

Institute for STEM Education



Stony Brook University
College of Engineering
and Applied Sciences

Strobe Light

Student Lab Guide



Engineering Teaching Laboratory

Name _____ Date _____

Lab Partner(s) _____

NEW TERMS

Electric Circuit: Electric circuits are paths for transmitting electric current, or moving electricity. Such circuits allow electricity to be used to provide power to lights, appliances, and many other devices

Capacitor: a device used to store electric charge. It is similar to a battery except it stores energy instead of providing new energy. These are used to amplify power supplies and filter out electronic ripples.

Resistor: a device that is designed to resist the passage of an electric current.

Phototransistor: a transistor that is sensitive to light. A transistor is a semiconductor device that can be either used as an amplifier of a signal or as a switch. In this design the phototransistor, Q1, will be used as a switch.

Integrated Circuit (IC): An IC is a collection of electronic components (resistors, transistors, capacitors, etc.) all stuffed into a tiny chip, and connected together to achieve a common goal. In this design, the IC will function as a timer.

Printed Circuit Board (PCB): a board that mechanically supports and electrically connects electronic components using conductive tracks, pads, and other features etched into the nonconductive board in copper. Components are generally soldered onto the PCB.

Sampling: the act of choosing a subset of similar samples from a set of samples. One can sample music, optics, motion and much more. Today we will design a strobe light as an optic sampler.

Electromagnetic radiation: a kind of radiation including visible light, radio waves, gamma rays, and X-rays, in which electric and magnetic fields vary simultaneously.

Aliasing: the misidentification of a signal frequency, introducing distortion or error which can make one real object can be observed in many different ways depending on how it is sampled.

Stroboscopic effect: a visual phenomenon caused by aliasing that occurs when continuous motion is represented by a series of short or instantaneous samples.

Terms to be familiar with:

Circuits
Series
Parallel
Voltage
Electricity
Conductors
Insulators

INTRODUCTION

Current, voltage, and resistance are related through Ohm's Law ($V = I * R$). Simply put, a current is defined as a voltage across a known resistance and a voltage is defined as the current through a known resistance. Putting together voltage, current, and resistance develops a circuit. Circuits are very powerful tools used all throughout our daily lives. They are used to turn on our lights in the house and power our electronic devices. Circuits are composed of various components that contribute to its functionality. They all need a power source to function and have different combinations of resistors and capacitors to determine what the output signal will be. The output can be regulated by how many of these components are present, as well as the components' values. This will lead to different circuits making different signals. In this lab activity, a circuit will be built to control the flash rate of a light.

The human eye is able to detect flashing lights up to a certain flash rate that varies from person to person but is usually somewhere around 60 times per second. At flash rates higher than this frequency, the human eye can no longer detect the brightness variations and the light appears to be constantly illuminated. Human vision also exhibits *persistence*, which means that the image of a briefly illuminated object is retained by the visual system for a brief instant even after the light has been extinguished. This effect is exploited in motion picture films – the images are displayed as a series of brief flashes that appear to be continuous.

If a flashing light is used to illuminate an object in an otherwise dark environment the object will only be visible when the light is shining. Since the light is on for only 1% of the duration of each flash, the object is effectively only visible for 1% of the time and it is in the dark for the other 99% of the time. If the object is in motion, and the flashing is faster than can be directly observed by the human eye, the moving object will appear as a series of apparently stationary objects. Thus, a dancer would appear to be in multiple places at once – with each image perfectly clear and apparently stationary.

When an object illuminated by a flashing light in an otherwise dark room is observed it appears to leave a trail of stationary objects in its wake. We say the position of the object has been *sampled* by the flashing light since the position is only recorded once during each flash. This process of making measurements at regular intervals is known as sampling and it is important in many fields. For instance, a self-driving car may use a radar system to sample what is near the car at regular intervals, and a digital recording system uses a microphone to sample the local air pressure (i.e. sound) typically 44,100 times per second. The relatively poor audio quality of a cell phone conversation is due in part to sampling at a lower rate in order to minimize the data required to carry the conversation.

The sampler built here can be used to observe and measure many interesting physical phenomena. For instance, the device can be hung by a long string and used as a pendulum. If a camera capable of long exposures is used to observe the flashing pendulum a trail of dots will reveal the sampled location of the flasher. The velocity can be found from the spacing between the samples and the known flashing frequency of the unit. The potential energy can be measured by the change in height of the unit. These two measurements can be combined to show that the total energy (kinetic plus potential) of the pendulum remains constant during the swing. Long-exposure images can also be used to study elastic or inelastic collisions, the acceleration of a falling body, the acceleration of a ball rolling down a plane, the operation of Newton's cradle, or parabolic trajectories. In these cases, the flasher is used to illuminate the objects producing a trail of samples - the spacing between the samples and the known flash rate yields the velocity).

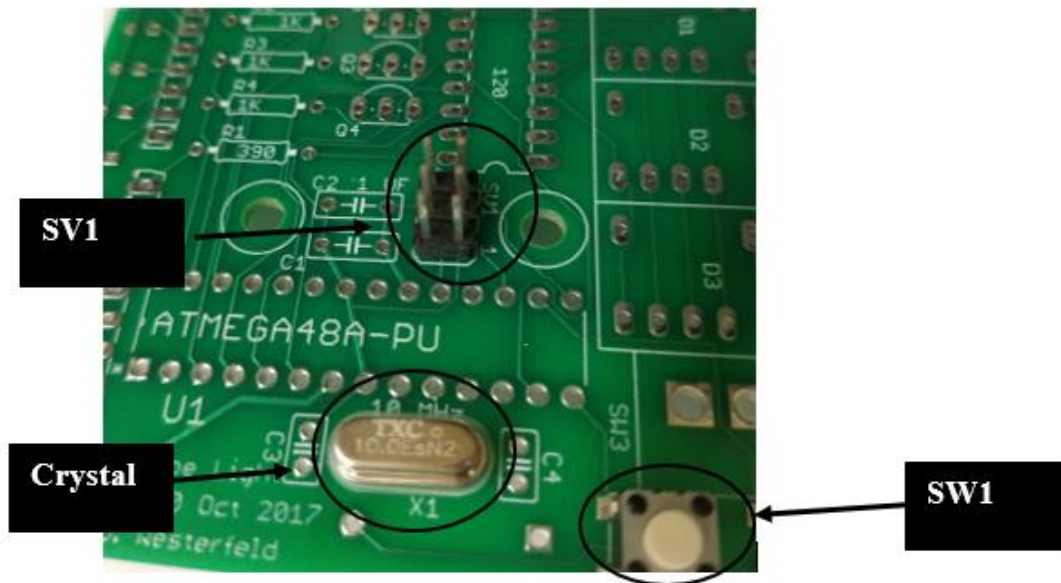
PROCEDURE

A) Value Critical

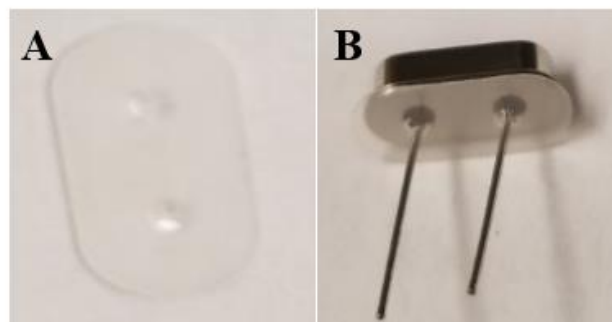
These components can be installed either way around, but you must be very careful to install the right component in the right holes. Check the resistor color codes carefully and ask for assistance if you are not sure Also, the different capacitor values may look very similar.



1. Install a 390 ohm (orange white brown gold) resistor at location R1.
2. Install a 100 ohm (brown black brown gold) resistor at location R2
3. Install a 100 ohm (brown black brown gold) resistor at location R3.
4. Install a 100 ohm (brown black brown gold) resistor at location R4.
5. The 0.1 μF capacitors is blue. Install it at location C2.
6. The 1 μF capacitor is the orange one that is all by itself. Install it at location C1.
7. The 22 pF capacitors are the orange components stuck to a piece of tape. Install one at location C3.
8. Install the other 22 pF capacitor at C4.



9. Install a tactile switch at location SW1. Align the switch so that the leads fit into the holes (the pin pattern is rectangular, not square) and press firmly to snap the switch into the board.
10. The quartz crystal is packaged in a metal can. To prevent short circuits, find the (nearly invisible) plastic insulator (A) and slide it all the way onto the crystal's (B) leads as shown below. Install the crystal at location X1. Trim the crystal leads.

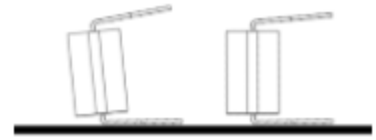


11. Install the 6-pin connector at SV1. The **pins have a long side and a short side; install it with the short pins going into the board.** These pins are too stiff to bend, so just turn the board over carefully and let the weight of the board hold it in place. Solder one pin of the 6-pin connector. Turn the board over and check that the connector is straight. If it has moved, ask for help in straightening it. Solder the remaining connections.

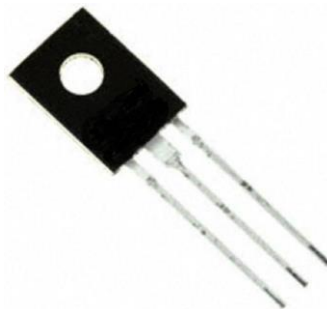
B) Orientation Critical

The following components must be installed in a particular direction. After installing the component, solder it down and trim the leads if necessary.

1. Locate the resistor array with two rows of pins (16 legged). Notice that the pins on one side of the chip are not parallel with the other side. Place the chip on a flat surface and bend all of the pins perpendicular to the chip body.



2. Look at the resistor array and notice that there is a small notch on one end – this notch also appears in the component outline on the circuit board at location RN1. **Align the notch on the chip with the notch on the board and install the resistor pack on the board.** Bend the corner leads to hold it in the board.
3. Locate the two resistor arrays that have a single row of 8 pins. Look carefully to see that there is writing on one side of the component. Note that there is a dot **at one end of the writing**. Look at the circuit board location **RP1** and notice that one of the end holes is marked differently than the others – it has a box around it and a partial X through it. **Install the resistor array at RP1 with the dotted end going into the X marked hole.** Bend the end two leads so that the component does not fall out.
4. Install another resistor array at **RP2**. **Again, install the resistor array with the dotted end going into the X marked hole.** Bend the end two leads to keep in place. Solder the resistor packs down.
5. Three of the transistors are the same and one is different. Take the different one and look at it from above. Notice that the body has a very slight taper. **Match the taper to the outline** at location **Q1** and install the part. There will be a 3mm (1/8 inch) gap between the board and the body of the transistor



6. The remaining transistors have a flat side and a curved side. **Install a transistor at Q2 with the curved side matching the outline on the board.** This component also has a 3mm gap to the board. Similarly, install transistors at Q3 and Q4.



7. Install the slide switch into location SW3. **Put the two switch pins into the holes with the metal pads.** There should be no pins in the hole without metal. Secure the switch with a clothes pin. Verify that the components are installed matching the outlines on the board and then solder them down. Trim the transistor leads.
8. Install the individual LEDs. **These LEDs are mounted on the solder side of the board and soldered on the component side.** It's a bit crowded on the top so solder from the edge in, trimming leads as you go to maintain access

- a. Inspect the 11 LEDs in your kit. Notice that they have one long lead and one short lead. Insert the LED at location LED0 with **the long lead going into the hole with the square pad. Be careful.**
- b. Similarly, install LEDs in locations LED1 through LED10 with **the long leads going into the holes with the square pads.**
- c. Solder the LEDs to the board and trim their leads.



9. Install the 7 segment (numeric) LEDs. Match the pin pattern of an LED with the hole pattern at D1 and install the part. Install another 7 segment LED at D2 and D3. Solder the components and trim their leads.



10. Notice that the 28-pin socket has a small notch in one end, similar to the resistor pack we saw before. Notice also that the outline for U1 has a (tiny) notch on one end (hint: it is near the first 'A' in ATMEGA). Install the socket in the board so that the notches are aligned. Be certain that the pins of the socket are perfectly aligned with the holes in the board and press the socket into place. Look at the back and verify that all 28 pins have come through. Solder the socket to the board

Socket



11. Using the table like you did with the resistor pack, bend the leads on the 28-pin microcontroller until they are parallel. Notice that the microcontroller has a small notch on one end. **Install the microcontroller in the socket with the notch in the chip aligned with the notch on the socket.**

Microcontroller



12. Turn your board over and you will find two holes, labeled '+' and '-'. Your battery pack has a red wire and a black wire. Put the red wire into the '+' hole and the black wire into the '-' hole. Solder the wires.
13. Put the **black wire from the battery pack into the round pad**. Solder the battery wires and trim off any excess wire.
14. Inside the battery pack, you will find two mounting holes. Notice how the holes are countersunk to receive the head of a screw. Install a #2-56 screw in one of the holes so that the head nestles into the countersink. The battery pack will be screwed to the solder side of your board as indicated by the white outline. Align the pack with the outline and pass the screw through the board.
15. Install a fiber washer over the end of the screw. Install a nut on the screw and tighten the screw just enough to take the slack out. Similarly, install the second screw. Gently snug the screws. Do not overtighten them.

16. Move the slide switch so that the slide is closer to the edge of the board. This is the OFF position. Install three AAA batteries in the pack, following the engraving inside the pack.

C) Testing

Ask the instructor or teaching assistant to load the testing software on your board so you can test your circuit.

QUESTIONS

1. What is the stroboscopic effect? How was this concept applied to our project?

2. What is aliasing? Please provide an example.

3. What do you think the software added by your instructor did to your design?

4. What does the Nyquist rate theorem tell us? What is an example of a device that applies this theorem in its functionality?

5. Which electrical component in your design was used to code the design?

6. What is the function of transistors in the hardware design?
