Bike Theft Lock & Chain Detector

Electrical & Computer Engineering

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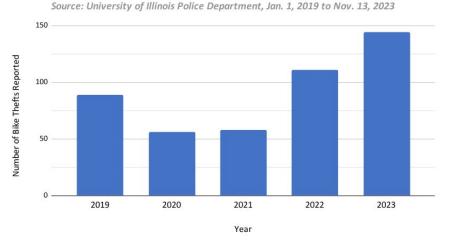Team 74

30 March 2024

Background

- An estimated 856-1070 bikes are stolen each year in Champaign-Urbana.
- Only 5-10% of bike theft cases are solved in the campus area.
- Bike theft often goes unnoticed when locks are cut (nighttime, limited witnesses).

Number of Bike Thefts Per Year on University of Illinois Campus
Source: University of Illinois Police Department, Jan. 1, 2019 to Nov. 13, 2023

Solution: The Bike Theft Lock & Chain Detector

1) Deters theft attempts.
2) Alerts the public & the bike owner to a crime.
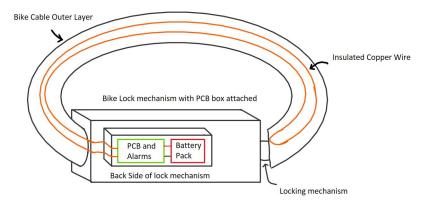3) Captures evidence that can enable bike recovery.

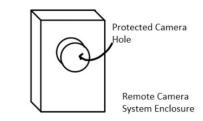# How it Works

Two Primary Modules:

Voltage Detection Subsystem

- A voltage is supplied the cable and an open circuit is detected by the microcontroller if the cable is cut.
- The primary microcontroller on the bike chain sends out a signal to trigger an alarm and triggers the client microcontroller (ESP32 camera module) to capture images.
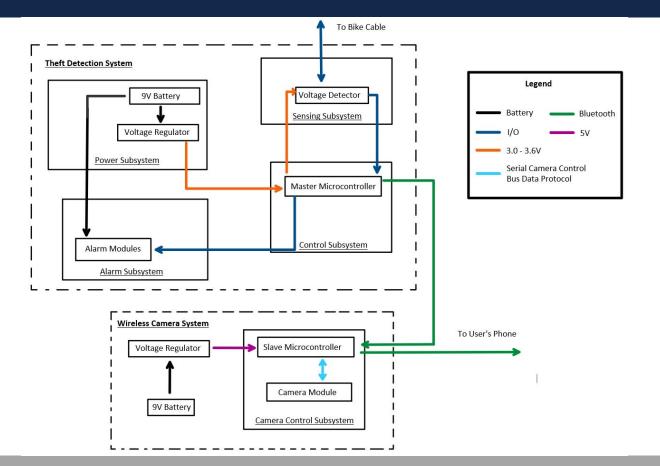
Camera Subsystem

- When the cable is cut, our camera positioned on the bike will record images that may potentially identify the criminal.
- These images are relayed to the user via Wi-Fi connection.

Bike Cable Outer Layer
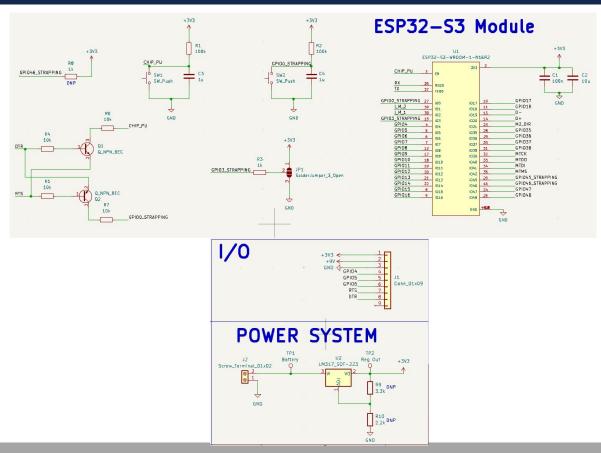
Insulated Copper Wire

Bike Lock mechanism with PCB box attached

PCB and Alarms

Battery Pack

Back Side of lock mechanism

Locking mechanism

Protected Camera Hole

Remote Camera System Enclosure

Block Diagram

ESP32 Microcontroller

- Voltage Regulator (9V->3.3V).

- Bluetooth and Wi-Fi.

- When wire is cut, alarm sounds.
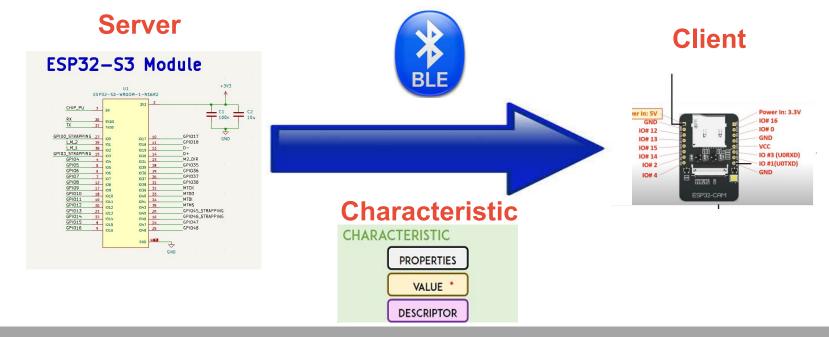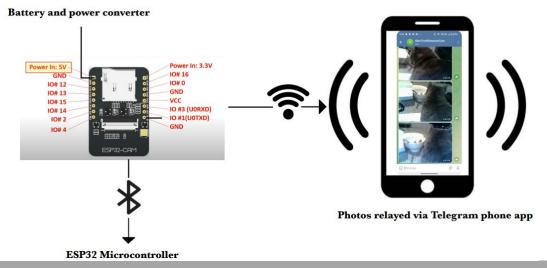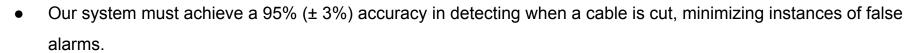 - Powered directly from the microcontroller.

ESP32 Bluetooth Server

- Bluetooth BLE: server that notify the client once open circuit is detected.
- Save energy.
- Client disconnect from server once signal is received in order to switch to Wi-Fi.

Server

Client

BLE

Characteristic

ESP32 Camera

- ESP32 Cam powered at 5V.
- Bluetooth connection with server microcontroller which disables after signal is sent to client.
- ESP32 Cam is connected to the internet via Wi-Fi.
- This allows the microcontroller to exploit both BT and Wi-Fi capabilities, despite having a single antenna.

- We utilize a Telegram bot to relay images over the internet to the bike user's phone.
- Includes 2 images and timestamps.

Battery and power converter

Power In: 5V
GND
IO# 12
IO# 13
IO# 15
IO# 14
IO# 2
IO# 4

Power In: 3.3V
IO# 16
IO# 0
GND
VCC
IO #3 (U0RXD)
IO #1(U0TXD)
GND

ESP32-CAM

ESP32 Microcontroller

Photos relayed via Telegram phone app

- Our system must achieve a 95% (± 3%) accuracy in detecting when a cable is cut, minimizing instances of false alarms.
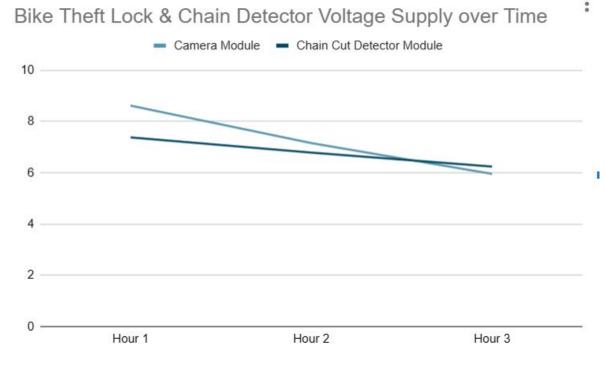- The system should capture images within 5 seconds (± 3 seconds) of detecting an open circuit. This will ensure that detection is prompt and evidence is collected in a timely manner.
- The system should set off an alarm within 5 seconds (± 3 seconds) of the cable being cut.
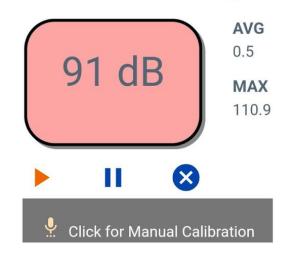- The batteries of the detector should last for about 3.0±0.5 hours.

- 0.57V average drop per hour for chain cut detector module.
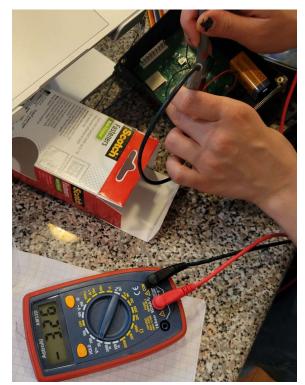- 1.33V average drop per hour for camera.

Bike Theft Lock & Chain Detector Voltage Supply over Time

Camera Module — Chain Cut Detector Module

Requirement: Alarm will be triggered within 1.5 ±0.25sec after the lock is cut.	**Verification**: 1.0 second after wire cut until alarm triggers.
Requirement: The subsystem provides a constant 3.3±0.3V voltage to the sensing subsystem.	**Verification:** 3.26V supplied from ESP32 IO-pin to sensing subsystem.
Requirement: 65±15 dB sound recorded from within 5 feet of alarm module.	**Verification**: 91dB sound detected 5 feet from the alarm.

Decibel reading captured on app.

Cable voltage reading.

Requirement: Capture images within 5 seconds ± 3 seconds of detecting an open circuit.	**Verification**: First photo captured 4.5 seconds after wire is cut.
Requirement: Indicate when the power supplied to the camera has reduced below 4.3V±0.1V.	**Verification:** Light indicates when voltage drops below 4.26V.
Requirement: Voltage regulator steps down the voltage from 9V to 5V±0.5V to power the camera control subsystem.	**Verification:** 5.19V supplied to the camera.

5.19V camera power voltage reading.
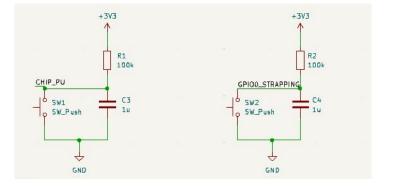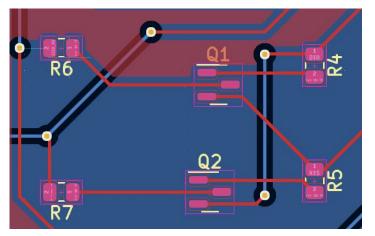
Ethical Considerations

- Illinois privacy laws: a person may not be secretly recorded in certain private spaces.
- Voltage: Not significant enough to cause any harm to an individual (below 50V).
- Waterproofing

Problems Encountered

- Voltage regulator not working as intended.

- Wires disconnecting inside camera enclosure.

- ESP32 disconnecting and reconnecting constantly due to capacitors by the switches.

- Shorting components while testing with multimeter.

- FTDI USB programming failure.

- Using Wi-Fi and Bluetooth in parallel.

Possible Future Improvements

- Have user capability to turn off alarm remotely via cellphone.
- Integrate an LTE chip with the ESP32 cam for greater range.
- Design a PCB instead of the ESP32-CAM module to reduce unnecessary power consumption.
- Improve battery life by supporting rechargeable batteries or 9V batteries in parallel.
- Improve battery life indicator.
- Boost alarm sound.

91 dB

AVG
0.5

MAX
110.9

Click for Manual Calibration

Questions?

References

[1] "Bike Theft in Champaign-Urbana," Bikelab, Sep. 12, 2014. [Online]. Available:
https://bikelab.shop/blog/bike-theft-champaign-urbana [Accessed Feb. 9, 2024].

[2] B Crane, "Bike Theft Surges on University of Illinois Campus, but Online Reporting System Aids Police Investigations," January 4 2024. [Online]. Available: CU-CitizenAccess, https://cu-citizenaccess.org/2024/01/bike-thefts-surge-on-university-of-illinois-campus-but-online-reporting-system-aids-police-investigations/. [Accessed Feb. 9, 2024]

[3] IEEE, "IEEE Code of Ethics," ieee.org, Jun. 2020. [Online]. Available:
https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed Feb. 10, 2024]

[4] ACM, "ACM Code of Ethics and Professional Conduct," Association for Computing Machinery, Jun. 22, 2018. [Online]. Available:
https://www.acm.org/code-of-ethics [Accessed Feb. 10, 2024]

[5] "Handson Technology Datasheet ESP32-CAM WiFi+Bluetooth+Camera Module." [Online] Available:
https://www.handsontec.com/dataspecs/module/ESP32-CAM.pdf [Accessed Feb. 10, 2024]

[6] Texas Instruments, "LM317 3-Terminal Adjustable Regulator," Texas Instruments, 2020, [Online]. Available:
https://www.ti.com/lit/ds/symlink/lm317.pdf. [Accessed: Feb. 10, 2024]

[7] eneloop101, "ENELOOP RECHARGEABLE BATTERIES, THE BEST!," [Online]. Available:
https://eneloop101.com/batteries/eneloop-test-results/ [Accessed: Feb. 18, 2024]

References (Continued)

[8] National Semiconductor, "LM117/LM317A/LM317 3-Terminal Adjustable Regulator," Jameco Electronics Jun. 2006 [Online].
Available: https://www.jameco.com/Jameco/Products/ProdDS/898800.pdf [Accessed Feb. 22, 2024]

[9] "ESP32-S3-DevKitC-1," Espressif, Nov. 30, 2002. [Online]. Available:
https://dl.espressif.com/dl/schematics/SCH_ESP32-S3-DevKitC-1_V1.1_20221130.pdf. [Accessed Feb 22, 2024]

[10] Espressif Systems, "ESP32-S3-WROOM-1 ESP32-S3-WROOM-1U Datasheet,"
Espressif Systems 2023 [Online]. Available:
https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf [Accessed Feb. 22, 2024]

[11]"Train-the-Trainer: Basic Electricity Safety," OSHA, April 2019. [Online]. Available:
https://www.osha.gov/sites/default/files/2019-04/Basic_Electricity_Materials.pdf [Accessed Feb. 22, 2024]
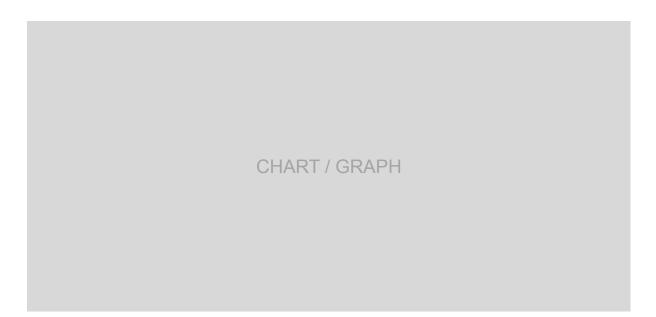
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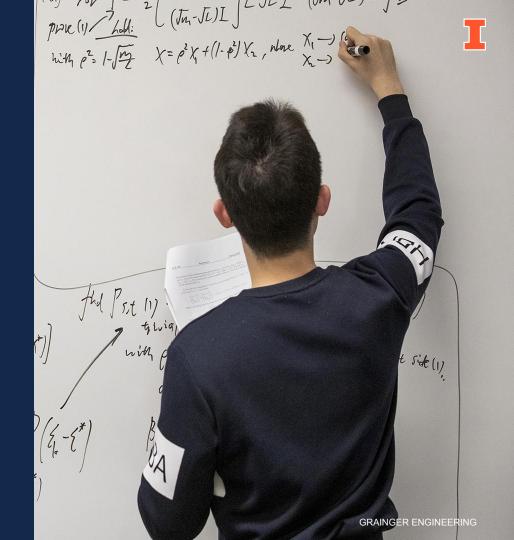
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