

Automated Pill Dispenser

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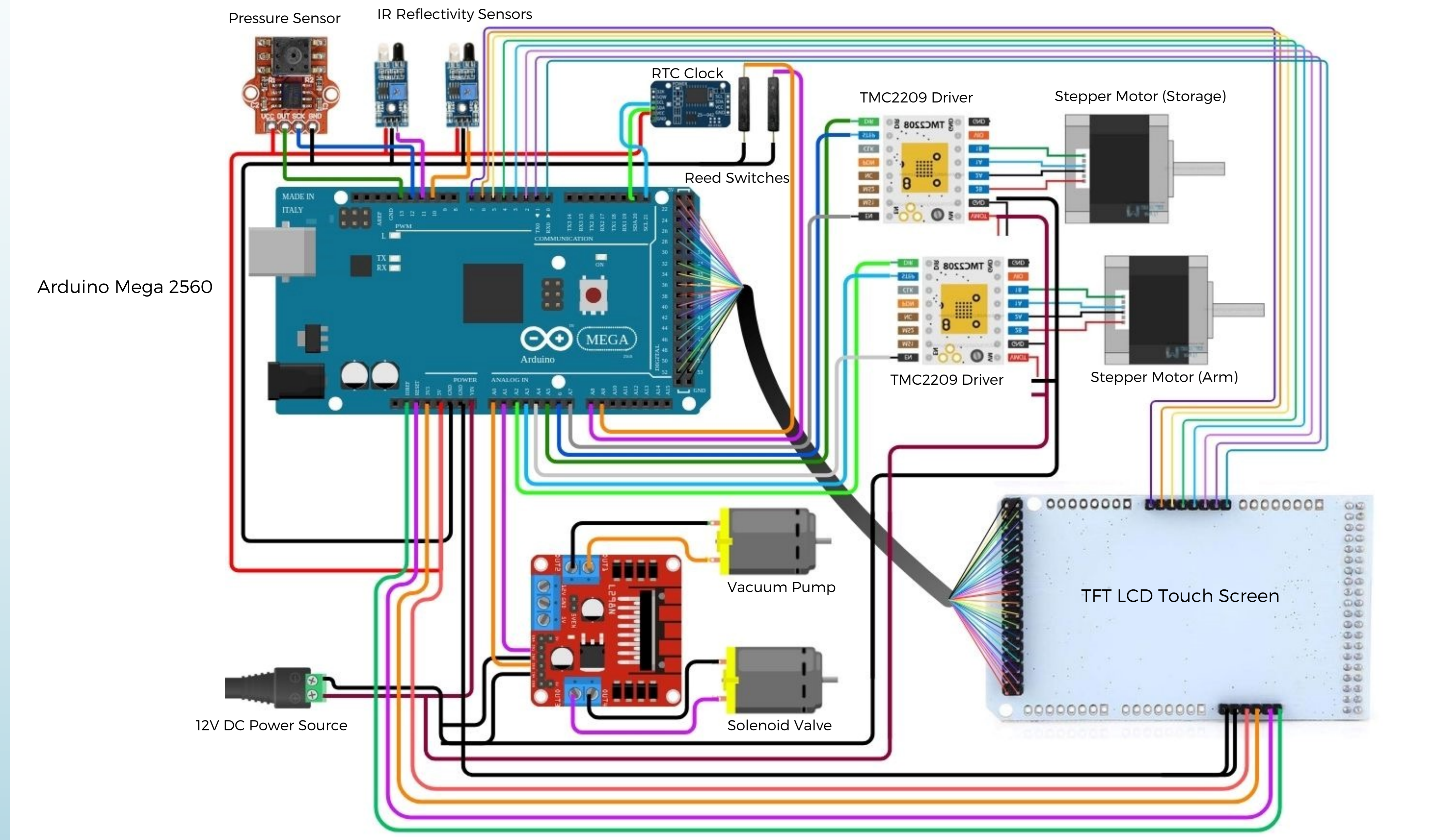


Project Definition

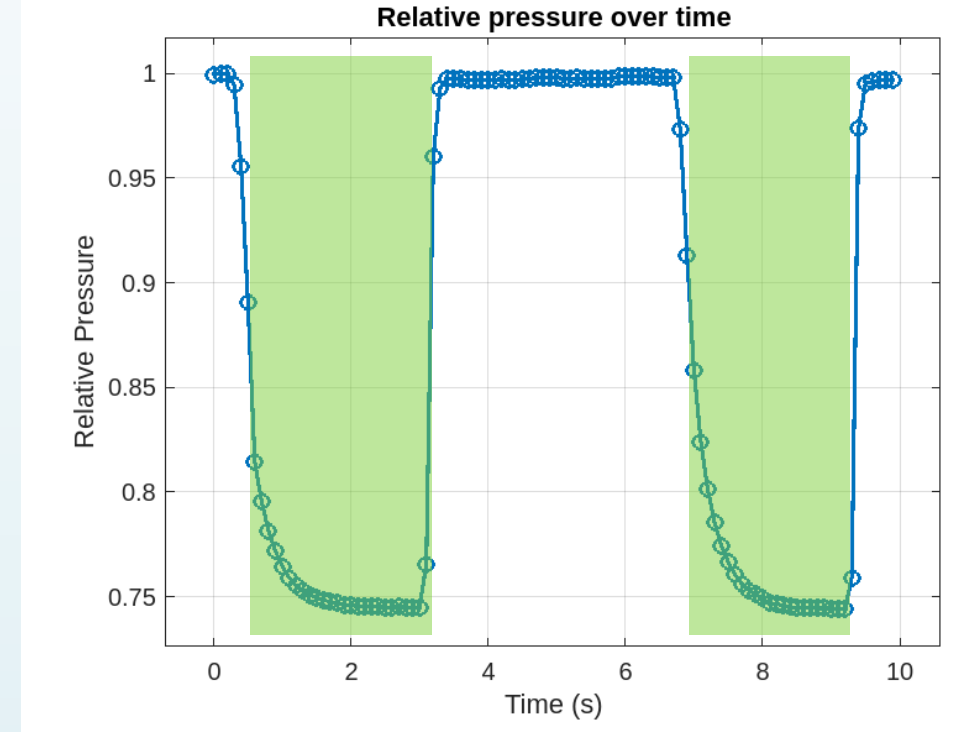
Design a safe, easy-to-use, automated, universal pill dispenser for a diverse range of users to reduce medication non-adherence.

Features and Capabilities

- Compatible with all pills 5mm diameter and larger
- Stores up to 10 types of pills
- Each storage compartment holds minimum of 30 pills
- Touch screen interface for easy and efficient use
- Easy to program customized medical schedule to automatically dispense pills
- Can manually dispense a desired number of pills using touch screen interface
- Maintains programmed schedules through power outages using Real Time Clock Module battery
- Uses a single 12V DC power supply
 - 4.8W standby power
 - 30W when dispensing
- Pills dispensed into dish for retrieval
- Single location to refill pill storage compartments
- 30 cm x 30 cm footprint, convenient for tabletop use
- Does NOT require external connections to WIFI or Computer
- Redundant validation systems to ensure correct pill and time (see "Performance and Reliability")



Performance and Reliability



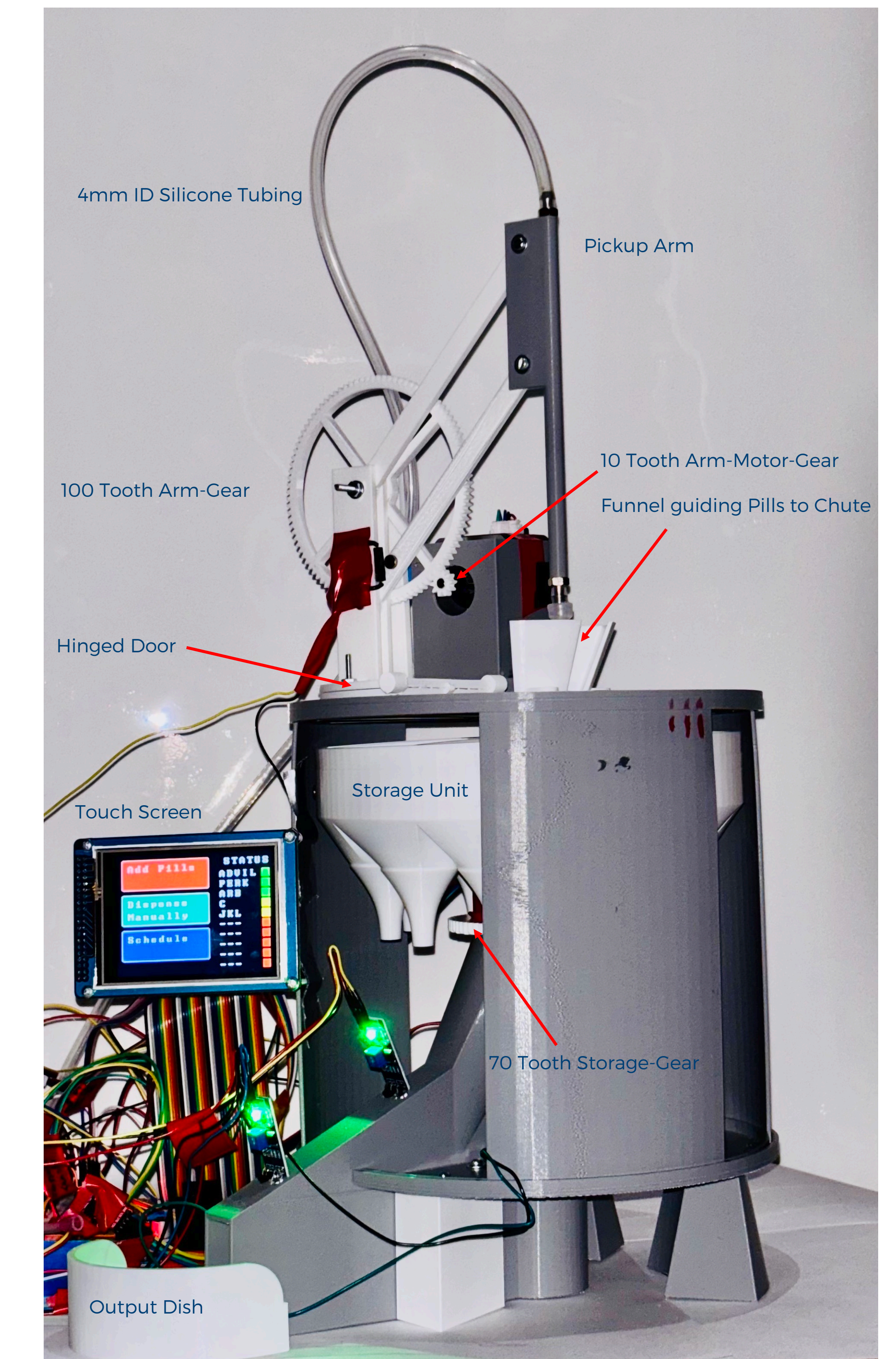
Pressure sensor measuring pill attachment
(Green boxes indicate time with pill attached)

Pressure sensor pill attachment detection:
100% reliability (200+ trials)

Pill Dispensing Infrared Sensor:
100% reliability (200+ trials)

Pickup reliability: Dispenses the correct pill at scheduled time with 100% accuracy

Final Prototype



Mechanical Systems

Vacuum System to Pick Up and Release Pill

- o 12V DC vacuum pump
- o -81kPa vacuum at ~10 Lpm airflow
- o 2 position, 3-way 12V solenoid valve

Pickup Arm

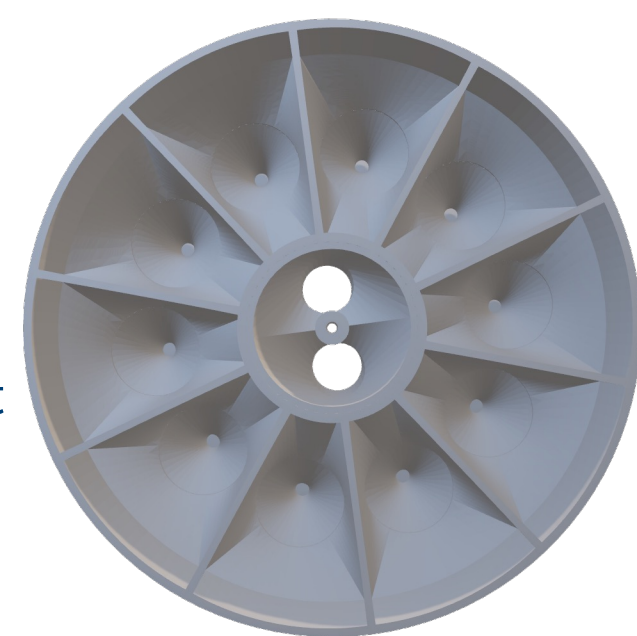
- o Nema 17 Stepper Motor, TMC2209 motor driver
- o Arm uses double linkage to stay vertical while moving laterally
- o 1:10 motor to arm-gear ratio for sufficient torque
- o Torque requirement using calculated moment of inertias = 5 N-cm
- o Factor of safety = 80, neglecting friction
- o Silicone nipple for pill attachment
- o M5 threads for easy nipple change



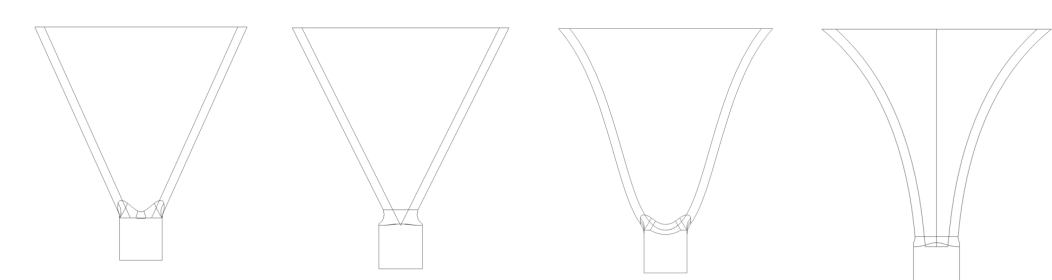
Pill attached to silicone nipple

Carousel Storage System

- o Carousel storage system rotates pill compartment to pickup arm
- o Nema 17 Stepper Motor, TMC2209 motor driver
- o 16:70 motor to gear ratio for driving storage
- o Storage compartment interior shape designed using fusion 360
- o Pickup arm drops pill through center of carousel
- o Conical, triangular, parabolic, and hyperbolic shapes were 3D printed and tested



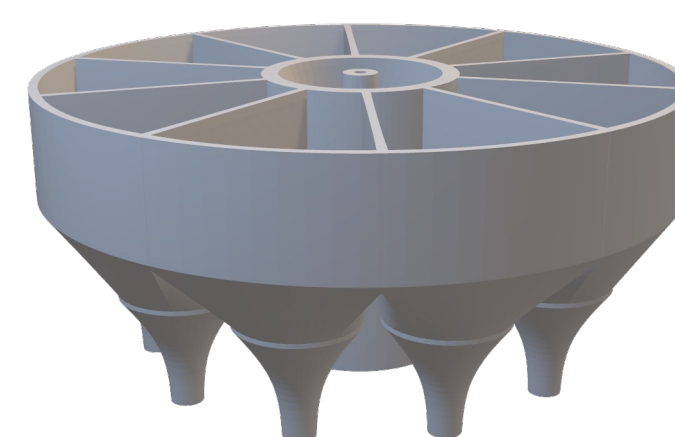
Top view of storage compartment with holes for pill drop-off in the center



Storage shape alternatives (from left to right: conical, triangular, parabolic, hyperbolic)

Housing

- o 3D printed housing
- o 7x3x3 mm rolling-element bearing
- o 3 mm axle for rotation
- o Output chute delivers pill to retrieval dish
- o Hinged door for pill refill



Final storage unit with 10 hyperbolic compartments

Overall Design and Validation Systems

Robust, year-long design process resulted in pickup arm and delivery chute fixed at "6 O'clock", and carousel storage unit rotating 360 degrees, minimizing moving parts. Redundant validation systems using numerous sensors ensure safety.

Air Pressure Sensor

- o Measures stagnation pressure of output stream of vacuum pump to detect pill attachment on nipple.

Infrared Sensors

- o Two redundant infrared sensors independently detect a pill passing through the chute
- o One emitting diode and one receiving diode for each sensor

Stepper Motor step count

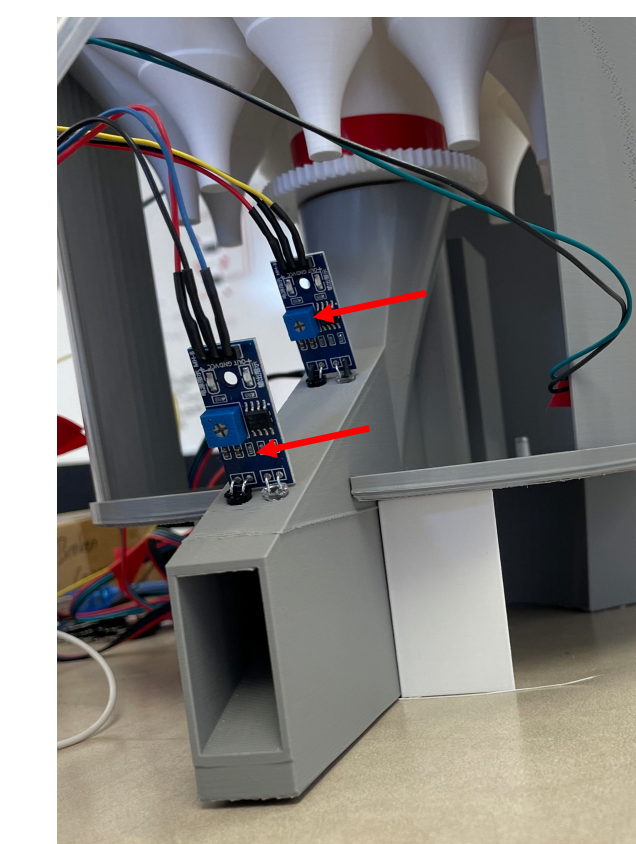
- o Using the TMC2209 motor driver, precise steps can be counted
- o 1600 micro-steps per revolution

Reed Switches

- o Normally open - closes in the presence of a magnetic field
- o Magnets mounted on storage unit and arm
- o Calibrates the position of pickup arm, storage unit, and stepper motor



Pickup arm with reed switch



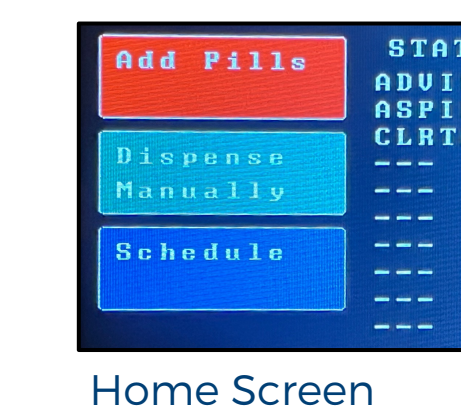
Output chute with IR sensors

User Interface

The user interface was created in Arduino IDE using the UTFT and URTouch libraries created by Rinky-Dink Electronics. With over 1500 lines of code, the interface has the following capabilities:

Home screen

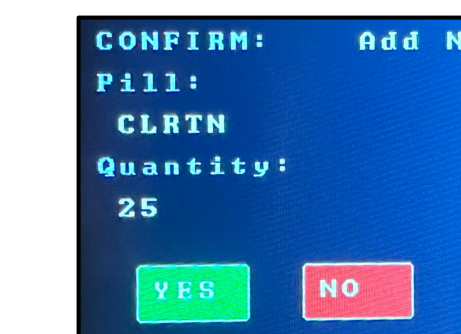
- o Add, Dispense, Schedule Pills
- o List of pills in system
- o Status of pills
 - o Red: no more pills left
 - o Yellow: < 10 pills left
 - o Green: > 10 pills left



Home Screen

Add New Pill function:

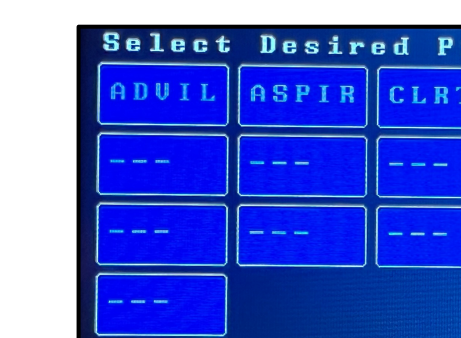
- o Enter name of pill
- o Enter quantity added
- o Confirm info or cancel addition



Confirmation Screen to add new pill

Add Existing Pill function

- o Select pill type to add
- o Select quantity added
- o Confirm info or cancel addition



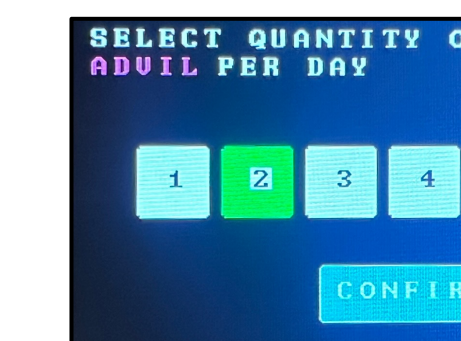
Pill Type Selection

Dispense Manually function

- o Select desired pill & quantity
- o Desired pill(s) will automatically be dispensed to retrieval dish

Schedule Dispensing

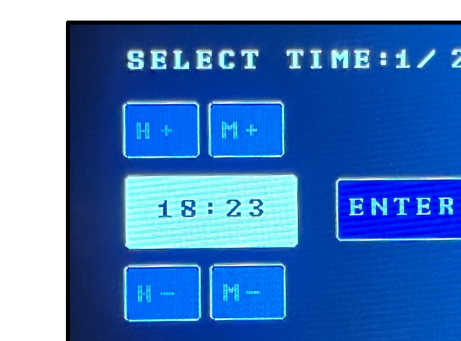
- o Select pill type and quantity
- o Schedule up to four times per day for pill to be dispensed
- o Interface gets time from Real Time Clock (RTC) module and dispenses desired pill



Scheduling Quantity

Memory

- o Device stores all information in internal EEPROM memory in case of power outage



Scheduling Screen

Acknowledgements

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Video of Prototype