Jeopardy Engineering

Ryan Boles

Christine Bryant

Daniel Benedict

Brian Misutka

Andrew Yoder

December 5, 2008

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Introduction

A quiz game was designed for use as an introductory engineering activity for high school students. This quiz game design has been titled "Jeopardy Engineering." The intention of this manual is to provide a detailed description of the design and all of the components, as well as the rules for the use of the game. This activity will give high school students the opportunity to test and learn some engineering concepts hands-on by building a circuit they will use to play a trivia game. By seeing an application of these engineering concepts, the activity will help provide the students with a more concrete and accurate idea of what the engineering profession is about. By connecting science and math concepts the students are currently learning in classes to solving problems the students are interested in, the activity is expected to increase excitement about the field, as well as clarify any misconceptions about the purpose of the profession. In order to implement this activity in a high school classroom, it was designed to be difficult enough to illustrate interesting concepts, while being simplified enough for high school students to understand and build within an estimated 1.5 hours. In order for the activity to be the most useful in creating interest among students, it was designed to be repeatable. Therefore, all materials used in the design are reusable or easily replenished. By designing the activity to meet these requirements and providing this complete instructional manual, it is hoped the teacher will be able to teach students about the engineering field without the help of the team and incorporate these concepts in the regular curriculum if desired.

Design Motivation

The "Jeopardy Engineering" concept described in this report is intended to address the lack of interest in science, technology, engineering, and math fields among the youth in the United States and to propose a solution. At the present time there is a shortage of engineers across the United States. Due to low interest in the science, math, technology, and engineering fields among the youth, the United States faces a major problem as the baby-boomers reach retirement age. Since our society relies on innovative technology in most areas of everyday life, students skilled in science, technology, engineering, and math are in high demand to fill these positions. Engineering concepts are not typically taught in high school curricula. This causes the youth to have misconceptions about what engineers really do. In order to increase the number of high school students entering college with the drive and passion to become an engineer, the application of engineering in everyday problems must be taught at the high school level. The motivation for this project is to reach out to students before they begin their higher education and expose them to engineering. By giving the students ownership of a project and challenging them, the "Jeopardy Engineering" concept is hoped to spark an interest in engineering, in particular electrical engineering.

Design Overview

The design for the game is based off of the TV show Jeopardy. However, instead of 3 individual players as in the TV show, there can be two or more groups of players with this modified version. The game rules can be modified based upon the judgment of the teacher. The design consists of a circuit that can be built

and used by students to play the game. The circuit design was found online by one of the members and followed, but expanded to include more circuits each on a separate breadboard [1]. The circuit consists of a group of push-button devices that can be used by students to "ring in" to answer a question which automatically triggers an audible buzz from the game buzzer. Once someone rings in, a timer circuit will count down the time allowed to answer the question. A block diagram of the system design is shown below in Figure 1.

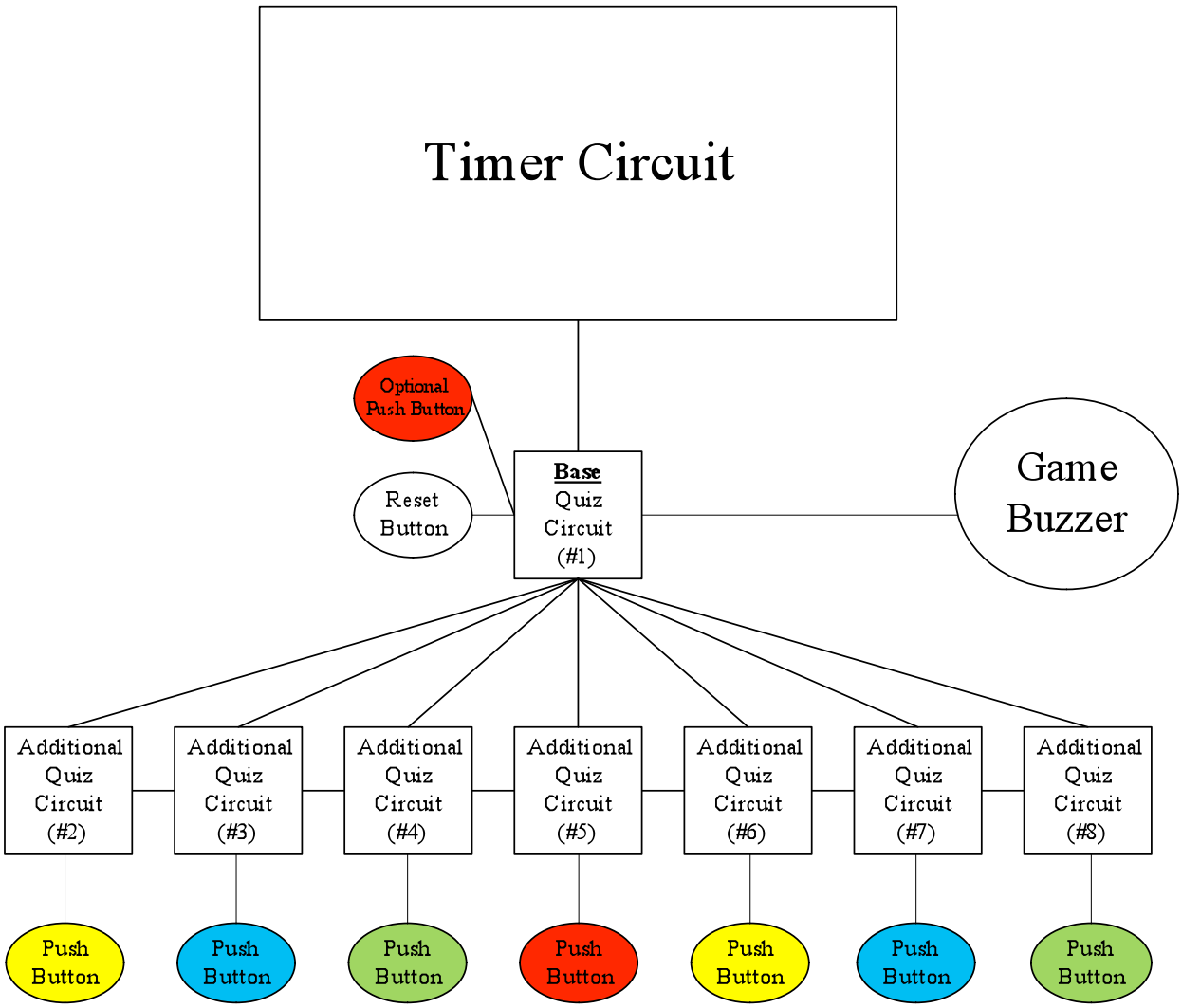


Figure 1: Block Diagram of the System Design

There are two main components of the quiz game. The first part is the base quiz circuit that controls the game. This circuit consists of the main power supply for the system and the game reset button and an audible buzzer. Similar to the base quiz circuit are additional quiz circuits which each consist of a ring in button for the game participants to push to answer a question and an LED that lights up to show they rang in first and may answer the question. The second part of the system is the timer circuit. This is responsible for counting down the amount of time remaining for the first participant that rang in to answer

the question. For example, six seconds has been configured in the timer circuit. The participant who rang in will have six seconds from the point they press the button to answer the question. Corresponding LEDs illuminate each second to indicate how much time they have remaining to answer the question. Once this time has expired, a second buzz will sound to show that their time has expired and the question can be reset for another group to answer. The two components will be discussed in more detail later, as well as how they interface and connect with one another.

The base quiz circuit is a normal quiz circuit with a few more components added onto it in order to function with the timer circuit. The teacher can decide how many additional quiz circuits they would like to add to the system. These additional quiz circuits are all built identically to each other, which makes it easy to accommodate any size class. The integration of additional quiz circuits allows more students to get involved in the circuit building.

Students will not only play the game, but they will also help to build it. The Jeopardy game has two main exercises involved with it. The first exercise is the students building the actual circuits that will be used to play the game. The second exercise is getting time to play with the circuit by using it to answer questions in a Jeopardy-type format. Students will be able to individually build their part of the circuit and connect it to the other circuits that their fellow students have built.

The concept of the game is simple. Once a question is asked the students will race to push their button to answer the question. Once a button is pressed by a student, their corresponding LED will light on their quiz board signifying they were the first to press their push button. Meanwhile all of the other buzzers are disabled from ringing in. Once the game participant pushes the buzzer, the countdown timer will begin with a visual output of the remaining time they have to answer the question. This countdown timer is displayed from the game timer. If they do not answer the question in time, a buzzer will sound. At this point, the game can be reset by the game moderator to allow another participant to ring in to answer the question.

Background Overview

The purpose of this background overview is to provide a general explanation of the concepts and components used in the quiz game design. Since the goal of the design is to expose students to some basic elements of circuit theory, students and teachers are not expected to have a strong knowledge of circuit theory in order to complete this activity. The background information is intended to support the understanding of the circuit design.

Analog Circuit Theory

Generally stated, analog circuits control voltage and current. Analog signals can be expressed using an almost infinite number of states. Analog circuit components are used throughout the design described in this report. When a game participant presses a push button, analog circuit components aid in communicating between the push button and the corresponding quiz circuit. Through the use of analog components, other participants are disabled from ringing in after the first person. These components also help to activate the game buzzer to show that a participant rang in to answer a question. Analog

components help to maintain a common voltage level for the entire circuit to operate safely and effectively.

Digital Logic

Digital logic uses only two possible values for inputs and outputs, "1" and "0", which are defined by high and low voltage levels, respectively. Generally, an output of 1 indicates that a component is on and an output of 0 indicates that a component is off. Digital logic can be utilized to compute simple mathematical operations, such as the timer circuit countdown from 6 seconds to 0 seconds, using Boolean algebra. Boolean algebra uses truth tables to complete mathematical operations between digital logic values (a 1 or a 0). This simple two-state system is used in all digital electronics, from cell phones to computers to remote controls. Many times digital logic components are used in conjunction with analog circuits to achieve a desired operation, which is the case with the design described in this report.

Circuit Components

The circuit components listed are used in the "Jeopardy Engineering" design. There are a few components that require some explanation in order to be used correctly. The information supplied is intended to describe the function of each component.

Breadboards

Breadboards are used to temporarily connect components of a circuit and allow the components to be easily removed and replaced. The use of breadboards allows the system to be built over and over again, without the need to order additional parts. A breadboard allows the circuit components to be temporarily connected. This allows for the kit to be disassembled or altered easily. Unlike the alternative option of soldering the components into place, the components are pushed into holes in the breadboard. An example of an empty breadboard is shown below in Figure 2.

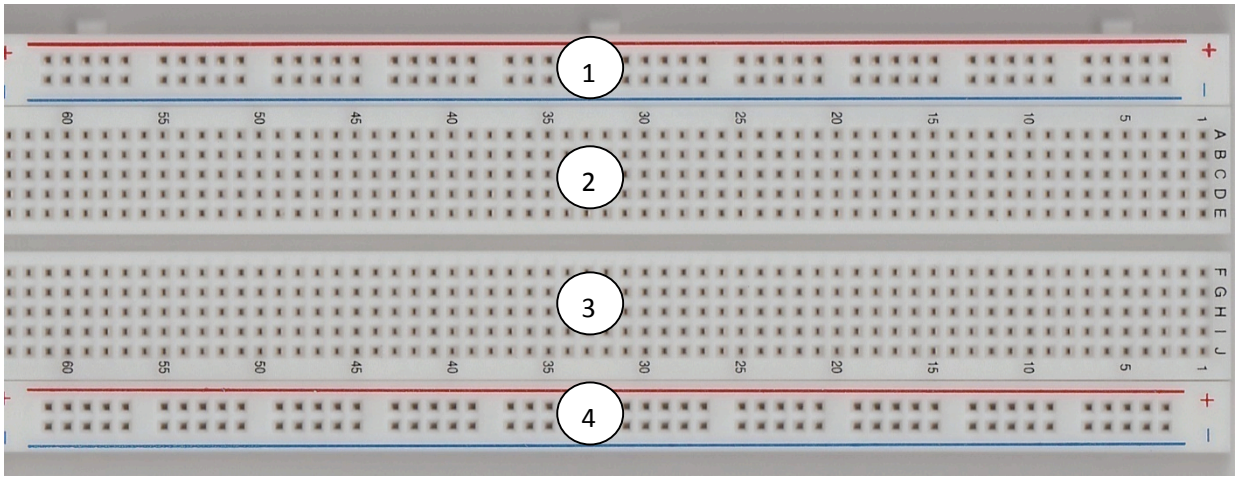


Figure 2: An Empty Breadboard

The breadboard is broken into four main sections. Sections 1 and 4 are often referred to as "bus lines." All of the holes in the first horizontal row are connected together. Likewise, the holes of the second horizontal row are connected together. However, horizontal rows 1 and 2 are not connected to each other. Many times, these buses are used for the voltage source (+ voltage) and for the ground (- voltage). Figure 3 illustrates how the holes on the breadboard are connected together.

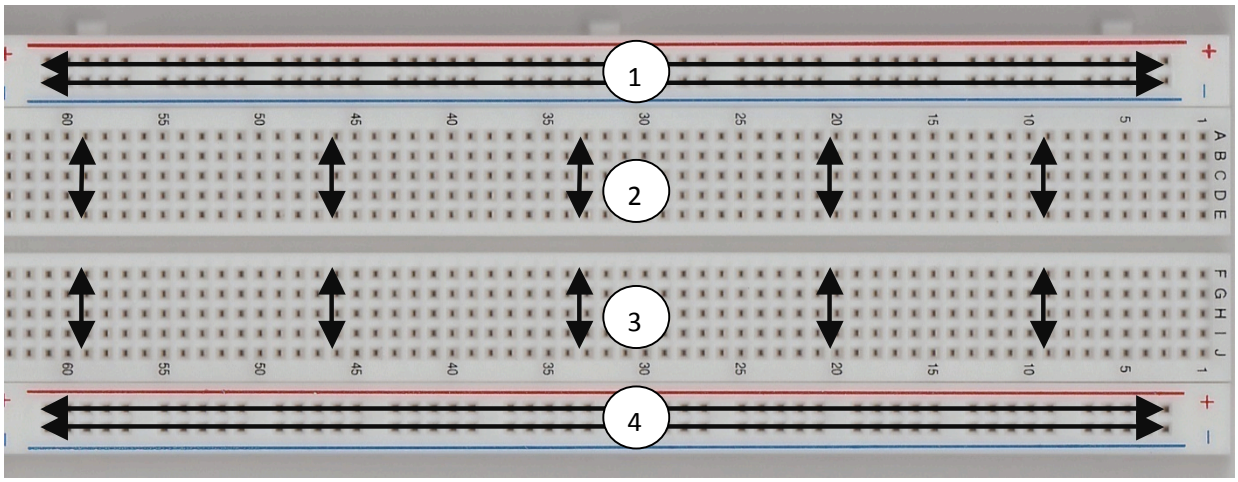


Figure 3: Schematic of Breadboard Connections

Unlike sections 1 and 4 where the holes are connected horizontally, the holes in sections 2 and 3 are connected vertically. In other words, in sections 2 and 3 the holes in each vertical row, or column, are connected. The gray line that separates sections 2 and 3 (the separating line in the middle of Figure 3) prevents those vertical rows from being connected together. A vertical row in section 2 can be connected to a vertical row in section 3 using a jumper wire to connect a hole in one of the vertical rows of section 2 to a hole in section 3. Once this is completed, the two vertical rows in sections 2 and 3 are connected together.

All circuit components have conducting pins, or leads. Simply place the pins into their corresponding holes on the breadboard. A small amount of force will be needed to push the pins down into the holes. It is important to make sure that none of the conducting pins are touching any other pins of any other components.

Resistors

Resistors restrict the amount of current that can flow in an electrical circuit. The resistors have different values that are indicated by the different color stripes around the ceramic part of the resistor.

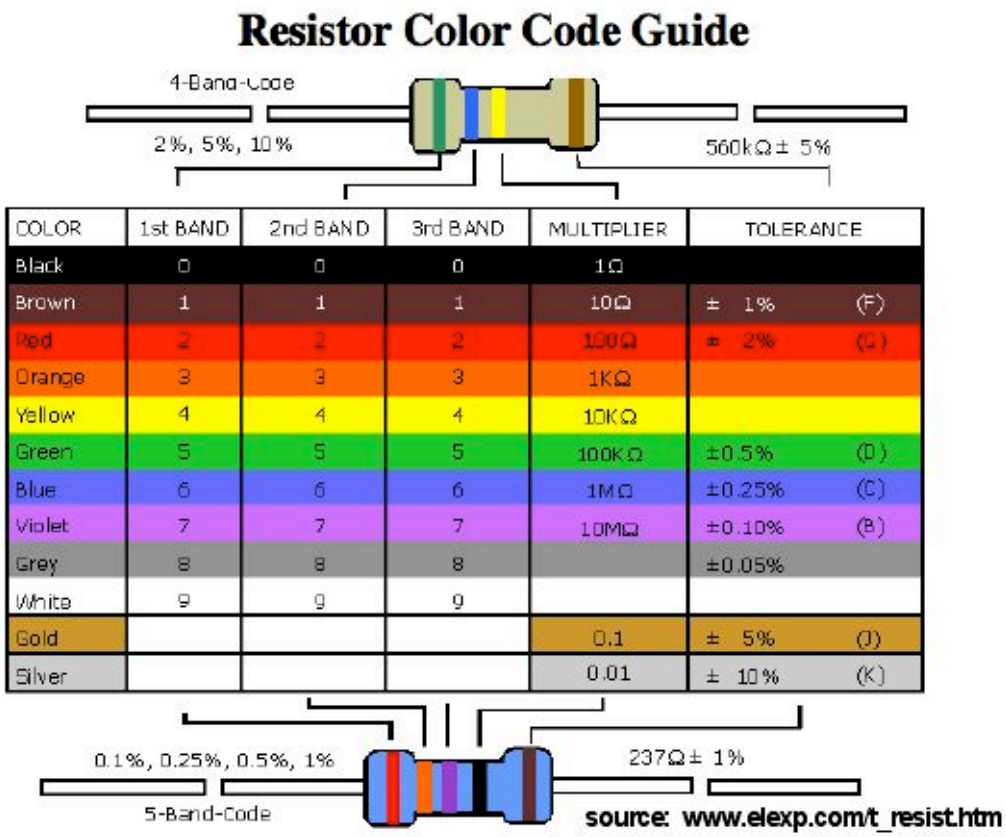


Figure 4: Resistor Color Code [2]

Figure 4 helps illustrate the resistor color code and how the resistance is determined from it [2]. The first two bands just use the indicated numbers. The third band is a multiplier of the indicated amount. The fourth band defines the tolerance of the resistor. Using the top resistor from Figure 4 we will calculate the value. Since the first band is green and the second is blue the first two numbers are 5 and 6 respectively. The third band is yellow which corresponds to a multiplier of 10,000. Using these three values the resistance is 56*10,000 which equals 560,000 Ω (ohms) which is commonly expressed as 560k Ω.

Capacitors

Capacitors are in essence a battery. When they are connected to a circuit they will store an electrical charge like a battery and when the circuit no longer has a source the capacitor will discharge the energy it stored earlier. The Jeopardy Engineering design utilizes two different capacitors, one is a ceramic and the other is an electrolytic capacitor.

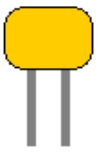


Figure 5: Ceramic Capacitor [3]

Figure 5 illustrates what a ceramic capacitor looks like [3]. The ceramic capacitor has no orientation with respect to voltage like a diode or LED does. These capacitors are used in each of the quiz circuits.

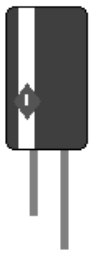


Figure 6: Electrolytic Capacitor [3]

Electrolytic capacitors do have a specific orientation with respect to voltage like a diode or LED. Figure 6 shows what an electrolytic capacitor looks like and how to determine the component's orientation [3]. The electrolytic capacitors have a stripe on the side of the cathode to assist in recognition of the correct orientation. These capacitors are used in the timer circuit and in the base quiz circuit.

LEDs

A light emitting diode (LED) is a device that emits light when a current is applied to it. LEDs are widely used as indicator lights on electronic devices. An LED is usually a small area light source. Optics are often added to the LED to assist in reflection and shape its pattern of radiation. The color of the emitted light depends on the composition of the semiconducting material used and can be ultraviolet, infrared, or visible. The reason LEDs are used so frequently is because they have low power consumption, are highly reliable, and are cheap.

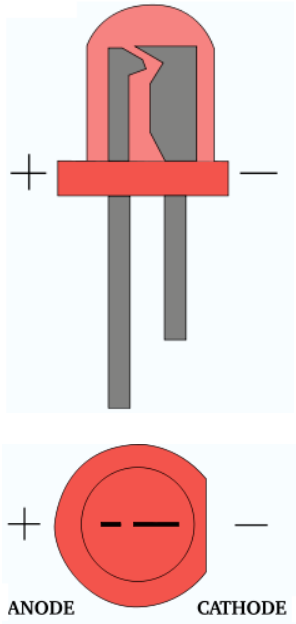


Figure 7: LED Diagram [4]

Figure 7 illustrates what the LED looks like and how it should be oriented to work properly [4]. Figure 7 also shows the electrical schematic symbol for the LED.

Diodes

A diode is a device that resembles a switch. It has a certain orientation with respect to voltage meaning that one side needs to be at a higher voltage,+, and the other at a lower voltage,-, in order to work. If the diode is oriented correctly it will allow current to flow, but if it is oriented incorrectly it will not allow current to flow.

Figure 8: Diode Diagram [5]

Figure 8 shows the orientation of the diode which is also used to help students identify what the diode looks like and how it needs to be oriented in order to work properly [5].

Shift Registers

A shift register is an integrated circuit with inputs, outputs, and features varying by model. The shift registers used in this project are configured to shift serially and has several inputs. Among these inputs are a clock signal and a shifter input. Every time the clock signal pulses the shift register will transfer the current value at each output and move it to the next output. The first output receives its shifted value from the input and value on output4 is lost upon the shift. Figure 9 shows a picture of what one of the shift registers looks like [6].

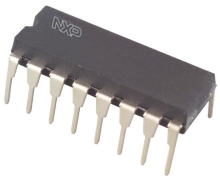


Figure 9: Shift Register [6]

555 Timers

At the heart of this project is the 555 timer, a versatile integrated circuit (IC) with a wide variety of applications and configurations. In general, there are three different modes that the timer can operate in. These modes are referred to as monostable, bistable, and astable. The timer in all modes is triggered, by its input transitioning from high to low or digital logic ‘1’ to ‘0’.

The first of these states, monostable, is stable only in the low output state. This means that when the timer is triggered, the output goes high for a brief period before switching back to its original low state. This project does not use this configuration of the 555 timer.

In a bistable configuration, the timer can maintain either a low or high output. Initially, the output is held low, but when the device is triggered it switches to high and will maintain that value until it is reset. This is the configuration that makes the quiz board and buzzers work. It is this feature that "locks out" all of the other participants after the first one has rang in to answer the question.

Counting down is achieved with the help of an astable 555 timer. Astable means that the timer is not stable in either state, which makes it ideal for an oscillator application. The device can be used in this configuration to switch between states ant multiple frequencies. For this mode, the input becomes part of the configuration and the user has no controlled input to the device. Our astable 555 timer produces an alternating signal that acts as a clock allowing the countdown to count at one Hz. Figure 10 shows what a 555 timer physically looks like [7].

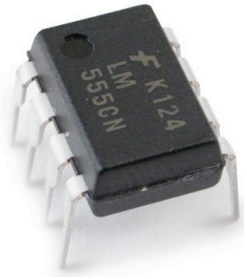


Figure 10: 555 Timer [7]

System Overview

The intention of this system overview is to describe the functionality of the "Jeopardy Engineering" design. The overall system is separated into two main circuit designs, the timer circuit and the quiz board designs. In order to power these circuits we utilize a power adapter that plugs into any wall outlet. The adapter steps the voltage down from 120 volts AC to 5 volts DC. It then uses an adapter with two wires to be able to transfer the power to the timer circuit. The adapter can be seen in Figure 2. The quiz circuits were originally designed to operate on a 9 volt battery [2], but the timer circuit components could only handle 5 volts and therefore the voltage for the entire design was reduced to the 5 volt level. This in no way hindered the quiz circuits operation. The function of each circuit design is described in this section.

Timer Circuit Overview

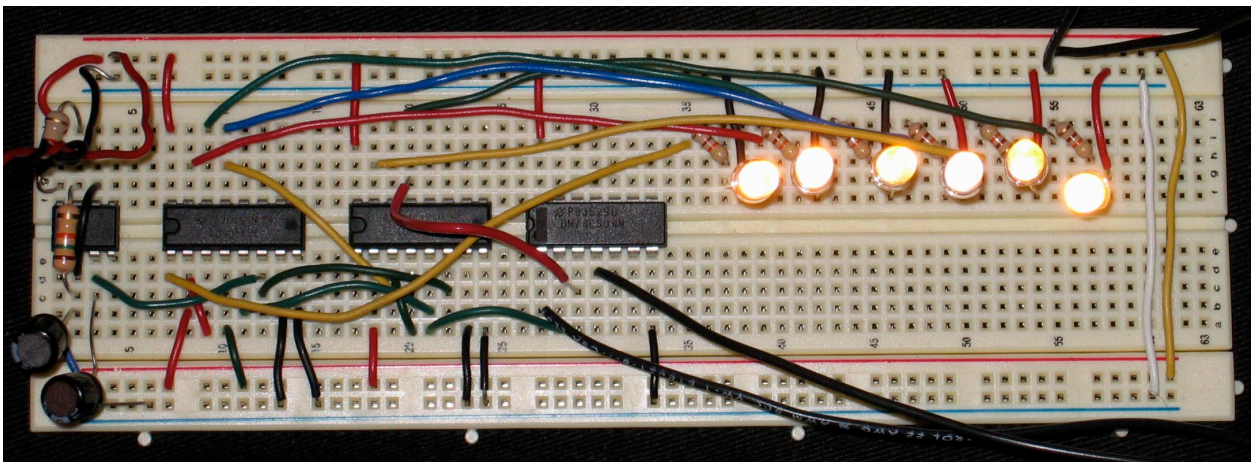


Figure 11: A Photograph of the Timer Circuit

Figure 11 shows a photograph of the Timer Circuit. This is not intended to be built by the students but will be an important part of the quiz game. When a student pushes their push button to ring in, this timer circuit will be enabled and the countdown timer will begin. The LEDs are used as a visual aid to the students and will act as a clock. After one second the first LED will be lit. After two seconds the first and second LEDs will be lit. After three seconds the first, second, and third LEDs will be lit. This pattern will continue until all six LEDs are lit, indicating that the student has run out of time to answer that particular question. Once all six seconds have expired, or all six LEDs are lit, the circuit will reset automatically and all LEDs will turn off. When a student pushes his or her push button again, the process will repeat itself.

Quiz Board Overview

The base quiz board and additional quiz boards are the components that the students will get to have the most experience with. The building of the timer circuit is a separate process, and should be built separately from this activity. The components behind the timer circuit are fairly complex, and may require a high amount of time to build. All of the additional quiz circuits as shown in the system block diagram are identical to each other. A student handout has been produced by the designers of this project to give the students a guide to build these additional quiz circuits. The base quiz circuit will require a few additional components that the identical additional quiz circuits do not contain. Schematics will be provided on how to build the base quiz circuit, and how to build the additional quiz circuits.

These quiz boards can be purchased in kits. The kit contains enough parts to make one base quiz board and three additional quiz boards. For example if two kits are purchased, a total of eight quiz circuits can be built. This equates to one base quiz circuit and several additional quiz circuits.

Base Quiz Board

First, the base quiz circuit must be built. The base quiz circuit is responsible for controlling all of the other additional quiz boards. The game buzzer, reset button, and connections to the game timer are made from it. Only one base quiz circuit must be built for the entire system. A picture of an assembled base quiz circuit is shown in Figure 12.

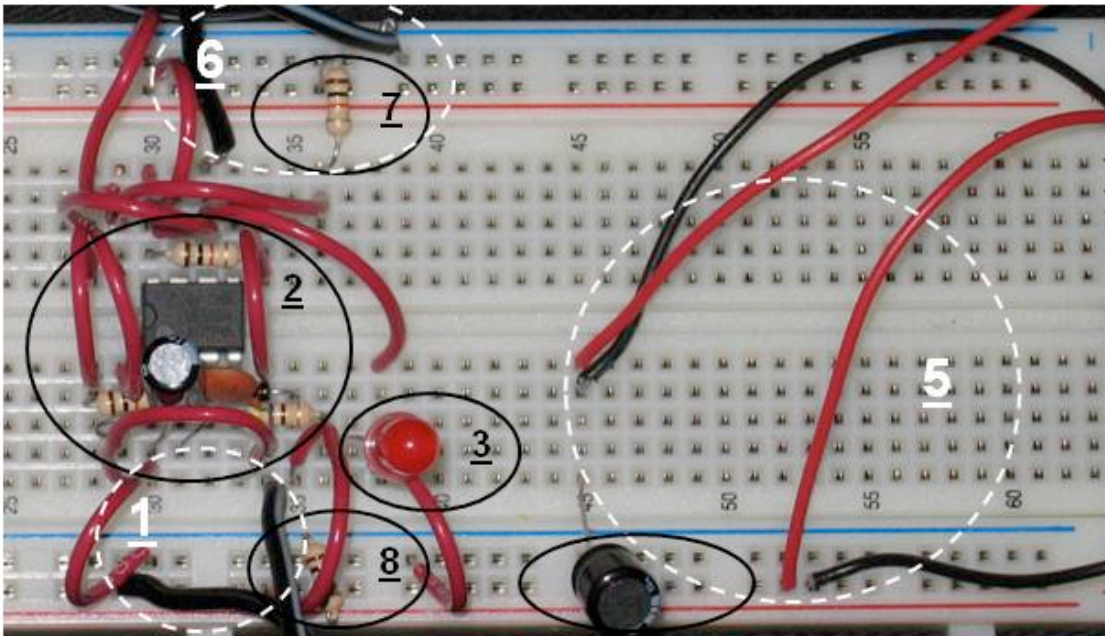


Figure 12: An Assembled Base Quiz Circuit

The function for each of the circled areas is listed below:

1. The white dotted circle #1 contains the two black wires that connect to the push button that is used by the game participants to ring in to answer a question. Once the button is pressed down, a signal (voltage) is sent to the rectangular black device in circle #1.

2. Circle #2 contains several important components. The first is the black rectangular device, which is called the 555 timer. This device is responsible for controlling the game buzzer, resetting the circuit after a question is done, lighting a LED to show which participant has pressed their push button first, and disabling all of the other push buttons to not allow any of the other participants to ring in. Notice the small half circle and full circle that are on the top of the 555 timer on the left hand side. These can be used for proper orientation of the 555 timer onto the breadboard. The resistor above the 555 timer and the two below it are responsible for delivering a safe voltage for the 555 timer to operate on. They are also used to lower the amount of current through other devices on the breadboard. This works by using a combination of digital logic and analog circuit theory. The large black capacitor (1µF) in circle #2 is responsible for properly discharging current out of the circuit safely. The smaller brown capacitor (0.1µF) ensures that the game participants only need to press their push

button once to ring in, and not have to continue to press down on the button after the initial push.

3. Circle #3 contains the colored LED that is illuminated if the push button on that corresponding quiz circuit is activated before any of the other push buttons on any of the other circuits. This is a visual signal to show which game participant has rung in first using their push button. The LED turns dark once their time has expired to answer the question, or the game has been manually reset.

4. Circle #4 contains a 47µF capacitor that allows the buzzers to function properly by controlling their voltage and current levels. Current and voltage are slowly discharged from the buzzers into the circuit ground. This allows for the buzzers to only sound for one second, before fading away. The buzzers are sounded when a game participant has rung in to answer a question, or when the time to answer the question has expired.

5. Circle #5 contains the 4 red and black wires for the game buzzers (buzzers not pictured). Each buzzer contains a black and red wire.

6. Circle #6 contains the two black wires for the game reset button. This button can be pressed by the game operator (or person asking the questions) to manually reset the game, game timer, and all LEDs. This would be used in the case of a participant answering the question before the game timer has expired or the person answering the question wrong. The button can also be held down to disable all of the push buttons used to ring in. This button can be held down while the question is being asked to disable anyone from ringing in to answer the question. The reset button can then be released once the question is done being read so the game participants can ring in.

7. Circle #7 contains a resistor that will lower the amount of current that is given to the push buttons used to ring in. This is desired for safe operation of the 555 timer.

8. Circle #8 contains a resistor that has the same function as the resistor in circle #7.

All of the thicker, red cables shown are "jumper cables." These are used to connect rows and columns of holes on the breadboard to other rows and columns. It is important when using these breadboards that the blue line is at the top when looking at the breadboard and the red line is at the bottom. This will be explained further in the assembly instructions later in this document.

Additional Quiz Boards

The additional quiz boards allow multiple participants to play the game. Each additional quiz board contains a push button for the participant to ring in to answer a question. They also contain a colored LED that lights up if the player playing on the corresponding board was first to ring in. It is recommended that a breadboard be purchased for each base quiz circuit and each additional quiz circuit. This allows for the maximum amount of student participation, as a group of students can focus in on building the circuit on their own breadboard. A picture of how an additional quiz board is shown in Figure 13.

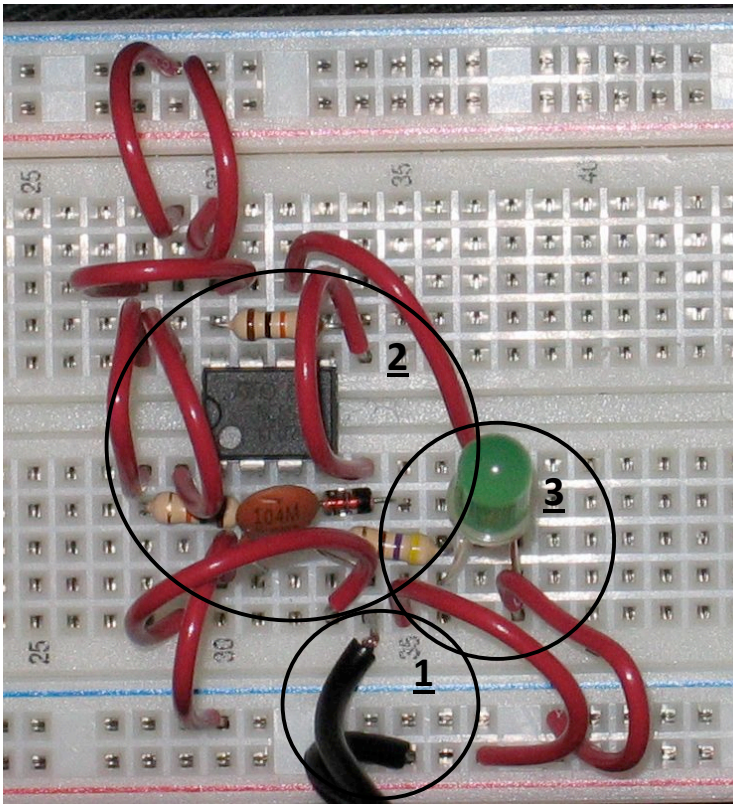


Figure 13: An Assembled Additional Quiz Circuit

Notice how Figures 12 and 13 look fairly identical. The only difference between the base circuit and the additional circuit is that the additional circuits do not contain a couple of the resistors and capacitors that the base circuit contains (Circles #4, 7, 8). Also, only the base circuit contains the game buzzer and reset button (Circles #5, 6). The game buzzers and reset button from the base circuit are shared by all of the connected additional quiz circuits. For a listing of the function of the components within each circle, please refer back to the component descriptions under in the base quiz circuit.

Assembly Instructions

The assembly instructions in this section are intended to provide a step-by-step description of the assembly process of each of the two circuit designs, as well as the networking of the entire system. The intention is that students should assemble the quiz board circuits, while the timer circuit assembly and the networking of the system are to be completed by the teacher. Each assembly process is described separately within this section.

Timer Circuit Assembly

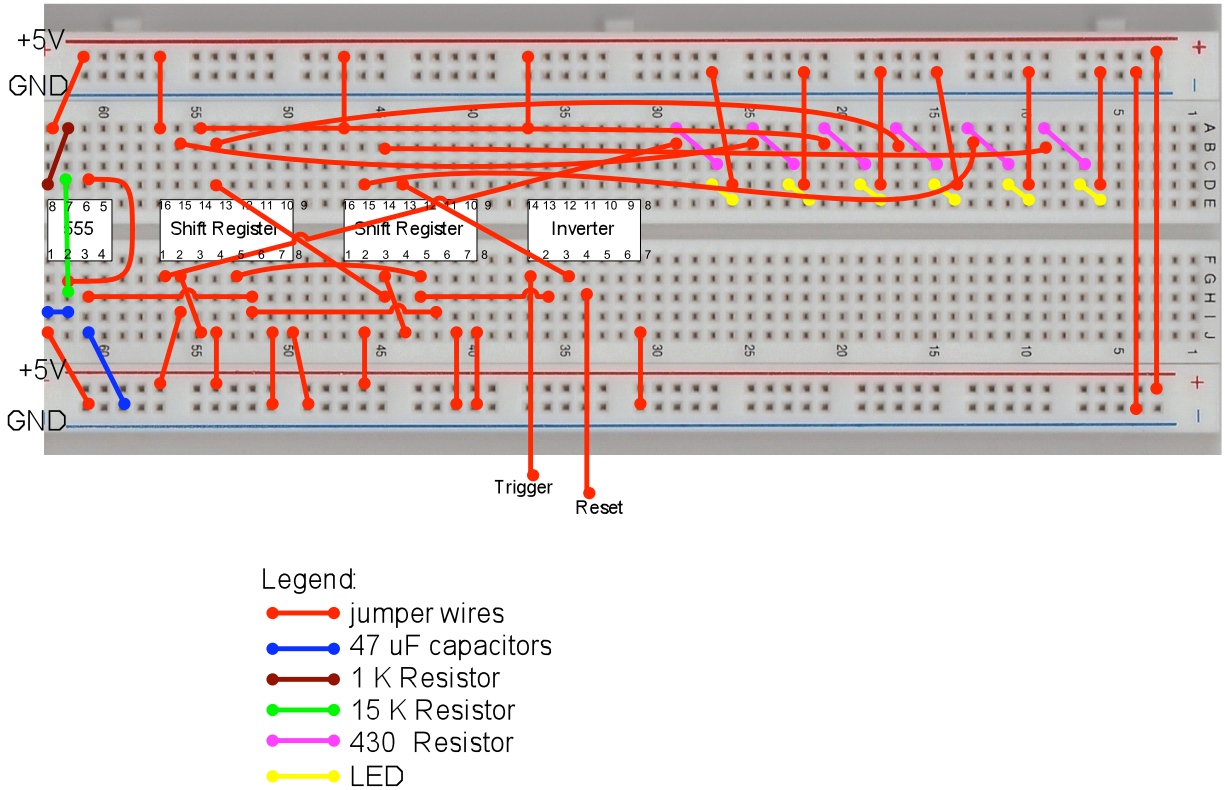


Figure 14: Timer Circuit Schematic

Figure 14 shows the timer schematic and could be useful in conjunction with the following assembly instructions. Note that busses 1 through 4 is not used quite the same in this circuit as in the quiz board circuit. Busses 2 and 4 are used as + voltage power rails. Busses 1 and 3 are both connected to ground. These 4 rows run the entire horizontal length of the breadboard.

1. The following parts ordered apart from the quiz kits can now be set aside for this assembly:

Component	Qty
22 AWG Wire (per foot)	1
830 point breadboard	1
1k ohm Resistor (1.0KH-ND)	1
15k ohm Resistor (15KH-ND)	1
47 uF Capacitor (P834-ND)	2
555 Timer (296-1411-5-ND)	1
Shift Register (296-2163-5-ND)	2
Inverter (296-1435-5-ND)	1
470 ohm Resistor (470H-ND)	6
LED's	6
Power Supply Jack	1
5V Power Supply (T314-P6P-ND)	1

2. From the spool of wire, cut 22 small pieces of wire each 1 inch long*. These will be used for short wire jumps to and from circuit components. The two ends of the wire will need to be stripped off to expose the silver wire inside of the colored outside protective coating. All wire ends for the remaining steps must also be stripped. (For more information on stripping wire: http://www.ehow.com/how_2072917_strip-wire.html)

3. Also from the spool of wire, cut 4 pieces of wire each 4 inches long*. These will be used for bridging busses on this board and for connecting the power supply jack.

4. Again cut 5 pieces of wire roughly 3 inches long*, these will be used for jumping medium length gaps between shifters, the inverter and the 555 timer.

5. For the last wires, cut 6 pieces each roughly 5 inches long*. These will be used to connect the shift registers to the LED's.

6. Now take the power supply jack from the parts list and use 2 wires from step 3, using one end from each wire, and place the wire into the hoops in the back of the jack. If a soldering gun is available, it might be easiest to solder these wires tightly in place onto the loops. If a soldering gun is not available, tightly wrap the bare wire around inside of each hole, making sure that the two wires do not touch each other. Once this is done, pull the two free ends of the wire side by side and, holding them steady, twist the jack to tighten the wires together. Leave an inch or so untwisted on the free hanging end of the wire.

7. Using a breadboard from the parts list, arrange the breadboard so the solid red line is at the top of the breadboard, and the solid blue line is at the bottom of the breadboard.

8. Place the 555 timer into the corresponding holes on the breadboard as shown in the schematic. Pay particular attention to the orientation of the chip.

Note: Great care should be taken not to bed the pins as you place this and other devices into the breadboard. Pay attention to the 'notched' end of the 555 timer, inverter, and shifters. The notch is always oriented to the left.

9. Repeat step 8 for the two shift registers.

10. Repeat step 8 for the inverter.

11. Place the 1k ohm resistor into the corresponding holes as shown in the schematic. The two lead wires on each side of the resistor can be bent to the proper orientation to fit each lead into its corresponding hole. It does not matter which lead (wire) out of the capacitor goes into which breadboard hole. These leads can be shortened in length by using scissors to shorten if desired

12. Repeat step 11 for the 15k ohm resistor.

13. Repeat step 11 for the six 470 ohm resistors.

14. Place the two 47uF capacitors in the corresponding holes as shown in the schematic. Be VERY sure to install these correctly as they are both polarized capacitors. This means that incorrect installation will likely result in a destroyed component. A large grey stripe denotes the negative (-) lead. The capacitor on the left will have the negative lead facing left and the capacitor on the right will have the negative facing down (away from the 555 timer).

15. Place the LED's into the corresponding holes on the breadboard. Please note that the longer lead is the (+) connection. The LED should be oriented on the board so that the longer lead is in the left hole, and the shorter end is in the right hole.

16. Place all 1 inch wire pieces into the corresponding holes as shown in the schematic. All of these but 3 will originate from one of the busses. The exceptions are the wire bridging over the 555 timer. The next two exceptions are located on the shift registers in the same relative pin position, starting in pin 2 and ending in pin3.

17. Next place all 3 inch wire pieces into their corresponding holes as shown in the schematic. These wires are used to make connections between the 555 timer, inverter, and the two shift registers.

18. Place the two remaining 4 inch wire pieces on the far right side of the board as indicated on the schematic. These will jump the busses together red to red and blue to blue.

19. Finally, place the two free ends of the power jack wires into the red and blue busses. To ensure that you install this with correct polarity, the following steps may be taken to double check.

    - Grab an unused breadboard.
    - Place the two free ends of the jack wires into 2 separate columns with 1 column in between them. (Middle section of the breadboard.)

- Use a 470 ohm resistor (can be taken from anywhere as it can be replaced when this test is finished) and jump from the column of either wire from the jack into the column directly between the two.
- Using one of the LED's (any of them, but preferably from the quiz board circuit as they are more durable than the timer circuit LED's) jump from the middle column to the remaining jack wire.
- Plug the power supply into an outlet and connect to the jack.
- Pay close attention to the orientation of the LED. It will only shine if its positive lead (the longer one) is oriented toward the positive jack wire. If it does not initially come on, then the long lead of the LED points toward the ground wire from the jack. If the light comes on then the long lead points toward the positive wire from the jack. Find a way to mark the polarities of the wires coming from the jack. A permanent marker works well for this.

* Indicates that the measurement is a rough estimate is given to leave slack in the wire. However, because the timing circuit only needs to be assembled once it is acceptable to use the following, or your own, method to cut pieces that are only as long as required. This causes the board to appear much cleaner and makes it more difficult to accidentally remove a wire.

- Taking the wire spool in hand, strip the hanging end of the wire around ¼" back.
- After unwinding the wire a few turns, place the stripped end into its final resting hole in the breadboard.
- Lay down the slack wire in a straight line toward and covering the hole that the opposite end of the wire will be plugged.
- Measure between ¼" and ½" past this second hole and cut.
- Strip the cut end of the wire ¼" back from the end.
- Put a 90 degree bend in the wire at the freshly cut end where the bare wire meets the colored insulation. Insert into final position.
- Repeat this for each wire.

Quiz Board Assembly

The base quiz circuit assembly and the additional quiz circuits assembly are described separately within this section.

Base Quiz Circuit

The base quiz circuit should be built on one of the breadboards shown in the parts list. Figure 15 a schematic of how to orient all of the circuit components on the breadboard is shown below.

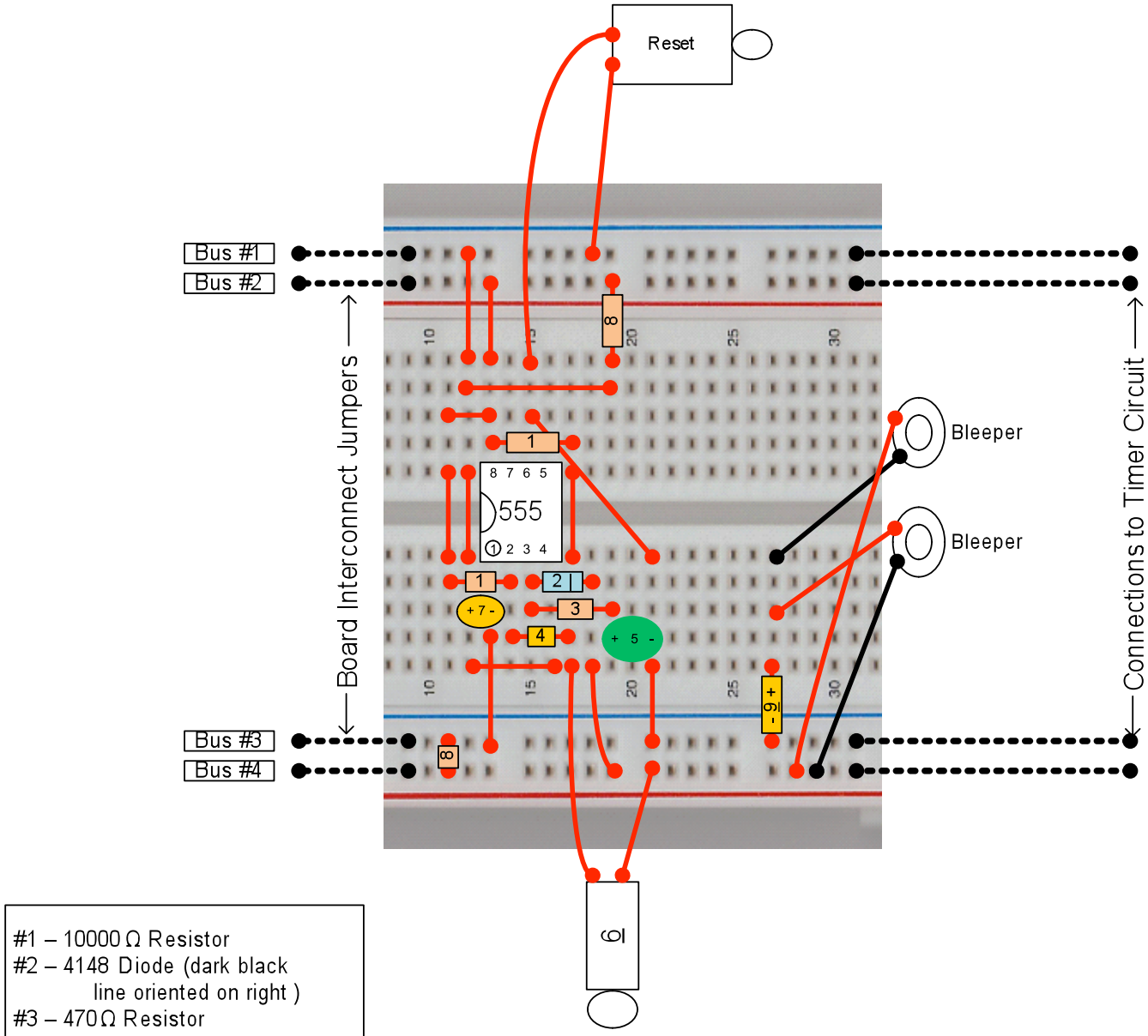


Figure 15: Base Quiz Circuit Schematic

Note that bus #1 is the very top horizontal row of holes on the breadboard. Anything connected into any of the holes in this row will be connected to the game reset line. The same goes for bus #2, 3, 4, except these are for the system power, ground, and trigger, respectively. These 4 rows run the entire horizontal length of the breadboard.

20. From the quiz kits that were ordered, set aside (2) 10000Ω resistors, (1) 4148 Diode, (1) 470Ω resistor, (1) 0.1µF resistor, (1) Colored LED, (1) Colored push button, (2) 1000Ω resistors, (1) black push button, (2) buzzer speakers (one from each kit ordered), and the black speaker wire. From the additional parts that were ordered, get a 47µF capacitor and a spool of wire.

21. From the spool of wire, cut 15 small pieces (approx 3 inches) of wire. The two ends of the wire will need to be stripped off to expose the silver wire inside of the colored outside protective coating. (For more information on stripping wire: http://www.ehow.com/how_2072917_strip-wire.html)

22. Also from the spool of wire, cut 4 pieces of wire (approximately 1 foot) to connect the base quiz circuit to the game timer. Follow the same procedure as step 2 for stripping the wires.

23. From the speaker cables included in the circuit kit, cut approximately a foot of wire and strip both ends of the wire. Notice here that there is a pair of wires connected together; make sure to strip both wires on both ends. Cut 2 pieces of wire 1 foot long.

24. Grab the black push button from the quiz kit and take one end of the speaker wire cut in Instruction #4 and place each end of the stripped wire in each of the 2 holes on the push button. If a soldering gun is available, it might be easiest to solder these wires tightly in place onto the push button. If a soldering gun is not available, tightly wrap the bare wire around inside of each hole, making sure that the two wires do not touch each other.

25. Repeat this same process for the colored push button that will be used as the ring in button.

26. Using a breadboard from the parts list, arrange the breadboard so the solid blue line is at the top of the breadboard, and the solid red line is at the bottom of the breadboard.

27. Place components labeled as “1” (10000Ω resistor) into the corresponding holes on the breadboard shown in the schematic. The two lead wires on each side of the resistor can be bent to the proper orientation to fit each lead into its corresponding hole. It does not matter which lead (wire) out of the capacitor goes into which breadboard hole. These leads can be shortened in length by using scissors to shorten if desired.

28. Place the component labeled as “2” (4148 diode) into the corresponding holes on the breadboard shown in the schematic. The black solid line on the diode should be oriented on the right hand side. Place the two leads down into the breadboard holes.

29. Repeat step 8 for the component labeled as “3” (470Ω resistor).

30. Repeat step 8 for the component labeled as “4” (0.1µF capacitor).

31. Place the component labeled as “5” (Colored LED) into the corresponding holes on the breadboard. Please note that the longer lead is the (+) connection. The LED should be oriented on the board so that the longer lead is in the left hole, and the shorter end is in the right hole.

32. From the reset button created in step 4, strip the 2 wires on the other end of the wire from the reset button. These wires should then be placed into the holes of the breadboard as shown in the schematic. It does not matter which wire from the pair goes into which hole.

33. Repeat step 13 for the push button used by the game participants. It is important to note once again that the base quiz circuit has 2 push buttons, one for the participants to use to ring in, and the other to be used for the reset button.

34. Repeat step 12 for component labeled as “7” (1µF capacitor). The longer lead should be oriented on the left hand side, and the shorter lead should be oriented on the right hand side.

35. Repeat step 8 for the components labeled as “5” (1000Ω resistor).

36. Repeat step 12 for component labeled as “9” (47µF capacitor). The longer lead should be oriented on the top, and the shorter lead should be oriented facing the bottom of the breadboard.

37. Using the 2 quiz buzzers (“bleepers”), strip the end of each of the wires coming out of them back approximately ¼”. Connect the red and black wires from each bleeper to the breadboard as shown in the schematic.

38. Using the 4 wires created in step 3, place one end of stripped wire into the breadboard on each horizontal bus (Bus #1, 2, 3, 4) as shown in the schematic. These will be used to connect the game timer to the base quiz circuit.

Additional Quiz Circuits

The assembly of the additional quiz circuits is fairly similar to that of the base quiz circuit. Again, a schematic is shown to help place the components correctly on the breadboard. This schematic is Figure 16 which is shown below.

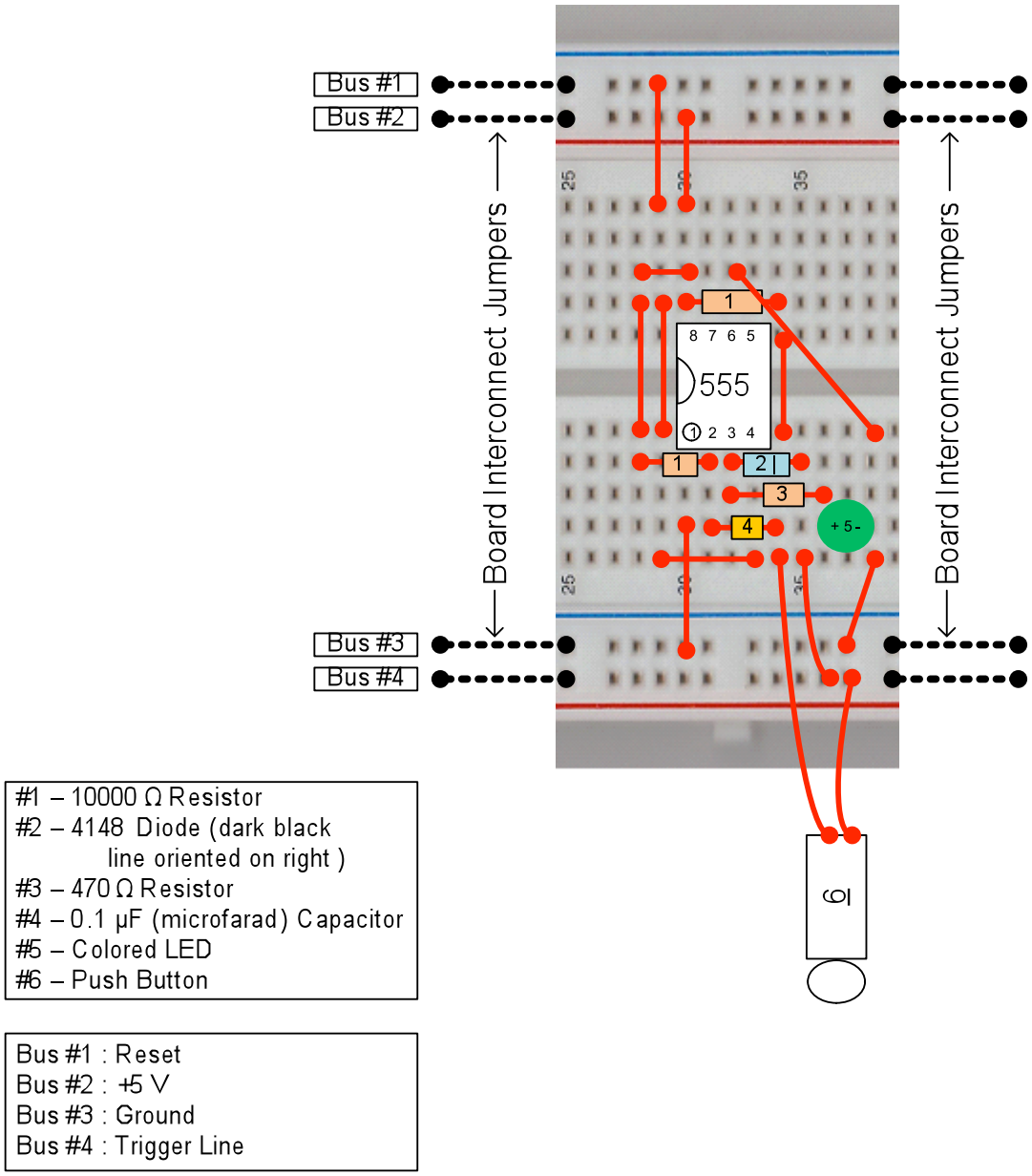


Figure 16: Additional Quiz Board Schematic

1. From the quiz kits that were ordered, set aside (2) 10000Ω resistors, (1) 4148 Diode, (1) 470Ω resistor, (1) 0.1µF resistor, (1) Colored LED, (1) Colored push button, and the black speaker wire. From the additional parts that were ordered get a spool of wire.

2. From the spool of wire, cut 15 small pieces (approx 3 inches) of wire. The two ends of the wire will need to be stripped off to expose the silver wire inside of the colored outside protective coating. (For more information on stripping wire: http://www.ehow.com/how_2072917_strip-wire.html)

3. Also from the spool of wire, cut 4 pieces of wire (approx 1 foot) to connect the additional quiz circuit to the base quiz circuit. Follow the same procedure as step 2 for stripping the wires.

4. From the speaker cables included in the circuit kit, cut approximately a foot of wire and strip both ends of the wire. Notice here that there is a pair of wires connected together; make sure to strip both wires on both ends. Cut 2 pieces of wire 1 foot long.

5. Grab the colored push button from the quiz kit and take one end of the speaker wire cut in Instruction #4 and place each end of the stripped wire in each of the 2 holes on the push button. If a soldering gun is available, it might be easiest to solder these wires tightly in place onto the push button. If a soldering gun is not available, tightly wrap the bare wire around inside of each hole, making sure that the two wires do not touch each other.

6. Using a breadboard from the parts list, arrange the breadboard so the solid blue line is at the top of the breadboard, and the solid red line is at the bottom of the breadboard.

7. Place components labeled as "1" (10000Ω resistor) into the corresponding holes on the breadboard shown in the schematic. The two lead wires on each side of the resistor can be bent to the proper orientation to fit each lead into its corresponding hole. It does not matter which lead (wire) out of the capacitor goes into which breadboard hole. These leads can be shortened in length by using scissors to shorten if desired.

8. Place the component labeled as "2" (4148 diode) into the corresponding holes on the breadboard shown in the schematic. The black solid line on the diode should be oriented on the right hand side. Place the two leads down into the breadboard holes.

9. Repeat step 7 for the component labeled as "3" (470Ω resistor).

10. Repeat step 7 for the component labeled as "4" (0.1μF capacitor).

11. Place the component labeled as "5" (Colored LED) into the corresponding holes on the breadboard. Please note that the longer lead is the (+) connection. The LED should be oriented on the board so that the longer lead is in the left hole, and the shorter end is in the right hole.

12. From the push button created in step 5, strip the 2 wires on the other end of the wire from the colored push button. These wires should then be placed into the holes of the breadboard as shown in the schematic. It does not matter which wire from the pair goes into which hole.

13. Using the 4 wires created in step 3, place one end of stripped wire into the breadboard on each horizontal bus (Bus #1, 2, 3, 4) as shown in the schematic. These will be used to connect this quiz circuit to the base quiz circuit if an additional quiz board has not does this yet. If an additional quiz board has been connected to the base circuit, then connect these 4 wires to any additional quiz circuit to the same "busses". Meaning, bus #1 on this additional quiz circuit should be connected to bus #1 on any of the other additional quiz circuits.

Networking Instructions

The quiz circuits are networked together by using wires of any length to connect each of the four "busses" together.

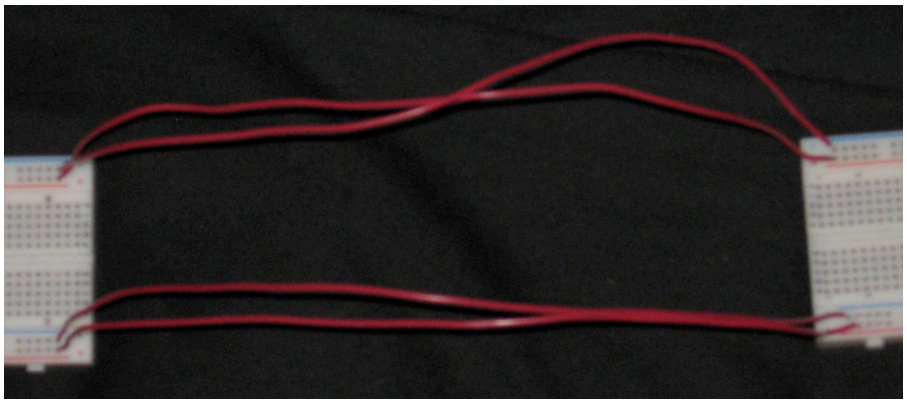


Figure 17: Quiz Circuits Interconnected

Figure 17 shows how the quiz circuits are interconnected and daisy chained with wires. These "busses" are the two blue and two red columns of holes on the breadboards as seen in Figure 17. The timer circuit makes four connections to the base quiz circuit. The first two are connections of the power and ground busses of the timer circuit and the base quiz circuit.

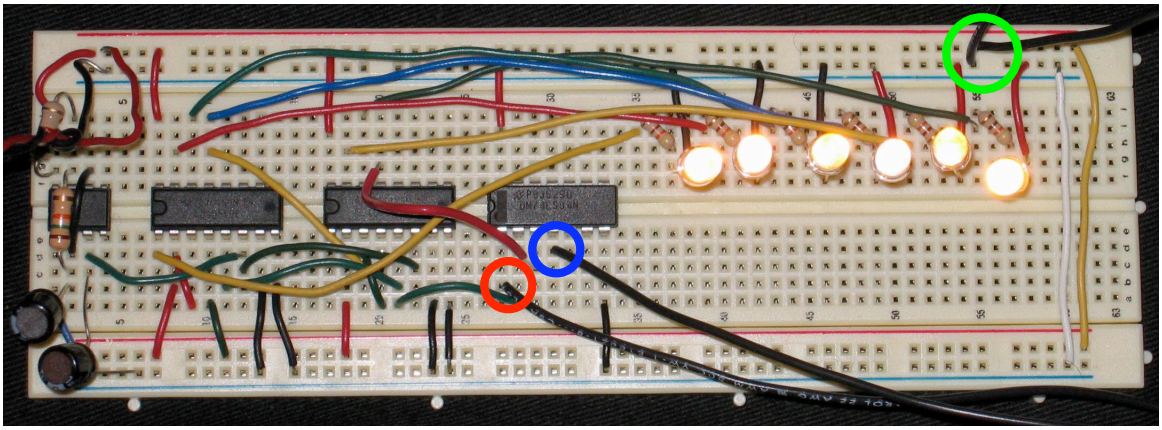


Figure 18: Reset Bus Connection

Figure 18 shows these two connections inside the green circle. Figure 18 also illustrates the connection of the reset bus from the base quiz circuit to the 4th pin of the inverter, which is in the blue circle. The final connection is the one from the trigger bus of the base quiz circuit to the 1st pin of the inverter on the timer circuit which is the red circle in Figure 18.

Troubleshooting

It is strongly recommended that you double check all connections and integrate one buzzer circuit at a time to simplify troubleshooting as much as possible. It is highly suggested that someone triple checks connections for the special case circuits. Figure 19 shows the design group troubleshooting the quiz circuits during the first in-class use of the design.

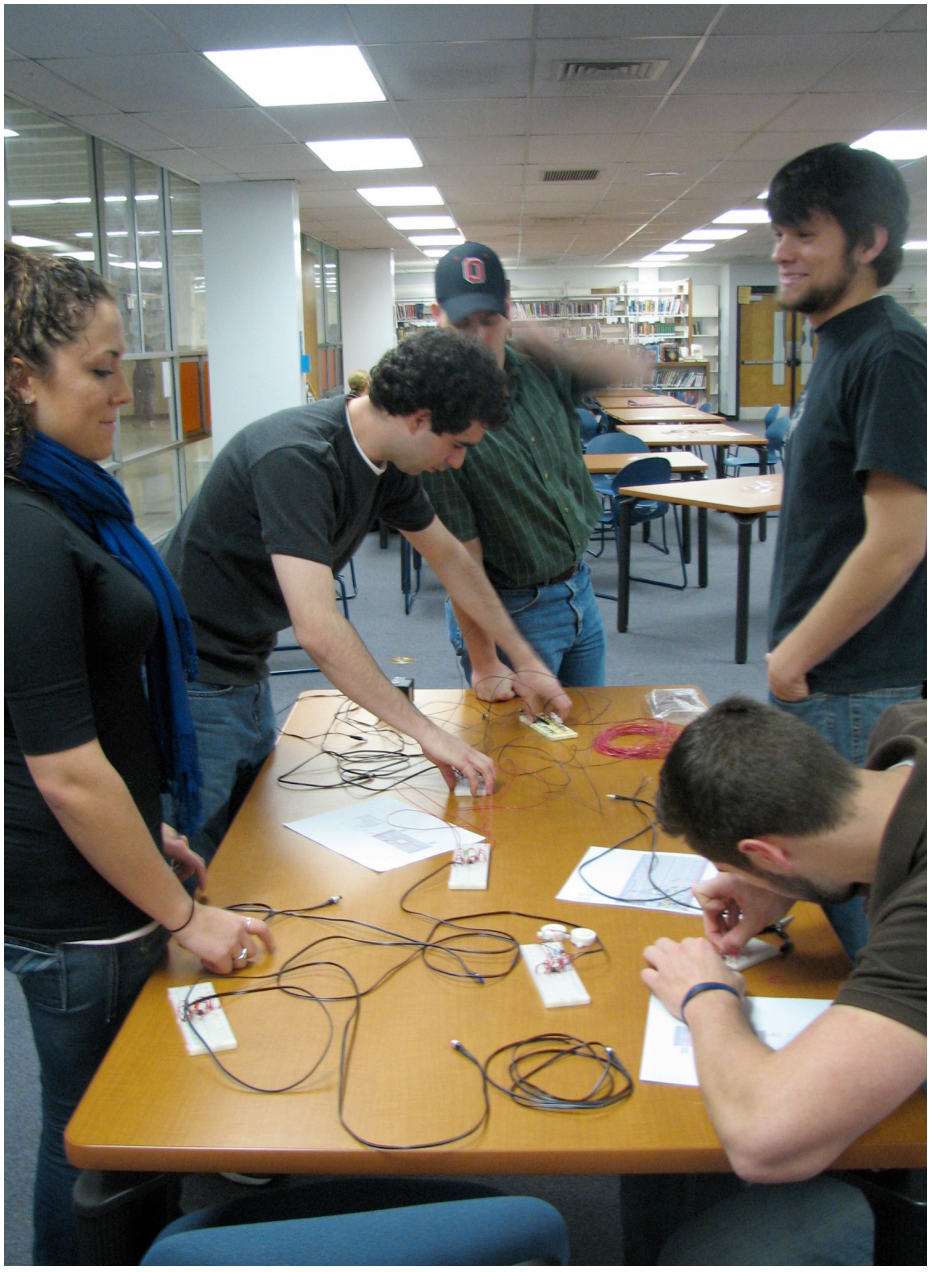


Figure 19: A picture of troubleshooting the quiz circuits.

Symptom	Possible Cause(s)	To Check
No lights come on, unit not operational.	No power, essential error in networking. Special case circuitry not connected correctly.	All network connections between buzzer circuits and timing circuit as well. Check all power connections and special case connections.
Multiple groups can buzz in at the same time.	Miss-wire in quiz board circuit.	Push button connections; be sure they connect to the correct end of the capacitor. Be sure that capacitor is installed correctly. Check all connections to Trigger Line buss. Check component orientation.
A quiz board circuit does not reset or turns on by itself.	Miss-wire in quiz board circuit. Likely in reset connections or the Trigger Line connections.	Circuit connections to Reset and Trigger Line busses. Check overall connections very carefully.
Strange patterns coming from the bleepers.	Capacitor installed incorrectly.	Double check polarity of the bleeper capacitor. Note: The capacitor should NOT be warm. Incorrect installation of a polarized capacitor could destroy the capacitor.
One player buzzing in makes other buzzers activate.	Special case circuitry not connected correctly. Miss-wire in one or more quiz board circuits.	Check special case connections carefully.
Counting LED's working improperly.	Miss-wire in quiz board or reset/trigger connections on timer circuit.	Reset/trigger connections on and between timer circuit and quiz boards.

General concerns to watch for:

- Broken wire leads. Give a light tug on wire ends to quickly and easily check for this.
- Diodes, LED's, and capacitors installed with correct polarity where applicable.

Game Instructions

When you are ready to begin playing the game, this section will guide you through the intended operation of the completed Jeopardy circuitry.

The Jeopardy Questions

Along with this documentation, you should have received a Jeopardy PowerPoint file that contains a Jeopardy game template [8]. The questions were aimed at the particular school where the first in-class use of this project was implemented and involve the subject matter currently being taught in that class. It is encouraged that the questions and categories be altered to fit the subject matter currently being taught to the class.

An important difference between the television show Jeopardy game and the PowerPoint game is the format of the questions. Due to the nature of the questions supplied, the format is question and answer instead of the standard game format where the answer is supplied and the player gives the question.

It is important to note that while navigating through questions and answers, the PowerPoint game will operate undesirably if the text box is clicked. Click on the background of the question and answer slides to operate the game as intended. Clicking any category title will bring you to the final Jeopardy question after all questions have been asked.

To select a question, click on the point value as shown in Figure 20.

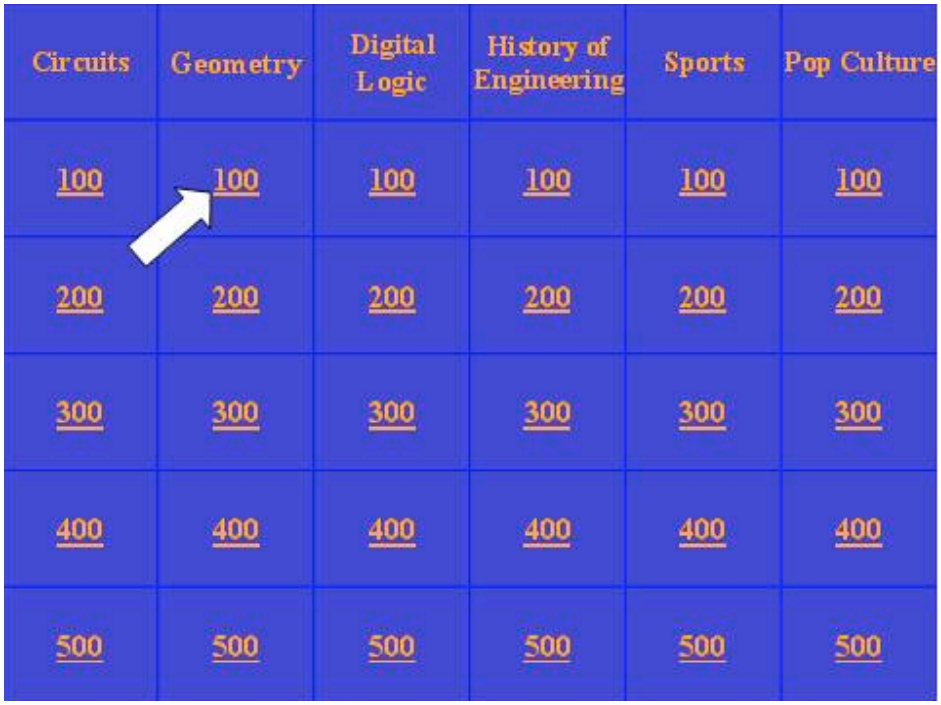


Figure 20: Jeopardy Board [8]

The question corresponding to that category and point value will appear. To display the answer, click the background outside of the textbox as shown in Figure 21.

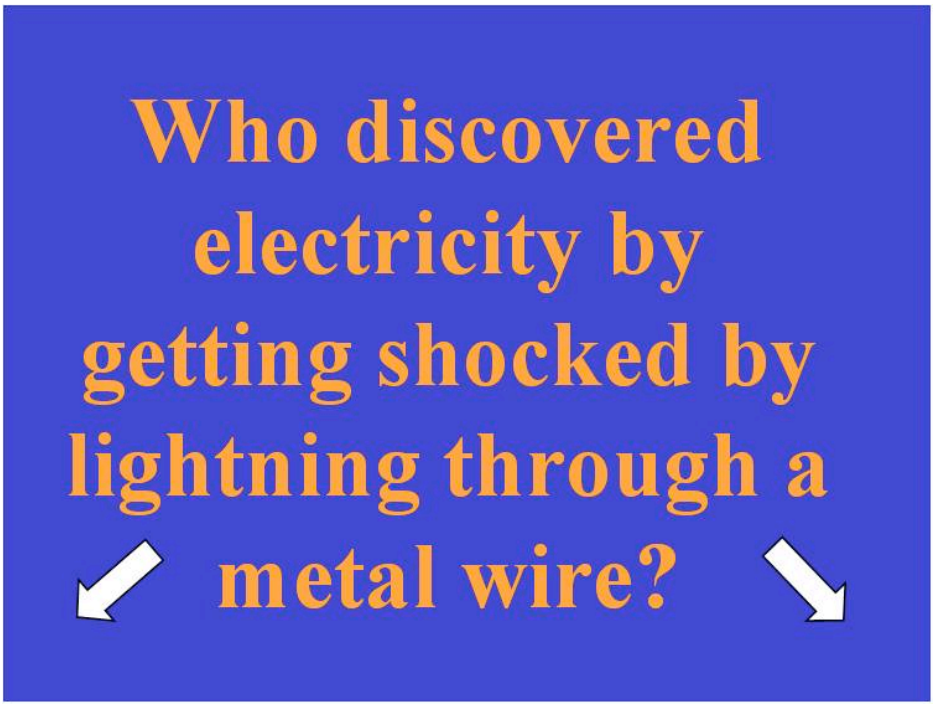


Figure 21: Jeopardy Question Slide [8]

The answer corresponding to that question will appear. To return to the Jeopardy board, click the background outside of the textbox as shown in Figure 22.

Figure 22: Jeopardy Answer Slide [8]

Game Instructions

It is recommended that you use the same groups as used in assembling the circuits and have each group use their own circuit for ringing in. If this will not work, you may split up the class as you see fit.

You can have the groups select a captain to do the ringing in or have the players in each team alternate positions at the push button for successive questions. It is recommended that each group line up and rotate through team members after each question.

Next, decide who goes first. It is recommended that the moderator holds the manual reset. When it is released, the first team to ring in will go first. The first team will choose the first category and point value.

When the first category and point value have been chosen, click the point value and read the question. Anyone can ring in to answer a question unless the question is the daily double. There is only one daily double and only the group that chose the question may answer.

Note: We suggest holding in the manual reset button while asking the question and releasing it once you've finished. This ensures everyone equal opportunity to ring in and prevents ringing in before the question has been read.

The first person to ring in will have a lit LED in front of them. They will then have six seconds to answer as shown by the counting LED's of the timer circuit. Once the time is up another group can ring in to answer if the first group answered incorrectly. The group that answers a question correctly is awarded that question's point value and may choose the next question.

This will continue until all 30 questions have been answered. Once the 30 questions are done it is time for Final Jeopardy. Click any category title and follow the link to Final Jeopardy. Teams may then wager up to the full amount of points they possess and answer the question as a group. The Final Jeopardy question is intended to be challenging, so group cooperation is encouraged. All teams are given thirty seconds to come up with an answer.

The group with the highest point value is declared the winner. It is also recommended that the student to answer a question correctly or the winning group members be rewarded. This is optional, but recommended because it helps add further reward for participation.

Conclusion

This manual provided a detailed description of the "Jeopardy Engineering" design. The use of the activity described in this report is expected to increase interest in science, technology, engineering, and math fields among the youth in the United States.

The quiz game was designed to be straightforward enough for high school students to build and understand with some guidance. This manual provides the teacher with all necessary information for understanding and building the design. The intention of the circuit building activity is to demonstrate the applicability of science and mathematics through a fun activity. Digital logic, basic physics, and math will be utilized in the building process. The game rules and supporting student handout are included and the supporting PowerPoint presentations are attached to assist in the classroom game activity. The intention of the game portion of the activity is to demonstrate some of the concepts learned in the circuit-building portion of the activity and trigger the students' interest in engineering. Through this experiment, students will gain a better understand of the engineering profession, as well as gaining an appreciation for the practical use of science and math concepts learned in the classroom.

Citations

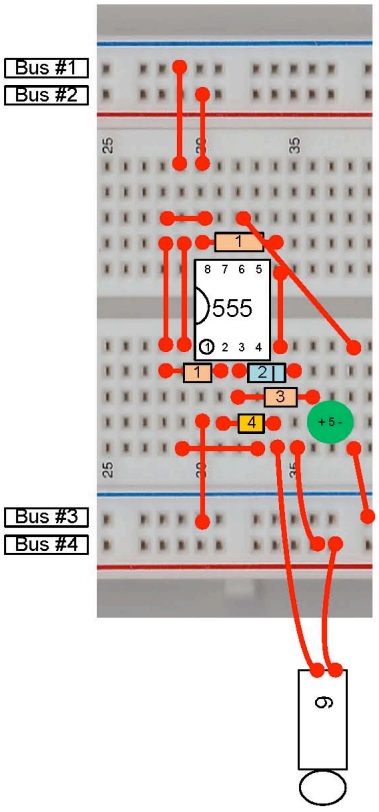
1. (http://www.rshelectronics.co.uk/electronicsclubkits.htm).
2. (http://reprap.org/bin/view/Main/Resistor).
3. (http://www.theguestroom.net/manuals/Assembling%20Your%20MegaSquirt_files/capacitors.gif).
4. (http://www.societyofrobots.com/images/electronics_led_diagram.png).
5. (http://www.societyofrobots.com/electronics_basic_components_tutorial.shtml).
6. (http://media.digikey.com/photos/NXP%20Semi%20Photos/568-16-DIP.jpg).
7. (http://www.solarbotics.com/assets/images/lm555/lm555_pl.jpg).
8. (http://teach.fcps.net/trt10/PowerPoint.htm).
9. (http://www.kpsec.freeuk.com/projects/quiz.htm).

Appendix A: Parts List

	Descripti on	Total	Total Price	Vendor	Website
Quiz Circuit	Quiz Game Kit (details below) (1100-170)	2	$ 29.20	The Electronics Club	htt p://www.kpsec.freeuk.com/projects/quiz.htm
	470 ohm Resistor	8			
	1k ohm Resistor	4			
	10k ohm Resistor	16			
	0.1 uF Capacitor	8			
	1 uF Capacitor	2			
	1N4148 Diode	8			
	LED (Red, Yellow, Blue, Green)	8			
	NE555 IC Timer	8			
	Audible Bleeper	2			
	On/Off Switch	2			
	Push Butt ons (reset & team)	10			
	Batt ery Clip for 9V Batt ery	2			
	Speaker Cable (8m)	2			
	22 AWG Wire (per foot)	80	$ 20.00	FrozenCPU	htt p://www.frozencpu.com/cat/l3/g4/c155/s325/list/p1/Electronics-Wire_Connectors_Pins-22_AWG_Wire-Page1.html
	830 point breadboard	8	$ 39.60	Pololu	htt p://www.pololu.com/catalog/product/352
Timer	1k ohm Resistor (1.0KH-ND)	5	$ 0.26	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=1.0KH-ND
	470 ohm Resistor (470H-ND)	6	$ 0.36	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=470H-ND
	15k ohm Resistor (15KH-ND)	5	$ 0.26	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=15KH-ND
	47 uF Capacitor (P834-ND)	5	$ 0.75	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=P834-ND
	555 Timer (296-1411-5-ND)	1	$ 0.44	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=296-1411-5-ND
	Shift Register (296-2163-5-ND)	2	$ 2.88	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=296-2163-5-ND
	Inverter (296-1435-5-ND)	1	$ 0.96	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=296-1435-5-ND
	LEDs (516-1342-ND)	6	$ 3.18	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=516-1342-ND
	Power Supply Jack (#48-258B)	1	$ 1.75	Acti on Electronics	htt p://www.acti on-electronics.com/dcpowerplugs.htm#Adapters
	5V Power Supply (T314-P6P-ND)	1	$ 7.38	DigiKey	htt p://search.digikey.com/scripts/DkSearch/dksus.dll?Detail?name=T314-P6P-ND
Total		203	$107.02		

Appendix B: Student Handout

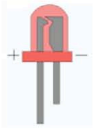
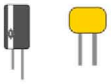
QUIZ GAME CIRCUIT



#1 – 10000Ω Resistor
#2 – 4148 Diode (dark black line oriented on right)
#3 – 470Ω Resistor
#4 – 0.1 µF (microfarad) Capacitor
#5 – Colored LED
#6 – Push Button

Bus #1 : Reset
Bus #2 : +5 V
Bus #3 : Ground
Bus #4 : Trigger Line

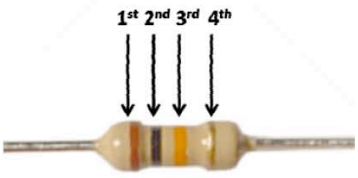
COMPONENT OVERVIEW

LED		Emits light when an electric current is applied in one direction
Diode		Allows electric current to flow in only one direction
Capacitors		Stores energy (like a charged battery)
Resistors		Prohibits the amount of electric current
555 Timer		Synchronizes the digital logic

For LEDs and Capacitors:

- Long lead is positive (anode)
- Short lead is negative (cathode)

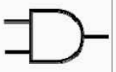
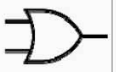
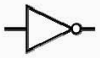
RESISTOR COLOR CHART



Note: We are ignoring the 4th band for this experiment.

Color	1st band	2nd band	3rd band (multiplier)
Black	0	0	$\times 10^0$
Brown	1	1	$\times 10^1$
Red	2	2	$\times 10^2$
Orange	3	3	$\times 10^3$
Yellow	4	4	$\times 10^4$
Green	5	5	$\times 10^5$
Blue	6	6	$\times 10^6$
Violet	7	7	$\times 10^7$
Gray	8	8	$\times 10^8$
White	9	9	$\times 10^9$

DIGITAL LOGIC OVERVIEW

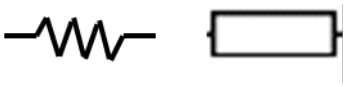
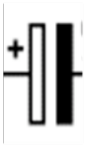
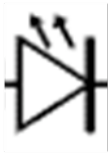
Logic	Symbol	Boolean algebra	Truth table
AND		A·B	INPUT A B / OUTPUT A AND B 0 0 0 0 1 0 1 0 0 1 1 1
OR		A+B	INPUT A B / OUTPUT A OR B 0 0 0 0 1 1 1 0 1 1 1 1
NOT		$\bar{A}$	INPUT A / OUTPUT NOT A 0 1 1 0

For this experiment:

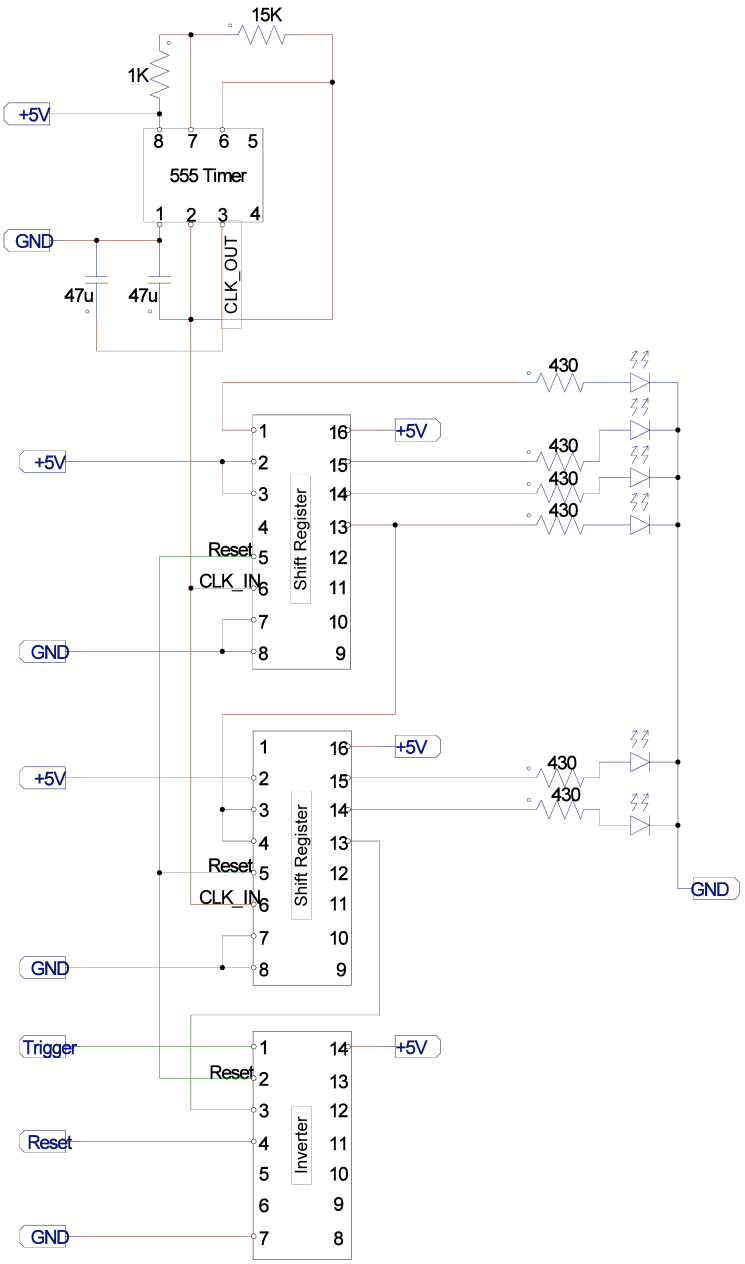
- Ground is represented by logic 0
- 5 Volts is represented by logic 1

Appendix C: Electrical Circuit Schematic Symbols

Electrical Schematic Symbols

Resistor	
Ceramic Capacitor	
Electrolytic Capacitor	
LED	
Diode	

Appendix D: Timer Circuit Schematic



Appendix E: Quiz Board Schematic [9]