PLC Programming Rules #1-3

1) Ladder diagrams are drawn vertically with inputs on the left and outputs on the right.
2) Each rung of the ladder has one (and only one) output.
3) An individual output device can appear on the ladder diagram only once. (can be actuated only once)
PLC Programming Rules #4-5

4) An individual physical input device (limit switch, push-button, pressure switch, etc.) may be used as many times as necessary on the ladder diagram in both N.O. and N.C. configurations.

5) Internal contacts of the PLC are represented as conventional control relays and contacts.
PLC Programming Rules #6-8

6) Control relay *coils* (outputs) appear on the ladder diagram only once.

7) Control relay *contacts* are inputs and may be used as many times as necessary on the ladder diagram in both N.O. and N.C. configurations.

8) Any rung of the ladder diagram may be "OR"ed with a following rung at only one location.

_Understand_ the difference!
"OR" Connections

Invalid "OR" Connections

Valid "OR" Connections
General Logic Design

Push a button to get things started
= close something to get things started!

N.O. functions to activate the control relay

N.C. functions to deactivate the control relay

Do the something until a trigger is tripped to stop

Safety interlocks

C_i = the switch that turns on Y_i, provided all safety interlocks are functioning
Basic Logic Design

▶ What conditions must be true to turn on output $Y_i$?
  ▪ Use these conditions in series to activate the control relay $C_i$

▶ What happens to turn output $Y_i$ off?
  ▪ Use these conditions in parallel to deactivate the control relay $C_i$

▶ Use safety interlocks to prevent invalid simultaneous outputs
PLC In-Class Problem #1

Hydraulic pump

Directional control valve, double solenoid activated

Pressure relief valve

Retracted

Extended

Sol A

Sol B

LS-1

LS-2
PLC Wiring Diagram

+120VAC

Start-A
LS-1
LS-2
Start-B

Inputs

<table>
<thead>
<tr>
<th>X0</th>
<th>Y0</th>
</tr>
</thead>
<tbody>
<tr>
<td>X1</td>
<td></td>
</tr>
<tr>
<td>X2</td>
<td></td>
</tr>
<tr>
<td>X3</td>
<td></td>
</tr>
</tbody>
</table>

Outputs

<table>
<thead>
<tr>
<th>Sol-A</th>
</tr>
</thead>
</table>

+120VAC

Sol-B
Task Description – IC #1

► If the cylinder is fully retracted, pressing either pushbutton will fully extend the cylinder (by activating Sol. B).

► If the cylinder is fully extended, pressing either pushbutton will fully retract the cylinder (by activating Sol. A).

► Once the cylinder reaches either the fully extended or fully retracted position, “center the valve” by turning off both solenoids to unload the pump.
Task Description – IC #2

► When the “Fill” button is pressed, run the Fill Pump until Float Switch #1 is activated or the Stop button is pressed.

► When the “Empty” button is pressed and Float Switch #2 is activated, run the Empty Pump until Float Switch #2 is de-activated or the Stop button is pressed.
PLC Design Tips #1 & 2

► Dedicate control relays for specific functions (such as starting the system, activating a solenoid, etc.)

► Control relays are essentially “free” once a programmable controller has been purchased, so don’t be miserly!
PLC Design Tips #3 & 4

► Control relays almost always use a holding circuit, so design in terms of both a “turn ON” and a “turn OFF” rung with an “OR” connection between them.

► Note that some circuits will require multiple rungs for turning ON or OFF, which must be connected through the OR structure.
PLC Design Tips #5 & 6

► Be absolutely certain that any holding circuit formed will be actively turned off by your system.
  ▪ Do not depend on a power shutdown to release any holding circuits.

► Provide safety interlocks either on the “turn ON” rung before the control relay or on the associated solenoid activation rung.