ECE 445 Group 22 Fall 2020

COVID-19 TEST KIT DISTRIBUTION MACHINE

Richard Ding, Daniel Polyakov, Brian Zheng

Introduction

Current situation:

- Ongoing COVID-19 Pandemic and the possibility of a future pandemic
- Private and public sector need

Idea:

- Automated Machine with authentication that can distribute testing kits
- Can interact with a database on server for verification and testing registration

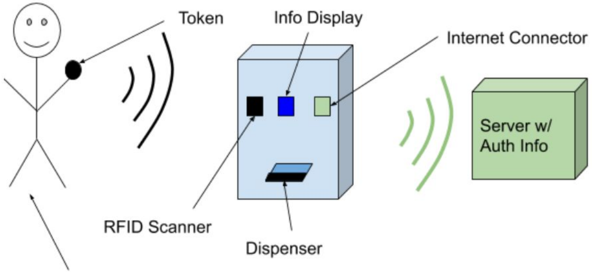


Figure 1: Visual of the Machine and Operation

— Objectives

· Labor Reduction -> 0 extra labor assistance

· Less unsafe contact -> 0 need to touch the machine

· More security -> 1 Verification token usage for each user

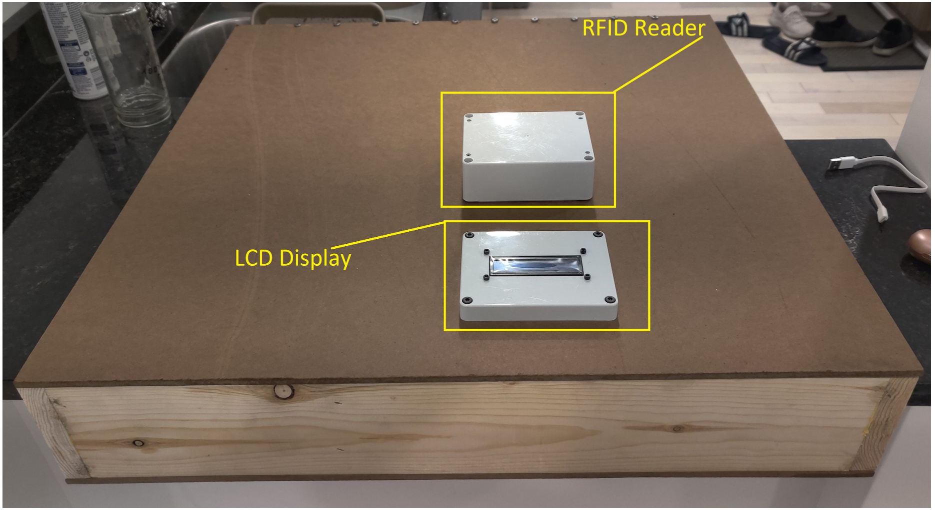
· More extensibility -> Wirelessly connection enabled

· More data stability -> Run with SQL, cloud deployable

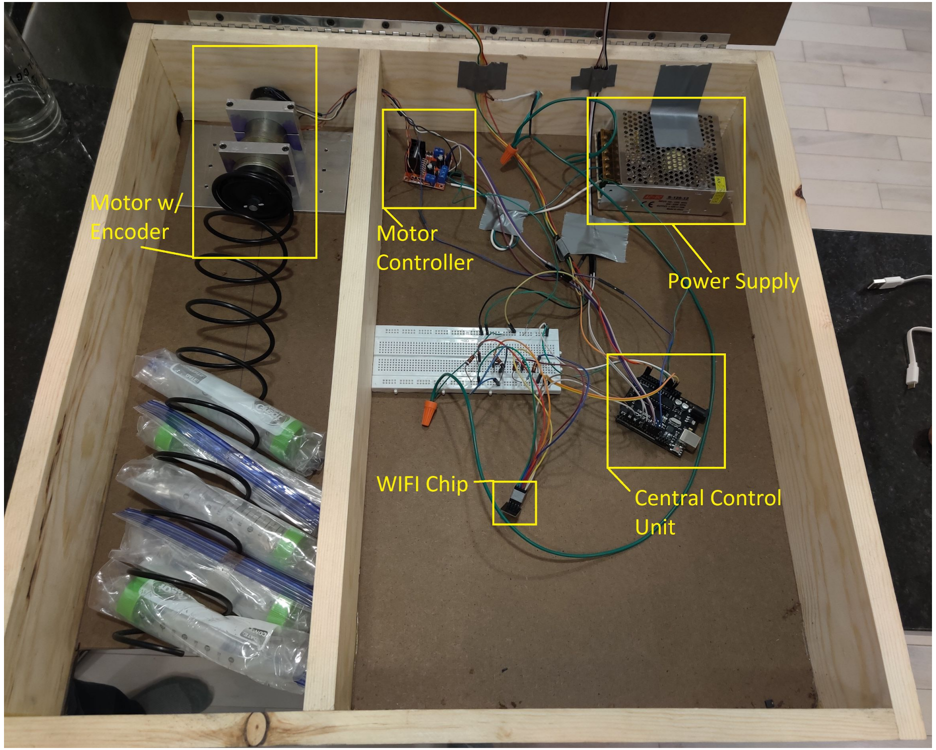
· Time saving -> Last no more than 1 min for each user

_ Picture of the Prototype

Outer View

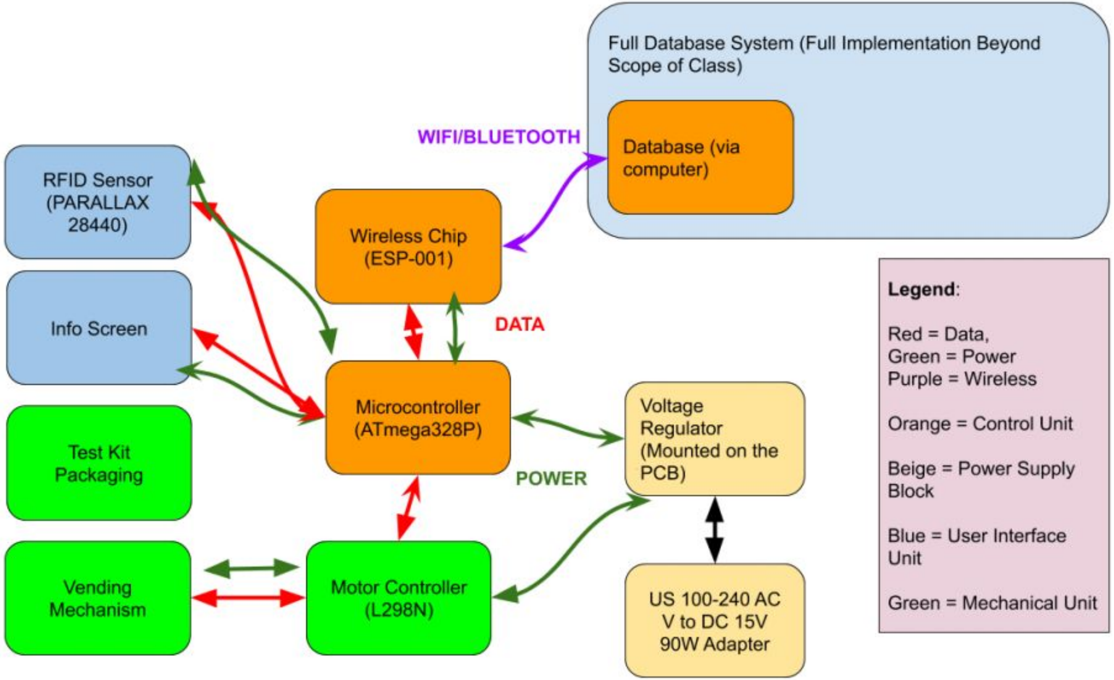


Inner View

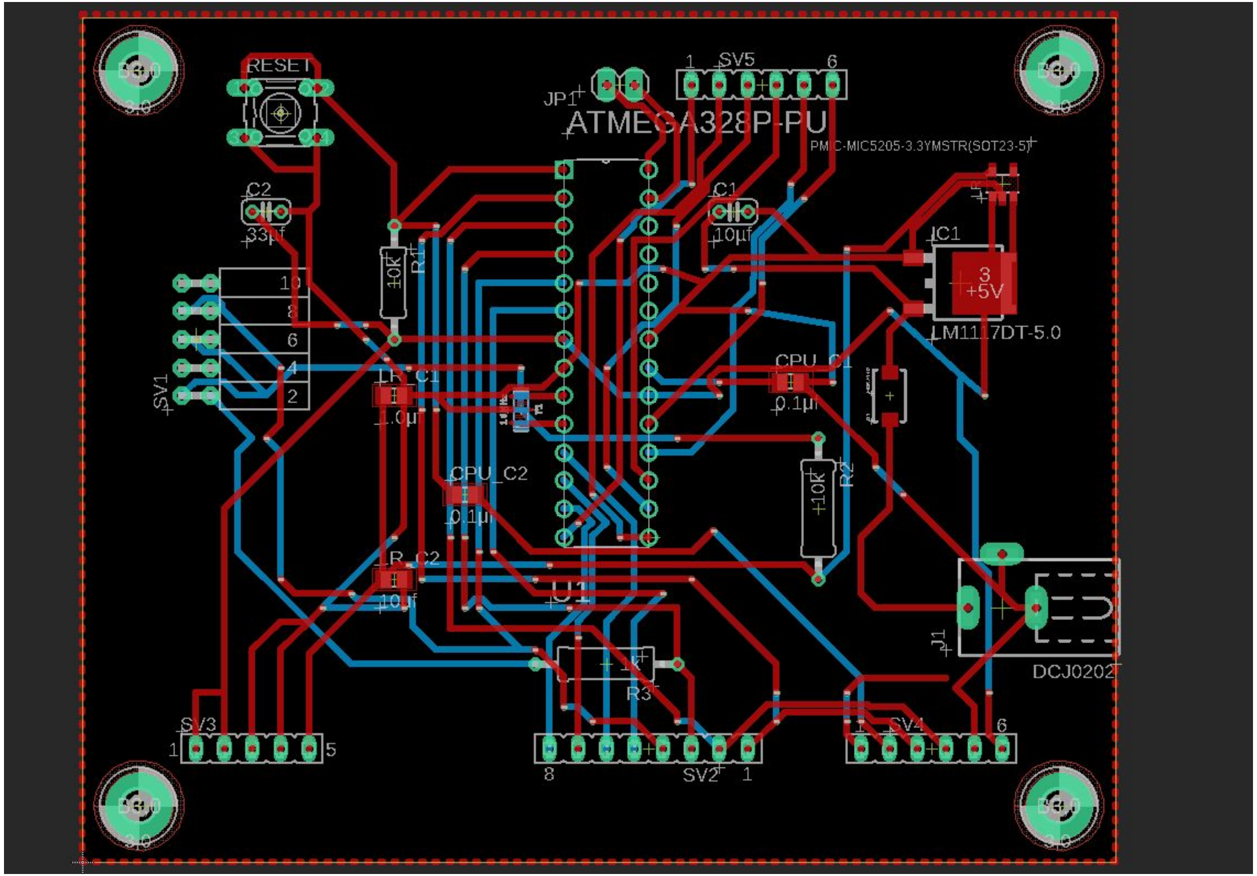


Block Diagram

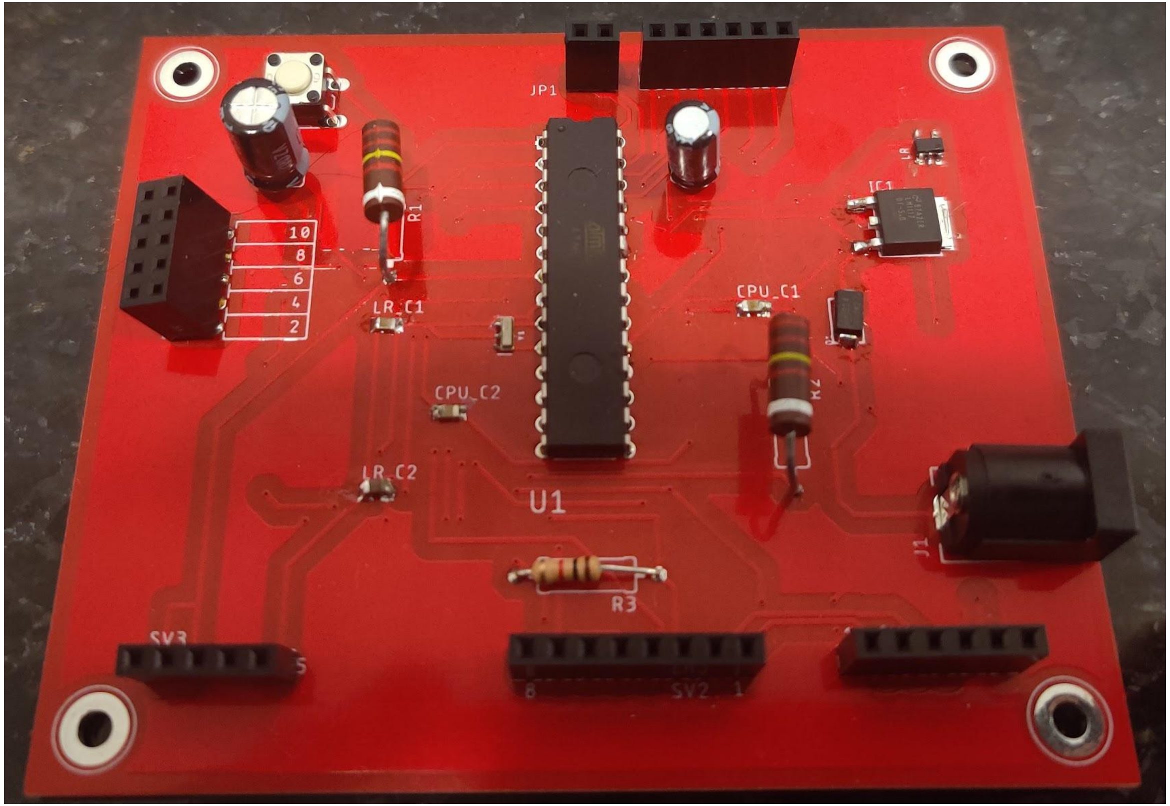
- <u>Power subsystem</u>
  2 Linear Regulators
  12 to 5V and 5 to 3.3V
- <u>Control Unit subsystem</u>
  ATmega328P 5V
  ESP-001 3.3V
- <u>Mechanical subsystem</u>
  L298N Motor Controller
  A motor with encoder
  A spiral
- <u>User Interface subsystem</u>
  An info display
  RFID Sensor



_ PCB Design Board View

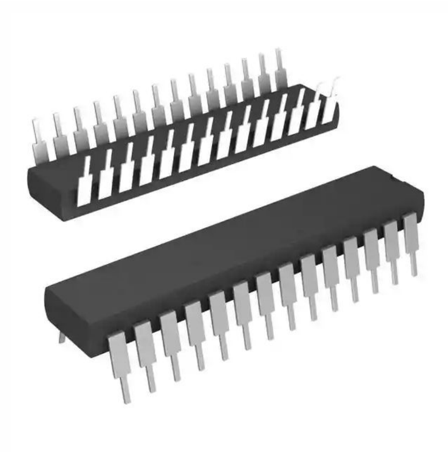


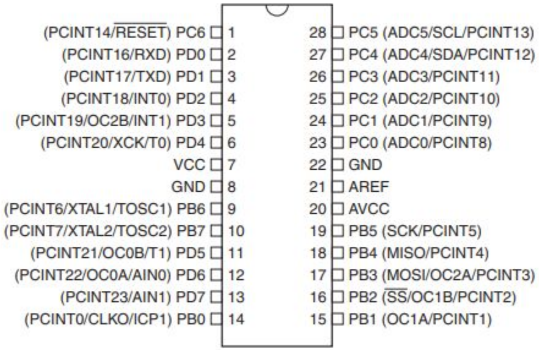
_ PCB Board Physical View

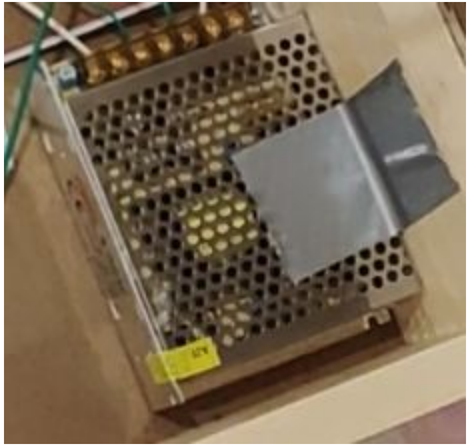


Hardware Overview (in-house)

- ATMEGA328P-PU
- Voltage Linear Regulators (Convert from 12 V DC -> 5 V DC -> 3 V DC)

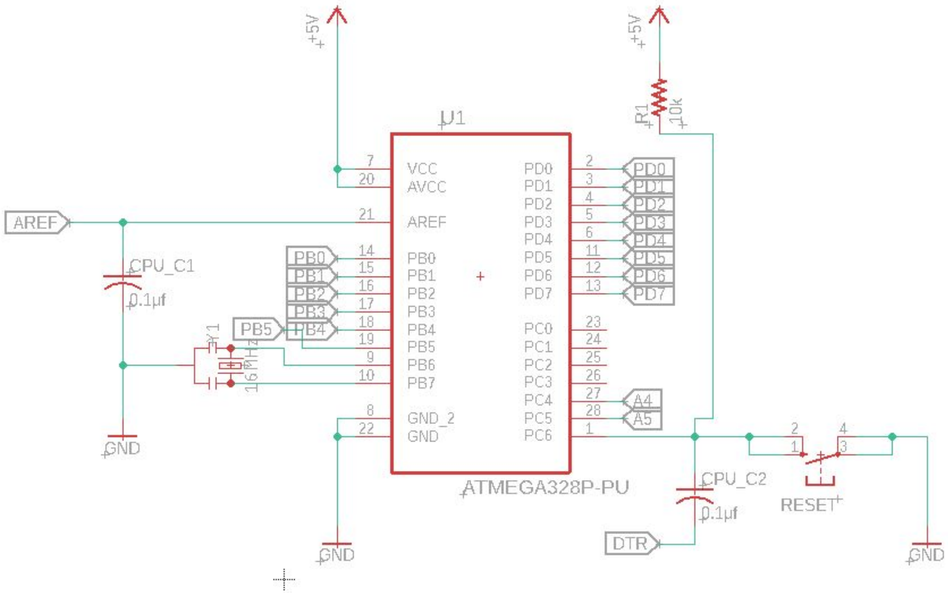






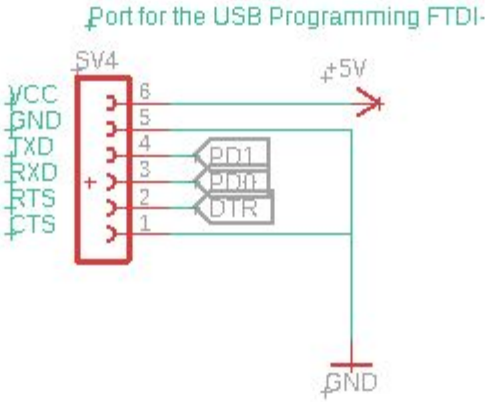
Central Control Unit (ATMega328P-PU)

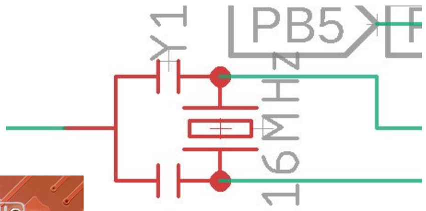
- Communicaticates with all components (RFID, Wi-Fi, and Motor Controller)
- Receive signal from the server, the RFID
- Sends outputs to the L298N motor controller, and communicates with the ESP-001 Wi-Fi Chip

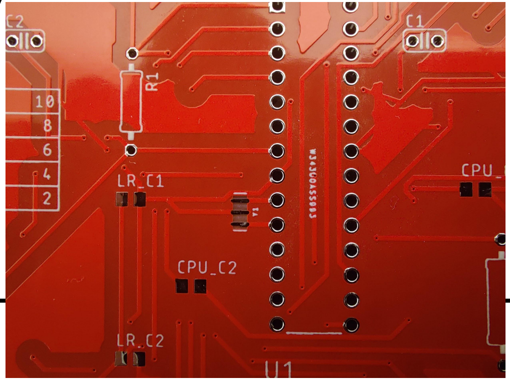


PCB Failure (ATMega328P-PU)

- Programming problems (the USB serial did not interface with board)
- Voltage regulators, capacitors ruled out; all functioned as intended
- Pin connections and ports were correct
- 16 MHZ crystal likely shorted due to small size (commonly causes errors if improperly connected)
- USB serial was set to correct port, board, a firmware in the Arduino ISP

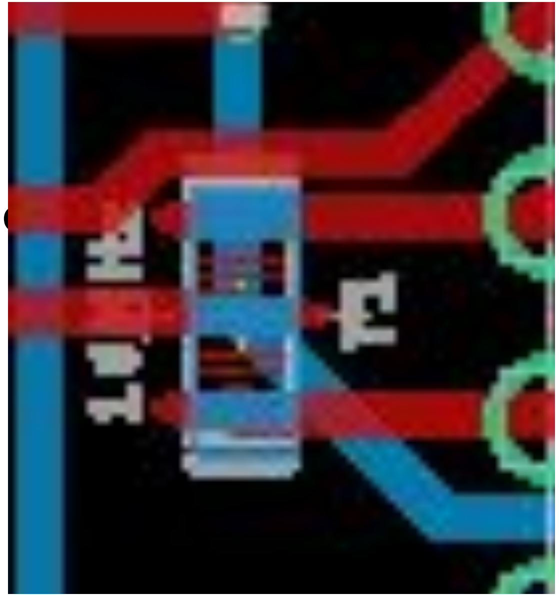


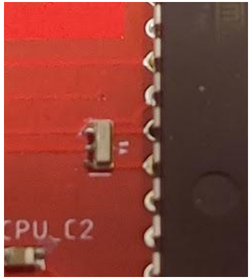




PCB Improvements

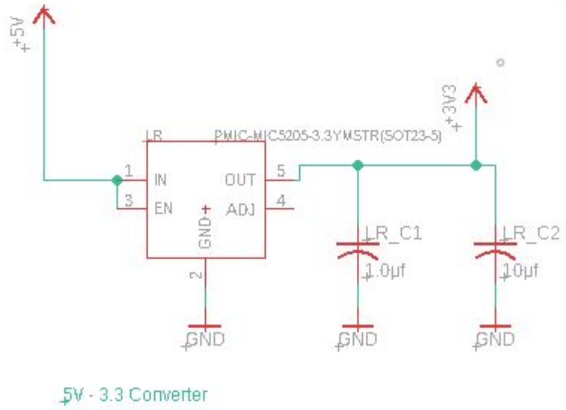
- PCB did not make use of a chip mount: easy removal of the microcontroller would reduce tim and allow for easier debugging and reprogramming
- Test the USB FTDI beforehand to ensure the ATMEGA328 can communicate
- Use a larger 16 MHZ crystal

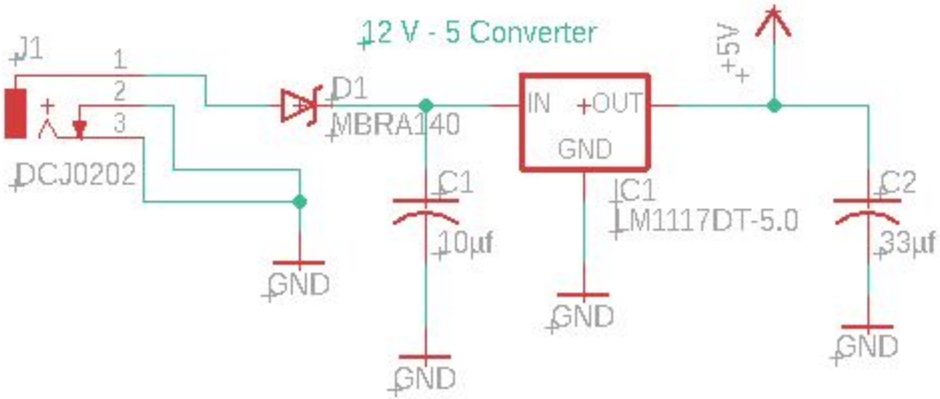




Voltage Linear Regulators

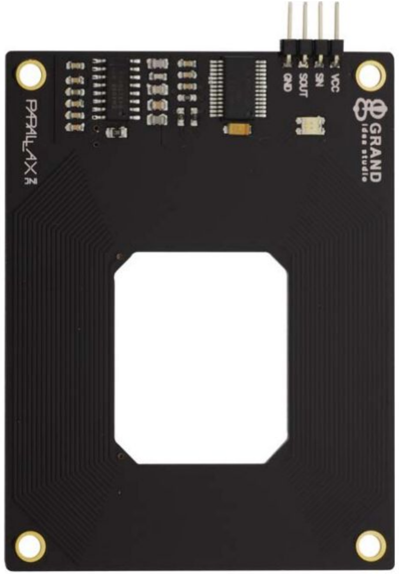
- Convert DC Power 12V (L298N) -> 5V (ATMEGA) -> 3.3V (ESP-001)
- 12 - 5 V (Texas Instruments LM117)
- 5 - 3.3 V (MicroChip MIC5205 Low Noise (3.3 V))

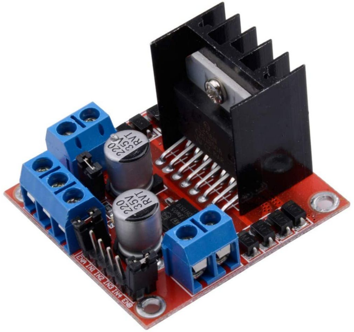


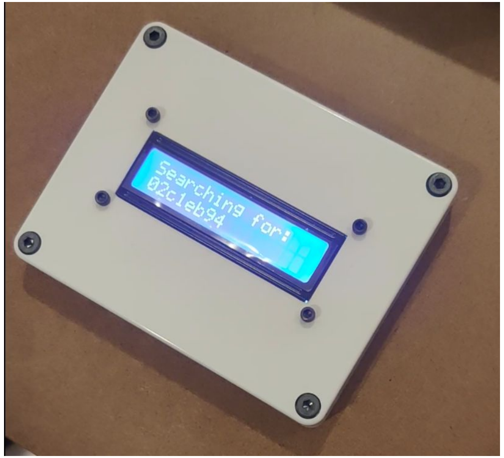


Hardware Overview (Outsourced)

- PITTMAN GM9413D631 Motor with Encoder
- L298N Motor Controller
- Parallax 28440 RFID
- ESP 001 Wi Fi Chip
- LCD
- Power Supply







PITTMAN GM9413D631 Motor with Encoder

- 5 V Encoder
- 12 V Motor
- 65:5:1 Ratio
- Physical calculation of the encoder pulse per revolution (PPR) yielded approximately 1176 PPR (~1200 PPR)
- Using encoder yields more accurate positioning for the machine to determine when to stop the motor

PITTMAN MOTOR Encoder Calculation

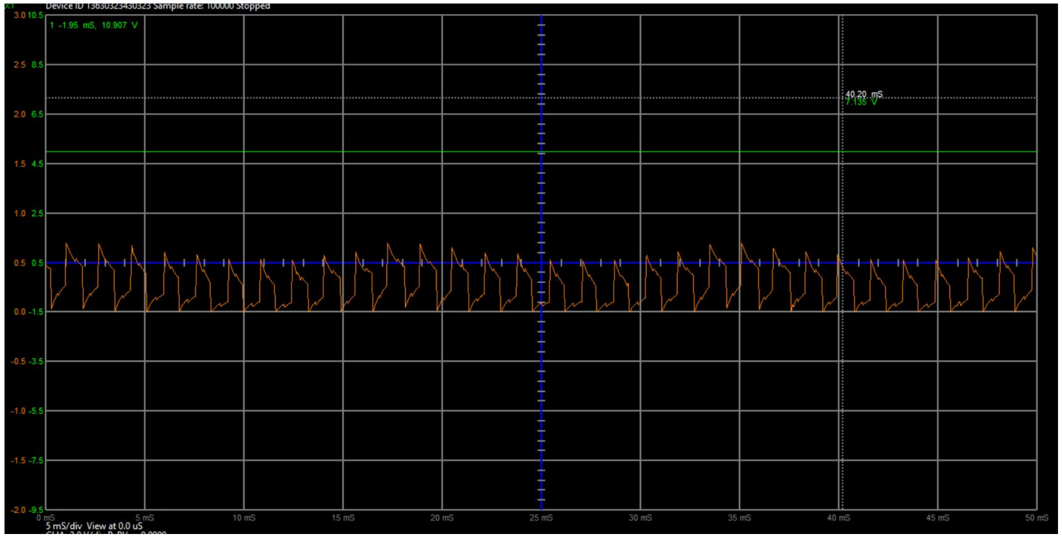
$$Encoder\ PPR = \frac{60\ seconds}{rpm} \times pulse\ per\ second$$

- To calculate the proper spin of the motor, one must calculate the total amount of pulses needed to conduct a 360 degree rotation (Pulses Per Revolution or PPR).
- Most encoders come with two outputs, only one output needed (only one direction for the motor)

Motor Calculation (continued)

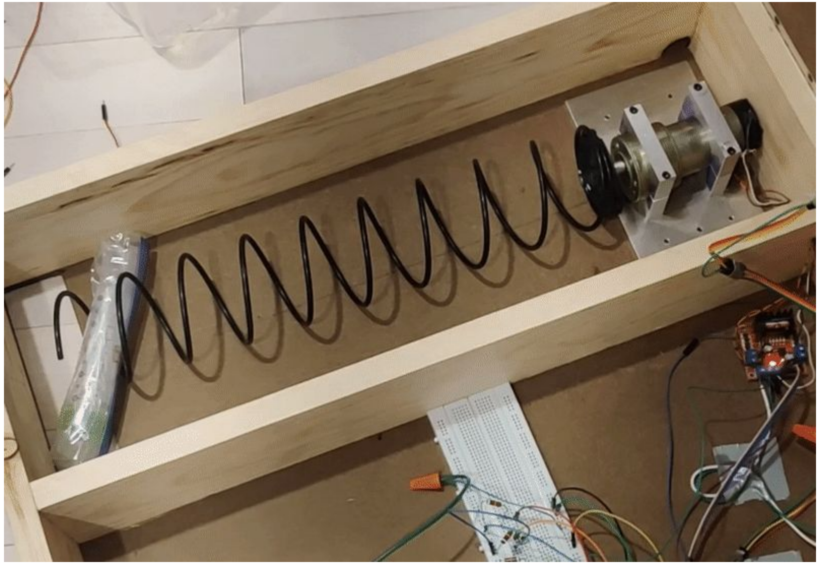
- Using a 5V source to power the motor:
- 30 pulses in 50 mS (or 600 pulses in 1 second)
- RPM: 30.6 rotations per minute.
- Resolution of encoder: 360 degrees/ PPR = .3 degrees per pulse

Measurement of Encoder Pulse (30 pulses over 50 mS)



$$Encoder\ PPR = \frac{60\ seconds}{30.6\ rpm} \times 600\ pps\ =\ 1176\ PPR$$

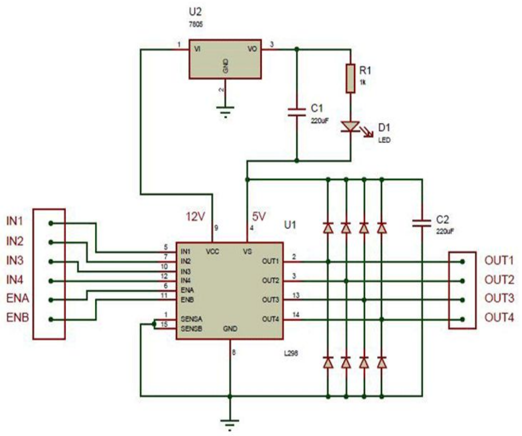
External Factors that can affect a motor's speed

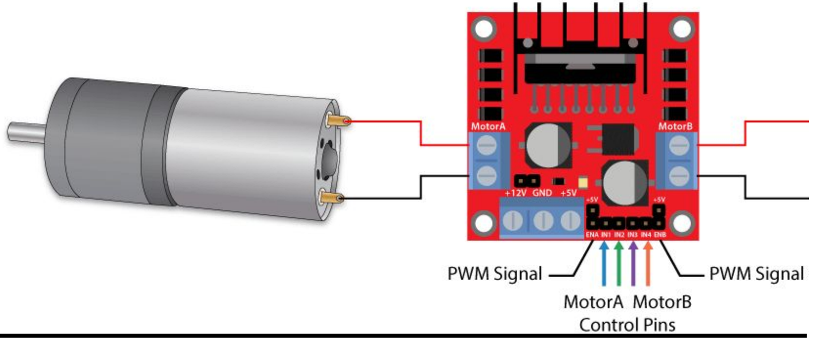


- Friction (what the spiral holds can affect the weight and tension)
- Temperature
- Connections (voltage and power supplied to the controller)
- Winding

L298N Motor Controller

- 12 V (more than enough power)
- Provides the power needed to operate the motor
- Can also serve as an auxiliary power for the central control unit if the external power supply fails (via 5V output)





External Power Supply

- LEDMO Switching Converter, AC/DC Power Supply Adapter Transformer Driver for LED Strip Lights, AC 100V/240V to DC 12V, 10A, 120W
- Serves as the main source of power for the central control unit
- US Plug
- Connected directly to the PCB DC power port

Parallax 28140 RFID

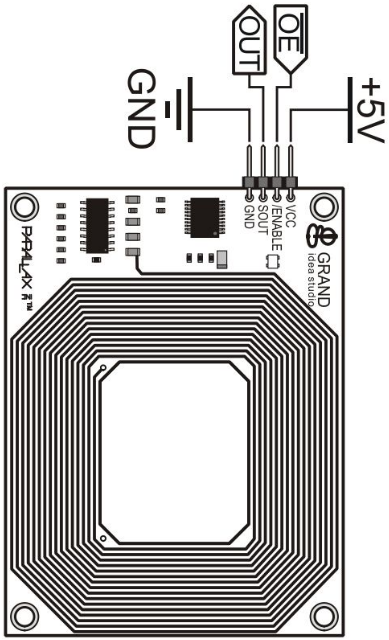
- Necessary for reading RFID tokens from the machine
- 125 kHz
- 5V Input

Parameter	Ideal Value	Tolerant Range	Test Value
Vcc	5.0 V	5.0 ± 0.5 V	5.07 V
Icc	108 mA	108 + 92 mA	112.8 mA

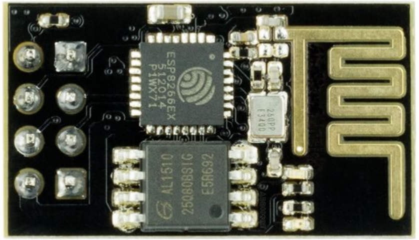
Verification Table

At V_{CC} = +5.0V and T_A = 25ºC unless otherwise noted

Parameter	Symbol	Test Conditions	Specification			Unit
			Min.	Typ.	Max.	
Supply Voltage	V_{CC}	---	4.5	5.0	5.5	V
Supply Current, Idle	I_{IDLE}	---	---	9.4	---	mA
Supply Current, Active	I_{CC}	---	---	108	200	mA
Input LOW voltage	V_{IL}	+4.5V <= V_{CC} +5.5V	---	---	0.8	V
Input HIGH voltage	V_{IH}	+4.5V <= V_{CC} +5.5V	2.0	---	---	V
Output LOW voltage	V_{OL}	V_{CC} = +4.5V	---	---	0.6	V
Output HIGH voltage	V_{OH}	V_{CC} = +4.5V	V_{cc} - 0.7	---	---	V



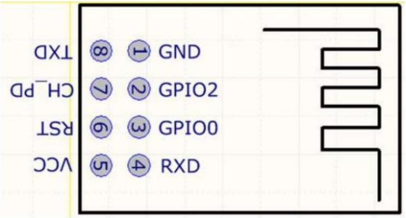
ESP-001 Wi-Fi Chip



- WiFi Protocols 802.11 b/g/n
- Frequency 2.4GHz
- Operating Voltage 3.3V

Operating Condition	Ideal Value	Tolerant Range	Tested Value
Operating Temperature	20 ℃	-40 ℃ to 125 ℃	25 ℃ to 36 ℃
Supply Voltage	3.3 V	3.3 ± 0.3 V	3.28 V

Verification Table



Operating Condition	Symbol	Min	Typ	Max	Unit
Operating Temperature		-40	20	125	°C
Supply voltage	VDD	3.0	3.3	3.6	V

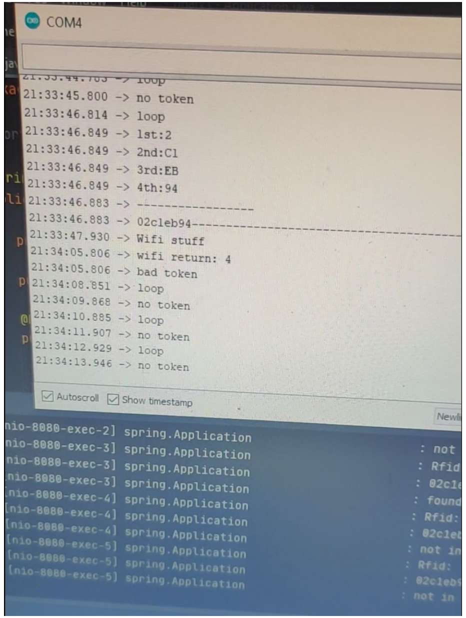
Datasheet Table

LCD

- SunFounder IIC I2C TWI 1602 Serial LCD Module Display
- Standard interface into ATMEGA

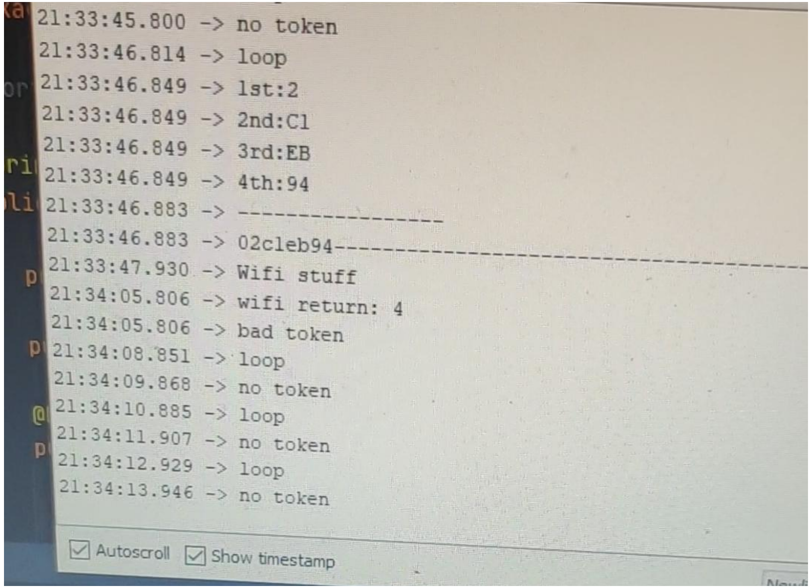
Software Overview

- Software in machine
  - ATMEGA running code to manage the RFID, LCD, Motor controller
    - Serial communication with the WIFI chip
  - ESP WIFI running code to manage web communication with server
- Software off machine
  - Authentication Server
  - Running in Java Spring boot



ATmega
Running Code

- Controls RFID and LCD chips
- Interfaces to Wifi Chip on Serial Connection
- Interfaces to L298N Motor Controller
    - Does’t send signals to motor directly.
- Directly receives the encoder PPR

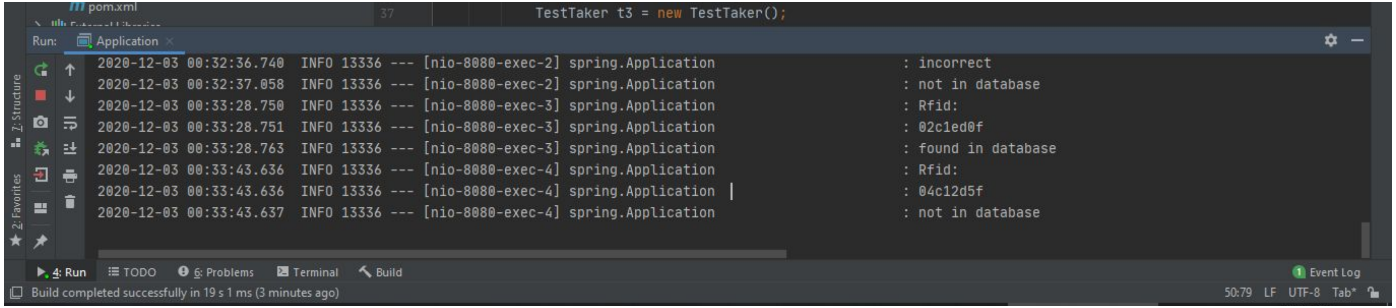


ESP-01 WiFi Chip Running Code

- Accepts RFID tokens from ATMEGA, interprets results from server, and returns if valid or not
- Very common and low cost chip running C code
- Connects to Wifi then waits for ATMEGA code
- Hardcoded server host and Wifi ssid/pass

Server Side
Running Code

- Accepts RFID tokens, returns if they're valid or not
- REST-ful type endpoint written in Java Springboot
  - Easy to create endpoints and manipulate data
- Running SQL on the backend
  - Highly expandable
- Highly versatile
  - Deployable to your favorite cloud hosting service



Conclusion

- Can help government, school and enterprises with COVID testing
- Safe for both human resources and property
- Affordable, about 100-150$ for basic components
- Easy to assemble and place

_ Potential Improvements

- Expand the size of the machine to make it contain more testing tubes
- Construct a more complexed database for a more complete and stable data storage
- Compatibility and support with tracing apps (i.e. Safer Illinois, COVIDWISE) to record testing information and make testing reminder for users
- More practical verification tokens to make the system more accessible like ICard

Thank You

--GROUP 22