Interactive Breadboard Digital Logic Teaching Aid

Project Proposal

ECE 445 - ECE Senior Design

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Table of Contents

1.0 Introduction

1.1 Purpose

Digital logic is often difficult to learn because of the lack of easy to understand hands-on components to learning. Part of learning digital logic is the difficult learning process involved with breadboard design. This project aims to fill this gap. Creating a large interactive breadboard will allow both students and teachers unfamiliar with digital logic to build and test functional circuits. The Interactive Breadboard is aimed for students ranging from the high-school level to the introductory college level. At the high school level, students will learn digital logic circuits by walking through labs programmed by their teachers. Higher level students can program their own designs and use the Interactive Breadboard as an aide to ensure that their designs are built properly. We hope that by providing this functionality to students the Interactive Breadboard will make learning digital logic a less frustrating and more rewarding experience.

1.2 Objectives

1.2.1 Goals

- Require no extra special equipment, all required materials will be included in the package
- Write a complete “lab manual” to include several labs that can be completed
    - Basic logic gate functionality
    - Creating larger gates from smaller gates
    - Create logic gates with a different kind of logic gate
    - Full adder
    - Multiplexer/demultiplexer
    - Decoder
    - Comparator
    - Flip Flop
- Allow more labs/functionality to be downloaded into board for additional content
    - Create a language spec to allow users to program their own labs

1.2.2 Functions

- Breadboard will have sensors to detect when chips and wires have been inserted and unplugged for error checking
- Microcontroller will use a prober to figure out what type of chip was placed
- Each female socket will be accompanied by an LED for visual indications where chips and wires should be placed
- A 7-segmented display will lab number and current step which corresponds to written lab manual
- Forward and back buttons will allow the user to proceed to the next step in a lab, or return to a previous step
- LEDs will indicate errors in a step, preventing user from continuing until error has been resolved

1.2.3 Benefits

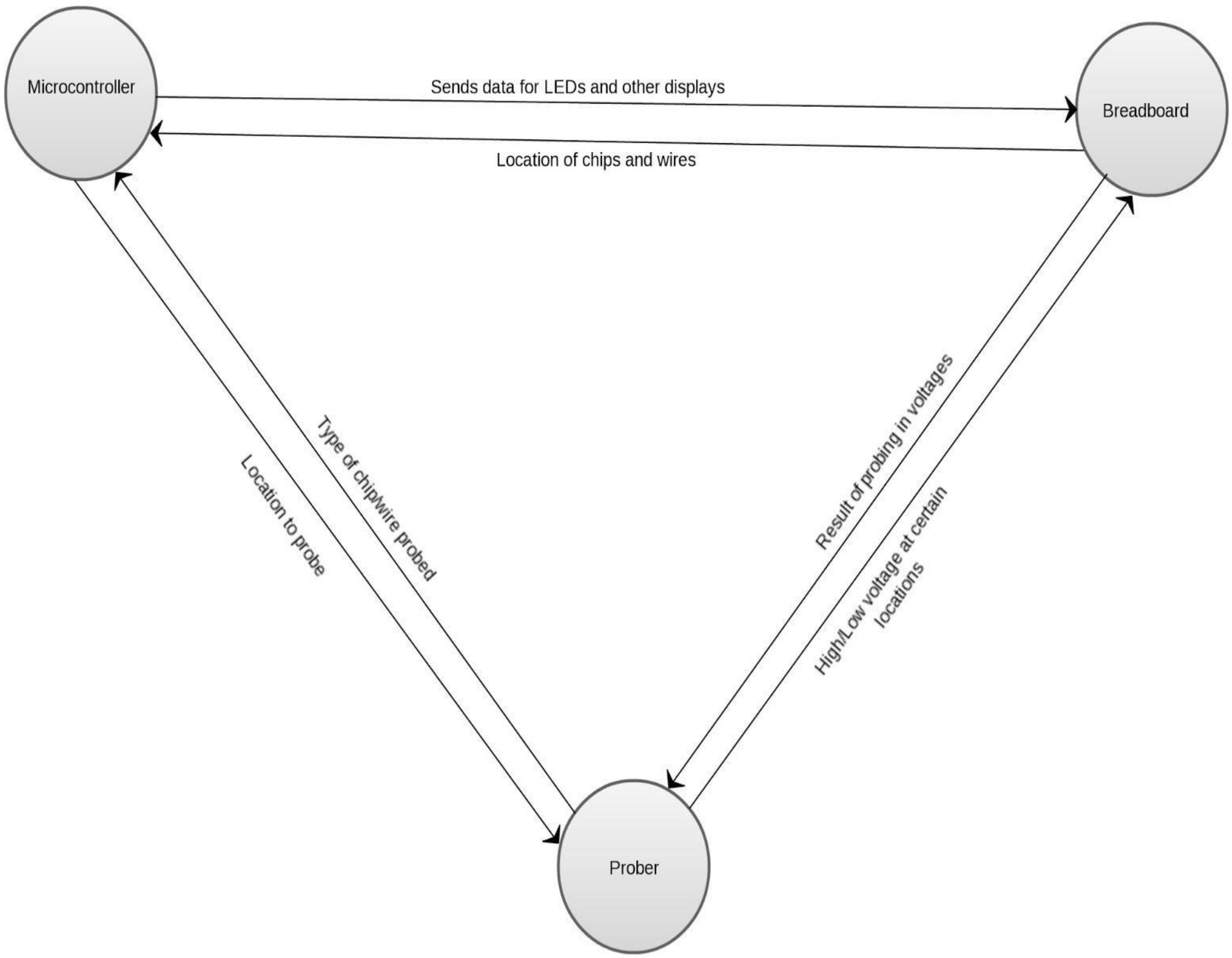
- Students with no to limited knowledge on digital logic will be able to complete labs and gain knowledge on basic digital logic functionality
- Science teachers with no to limited knowledge on digital logic will be able to use this tool as a teaching aide
- Students with intermediate knowledge on digital logic will be able to use the Interactive Breadboard to ensure their designs are being built correctly
- Visual cues to user to ensure labs are being done correctly through every step

1.2.4 Features

- Runs off standard 120v 60Hz outlet
- Enlarged breadboard with enlarged chip enclosures for easy usability
- Visual representation of logic gates printed directly on enlarged chip enclosures
- Uses a grid of standard female banana jacks
- Lab manual will not only give explicit instructions, but supplement with relevant learning material such as truth tables, karnaugh maps, and diagrams
- Programmable labs with its own language specifications

2.0 Design

2.1 Block Diagrams



2.2 Block Descriptions

The top-most level description of the Interactive Breadboard can be split into three different modules: the microcontroller, the prober, and the breadboard.

2.2.1 The Microcontroller

This module holds all of the data and logic for the entire project. This includes what chips have been placed, where they have been placed, and what kind of chips they are. It also holds the data for the different steps of a lab and what step the user is currently on.

The microcontroller can determine whether or not a step is finished properly. This data is then sent to the breadboard to display to the user. Finally the microcontroller also has a list of logical checks to send to the probe to execute upon the insertion of a chip. The microcontroller receives the chip data from the prober and stores it into its data structures.

2.2.2 The Prober

The prober module is used to determine what exactly has been placed on the breadboard. This is accomplished by electrically probing certain locations of the breadboard with specific voltages as determined by the microcontroller. After probing different voltages to the breadboard the prober receives different voltages back. The prober sends these resulting voltages to the microcontroller to determine what chip has been placed.

2.2.3 The Breadboard

This module is the physical display component of the project. It holds the actual breadboard for users to place chips on as well as LEDs as displays to tell the users whether or not their lab is working properly. When chips are placed the breadboard sends that information to the microcontroller. Different spots on the breadboard are probed by the prober.

3.0 Requirements and Verification

3.1 Requirements

3.1.1 Microcontroller

The controller must have the proper algorithms and data structures stored so that the controller can guide the user through the lab properly. The controller must send some sort of readable signal to both the breadboard and the probe so that the other parts of the system knows how to function. It must have a certain amount of memory to store the information of how the chips and wires on the breadboard are connected. The microcontroller must additionally be able to parse an input language that specifies how the different steps of a lab. The controller must be able to receive input voltages from the probe and logically determine what chip was detected.

3.1.2 Breadboard

Breadboard must have a certain amount of LEDs: LEDs to signal the general area which the chip can be placed and LEDs to signal whether or not to continue to the next step and to signal whether the chip has been detected. Additionally it must also have a 7-segment display to show which step the user is on. The breadboard must have the proper interconnects between LEDs, microcontroller and the probe. The breadboard must be able to tell the microcontroller where and when a chip has been placed. The breadboard must be able to allow the prober to send input voltages and then be able to send output voltages back to the prober at any given grid in the breadboard.

3.1.3 Probe

The probe must include some sort of physical detection mechanism with a sensor, be able to send a readable signal concerning the location of where the chip is and be able to send the correct voltage to the required location, and receive the output signal to be sent to the microcontroller for checking.

3.2 Verification

3.2.1 Microcontroller Verification

Microcontroller must be able to control all of the LEDs that are connected to the breadboard, i.e. there must to be a way to validate proper signalling by the microcontroller as well as having the proper area on the breadboard light up. It also must be able to step through each lab correctly and detect the proper chips and wires that are connected, testing will be done on a sample lab where pre-programmed instructions on the microcontroller will be carried out, to see if proper chip detection as well as proper instructions are showing up on the seven segment display. Microcontroller must also be able to send the proper signal to probe such that the intended socket receives the proper voltage, testing will be done by measuring the voltage in the socket using a digital multimeter.

3.2.2 Breadboard Verification

The breadboard must have proper interconnects to the LEDs, probes and Microcontroller and sockets. Testing will be done by sending both current and electrical signals through the interconnects and seeing if the correct signal appears on the other end. The board must also be detected for additional unintended signals that appear on wires they shouldn’t be appearing on, which will be tested by using a digital multimeter as well.

3.2.3 Probing Verification

Physical sensors must detect the location of the chip and properly send the signal to the microcontroller, testing will be done by a DMM. Probe must send proper voltage (~5V) to correct socket on breadboard and also be able to detect at the proper socket location the response of the chip tested. Fidelity of the probing will be done by placing a sample gate on the proper location and seeing if the output of the gate matches with a truth table and seeing if it is the correct gate advertised.

3.3 Tolerance Analysis

The tolerance analysis will be the percentage of chips that are correctly detected out of a collection of one hundred chips. Chip detection fidelity is incredibly important for this project as it directs the microcontroller to move on to the next step of the lab, faulty chip detection will ultimately determine whether the user has correctly built the design as well as whether they completed the lab correctly.

4.0 Cost and Schedule

4.1 Cost Analysis

4.1.1 Labor

Name	**Hourly Rate**	**Project Hours**	**Total** (Rate x hours x 2.5)
Harrison Hilgers	\$35.00	150	\$13,125
Simon Huynh	\$35.00	150	\$13,125
Norman Lee	\$35.00	150	\$13,125
Outsourced Machining Labor	\$35.00	10	\$350.00
Total		450	\$39,725

4.1.2 Parts

- **Bold** items denote non-standard lab parts which require ordering (Out of pocket)

Item	Part Number	Retailer	Quantity	Unit Cost ($)	Total ($)
Female Banana Sockets	160871846833 (Ebay)	Ebay (cao19961023)	**500**	**.092**	**$45.99**
Male Banana Plugs	160928712459 (Ebay)	Ebay (cao19961023)	**100**	**.380**	**$37.98**
LEDs	290809724031 (Ebay)	Ebay (gc_supermarket)	**500**	**.0136**	**$6.80**
220 ohm Resistors	110938980221 (Ebay)	Ebay (elanil)	**500**	**.00858**	**$4.29**
2 Digit 7-segment Display	260962277479 (Ebay)	Ebay (onsitecomponents)	**2**	**.55**	**$1.10**
Microcontroller			1		**$50**
Sheet Metal		ECE Machine Shop	**~5 sqr feet**	**$10**	**$50**
Paint	-	Local Retailer	-	-	$10
Quad 2-input NAND Gate	360533538299 (Ebay)	Ebay (maj-electronics)	2	.495	$.99
Quad 2-input NOR Gate	360529236936 (Ebay)	Ebay (maj-electronics)	2	.495	$.99
Quad 2-input OR Gate	321036033442 (Ebay)	Ebay (maj-electronics)	2	.495	$.99
Quad 2-input AND Gate	321032828773 (Ebay)	Ebay (maj-electronics)	2	.495	$.99
NOT Gate	320918038590 (Ebay)	Ebay (maj-electronics)	2	.495	$.99
Quad 2-input XOR Gate	321037067777 (Ebay)	Ebay (maj-electronics)	2	.495	$1.29
Dual 4-input NOR	360529236936 (Ebay)	Ebay (maj-electronics)	2	.495	$.99

Op Amp	221052703545 (Ebay)	Ebay (maj-electronics)	2	.495	$.99
Chip Sockets	320963095559 (Ebay)	Ebay (maj-electronics)	15	.198	$2.97
24 Gauge Wire	H03429-10R (HobbyEngineering)	HobbyEngineering.com	100’	-	$8.49
DC Power Supply	B0002MQGI6	Amazon.com	2	26.69	$53.38
~100 pages printing		EWS	100	.04	$4
Out of Pocket Total					**$206.16**
Total					**$283.22**

4.1.3 Grand Total

	Total
Labor	$39,725
Parts	$283.22
Total	$40,008.22

4.2 Schedule

Week of	**Person - Task**
February 3	Harrison - Finish and turn in project proposal Simon - Learn microcontroller code, begin to code microcontroller logic Harrison - Order parts from Ebay
February 10	Norman - Design chip/wire recognition algorithm (prober) Harrison - Contact professors and potential sponsors
February 17	Harrison - Sketch up enclosures and discuss with machine shop Norman - Design physical prober to interface with both the microcontroller and breadboard
February 24	Harrison - Design and submit Eagle sketches for chip mounts Simon - Finalize code and logic for controller module Norman - Design review
March 3	Harrison - Construct physical enclosures & board: mount banana plug jacks & LEDs Simon - Design user inputtable code for microcontroller
March 10	Harrison, Simon, & Norman - Individual Progress Reports
March 17 Spring Break	
March 24	Harrison - Write lab manual for labs Simon - Finalize and test user inputtable lab language Simon - Prepare mockup demo Norman - Prepare Mock-up presentation
March 31	Harrison - Finish writing lab manual Norman - Safety testing
April 7	Simon - Prepare demo Harrison - Ensure written labs completely function
April 14	Norman - Finalize project, ensure functionality
April 21	Harrison - Prepare presentation Norman - Prepare final paper Simon - Demo
April 28	Harrison - Presentation Norman - Final Paper Simon - Ensure lab supplies are returned