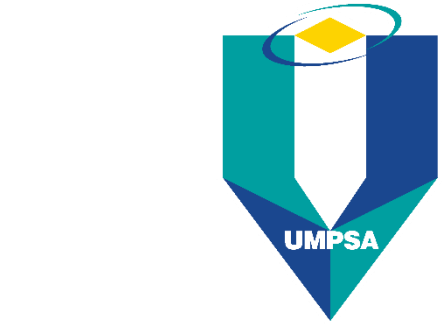

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FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING TECHNOLOGY

BVI 1135 FLEXIBLE MANUFACTURING SYSTEM I

ASSIGNMENT

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SUBMISSION DATE: 30/1/2025

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1. Table of Contents

2. Introduction

- **Background:**
  This project involves developing a pick-and-place and assembly system integrated with a graphical user interface (GUI). The system is programmed using CX-Programmer for PLC logic and CX-Designer for GUI. The aim is to demonstrate how automation enhances precision, efficiency, and usability in manufacturing systems.

- **Objective:**
  To design, implement, and demonstrate a pick and place using a robotic system capable of picking and assembling components with actuator and control finished goods through gripper arm in a GUI.

- **Scope:**
  This project focuses on robotic automation in manufacturing, specifically for pick-and-place operations. It integrates a PLC for control and a GUI for user interaction, excluding external data analytics or cloud integration.

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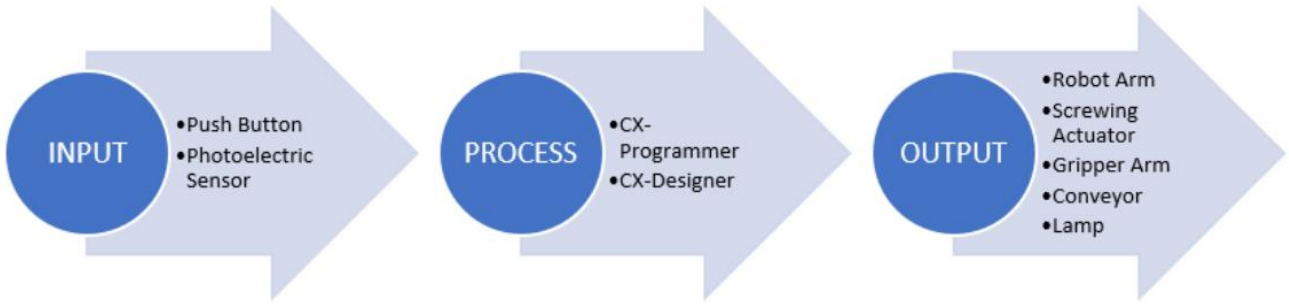
3. System Design

- **Overview:**
  The system consists of a pick-and-place robotic arm, conveyors for moving raw material, photoelectric sensors, actuators for screwing a nut, and a PLC to control operations. A GUI provides real-time monitoring and control capabilities for the user.

- **Block Diagram/Architecture:**
  This is our block diagram that consist of main component and their relationship which is Input, Process and Output.



- **Input/Output Assignments:**
  Below is our detailed table of the system inputs and outputs:

  i) Input

Component	Address	Description
PB_Start	0000	Initiate a system to start all process
PB_Stop	0001	Initiate a system to stop all process
Photoelectric Sensor1 Conveyor 1	0003	Detect raw material on conveyors to initiate the next process
Photoelectric Sensor1 Conveyor 2	0004	Detect raw material on conveyors to initiate the next process
Photoelectric Sensor2 Conveyor 2	0005	Detect raw material on conveyors to initiate the next process
Auto Mode	0009	Initiate the auto run mode
Maintenance Mode	0010	Initiate the maintenance mode

  ii) Output

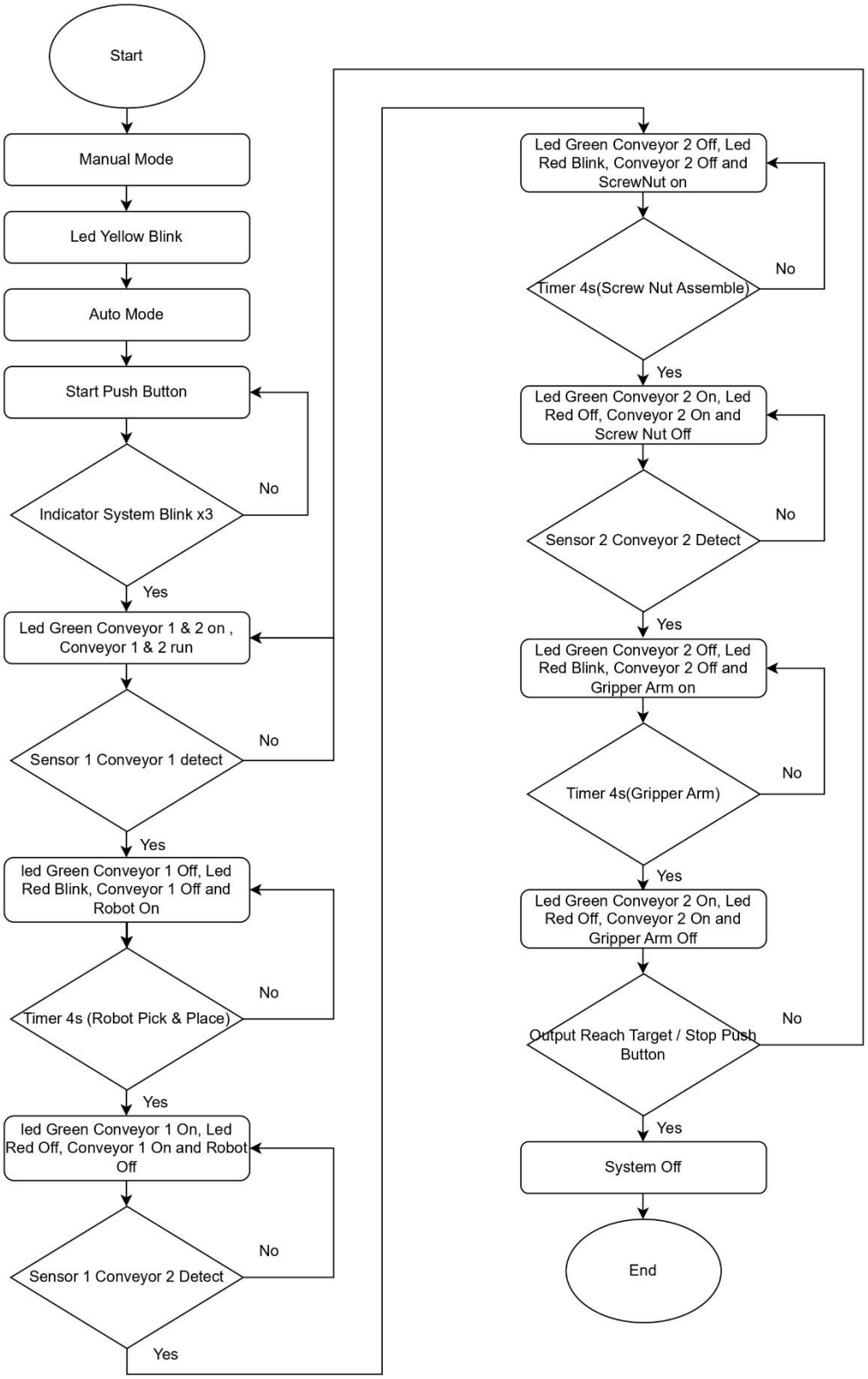
Component	Address	Description
Led Red Conveyor 1	0200	Indicating conveyor 1 stop condition
Conveyor 1	0201	Control the movement of raw material
Robot Arm Pick & Place	0202	Pick and Place raw material into Conveyor 2 from Conveyor 1
Screw Nut Actuator	0204	Assembling the nut into raw material
Led Green Conveyor 1	0205	Indicating conveyor 1 start condition
Conveyor 2	0206	Control the movement of raw material
Led Green Conveyor 2	0207	Indicating conveyor 2 start condition
Gripper Arm	0209	Move finished good item into Pallet
Led Red Conveyor 2	0210	Indicating conveyor 2 stop condition
Led Yellow	0212	Indicating system is in maintenance mode

iii) Internal

Component	Address	Description
KEEP	40.00	System Start
KEEP	40.01	On & Off Conveyor 1
KEEP	40.02	Sensor 1 Conveyor 1
KEEP	40.03	Run Screw Nut Actuator
KEEP	40.05	Run Gripper Arm
KEEP	40.06	On Led Red Conveyor 2
DIFD	45.00	Fall Edge Sensor 1 Conv 1
DIFU	45.01	Fall Edge Sensor 1 Conv 2
DIFU	45.02	Rise Edge Sensor 2 Conv 2
DIFD	45.03	Fall Edge Gripper Arm
CNT	0002	Count System Indicator Blink
TIM	0008	Off System Indicator
TIM	0009	On System Indicator
TIM	0003	Off Robot
TIM	0000	Off Blinking Red Conv 1
TIM	0001	On Blinking Red Conv 1
TIM	0004	Off Screw Nut Actuator
TIM	0005	Off Gripper Arm
TIM	0006	Off Led Red Conveyor 2
TIM	0007	On Led Red Conveyor 2
TIM	0010	Off Led Yellow
TIM	0012	On Led Yellow
++ (INC)	D10	Inc & Cmp Data D10
CMP	#3, D10	Inc & Cmp Data D10
MOV	#0, D10	Inc & Cmp Data D10

4. Flowchart and Program Logic

- **Flowchart:**
  This is a Flowchart that show overall our system program logic:



- **PLC Program Description:**

The PLC program uses inputs from sensors to detect objects and determine their position, also using a Push Button to start and stop the system. This system also has an auto mode and maintenance mode initiated by Push Button. Based on these inputs, after raw material arrives at the Photoelectric 1 Conveyor 1 stops and then robotic arm performs pick & place operations and Photoelectric sense the material and signals Actuator to assemble the nut. Conveyor 2 runs and stops after Photoelectric 3 sensed; Gripper moves finished item to the pallet. This system has features of production limitation, 3 times maximum production has been set on memory and system will off after reach the value.

- **Code Snippets:**

This is an explanation of ladder diagram rung by rung

Rung	Description
Rung 0 :	Interlock for Auto Mode using 0.09
Rung 1 :	Keep the signal from pb start to run the system. PB stop 0.01 and Off System 40.07 to reset the keep
Rung 2 :	Main Led blinking after receive signal from keep 40.00 using a T0008 and T0009. T0008 off the Led after 1s then the C0002 is to off the system indicator after blink 3 times
Rung 3 :	T0008 activate the T0009 to make a blinking sequence
Rung 4 :	Count the system indicator blink for 3 times. PB Stop reset the counter
Rung 5 :	Keep the signal from CNT0002 to On the Conveyor 1, T0003 also will on Conveyor 1 after 3s. 40.02, 0.01 and 40.07 reset the keep.
Rung 6 :	On conveyor 1 and Led Green Conveyor 1 after receive signal from 40.01 On & Off Conveyor1
Rung 7 :	Receive a falling edge signal from sensor 1 Conveyor 1
Rung 8 :	Keep the signal from DIFD Sensor 1 Conveyor 1. It reset by T0003, 0.01 and 40.07
Rung 9 :	On Pick & Place robot and T0003 off the robot after 3s. Led Red Conveyor 1 blinking using T0000 and T0001
Rung 10 :	T0000 activate the T0001 to make a blinking sequence
Rung 11 :	On Conveyor 2 and Led Green Conveyor 2 after counting System Indicator
Rung 12 :	Receive rising edge from the Sensor 1 Conveyor 2
Rung 13 :	Keep the signal from DIFU sensor 1 Conveyor 2 to Run Screw Nut Actuator. T0004, 0.01, 40.07 and 0.10 will reset the keep

Rung 14 :	On Screw Nut Actuator and T0004 off the Actuator after 4s
Rung 15 :	Receive rising edge from the Sensor 2 Conveyor 2
Rung 16 :	Keep the signal DIFU Sensor 2 Conveyor 2 to Run Gripper Arm. T0005, 0.01, 40.07 and 0.10 reset the keep
Rung 17 :	On Gripper Arm and the T0005 off the Gripper after 4s
Rung 18 :	Keep the signal from KEEP 40.03 to On Led Red Conveyor 2. Reset by T0007, 0.01, 40.07 and 0.10
Rung 19 :	On Led Red Conveyor 2 and T0006 off the led after 1s
Rung 20 :	T0006 activate T0007 to make a blinking sequence
Rung 21 :	Receive signal falling edge from the 2.09 Gripper arm
Rung 22 :	Incrementing data on D10 increase by 1
Rung 23 :	Comparing the data #3 with D10 are equal or not. If equal 40.07 will on to reset all system
Rung 24 :	Reset the D10 into #0 using a 0.00 PB Start to repeat cycle again after system off
Rung 25 :	Interlock Clear for Auto Mode
Rung 26 :	Interlock for maintenance mode using 0.10
Rung 27 :	2.12 Led Yellow will be on after executing the maintenance mode. T0010 off the led after 1s
Rung 28 :	T0010 activate T0012 to make a blinking sequence
Rung 29 :	Interlock Clear for Maintenance Mode

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5. Graphical User Interface (GUI) Design

- **Interface Layout:**
  The GUI contains button to manually control the start and stop system, a status indicator showing the condition of Conveyor. Photoelectric sensor showing it placement the system and Robot, Actuator and Gripper make the manufacturing process.

- **User Interaction:**
  Users can initiate operations by pushing the button and monitor the real time process on GUI and receive an indicator to define the system condition and system error.

- **Features:**
  The GUI also includes light indicator of system conditions and trigger alert, added a modern technology which is Robot that can handle the operation smoothly and precisely. Visual feedback on the movement of raw materials, actuating and robotic arm operations also a clear layout of the assembly process components. This system includes the Auto mode and Maintenance mode features and it's also having an auto stop system according to the limitation production on the system

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6. System Integration

- **PLC and GUI Interaction:**
  The GUI communicates with the PLC to display the system's status and control the operations. For instance, the PB_Start button sends a signal to the PLC to initiate the process, and the PLC updates the GUI, all sensors trigger the actuator and robot arm to complete the overall system operations. All components also send feedback to the PLC to successfully complete the entire system operations.

- **Challenges:**
  The difficulty of developing this system is to ensure the system is working following the sequence and must make a debug on the Ladder Diagram. Doing an auto stop system when completing a number of productions was challenging, because of to make sure the max value of production is set properly on the plc memory and ensure the system will stop after it reaches the value. It resolved by using an ++ (INC) instruction to increment value on D10 by 1, also used a CMP instruction to ensure if the value on D10 is equal with the max value it will reset or stop overall system.

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7. Testing and Results

- **Testing Procedures:**
  The system was tested for its ability to detect objects, perform pick-and-place tasks, assembly task and display status updates on the GUI.

  i) Run the system by pushing the PB_Start and pushing the PB_Stop to stop the entire system

  ii) Ensuring both conveyors are running properly following the sequence

  iii) Detecting raw materials on Conveyor 1 using photoelectric sensors 1 and ensure the Conveyor 1 stopped then Robotic Arm pick & place the raw material into the Conveyor 2

  iv) Detecting raw materials to photoelectric sensor 1 on Conveyor 2 and ensure the conveyor stop then the actuator assembling the nut into the raw material

  v) Ensuring conveyor 2 run again after assemble process complete

  vi) Detecting raw materials to photoelectric sensor 2 on Conveyor 2 and ensure the conveyor stop, the gripper arm place the finished item into the pallet

  vii) Ensure overall operation in the system are repeated in cycle to achieve an automated system

  viii) Ensure all the light indicator, which is system indicator, both conveyor indicator is work properly following the sequence

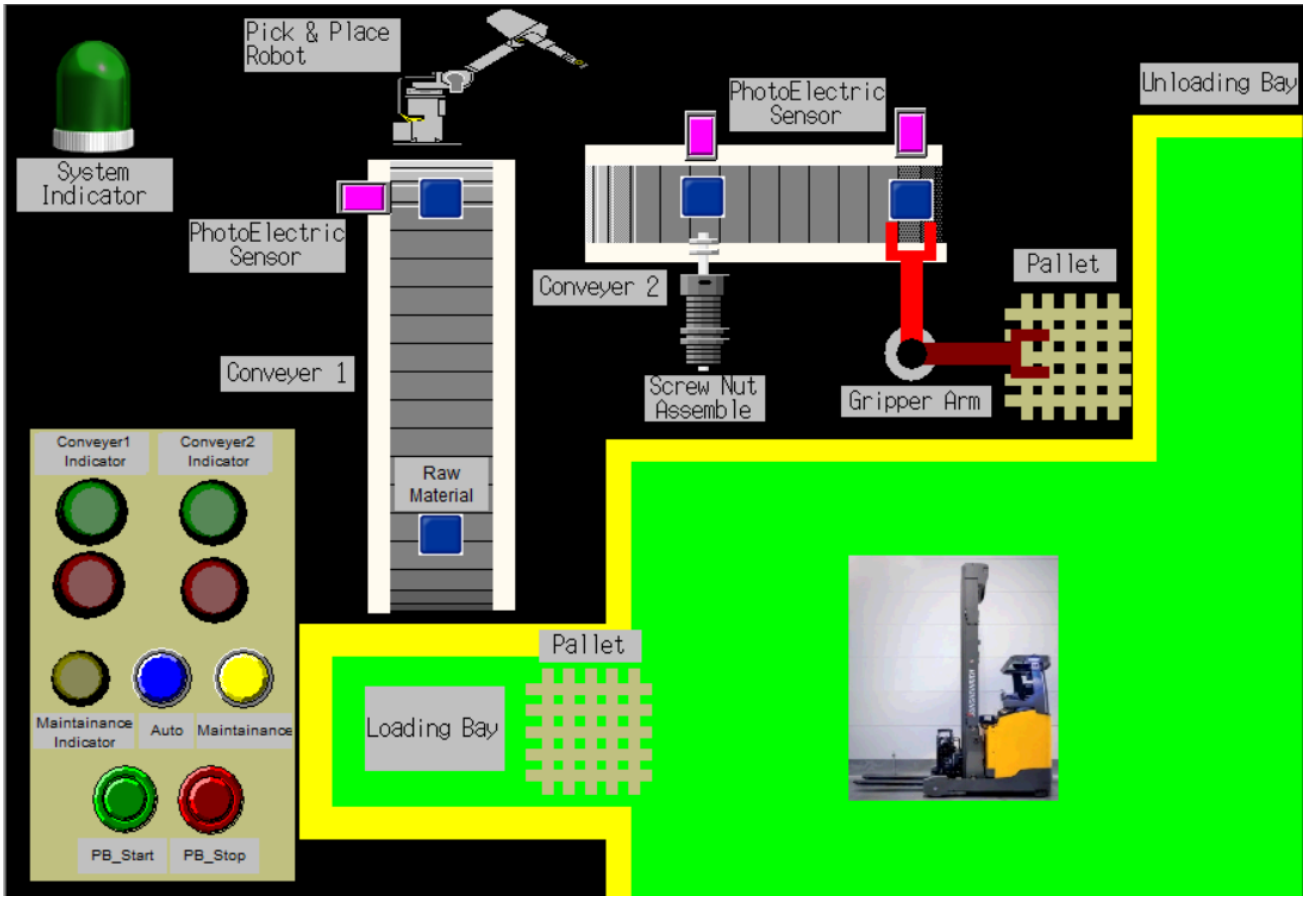
  ix) Testing the Auto Mode and Maintenance Mode function

x) Do dummy testing of the system that will stop after complete processing 3 items. It's to set the limitation of the system can work to further maintenance, resting the system or can set the maximum production that produced from the system.

- **Results:**
  The system successfully performed all operations, with accurate status updates and minimal errors. The system successfully detected materials, performed pick-and-place tasks, assembling tasks and displayed real-time updates on the GUI. Also, the maintenance mode and auto off system are successfully work as well and all operations met the expected requirements.

  Project Demonstration Link: https://youtu.be/fPoc4D8JJm0
  Slide Presentation Link Video: https://youtu.be/M0B4RcbhA_Q

- **Screenshots/Photos:**
  This is our visual representation of the system that visualize overall system using a GUI on CX-Designer:



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8. Conclusion

- **Summary:**
  The project successfully demonstrated a pick-and-place and assembly system with PLC and GUI integration, achieving the objectives of automation and user control. All input and output in this system are working properly and achieving our objective which is to design, implement and demonstrate the pick & place and assembly system with a GUI, automation control and real-time user control and interfaces.

- **Achievements:**

  i) Seamless integration of PLC logic and GUI.

  ii) Successful implementation of the pick-and-place system.

  iii) Successfully designing an automated system in manufacturing fields.

  iv) Both Conveyor successfully handling the movement of raw material from loading bay into the unloading bay

  v) The sensor makes the stop placement of the raw material into the right positioning

  vi) Robot Arm achieve to pick and place the raw material into another place

  vii) Screw nut actuator work properly to assemble the nut into the raw material, and the gripper arm place the finished item into the pallet

- **Limitations and Future Work:**
  The system is limited to a specific set of tasks. It could not be able to detect various types of raw material. In the future, this system could be expanded to include more advanced sensors and extend functionality to handle diverse operations. Implement advanced sensors for example, like vision system for better object detection and handling, improving accuracy in pick-and-place tasks. It can detect various types of raw materials and enhance the flexibility of the system. This system also can implement cloud-based monitoring and analytics for real-time performance tracking, diagnostics, and remote control. It is good to make an analysis of the system to ensure the system is in good condition or needs a better improvement or another upgrade of the component.

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9. References

Exotec. "Guide to Conveyor Systems: Types, Uses, & Benefits." *Exotec*, 23 July 2024, www.exotec.com/insights/guide-to-conveyor-systems/.

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Wikipedia. "Pick-And-Place Machine." *Wikipedia*, 21 June 2021, en.wikipedia.org/wiki/Pick-and-place_machine.

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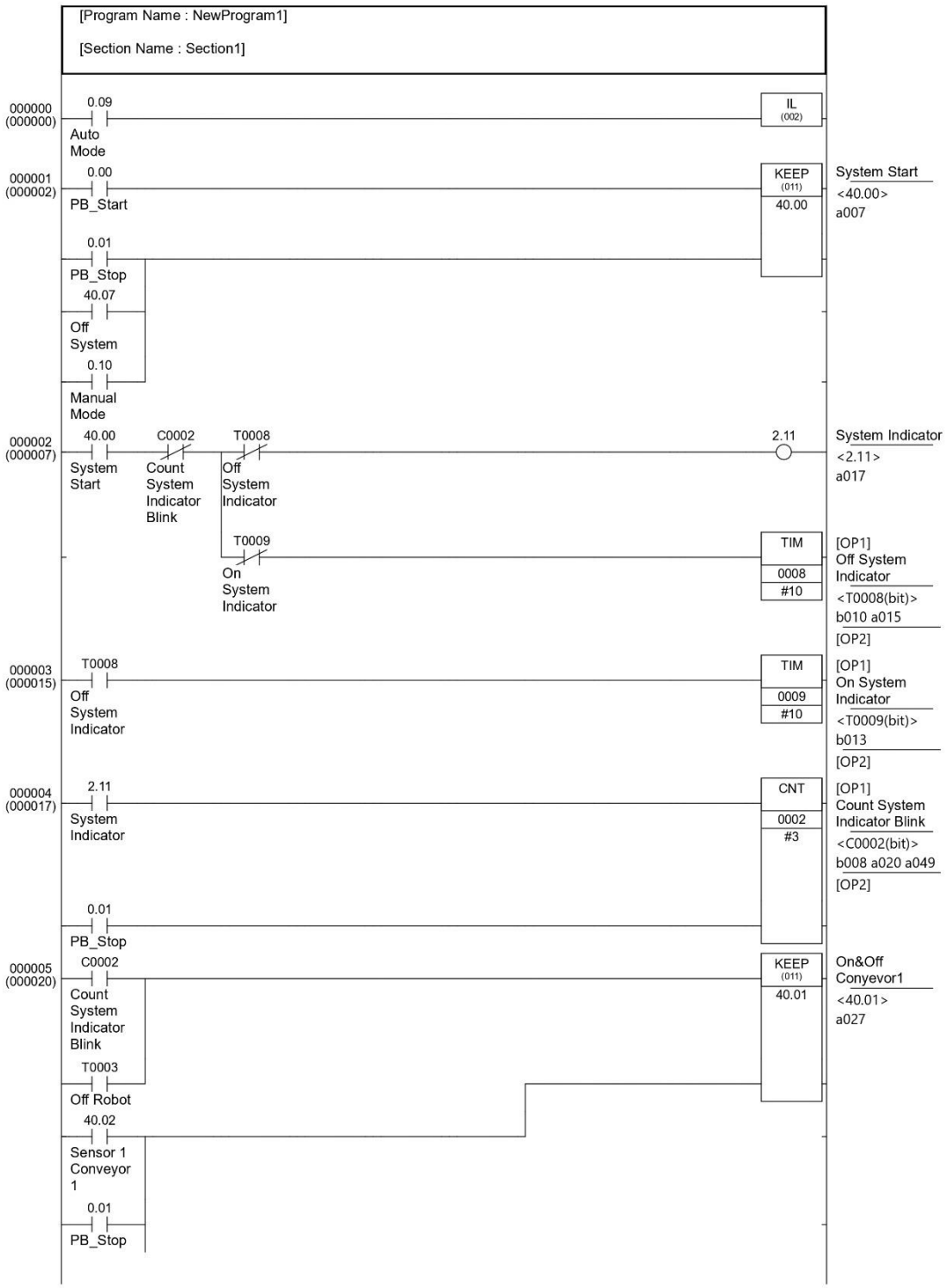
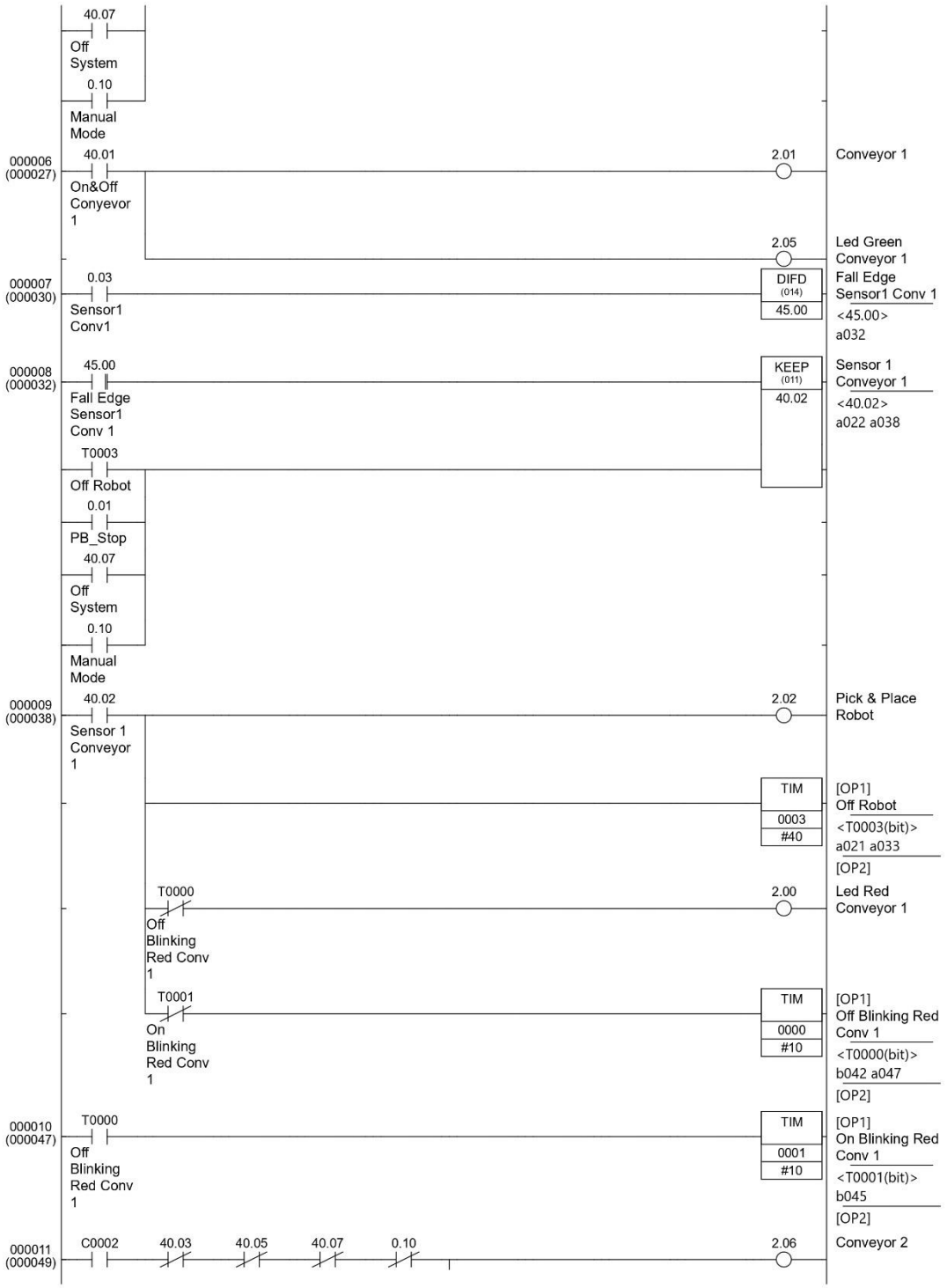
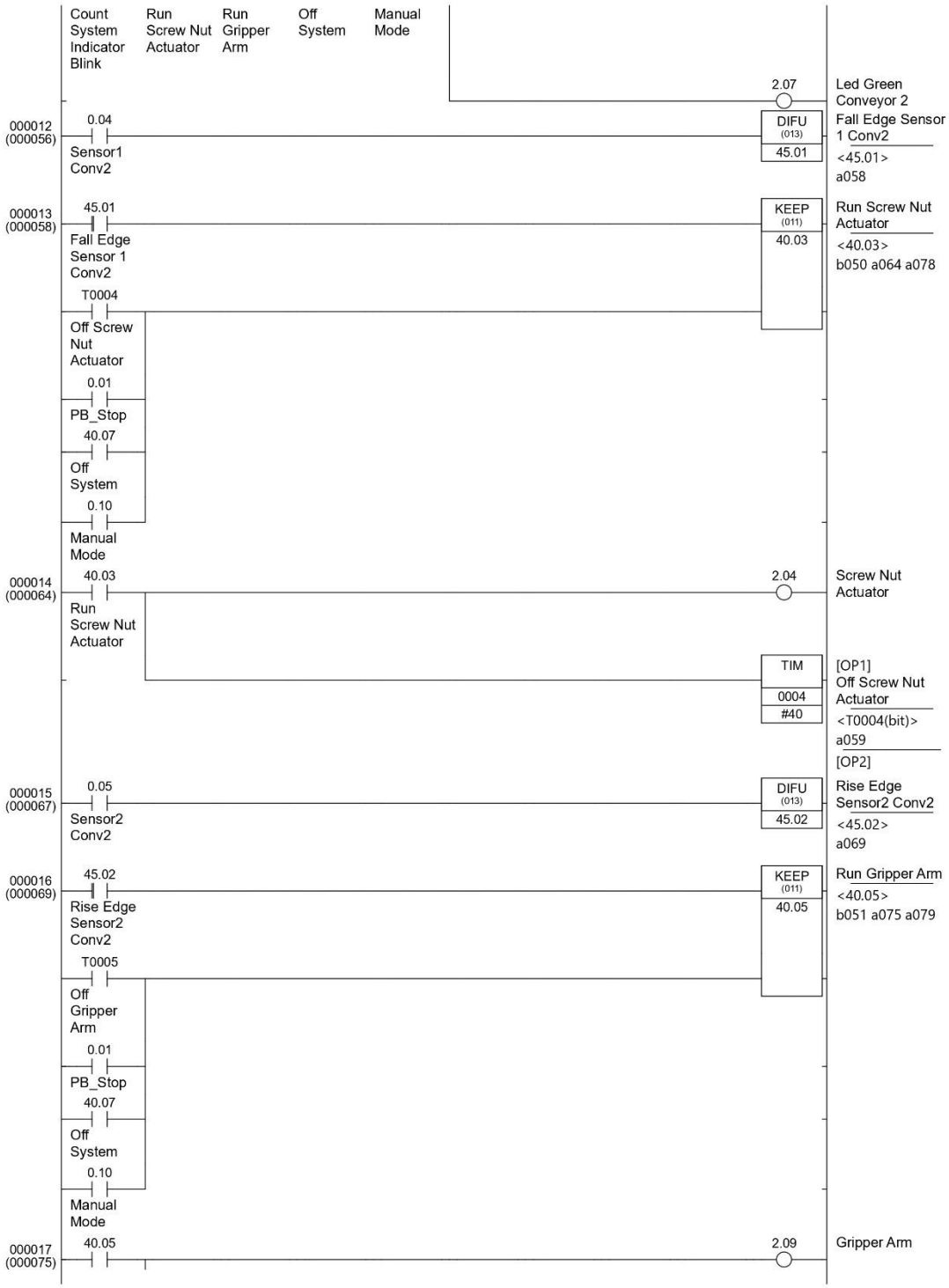
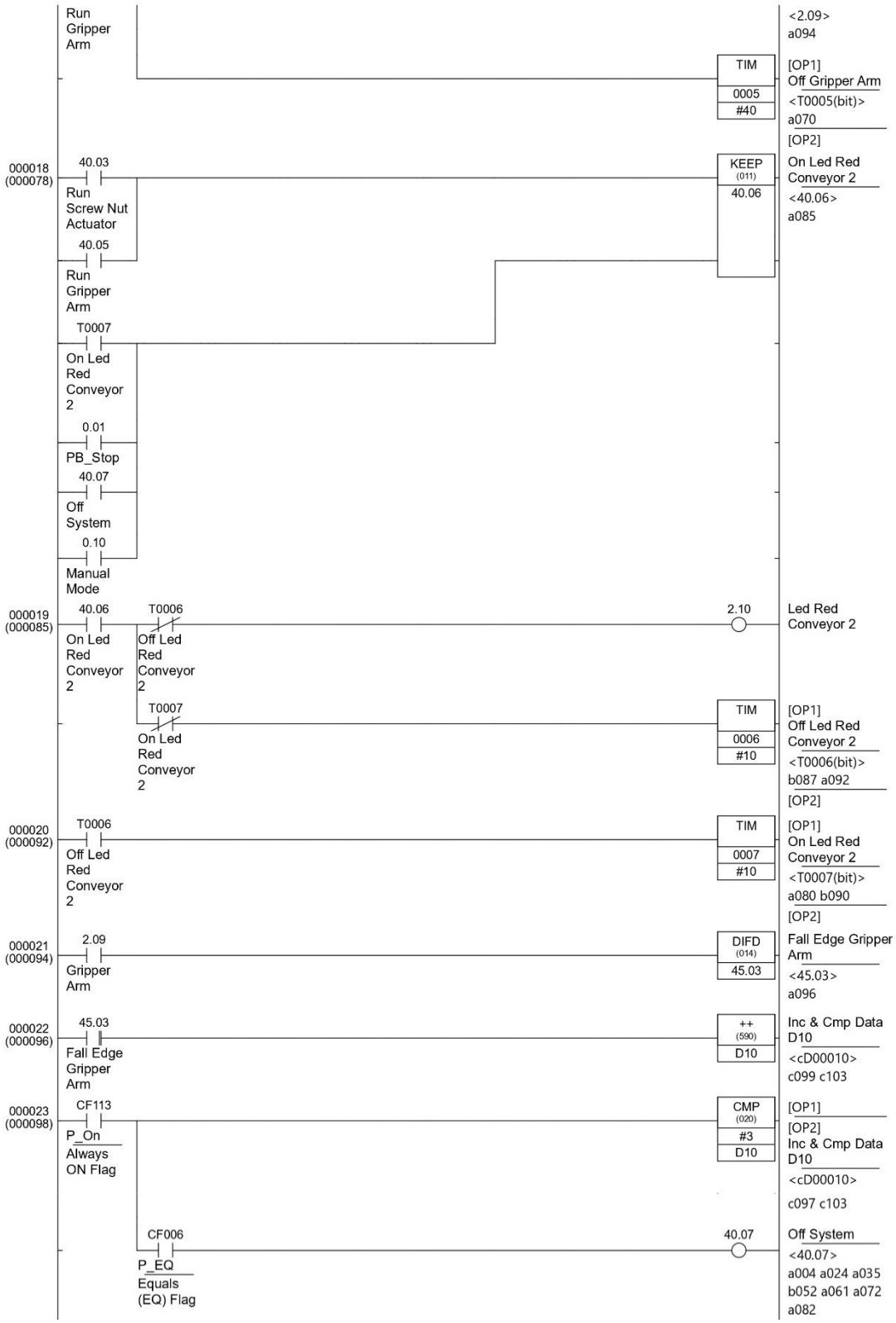
10. Appendices

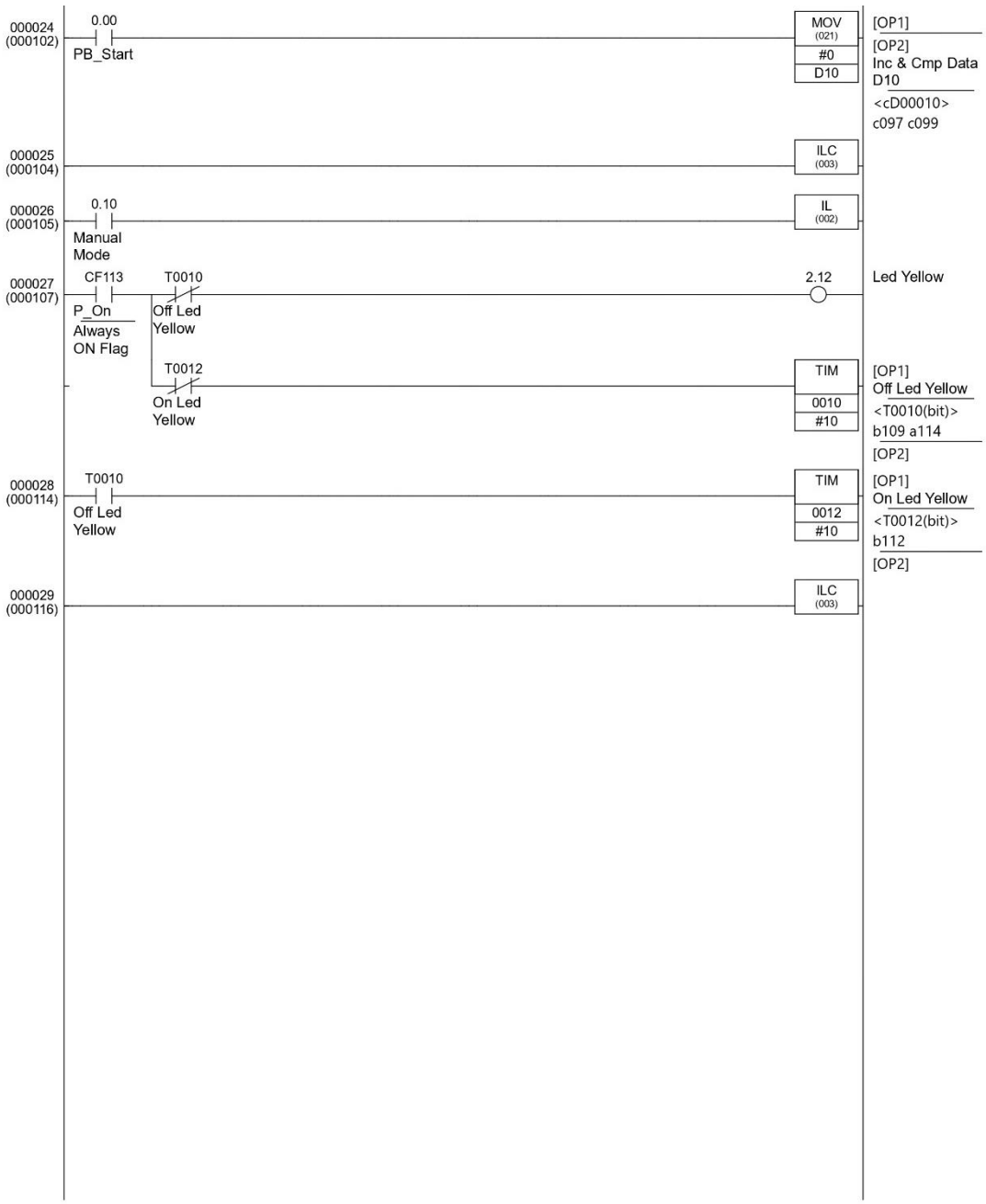
- PLC Ladder Diagram




40.07
Off System
0.10
Manual Mode
000006 (000027)
40.01
On&Off Conyevor 1
2.01
Conveyor 1
2.05
Led Green Conveyor 1
000007 (000030)
0.03
Sensor1 Conv1
DIFD (014)
45.00
Fall Edge Sensor1 Conv 1
<45.00>
a032
000008 (000032)
45.00
Fall Edge Sensor1 Conv 1
KEEP (011)
40.02
Sensor 1 Conveyor 1
<40.02>
a022 a038
T0003
Off Robot
0.01
PB_Stop
40.07
Off System
0.10
Manual Mode
000009 (000038)
40.02
Sensor 1 Conveyor 1
2.02
Pick & Place Robot
TIM
0003
#40
[OP1]
Off Robot
<T0003(bit)>
a021 a033
[OP2]
T0000
Off Blinking Red Conv 1
2.00
Led Red Conveyor 1
T0001
On Blinking Red Conv 1
TIM
0000
#10
[OP1]
Off Blinking Red Conv 1
<T0000(bit)>
b042 a047
[OP2]
000010 (000047)
T0000
Off Blinking Red Conv 1
TIM
0001
#10
[OP1]
On Blinking Red Conv 1
<T0001(bit)>
b045
[OP2]
000011 (000049)
C0002
40.03
40.05
40.07
0.10
2.06
Conveyor 2


Count System Indicator Blink
Run Screw Nut Actuator
Run Gripper Arm
Off System
Manual Mode
2.07
Led Green Conveyor 2
000012 (000056)
0.04
Sensor1 Conv2
DIFU (013) 45.01
Fall Edge Sensor 1 Conv2 <45.01> a058
000013 (000058)
45.01
Fall Edge Sensor 1 Conv2
KEEP (011) 40.03
Run Screw Nut Actuator <40.03> b050 a064 a078
T0004
Off Screw Nut Actuator
0.01
PB_Stop
40.07
Off System
0.10
Manual Mode
000014 (000064)
40.03
Run Screw Nut Actuator
2.04
Screw Nut Actuator
TIM 0004 #40
[OP1] Off Screw Nut Actuator <T0004(bit)> a059
[OP2]
000015 (000067)
0.05
Sensor2 Conv2
DIFU (013) 45.02
Rise Edge Sensor2 Conv2 <45.02> a069
000016 (000069)
45.02
Rise Edge Sensor2 Conv2
KEEP (011) 40.05
Run Gripper Arm <40.05> b051 a075 a079
T0005
Off Gripper Arm
0.01
PB_Stop
40.07
Off System
0.10
Manual Mode
000017 (000075)
40.05
2.09
Gripper Arm


Run Gripper Arm
<2.09>
a094
TIM
0005
#40
[OP1]
Off Gripper Arm
<T0005(bit)>
a070
[OP2]
000018
(000078)
40.03
Run Screw Nut Actuator
KEEP
(011)
40.06
On Led Red Conveyor 2
<40.06>
a085
40.05
Run Gripper Arm
T0007
On Led Red Conveyor 2
0.01
PB_Stop
40.07
Off System
0.10
Manual Mode
000019
(000085)
40.06
On Led Red Conveyor 2
T0006
Off Led Red Conveyor 2
2.10
Led Red Conveyor 2
T0007
On Led Red Conveyor 2
TIM
0006
#10
[OP1]
Off Led Red Conveyor 2
<T0006(bit)>
b087 a092
[OP2]
000020
(000092)
T0006
Off Led Red Conveyor 2
TIM
0007
#10
[OP1]
On Led Red Conveyor 2
<T0007(bit)>
a080 b090
[OP2]
000021
(000094)
2.09
Gripper Arm
DIFD
(014)
45.03
Fall Edge Gripper Arm
<45.03>
a096
000022
(000096)
45.03
Fall Edge Gripper Arm
++
(590)
D10
Inc & Cmp Data D10
<cD00010>
c099 c103
000023
(000098)
CF113
P_On
Always ON Flag
CMP
(020)
#3
D10
[OP1]
[OP2]
Inc & Cmp Data D10
<cD00010>
c097 c103
CF006
P_EQ
Equals (EQ) Flag
40.07
Off System
<40.07>
a004 a024 a035
b052 a061 a072
a082


000024
(000102)
0.00
PB_Start
MOV
(021)
#0
D10
[OP1]
[OP2]
Inc & Cmp Data
D10
<cD00010>
c097 c099
000025
(000104)
ILC
(003)
000026
(000105)
0.10
Manual
Mode
IL
(002)
000027
(000107)
CF113
P_On
Always
ON Flag
T0010
Off Led
Yellow
2.12
Led Yellow
T0012
On Led
Yellow
TIM
0010
#10
[OP1]
Off Led Yellow
<T0010(bit)>
b109 a114
[OP2]
000028
(000114)
T0010
Off Led
Yellow
TIM
0012
#10
[OP1]
On Led Yellow
<T0012(bit)>
b112
[OP2]
000029
(000116)
ILC
(003)