University of Central Florida

Department of Electrical and Computer Engineering
Senior Design EEL 4914

Advanced BreadBoard
Group 20

Research Paper

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1. Description of Project

1.1 Introduction

The breadboard is an engineering tool that allows the building of a temporary circuit without the use of solder. Without solder, the components on the circuit can be easily assembled and reassembled. The breadboard typically consists of a plastic chassis and lines of metal strips to connect the nodes. Circuits built on breadboards are for demos rather than final product. The simple design of the breadboard makes it so that it serves only one function to its user, but this simplicity allows it to be improved upon.
The Advance Bread idea is to redesign the breadboard so that it has advanced features to assist the user in creating a successful circuit.

1.2 Project Motivation and Explanation

The idea for the project came from the team's time in the Linear Circuits Labs. The correct use of the breadboard was integral to success in the laboratory. Understanding how to use the breadboard was straightforward, but applying it in practice proved to be more challenging than expected. Two major challenges of using the breadboard were translating the schematic to a physical board and debugging for components placed incorrectly. The first issue comes from connecting the idea of nodes in a schematic and nodes on the breadboard. Many mistakes come from a lack of understanding of nodes, especially when ground is involved. The second issue consumes a significant amount of lab time because open or short circuits can be hard to spot. Labs are designed to give an application to theory, but unfortunately the majority of the time is spent trying to learn how to use the hardware. The Advanced Bread project aims to resolve these issues by adding a graphical user interface (GUI) that will simplify the process of transitioning a schematic to components on a board and identifying open and short circuits.

This new smart-board will include a GUI that a user can use to draw their schematic. An algorithm will then decide how to place that schematic on the breadboard which will also illuminate which nodes to occupy. The breadboard will be made to house leds under all the nodes and connect to a laptop with the software. This breadboard will also have fewer nodes than a typical board to make it easier for the user to learn how to use it. The overall deliverable is a breadboard with LEDs and an open/short circuit test along with a GUI and algorithm for design planning. This project will serve as a stepping-stone for others to develop the breadboard. There is a need for hardware to be more advanced to keep up with the ever-evolving software and advanced algorithms. With the increased accessibility and affordability of microprocessors, at-home projects are on the rise. This project will allow untrained users to become more familiar with circuit designs. The conclusion to this project will show how the breadboard can become an advanced feature in teaching of circuit design and integration.

1.3 Goals and Objectives

This redesigned breadboard aims to reduce the errors that can come from designing and testing on a regular breadboard. Designing on a breadboard can be difficult because components fall out of the nodes and the board itself is not very portable. One of the objectives will include a locking mechanism inside the board that clamps the component into place. This clamp will come from the side and push the wire of the component against a wall to keep it in place. Figure 1 describes the lock and unlocking processes. The left image shows the natural position of the unlock state while the right image shows the locked state. On this clamp, or red bar, the metal strip will be placed and this will span all of the holes of this node as seen in Figure 2. Another point of interest is tackling the problem of placing components in the wrong nodes which can be hard to debug. To solve this, the second objective of this project is to assist users in placing components in the right node as designed in the GUI. The GUI will have a virtual breadboard that will match the physical board. There, the user can pick-and-place virtual components into certain nodes. Once done, the GUI will send this information to the physical breadboard where the nodes that are occupied in the virtual breadboard will light up with an LED as seen in Figure 3. A microcontroller is being considered to control the LEDs in the physical board to make programming and implementation more direct. The number of nodes in a typical breadboard can range but include more than 20 rows with five holes per node. The redesigned breadboard will utilize a handful of nodes with only a few holes in each. This will minimize the number of motors needed and keep the size and complexity of the board more manageable.

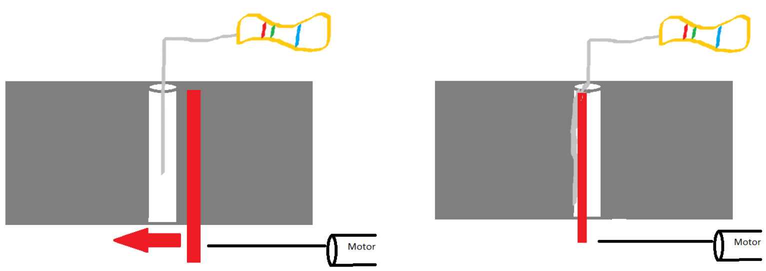


Figure 1. Side-View of Locking and Unlocking Method.

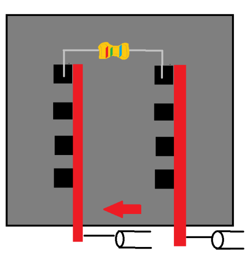


Figure 2. Top-Down View of Locking Mechanism.

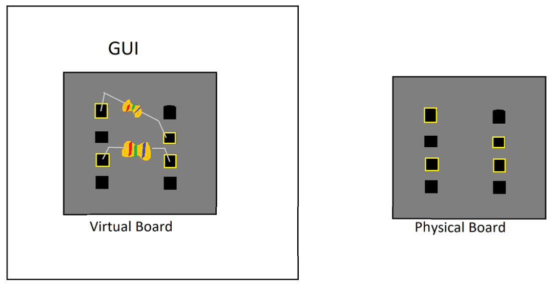


Figure 3. Virtual and Physical Board Relation.

This project is being made for students in labs with little access to more advanced resources. Our design is not made for final product production, rather, as a replacement for the common breadboard in testing environments. The board should be compact and contain few parts to allow for mobilization. The objective of locking/unlocking is to help the student remove the uncertainty that a circuit is incorrect because of a component being knocked off. The second objective of utilizing the GUI with LEDs will help the student learn how to place components in a breadboard with the understanding of holes corresponding to the same nodes.

2. Requirements and Specification

2.1 Specifications

The goal for our hardware design would be to let the PCB control the motors and connect wirelessly to the GUI using WiFi or bluetooth. Since we may not need a long distance communication between the GUI and the Advanced Breadboard, we are more likely to opt with the bluetooth feature instead. This GUI will be able to provide a user interface for a Windows 10 computer through a wireless connection. From there, we will have LED lights to indicate which nodes should be occupied. Finally, a locking mechanism will be used to lock any components connected to the breadboard and keep them in place. We will be demoing Specification 4, 7, and 8. Specification 4 will be presented by having a prototype GUI that connects to the breadboard without any cabling. Specification 7 will show that the motor can move a wall into another wall in 4 seconds or less to mimic locking a component into place. Specification 8 will showcase a demo program where if the demo-GUI activated LED1 then that corresponding LED will light up.

Specifications		
1	**Weight**	**< 10lbs**

2	**Size**	**Fit in two hands**
3	**Computer Interface**	**External Windows Computer**
4	**Computer Connection**	**Wireless Connection**
5	**Power Consumption**	**3.3V - 5.8V**
6	**Runtime**	**< 30 Seconds**
7	**Locking Mechanism Time**	**< 5 Seconds**
8	**Accuracy**	**80%**
9	**Wireless Connection**	**Up to 5 ft**
10	**Cost**	**< $200**

2.2 Requirements

This section will focus on the requirements that have been setup for this project. These requirements will be used as goals that need to be met when designing the device. Furthermore, this will make the designers understand what the users want and what they need.

General Requirements:

- The device shall be used by one person
- The device shall have a wireless connection with a computer for up to 10 ft
- The device shall lock the components in less than 3 seconds
- The device shall be small enough to be held with 2 hands
- The GUI shall have a user friendly interface that requires no training to use
- The device shall have red LEDs for light indication
- The LEDs shall be bright enough to be seen up to 3 feet away
- The device shall have a button for the locking mechanism
- The device shall be powered by batteries
- The device shall be affordable for an average person

Possible Constraints:

- Power Supply
- Reliability
- Sustainability
- Cost
- Testing Process

- Time

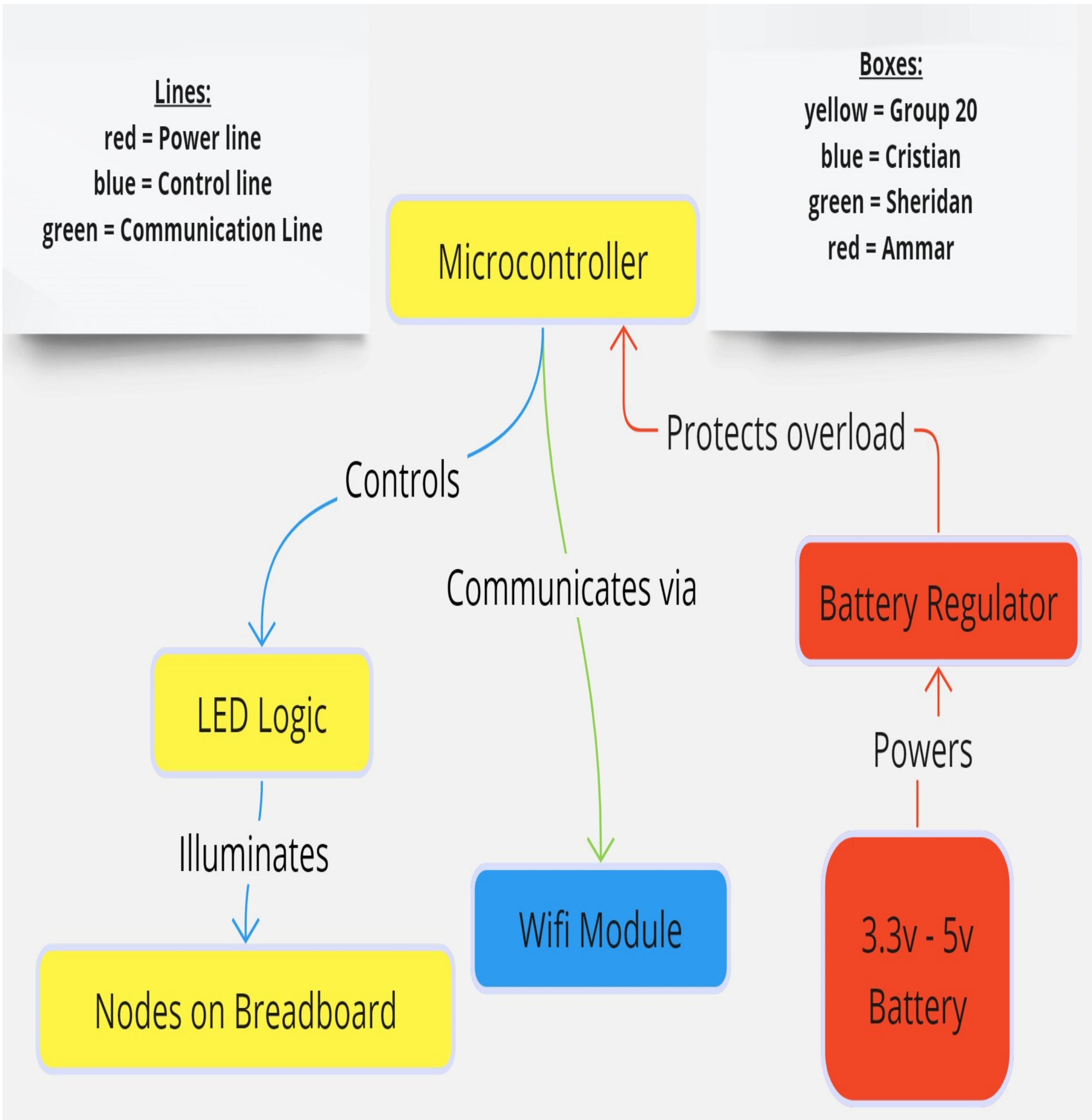
2.3 House of Quality

		Engineering Requirments	Size	Power	Locking Mechanism	LEDs	GUI	Wireless Connection
User Requirements	Cost		▲	○	▲	▲	▼	○
	Size		▲	○	▲	○	▼	○
	Usability		▲	▼	○	○	▲	○
	Speed		▼	○	▲	▼	▲	▲
	Weight		▲	▲	▲	○	▼	▼
	Target for Engineers		Small enough to be held by two hands	Battery powered 3.3V-5.8V	speed < 2 seconds	can be seen up to 3 ft	requires no training	connection up to 10 ft

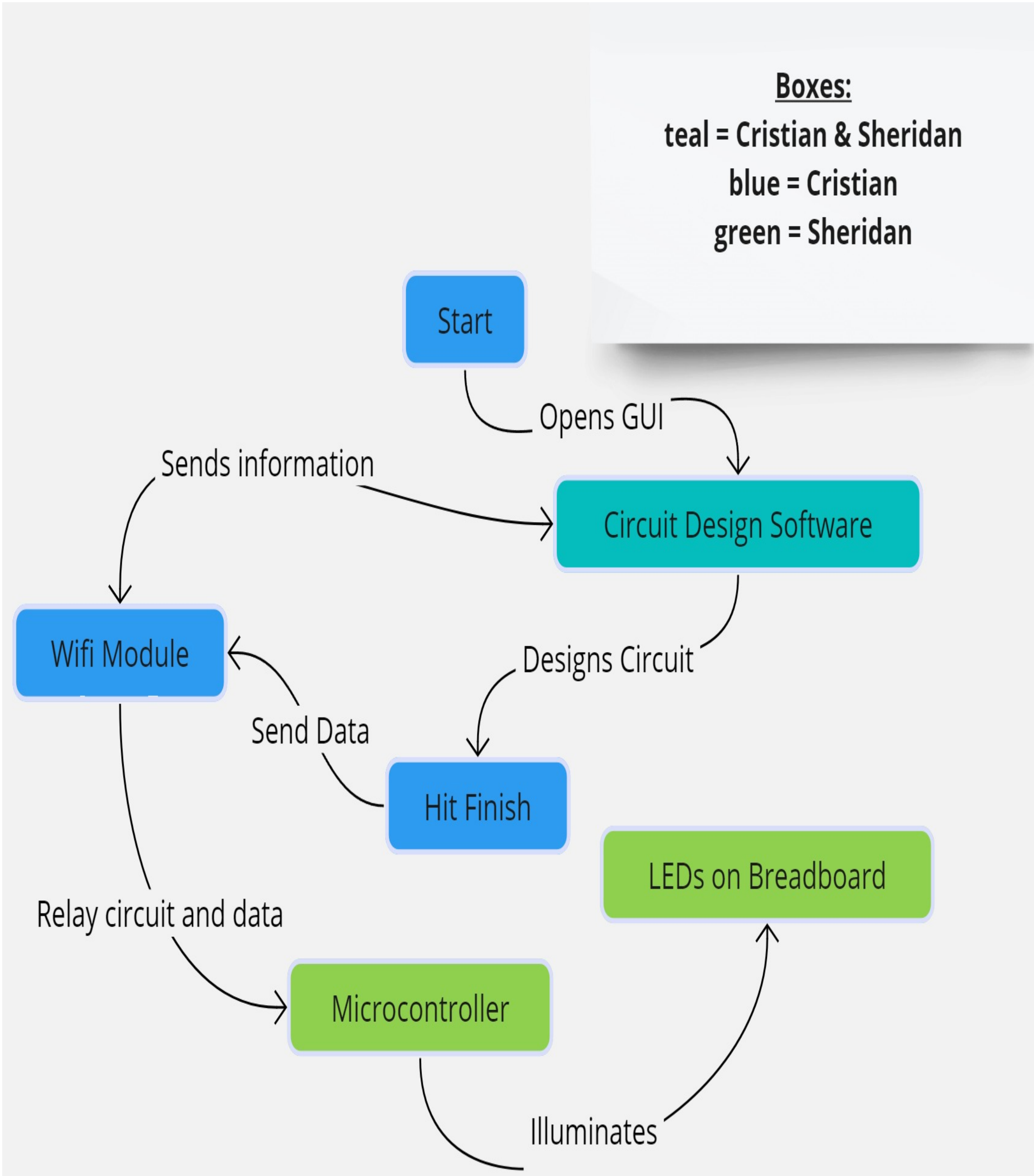
Relationship	
Strong	▲
Moderate	○
Weak	▼

3. Diagrams

3.1 Hardware Flow



3.2 Software Flow



4. Budgeting and Financing

4.1 Funding Overview

The project was designed in a way that allowed the team to financially support it since no sponsors are involved. It is expected to find the majority of the parts fairly cheap as long as lead times remain reasonable. These estimations do not include campus resources and personal resources because inventory has not been taken by the team as of yet. These resources include the Senior Design Lab and the Robotics Club which may have some parts available at cheaper rates. Additionally the team has personal access to 3D printing that can reduce this cost as many parts can be designed and printed. Electronic components like LEDs will depend on the decision of whether or not a microcontroller will be necessary or if it will be incorporated into the pcb. All three members will equally commit to purchasing the following items as needed:

Part	# Units	Estimated Price Per Unit	Total	Estimated Place of Order
Motors	5	$10	$50	Amazon
PLA Plastic	2 rolls	$20	$40	Amazon
Micocontroller	1	$20	$20	Amazon
LEDs	10	$1	$10	Amazon
Custom PCB	1	$80	$80	Texas Instruments

5. Milestones

5.1 SD1 Milestones

Number	Milestone Task	Assigned To	Start Date	End Date	Status
1	Initial Team Meeting	Group 20	8/21/2023	8/23/2023	Completed
2	Project Clarification	Group 20	8/24/2023	8/28/2023	Completed
3	10 Page DC Initial	Group 20	9/1/2023	9/15/2023	Completed
4	Motor & Clamp Research	Sheridan	9/11/2023	10/31/2023	In Progress
5	LED Integration and Wiring	Ammar & Sheridan	10/1/2023	10/31/2023	Pending
6	Software Design	Cristian	9/11/2023	10/31/2023	Initial Designs In Progress

7	60 Page Draft	Group 20	10/20/2023	11/3/2023	Pending
8	Update Website	Group 20	9/15/2023	1/1/2023	Working on Connection
9	Prototype Testing	Group 20	11/21/2023	11/30/2023	Pending
10	90 Page Report	Group 20	11/25/2023	12/5/2023	Pending

5.2 SD2 Milestones

Number	**Milestone Task**	**Assigned To**	**Start Date**	**End Date**	**Status**
1	Review Senior Design 1 Progress	Group 20	1/8/2024	1/12/2024	Pending
2	Complete Project Design/Testing	Group 20	1/15/2024	3/20/2024	Pending
3	Prepare Presentation	Group 20	3/21/2024	4/1/2024	Pending
5	Final Presentation	Group 20	4/1/2024	TBD	Pending