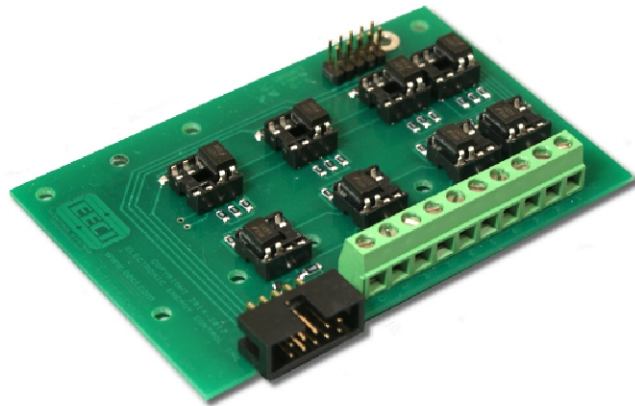


# EX-8M MULTI-FUNCTION EXPANSION MODULE

TECHNICAL REFERENCE



Click for more info: [www.eeci.com/ex-8mp.htm](http://www.eeci.com/ex-8mp.htm)

PHONE..... (937) 349-6000  
 ORDERS..... (800) 842-7714  
 TECH SUPPORT... (937) 349-6000  
 E-mail..... [sales@eeci.com](mailto:sales@eeci.com)

[www.eeci.com](http://www.eeci.com)  
*Click for Website*

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## SPECIFICATIONS

Power Supply.....	5VDC (powered from USB port or device power adapter)
Channels.....	8 relays/outputs or 8 inputs (or combinations)
Input Voltage Range.....	3.3 volts up to 18 volts (default) other voltage ranges available Minimum 1.5ma needed to turn input on (DC or AC)
Output Signal.....	Photo transistor, maximum 100mW draw (20ma at 5V) switching voltage range 3.3 VDC to 48 VDC
Adds Relay I/O Control to....	All ADC-U series, all ADC-WIFI series, all ADC-ENET series, all ADC-RS232 series, all ADC-RS485 series Analog to Digital Converters and to the AR-2MF Relay Interface, CO-485USB converter
Relay Port Compatibility.....	All EECI relay cards with ribbon cables (low power relays* or solid state relays may be connected directly to the EX-8M terminal block) * not to exceed 100mW
Weight.....	1.25 ounces
Size.....	2.675 by 3.75 inches (EX-8MS: 2.75 by 3.1 inches)

## DESCRIPTION

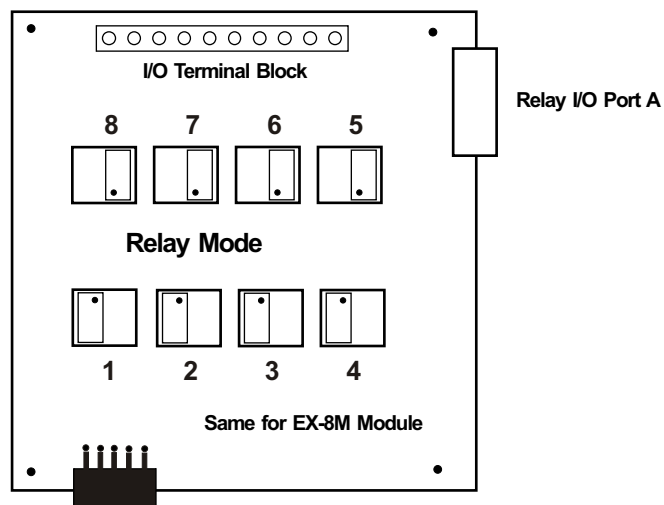
The EX-8M provides software control of 8 relays/outputs or monitoring of 8 inputs (or combinations of inputs and outputs). An optional dual I/O mode will allow input of information along with relay control. The input mode will provide input interfacing for on/off equipment status, keypads or other types of digital signals. Inputs may be used to monitor contact status or to monitor AC or DC voltages (+) or (-) 3.3 volts to 18 volts (other voltage ranges available). The optically isolated inputs are bidirectional and may be used with a positive common, a negative common or AC signals. Multi-Function capability allows connection of a variety of 8 bit I/O devices. A large variety of relay cards may be connected.

## 24 HOUR TECHNICAL SUPPORT

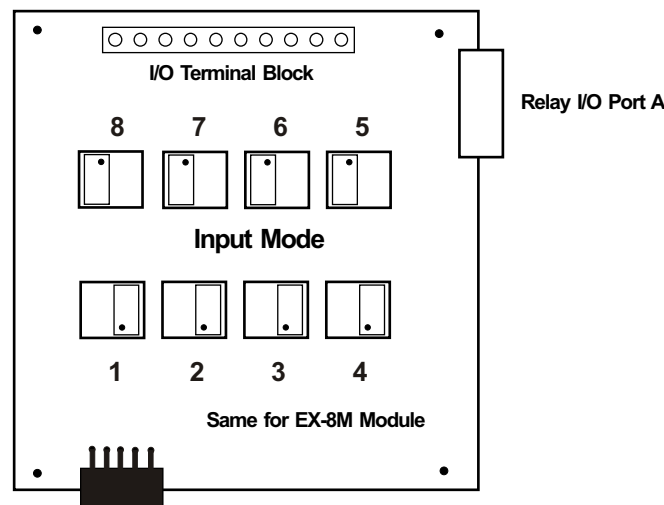
Technical support for our products is available by calling (937) 349-6000. If a technical adviser is not available, please leave your name, phone number and a time that you can be reached. Your call will be returned as soon as possible and within 8 hours. Calls received during normal business hours are usually returned within minutes.

**CONNECTION DIAGRAM**

**EX - 8 M S  
MULTI-FUNCTION  
EXPANSION MODULE**



The opto isolator positions above are shown in their default position (all set for relay mode)



The opto isolator positions above are all shown in input mode

**IMPORTANT:** Always discharge any static electricity from your body by touching the bare metal on the back of your computer before handling your EX-8MS Interface card or attached hardware.

**SET-UP AND TESTING**

Upon receiving your EX-8M, you should connect and test the operation of the hardware to verify proper operation. Please set-up and test the EX-8M as follows (Windows XP\*, Vista, Windows Server, Windows 7, 8.1,10 or later)  
\*service pack 3

**(1)** Connect your EX-8M Expansion module to any compatible EECI product, then connect to any available USB port. If you have previously installed the device driver for your EECI product and verified the version of the USB Com driver, you may skip step 2 and test your relays (jump to step 3). If you have not yet installed the device driver\* for your EECI product, you should install the device driver as described in the product's Quick Start reference sheet.

**(2)** Check your USB Com driver by going to Control Panel/Device Manager/Ports (see detail on the next page for your Windows version) or click the "Open Control Panel" button on the supplied CD start window. Click the small triangle (or +) to the left of Ports to expand the Ports category, right click the Prolific USB to Serial Comm Port, click properties and open the driver tab. Your USB Com driver must be Prolific version 3.4.62.293 or higher (dated 10/17/2013 or later). If your USB Com driver is up to date then please note the Com port number assigned and jump to step 3.

If your USB Com driver is not up to date or is not installed, click the "Update Driver" button (under driver tab). If the driver does not update, disconnect the USB cable from your computer and install the updated USB Com driver (located on your EECI product's CD startup window, or in the USB Com driver folder or from Windows Update).

**(3)** After you have verified or installed an up to date USB Com driver, reconnect your EECI product to any available USB port on your computer. Load your product's device driver by double clicking on the desktop icon and verify that you are connected to the correct Com port. You may verify that you are connected to the com port assigned to your product by unplugging the USB cable and watching the entry in device manager. The entry should disappear and then reappear when you reconnect the USB cable.

\*Please note that the Microsoft .Net Framework must be installed on your system. If the .Net Framework is not installed on your computer, the installation program (Software Interface) will attempt to download and install the .Net Framework from the Microsoft web site through your internet connection. This may take 5 minutes or longer. In order for the .Net Framework to install correctly, your computer must be up to date with Windows update. This is especially important with Windows XP and Vista. You may update your computer by clicking on the start button, All Programs, Windows Update and clicking on "Check for Updates".

**(4)** Click the Setup button in your User Interface and click the Relay Control button. Select the EX-8M under Device and click Apply (see page 7).

**(5)** Test your relays by clicking the relay buttons for each relay. The relay should energize when the button is red and de-energize when the button is green. Click the "8" option under Sequence to auto test all 8 relays. This will sequence all relays on and off at about a 1 second interval between relays.

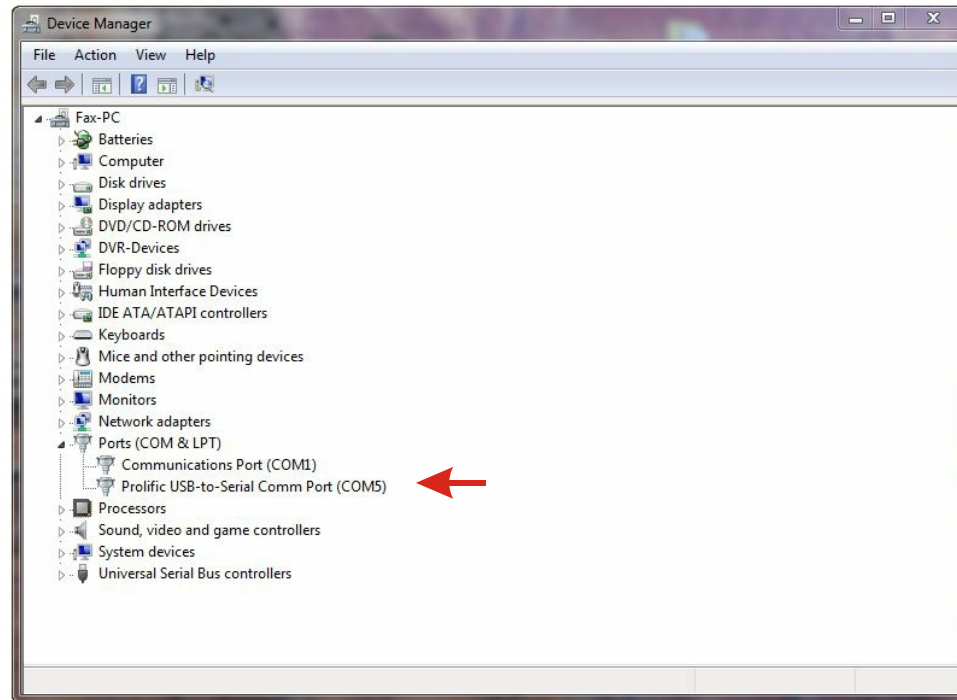
**(6)** You may set your EX-8M to input mode by reversing the opto isolators on the circuit board as shown on page 2 or 5 and connecting your input signals to the RCT-8 terminal block (connected to your EX-8M - unplug relay card).

**(7)** Test your inputs by clicking the Setup button on your EECI product's User Interface and then clicking on the Input Setup button. Check Enable then click Apply. The indicator box to the right of the label will show a zero when no voltage is applied to the terminal block and a one when voltage is applied to the input. Terminal 10 is the common (- or +) for all eight inputs. The default voltage input range for the EX-8M is 3.3V to 18 volts (DC or AC). See page 6 for terminal assignments and pages 2 and 5 for additional info.

## HOW TO OPEN DEVICE MANAGER

### Windows XP, VISTA or Windows 7

Click the Start Button (lower left of screen), then Control Panel (right side). With the view set to classic view, small or large icons, click (or double click) the Device Manager icon. With Windows XP you will need to click the System icon (in Control Panel) then the Hardware Tab then the Device Manager button. You may also use the supplied CD to open Device Manager by clicking the "Open Device Manager" button when the CD auto starts.



### Windows 8, 8.1 and Windows Server 2012

Move your mouse cursor to the lower right side of your screen and click on Settings. Click on Control Panel near the top and click on the Device Manager icon.

## TROUBLE-SHOOTING THE EX-8M

(1) Verify that your USB com driver is installed by going to Device Manager and checking for the Prolific USB to Serial Comm Port entry. Right click on the entry, then Properties, select the Driver tab and verify that the driver is dated 8/15/2014 or later. If the driver is out of date, connect to the Internet and click the Update Driver button. Please note that an out of date driver may allow your EECI product to partially function and/or with erratic operation.

(2) Verify that the Prolific USB to Serial Comm Port entry is the com port used by your EECI product. You may do this by watching the entry in Device Manager and unplugging your EECI product from your computer USB port. The entry should disappear and then re-appear when you plug your EECI product back in to your computer USB port.

(3) Verify that you are supplying 12VDC to the relay card (relays should be labeled 12VDC on top). A multi-meter may be used to measure the voltage and for the correct polarity.

(4) Verify that you have the EX-8M or EX-8MS selected under Device in your User Interface (under Setup/Relay Control). Be sure to click Apply after selecting.

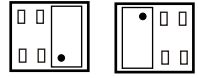
(5) Try replacing the USB cable and/or using a different USB port.

(6) Verify that your EECI product's Software Interface is correctly installed and running. Click the EECI icon in your system tray (bottom right) and check for the correct com port setting (should show the correct com port open). If the window below the COM indicator shows "COM Not Found!" then a com port issue is the problem (check for another program that may be using the com port). You may right click the taskbar at the bottom of your screen, then Task Manager to view running applications.

(7) Remove your EECI product's USB cable from your computer, wait 5 seconds and plug back in. Open the User Interface by clicking on the EECI icon in your system tray and double click on the blue EECI logo to reset the com port. You should see a reset message followed by a COM open indication. Click Setup and uncheck "Allow External Commands". If this corrects the issue that you are experiencing then an external application is the problem.

● circuit board edge

**USING THE EX-8M INPUT MODE**



Each channel may be set independently for input mode or to control a relay. Channel numbers are located next to the 8 pin sockets.

Inputs are turned on with a voltage input or contact closure. The default voltage input range is 3.3 volt up to 18 volts. Any voltage within this range will turn on the input as long as a minimum of 1.5ma is supplied. The voltage may be AC or DC and may have a common (+) or a common (-). Other voltage ranges are available.

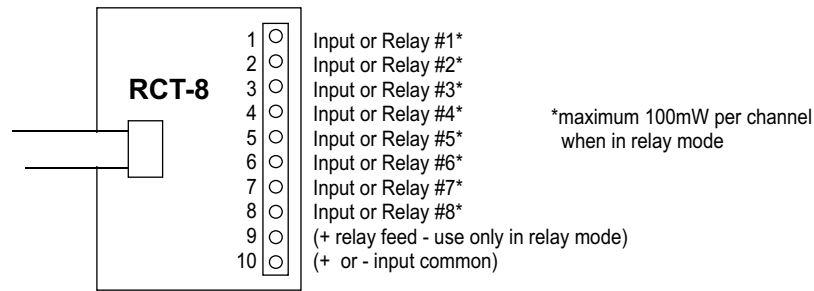
A channel is set to relay/output mode by placing the opto coupler on the right side of the 8 pin socket with the dot on the opto coupler away from the edge of the circuit board (as shown above).

A channel is set to input mode by placing the opto coupler on the left side of the 8 pin socket with the dot on the opto coupler closest to the circuit board edge.

When using the dual I/O mode, all opto couplers should be left in the relay mode position (output).

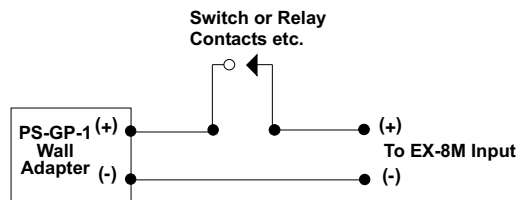
**USING THE EX-8M INPUT MODE (continued)**

**PORT A Input connections (also for the terminal block on the EX-8M)**

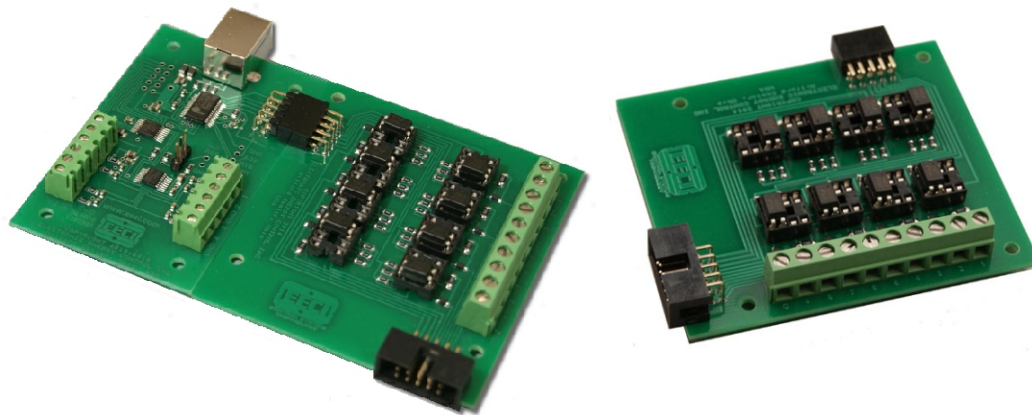


Low power relays\* or solid state relays may be connected directly to the EX-8M terminal block)  
 \* relay coil not to exceed 100mw

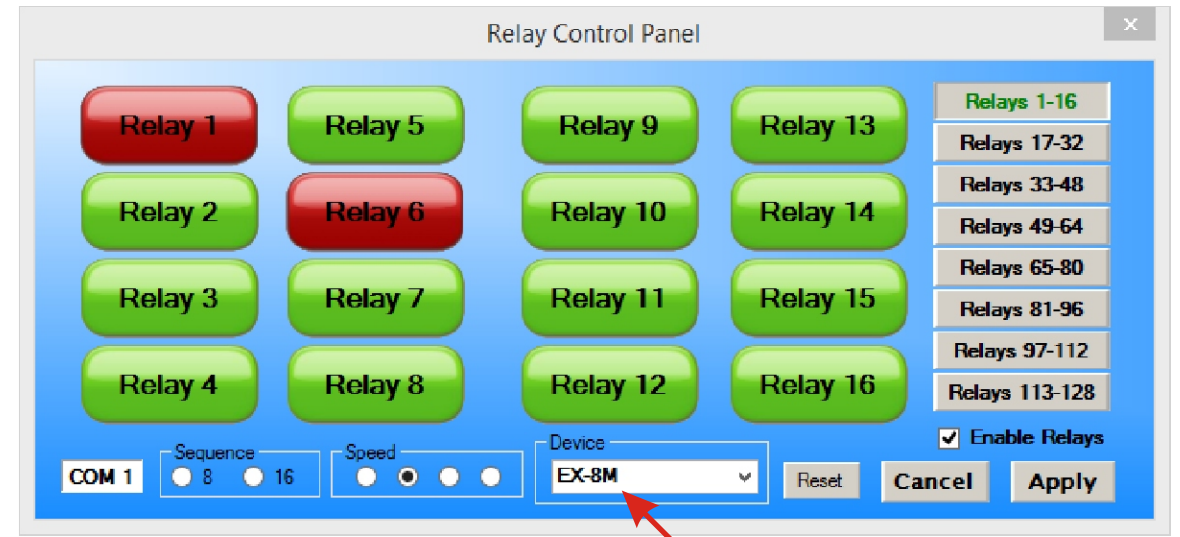
The PS-GP-1 wall adapter (or other power source) may be used to monitor for a contact closure (shown below). The 5 volt USB power feed on the Aux Port may also be used, but it is best to maintain electrical isolation from the USB port to protect your computer and your EECI product.



**EX-8MS (side mount version)**



**CONTROLLING RELAYS CONNECTED TO THE EX-8M**



After connecting the EX-8M, you must set your EECI product to connect with the EX-8M. This is done by opening the User Interface and clicking Setup, then Relay Control. The above window should appear. Select the EX-8M under Device and click Apply. This setting is saved in the settings file "product-set.ini" which is created in the folder c:\eec\product.

You can manually set the state of the relays by clicking on the relay buttons. The button will turn red when the relay is energized and will turn green when the relay is de-energized. Clicking a relay button with that channel in relay mode will display the relay state for that input and force that channel into relay mode. The button names may be changed using Setup.

Clicking the Setup button allows you to set the input enable for each of the 8 channels. The com port, baud rate and sampling rate settings are changed below. Un-checking the Allow External Commands box will prevent other Windows applications from sending or receiving data from the EX-8M. A password protected version of the Software Interface is available. Please contact technical support for more information.

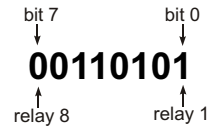
**USING THE EX-8M OUTPUT MODE**

The EX-8M outputs have a photo transistor output that is capable of directly driving LEDs, solid state relays, small reed relays and other devices that require 100mW or less of power to operate (use the terminal block to connect, see above). The maximum voltage that may be applied to pin 9 on Port A is 48 volts DC. The maximum allowed current through the photo transistor must be limited to 20ma at 5 volt, 10ma at 10 volts, 5ma at 20 volts and lower at higher voltages (ratio metrically). A variety of relay cards and relays are available for connection to the EX-8M outputs. The RYD-8 driver card may be used to directly power devices that require more then the 100mW that the photo transistors allow. The RYD-8 may be used to control large power relays, contactors or other devices that draw up to 3 amps or less. See page 2 or 5 for the opto isolator position for output (relay mode).

## EX-8M CONTROL SOFTWARE

The software control interface uses just 3 bytes to send and receive data to and from the EX-8M. One byte is used for relay control, one byte is used for input enable control and one byte is used for monitoring inputs. Shown below is a description of these control bytes:

**RELAY BYTE:** **00110101** controls Relays 1 thru 8



The above byte shows relays 1, 3, 5 and 6 energized with a decimal equivalent of 53.  
To energize all 8 relays, set all bits to 1 (decimal equivalent of 255).  
To de-energize all 8 relays, set all bits to 0 (decimal equivalent 0).

**INPUT ENABLE BYTE:** **11000100** sets channels 1 thru 8 to Input Mode

The above byte shows inputs 3, 7 and 8 enabled with a decimal equivalent of 196.

**INPUT BYTE:** **00110001** provides state of Inputs 1 thru 8

The above byte shows inputs 1, 5 and 6 turned on (decimal equivalent 49).

The EX-8M relays are controlled by sending the Relay Control Byte to the EX-8M Software Interface.

The EX-8M channels are switched to Input Mode or Relay Mode by sending the Input Enable Byte to the EX-8M Software Interface.

These 2 control bytes (Relay and Input Enable) may be sent one at a time or both and in any sequence.

The state of the EX-8M inputs are determined by reading the Input Byte. Bits set high indicate that the input is on.

The update rate of the relay/outputs and/or inputs are set in the EX-8M Software Interface by clicking the Setup button, entering the Sample Rate and clicking Apply. The default rate is 250ms (4 times per second). The Allow External Commands box in Setup must be checked in order for other applications to interact with the EX-8M.

Shown on the following page are several examples for use with Microsoft Visual Studio. These examples will run in all versions of Visual Studio including Visual Studio Express. The supplied EX-8M examples are used with programming languages Visual Basic, Visual C#, Visual C++ and ASP.Net. Please contact EECI technical support for additional source code examples.

## SIMPLE PROGRAMING EXAMPLE IN MICROSOFT VISUAL BASIC .NET

### EX-8M Relay Control Example

To use this example in Visual Basic, copy the code module (supplied on your CD) to a sub called setRelay(). From the toolbox drag two buttons and a textbox to your form. Insert the following code into the button click subs. One button will energize the relay number that you enter into the textbox. The other button will de-energize the relay.

```
Private Sub Button1_Click(sender As Object, e As EventArgs) Handles Button1.Click
    relay = Int(Val(TextBox1.Text)) 'set variable relay to an integer 1 to 8
    If relay > 0 And relay < 9 Then setRelay() 'set EX-8M relay - energize relay
End Sub
```

```
Private Sub Button2_Click(sender As Object, e As EventArgs) Handles Button2.Click
    relay = Int(Val(TextBox1.Text)) + 8 'set variable relay to an integer 9 to 16
    If relay > 8 And relay < 17 Then setRelay() 'set EX-8M relay - de-energize relay
End Sub
```

### EX-8M Input example

To use this example in Visual Basic, copy the code module (supplied on your CD) to a sub called readInputs(). From the toolbox, drag (8) labels and a timer control to your form. Insert the following code into the timer sub. The state of the (8) EX-8M inputs are displayed in labels 1 through 8.

```
Private Sub Timer1_Tick(sender As Object, e As EventArgs) Handles Timer1.Tick
    readInputs() 'collect inputs status

    If inputs <> inputByte(0) Then 'have inputs changed?
        Z = 1 'select bit 0 (first byte)
        For W = 1 To 8
            B = inputByte(0) And Z 'check bit
            If B > 0 Then MyLabelArray(W).Text = "1" Else MyLabelArray(W).Text = "0" 'bit set?
            Z = Z * 2 'advance to next bit
        Next W
        inputs = inputByte(0) 'input states 1 to 8 are stored in inputByte(0)
    End If
End Sub
```

## SIMPLE PROGRAMING EXAMPLE IN MICROSOFT C# .NET

### EX-8M Relay Control Example

To use this example in Visual C#, copy the code module (supplied on your CD) to a sub called set\_relay(). From the toolbox drag two buttons and a textbox to your form. Insert the following code into the button click subs. One button will energize the relay number that you enter into the textbox. The other button will de-energize the relay.

```
private void button1_Click(object sender, EventArgs e)
{
    relayNumber = Convert.ToInt32(textBox1.Text);
    relayByte = relayByte |= 1 << relayNumber-1;    //set relay bit
    set_relay();    //energize relay
}

private void button2_Click(object sender, EventArgs e)
{
    relayNumber = Convert.ToInt32(textBox1.Text);
    relayByte = relayByte &= ~(1 << relayNumber-1);    //clear relay bit
    set_relay();    //de-energize relay
}
```

### EX-8M Input example

To use this example in Visual C#, copy the code module (supplied on your CD) to a sub called read\_inputs(). From the toolbox, drag (8) labels and a timer control to your form. Insert the following code into the timer sub. The state of the (8) EX-8M inputs are displayed in labels 1 through 8.

```
private void timer1_Tick(object sender, EventArgs e)
{
    read_inputs();    //collect the status of inputs from the EX-8M

    bitOfByte = 0;    //set to input 1
    check_bit();    //determine if input bit is set
    if (bit == true){
        label1.Text = "1";    //display input state
    }
    else {
        label1.Text = "0";
    }

    bitOfByte = 1;    //set to input 2
    check_bit();
    if (bit == true)
    {
        label2.Text = "1";
    }
    else
    {
        label2.Text = "0";
    }
}

private void check_bit()
{
    bit = (inputByte[0] & (1 << bitOfByte)) != 0;    //determine if bit is set - bit 0 to 7 - result bool
}
```

## RELAY RESPONSE SPEED

The speed at which the relays respond to a software command is directly related the baud rate setting of your EECI product and the sample rate set in the user interface. The higher the baud rate setting, the faster a relay (or group of relays) will respond to software transmissions. The default setting of 115,200 baud will allow your software to energize and de-energize groups of relays almost instantly when the sample rate is set to 50 ms (located in the User Interface Settings).

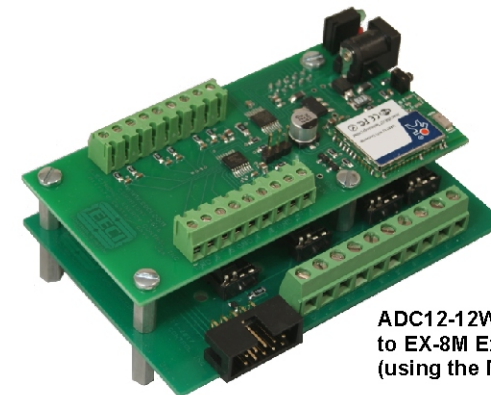
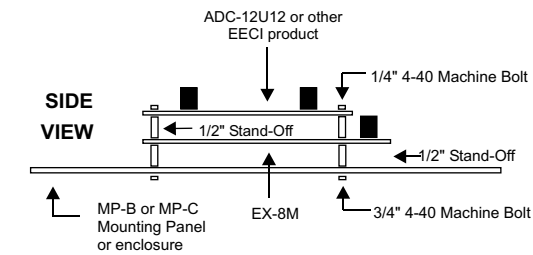
## AUTO START-UP FOR THE EX-8M

You may install your device driver permanently by checking the "Driver Only" check box under Setup in your products User Interface. The "Driver Only" check box should not be checked unless your product is connected at all times. You will then always see your device's system icon in your system tray\* along with the other system devices (such as your speaker, printer or display adapter). Click your product's icon in your system tray to open the User Interface. If the device driver is not installed permanently, you will need to double click the desktop icon to load the device driver each time your system starts.

When the EX-8M is first powered, the relays which are connected will normally power-up in a de-energized state. Your program should reset all the relays to a known state when your program is first started.

## MOUNTING

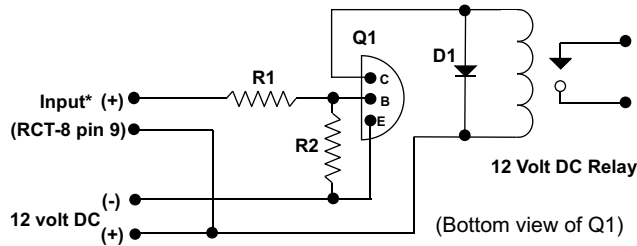
The EECI product and EX-8M cards may be mounted in an enclosure or on a metal mounting panel using the MT-2 stand-off mounting hardware as shown below. The EECI product and EX-8M will attach to the stand-off spacers using 4-40 machine screws (mounting holes are provided on the EECI product and the EX-8M). Contact technical support for more information on mounting panels and various mounting layouts.



ADC12-12WIFI shown mounted to EX-8M Expansion Module (using the MT-2 Stand-off Kit)

### RELAY INTERFACING

In the event that you wish to use existing control relays with the EX-8M, you may use the RYD-8 relay driver card or construct a relay driver circuit as shown below. The voltage and current output of the relay output port is too low for most relays (with the exception of some types of solid state relays and reed relays). We recommend the use of the following circuit to drive most types of mechanical and reed relays with 12 volt DC coils (200 MA maximum).

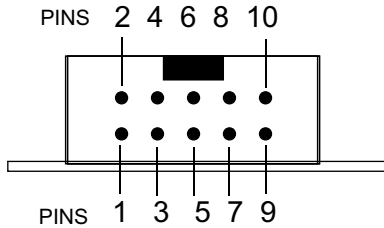


#### PARTS LIST

- (Q1) NPN Transistor...MPS6560 or (Radio Shack 276-2009)
- (D1) Diode.....1N4148 or (Radio Shack 276-1122)
- (R1, R2) Resistor.....3K, 33K (Radio Shack 271-1328, 1341)
- (Relay) Radio Shack 275-214, 275-206, 275-233 or equivalent

\*connect to opto isolator output from the EX-8M using the RCT-8 (pin 9 is common)

#### PORT A HEADER CONNECTOR PIN-OUT



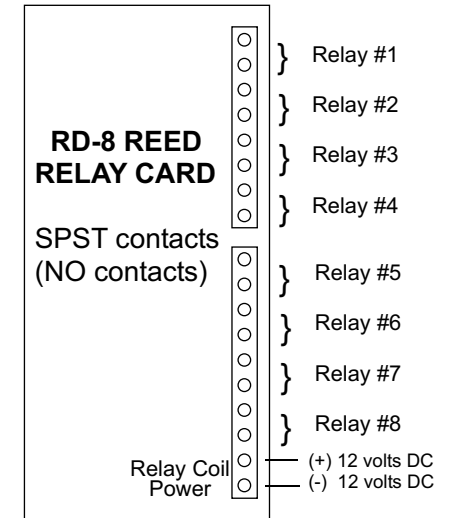
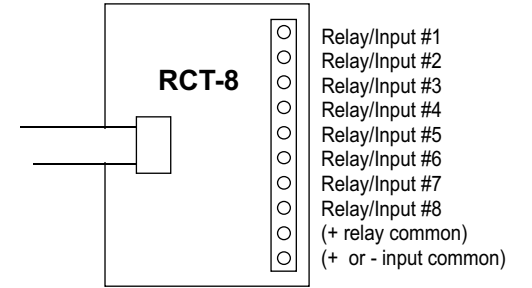
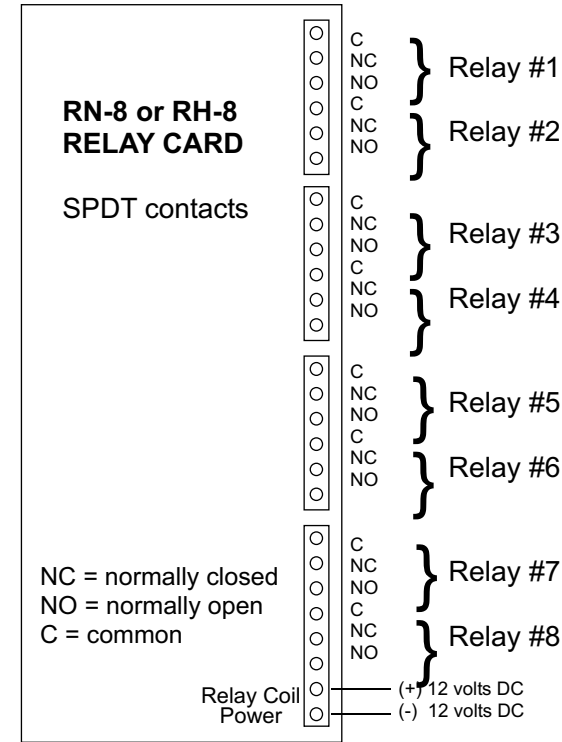
HEADER PIN-OUT FOR PORT A ON THE EX-8M

NOTE: Key notch is on top. View is looking into header pins.

#### PIN CONNECTIONS

- (1) Relay #1 or Input #1
- (2) Relay #2 or Input #2
- (3) Relay #3 or Input #3
- (4) Relay #4 or Input #4
- (5) Relay #5 or Input #5
- (6) Relay #6 or Input #6
- (7) Relay #7 or Input #7
- (8) Relay #8 or Input #8
- (9) Opto (+) (used for relay control only)
- (10) Signal Common (used for inputs only)

### CONNECTION DIAGRAMS FOR RELAY CARDS AND RCT-8



#### SPECIFICATIONS RH-8 RELAY CARD

Size.....	2.75" by 6"
Weight.....	8 ounces
Number of Relays.....	8
Contact rating (AC).....	12 amp 250 VAC
Contact rating (tungsten).....	3 amp 360 watt
Contact rating (DC).....	12 amp 24 VDC
Contact rating (horsepower)...	1/3 HP 240 VAC
Contacts.....	SPDT
Power requirements.....	12 volts DC 500ma
Terminal block rating.....	125 volts
Optional heavy duty block.....	250 volts

#### SPECIFICATIONS RD-8 REED RELAY CARD

Size.....	2.25" by 4.875"
Weight.....	3.5 ounces
Number of relays.....	8
Contact rating (DC).....	10 VA 200 VDC
Contact rating (AC).....	10 VA 200 V peak
Max switching current.....	1/2 amp
Contacts.....	SPST
Power requirements.....	12 Volts DC 200ma
Terminal block rating.....	125 volts
Optional heavy duty block.....	200 volts

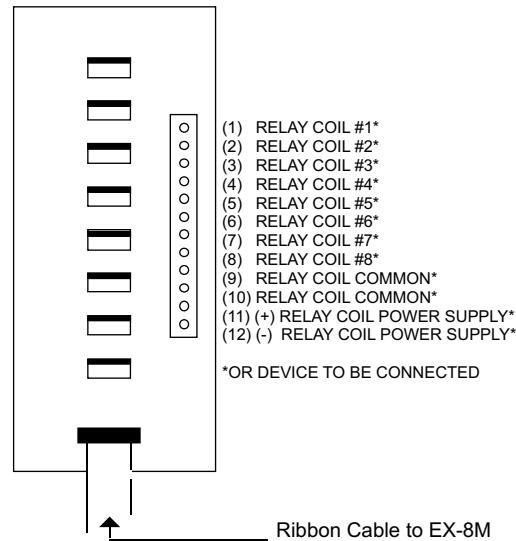
## CONNECTION OF THE RYD-8 TO THE EX-8M

### SPECIFICATIONS RYD-8 RELAY DRIVER CARD

Size..... 2.25" by 4.875"  
 Weight..... 2.5 ounces  
 Relay Outputs..... 8  
 Maximum current rating..... 3 amp (requires heat sinks above 1.5 amps)  
 Input voltage range..... 5 to 48 volts DC (voltage must match relay coil requirement)

**DESCRIPTION:** The RYD-8 relay driver card provides (8) relay drivers for connection directly to relay coils, contactor coils or other devices (such as motors, lamps, solenoids, etc.). The ribbon cable provided with the RYD-8 will connect directly to a relay output port on the EX-8M Interface which allows the RYD-8 relay driver to provide software control of the relay or device to be connected to the terminal block on the RYD-8. The RYD-8 relay driver card will power relays or other devices which require 3 amps or less and operate within the voltage range of 5 to 48 volts DC. The output voltage of the RYD-8 (for powering the relay coil or device) is equal to the RYD-8 power input which is applied to terminals (11) and (12) on the RYD-8 terminal block. All eight relay coils (or other devices which are connected to the RYD-8) must operate at the same voltage and must operate at the voltage that is applied to terminals (11) and (12) on the RYD-8 terminal block.

### RYD-8 CONNECTION DIAGRAM



One side of the relay coil of each relay must be connected to one of the relay common terminals (two terminals are provided for all eight relays, terminal #9 and terminal #10).

ALL EIGHT RELAY COILS (or connected device) MUST OPERATE AT THE SAME VOLTAGE.

**HEAT SINKS:** Heat sinks should be installed on the power transistors on the RYD-8 relay driver card if the relay coil or the device to be connected requires more than 1.5 amps continuous (or 5 watts). A heat sink kit is available for this purpose (specify RYD-8 heat sink kit). Please contact technical support for additional information.

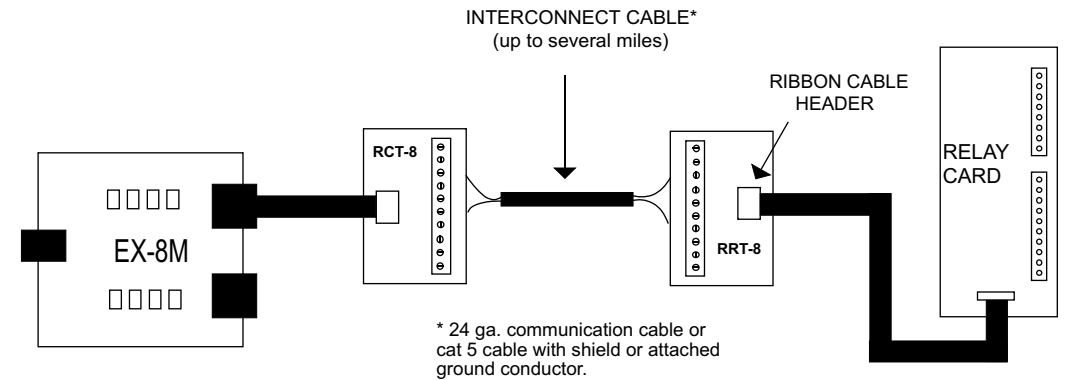
Relays or devices connected to the RYD-8 may be located up to several miles from the RYD-8. The only limiting factor is the voltage drop in the relay interconnect wire. A number of different types of relays with various contact configurations are available for connection to the RYD-8. Contact technical support for more information.

The ribbon cable on the RYD-8 may be connected to the relay output port on the EX-8M in the same manner as the relay cards are connected.

### REMOTE CONNECTION OF RELAY CARDS OR RELAY DRIVER CARDS

The relay card may be located up to several miles away from the EX-8M. Plug the RCT-8 into Port A of the EX-8M. The remote relay card may then be connected to the RCT-8 using low cost 24 gauge 6 pair communication cable, cat 5 network cable or other types of cable. The RCT-8 terminal block or RCP-8 (DB-9 connector) ribbon cable adapters should be used at the EX-8M for connection to the interconnect cable (see illustration below). Relay cards may be ordered with a header in place of the ribbon cable or the RRT-8 terminal block may be used to make the connection to the interconnect cable. The relay card ribbon connector may be replaced with a DB-9 connector in place of the header for direct connection to the interconnect cable. All relay cards are available with header sockets, RJ-45 or DB-9 connectors installed in place of the ribbon connector (specify when ordering).

The following illustration shows how relay cards or relay driver cards may be connected to the EX-8M. The relay card or relay driver card must be powered at the remote location.



### WARRANTY AND CARE OF THE EX-8M

The EX-8M Relay Interface is warranted against factory defects for a period of 90 days from the date of purchase. The EX-8M has proven to be extremely reliable in actual operation during field tests. We recommend that the EX-8M and associated hardware be installed in a suitable enclosure (4 mounting holes are provided on the circuit board) and that reasonable precautions be taken to protect the circuit from static discharge. The most likely damage to occur is that caused by static discharge to the circuit board during handling or caused by lightning storm discharge through connected equipment.





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