System Subsystem Design Description

for the

KNEAD Example System

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DOCUMENT CHANGE HISTORY

The following table is a simple list of released revisions sent for review. Records of reviews and the review artifacts are saved with reviewer information in the The KNEAD Projectartifact repository.

Change Record

Date	Version	Author(s)	Change Reference
24 Feb 2024	P1	Lewis Collier	Preliminary DRAFT version
21 Apr 2024	v0.1	Zachary Steinberg	DRAFT version
06 May 2024	v1.0	Zachary Steinberg	Final version

Each subsequent "section" outlines changes in each release.

Items in this version that are marked with change bars have been modified from the most recent previous version (e.g. P3 changes from P2) or are new as of the current revision. A list of all changed items may be found in the Index section under the heading "All Changes This Version".

Draft P1 Preliminary version of this document.

Draft v0.1 Draft Version for Design Assignment 2.

Final Version v1.0 Final Version for final Project.

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CHAPTER 1

Scope

This document provides the System / Subsystem Design Description (SSDD) for the Garden Control System. The system will be referred to as the GCS.

1.1 Identification

The Garden Control System described in this document shall be known as GCS version 1. However, the Operational Concept Description OCD described herein shall be applicable to pre-releases such as Beta-releases for a phased release as listed for each requirement. The major system interfaces and capabilities are fully specified in Chapter 3.

1.2 System Overview

The Garden Control System will be able to measure moisture levels and control irrigation in raised garden beds. The purpose for GCS is to maintain ideal gardening and growth conditions for fruits, vegetables, and other garden plants throughout a growing season. The goal for GCS is to automate the watering process for DIY gardeners. GCS will monitor temperature, moisture levels, and additionaly environmental factors to determine when to water the plants. Garden Control System is being developed by Zachary Steinberg and sponsored by University of Maryland Graduate Engineering. The operator and maintaner of GCS will also be Zachary Steinberg. The GCS will be operated outside along raised garden beds. GCS is designed to be used by home gardeners. It is not intended for industry. GCS will be controlled by a Raspberry Pi Pico W microcontroller board.

Figure 1 shows the development kit used for the GCS system. This diagram shows the major external interfaces that provide the capabilities of GCS. As are shown, the GCS can monitor and maintain a garden system through it's environmental sesnors and control of a water pump.

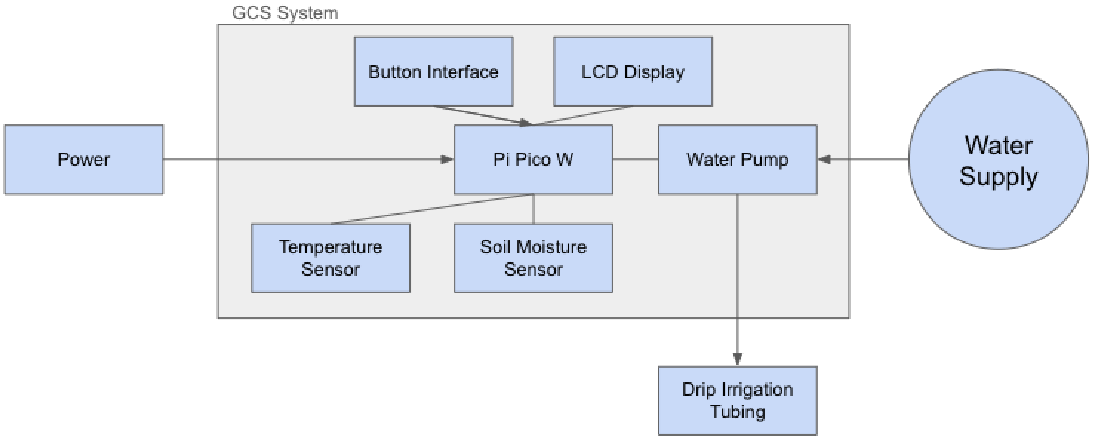

Figure 1: System Overview for the Garden Control System

1.3 Document Overview

This section provides information about this document's security/privacy considerations, contents, structure, and version information. This section also provides information regarding how specifications are formatted in this artifact and how they can best be understood.

1.3.1 Security and Privacy Considerations

This document is not subject to CUI restrictions.

This document format is based upon the guidance in the SSDD DID [1]. The system design is documented following the guidelines of ISO-12207 [2] and MIL-STD-498 [3] (from which ISO-12207 originated). The goal of this artifact is to provide a road map to the design implementation through either linkage to the development items (for example code, hardware, and CAD drawings) or, for larger systems, segregated documentation such as Software Design Description (SDD), Hardware Design Description (HDD), or Interface Design Description (IDD) artifacts. This document follows the listed SSDD sub-section order.

Section 1 provides an overview of the system and this document.

Section 2 lists general and application-specific reference documents as well as glossary terms and acronyms.

Section 3 presents the system-wide design decisions.

Section 4 provides the detailed system architecture design.

Section 5 provides any applicable requirement traceability.

Appendices if needed, provide additional information as may be needed.

1.3.2 Document Version Information

This document was produced in LaTeX and *BibLaTeX/Biber*. The editing and document preparation were performed using MiKTeX version 2.9 with the build option [LaTeX ⇒ PS ⇒ PDF]. The LaTeX*svn-multi* package was used to glean SVN tracking information, when files are stored in an "SVN" version control system. The style `KNEADdocument` was used to provide the LaTeX and *BibLaTeX/Biber* formatting details.

CHAPTER 2

References

This section provides a list of referenced items for this document.

2.1 Acronyms and Abbreviations

This section defines acronyms and abbreviations used in this and related documents.

Table 1: Acronym Definitions

Acronym	Definition
GCS	Garden Control System
UMD	University of Maryland
MAGE	Maryland Applied Graduate Engineering
ENPM	Engineering Professional Masters
End of acronym definition table	

2.2 Glossary and Definitions

This section defines glossary terms used in this and related documents.

Table 2: Glossary Terms and Definitions

Glossary Term	Definition
Communications	Communication is information transfer, among users or processes, according to agreed conventions.
Customer	The local government project lead who is acting as a general manager for the sponsor to ensure that the contractor team executes the project according to stakeholder goals.
Raised Garden Bed	Raised-bed gardening is a form of gardening in which the soil is raised above ground level and usually enclosed in some way.
Drip Irrigation	Drip irrigation is a method of watering plants by slowly dripping water through pipes with holes into the soil, either buried or slightly above ground.
End of glossary terms table	

2.3 Referenced Documents

This section lists the referenced documents for this document. The references are categorized into two categories:

External Documents not directly associated with this project.

Project Documents that are directly associated with this project.

2.3.1 External Documents

[1] DI-IPSC-81432. *Data Item Description for System/Subsystem Design Description*. Dec. 31, 1994.

[2] IEEE and EIA. *Software life cycle processes*. Mar. 1998.

[3] MIL-STD-498. *Military Standard Software Development and Documentation*. Dec. 31, 1994.

2.3.2 Project Specific Documents

CHAPTER 3

System-wide Design Decisions

This section provides an overview of the system wide design decisions for GCS. The system wide design decisions overview will be broken into three sections. Each section will represent one of the GCS modes. Each mode represents a different method GCS uses to control the irrigation system. Users can switch between modes via a button interface and the active mode will be displayed on the GCS LCD display.

The three modes for GCS are:

Active Monitoring Environmental data is actively monitored to determine if and when the GCS irrigation system needs to activate.

Scheduled The GCS irrigation system is on a set schedule and regularly activates/deactivates.

Manual Activation The GCS irrigation system can be manually activated.

3.1 Active Monitoring

The active monitoring mode is the main feature of the Garden Control System. GCS will be monitoring temperature data through a temperature sensor and soil moisture data through a soil moisture sensor. Environmental thresholds will be set and if the measured data crosses an environmental threshold, the GCS irrigation system will be activated/deactivated.

3.1.1 Temperature Threshold

Temperature is measured in °C within 0.5 °accuracy. The temperature data's output resolution is to the nearest hundreth of a °C. Generally, plants begin to experience stress when temperatures are above 86 °F or 30 °C. The temperature threshold value will be set as a system wide environmental variable. The value for the temperature threshold will be 86 °F or 30 °C. This temperature threshold represents when it is too hot for plants. When GCS measures a temperature at or above the threshold value for 5 consecutive minutes, GCS will activate the irrigation system for 30 minutes. After 30 minutes, GCS will deactivate the irrigation system. GCS will then wait 6 hours before activating again to prevent over watering. During this 6 hour time period, soil moisture threshold will not be able to trigger the irrigation system to activate.

3.1.2 Soil Moisture Thresholds

Soil Moisture is measured by the resistance of the soil. Valid measured values are between 0 - 1023. 0 being completely moist and 1023 being completely dry. If the value measured is between 600 - 1023, the soil is considered dry. If the value measured is between 370 - 600, the soil is considered humid. If the value measured is less than 370, the sensor is most likely submerged under water. There will be two soil moisture thresholds: a dry moisture threshold and a wet moisture threshold. Both values will be set as system wide environmental variables. The value for the dry soil moisture threshold will be 650. The value for the wet soil moisture threshold will be 450. When GCS consistently measures the soil moisture level at or above 650 for 5 consecutive minutes, GCS will activate the irrigation system. The GCS irrigation system will remain active until the measured moisture level is at or below the wet soil moisture threshold of 450 for 5 consecutive minutes.

3.2 Scheduled

The scheduled mode will allow users to set a watering schedule for their garden. There will be three preset schedules available for users to select. Users will be able to toggle between the different schedules by pressing the button for the scheduled mode multiple times. Users can preset the GCS irrigation system to activate every 3 hours, 6 hours, or 12 hours. When the scheduled mode is active, GCS will use the pico-sdk to get the current time and set a time the GCS irrigation system will activate. The GCS irrigation system will activate for 30 minutes every 3, 6, or 12 hours.

3.3 Manual Activation

The Manual Activation mode will allow users to manually control when their garden gets watered. Users will be able to manually activate the GCS irrigation system by pressing the same button that switches GCS to the Manual Activation mode. When the GCS irrigation system is manually activated, it will run for 30 minutes. After 30 minutes, the GCS irrigation system will deactivate and GCS will wait for the next manual activation. Users will also be able to deactivate an active irrigation system. If the GCS irrigation system is running, a user can press the Manual Activation mode button and the irrigation system will deactivate.

CHAPTER 4

System Architectural Design

This chapter describes the system architectural design for the Garden Control System. An overview of all system components is shown in Figure 2

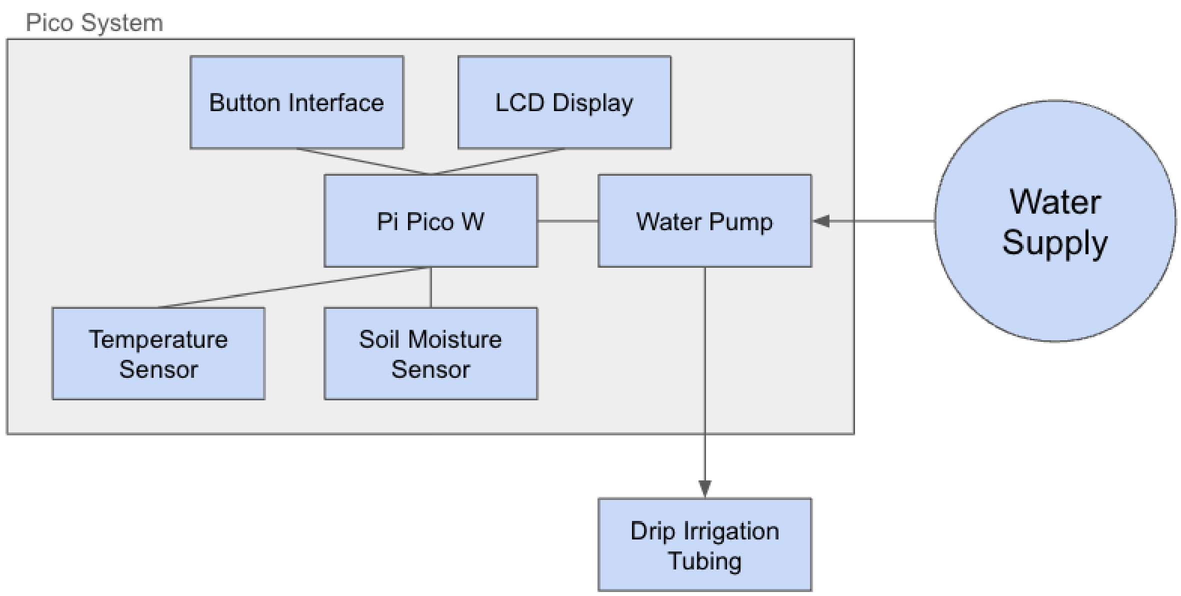

Figure 2: System Architectural Overview Diagram

4.1 System Components

This section lists and describes the system components.

4.1.1 Raspberry Pi Pico W

Project Unique ID **Pico_1**

Relationships All Components

Purpose The Raspberry Pi Pico W is the microcontroller of the entire Garden Control System. Satisfies requirement 3.10.1.1.

Development Status Existing

Description Raspberry Pi Pico W

4.1.2 Temperature Sensor

Project Unique ID Sense_1

Relationships Interacts with Pico_1

Purpose The temperature sensor measures environmental temperature data. Satisfies requirement 3.2.1.4.

Development Status Existing

Description BME280 Temperature Sensor

4.1.3 Soil Moisture Sensor

Project Unique ID Sense_2

Relationships Interacts with **Pico_1**

Purpose The soil moisture sensor measures the soil moisture of the user's garden. Satisfies requirement 3.2.1.5.

Development Status Existing

Description I2C Capacitive Moisture Sensor

4.1.4 Water Pump

Project Unique ID Pump_1

Relationships Controlled by **Pico_1**

Purpose The water pump pumps water from the water supply to the drip irrigation tubing. This is how the irrigation system activates. Satisfies requirement 3.2.1.2.

Development Status Existing

Description US Solar Pump B3A 5V PWM Circulating Pump

4.1.5 Button Interface

Project Unique ID Int_1

Relationships Interacts with **Pico_1** and **Int_2**

Purpose The button interface controls mode changes for GCS. Satisfies requirement 3.2.1.6.

Development Status Existing

Description GPIO Pin Buttons

4.1.6 LCD Display

Project Unique ID Int_2

Relationships Interacts with **Pico_1** and**Int_1**

Purpose The LCD Display displays the active mode for . Satisfies requirement 3.2.1.7.

Development Status Existing

Description Adafruit Standard HD44780 LCD

4.1.7 Drip Irrigation Tubing

Project Unique ID Out_1

Relationships Connected to **Pump_1**

Purpose The drip irrigation tubing control how much water leaves the irrigation system. Satisfies requirement 3.2.1.1.

Development Status Existing

Description Rain Bird Drip Irrigation Tubing

4.2 Concept of Execution

This section describes the concept of execution based on the system components.

An overview of the concept of execution is shown in Figure 3

The Raspberry Pi Pico W controls the entire Garden Control System. The button interface allows users to switch between GCS active watering modes. The LCD display will show users which watering mode is active. When the active monitoring mode is active, the temperature and soil moisture sensors will provide GCS with environmental information. If the environmental information meets any of the set environmental thresholds, the irrigation system will be activated. The water pump controls when the irrigation system is active. GCS activates/deactivates the water pump to control the irrigation system.

4.3 Interface Design

This section describes the internal and external interface design based on the system components.

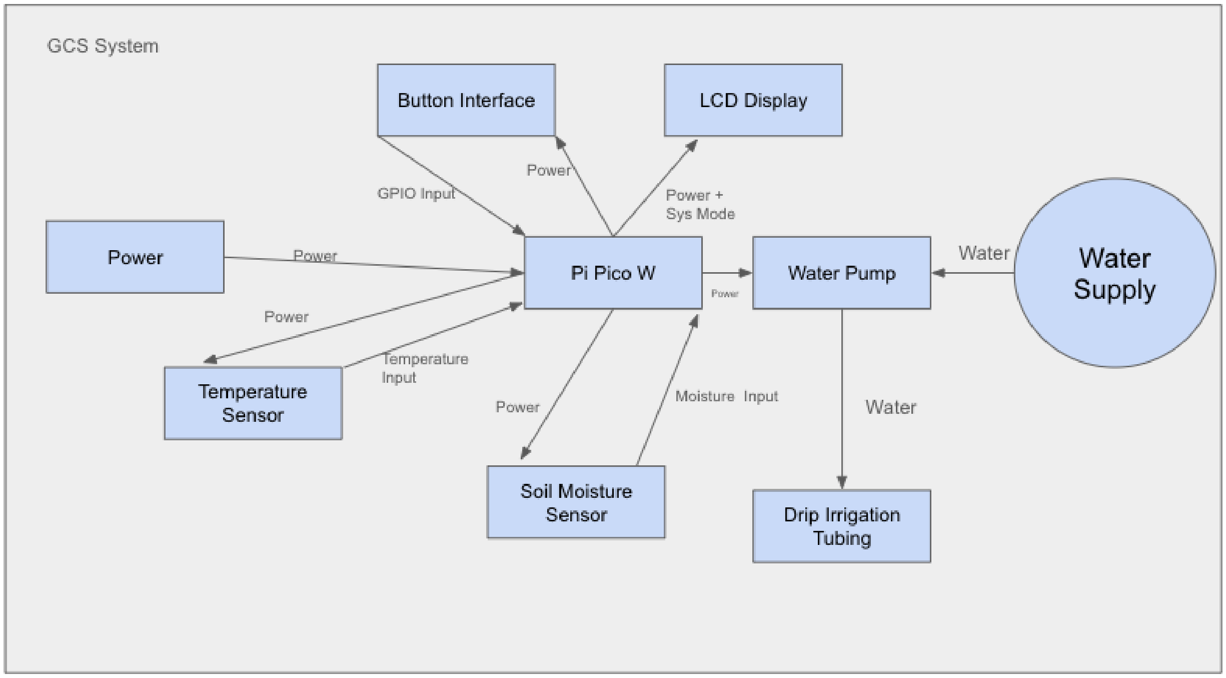

Figure 3: Concept of Execution Diagram

4.3.1 Raspberry Pi Pico W

Type of Interface System microcontroller

Project Unique ID Pico_1

Name Raspberry Pi Pico W

Technical Name RP2040 Raspberry Pi Pico W

4.3.2 Temperature Sensor

Type of Interface Environmental Sensor

Project Unique ID Sense_1

Name Temperature Sensor

Technical Name BME280 Temperature Sensor

4.3.3 Soil Moisture Sensor

Type of Interface Environmental Sensor

Project Unique ID Sense_2

Name Soil Moisture Sensor

Technical Name I2C Capacitive Moisture Sensor

4.3.4 Button Interface

Type of Interface Control Button Interface

Project Unique ID Int_1

Name Buttons

Technical Name GPIO Pin Buttons

4.3.5 LCD Display

Type of Interface Visual Interface

Project Unique ID Int_2

Name LCD Display

Technical Name Adafruit Standard HD44780 LCD

CHAPTER 5

Traceability

This section provides traceability of the system components and interfaces to the design requirements. Traceability will be updated at a later time.

CHAPTER 6

Schedule

There is currently no schedule for the Garden Control System project.

APPENDIX

Notes

ALL-Appendix :: This section shall contain any general information that aids in understanding this document (e.g., background information, rationale, etc.)

This section provides notes, as necessary, to document the system /subsystem design description.