Automated Sandblaster

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- Executive Summary
- Problem Statement and Solution
- Procedural and Technical Flow Diagrams
- Software Design
- Hardware Design
- Circuit Simulations
- Prototype Testing
- Project Illustrations
- Conclusion

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Executive Summary

- Manual Sandblasting was inefficient and a health hazard
- An Automated Sandblaster would provide the employee with more time to operate the lasers
- Allows the company to expand its business potential due to the labor time redirected toward more laser operations
- New Automated System has a better exhaust system and the operator can push the display button and proceed to other tasks
- Extra company revenue in the form of labor saved and business expansion

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Problem Statement and Solution

- The employee was forced to waste a significant amount of time manually sandblasting the burnt on residue from the parts
- Manual Sandblaster was restricting business potential
- Operator was inhaling harmful glass bead particles

Solution

- To build an Automated Sandblaster that will allow the operator to have a machine sandblast the parts while they continue production labor
- Improve exhaust system and allow the operator to push HMI button and walk away from the machine.

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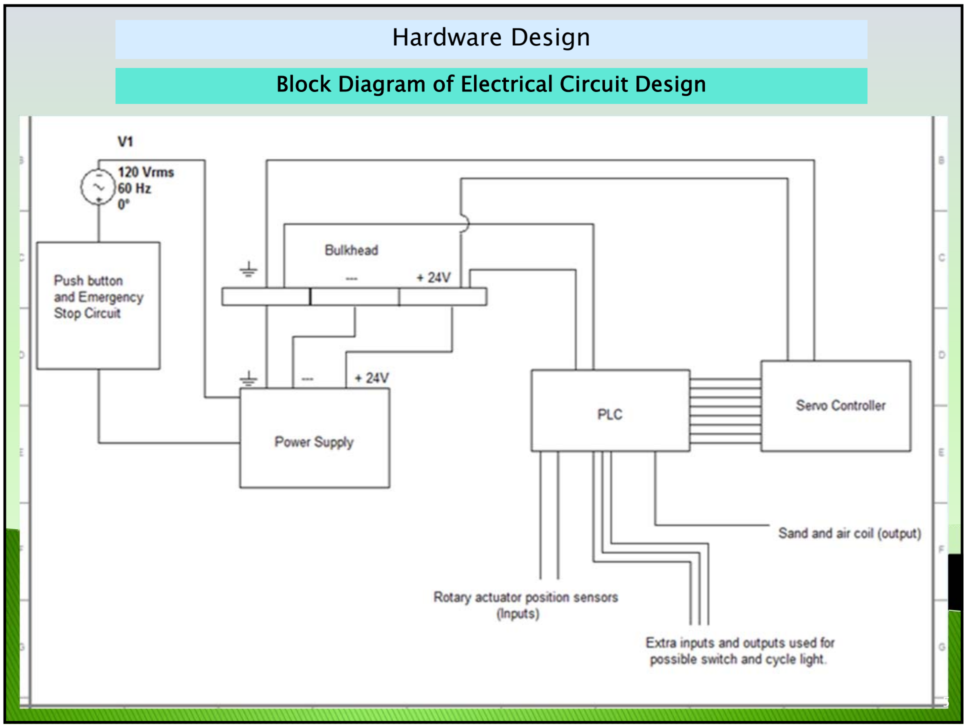
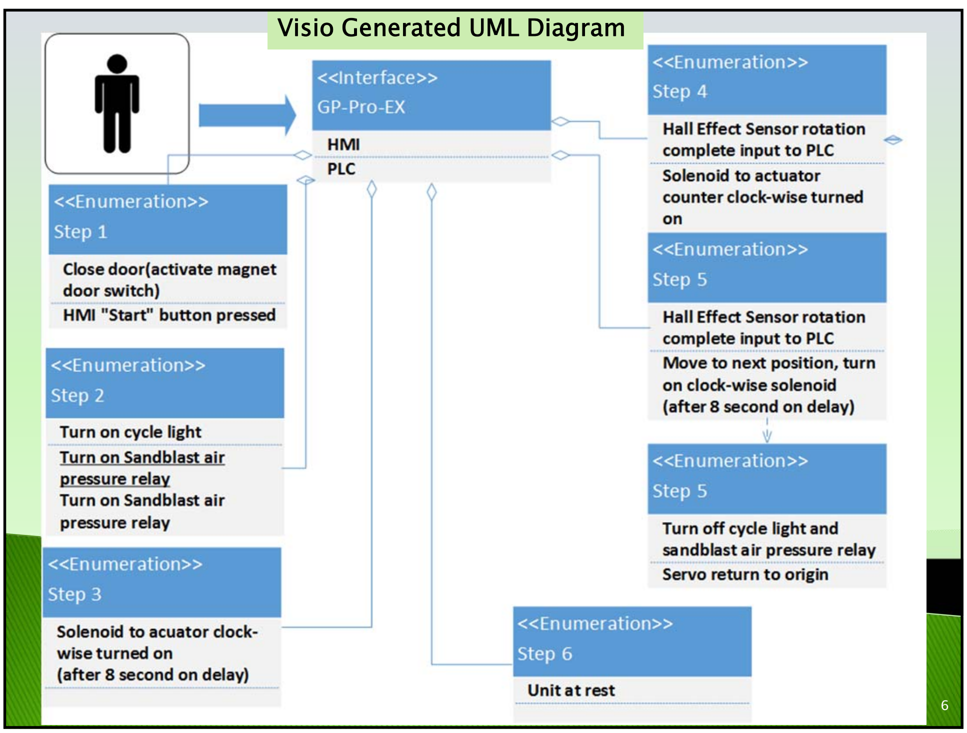
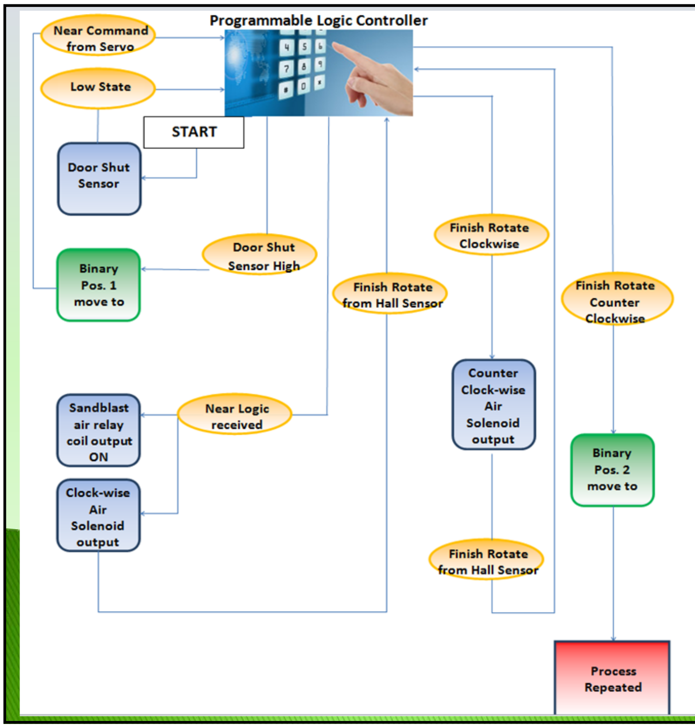

Hardware Design
Block Diagram of Electrical Circuit Design
V1
120 Vrms
60 Hz
0°
Push button and Emergency Stop Circuit
Bulkhead

+ 24V

+ 24V
Power Supply
PLC
Servo Controller
Sand and air coil (output)
Rotary actuator position sensors (Inputs)
Extra inputs and outputs used for possible switch and cycle light.


Visio Generated UML Diagram
<<Interface>>
GP-Pro-EX
HMI
PLC
<<Enumeration>>
Step 1
Close door(activate magnet door switch)
HMI "Start" button pressed
<<Enumeration>>
Step 2
Turn on cycle light
Turn on Sandblast air pressure relay
Turn on Sandblast air pressure relay
<<Enumeration>>
Step 3
Solenoid to acuator clock-wise turned on
(after 8 second on delay)
<<Enumeration>>
Step 4
Hall Effect Sensor rotation complete input to PLC
Solenoid to actuator counter clock-wise turned on
<<Enumeration>>
Step 5
Hall Effect Sensor rotation complete input to PLC
Move to next position, turn on clock-wise solenoid
(after 8 second on delay)
<<Enumeration>>
Step 5
Turn off cycle light and sandblast air pressure relay
Servo return to origin
<<Enumeration>>
Step 6
Unit at rest
6



Technical Flow Process for PLC logic.

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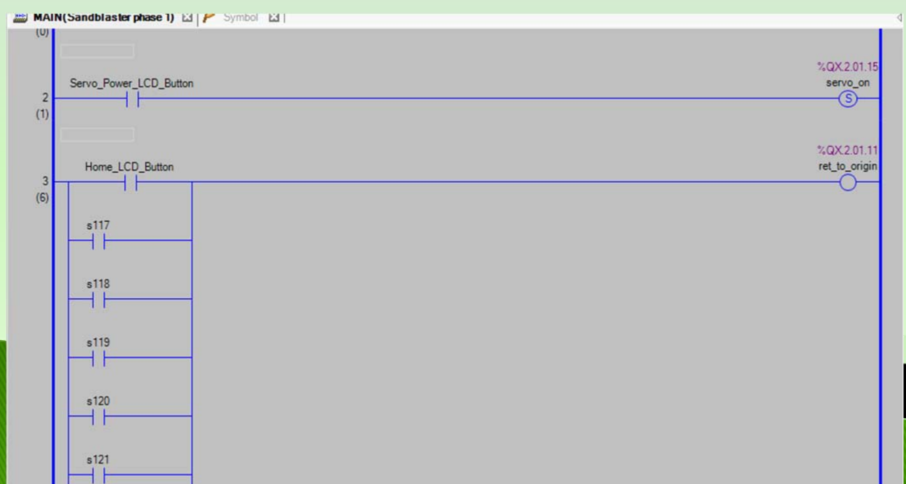
Software Design: Key portions of the ladder logic program

Allocations of Servo power LCD display button to real world output and return-to-origin LCD display button to real world output



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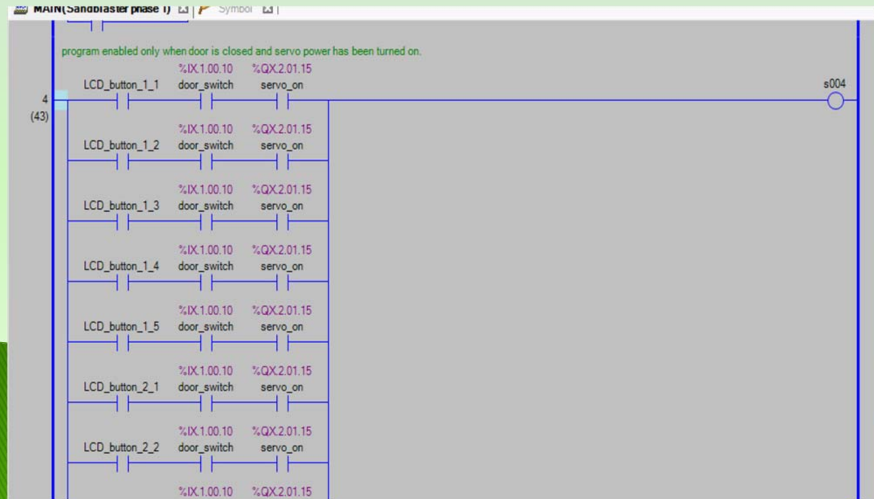
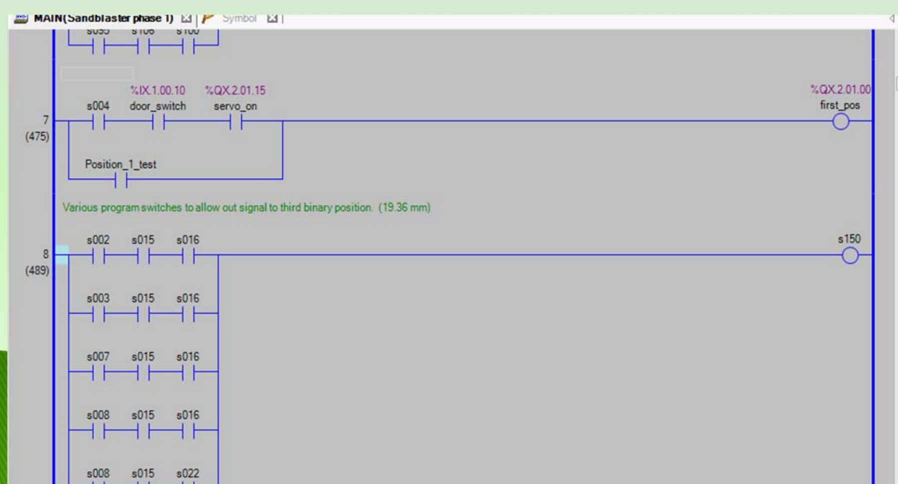
Software Design: Key portions of the ladder logic program

Some of the choices of number of parts-number of rotations buttons going to out pulse bit.



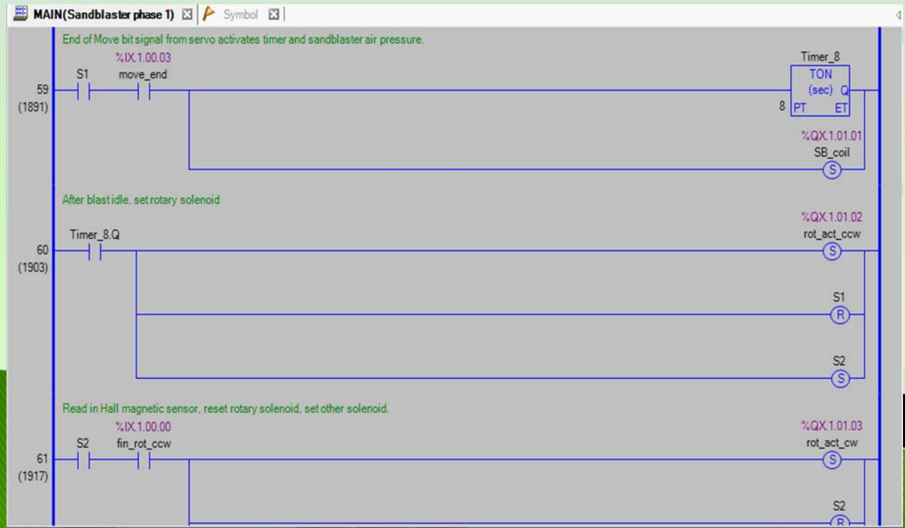
Software Design: Key portions of the ladder logic program

Figure 5: Section of the program showing where the previous internal memory bit switch s004 is placed as an input to binary position move 1 in a different rung.



Software Design: Key portions of the ladder logic program

Beginning of rotation routine of the program



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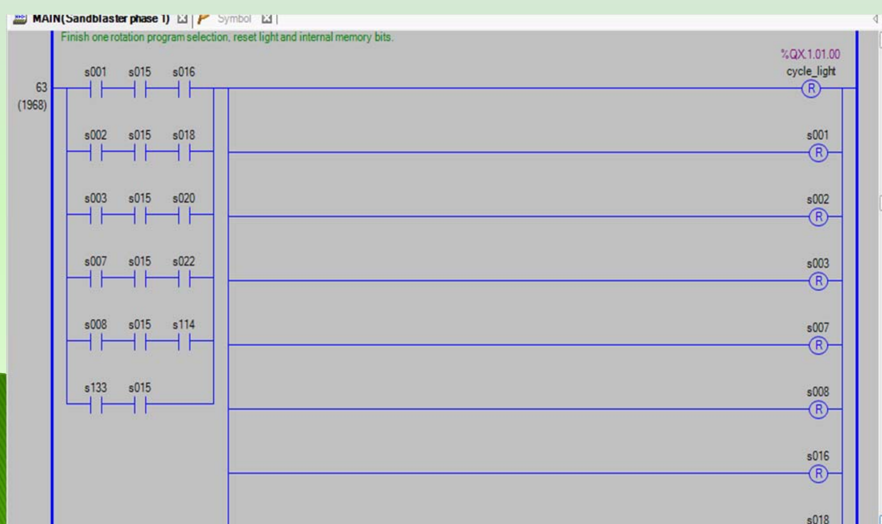
Software Design: Key portions of the ladder logic program

End of one rotation program process



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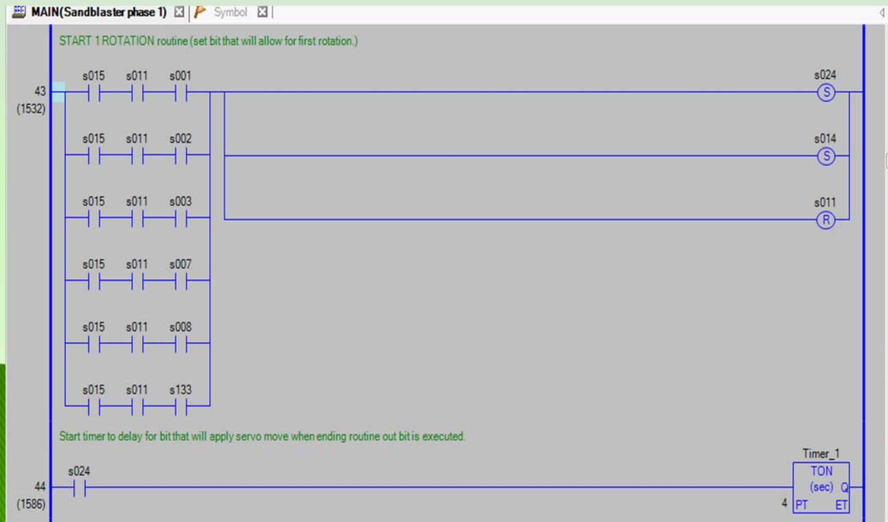
Software Design: Key portions of the ladder logic program

Logic to activate another binary move if needed



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Software Design: Key portions of the ladder logic program

Backlight change feature from Amber Backlight default screen to Red Backlight

Base 6(6 parts ...) | Base 7(I/O Test) | Base 8(Position...) | Base 9(Untitled) | Base 10(Untitled) | **Backlight** | EXM(Unt

Backlight Color Settings

Number	Action Mode	Action Address	Condition	Comment
1	Bit Action	s004	Bit ON	
2	Bit Action	Servo_Power_LCD_Button	Bit ON	
3	Bit Action	Home_LCD_Button	Bit ON	
4	Bit Action	Sand_Blast_test	Bit ON	
5	Bit Action	Cycle_light_test	Bit ON	
6	Bit Action	Rot_clockwise_test	Bit ON	
7	Bit Action	Rot_counterclock_test	Bit ON	
8	Bit Action	Door_sensor_test	Bit ON	
9	Bit Action	Position_1_test	Bit ON	
10	Bit Action	Position_2_test	Bit ON	
11	Bit Action	Position_3_test	Bit ON	
12	Bit Action	Position_4_test	Bit ON	
13	Bit Action	Position_5_test	Bit ON	
14	Bit Action	Position_6_test	Bit ON	
15	Bit Action	Program_reset_button	Bit ON	
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Software Design: Key portions of the ladder logic program

PLC software base screen creation

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Software Design: Key portions of the ladder logic program

Beginning of the I/O test portion of the program

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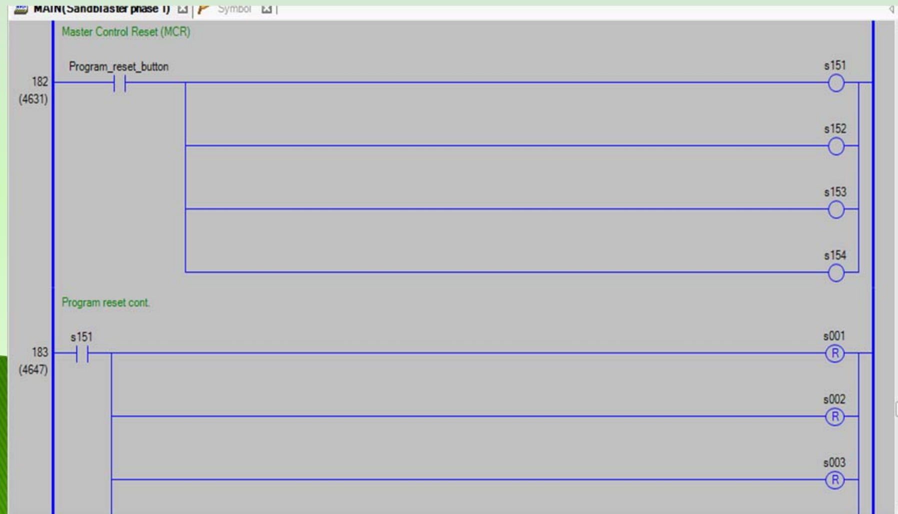
Software Design: Key portions of the ladder logic program

Portion of the MCR (Master Control Reset) of the program



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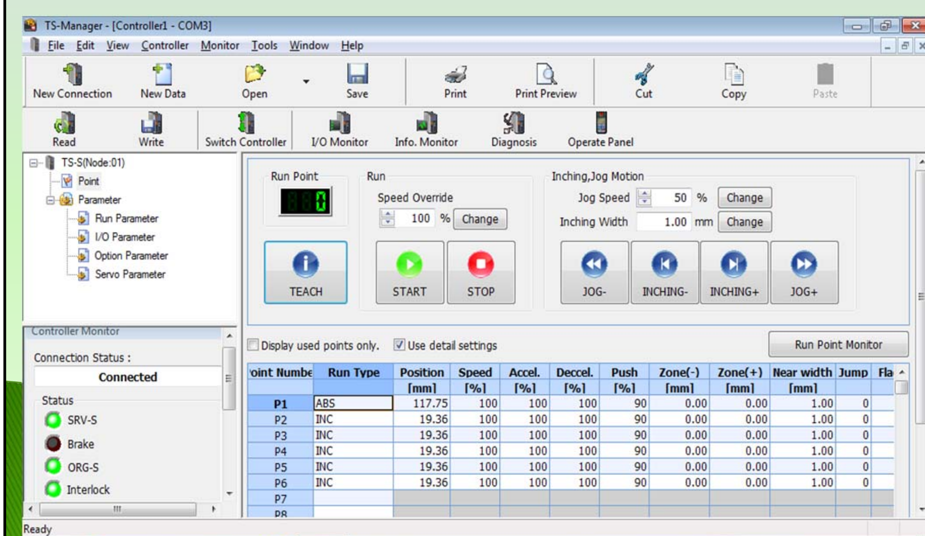
Software Design: TS-Manager servo software screen



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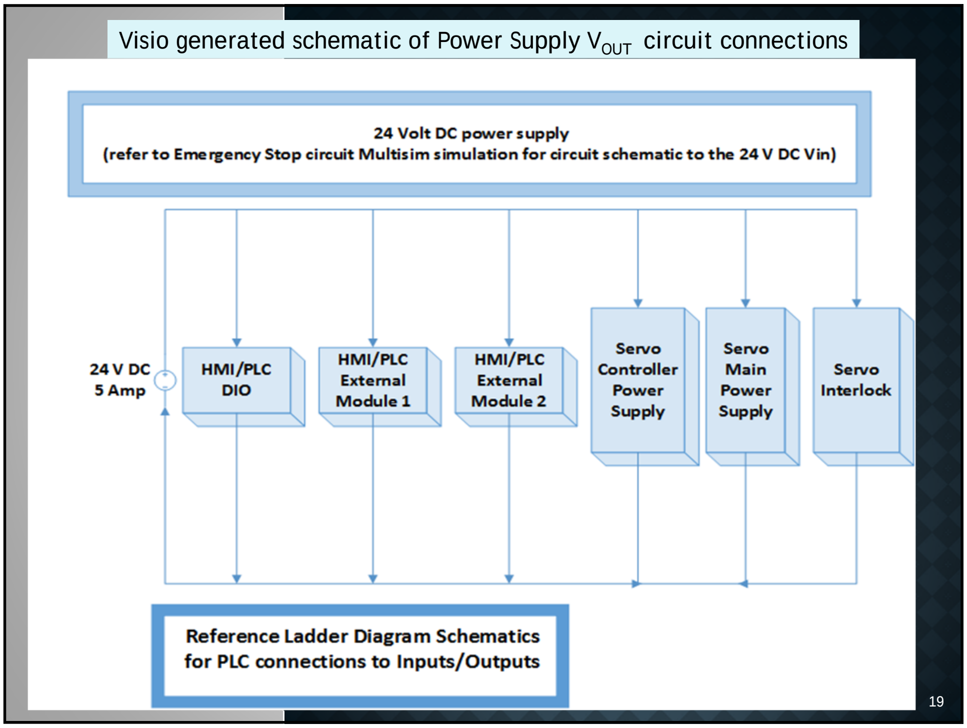
Visio generated schematic of Power Supply V_OUT circuit connections
24 Volt DC power supply
(refer to Emergency Stop circuit Multisim simulation for circuit schematic to the 24 V DC Vin)
24 V DC
5 Amp
HMI/PLC DIO
HMI/PLC External Module 1
HMI/PLC External Module 2
Servo Controller Power Supply
Servo Main Power Supply
Servo Interlock
Reference Ladder Diagram Schematics for PLC connections to Inputs/Outputs
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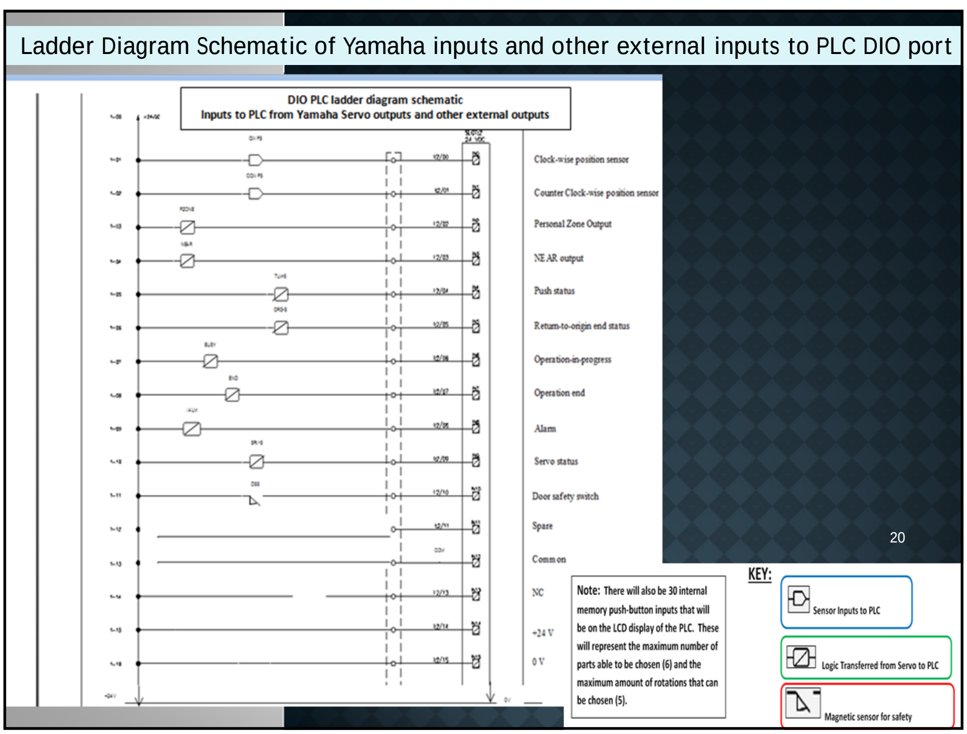
Ladder Diagram Schematic of Yamaha inputs and other external inputs to PLC DIO port
DIO PLC ladder diagram schematic
Inputs to PLC from Yamaha Servo outputs and other external outputs
Clock-wise position sensor
Counter Clock-wise position sensor
Personal Zone Output
NEAR output
Push status
Return-to-origin end status
Operation-in-progress
Operation end
Alarm
Servo status
Door safety switch
Spare
Common
NC
+24 V
0 V
Note: There will also be 30 internal memory push-button inputs that will be on the LCD display of the PLC. These will represent the maximum number of parts able to be chosen (6) and the maximum amount of rotations that can be chosen (5).
KEY:
Sensor Inputs to PLC
Logic Transferred from Servo to PLC
Magnetic sensor for safety
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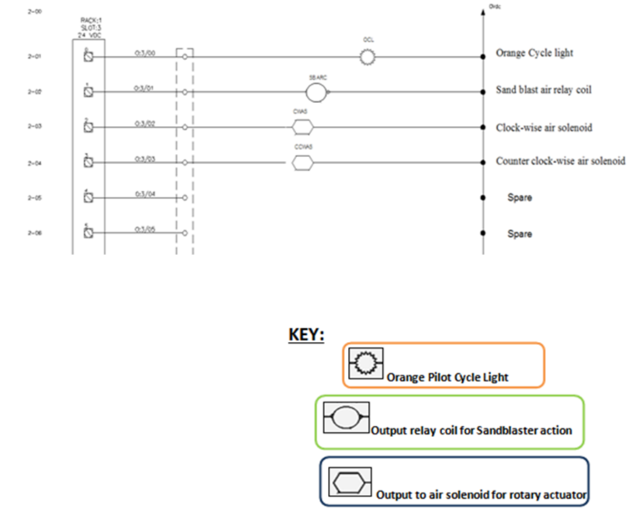
Ladder Diagram Schematic of the remaining PLC DIO bits used for real world outputs.

Additional DIO PLC I/O's (These were allocated as outputs, implemented through PLC software)
In the PLC software the programmer can choose to have the External Module addresses be either Inputs or Outputs



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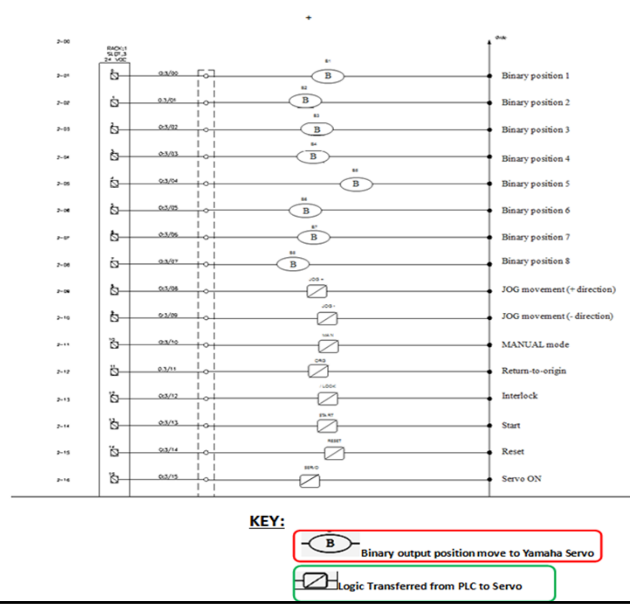
Ladder Diagram Schematic of the remaining PLC DIO bits used for real world outputs.

Note: External I/O module (model # EXM-DRA16RT)
chosen all outputs (this is done through the PLC software)
All of these outputs are received from the Yamaha SRD05 linear actuator pre-programmed logic



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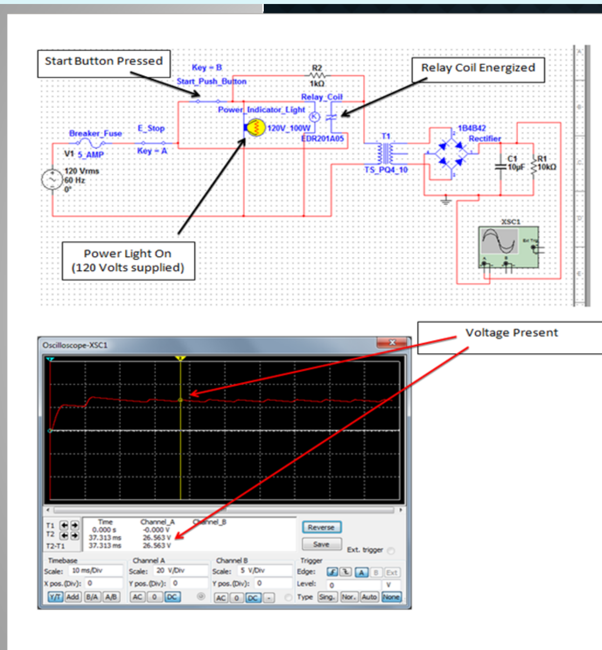
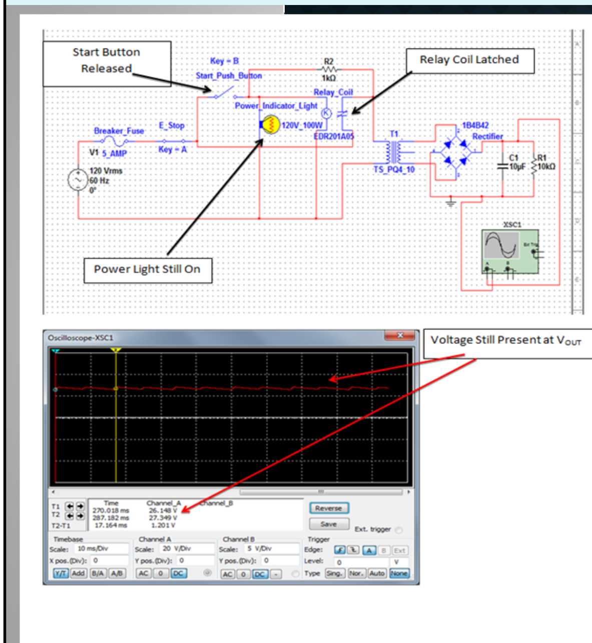
MultiSim Circuit Simulations



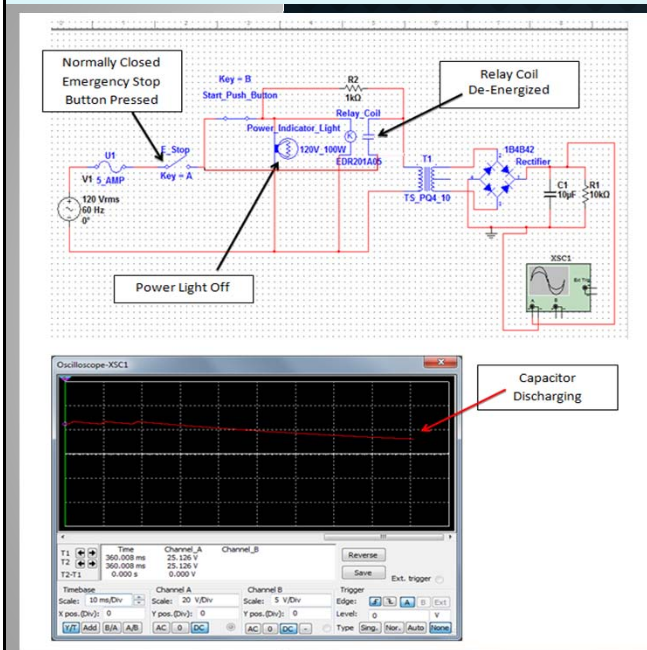
- Start Button Pressed
- Relay Energized

MultiSim Circuit Simulations



- Start Button Released
- Relay is Latched

MultiSim Circuit Simulations



- Emergency Stop pressed
- Relay coil De-Energized and current disrupted
- When Emergency Stop is released current will not be provided again until Start Button is pressed

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Prototype Testing

# of Moves Chosen	# of Moves Executed
1	1
2	2
3	3
4	4
5	4 (incorrect move)
6	6
1	1
2	2
3	3
4	4
5	5
6	5 (incorrect move)
1	1
2	2
3	3
4	4
5	5
6	6
1	1
2	1 (incorrect move)
3	3
4	4
5	5
6	6

# of Rotations Chosen	# of Rotations Executed
1	1
2	2
3	3
4	4
5	5
1	1
2	2
3	3
4	4
5	5
1	1
2	2
3	3
4	4
5	5

- Error Identified: Missing Binary 2 (01) position move
- Solution: Bypass binary 2 move with increment 19.36 mm to position three.

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Prototype Testing

DCC 500 sandblasting time result comparisons

# of Parts Sandblasted	Manual Sandblasting Time (minutes)	Auto Sandblaster Loading Time (minutes)	Time Saved (minutes)
1	2.1	0.4	1.7
2	3.8	0.5	3.3
3	5.3	0.6	5.3
4	7.2	0.6	6.6
5	8.7	0.8	7.9
6	10.1	0.9	9.2
1	1.9	0.3	1.6
2	3.7	0.4	3.3
3	5.4	0.4	5
4	7.9	0.5	7.4
5	9	0.6	8.4
6	11.3	0.8	10.5

Hardware Testing and Validation

AC 120 V source voltage measurement

- Instrument used for measurements: DMM – Cen-Tech P35761

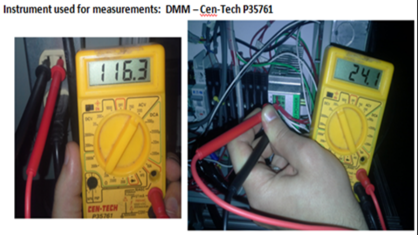

Figure 1: New DMM used for measurements

- Incoming line voltage – 116.3 volts
  - Power company's nominal voltage = ± 5%, or 10%
  - $\frac{116.3-120}{120}$ *100% = - 3.08% (within tolerance)

3 parts (Manual Sandblast): 5.3 + 5.4 = 10.7/2 = Avg. 5.35 min.
Time Saved (Auto Sandblast): 5.3 + 5 = 10.3/2 = Avg. 5.15 min.
5.15/5.35 *100% = 96.3 % Time Saved

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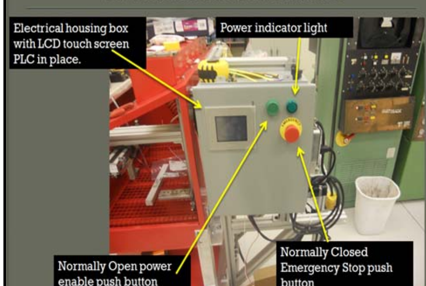
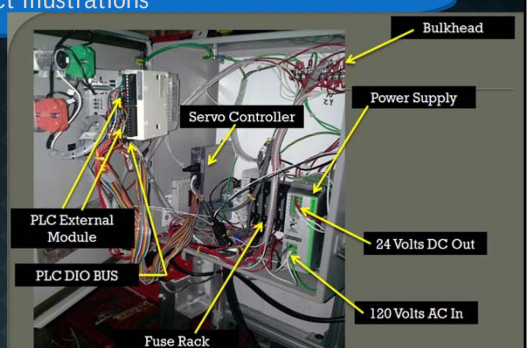
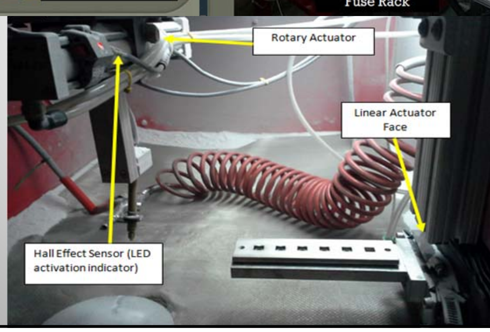
Project Illustrations

Circuit Panel Box Mounted







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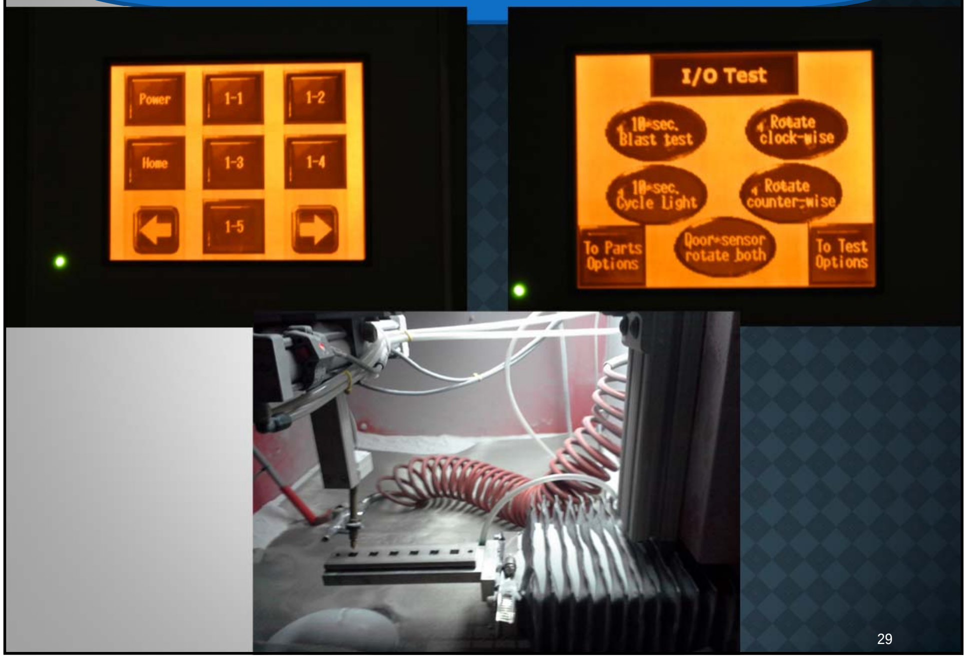
Project Illustrations



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Conclusion

- ❖ Plan ahead for the unknown delays in the project schedule
- ❖ Documentation and testing is essential to a well-rounded project
- ❖ Planning ahead and allocating extra time did not allow the problem to make the project a failure
- ❖ Valuable experience for me both in quality software engineering and hardware engineering
- ❖ The project was maintained with the original scope, and schedule. This came at the expense of extra labor time being allocated toward the project completion
- ❖ The system is more efficient, saves the company money in the form of labor, allows the company to expand its business efforts, and is a health benefit to the laser operator

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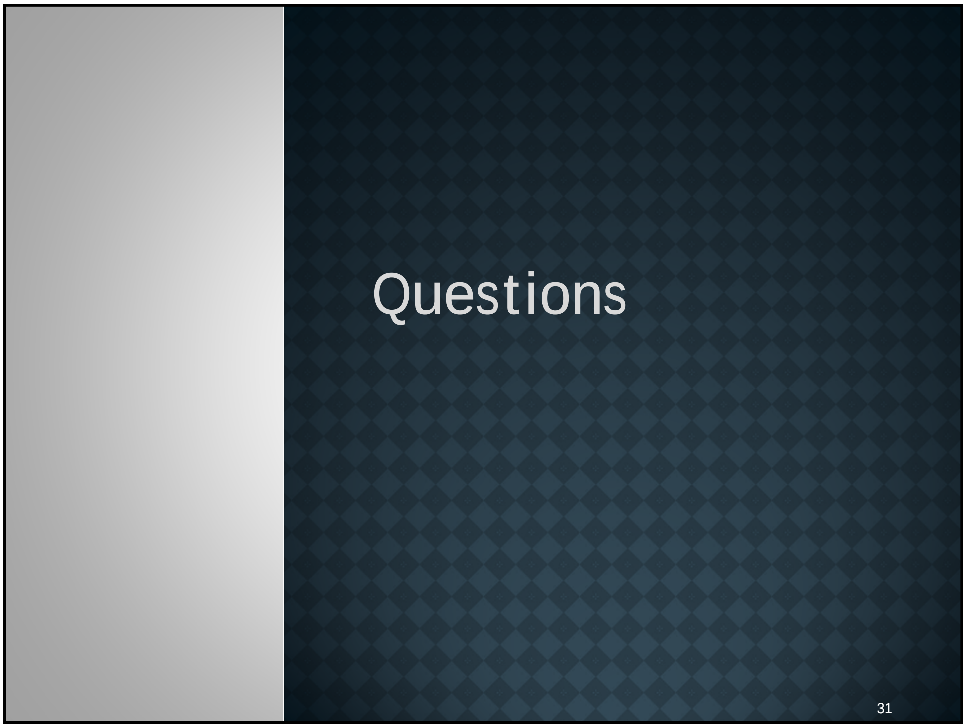
Questions
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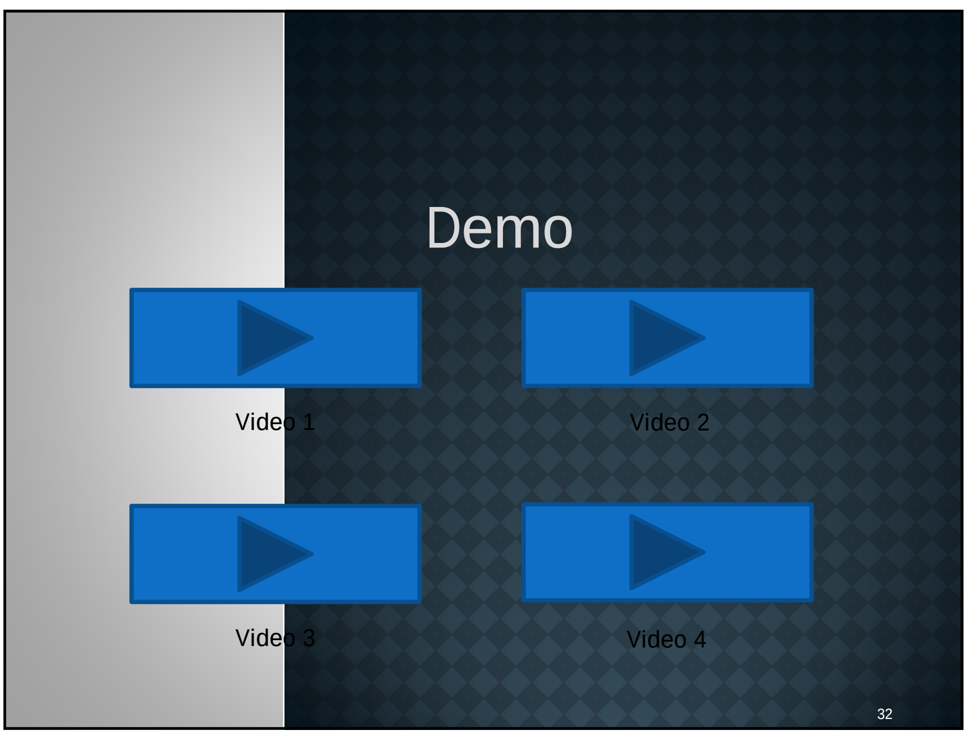
Demo
Video 1
Video 2
Video 3
Video 4
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