Aim

To design a circuit that keeps a plant in optimal light conditions.

Introduction

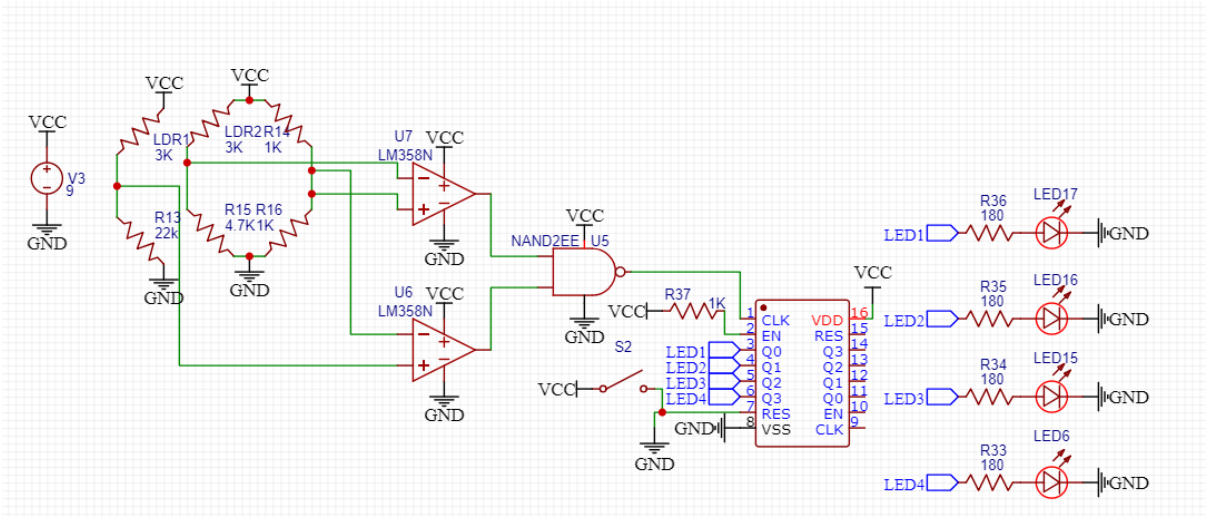
I was assigned the task to develop a system to ensure a plant stays in optimal light conditions. To do this I will use LDRs to detect the amount of light that the plant is exposed to and then determine if the pant should be moved or not. The circuit will be catered to the Monstera plant, but with some modifications to the resistors, it can be catered to any plant.

Method and Design and Calculations

Firstly, I needed to find out exactly what plant I was catering for, after some brief research I found out it was a Monstera adansonii, which has a minimum light requirement of 100 candles and a maximum of 500 candles. This converts to roughly between 1100 and 5400 lux.

> Monstera Deliciosa light requirements are a minimum of 75- to 100-foot candles, and a preferred level of 200- to 500-foot candles. Other Monstera varieties, like Monstera Adansonii, will also be happy with the same light levels.

After finding that out, I needed to find out how much resistance the LDRs had at those specific lux points, by using the lux sensor on my phone to determine how much light the LDRs were exposed to and when I found the correct light levels, I used the ohmmeter function on my multimeter to determine the resistance of the LDRs at that level. After some testing I noticed a large disparity between the resistance of the LDR when exposed to natural sunlight and artificial light of the same lux levels. I concluded that this was due to the presence of UV light within sunlight (this will be further covered in results). With those factors in consideration and attempting to use mostly components I had on hand this was what I designed:



I used the CD4011 for the NAND gate and the 2 op-Amps in the LM358N (I had these ICs already). The only components that I did not have on hand and had to purchase was a CD4520 IC (a dual binary counter) which counts how many times the plant is in suboptimal conditions (normally instead of a counter a motor would be used to move the plant into optimal lighting), four 180-ohm resistors (all other resistors I had on hand) and 4 red LEDs (all components were bought from Yebo Electronics and the total spent was R40.48 which is under the R50 budget I was allowed to purchase extra components). With this circuit, the counter will count every time the LDR resistance is above 22k or below 4.7k, whenever the LDR resistance is between those values, the light levels that the LDRs are exposed to are optimal and therefore the counter will not count. To determine the resistance needed for the LEDs used for the counter IC I measured with my multimeter and got 5V with a 1.8V voltage drop across my specific LED, my LED had a recommended working current of 20mA, to work out resistance. R = (5-1.8)/0.02 = 160 ohms. I can only get 150R and 180R, I decided to get 180R to be safer and ensure I do not blow the LED.

Results

I found the resistance to be around 5x greater using artificial light vs natural light (with the same measured lux rating), for demonstration purposes I will be using the artificial light values (22k ohm as max and 4.7k ohm as minimum) so that when demonstrating, I do not need to rely on sunlight on the day of demonstration (in case of cloudy/ rainy weather). I would use 4.4k ohm (4.7k ohms is the closest I could find) resistance instead of the 22k, and 940 ohm (or another resistance as close as possible – 1k was the closest I could find) instead of the 4.7k ohm resistance for the actual plant in sunlight. Once the circuit was built, it did what was expected as stated in the method. Increase the value of the counter whenever the LDRs/ plant were in suboptimal conditions. The reset button, reset the counter – making the counter start at 0000 again.

Conclusion

I managed to design a circuit that functions properly; however, I would have preferred to use an actual lux meter to get more accurate lux readings. So that I could determine what resistors to use with more accuracy. For this to work with another plant, the resistance values would need to be remeasured with the light requirements of that plant in mind.

References

https://monsteraguide.com/best-monstera-light-conditions/

https://circuits-diy.com/cd4520-dual-binary-up-counter-datasheet/

https://circuits-diy.com/lm358-low-power-dual-op-amp-datasheet/

https://circuits-diy.com/cd4011-quad-2-input-nand-gate-datasheet/

https://www.fort777.co.za/index.php?main_page=product_info&cPath=269_456_605_627_637_638_641&products_id=3451