# Car Catalytic Converter Theft Prevention

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# 1. Introduction , Objectives and Background

## 1.1 Problem

A catalytic converter is a device on cars that converts toxic gas from the car's engine into non-toxic gas. This device uses precious metals to convert the gas and is located at the bottom of the car. Car Catalytic Converter has become an increasingly common problem for various reasons, the first reason being that it's very easy to steal. The converters can be easily removed by thieves, and it can also be done very quickly. Another reason that thieves tend to steal these converters is that they are valuable as scrap metal. They contain precious metals and can be sold to scrap yards ranging from 150 to 200 dollars a piece. Finally, what makes these converters an easy steal is due to the fact that they are hard to trace, so the thieves can easily get away with it [3]. In the past year, car catalytic converter theft has risen by 400% [1].

These thefts are a large inconvenience to many car owners. According to an incident in Champaign County, the car owner paid $1,900 for replacement and repairs [2]. Most victims end up having little evidence aside from stolen converters, and low quality video evidence.

## 1.2 Solution

According to experts, car owners can prevent car catalytic converter theft by adding a camera, motion sensors or flood lights to deter thieves [3]. We will implement this into our solution. Our solution is to create a surveillance device for catalytic converter theft. The device would be able to detect suspicious activity, be compatible with a standard car's electrical system, give real time notifications to the owner when the crime is happening, and would be mounted discreetly. Another feature would be having a camera functionality to solve the low quality surveillance video issue, and setting off an alarm when the suspicious activity occurred.

To create this device, we will use a vibration or motion sensor to detect if a thief attempts to move the car when it is parked. This sensor will trigger the alarm system which will scare off the thief. Then, it will send a notification to the car owner's mobile phone or device. The sensor will also trigger the camera to try to capture the thief and create evidence for the theft.

## 1.3 Visual Aid

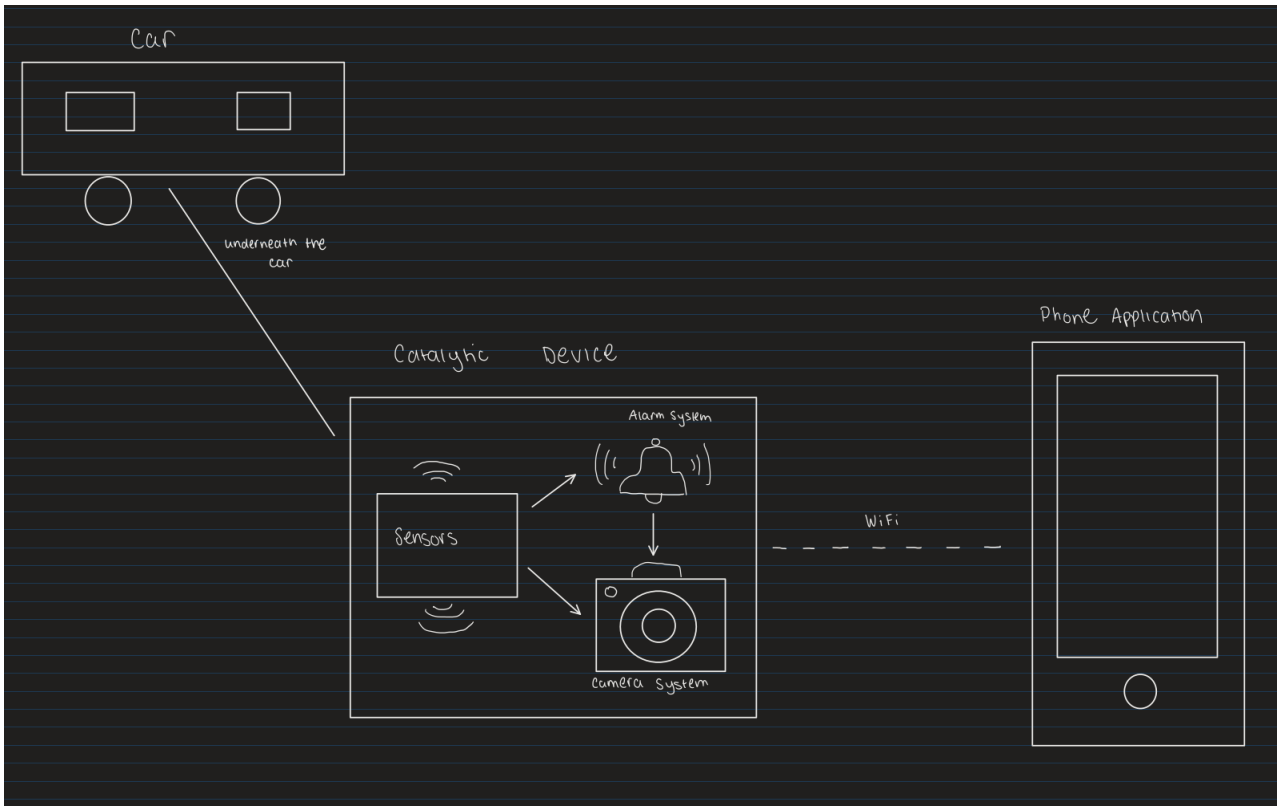

Figure 1: Visual Representation of the Solution

### 1.4 High-Level Requirements

1) The device must be able to trigger the sensor within 5-15 seconds after the car has been tampered with. The device must also trigger the sensor at least 3 out of 5 times after it has been tampered with.
2) After the sensors are triggered, the system must trigger the alarms and send a notification to the user within 5-15 seconds. The camera must also start recording within 30 seconds after the sensor has been triggered.
3) The system must be able to display a high quality camera feed, and the camera feed must be between 3 to 5 minutes long.

## 2. Design

### 2.1 Block Diagram

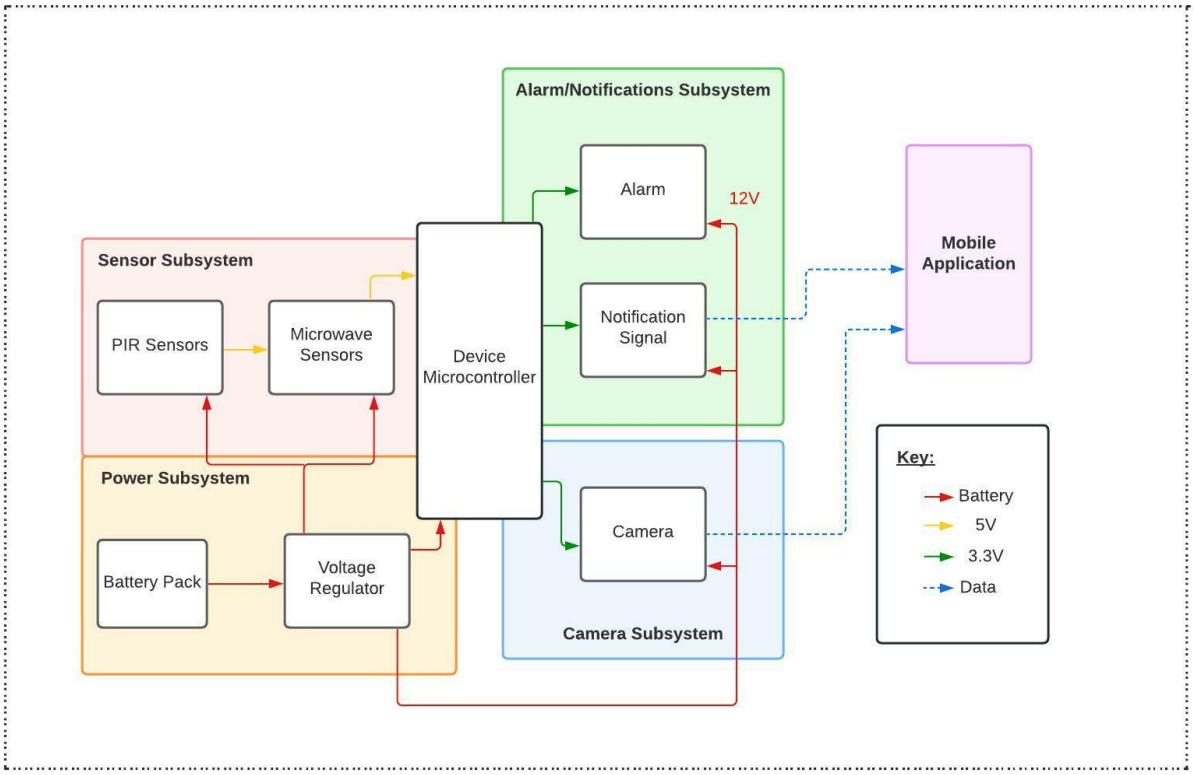


Figure 2: Block Diagram of the Solution

## 2.2 Subsystem Overview and Requirements

### 2.2.1 Power Component

The purpose of the Power subsystem is to be able to power the other adjoining subsystems in order for them to function cohesively. Our power subsystem comprises a 12 Volt Battery, that will power the Sensor subsystem, Alarm subsystem and Camera subsystem. A requirement for this subsystem is that it needs to output 12 Volts of energy, in order to power the adjoining subsystems.

### 2.2.2 Sensor Subsystem

The Sensor Subsystem is made up of tilting and vibrations sensors. The main purpose of this subsystem is to be able to sense any suspicious activity occurring, and then accordingly and accurately alarm the system. The sensors will be triggered if a car that is in park is tilted or if any vibration is detected in the undercarriage.

Sensors that can detect this activity include the Passive Infrared (PIR) sensor, which is used to detect the presence of a human, Microwave sensors that use continuous waves of microwave radiation to detect motion, and Dual Tech Motion Sensors, which incorporates both PIR and Microwave sensors in order to have less false positives.

The Passive Infrared (PIR) sensors are small, low power, easy to use, and inexpensive. The way it senses movement is by sensing the change in temperature between the background

and a warm body. The sensors contain  a pyroelectric sensor that detects levels of infrared radiation, which is useful as the human body emits a good amount of heat. The way the sensor works is that the PIR has two slots made of a special material that is sensitive to infrared. When the sensor senses a differential change between the two slots, this causes a pulse, saying that it has detected a movement. Due to this, the amount of false positives this sensor has is very minimal, but also because of this specific design, the amount of area this sensor can cover isn't as much [4].

Microwave Motion Sensors use continuous waves of microwave radiation to detect motion. The way they work is that  it sends out a high radio frequency and measures the reflection off an object by sensing a frequency shift. If it does detect a frequency shift, the motion detector is activated. Microwave sensors can cover a larger area than PIRs, but they tend to be more expensive. They also cause more false positive alarms [4].

Dual Tech Motion Sensors incorporate both PIR and Microwave sensors to have less false alarms. A quick rise in temperature in the room can cause the PIR to go off while wind can move an object and trigger the microwave sensor. With the Dual Tech/Hybrid, both sensors will need to sense changes which will trigger it on, causing false alarms to be extremely low. The drawback with these sensors is that they tend to be very expensive and used in more high risk scenarios [4].

After analyzing the different types of sensors, the system will include a mix of both PIR and Microwave sensors. The requirement for this subsystem is to accurately and quickly sense suspicious movement, and once that movement is sensed, it should be able to trigger the alarm system that will make the alarm noise, the camera system to start recording to feed, and send a notification to the user, alerting them of the activity. The sensors should only trigger the other subsystems if there is suspicious activity/movement for more than a few seconds, and when the movement/activity is continuous.

### 2.2.3 Alarm Subsystem

The Alarm Subsystem is comprised of two components: a physical alarm and a notification alert sent to the user. This subsystem utilizes a 120 dB, battery operated, voltage controlled alarm [5] and sends a notification to the car owner's phone via WiFi. The purpose of this subsystem is to set off an alarm and alert the owner if a thief attempts to steal a catalytic converter from a car. The Alarm Subsystem will be triggered by the Sensor Subsystem, i.e., when the vibration and tilting sensors are triggered. If the sensors are triggered for longer than a few seconds, the Sensor Subsystem will send a signal to the alarm subsystem, which will trigger the alarm to start ringing.

The 120dB alarm will be attached to the undercarriage of the car alongside the remaining subsystems and is wear resistant, impact resistant, heat resistant, and low temperature resistant [5]. These features will help combat the various temperatures and wear and tear that the alarm will be exposed to. Additionally, the alarm will continue to function even if the car heats up or overheats. Another important feature is impact resistance, which ensures that the alarm will continue to ring (to a certain extent) even if a thief attempts to break or remove it. The alarm by default will ring for 3-5 minutes before shutting off. However, the owner can manually turn off the alarm sooner through their phone.

When the Alarm Subsystem is triggered, a notification will be sent to the owner of the car informing them of any suspicious activity. This function will be dependent on WiFi, as the device will use WiFi to send the notification to an app on the owner's phone, alerting them of potential theft in real time.

#### 2.2.4 Camera Subsystem

The Camera Subsystem consists of two aspects: the physical camera and the camera live footage. The purpose of the camera is to capture footage of the theft. The camera subsystem will be triggered by the Sensor Subsystem. When the Sensor Subsystem detects motion and vibrations, it will send a signal to the Camera Subsystem which will turn on the camera and record footage.

The camera specifications will be based on the microcontroller the team decides to create. The camera must be compatible with the microcontroller's ports as the microcontroller will need access to turning on and off the camera. It must also be compatible with the microcontroller's interface as it needs to allow the camera files to be received and sent to an external system, the mobile app.

This camera will either capture a video or capture a series of images within a specific amount of time. According to the high-level requirements, the camera must be able to capture between 3 to 5 minutes of footage and upload it to the car owner's mobile phone. Along with the notification system, we can add the camera footage on the mobile app. This is where the car owner can retrieve the live camera footage. The camera must also face a direction where it can spot the thief as well as capture high-quality images. This means when the car is tampered with the device can capture the thief in quality lighting.

## 2.3 Tolerance Analysis

An important risk factor that we identified is the accuracy of our sensors in the sense that if they are able to detect the suspicious activity accurately and quickly, in order to signal the other subsystems. If our sensors aren't able to detect suspicious behavior/movement, it can't signal the alarm system or the camera system, hence not being able to notify the user. With this risk factor in mind, it is key to analyze the different types of sensors we could use, and which ones will be most beneficial for our project. It is worth noting that a successful sensor will be able to detect heat signatures, hence not just triggering when inanimate objects blow by such as leaves or other miscellaneous objects. Another important aspect of the sensor is being able to detect suspicious activity in a measurable area, which in hindsight means the sensor should be able to cover a decent amount of area. With these key characteristics in mind, we were able to find sensors that possess these attributes.

Going off the aspect of sensors, we also needed to understand sensors as a whole, and the characteristics they have. One characteristic of sensors that is very important to our device is the sensor's response time. Sensors don't change their output state immediately, rather, they change to a new state, which is referred to as the response time. The response time is defined as the time required for the sensor output to change from its previous state [6].

## 3. Ethics and Safety

One of the safety issues that will need to be considered is the device's power system. We can charge the device with the car's battery, but we will need to add safety features so it does not drain the car battery. One solution would be to only turn on the device when the car is parked. Another solution would be to use a rechargeable battery that way the device is not constantly using power from the car.

Another safety concern is the car electronics damaging our device or our device damaging the car. This will become a greater issue while testing our device on the car. We will need something to separate our device and the car. We can create a cover for our device from 3-D printed material.

Our device doesn't discriminate in the sense of who can/cannot use it. The device can be used by anyone who has the issue of their car's catalytic converter system being stolen or even tempered with. With that being said, the device is open to the public, and thereby complies with section 7.8 II-7 of the IEEE Code of Ethics. Our device also abides by section 7.8 I-1 , as the device is promoting safety by trying to reduce the number of stolen catalytic devices, which increases the safety of the car itself, and the person driving the car [7].

## References


1. Way, “Catalytic converter thefts: Most targeted cars listed.” Way.com. [Online]. https://www.way.com/blog/catalytic-converter-thefts-most-targetted-cars-listed/ [Accessed: 10-Feb-2022].
2. The News-Gazette , “Catalytic-converter thefts have victims’ vehicles, wallets feeling the pain.” news-gazette.com. [Online]. https://www.news-gazette.com/news/local/courts-police-fire/catalytic-converter-thefts-have-victims-vehicles-wallets-feeling-the-pain/article_cc7a5545-c3a5-54f3-bbda-3ae1d1c94c5c.html [Accessed: 10-Feb-2022].
3. American Family Insurance, “How to Prevent Catalytic Converter Theft.” amfam.com. [Online]. https://www.amfam.com/resources/articles/on-the-road/prevent-catalytic-converter-theft [Accessed: 10-Feb-2022].
4. Arrow, “How Do Motion Sensors Work? Types & Applications.” arrow.com. Online]. https://www.arrow.com/en/research-and-events/articles/how-motion-sensors-work#:~:text=Motion%20Sensors%20Explained&text=There%20are%20three%20types%20of,%2C%20and%20Dual%20Tech%2FHybrid [Accessed: 10-Feb-2022].
5. “Electronic Buzzer Alarm,” *Amazon*. [Online]. Available: https://www.amazon.com/Electronic-Buzzer-Security-Speaker-Burglar/dp/B0875WCSB5/ref=sr_1_13?keywords=12+volt+alarm+siren&qid=1644354141&sr=8-13. [Accessed: 10-Feb-2022].
6. NI, “Sensor Terminolog.”ni.com. [Online].https://www.ni.com/en-us/innovations/white-papers/13/sensor-terminology.html [Accessed: 10-Feb-2022].
7. IEEE Board of Directors. “IEEE Code of Ethics.” IEEE Code of Policies, Section 7 - Professional Activities (Part A - IEEE Policies). https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 10-Feb-2022].