OTTER RFID ANTENNA SYSTEM

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1.0 Introduction

1.1 Motivation

The Illinois Prairie Research Institute requires a robust RFID antenna system in order to track the movement of river otters into and out of a pond. River otters have only very recently been found in significant number in the state of Illinois, and researchers would like to monitor otter behavior to determine their impact on the ecosystem. Most commercial systems available that can read passive RFID tags from a great distance cost tens of thousands of dollars. The purpose of this project is to develop a viable system at only a fraction of the cost of a commercially available RFID antenna and receiver system.

1.2 Objectives

1.2.1 Goals

- To make an otter tracking RFID antenna system at a low cost
- To store data acquired and provide it to researchers for analysis
- To design an energy efficient system requiring minimal battery replacement

1.2.2 Functions

- To read the unique PIT (passive integrated transponder) tag IDs to identify otters
- To keep a log of otter movement into and out of the pond

1.2.3 Benefits

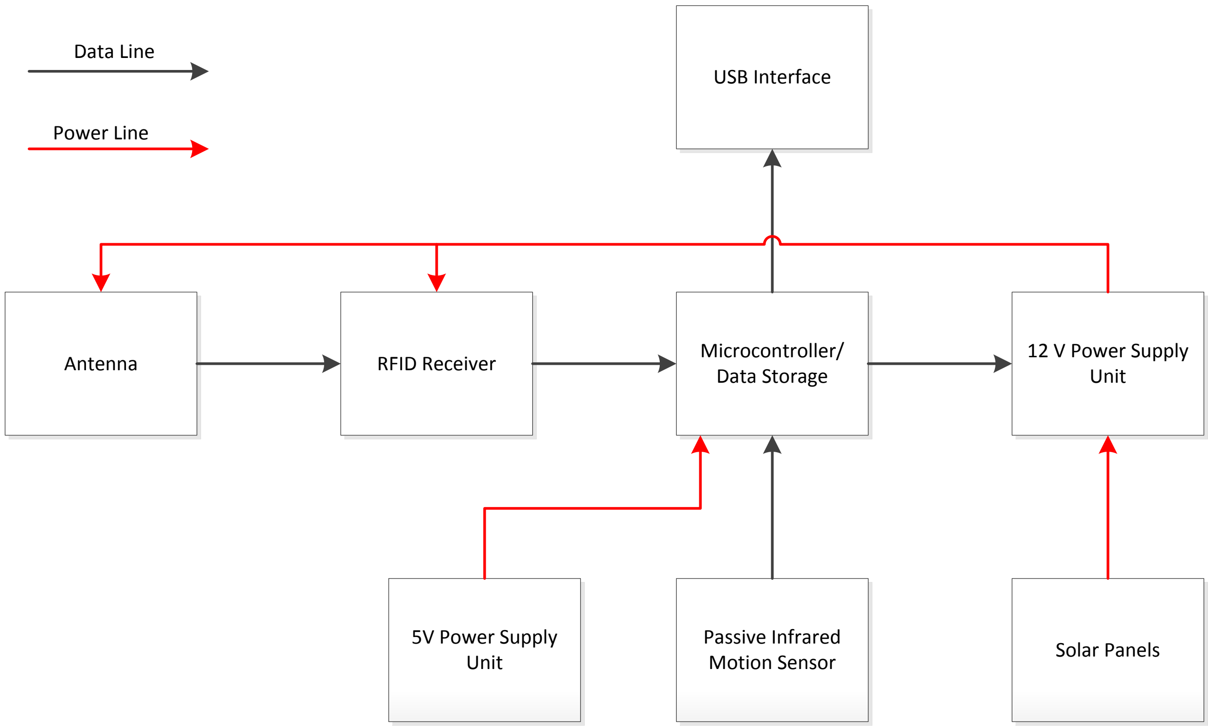
- Data acquired easily accessible by researchers
- Allows tracking of river otter terrestrial behavior in a certain area
- Cheaper RFID tracking and data collection system compared to commercially available systems

1.2.4 Features

- Solar panels to recharge batteries powering the system
- Two passive infrared (PIR) sensors to detect direction of movement and manage power consumption
- Easy access to acquired data via USB flash drive
- Energy efficient design that allows for continued use for at least a week

2.0 Design

2.1 Block Diagram



2.2 Block Descriptions

1. Antenna

The antenna that we will be using is a commercially bought rectangular loop antenna which operates at 134.2 kHz. The antenna will send a signal to the PIT tags which will power them. Using the power transmitted by the antenna, the PIT tags in return will send the unique ID number back to the antenna. The antenna then sends the data received to the RFID receiver unit. The antenna will draw power from the 12 V power supply.

2. RFID Receiver

The RFID receiver used will be a commercially bought unit. Its function will be to receive the modulated signal that the antenna sends and to demodulate it. The receiver then sends the signal forward to the Microcontroller/Data Storage unit for analysis and storage.

3. Microcontroller/Data Storage

The microcontroller receives digital signals as inputs from two passive infrared (PIR) motion sensors. When motion has been detected, the microcontroller will signal to the 12 V power supply to start powering the antenna and receiver units. The microcontroller/data storage unit will then receive information from the RFID receiver once an otter's PIT tag has been read. The unit will store the identification information, the time, and movement direction.

4. Passive Infrared Motion Sensor

The system will incorporate two passive infrared (PIR) motion sensors, which will provide signals to the microcontroller when motion has been detected. The two PIR sensors will also provide researchers information about the direction of movement of the otters based on which sensor detects motion.

5. USB Interface

The USB interface will allow researchers to download the saved data to a flash drive. The USB interface will interact with the microcontroller and memory to download the information to a connected flash drive.

6. 12 V Power Supply Unit

This unit is the main power source for the antenna and RFID receiver using a 12V car battery. When motion is detected, the microcontroller signals the power supply unit to power the antenna unit and the RFID receiver unit. To extend the battery life, a solar panel will be connected to the unit to charge the battery.

7. Solar Panels

The solar panel will be connected to the 12V car battery to charge to extend the battery life. The solar panel attaches to the 12V car battery via battery clamps.

8. 5 V Power Supply Unit

This unit powers to the microcontroller/data storage unit. A rechargeable 9V battery will be used, so when it has been discharged, it does not have to be replaced with new battery every time.

3.0 Requirements and Verification

3.1 Requirements

1. Antenna

- The antenna must be able to read a PIT tag at a minimum distance of 6".

2. RFID Receiver

- It should demodulate the signal received from the antenna and the unique ID number that is sent by the PIT tag and send that information to the microcontroller.

3. Microcontroller/Data Storage

- The microcontroller must signal the 12 V power supply to provide power to the antenna and RFID receiver when motion has been detected.
- The microcontroller must properly process and store otter ID information when the PIT tag is read.
- The data storage system must have the capacity to store a week's worth of otter movement data.

4. Passive Infrared Motion Sensor

- The PIR sensor must detect otter movement at a minimum range of 5 m.

5. USB Interface

- The USB interface must properly download the saved data to a connected USB flash drive.

6. 12 V Power Supply Unit

- The battery should not be discharged when motion has not been detected.
- If the solar panel cannot charge the battery due to weather conditions, the battery should last at least for a week by itself.

7. Solar Panels

- The solar panels must recharge the 12 V battery when sunlight is present.

8. 5 V Power Supply Unit

- The unit should supply a voltage of 5V +/- 5%.

3.2 Verification

1. Antenna

- The PIT tag will be moved across the antenna at a distance of 6”. The output of the antenna will be measured by an oscilloscope to verify that data is being read.

2. RFID Receiver

- Probe the output of the receiver with the oscilloscope to verify that data read from the PIT tags are being sent to the microcontroller unit.

3. Microcontroller/Data Storage

- Probe the output from the microcontroller with the oscilloscope to verify that a signal is sent when movement is detected.
- The memory unit will be directly accessed to verify data acquisition.

- Estimations and calculations will be made to determine the frequency of otter movement and the memory required to store that amount of information.

4. Passive Infrared Motion Sensor

- Probe the output of the PIR sensor with the oscilloscope to verify that a signal is generated when there is motion at a 5 m distance from the sensor.

5. USB Interface

- Download the data from the storage unit to a USB flash drive and verify on a PC data was properly downloaded.

6. 12 V Power Supply Unit

- The 12V power supply will be probed by an ammeter to verify that no current is drawn when no movement is detected.
- Power consumption calculations and simulations will be made to ensure the battery lasts at least a week.

7. Solar Panels

- The output will be probed using an ammeter to ensure verify current generation when the panel is exposed to sunlight.

8. 5 V Power Supply Unit

- The power supply will be probed with an oscilloscope while the entire system is under operation to verify that voltage thresholds are met.

3.3 Tolerance Analysis

The microcontroller/data storage unit is the most critical part of the design. Specifically, the signal that the microcontroller sends to the 12 V power supply is vital for power management and the longevity of the system without requiring replacement batteries. First, the microcontroller must be tested with the code developed for signaling the power supply when motion is detected. Each sensor input will be toggled on the microcontroller, and the output signal that should be sent will be probed using an oscilloscope. The output signal that is sent must be clear and any oscillations that can be interpreted as a false-positive must be avoided. The specifications and thresholds of BJT switch used will define the limits of the oscillations to avoid false-positive signaling.

4.0 Cost and Schedule

4.1 Cost

4.1.1 Labor

Name	Hourly Rate	Total Hours Worked	Total = Hourly rate x 2.5 x Total Hours Worked
Jinwoo Bae	$35.00	200	$17500.00
Charles Huang	$35.00	200	$17500.00
Sumsaamuddin Mohammed	$35.00	200	$17500.00
Total			$52500.00

4.1.2 Parts

Part	Part Number	Unit Cost	Quantity	Total
PIC Microcontroller	PIC24FJ32GB002	$4.00	1	$4.00
PIR Motion Detector	555-28027	$11.00	2	$22.00
Solar panel package		$70.00	1	$70.00
12 V Battery		$100.00	2	$200.00
Antenna	ANT-GO1E-30	$240.00	1	$240.00
Receiver	RFM-007B	$350.00	1	$350.00
PCB		$30.00	1	$30.00
Capacitors		$0.50	4	$2.00
9 V Rechargeable Battery Pack		$15.00	1	$15.00
Casing		$30.00	1	$30.00
Flash Drive		$10.00	1	$10.00
USB Type A receptacle		$1.50	1	$1.50
Memory	MX29F400CBMI-70G	$2.00	1	$2.00
BJT	MJE5850G	$3.00	1	$3.00
Total				$979.50

4.1.3 Grand Total

Labor	$52500.00
Parts	$979.50
Grand Total	$53479.50

4.2 Schedule

Week	Task	Responsibility
9/16	Research solar panels and rechargeable batteries	Jinwoo
	Finalize project proposal	Charles
	Research RFID antenna and receiver unit	Sumsaamuddin

9/23	Research and design solar panel and power supply units	Jinwoo
	Research and design microcontroller/data storage unit	Charles
	Research how to program code for microcontroller Sign up for design review	Sumsaamuddin
9/30	Finalize power supply and solar panel design schematic	Jinwoo
	Complete schematic for the PCB	Charles
	Begin programming code for microcontroller to receive and store data from RFID receiver	Sumsaamuddin
10/7	Build the 12 V power supply unit with solar panels	Jinwoo
	PCB physical layout for microcontroller and USB interface units Put in order for PCB and parts	Charles
	Program code for microcontroller to implement PIR sensor functionality	Sumsaamuddin
10/14	Build the 5 V power supply unit Test 12 V power supply unit with antenna and RFID receiver units	Jinwoo
	Verify that antenna and receiver unit are reading PIT tags	Charles
	Program code for microcontroller for data acquisition	Sumsaamuddin
10/21	Research and design physical enclosure for microcontroller/PSU/solar panels	Jinwoo
	Populate the PCB with components	Charles
	Research and design physical enclosure for antenna	Sumsaamuddin
10/28	Mock-Up Demo Preparation Order physical enclosure for microcontroller/PSU/solar panels	Jinwoo
	Program microcontroller with code developed Assemble entire system and begin testing overall functionality	Charles
	Test PIR sensors with the microcontroller Order physical enclosure for antenna	Sumsaamuddin
11/4	Mock-Up Demo Preparation Work with machine shop on physical enclosure for microcontroller/PSU/solar panels	Jinwoo
	Schematic capture and layout of second revision PCB Mock-Up Presentation Preparation	Charles
	Mock-Up Demo Signup Mock-Up Presentation Signup Work with machine shop on physical enclosure for antenna	Sumsaamuddin
11/11	Begin assembly of physical enclosure	Jinwoo
	Order second revision PCB	Charles
	Order / work with machine shop on antenna enclosure	Sumsaamuddin
11/18	Thanksgiving Break	Jinwoo
		Charles
		Sumsaamuddin
11/25	Assembly of physical enclosure for microcontroller/PSU/solar panels	Jinwoo
	Begin final paper Populate second revision PCB with components	Charles
	Sign up for demo and presentation Assembly of physical enclosure for antenna	Sumsaamuddin

12/2	Prepare presentation	Jinwoo
	Final paper	Charles
	Prepare and assemble final demo unit	Sumsaamuddin
12/9	Presentation preparation	Jinwoo
	Final paper	Charles
	Place any finishing touches on completed design in preparation for field deployment	Sumsaamuddin