

System Design for Pot-pulator

Team #24, The Nursery Project

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January 18, 2023

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.

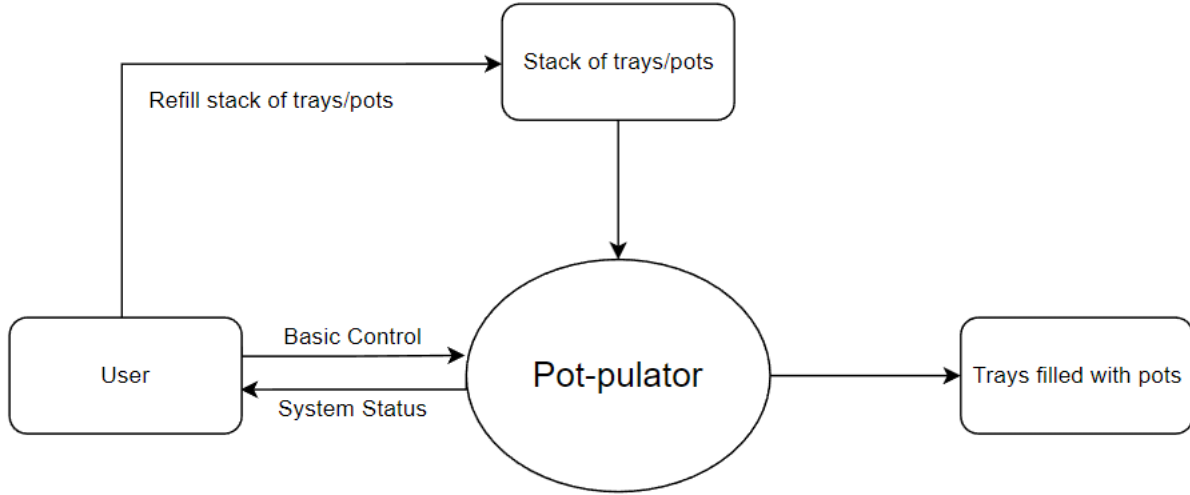


Figure 1: System Context Diagram

6 Project Overview

6.1 Normal Behaviour

The Pot-pulator needs to be filled with empty pots and trays by the user. Upon pressing the "start" button, the Pot-pulator begins its operation with no further interaction required by the user. Under normal operation, the ideal behaviour of the Pot-pulator will be as follows:

1. User fills the machine with empty pots and trays
2. User presses the start button
3. Raise the platform containing the trays until the stack reaches the top
4. Take the top tray off of the stack and place it on the conveyor belt
5. Proceed to move the conveyor and position the tray correctly to prepare for pot insertion
6. Stop the conveyor when pots and drop the pots 2 at a time in the tray
7. Continue moving the conveyor to the next available slots in the tray
8. Repeat steps 6 and 7 until the entire tray is filled with pots (10 pots)
9. Once the tray is filled with pots, the verification subsystem determines if all the pots have been placed correctly in the tray

Throughout the operation of the device, the user interface displays the current status of the machine.

6.2 Undesired Event Handling

The Pot-pulator is vulnerable to many undesired events during operation. The user will be notified should anything go wrong with the system via the user interface, LEDs, and sound.

6.2.1 Pot/Tray Misalignment

A very common issue that could arise with the Pot-pulator is that there is the possibility of a pot not being placed correctly in the tray due to misalignment. To mitigate this risk, the verification subsystem was implemented to ensure that there are pots in all of the tray slots. If there are missing pots, the user will be notified and the tray may be removed from the conveyor by hand.

6.2.2 Motor Jam/Malfunction

If a motor is unable to turn or fails, the system comes to a stop and the user is notified about the issue. The user is then expected to remove the object that is blocking the motor from moving. If the motor refuses to turn even without obstruction, the motor will most likely need to be replaced by a qualified individual.

6.3 Component Diagram

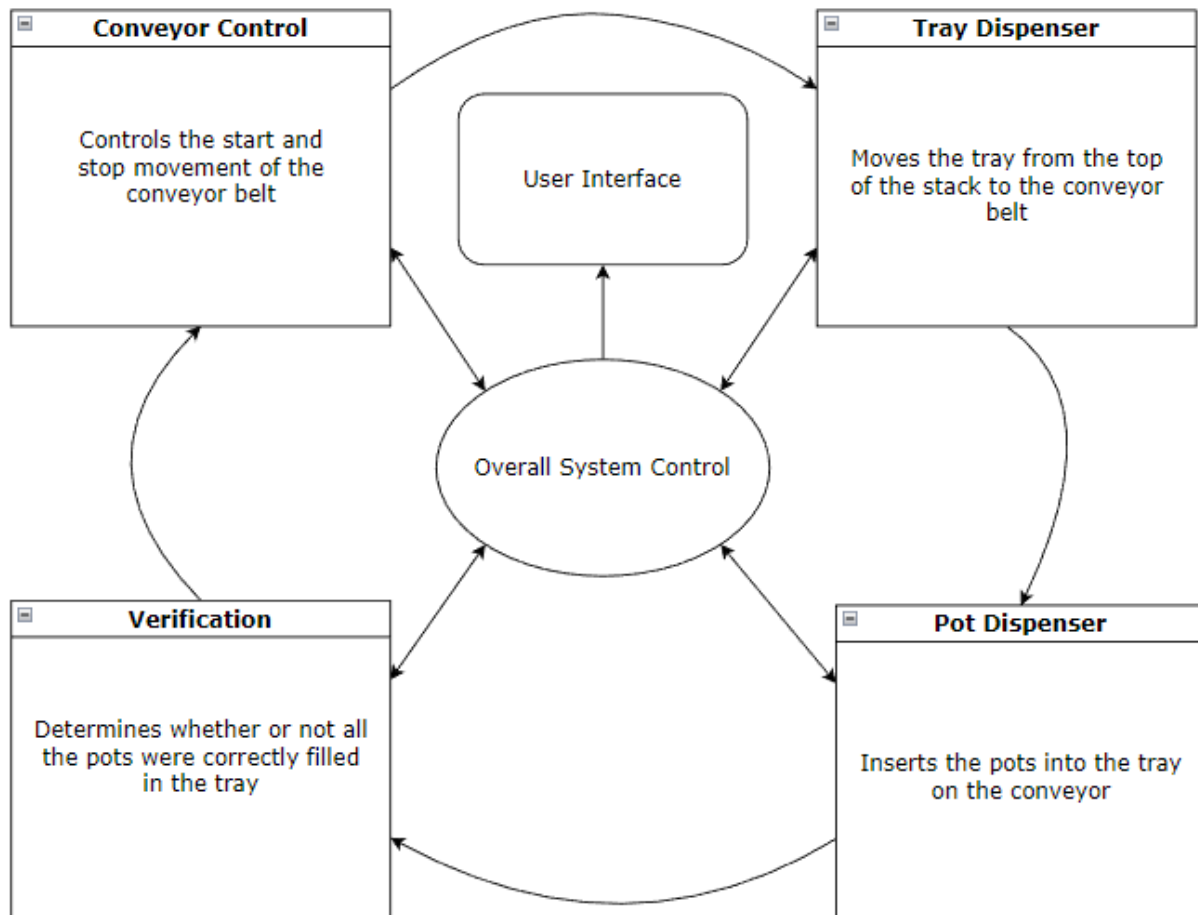


Figure 2: Component Diagram

6.4 Connection Between Requirements and Design

The table below shows the traceability between design components and requirements specified in the SRS.

Table 1: Requirements and System Design

Component	Corresponding Requirement
Overall System Control	NFR11, NFR12
Conveyor Control	CR1, CR2, CR3, CR4, CR5, CR6, NFR8
Tray Dispenser	TDR1, TDR2, TDR3, TDR4, TDR5, TDR6, TDR7, NFR4, NFR10, NFR13, NFR16
Pot Dispenser	PDR1, PDR2, PDR3, PDR4, PDR5, PDR6, PDR7, PDR8, NFR4, NFR9, NFR14, NFR15
Verification	VR1, VR2, NFR5
User Interface	NFR7

7 System Variables

[\[Include this section for Mechatronics projects —SS\]](#)

7.1 Monitored Variables

7.2 Controlled Variables

7.3 Constants Variables

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 holding 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 into 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 Design of Communication Protocols

[If appropriate —SS]

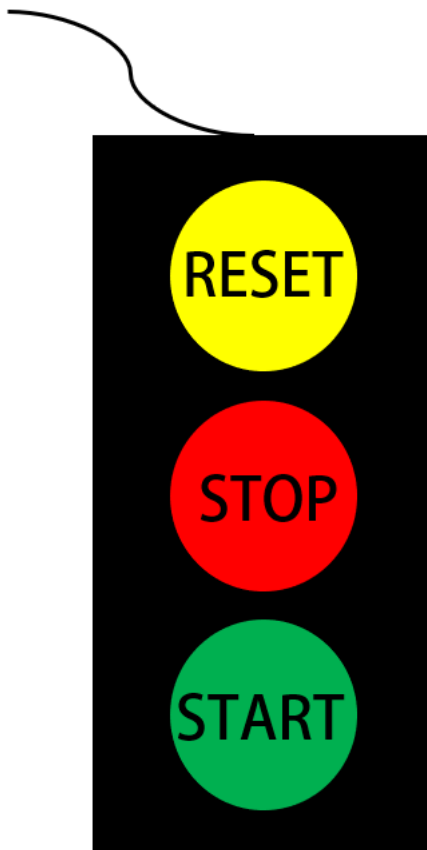
12 Timeline

[Schedule of tasks and who is responsible —SS]

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

B.3 Tray Elevator

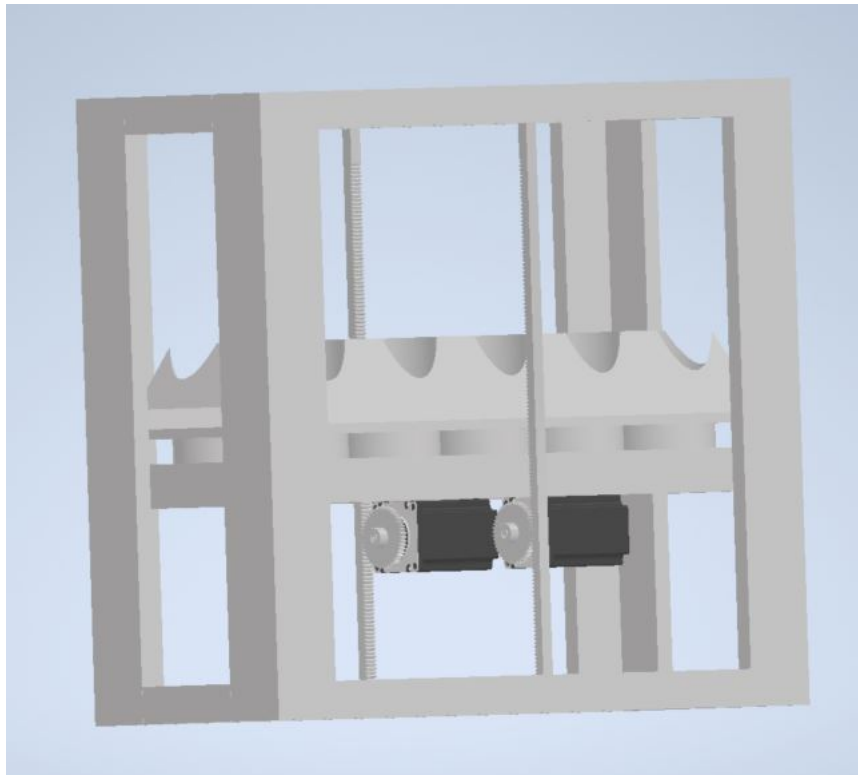


Figure 3: Tray Elevator (side)

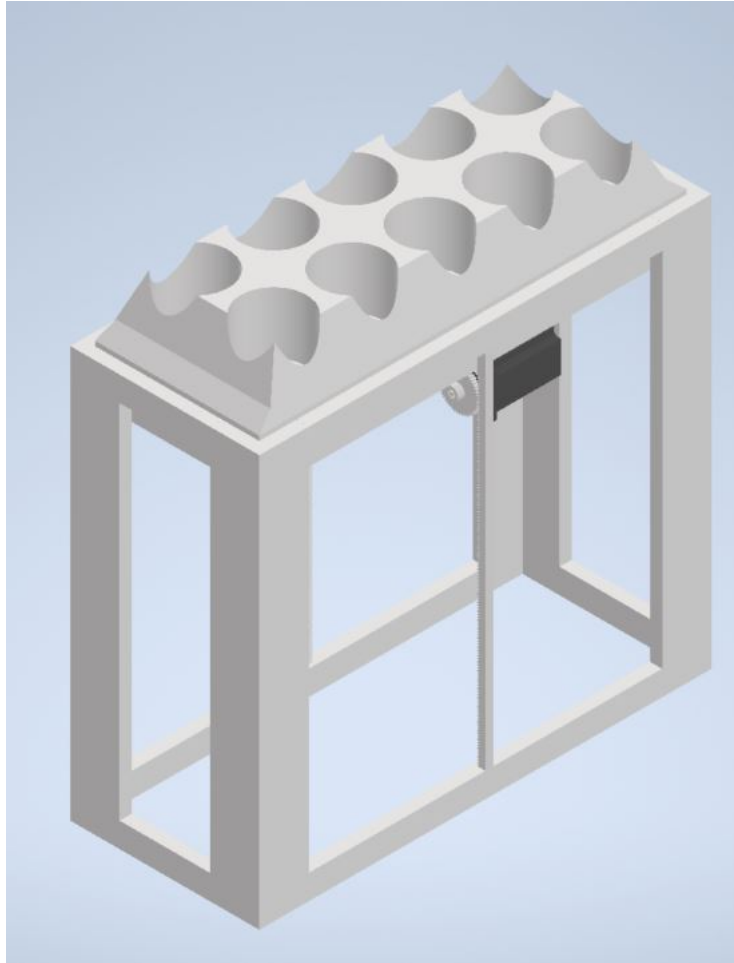


Figure 4: Tray Elevator (orthographic projection)

C Electrical Components

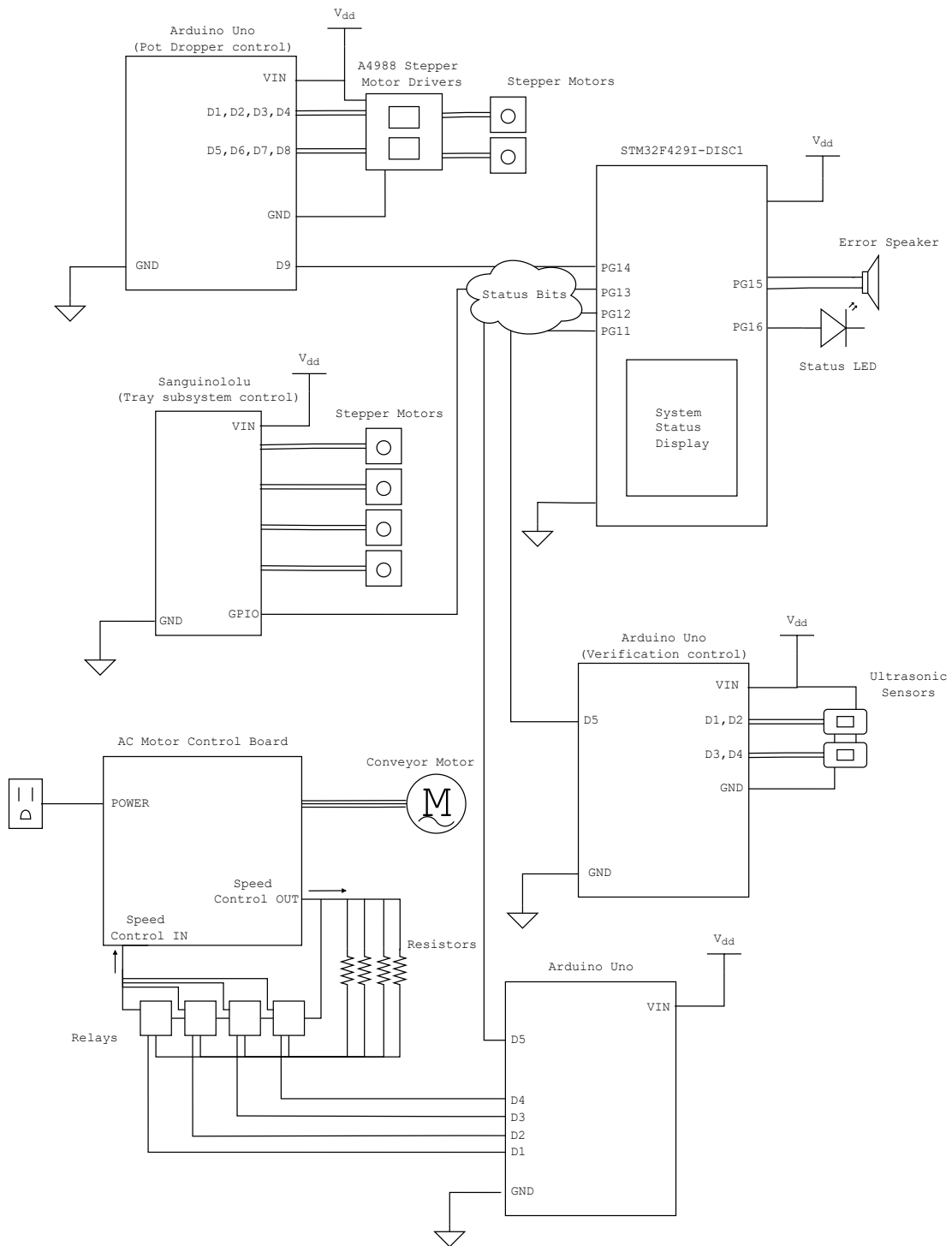


Figure 5: Circuit Diagram

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)