Automated Hydroponics

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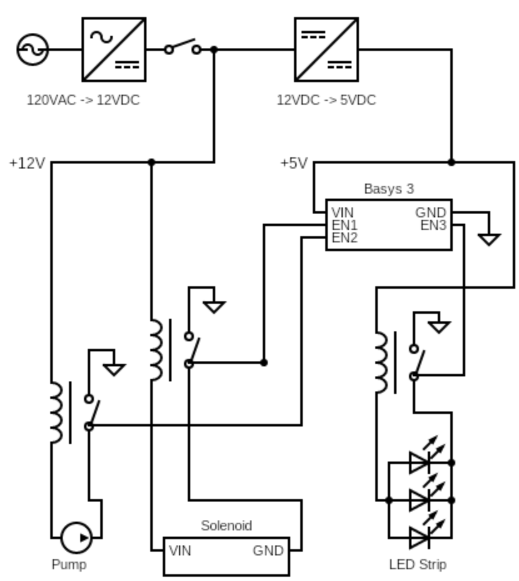
Project Summary

This project created an automated hydroponics system capable of dispensing nutrient solution, aerating the water, and toggling grow lights. These three operations were considered the core of any minimum viable product for a hydroponics system. The nutrient solution is required because this is a closed system with no natural nutrient or mineral replenishment from the environment so they need to be externally added. Similarly, our project was modular and intended for indoor usage, this meant that an alternative light source was required as part of the system. Lastly, the water needed to be aerated to ensure the water remains clear, odorless, and free of dangerous algae and bacteria.

To begin the project, an acrylic tank was constructed to hold the water, pump, and the plant. This tank served as the foundation of this project, holding large quantities of water that could damage not only the electronics in the system but also whatever environment it was placed in. It was crucial that this tank was water-tight, had ample space for whatever plant may be in the system, and left enough room for the electronics.

This project heavily focused on the electrical and hardware aspects to ensure reliability of the system. The pump, lights, and solenoid for the nutrient solutions were all controlled via five volt relays. One problem that had to be addressed was logic level shifting from the Basys to the relays. The Basys outputs 3.3V logic, and this had to be boosted to 5V to control the relays. This was accomplished using a BSS138 mosfet that was connected to the high voltage of 5V from the 5V bus and the low voltage of 3.3V from the pmod power supply on the Basys. The solenoid was 12V which was supplied from the laptop charger that outputs 12VDC, and then this voltage was dropped down to 5V to power the rest of the components.

The software consisted of a multiple day timer that would trigger specific relays to perform the desired operation. The Basys3 Board contains an internal clock, but does not contain any sort of built in timer module, so one needed to be created. Luckily, timers can be simply implemented by counting clock cycles. The default clock speed on the Basys3 Board is 100MHz, which means every 100,000,000 clock cycles result in one second, then sixty seconds is a minute and so on. Using this method, the timer was built up to multiple days as this was the largest individual time needed in this application, but could be modified to count even higher. The individual denominations were used as input and output components such that they were able to be read in the controller module and in the timer module itself, as Vivado does not allow reading of an output type. After the timer was completed, the controller module was as simple as checking for specific regions of values according to the plant's needs.



Details

Hardware:

- 120VAC to 12VDC laptop charger
- 12V solenoid
- 12VDC to 5VDC buck converter
- 5V power rail
- Three 5V relays
- Three logic level shifters (BSS138)
- 5V pump
- 5V LED
- Basys 3

Software:

- VHDL
    - Process Block
    - 100 Mhz internal clock
    - Pmod port manipulation

An explanation of how each aspect works can be found in the project summary.

Conclusion

While we encountered a few issues with this project, most were relatively small and simply required additional research or a change in implementation. A problem we had when creating the software was getting the VHDL program to remain operational when plugged into wall power as opposed to a computer. We were able to work around this by importing the program onto Basys's RAMby just following a guide from Xilinx. Two hardware issues were dealing with shifting the logic voltage level, and finding a way to power the various components all at different voltages with a single power input. The first was solved using a few MOSFETS, and the second was solved by adding a buck converter to step the voltage from 12V to 5V for the Basys3 and using the 3.3V output from the Basys3 to drive the smaller components as well.