System Design for Pot-pulator

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1 Revision History

Date	Version	Notes
2023-01-18	Juan Moncada, Aaron Billones, Steven Ramundi, Gillian Ford	Initial release

2 Reference Material

This section records information for easy reference.

2.1 Abbreviations and Acronyms

symbol	description
ProgName	Explanation of program name
[... —SS]	[... —SS]

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3 Introduction

The Pot-pulator is a machine with purpose of aiding Sheridan Nurseries in populating their trays with pots, in order to prepare them for filling with soil and seeds.

Their current method of populating the trays with pots is a process with little to no automation, requiring many manual hours of labour. Each year, 250,000 annual plants need to be produced by the nursery. Recently, the supervisors have found it increasingly more difficult to fill positions with enough workers to run the operation smoothly and meet production demand. The Pot-pulator will alleviate the large reliance on manual labour and improve the overall efficiency of the nursery.

This document consists of a detailed design overview of the Pot-pulator. The system overview, system variables, user interfaces, hardware design and electrical design will be presented in this document.

4 Purpose

This document describes the overall system functionality and the design overview of the Pot-pulator. It will describe how the mechanical, electrical, and software components will interact with each other, and the various design decisions made within the system. The Module Guide (MG) and Module Interface Specification (MIS) are additional design documents that provide a further in depth design of the components in each module of the system.

5 Scope

The following figure shows the boundary between the Pot-pulator device and its functionality within the given environment.

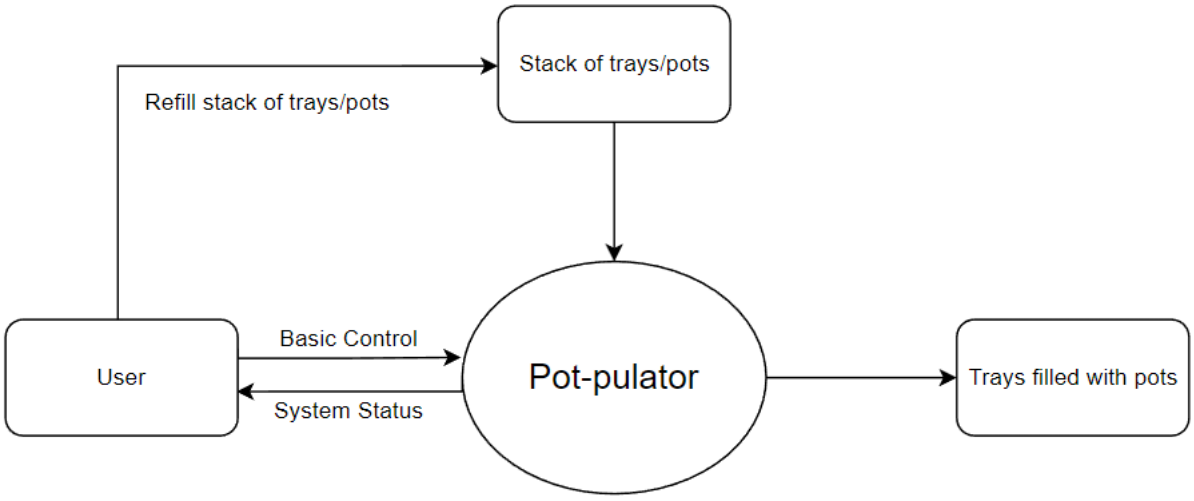


Figure 1: System Context Diagram

6 Project Overview

6.1 Normal Behaviour

6.2 Undesired Event Handling

[How you will approach undesired events —SS]

6.3 Component Diagram

6.4 Connection Between Requirements and Design

[The intention of this section is to document decisions that are made "between" the requirements and the design. To satisfy some requirements, design decisions need to be made. Rather than make these decisions implicit, they are explicitly recorded here. For instance, if a program has security requirements, a specific design decision may be made to satisfy those requirements with a password. —SS]

7 System Variables

[Include this section for Mechatronics projects —SS]

7.1 Monitored Variables

Variable	Description	Type	Units
Sensor Distances	Measured distances that the sensor identifies	Distance	mm
System State	Determines the state of the system (ie. Ready, Running, Error, Success)	State	N/A
Tray/Pot Weight	Weight of the trays/pots to verify number in the stack	Weight	kg
Tray/Pot Height	Height of the trays/pots to verify number in the stack	Height	m

7.2 Controlled Variables

Variable	Description	Type	Units
Motor Speeds	The speeds at which the motors in the system will turn	Speed	rad/s
Voltage In	Voltage going into the system	Voltage	V
Current In	Current going into the system	Current	A
LEDs	LED status lights	Boolean	N/A

7.3 Constants Variables

Variable	Description	Type	Units
Motor Acceleration	The acceleration at which the motors in the system will turn	Acceleration	rad/s^2
Pots Dispensed	Pots dispensed by the system per cycle	Quantity	pots per cycle
Trays Dispensed	Trays dispensed by the system per cycle	Quantity	trays per cycle
Total Distance	Total distance travelled by trays	Distance	m

8 User Interfaces

[Design of user interface for software and hardware. Attach an appendix if needed. Drawings, Sketches, Figma —SS]

The User Interface will consist of a set of buttons to allow the operator to safely interact with the machine. It will also consist of audible and visual signals to alert the operator of any action required (e.g. tray/pot restock, verification error, etc.). See Appendix A for interface layout concept.

9 Design of Hardware

9.1 Conveyor

The conveyor subsystem will be comprised of:

- 1 conveyor (including belt, motor, gear box and framing)
- 1 Arduino Uno microcontroller

The conveyor has been acquired from Sheridan Nurseries and will not require fabrication.

9.2 Pot Dropper

The pot dropper subsystem will be comprised of:

- 4 stepper motors
- 4 stepper motor drivers
- 1 Arduino Uno microcontroller
- 4 pot dropper screws
- 1 ultrasonic range finder

The pot dropper will be fabricated with steel x-beam framing to support the mechanism. See Appendix B.1 for a CAD diagram of the pot dropper screw.

9.3 Tray Dropper

The tray dropper subsystem will be comprised of:

- 2 stepper motors
- 1 Sanguinololu driver board
- 2 belts

- 4 belt bearings
- 1 steel x-beam frame
- 1 tray dropper end-effector

The tray dropper will be fabricated with x-beam framing to support the mechanism. The stepper motors and belt bearings will be attached to the framing, and the belts will be secured to the bearings. See Appendix B.2 for a CAD diagram of the tray dropper end-effector.

9.4 Tray Elevator

The tray elevator will be comprised of:

- 4 L-shaped wood frame supports
- 4 long wood frame supports
- 4 short wood frame supports
- 1 wood raising platform
- 1 ultrasonic range finder
- 2 spur gears
- 2 racks
- 2 stepper motors

The wooden frame will be fabricated with screws and wood glue. The stepper motors will be attached to either side of the wood platform responsible for hodling the stack of trays. The spur gears will be attached to the stepper motors. The racks will be attached in the centre of the long wood supports on either side of the frame, and will mesh with the spur gears. This will enable the stepper motors to control the lifting and lowering of the tray elevator based on its current capacity (see Appendix B.3 for CAD diagram).

9.5 Verification

The verification subsystem will be comprised of:

- 2 ultrasonic range finders

10 Design of Electrical Components

The Pot-pulator has a number of electrical components in the system. A complete overview of the circuit diagram can be found in section C of the appendix. To improve modularity and for easier troubleshooting, the electrical components were divided in to 4 subsystems based on the control of the system: conveyor control, pot control, tray control, and verification. These subsystems are each controlled using an Arduino Uno while being monitored by the main microcontroller (STM32F429I-DISC1). For each subsystem, its respective Arduino controls the motors and reads sensor/switch/button values in order to ensure smooth operation. The Arduino relays the operation status to the STM32F429I-DISC1 via status bits, that are sent from each of the subsystems to the STM32F429I-DISC1 at all times. If an error were to occur in one of the subsystems, the STM32F429I-DISC1 will be notified and tell all other subsystems to pause operation.

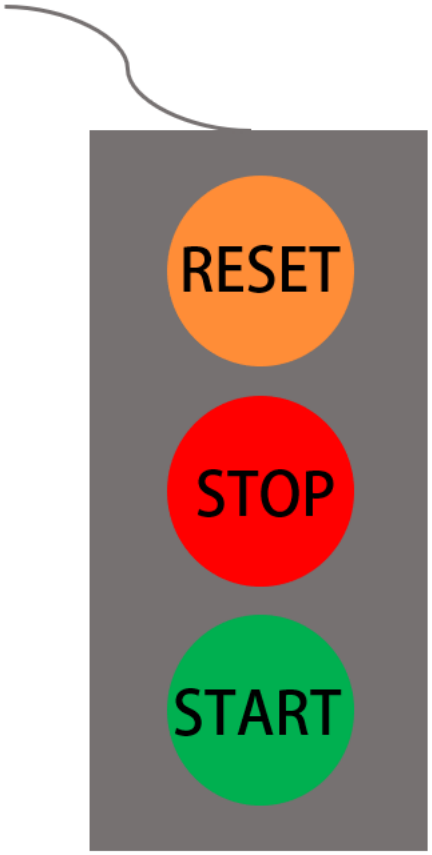
11 Timeline

[Schedule of tasks and who is responsible —SS]

Task	Description	Team Member(s)	Deadline
Pot Dropper Design	Design of pot dropper hardware and software	Juan Moncada and Gillian Ford	Juanuary 23, 2023
Tray Dropper Design	Design of tray dropper hardware and software	Steven Ramundi and Aaron Billones	January 23, 2023
Pot Dropper Fabrication	Fabrication of pot dropper frame and apparatus	Juan Moncada	January 31, 2023
Tray Dropper Fabrication	Fabrication of tray dropper and elevator frame and apparatus	Steven Ramundi and Aaron Billones	January 31, 2023
Verification Fabrication	Fabrication of verification System	Gillian Ford	January 31, 2023
Electrical Fabrication	Fabrication and assembly of all electrical components	All members	February 2, 2023
Testing	Testing of all subsystems and components	All members	February 6, 2023

A Interface

An example of a status message alerting the machine operator that the pot dispenser requires refill. This would be accompanied by an audible alert.



Concept of the button interface used by the operator to control the machine. Handheld as to mitigate any safety concerns with a machine-mounted apparatus.

B Mechanical Hardware

B.1 Pot Dropper

B.2 Tray Dropper

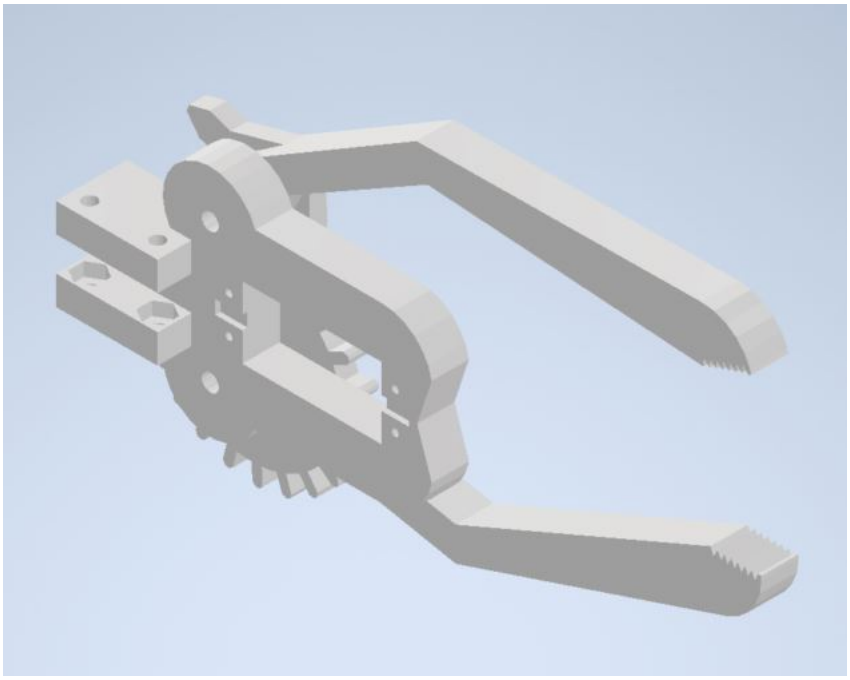


Figure 2: Tray Dropper End-Effector

B.3 Tray Elevator

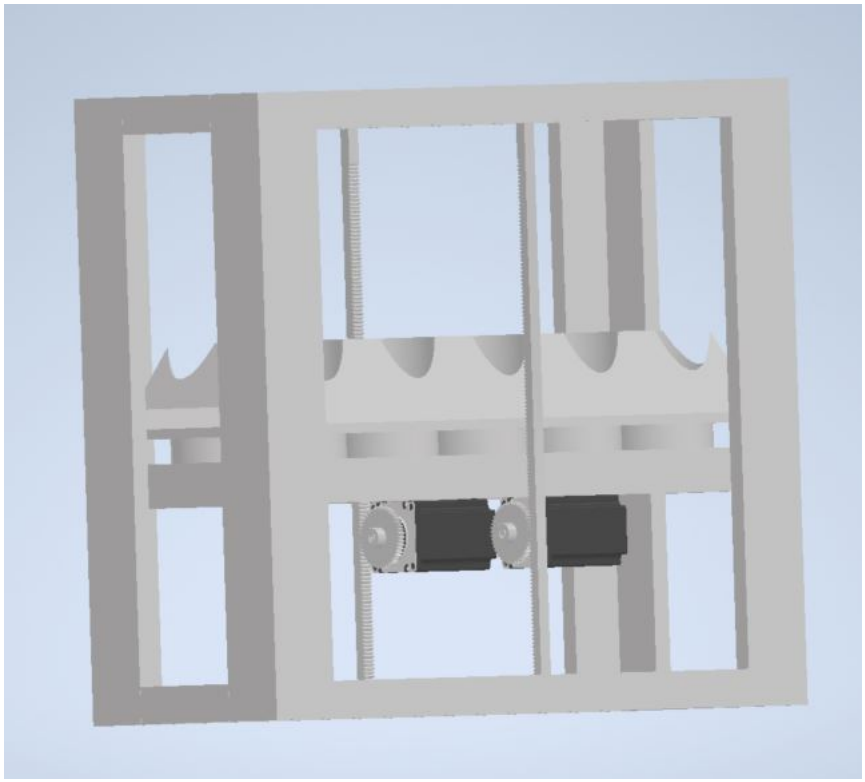


Figure 3: Tray Elevator (side)

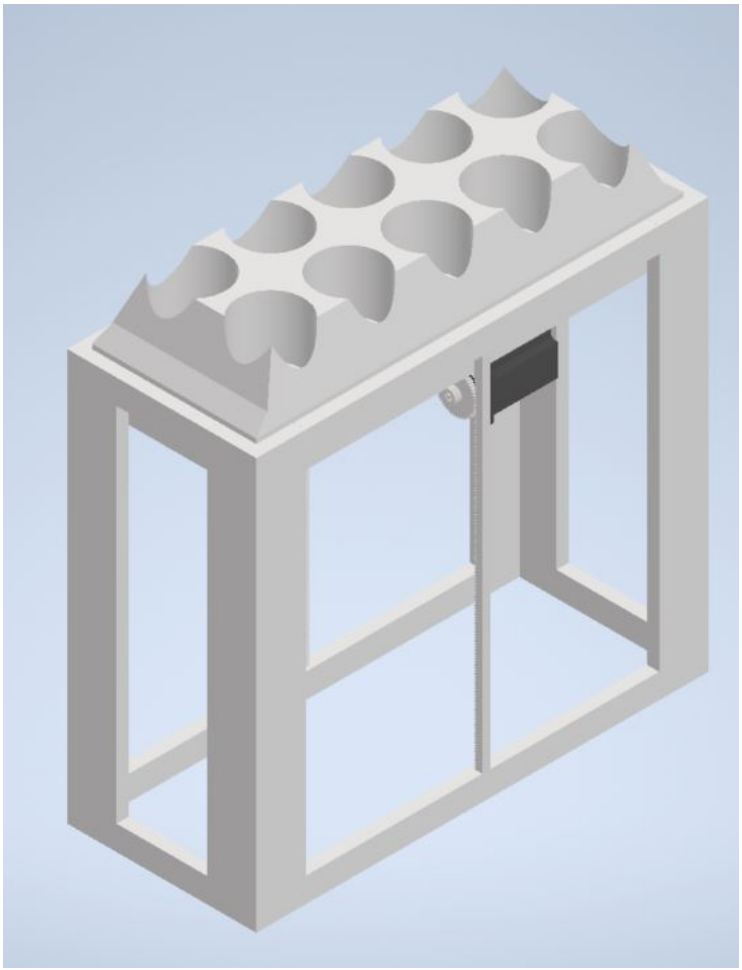


Figure 4: Tray Elevator (orthographic projection)

C Electrical Components

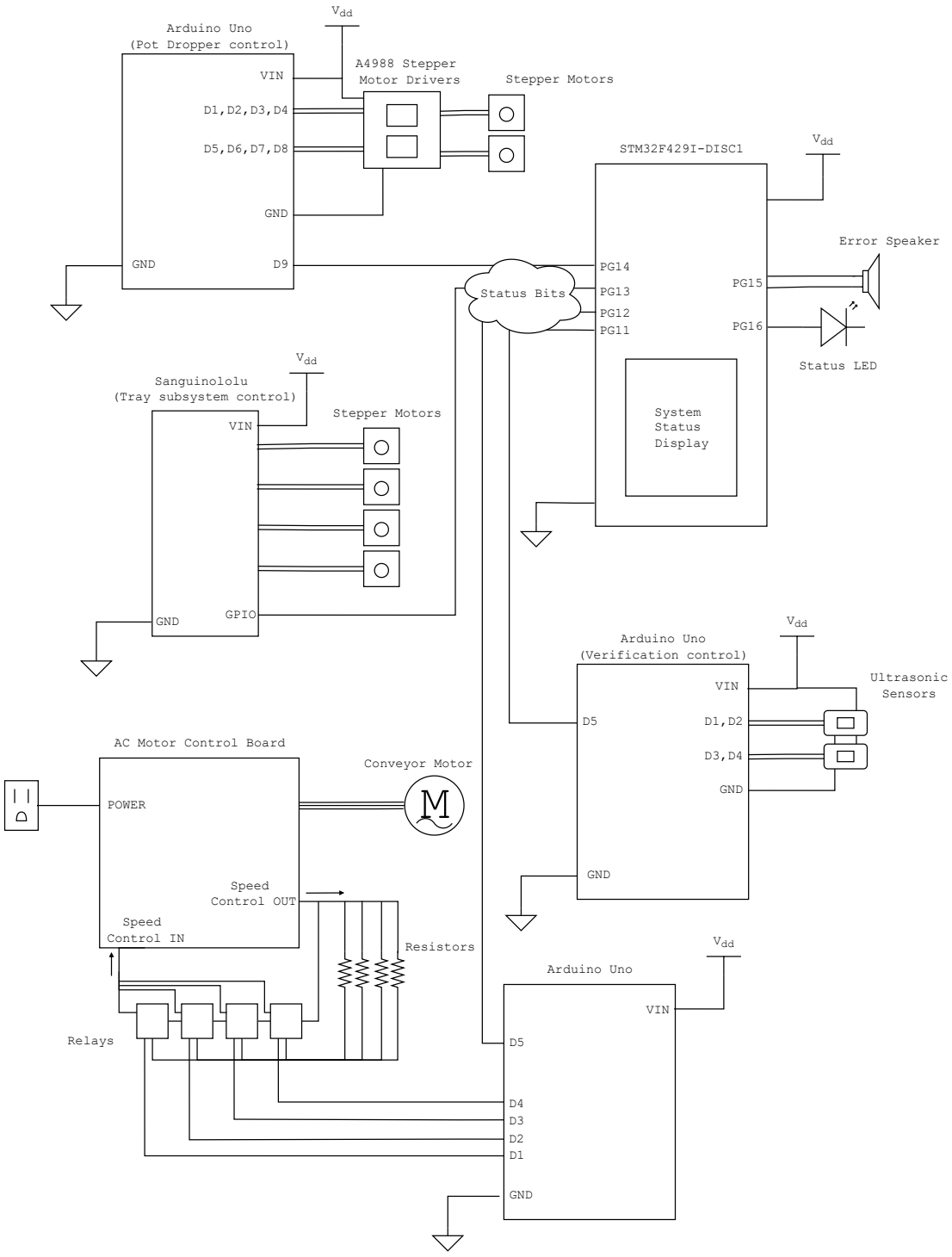


Figure 5: Circuit Diagram

D Communication Protocols

E Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Problem Analysis and Design. Please answer the following questions:

1. What are the limitations of your solution? Put another way, given unlimited resources, what could you do to make the project better? (LO_ProbSolutions)

2. Give a brief overview of other design solutions you considered. What are the benefits and tradeoffs of those other designs compared with the chosen design? From all the potential options, why did you select documented design? (LO_Explores)