GRP 1: Final Report

COMPSYS 704: Advanced Embedded Systems

Project 1

Group 7

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1. Introduction

Advantech Ltd., a company for manufacturing and delivery of sensitive and high value bottled liquids, have decided to build a new manufacturing facility that will automate the manufacturing process within the existing facility, provide advanced system for monitoring and controlling environmental conditions and access and security control.

This project is to develop this solution leveraging IoT concepts, synchronous programming and system-level designing. The chosen language and environment to create this is System J and Java. This is a final report documenting the final design of the Automatic Bottling System (ABS). This report includes details on the ABS-specific brief and an overview of the design.

2. Brief

Overall Brief

The solution is facility wide. Incorporated in multiple parts of the physical facility as well as in the purpose of the facility, it has the following requirements:

- A developed Automated Bottling System (ABS), as this is facility's purpose, to output orders of bottled goods
- Be able to monitor who is within the facility as well as specifically where they are
- Be able to provide security in the form of only allowing selected personnel in general and specific areas of the facility (e.g. restricted access to the main office)
- Continuously monitor and adjust the facility's climate factors such as humidity and heat to desired conditions. Even able to adjust the climate of specific areas differently within the facility
- Receive and process orders from registered customers for bottling

These are the high-level requirements from which more detailed and specific requirements stem from.

ABS Brief

Within this is the specific brief for the ABS part of the entire design. The following is the requirements of the ABS

1. Completes the following tasks in order.
   1.1. Brings the next new bottle along to be filled with an order.
   1.2. Fill the bottle with the order, mixing multiple liquids in one bottle if required.
   1.3. Place the lid upon the bottle.
   1.4. Screw the lid down tightly on the bottle to prevent spilling in future transport.
   1.5. Push the bottle along to the next point of the production line, likely to be a collection point.
2. Have a rotary table with 5 positions at which bottles can be at any given time. This rotary table will help with advancing a bottle onto the next task to be operated on it.
3. Have sensing to detect when a bottle is present or not present at a position on the rotary table.
4. That up to four liquids can be mixed into one bottle without overfilling the bottle.
5. ABS is able to receive and hold orders for bottles.
   5.1. Order will hold a description of the portion of each liquid to be mixed into the bottle.
   5.2. Order will contain how many duplicates of that bottle mix is required to satisfy the order.
6. ABS system is able to temporarily suspend all operation if it is detected that someone is near the system

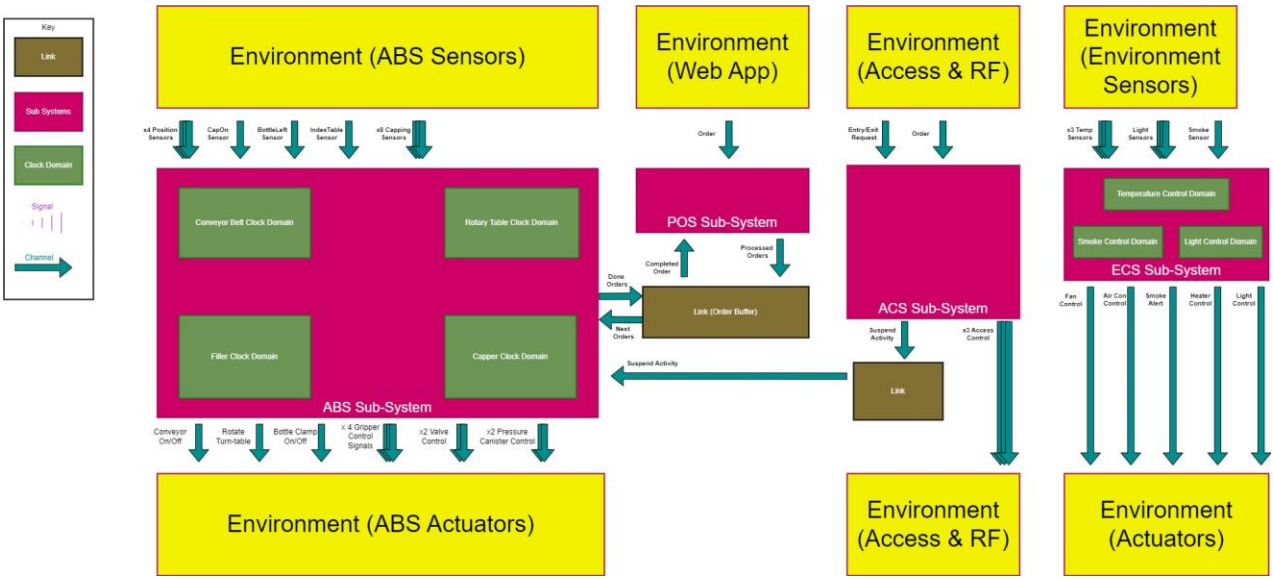
3.Design

The following section explores the design the ABS. The entire ABS system was made with two sides to it. One side being the System J side where all the logic and computation was done. The other side was Java, using libraries such as Java Swing to provide a graphical user interface (GUI) to portray the workings of the system. The following section goes into detail of the overall design on both sides, and how it connected with the wider system of systems.

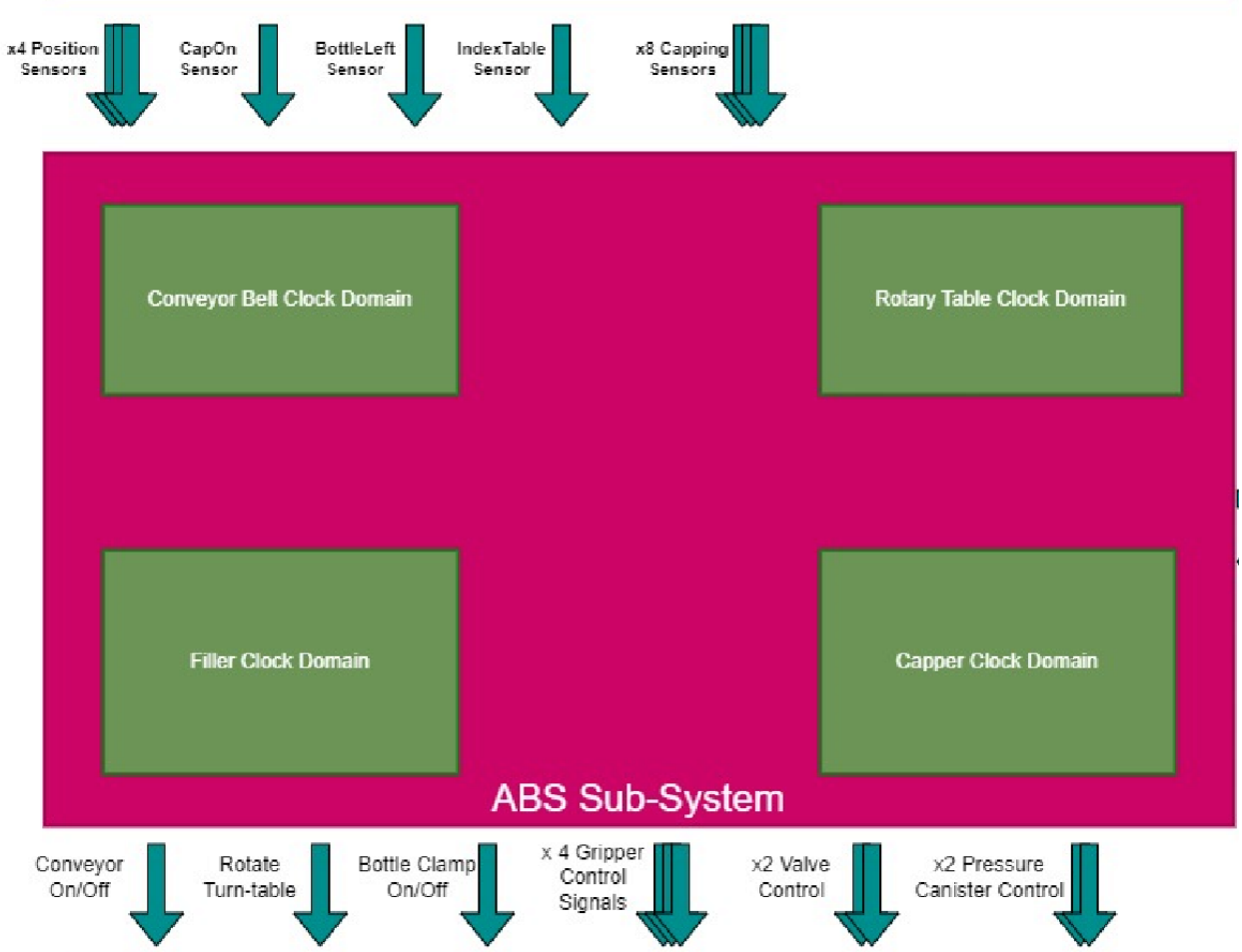
It must be noted that description of clock domain signals, variables and in depth operation steps will not be found within this document. For those details, refer to the related compendium that should have come included with this report.

Overall Design

As shows by the below <<Figure 1>>, the overall design is a collection of sub-systems running independently yet working with each other to fulfill the entire brief. A decentralized approach was chosen to allow for sake of modularity, ease of task allocation, and to reduce the chances of harmful coupling. While this report focuses on the ABS, seeing the entire solution at a high level assists in providing understanding where the ABS fits with everything.



The following figure (<<Figure 2>>) shows the specific design of the ABS (again it is still a high level graphic but with additional details for understanding). The operation of the ABS System is centralized with a plant. This plant is the simulator of the ABS, receiving command signals, making changes and sending the results to be viewable on the GUI, as well as back to the controllers. There are multiple controllers, each one handling the operation of one station or component in the ABS.



ABS System J

The Automatic Bottling System (ABS) is the sub-system tasked with the main objective of the facilities. This is to intake orders and act upon them by loading bottles, filling them with the ordered mix, capping securely closing the bottle, and passing it on. It does about doing this by having multiple stations that the bottle passes through to complete each task.

These different stations were described as controllers, with the use of System J clock domains to construct them. Due to each station being programmed in a different clock domain, the stations all run independent of each other, using channels to communicate between each other when necessary

Capping Station

The capping station is responsible for placing the caps on bottles. The logic is as follows:

1. Grip the bottle
2. Grip the cap
3. Lower the cap onto the bottle
4. Twist the cap into the final position
5. Release the cap, and raise the arm
6. Release the bottle

Conveyor Belt

The conveyor belt is responsible for moving the bottles in and out of the rotary table so that the machine can operate successfully.

It starts up, then waits for a bottle to leave from position 5 and a bottle to be present at position 1 before stopping and awaiting further instruction from the controller.

Filler

The filler station has 4 pressure cylinders that can be filled and then poured into a bottle waiting. It will receive its instructions on the proportions of each liquid to pour, as well as how many iterations of that mix to do from an array stored by the ABS. This information is originally received from the POS system externally. The filler will receive additional information from a position sensor to know whether a bottle is present to be filled.

The order of operation is as follows:

1. Check if a bottle is at position 2, if not, wait until it arrives
2. For each of the 4 Fillers:
    1. Turn on the valve injector.
    2. Check if a pressure canister is at bottom, if so bring it up to fill the bottle with liquid.
    3. Stop at point where each reaches required proportion for bottle (timer is used).
    4. Turn off the injector.
    5. Open the inlet.
    6. Force down the pressure canister.
    7. Wait until the cylinder is fully extended (i.e., at bottom)
    8. Close the inlet.
    9. Signify filler is done so next one can fill its portion of bottle.
3. Wait for bottle to be moved along to the next station of ABS

This will continuously loop unless signaled to stop or temporarily suspend

Lid Loader

The lid loader coordinates the placement and tightening of lids onto the bottles.

Rotary Table

The rotary table is responsible for shifting the bottles between the different abs machines.

The main functionality is the control of the rotator motor paired with the sensors that signal when the table is aligned with the stations. The rotary table is also in charge of identifying an error with a bottle cap in position 1 that needs to be manually fixed by a plant worker.

ABS GUI

The GUI can be demonstrated using guiTest.sysj. This will run a short “animation” displaying the operation and use of the GUI.

The GUI for the ABS allows managers of the plant to monitor the system as it operates. The current state of each machine is shown with icons and text, so that factory workers can ensure smooth operation. There are three sections of the gui, one for the conveyor and rotary table, one for the filler, and one for the capper. Across all three sections, we display all the information known to the ABS subsystem. Sensor signals are displayed visually with various images, this includes things like a bottle at position 1 or the capper fully extended. Transitive signals are represented with text labels, these are things like retracting the capper or shifting the canister.

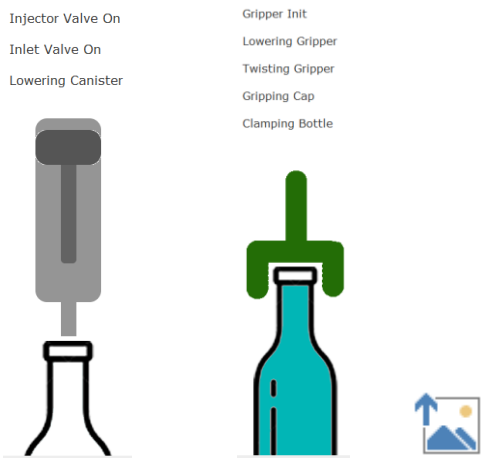
GUI Generation

The GUI is operated via the Java Swing library. All the components are procedurally generated from storage arrays. All of the images are the same size, with excess space being transparent. An array of image names is used to create and identify a series of JLabel components, which are then stored in a hashmap for later access. When various parts of the GUI need to update an image, they retrieve the JLabel object from the hashmap by referencing its image name, and alter the properties as needed.

A similar process is used to coordinate the generation of the text labels. An array of names is used to reference and fill the JLabels while a seconds array holds their locations. Once again the resulting objects are stored in a hashmap to be referenced later.

Communication with ABS

The ABS Clock Domains emit dual signals during operation. Along with the regular signals for operation and sensing, a duplicate copy of these signals is emitted for the GUI. These GUI signals are received via a socket listener wrapped in a buffered reader. The output from this buffered reader is processed with regular expressions to extract the signal name and status. The signal name and status are then combined and feed into a switch statement that makes the relevant changes to the gui. Images on the GUI are displayed or hidden, and message boxes are altered to match the current events.



ABS Connections & Interfacing <<Frank's Part>>

4.Conclusion

In summation, the team went about designing an Automatic Bottling System (ABS) as part of a wider system of systems to manage an Advantech Ltd., facility. It was made leveraging IoT concepts, synchronous programming and system-level designing.

The solution had diverse as well as multiple requirements to be satisfied in order to be a system of systems that satisfies facility requirements of online ordering, security, environment control and automatic bottling. This report

focused specifically on the brief and design of the ABS, explaining its various feature requirements, how each was implemented as well as how it all interfaced and communicated with the wider solution.

The entire ABS design was conceptualized and implemented using System J and Java. The team solution stuck close to the brief with only small differences from initial specification. The solution should prove helpful to Advantech Ltd.