Automation of chlorination in a water treatment plant

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Summary

- General idea
- Functional Requirements
- Tables
- Sequential Function Chart
- Ladder Diagram
- Components choice

General Idea

A water treatment plant is designed to remove impurities and contaminants from raw water sources to produce safe and clean drinking water. The treatment process typically consists of several stages, including:

- Pre-treatment
- Coagulation and Flocculation
- Sedimentation
- Filtration
- Disinfection or Chlorination
- Final testing and Distribution

Chlorination is a process of adding chlorine to water to kill harmful microorganisms, such as bacteria, viruses, and protozoans, that can cause waterborne illnesses. Chlorine is a powerful disinfectant and is widely used in water treatment plants around the world.

The chlorination process typically involves the following steps:

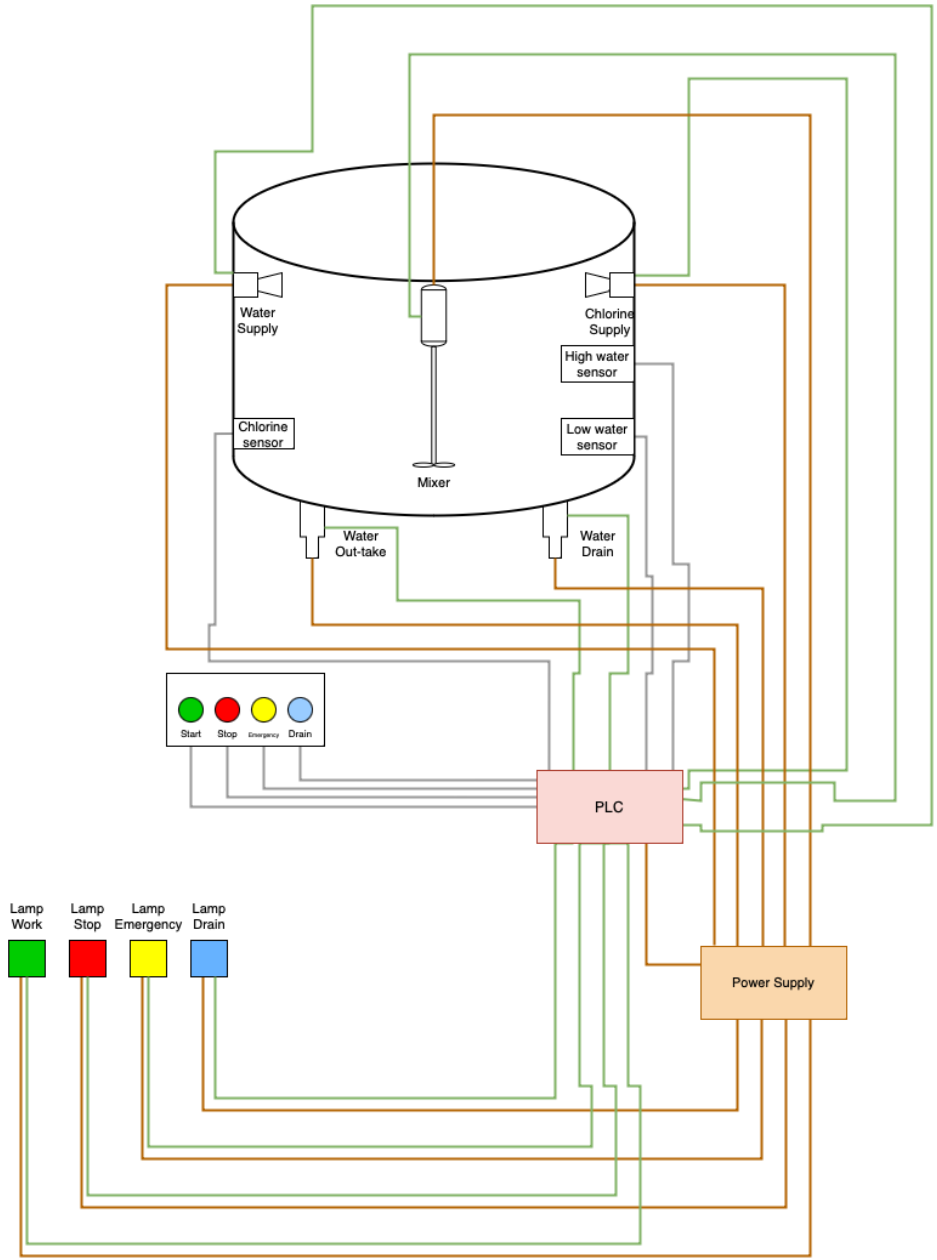
1. Pre-chlorination
2. Primary chlorination
3. Chlorine contact time
4. Dechlorination

Functional Requirements

Assuming that the pre-chlorination process is regulated in another infrastructure by another PLC, we isolate our case of study to the management of just the chlorination tank.

Functional Requirements

- Manage the water intake, checking the water levels in the tank
- Manage the chlorine emission, checking the chlorine concentration
- Mix the water with the chlorine
- Let the water rest for 30 minutes
- Manage the chlorated water outgo
- Be able to manage problematic scenarios
- Be able to stop the process
- Be able to resume the process
- Manage two different outputs of water:
  - Normal outtake to procede with the water treatment process
  - Drain to free the tank of unusable water


Water Supply
Chlorine Supply
High water sensor
Chlorine sensor
Low water sensor
Mixer
Water Out-take
Water Drain
Start
Stop
Emergency
Drain
PLC
Lamp Work
Lamp Stop
Lamp Emergency
Lamp Drain
Power Supply

Label	I/O Address	Comment
Start	I0.0	Start button
WL1	I0.1	Low water level sensor
WL2	I0.2	High water level sensor
CH1	I0.3	Residual chlorine sensor
Stop	I0.4	Stop button
Drain	I0.5	Drain button
Emergeny	I0.6	Emergency stop button

Table: Input table

Label	I/O Address	Comment
HL1	Q0.0	Lamp work
HL2	Q0.1	Lamp stop
HL3	Q0.2	Lamp emergency stop
HL4	Q0.3	Lamp emergency drain
PM1	Q0.4	Pump for water intake
PM2	Q0.5	Pump for water drain
PM3	Q0.6	Pump for emergency drain
PM4	Q0.7	Pump for chlorine supply
M1	Q1.0	Mixer

Table: Output table

Label	I/O Address	Comment
State0	M2.0	SFC state variable
State1	M2.1	”
State2	M2.2	”
State3	M2.3	”
State4	M2.4	”
State5	M2.5	”
State6	M2.6	”
State7	M2.7	”
SS	MB0	Suspended state value

Table: Internal varibles table

Sequential Function Chart

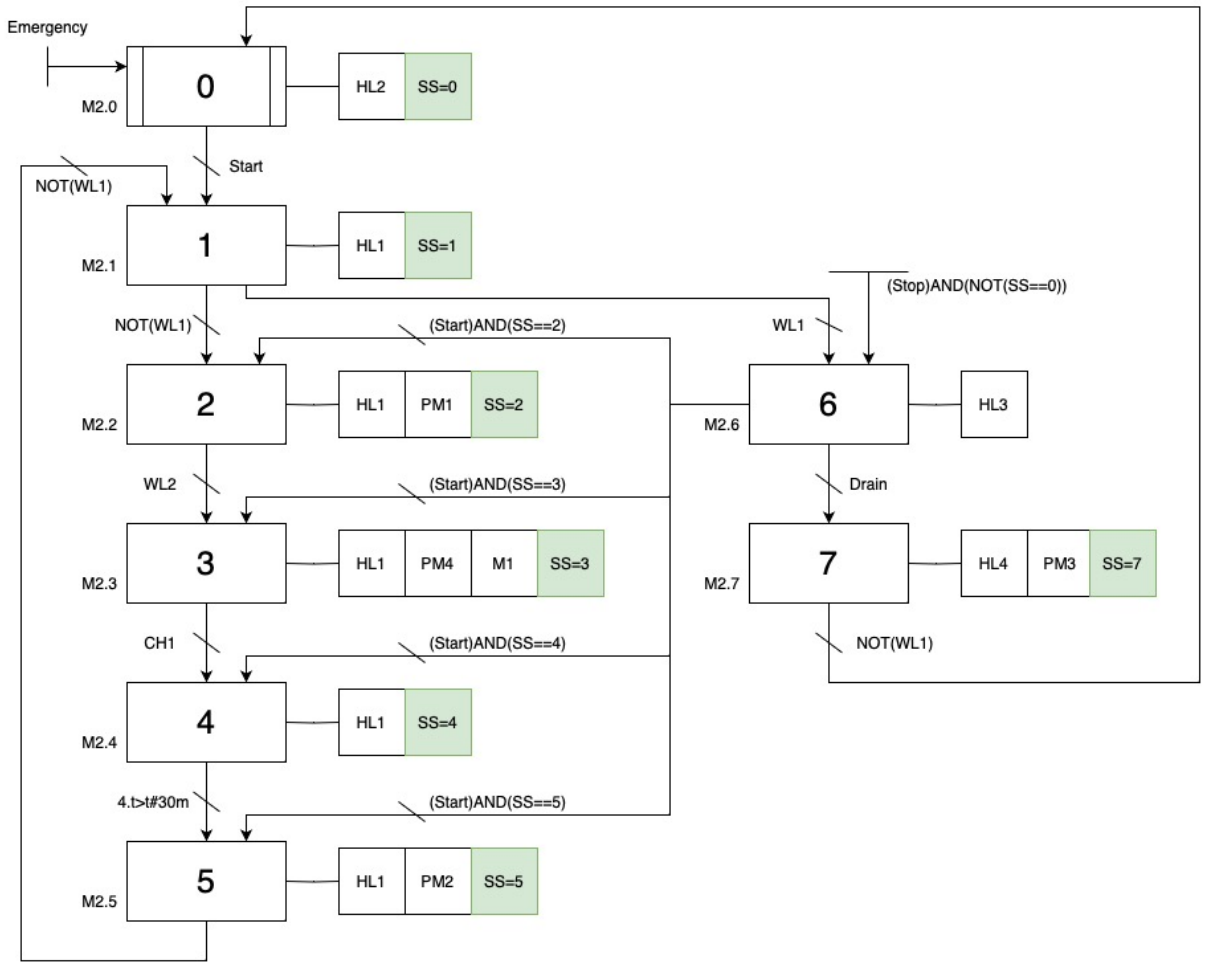


Figure: SFC Diagram

Ladder Diagram
Initialization

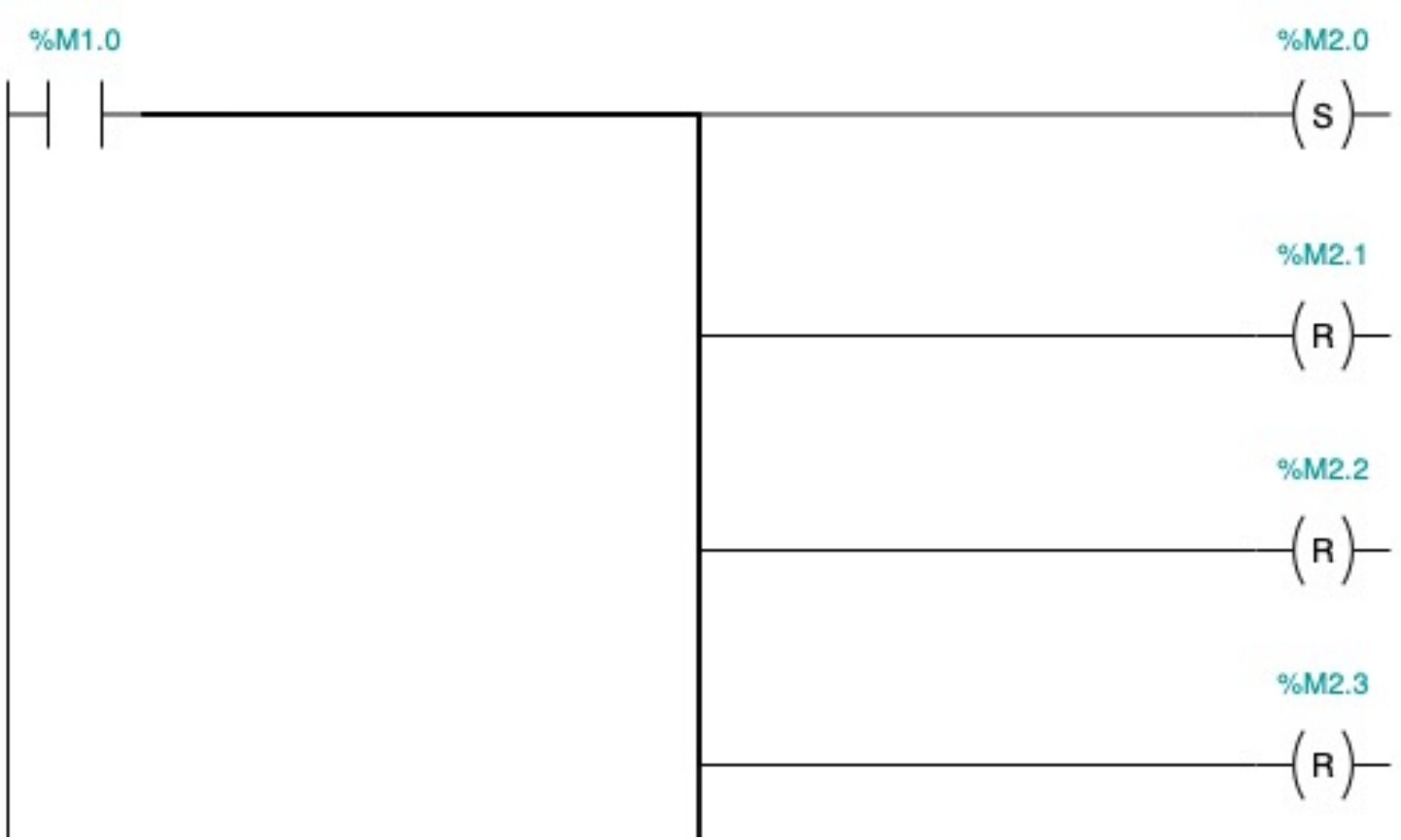


Figure: Initialization - Ladder diagram part 1

Ladder Diagram
Initialization

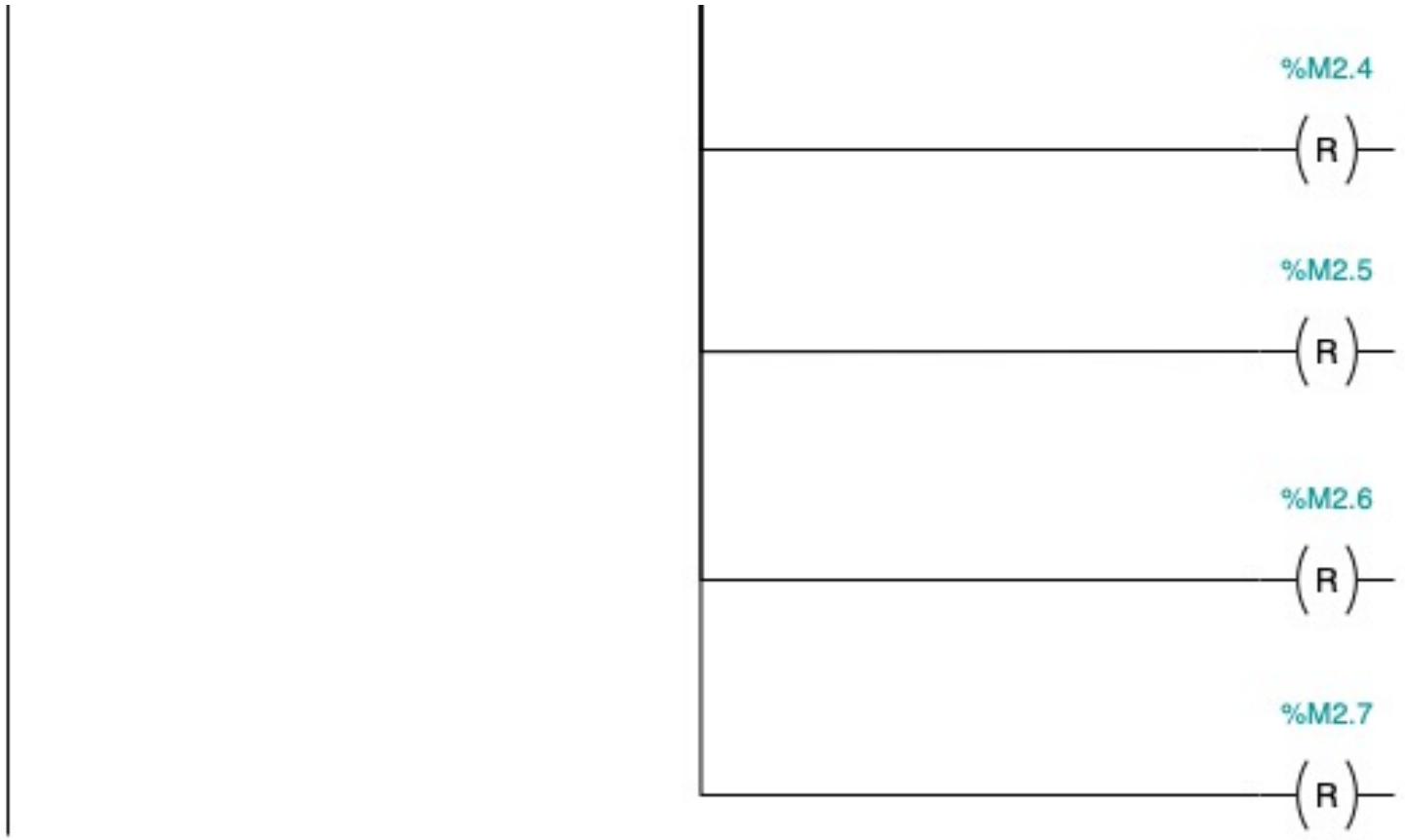


Figure: Initialization - Ladder diagram part 2

Ladder Diagram
State Machine

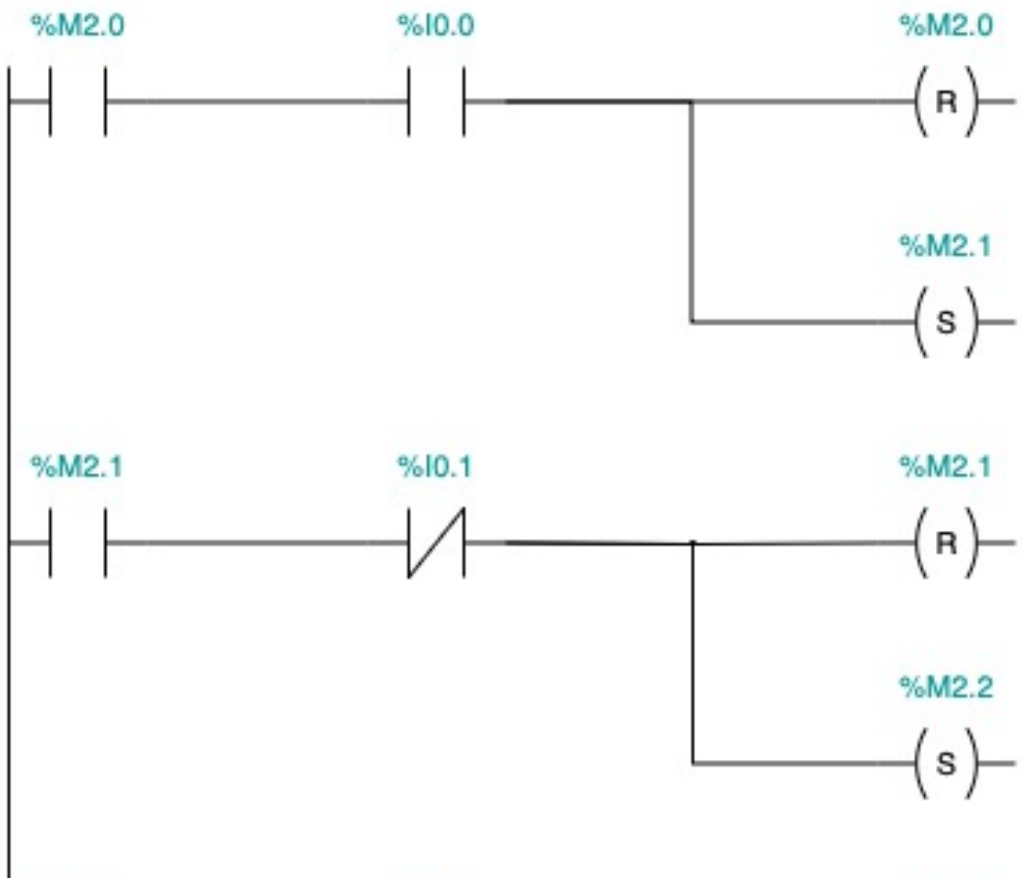


Figure: State Machine - Ladder diagram part 1

Ladder Diagram
State Machine

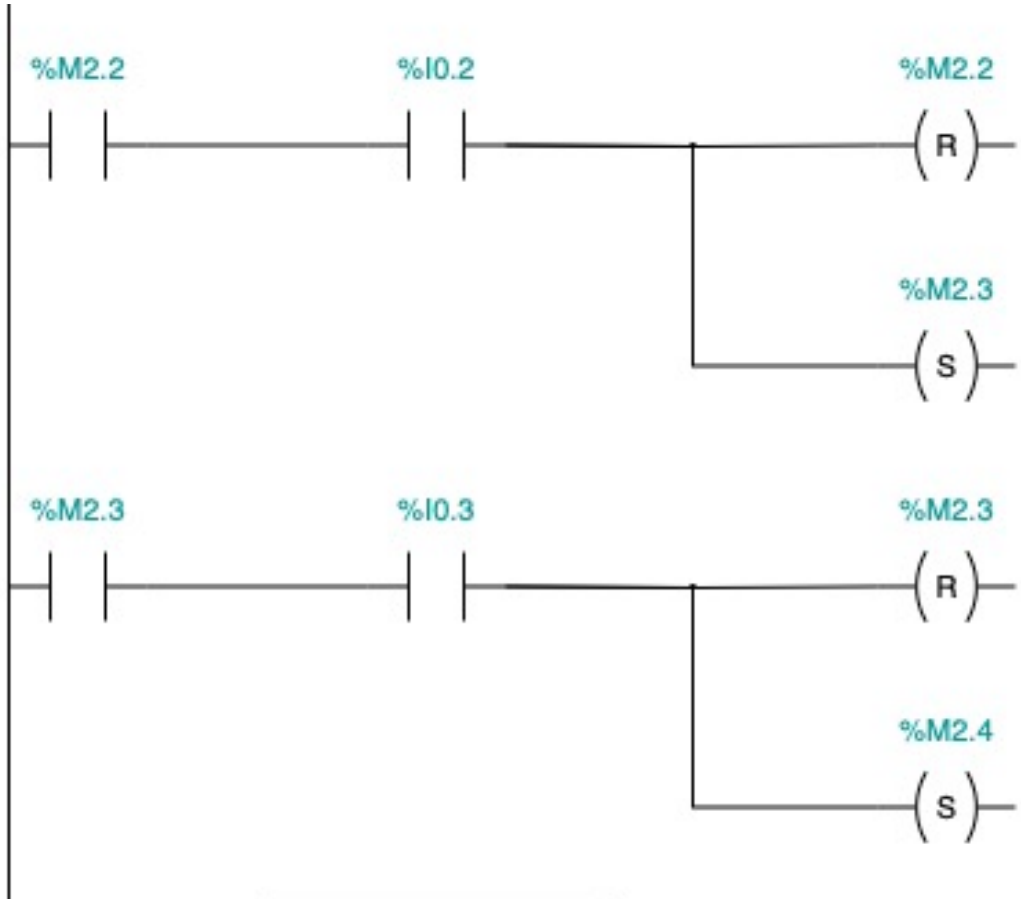


Figure: State Machine - Ladder diagram part 2

Ladder Diagram
State Machine

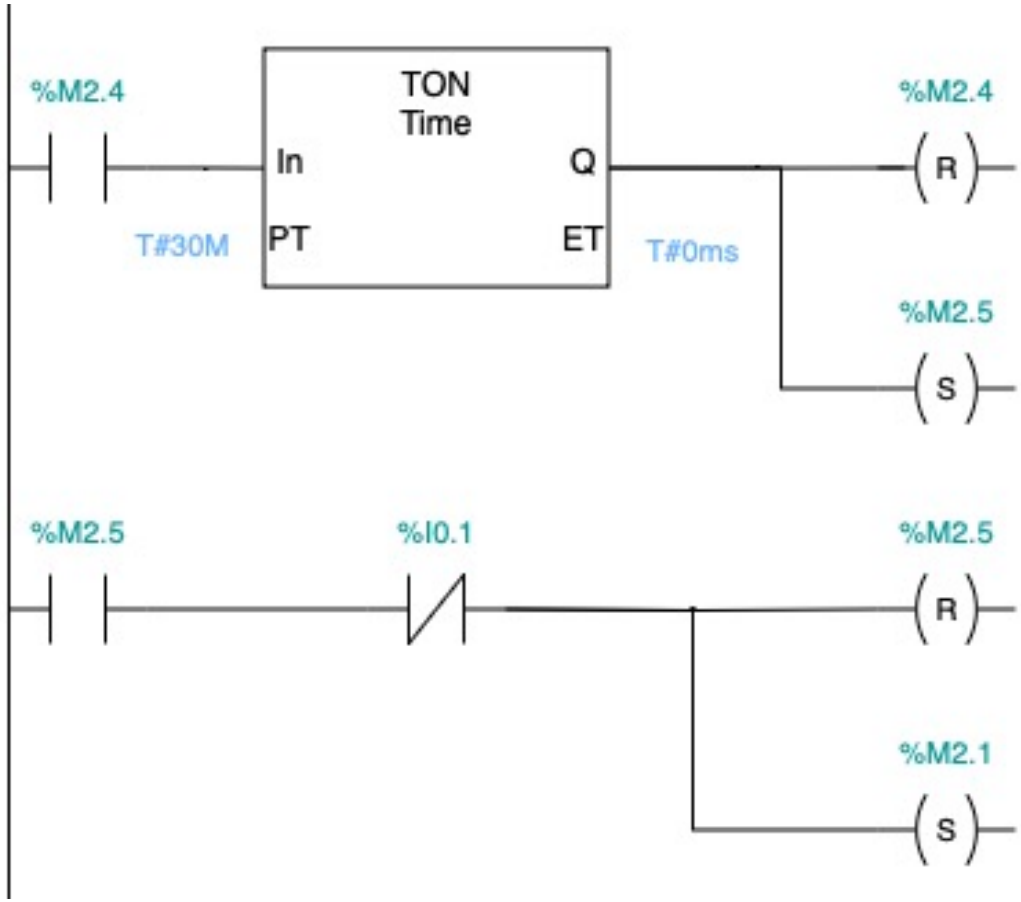


Figure: State Machine - Ladder diagram part 3

Ladder Diagram
State Machine

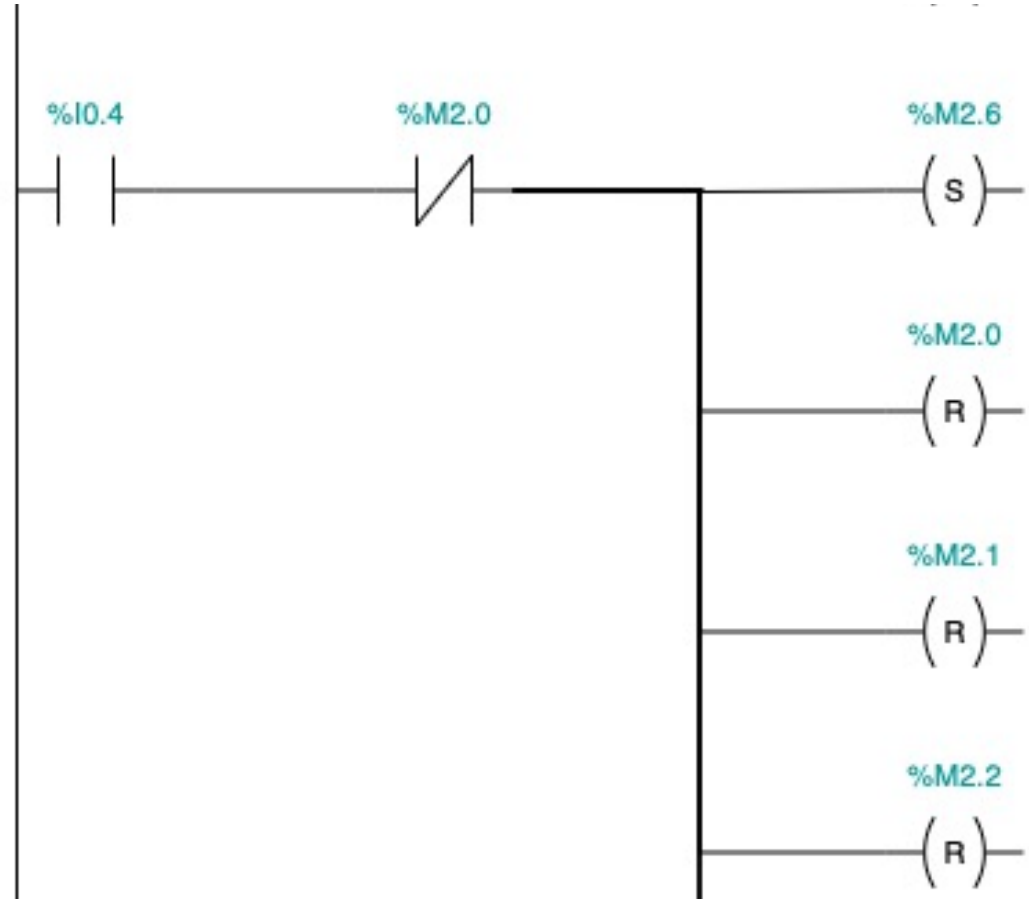


Figure: State Machine - Ladder diagram part 4

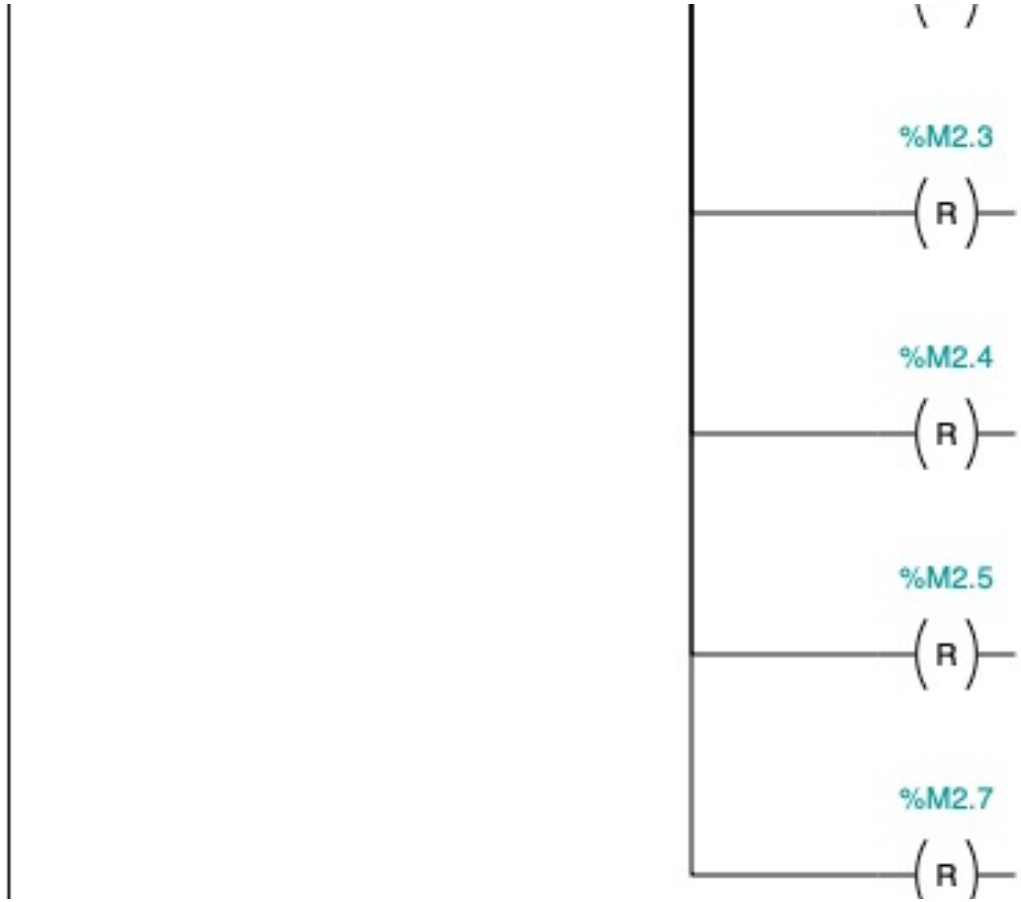


Figure: State Machine - Ladder diagram part 5

Ladder Diagram
State Machine

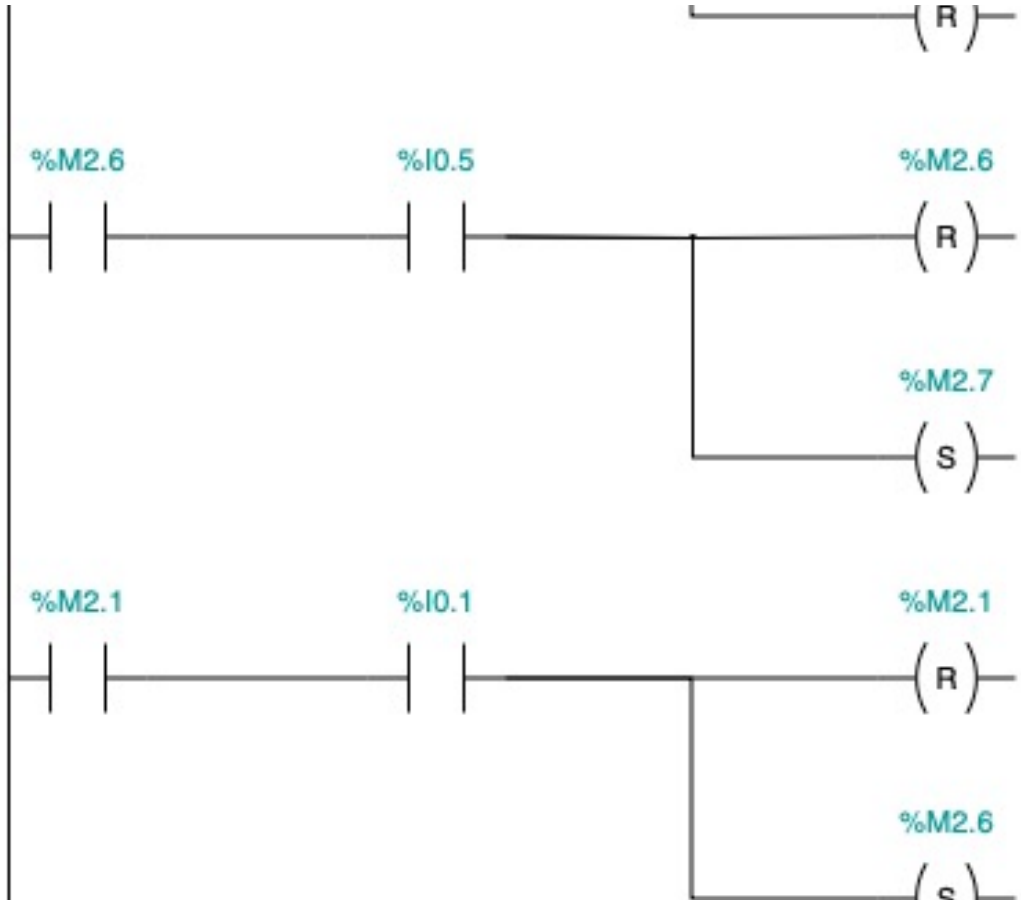


Figure: State Machine - Ladder diagram part 6

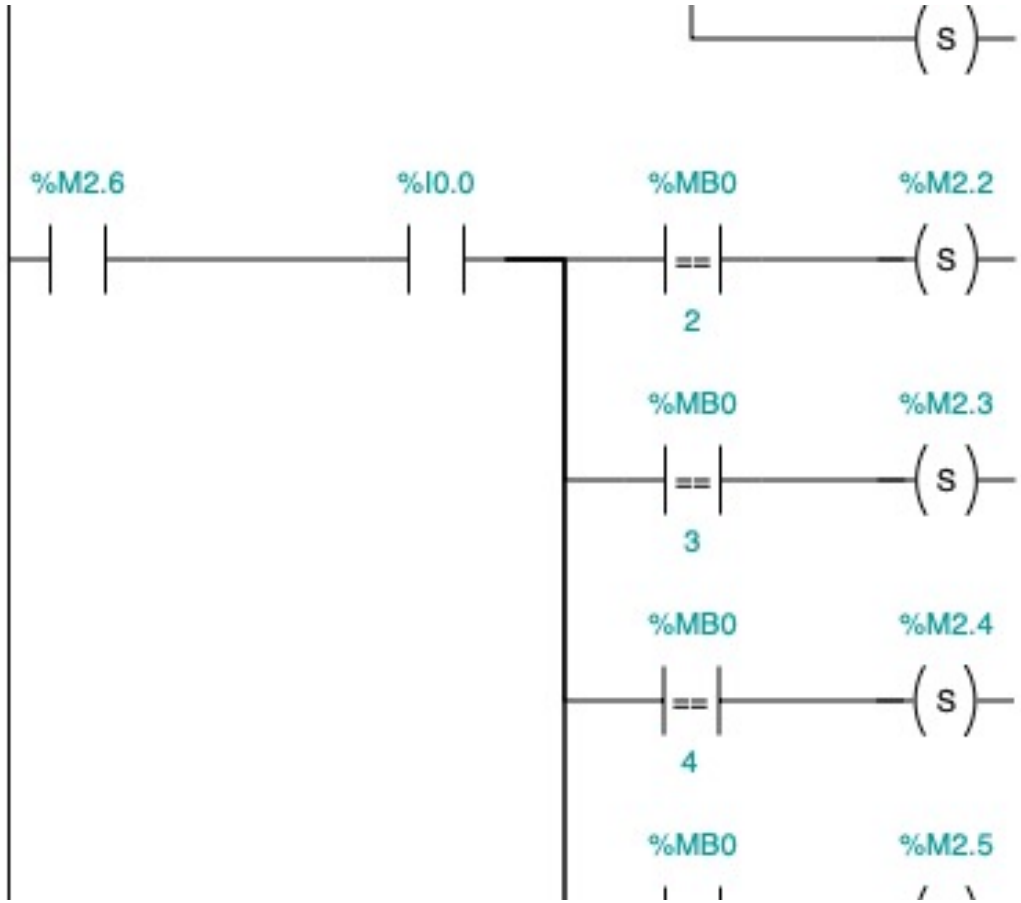


Figure: State Machine - Ladder diagram part 7

Ladder Diagram
State Machine

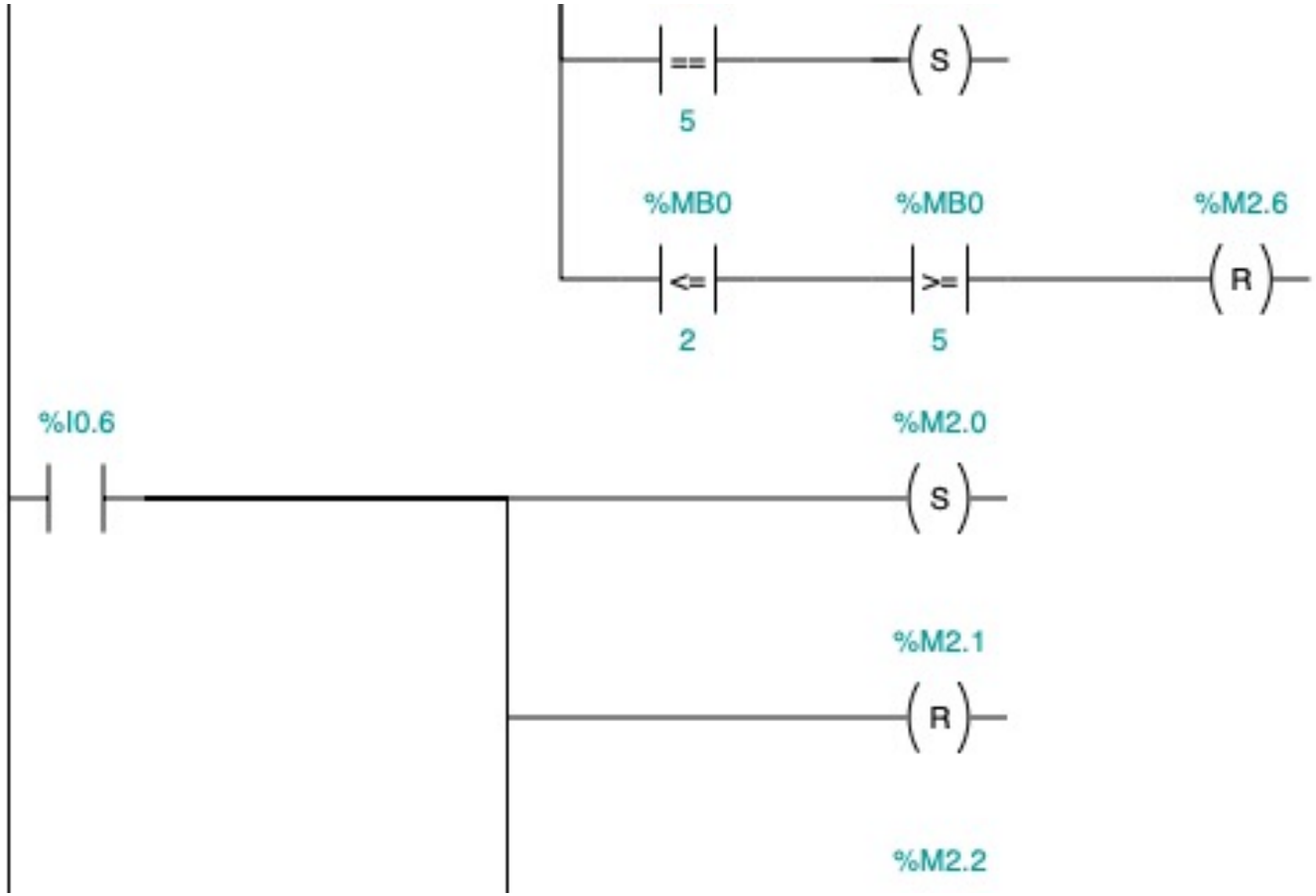


Figure: State Machine - Ladder diagram part 8

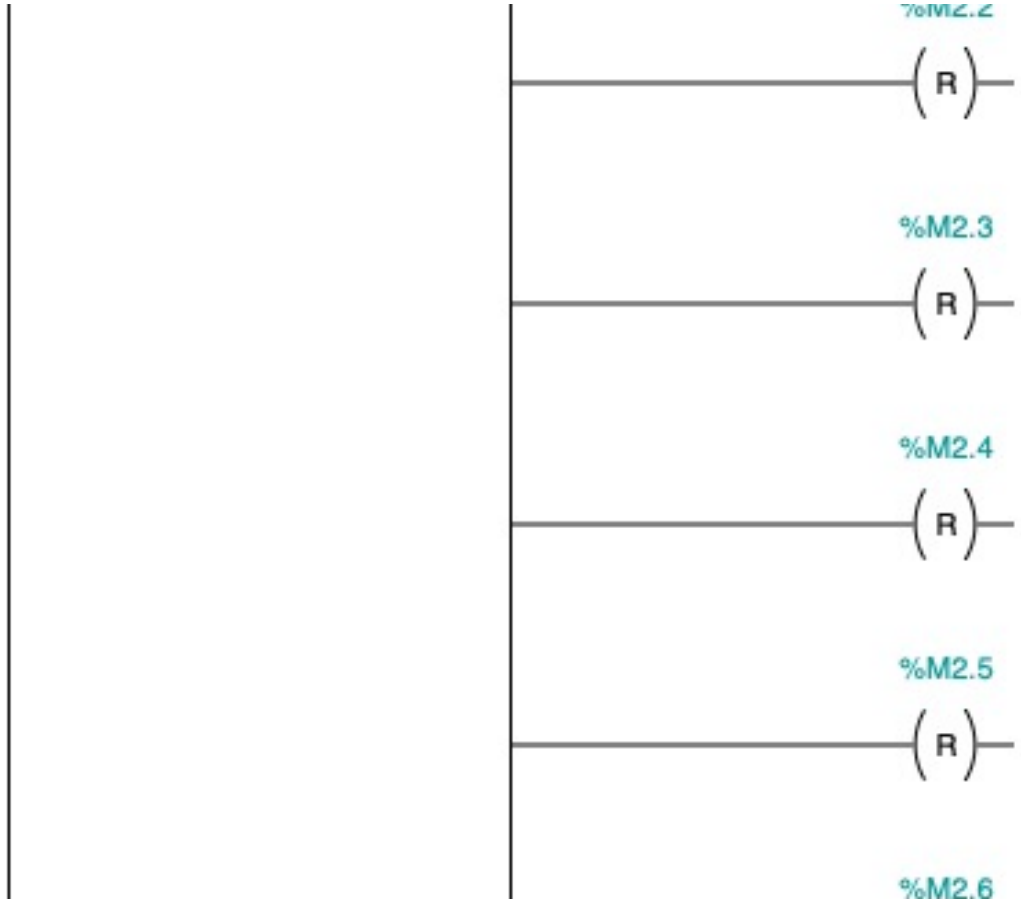


Figure: State Machine - Ladder diagram part 9

Ladder Diagram
State Machine

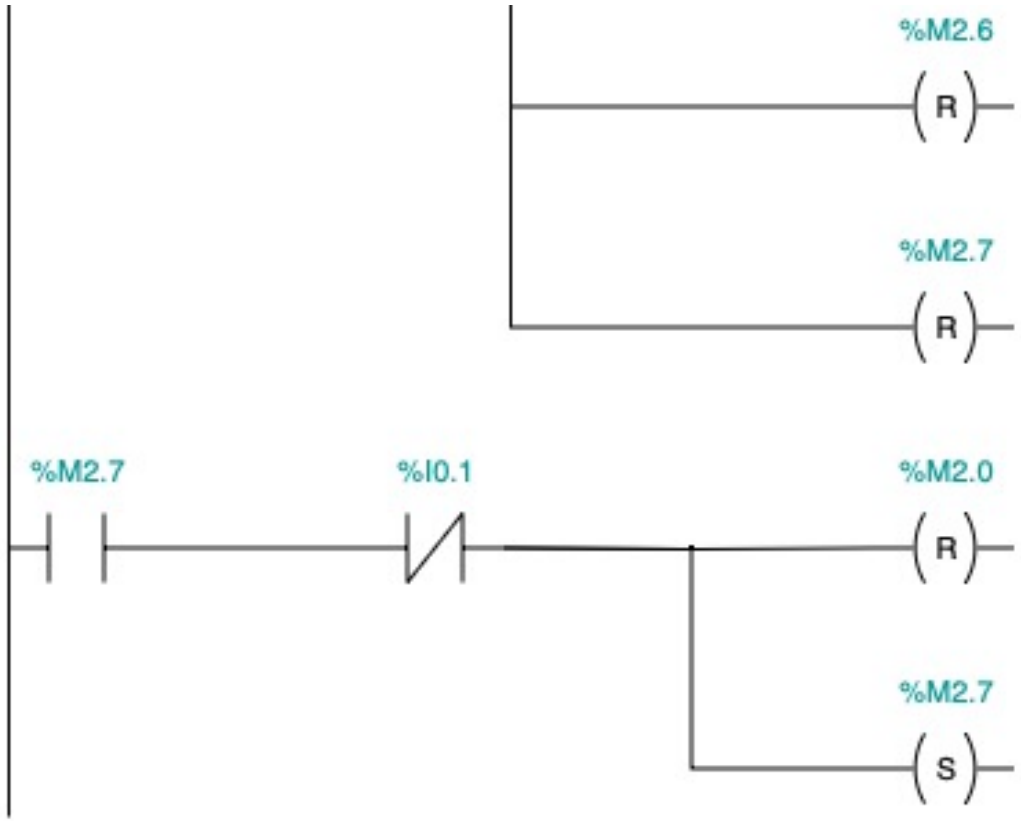


Figure: State Machine - Ladder diagram part 10

Ladder Diagram

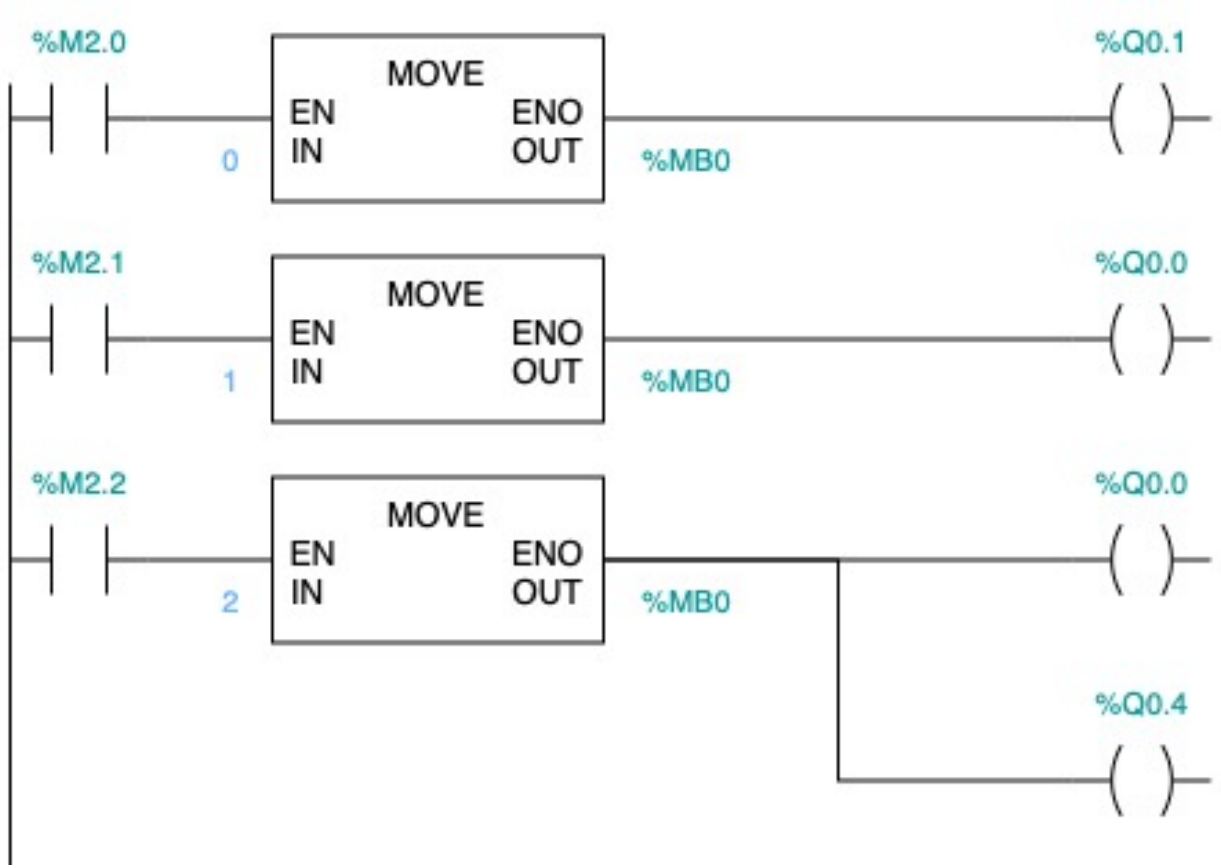


Figure: Busines Logic - Ladder diagram part 1

Ladder Diagram

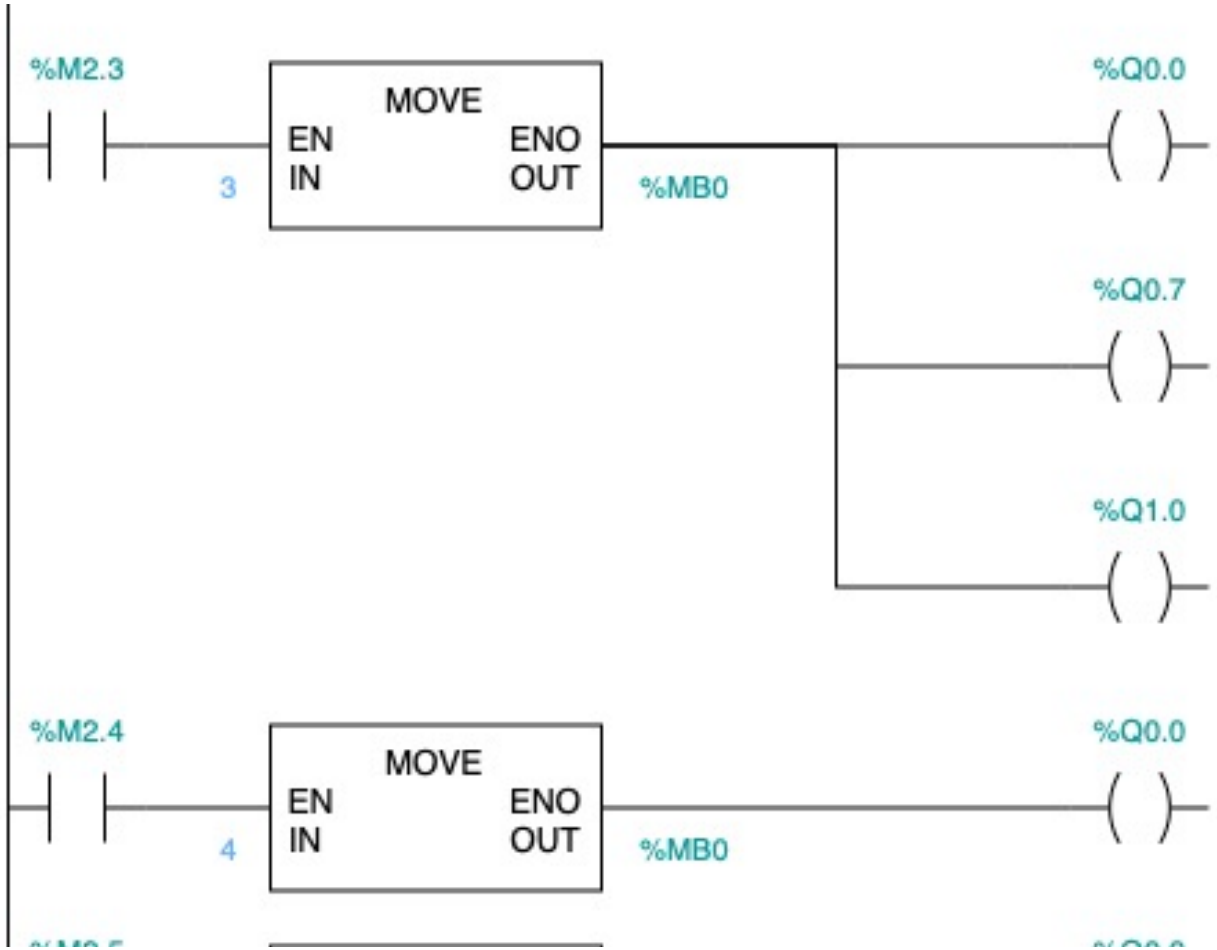


Figure: Busines Logic - Ladder diagram part 2

Ladder Diagram

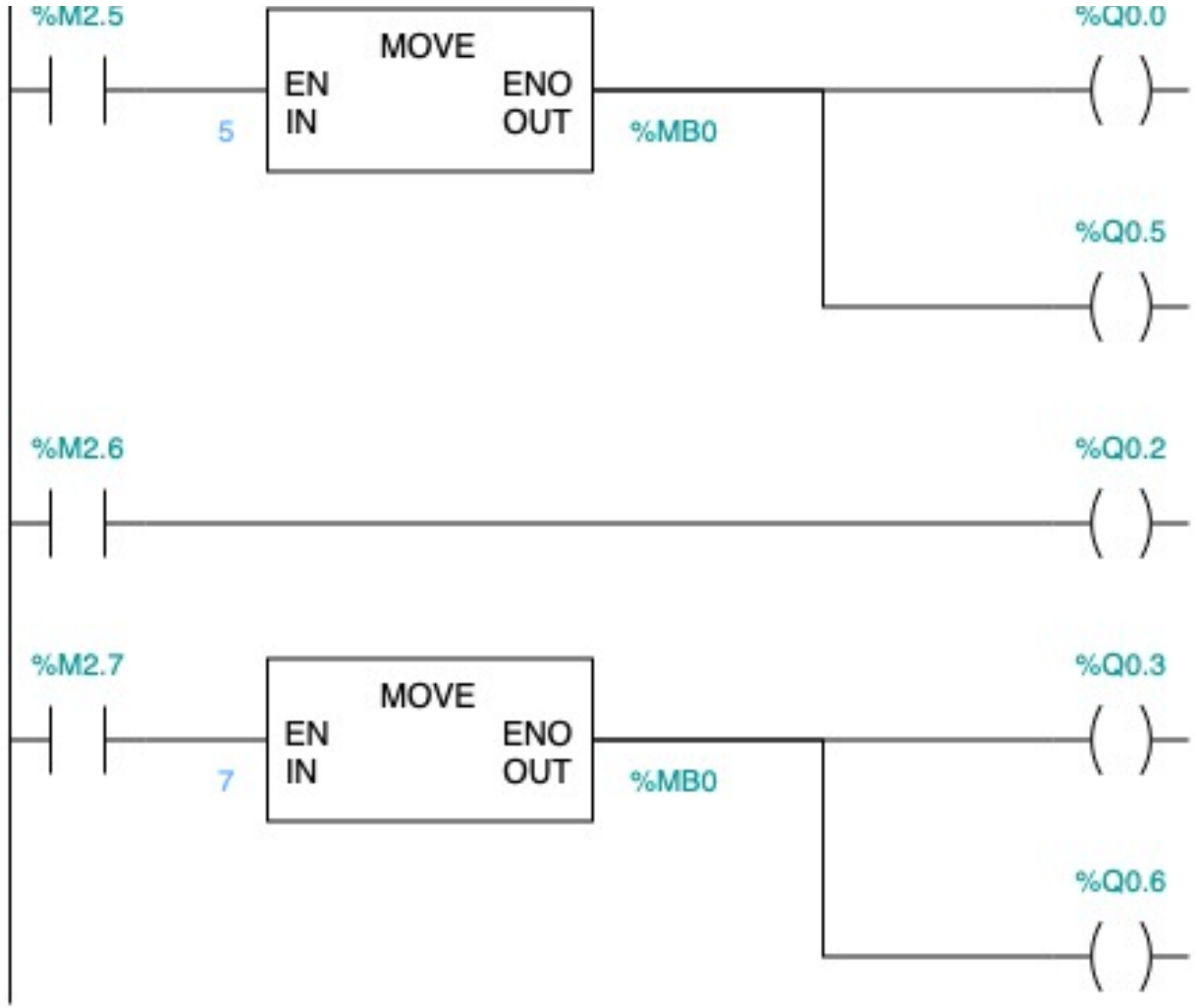


Figure: Busines Logic - Ladder diagram part 3

Components Choice

- **Water level sensors:** FST700-204 Modbus Capacitive Liquid Electronic Oil Level Sensor 198.54$ x2 $\approx$ 361.70€
- **Residual chlorine sensor:** Sensorex FCL502-MA 1293.88€
- **Industrial tank mixer:** Savino Barbera AN30 direct-drive mixer
- **Water pumps:** Savino Barbera OP125E horizontal pump
- **Chlorine pump:** Savino Barbera OA20 horizontal pump