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ECE 445 Proposal

Introduction

Objective:

Current sump pumps are energy efficient and due to their current design, can flood when they don't necessarily need to. The way we plan to fix this is by making a variable speed sump pump. We hope by varying the speed instead of turning on and off many times, we can save energy. We also hope that the sump pump would flood less in high water flow situations because instead of only turning on once the sump is full, it would detect the high rising water sooner and turn on to its highest setting quickly.

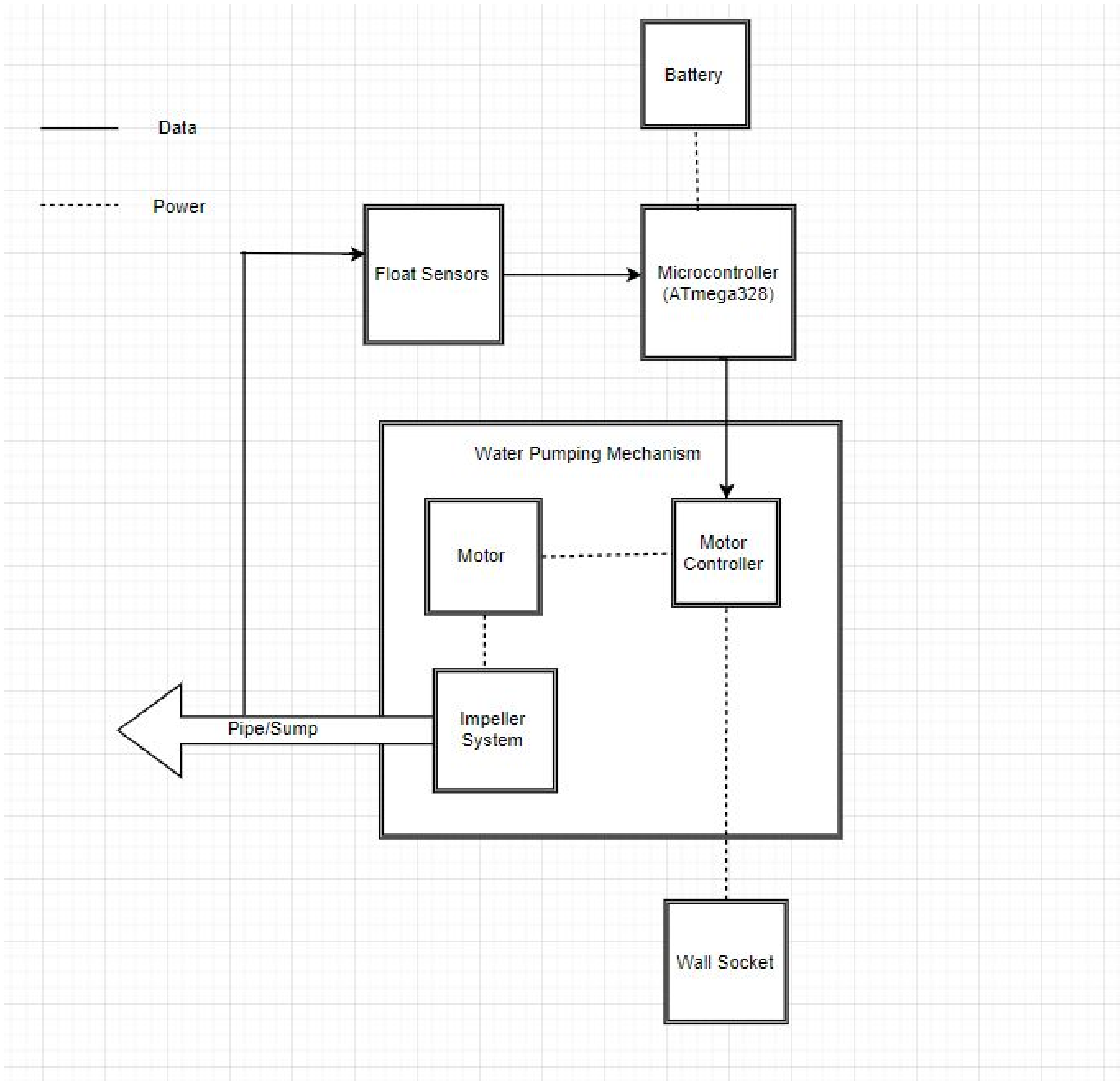
Background:

Current sump pumps on the market function just by turning a motor on when a float switch is triggered and the sump is filled.Our project aims to save energy and increase the longevity of the pump by making the process more efficient. We plan to do this by detecting how fast the water level is rising and adjusting the speed of the motor accordingly. If the water is rising quickly, the motor should move faster and if the water is increasing slowly, the motor should run slower.

High-level requirements list:

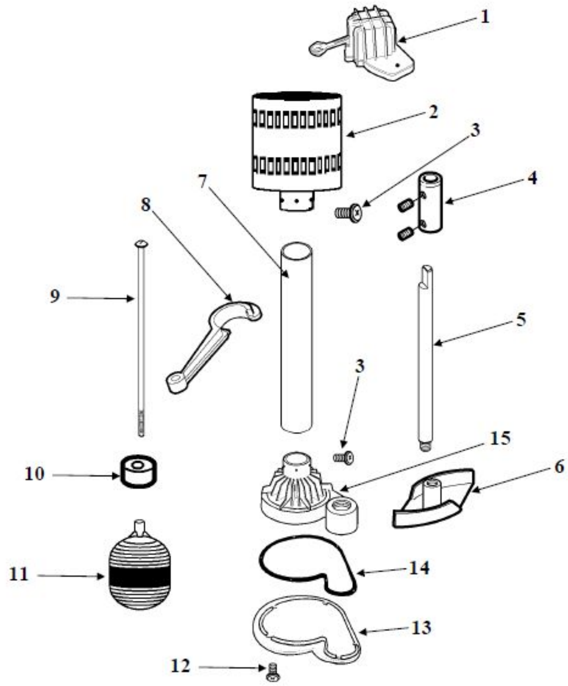
- The first characteristic the we hope to achieve with our pump is how quickly our sump pump reaches the maximum flow rate. We hope to be able to have the motor pumping at its maximum flow rate before the sump gets completely full unlike the typical sump pump to help prevent flooding.
- Second, we hope to reduce the latency between the sensors detecting a change in water level to the motor changing speeds down to 1 second at the longest. The reason for this, is that latency is important in general because, the faster the rate of flow of water into the sump, the faster it will fill up, and the faster it will need to react in order to keep from overflowing. We think 1 second is a good target because it means that the motor is reacting quickly, but also is not too fast. The reason we don't want it to be too fast is because if the water is sloshing around, then the water level readings may be changing quickly, and we do not want that to correspond to the motor speed changing quickly just because the water is sloshing. We want the motor speed to be based on the volume of water in the pump, and we are using the water-level as a proxy for this value based on the approximation that the water will usually not be sloshing on average.
- Lastly, our goal is to achieve a higher level of energy efficiency than current sump pumps. We have determined that if the power drawn in by our sump pump does not exceed 334.8 Watts on average, then our pump will successfully be more efficient than the sump pump we are comparing it to.

Block Diagram



Physical Design

The approximate dimensions of the sump pump are 7x 31.5x 9 inches. Its weight is 13.2 pounds. A rough diagram of our sump pump is seen as follows:



Our sump pump model is 92333

		Part # for models:					
Ref #	**Description**	**92333**	**92301**	**92302**	**92553**	**92551**	**92552**
1	Switch	99100	99100	99100	99100	99100	99100
2	Motor	YYB-200	YYB-200	YYB-200	YYB-300	YYB-300	YYB-300
3	Screw (Qty 3)	99110	99110	99110	99110	99110	99110
4	Coupling	99112	99112	99112	99112	99112	99112
5	Drive Shaft	99113	99114	99114	99113	99114	99114
6	Impeller	99116	99118	99118	99116	99118	99118
7	Column	99119	99120	99122	99119	99124	99122
8	Float Rod Guide	99126	99128	99128	99126	99128	99128
9	Float Rod	99129	99131	99131	99129	99131	99131
10	Grommet	99130	99130	99130	99130	99130	99130
11	Float Ball	99132	99134	99134	99132	99134	99134
12	Screw (Qty 6)	99136	99137	99137	99136	99137	99137
13	Base (Volute)	99140	99142	99144	99140	99142	99144
14	Gasket	N/A	99138	99138	N/A	99138	99138
15	Base (Housing)	99146	99148	99150	99146	99148	99150

Functional Overview

- Microcontroller
    - The function of the microcontroller is to receive data from the float sensors and then send data to instruct the motor on how quickly to operate to the motor controller in the water pumping mechanism. The microcontroller receives power from a 9v battery and data from the float sensors. It sends data to the motor controller.
- Float Sensors
    - There are three float sensors placed in three different depths in the sump. One will be an emergency switch that flips when water hits the top of the sump so that the motor will immediately run on high if that switch is flipped. The other two switches will be used to determine how fast the water is rising which the float sensors will send to the microcontroller. The float sensors send data to the microcontroller and create data based on the water influx into the sump.
- Water Pumping Mechanism
    - The water mechanism consists of a sealed impeller to the case that is immersed in the liquid and has to pump water or other liquids (in our case only water). It must be very well sealed with the mechanical seal system, to avoid that the pumped water does not enter the pump motor, avoiding any possible short circuit.
    - The water pumping mechanism will be drove directly from the motor, whose speed will be varied by the motor controller. The higher the water level is the faster the water will be pumped out. The electric motor is directly connected to the impeller by the same shaft.

Block Requirements

- Microcontroller:
    - Needs to respond quickly and send the appropriate signal to the motor controller within a couple milliseconds after receiving the signal from the float sensors
- Float Sensors:
    - Need to be far enough away from each other to not get stuck or bang into each other
    - Needs to be responsive enough to send signals to the microcontroller before the tank fills up
- Water Pumping Mechanism:
    - Needs to be able to reliably pump 2700-3800 GPH (Gallons per Hour) at maximum as that is a standard for ⅓ HP sump pump that we are trying to emulate. When the water inflow rate is lower however, it should not be at max GPH.

Procedures

Risk Analysis:

The most critical part of the project is the motor controller. It the base of all the project because it is the component that will allow us to change the speed of the pump depending on the water level detected by the sensors. An acceptable tolerance range of this component could be that it will be capable of varying the speed of the pump in three levels (low/medium/high) depending on the water-level recorded by the sensors.

Ethics and Safety:

In regards to our project, since it pretty closely resembles the sump pumps that are currently in use around the world, it basically has the same ethical and safety issues as current sump pumps. In accordance with the IEEE Code of Ethics, line 1, we are "to hold paramount the safety, health, and welfare of the public, to strive to comply with ethical design and sustainable development practices, and to disclose promptly factors that might endanger the public or the environment". The way in which this applies to us is the safety of the moving parts being properly controlled, and the water being manipulated in a safe way. Some safety precautions include things like never allowing children to use or get too close to an accessible sump pump without adult supervision. Also, the power outlet that the sump pump is connected to must be at least 6 feet above the ground to prevent issues with the room flooding and possibly getting into the outlet. Our sump has the same safety warnings as any high power home appliance with a high rpm (rotations per minute) moving part. Caution needs to be used such that whenever the moving parts (impeller, axis, and motor) are being exposed or interacted with, especially for maintenance or replacement, the whole device must be completely powered off and you need to wait until all parts stop moving before interacting with it.

What is unique about our project is that the motor can run at different speeds. So, the safety and ethical concerns related to that include making sure that the motor doesn't attempt to run faster that it is capable of. For instance, in an adversarial condition, someone may try to make the pump run so fast that it damages the pump and pieces fly out of the mechanism because it is rotating at such a high speed. This is not something to worry about though because the rotating impeller will be in an enclosure. Also, the pump will not be connected over a network, so the only will an adversary can tamper with the pump is by having physical access to it.

Some caution does need to be taken while working in the lab since we will be working with water. During testing, we need to make sure we always keep the water contained. We can do this by always conducting our experiments in a larger enclosure such as a tub. We also need to properly handle the amount of power our device is drawing. If we find any safety concerns in addition to this, we must disclose them to anyone who will be working with this device immediately. This includes everyone in our team, and our TA. Once found, we need to come up with a plan on how to deal with any of these newly discovered issues before proceeding to work with the pump again.