This is the Revision A verion of the Motor2 RoboBrick. The status of this project is finished. This revision is replaced by Revision C.

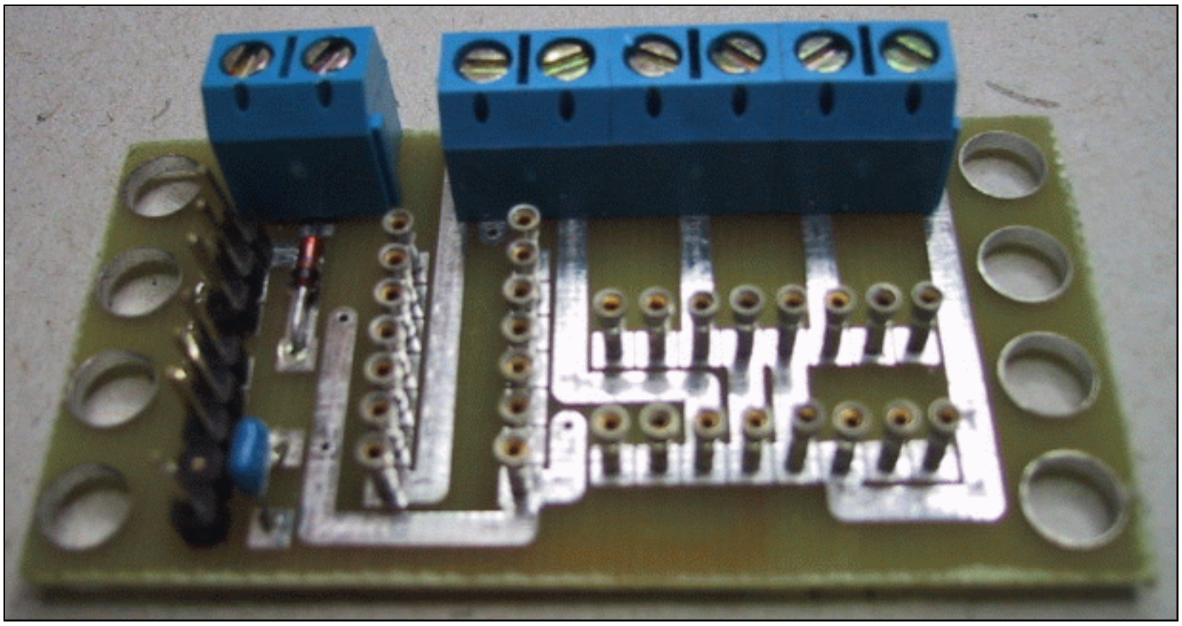
# Motor2 Robobrick (Revision B)

## Table of Contents

This document is also available as a PDF document.

## 1. Introduction

The Motor2 RoboBrick allows for control of up to two small DC motors via pulse width modulation.



## 2. Programming

The Motor2 RoboBrick can control up to two motors called 0 and 1 respectively. Each motor has a condition, power mode, direction, and speed. The condition is either on or off (i.e. freewheel.) The two power modes are pulsed and continous. The two directions are forward and backward. The speed is a number between 0 and 255 inclusive. There is one additional variable associated with each motor called ramp and a few additional variables that are shared between the two motors.

Pulsed mode is standard motor control via pulse width modulation (PWM.) When the speed is 0, no pulses are sent to the motor. When the speed is 255, the motor is full on. When the speed is 128, 50% duty cycle pulses are sent to the motor. The direction bit, controls what direction current is pulsed into the motor.

In continuous mode, power is continuously applied either forward or backward through the motor. In continuous mode, when the speed is 128, 50% duty cycle pulses are sent to the motor, where half the cycle is sends current forward through the motor and the other half is sends current backward through the motor (thereby cancelling out and resulting in a rotational speed of 0.) While continous mode consumes more power than pulsed mode, it sometimes provides better motor speed control at slow speeds.

The ramp variable is used to slow down the rate at which motor speeds are changed. When the ramp variable is non−zero, it specifies the rate at which motor speed changes (i.e. the speed ramp.) The ramp rate is measured in ticks (1/3 of a bit time at 2400 baud, or 1/7200, or 138μS. A ramp rate of 1, means the pulse widths will be changed every 138μS. A ramp rate of 100 means the pulse widths will be changed every 100 × 138μS or every 13.8mS. This allows the user to slowly speed up and slow down the motor. Please note, that ramp only applies to speed, changing the motor direction is immediate. (Sorry!)

For safety reasons, you might want the motors to shut off if the controlling program crashes. This is accomplished with a variable called the failsafe delay variable which is shared between both motors. When the failsafe delay variable is set to a non−zero value, it causes another variable called the failsafe counter to be initialized to the same value. Every 256 ticks (= 256 × 138μS = 35.5mS), the failsafe counter is decremented. If the failsafe counter ever decrements to 0, it immediately turns off both motors without any ramping. Every time a speed command is sent to the Motor2 RoboBrick, the failsafe counter is reinitialed to contain the failsafe delay variable. Thus, by occasionally sending commands that set the speed of either motor, the failsafe counter can be kept non−zero. Alternatively, there is a command that just reinitializes the failsafe counter without affecting the speed. The maximum amount of time between commands that reset the failsafe counter is 255 × 35.5mS or approximately 9 seconds. If the controlling program crashes, it will stop sending commands to the Motor2 RoboBrick and eventually, the failsafe counter will decrement to zero and stop both motors. There is yet a third variable called the failsafe error counter that is incremented each time a failsafe shut down occurs. The failsafe error counter can be read with yet another command. Lastly, both motors can be restarted by simply sending another command that sets the speed of either motor.

Finally, there is one other variable that is shared between the two motors called the prescaler. The prescaler is 3−bits wide and controls duty cycle width of the pulses are sent to the motor. The table below summarizes the prescaler to duty cycle relationship:

| **Prescaler** | **Duty Cycle Width** |
|---|---|
| 000 | .5μS |
| 001 | 1μS |
| 010 | 2μS |
| 011 | 4μS |
| 100 | 8μS |
| 101 | 16μS |
| 110 | 32μS |
| 111 | 64μS |

The Motor2 commands are summarized in the table below:

| **Command** | | **Byte Value** | **Discussion** |
|---|---|---|---|

| | **Send/ Receive** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** | |
|---|---|---|---|---|---|---|---|---|---|---|
| Set Quick | Send | 0 | 0 | *h* | *h* | *h* | *h* | *d* | *m* | Set motor *m* speed to *hhhh hhhh* and direction to *d* (0=forward, 1=backward). |
| Set Low | Send | 0 | 1 | *l* | *l* | *l* | *l* | *d* | *m* | Set low order 4 bits of motor *m* speed to *ll* and direction to *d* (0=forward, 1=backward). |
| Set Ramp | Send | 1 | 0 | 0 | 0 | 0 | 0 | 0 | *m* | Set the ramp for motor *m* to *rrrrrrrr* (00000000=no ramp (default)). |
| | Send | *r* | *r* | *r* | *r* | *r* | *r* | *r* | *r* | |
| Set Failsafe | Send | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | Set the failsafe delay variable to *ffffffff* (00000000=off (default)). |
| | Send | *f* | *f* | *f* | *f* | *f* | *f* | *f* | *f* | |
| Reset Failsafe | Send | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | Reset the failsafe counter to the failsafe delay variable. |
| Set Speed | Send | 1 | 0 | 0 | 0 | 0 | 1 | *d* | *m* | Set motor *m* to speed *ssssssss* and direction to *d*. |
| | Send | *s* | *s* | *s* | *s* | *s* | *s* | *s* | *s* | |
| Set Mode | Send | 1 | 0 | 0 | 0 | 1 | 0 | *x* | *m* | Set motor *m* mode to *x* (0=pulsed (default), 1=continuous). |
| Set Direction | Send | 1 | 0 | 0 | 0 | 1 | 1 | *d* | *m* | Set motor *m* direction to *d* (0=forward (default), 1=reverse). |
| Set Prescaler | Send | 1 | 0 | 0 | 1 | 0 | *p* | *p* | *p* | Set prescaler to *ppp* (000=fast, 111=slow (default)). |
| Read Failsafe | Send | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | Read the return the failsafe delay variable *ffffffff*. |
| | Receive | *f* | *f* | *f* | *f* | *f* | *f* | *f* | *f* | |
| Read Prescaler | Send | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | Read the return the prescaler *ppp*. |
| | Receive | 0 | 0 | 0 | 0 | 0 | *p* | *p* | *p* | |
| Read Speed | Send | 1 | 0 | 0 | 1 | 1 | 0 | 1 | *m* | Read the return the speed *ssssssss* for motor *m*. |
| | Receive | *s* | *s* | *s* | *s* | *s* | *s* | *s* | *s* | |
| Read Mode/Direction | Send | 1 | 0 | 0 | 1 | 1 | 1 | 0 | *m* | Read the mode *x* (0=pulsed, 1=continuous) and direction *d* (0=forward, 1=reverse) for motor *m*. |
| | Receive | 0 | 0 | 0 | 0 | 0 | 0 | *x* | *d* | |
| Read Ramp | Send | 1 | 0 | 0 | 1 | 1 | 1 | 1 | *m* | Read and return the ramp *rrrrrrrr* for motor *m*. |
| | Receive | *r* | *r* | *r* | *r* | *r* | *r* | *r* | *r* | |
| Read Failsafe Errors | Send | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | Read and return the failsafe error counter *eeeeeeee*. Reset the counter. |
| | Receive | *e* | *e* | *e* | *e* | *e* | *e* | *e* | *e* | |
| Read Failsafe Counter | Send | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | Read and return the failsafe counter *cccccccc*. |
| | Receive | *c* | *c* | *c* | *c* | *c* | *c* | *c* | *c* | |
| Read Actual Speed | Send | 1 | 0 | 1 | 0 | 0 | 0 | 1 | *m* | Read and return the actual speed for motor *m* |
| | Receive | *e* | *e* | *e* | *e* | *e* | *e* | *e* | *e* | |
| Set On/Off | Send | 1 | 0 | 1 | 0 | 0 | 1 | *o* | *m* | Set motor *m* to condition *o* (0=off 1=on) |
| Reset | Send | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | Reset the entire motor controller |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Read On/Off | Send | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | Read the on/off condition of motor 1 and 0 |
| | Recieve | 0 | 0 | 0 | 0 | 0 | 0 | *a* | *b* | The on/off condtion of motor 1 (*b*) and motor 0 (*a*) |
| Shared Commands | Send | 1 | 1 | 1 | 1 | 1 | *c* | *c* | *c* | Execute shared command *ccc*. |

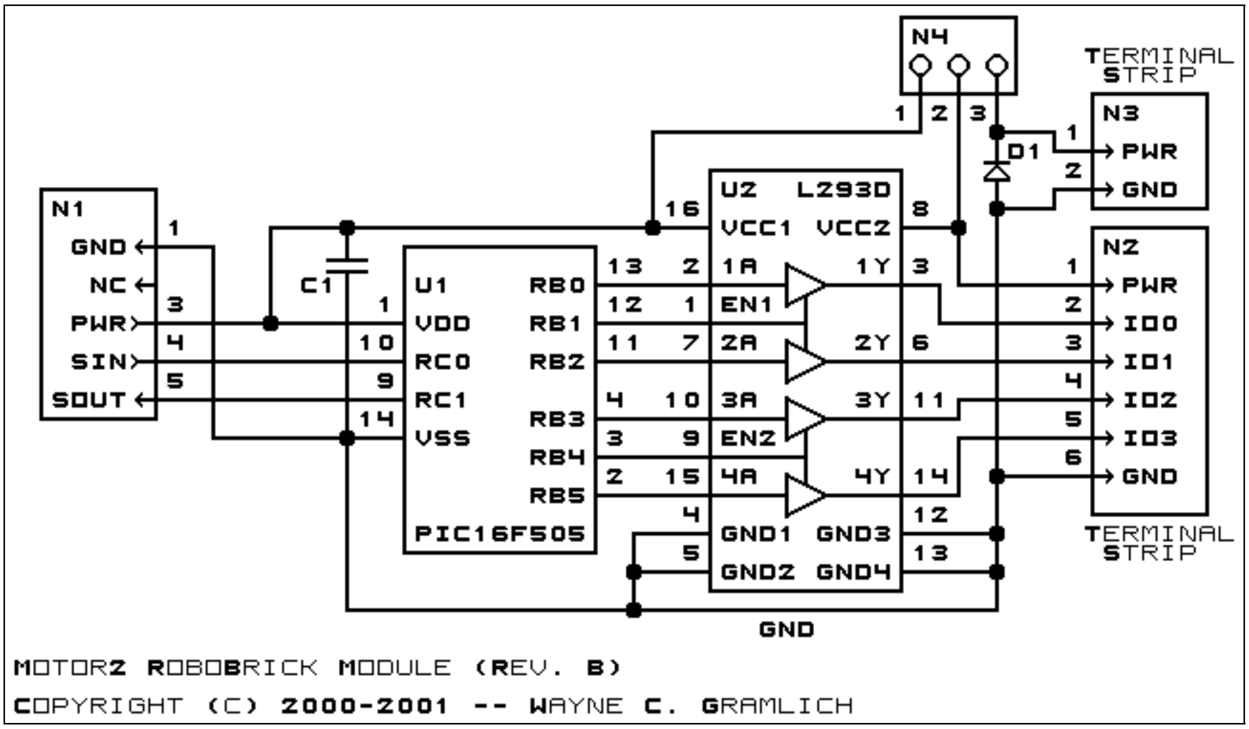
On power up, the Motor2 RoboBrick sets all variables to zero. The motor modes default to pulsed forward.

# 3. Hardware

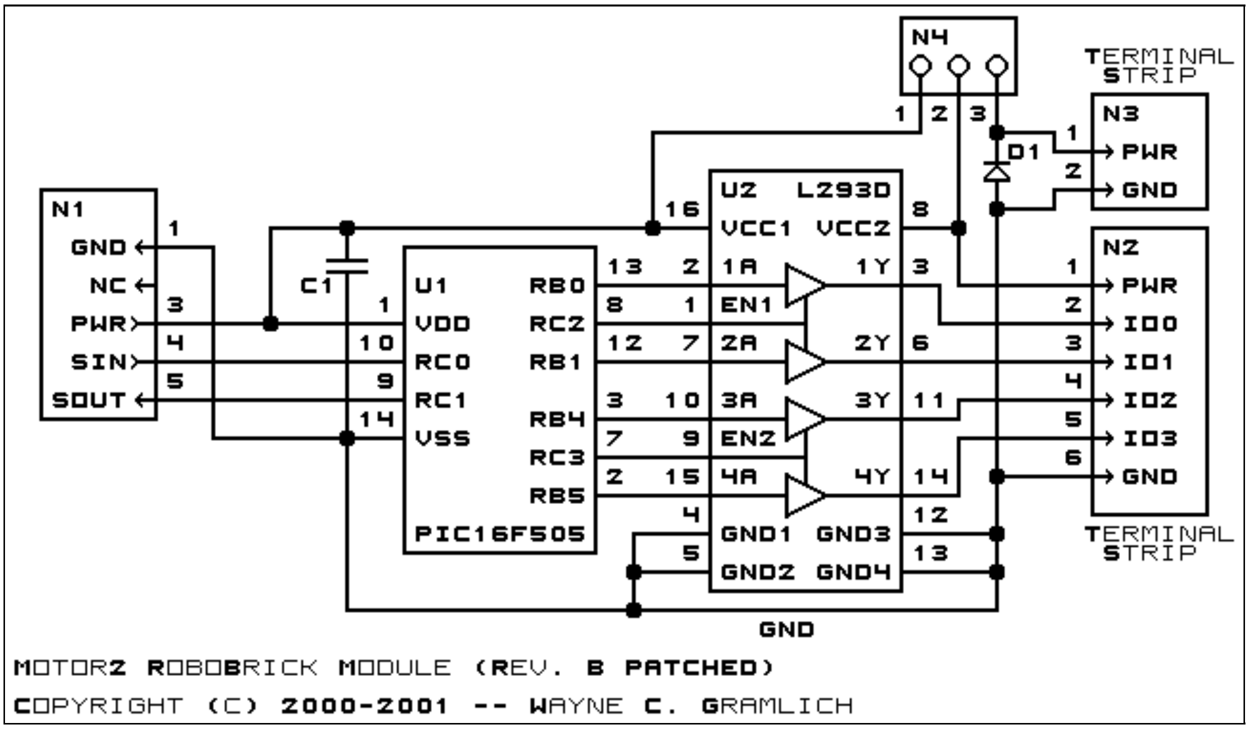
The hardware consists of a circuit schematic and a printed circuit board.

## 3.1 Circuit Schematic

The schematic for the Motor2 RoboBrick is shown below:



The pins connections were pretty seriously bungled and the boards had to be patched as follows:



The parts list kept in a separate file −− motor2.ptl.

## 3.2 Printed Circuit Board

The printed circuit files are listed below:

*motor2_back.png*
: The solder side layer.

*motor2_front.png*
: The component side layer.

*motor2_artwork.png*
: The artwork layer.

*motor2.gbl*
: The RS−274X "Gerber" back (solder side) layer.

*motor2.gtl*
: The RS−274X "Gerber" top (component side) layer.

*motor2.gal*
: The RS−274X "Gerber" artwork layer.

*motor2.drl*
: The "Excellon" NC drill file.

*motor2.tol*
: The "Excellon" NC drill rack file.

# 4. Software

The Motor2 software is available as one of:

*motor2.ucl*

The µCL source file.

*motor2.asm*
: The resulting human readable PIC assembly file.

*motor2.lst*
: The resulting human readable PIC listing file.

*motor2.hex*
: The resulting Intel® Hex file that can be fed into a PIC12C5xx programmer.

The Motor2 test suite is available as one of:

*motor2_test.ucl*
: The µCL source file.

*motor2_test.asm*
: The resulting human readable PIC assembly file.

*motor2_test.lst*
: The resulting human readable PIC listing file.

*motor2_test.hex*
: The resulting Intel® Hex file that can be fed into a PIC16F84 programmer.

## 5. Issues

The following fabrication issues came up:

- RB3 is input only, the traces need to hooked up to different pins. Hook the enables to RC2 and RC3. Hook motor 0 to RB0 and RB1 and motor 1 RB4 and RB5.
- The holes for N1 (size 3) are too large and should be made smaller (size 2).
- D1 interferes with N3, it should be moved to the left.
- Think about adding labels to N4.
- Think about adding labels to N2 and N3.
- Think about driving everything through diodes with pull up resistors so that the voltage for the L293D can be greater than or less than 5 volts.
- Seriously consider removing N4.

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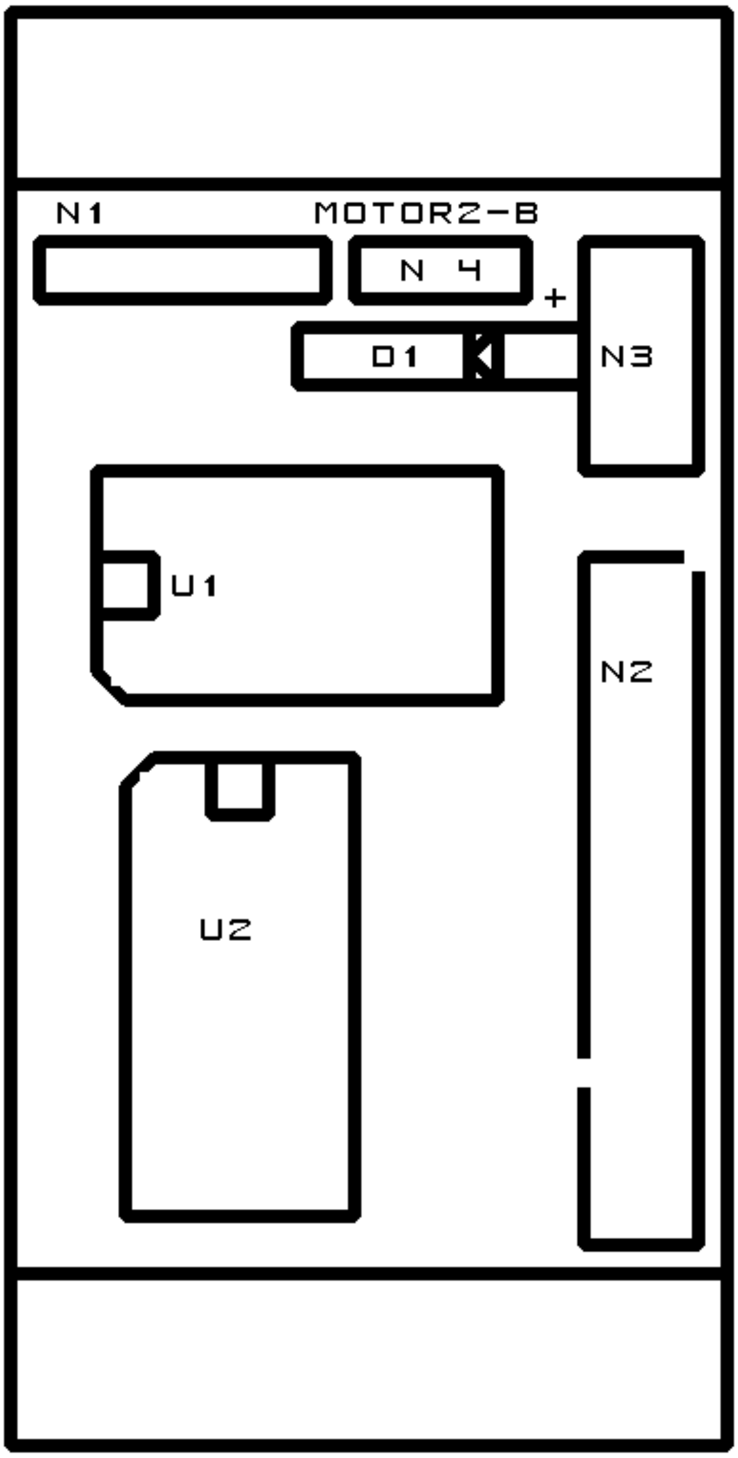
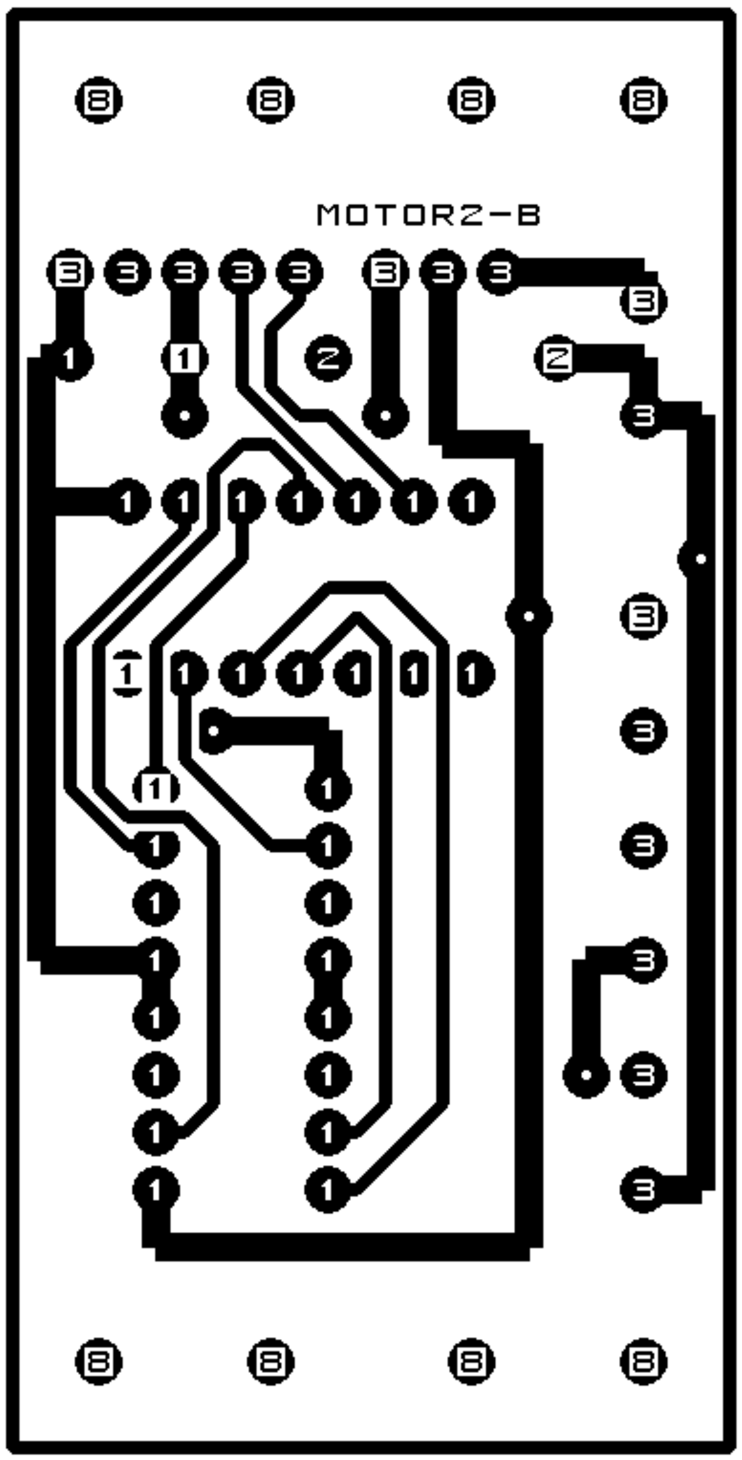
## A. Appendix A: Parts List

```
# Parts list for Motor2 RoboBrick (Rev. B)
#
C1: Capacitor10pF − 10 pF Ceramic Capacitor [Jameco: 15333]
C2: Capacitor2200uF − 2200 uF 6.3V Electrolytic Capacitor [Jameco:133145]
D1: 1N5400 − 1N5400 Diode [Jameco: 77075]
N1: Header1x5.RBSlave − 1x5 Male Header[5/40 Jameco: 160881]
N2: TerminalStrip6.Motor2 − 6 terminal terminal strip [2 Jameco: 189667]
N3: TerminalStrip2.Motor2 − 2 terminal terminal strip [Jameco: 189675]
N4: Header1x3.Motor2 − 1x3 Male Header [3/40 Jameco: 160881]
U1: PIC16C505.Motor2 − Microchip PIC12C505 [Digikey: PIC16C505−04/P−ND]
U2: L293D − Dual H−Bridge with protection diodes built in [Digikey: 296−9518−5−ND]
```

## B. Appendix B: Artwork Layer



## C. Appendix C: Back (Solder Side) Layer



## D. Appendix D: Front (Component Side) Layer