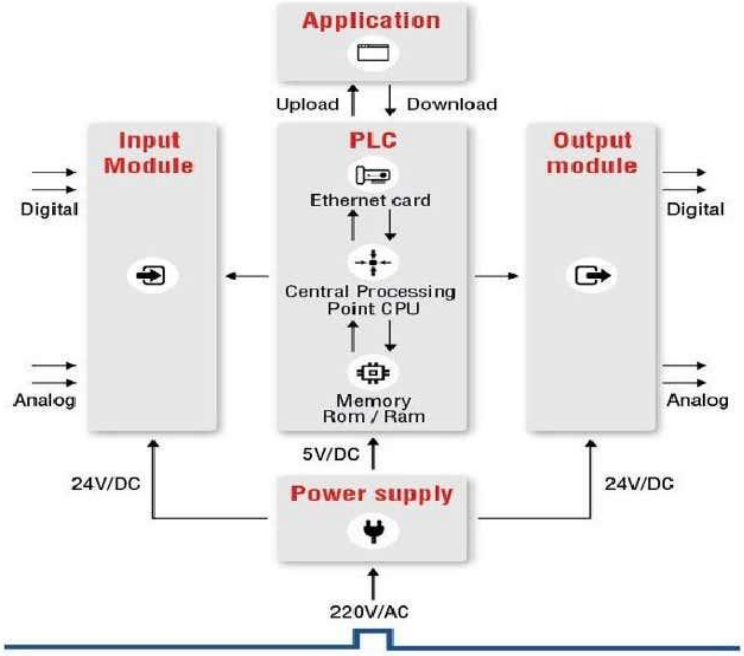
Introduction

The Industrial sector and Electrical section are the most important tools of the Programmable Logic Controller (PLC). Nowadays, Factory Automation is usually adept with programming logic controllers (PLCs) Programming logic control systems types of advantage: Flexible, Faster response time, modular design, Easy to repair and expand. In this assignment usual procedure of some command techniques which can use to learn in the field of programmable logic Controls (PLC). It will be used for real industrial automation projects. By this assignment we can knowledge and understanding of PLC Ladder Logic design, Grafcet design, and Petri net design which will help to understand for future work. Furthermore, become familiar with the PLC and real project documents to do next time. To gain how to implement and test Industrial automation projects. This assignment will be an assistant to gain the selection, Hardware, and software components essential of a programmable controller. We can learn the simulate and the safety controlling system of an industrial process.

the assignment involves explaining demanding knowledge of the feedback control system. It helps to learn the Ability to program real industrial automation projects and developing control systems with PLC. The assignment is going to explain an efficient approach and inclusive concept of Ladder Logic methods, Grafcet, Petri nets. In addition, Include the diagram of the actuator and sensors work cell and describe the purpose of all sensors and actuators. Petri net model design will include the project also supervisory control structure. Will present a grafcet to ladder diagram with a brief explanation to understand how the system work. Moreover, it will describe a project to design PLC based control systems.

PLCs are useful tools form of a microprocessor-based controller that able to programmable memory to store instructions and appliance functions such as processes, timing, sequencing, counting, and logic. PLC model 084 in 1969 was first invented by Dick Morley. In addition, designed a computer with three components: memory, processor, logic solver. Nowadays, as specified by the International Electrotechnical Commission (IEC) 61131 there are five programming languages used to code in PLCs. Ladder logic is the most popular one function block diagram (FBD), Structured Text (ST), Instruction List (IL) and Sequential function Chart (SFC). Nowadays, PLCs are using a different type of Industrial Control Systems (ICS). It has been changed widely relays, Timers.



The above diagram is shown in the basic structure of PLC. The central processing unit control and system bus connect with all the support devices.

CPU: The brain of the microcontroller is CPU and is accountable for fetching the instructions from memory. In a microcontroller, every part of the single system connects with the CPU.

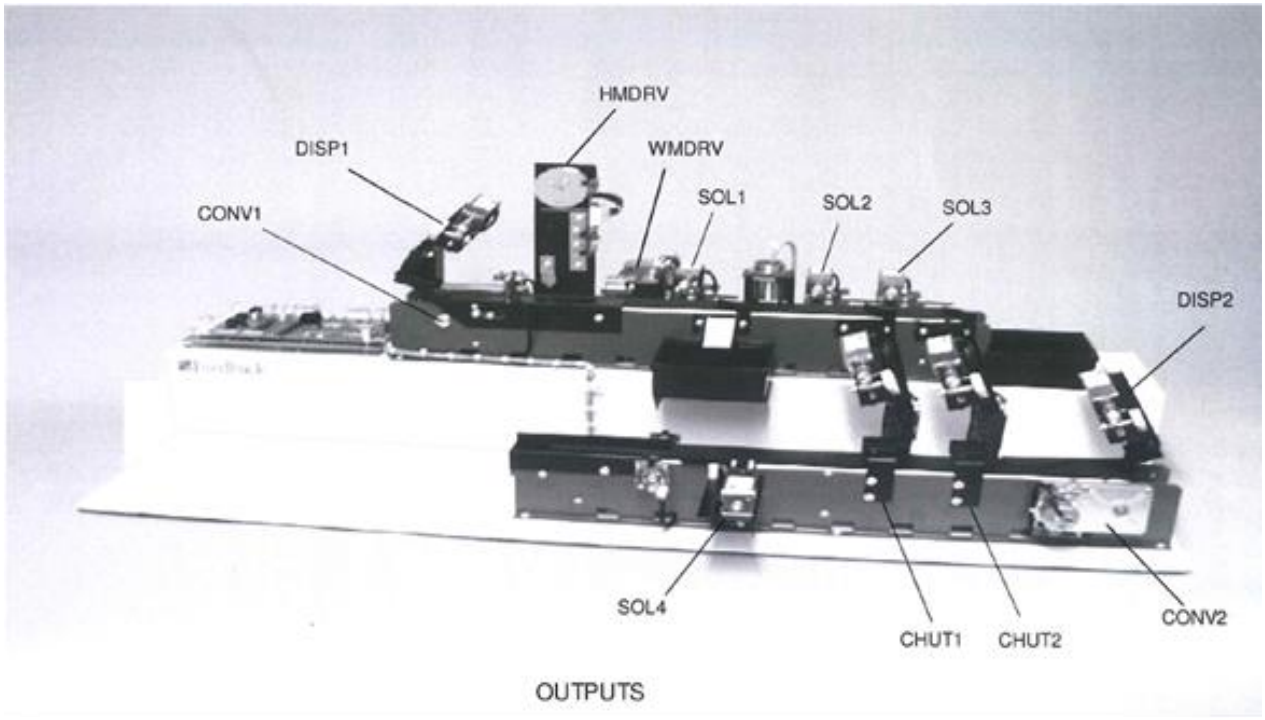
Power supply: This part is benefited to provide the needed power to the complete PLC system, and it converts from AC Power to DC Power which is required to 24V DC supply for the CPU and I/O module.

Memory: Microprocessor and Microcontroller function is the same. So, it is beneficial to store data and the program also has a defined amount of RAM and ROM or Flash technology for storing the program source code.

Input/Output: Input devices mostly used sensors, switches, pushbutton, etc and output devices can be an actuator, valves, relays, etc. I/O system uses to interface input and output devices with a microprocessor.

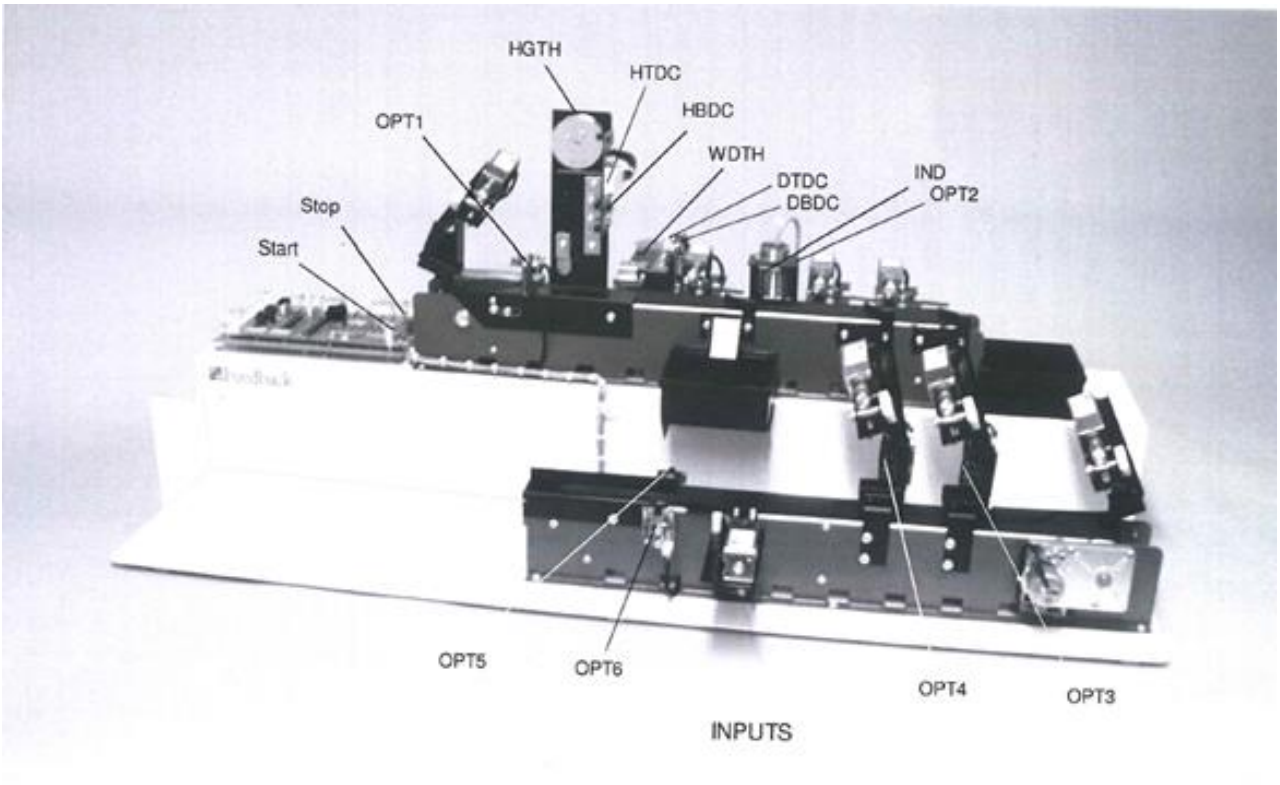
System Description

Diagram of work cell description of its construction:



Work cell actuators

there have a CONV1 which runs the top conveyor and CONV2 actuators it is run the bottom conveyor. At the first step, there has a dispensing area where storage plastic/metal rings then DISP1 solenoid that will drop plastic/metal ring on to the upper conveyor belt. As can be seen, HMDRV little solenoid can drive the sensor down to measure the thickness of components. Furthermore, the SOL2 actuator can force the ring down to the chute in the same way the SOL3 actuator use for the plastic ring. In addition, CHUT1 and CHUT2 actuators in the assembly section can open a solenoid arm bar and send them into the assembly area. Disp2 actuator work for the pugs as well open the arm bar to go for assembly area. Finally, the SOL4 actuator can help to go the product right or left side that depends on what type of component they are.



Work cell Sensors

Firstly, there have a start and stop switch to run the whole system. OPT1 sensor help to inform there exists component or not just before the measurement station. After that measuring station sensors HGTH, HTDC, HBDC those help to measure the thickness of the ring. Moreover, OPT2 sensor can detect the which type of metal/plastic ring also IND sensor can differentiate between plastic and metal. OPT3 and OPT4 can calculate how many rings in the assembly area or empty position of that area. Finally, the last area OPT5 and OPT6 where can identify and decide which direction the assembly product will go left or right side.

Actuators:

MicroLogix 1000 PLC Output	Wire Colours	Work cell Input	Work cell Actuator Description
O/1 [O:0/1]	White/Green	CONV1	Upper conveyor motor
O/2 [O:0/2]	Yellow/Red	DISP1	Ring release solenoid, ring loading chute
O/3 [O:0/3]	Red/Brown	HMDRV	Height/thickness motor drive
O/4 [O:0/4]	White/Red	SOL2	Flipper solenoid at 1st ring chute
O/5 [O:0/5]	Red/Blue	SOL3	Flipper solenoid at 2nd ring chute
O/6 [O:0/6]	Yellow/Blue	CHUT1	Ring release solenoid, 1st ring storage chute
O/7 [O:0/7]	Orange/Green	CHUT2	Ring release solenoid, 2nd ring storage chute
O/8 [O:0/8]	Yellow/Green	DISP2	Peg release solenoid, peg loading chute
O/9 [O:0/9]	Blue/Black	CONV2	Lower conveyor motor
O/10 [O:0/10]	Red/Black	SOL4	Assembly sort solenoid

Conv1: conv1 is used to run the upper conveyor motor and carry the ring step by step.

Disp1: Disp1 is beneficial to release the ring to conveyor and ring loading chute is store the rings.

HMDRV: HMDRV is used to drive the motor and check the height/thickness of the ring.

Sol2&Sol3: Sol2 and Sol3 are used to 1st and 2nd chute the ring from the sort area by Flipper solenoid.

Chut1&Chut2: chut1 and chut2 are used to release the ring 1st and 2nd to the assembly area by ring release solenoid and 1st and 2nd ring storage chute.

Disp2: Disp2 is benefitted to release the Peg to the assembly area bottom conveyor by release solenoid and to storage the peg loading chute.

Conv2: Conv2 is helping to run the bottom belt area and carry the peg and ring to the assembly collection area.

Sol4: Sol4 is used the separate the ring plastic in the collection area it pushed the plastic ring to go right side by sort solenoid.

Power:

MicroLogix 1000 PLC Output	(Wire Marker on) Wire Colour(s)	Work cell Input	Work Cell Input Description
DC COM	Brown & Green on Black	24PLC	PLC PSU 24V
VAC VDC	Brown & Purple on Red	0VPLC	PLC P0V

Sensors:

MicroLogix 1000 Input	(Wire Marker on) Wire Colour(s)	Work cell Output	Work cell Sensor Description
I/1 [I:0/1]	Grey	OPT1	opto sensor ahead of height/thickness gauge
I/2 [I:0/2]	Purple	HBDC	Height/thickness gauge bottom dead centre
I/3 [I:0/3]	Orange	HTDC	Height/thickness gauge top dead centre
I/4 [I:0/4]	Brown	HGHT	Ring height/thickness OK
I/5 [I:0/5]	Pink	IND	Inductive sensor
I/6 [I:0/5]	Dark Blue	OPT2	Opto sensor at inductive sensor
I/7 [I:0/7]	Brown & Red or Yellow	OPT3	Ring present in assembly area, 1st chute
I/8 [I:0/8]	Red	OPT4	Ring present in assembly area, 2nd chute
I/9 [I:0/9]	Green/Red	OPT5	Assembly collection area 2 full sensor
I/10 [I:0/12]	White	OPT6	Assembly collection area 1 full sensor
I/11 [I:0/11]	Blue		Start button (BLACK) in box on flying lead
I/12 [I:0/12]	Green		Stop Button (RED) in box on flying lead

Opt1: Opto sensor ahead of height/thickness gauge active the Height/ thickness motor drive in the measurement area.

HBDC: It will check the ring level is too small or not height/thickness gauge bottom dead Centre.

HTDC: It will check the ring level is too big or not height/thickness gauge top dead Centre.

HGHT: HGHT is used to check the ring level is ok to go with the requirement gauge.

IND: IND is used to identify the metal ring which will help to activate the metal ring actuator.

OPT2: Opto sensor is used at Inductive sensor to identify the metal or plastic ring.

OPTO3&OPTO4: these sensors help to identify there have been ring or not. If there have a ring, then activate the actuator to release the ring.

OPTO5&OPTO6: opto5 and opto6 are used in the assembly collection area to identify the metal or plastic complete assembly product. If it's plastic, then activate the actuator to push the plastic to go right side.

PLC model and programming software used: Feedback PLC Work cell 34-120 / Allen-Bradley MicroLogix 1000 PLC Wiring

Requirements

Automation requirements:

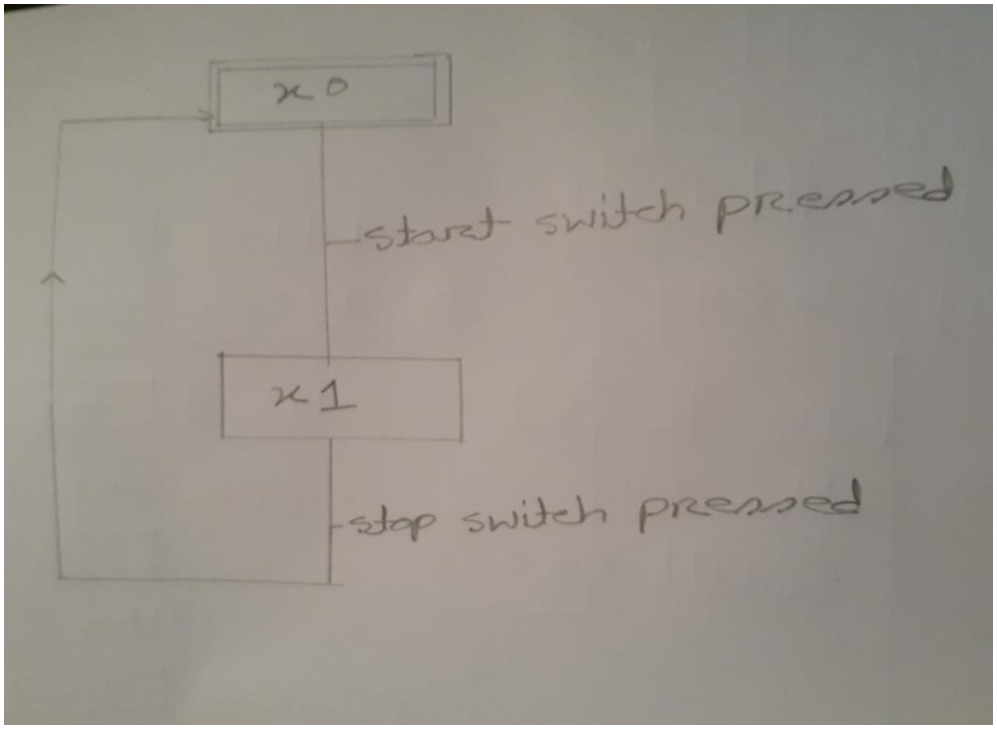
1. Two push-button switch want to control the conveyor motors.
2. Ring loading chute needs to storage the rings that ring release purpose want a solenoid.
3. Opto sensor wants to stop the conveyor and check how thick the rings.
4. For Ring measurements wants HGTH, HTDC, HBDC sensors also need an HMDRV motor drive to up and down the measurement position.
5. Identify the Metal or plastic ring that need an inductive sensor and Opto sensor.
6. For the first ring, chute need a flipper solenoid to send the plastic ring present assembly area and for assembly, desire need a ring release solenoid.
7. the second ring, chute need a flipper solenoid to send the metal ring present assembly area and for assembly, desire need a ring release solenoid.
8. To storage, the peg needs peg loading chute also want a peg release solenoid which will release the peg for assembly.
9. Collect the metal or plastic assembly rings need assembly collection areas 1 and 2 with Opto sensor to identify and select which side will go by the assembly sort solenoid will push the product.

Automation constraints:

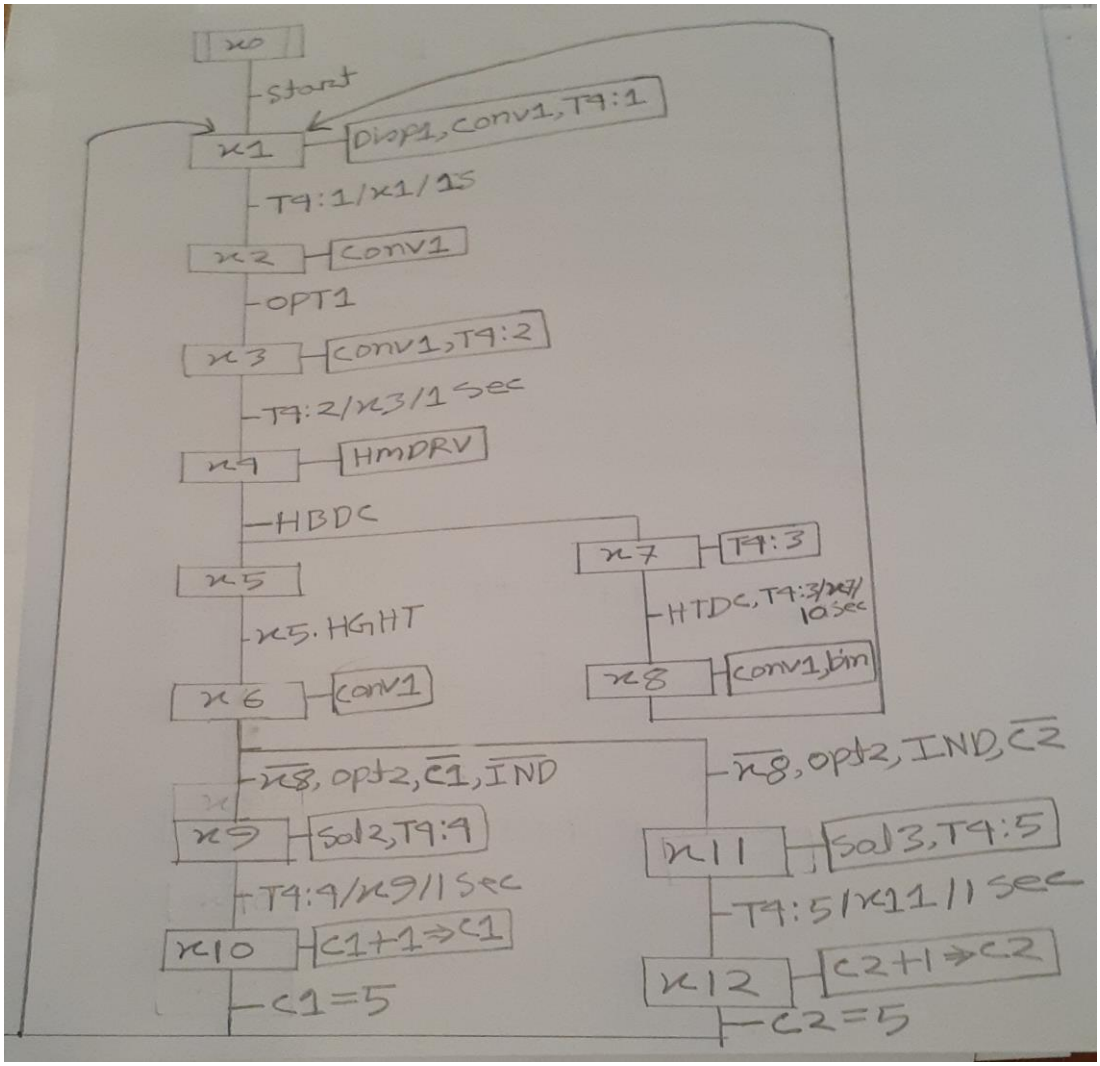
1. In the measurement area, there will release one ring when the ring clears the plastic/metal sensor system, release another ring.

2. When sensors will identify the type of ring then operate ring release solenoid to chute ring correct assembly area.
3. If there are insufficient pegs, then released a limit number of rings into the chute.
4. If several rings are full in the counter system, then it will go to the bucket.
5. IF 1st chute assembly area ring is detected or not detected then check the second chute assembly area, release a peg.
6. In the collection, area should check the diversion of complete assemblies.

Program Design (GRAFCET)

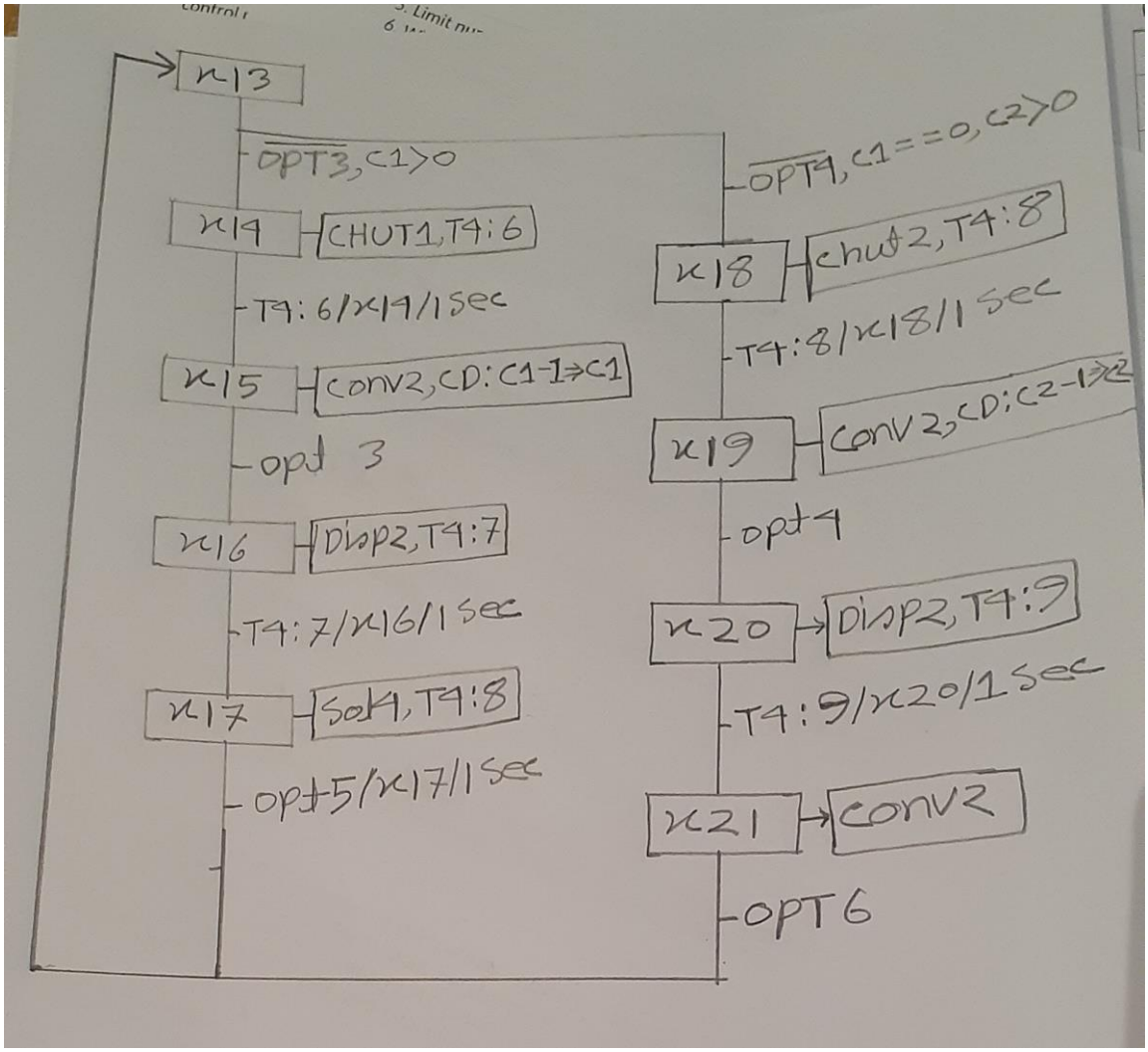


To begin, the start and stop button which does not automatically hold the device with this small loop is used to memories the procedure of the control system. The initial step in which the system is held ready to start and stop is used to go back to the initial state of this loop.



The signal of the start button(x0) enables the start of the loops. the ring release solenoid will release a ring to the upper belt at the same time the upper conveyor motor is switched on until the opt1 sensor ahead active. Furthermore, when the condition of those judgement complete X4 will activate the Height/thickness motor drive wheel turning until the height/thickness gauge bottom dead Centre is enabled. Now the ring in the measured spot and checked up; at this moment the conveyor belt is stopped for a few seconds to follow the timer time schedule. So, the height/thickness gauge top dead Centre will check if this ring is too big then the Ring height/thickness sensor will not check the level and the wheel will continue to check the HTDC (height/thickness top dead Centre) if there is not match the ring with the condition then the loop will stop, therefore, the ring will be ignored and send to in the bin.X5 with fulfill condition by turning HGHT then it goes to the sort area.

In the sort area, there have some condition X9 deals with the plastic ring and the flipper solenoid2 where if the ring is not x8, not IND, not c1=0 then it will active the solenoid and timers to go down the plastic ring into the assembly area. When it will arrive in x10 then counting will count the product their maximum allows 5 rings otherwise it will go to the bin. In the same way, a metal ring is worked but there has one extra condition where the inductive sensor (IND) must active then the solenoid 3 will be active to goes down the products in the metal assembly area.



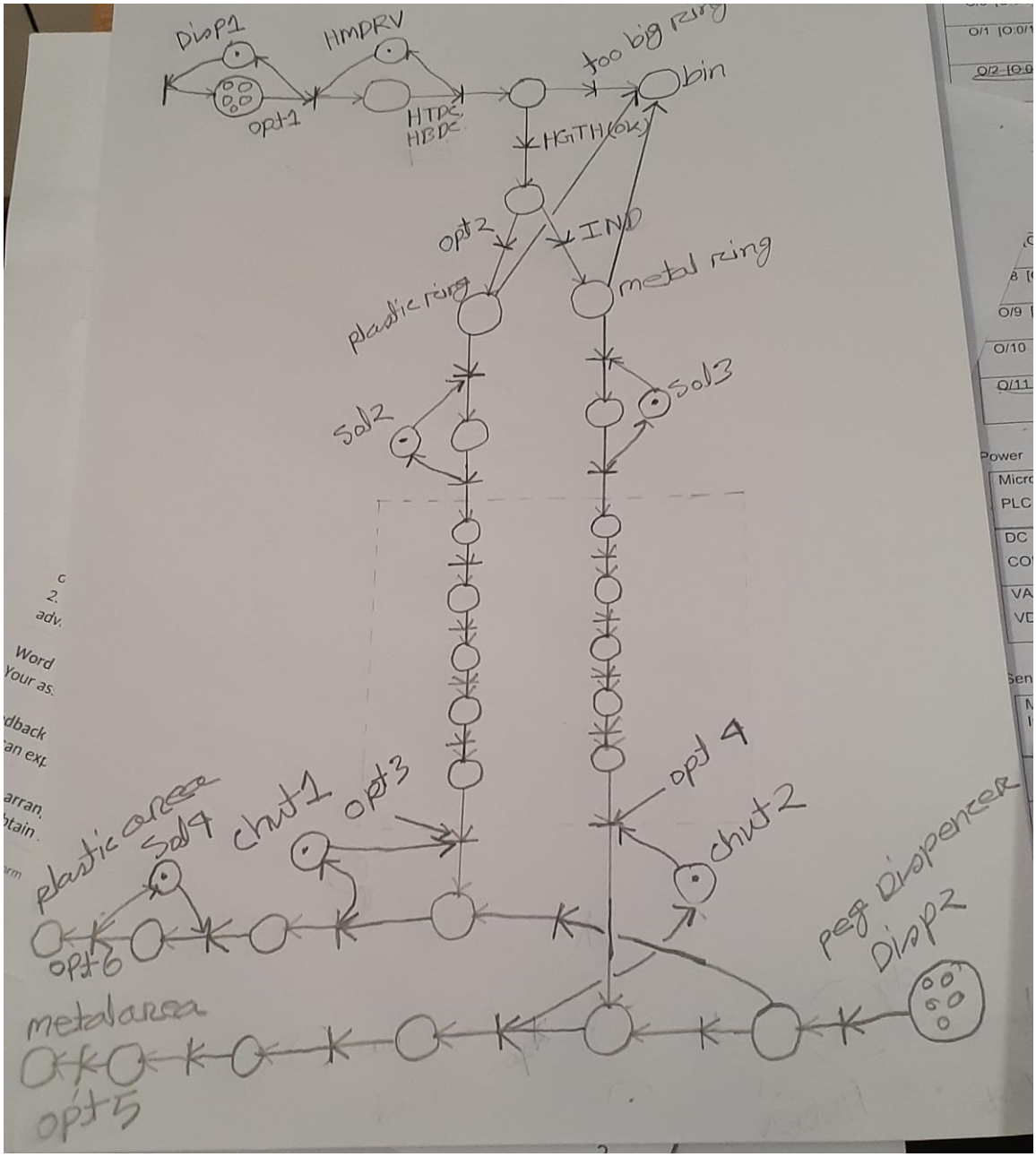
As we can see opt3 is not active that means if there is no ring in the assembly area then active the CHUT1 solenoid for few seconds to goes down and active the opt3 sensor. When the sensor detects the ring then will active the DISP2 peg dispenser solenoid for few seconds to release the peg and complete the assembly product. Finally, in the Storage area if this product is a plastic ring then will active the solenoid4 to push the ring by arm bar to go another side at the same time OPT5 sensor will confirm this is a plastic product or not.

On the other hand, X18 this is will storage metal rings but there has one condition always gives the priority to plastic ring goes down to the assembly when the plastic ring is empty then will activate the metal ring area. When op4 is not active that means if there is no ring in the assembly area then active the CHUT2 solenoid for few seconds goes down and active the opt4 sensor. When the sensor detects the ring then will active the DISP2 peg dispenser solenoid for few seconds to release the peg and complete the assembly product. Finally, the aOPT6 sensor will confirm this is a metal product or not.

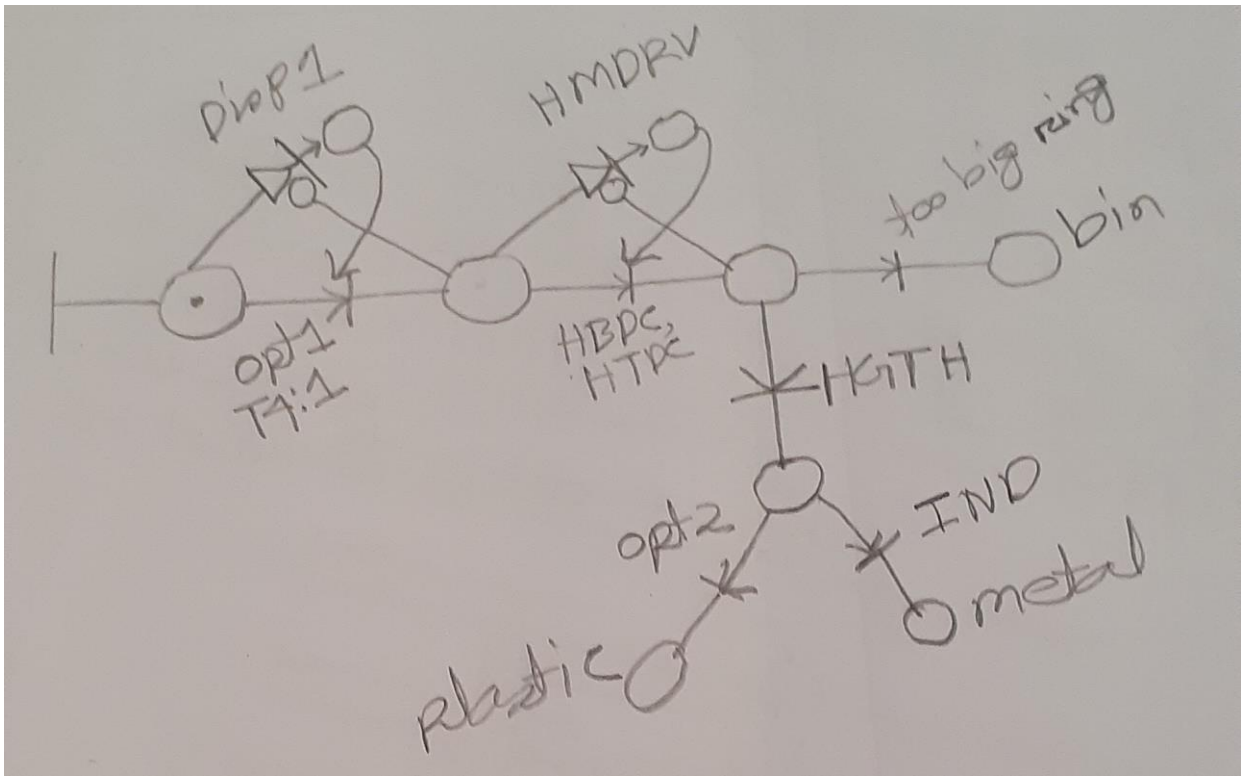
In the sort area, I haven't understood how solenoid2 and solenoid3 active then I have understood there have an inductive sensor that will identify the metal ring and will active the metal ring solenoid to goes down the ring in the metal assembly area. Furthermore, I was facing a problem with the peg dispenser when It will active then I understood when opt3 and opt4 identify there have any ring then will be active in the DISP2 solenoid.

Petri net

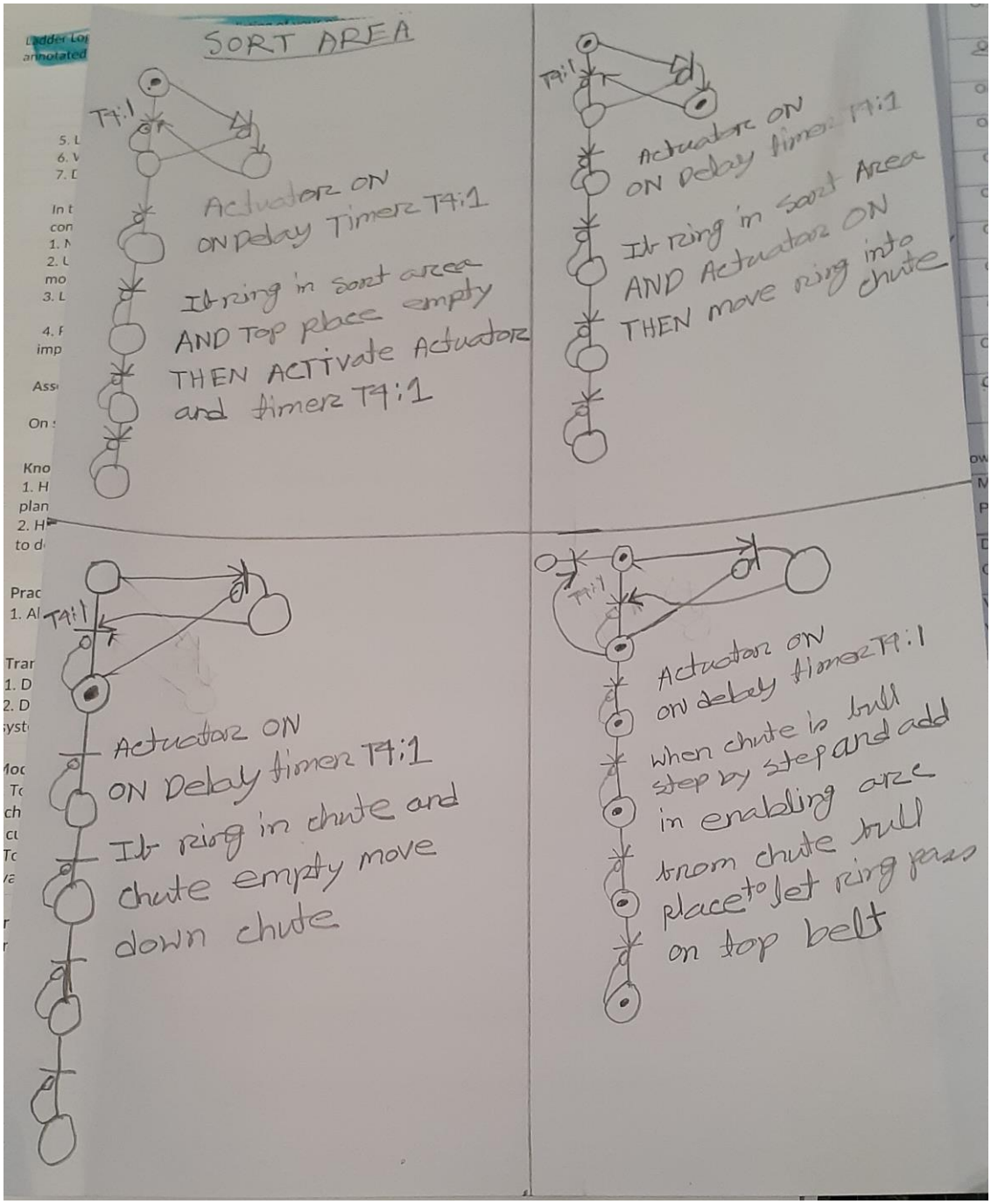
Petri net Model:



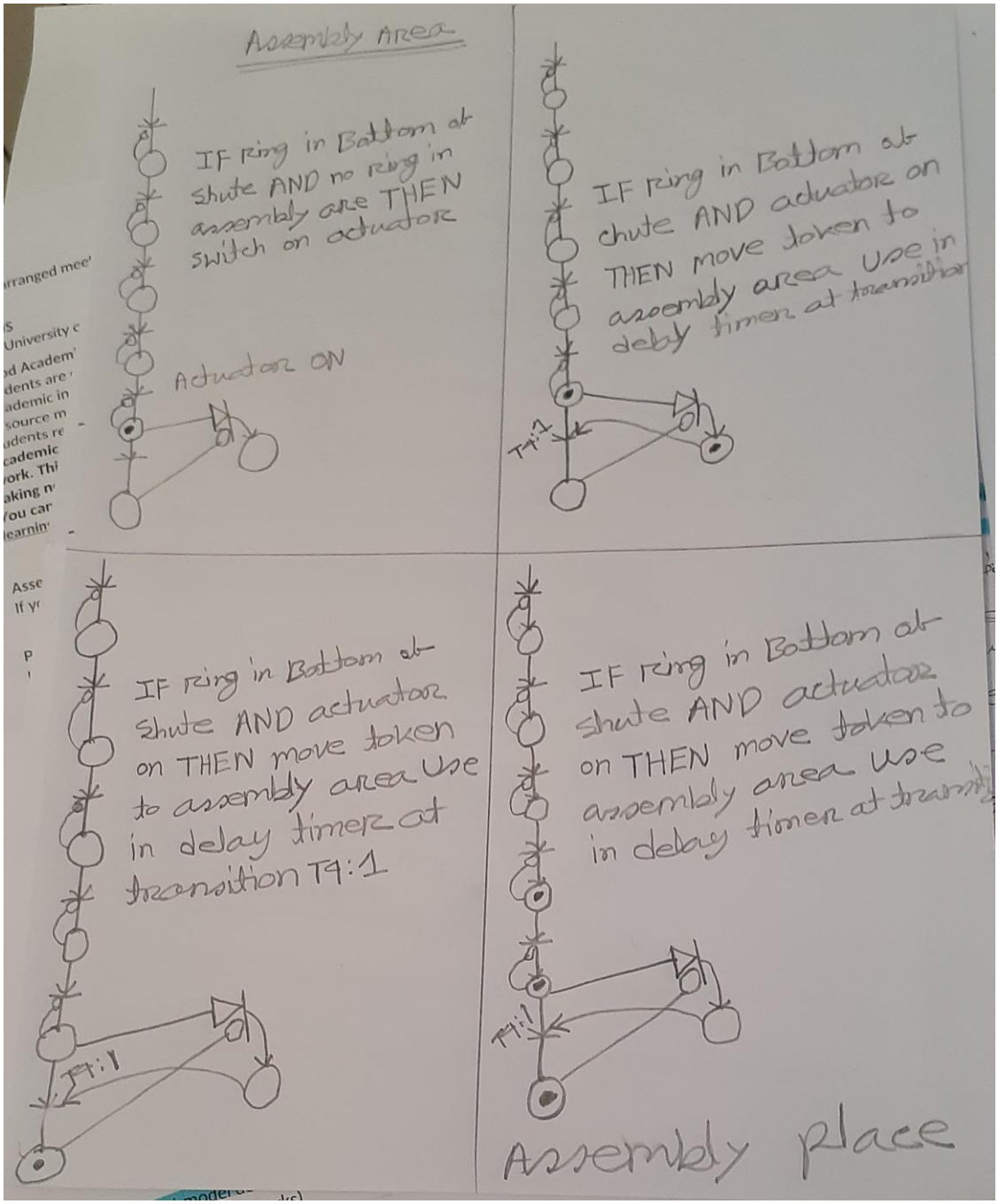
Petri net Supervisor:



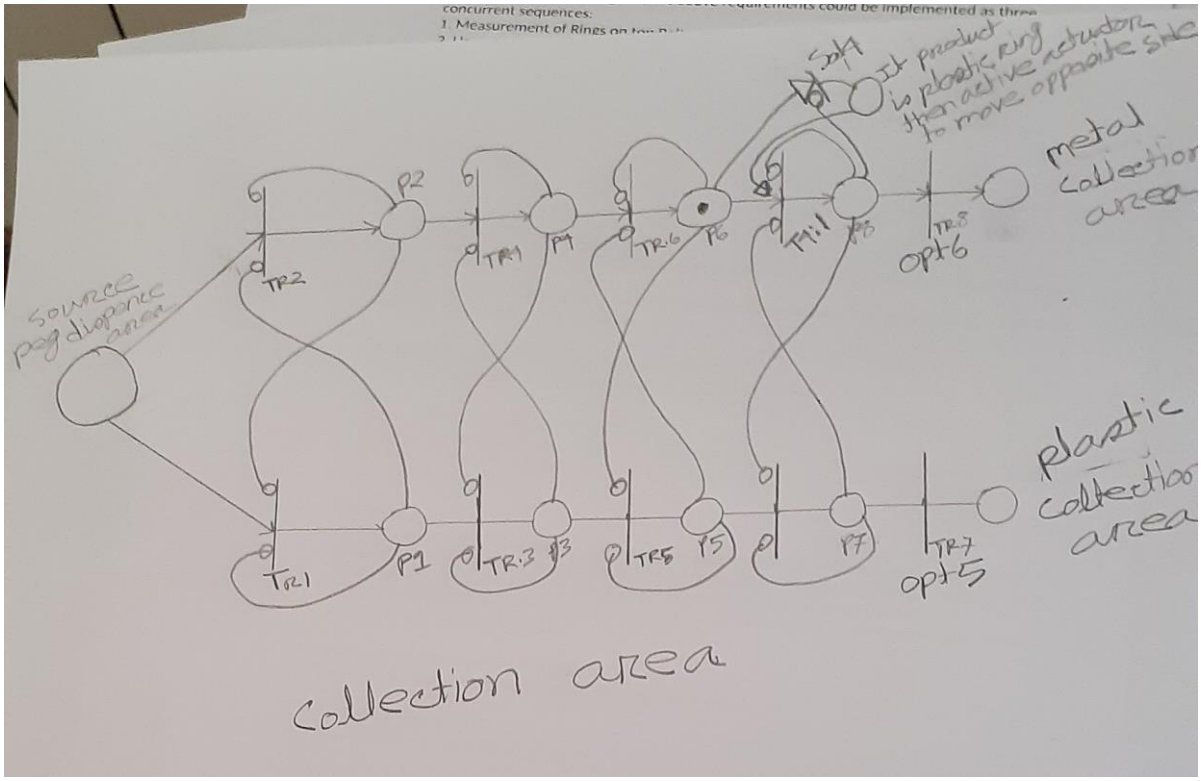
Top Conveyor


SORT AREA
T4:1
Actuator ON
ON Delay Timer T4:1
It ring in sort area
AND Top place empty
THEN ACTIVate Actuator
and timer T4:1
T4:1
Actuator ON
ON Delay timer T4:1
It ring in sort Area
AND Actuator ON
THEN move ring into
chute
T4:1
Actuator ON
ON Delay timer T4:1
It ring in chute and
chute empty move
down chute
T4:1
Actuator ON
on delay timer T4:1
when chute is full
step by step and add
in enabling arc
from chute full
place to let ring pass
on top belt

Sort Area

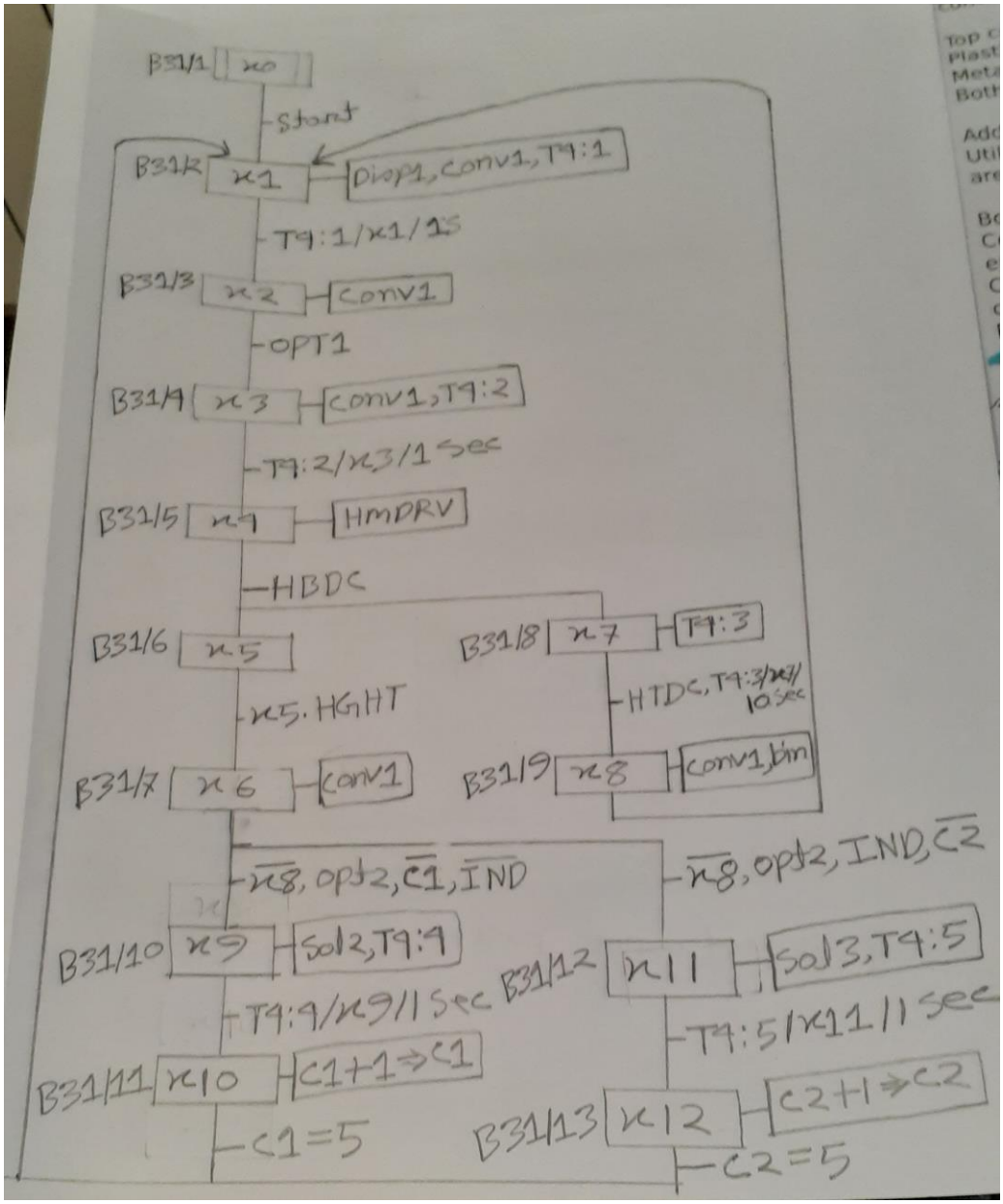


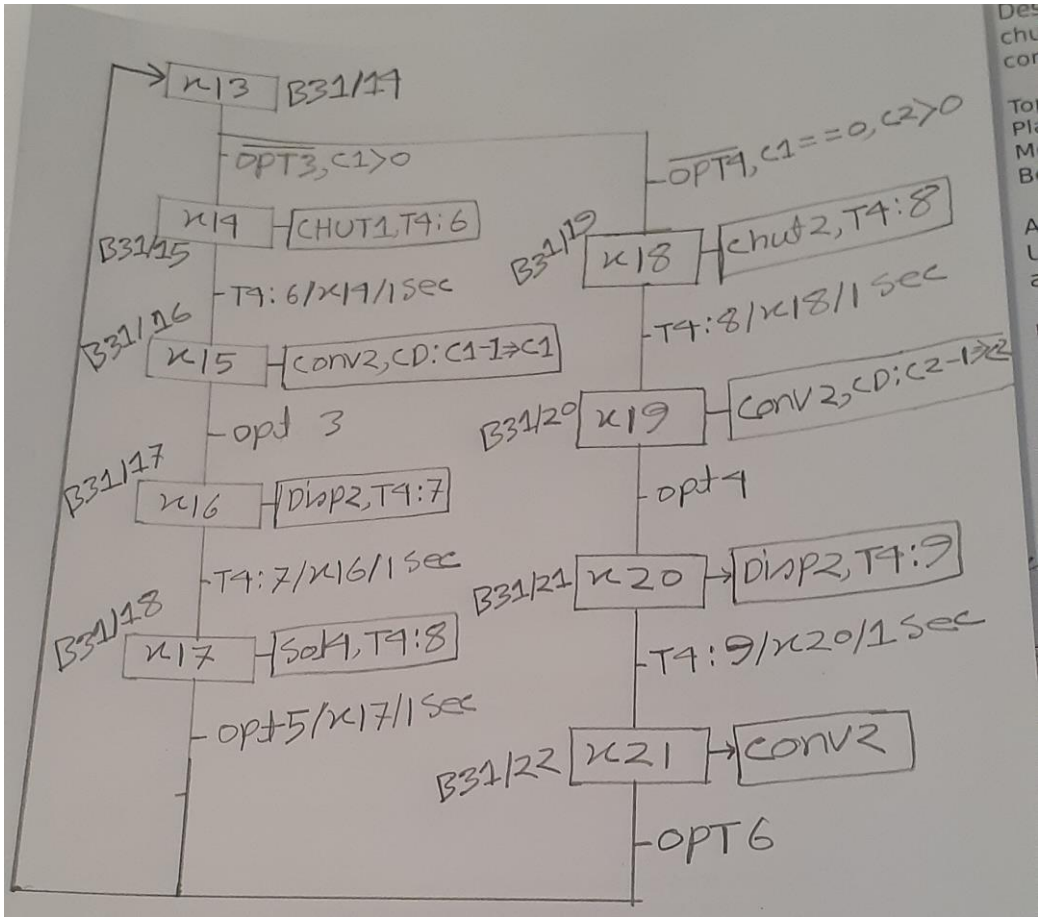
Assembly Area



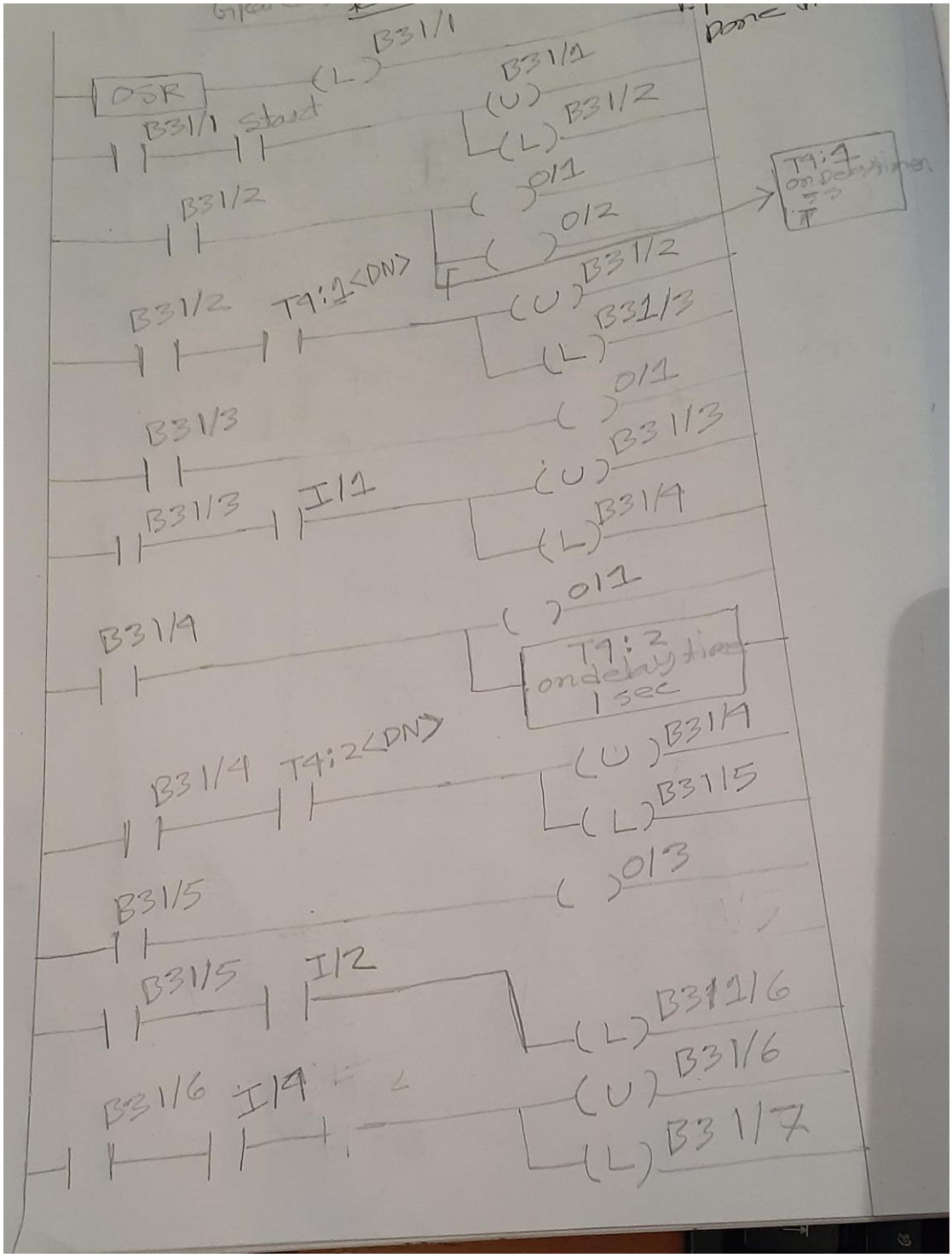
Storage Area

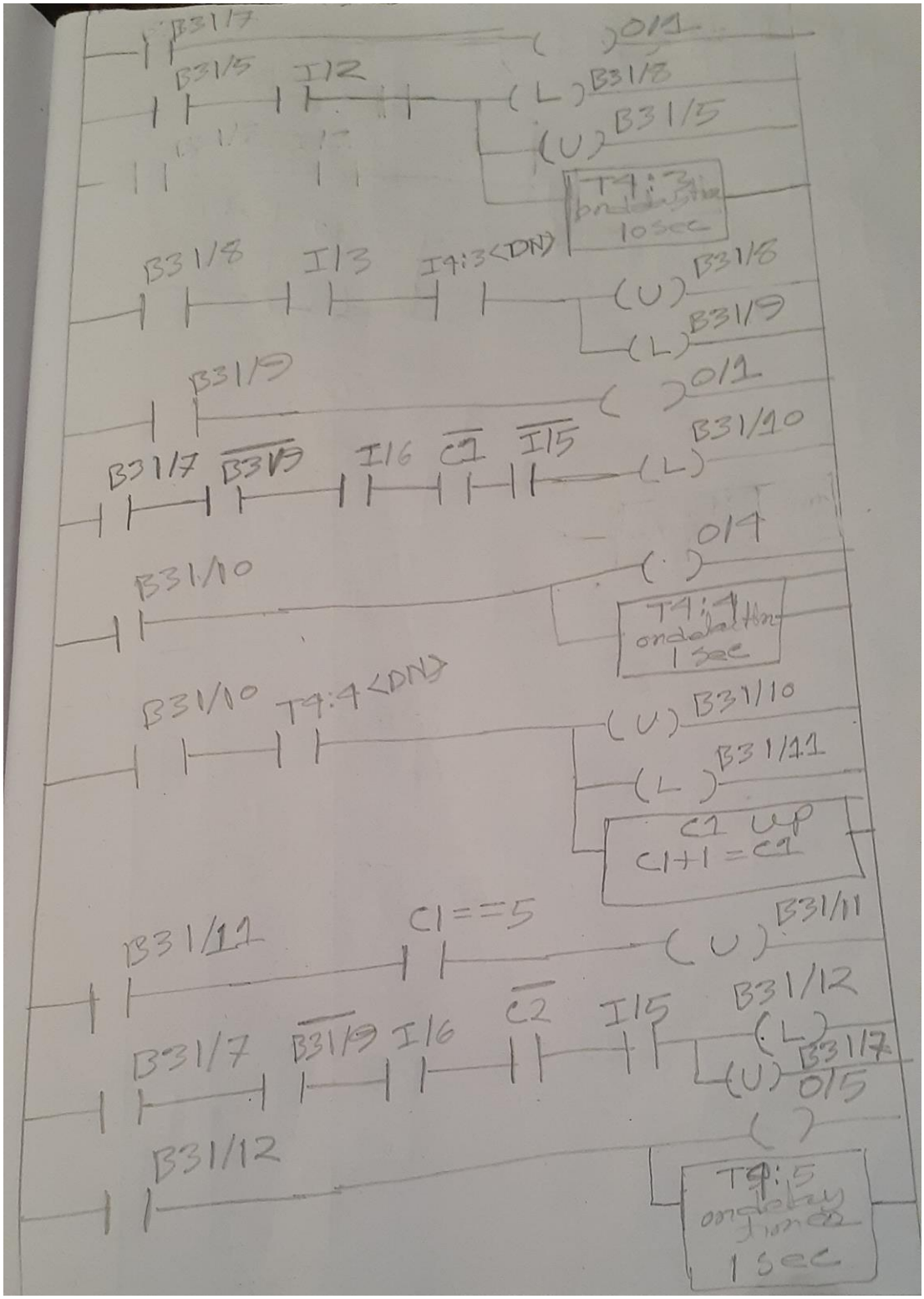
Ladder Diagram

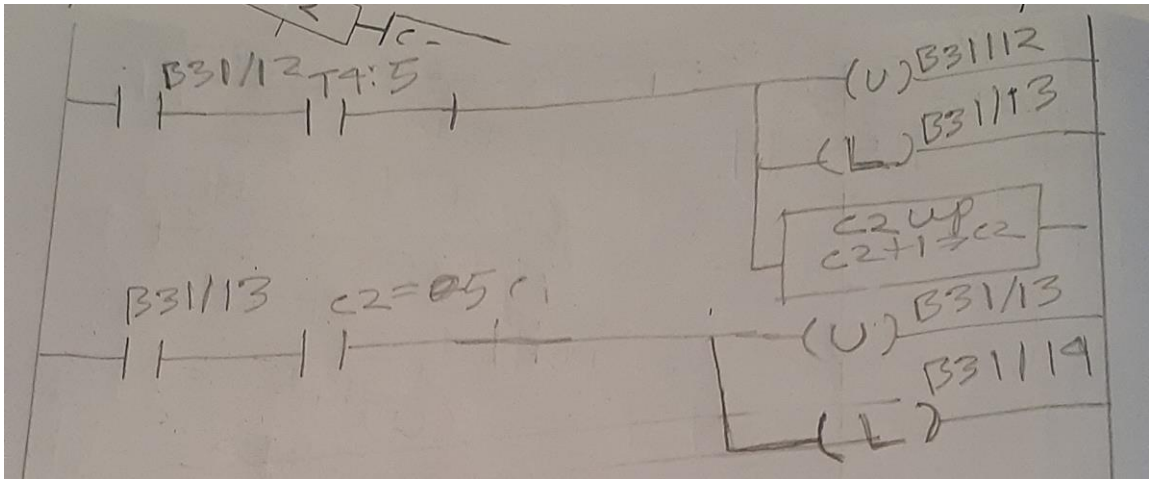

B31/1
x0
Start
B31/2
x1
Disp1, conv1, T9:1
T9:1/x1/1s
B31/3
x2
conv1
OPT1
B31/4
x3
conv1, T9:2
T9:2/x3/1 sec
B31/5
x4
HMDRV
HBDC
B31/6
x5
x5. HGHT
B31/7
x6
conv1
B31/8
x7
T9:3
HTDC, T9:3/x7/10 sec
B31/9
x8
conv1, tin
x8, opt2, C1, IND
x8, opt2, IND, C2
B31/10
x9
sol2, T9:4
T9:4/x9/1 sec
B31/11
x10
C1+1⇒C1
C1=5
B31/12
x11
sol3, T9:5
T9:5/x11/1 sec
B31/13
x12
C2+1⇒C2
C2=5

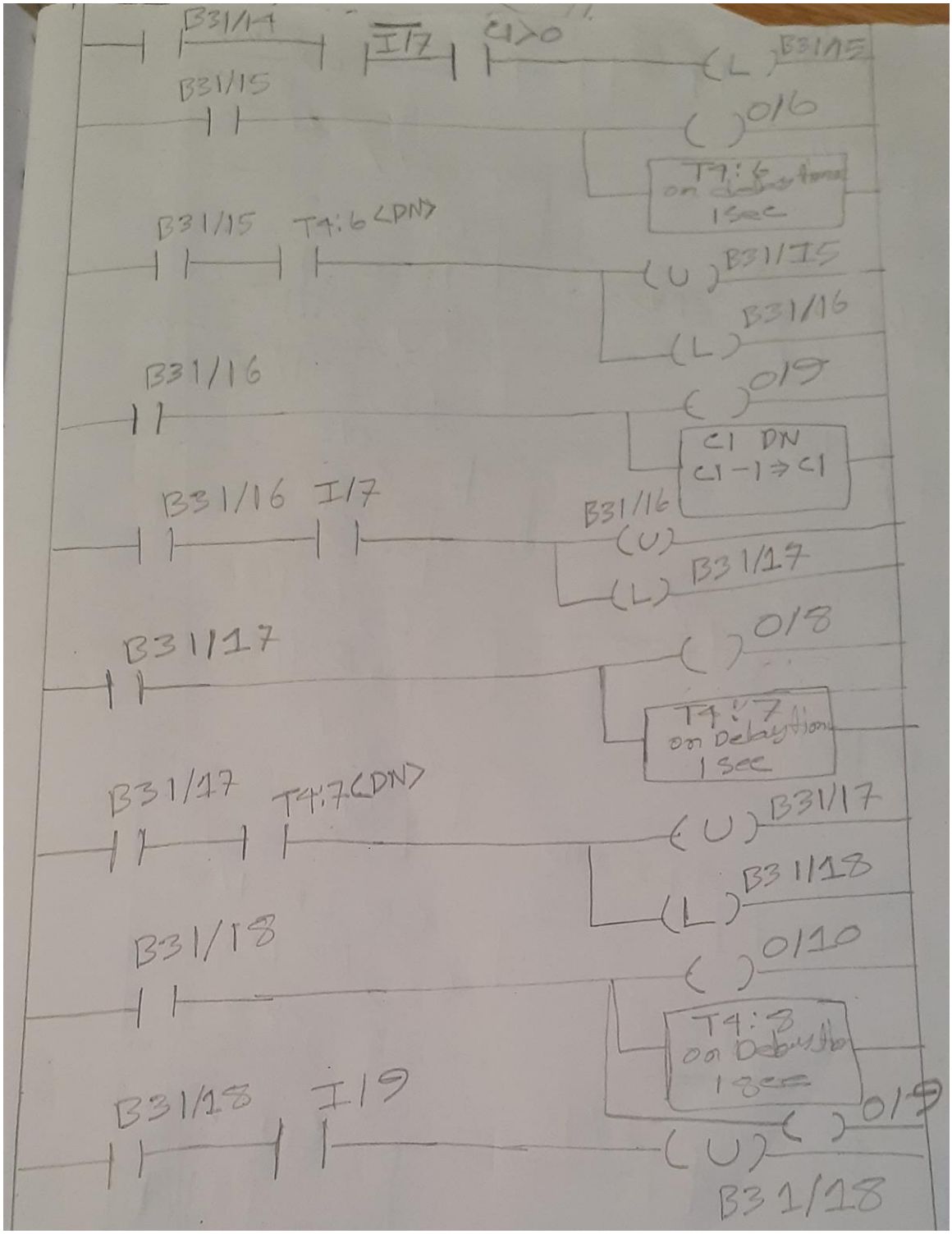


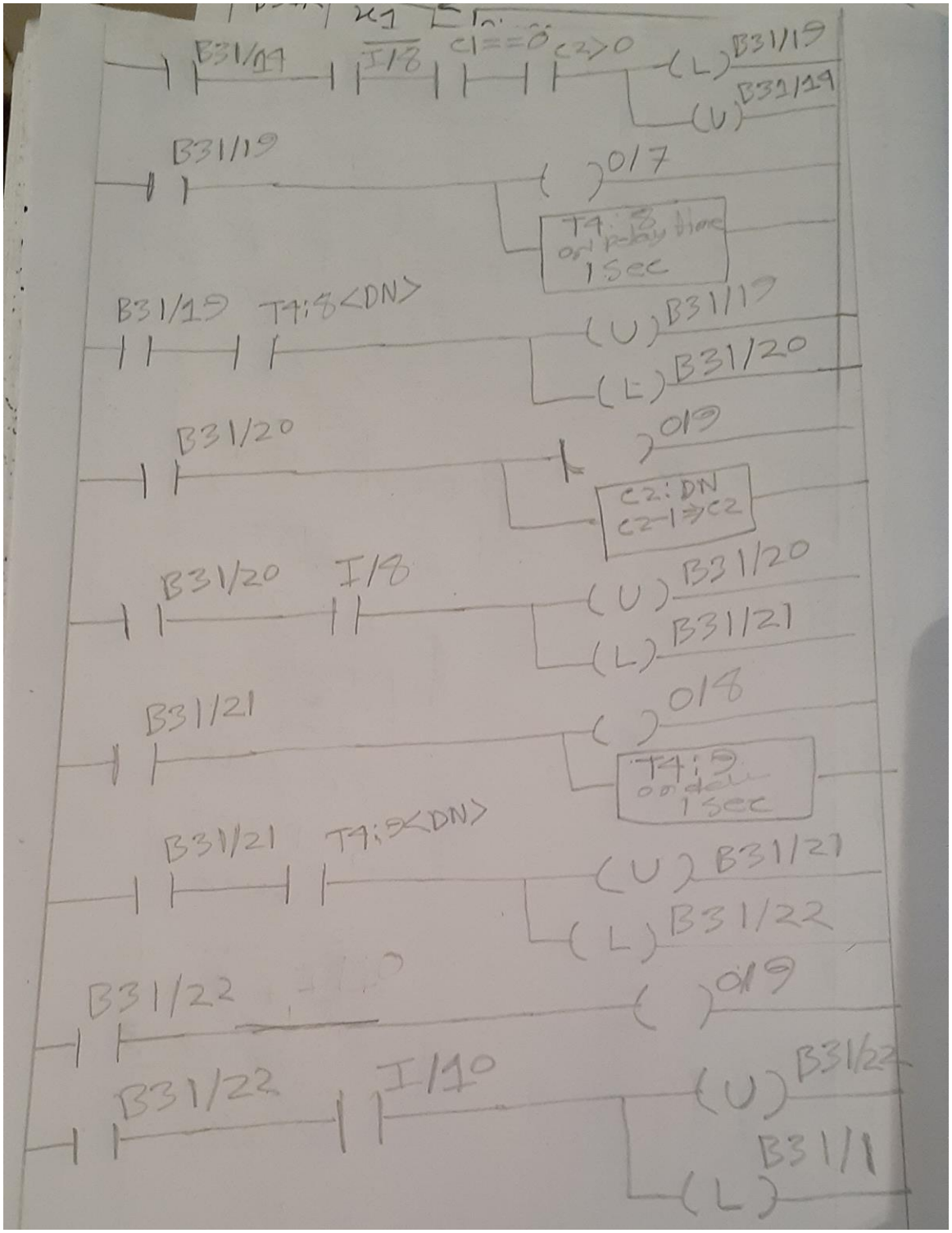
Input		Output	
I/1	OPT1	O/1	CONV1
I/2	HBDC	O/2	DISP1
I/3	HTDC	O/3	HMDRV
I/4	HGTH	O/4	SOL2
I/5	IND	O/5	SOL3
I/6	OPT2	O/6	CHUT1
I/7	OPT3	O/7	CHUT2
I/8	OPT4	O/8	DISP2
I/9	OPT5	O/9	CONV2
I/10	OPT6	O/10	SOL4


OSR
B3/1
Start
(L) B3/1
B3/1
(U)
(L) B3/2
B3/2
( ) O/1
( ) O/2
T9:7
B3/2
T9:1<DN>
(U) B3/2
(L) B3/3
B3/3
( ) O/1
B3/3
I/1
(U) B3/3
(L) B3/4
B3/4
( ) O/1
T9:3
1 sec
B3/4
T4:2<DN>
(U) B3/4
(L) B3/5
B3/5
( ) O/3
B3/5
I/2
(L) B3/6
B3/6
I/4
(U) B3/6
(L) B3/7


B3/7
O14
B3/5
I:2
(L) B3/8
(U) B3/5
T4:3
on delay
10sec
B3/8
I:3
T4:3<DN>
(U) B3/8
(L) B3/9
B3/9
O12
B3/7
B3/9
I:6
C1
I:5
(L) B3/10
B3/10
O14
T4:4
on delay
1sec
B3/10
T4:4<DN>
(U) B3/10
(L) B3/11
C1 UP
C1+1=C1
B3/11
C1==5
(U) B3/11
B3/7
B3/9
I:6
C2
I:5
B3/12
(L)
(U) B3/7
O15
B3/12
T4:5
on delay
1sec


B31/12
T4:5
(U) B31/12
(L) B31/13
C2 UP
C2+1 = C2
B31/13
C2=05
(U) B31/13
B31/19
(L)


B31/14
I:7
C1>0
(L) B31/15
B31/15
( ) O:6
T4:6
On Delay Time
1 sec
B31/15
T4:6 <DN>
(U) B31/15
(L) B31/16
B31/16
( ) O:9
C1 DN
C1 - 1 ⇒ C1
B31/16
I:7
B31/16
(U)
(L) B31/17
B31/17
( ) O:8
T4:7
On Delay Time
1 sec
B31/17
T4:7 <DN>
(U) B31/17
(L) B31/18
B31/18
( ) O:10
T4:8
On Delay Time
1 sec
B31/18
I:9
( ) O:9
(U)
B31/18



Explanation of Program

First thing first, there has been used One Shot Rising (OSR) which instruction permits a programmer to make a scenario where output energized for a single scan. Firstly, B3 1/1 has been latched to run the system then used start open contact for switching purpose when switch on then B3 1/1 will unlatch, and B3 1/2 will latch with energize the O/1 and O/2 to start conveyor and dispenser solenoid with T4:1 timer. When T4:1 done then unlatch B31/2 and latch B3 1/3 after that will energize O/1(conv1) again when it will I/1 then unlatch B3 1/3 and latch B3 ¼ and energize the O/1 again with T4:2 timer. Furthermore, T4:2 will complete the unlatch B3 ¼ and latch B3 1/5 then energize O/3. I/2 will check the thickness of the ring then letch B3 1/6 and check I/4 when I/4 active then unlatch B3 1/6 and latch B3 1/7. B3 1/7 will energize O//1(Conv1). B3 1/5 will check and I/2 also check then latch B3 1/8 and unlatch B3 1/5 with T4:3 timer. If there is I/3 active and T4: 3 done, then unlatch B3 1/8 and latch B3 1/9 then it will energize O/1.

In the sort area there will check B3 1/9 is not active and I/6 is active and C1 is empty and this is not I/5 then it will latch B3 1/10. B3 1/10 will energize O/4(Sol2) with a T4:4 timer to go the ring into the assembly area. When T4:4 timer is done the time then will unlatch B3 1/10 and latch b3 1/11 with C1 counter to count the ring. There is a maximum allows 5 rings, so, C1 will check to fulfill the condition when it will complete then unlatch B3 1/11. If I/5 is active, then will check some condition contacts no B3 1/9 and C2 is empty and I/6 is active then it will latch B3 1/12 and unlatch B1 1/7 besides will energize O/5(SOl3) with T4:5 timers. When T4:5 will be done then it will unlatch B3 1/12 and latch B3 1/13 with C2 counters to count the ring. There is maximum allows 5 rings, so C2 will check to fulfill the condition when it will complete then unlatch B3 1/13 and latch B3 1/14.

Next, In the assembly area B3 1/14 is active and I/7 is not active, C1>0 then latch B3 1/15 besides will energize O/6 with T4:6 timers. When T4:6 will be done then it will unlatch B3 1/15 and latch B3 1/16 besides will energize O/9 and C1 will count down –1 ring. At this moment, I/7 is active then unlatch B3 1/16 and latch B3 1/17 besides will energize O/8 with T4:7 timers. When T4:7 will be done then unlatch B3 1/17 and latch B3 1/18 besides that will energize O/10 and O/9 with T4: 8 timers. When I/9 is active then unlatch b3 1/18. Similarly, B3 1/14 is active and I/8 is not active, C1== 0, C2>0 then latch B3 1/19 and unlatch B3 1/14 besides will energize O/7 with T4:8 timers. When T4:8 will be done then it will unlatch B3 1/19 and latch B3 1/20 besides will energize O/9 and C2 will count down –1 ring. At this moment, I/8 is active then unlatch B3 1/20 and latch B3 1/21 besides will energize O/8 with T4:9 timers. When T4:9 will be done then unlatch B3 1/21 and latch B3 1/22 besides that will energize O/9. When I/10 is active then unlatch b3 1/22 and latch B3 1/1.

In this assignment has used so many ON delay timers to active actuator and flipper solenoid to release the ring on a conveyor belt and chute the ring to go right way by armbar. Furthermore, we have used so many flags used to recognize the next step of the program. Flags area usually contains a Boolean (true or false) value which is a coil, no contact, close contact, latching, unlatching, etc.

Testing

This project is going to imagine now written on the program and it is going to check now first time with the real system Technology will help to reduce human errors and reusable for different PLCs.

When testing would expect to complete some step and procedure properly:

1. In measurement, area would expect to stay a few seconds to measure the ring.
2. When two big rings come down must test the two bigger rings don't end to going down the chute area would expect to go straight through to the bucket.
3. To check the inductive sensor, identify the metal ring and would expect to go down the metal ring chute area.
4. In the sorting area sudden type of complete assembly goes down and expect to go in a certain direction.
5. To check the plastic ring going down the plastic chute and metal ring going down the metal chute.
6. If it goes plastic ring goes down the chute in sort area top conveyor would expect to go down the first chute when the chute fills up stop sending them down let them goes alone to bucket.
7. When the chute is full it wouldn't expect to go down and go straight through the bucket.
8. If there is make a sudden type of assemblies that do expect the certain ring to be dropped in an assembly area.
9. The ring in the assembly area doesn't put plastic or metal ring until the peg and conveyor run.
10. In the assembly area at first check, the plastic ring then chutes for assembly. If there is an empty plastic ring, then expect to activate the metal ring to the chute for assembly.
11. Metal type of assembly goes straight left side and would expect to plastic type of assembly goes right side in the collection area.

Explore all the combinations would come up with a various individual tests and those features earlier bug detection and avoid human errors could say the code is working correctly. If it wouldn't work properly then go back and modify the code to solve the problem.

Discussion

In this assignment, there are so many ways to solve this control problem by PLC which If human does the work manually will be difficult to identify and activate the device. So, PLC has done so much effect on this project going to share step by step:

1. In the measurement section will be difficult to identify an exact ring but few sensors can be able to do it and recognize exact ring to go in the manufacturing.
2. This is very difficult to identify which one is a plastic or metal ring, so it helps by inductive sensor easily identify the metal ring.
3. There have been used many timers to active the actuator which helps to solve the control problem.
4. There have been used counters to storage the ring in the assembly area if more than coming in the assembly area it goes straight way in a bin which solves the control problem.
5. In the assembly area it's difficult to release the ring on time but there has a procedure to release the ring on time delay by PLC.

6. To use PLC the production will increase and capable to do the fast work.
7. In the storage area PLC can help to separate the different types of products.
8. To use the conveyor belt and motor controlling capable to carry the product by PLC.
9. It can remove the unexpected rings those is now allowed for production.
10. PLC can reduce the error and work perfectly to follow a ladder diagram.

If we use, there to measure the width/diameter of a ring it will help to select the perfect weight product. We can identify the maximum or minimum acceptable width/diameter ring. For instance, if identified the ring width/diameter gauge maximum then reject the ring to a bucket by flipper solenoid. Finally, when we will see the width/diameter of the ring is ok then it will go to the sort area and complete the assembly product.

From my side, I don't there have any limitations or weaknesses in my solution everything will work perfectly as the expectation of manufacturing output. So, there will measure the ring then select the ring in the sort area and then release the ring in the assembly area as on time to complete the assembly product then separate the product dividedly.

Conclusion

The above study has helped to understand the control system, as well as programmable logic controllers, have used that most companies and factories. In addition to use in the assignment different functions and logic, will help in my future work. Moreover, the use of grafcet to ladder diagram and Petri net have been discussed for improving knowledge.

This exercise is like a real industrial automation project. So, this exercise will help to share in the job interview and get easily future work.

Reference:

1. **Overview of Industrial process automation**: Author: Sharma, K.L.S., Publisher: Elsevier Publication Date: 2017, Edition: Second Edition
2. **Programmable logic Controller** w.bolton, Fifth Edition, 2015
3. **Programmable Logic Controllers (4th ed.)**. Rabiee, M. (2017) Tinley Park, IL: Goodheart Wilcox.