Alarm Circuit
Intruder Detecting Mat with a 555 timer

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Open Ended Design Project

Description:
This experiment explores an Alarm Security Circuit. The circuit is driven by the 555 Timer IC circuit. An open contact of the circuit at the trigger pin 2 is connected to a detecting mat which will activate an audio output buzzer when the mat detects an intruder.

Overview:
The design project herein demonstrates the 555 Timer IC in the monostable operation. Otherwise known as a "one shot" pulse generator, this configuration allows the user to set a time delay to control a circuit requiring a specific time duration. An event in the input pin will cause an output in the output pin of the 555 for the delayed time. In this application the detecting mat will activate the alarm when someone (intruder) steps on it. Once the alarm is triggered, it will eventually switch off the audio output buzzer after a predetermined time; this will be long enough to frighten the intruder away or alert nearby passerby, but not so long that it become a nuisance to yourself.

In the base state when the detecting mat doesn't detect an intruder, the trigger pin is tied to VCC through R1, and the output doesn't display an output. The internal BJT connecting at the discharge pin is displaying a base current leading VCC to ground through the resistor R2, and the C1 capacitor to be discharge. The comparator at the input pin monitors the input and compares it to 1/3 of VCC. When the detecting mat detects an intruder, the mat will act as a switch and the input pin will be shorted to ground. It is because the input pin sees ground and is below 1/3 of VCC, the comparator would show a high on the set of the flip flop. Also, the Q of the flip flop will be set to high and be shown at the output pin. At the same Q' of flip flop would display a low and switch off the base current of the internal BJT at the discharge pin. This will cause the C1 capacitor to charge through the R2 resistor. The comparator at the threshold pin monitors the capacitor voltage and compares it to 2/3 of VCC. When the intruder steps off the mat, the comparator at the input pin would display a low at the flip flop set. When the capacitor reaches 2/3 of VCC the comparator at the threshold would display a high at the reset. This would reset the flip flop and the Q would display a low and be shown at the output pin. At the same time the Q' of the flip flop would display a high and switch on the base current of the internal BJT at the discharge pin. This would return the 555 timer to its base state where the VCC is grounded. The R2 resistor and the charge of the C1 capacitor is discharging to ground through the discharge pin. The comparator at the threshold pin would display a low on the reset of the flip flop and would hold its current state.

Additionally, the R1 and R2 resistor prevents VCC from being shorted to ground. The Control Voltage pin of the LM555 Timer provides access to the 2/3 of VCC voltage divider point. This allows an external control to the threshold and trigger levels to be above 2/3 of VCC. When not in use, the LM555 datasheet recommends that the pin be connected to ground through a 0.01 μF bypass capacitor. This bypass capacitor is to "clean up" the signal and prevent possible fluctuations in the RC time delay circuit. The LM555 Timer IC can be re-setted by tying the reset pin to ground. During normal operation, this pin is connected to VCC, to deactivate it.

Graphics and Implementation:

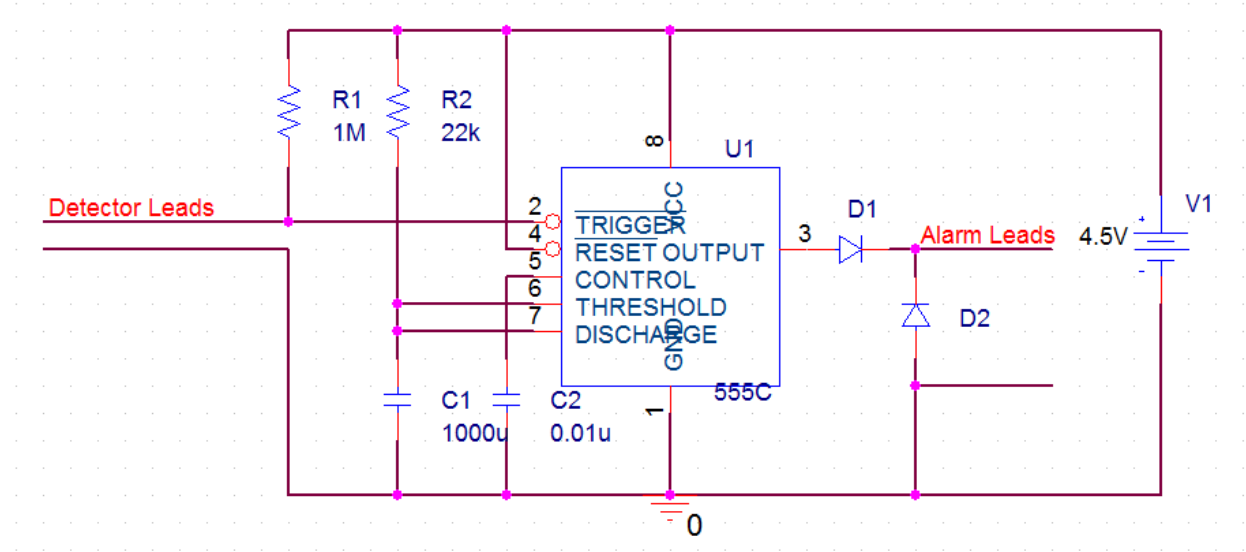

Figure 1: A Complete Alarm Circuit Diagram

In Fig.1, the alarm circuit is made up of four different building blocks: the input or detection portion, the output or the alarm portion, the control circuitry with 555 timer IC, and the power supply. The power supply is coming from the three batteries (each battery supply 1.5). The input part of the circuits has connected a 1M resistor and the sensor mat, which is connected to the trigger pin. The control system or control circuitry with the LM555 timer IC consists of the 22k resistor, and the 1000µF and 2 other pins of the LM555 timer IC. At last, the output connects with two other diodes and pin3 of the LM555 timer IC, as well as ground.

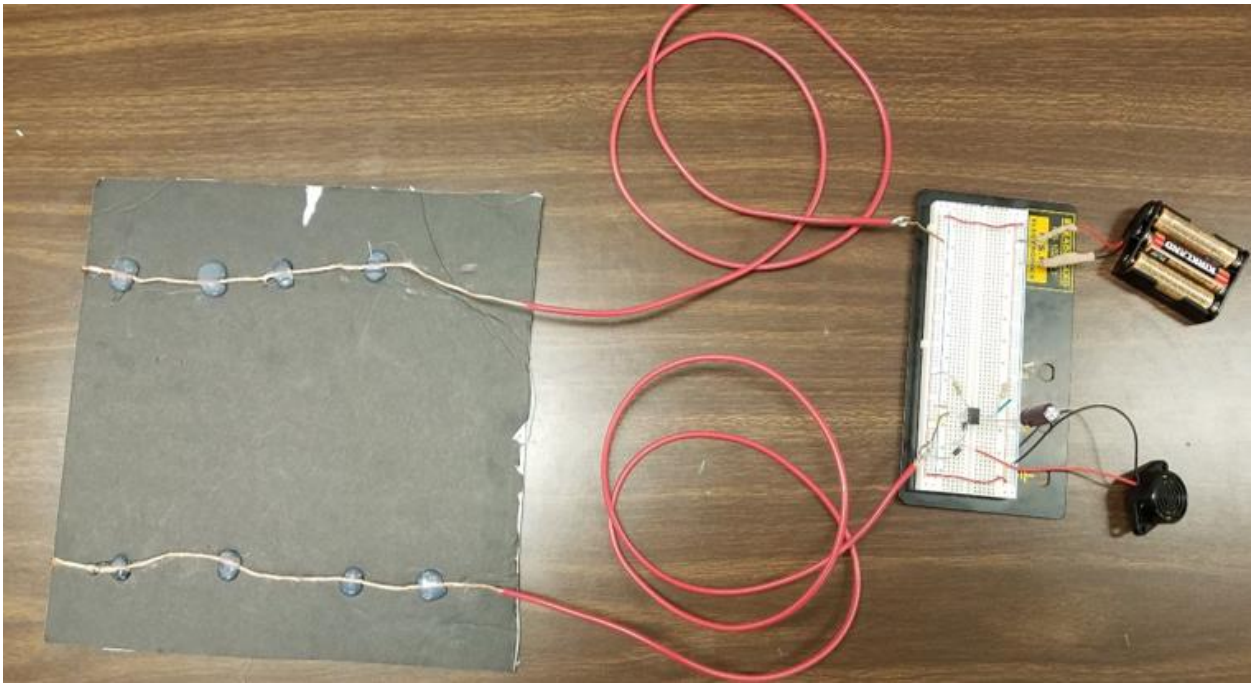

Figure 2: A Pressure Sensitive Mat

The sensitive mat was built with foam board and copper wires. As you can see in Fig.2, we connected a long wire, so we can move the mat around with less problem. However, the circuit is sending the signal through the wire and we used hot glue to hold the two leads on to the board. The two wires have each a current coming from the built circuit. One of the wires works as a ground, and the other wire works as the signal from the entire circuit.

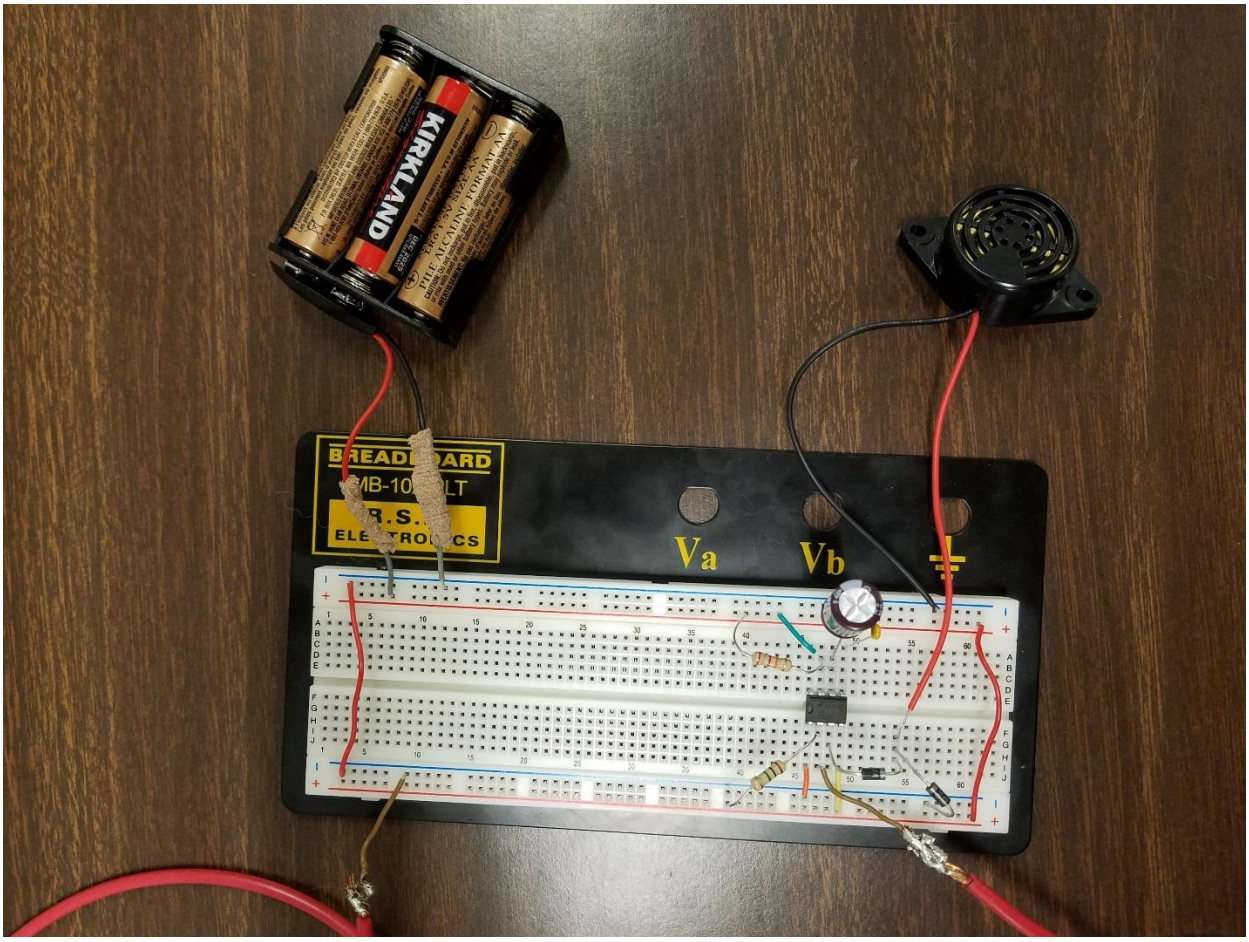

Figure 3: A Complete Circuit Layout on Breadboard

Figure 3 (Entire Circuit Layout/Description):
This circuit is powered by three 1.5V batteries that are wired in series to create 4.5V power supply. This will provide the minimum voltage required to operate the LM555 Timer IC, as the LM555 requires between 4.5V-16V.

After connecting the 4.5V batteries power supply to the circuit, the detecting mat is open, and the trigger pin is tied high. It is because the trigger pin is inverted, there should not be an output and we should be able to see nothing happens just yet. But, when the detecting pad detects an intruder, the circuit is close, and the trigger pin is tied low, below 1/3VCC. Due to this inverted trigger pin, it will create an output and activate the audio output alarm for a period that is predetermined, once the intruder steps off the detecting

mat. The length of time that the alarm will sound depends on the resistor, R2, and capacitor, C1, which are connected to the threshold and discharge pins. This time delay is calculated from the formula: Time = 1.1 x R2 x C1. In this case we have 24.2 seconds = 1.1 x 2KΩ x 1000μF. We can change the time delay for the circuit by changing either the resistor, the capacitor, or both. For example, if we replace the capacitor with a 100μF capacitor we would reduce the time, such that 2.42 seconds = 1.1 x 2KΩ x 100μF.

Experiment:

As circuit works as expected, we can set the pressure sensitive mat in a place that we want to protect from an intruder. For instance, we can place the pressure pad under a mat on our bedroom and/or on a doorway of our house. Now we can switch on the very alarm when we leave our room; doing so, if someone steps on the mat, he/she will get a surprise. Of course, when that happens intruder will try to escape, but it won't matter even if they have step off the pressure mat because the monostable circuit that we built will continue to operate the buzzer for 24.2 seconds. The buzzer will make a pretty loud noise that will frighten away the intruder, and it will also warn us that someone (a possible intruder) has entered our room; we can investigate the very situation.

Materials Used:

The components that was used are a 555 Timer IC, an Audio Buzzer, 2 1N4003 diode, a 1000μF capacitor, a 0.01μF capacitor, 3 AA batteries, a 1M resistors, a 22K resistors, and a detecting mat. A 100μF capacitor was also used to demonstrate how changing the capacitor and the resistor that is connected to the threshold and discharge pins changes the delay for the alarm.

Challenging Things About the Project:

- Building the pressure mat: Initially we try to build the mat using a foil paper because we thought it is a good conductor, but soon realized that it pretty much short-circuited the trigger pin2 to the ground and switch (buzzer) was on without any delay on time.
- Allocating time: Since we all have had different work/school schedule, we did face a minor problem working together on this project.

Interesting Things About the Project:

- In the process we realized the time delay is mainly conjoined with Capacitor. Meaning, for this very circuit higher the capacitor values, higher the buzzer time will be.
- We can also connect LED to the output ports which are pin3 and resistor, and it would be on for about 24 seconds too.
- We also build the circuit using different valued resistors and construct the very information: For this circuit resistor with 22 Ohm wouldn't alarm the circuit because it causes time delay to be below 0.0242 seconds.

Works Cited

1. Instruments, Texas. “LM555 Timer (Rev.D).” Timer, Jan. 2015.
2. Scherz, Paul, and Simon Monk. *Practical Electronics for Inventors*. McGraw-Hill Education, 2016.
3. Dossis Nick. *Basic Electronics for Tomorrow Inventors*. Thames and Kosmos. 1st Edition.