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ECE 110 Honors Project Final Report: Electronic Bike Theft Deterrent

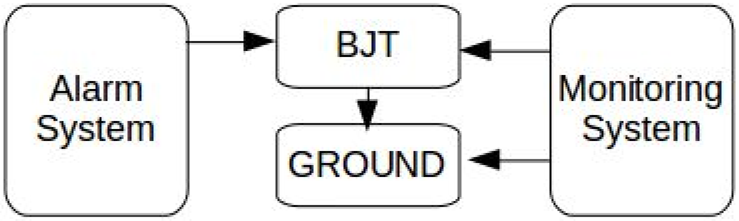
I. Introduction

If you plan on using a bike as your main mode of transportation, a bike lock is a necessary item, especially on a college campus. However, with the right equipment, a thief can easily overcome the protection of a bike lock, whether it's a u-lock, chain lock, or wheel lock. A lock can be an easy way to deter theft, but if a thief actively chooses to steal a bike, it becomes easy to surpass the low level of protection provided by a basic lock. When it comes to bike theft prevention, a more advanced lock system could greatly reduce the likelihood of a bike being stolen.

In devising a solution, we wanted to find a cost-effective way to deter theft. The cost to downright prevent theft would be too high compared to the price of a bike, but it would not be too difficult to greatly deter theft. With our system, we added a high-volume buzzer that goes off when the circuit is broken (which occurs when the bike lock is broken). The system adds a cheap level of extra protection against theft, and it would greatly boost the bike's security. As soon as the thief breaks the lock, the alarm would go off, alerting anyone nearby that a theft is in progress. And as long as the alarm was connected to the bike itself, the thief would have to take the extra time to disable the alarm before running off with the bike. It is a simple added level of safety to bike locks that would help to deter theft.

II. Design

Block Diagram



Block Descriptions

- <u>Monitoring System:</u> The purpose of the monitoring system is to detect if the bike lock has been cut in anyway. The system has five main components. It consists of a 3 volt source (2 1.5V batteries) in series with a green LED (to indicate the system is on), a 470 Ohm Resistor, and a switch (for us to turn it on and off during testing). The final component is a wire that would loop the length of the bike lock and connect after the switch and before the batteries. Based on the status of the monitoring system there will be a different voltage at the node connected to the BJT transistor base. When there is nothing out of the normal, this node has a voltage of zero. If the lock has been severed, the node has a voltage of 0.7 volts (BJT turn-on Voltage). This works due to the wire that is running along the bike lock. This wire connects the base of the BJT to ground (0 volts) making all 3 volts drop across the resistor and LED between the node and the batteries. If the lock is cut, this connection no longer exists. Thus, there is less of a potential difference across the resistor (the LED drop is approximately constant) leaving a voltage drop to occur across the BJT.

- Alarm System: The alarm system has three components. It has a piezo buzzer, a red LED, and a 24V source (two 12V batteries). The system's purpose is to indicate that the bike is being tampered with and/or stolen. All three components are connected in series. First the voltage source, then the buzzer, and then the LED. When the alarm system is activated, the buzzer will sound and the LED will turn on. The system is connected to the collector of the BJT. When the BJT is on the circuit will be completed and the alarm sound.
- BJT: The BJT transistor acts as the controller for the alarm system. It controls the alarm system based on the state of the monitoring system. The monitoring system is connected to the base. The alarm system is connected to the collector and the emitter is grounded.

Drawings and Pictures

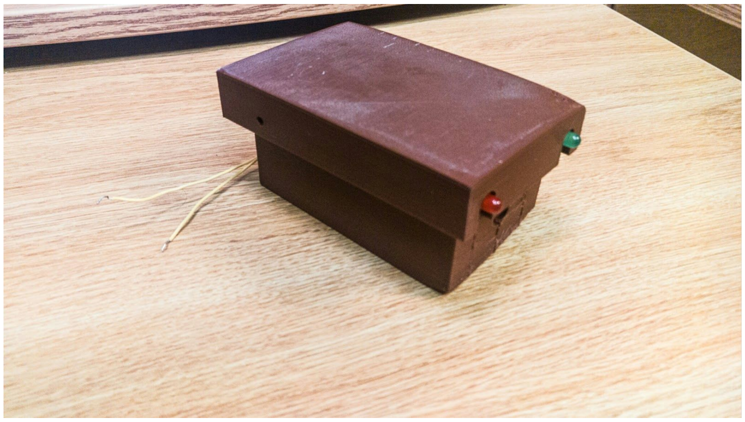


Image one: This image shows the final product. On the front of the container, the two LEDs (red and green) are visible. The two yellow wires on the back of the container would loop around the bike lock.

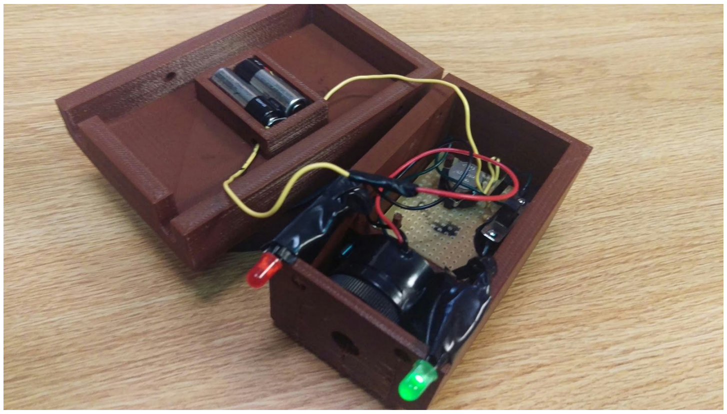


Image two: The interior of the container is shown. The 12V batteries are mounted on the top of the container. The green LED is on indicating that the system is active.

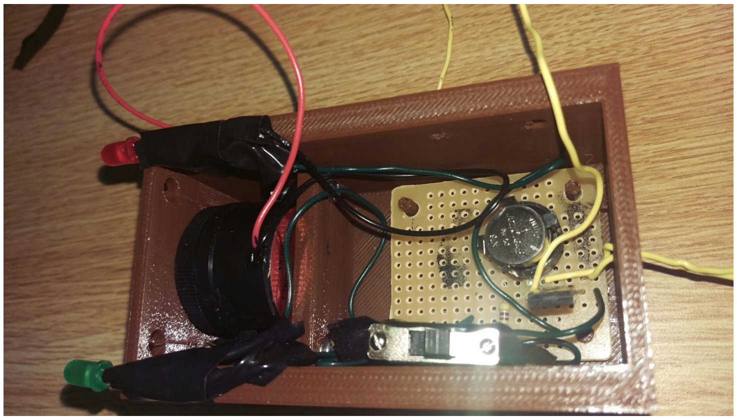
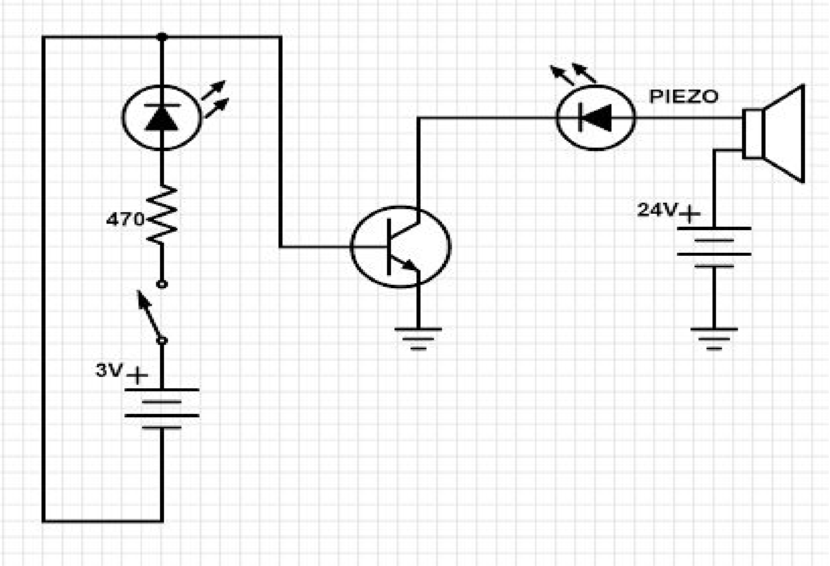


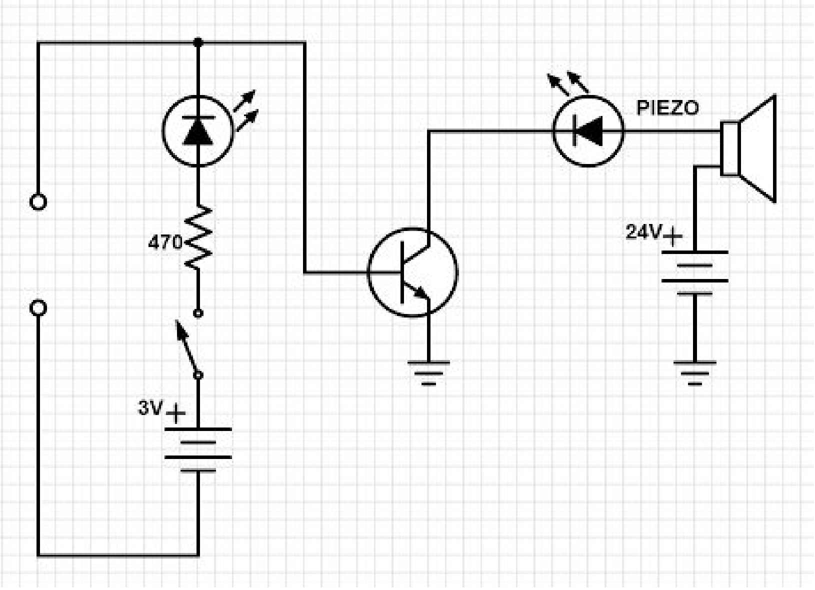
Image three: On the left is the alarm system and green LED. The alarm is mounted to the half height wall using the ⅛” bolts it came with. The protoboard is mounted on four pegs on the bottom of the box. With the top on, the 12V batteries fit in the space between the components on the protoboard and the half-wall.

III. Results

Our project worked as expected. Once the mock lock was “cut” from the bike, the alarm and the red light activated. Before this happened, the green LED was on to let the bike user know that the system was armed. This would hopefully deter any would-be bike thief from committing the theft. The complete un-cut lock circuit schematic is shown below:



The switch in the main branch of the base acts as an arming mechanism. If the switch is open, there is no possible way for a voltage difference to reach the base of the transistor, which means that the piezo buzzer will not sound if the branch is cut. When the system is armed and the lock is cut (see schematic below), the current is forced through the transistor, creating a voltage drop, which connects the emitter and the collector, and allows the piezo buzzer to sound.



If the system is on and armed while the lock still connected, the power consumption is just the voltage times the current. This would be 3 Volts times the current through the resistor. Due to ohm’s law, the current through the resistor is (3-2.1)/470, which is approximately 2 milliamps. Therefore, the power consumption on standby is 6 milliwatts. The 3-volt source has about a 0.3 amp hour rating, so that means that, on standby, the system would last approximately 150 hours. This standby power consumption is a bit higher than our team would have hoped for, but we also wanted to make sure that the bike user could see the green light in daylight to ensure the system is armed. When the buzzer is going off, the power consumption is a lot higher, but it does not need to continue for as long as the standby system.

IV. Future Work

Through our project we learned a lot about the process of taking an idea to a final product of sorts. We had to weigh the options of making the product have many features or making it more feasible. We decided to try and create a more feasible project. There are several areas that we will look to improve in order to make this a useful tool. First of all, the problem of power consumption and being on/off. When the system is activated it consistently has a small power consumption. This means that it drains the battery even if the bike is being ridden or stored somewhere that it does not need to be locked. The power is being drained whether the lock is being used or not. To combat this in our product we have a switch (seen above in image three and the schematics). This switch allows us to turn it off when it is not in use. Obviously, on a real product this would make it an ineffective deterrent - a thief could just turn off the alarm. We can look into a way that only the owner of the bike could turn off the system. The switch could remain if the box was secured in a way that only the owner could open it and it could not easily be broken into.

A second way that we can improve the system is by improving the container. The current container does hold all of the components in a way that works - it would even be able to be mounted underneath most bike seats. It is still bulkier than it needs to be. The walls and base are thicker than they need to be (due to the fact that we were unsure of the strength of the 3D printed material). This could be scaled down to make it about ½” smaller in both directions. Additionally, we do not need the entire protoboard, it could be cut in half or even only be one third the size. The batteries and LED’s could also be mounted in a more compact way. Putting all of these options together would allow the container to be much more compact.

One other improvement we could make that would help enable the previous improvement would be better battery contacts/holders or overall battery system. The batteries need to be accessible so that they can be changed as needed. This is why the 12V batteries are currently on the top of the container. The system also has the 1.5V batteries. Perhaps we could look into a way to have these replaced with a capacitor charged by the 12V battery or a voltage divider circuit at some point to reduce the number of batteries. This would also allow the system to be smaller and enable the green light to indicate that the 12V batteries are still good as well. Even if this change is not made, the 12V batteries need a more reliable mounting system so that they have a constant connection to the circuit. This is the most important improvement that could be made as it would allow the system to consistently function. Our current mounting locations and systems proved to be somewhat unreliable and took up more space than necessary. If all of these improvements were to happen, we would have an even more feasible product - it would be smaller, cheaper, and more reliable.

V. Conclusion

When everything was in order, the bike theft prevention system exceeded our expectations. When everything was set up properly, the circuit worked properly and the buzzer would be loud enough to alert passersby that a theft was in progress. In addition, the 3D-printed container successfully contained all of the circuitry and wires, creating a fully-contained “final product”. Throughout the course of the project, we were also able to follow our set schedule each week, making only slight adjustments as we went along. We began with a basic concept, but by the end of the project, we had a proper product that could be mounted to a bike and used in a true bike lock system.

However, along the way we also had our fair share of unexpected events. In our initial plan, we wanted to add a wifi shield with a microcontroller to allow the system to alert the owner of the bike that their bike was being stolen. This system was too complex and expensive, so we limited the anti-theft system to a simpler circuit with only a buzzer. In general, we also ran into constant issues debugging the circuit. Nearly every week, either the wires weren’t connected properly, the batteries ran out of juice, the LEDs burned out, or the soldered connections broke. We spent an inordinate amount of time fixing problems with the circuit, and it limited the time we had to actually work on the circuit and improve it. Overall, we had to work around major changes in our design on top of issues pushing our work forward, making it difficult (but not impossible) to have our final product ready by the end of the semester.

By the end of the project, we came away with a much better understanding of engineering and project teamwork. First, we learned a lot about how to build a final, functioning product from an idea. We had to conceptualize, brainstorm, design, prototype, revise, debug, finalize, and ultimately create our bike theft prevention system. After the project, we have come away with a greater understanding of the nuances involved in carrying out an idea from the initial concept to its final form, growing and shaping it throughout the process. We also learned about the intricacies involved in real-life engineering. When working on real projects, you plan for all the problems you imagine you could face, but new problems can still come up. If you want to succeed, you must be able to adapt to changes and possibly use them to your advantage. We have realized that a project requires a lot of planning and preparation, but there can still be unpredictable changes that you have to learn to deal with. Finally, we learned how to (truly) work as a team. In the beginning, we believed we were automatically working as a team since we had the same project, but we were working off our respective ideas as if we were carrying out three different projects. We had to learn to share our thoughts to make decisions as a team. We learned to bounce ideas off of each other and make sure we were all working toward the same goals instead of having our own agendas. In the end, this project has taught us a lot about working as an engineering team to produce a real product that solves a real-world problem.