Water & Pollution Level Monitoring System for a Green Roof

Engineering 90 Senior Design Project Proposal
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Introduction

A green roof is a specially designed rooftop made of a drainage system, soil, plants and several special layers that hold the soil on top of the original roof. The purpose of a green roof is to reduce stormwater runoff and filter pollutants from the water. The goal of this project is to design and implement a monitoring system for a green roof that can detect flow rate of water off of the roof and collect water samples for water quality analysis. There have not been extensive quantitative evaluations of green roof performance because such a monitoring system has never been constructed. The system we plan to design and construct will fill this void and allow precise analysis of green roof performance. In this proposal we present a technical discussion of the background necessary to begin the project, a detailed project plan, a list of required materials and a CPM timeline.

Technical Discussion

To measure the flow rate of stormwater runoff from the roof, we will use a Pelton turbine system. The turbine will rotate at a velocity proportional to the flow rate of the water passing through it. An infrared detector will measure the rotational velocity of the turbine. A beam of infrared light will shine parallel to the shaft of the turbine at a small distance above the shaft, and as the turbine rotates, its fins will block the infrared beam. The intensity of the light will be converted to an electrical signal using a photoresistor or photodiode, and the signal will have a measurable frequency of high and low values. The velocity of the turbine and therefore the flow rate can be calculated from this frequency value.

The level of the water table on the roof will be measured with a circuit using a 555 timer. The capacitance in the timing circuit will be designed to vary with water table height, and the change in capacitance will affect the frequency of the 555 timer output. The frequency can be calibrated so that we can use it to calculate the level of standing water on the roof.

The signals produced from the flow rate turbine and the water table timing circuit will be analyzed by a PIC microcontroller on the roof. The PIC will measure the frequency of both signals. The frequency measurements will be transmitted wirelessly from the roof to a computer that will record them. The wireless transmitter operates at 433 MHz, which is unfortunately one of the frequencies used by cellular phones, so the transmitter is vulnerable to noise. We will implement a coding scheme that will reduce the noise in the transmitted signal.

A possible option for the sample collector is a simple mechanical device with two sample collection containers. A better solution would be a collector device that is run by a control system.

The PIC chip will be powered by a photovoltaic cell with 5 V output. The cell will charge a battery so the system can run at night.

Project Plan

Task 1

Objective – To design and implement a system to measure the flow of water off the roof and the water table level.

Approach –

a. Initial testing of the original model (the Pelton turbine, water table capacitor and measurement system using the PIC). (2 weeks)
b. Study the layout of the roofs on Papazian and the New Dorm. Plan general design of the entire system including flow meter, water level meter, data transmitter, photovoltaic panel and sample collector. (2 weeks).
c. Design and implement the flow meter device, water level meter device, transmitting and receiving circuit boards. (4 weeks).

Output – A well-designed and functional flow meter and water level meter that can transmit data to a computer.

Task 2

Objective – To design and implement a water sample collector.

Approach –

a. Research common designs for water sample collectors that can operate within pipes. (3 days).
b. Choose a design for a sample collector and modify it for our needs. (1 week).
c. Construct the sample collector in the machine shop. (2 weeks).

Output – A well-designed and functional water sample collector.

Task 3

Objective – To implement and debug the entire system.

Approach –

a. Use controlled amounts of water to test different components of the system. (4 days).
b. Ensure that data transmitted over the wireless system will not be corrupted by noise; check to see if encoding scheme is working. (1 week).

Output – A system that can run properly in all conditions and that transmits usable data.

Task 4

Objective – A photovoltaic cell that charges a battery and power the PIC microprocessor.

Approach –

a. Research and choose a photovoltaic panel and battery that will be appropriate for our design. (2 days).
b. Connect photovoltaic panel and battery to system and test. (2 days).
c. Determine optimal orientation of panel. (3 days).

Output – a solar-powered system which is sufficient to run the system even in poor insolation conditions.

Task 5

Objective – To measure the performance of green roofs on Papazian and the New Dorm using data from our system.

Approach –

a. Record data for several rainstorms and compare to rainfall measurements to see how much rain the green roofs can absorb. (2 weeks)
b. Analyze the samples from the collector to see the concentration of pollutants in the outflow. (1 week)

Output – An evaluation of the cost-effectiveness of the green roofs on Papazian and the New Dorm.

Materials

We have:

- PIC microcontroller chips
- Wireless transmitter, receiver chips
- Computer for data logging and processing

We may need:

- Printed circuit boards - $75
- Sample collector - $100
- Turbine materials (piping, etc) - $50

We need:

- Photovoltaic panel - $50 (6 V, 3 W)
  http://www.solar-electric.com/solar-panels-1-to-39-watts.html

Milestone Chart
Water and Pollution Monitoring System for a Green Roof

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Activity																
1a																
1b																
1c																
2a																
2b																
2c																
3a																
3b																
4a																
4b																
4c																
5a																
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