (default is 50) Motor will move 50 encoder ticks away from desired position before position correction takes place. If aC is set to too small of a value, the motor may oscillate back and forth trying to locate the exact position. Use a larger aC value.

### Third: Set the Overload Timeout Value:

This is the number of re-tries allowed under a stall condition: /1au10000R (default is 10)

### Fourth: Enable the Feedback mode:

Zero the positions prior to enabling the feedback mode: /1z0R  
Issue /1n8R to enable the feedback mode.

## **Overload Report Mode**

Overload report mode when enabled, will compare the encoder value to the commanded position at the end of a move and report an error if the two values do not match within the range given by "aC". When this error occurs the drive will exit from any loops or strings it may be executing.

Overload report mode is enabled by /1n16R, and requires the encoder ratio to be entered correctly via the "aE" command. Issue a /1zR to zero both the encoder and position counter just prior to issuing /1n16R. Only the Position Correction mode or the Overload Report mode may be turned on at one time.

### Notes:

1. When any command is received by the drive it will always respond with its status. The drive will only accept a command when it is not busy. This status byte received must be checked to ensure that the unit was not busy and that the command was accepted. This is especially important when position correction mode is enabled, because the drive may be attempting to correct position all by itself, and will reject an externally (via RS232) received command if it is busy in the middle of a correction move.
2. When position correction mode is enabled, /1n8R, then the drive will keep retrying any stalled moves, and will NOT halt any strings or loops upon detection of a stall.
3. During position correction mode /1T will halt any move, but there is a possibility that the drive may instantly reissue itself a position correction command, especially if it is fighting a constant disturbance. It may be necessary to issue a /1n0R to positively halt a move in progress.
4. Position correction mode is inhibited if the encoder underflows and goes negative (but will automatically resume if a move is made into the positive range). If position correction is required at the zero point, please redefine zero to be a slightly positive number with the "z" command. Eg /1z10000R
5. If the encoder ratio is changed from its default of 1000, the allowed max position will be decreased from  $+2^{31}$  by the same ratio.

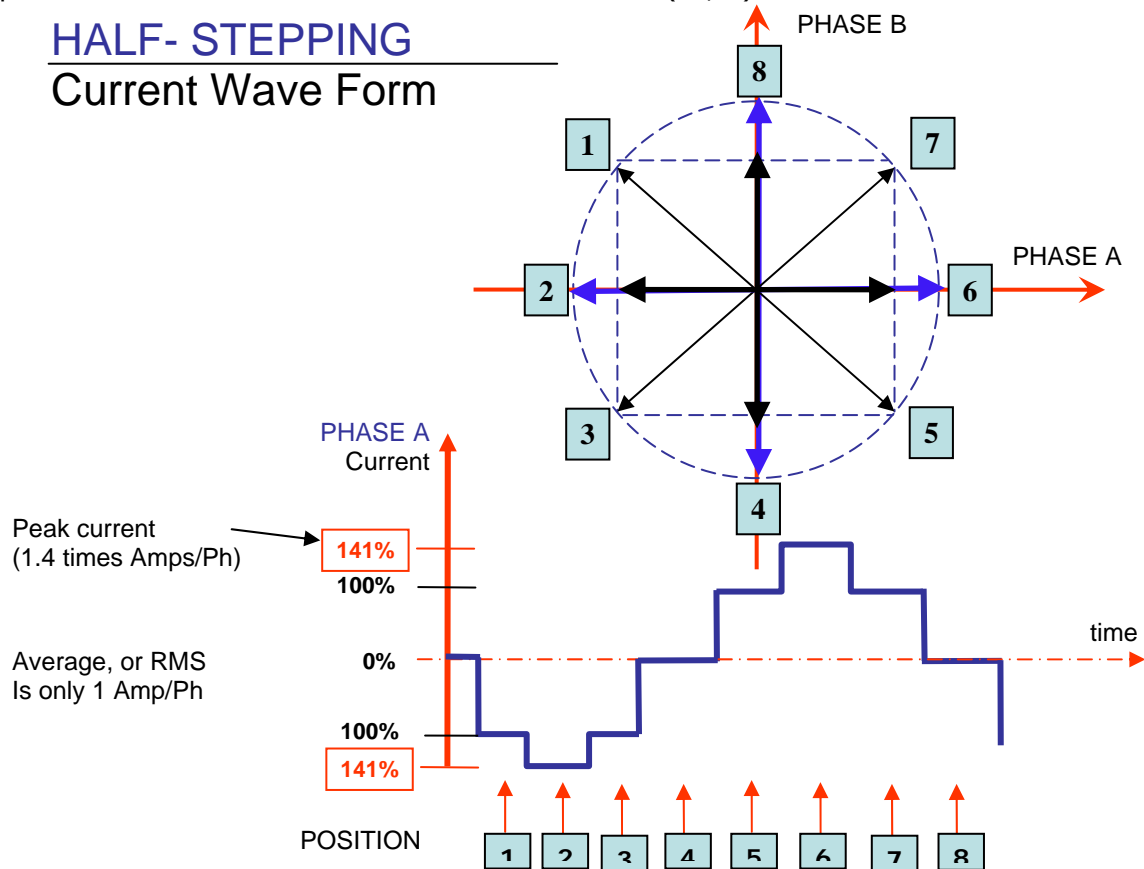
## **Peak current versus Amps/Phase**

Where does the 1.4 times come from? Current is continuously changing when a motor steps. If the motor is rated for 1.0 A/Ph, it may receive 0 Amps, 1 Amp, 1.4 Amps, or anything in between if you are microstepping. For ease of explanation, we will look at the current waveform when we half step, or set the driver/controller to 2x microstepping.

If we take a look at both the A and B phases, and plot on an X-Y chart of when each phase receives current, and how much it receives, it will look like the chart below.

Beginning at position 1, Phase A receives negative current, and Phase B receives positive current. Let's assume it is at coordinate (-1, 1).

## HALF-STEPPING Current Wave Form



The position versus time graph just above, plots only the A Phase, following the eight different steps the motor will make. Current is changing with each position. Recall that a negative in electronics simply means reverse direction of current flow.

<p>1.41 AMP (<math>\sqrt{2}</math>)</p> <p>1 AMP</p> <p>1 AMP</p>	<p>Take a look at position #7. If we were to draw the arrow at position 7 as the hypotenuse of a triangle, it would look like the triangle to our left. Recall from geometry a 90°-45°-45° triangle is a 1-1-<math>\sqrt{2}</math> combination. The <math>\sqrt{2}</math>, or 1.4 value is also the radius of the dotted circle shown above. Therefore, during certain steps, Phases A or B will receive 1.4 Amps of current. But the average, or RMS current throughout these 8 steps is only 1.0 Amps. RMS and Amps/Phase is the same meaning.</p>
<p>The 1.4A along this hypotenuse is also known as the 2-Phase On position, since both A and B Phases are "On" and receive current. It is also known as the <b>peak current</b>.</p>	
<p>As we see the waveform that's plotted for the A Phase, the highest value on the curve is known as the peak value.</p>	
<p>Motors have a rated current, or average RMS value since in operation, the current is continuously changing. The most logical way to describe a rating is to take an average, or RMS (root means squared) value. But drivers understand current in terms of peak current, therefore the conversion is: <b>Amps/Phase x 1.4 = Amps Peak</b></p>	

### Step and Direction Mode

The R356 unit can be configured as a driver only by first connecting it to your PC and saving the special mode "n96" in program memory storage zero.

1. First connect to your PC and save n96 in storage zero:  
/1s0n96R
2. Next, connect the positive side of a TTL squarewave for step pulses to Pin 11 (Blue/white wire).
3. Connect a +5VDC supply to Pin 4 (Yellow wire).
4. Tie together the negative pin of the step pulse to the negative 5VDC supply. This becomes your signal ground.
5. Change direction of rotation on the fly by connecting or disconnecting Pin 3 (White/green wire) to the signal ground that was just created in Step 4.

The unit can still accept commands via RS485 when in step & direction mode, but move commands via RS485 will override step pulses.