Lab 4

In this Lab, we will develop an algorithm and write the ladder diagram for the Mitsubishi FX1S PLC controlling the operation of the Feedback® 34-150 Elevator (Figure 1 in the Appendix illustrates the Elevator Module which we shall use).

Problem Statement:

Design Ladder Diagram that will automatically control the operation of the Elevator through two levels (first and top) using the level pushbuttons.
The elevator is initially at the bottom level and waits until either the level 4 car pushbutton is pressed or the level 4 elevator call pushbutton is pressed.
The elevator travels to the top floor with 60% speed, reducing its speed to 30% when approaching its destination, and then fully stops by activating the brake when it reaches its destination.
The car door is opened (for 5 seconds) and then closed. The elevator then waits until either level 1 car pushbutton is pressed or the level 1 elevator call pushbutton is pressed, which makes the elevator travel to its new destination (Level 1) according to the same rules. The above sequence is repeated infinitely.

Bonus Part

Design Full Elevator algorithm, assuming the Elevator is initialized at Level-1. The floor request handling algorithm is as follows:

Arrive at a floor sequence

The sequence of operations is to sense arrival, slow down and stop. The brake is then applied and the door opened. The steps are as follows:

- Poll the destination floor sensor to detect the approach signal.
- When the signal is received, reduce car speed to 30%.
- Poll the destination floor sensor to detect the arrival signal.
- When the signal is received, set the speed to zero and apply the brake.
- Sound the arrival bell.
- Turn off floor call LEDs.

- Turn off up/down arrow LEDs.
- Open the car door.

Depart from a floor sequence

The departure steps are as follows:

- Close the car door
- Set the motor direction
- Turn on the appropriate up/down arrow LEDs
- Release the brake
- Set the motor to the desired speed

Floor request handling algorithm

- Step 0: Poll for any requests (floor requests or car requests).
- Register first request (ignore any further requests).
- Turn on the floor acknowledge LED for the appropriate request switch.
- If not at correct floor:
    - Perform *"Depart from a floor sequence"*
    - Perform *"Arrive at a floor sequence"*
    - Allow passengers to leave/enter (time delay)

  Else:
    - Open door – Allow passengers – close door
- Step 1: Poll only the car floor request for the destination floor (register first request and ignore further requests).
- If no requests in certain specified time:
    - Go to Step 0

  Else:
    - Perform *"Depart from a floor sequence"*
    - Perform *"Arrive at a floor sequence"*
    - Allow passengers to leave/enter (time delay)
    - Go to Step 1

Appendix

General description

The 34-150 Elevator, shown in Fig. 1, provides an application of Programmable Logic Controllers (PLCs). The advanced features of the unit allows complex analog and discrete control techniques to be developed (we will focus on discrete control techniques in this Lab).

Fig. 1 - Feedback® 34-150 Elevator Trainer

Overview and basic features

The motorized elevator car can be controlled (using an external controller) to move between four floors in response to requests from call pushbuttons located at each floor and 'within' the elevator car (these buttons are located on an external panel). The car door is motorized so on arrival at a floor it can be opened to allow passengers to enter/leave. Logic sensors are located on each floor to indicate the presence of the car. These sensors also provide advance warning of arrival as the car approaches each floor to allow the car to be slowed prior to arriving at the destination floor.

The internal motor controller unit provides closed-loop motor speed and current control and ha both discrete and analog interfaces. This allows the elevator to be controlled by a basic PLC using only discrete I/O (a minimum of 16 inputs and 16 outputs) as a simple discrete output can be used to request a fixed car speed. More sophisticated control may be implemented if analog I/O is available, as the elevator interface provides signals for motor speed and current demand, motor speed feedback, car position feedback and mass of the car under static conditions. For example, the integral motor speed loop may be opened and an external controller may be used to implement the speed loop externally instead.

Visual indication of the position of the elevator car as it arrives at each floor is provided by LEDs on the front of the unit. Front panel LEDs in the shape of arrows are provided to indicate the direction of travel of the car. These LEDs must be driven by the PLC.

Drive Motor Management

The elevator car is raised and lowered by a DC Motor via a 200:1 gearbox which is coupled to a toothed drive sprocket (see Fig. 2). One end of a toothed drive belt is connected to the car and the other end is connected to a counterbalance weight which balances the car at about 40% load.

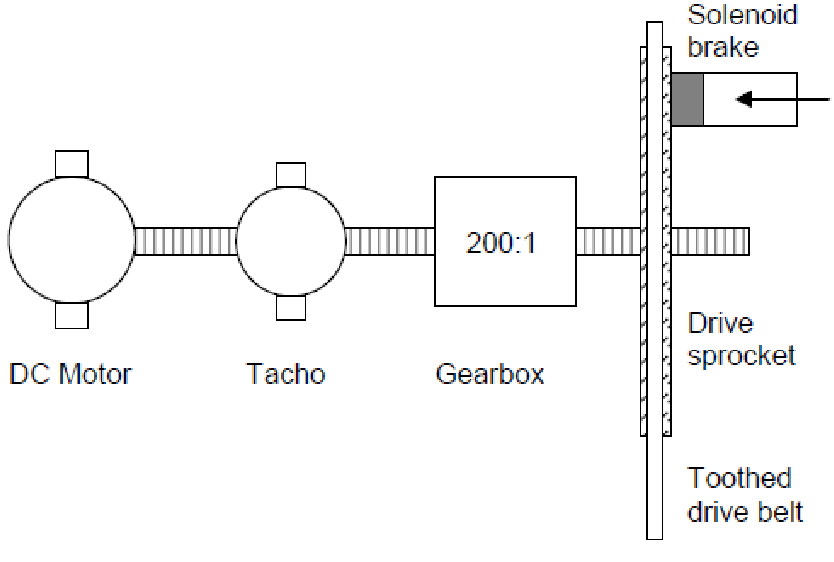

Fig. 2 - Drive Motor Arrangement

The motor is driven by a fully protected power amplifier with an integral current control so if the motor is stalled, current is limited to a safe maximum value. A mechanical brake (driven by a solenoid) operates on the motor so that the car can be held in position. The brake is normally applied when the brake release output is held low or left floating and also when the unit is unpowered. Driving the brake release output high releases the brake.

Integral speed and current control

A tacho is coupled to the motor and used to drive an integral closed-loop speed controller (see Fig. 3). The external speed demand can be in the form of a continuous analog signal or a fixed speed demand (e.g full speed, half speed). The tacho output is made available externally either for monitoring or control purposes. A changeover switch is incorporated into the control circuit (located on the elevator rear panel) to select between speed control and current control mode. By selecting the current position of this switch, the internal speed control loop is opened and a current demand may be input. In this case the speed control loop must be implemented using an external controller.

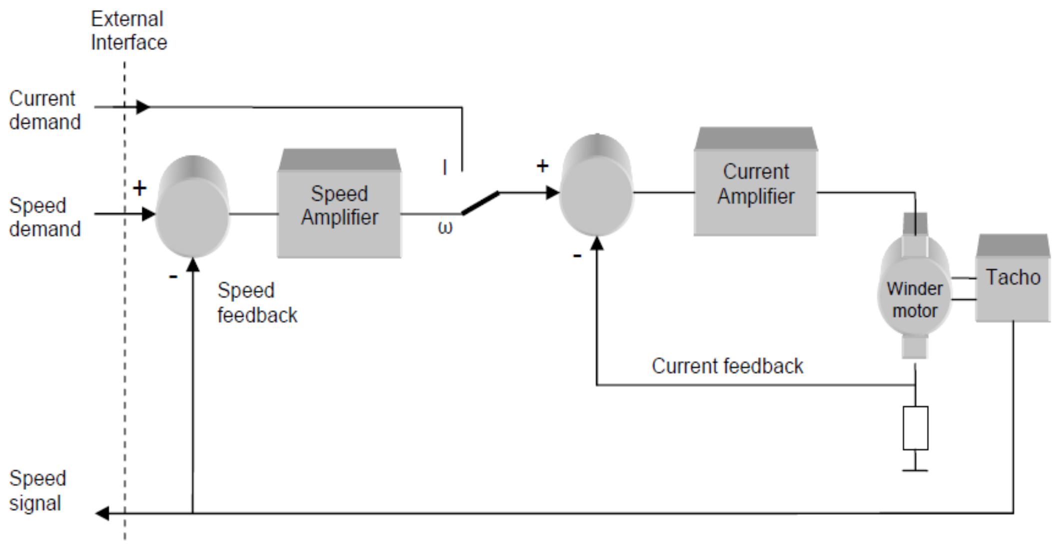

Fig. 3 - Integral speed and current control

Elevator car

The elevator car door is motorized and can be operated using the “door control” signal input. Taking this input high opens the door. Taking it low closes the door. The door motor is controlled by an internal circuit which responds to the door control input by opening or closing the door as required and then removes power from the door motor automatically. Microswitches detect the door status and “door open”/ “door closed” signals are made available at the rear panel for use by the PLC. Visual indication of the position of the elevator car as it arrives at each floor is provided by LEDs on the front of the unit. These LEDs are driven by the PLC. Front panel LEDs in the shape of arrows are also provided to indicate the direction of travel of the car. These LEDs must also be driven by the PLC.

Call pushbuttons

Elevator call pushbuttons are provided for each floor with separate up/down pushbuttons for Floor 2 and Floor 3. This enables the PLC to differentiate between requests for upward or downward travel. A separate set of floor request pushbuttons is provided on the front panel to represent the request pushbuttons inside the car.

Logic control

The elevator is designed so that it can be controlled using only discrete signals. In this case, the car movement can be controlled using a subset of five logic inputs: 100% speed, 60% speed, 30% speed, direction and brake release. Typically only two speeds will be used: 60% for 'full speed' and 30% when approaching a floor. At 100% speed the car travels at approximately 0.1 m/s and takes approximately 7 seconds to travel from Floor 1 to Floor 4.

The sequence of operations is as follows: the direction input should be set first to select the direction of travel (up or down), the brake is released then one of the speed inputs can be driven high to select the desired speed. The car will move with the commanded speed and direction. When it approaches a floor, the floor sensor signal will become active and this can be used by the external controller to slow the car by driving the 30% speed input. As the car continues towards the floor the floor sensor will go inactive. Once the car arrives at the floor, the floor sensor will become active again at which point the car should be stopped and the brake applied.

The car is prevented from traveling above Floor 4 or below Floor 1 by physical end-stops. Microswitches are triggered when the car reaches the end-stops which reduce the motor power amplifier output so the unit is protected. Front panel LEDs indicate when the travel limits have been reached.

A "manual" control is provided on the front panel which allows the car to be manually driven up and down at 60% speed (the brake is released automatically). This is particularly useful testing and debugging as it allows the car to activate all floor sensors in turn to check that they are being read correctly by the PLC.

Interface with external controller

The elevator is connected to the external controller via a set of connectors located on the rear panel as shown in Fig. 4. Table 1 shows the external signal connection summary. Tables 2 and 3 contain the connections between the Mitsubishi FX1S-PLC and the Elevator (PLC Inputs/Outputs).

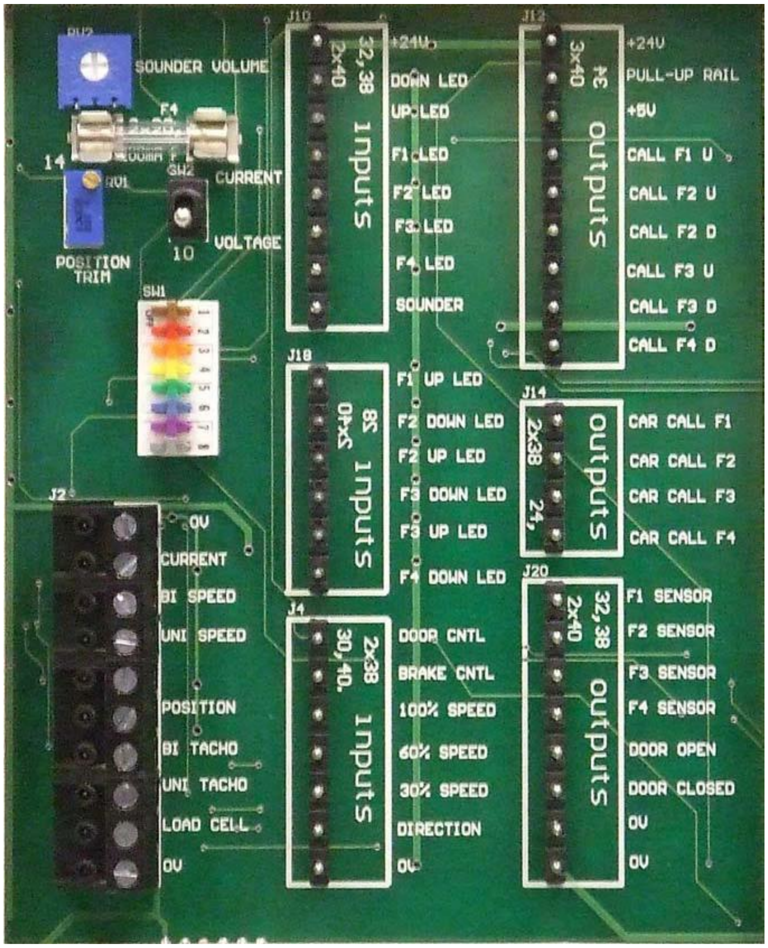

Fig. 4 - Interface with external controller

PLC Discrete Inputs	PLC Discrete Outputs
Elevator Outputs	**Elevator Inputs**
Connector J12	**Connector J10**
Floor 1 up call pushbutton	Car going down indicator
Floor 2 up call pushbutton	Car going up indicator
Floor 2 down call pushbutton	Destination Floor 1 (car indicator)
Floor 3 up call pushbutton	Destination Floor 2 (car indicator)
Floor 3 down call pushbutton	Destination Floor 3 (car indicator)
Floor 4 down call pushbutton	Destination Floor 4 (car indicator)
	Chime
Connector J14	**Connector J18**
Car Floor 1 call pushbutton	Car 'on its way' Floor 1 up LED
Car Floor 2 call pushbutton	Car 'on its way' Floor 2 down LED
Car Floor 3 call pushbutton	Car 'on its way' Floor 2 up LED
Car Floor 4 call pushbutton	Car 'on its way' Floor 3 down LED
	Car 'on its way' Floor 3 up LED
	Car 'on its way' Floor 4 down LED
Connector J20	**Connector J4**
Floor 3 sensor	Open/close car door
Floor 1 sensor	Brake release
Floor 2 sensor	Car 100% speed
Floor 4 sensor	Car 60% speed
Car door open	Car 30% speed
Car door closed	Car direction up/down

Table 1 – External Discrete Signals Summary

PLC I/O Point	34-150 Connector	Function	Detail
	J12 P1[3]	Power rail	+24V rail output
	J12 P2[3]	Output pull-up	Output common pull-up point
X0	J12 P4	Floor call pushbuttons	Floor 1 call pushbutton – UP
X1	J12 P5		Floor 2 call pushbutton – UP
X2	J12 P6		Floor 2 call pushbutton – DOWN
X3	J12 P7		Floor 3 call pushbutton – UP
X4	J12 P8		Floor 3 call pushbutton – DOWN
X5	J12 P9		Floor 4 call pushbutton – DOWN
X6	J14 P1	Pushbuttons 'inside' car (mounted on panel LHS)	Car panel – select Floor 1 pushbutton
X7	J14 P2		Car panel – select Floor 2 pushbutton
X10	J14 P3		Car panel – select Floor 3 pushbutton
X11	J14 P4		Car panel – select Floor 4 pushbutton
X12	J20 P1	Floor location sensors	Car at Floor 1 sensor
X13	J20 P2		Car at Floor 2 sensor
X14	J20 P3		Car at Floor 3 sensor
X15	J20 P4		Car at Floor 4 sensor
X 16	J20 P5	Door open switch	Mimic indication – car door open
X 17	J20 P6	Door closed switch	Mimic indication – car door closed

Table 2 – Mitsubishi FX1S PLC Connection Table (PLC Inputs)

PLC I/O Point	34-150 Connector	Function	Detail
0V[4] S/S[4]	J20 P7	Power rail	0V
Y0	J4 P1	Door control	Open/close car door
Y1	J4 P2	Brake control	Release car brake
Y2	J10 P3	Car going up	Front panel 'going up' arrow
Y3	J10 P2	Car going down	Front panel 'going down' arrow
Y4	J18 P6	Elevator 'on its way' indicators	Illuminate Floor 4 down indicator LED
Y5	J18 P5[1]		Illuminate Floor 3 up indicator LED
Y5	J18 P4[1]		Illuminate Floor 3 down indicator LED
Y6	J18 P3[2]		Illuminate Floor 2 up indicator LED
Y6	J18 P2[2]		Illuminate Floor 2 down indicator LED
Y7	J18 P1		Illuminate Floor 1 up indicator LED
Y8	J10 P7	Elevator destination	Illuminate Floor 4 indicator LED in car
Y9	J10 P6		Illuminate Floor 3 indicator LED in car
Y10	J10 P5		Illuminate Floor 2 indicator LED in car
Y11	J10 P4		Illuminate Floor 1 indicator LED in car
Y12	J4 P4	Logic motor control	Motor 60% speed demand
Y13	J4 P5		Motor 30% speed demand
Y14	J4 P6		Motor direction up/down
Y15	J10 P8	Sounder	Bell to announce arrival of car at floor
0V	J4 P7	Power rail	0V
COM0–COM3 24V[5]	-		

Table 3 – Mitsubishi FX1S PLC Connection Table (PLC Outputs)