

Automated Hydroponics

General Overview

Hydroponics is the technique of growing plants using water-based nutrients instead of soils.

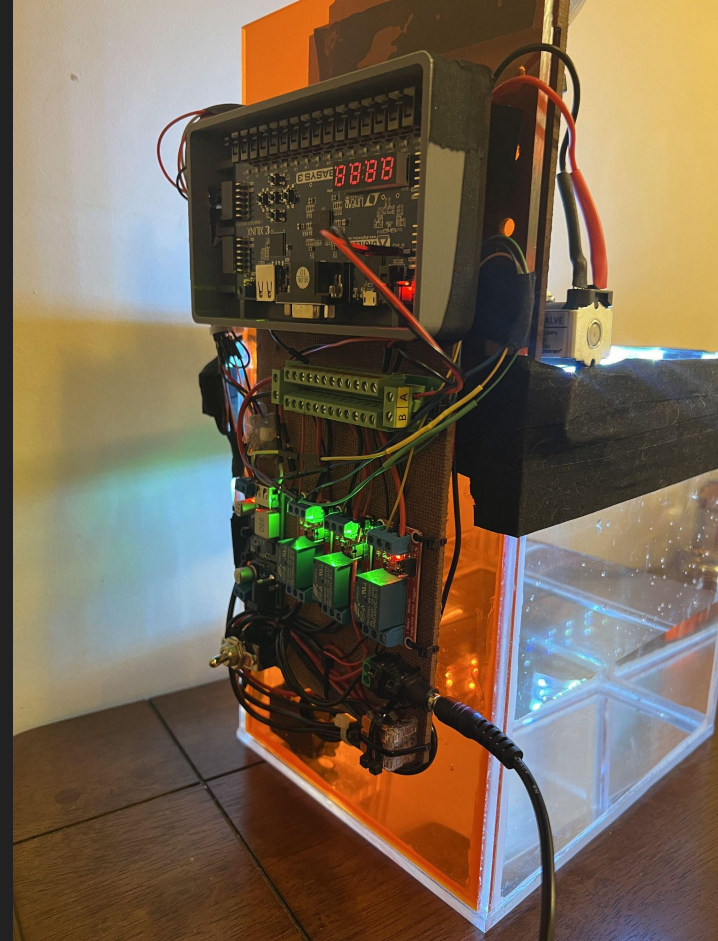
Project Encompassed:

- Watertight Tank
- Pump to circulate water
- Solenoid to release nutrients
- VHDL program to drive these elements



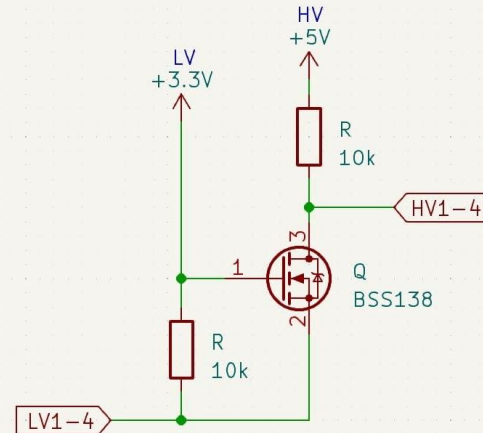
Hardware

- 120AC to 12VDC (Laptop Charger)
- 12V Solenoid
- 12V to 5V buck converter
- 5V power rail
- Three 5V relays
- Three logic level shifters
- 5V pump
- 5V lights
- Basys3



Logic Level Shifting

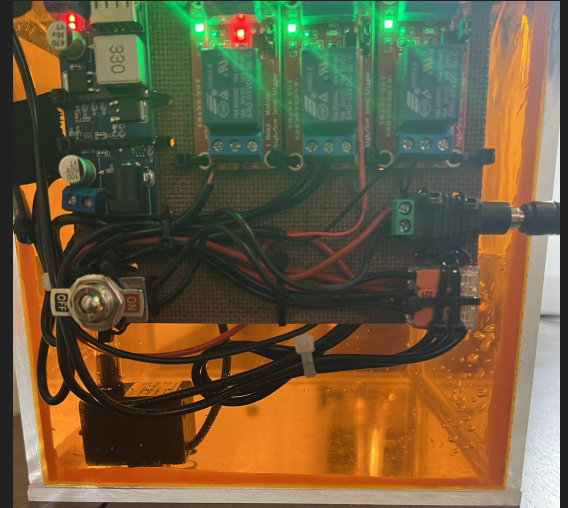
- Basys 3 outputs 3.3V logic
- Relays need 5V
- Used 3 BSS138 mosfets to shift digital levels
- Advantage of this configuration is that the shift is bi-directional
- 5V power from power rail
- 3.3V power from Basys3



LEVEL SHIFTER CIRCUIT DIAGRAM

5V Rail

- Basys 3
- LED Lights
- Pump
- Level Shifters
- Relays



Relay Components

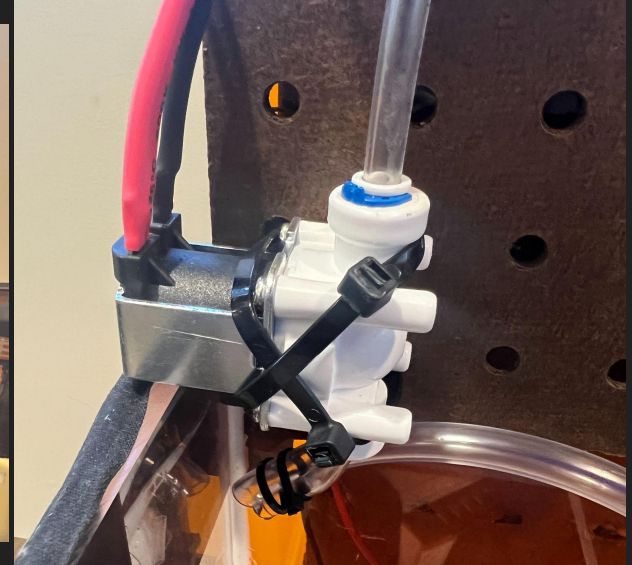
Pump



LED Lights



Solenoid



Software

- Coded in VHDL.
- Used a 100MHz clock to drive our processes.
- Used a component to act like an internal timer.
- The top module uses this timer to know when to turn on and off one of our three pins.

VHDL Code (Timer)

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use ieee.numeric_std.all;

entity timer is
generic(ClockFrequency : integer);
    Port ( clk : in STD_LOGIC;
          rst : in STD_LOGIC;
          seconds : inout integer;
          minutes : inout integer;
          hours : inout integer;
          days : inout integer);
end timer;
```

```
architecture Behavioral of timer is
    signal ticks : integer;
begin
    process(clk) is
    begin
        if rising_edge(clk) then
            if rst = '1' then
                ticks <= 0;
                seconds <= 0;
                minutes <= 0;
                hours <= 0;
                days <= 0;
            else
                if ticks = ClockFrequency - 1 then
                    ticks <= 0;
                    if seconds = 59 then
                        seconds <= 0;
                        if minutes = 3 then
                            minutes <= 0;
                            if hours = 23 then
                                hours <= 0;
                                if days = 3 then
                                    days <= 0;
                                else
                                    days <= days + 1;
                                end if;
                            else
                                hours <= hours + 1;
                            end if;
                        else
                            minutes <= minutes + 1;
                        end if;
                    else
                        seconds <= seconds + 1;
                    end if;
                else
                    ticks <= ticks + 1;
                end if;
            end if;
        end if;
    end process;

end Behavioral;
```


VHDL Code (Top Module Entity)

```
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;

entity testwait is
    Port ( clk : in STD_LOGIC;
          JC7 : out STD_LOGIC;  -- LED Lights
          JC8 : out STD_LOGIC;  -- Mineral Water Feed
          JC9 : out STD_LOGIC); -- Water Pump
end testwait;

architecture Behavioral of testwait is
    constant ClockFrequency : integer := 100e6; --100MHz
    signal rst : std_logic := '0';
    signal seconds : integer;
    signal minutes : integer;
    signal hours : integer;
    signal days : integer;
begin
    my_timer: entity work.timer(Behavioral)
        generic map (ClockFrequency=>ClockFrequency)
        port map (clk=>clk,rst=>rst,seconds=>seconds,minutes=>minutes,hours=>hours,days=>days);
```

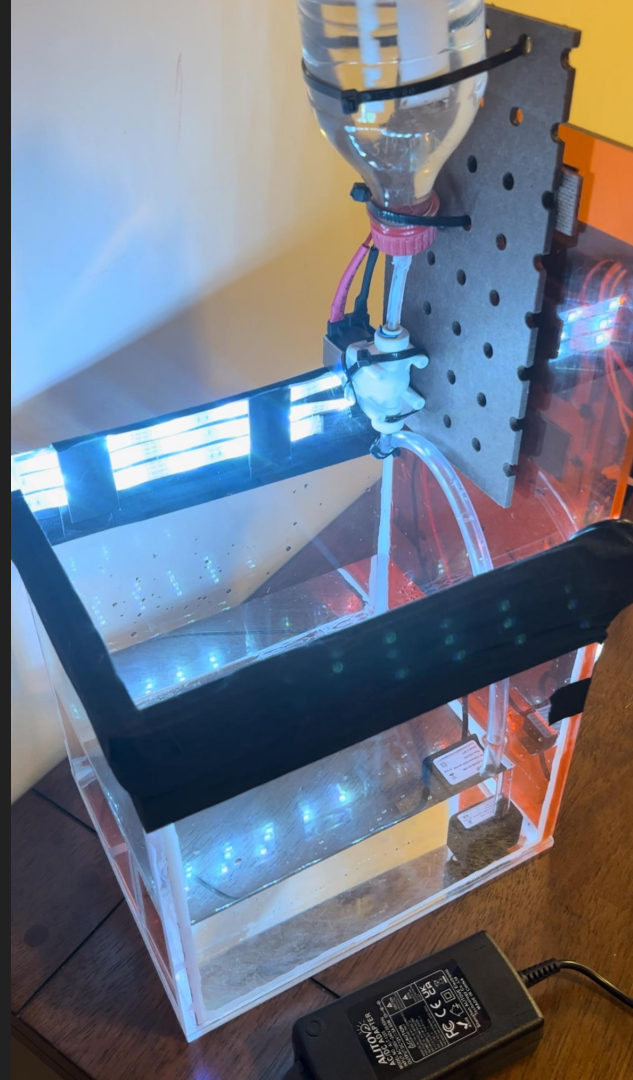
VHDL Code (Top Module Architecture)

```
-- Process Block for Actual Design Implementation
-- Uncomment this to run implementation. Comment out demo code.
-- Begin Program at 7am so at 23 hours it will be 6am
process(clk) is
begin
    if rising_edge(clk) then
        -- LED Lights
        if hours > 9 and hours < 23 then
            JC7 <= '1';
        else
            JC7 <= '0';
        end if;
        -- Mineral Water Feed
        if days = 3 and (hours = 12 and minutes = 30) and (seconds > 10 and seconds < 11) then
            JC8 <= '1';
        else
            JC8 <= '0';
        end if;
        -- Water Pump
        if (hours = 12 and minutes = 30) and (seconds > 10 and seconds < 40) then
            JC9 <= '1';
        else
            JC9 <= '0';
        end if;
    end if;
end process;
```

Putting it all Together

Demo

- Day and night cycle
- Adequate nutrient distribution
- Aeration of the water
- Features guest star Molly





Questions?