Florida Light and Power

Image Recognition for Pad Mounted Equipment

Preliminary Detailed Design

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Preliminary Design Report

Introduction

Pad mounted transformers are common devices in residential areas, as they convert higher main-line voltages to lower voltages needed for households. Currently, when one transformer experiences a fault, all transformers connected to it must be manually inspected in order to locate where the fault has occurred. This is a laborious and time-consuming process. To address this problem, this project's goal is to develop a hardware beacon that indicates faulted FPL pad mounted equipment. Then, to collect a sample image library and train a corresponding image recognition system to detect and locate the beacons from autonomous drone or ground vehicle footage. Related requirements are to accurately indicate faulted equipment from a distance of up to 50 feet and in various environmental conditions. Also, to securely mount a beacon to the pad-mounted equipment. Finally, to develop a real-time image recognition system to locate transformers and beacons with 80% accuracy.

Selected Concept

The selected design is a hard plastic lever that will securely mount to the transformer's exterior. It has a smooth exterior to minimize the potential of damage from tampering or environmental factors. The surface is slightly sloped which allows water to drain off of it quickly. After the beacon has been mounted, a durable sealant will ensure that the design is watertight and long-lasting in a variety of conditions. When a fault has occurred, a pre-existing internal fault current indicator sends power to the design. This causes the lever to rise and turns on an LED on the end of the lever. The computer vision system will be trained to detect the change in shape of the beacon and the location of the LED. It will first locate the transformer, then the beacon, and finally denote if the beacon lever is up or down. If the lever doesn't lift, the LED will still be visible to provide an additional detection option. This design was selected for its ability to be visible in a variety of conditions and transformer locations.

Preliminary Design

The initial state of the device will have the lever arm down and the LED off. The picture below shows the preliminary CAD drawing of the design. The big green box represents the transformer. The device is curved to satisfy a few of the customer requirements, one being the device needing to last and also not be intrusive to both the transformer and the surroundings. A curved design will prevent standing water on the device, which will help it withstand rainy weather conditions.

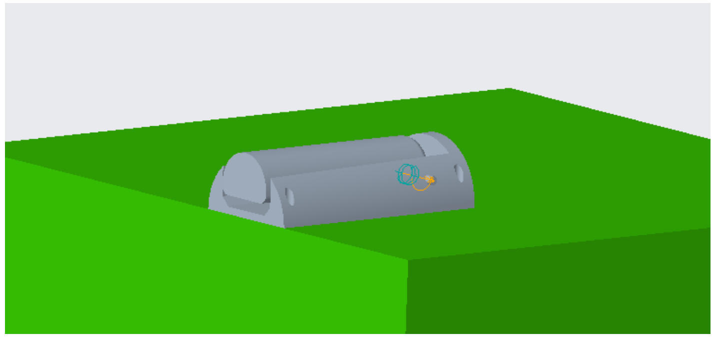


Figure of CAD in initial state

After the device receives power from the FCI it will spring to the open state where the lever arm is lifted to a 90 degree angle and the LED will be powered. This is shown in the figure below.

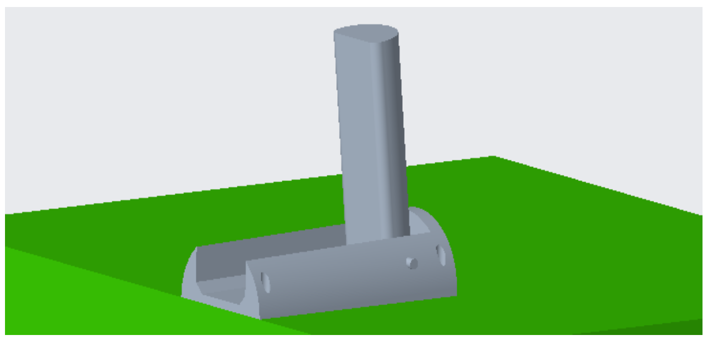
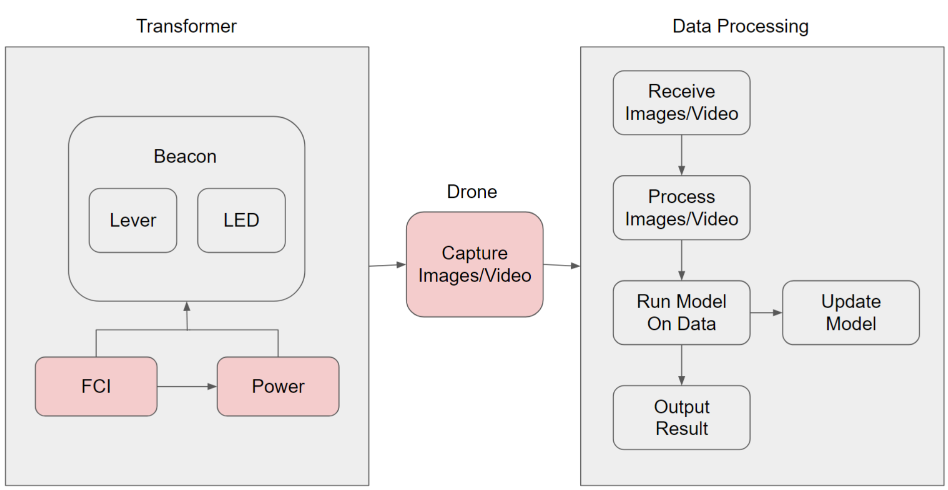


Figure of CAD in open state

When the lever arm is up it will be locked in place until a FPL technician comes to reset the device when they fix the fault in the transformer. This upraised position is what the computer vision system will detect before indicating that the device has experienced a fault. The top face of the lever is an LED that will also turn on when the device is upraised.



Block diagram - selected design concept.

Implementation of Components

The red component blocks on the block diagram are components that are being handled by FPL. Their inputs and outputs impact the project's design, but the team is not responsible for their functions or design. This means the team can treat the FCI as a "black box" and aren't responsible for detecting a fault. Rather, the design can assume a fault has occurred if it has received power. Similarly, the team isn't responsible for the drone system to locate and take video footage of the pad mounted transformers. The videos and images from pre-existing drone systems will be delivered as input to the computer vision system.

The transformer has two main components, the beacon and the FCI. The FCI is a pre-existing fault current (not the team's responsibility) indicator that detects if the transformer has a fault. When the FCI detects a fault it will send a signal and power to the beacon design. The beacon is made of two subcomponents, the lever and LED. When power is received the lever will raise to an upright position, simultaneously the LED will turn on.

Next an dorne will be used to capture an image of the transformer. All components of the drone from controlling and capturing the images or video will be handled by FPL.

Finally the computer vision system will process the images and videos taken by the drone. First it will receive the images or video from FPL. Once the images or videos are received they will be sorted into a directory along with corresponding location data. Then the images or videos will be tested on a trained machine vision model. Results will be formatted and outputted to incorporate with FPLs current system. Results can also be used to improve the model by retraining later on new data.

Component	Input	Output
FCI	Transformer Fault	Binary Signal
Power	FCI Signal	Power
Lever	FCI Signal / Power	Visual Change of Transformer
LED	FCI Signal / Power	Visual Change of Transformer
Drone	Physical State of Transformer	Images/Video
Receive Images/Video	Images/Video	Images/Video

Process Images/Video	Images/Video	Raw Data
Run Model on Data	Raw Data	Identification of State of Transformer
Update Model	Identification of State of Transformer	N/A
Output Result	Identification of State of Transformer	Text

Block Diagram Input Output Table

Summary

A system or device device should be implemented to quickly determine where the fault has occurred. The current beacon design will serve the purpose of that device. The beacon's design ensures that it will be safe to anyone who comes into contact with it, by featuring a round platform where the beacon rests until it receives power. It will be connected to the platform via a hinge connection that will allow for an upward rotation. The ability of the beacon to lift up will allow it to avoid obstructions that may hinder the output signal. The beacon and platform will be made of a lightweight and durable plastic. All aspects and components of the design were assessed based on what would produce the highest possible efficiency and confidence level.