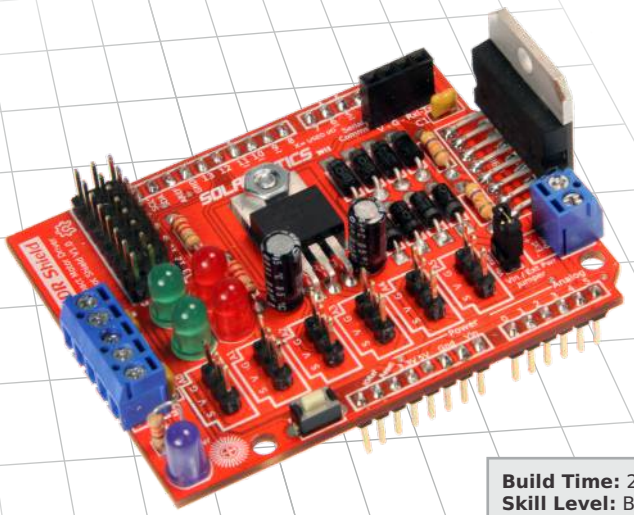
Compact Motor Driver Robot Shield

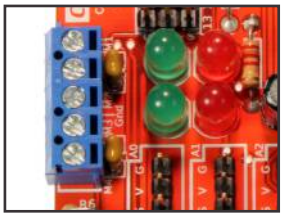


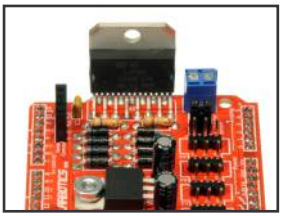
Build Time: 25 mins
Skill Level: Beginner (2/5)

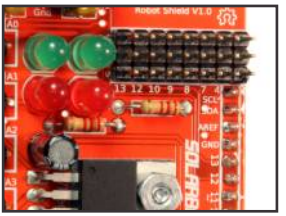
Here's your task - putting Arduino brains into the soulless shell of your mechanical monster. Ah, but what are brains without **brawn?** Give your project a muscular interface with the CMDRShield! Drive TWO gear motors or a single stepper motor, *and* to control 8 servos at the same time!

- 6.5V to 30V, 4A capable L298 motor driver
- Servos powered from 5VDC, 5A powerful regulator
- Motor direction indicator LEDs
- GVS (Gnd/V/Signal) servo & analog breakout ports
- 4-pin Serial breakout port
- R3/backward SDA and SCL compatibility
- Arduino + Shield can run off of a single power supply

RoHS COMPLIANT







SOLARBOTICS Ltd
www.solarbotics.com
1-866-276-2687

Here's an empty (hm, *almost* empty) page to scribble on.

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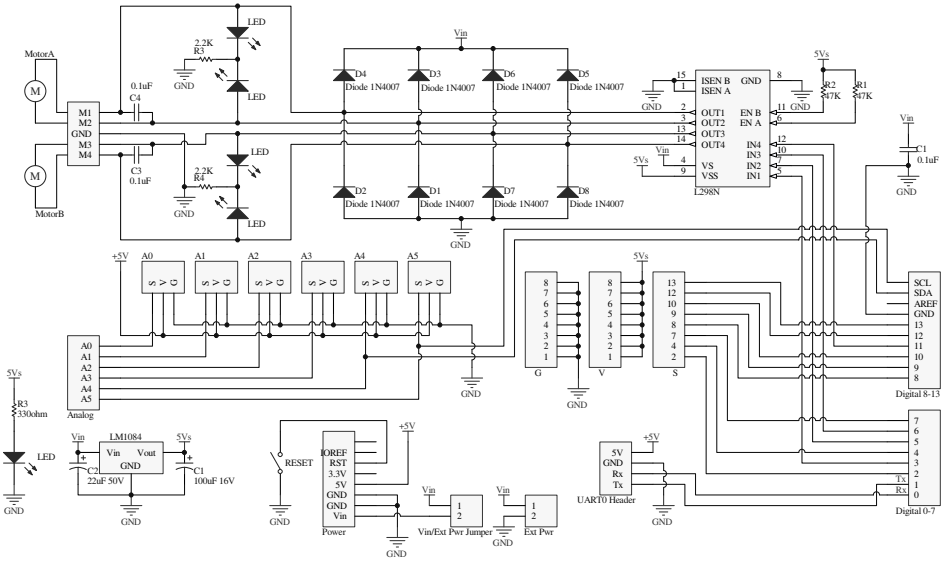
Theory of Operation



Theory of Operation

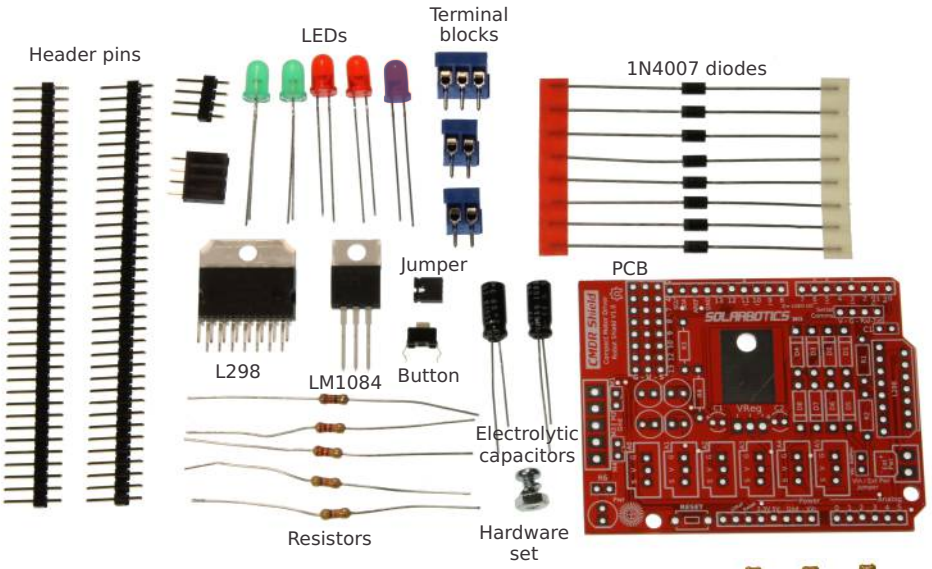
The CMDR (pronounced “commander”) shield is an all-in-one solution for driving a pair of DC motors, or a stepper motor, 8 servos *and* still offer easy access to all your analog lines. Power can be supplied via the external voltage port on the shield, which gives you the best current capabilities or it can be optionally come from the Arduino 2.1mm barrel jack.

Since the L298 motor driver can drive up to 4A and the LM1084 voltage regulator can consume up to 5A, it is wise to use a power source capable of 9A, especially if you will be using most of the capabilities of this shield. Lithium Polymer (aka: LiPo) batteries are excellent for providing this sort of capability, such as our 7.4V 2200mAh battery. Your voltage source should be **higher than the 6.5V** lower-limit necessary for proper stable regulation from the LM1084 regulator.

For best performance, the CMDRShield uses Arduino PWM lines 3,5,6 & 11. We recommend a heat sink for the L298 IC, as it is usually the first to reach its thermal limits causing motor shutdown.

Parts List

- 1 x CMDR Shield printed circuit board (PCB)
- 1 x L298 motor driver chip
- 1 x LM1084 5V/5A voltage regulator
- 1 x Electrolytic cap set = 22µF 50V capacitor & 100µF 16V capacitor
- 3 x 0.1µF ceramic capacitors
- 1 x 3-position terminal block
- 2 x 2-position terminal block
- 2 x 47k Enable pull-up resistors (yellow / violet / orange)
- 2 x 2.2k LED current limiting resistors - (red / red / red)
- 1 x 330ohm power LED current limiting resistor (org / org / brown)
- 2 x Red LEDs
- 2 x Green LEDs
- 1 x Blue LED
- 8 x 1N4007 EMF-protection diodes
- 2 x 36-position male header strips
- 1 x 4-position male header strip + 4-position female header
- 1 x Reset push button
- 1 x Jumper
- 1 x Hardware set (#4-40 x 1/4, #4-40 hex nut, and #4 lock washer)



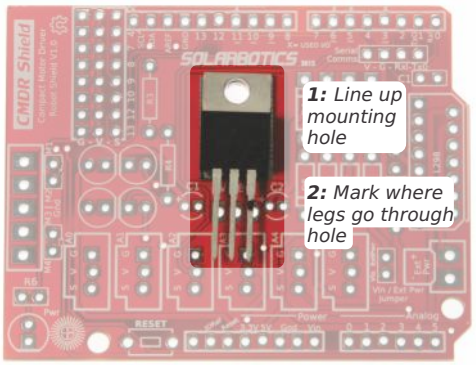
Tools & Materials Needed:

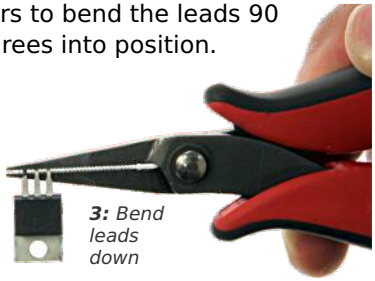
-Soldering Iron
-Solder
-Flush/side cutters
-Needle-nose pliers
-Safety glasses
-No.0 Philips screwdriver

We strongly suggest you inventory the parts in your kit to make sure you have all the parts listed. If anything is missing, contact Solarbotics Ltd. for replacement parts information.

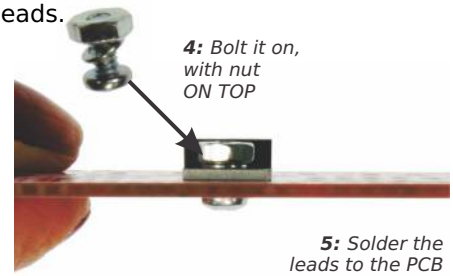
Construction!

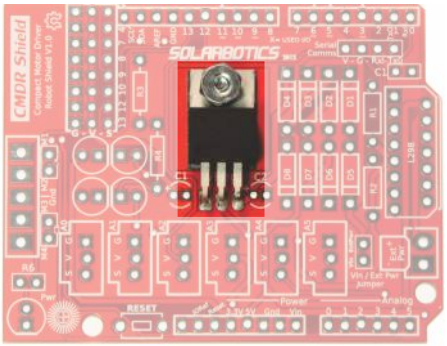
Step 1 - The LM1084 5V Regulator: We'll be bolting this part down to the PCB for better heat-dissipation, so start by lining up the hole on the tab of the regulator to the hole of the PCB. Use a marker to mark where the legs need to bend down 90° to go through the solder pads, and use your trusty needle nose pliers to bend the leads 90 degrees into position.





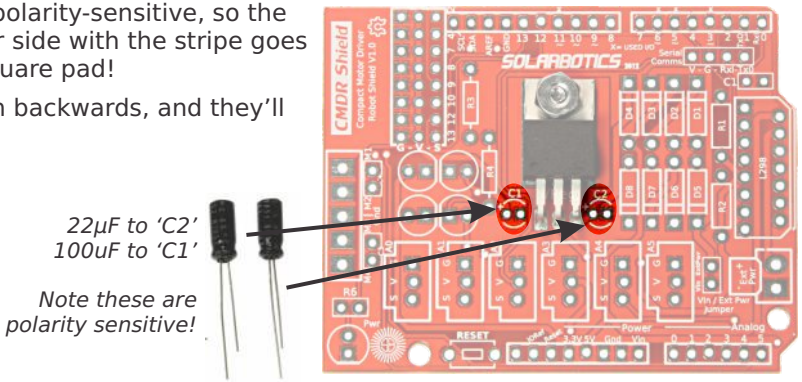
Insert the leads into the PCB, and bolt the LM1084 to the PCB with the #4-40 hardware set, **with the nut on top!** Tighten up the assembly for a snug fit, then solder in and trim the leads.





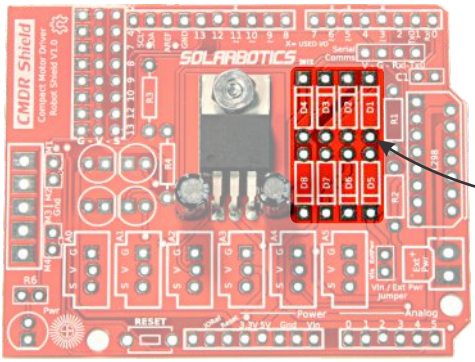
Step 2 - Installing the Electrolytic Capacitors: They look the same, but are two different capacitors. Don't mix them up! The 22µF capacitor is installed to 'C2', and the 100µF capacitor is installed to 'C1'. They're polarity-sensitive, so the capacitor side with the stripe goes to the square pad!

Get them backwards, and they'll go POP!

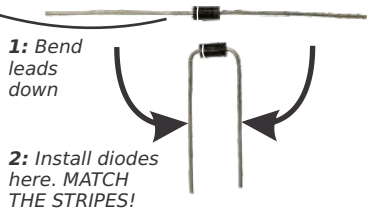


Construction!

Step 3 - Diodes (And lots of them!): There are eight 1N4007 diodes used to protect the circuitry from the electrical noise generated by the motors. Suddenly cutting power to a motor makes the motor coils generate a wicked reverse voltage spike that can kill electronics, but these diodes fix that problem. You can even spin a connected motor and it will generate power through these diodes, and power up the rest of the circuit!



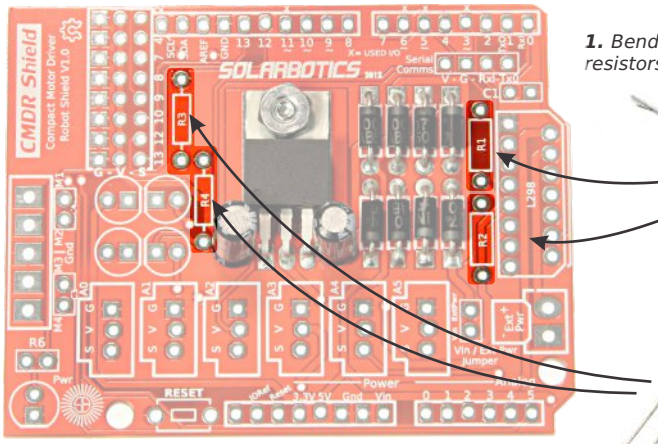
Install the diodes at positions ‘D1’ through ‘D8’, matching the diodes striped end to the stripe on the PCB. DO NOT get them in incorrect, or *POOF*!



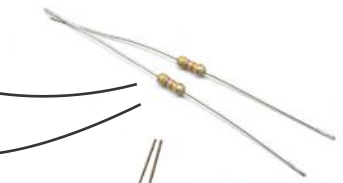
***1:** Bend leads down*

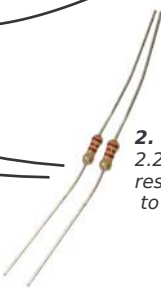
***2:** Install diodes here. MATCH THE STRIPES!*

Step 4 - The Resistors: The 47k (yellow / violet / orange) resistors keep the L298 motor driver IC “pulled high to Vcc”, meaning it’s turned on. Install these at positions ‘R1’ & ‘R2’. There isn’t much space, so bend the legs down close to their bodies. The 2.2k (red / red / red) limit power to the indicator LEDs. These are installed in positions ‘R3’ & ‘R4’.



***1.** Bend leads of 47k (Yel/Vio/Org) resistors and insert at ‘R1’ & ‘R2’*



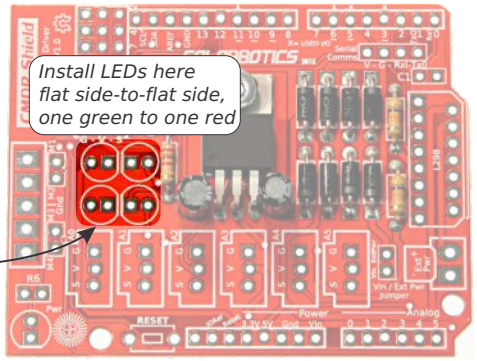


***2.** Bend leads of 2.2k (Red/Red/Red) resistor, and install to ‘R3’ & ‘R4’*

Construction!

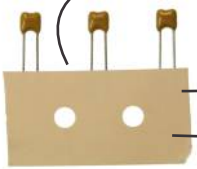
Step 5 - Installing the LEDs: The four LEDs show what the outputs of the L298 chip are doing. When the output channel is on, so is the LED. Install them where shown, using one LED of each color.

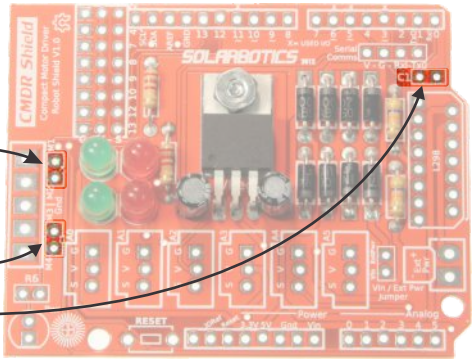
They can only be installed with the flat sides of the LEDs facing each other, with the shorter (cathode) lead installing to the square pad.



Step 6 - 0.1µF Capacitors: The small 0.1µF (marked '104') capacitors provide general noise-filtering to the motor outputs, and power smoothing to the motor IC. These are installed to positions 'C1', 'C3' & 'C4'. Unlike the polarity-sensitive electrolytic capacitors you installed at the beginning, these can be installed either way around.

0.1µF capacitors to positions 'C1', 'C3' & 'C4'

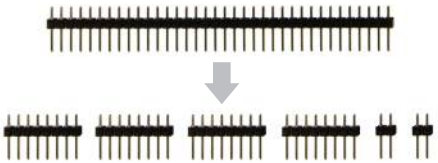


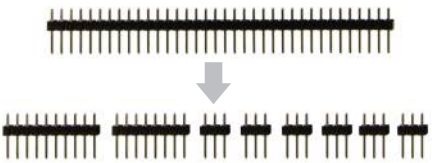


Step 7 - Preparing the Male Header Pins:
Use pliers or snips to snap the two lengths of 36 pins into the following units:

Length #1
4 x 8-pin headers
2 x 2-pin headers

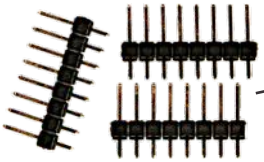
Length #2
1 x 10-pin header
1 x 8-pin header
6 x 3-pin headers



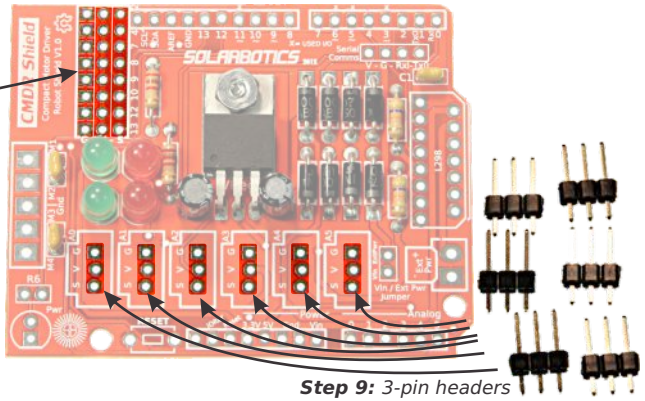


Construction!

Step 8 - 8-Pin Strip Installation: The 3 x 8-pin headers are installed into the 3 vertical rows that make up the “GVS” digital header section. These make it easy to add servos and similar accessories, which are powered from the 5V, 5A LM1084 voltage regulator.



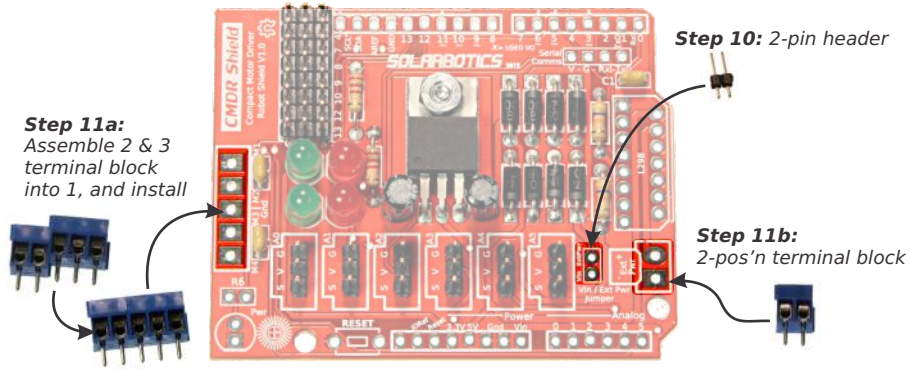
Step 8: *8-pin headers*



Step 9: *3-pin headers*

Step 9 - 3-Pin Strip Installation: The 6 x 3-pin headers are installed at locations ‘A0’ to ‘A5’. These pins connect to the Arduino analog lines, and use the 5V source from the Arduino board to help isolate these lines from possible motor noise.

Step 10 - 2-Pin Header: Finish with the pins by installing the 2-pin header to the ‘Vin/Ext Pwr’ position. This jumper will allow you to select if you want your Arduino powered by through the CMDR Shield (jumpered), or externally from the 2.1mm power jack (open).

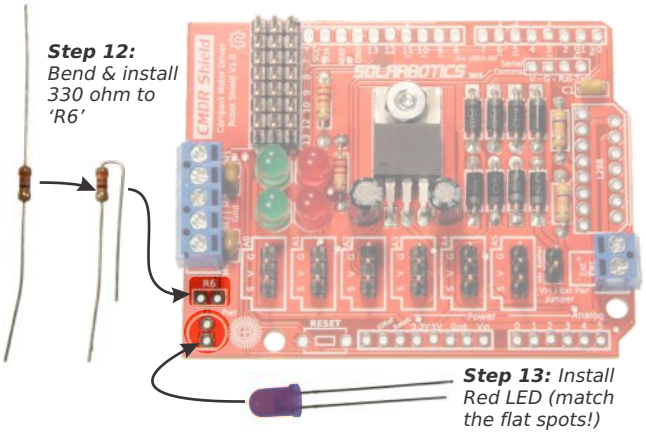


Step 11 - Terminal Blocks: Combine a 2 & 3-position terminal block into a 5-position one, and install it where shown. Make sure the side holes face outwards, or you’ll be doing some funky gymnastics to install your motor wires!

Install the 2-position terminal block on the other side, which is used for adding an external motor power source.

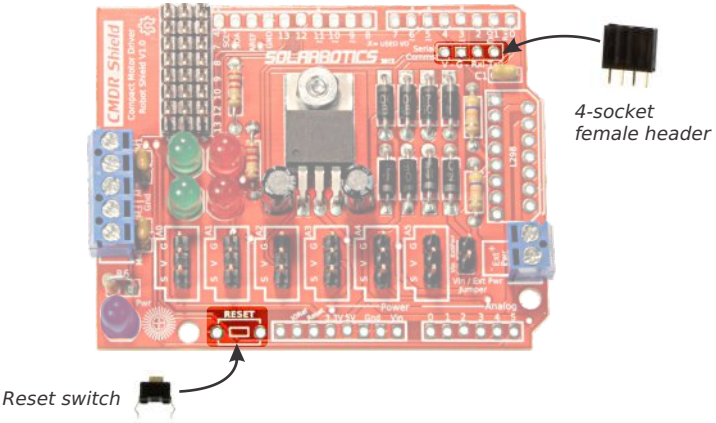
Construction!

Step 12 - Installing the Power LED Resistor: The 330ohm (orange / orange / brown) resistor is installed to position ‘R6’. Neatly bend the resistor lead over 90°, then over again another 90°. Sure you could do a simple “bend it right over”, but the two 90° bends look so much nicer.



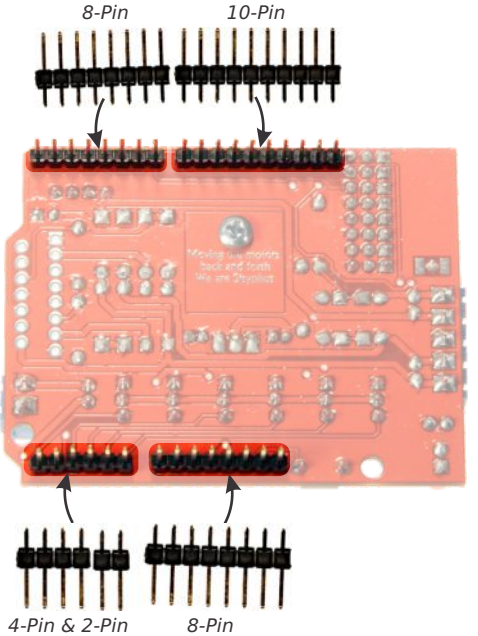
Step 13 - Installing the Power LED Resistor: The red LED installs directly below resistor. Remember to match the flat side of the LED to the flat mark on the PCB (or note the shorter LED lead goes to the square pad).

Step 14 - Solder on the Female Header and Reset Button: This handy serial communications breakout port gets the 4-socket female header soldered to it. Mount and solder the small pushbutton switch to the ‘RESET’ position.

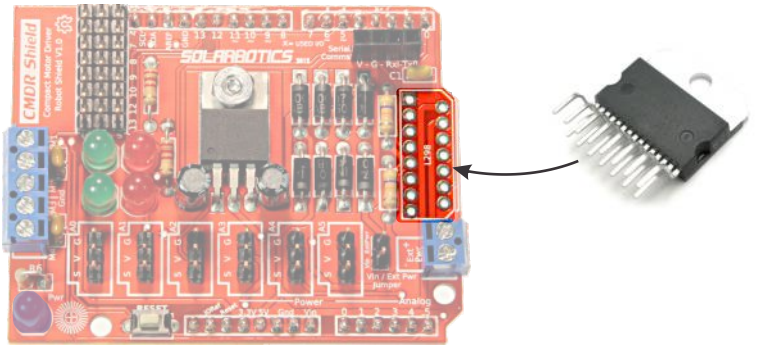


Construction!

Step 14 - Solder on the Shield Headers: Let's flip the board over and install the mating male pin headers. This is a bit of a hodge-podge of pins, so pay attention to the diagram!

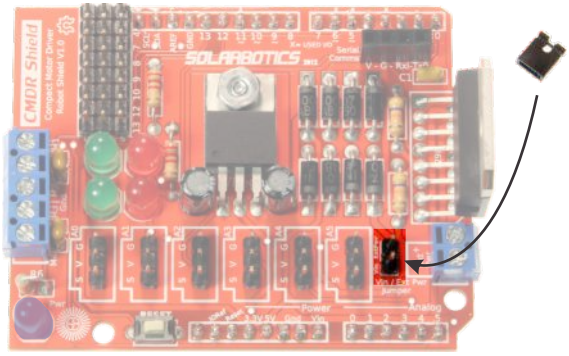


Step 15 - Installing the L298: The time has come to install the heart and soul of the shield; the L298 chip. The chip is oriented with the metal tab towards the back of the PCB. The chip has its pins keyed so that it would take a bit of... skill... to install it backwards!



Construction!

Step 16 - Power Jumper & Power Considerations: You are almost finished. If you want to power your Arduino from the same power that is going to your CMDR Shield, use the jumper. If not, plug it onto only 1 lead of the pair (storing it for later).



Sometimes you will want to power the shield from a separate power supply to isolate the noise generated by the motors from the power feeding your Arduino, but for quality motors, or high capacity batteries, use the jumper.

Note: If you have the “Ext Pwr jumper” installed, you are limited to the maximum voltage your Arduino/Freeduino is designed for! The Arduino Uno R3 input limit is 20V (regulator limitation) and the Freeduino limit is 16V (input capacitor limitation).

If you want to use the maximum rated 30V input the L298 will handle, remove the jumper, and use separate power for your Arduino/Freeduino! Additionally, bolt a heat-sink to the metal tab on the L298 to dissipate excess heat that will be generated at these higher power settings.

Low voltage operation for the L298 and Arduino tests down to 3VDC, but ideally, you will want to supply ‘Ext Pwr’ terminal block with 6.5VDC or better.

Batteries: Find yourself a healthy battery that can quickly discharge enough to power your CMDR Shield. We like using 7.4V 2200mAh Lithium Polymer batteries that can discharge 35 times their rated capacity (2200mAh * 35 = 77Ah!). Our tests show a maximum of 4A is what the un-heat-sinked L298 can do before the thermal limits kick in and shuts it down. A battery featuring a healthy discharge rating means that the voltage won’t “sag” under load, and cause a low-voltage brownout that may reset your Arduino/Freeduino.

Power Supplies: You can use an external DC power supply, but expect to use something better than a wall-wart power adapter. Most 12V adapters are rated under 1A, which a pair of motors will suck up pretty easily. Something with a minimum 2A current-sourcing ability is much more robust, and will avoid the dreaded “brownout”.

Construction!

Brown-Outs: Let's discuss "Brown-outs". No, not when the Godfather of Soul leaves the building ("Unh! Ah! Gotta go now!"), although he was awesome. We are talking about having a system voltage sag that can reset (and potentially damage) your Arduino chip (microcontroller).

Voltage sag happens when the power supply or battery cannot deliver the current needed by the application. It's all based on our friendly V=IR calculation, relating current(I), resistance(R), and voltage (V). With an ideal voltage source, this equation says that if the resistance drops (like a motor being turned on), the current goes up. But a battery is not a ideal source - when it sees more current draw, its voltage drops too. Draw too much current, and your weak voltage source will fall, and if it dips below 2.7V, the microcontroller will trigger it's BOD (Brown out Detection) and reset itself. A good indication that you are having brownouts is to watch the Power LED on the CMDR Shield and see if it ever turns off. The power LED may flicker under large current spikes (like motors rapidly changing directions), but it should never turn off unless you are experiencing a brownout or short circuit.

You can power your whole Arduino / CMDR Shield through the Arduino barrel jack with the 'Ext Pwr Jumper' installed, but you will best avoid brownouts by using the 'Ext Pwr' Terminal block as it can handle much more power than the barrel jack.

What's the answer? Use a "stiff" battery or power supply with a 9Ah discharge ability we mentioned earlier (especially when using larger motors).

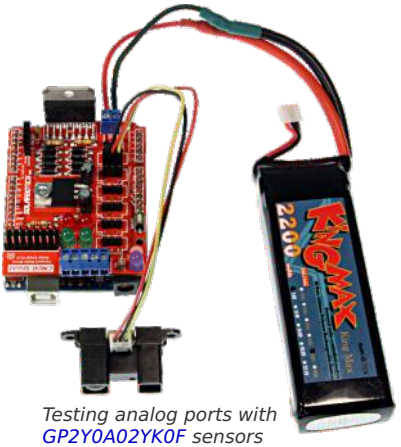
Here's a little helpful advice: When hooking up the 'Ext Pwr' battery, hook up the "+" Red wire first! Hooking up the "-" black wire first exposes you to the risk of shorting your battery out through the metal L298 heat sink tab, which is connected to ground! Trust us on this one...

Testing - Digital/Analog Signals

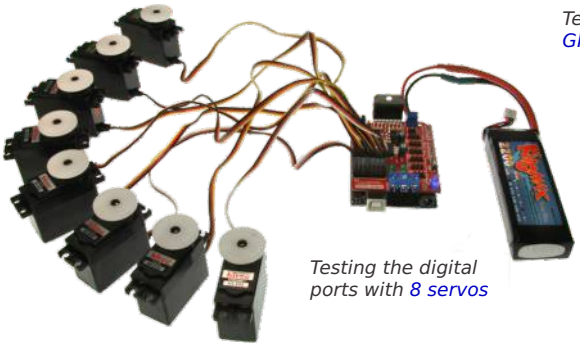
Now that your CMDRShield is successfully powered up, let's test it.

L298 Motor Outputs: Without motors installed, just send a high signal to pins 3,5,6, and/or 11 and watch as the output LEDs turn on.

Testing L298 outputs



Testing analog ports with GP2Y0A02YK0F sensors



Testing the digital ports with 8 servos

Servos: Load up the example program in the Arduino IDE called "Servo -> Sweep". Add-in the GVS header digital ports D2-D13 (except D3, D5, D6, & D11 as they are L298 control lines) and run the program. Your servos will be wired up as follows:

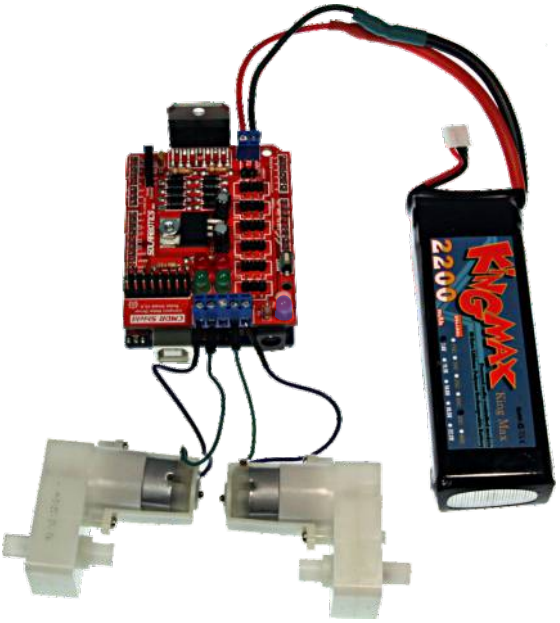
G - Ground - black or brown wire
V - +5V from LM1084 - red wire
S - Signal - yellow, orange, or white wire

Analog Sensors: To read an analog sensor on the SVG headers (yes they're labeled backwards so you don't easily mix them up with the digital lines), use the analog ports A0-A5. Use the Arduino IDE sample program "AnalogInput". Your analog sensors will be wired up as follows:

S - Signal - yellow or white wire
V - +5V from 'duino board - red wire
G - Ground - black wire

Testing - Dual H-Bridge

To test the Dual H-Bridges of the (L298), send a high signal to digital ports D3,D5,D6, & D11 as they are tied to the inputs to the L298. Please see the example program in the Arduino IDE called 0.1Basics -> Blink and change the output pin to 3,5,6,or 11. Wire it up as shown below.



Using the four control lines of your microcontroller, you'll be able to drive each motor in either direction (backward and forward) and brake (turn off by shorting) either motor. The high-impedance mode of your I/O pins (e.g.: setting the pin to "input"mode) will also allow you to coast the motors. Setting pin 3 to *high* and 5 to *low* will spin motor A in one direction.

Setting pin 5 to *low* and 3 to *high* will spin it in the opposite direction.

Doing the same on pins 6 and 11 will control motor B in a similar manner. If you set both control pins both high or both low, this will rapidly stop ("brake", not "break"!) the motor.

We used these particular digital for their **Pulse Width Modulation** (PWM) control. Using PWM allows you to slow your motors down via software pulsing commands. Leave one pin high (or low), and pulse the other to vary the speed. Learn about this feature by using the Arduino command *AnalogWrite*. Check out the Arduino IDE example code "0.3Analog -> Fading" sketch to help you out.

L298 Performance Characteristics

Here's the nitty gritty on the L298 chip as we tested it. You can find full manufacturer's datasheets online:
http://content.solarbotics.com/products/datasheets/sgs_l298_motor_driver_ic.pdf

Solarbotics Measured Characteristics

Test	IC Voltage		
	9V	12V	18.95V
Quiescent current draw, IC enabled (mA)	31.3	31.6	31.9
Quiescent current draw, IC disabled (mA)	5.7	5.91	6.1
IC Vout (no load)	8.3	11.25	18.09
IC input impedance (ohms)	127k	133k	140k
Single bridge peak output current (A)	2.78	2.92	Thermal Overload
Voltage drop across 8 ohm load (V)	6.63	9.24	15.16
Current delivered to 8 ohm load (A)	0.829	1.155	1.895
Equivalent internal resistance (ohms)	2.86	2.39	2.00

Note:

Without modification, the maximum voltage input to the compact motor driver board is 30V, this is the maximum voltage that the on-board 5V regulator can handle. Operation is restricted by the voltage regulator, but if you can work around that (remove the regulator), the next limit is 50V (the limit of the L298!).

SGS Thompson Datasheet Characteristics

Logic / Motor supply maximum voltage . . . . . .6V to 50V
Input & enable line voltage range (max) 7V
Peak output current (nonrepetitive), t <= 100µS (each channel) 3A
Continuous output current (each channel) 2A
Total continuous heat dissipation 25W

Logic Table

Enable	L1	L2	Result
L	L	L	OFF
L	L	H	OFF
L	H	L	OFF
L	H	H	OFF
H	L	L	BRAKE
H	L	H	FORWARD
H	H	L	BACKWARD
H	H	H	BRAKE
PWM	L	L	PULSE-BRK
PWM	L	H	FWD-SPD
PWM	H	L	BCK-SPD
PWM	H	H	PULSE-BRK

Enable	L3	L4	Result
L	L	L	OFF
L	L	H	OFF
L	H	L	OFF
L	H	H	OFF
H	L	L	BRAKE
H	L	H	FORWARD
H	H	L	BACKWARD
H	H	H	BRAKE
PWM	L	L	PULSE-BRK
PWM	L	H	FWD-SPD
PWM	H	L	BCK-SPD
PWM	H	H	PULSE-BRK

Other Stuff That You Might Find Handy

SB-Freeduino
$26.00ea (SKU: 28920)

The Freeduino is based on the open source project version of the Arduino Diecimila. We've adapted the design for more convenience as a semi-kit!

Sharp Analog Distance Sensor 20-150cm
$14.95ea (SKU: 35235)

These are great distance sensors that should be near the top of anybody's list for simple & effective obstacle detection!

Gear Motor 9 - 143:1 90 Degree Shaft
$7.00ea (SKU: GM9)

This 143:1 gear motor is much like the GM3 gear motor but runs at nearly twice the speed. Great for robots needing speed over torque!

Servo S03N
$12.95ea (SKU: Servo)

These GWS S03N standard servos are a common, useful servo that are also very receptive to being converted to gear motors by removing their internal drive circuitry.

Polymer Lithium Ion Battery - 2200mAh 7.4v
$15.95ea (SKU: 50880)

This high discharge LiPo is a great way to power any R/C, robotic, or portable project. This is an excellent choice for anything that requires a small battery with a lot of punch.

Visit us online for more info and cool stuff:

www.solarbotics.com

Solarbotics Ltd.
3740D - 11A Street NE, Suite 101
Calgary, Alberta T2E 6M6
Canada

Toll Free: 1-866-276-2687
International: +1 (403) 232-6268
Fax: +1 (403) 226-3741

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