Introduction

This document outlines the design and operational parameters of a three-floor elevator system, comprising the Ground Floor (GF), Floor 1 (F1), and Floor 2 (F2). The system is designed to provide efficient and safe vertical transportation, governed by predefined rules and facilitated by a network of lamps and switches.

Objective

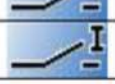
Design and implement an elevator system using Programmable Logic Controllers (PLCs) that efficiently manages transitions between three floors: Ground Floor (GF), Floor 1 (F1), and Floor 2 (F2). The system should intelligently handle elevator directions and door operations to provide a smooth and accessible experience.

In short, to design and implement a reliable and efficient three-floor elevator system that provides safe and smooth vertical transportation, while meeting the operational requirements and user needs.

Interface

The interface consists of:

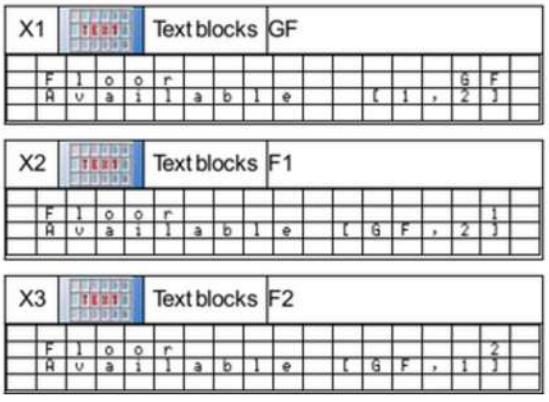
Physical inputs

No	Symbol	Function	Lock	Parameters	Location of (L/C)	Comment
I1		Discrete inputs	---	No parameters	(58/5)	F2_EXT_DOWN
I3		Discrete inputs	---	No parameters	(57/5)	F2_IN
I5		Discrete inputs	---	No parameters	(63/5)	S_Weight
I6		Discrete inputs	---	No parameters	(26/4) (48/1)	S_Infrared
I7		Discrete inputs	---	No parameters	(59/5)	F1_EXT_UP
I8		Discrete inputs	---	No parameters	(60/5)	F1_EXT_DOWN
I9		Discrete inputs	---	No parameters	(56/5)	F1_IN
IB		Discrete inputs	---	No parameters	(62/5)	SOS
IC		Discrete inputs	---	No parameters	(48/4) (50/4) (59/1)	ON
ID		Discrete inputs	---	No parameters	(61/5)	GF_EXT_UP
IF		Discrete inputs	---	No parameters	(55/5)	GF_IN

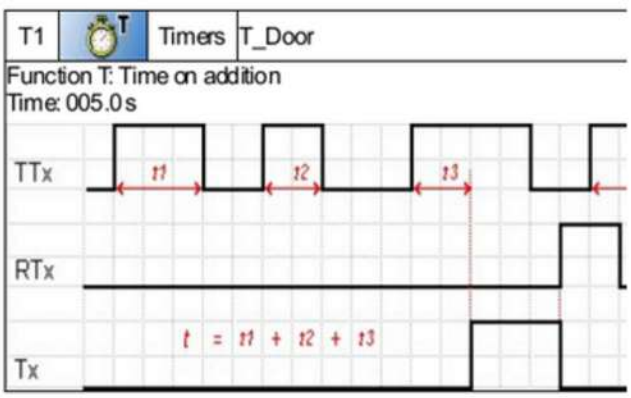
Physical outputs

No	Symbol	Function	Latching	Location of (L/C)	Comment
Q1		Discrete outputs	No	(4/6) (21/2) (41/3) (53/4) (58/2) (58/6)	F2 DOWN
Q2		Discrete outputs	No	(8/6) (9/3) (29/6) (33/1) (46/1)	Motor_UP
Q3		Discrete outputs	No	(6/6) (16/3) (46/4)	F2 Door CLOSED
Q4		Discrete outputs	No	(4/1) (6/1) (15/2) (21/6) (22/1) (28/1) (43/1) (49/3)	F2 Door OPENED
Q5		Discrete outputs	No	(16/4) (63/6)	S_Weight
Q6		Discrete outputs	No	(48/6)	S_Infrared
Q7		Discrete outputs	No	(2/6) (41/5) (55/2) (59/6) (61/2)	F1 UP
Q8		Discrete outputs	No	(3/6) (24/2) (42/5) (56/2) (60/6) (62/2)	F1 DOWN
Q9		Discrete outputs	No	(5/6) (16/2) (46/3)	F1 Door CLOSED
QA		Discrete outputs	No	(2/1) (3/1) (5/1) (12/4) (14/2) (24/6) (25/1) (27/1) (42/1) (48/3) (51/1)	F1 Door OPENED
QB		Discrete outputs	No	(26/5) (45/1) (49/1) (50/6)	SOS
QC		Discrete outputs	No	(34/6)	Motor_ON
QD		Discrete outputs	No	(1/6) (18/2) (43/3) (61/6) (63/2)	GF UP
QE		Discrete outputs	No	(8/3) (9/6) (31/6) (34/1) (39/1) (47/1)	Motor_DOWN
QF		Discrete outputs	No	(7/6) (16/1) (46/2)	GF Door CLOSED
~~QG~~		~~Discrete outputs~~	~~No~~	(1/1) (7/1) (12/2) (13/4) (18/6) (19/1) (26/1) (41/1) (47/3)	~~GF Door OPENED~~

Text block

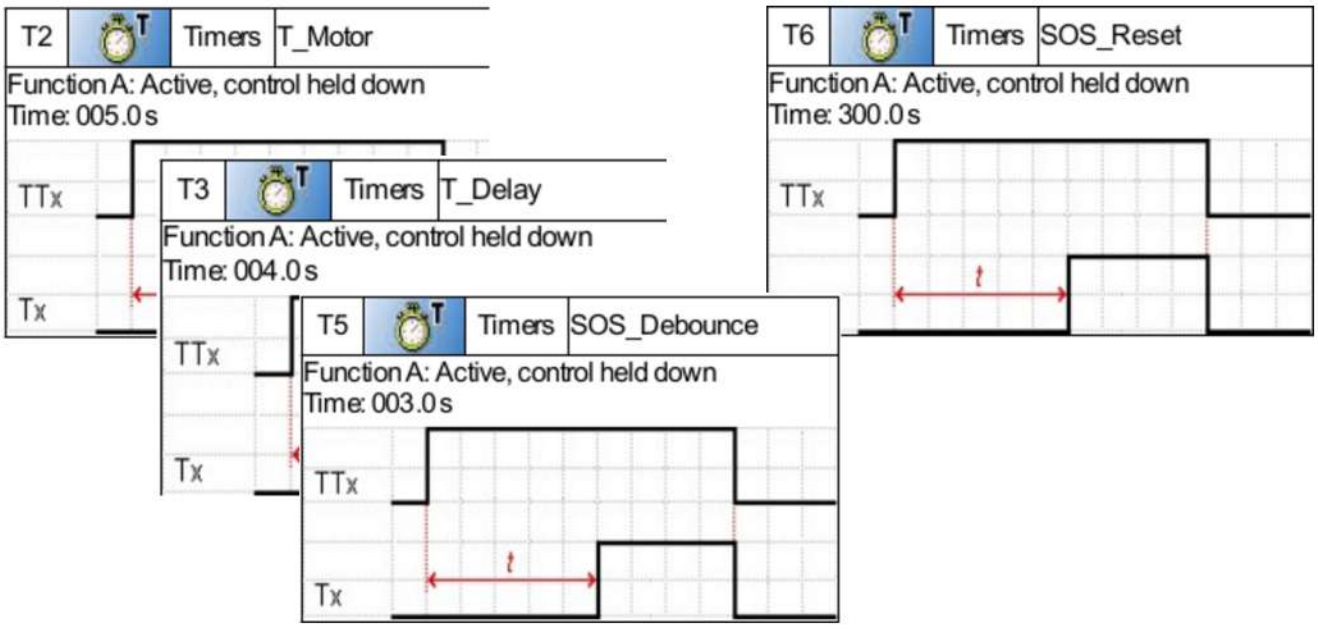


Timer

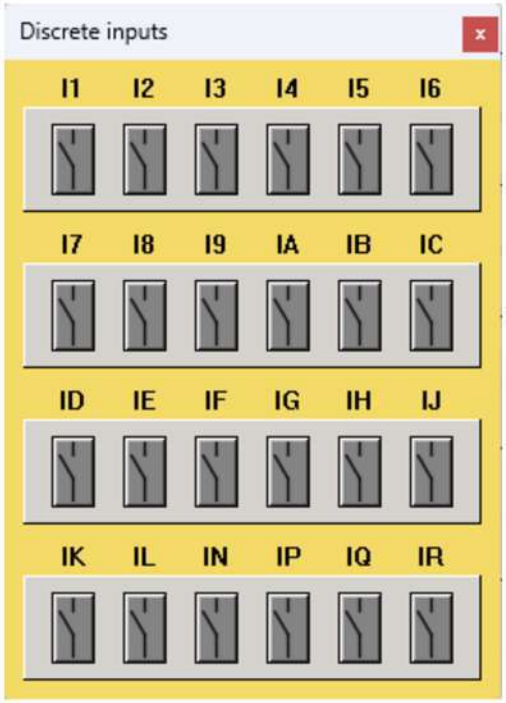


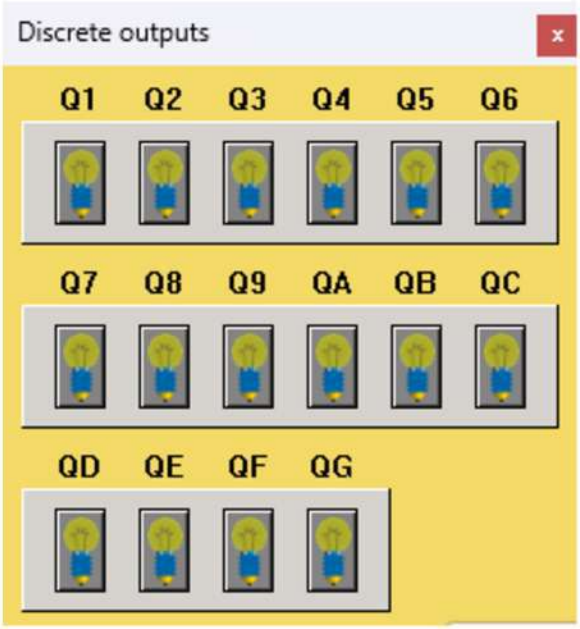
Configurable functions

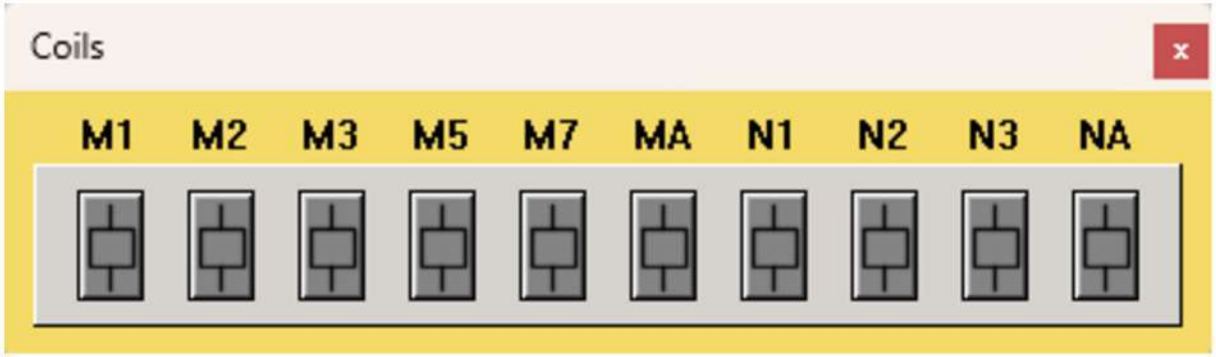
No	Symbol	Function	Lock	Latching	Parameters	Location of (L/C)	Comment
A1		Analog comparators	No	---	Ig <= 8.0	(26/3)	
C1		Counters	No	No	Value to attain: 8 Pulses Output ON when the preset value is reached	(36/6) (39/6)	Floor
M1		Auxiliary relays	---	No	No parameters	(12/6) (17/2) (42/3) (55/6) (64/2)	GF_IN
M2		Auxiliary relays	---	No	No parameters	(13/6) (23/2) (40/5) (43/5) (54/2) (56/6) (60/2)	F1_IN
M3		Auxiliary relays	---	No	No parameters	(15/6) (20/2) (40/3) (52/4) (57/2) (57/6)	F2_IN
M5		Auxiliary relays	---	No	No parameters	(24/3) (53/6)	UP_Priority
M7		Auxiliary relays	---	No	No parameters	(53/5)	
MA		Auxiliary relays	---	No	No parameters	(37/6) (40/2) (51/6)	F1_elevator
N1		Auxiliary relays	---	No	No parameters	(8/1) (29/1) (30/2) (40/4) (53/1) (54/6)	Elevator_UP
N2		Auxiliary relays	---	No	No parameters	(9/1) (31/1) (32/2) (42/4) (64/6)	Elevator_DOWN
N3		Auxiliary relays	---	No	No parameters	(33/3) (44/6)	Elevator_STOP
NA		Auxiliary relays	---	No	No parameters	(13/1) (16/6)	M_1
T1		Timers	No	No	See details below	(10/1) (10/6) (18/5) (21/5) (24/5) (26/6)	T_Door
T2		Timers	No	No	See details below	(33/6) (35/1) (35/6)	T_Motor
T3		Timers	No	No	See details below	(18/4) (21/4) (24/4) (40/6) (44/1) (46/6) (52/2)	T_Delay
T5		Timers	No	No	See details below	(50/1) (62/6)	SOS_Debounce
T6		Timers	No	No	See details below	(49/6) (50/3)	SOS_Reset
V1		Counter comparators	No	---	C1 + 0 = 0	(12/1) (13/3) (18/1) (26/2) (32/1) (54/1) (57/1)	GF
V2		Counter comparators	No	---	C1 + 0 = 1	(11/1) (12/3) (14/1) (24/1) (27/2) (37/5) (40/1) (52/1) (58/1) (64/1)	F1
V3		Counter comparators	No	---	C1 + 0 = 2	(15/1) (21/1) (28/2) (30/1) (60/1) (63/1)	F2
X1		Text blocks	---	---	See details below	(32/6)	GF
X2		Text blocks	---	---	See details below	(11/6)	F1
X3		Text blocks	---	---	See details below	(30/6)	F2



In the simulation, every input is depicted as a switch, and each output is symbolized by a light bulb. The push button is characterized as Zx Keys. Similarly, counter values and coil states are illustrated below.

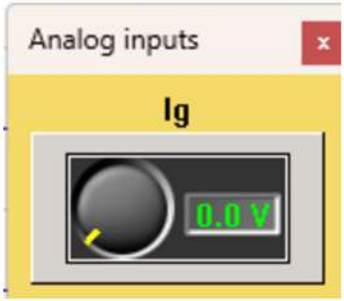






Function blocks

No	Function	Label	Type	Preset	Comment
001	Timer	T1	T: Active time	T1 = 005.0 S	T_Door
002	Timer	T2	A: Active, con	T2 = 005.0 S	T_Motor
003	Timer	T3	A: Active, con	T3 = 004.0 S	T_Delay
004	Timer	T5	A: Active, con	T5 = 003.0 S	SOS_Debounce
005	Timer	T6	A: Active, con	T6 = 300.0 S	SOS_Reset
006	Counters	C1	Output ON wh	C1 = 00008	Floor
007	Analog	A1	5: Ig <= 8.0	R = 8.0V	
008	Counter compa	V1	C1 + 0 = 0		GF
009	Counter compa	V2	C1 + 0 = 1		F1
010	Counter compa	V3	C1 + 0 = 2		F2
011	Text block	X1			GF
012	Text block	X2			F1
013	Text block	X3			F2



Components

This design uses the following components:

1. Programmable Logic Controller (PLC)

- Why: *Main controller for handling elevator logic, sensor inputs, and motor/door control.*
- Model: *Siemens S7-1200 or Allen-Bradley MicroLogix 1400*
- Price: *$400-$800*

2. Motor and Variable Frequency Drive (VFD)

- Why: *Provides smooth and adjustable control of elevator motor speed for comfort and safety.*
- Model: *ABB ACS355 VFD*
- Price: *$500-$1,000*

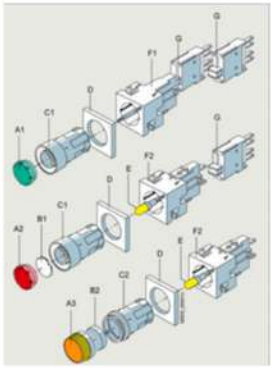
3. Position Sensors (Limit Switches/Proximity Sensors)

- Why: *Detects elevator car position at each floor for precise stopping.*
- Model: *Omron D4C-1620*
- Price: *$30-$50 per switch*

Components

This design uses the following components:

4. Floor Selection Buttons and Indicator Lights



- Why: *Allows floor selection and displays elevator status to passengers.*
- Model: *Siemens SIRIUS Pushbuttons and LED indicators*
- Price: *$10-$20 per button/light*

5. Safety Relays and Emergency Stop Button

- Why: *Ensures emergency stops for safety and power cutoff.*
- Model: *Pilz PNOZ X3 Safety Relay*
- Price: *$100-$200*

6. Door Actuator and Control Module

- Why: *Controls door opening and closing securely when the elevator reaches a floor.*
- Model: *Panasonic GM Series Door Operator*
- Price: *$200-$400*

Methodology

Operation Summary
General Operation:

- Elevator responds to push button inputs for each floor.
- Doors open and stay open for 5 seconds if no obstacle is detected.
- If the infrared sensor detects an obstacle, the door remains open until it is cleared, and the timer resumes for the remaining time.

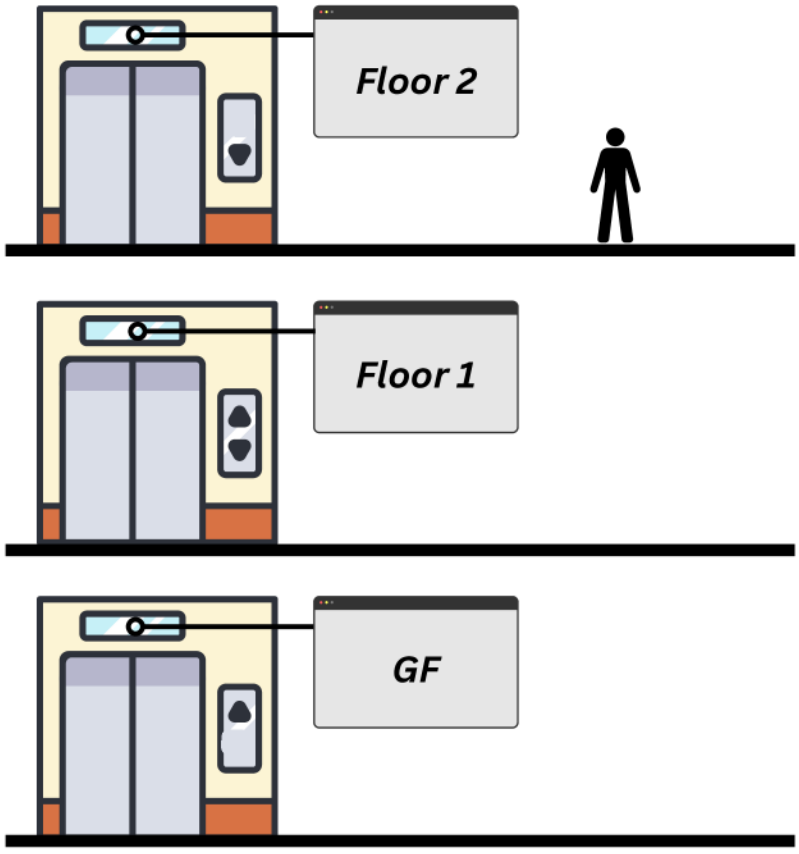


Figure not up to scale.

Inside the Elevator:

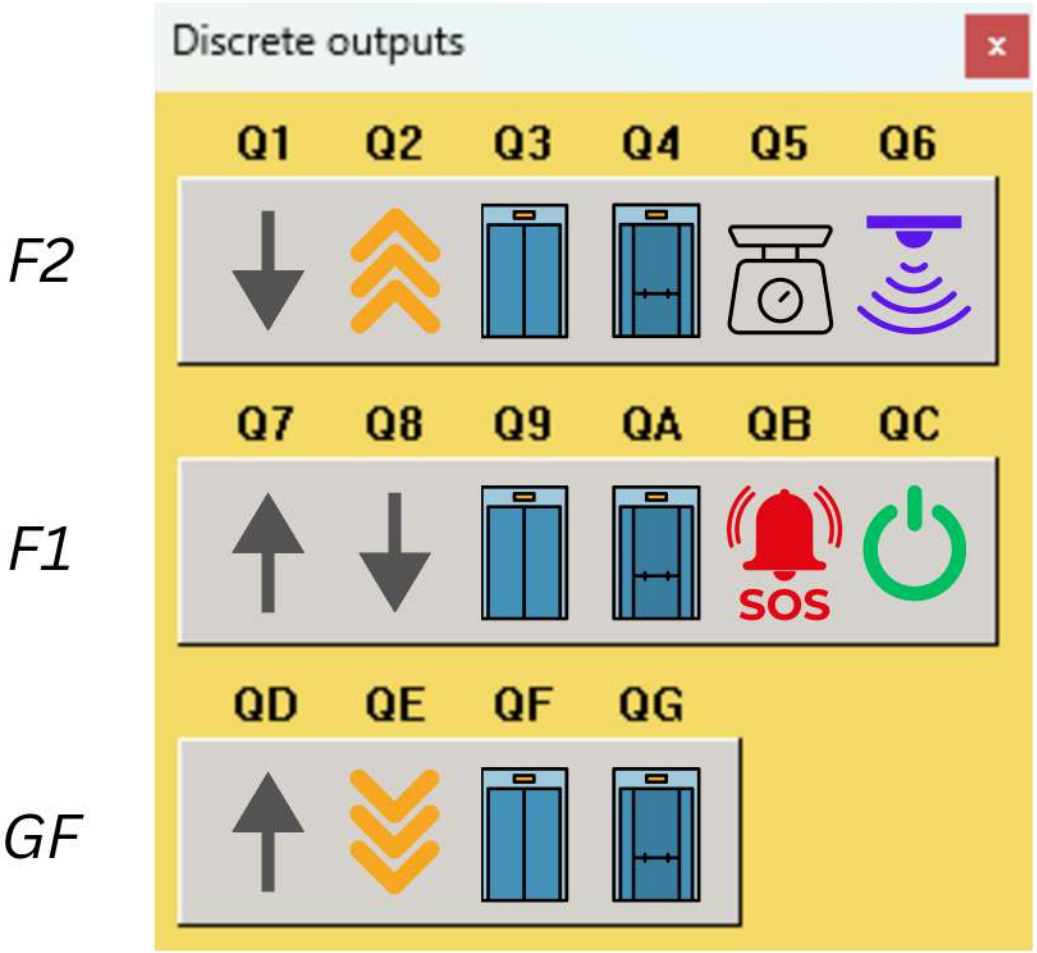
- Elevator moves only if the door is closed and the weight sensor indicates a load inside.
- If an internal button is pressed without a weight detected, the button's relay resets automatically.

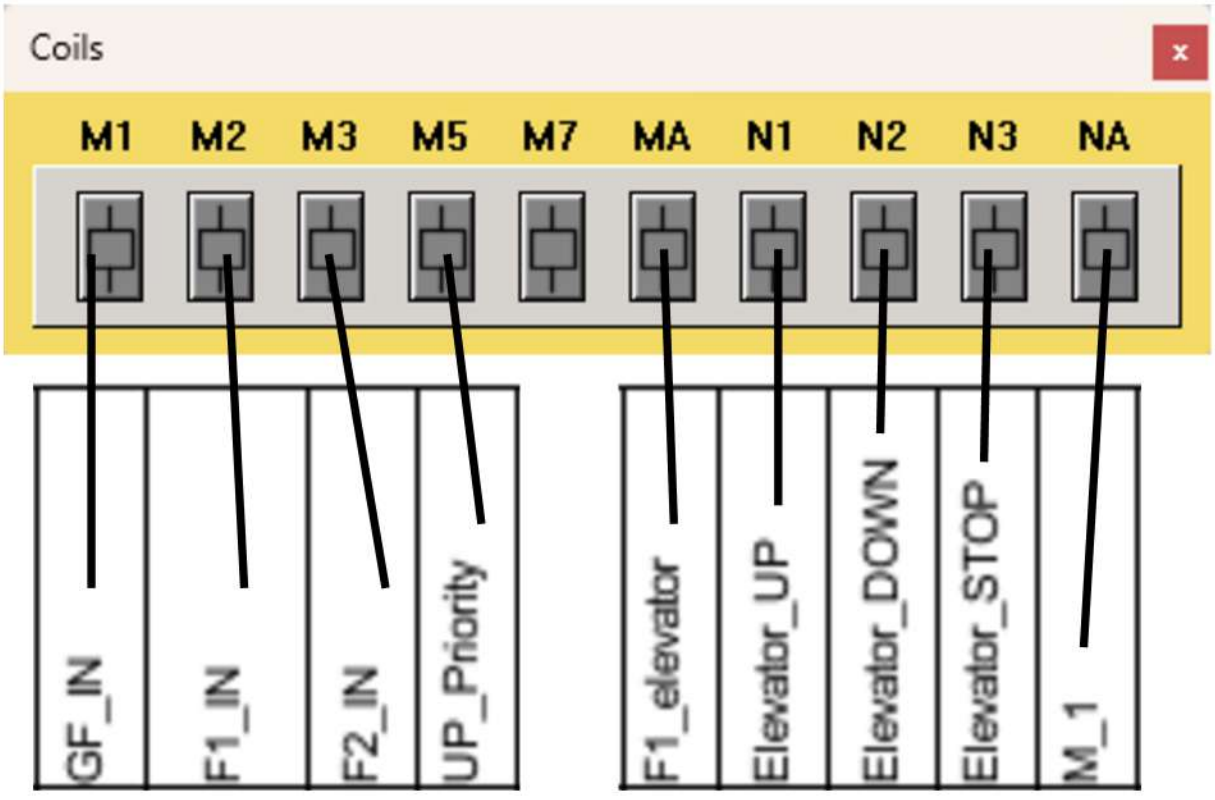
Priorities:

- Up and Down Priority: If moving up, the elevator completes upward travel before responding to down requests. Similar priority applies for internal buttons, where the elevator finishes its current direction before switching.
- Dual Button Press at Floor 1: If both up and down buttons are pressed, the elevator prioritizes the direction requested by the first-pressed internal button.

PLC Interface

The outputs that will be controlled are as follows:

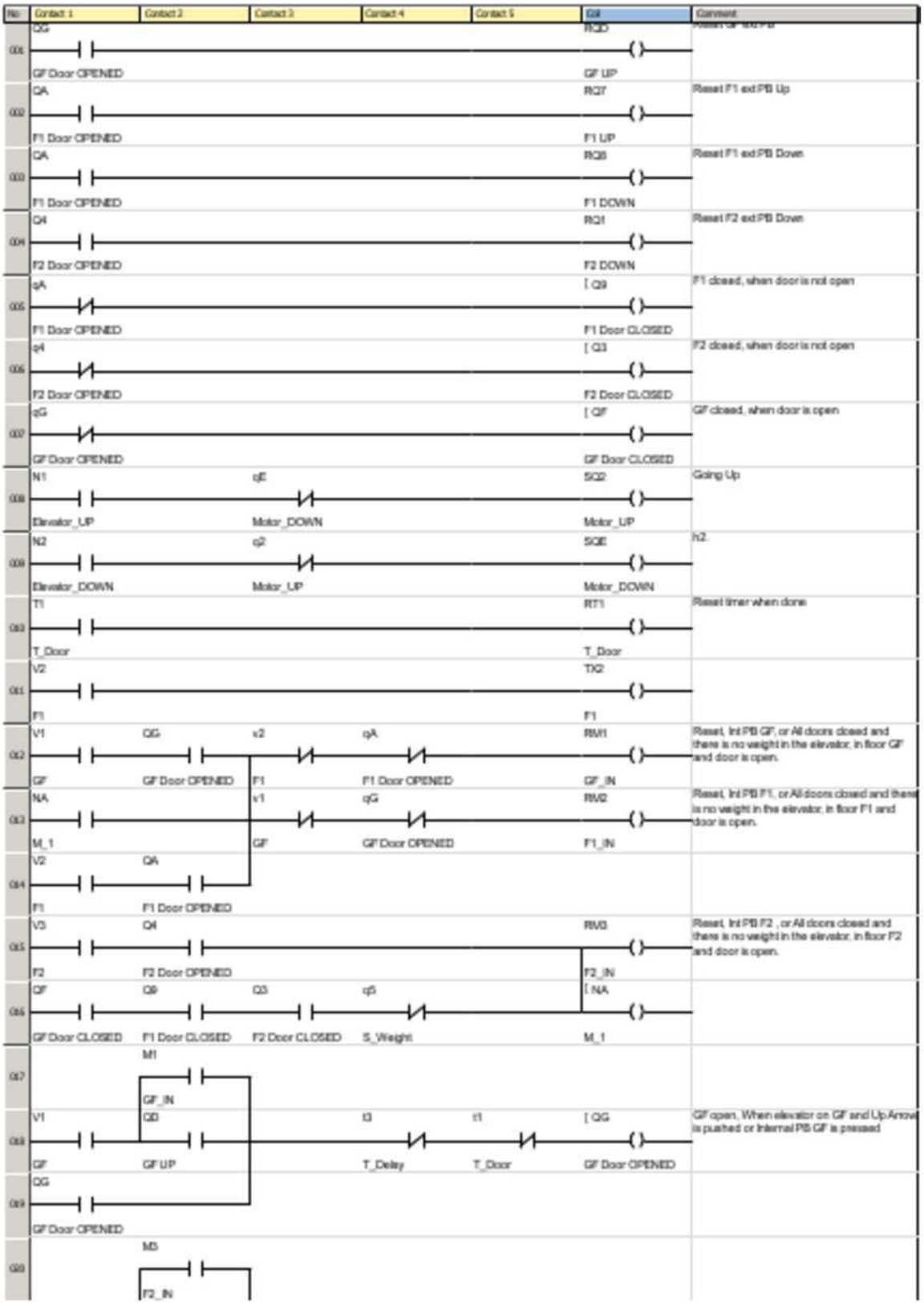


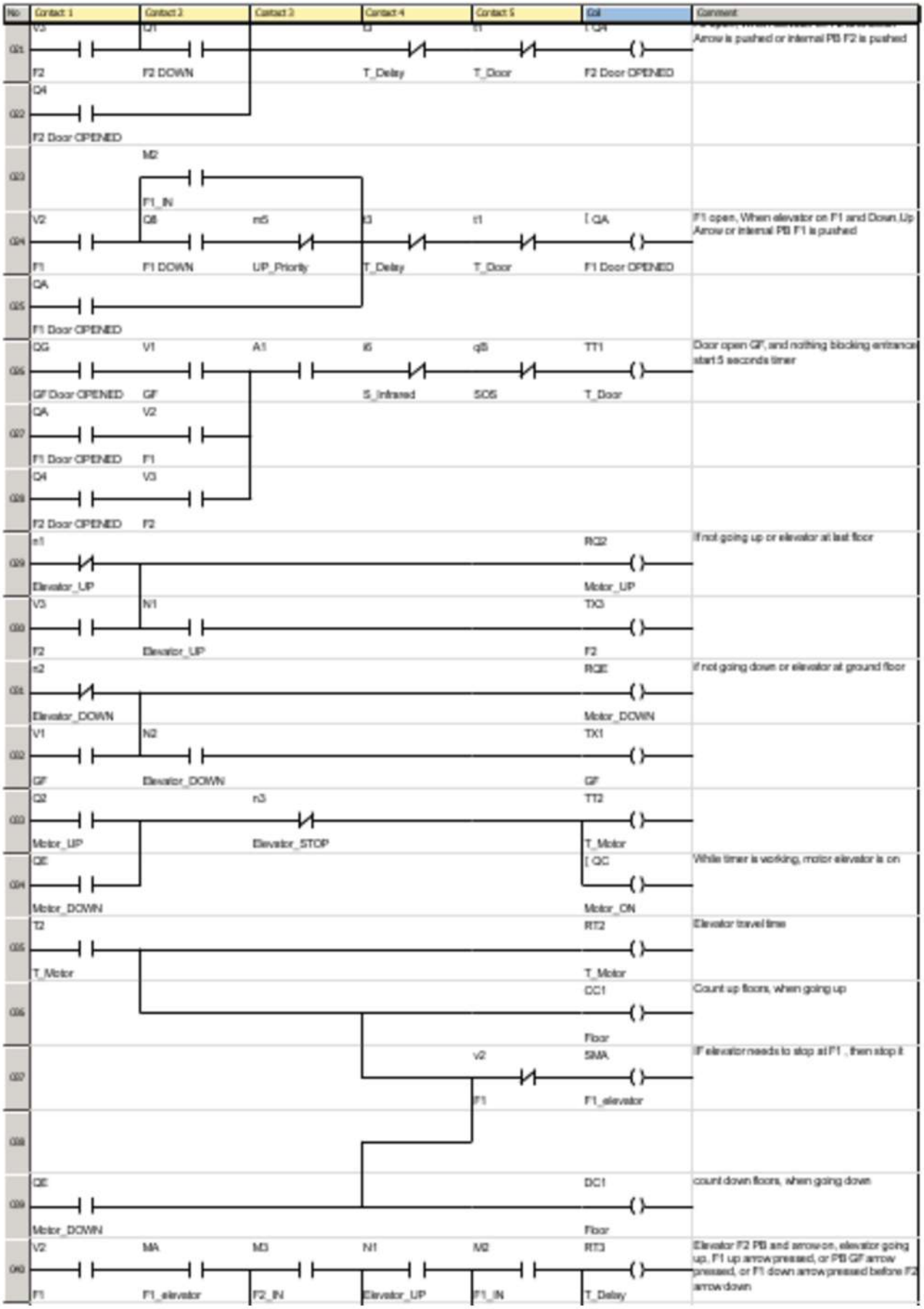


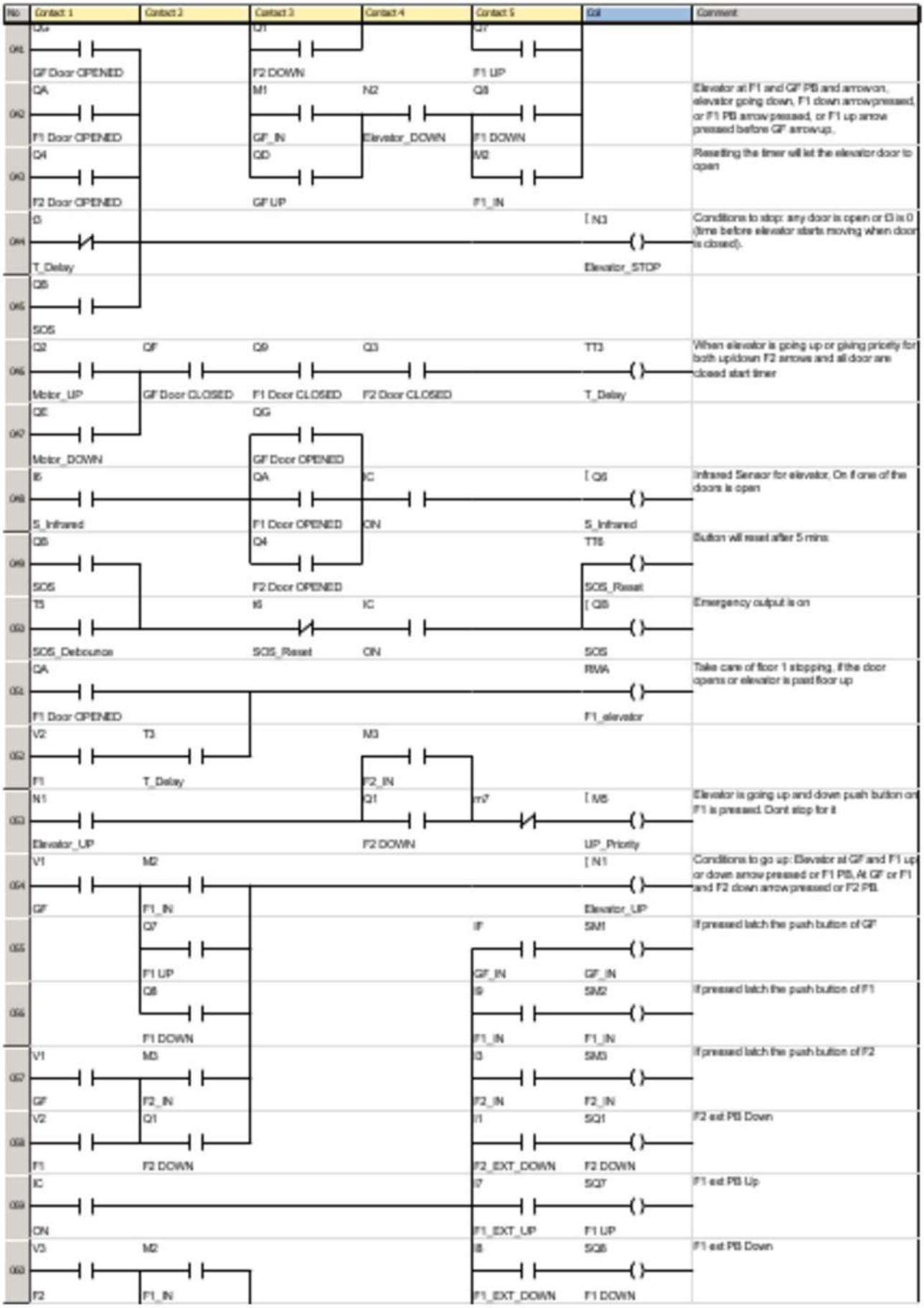
The System:

Below is the system design that fulfills the objective and focuses on all the scenarios listed.

Program diagram




No
Contact 1
Contact 2
Contact 3
Contact 4
Contact 5
Coil
Comment
Q1
V3
Q1
I3
I1
[QA
Arrow is pushed or internal PB F2 is pushed
F2
F2 DOWN
T_Delay
T_Door
F2 Door OPENED
Q2
Q4
F2 Door OPENED
Q3
M2
F1_IN
Q4
V2
Q8
m5
I3
I1
[QA
If1 open, When elevator on F1 and Down Up Arrow or internal PB F1 is pushed
F1
F1 DOWN
UP_Priority
T_Delay
T_Door
F1 Door OPENED
Q5
QA
F1 Door OPENED
Q6
QG
V1
A1
I6
q8
TT1
Door open GF, and nothing blocking entrance start 5 seconds timer
GF Door OPENED
GF
S_Infrared
SO6
T_Door
Q7
QA
V2
F1 Door OPENED
F1
Q8
Q4
V3
F2 Door OPENED
F2
Q9
n1
RQ2
If not going up or elevator at last floor
Elevator_UP
Motor_UP
Q10
V3
N1
TX3
F2
Elevator_UP
F2
Q11
n2
RQE
If not going down or elevator at ground floor
Elevator_DOWN
Motor_DOWN
Q12
V1
N2
TX1
GF
Elevator_DOWN
GF
Q13
Q2
n3
TT2
Motor_UP
Elevator_STOP
T_Motor
Q14
QE
[QC
While timer is working, motor elevator is on
Motor_DOWN
Motor_ON
Q15
T2
RT2
Elevator travel time
T_Motor
T_Motor
Q16
CC1
Count up floors, when going up
Floor
Q17
v2
SMA
If elevator needs to stop at F1 , then stop it
F1
F1_elevator
Q18
Q19
QE
DC1
count down floors, when going down
Motor_DOWN
Floor
Q40
V2
MA
M3
N1
M2
RT3
Elevator F2 PB and arrow on, elevator going up, F1 up arrow pressed, or PB GF arrow pressed, or F1 down arrow pressed before F2 arrow down
F1
F1_elevator
F2_IN
Elevator_UP
F1_IN
T_Delay


No
Contact 1
Contact 2
Contact 3
Contact 4
Contact 5
Coil
Comment
001
GF Door OPENED
F2 DOWN
F1 UP
002
F1 Door OPENED
GF_IN
Elevator_DOWN
F1 DOWN
Elevator at F1 and GF PB and arrow on, elevator going down, F1 down arrow pressed, or F1 PB arrow pressed, or F1 up arrow pressed before GF arrow up.
003
F2 Door OPENED
GF UP
F1_IN
Resetting the timer will let the elevator door to open
004
T_Delay
Elevator_STOP
Conditions to stop: any door is open or I3 is 0 (time before elevator starts moving when door is closed).
005
SOS
006
Motor_UP
GF Door CLOSED
F1 Door CLOSED
F2 Door CLOSED
T_Delay
When elevator is going up or giving priority for both up/down F2 arrows and all door are closed start timer
007
Motor_DOWN
GF Door OPENED
008
S_Infrared
F1 Door OPENED
ON
S_Infrared
Infrared Sensor for elevator. On if one of the doors is open
009
SOS
F2 Door OPENED
SOS_Reset
Button will reset after 5 mins
010
SOS_Debounce
SOS_Reset
ON
SOS
Emergency output is on
011
F1 Door OPENED
F1_elevator
Take care of floor 1 stopping, if the door opens or elevator is past floor up
012
F1
T_Delay
F2_IN
013
Elevator_UP
F2 DOWN
UP_Priority
Elevator is going up and down push button on F1 is pressed. Dont stop for it
014
GF
F1_IN
Elevator_UP
Conditions to go up: Elevator at GF and F1 up or down arrow pressed or F1 PB, At GF or F1 and F2 down arrow pressed or F2 PB.
015
F1 UP
GF_IN
If pressed latch the push button of GF
016
F1 DOWN
F1_IN
If pressed latch the push button of F1
017
GF
F2_IN
If pressed latch the push button of F2
018
F1
F2 DOWN
F2_EXT_DOWN
F2 DOWN
F2 ext PB Down
019
ON
F1_EXT_UP
F1 UP
F1 ext PB Up
020
F2
F1_IN
F1_EXT_DOWN
F1 DOWN
F1 ext PB Down

Estimated Price Breakdown

- PLC: $400 - $800
- Motor and VFD: $500 - $1,000
- Position Sensors (3 floors): $90 - $150
- Floor Buttons & Lights (3 floors): $60 - $120
- Safety Relay & Emergency Stop: $100 - $200
- Door Actuator: $200 - $400
- Power Supply: $50 - $150

- **Total Cost: $1,400 - $2,820**

Additional Suggestions

1. **Floor Arrival Announcements:**

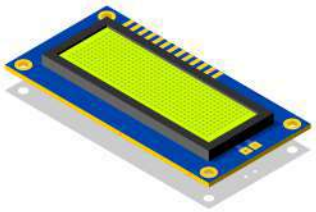
- Enhancement: Install a voice announcement system that announces the floor number as the elevator arrives.
- Reason: This is beneficial for visually impaired users and enhances accessibility.

2. **Accessibility Features:**

- Enhancement: Ensure all buttons and displays are at accessible heights for individuals with disabilities.
- Reason: This ensures inclusivity for all users.

Key Features

- **Text Display LCD:** Installed on each floor and inside the elevator to indicate available floors and operational status.



- **Emergency Button:** Included for immediate stopping and user safety in case of an emergency.

- **Weight Limit Sensor:** Added to detect the presence of weight inside the elevator, ensuring safe operation.

- **Motor Warm-Up Time:** The elevator does not move immediately after the door closes, allowing the motor time to warm up for optimal performance.

Conclusion

The system is designed to be simple and efficient, with a straightforward sequence of states that minimizes complexity and reduces the risk of errors, making it easier to implement and maintain.