

## Digital I/O Board Kit (#27113)

The Parallax Digital I/O Board Kit enables your microcontroller to interface to high voltage circuits allowing you to read up to 8 optically isolated inputs and control up to 8 isolated outputs. Inputs can be a voltage from 5-30VDC (AC compatible) and outputs can be either mechanical or solid state relays that can switch up to 12A loads, such as cooling fans, solenoids, heating elements and more.

Simple parallel input/output control for ease of use or you can use the serial interface to minimize I/O pin usage. The logic circuits operate from 3.3V to 5V making them compatible with most microcontrollers. The ICs in the kit are all socketed making replacement easy should it ever be necessary. 8 green and 8 red LEDs indicate the status of input and outputs. 2 yellow LEDs indicate relay/logic power. Inputs can be configured to handle a different range of input voltages by changing a couple of components.

### Features

- Mechanical or Solid State Relay output
- Configurable Input Voltage range
- Serial or parallel interface to inputs/outputs
- LED indication of power and input/output status
- AppMod compatible connection for Board of Education

### Key Specifications

- Power requirements: 12VDC @ 1A for relay power and 3.3 – 5VDC for logic power
- Communication: Parallel or Synchronous Serial
- Operating temperature: +32 to +158°F (0 to +70°C)
- Dimensions: 7.25" L x 4.50" W x 1.00" H (184.1mm x 114.3mm x 25.4mm)

### Application Ideas

- Isolated power control of high voltage/current devices from your microcontroller, such as heating elements, blower fans, solenoids, lighting systems and more
- Isolated monitoring of high voltage signals such as doorbell, alarm or other signals.

### Product Notices

- Relays are not included with this kit and must be purchased separately. Mechanical Relays are part #400-00052 and Solid State Relays are part #400-00053.
- This product comes as a kit and must be assembled by the customer. Soldering experience is required to assemble this kit and the following tools are required; Safety Glasses, Soldering Iron, Solder, Flux (optional), Diagonal Cutters (to remove extra leads), Needle-Nosed Pliers (optional, to bend/form leads)
- This product is capable of switching high voltages. Observe the safety precautions listed in this documentation.

## Bill of Materials

Part #	Designator	Description	Quantity
200-01040	C1-C3	Capacitor, .1uF Monolithic, 100V, 10%	3
201-01075	C4	Capacitor, 1000uF, Electrolytic, 25V, 20%	1
350-00006	D1-D8	LED, Red T1-3/4	8
350-00007	D26, D28	LED, Yellow T1-3/4	2
350-00001	D9-D16	LED, Green T1-3/4	8
501-00006	D17-D24	Diode, 1N4004 Rectifier	8
501-00007	D25	Diode, Schottky, 40V/3A	1
179-00050	RN1	Resistor Network, 8-ISO, 1K, 1/4W, 2%, DIP-16	1
150-01020	R1-R8,R33,R42	Resistor, 1K, 1/4W, 5%	10
156-02235	R1_B-R8_B	Resistor, 560, 1/4W, 5%	8
150-02210	R9-R16,R34	Resistor, 220, 1/4W, 5%	9
150-01030	R17-R24,R43	Resistor, 10K, 1/4W, 5%	9
156-02240	R25-R32	Resistor, 1.5K, 1/4W, 5%	8
602-01040	U1-U8	IC, 4N25 Optoisolator, DIP-6	8
500-00005	U9	IC, ULN2803 Darlington Array, DIP-18	1
602-00009	U10	IC, 74HC595 Shift Register, DIP-16	1
602-00010	U11	IC, 74HC165 Shift Register, DIP-16	1
452-00052	S1-S8	Socket, IC, DIP-16	8
452-00053	S9	Socket, IC, DIP-18	1
452-00054	S10-S11	Socket, IC, DIP-16	2
452-00012	J1-J17	2-Position Terminal Block	21
452-00007	J18	2.1mm DC Barrel Jack	1
452-00049	J19	2x10 (20-pin) Dual Row Header	1
452-00048	J20	2x5 (10-pin) Dual Row Header	1
451-00301	JP1	3-pin SIP Header	1
451-00201	JP2	2-pin SIP Header	1
452-00009	—	Shorting Block (Shunt)	1
300-27113	PCB1	Raw PCB	1

## Resources and Downloads

You may download free example programs, articles, videos etc. from the Digital I/O Board product page on our website. Check back periodically for updates or additional examples including example programs, customer applications, articles, etc.

<http://www.parallax.com>

Search for 27113 on our website.

## Assembly Instructions

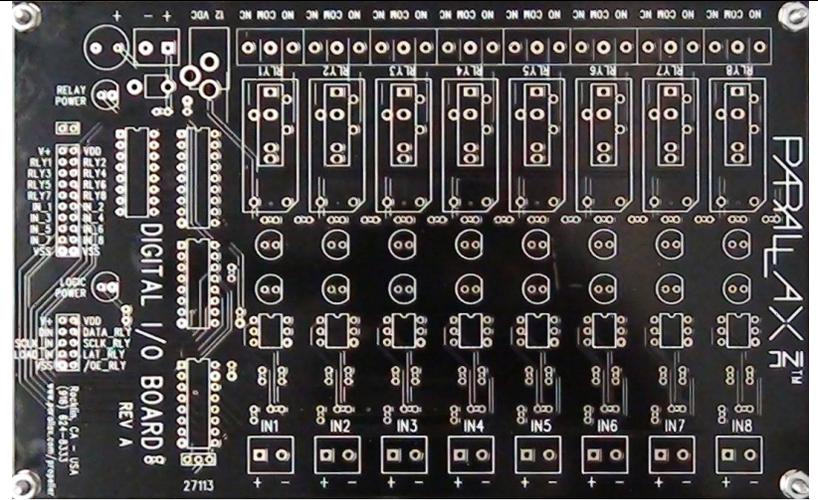
Before starting assembly be sure you have the necessary tools and a clean area to work in. Start with the lower profile components and work our way up to taller components.

### Step 1:

Be sure the PCB is free of dirt and excessive fingerprints.

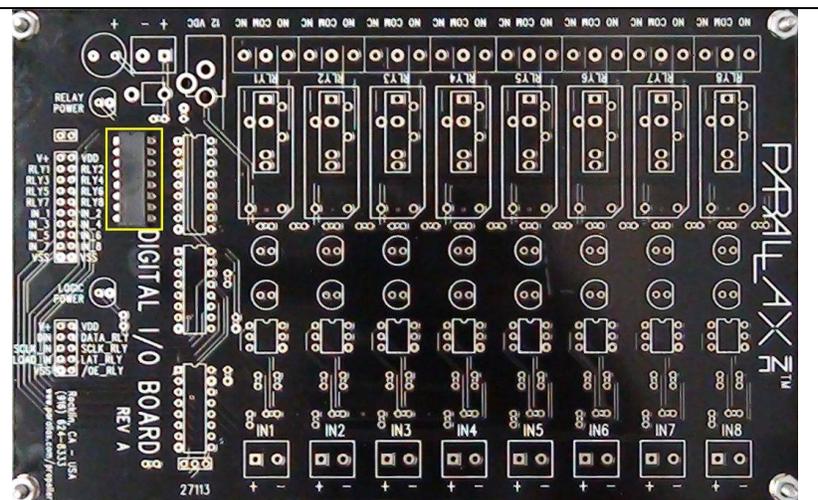
Set your board in a position to start installing and soldering groups of components.

In the following steps the component locations will be highlighted with a yellow square / circle.



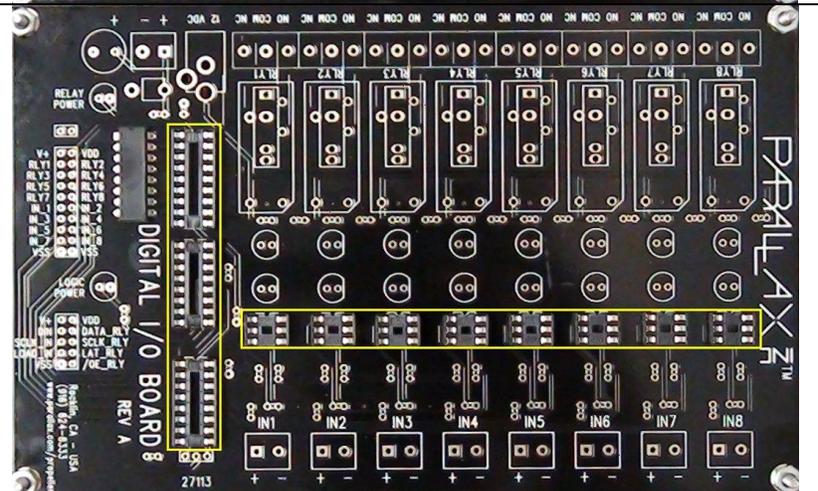
### Step 2:

Install Resistor Network RN1 into the location shown to the right. The notch should be toward the top. Solder this device in carefully, avoiding overheating the component as will all components from this point.



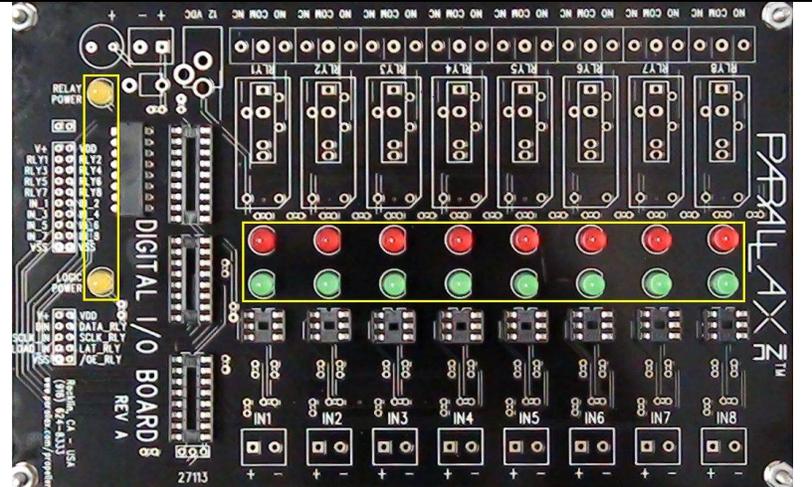
### Step 3:

Install the sockets, S1-S8 and S9, S10 and S11 as shown to the right. Notches should be toward the top. Solder these in place.



**Step 4:**

Install and solder the Yellow, Red and Green LEDs in their respective positions on the PCB as shown. You may find it easier to solder these one at a time.



**Step 5:**

Install Diodes D17-D24 as shown to the right. The components stand on end in the right hole with the stripe facing up (as shown in the inset) and the other lead bent over into the left hole. This is vertical mounting of an axial component.



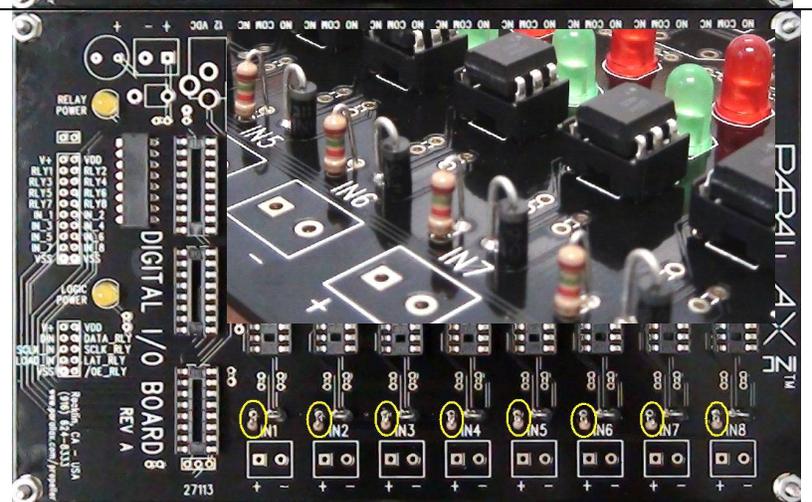
**Step 6:**

If you will be using input voltages outside the range of 15-30VDC then please skip this step until you read the section on 'setting the input voltage range'.

Install the 1.5K resistors R25-R32 into the positions shown at right.

Color code is: Brown, Green, Red, Gold

Inset shows details.

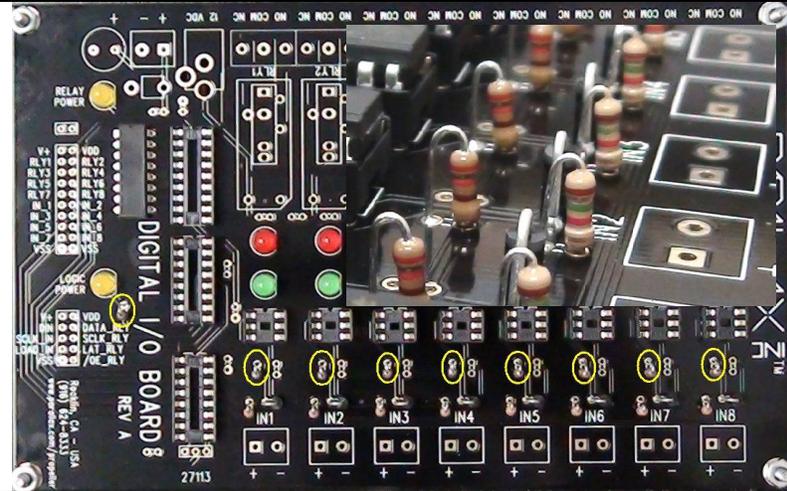


**Step 7:**

Install the 220 ohm resistors R9-R16 and R34 into the positions shown at right.

Color code is: Red, Red, Brown, Gold

Inset shows details.

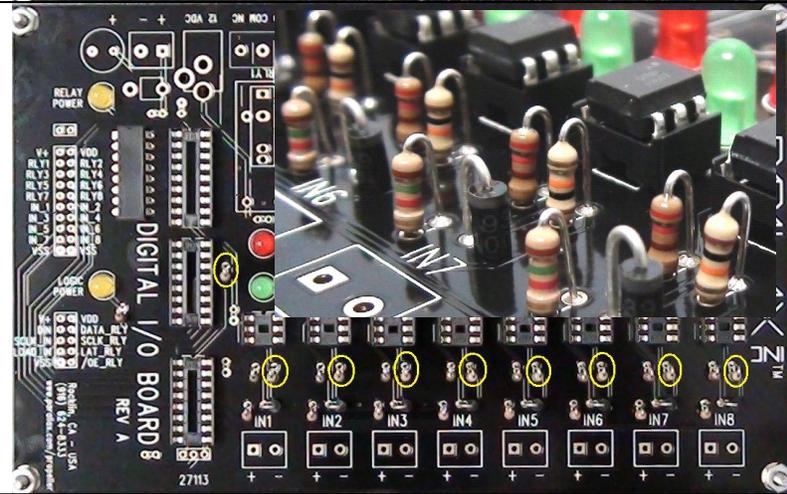


**Step 8:**

Install the 10K resistors R17-R24 and R43 into the positions shown at right.

Color code is: Brown, Black, Orange, Gold

Inset shows details.

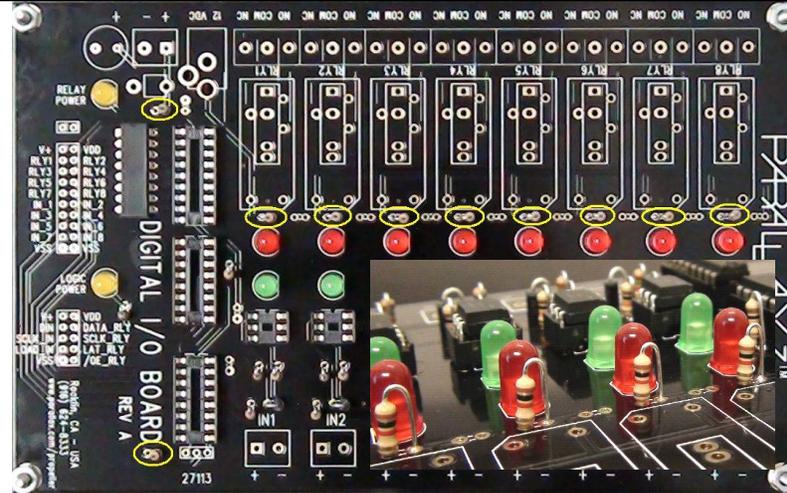


**Step 9:**

Install the 1K resistors R1-R8, R33 and R42 into the positions shown at right.

Color code is: Brown, Black, Red, Gold

Inset shows details.

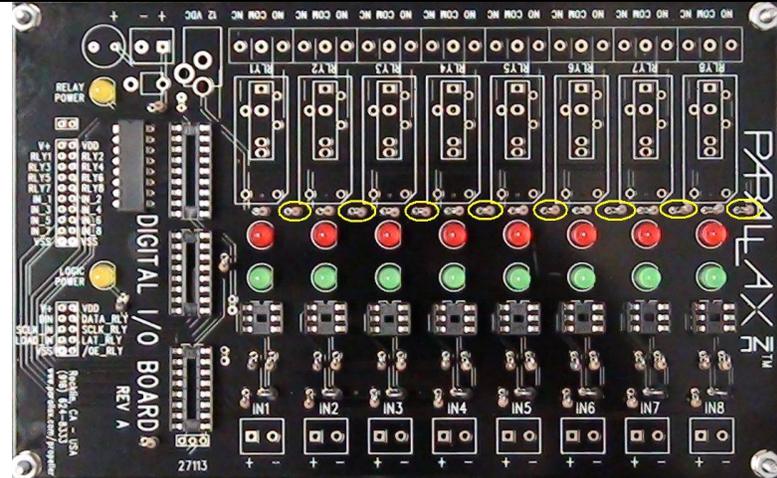


**Step 10:**

Install the 560 ohm resistors R1\_B-R8\_B into the positions shown at right.

Color code is: Green, Blue, Brown, Gold

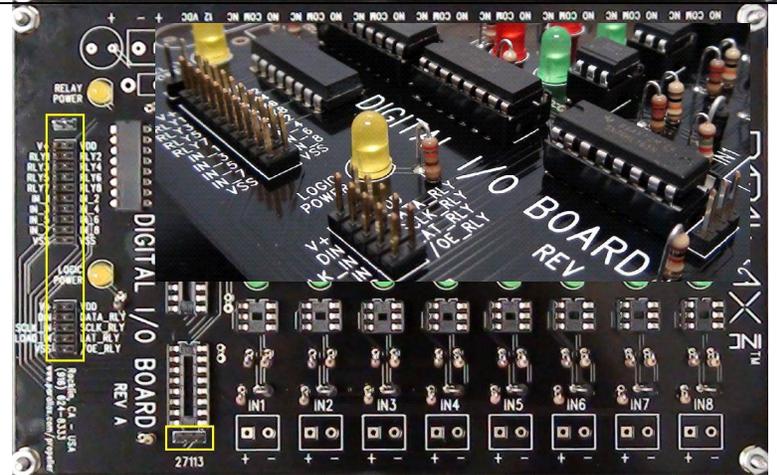
Install these in the same manner as previous resistors.



**Step 11:**

Install the headers resistors J19, J20, JP1 and JP2 into the positions shown at right.

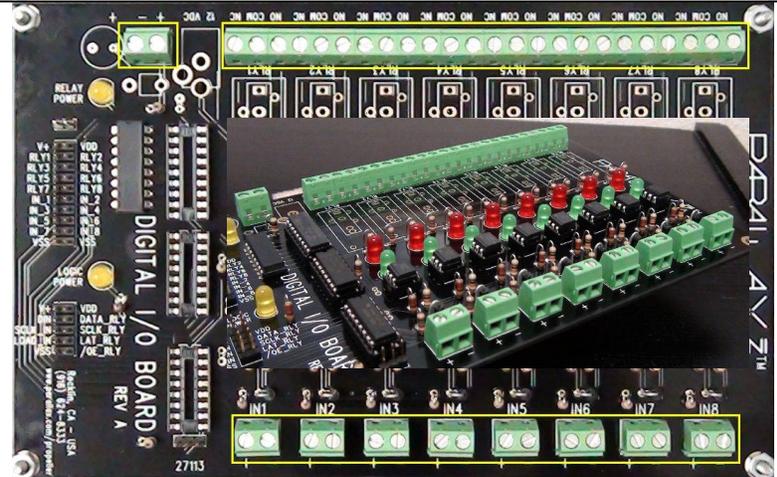
Inset shows details.



**Step 12:**

Install the Terminal Blocks J1-J17 (21 pcs total) into the positions shown at right.

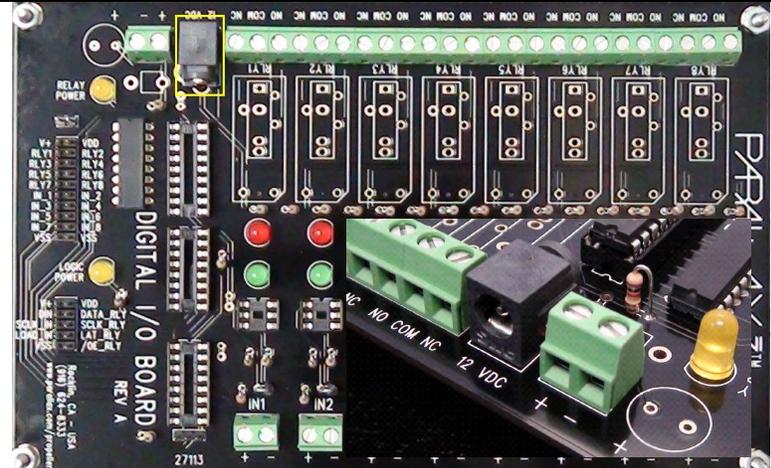
Note: 12 Terminal Blocks must be snapped together for the relay connections. These slide together vertically to create one long strip.



**Step 13:**

Install the 2.1mm DC Barrel Jack J18 into the position shown at right.

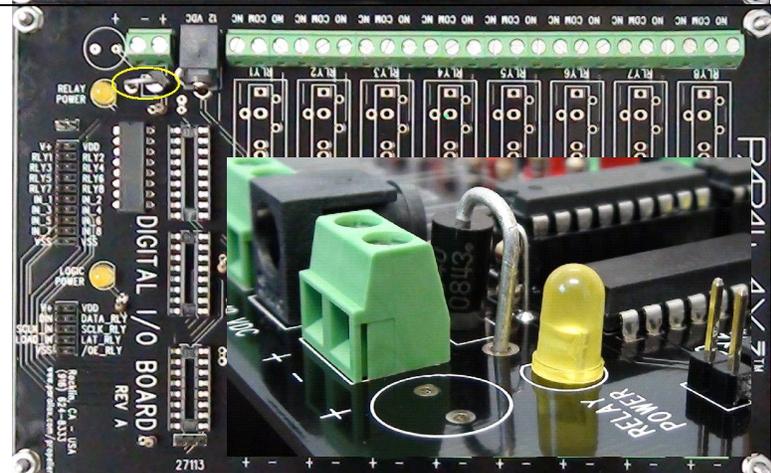
Inset shows details.



**Step 14:**

Install Diode D25 into the position shown at right.

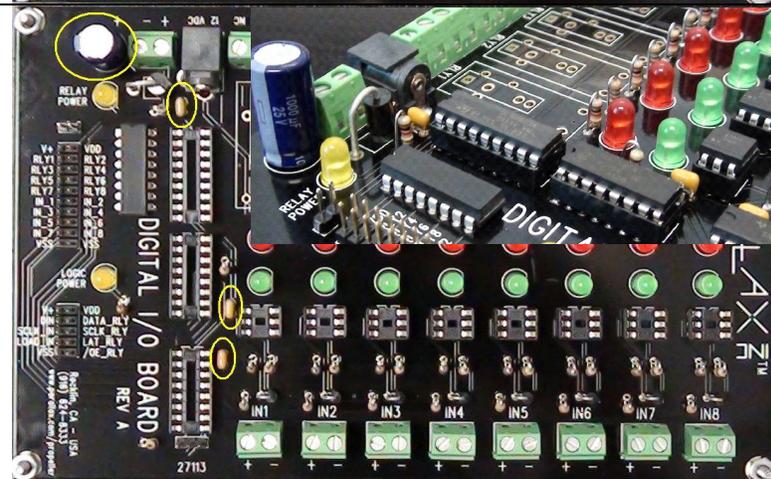
With the diode mounted in the right (side with square) the stripe should be on the bottom. The other lead should bend over into the left hole. Inset is from other side.



**Step 15:**

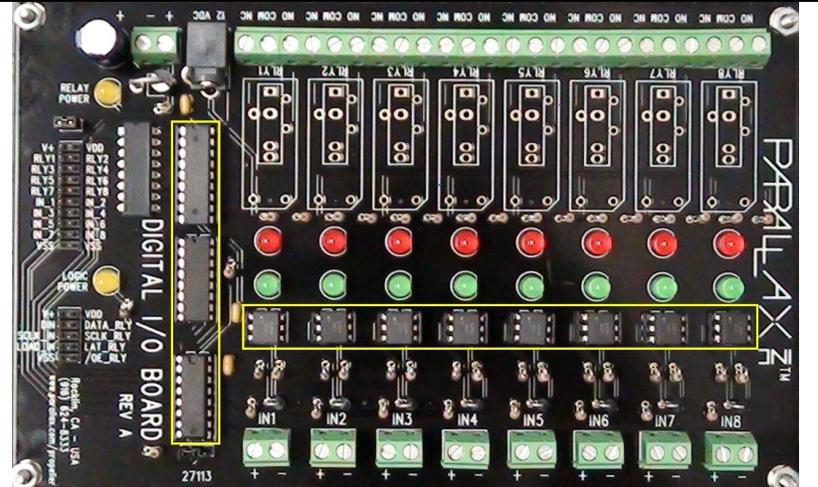
Install Capacitors C1-C4 into their respective positions as shown at right. Observe proper polarity on C4. C1-C3 are non-polarized.

Inset shows details.



**Step 16:**

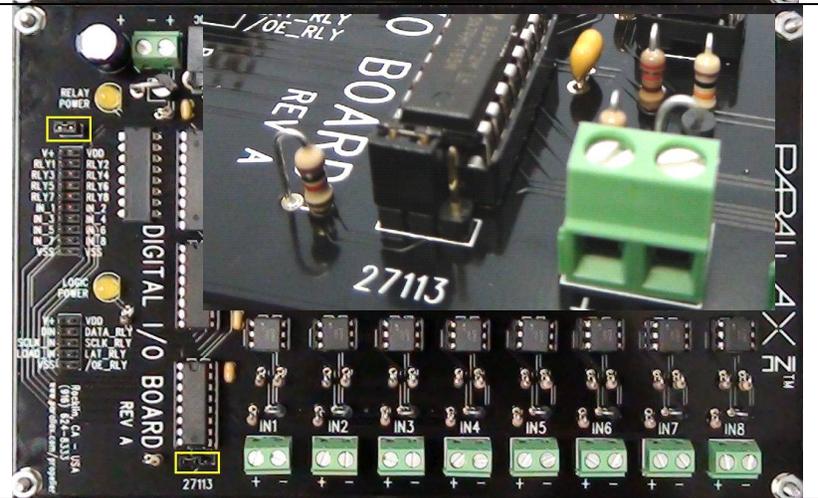
If you have not already done so you may now install the ICs in their respective slots. Be sure the notches or pin 1 indicators are at the top for all ICs. The ULN2803 (U9) goes on top, the 74HC595 (U10) is in the middle and the 74HC165 (U11) is on the bottom.



**Step 17:**

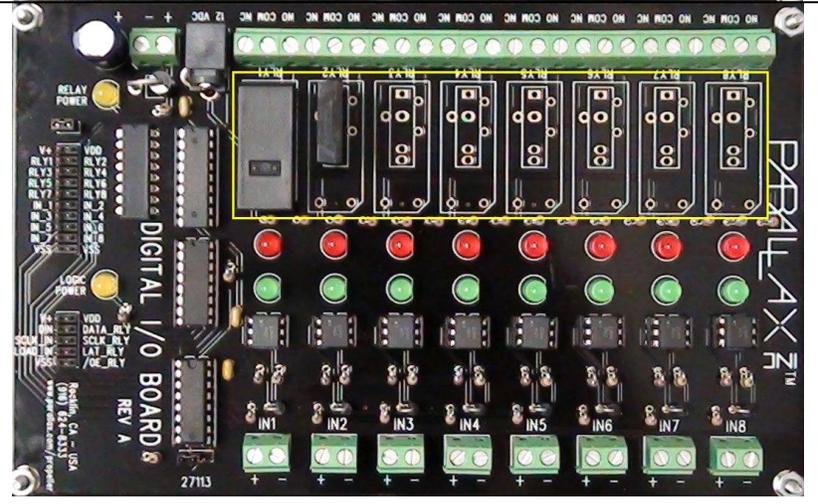
If you have not already done so you may now install the shorting blocks (shunts). The details for these are covered later in this documentation.

Inset shows detail for JP1 (set for inverted serial data).



**Step 18:**

Install the relays you have chosen for your application in any position. Relays only install in one direction and you cannot mount both types in the same slot as they are mechanically interlocked. You do not need to fill all slots to use this board.



## Relay Selection (Mechanical or SSR)

The Digital I/O Board is capable of using Omron Mechanical Relays (#400-00052) or Sharp Solid State Relays (#400-00053). You can use either relay in any of the eight available relay slots in any combination. The slots are mechanically interlocked to prevent you from using both types in the same position. The Mechanical Relays can switch up to 250VAC @ 12A (24VDC). The Solid State Relays can switch up to 240VAC @ 8A (AC ONLY). Unlike the mechanical relays, solid state relays do not exhibit contact noise or arcing. These Sharp Relays even provide zero-crossing detection to reduce switching noise, however they can only switch AC voltage, not DC.

## Relay Power

No matter which relays you use the Digital I/O Board requires a separate 12V @ 1A power supply for the relays. This power is provided through 2.1mm Barrel Jack at the top left of the board or optionally via the 2-position terminal block next to it. The terminal block is labeled + and – which the DC barrel jack is center tip positive, making it compatible with our power supplies (Parallax recommends #750-00007). Minimal reverse polarity protection is provided by diode D25.

## Logic Power

The control logic requires power from the host microcontroller for the inputs to function. This will be either 3.3V or 5V from your microcontroller provided to the VDD pin on the Digital I/O Board. Your microcontroller's ground should connect to the VSS pin. This allows the Digital I/O Board to operate at a signal level compatible with your microcontroller. The V+ pin allows your microcontroller to get supply voltage from the Digital I/O Board (reducing the need for an additional power supply). If your microcontroller's board has an on-board voltage regulator, you can obtain V+ from the Digital I/O Board and then send your regulated output back to the VDD pin. V+ will be at the voltage of the relay supply (typically ~12VDC).

## Connecting and Testing (Parallel Interface)

Using the parallel interface (2x10 header) controlling relays is as simple as making a pin HIGH or LOW. To energize a particular relay make its control pin HIGH. To turn it off bring that pin LOW. If your microcontroller's output pins are set to input the relays will also turn off due to internal pull-down resistors within the ULN2803 IC. Inputs are easily read by reading a HIGH or LOW on their output pins (labeled IN\_1 through IN\_8). Note that because the optocoupler inverts the signal, the pins will read HIGH when that input is inactive and will read LOW when that input is active.

Note: Do not use the parallel and serial circuits at the same time. Use only one type of interface.

## Connecting to an AppMod Header

The parallel interface (2x10 header) was designed to be compatible with the AppMod header on our popular Board of Education development board. You could use a ribbon cable (not included) to connect both boards together instantly connecting all necessary power and ground for a fully functioning parallel control system.

When using the AppMod interface there are two additional considerations. You should use the I/O declarations in the example code for the AppMod because the I/O pins are now mapped to specific pins on the Digital I/O Board and these may not be what you expect. Also, the V+ connection allows the BoE to get power from the Digital I/O Board. If you do not want this to happen you must remove the 2-pin shunt from JP2 above the parallel interface. This disables the V+ pin on that header, but still allows the BoE to provide 5V to VDD on the Digital I/O Board.

## Connecting and Testing (Serial Interface)

The serial interface (2x5 header) allows you to reduce the number of pins required to control the Digital I/O Board by serially shifting data to/from the board over a synchronous serial interface. Whereas full control requires 16 I/O pins using the parallel interface, the serial interface can provide full control with as few as 4 I/O pins.

The pins labeled DATA\_RLY, SCLK\_RLY, LAT\_RLY and /OE\_RLY are connected to a 74HC595 serial to parallel shift register. These pins have the following functions: DATA\_RLY is serial data going out to the shift register. This data is sent MSB first (8 bits) synchronously with the SCLK\_RLY pin. On the BASIC Stamp this can be achieved with the SHIFTOUT command. Once the data has been shifted out the LAT\_RLY pin must be pulsed to latch the data onto the outputs. /OE\_RLY must be LOW in order for the 74HC595 to drive the relays. This can be tied to VSS or controlled via an I/O pin.

The pins labeled DIN, SCLK\_IN and LOAD\_IN are connected to a 74HC165 parallel to serial shift register. These pins have the following functions: DIN is serial data from the shift register sent synchronously with a clock pulse on SCLK\_IN generated by the host microcontroller. On the BASIC Stamp this is achieved with the SHIF TIN command. Before data is shifted in the current contents of the inputs must be loaded. This is accomplished by pulsing the LOAD\_IN line from HIGH to LOW and then back to HIGH. This line must remain HIGH during shift operations and must only go LOW during a LOAD operation.

The DIN line has a 1K resistor in series to allow sharing of the 74HC165 data line with the 74HC595 DATA\_RLY line. By connecting these lines together and also connecting SCLK\_RLY to SCLK\_IN you can reduce the number of I/O pins required by your microcontroller down to four (4). In this configuration LAT\_RLY and LOAD\_IN must have their own I/O pins and /OE\_RLY can be connected to VSS. This circuit provides a half-duplex system where you can access one shift register at a time. For full duplex operation the DIN and DATA\_RLY lines must be separate and for independent operation the SCLK\_RLY and SCLK\_IN must also be separate.

Note: Do not use the parallel and serial circuits at the same time. Use only one type of interface.

## Communication Protocol

The serial protocol (synchronous serial) used by the 74HC595 and 74HC165 is defined in more detail in the datasheets for each device. BASIC Stamp users can also download the free PDF and example code for the Stamp Works kit and review experiments 23 through 25 which deal with these shift registers both independently and together.

## Mode Jumper (JP1)

The 3-pin jumper just below the 74HC165 determines whether the data shifted in from the shift register is inverted or not. Because the optocouplers inherently invert the data, when reading inactive inputs you get all ones instead zeros which isn't very intuitive. This jumper allows you to invert the data to normalize the output and make it more intuitive. In the 1-2 position data is inverted and when an input is active is will make its output go HIGH. With JP1 in the 2-3 position data is not inverted and when an input is active you will get a LOW.

Note: The Parallel interface is unaffected by this jumper. Therefore the parallel signals from the 74HC165 are always inverted

## Setting Input Voltage Range

This kit comes with 1.5K resistors on the inputs (R25-R32). These resistors were chosen as the defaults based on a typical input voltage range of 15-30VDC (24 nominal). If you wish to input a different range of voltages you will need a different resistor value in place of the default 1.5K unit. To calculate this value it is necessary to have a few key pieces of information. First and foremost the Digital I/O Board is configured to require a minimum of 8mA of current across an optocoupler LED for the output transistor to trigger an output. Ideally you'll probably set the current range for your input voltage to 10-20mA.

Given this range of current we can calculate the required resistor using the following math:

$R = (V_{IN} - V_{FWD}) / I_{LED}$  (where  $V_{FWD}$  is the LED forward voltage,  $I_{LED}$  is LED current and  $V_{IN}$  is our input voltage)

Assuming we want be able to input a 12V signal and accounting for the typical forward voltage for the 4N25 of 1.2V we can now calculate as follows:

$$R = (12V - 1.2V) / 0.01 = 1080$$

The closest value is 1K which will mean a current of 10.8mA @ 12V using  $I = (V_{IN} - V_{FWD}) / 1000$

We can also calculate the maximum voltage we want on the input using a 1K resistor:

$$V_{INMAX} = (1000 * 0.02) + 1.2 = 21.2V$$

## Sensitivity

Because of the way the input LEDs are driven on the output, they will indicate voltage on an input even when it is not sufficient to trigger and output. Voltage as low as 2V will cause the LED to start to glow, however the output won't trigger until the minimum current has been reached. This provides some safety in the sense that you'll have an indication of input voltage in spite of the outputs not being triggered.

## Precautions

As with any device capable of switching high voltages, precautions should always be taken to avoid damage and/or injury. The following precautions are recommended in addition to any precautions by the manufacturer of any equipment connected to this device.

- The Digital I/O Board should be mounted inside a suitable enclosure or electrical panel using standoffs. The board should not be able to move.
- Any electrical connections to the board should be secured so they can not move and any wires extending outside the enclosure should have strain relief.
- Any incoming voltage rails to be switched by the relays should be fused prior to entering the Digital I/O Board.
- Always be sure any incoming voltage rails are powered off prior to connecting them to the Digital I/O Board.
- When connecting the V+ pin to VIN on another board, be sure that board does not have its own power supply. The target board will now get power from the Digital I/O Board.

## Specifications

Symbol	Quantity	Minimum	Typical	Maximum	Units
V+	Relay Supply Voltage	9	12	15	V
VDD	Logic Supply Voltage	3.3	—	5	V
I <sub>LED</sub>	Input LED Forward Current	8	10	20	mA
I <sub>IDLE</sub>	Idle Current (Relay Power Only, Off)	—	10.5	—	mA

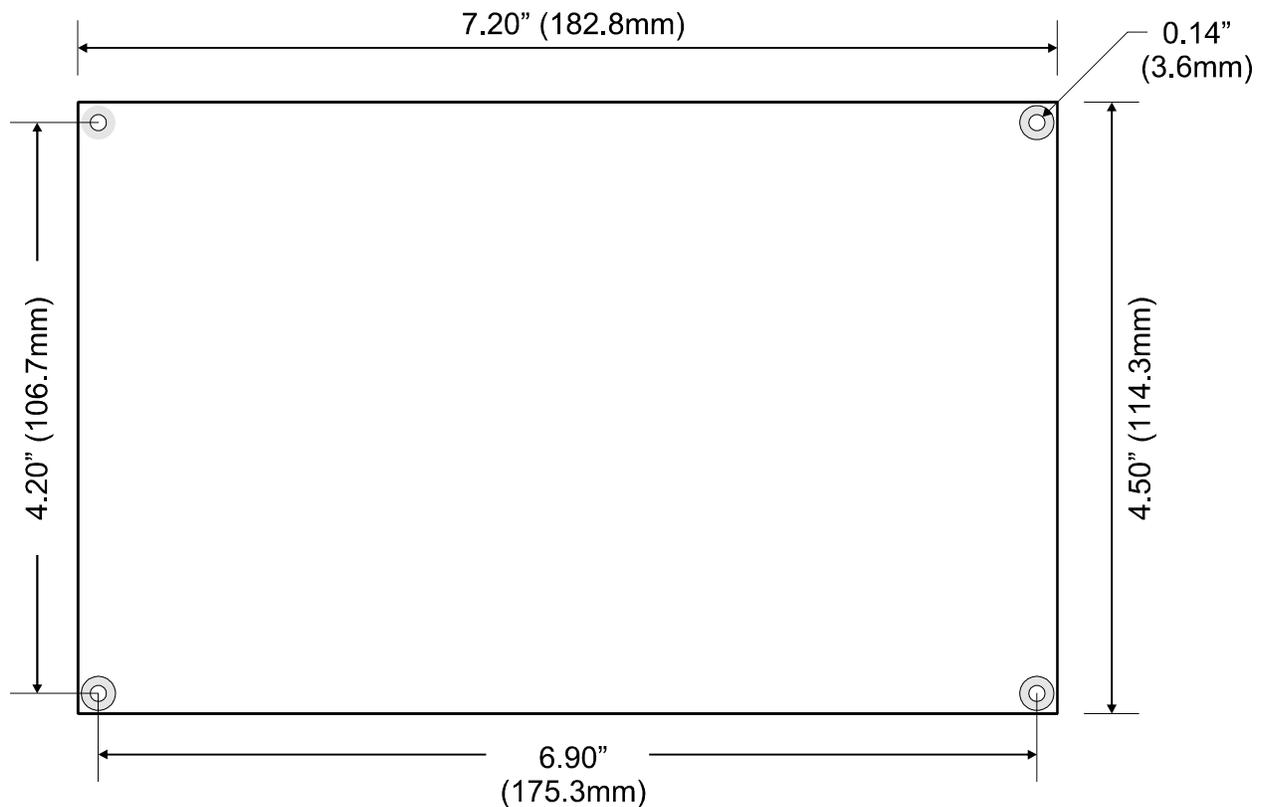
## Pin Definitions for 2x10 Header (Matches AppMod connector)

Pin	Name	Function
1	V+	Relay Power (Can be disconnected via JP2)
2	VDD	Logic Power
3	RLY1	Relay 1 Control Line
4	RLY2	Relay 2 Control Line
5	RLY3	Relay 3 Control Line
6	RLY4	Relay 4 Control Line
7	RLY5	Relay 5 Control Line
8	RLY6	Relay 6 Control Line
9	RLY7	Relay 7 Control Line
10	RLY8	Relay 8 Control Line
11	IN_1	Input 1 Signal
12	IN_2	Input 2 Signal
13	IN_3	Input 3 Signal
14	IN_4	Input 4 Signal
15	IN_5	Input 5 Signal
16	IN_6	Input 6 Signal
17	IN_7	Input 7 Signal
18	IN_8	Input 8 Signal
19	VSS	Ground
20	VSS	Ground

## Pin Definitions for 2x5 Header

Pin	Name	Function
1	V+	Relay Power (output to host controller)
2	VDD	Logic Power (input from host controller)
3	DIN	Serial Data In from 74HC165 (output to host controller)
4	DATA_RLY	Serial Data Out to 74HC595 (input from host microcontroller)
5	SCLK_IN	Synchronous Serial Clock (input from host microcontroller)
6	SCLK_RLY	Synchronous Serial Clock (input from host microcontroller)
7	LOAD_IN	Load Inputs (input from host microcontroller)
8	LAT_RLY	Latch Relay Output (input from host microcontroller)
9	VSS	Ground
10	/OE_RLY	Relay Output Enable (input from host microcontroller)

## Module Dimensions



## Module Schematic

A full size schematic in PDF format is available from the product page on our website.