

# System Validation Project Report

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## 1 Introduction

This is a project done as part of TU Delft's IN4387 System Validation course. The project concerns designing, modelling and validating a controller for a Transfer system in an Industrial Silicon Wafer production plant. The system consists of a UV Lamp that projects a design onto a wafer inside a vacuum chamber. The wafers are transferred to the Lamp via two Airlocks. The wafers are handled by robots from their initial position on Input stacks to their final position on Output stacks.

## 2 Requirements

### 2.1 System Components

The system consists of the following physical components:

- Lamp/Projector: L
- Inner Doors: DI1, DI2

- Outer Doors: DO1, DO2
- Input Stacks: I1, I2
- Output Stacks: O1, O2
- Airlocks: A1, A2
- Outer Robots: R1, R2
- Inner Robot: R3

## 2.2 Functional Requirements

### 2.2.1 Overall requirements of the System:

- The wafers move along the production line from their Initial state (on the Input Stacks), are printed on by the Lamp and reach the Final state (on the Output stacks).
- As long as the Output Stacks are not full, wafers keep moving along the production line.
- Both the Inner and Outer Doors of an Airlock MUST NOT be open at the same time. (Safety)
- Doors must not be closed while the robot is picking up/placing a wafer in the Airlock (Safety)
- Doors must not get stuck (Safety)
- Robots must not stop before reaching their destinations (Safety)

### 2.2.2 System Component Requirements:

These are the individual component requirements:

#### 1. Lamp L

- The Lamp should be undisturbed during printing. (Safety)
- The Lamp will turn off after completion of printing.

#### 2. Inner Doors: DI1, DI2

- The Inner Doors may be opened ONLY if the Outer Doors are closed. (Safety)

3. Outer Doors: DO1, DO2

- The Outer Doors may be opened ONLY if the Inner Doors are closed. (Safety)

4. Output Stacks: O1, O2

- No Wafer shall be put on a full Output Stack. (Safety)

5. Outer Robots: R1, R2

- The Outer Robots will pick up a wafer from its corresponding Input stack.
- The Outer Robots will place the Input wafer on its corresponding Airlock.
- The Outer Robots will pick up a finished wafer from its corresponding Airlock.
- The Outer Robots will place the finished wafer on its corresponding Output stack.
- The Outer Robots will pickup the next Input wafer ONLY after delivering a finished wafer to its corresponding Output Stack. (Safety)



6. Inner Robot: R3

- The Inner Robot will pick up a detected Input wafer from an Airlock.
- The Inner Robot will place the Input wafer on the Lamp ONLY when the Lamp's stack is empty. (Safety)
- The Inner Robot will pick up a finished wafer from the Lamp.
- The Inner Robot will place the finished wafer on its corresponding Airlock.
- The Inner Robot will pickup the next Input wafer ONLY after delivering a finished wafer to its corresponding Airlock. (Safety)




## 3 Interactions

### 3.1 Commands to Actuators

The following are the commands given by the controller to the actuators of the system. The meaning can be interpreted as:

### **Command( Target actuator, optional parameters)**

- MoveTo(x, D) [x : R1, R2, R3 ; D: Lamp, Airlocks, Input/Output Stacks] Move to assigned destination.
- PickupWafer(x, D) [x : R1, R2, R3 ; D: Lamp, Airlocks, Input Stacks] Picks up the wafer. 
- PlaceWafer(x, D) [x : R1, R2, R3 ; D: Lamp, Airlocks, Output Stacks] Places the wafer.
- OpenDoor(x) [x : DI1, DI2, DO1, DO2] Opens the corresponding door.
- CloseDoor(x) [x : DI1, DI2, DO1, DO2] Closes the corresponding door.

## **3.2 Reading Sensors**

The following are the commands used by the controller to read the data provided by the sensors of the system. The meaning can be interpreted as:

### **Command(Target sensor, Return Value by sensor)**

- CheckInputStack(x, a) [x: I1,I2 ; a: Present, Absent]
- CheckOutputStack(x, a) [x: O1,O2 ; a: Full, Empty]
- CheckLamp(L, a) [L: Lamp ; a: Busy, CompletedPrinting]
- CheckAirlock(x, a) [x: A1,A2 ; a : WaferPresent, WaferAbsent]



## 4 Architecture

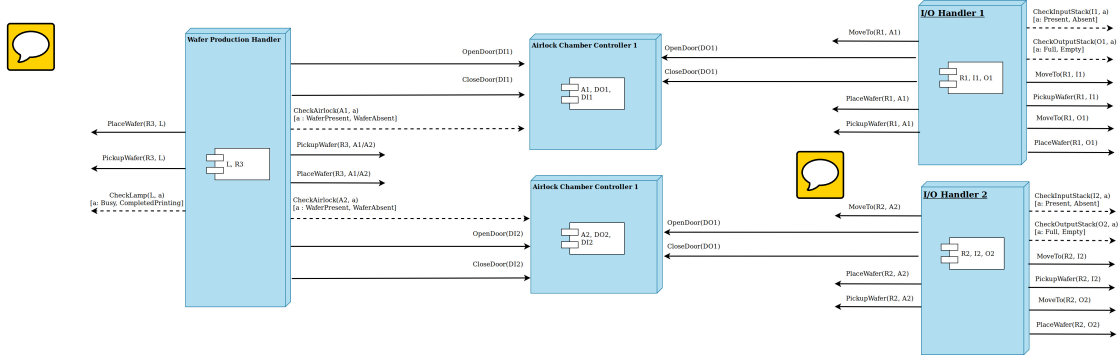


Figure 1: Architecture Diagram of System

Figure 1 shows the Architecture of the system described above with five parallel controllers along with the various entities (Sensors and Actuators) they control. The Dashed lines represent sensor information while the solid lines represent Actuating signals.