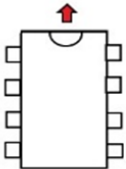
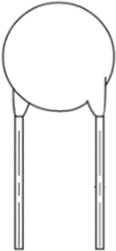

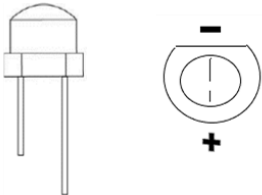
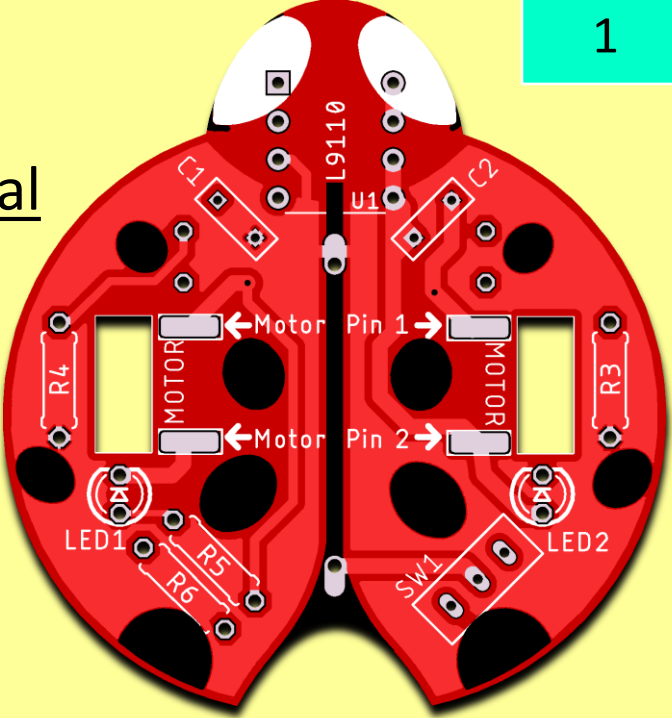


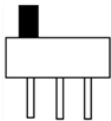


Label	Description	Orientation
U1	Motor Driver IC-8 pin chip used to drive the motors clockwise and counter-clockwise based on CW and CCW input signal	 Indent marking must face upwards towards bug eyes
C1,C2	Ceramic Capacitor- 473 value (47nF)- Filters out voltage ripples and spikes by storing and releasing energy quickly that was collected from coin cell	 none
Motor	Vibration Motor - DC Motor that swings a hidden counter weight CW or CCW depending on voltage polarity.	 See Page 5 for instructions
LED1, LED2	Red LED - Two prongs cathode (-) and anode (+)	 Flat edge of LED pointing up


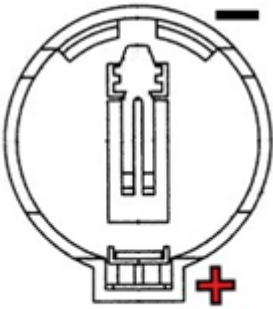
Top Side Parts List & Visual

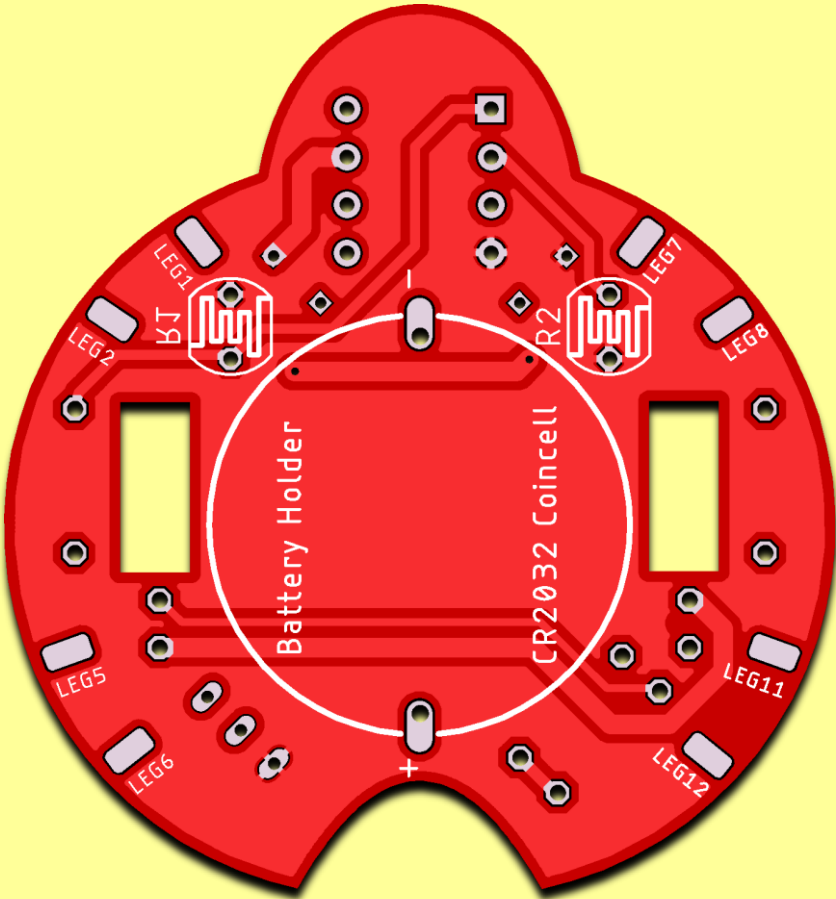
Description



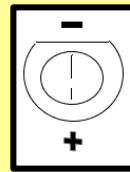
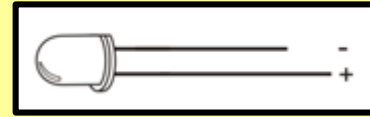
Label	Description	Orientation
R3, R4	10K Ohms- set the brightness threshold to activate the motors	10 k Ω \pm 1% (F)  none
R5, R6	200 Ohms - limits current to the red LED's	200 Ω \pm 1% (F)  none
SW1	3-Pin switch - turns bugbot off/on	 none

BOTTOM SIDE Parts listing and label for placement on circuit board

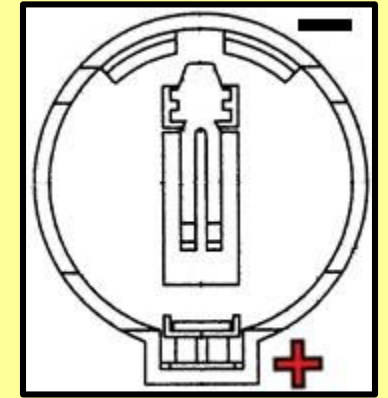
Label	Description	Orientation
R1, R2	LDR - Light dependant resistor	 None
Battery Holder	Compatible with CR2032 coin cell batteries	



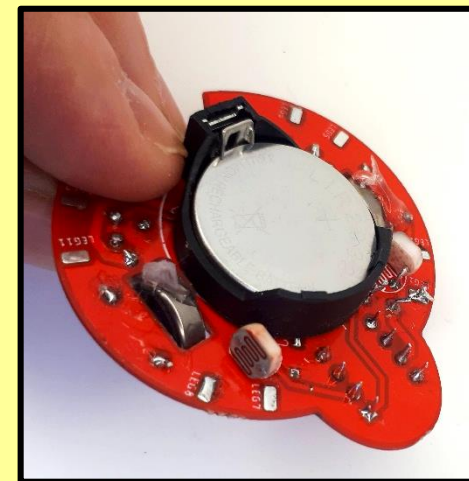
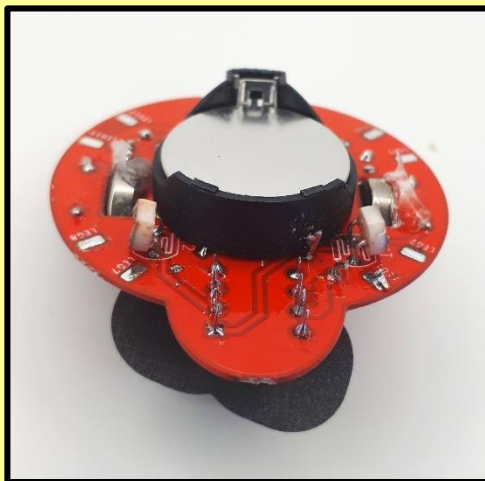
4. The red LEDs have polarity. The long leg is the positive, and short leg is negative. These straw-hat LEDs have a flat side and a round side. Make sure the flat side (-) is pointing up as you place it into the board. Use the images to the right as a visual reference.




5. Soldering components on the top side should be done before the back side. Once the top side is completely soldered and wires trimmed, begin the back side with the battery holder. The battery holder has plus and minus orientation. make sure the polarity matches the markings on the circuit board. Next, solder on the top side. Trim wires when done.



6. On the back side, leave some extra length for the LDRs to sit on edge (90°) as shown in the images below. Testing indicates that this allows the LDRs to function more effectively in this orientation.




7. Use this resistor color chart to calculate resistor value. 200 ohm resistance is calculated by looking each band up on the table from left to right. The first three bands create our digits: red band (2), black band (0), black band (0) and black band 1x which creates the value 200 multiplied by the multiplier 1x to give us our final value 200Ω with tolerance of 1% (brown band). Try to apply this method to identify resistors R3 and R4.



4-Band-Code

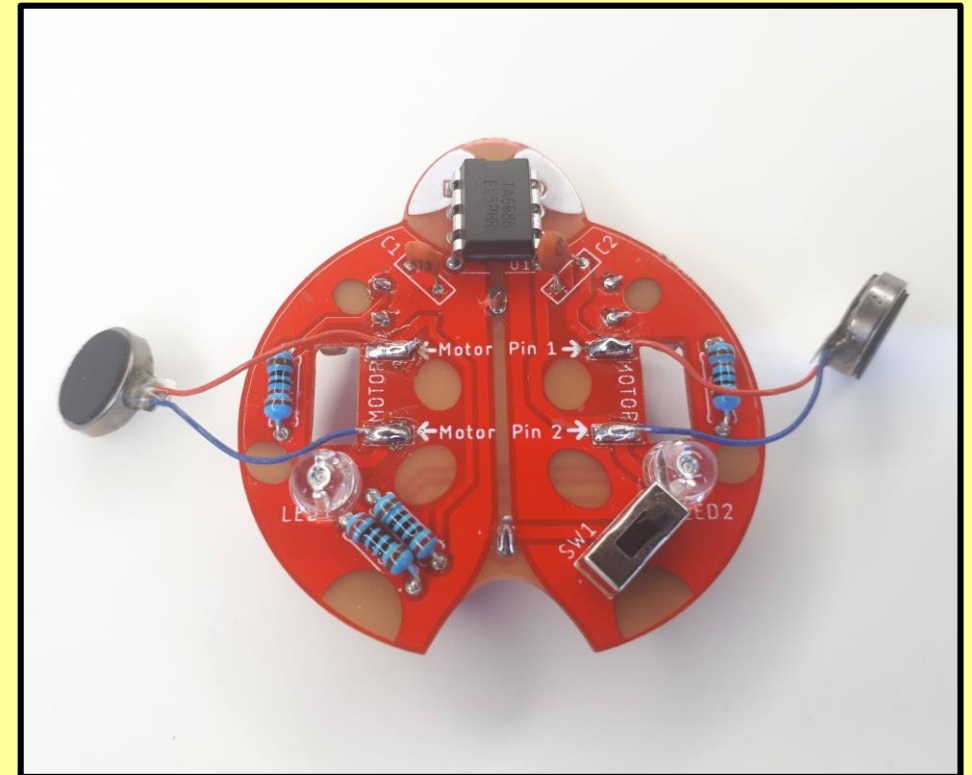
COLOR	1 ST BAND	2 ND BAND	3 RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

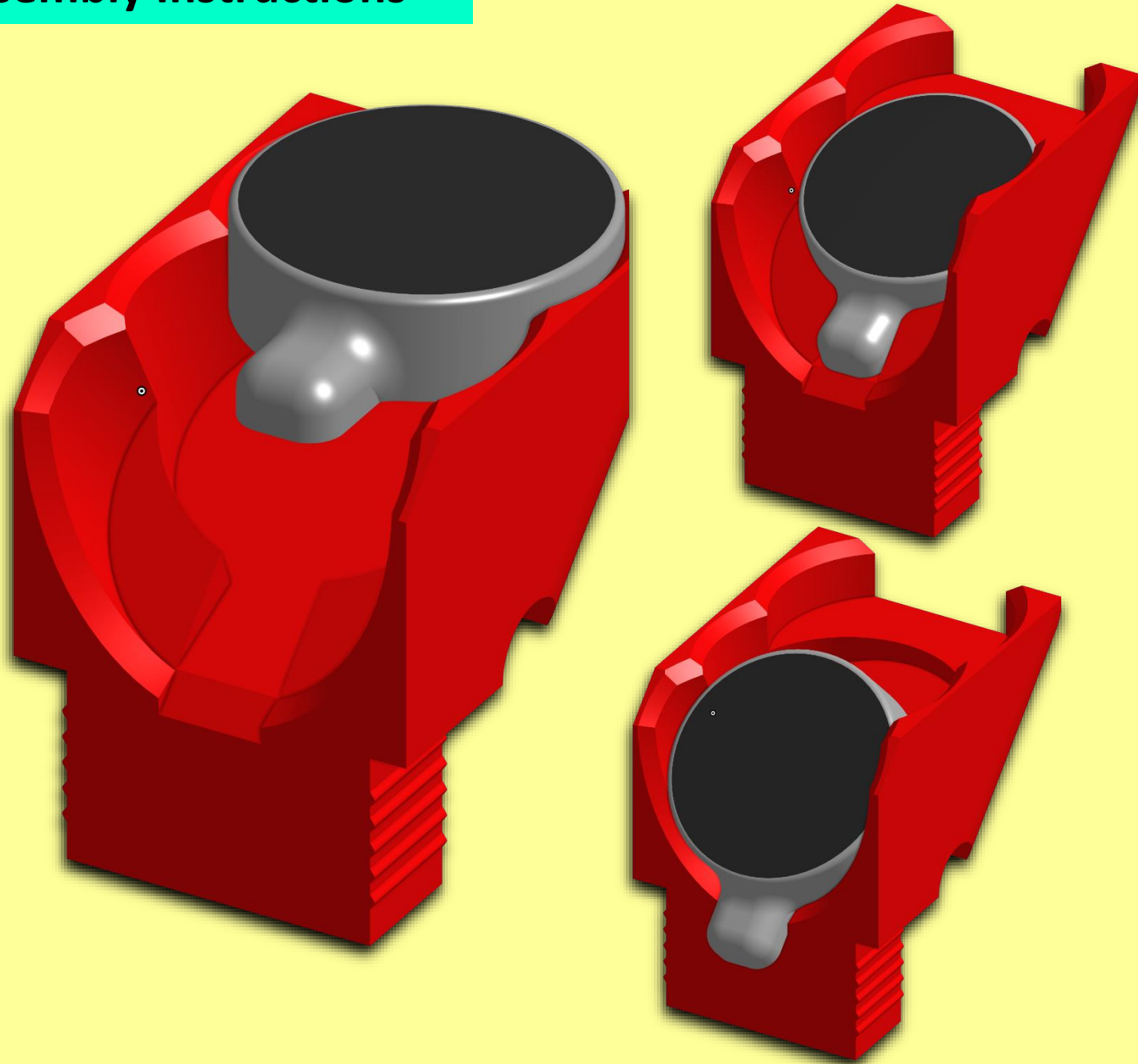


5-Band-Code

1. Follow the tables on pages 1 and 2 to match the components with their footprints on the PCB board. After inserting all components through their holes, do one of the following before turning the PCB over for soldering, to prevent the parts from falling:
 - a. Tack the parts down with tape so that they may lay flat.
 - b. Bend the pins of each part over to keep the part in place.
 - c. Solder one pin and confirm that the part is laying flat before continuing to the rest of its pins.

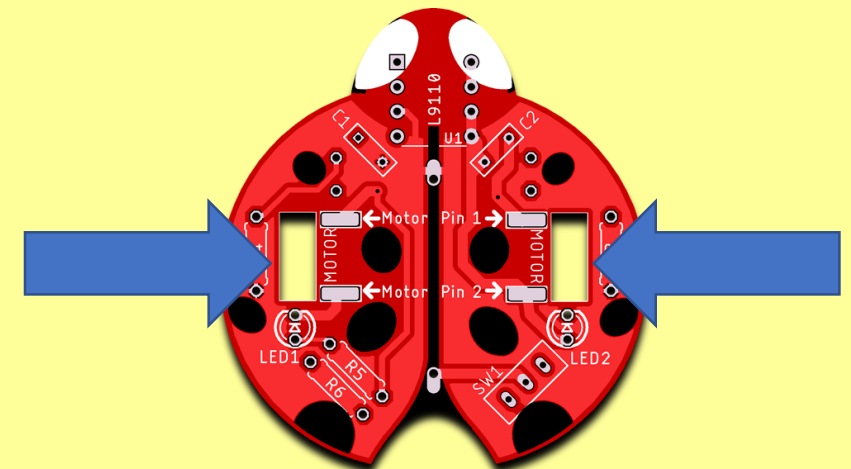
2. The vibration motors each have two colored wires. When soldering these wires to the ladybug bot, match the red wires to the pads next to “←Motor Pin 1→” and do the same with the blue wires for “←Motor Pin 2→”.



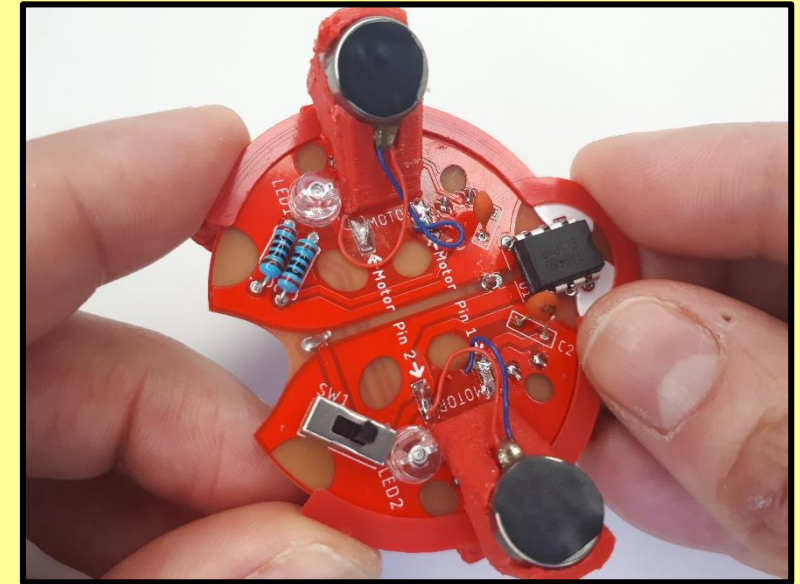
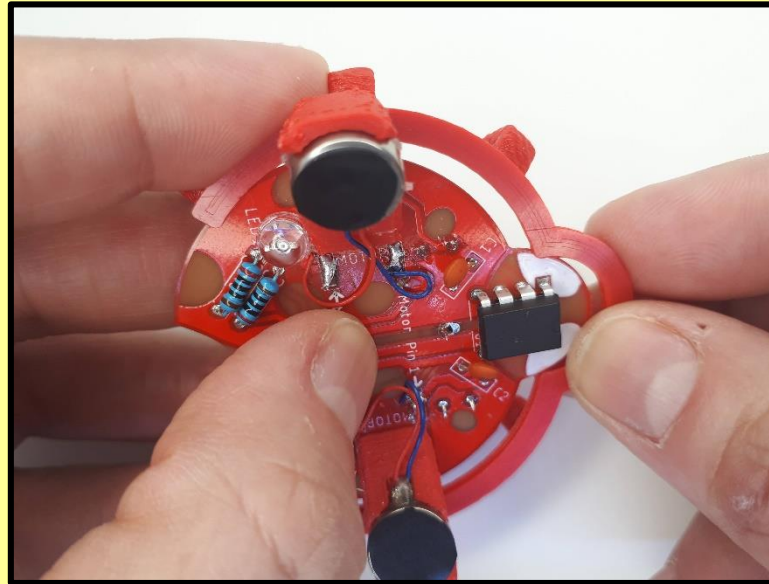
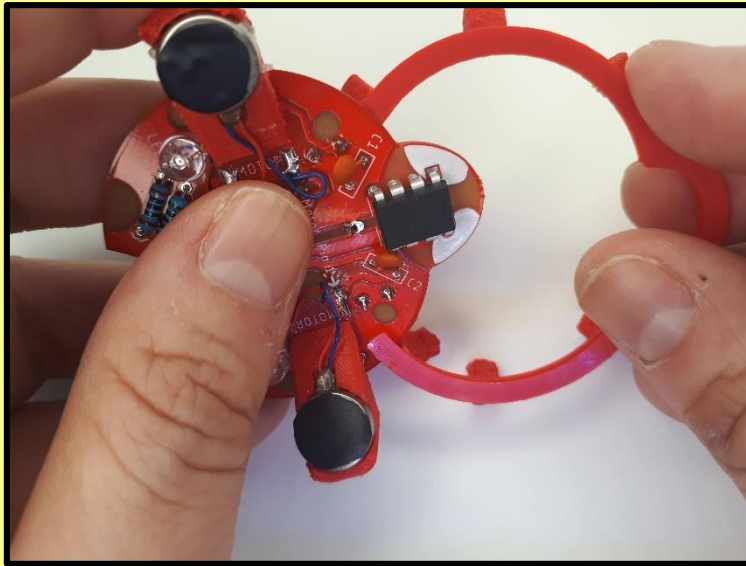


4. Place the two 3D printed parts (left images) into the circuit board by pressing firmly into the board's rectangular cutout as shown in the picture below.

Experiment with the motion of the ladybug bot by placing the motor on the 0° , 22.5° , and 45° inset angles.



7. When you are done soldering all the components, take the bug frame and push the circuit board into the inset gap (Frame can be flexed).

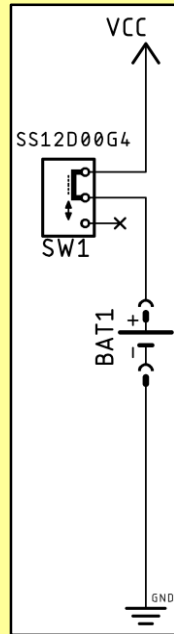


8. Insert a coin cell battery with the plus side up, flip on the switch and grab a flashlight. Point the flashlight on the floor next to the bug in a dark room to make it move around.

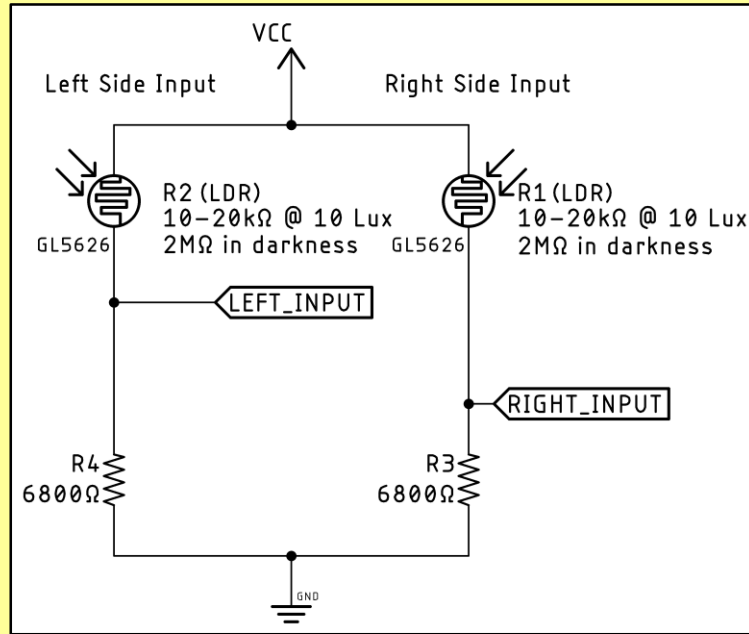
Problem	Possible cause	Solution
Bugbot doesn't work	Cold Solder joint connection, Battery upside-down	Visually inspect the board for soldered joints that do not look shiny or conical in shape and resolder them.
Bugbot turns only one way	Motor wires broken or not soldered, LDRs and resistors not properly soldered, wrong resistors in wrong positions	Inspect the board for possible causes, resolder connections, place components in proper positions.
LEDs are not lighting up and bugbot barely moves	Coincell battery has low voltage	Replace dead coincell with a new CR2032.
LEDs are still not lighting up	Wrong resistor value being used	Check the color code of the resistor and replace with proper 200Ω value.
Both LEDs are lighting up together	Orientation of one LED is wrong	Desolder LED and reverse its orientation.
One LED is still lighting up, but dimly	Check if Capacitor C2 is properly soldered	Resolder C2. If the issue remains, replace it with a larger value ceramic capacitor. Some motors will produce more voltage spikes (electrical noise) than others.
I broke a part and don't have a replacement		Contact us and we'll give you the part number and name so you can source it in your local area.

CIRCUIT DIAGRAM

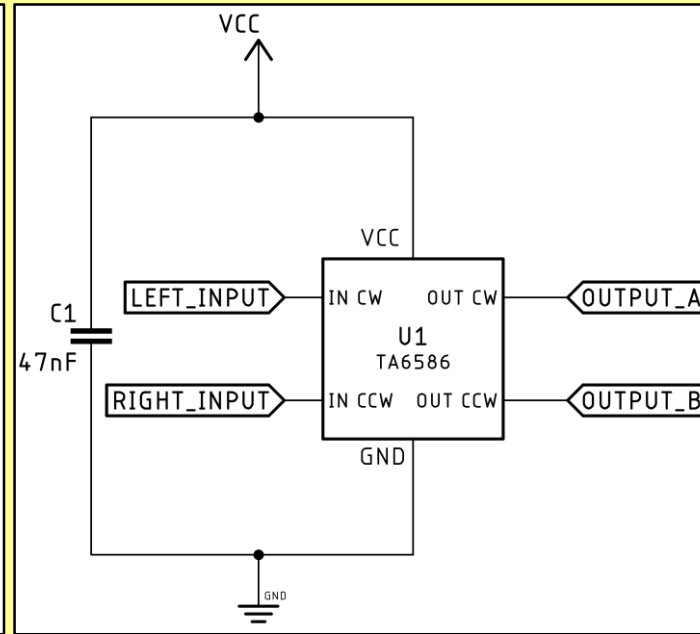
Power



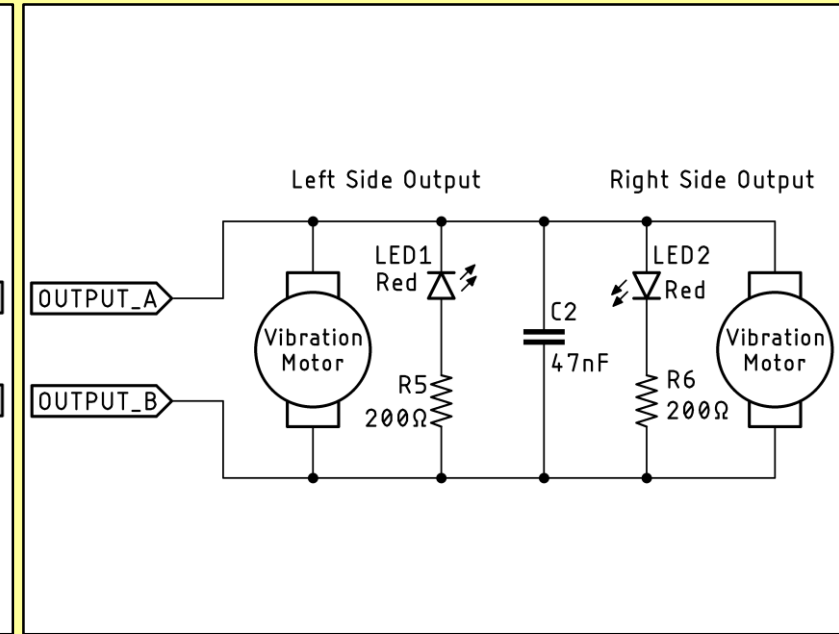
Light Sensing



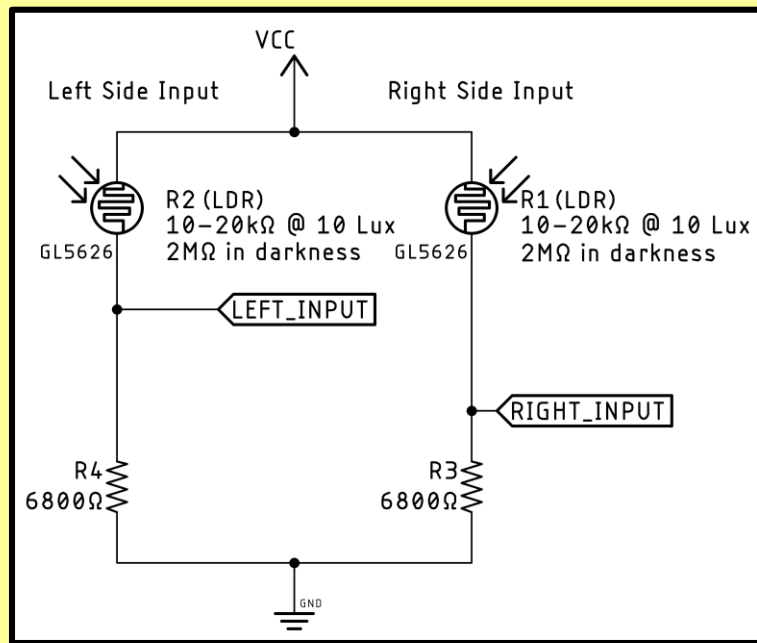
Control



Vibration Motors and LED Indication



Light Sensing



The light sensing circuit operates through two separate voltage dividers (a circuit that steps down a voltage based on the ratio of its resistances). Assuming $V_{CC} = 2.5V$ under load, and a minimum Input voltage threshold = 2.2V for the control IC's two inputs is needed, the LDR's threshold resistance can be found using the equation:

$$R_2 = R_4 \left(\frac{V_{CC}}{V_{Left_Input}} - 1 \right)$$

It can be seen from the equation above that in order to generate a strong enough signal to activate the ladybug bot, R2 must have a resistance of _____Ω. However, when $V_{CC} = 3V$, R2 must be _____Ω.

This means that as the coincell battery is discharged, the bugbot's light sensing circuitry will gradually become _____ sensitive, and its LDR will require _____ light to activate the ladybug bot.

R2 = 927.27 ; R2 = 2,472.72 ; less ; more

A “truth table” is a mathematical description showing which combination of inputs will produce a set of outputs. For our Ladybug bot, we will use F to describe a False/low voltage signal (<0.5V) and T to describe a True/high voltage signal (>2V)

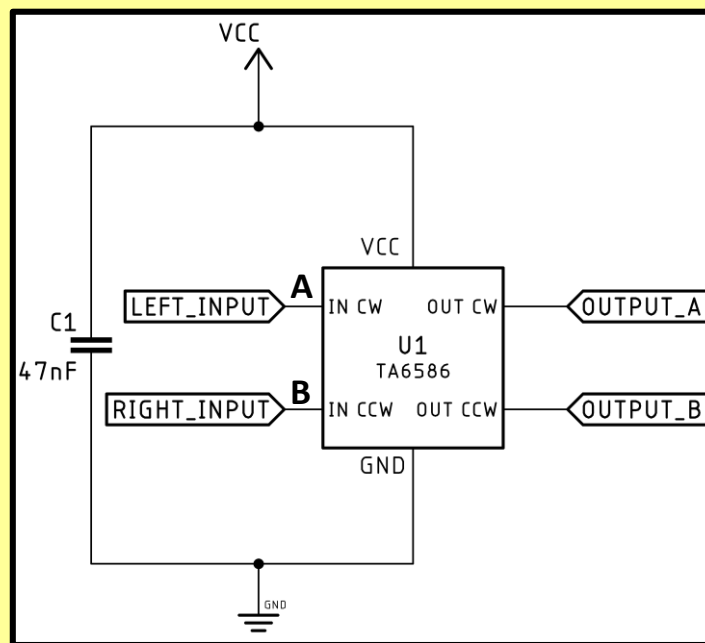
Ladybug Bot Truth Table using TA6586 IC

Left Input	Right Input	Output A	Output B	Motion
F	F	NC	NC	Stop
T	F	VCC	GND	CW
F	T	GND	VCC	CCW
T	T	GND	GND	Stop

Table Assumes motor wiring and orientation is as directed in this manual

- **F** – False/Low – (<0.5V)
- **T** – True/High – (>2V)
- **NC** – No Connection – Open
- **VCC** – V+ Supply Voltage
- **GND** – V- Supply Voltage

Control



A logic gate is a term used in digital logic to describe how two inputs will be compared to produce an output. “XOR” stands for “Exclusive OR”, meaning that one or the other input may be TRUE to produce a TRUE signal at the output, but not both.

XOR Logic Gate Truth Table

Input		Output
A	B	A XOR B
F	F	F
F	T	T
T	F	T
T	T	F

Compare the above truth table with the OR logic gate below to consider the advantages and disadvantages of this system.

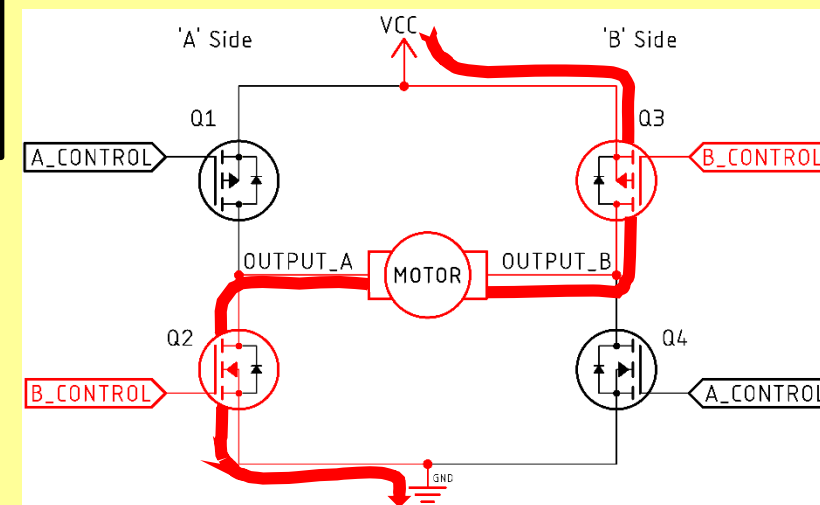
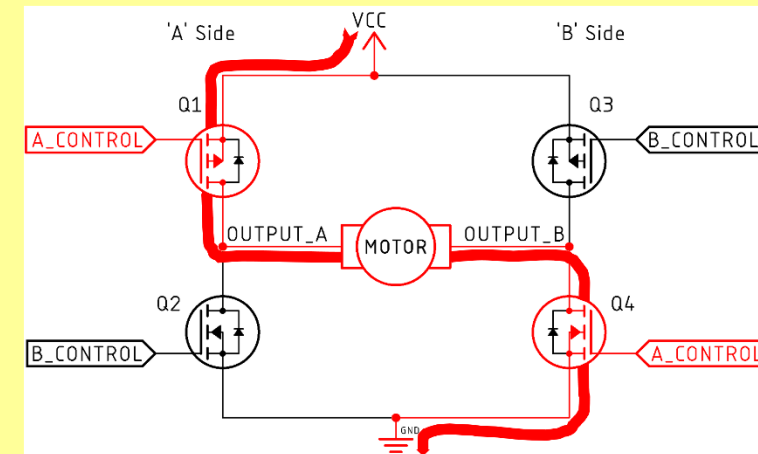
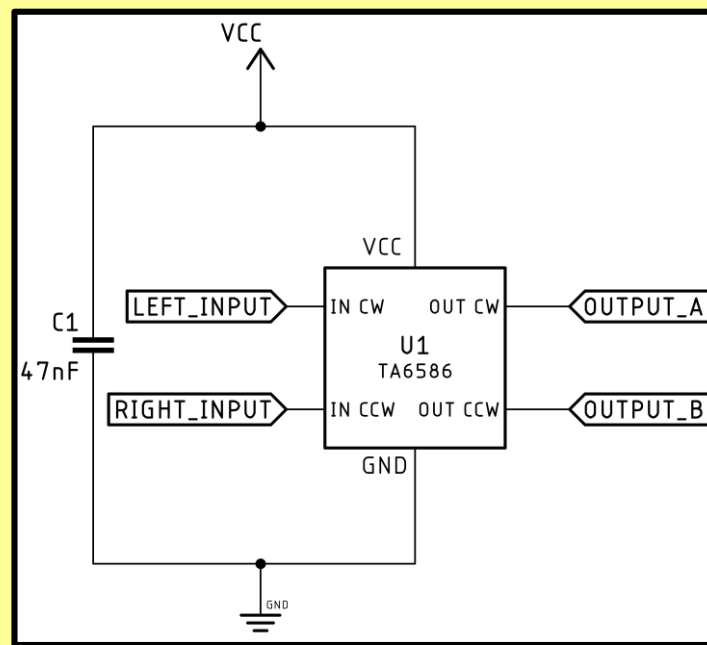
OR Logic Gate Truth Table

Input		Output
A	B	A OR B
F	F	F
F	T	T
T	F	T
T	T	T

The Vibration Motors are controlled by the TA6586 motor driver IC. The TA6586 first reads the voltage of a light-sensitive resistor divider, then uses the state of its two inputs in an XOR digital logic gate to determine the polarity of DC voltage that should be sent to its two outputs, Output A and Output B, of the Ladybug Bot circuit.

The ability to reverse the polarity of the motors is achieved by a circuit configuration inside the TA6586 called an “H-Bridge”. Depicted below, this H-bridge contains four transistors that act as switches to connect VCC and GND to either of the outputs. This feature allows one motor to perform both CW and CCW movements on a bugbot.

Control



Vibration motors rotate a small counterweight to create forces that translates into displacement.

This displacement creates vibration in materials when the motor is attached to their surface.

The strength of the vibration produced by the motor is affected by the **mass** of the counterweight, the **distance** between the counterweight and the center of the motor shaft, and the **speed** of rotation. In electric motors, this is proportional to the **voltage** applied to its terminals, and the resulting **current** that flows through it.

A bug bot moves by repeatedly lifting itself into the air and pivoting from what should be chaotic vibrations. This results in something that we can call useful motion – something that produces linear or rotational displacement.

By placing the motors on different angles (0°, 22.5°, 45°) in the 3D printed motor holder, we force the counterweight to spin on a new axis, which will change the proportion of centrifugal forces that contribute towards lift and forward displacement. The 3D printed legs help the ladybug bot move with as little resistance as possible. 3D printing bugbot legs using PLA plastic allows the frame to be strong and flexible, thereby keeping its shape. This is important because the frame will keep the bug bot leveled to the ground, making the ladybug bot's behavior predictable.

To learn more about how vibration motors work please visit precision motors:

<https://www.precisionmicrodrives.com/vibration-motors/>