

Application Note: Power and the Pump

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Abstract

All around the world, growing nations have trouble with sanitary conditions in their hospital surgery rooms. Because of these unsanitary conditions, a large percentage of people will get a bacterial infection post-operation. The project is to design a device that can be used during a surgery that will pump antimicrobial to the surface of a surgical tool during operation as well as the surgical tool that will be used in the surgery. The constraints include the use of microchannels, a microcontroller that is able to control the pressure and speed that the fluid suffices the surface, the battery needs to last the entire length of the surgery, and be inexpensive and reasonable for third world countries to use to prevent infection after an operation.

The original idea the group had for the project was to use a micropump. This would mean that we would have a small pump that would directly pump our antimicrobial into the tubing that would eventually lead through the microchannels to the surface of the surgical tool. The antimicrobial would either be in a container that the pump would have tubing connected to get it to the tubing toward the tool's surface or be directly in a container that is connected to the micropump. This would have an accurate rate of flow and would have accomplished the goal that we were seeking. This micropump would have had to be powered by a battery. By hooking up a silicon ion battery, like what phones use, the micropump would get the energy required to run the system. A circuit would need to be built to get the right power and voltage to the pump. The battery might have a different voltage output that would be needed for the micropump so a step down or step up converter would need to be built. Depending on the energy burned from a six hour long surgery, more batteries might need to be interconnected. Not only does the pump need to be powered, the microcontroller also needs to be powered. The circuit would need to have

another part of it that ran around a lower voltage to be able to power that said microcontroller.

This idea turned out to be expensive. The micropump ran around two hundred to three hundred dollars. The project is built to be able to access the markets in third world countries where it would be used so a different idea would need to be used.

After a visit to the veterinary college here at MSU, a new idea began to prosper. Instead of having a micropump to pump the substance to the surface of the tool, a regular air pump will be used to inflate a pressure bag that has an IV bag filled with a diluted antimicrobial. The pump will apply a pressure to the bag that will force the fluid in the IV bag down to the surgical tool. The pressure will also be strong enough to force the fluid through the microchannels that are inside the surgical tool. Luckily, a change in the type of the pump does not necessarily mean the the design of the battery and the circuit need to be changed. A silicon ion battery or batteries, depending how long it needs to be powered or how much voltage is required, can be used to power the tool for the six hours.

Introduction

Power is an important part of any electrical system. It provides the energy required for a system to run. The pump that is used in the design project is no different than these other systems.

Energy is required by the pump to pump the antimicrobial through the tubes to the surface of the tool. This aids with the goal of keeping the surface of the surgical tool as clean as possible throughout the surgery.

Objective

The objective of this walkthrough is to teach the reader everything they need to know about how to design the power aspects of this project. It is also to teach how the pump is an integral part of this design and how it works to pump the antimicrobial diluted in the IV bag to the surface of the tool. After reading this, the user should be an expert on these two design applications and be able to replicate the power circuit and the connections necessary in that circuit as well as how to use the pump and where it should go. It will describe the original idea in detail first along with the issues that are involved. Then, it will describe the idea that was produced.

Initial Design Idea with the Pump

The use of a micropump was the key factor in the original idea. Figure 1 shows a block diagram of the initial design. The silicon ion battery is connected by wire to the circuit board. This is the voltage input to the circuit. From the step down in the circuit, power is transferred to the microcontroller to power it. The other output of the circuit goes to power the micropump and then back to ground in the circuit. The micropump, with the container of the diluted fluid, pumps the fluid into the tubing. The tubing then flows into the microchannels and eventually to the surface of the tool. A sensor detects the flow at the end of the tubing before the microchannel and inputs the data into it and adjusts the micropump on how much pressure to use. Because this idea was expensive, a new idea needed to happen. To implement the micropump, a low flow micropump would need to be purchased. A low flow micropump means a micropump that will pump fluid in the microliters into the tubing. The pursuit of this design was halted. If the user wanted to implement this design, they would need to acquire information on micropumps to see how they would work in this design application. Also, the procedures needed to use the microcontroller to adjust the pressure input by the micropump on the fluid. This website has

research papers on the implementation of micropumps into systems and would be a good location to find answers to any questions.

http://www.mdpi.com/journal/micromachines/special_issues/micropumps

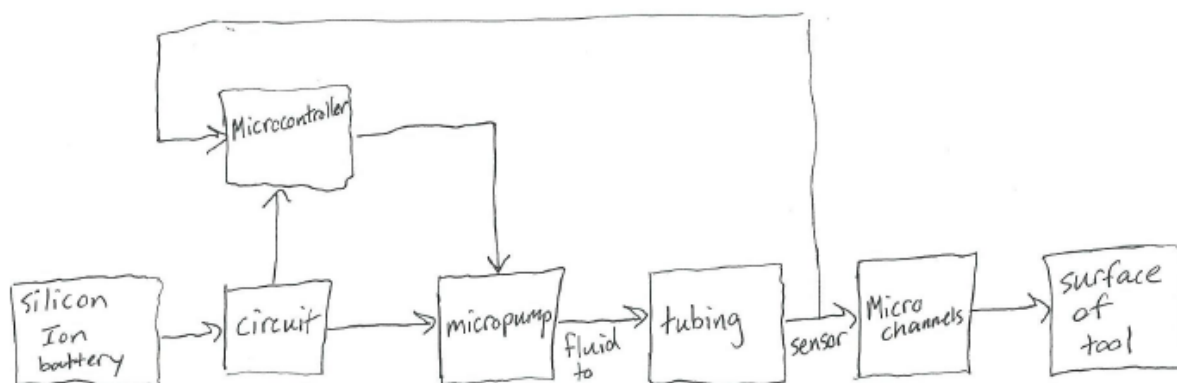


Figure 1 Block Diagram of Initial Design Idea

Current Design Idea with the Pump

A new design idea was inspired by the information gathered on a trip to the veterinary college here at MSU. Because the cost of procedures on animals is all out of pocket payment by the owners, veterinarians work to keep costs low. This is what was needed for our design.

Figure 2 shows a block diagram of the final design. Easily deciphered, the block diagram shows the same kind of initial setup with the battery and the battery circuit powering the pump and the microcontroller. But this time, an air pump is being used to inflate a pressure bag. Any air pump will do as long as it is connected to the programmed microcontroller and is able to connect to the pressure bag. The pressure bag will put a force on the IV bag that is filled with the diluted solution. This will force it down the tubing through the microchannels and finally to the surface of the tool. A desired pressure may be necessary in the surgical room for the flow. This is set

with the microcontroller that will input the signal to the air pump. It will tell it when to inflate to add more pressure and when to deflate to reduce the pressure. This reduced the cost of the design immensely. The price of an air pump is thirty to forty dollars compared to the price of a micropump that can be upwards of three hundred to four hundred dollars for the type that would be needed to get the flow that we are looking for the fluid to run at in the tubing.

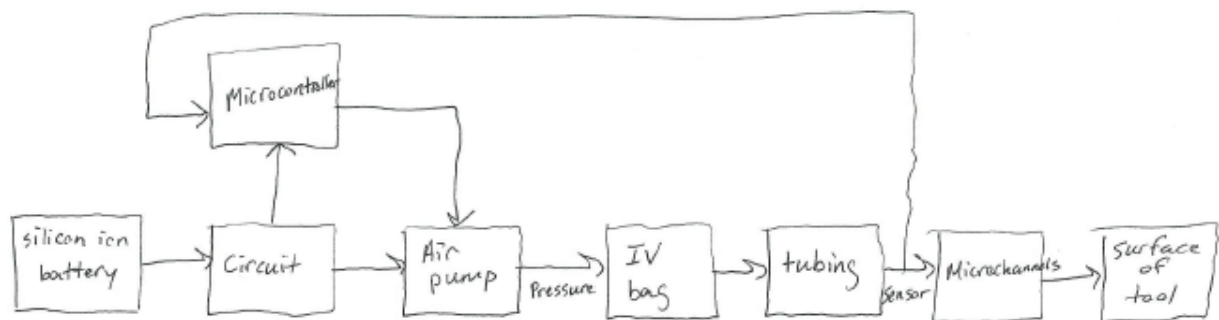


Figure 2 Block Diagram of Current Design

Circuit Design to Power Microcontroller and Pump

Already discussed earlier, the battery will be powering the circuit. To implement this into the design, wiring will need to go from the battery as the input into the circuit and from ground back to the battery. Figure 3 shows the design of the step down circuit that will be needed to be used to power both the microcontroller and the micropump. J2 is the battery input to the system. The battery that is being used runs at 9 volts. A list of the variables and their values is shown in Figure 4. The 5 volts is enough to power the air pump. At node 3, a wire will run to the air pump and another from the air pump back to the ground of the circuit. The 3.3 volts at node 4 will be able to power our microcontroller. So like node 3, at node 4 a wire will run to the microcontroller and from the microcontroller to ground.

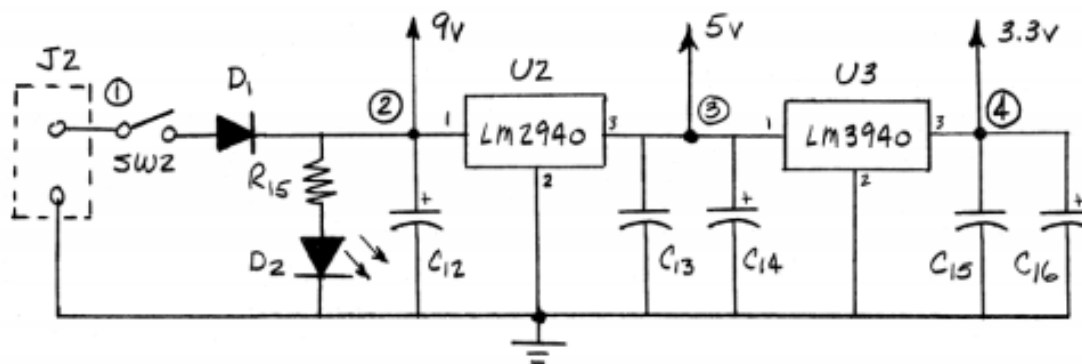


Figure 3 Power Supply Circuit

C13 and C15- 0.1 μ F capacitor
 C12, C14 and C16- 47 μ F capacitor Polarized
 D1- 1N5819 diode
 D2- Orange LED
 SW2- Breadboard SPDT Power off/on switch
 U2- LM2940CT 5 V, 1 A voltage regulator
 U3- LM3940IT 3.3 V, 1 A voltage regulator

Figure 4 List of variable values

Conclusion

Making an inexpensive surgical tool was critical to this design project. The target consumer is third world countries that do not have the money for care that here in the United States has. The pump and power are critical parts for a fully functioning design. Energy is required to pump the antimicrobial to the surface of the tool. Also without the pump, well, there is no pumping the antimicrobial to the surface either. With the information in the design sections, a user could easily be able to replicate it and understand its functionality. They should also fully understand the pump and the integrated part that it has in the design. Future designs could be done to condense the size of this entire design. A new circuit placed in the same container as the pump to reduce the total size and to help make it more portable.