

# **Automated Greenhouse**

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## **Introduction:**

One of my many hobbies is gardening: I grow tropical plants for my room, flowers for the yard, and vegetables for the garden. One of the many problems of growing plants in the Midwest is the ridiculously short growing season. The growing window is usually from mid-May to mid-September, and the rest of the year is either cold like the winter or actually is winter.

One way people extend the growing season is to start growing their plants in a greenhouse, but that can come with a variety of problems:

1. Unlike a house, an inexpensive greenhouse house has no way of regulating its temperature.
  - a. With temperature being a crucial factor in germination and growth rate, having no regulation is detrimental.
2. There isn't any air circulation.
  - a. This can cause mildews or diseases in your plant population.
3. Implementing some sort of cooling and heating system can cost a lot of money.

I ended up buying a relatively inexpensive greenhouse. It came with metal framing, shelving for the trays, and a transparent plastic cover. All I had to do was somehow regulate the temperature and airflow.

## **The project:**

I decided to regulate the system with a microcontroller, more specifically, an Arduino Uno. I would then use it to control a variety of relays, motors, and sensors for the greenhouse. I like to divide Arduino projects by code, circuitry, and physical implementation/construction. So, I will cover what I did for each of these categories.

## **Physical Construction:**

Because the greenhouse is going to have to deal with very cold nights and very hot days in the spring, I needed an efficient cooling and heating system. From the sunlight alone, the greenhouse can get up to 108 degrees during the day.

For the cooling system, I decided to have a box fan on the backside of the greenhouse. In order to produce a good airflow, I also needed a vent on the front of the greenhouse.

This combination would cool the greenhouse very quickly because there is air coming in and air going out. Without the vent, the fan would struggle to cool down the greenhouse.

The box fan and another fan for the bottom of the greenhouse are controlled by a relay module. The relay module is wired to an extension cord that plugs into the fan.

The small bottom vent was just a house vent with a metal lever on the back. I was able to mount a servo motor to the lever so that it could open and close the vent. I cut up a plastic bin lid and mounted the vent to it so that I had some way of attaching it to the greenhouse cover.

I created a crude frame for the box fan and created a cover for it from another plastic bin lid. The cover was attached to the frame with duct tape so that the cover could be lifted up and down. Then, I added a piece of metal to the cover so I could attach a string to it. The idea was to have a stepper motor wind up the string to open the cover. The reason why I didn't use another servo motor was that the cover would be too heavy and too big for an inexpensive servo. The stepper motor had to be outside of the greenhouse so I used a Tupperware container to protect it from water damage.

For heating, I used a space heater and a circulating fan that would be controlled by another relay module. One thing I had to keep in mind was that a typical space heater can use up to 3000 watts, which exceeds the limitations of a general relay module. I had to use a relay module that would be able to handle that type of wattage. An extension cord was wired to the relay board that plugged into the space heater and fan.

Lastly, a waterproof temperature sensor was placed in the greenhouse to monitor the temperature.

With all the parts put together, this is what the greenhouse looks like: (diagram)

### **The Circuit:**

I needed to wire up 2 relay modules, 1 temperature sensor, 1 servo motor, and 1 stepper motor. I needed a stepper motor driver module and a 12-volt power supply to power the stepper motor. I also needed a 5-volt power supply for the Arduino and another 5-volt power supply to power the relays and temperature sensor. The servo motor was powered by the Arduino directly. All of the parts are connected to the GPIO pins on the Arduino. Here is the final circuit diagram: (diagram)

### **The Code:**

It's important not to rush to coding for these types of projects. We need to know the construction of the project before we can make a circuit for it, and we need to know the components in the circuit so we know what to program. The program itself isn't very complex. I programmed functions for opening and closing both kinds of vents, as well as turning on and off the heater and fans. Then in the main loop, I check the temperature. If the temperature falls under a specified amount, the heater will turn on. If the temperature rises above a specified amount, the vents open, and the fans turn on.

I actually wrote this code when I was in High School. There would be a couple of things that I would change about the code, but for the most part, it's pretty good. I would probably divide the functions into multiple Arduino IDE tabs.

I actually run the fans and heater for one minute straight before checking the temperature again. This prevents cycling. Cycling is where the fans or heater have to turn on and off repeatedly. This happens when a temperature floats around a bounds. The heater kicking on for a moment raises the temp by a couple of degrees and then has to kick back on right away when the temperature falls. Running it for a minute straight guarantees that the heater will raise the temperature high enough to prevent it from having to turn on again right away.

### **The Demo:**

Here is what the greenhouse actually looks like. As you can see, the servo motor vent is mounted to the front and the box fan is mounted to the back. The entire greenhouse is actually mounted to the A-frame of a playhouse to provide support from the wind. The plastic ends of the greenhouse cover are folded into the greenhouse to prevent air leaks and the Arduino box is just set up on one of the greenhouse shelves. As a demonstration, I used hot water to artificially raise the temperature in the greenhouse to show what happens when it gets too hot in the greenhouse. As you can see, the box fan lid is raised up by the stepper motor and the fan turns on. The servo motor also opened the bottom vent. Then after one minute, the fan turns off, and the vents close.

Heating the greenhouse doesn't really need a demonstration because the space heater just turns on for one minute and then turns off.

### **Conclusion:**

Here is the progression of last spring's seedlings. I have used this greenhouse for years now, and it allows me to start my garden early.

If you have any questions or comments about the project, feel free to email me. Thank you for watching and I hope you learned something.

