Autonomous Sprinkler System with Object Avoidance

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Overview

- Recognition of the Need
- Functions and Features
- Preliminary Research
- Sensor and Actuator Selection
- Mechanical Design
- Circuit Design
- Program
- Prototype
- Safety
- Automatic/Manual Control Modes
- Materials and Cost
- Limitations and Future Work
- Conclusion

Recognition of the Need

- Most home sprinklers:
  - Are time-controlled
  - Do not contain sensors
- Sensors are sold separately
  - Costly and impractical
  - Proprietary equipment

Recognition of the Need

- A conventional lawn sprinkler will activate:
  - Though it has rained
  - Though you are standing in front of it
  - No matter the temperature or the brightness of the day
- Will not deactivate until its timer has run up
  - Open-loop system

Functions and Features Requirements

- An autonomous home sprinkler system that must:
  - Check weather to determine if sprinkler should activate
  - Time how long the sprinkler is activated
  - Detect objects
  - Control flow rate to avoid these objects
  - Cover an 11ft radius (22ft diameter)
  - Provide a mode to manually override flow rate control

Preliminary Research

- Temperature
  - extreme high temperatures → water can burn foliage
  - extreme cold temperatures → water freezes → will not absorb in soil and cause frostbite
- Time of day
  - early morning: less water evaporates → soil soaks well
  - midday: water evaporates too much →
  - late afternoon: early enough for plants to dry
  - late night → very little water evaporation, cold temperatures can cause water diseases

Preliminary Research

- Amount of water
  - One inch of water (623 gal/1000 sqft) will soak 6-8 inches of soil
  - Too much water will cause run-off
    - drowns the plants
  - If there was rain, watering is not necessary or less water required (Depends on amount of rain)
  - Must dry between watering
    - otherwise diseases, insects, drowned root damage, etc.

Preliminary Research

- Light
  - hot, sunny day → large amount of evaporation
  - cloudy day →less water evaporation→ less watering required
- Time Elapsed
  - (SquareftArea x .62)/GPM = minutes to water

Sensor and Actuator Selection

- Sensors
  - Photoresistor
  - DS1620 Temperature sensor
  - Soil moisture sensor
  - PING))) Range Finder
  - Pressure sensor
  - Pushbuttons
  - Potentiometer

[Temp. Sensor]


[Moisture Sensor]


[Photoresistor]

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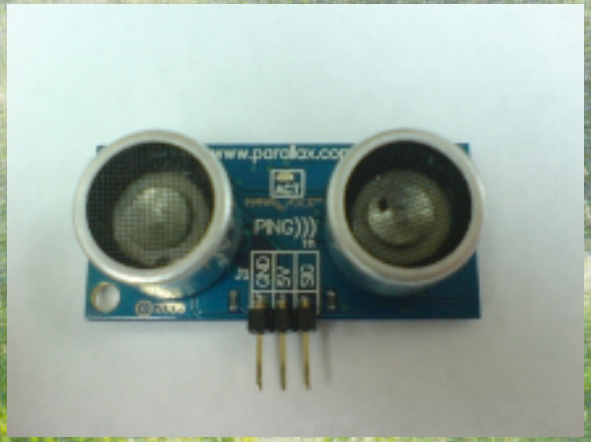
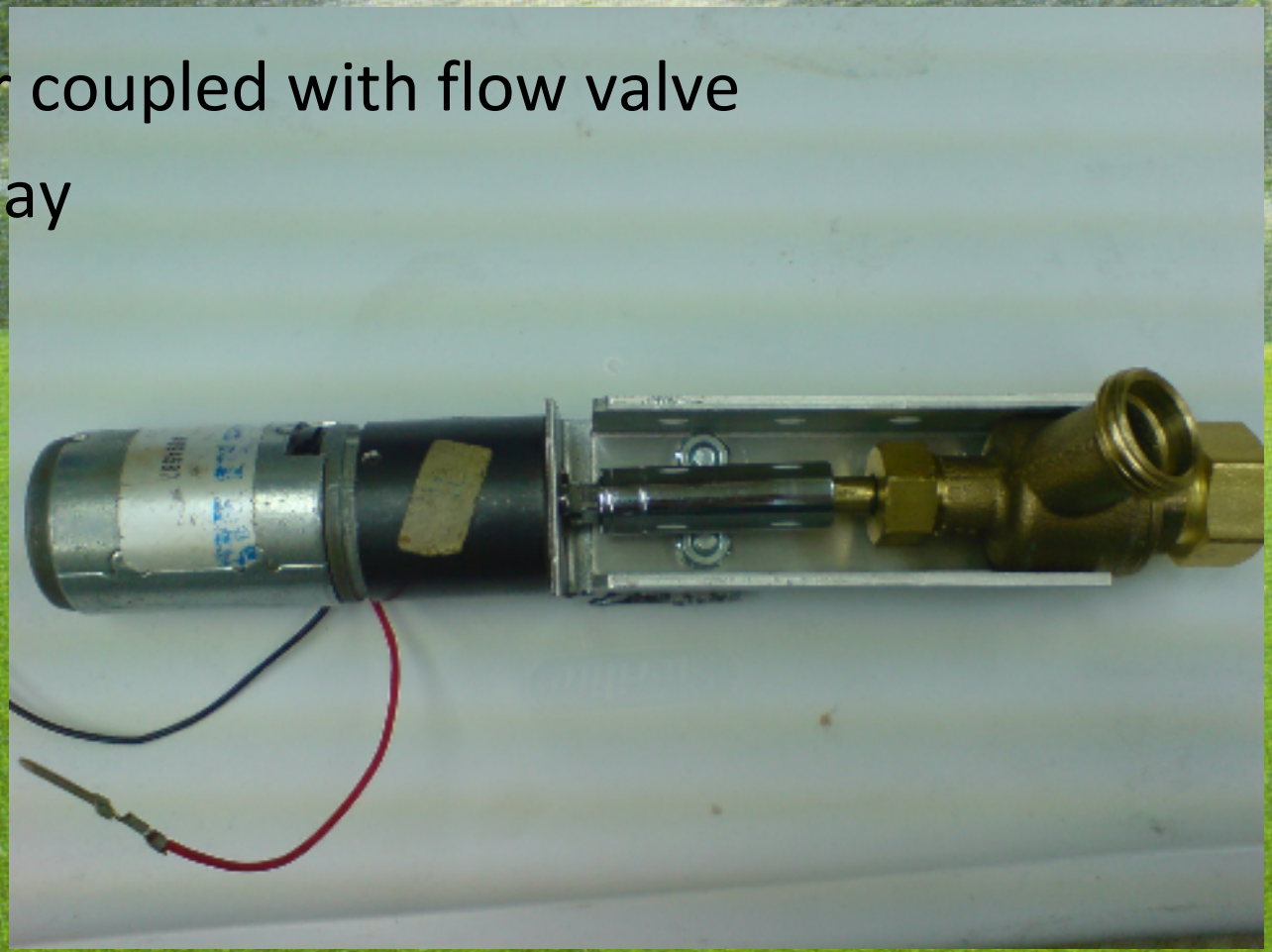


[Ping))) Distance Sensor]

[Pressure Sensor]

Sensor and Actuator Selection

- Actuators
  - DC motor coupled with flow valve
  - LCD Display



Mechanical Design

- Two Subassemblies constructed:
  - First → large project box assembly
  - Second → sprinkler head / small project box assembly
- Large Project Box:
  - Contains circuit board and attached motor-valve
  - LCD and pushbuttons mounted for user interface

Mechanical Design: Project Box

Mechanical Design

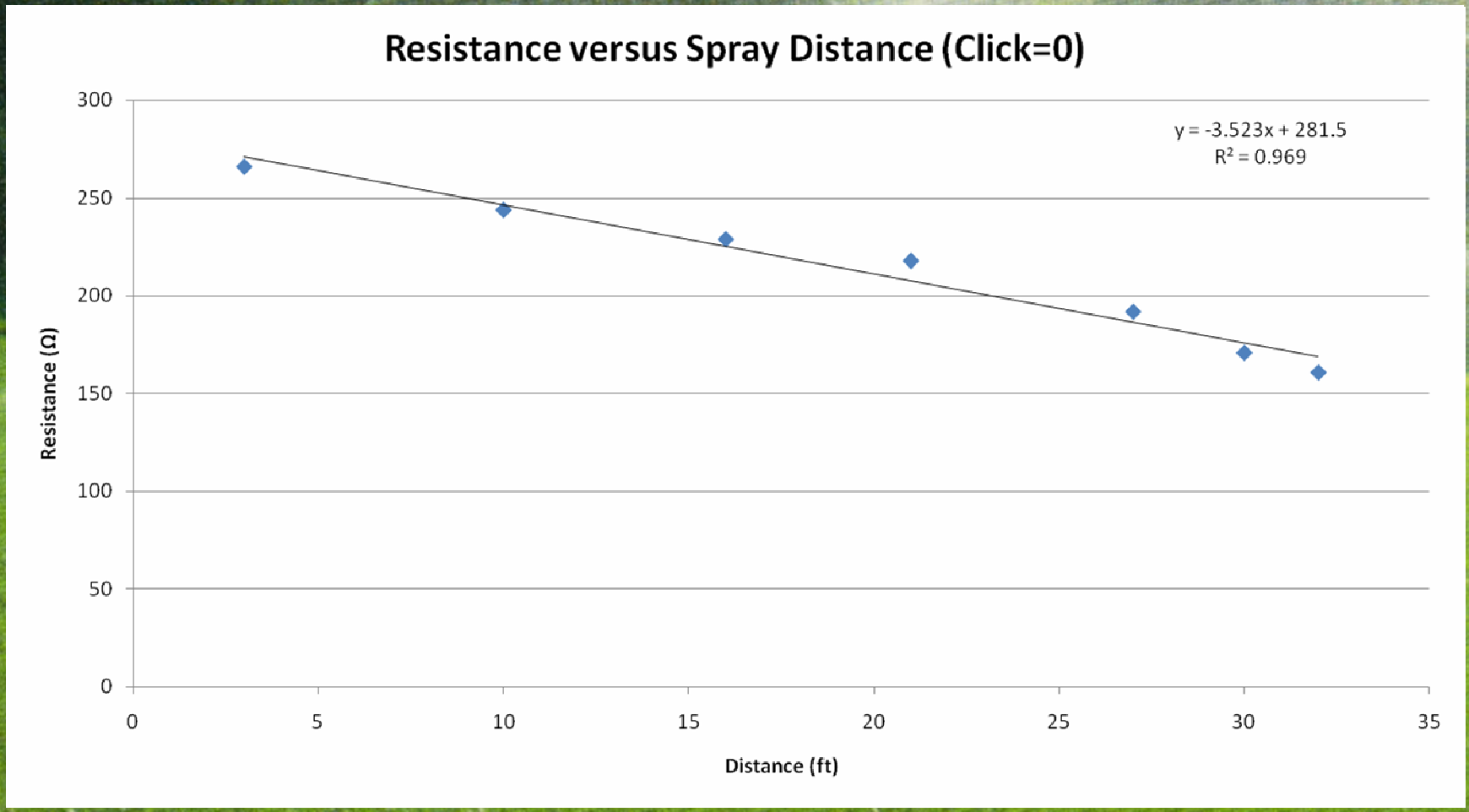
- Small Project Box:
  - Contains range finders
  - Pressure and soil moisture sensors plug in
- Motor :
  - must alter flow rate quickly
  - must be powerful enough to drive valve
- 2 PING))) Distance sensors instead of 1 with servo
  - Less complex, fixed orientation, must see both sides of water jet

Mechanical Design: Sprinkler Head

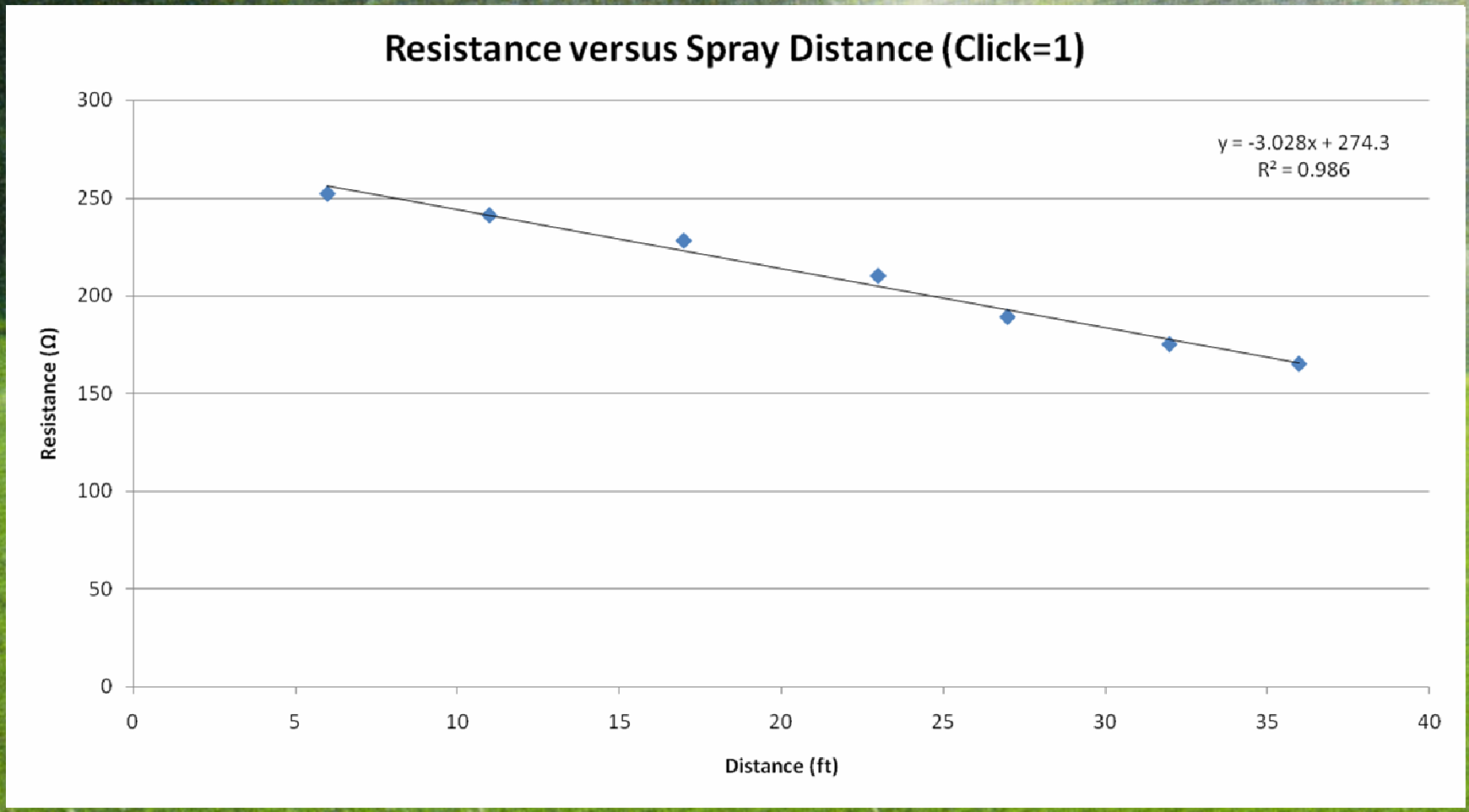
[Sprinkler Head + Spike]

[Sprinkler Head]

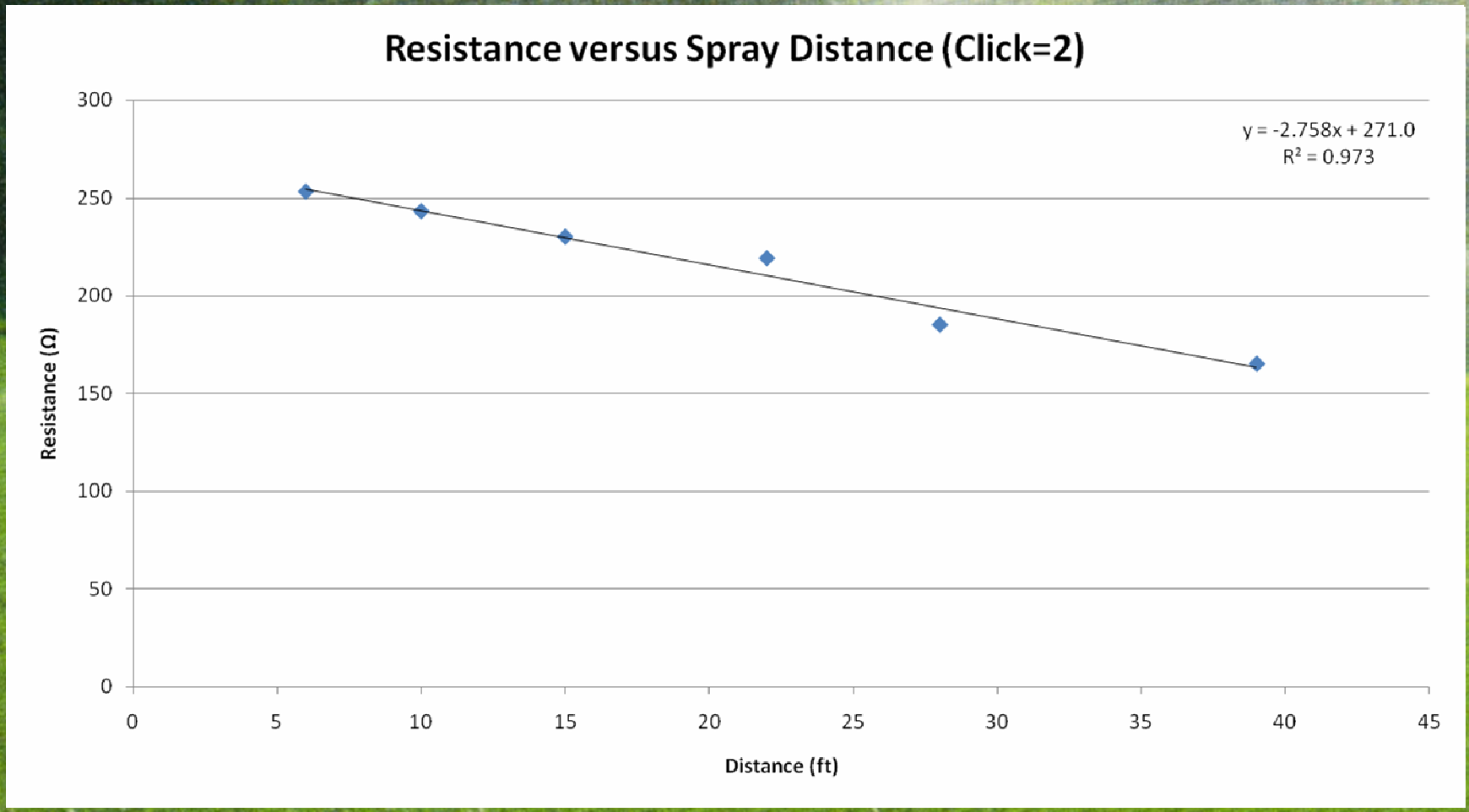
Sprinkler Pressure Data



Sprinkler Pressure Data (Cont.)



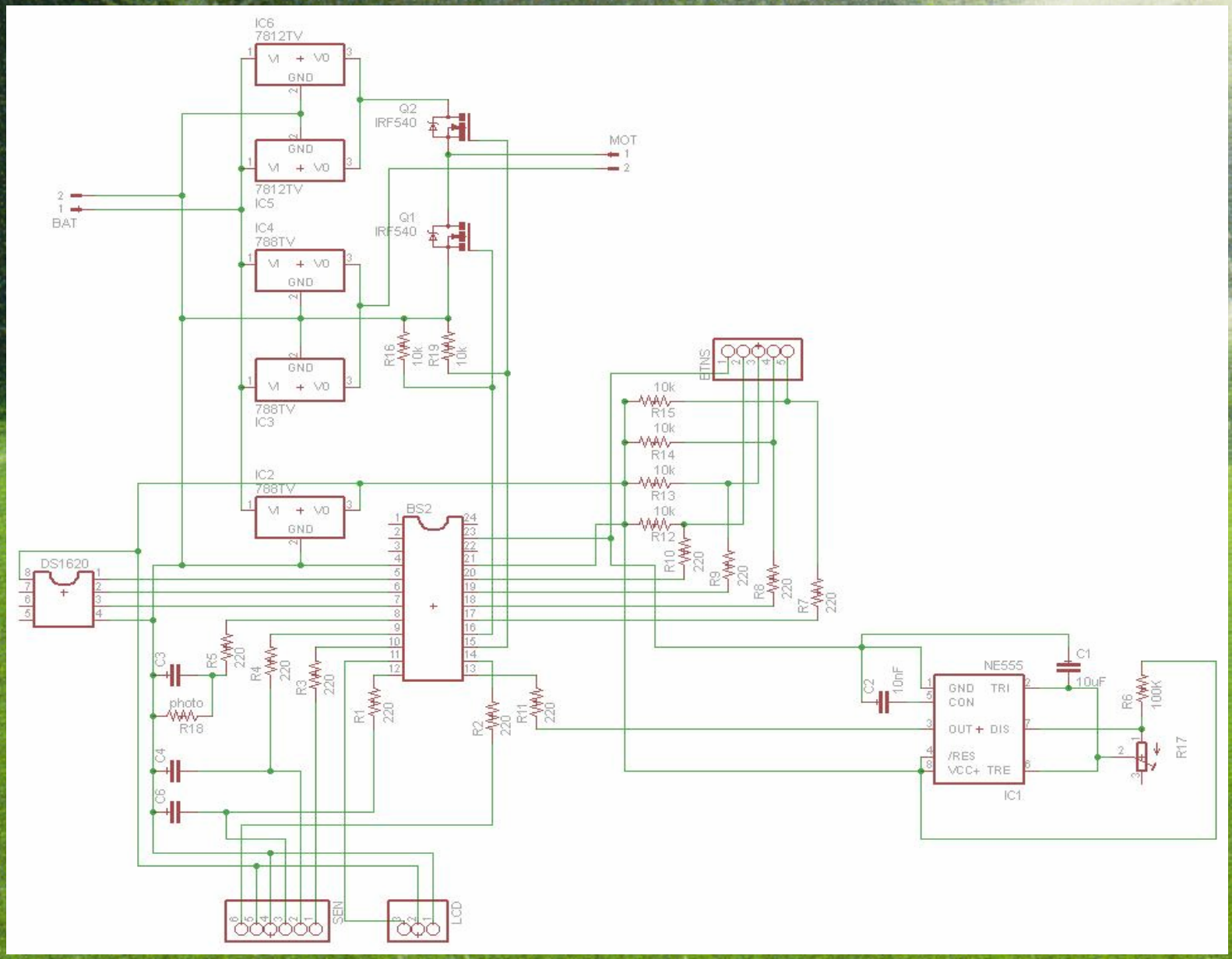
Sprinkler Pressure Data (Cont.)



Circuit Design

- Use of PCB instead of breadboard
  - Increases reliability
  - Decreases space and # of components
- Cadsoft Eagle used to design circuit
- Main Features:
  - Parallel RC circuits for most sensors
  - 555 Timer Astable Multivibrator circuit
  - Temperature sensor circuit
  - Half bridge using dual power supply and dual MOSFETs

Circuit Design



Program

- Menu allows selection between Auto/Manual control
- Main Features:

Auto:

- RCTime command obtains analog sensor inputs
- 555 Timer fine-tuned to output 0.5Hz → timing
- IF…THEN statement nesting for weather checking
- Continuous monitoring of ultrasound while active

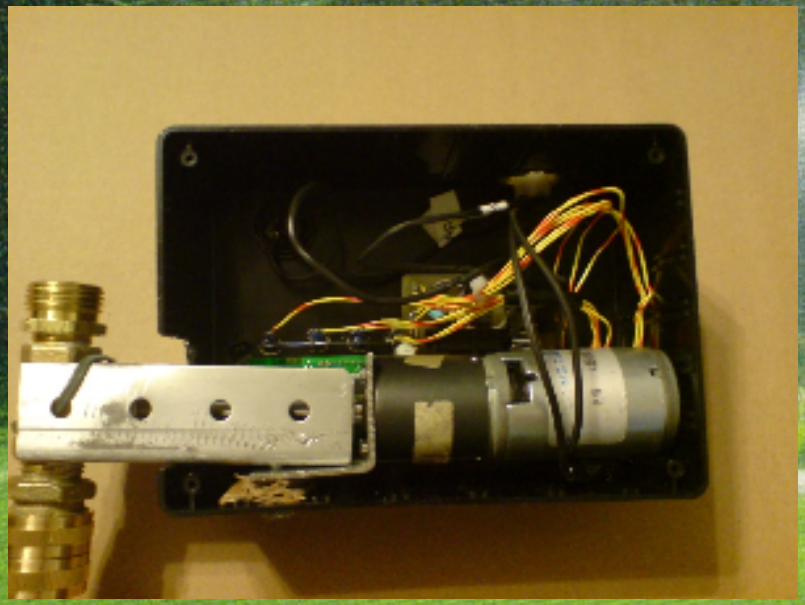
Program

Manual:

– Position control of DC motor-valve assembly

– Pushbuttons for return to menu and responses

Prototype



Back/Inside (Control Unit)

Front (Control Unit)

Prototype (Cont.)

Autonomous Sprinkler System

Safety

- Safety resistors used in circuitry
- Electronics contained in container
- DC motor circuit electrically isolated from BS2 circuit and has series RC transient suppressor
- Kill switch for immediate user termination
- Warnings during manual mode

Automatic Control

- Motor Control
  - Sprinkler avoids objects that are not meant to be sprayed
  - PING)))
  - Pressure sensor used to locate motor position
- Moisture sensor, Light sensor
  - Finds water content in soil to decide whether to water
- Light sensor
  - Determines (Night/Day) to decide whether to water
- Temperature sensor
  - Determines air temperature to decide whether to water

User Interface / Manual Control

- LCD screen and four pushbuttons
- Menu
  - Welcome user and introduce product
  - Provide simple monitoring and motor control
  - User can request sensor data

Materials & Cost

Part #	Item	Item Cost ($)	Quantity	Total Cost ($)
01	Basic Stamp 2 Module	49.00	1	49.00
02	Sprinkler Head	4.99	1	4.99
03	Hose	11.00	1	11.00
04	Project Box (big)	4.99	1	4.99
05	Project Box (small)	2.99	2	5.98
06	LCD	29.99	1	29.99
07	Pushbuttons	0.99	4	3.96
08	Pressure Sensor	19.99	1	19.99
09	Photoresistor	1.99	1	1.99
10	Moisture Sensor	0.99	1	0.99
11	Temperature Sensor	6.99	1	6.99
12	Range Finder	29.99	2	59.98
13	Killswitch	0.99	1	0.99
14	555 Timer	1.99	1	1.99
15	Resistors	0.15	10	1.50
16	Capacitors	0.20	5	1.00
17	Jumper Wire	0.05	20	1.00
18	PCB	2.00	1	2.00
19	LED	0.50	2	1.00
20	Additional Accessories			15.00

Limitations and Future Work

- Cost
- Distance sensor
  - Increase distance sensing range
- Weather sensing
  - Improve weather sensing precision
- Better motor control
- More interactive menu
- External EEPROM for weather data storage
- Security Capabilities
- Sprinkler networking

Conclusion

- Project scope was made too large
  - Unnecessarily complicated design decisions
- Printed circuit too time consuming
  - Despite its advantages → took days to make


Thank you for your time!
Any Questions?