LabJack

Published on *LabJack* (https://labjack.com)

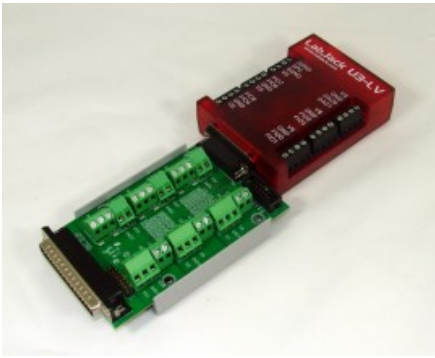# PS12DC Datasheet

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PS12DC Power Switching Board
Stock: In Stock
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PS12DC Datasheet Overview

The PS12DC is a power switching board designed for medium to low current DC power switching applications. Controlled through 12 digital outputs, the board can switch power sources ranging from 5 to 28V DC. Attach the PS12DC to the DB15 connector presented on all compatible devices, and toggle the states of the EIO and CIO digital output lines to turn the switches on/off. This device requires at least one compatible power supply, and a multi-channel digital output source, such as a LabJack, or Arduino.

Features

- 12 digitally controlled switches with LED indicators
- Optical isolation
- Handles 5 - 28 Volt supply
- Up to 750mA/chan
- Thermal (self-resetting) fuse protection
- Flyback protection
- Snaptrack/DIN-rail compatible, with TE Connectivity P/NTKAD

Compatible Devices

- U3-HV, U3-LV, U6, UE9, T7, T4
- Other (Arduino, etc, see related section)

Typical Applications

- Solenoid Valves/Actuators
- Relays
- Simple DC Motors*
- Horns/Bells/Alarms
- Blowers/Fans
- Low Voltage DC Lighting
- LED Drivers

*If using a larger DC motor (above 12V DC, or bigger than 1" diameter as a general rule), we recommend installing supplementary snubber diodes, and inrush limiters, as large flyback and inrush currents can overwhelm the protection circuitry on the PS12DC, resulting in damage. Basically just buy a few of these $0.80 parts, and put one in series with each motor. See the end of Appendix D for details.

How To Use

You will need a LabJack, a PS12DC, and something to control. The diagram below demonstrates how to make connections for controlling a DC motor, and a fan.

- Option A - Items are powered by 5V power supply (VS) located on the LabJack, this is the most basic connection.
- Option B - Items are powered by 12V external power supply.
- More Options - See Appendix A - Wiring Diagrams
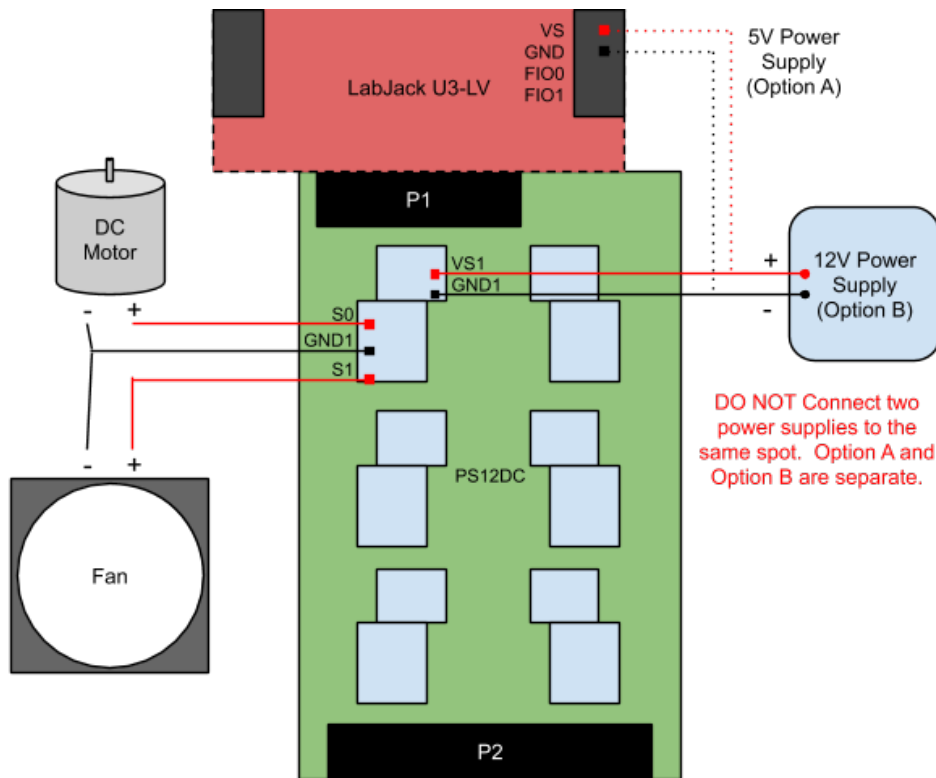
Once the wires are attached, turn the DC Motor on and off by toggling the state of the appropriate digital control line. When the control IO is output-low, S0 will sit at 0V. When the control IO is output-high, S0 will be at the voltage connected to VS1. Look at the IO Reference table below to identify which control line to toggle. The DC motor is connected to S0, so that means a state change in EIO0 will turn it on and off.

**Table 1.** Digital I/O pins for each switch

Switch #	Digital IO
S0	EIO0
S1	EIO1
S2	EIO2
S3	EIO3
S4	EIO4
S5	EIO5
S6	EIO6
S7	EIO7
S8	CIO0
S9	CIO1
S10	CIO2
S11	CIO3

If the PS12DC is attached to the LabJack differently than in the picture above, there will be a different corresponding digital IO line. The full pinout details can be seen in Appendix C - Pinout Info .

Download LJControlPanel to get started, or create a program in one of our supported languages to communicate with the LabJack. It will also be necessary to install the UD driver, so the LabJack is recognized over USB.

Other Compatible Devices

Connect a PS12DC to any device with 3.3V to 5V digital outputs through the use of the P3 pin header. This includes Arduino, homemade boards, PCI DAQ boards, etc. Please note that when using other digital output boards, support is limited to the PS12DC. The image below shows an example of how to connect a PS12DC to an Arduino.
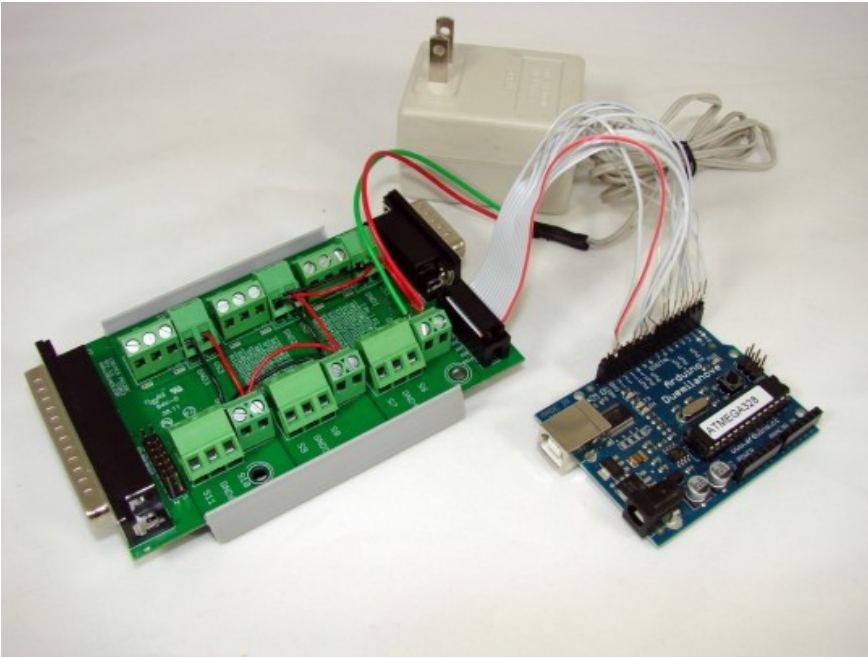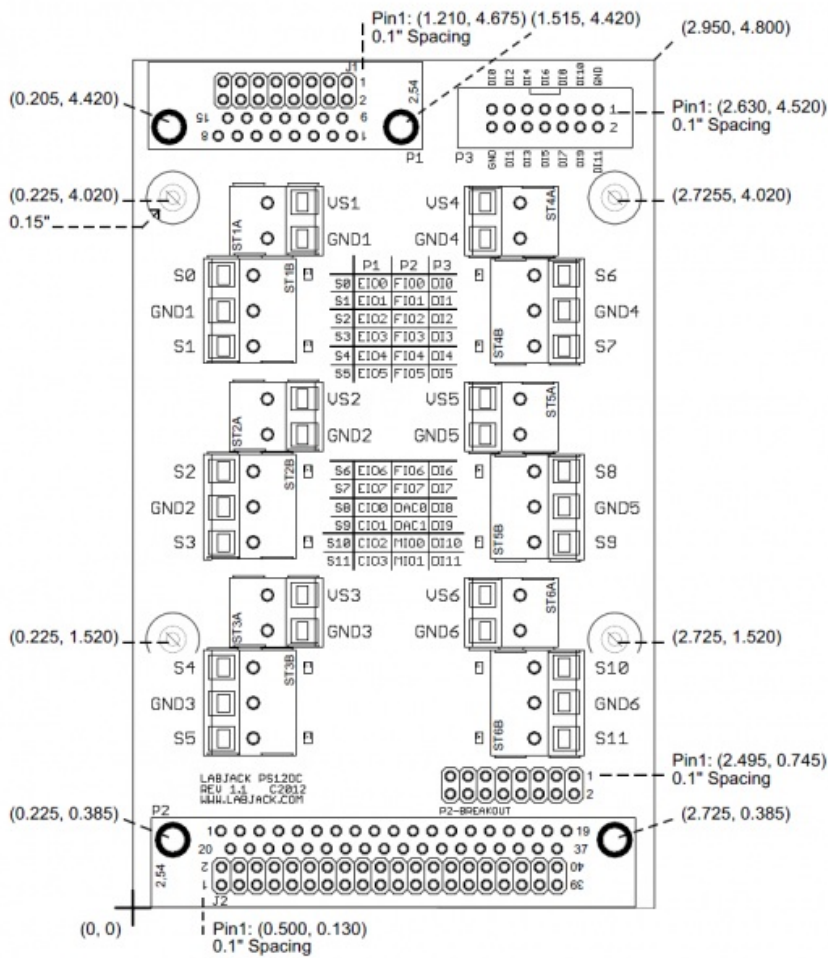
The Arduino has 14 digital IO pins, the first 12 are connected to the PS12DC, and the two GND wires on the PS12DC are tied to GND on the Arduino.

Multiple PS12DC boards can be connected to a single compatible LabJack, as shown in the image below. See Appendix B - Connection Options for more information.
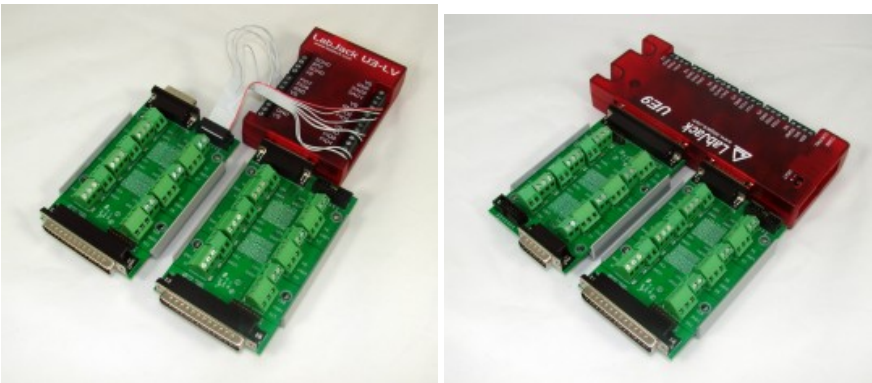

Dimensions

PS12DC PCB Dimensions.dxf

Troubleshooting

If there are problems with the PS12DC, insure the following:

1. There is a working power supply (5 to 28V) connected to one of the power supply blocks, e.g. VS1/GND1. Connect wires to VS as shown below if no power supply is available.
2. The switch number under inspection is being powered. For instance, if checking S8, verify that VS5/GND5 are connected to a working power supply.
3. Verify that the LEDs turn on and off when the digital output states on the LabJack are toggled high and low. This can be accomplished by opening LJControlPanel (for U3, U6, or UE9) orKipling (for T-series), and checking/un-checking the boxes next to the digital output of interest[1]. Or download the test program (U3, U6, or UE9 only): LJTestPS12DC.zip
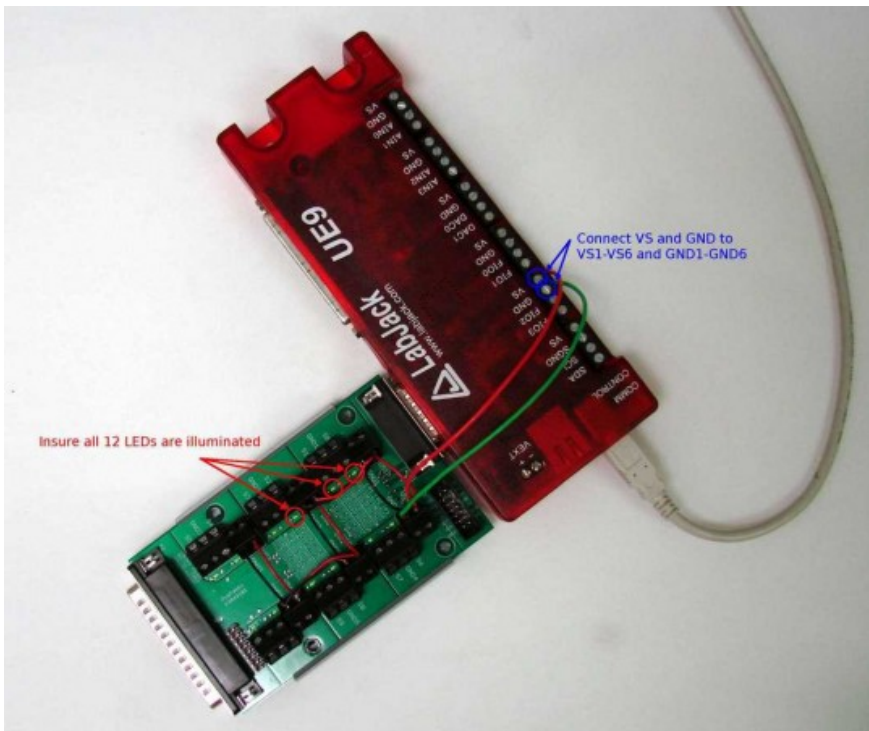
[1] To test operation of the PS12DC on T-series devices navigate to the Dashboard tab of Kipling. Note that using the Register Matrix will not work for testing the PS12DC. From the Dashboard tab set the IO of interest (See the pinout info page) to "Output" and toggle the High/Low selection. When set "High" the LED next to the corresponding switch on the PS12DC should light up.

Appendix A - Wiring Diagrams
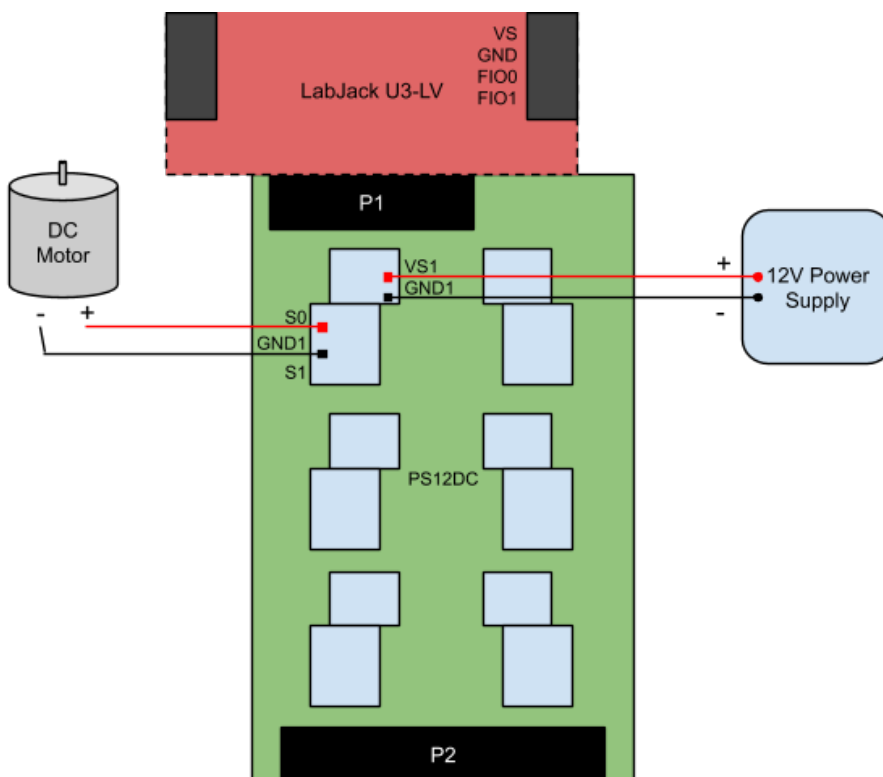
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Figure A1. Simple

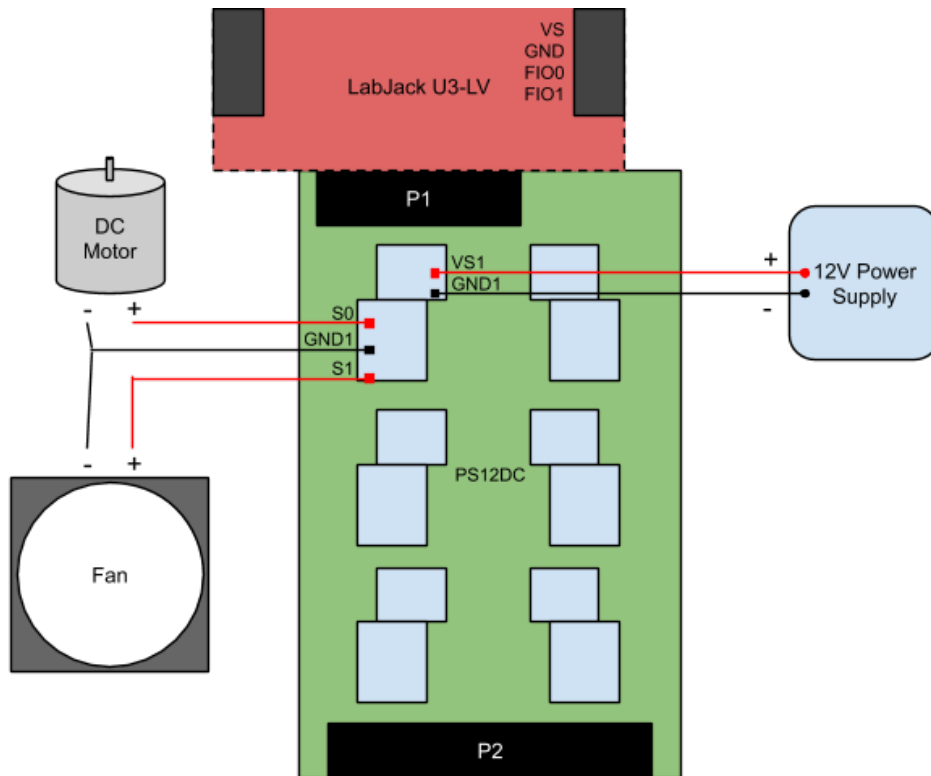There is only 1 external power supply, and 1 item being controlled.

Figure A2. Multiple Items

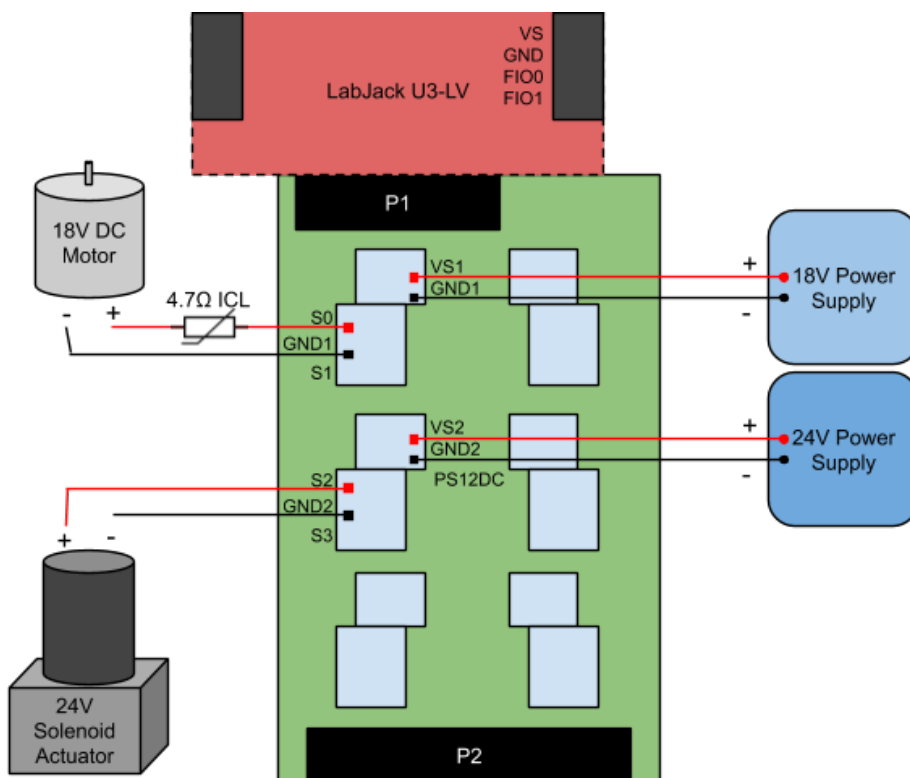There is 1 external power supply, and 2 items being controlled.

Figure A3. Multiple Power Supplies

There are 2 power supplies, and 2 items being controlled. The high voltage DC motor requires a4.7Ω inrush current limiter

to help protect the PS12DC from the large inductive load inherent to a DC motor. See Appendix D for more information.
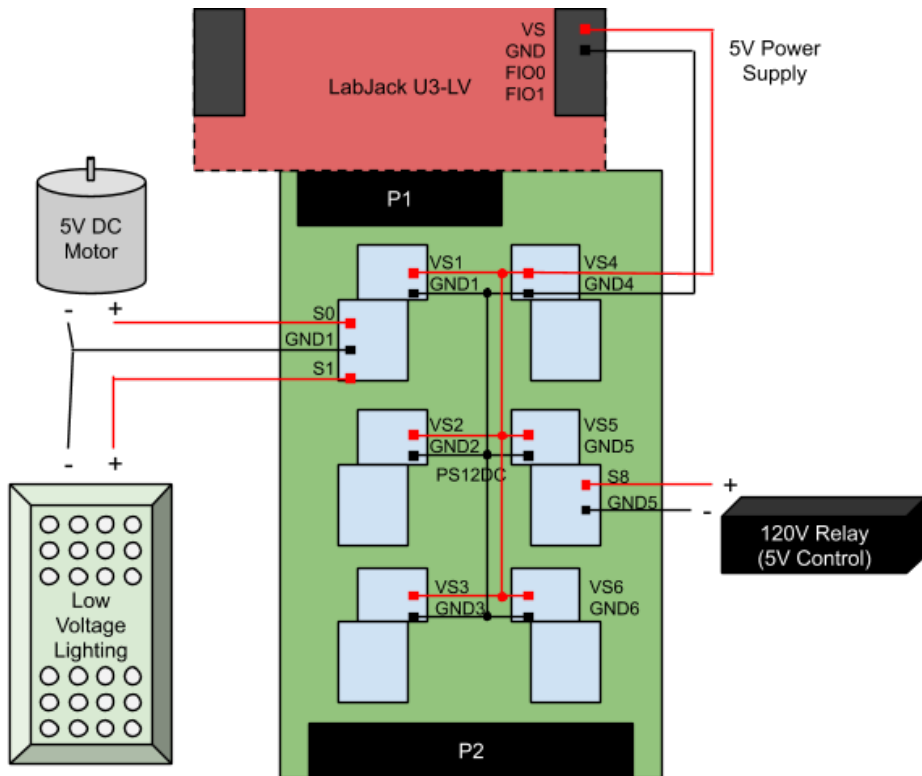

Figure A4. Multiple Items, Single Supply

5V is distributed to all 6 power supply blocks. All 12 switches are fed 5V from the LabJack. This is a common configuration for simple testing, since the LEDs will illuminate when the LabJack is powered on, and it does not require an external power supply.

Appendix B - Connection Options

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Summary

The PS12DC can be connected several ways, the most common is through the DB15 connector. The following sections explain how to connect the board by using the extra connectors, and details about using multiple PS12DC at a time.

Single PS12DC

The PS12DC can be connected according to any of the following figures. All 12 switches will be operational, and their corresponding digital control lines can be referenced in Appendix C - Pinout Info.
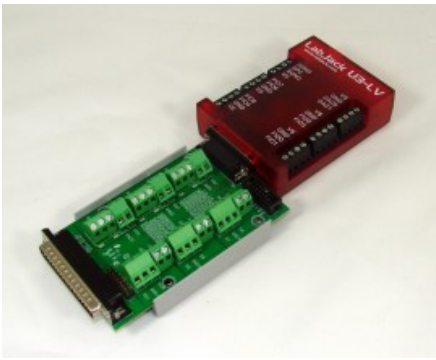
Figure B1. Connected by P1 - DB15 Connector

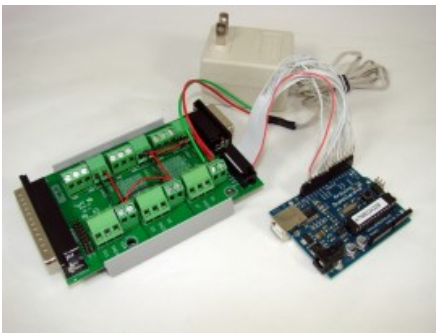**Figure B2. Connected by P2 - DB37 Connector**

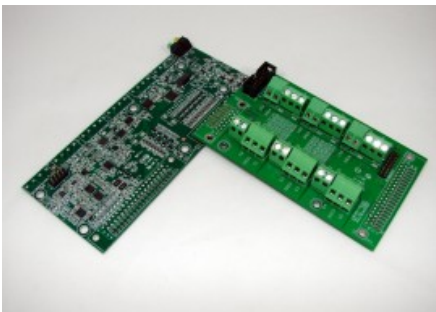**Figure B3. Connected by P3 - 14 Pin Header**

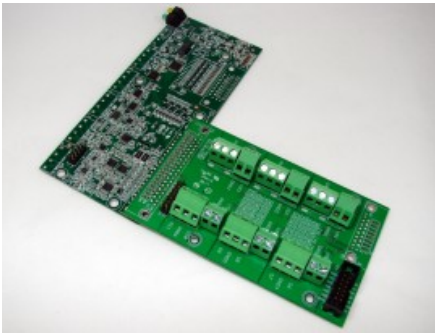**Figure B4. Connected by J1 - 16 Pin OEM Header Location**

Figure B5. Connected by J2 - 40 Pin OEM Header Location

Two PS12DC

This section explains how to connect a second PS12DC to each LabJack device, and the number of additional channels provided. It is assumed that the first PS12DC is connected to a LabJack through the DB15 connector.

- **U3-LV: (10 addtl. switches)** Connect a second PS12DC to the U3-LV by wiring the P3 header to the screw terminals. A ribbon cable with a rectangular connector is recommended for the task. Attach the female connector to the board, and splice the wires for the screw terminals on the U3-LV. DI0-DI7 would be wired to FIO0-FIO7, and two of the remaining digital input lines (DI8, DI9) can be connected to DAC0 and DAC1. Connect the two GND pins to GND on the U3.
  - Something like NKK Switches part number ISDCB812 (12 inch), or ISDCB824 (24 inch) would work, but anything with at least 14 positions, and 0.1" spacing should do the job. It also works to combine a 2x7 14-pin dual row IDC socket with some rainbow ribbon cable, if you prefer to assemble the cable yourself.
- **U3-HV: (6 addtl. switches)** This is the same as the U3-LV, with the exception of the first 4 FIO channels; Since they are dedicated analog inputs, the U3-HV will limit the second PS12DC to only 6 extra channels, instead of the 10 possible for the U3-LV.
- **U6, U6-Pro: (10 addtl. switches)[1][2]** Connect the second PS12DC to the U6 via the P2 connector. Reference the silkscreen table for corresponding digital lines.
- **UE9, UE9-Pro: (12 addtl. switches)[1]** Connect the second PS12DC to the UE9 via the P2 connector. Reference the silkscreen table for corresponding digital lines.
- **T7, T7-Pro: (12 addtl. switches)[1]** Connect the second PS12DC to the T7 via the P2 connector. Reference the silkscreen table for corresponding digital lines.

[1]When connected to the DB37 connector on either the U6 or UE9, some of the analog inputs are covered up. To address the problem, those analog inputs re-appear on the PS12DC, under the P2-BREAKOUT header. Reference Appendix C - Pinout Info for details.

[2]The U6 shares CIO0, CIO1, and CIO2 with MIO0, MIO1, and MIO2. They are merely different names for the same digital channels. This causes some interesting behavior when two PS12DC are connected to a U6, since a state toggle in a CIO line will effect both boards. Switch S8 on P1 will toggle at the same time as S10 on P2 . Also S9 on P1 will toggle at the same time as S11 on P2. Because of this overlap, there are really only 10 unique channels provided by the second PS12DC, when connected to a U6.

OEM Capability

Connect an OEM PS12DC to an OEM LabJack by soldering a 0.1" spacing pin header to the LabJack, and then the OEM pin

header holes on the PS12DC. Either J1 or J2 would work. LabJack does not stock the OEM version, but it is possible to contact us and place a custom order. The image below shows a possible configuration for a custom PS12DC.
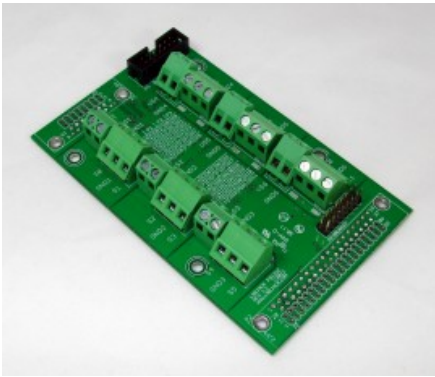
OEM PS12DC boards are useful for direct solder applications, when the functionality is already understood, and the device can be incorporated without the easy-to-use connectors.

Appendix C - Pinout Info

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Summary

P1, P2, and P3 are basically just 3 alternate ways to connect the PS12DC.
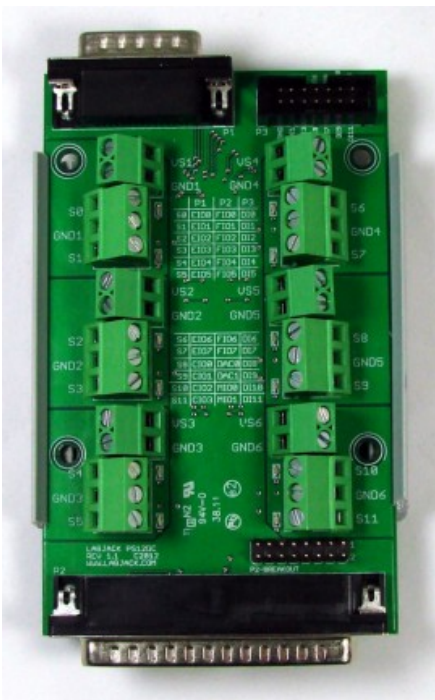
P1 - DB15 connector (top left): Mates to small and large LabJacks, like a U3

P2 - DB37 connector (bottom): Mates to only larger LabJack models, like a U6

P3 - 14 pin header (top right): Can be used to wire the board to any other digital output source, like an Arduino.

P2-BREAKOUT - 16 pin header (bottom): For access to covered-up analog inputs when the PS12DC is connected to a LabJack via P2.

When connected to a LabJack, or other digital output source, the name of the output can be determined by looking at the chart below.

Table C1. Channel output and PSU input based on switch number

Switch #	P1	P2	P3	Power Supply In
S0	EIO0	FIO0	DI0	VS1 GND1
S1	EIO1	FIO1	DI1	
S2	EIO2	FIO2	DI2	VS2 GND2
S3	EIO3	FIO3	DI3	
S4	EIO4	FIO4	DI4	VS3 GND3
S5	EIO5	FIO5	DI5	
S6	EIO6	FIO6	DI6	VS4 GND4
S7	EIO7	FIO7	DI7	
S8	CIO0	DAC0	DI8	VS5 GND5
S9	CIO1	DAC1	DI9	
S10	CIO2	MIO0	DI10	VS6 GND6
S11	CIO3	MIO1	DI11	

Table C2. P2 breakout

Pin	Analog Input
1	AGND
2	AIN0
3	AIN1
4	AIN2
5	AIN3
6	AIN4
7	AIN5
8	AIN6
9	AIN7
10	AIN8
11	AIN9
12	AIN10
13	AIN11
14	AIN12
15	AIN13
16	AGND

Example: Connect the PS12DC via the 15-pin D-Sub connector on a LabJackU3. You desire to toggle power to switch S9, so you locate the appropriate connector in-use, which is P1, and then follow the row for S9, which points to CIO1. This means that changing CIO1 from output-low to output-high will change the S9 terminal from 0V to whatever voltage is connected to VS5 and GND5.

Detailed pin-out

The detailed pin-out information below is for advanced users. It may be useful to people making a custom board that mates with the OEM PS12DC, or someone who needs to use the rails VM+ and VM- in addition to a PS12DC that is connected on P2. Most users need not concern themselves with this section.

Table C3. Detailed pin-out information for all connectors on PS12

P1		P3		P2		J2 (OEM)	
Pin	Connection	Pin	Connection	Pin	Connection	Pin	Connection
1	VS	1	GND	1	GND	1	GND
2	S9	2	S11	2	PIN2	2	GND
3	S11	3	S10	3	S6	3	PIN20
4	S0	4	S9	4	S4	4	PIN2
5	S2	5	S8	5	S2	5	S7
6	S4	6	S7	6	S0	6	S6
7	S6	7	S6	7	S11	7	S5
8	GND	8	S5	8	GND	8	S4
9	S8	9	S4	9	VM-	9	S3
10	S10	10	S3	10	GND	10	S2
11	GND	11	S2	11	S8	11	S1

Pin	Connection	Pin	Connection	Pin	Connection	Pin	Connection
12	S1	12	S1	12	AIN13	12	S0
13	S3	13	S0	13	AIN11	13	S10
14	S5	14	GND	14	AIN9	14	S11
15	S7			15	AIN7	15	MIO2
				16	AIN5	16	GND
J1 (OEM)				17	AIN3	17	VS
Pin	**Connection**			18	AIN1	18	VM-
1	GND			19	AGND	19	VM+
2	VS			20	PIN20	20	GND
3	S8			21	S7	21	S8
4	S9			22	S5	22	S9
5	S10			23	S3	23	AGND
6	S11			24	S1	24	AIN13
7	GND			25	S10	25	AIN12
8	S0			26	MIO2	26	AIN11
9	S1			27	VS	27	AIN10
10	S2			28	VM+	28	AIN9
11	S3			29	S9	29	AIN8
12	S4			30	AGND	30	AIN7
13	S5			31	AIN12	31	AIN6
14	S6			32	AIN10	32	AIN5
15	S7			33	AIN8	33	AIN4
16	GND			34	AIN6	34	AIN3
				35	AIN4	35	AIN2
				36	AIN2	36	AIN1
				37	AIN0	37	0
						38	GND
						39	GND
						40	AGND

Appendix D - Specifications

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Summary

- 5 to 28V supply voltage
- 750mA per channel
- Thermal (self-resetting) fuse protected >1.5A per pair
- Flyback protection >33V
- Operating temp –40 °C to 85 °C
- Maximum switching frequency: ~6kHz (see Switching Frequency section)

When at the upper limit of its operating voltage and current, the PS12DC can become hot to the touch; This is normal, but can be managed by supplying a fan or heat sink to the backside of the board. Reference the information below for further details on current limitations, and behavior at extreme temperatures.

Digital States

What a switch will do in each of the 3 LabJack I/O states.

- Output-high: Switch ON, the S# screw terminal will be at VS#
- Output-low: Switch OFF, the S# screw terminal will be at ~GND#
- Input: Switch is weak ON, due to LabJack internal pull-up resistors. LED will light up without anything on the switch, but marginal load on the switch will drop the output voltage significantly, and turn off the LED. Because behavior is ambiguous, the input I/O state is not recommended.

LEDs

Each LED is powered by the voltage connected on VS#/GND# (the power supply provided by the user). If a power supply is

connected to the switch block, e.g. VS1/GND1, and a positive voltage is applied to the digital inputs for that block, the LEDs will illuminate. An illuminated LED means that the switch is ON, and the voltage applied to the block is available at that switches' screw terminal.

Current Limit

The 750mA per channel rating is a base specification, but the board actually has a *Per Switch* and *Per Pair* rating. If only a single channel in a channel pair is in use, the per switch limit applies. If both channels in a channel pair are used, the per pair limit applies. Channel pairs are distinguished by the grouping of screw terminals. For instance, S0, and S1 constitute a pair, so you would connect the high current item(>750mA) to S0, and leave S1 un-connected.

Table D1. Current limits based on supply voltages

| Supply Voltage (V) | Current Limit | |
	Per Switch (A)	Per Pair (A)
5	0.5	1.0
9	0.7	1.4
12	1.0	1.5
18	1.1	1.5
24	1.5	1.5
28	1.5	1.5

There is a voltage drop across the switch associated with load current when using the PS12DC. It is rated at 750mA per channel, but it is recommended that at 5V, a load current of 500mA not be exceeded, since above this current the drop will be significant. Reference the graph below for details.

Voltage Drop vs Load Current at Supply Voltage
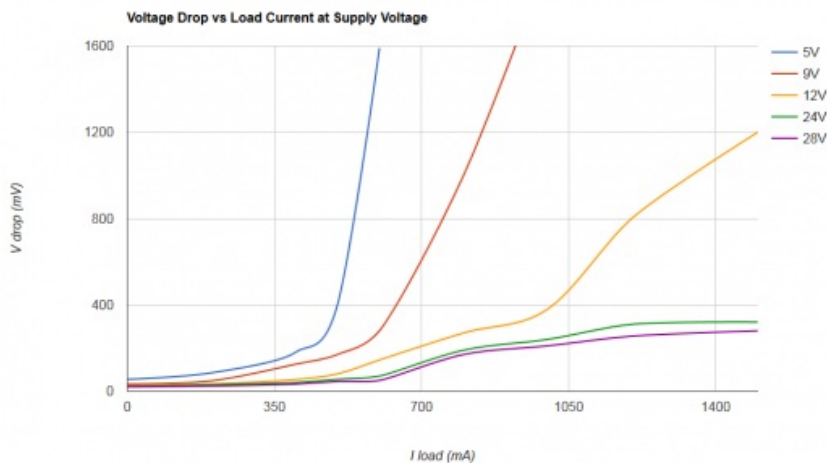
From a usage standpoint, the only items in the Typical Applications section that may draw more than 450mA are those involving motors. Before purchase, it is advised that you reference datasheets for the items to be controlled. If the current draw exceeds 1.5A on a power switching pair, this board will cut off power to avoid damage to itself.

Note: If you need a product that can handle more than 1.5A, the RB12 is a good option, although you will need to purchase the actual relay modules separately.

Switching Frequency

The switching speed of the transistors on the PS12DC are fast(4-18µS), but there is a substantial amount of capacitance on the S# terminals, so the falling edge will be delayed by large load resistances. Thus, to achieve fast switching frequency, it is necessary to discharge the capacitance through a small resistor. Simply add a 100Ω resistor between the switch output and the GND terminal (in parallel with whatever you have connected to the switch output). With a 100Ω resistor installed, the switching frequency is on the order of 2.5kHz.

Table D2. Switching frequencies based on load resistance

| Load Resistance (Ω)	Fmax (Hz)
47	6,000

100	2,500
1000	400
10000	120

Note that it is possible to install smaller resistor values(<47Ω) to further increase switching frequency, but the resistor should have a high enough power rating to handle the heat.

Temperature Related Characteristics

The PS12DC becomes warm under continuous usage; This is normal, but if the average board temperature becomes too hot, the fuses will trigger somewhat before their rated 1.5A maximum, and the board could end up cycling on/off intermittently depending on how fast it cools between cycles.

This temperature dependency is directly related to the thermal derating curve on the resettable fuse. The fuse trip current drops about 50% at the highest end of its operating temperature. See the graph below for further details.

Thermal Derating Curve
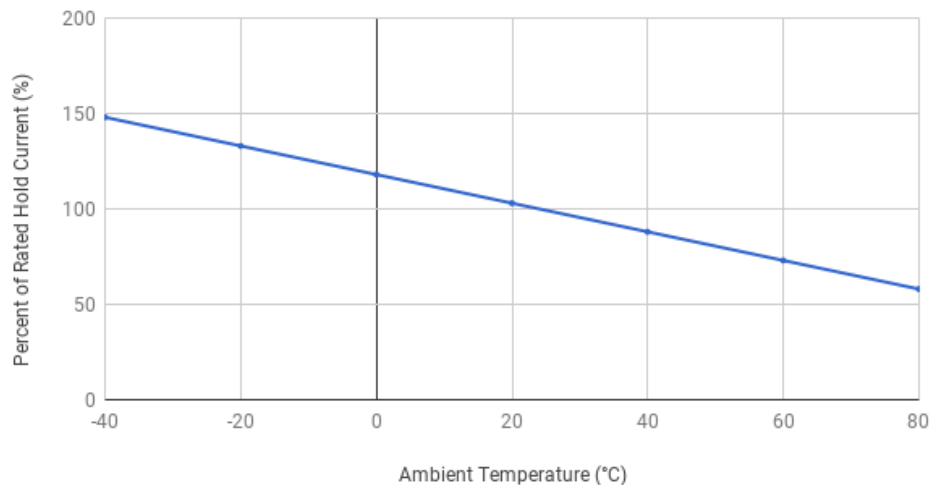
Adding heat sinks to the transistors can increase the per switch current limit, but exact figures depend on factors such as heat sink material, passive vs active cooling, and establishing good thermal contact with the transistor case. Bear in mind that the current limit of the resettable fuse is still temperature dependent, so any gains due to heat sinks would still be limited by the fuse holding current, which is 1.5A at 25 °C.

Large DC motors

If using a larger DC motor (above 12V DC, or bigger than 1" diameter as a general rule), we recommend installing supplementary snubber diodes, and inrush current limiters, as large flyback and inrush currents can overwhelm the protection circuitry on the PS12DC, resulting in damage.
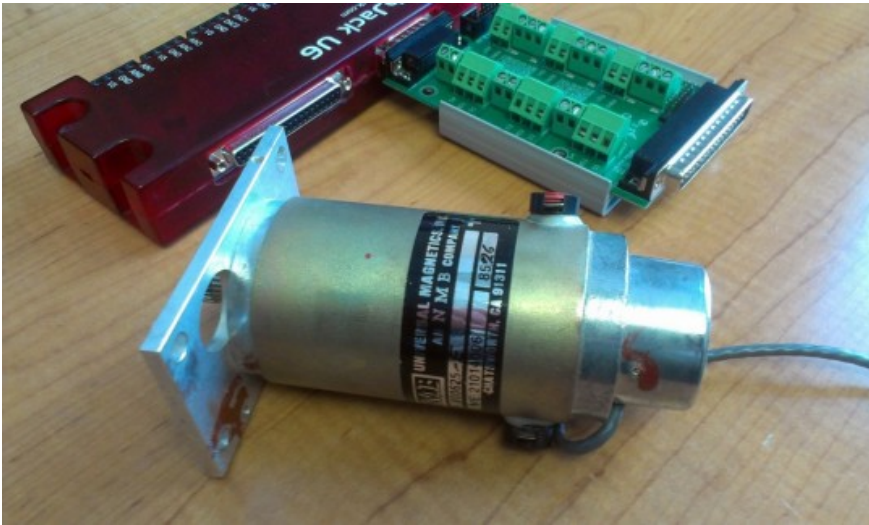
In DC motors
Voltage equation is **V = E - IaRa**
where
V = terminal voltage
E = Back emf
Ia = Armature current
Ra = Armature Resistance

In the beginning E = 0 and V = IaRa
where Ra is always very low, about = 0.01 ohm

So, if you calculate for Ia = V/Ra, you will get large current.

Using the equation above, if you have a 24V DC motor, and the armature resistance is 0.01ohm, the current spike would be very large. In order to protect the PS12DC, a 5Ω to 15Ω inrush current limiter installed in series with the motor wiring would be sufficient to protect the PS12DC. This B57153S479M 4.7Ω inrush current limiter is a good option for 12V to 24V DC motors in the 750mA to 1.5A range. We also tested this B57153S100M 10Ω inrush current limiter up to 28V DC, and it worked well.

Select an inrush current limiter based on the current required during normal operation. For example, if I'm using a 24V DC motor, and normally the motor will draw about 1A of current, I would select a limiter of 4.7Ω at 25C, and around 2A steady state max. Inrush current limiters basically have some resistance when their temperature is equal to ambient, and then as the part heats up, the resistance drops substantially. So if the motor draws 1A of current during normal operation, the resistance of the current limiter will drop from 4.7Ω to a lower resistance(~0.5Ω) during normal operation.

If you don't mind sinking some extra power, and a voltage drop, you could simply install a very high wattage resistor in series. A 5Ω 20Watt resistor would protect as well as an inrush current limiter, but at 24V, and 750mA, there would be a voltage drop of 3.75V. The resistor would get warm (super hot) because it'd be sinking 18W of power during normal operation. Here is an example of a 5Ω 20W resistor.

Appendix E - Additional Examples

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Multiple Power Supplies Example

Lets say you want to control a 9V fan, a 9V motor, and a 5V relay. The configuration closely resembles Figure 3 of Appendix A - Wiring Diagrams.

Connect the 9V power supply to an inward facing VS/GND pair. Next connect the 5V power supply in a similar fashion. The image shows a 9V PSU connected to VS4/GND4, and the 5V supply on VS3/GND3. Finally, wire the fan and motor to a switching pair, with the positive side on S6, S7, and the negative side on GND4. The remaining relay is connected to the same area as the 5V PSU, positive side to S4 and negative to GND3.
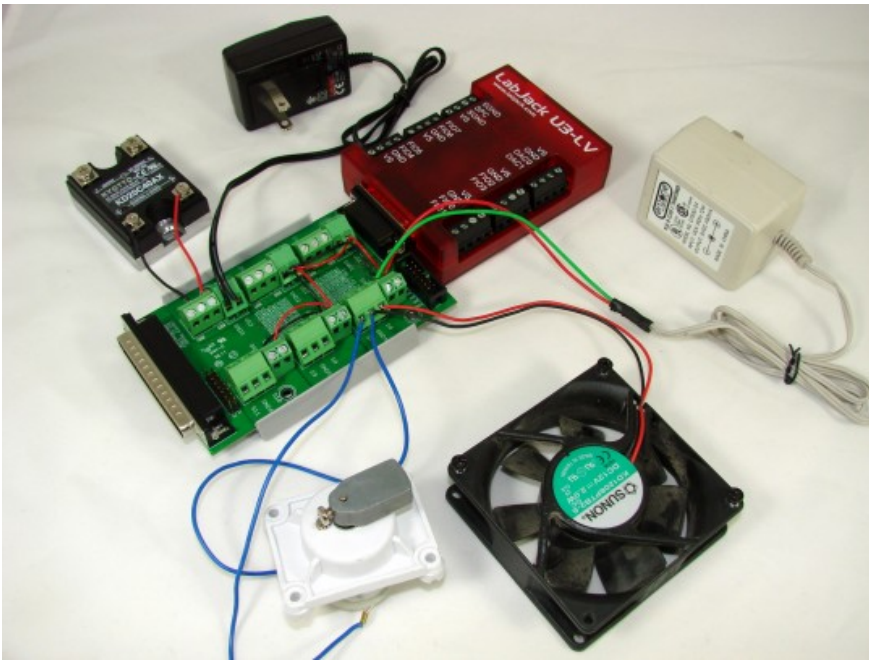
Note: In the image the 9V supply is also spread to remaining switching pairs, similar to Figure 4 of Appendix A, but they are unused.

Turning the equipment ON/OFF is done by referencing the chart printed on the center of the PS12DC. Since the LabJack is connected to P1, that is the column of interest. Scan down the side locating switches number S4, S6, and S7. Next to S4 you will see EIO4, S6 -> EIO6, and S7 -> EIO7. It is not readily visible in the photo, but Appendix C - Pinout Info also contains the chart. Turning each external device on is as simple as toggling the state of those digital lines(EIO4, 6, 7) to output high.

Video Example

The video below shows the two PS12DC boards controlling several 18V solenoid valves. A C++ script issues commands to the U3-LV, which in turn controls the solenoid valves to open and close rapidly. The setup is a prototype for an automated bartender; Each valve will be connected to a different alcohol, and will mix together to create a unique drink.