EE 494 S01

Internship

FINAL SUMMARY REPORT

Banner Engineering. Internship

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INTRODUCTION

The primary objective was to collaborate with production line employees in Banner production facility and recognize production areas that need improvements. Five different problems were recognized; the first problem was that the assembly procedure of four different sensor families were not documented, second problem was over heating of potted devices, third problem was error in auto-polisher functioning, fourth problem was broken printed circuit board(PCB) fixture, and fifth was time wasted in manually changing corset in PCB tester. This report summarizes all five problems, and the solutions implemented to solve them.

BACKGROUND

The first problem that production line employees faced was lack of documentation on assembly procedure of S18U, VSx and T8x sensors. As a result, new hires had no documentation to look up to while assembling different components to build S18U, VSx or T8x sensors. Which resulted in increase in device failure due to errors in assembling these sensors.

The second problem was over heating of potted devices and human error involved in keeping track of heating time. All the potted devices were kept on a tray and placed in the heating oven by potting station employees and heating time was manually tracked by them. As a result, the devices were over heated sometimes, or time tracking error lead to delay in sending the potted device to testing station. Banner production facility is aiming for a three-day rule, they want to assemble, pot, test and ship the products in three days. Due to over heating and loosing track of heating time, there is a unnecessary delay caused in this process and sometimes products take more than three days to ship.

The third problem was error in auto-polisher functioning. The auto-polisher was rotating counterclockwise while polishing the sheets, which lead to the brushes getting tangled and polisher getting stuck. Due to auto-polisher getting stuck sheets were not getting cleaned and hence can’t be re-used. Due to this production plant had to buy new sheet to replace the dirty ones.

The fourth problem was a broken PCB fixture. This PCB fixture was used by the production line employees to lock the PCB in place so that they can solder components on the PCB board. However, once the PCB was pulled up then it would get stuck and there was no way for employees to bring it down and remove the PCB board. Also, due to displacement in the fixture’s position sometimes the PCBs would get damaged. The fixture getting stuck and PCBs getting damaged was causing time loss and was causing damage to the products.

The fifth problem was time loss in changing the cord set in PCB tester. The PCB tester was used to test two different kinds of circuit boards, and to test both circuit boards employees had to open the tester and manually switch the cord set. This led to loss of time while testing the PCBs.

PROCEDURE

The procedure was divided into five parts, part one was documenting the assembly procedures for S18U, VSx and T8x sensors, second part was debugging the auto-polisher circuit, third part was automating the oven at the potting station, fourth part was fixing the broken PCB fixture and fifth part was designing a solution so that employees don't have to manually switch the cables themselves in the PCB tester.

A. Documentation

Existing documents related to S18U, VSx and T8x were downloaded from the Banner enquiry database. All the documents for each family were then compared for mutually inclusive procedure steps. For the mutually exclusive steps, a build order for each sensor was requested. Further, the production line built the sensors and photo of each step was captured. Previous documents and new photos were used to document the complete assembly procedure of S18U, VSx and T8x sensors.

B. Oven Timer System

To avoid over heating of potted devices and human errors associated with keeping track of heating time, an oven timer system was designed to automate the process. A programmable logic controller (PLC) from CLICK, 68 24V-photo electric sensors from Banner engineering and a 24 V touch screen from CMORE was used to design a timer system that will automatically detect a tray in the oven and would prompt user to enter the desired heating time on the CMORE touch panel. Furthermore, the timer system was designed to indicate the status of the tray by using red, yellow and green lights. Additionally, it was also designed to display the time entered by the user and time left for the heating to finish.

Once the system was designed, code for each sensor was tested for its functionality by entering different time values and was verified using an external timer. Furthermore, all the needed parts were ordered, including enclosures, two 24 V power supply, CLICK PLC, 4 digital I/O extensions, terminal blocks, din rails, cables for sensor, extension cables, cord sets, brackets, black tape, jumper connectors and sealing grommets.

Once all the parts arrived, then the sensors were wired in the oven and the timer system was designed. Four enclosures were ordered for 6 ovens. Oven 1, oven 2, oven 3 and oven 4 were combined, and Oven 5 and oven 6 were combined. Two CMORE touch panels and two indicator lights were installed on both the combinations. Three enclosures were designed to contain PLC, power supply and Input/output (I/O) extension for oven 1, oven 2, oven 3 and oven 4 respectively. One enclosure was designed to contain PLC, power supply and I/O extension for oven 4 and oven 5.

Once the enclosures were deigned and sensors were mounted on the oven, the sensor output was then connected to PLC and CMORE touch panel. Later, each sensor was individually tested for all the functions.

C. Auto-polisher

The auto-polisher circuit schematic was downloaded from Banner enquiry database. Later, each component on the schematic was tested including motor controller, power supply, connections and relays. Once, the fault was found the faulty components were replaced.

D. PCB Fixture

The PCB fixture schematic was downloaded from Banner enquiry database. Once the schematic was downloaded, the fixature was analyzed for internal faults. Once, the fault analysis was done, the faulty components were replaced. Furthermore, to fix the fixture lock down, the PLC and the safety controller were reprogrammed.

Once the fixture was fixed, it was sent to the production line to use and employees were asked to provide feedback. Later, employees complained about PCB fixture getting locked after few hours of use. To fix this, each component was tested for error. Then the PLC and the safety controller were reprogrammed to fix all the error and red, green and blue (RGB) light was installed on the PCB fixture to indicate sensor faults, systems faults and lockdown. Fixture was then again sent to the production line to use and employees were asked to provide further feedback. Again, based on employee feedback, the RGB light was reprogrammed, so the light pattern is intuitive and easier to understand. Also fixture unlocking was made to event based, so that fixture would unlock itself with one touch and the user wouldn’t have to hold the sensor until the fixture physically drops itself. This was done so that in case of an injury the fixture can be unlocked quickly.

E. PCB tester

To avoid switching cables and switching connectors in the PCB tester, eight double-pole single-throw (DPST) 24 V relays from automation direct, a 24V power supply from automation direct, and a switch from Banner engineering were ordered, so that the switching process can be automated.

Once the parts arrived, the switch and a power inlet were mounted on the PCB tester. Later, two input cable and a 12-pin connector were connected to one side of the relays and one 12-pin output cable and a 4-pin connector were connected to the other side of the relays. The switch was then used to connect and disconnect the inputs and the outputs.

RESULTS / ANALYSIS

A. Documentation

Documentation of S18U, VSx and T8x was verified by production line employees and their respective supervisors. Production line employees for each sensor family were asked to provide feedback if in any case any steps are missing or are incorrect. However, no feedbacks were received.

B. Oven Timer System

Timer system was designed for six ovens. CLICK PLC, Photo-electric sensors, CMORE touch panel and an indicator light was installed on the ovens and were wired in enclosures, Fig.1.

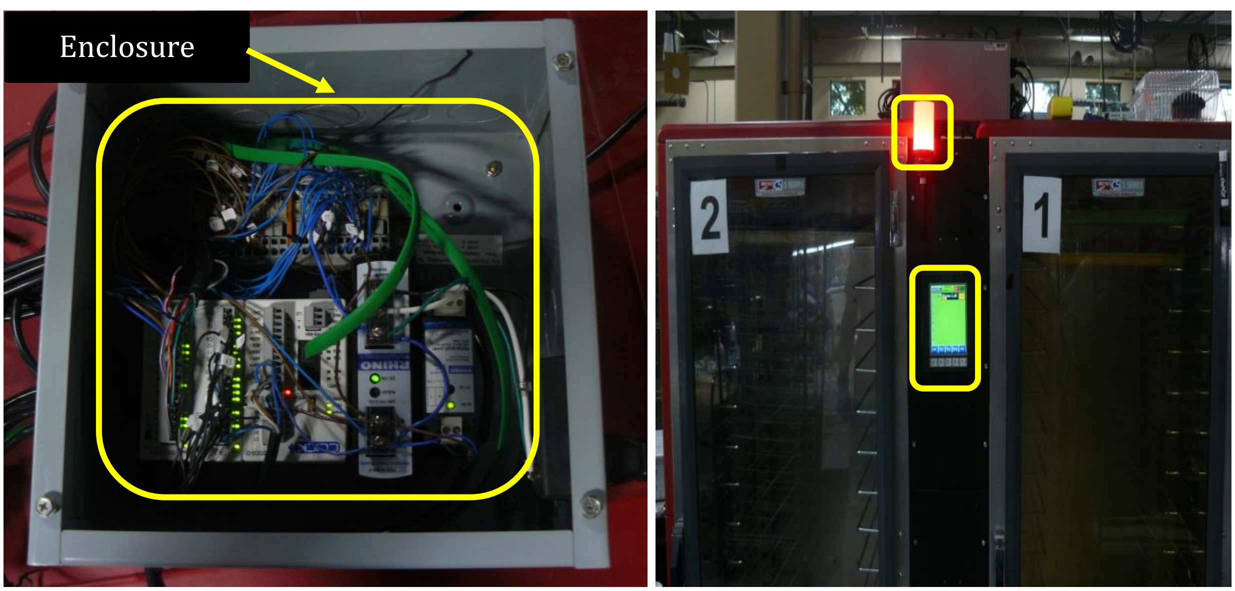


Figure 1: Enclosure and Ovens

Timer system would start with displaying the home screen on CMORE display. The home screen will give user the options to choose the oven he/she wants to use. Once the oven has been chosen and the tray has been inserted the CMORE display prompts user to either enter the desired heating time or shelf the tray, Fig.2.

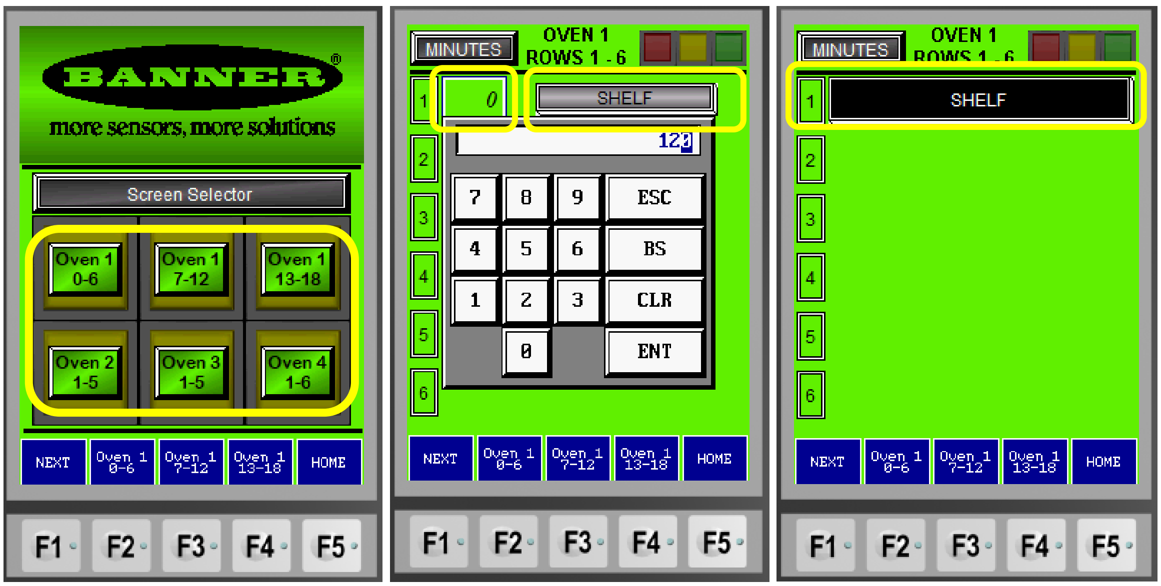


Figure 2: HOME screen

The timer indicates the status of the tray, by using red, yellow and green light. Red light will turn on once the time has been entered, yellow will turn on when 2 minutes is left, and green will turn on when the heating is done, Fig.3. Furthermore, it will display the user entered time, time left, will display done once the heating is done on the home screen and oven screen, Fig.5.

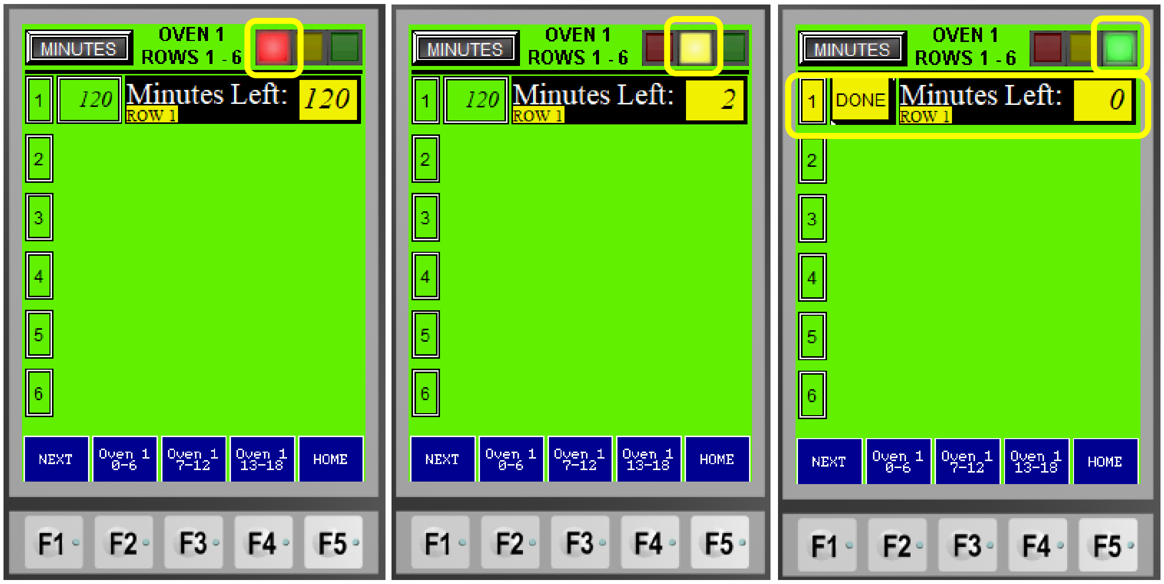


Figure 3: Timer started

The timer system also gives the user an opportunity to edit the entered time, or reset the timing by entering zero, Fig.4.

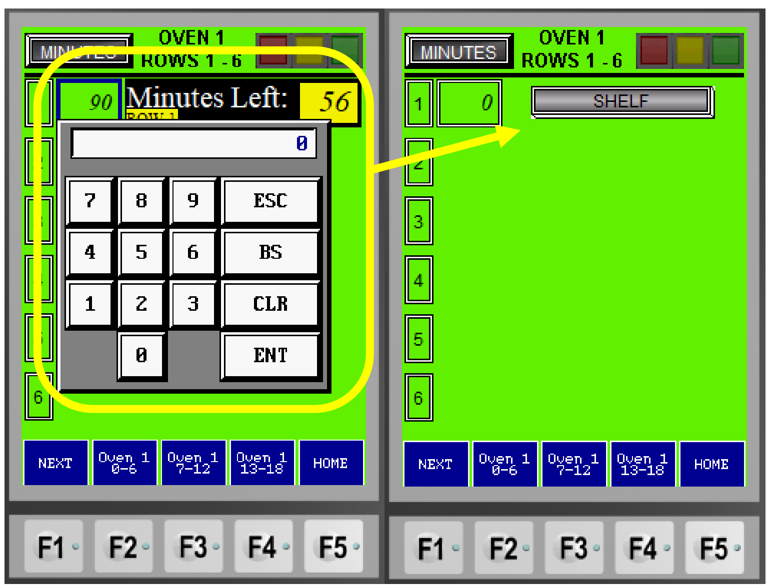


Figure 4: Reset

Furthermore, to navigate between screens or select a different oven, a user can use home screen or use blue function keys to change the screens. In case the touch screen breaks, the user can press function keys F1, F2, F3, F4 and F5 to navigate between screens, Fig.5.

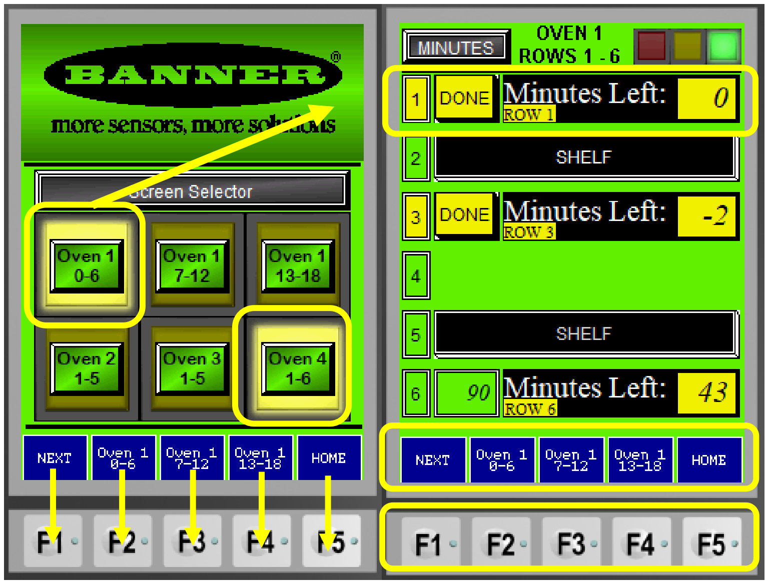


Figure 5: Navigation

C. Auto-polisher

Each component on the auto-polisher circuit was tested including the motor controller, power supply, connections and relays. The fault was found in one of the two relays; however, the two relays were solder on a PCB. Hence, the whole PCB was removed and was replaced by two discrete relays and resistors, Fig.5, which are easily replaceable if anything were to break in future.

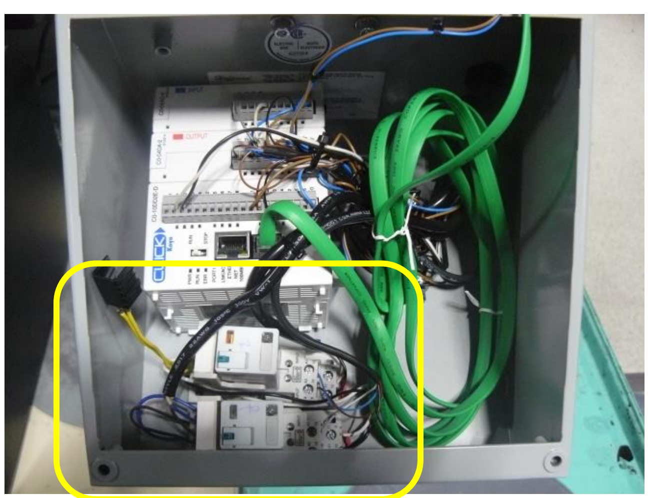


Figure 5: Relays and resistor

D. PCB Fixture

The PCB fixture was glitching i.e. sometimes it would pick up the input from the touch sensors and sometimes it would not. Hence, output of every component of the PCB fixture was probed and it was found that the touch sensor's output was connected to the safety controller and the safety controller was causing the glitch, Fig.6.

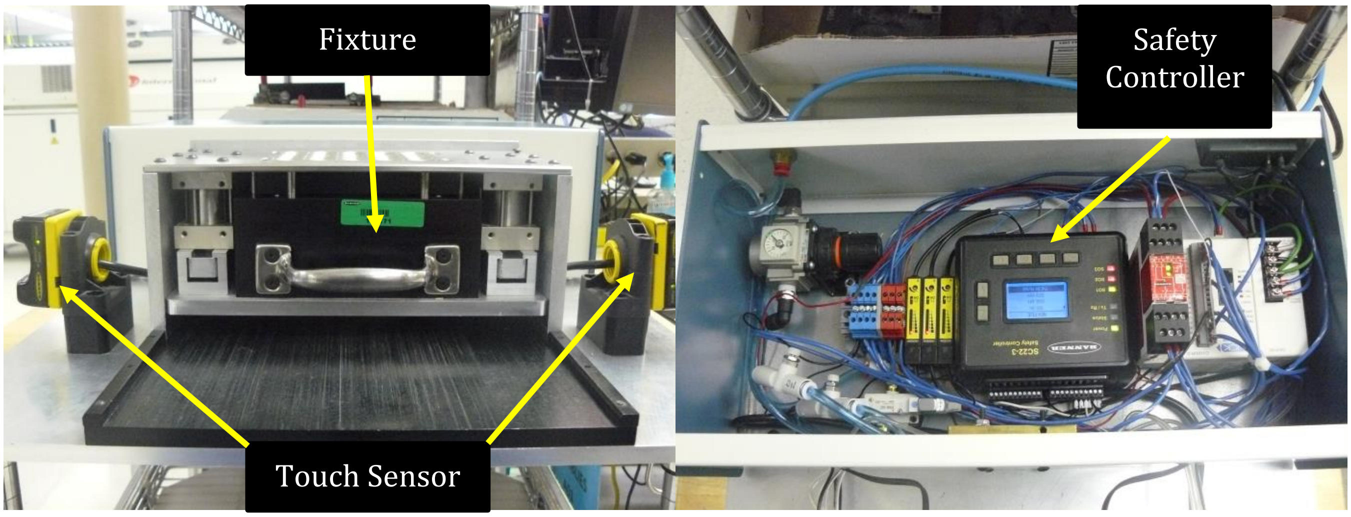


Figure 6: Fixture

The safety controller's code was analyzed, and it was discovered that the safety controller had 100 ms debounce time and 10 ms response time, hence, sometimes depending on when the sensor was touched, the PLC would either detect the sensor output as low or as high. This was caused because the instruction execution time of the PLC is less than the debounce time of the safety controller. Therefore, the sensor's output was removed from the safety controller and was connected directly to the PLC. The PLC was used to debounce the sensor's output instead the safety controller.

Furthermore, the fixture was using a solenoid to pump air in and out, which in response was moving the fixture up and down. As a result, the user had to touch the sensor until the fixture was completely pulled up or pulled down. If the sensor was let go in middle of the pulling operation, then the fixture would get stuck, with no way of fixing it other than opening the enclosure and disconnecting the solenoid from the power supply. Hence, the PLC was reprogrammed to make the system event dependent, i.e., the sensor must only be touched once, instead of touching it until the fixture has been pulled up.

Furthermore, the PLC was reprogrammed to have a hard reset and a soft reset. A soft reset lets the user touch the sensor for more than 5 seconds and will pull the fixture down if the fixture ever gets stuck. The hard reset lets the user pull the fixture down if the soft reset doesn't work (when the safety conditions are violated) by turning the power off and back on.

The safety controller was also reprogrammed to analyze the sensor's output and if at any time the sensor's output's frequency increases more than 10 Hz or if phase difference between both the finger while touching the sensor is more than 10ms, then the system will be locked.

After further testing it was also discovered that the fixture gets displaced from its position by a fraction of an inch, Fig.7.

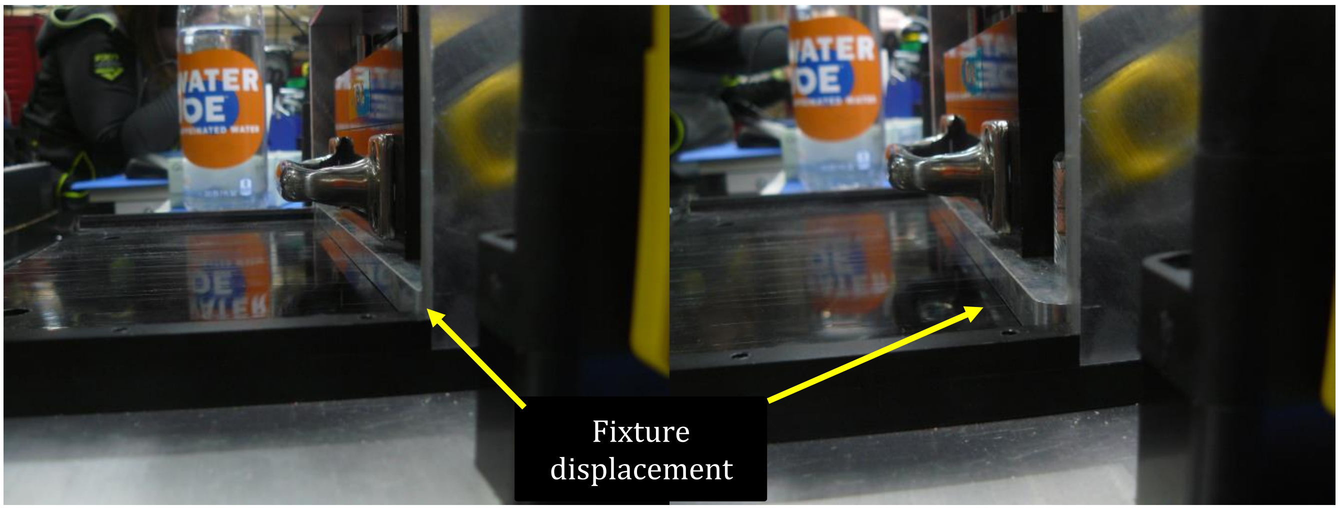


Figure 7: Fixture displacement

This happens after the fixture is used for few cycles. This displacement in fixtures position changes the distance between the rear sensors and the fixture, Fig.8.

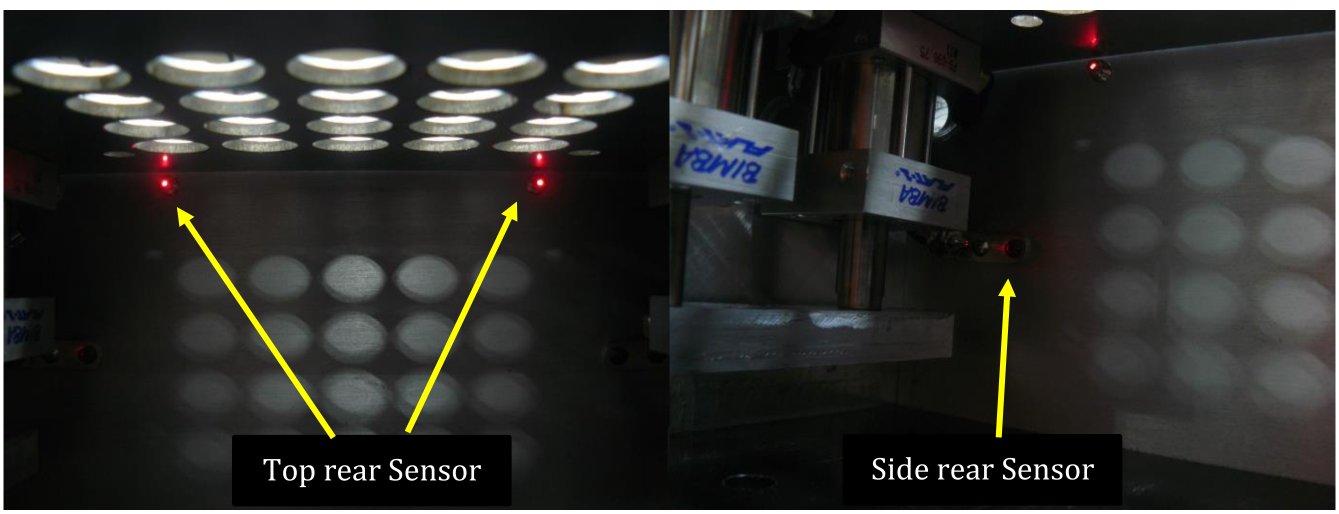


Figure 8: Top and side rear sensors

The sensors are calibrated for fixed gain/distance ratio. Since, the fiber-optic sensors are very sensitive to the distance, Fig.9, hence with the slightest increase in distance, the gain also must increase. And in this case, if the fixture is pulled up then this causes sensor fault, and the safety controller locks the fixture.

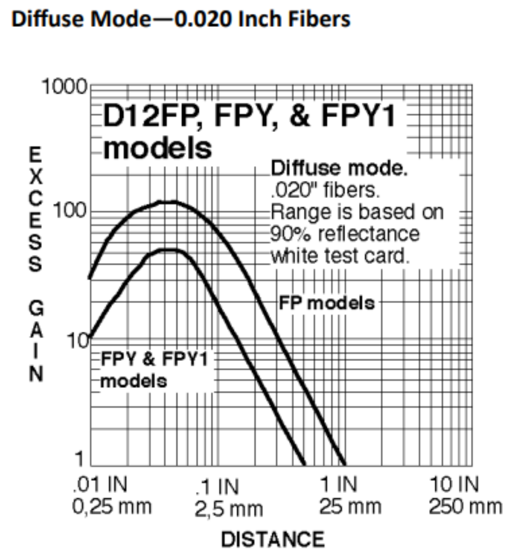


Figure 9: Distance vs gain

The fixture also displaces itself when it's pulled up, and this also causes sensor fault. This happens due to structural constraints of the fixture. The fixture's housing is not tightly screwed in, this is done to create a smooth pulling up and down operation. Furthermore, production line employees are also not touching the sensor long enough, safety controller sees this as the violation of safety condition and locks the fixture. To fix this, safety controller was reprogrammed to monitor and send sensor status, system status and lockdown status to the PLC. And an RGB light was used to indicate all these statuses. Red light will indicate fixture lockdown, blinking red light will indicate rear sensor fault, green light indicates when the fixture is safe to use, and white light would indicate the fixture displacement.

Once powered up, the system will reset itself and white light will stay on until the fixture is pushed all the way in. Once fixture is in right position, then it will check for the sensor faults, if fault detected then the fixture will be locked. If no fault detected, then the fixture is ready to use. To pull the fixture up user must hold the touch sensors until green light turns on. Green light is programmed to turn on after 390ms, this time is enough for fixture to go up and settle, in this way all safety conditions are met and debounce time is also not violated. To bring the fixture down, user can touch the sensors and fixture will come down. In pulling down operation user does not have to wait for the green light. This was done so that in case of an injury the fixture can be unlocked quickly.

However, if the user does not hold the sensor until the green light goes on then the fixture will get locked and can only be unlocked using hard or soft reset, Fig 10.

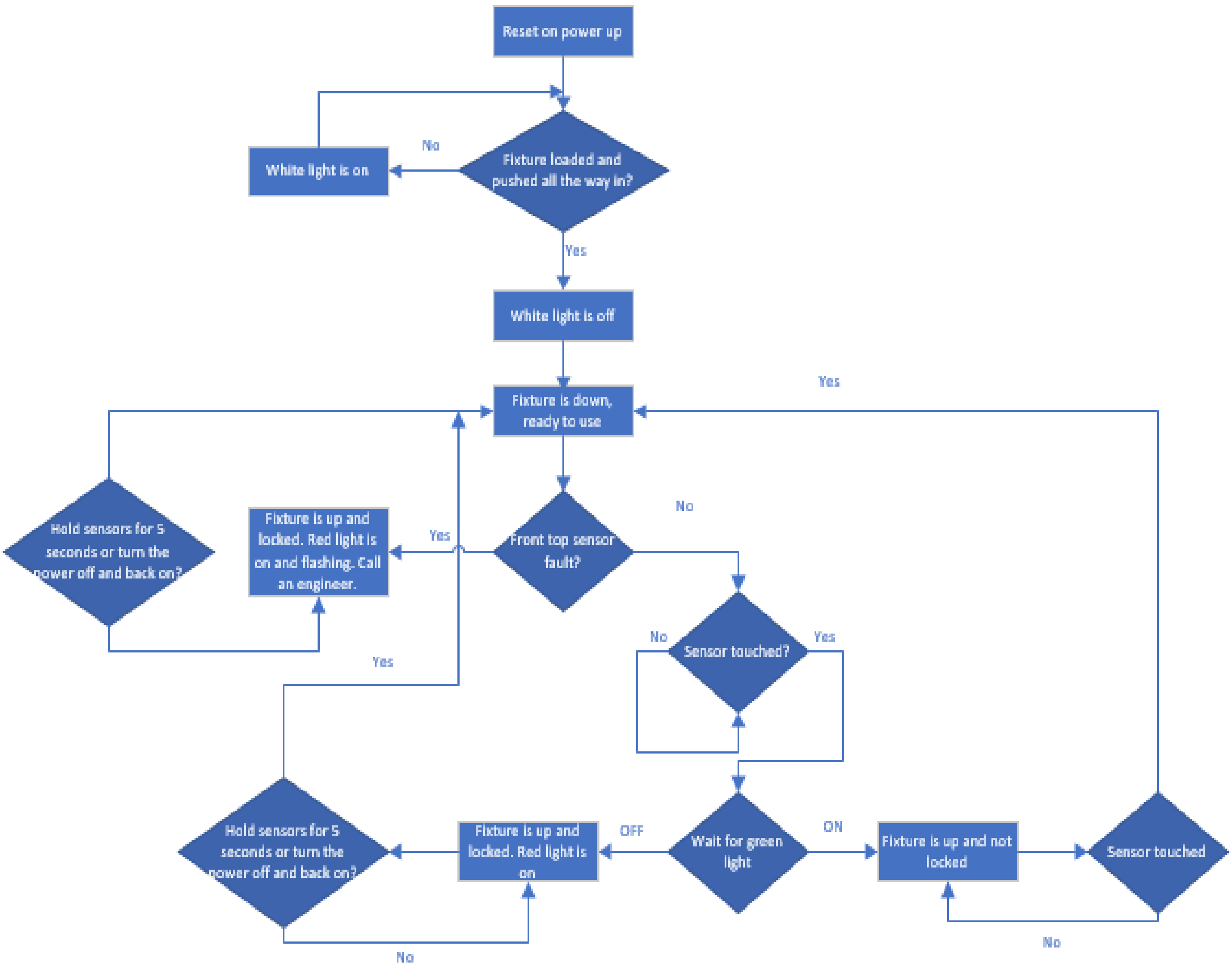


Figure 10: Fixture's operation

E. PCB tester

To avoid switching cables and connectors in the PCB tester, Fig.11, eight DPST 24 V relays from automation direct, a 24V power supply from automation direct and a switch from Banner engineering was used to automate the switching process.

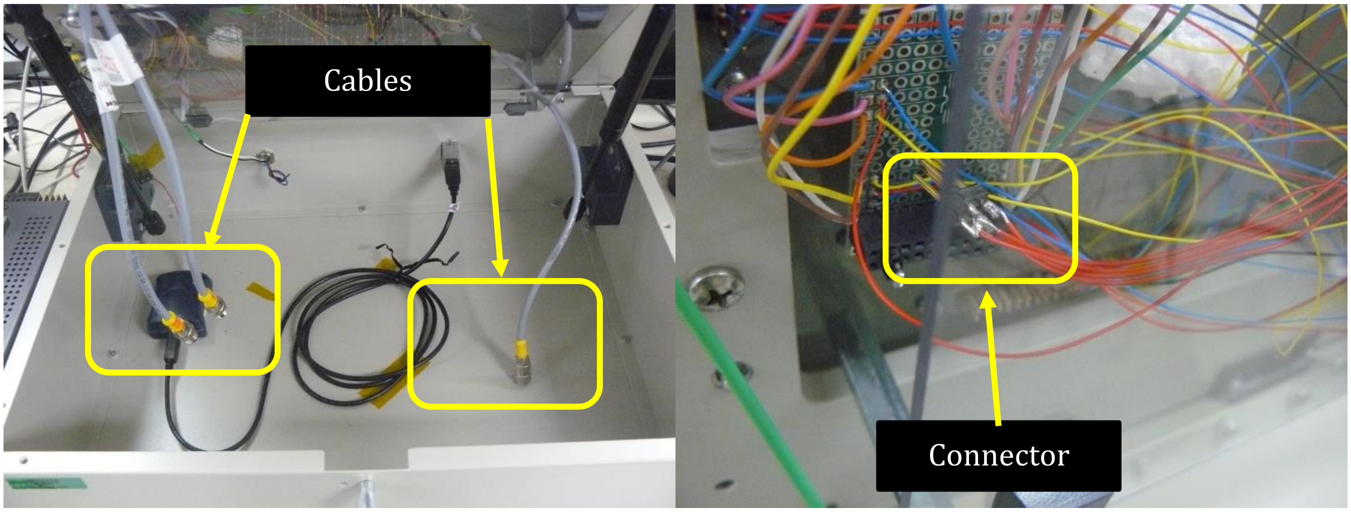


Figure 11: Two input, one output cable and 4 pin a connector inside the PCB tester

Six relays are used to switch between 2-relay PCB'S cable and 8-I/O PCB's cable. Two relays are used to connect and disconnect 4-pin connector, Fig.12. Since 2-relay PCB is tested the most, hence, 2-relay cable is the default connection. Once, the switch is flipped the relays will be powered and the output will be connected to the 8-I/O cable and 4-pin connector will also be connected, Fig.12.

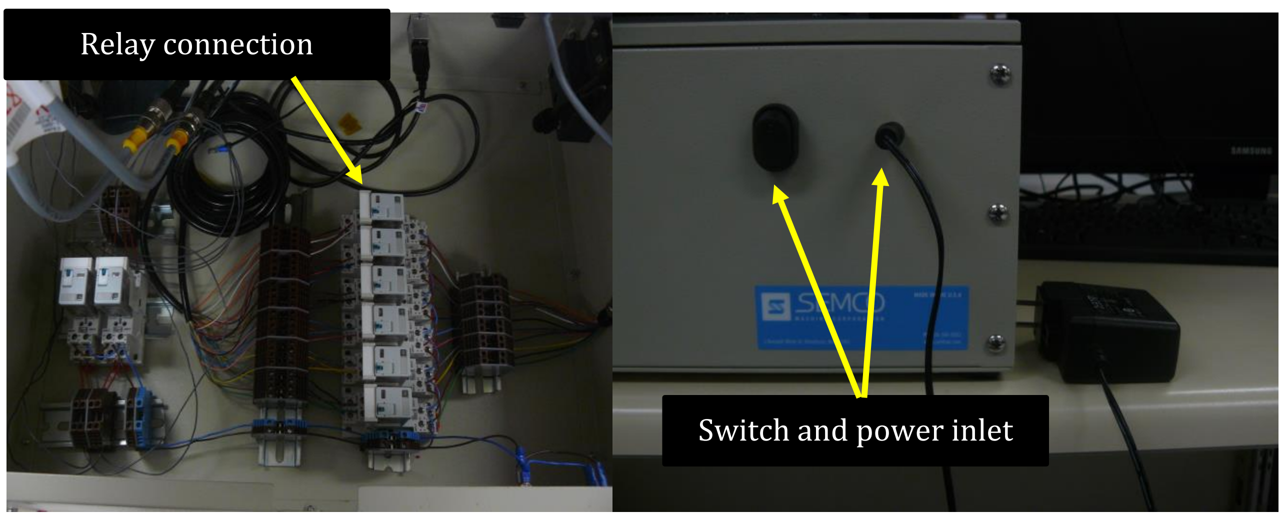


Figure 12: Relays wired, and switch installed

CONCLUSION

Documentation of the sensors are approved and uploaded. New hires who are using this documentation haven't complained about the documentation.

The over timer system has been installed on all six ovens and is tested for its functionality. With the timer system, the potting station are more efficient in keeping track of time and are not overheating the devices. Hence, Banner can now ship out more products on time, since the heating delay has been removed.

The Auto-polisher circuit has been tested and the components have been replaced. Now, the same sheet can be re-polished and re-used, and banner wouldn't have to buy new ones. Furthermore, if the relays break again then they are easily replaceable, since the PCB has been removed.

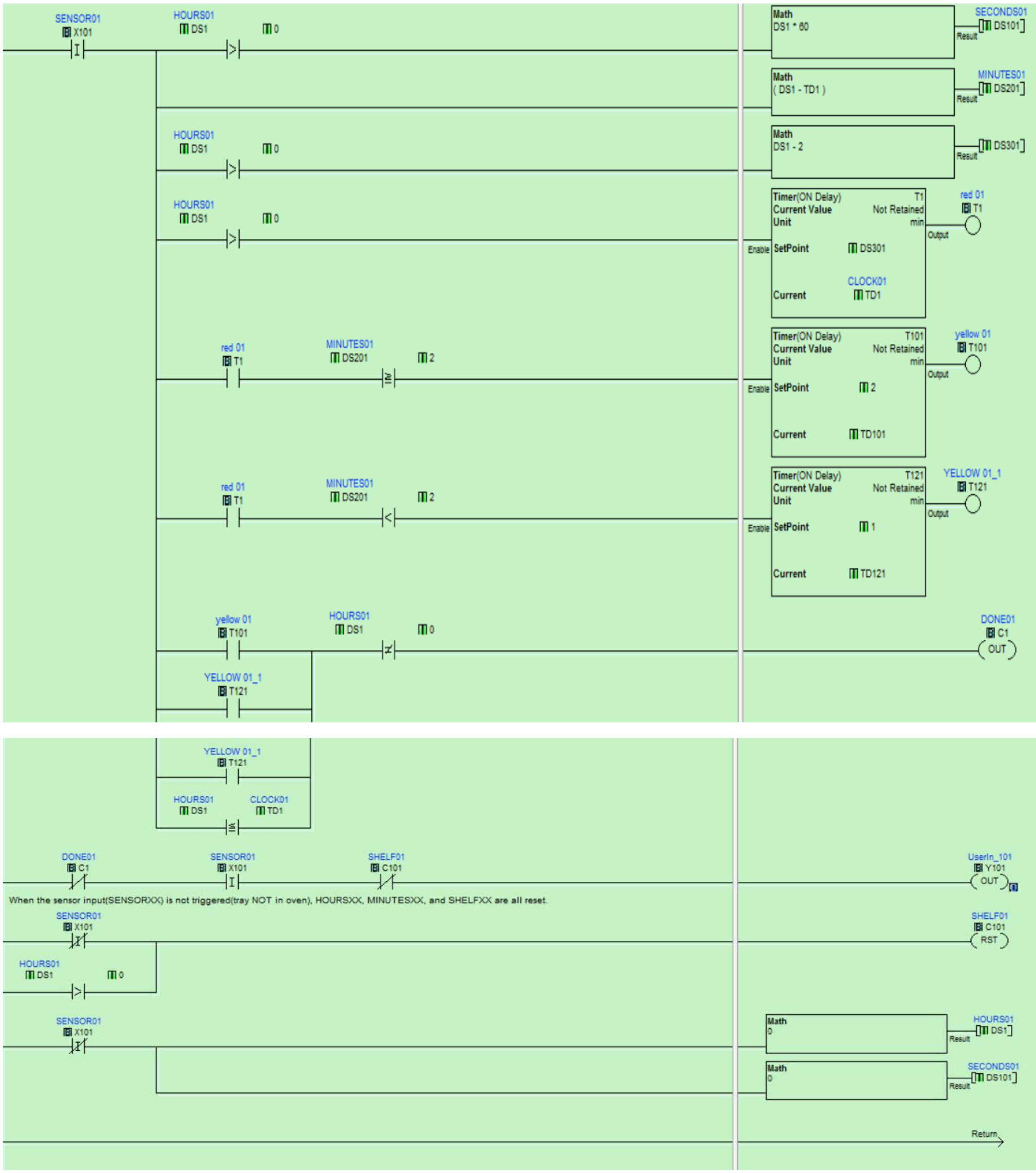
The PCB fixture has also been fixed and tested. With the addition of RGB lights, now users get constant feedback about fixture's status. White light indicates the if the fixture is in right position or not and green light indicates when the fixture is safe to use. With these two lights users will know the correct modes of operation and will not get the fixture stuck anymore. And if the fixture locks, then the red light will indicate that, and the user can always unlock it using hard and soft reset.

The relay circuit for PCB tester is working. However, there is an error in the testing software, hence the PCB's can't be tested anymore. Senior engineer is working on it.

Furthermore, as per the contract I have worked with PLCs, CMORE display and Banner sensors in oven timer project. And have used PCLs, Banner GUI, oscilloscopes, multimeters and power supplies in the fixture and PCB tester project.

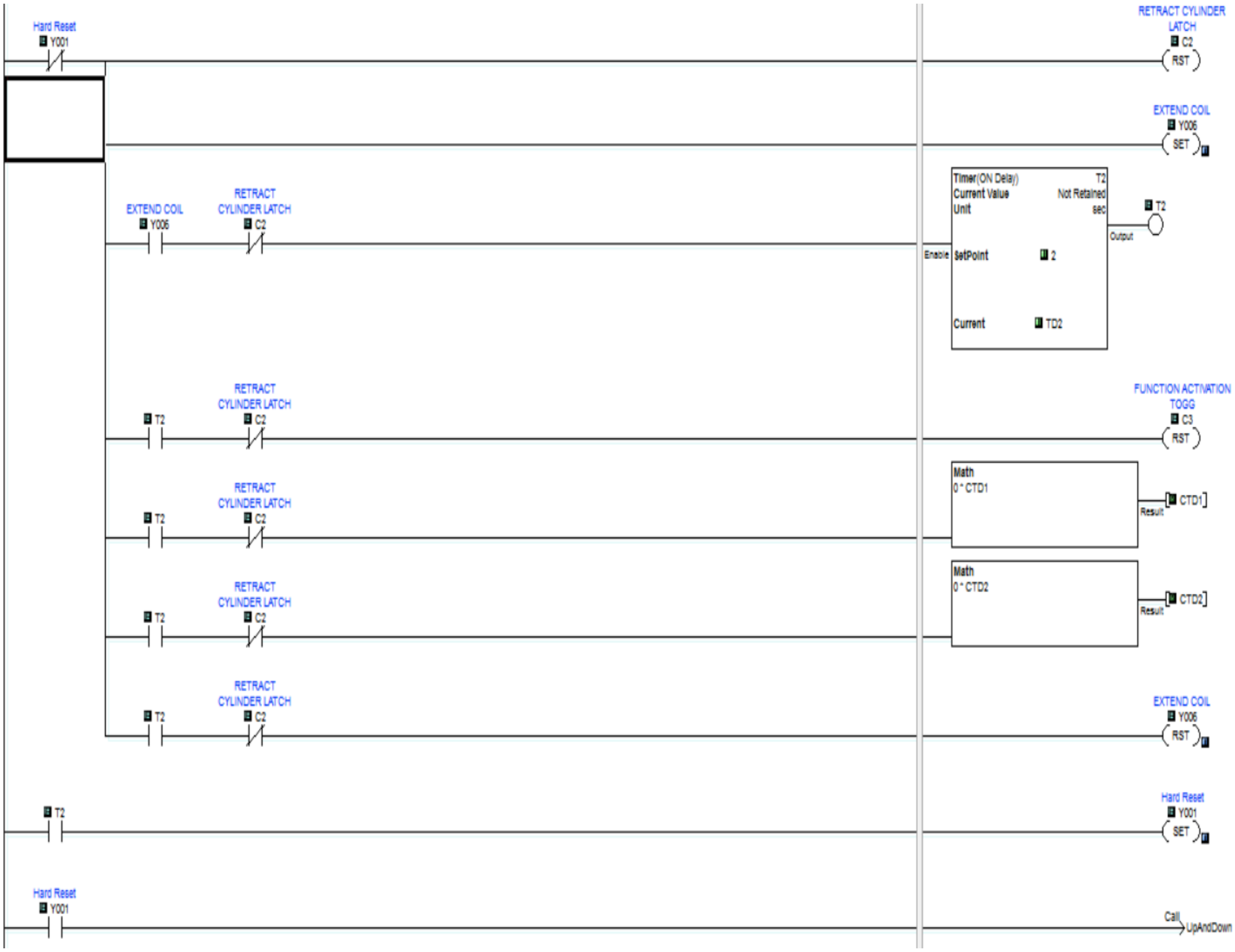
Appendix

Oven timer PLC code for sensor 1

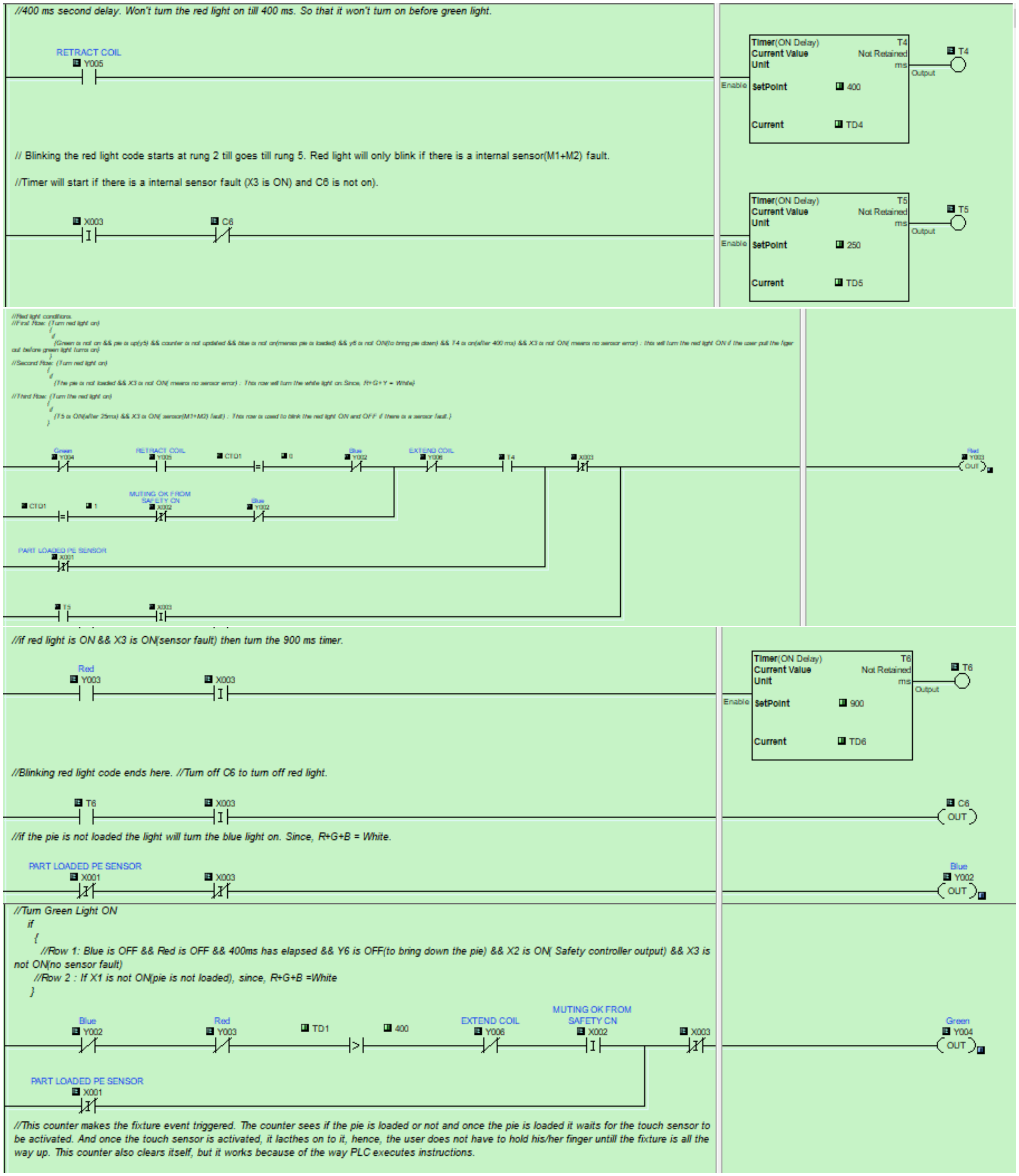


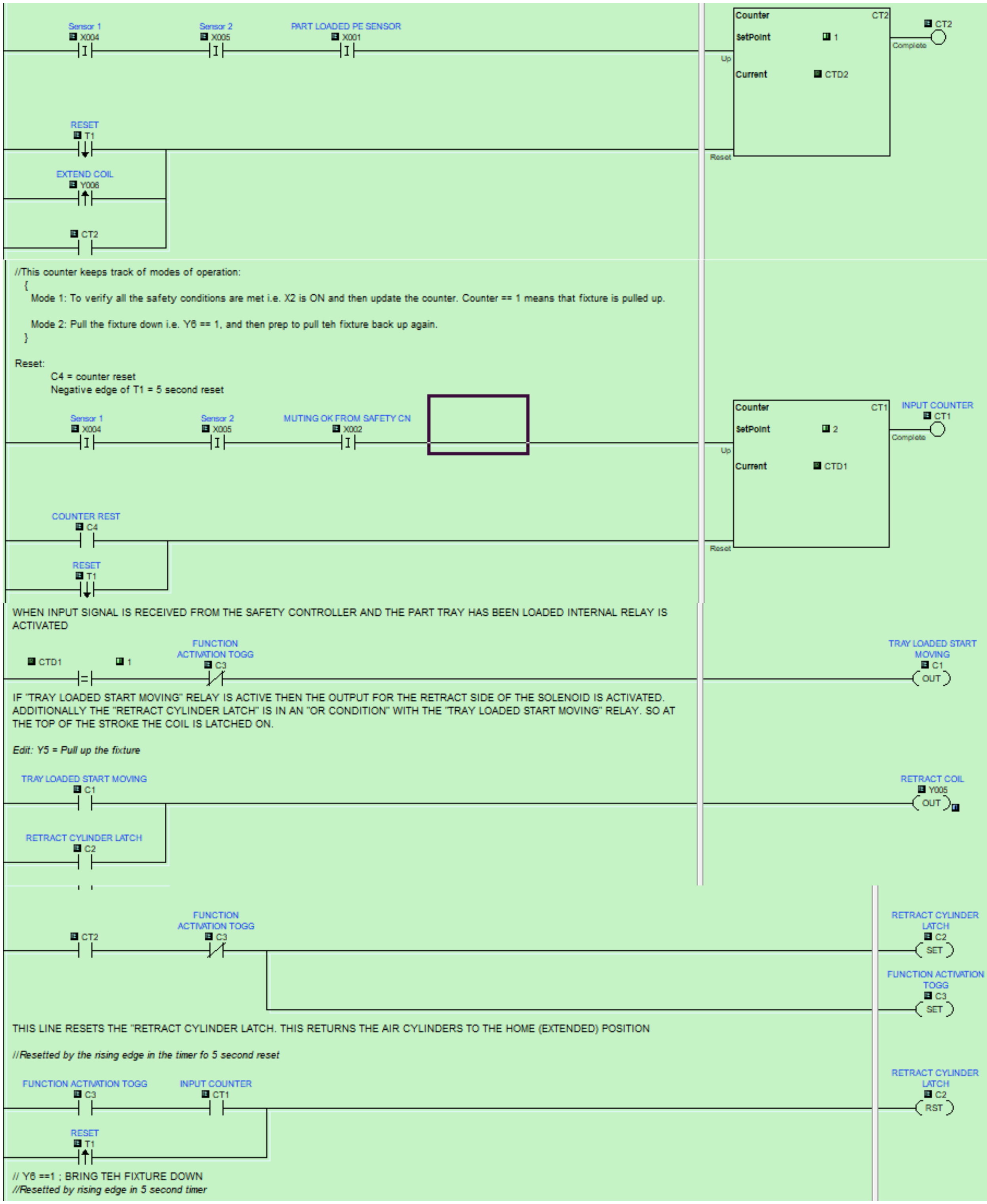
Fixture PLC code

Main:

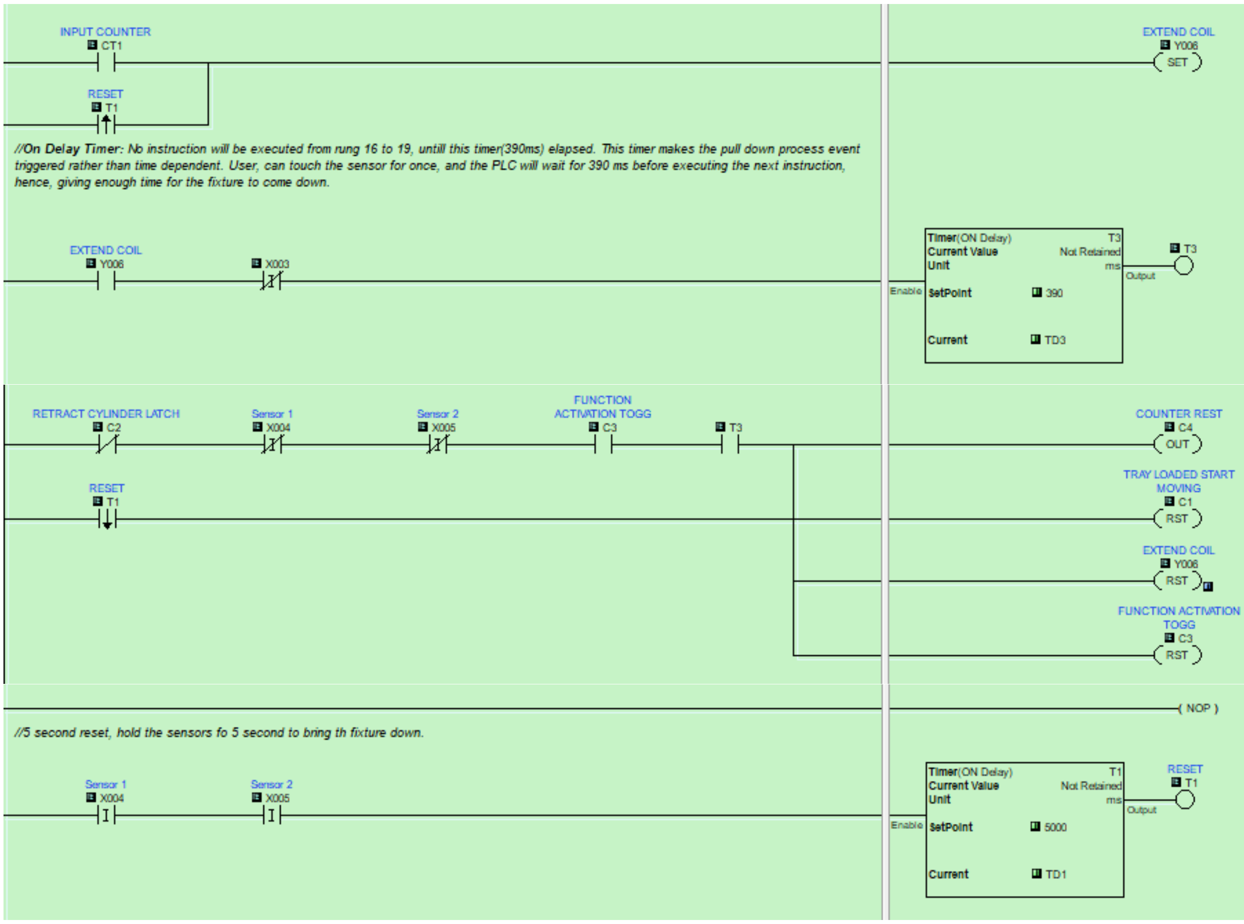


Subroutine:


//400 ms second delay. Won't turn the red light on till 400 ms. So that it won't turn on before green light.
RETRACT COIL
Y005
Timer(ON Delay)
T4
Current Value
Not Retained
Unit
ms
Output
T4
Enable
SetPoint
400
Current
TD4
// Blinking the red light code starts at rung 2 till goes till rung 5. Red light will only blink if there is a internal sensor(M1+M2) fault.
//Timer will start if there is a internal sensor fault (X3 is ON) and C6 is not on).
X003
C6
Timer(ON Delay)
T5
Current Value
Not Retained
Unit
ms
Output
T5
Enable
SetPoint
250
Current
TD5
Green
Y004
RETRACT COIL
Y005
CTD1
0
Blue
Y002
EXTEND COIL
Y006
T4
X003
Red
Y003
OUT
CTD1
1
MUTING OK FROM SAFETY CN
X002
Blue
Y002
PART LOADED PE SENSOR
X001
T5
X003
//if red light is ON && X3 is ON(sensor fault) then turn the 900 ms timer.
Red
Y003
X003
Timer(ON Delay)
T6
Current Value
Not Retained
Unit
ms
Output
T6
Enable
SetPoint
900
Current
TD6
//Blinking red light code ends here. //Turn off C6 to turn off red light.
T6
X003
C6
OUT
//if the pie is not loaded the light will turn the blue light on. Since, R+G+B = White.
PART LOADED PE SENSOR
X001
X003
Blue
Y002
OUT
//Turn Green Light ON
if
{
//Row 1: Blue is OFF && Red is OFF && 400ms has elapsed && Y6 is OFF(to bring down the pie) && X2 is ON(Safety controller output) && X3 is not ON(no sensor fault)
//Row 2 : If X1 is not ON(pie is not loaded), since, R+G+B =White
}
Blue
Y002
Red
Y003
TD1
400
EXTEND COIL
Y006
MUTING OK FROM SAFETY CN
X002
X003
Green
Y004
OUT
PART LOADED PE SENSOR
X001
//This counter makes the fixture event triggered. The counter sees if the pie is loaded or not and once the pie is loaded it waits for the touch sensor to be activated. And once the touch sensor is activated, it lacthes on to it, hence, the user does not have to hold his/her finger untill the fixture is all the way up. This counter also clears itself, but it works because of the way PLC executes instructions.



Sensor 1
X004
Sensor 2
X005
PART LOADED PE SENSOR
X001
RESET
T1
EXTEND COIL
Y006
CT2
Counter
CT2
SetPoint
1
Current
CTD2
Up
Reset
Complete
CT2
//This counter keeps track of modes of operation:
{
Mode 1: To verify all the safety conditions are met i.e. X2 is ON and then update the counter. Counter == 1 means that fixture is pulled up.
Mode 2: Pull the fixture down i.e. Y6 == 1, and then prep to pull teh fixture back up again.
}
Reset:
C4 = counter reset
Negative edge of T1 = 5 second reset
Sensor 1
X004
Sensor 2
X005
MUTING OK FROM SAFETY CN
X002
COUNTER REST
C4
RESET
T1
Counter
CT1
SetPoint
2
Current
CTD1
Up
Reset
Complete
INPUT COUNTER
CT1
WHEN INPUT SIGNAL IS RECEIVED FROM THE SAFETY CONTROLLER AND THE PART TRAY HAS BEEN LOADED INTERNAL RELAY IS ACTIVATED
CTD1
1
FUNCTION ACTIVATION TOGG
C3
TRAY LOADED START MOVING
C1
OUT
IF "TRAY LOADED START MOVING" RELAY IS ACTIVE THEN THE OUTPUT FOR THE RETRACT SIDE OF THE SOLENOID IS ACTIVATED. ADDITIONALLY THE "RETRACT CYLINDER LATCH" IS IN AN "OR CONDITION" WITH THE "TRAY LOADED START MOVING" RELAY. SO AT THE TOP OF THE STROKE THE COIL IS LATCHED ON.
Edit: Y5 = Pull up the fixture
TRAY LOADED START MOVING
C1
RETRACT CYLINDER LATCH
C2
RETRACT COIL
Y005
OUT
CT2
FUNCTION ACTIVATION TOGG
C3
RETRACT CYLINDER LATCH
C2
SET
FUNCTION ACTIVATION TOGG
C3
SET
THIS LINE RESETS THE "RETRACT CYLINDER LATCH. THIS RETURNS THE AIR CYLINDERS TO THE HOME (EXTENDED) POSITION
//Resetted by the rising edge in the timer fo 5 second reset
FUNCTION ACTIVATION TOGG
C3
INPUT COUNTER
CT1
RESET
T1
RETRACT CYLINDER LATCH
C2
RST
// Y6 ==1 ; BRING TEH FIXTURE DOWN
//Resetted by rising edge in 5 second timer


INPUT COUNTER
CT1
RESET
T1
EXTEND COIL
Y006
SET
//On Delay Timer: No instruction will be executed from rung 16 to 19, untill this timer(390ms) elapsed. This timer makes the pull down process event triggered rather than time dependent. User, can touch the sensor for once, and the PLC will wait for 390 ms before executing the next instruction, hence, giving enough time for the fixture to come down.
EXTEND COIL
Y006
X003
Timer(ON Delay)
T3
Current Value
Not Retained
Unit
ms
Enable
SetPoint
390
Current
TD3
Output
T3
RETRACT CYLINDER LATCH
C2
Sensor 1
X004
Sensor 2
X005
FUNCTION ACTIVATION TOGG
C3
T3
RESET
T1
COUNTER REST
C4
OUT
TRAY LOADED START MOVING
C1
RST
EXTEND COIL
Y006
RST
FUNCTION ACTIVATION TOGG
C3
RST
NOP
//5 second reset, hold the sensors fo 5 second to bring th fixture down.
Sensor 1
X004
Sensor 2
X005
Timer(ON Delay)
T1
Current Value
Not Retained
Unit
ms
Enable
SetPoint
5000
Current
TD1
Output
RESET
T1