Enel 380 Schematic Design Project: Touchless Car Wash

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ENEL 380

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Introduction:

A PLC or a Programmable Logic Controller is an industrial computer that can monitor inputs and outputs to make decisions based on ladder logic code that it is programmed with. This means that the PLC is paramount in automation and manufacturing tasks throughout the world. In our case, we will be creating a design for a touchless car wash that will be ran using a PLC.

Objectives:

Our objectives for this project are to lay out system requirements, features and details on how the car wash will run. Specifically, how each state interfaces with the PLC via ladder logic, block diagrams and state diagrams, as well as with written descriptions.

Subsystem Descriptions:

The subsystem descriptions are located in **our excel file in the folder**. While these descriptions represent overall what the system does and achieves it is not exactly how our PLC code works. This difference is due to restrictions on amount of inputs and how we laid out the plans for each subsystem before coding/ladder logic. Our assumptions for this included that the nozzles for commercial car wash systems did not need external input other than pressurized water entering the hose. Also, that the pumps included in these types of systems had the ability to control and set pressures that they output on their own without PLC programming needed. Finally, we also assumed that all of our motors would have the ability to do both forward and reverse motions/rotation.

Car Wash Features and Requirements Overview:

A touchless car wash has to be just that, a touchless car wash, this means that every step requires automation and interfacing with the PLC. A car wash should, at the very least, have rinse, soap, brush, wax, and drying functions. These functions allow it to perform its duty as a “car wash” and offers what a wand wash or manual wash can achieve with a dirty car coming out clean.

Our design to satisfy the requirement that a dirty car comes out clean without human/manual labor will include all of the functions outlined above. The ladder logic code will have 7 distinct states that reflect this: Off, Rinse, Soap, Brush, Wax, Dry and ShutterClose. The requirements for each state are as follows.

States

Off State:

In this state, the car wash will be in standby and waiting for the operator start button (which is located in the control room). Then there is a sensor at the beginning of the garage that will detect when the car has driven on the track. There will be an indicator light that will tell the user to put their car in neutral when the proximity switch has been switched. Once the proximity switch is enabled, the track will begin to move and turn on the undercarriage spray nozzle and pump to clean the undercarriage of the vehicle. The track will stop when the sensor disables again. It will be disabled as the track will have pulled the car into the correct position in the garage which is determined by another proximity sensor, and past the front garage door. This will then cause a switch to the rinse state.

Rinse State: The rinse state will have a timer that determines how long it will run for before going on to the soap state. For aesthetics, this section has blue LED lights that are on during it. Our default value is 30 seconds for all timer states but the dryer one which is a minute. During this time, the water pump will enable, enabling the rinse nozzles, as well as the forward motor relay for the spray nozzle rail. This rail is situated around and beside the car and will spray it from back to front. Once the rail has reached its end point, which is denoted with a limit switch and calibrated to take up the duration of the timer, the PLC will switch to the soap state.

Soap State: Exactly like the rinse state, but with a few differences. The nozzle will be spraying soap solution and the soap solution pump will be activated as a result. Also, the reverse motor relay for the spray nozzle rail will be activated as the rail will be in the full forward position from the rinse state. The nozzles will spray the soap solution as the rail moves from the front of the car to the back until it hits the backward limit switch on the rail. This again will be calibrated with a timer to ensure that it runs for 30 seconds. For aesthetics, this section has green LED lights that are on during it. After this is the brush state.

Brush State: This state will be used to agitate the soap and rinse it off the car. The nozzle rail will be in the backward position from the soap state, this means that the forward motor will be activated to move it. The brush system which is located on this rail will be turned on via the brush motors when this state begins. While the brushes normally don't reach the car, centrifugal force from the rotation of the brushes will cause them to scrub/hit the car. The normal rinse nozzles and water pump that were used in the rinse state will also be activated during the time that the brush system is. This state will run on a timer and the rail will move until it hits the forward limit switch. For aesthetics, this section has orange LED lights that are on during it. Once the timer runs out, it will move on to the wax state.

Wax State: In this state, the car will be hit with a wax solution that will form a protective layer on it. The nozzle rail will be in the forward position from the brush state and will move backward to the back of the car. Similar to all the other states, a timer will run to determine how long the solution will spray for and the rail motor runs until it hits the backward limit switch. For aesthetics, this section has purple LED lights that are on during it. Once the timer runs out, the drying state will begin.

Dry State: The dry state will begin by opening up the back-garage door. The back-garage door opens by turning on the shutter motor relay and running until it hits an upper limit switch which turns on an exit indicator light. During this it turns on the dryers via dryer motors. When the dryers turn on a one-minute timer begins, the dryers will run during this time or until the vehicle exits the garage which is detected via an exit proximity sensor. The proximity sensor is on when the car is in the garage/exit door area and off when it is not. When this proximity sensor turns off, the dryers will stop and the state will change to shutter close state. If a vehicle does not leave after the timer has elapsed (proximity sensor enabled when timer is off), the operator will shut down the car wash and deal with it.

Shutter State: There will be a 15 second delay in-between when this state begins to when the shutter begins to close, which is handled via a timer. Then assuming the proximity exit sensor is still off the shutter reverse motor is enabled and the door closes until the exit lower limit switch is enabled. The car wash goes back into the off state and the wash is done.

In terms of safety and operation of the car wash, each and every state after the off state will have built in a stop function which will switch it to off state. This function will set the off state and reset the

current state when any of the following occurs: the stop button is pushed in the control room, the middle proximity sensor (determines that the car is in the correct position in the car wash) is deactivated, the water tank low level float switch is activated, the soap solution tank low level float switch is activated or the wax solution tank low level switch is activated.

Potential Parts to be Used

Proximity Sensor (Switch) for Track:

https://www.digikey.ca/en/products/detail/dfrobot/FIT0658/12324936?s=N4IgjCBcoGwJwHYqgMZQGYEMA2BnApgDQgD2UA2iAMwwAMYNIxNttMArCALrEAOALIBABIfgCcAlgDsA5iAC%2BxMHAAccZCDSQseIqQoha3PoMgjx0ufMUgATAd5iSADwkBbCfwCeAAlwB3TxQAC3xcbnkgA

Datasheet:https://media.digikey.com/pdf/Data%20Sheets/DFRobot%20PDFs/FIT0658_Web.pdf

Interfaces with PLC with 0/1 output, Waterproof and should suffice for detecting tires on the track, operates at 5v, limited detection distance of 4mm may be an issue so we also had backup proximity sensor here with up to 40mm of detection: https://www.digikey.ca/en/products/detail/ifm-efector-inc/KI6000/12144861?s=N4IgjCBcoCwExVAYygMwIYBsDOBTANCAPZQDaIMArDAOwDMMIAuoQA4AuUIAyuwE4BLAHYBzEAF9JQA

Optical Sensor (Through-Beam) for Door sensors:

https://www.digikey.ca/en/products/detail/pepperl-fuchs-inc/MD17-73/9841259

Datasheet: https://files.pepperlfuchs.com/webcat/navi/productInfo/pds/208374_eng.pdf?v=20181211000210

Chosen as it has the ability to work and be modified to work in wet conditions and the distance (~10M) to reach across the wash bay. Outputs either high or low and requires 10V minimum to run.

Motors: Most motors need to have dual relay system for forward/reverse. PLC can supply up to

Relays: Relays used for powering devices will be the ones used in the labs. (782XBXM4L-12D or 782XDX2M4L-24D.)

Datasheet:https://urcourses.uregina.ca/pluginfile.php/2121776/mod_resource/content/2/8501CT1105.pdf

Temperature Sensor: Used in the labs. Will interface for heating the water/solutions in the tanks.

Datasheet:https://urcourses.uregina.ca/pluginfile.php/2137934/mod_resource/content/1/prosensextptp.pdf

Limit Switch: Used on the Rails and Exit Door, needs to be SPDT for two modes either “open” or “closed”. This one we found operates at 5V or 10MA which will work with the PLC inputs.

https://www.digikey.ca/en/products/detail/panasonic-electronic-components/ESE-24MH1T/286392

Datasheet: https://industrial.panasonic.com/cdbs/www-data/pdf/ATB0000/ATB0000C18.pdf

Float Switch: Single Float Switch, Located either at bottom of tanks or top for low or high levels respectively. https://www.cynergy3.com/sites/default/files/SSF50%202016.pdf

Datasheet: https://www.cynergy3.com/sites/default/files/SSF50%202016.pdf

Push buttons such as the ones used to start and stop will be the same as the ones used in the labs.

Spray Nozzles aren't very easy to find due to most of them being used in proprietary installations of touchless car washes. Here is an example website with some that we found**. https://www.kleen-ritecorp.com/c-882-spray-tips-nozzles.aspx.**

RGB Lights for the various states, just for aesthetics.
https://www.digikey.ca/en/products/detail/lumex-opto-components-inc/SML-LX1610RGBW-A/1994191

Datasheet: https://media.digikey.com/pdf/Data%20Sheets/Lumex%20PDFs/SML-LX1610RGBW,A.pdf

Custom Pumps have to be able to control and adjust pressure accordingly to how they are setup

Tanks are custom for the carwash similar to the pumps and will need to be setup.

Heater for the water will be an industrial style heater, perhaps a tankless heater, and would also be custom for the wash.

PLC will be the same one used in the labs. CP1L-M30DT-A.

Datasheet: https://urcourses.uregina.ca/pluginfile.php/2121775/mod_resource/content/1/cp1h_cp1l_ca_csm2131.pdf

Appendices

Ladder Logic Inputs/Outputs and States

Inputs:

Start Switch
Stop Switch
Middle Proximity Switch
Water Level Low (Float Switch)
Entrance Proximity Switch
Forward Limit Switch (Rail System Motor)
Reverse Limit Switch (Rail System Motor)
Soap Level Low (Float Switch)
Wax Solution Level Low (Float Switch)
Exit Door Upper Limit Switch
Exit Door Lower Limit Switch
Exit Proximity Switch (Optical Through-Beam)

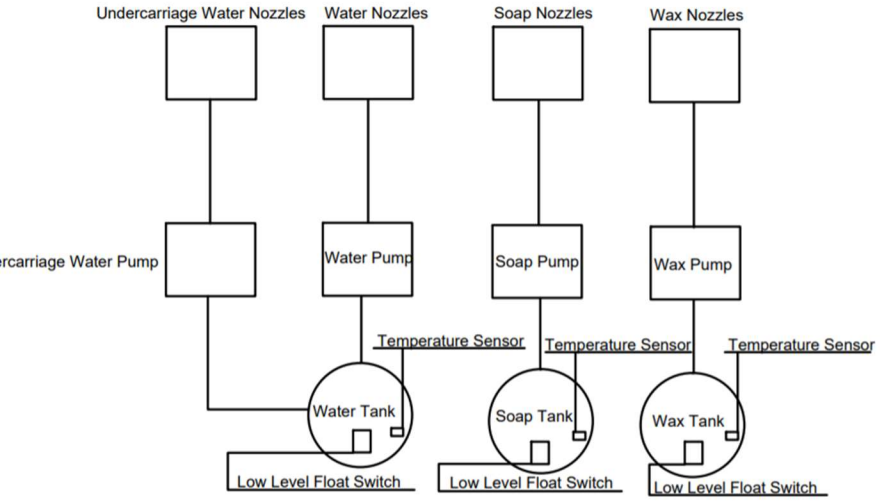
Outputs:

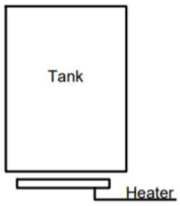
Forward Rail Relay	Water Heater Coil
Track Motor	Soap Solution Heater Coil
Undercarriage Water Pump	Wax Solution Heater Coil
Backwards Rail Relay	Dryer Coil
Green Lights	Water Pump Coil
Orange Lights	Soap Pump Coil
Purple Lights	Wax Pump Coil
Blue Lights	Brush Motors
Lower Shutter Relay (Exit Door)	Rail Motor
Upper Shutter Relay (Exit Door)	Neutral Indicator Light (Change car gear to Neutral)
Shutter Motor	Exit Indicator Light

States:

Off_State
Rinse_State
Soap_State
Brush_State
Wax_State
Dry_State
ShutterClose_State

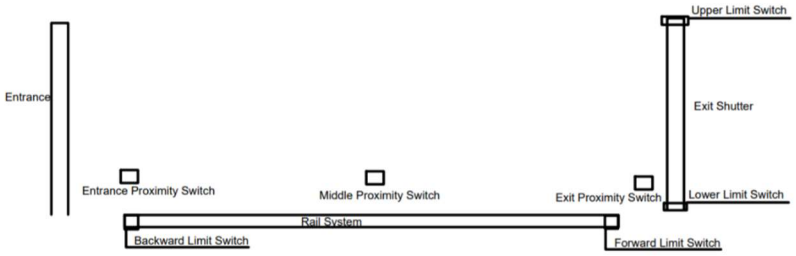
Wiring/Pipe Design Image

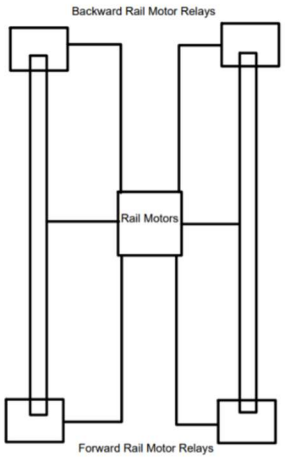




As shown in the block diagram above, each substance will have its own separate tank with a Low-Level Float Switch and a temperature sensor. The temperature sensors are wired to two CP1W-MAD11 extensions on the PLC. The PLC itself will provide majority of the power for most of the devices.

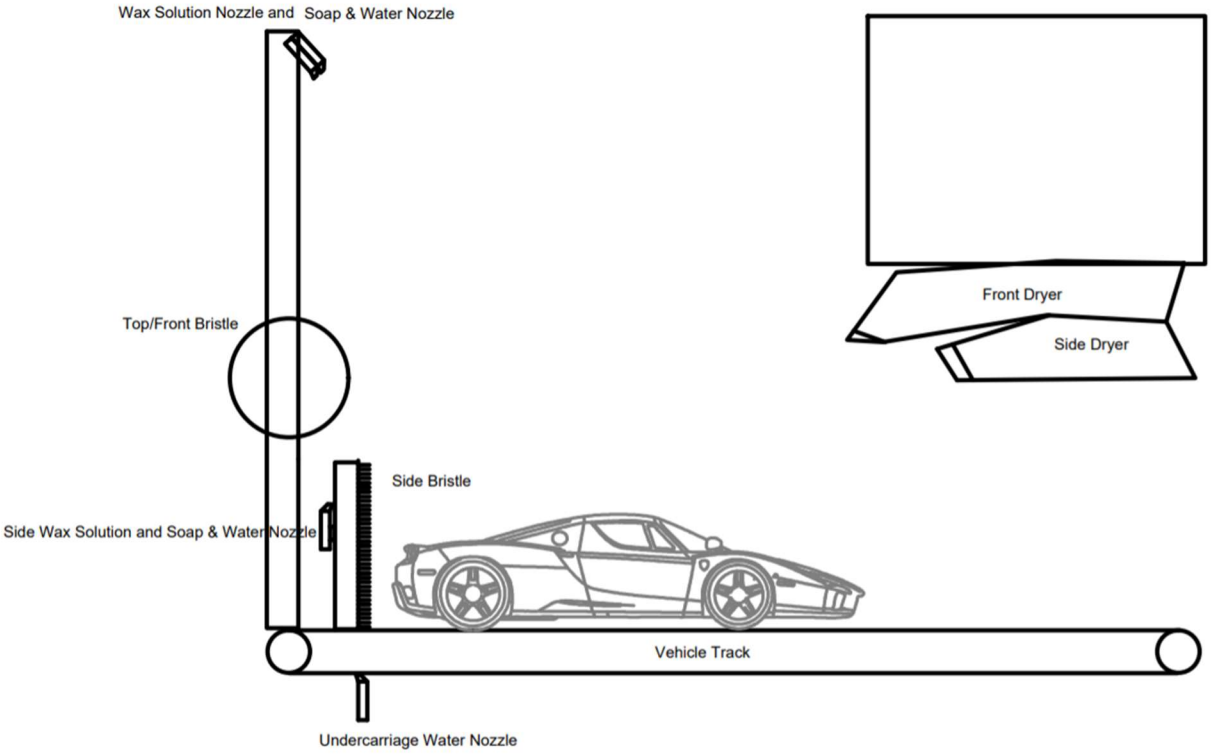
Rail System Drawing

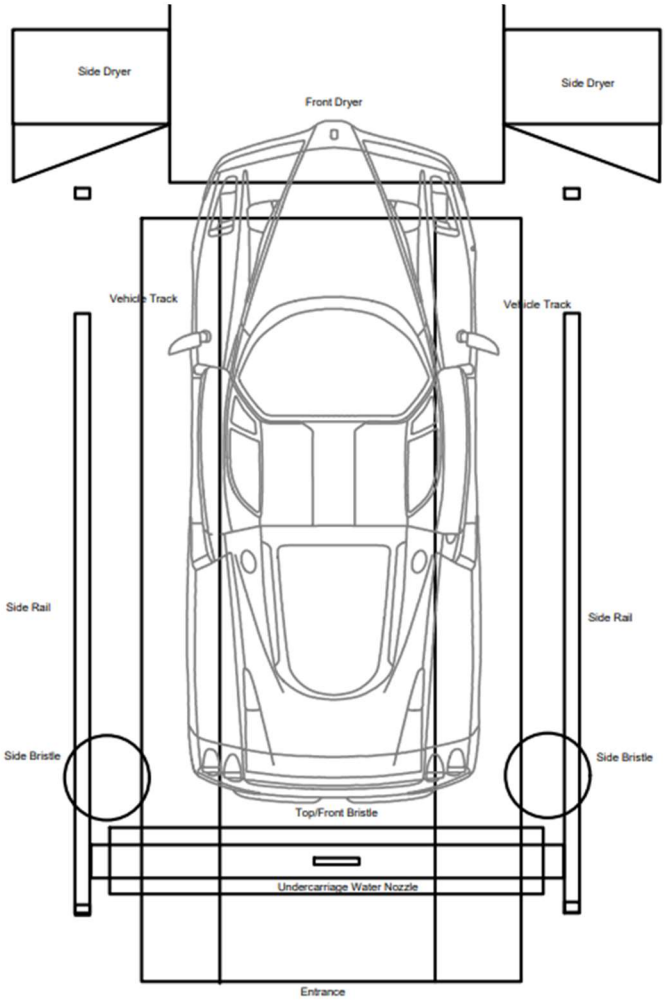




As shown in the block diagram above, the system uses three proximity switches. Each rail has two limit switches for two positions. Entrance proximity switch indicates vehicle entrance. Middle proximity switch indicates whether the vehicle is in the correct position. Entrance shutter will be manually opened by car wash system operator and will remain open until system is shut down. Exit proximity switch indicates for the exit shutter to remain open. All motors in overall system have a dual relay mechanism (except for track motor), which allows for forward and reverse rotation.

Car Wash Overview Drawing with Car for reference





State Diagram: *See attached PDF (State Diagram.pdf)

Ladder Logic Program: *See attached PDF (Ladder Logic Program.pdf)