

This is the Revision A version of the [Laser1 RoboBrick](#). The status of this project is [work in progress](#).

# Laser1 Robobrick (Revision B)

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## 1. Introduction

The Laser1 RoboBrick is a module that is designed to allow the use of a slightly modified laser pointer to detect passive reflector beacons at a distance of approximately 10 meters (or about 32 feet for the metrically impaired.) It is meant to be used in conjunction with the [LaserHead1](#) RoboBrick. It has a 3.1 volt power supply that can be turned on and off under program control to replace the batteries that come with the laser pointer. In addition, the Laser1 RoboBrick can send a pulses to a servo to cause it to slew back and forth under program control. In conjunction with 3 or more properly placed passive reflectors, the Laser1 RoboBrick can be used to triangulate a robot's position. We will not know how accurately until after it has been built and tested.

The basic idea behind this laser pointer system came from an article written by Jim Ubersetzig [[Ubersitzig1999](#)]. We are greatly indebted to Jim for figuring this system out in the first place and for E-mail support as we asked some follow on questions. The equations for doing triangulation can be found in a paper by Clare McGillem and Theodore Rappaport [[McGillem1989](#)]. A more recent on-line derivation of the formulas can be found in a paper by Richard Vannoy [[Vannoy2001](#)]. There is another paper by M. Bertke and L. Gurvits [[Bertke1994](#)] that explains how to deal with more than three beacons; alas, the math is quite a bit over my head. It should be mentioned that the McGillem and Bertke papers were found by scanning the bibliography of the fairly comprehensive treatment of robot navigation by Borenstein, Everett, and Feng [[Borenstein1996](#)].

By the way, we recently ran across another in-door navigation system developed at MIT --- [The Cricket Indoor Location System](#).

## 2. Programming

The initial software for the Laser1 RoboBrick will only be responsible for measuring the angles between the beacons and the robot proper. The next software/hardware reversion should be able to compute the (x, y) position of the robot, given the (x, y) positions of the beacons. The reason for the currently reduced functionality is because the floating point math libraries occupy more than the 2K of available code space on PIC16F628; indeed, all of the code appears to occupy a significant fraction of the 8K of code space available

in a PIC16F876.

The current design requires a servo that has been modified for continuous rotation [[AcronameServo](#), [SandbergServo](#), [Buse2000](#)]. This allows the LaserHead1 to sweep a full 360 degrees. An additional sensor is used to detect each time the LaserHead1 sweeps past a known location.

Since the Laser1 uses a PIC16F628 with a 16 bit Timer1 module and the PWM/Capture/Compare module, it is capable of resolving the time between the beacon reflection returns to the instruction rate of 5 MHz. Since it takes our current laser head 2–3 seconds to slew 360 degrees, we need a counter resolution of  $3 \times 5 \times 10^6 = 15$  million. Since 15 million is greater than 64 thousand, a 24–bit counter is needed.

{to be continued...}

The BIROD2 RoboBrick supports both the standard [shared commands](#) and the [shared interrupt commands](#) in addition to the following commands:

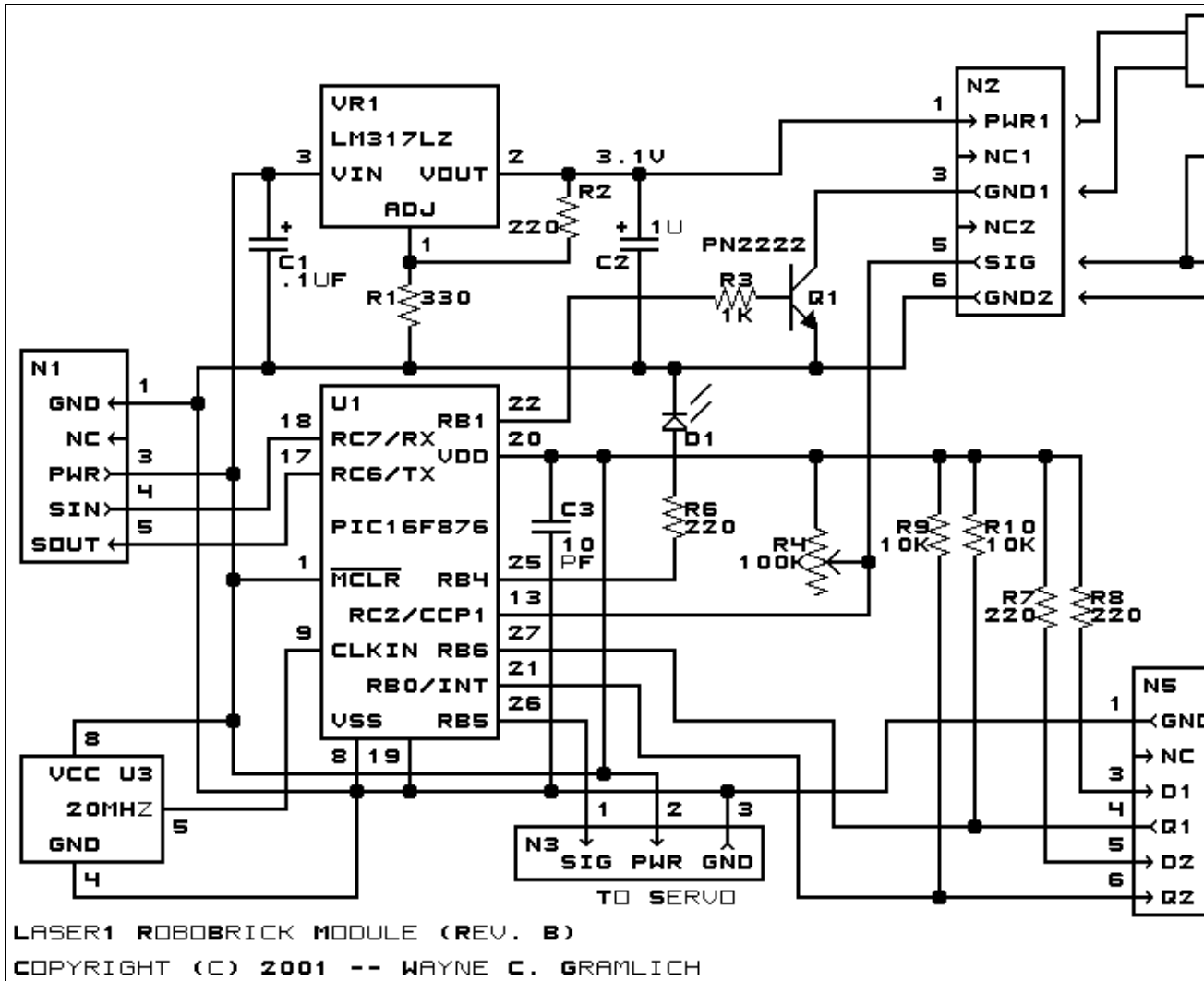
Command	Send/ Receive	Byte Value								Discussion
		7	6	5	4	3	2	1	0	
Set Laser Enable	Send	0	0	0	0	0	0	0	z	Set laser enable bit to <i>z</i> .
Read Laser	Send	0	0	0	0	0	0	1	0	Read and return the sweeping bit <i>s</i> , high bit <i>h</i> , low bit <i>l</i> , and laser bit <i>z</i> , and capture count <i>nnnn</i> .
	Receive	<i>s</i>	<i>h</i>	<i>l</i>	<i>z</i>	<i>n</i>	<i>n</i>	<i>n</i>	<i>n</i>	
Disable Servo	Send	0	0	0	0	0	1	0	0	Disable servo
Enable Servo Low	Send	0	0	0	0	0	1	0	1	Enable Servo Low
Enable Servo High	Send	0	0	0	0	0	1	1	0	Enable Servo High
Sweep	Send	0	0	0	0	0	1	1	1	Sweep
Set Servo Low	Send	0	0	0	0	1	0	0	0	Set servo low register to <i>lllllll</i>
	Send	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	
Set Servo High	Send	0	0	0	0	1	0	0	1	Set servo high register to <i>hhhhhhh</i>
	Send	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	
Read Servo Low	Send	0	0	0	0	1	0	1	0	Read and return servo low register of <i>lllllll</i>
	Receive	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	<i>l</i>	
Read Servo High	Send	0	0	0	0	1	0	1	1	Read and return servo high register of <i>hhhhhhh</i>
	Send	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	<i>h</i>	
Read Interrupt Bits	Send	1	1	1	0	1	1	1	1	Return the interrupt pending bit <i>p</i> and the interrupt enable bit <i>e</i> .
	Receive	0	0	0	0	0	0	<i>e</i>	<i>p</i>	
Set Interrupt Bit Commands	Send	1	1	1	1	0	<i>c</i>	<i>c</i>	<i>c</i>	Execute <a href="#">shared set interrupt command</a> <i>ccc</i> .
<a href="#">Shared Commands</a>	Send	1	1	1	1	1	<i>c</i>	<i>c</i>	<i>c</i>	Execute shared command <i>ccc</i> .

### 3. Hardware

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

### 3.1 Circuit Schematic

The schematic for the Laser1 RoboBrick is shown below:



The parts list kept in a separate file --- [laser1.ptl](#).

### 3.2 Printed Circuit Board

The printed circuit board files are listed below:

[laser1\\_back.png](#)

The solder side layer.

[laser1\\_front.png](#)

The component side layer.

[laser1\\_artwork.png](#)

The artwork layer.

[laser1.gbl](#)

The RS-274X "Gerber" back (solder side) layer.

[laser1.gtl](#)

The RS-274X "Gerber" top (component side) layer.

[laser1.gal](#)

The RS-274X "Gerber" artwork layer.

[laser1.drl](#)

The "Excellon" NC drill file.

[laser1.tol](#)

The "Excellon" tool rack file.

## 4. Software

The Laser1 software is available as one of the followin:

[laser1.ucl](#)

The  $\mu$ CL source code.

[laser1.asm](#)

The resulting human readable PIC assembly listing

[laser1.lst](#)

The resulting human readable PIC listing file.

[laser1.hex](#)

The resulting Intel<sup>®</sup> Hex file that can be fed into a PIC16F628 programmer.

## 5. Issues

Any fabrication issues go here:

## 6. References

[AcronameServo]

*Modifying Servos for Continuous Rotation*. Published online by [Acroname](#) at URL:

<http://www.acroname.com/robotics/info/ideas/continuous/continuous.html>.

[Bertke1994]

*Mobile Robot Localization Using Landmarks* by Margrit Bertke and Leonid Gurvits in the proceedings of the *1994 International Conference on Intelligent Robots and Systems (IROS '94)*, pages 135–142. URL: <http://www.umiacs.umd.edu/~betke/#landmarkpaper>

[Borenstein1996]

*"Where am I?" – Systems and Methods for Mobile Robot Positioning* by J. Borenstein, H. R. Everett, and L. Feng published by A. K. Peters, Ltd. ISBN: 156881058X. An on–line version of the paper is available at URL: <http://www.eecs.umich.edu/~johannb/pos96rep.pdf>. Note: There is a slightly different 1995 edition entitled *Navigating Mobile Robots: Systems and Techniques* that is out of print ASIN: 1568810660 .

[Buse2000]

*Variable Speed Control Modification to the Futaba S3003 RC Servo* by Lee Buse published in the *September 2000 issue* of the *Seattle Robotics Encoder*. URL: <http://www.seattlerobotics.org/encoder/200009/S3003C.html>.

[McGillem1989]

*A Beacon Navigation Method for Autonomous Vehicles* by Clare D. McGillem and Theodore S. Rappaport published in *IEEE Transactions on Vehicular Technology* Vol. 38 No. 3 August 1989, pages 132–139. Note: The algorithm proper can be found in equations (7) through (16). The derivation of the algorithm can be found in the appendix. In additin, I have written a [C program](#) that

implements the described algorithm.

[SandbergServo]

*The Sandberg Servo Modification Method* published by the [Portland Area Robotics Society \(PARTS\)](http://www.portlandrobotics.org/parts/) at URL: <http://www.portlandrobotics.org/servo/ds-hack.html>.

[Ubersitzig1999]

*A Circular Navigation System* written by Jim Ubersitzig, published in three parts in the [September](#), [October](#), and [November](#) 1999 issues of *The Robot Builder newsletter* of the [Robotics Society of Southern California](#). URL: <http://www.csulb.edu/~wmartinz/rssc/newsletters/>. Note: At the end of the third part of the series, there is mention of a continuation of the article (part 4) in the next month of "The Robot Builder"; to the best of our knowledge this continuation article has not actually been published.

[Vannoy2001]

*Accurate Autonomous Robot Laser Navigation Using Only Passive Reflectors* by Richard T. Vannoy II published in the [September 2001 issue](#) of the *Seattle Robotics Encoder*. URL: <http://www.seattlerobotics.org/encoder/200109/lasernav.htm>.

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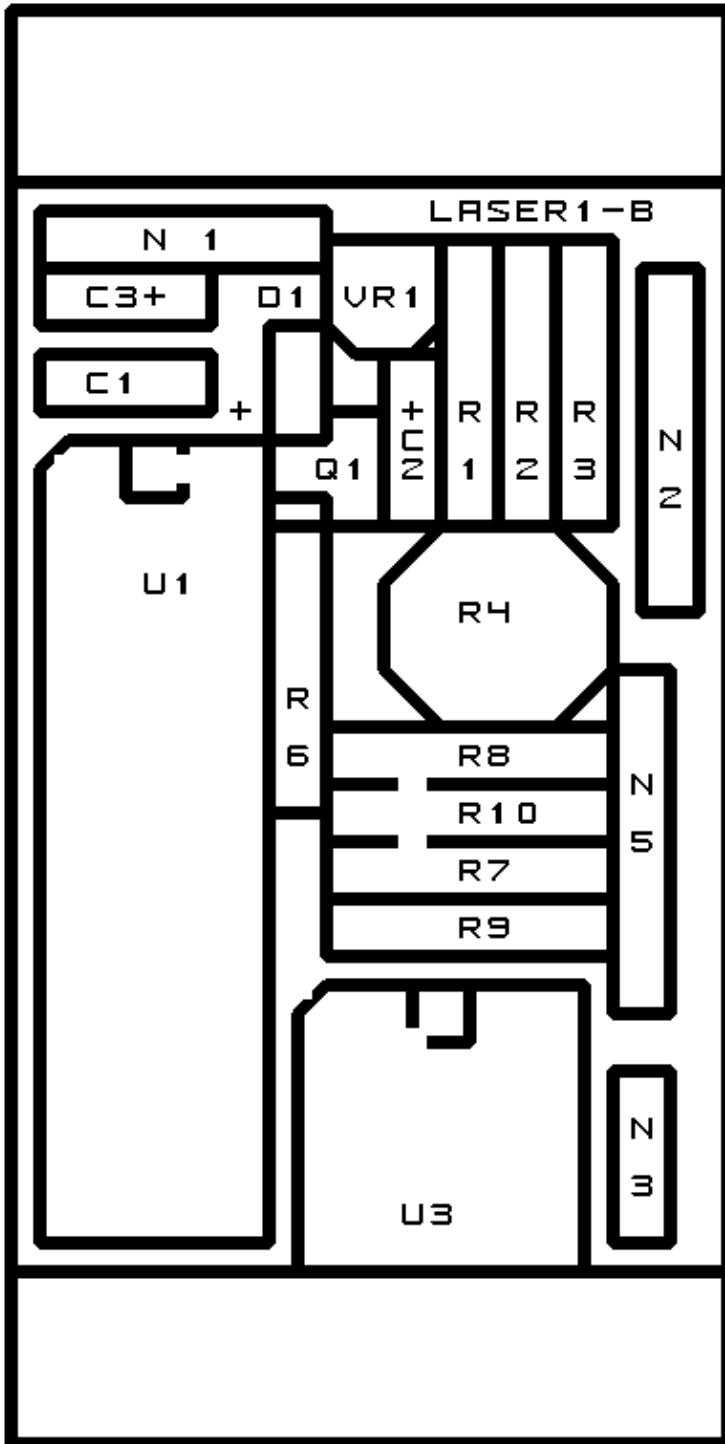
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## A. Appendix A: Parts List

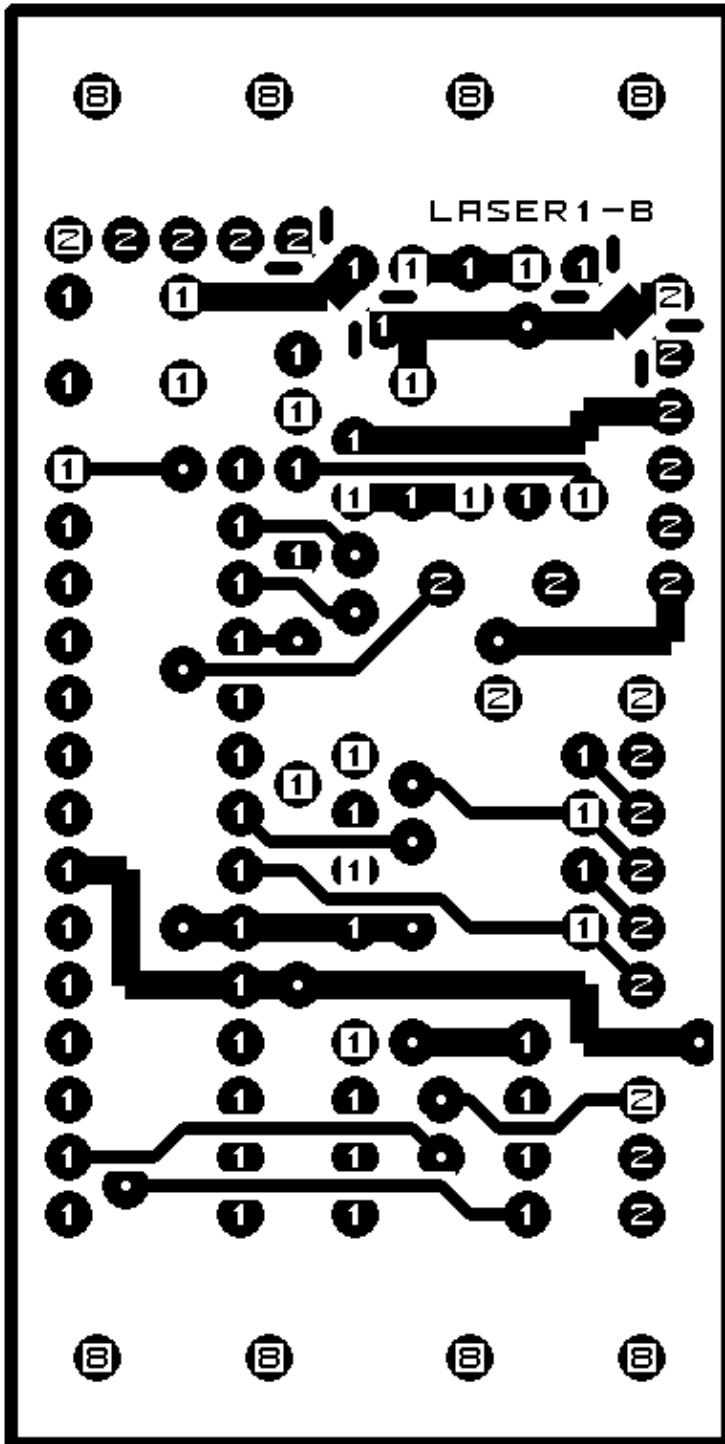
```
# Parts list for Laser1 RoboBrick (Rev. B)
#
C1: Capacitor100nF - .1uF Tantalum Capacitor [Jameco: 33486]
C2: Capacitor1uF - 1uF Tantalum Capacitor [Jameco: 33662]
C3: Capacitor10pF - 10 pF Ceramic Capacitor [Jameco: 15333]
D1: LEDGreen - Green LED [Jameco: 34606]
N1: Header1x5.RBSlave - 1x5 Male Header [5/40 Jameco: 160881]
N2: Header1x6.Laser1_Head - 1x6 Male Header [6/40 Jameco: 160881]
N3: Header1x3.Laser1_Servo - 1x3 Header Male Header[3/40 Jameco: 160881]
N4: Header1x3.Laser1 - 1x3 Male Header [3/40 Jameco: 160881]
N5: Header1x6.Laser1_Position - 1x6 Male Header [6/40 Jameco: 160881]
Q1: PN2222.EBC - NPN Transistor [Jameco: 28628]
R1: Resistor330 - 330 Ohm 1/4 Watt Resistor [Jameco: 30867]
R2: Resistor220 - 220 Ohm 1/4 Watt Resistor [Jameco: 30470]
R3: Resistor1K - 1K Ohm 1/4 Watt Resistor [Jameco: 29663]
R4: ResistorTrimPot100K.Laser1 - 100K Ohm Potentiometer [Jameco: 95484]
R6-8: Resistor220 - 220 Ohm 1/4 Watt Resistor [Jameco: 30470]
R9-10: Resistor10K - 10K Ohm 1/4 Watt Resistor [Jameco: 29911]
U1: PIC16F876.Laser1 - Microchip PIC16F876 [Digkey: PIC16F876-20/P-ND]
U3: Oscillator20MHzHalf - 20MHz Oscillator[Digkey: X220-ND]
VR1: LM317LZ - Adjustable Positive Voltage Regulator [Jameco: 23552]
```

## B. Appendix B: Artwork Layer





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



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

