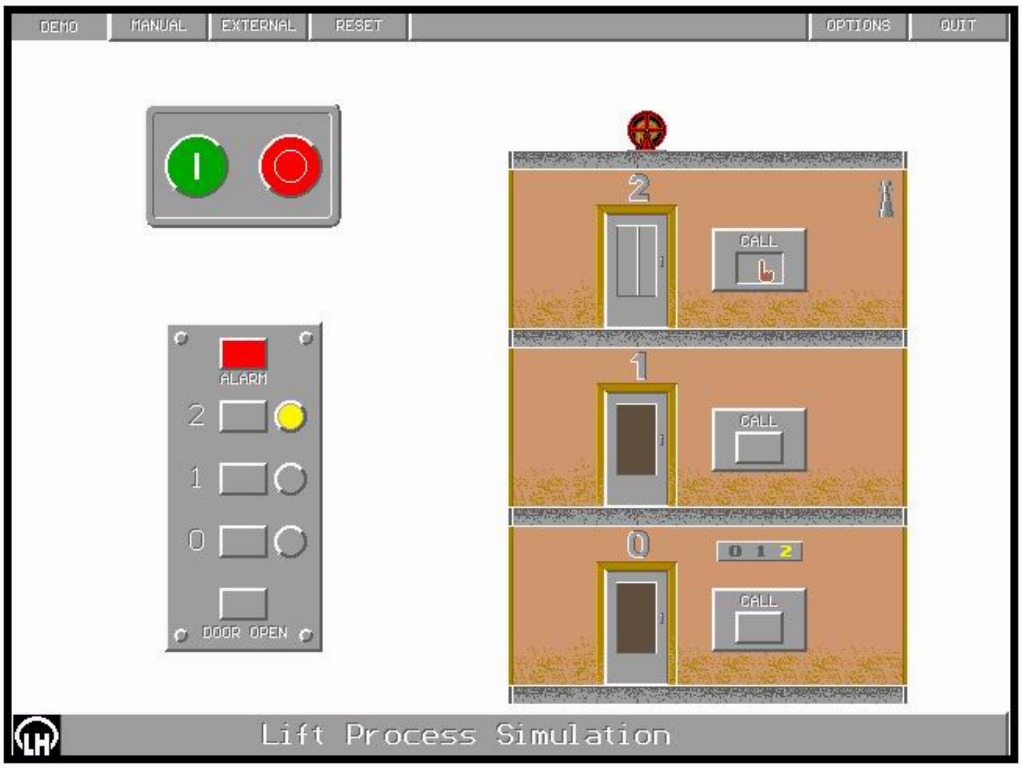
Lift Process Simulation

1 Demo Mode

1.1 Putting the System into Operation

After starting the program the process simulation appears immediately on the screen. The mouse pointer is visible in the form of a hand. The main menu items of the program can now be selected in the command line at top of the screen. Move the mouse pointer to the option button DEMO and briefly press the left mouse button.
The lift is immediately set into motion. The DEMO mode can be interrupted by pressing any key or the left mouse button.
The process runs automatically in the DEMO mode. The control of the lift facility is carried out by the program itself. The DEMO mode demonstrates the training objective of this practical exercise. In this case, the exercise has as its aim the realisation of an external control.
The automatic cycle in this mode must be worked out step-by-step in exercises during the course of the next chapter and replaced by a real control.



Screen shot of the lift process simulation in the DEMO operating mode

1.2 Description of the Lift Facility

In the process simulation we are dealing with a lift operating on 2 floors. The lift is visible on the right-hand side of the screen in the cross-section of the building. There is a lift door with a glass window on each floor. The lift cabin or cage is also equipped with a sliding door. The lift can be summoned from any floor by pressing the coming button, which then lights up. The lift motor is located on top of the roof and is used to move the cage up and down on the steel cables. The controls or operating elements in side the cage are shown in the bottom left-hand corner of the screen. Here there is a select button for each floor. These select buttons also light up after activation. There is one round indicator lamp next to each floor select button, which indicates the actual position (floor) of the cage. Similar indicator lamps are also located next to the door on the ground floor. In addition to the operating elements there is also an alarm button and a "open door" button, which will be dealt with in more detail in the following chapter.

In the top left-hand comer of the screen there is a pushbutton box with an on and off pushbutton. These are used to switch the entire system on and off. In the DEMO mode none of the operating elements can be operated. The process can only be observed. Naturally this DEMO mode only shows one lift control possibility. The variations for programming the lift facility are dealt with in the following chapters.

Exercise 1

When controlling facilities a basic distinction is drawn between sequence control system and logic control.

In the case of sequence control, it is expedient to break the process down into various steps, which can then to some extent be worked through one after another. In the case of logic control no specific sequence of repeating steps exists. Observe the lift facility in the DEMO mode. Which of the two forms of control would be most sensible here and why?

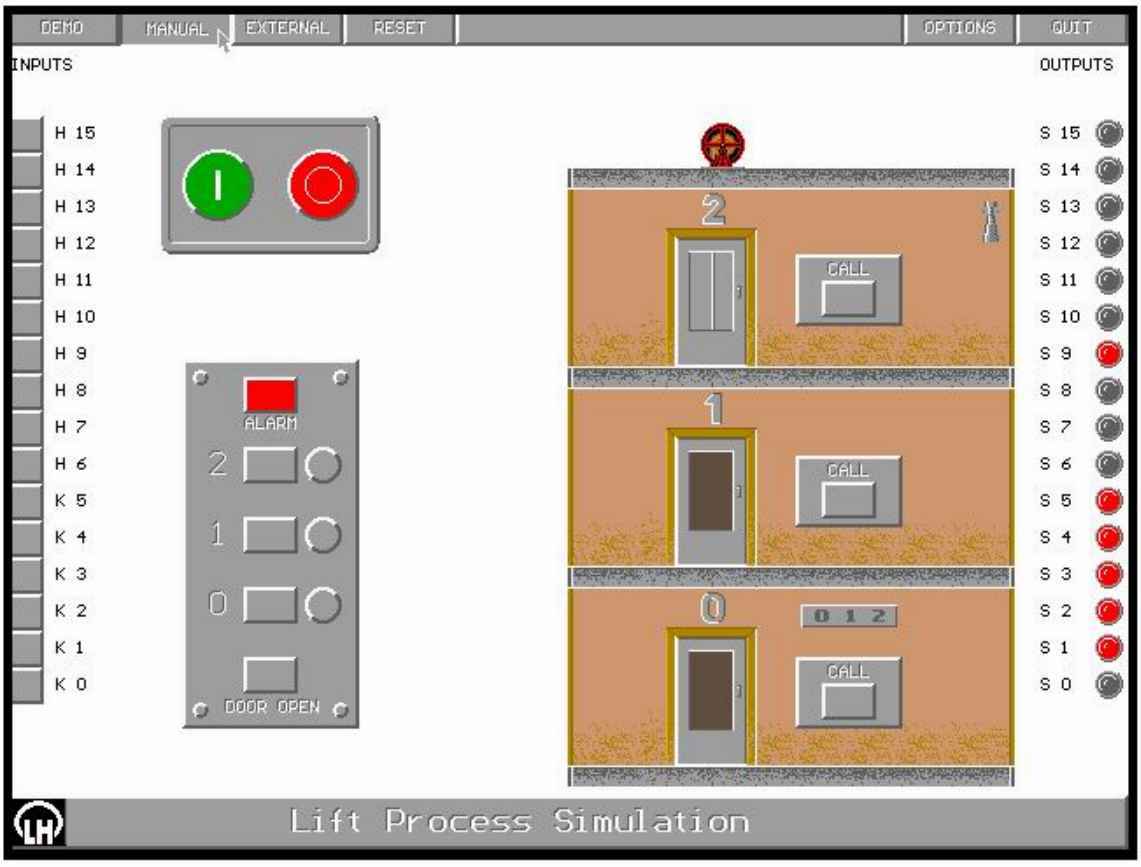
Exercise 2

Name some more application examples for both types of control!

2 Manual Control of the Process Simulation

2.1 Putting the System into Operation

In the MANUAL operation all of the existing process functions can be tested without connecting a controlling facility. All of the actuators and operating elements can be activated by the mouse and their response subsequently observed. The status of the process sensors and operating elements is indicated via LEDs. At the same time, this status is also output to the PC adapter and can actually be measured at the adapter's outputs.
The main menu items are displayed in the command line at the top of the screen. Move the mouse pointer to the option button OPTIONS and briefly press the left mouse button. A pull down window appears containing several selectable options. Now check whether the parallel interface, to which you have connected the PC adapter, is
indicated. If necessary, you can change the entry by clicking the mouse.
Click on the option button MANUAL in the upper menu bar. You will now find yourself in the manual operating mode of the process simulation.



Manual control of the lift process simulation

2.2Testing the Lift Facility

On the left side of the screen 16 switches appear and on the right side of the screen there are LEDs. The lift facility has a total of the 15 actuators or inputs (switch H9 is not assigned). The contactors are designated with K and the light indicators with H. By clicking on the switch the corresponding actuator is activated. There are also contactors for the lift motor, which moves the cage up and down and for opening the doors of the various floors. The light indicators are located within the cage in the floor select buttons and directly to the right of the buttons to indicate the last floor arrived at. Additional light indicators are installed in the lift call buttons next to the three floor doors. The switch numbers are identical to the input numbers of the PC adapter, which are used to externally control the process as will be shown in the next chapter.

The sensor or switch statuses of the facility are indicated via LEDs on the right side. All facility outputs are generally designated with S for switches and are set when the operating elements are activated using the mouse or when the lift cage activates a floor limit switch.

How can the switches and LEDs now be assigned to the elements of the lift facility? Briefly activate the pushbutton [B]. The screen now contains additional information. Now corresponding input and output digits appear next to the elements of the lift facility. This designation can also be switched on or off using the OPTIONS menu.

You can see, for example, that the lift cage is moved down via the switch K0 and up via K1. S0 is located under the green on-button and represents output 0. The output 0 can be set to logic 1 by activating the on-button by clicking the mouse. The LED then lights up.

The alarm button immediately activates the warning bell. It cannot be requested by an external control. In a real lift facility the alarm button is directly linked to a central lift emergency service, which is immediately able to communicate with the person seeking assistance via the intercom system.

We will now leisurely put the entire lift system to the test. Use the designations of the operating elements as an aid. A copy of this assignment list and sufficient space for comments can be found on the next page.

By clicking on the option button RESET in the menu bar at the top of the screen, the lift can be reset again in a defined starting position at any time.

Exercise 3

Activate the red off-button and observe its corresponding output S 1. Are we dealing with an NC (normally closed) or an NO (normally open) contact? Explain why this is the case?

Exercise 4

What happens when the cage is driven up via the contactor Kl although it is already located on the 2nd floor or when you simultaneously activate the pushbutton Kl for up and KO for down? Is this condition permitted?

Exercise 5

The operating elements are designed as pushbuttons and only supply a 1 -signal for the duration of actuation. Which logic elements permit you to reliably register this irregular event?

Exercise 6

On the next page you will find the prepared assignment list for the inputs and outputs of the lift facility. In the column labelled contact NO/NC, enter whether the outputs involved are normally open or normally closed contacts. For this use the international abbreviation NO for normally open and NC for normally closed.

Assignment list for the inputs and outputs

Input	Active for	Control	Designation	Comments
K0	1		Contactor lift down	
K1	1		Contactor lift up	
K2	1		Floor door opens at ground floor	
K3	1		Floor door opens at 1 st floor	
K4	1		Floor door opens at 2nd floor	
K5	1		Cage door opens	
H6	1		Lamp cage position ground floor	
H7	1		Lamp cage position 1st floor	
H8	1		Lamp cage position 2nd floor	
H9	/		Not assigned	
H10	1		Lamp lift call button ground floor	
H11	1		Lamp lift call button 1st floor	
H12	1		Lamp lift call button 2nd floor	
H13	1		Lamp cage select button ground floor	
H14	1		Lamp cage select button 1st floor	
H15	1		Lamp cage select button 2nd floor	

Input	NC NO	Control	Designation	Commentary
SO	NO		Green pushbutton ON	
Sl			Red pushbutton OFF	
S2			Ground floor door is closed	
S3			1st floor door is closed	
S4			2nd floor door is closed	
S5			Cage door is closed	
S6			Door open button in cage	
S7			Cage limit switch - ground floor	
S8			Cage limit switch - 1st floor	
S9			Cage limit switch - 2nd floor	
S10			Lift call button ground floor	
Sll			Lift call button 1st floor	
S12			Lift call button 2nd floor	
S13			Cage select floor button - ground floor	
S14			Cage select floor button - 1st floor	

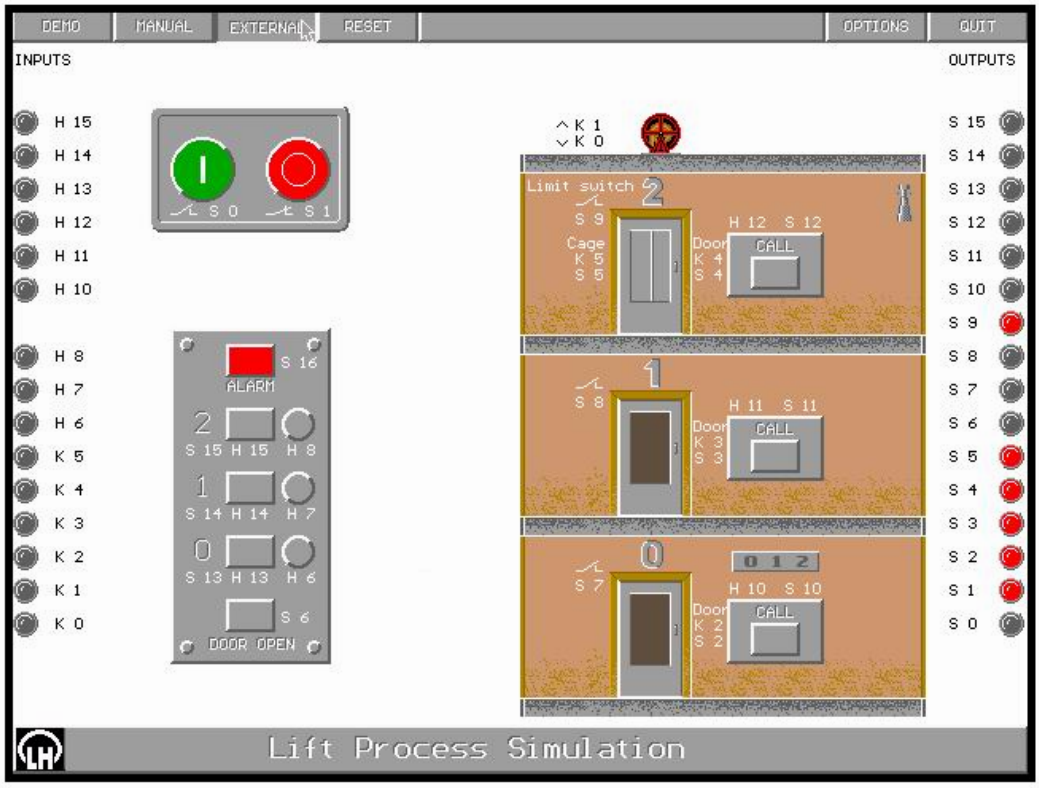
S15			Cage select floor button - 2nd floor	

NO = Normally Open supplies a 1-signal upon actuation
NC = Normally Closed supplies a 0-signal upon actuation

3 External Control of the Process Simulation

3.1 Putting the System into Operation

In the EXTERNAL operating mode the lift simulation is connected to a real control via the PC adapter.
The external control can only function if the PC adapter is installed!
Move the mouse pointer to the option button OPTIONS and briefly activate the left mouse button. Now several selectable options appear in the pull down menu. Now check whether the parallel interface, at which you have connected the PC adapter, is indicated. If necessary you can change the entry per mouse click.
Now click on the option button EXTERNAL in the upper menu bar. You now find yourself in the EXTERNAL operating mode of the process simulation. The screen configuration is similar to the MANUAL operating mode. The inputs of the PC adapter and thus the statuses of the signal indicators and contactors of the lift facility are now displayed by LEDs on the left side of the screen. A 1-signal at an input of the PC adapter causes the corresponding LED to light up. The corresponding function of the lift facility is activated.



Screen of EXTERNAL operating mode

The output statuses of the lift facility are also displayed via LEDs on the right edge of the screen. Their real status can now be measured at the outputs of the PC adapter.
The status display can be switched off using the OPTIONS button. Naturally, the lettering of the system elements already known from the manual operating mode can be superimposed on the screen or removed again as desired.
If control is to be performed using a PLC, this can now be connected to the PC adapter (see also Chapter 2.8 Installation of the PC Adapter). The inputs and outputs of the PLC can be selected as desired. The outputs of the PC adapter are connected with the digital inputs and the outputs of the PLC are connected to the inputs of the PC adapter. The assignment of the inputs and outputs should now be entered into the assignment table from exercise 6. Simply enter the designation of the PLC inputs and outputs in the column designated control.
In the following we shall continuously be referring to the inputs and outputs of the lift facility.
Later when programming the PLC, the assignment list will be absolutely indispensable.
Do not forget to connect the OV-rail of the PC adapter to the signal-ground of the PLC.
If a discrete control circuit is used to control the lift, wiring cannot be undertaken at present.
Here, the control logic must first be developed.
The DEMO operating mode from Chapter 3 demonstrated the actual objectives for the control of the lift operation. The process could be observed at leisure. Now the control must be developed step by step from the written description of the process.

Circuit components of the lift control:

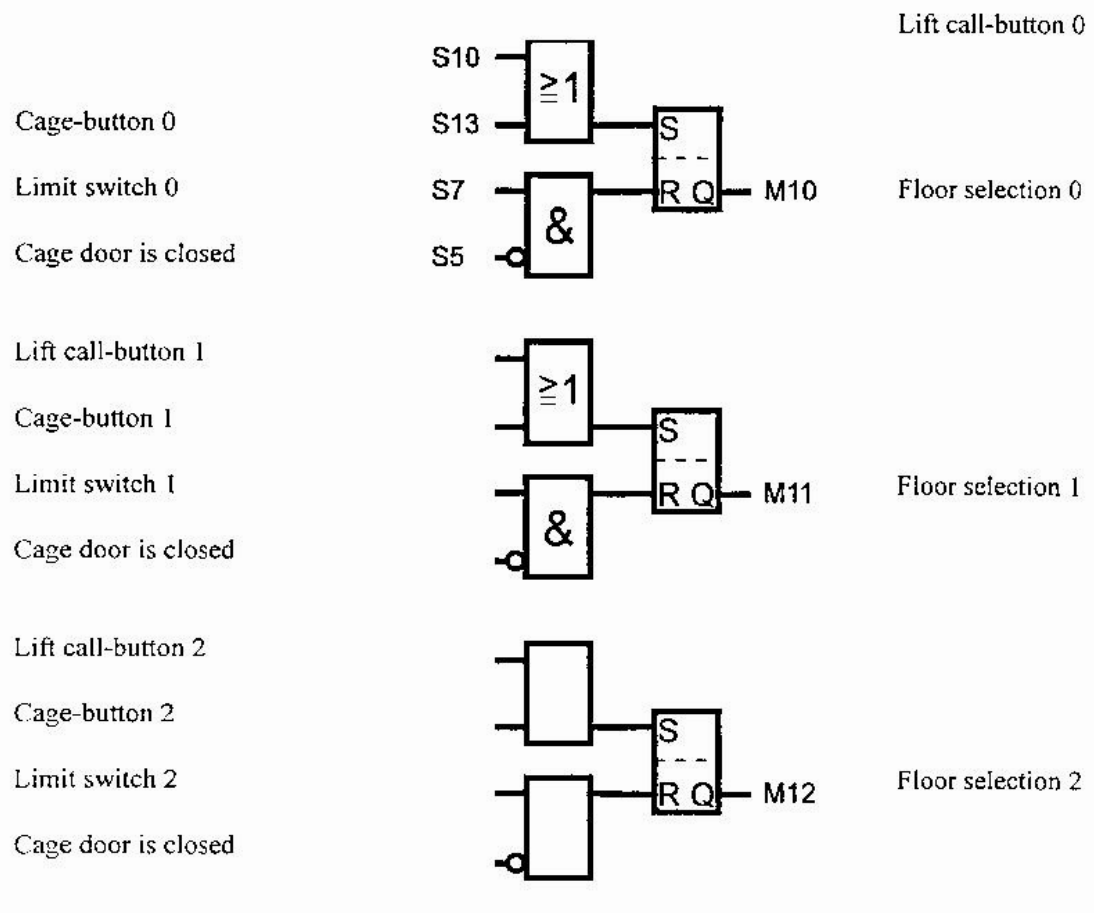
Chapter 5.2 Floor selection of the lift
5.3 Control of the doors
5.4 Determining up/down direction of lift
5.5 Control of the motor contactors
5.6 Signalling
5.7 Starting response

3.2 Floor Selection of the Lift

There are two operating elements for the selection of the desired floor. One operating element is the lift call button on the destination floor and the second is the floor selection button inside the cabin. If one of the buttons is activated, the floor selection is stored.
The floor selection should be reset once the destination floor has been reached and the cage door has opened. The designation of the pushbuttons can again be taken from the statement list in exercise 6. The pushbutton status is output on the appropriate outputs of the PC adapter.
All of the pushbuttons are designed as NO contacts. Since we have a total of three storeys, we need three floor selection markers.
Let's establish the following markers:
M10: Marker for ground floor selection (0 floor)
M11: Marker for 1st floor selection
M12: Marker for 2nd floor selection

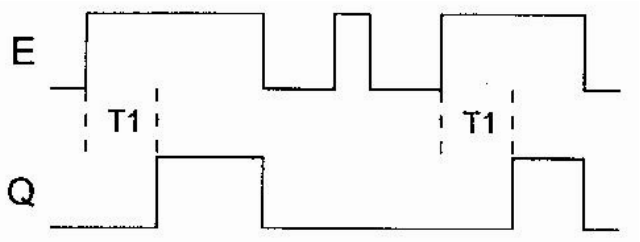
Exercise 7

Complete the following function diagram for floor selection. The designation of the pushbutton can be taken from the assignment list.

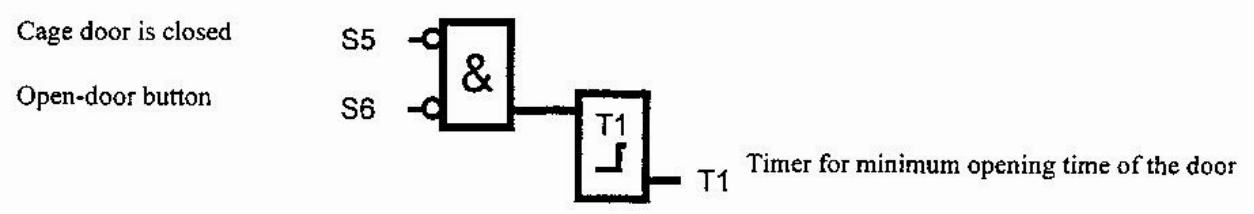


3.3 Control of the Doors

When the cage or cabin has reached the floor destination, the cage door and the corresponding floor door are supposed to be opened. The door remains opened at least for the time duration Tl. If any further floor selection has been stored, the door closes again. Should no further floor destination exist, the door remains open. If the open-door button within the cabin has been pressed while the door is open, the open-door time is prolonged by the time period Tl.
In order to control the time period Tl we use the closing delay timer Tl. When there is a signal change from 0 to 1 at the input E of the timer, the timer's setpoint time starts. If the input is reset during the operating time, the timer is also reset. When the set time has elapsed, the output Q of the closing delay timer supplies a 1-signal. The programming of the timer setpoint varies for each control and must be taken from the relevant manual.



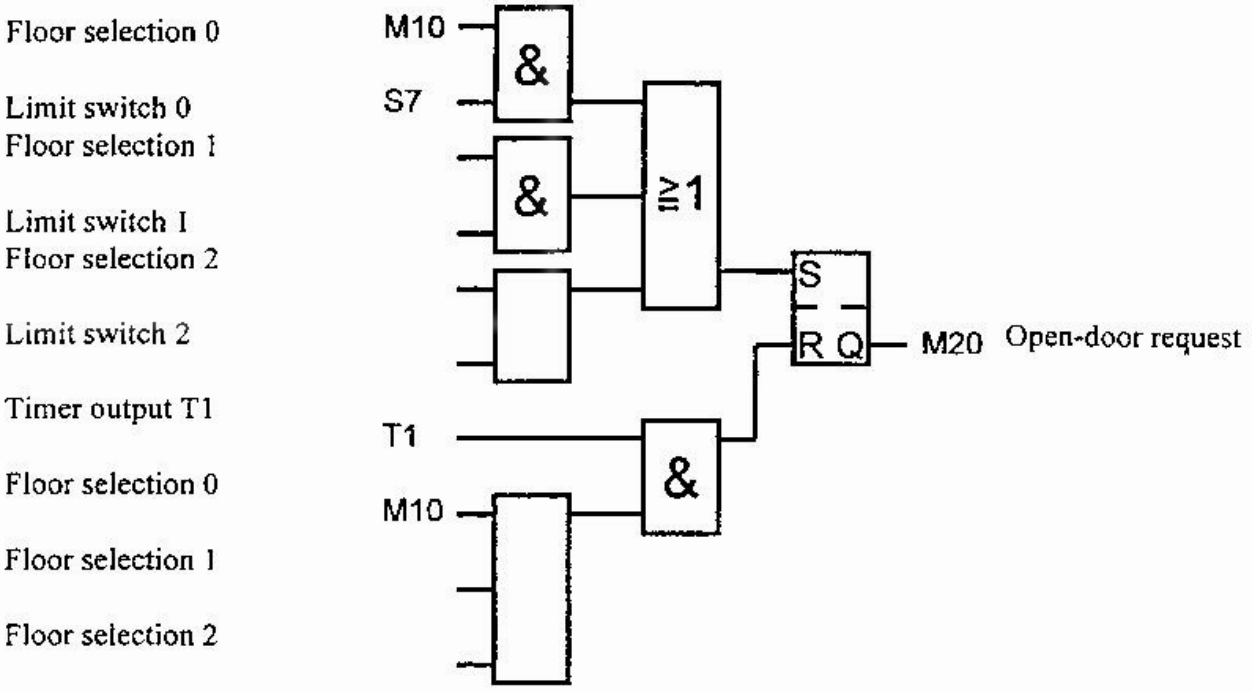
The timer starts when the door has opened and is reset again when someone has activated the open-door button in the cabin or the cage door has closed. This can be realised using an AND- gate in front of the timer input.



For the open-door request we have set a new marker.
M20: Open-door request

Exercise 8

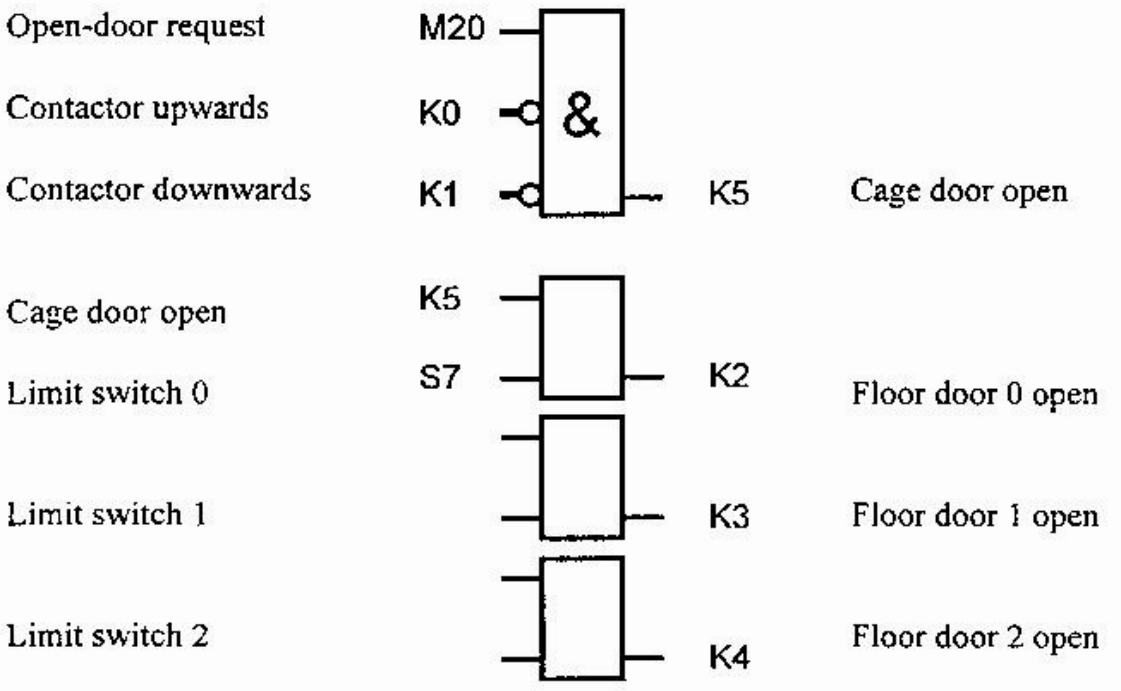
Complete the following logic diagram for the open-door request (marker M20).



Exercise 9

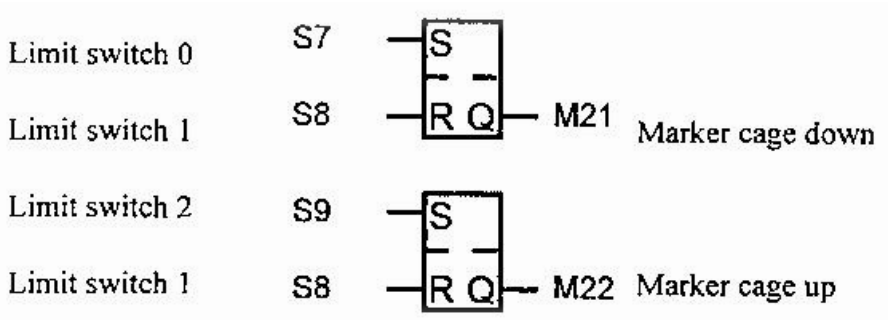
If a open-door request is present, and the cage is not moving, that is KO and Kl do not supply a 1-signal, then the cage door can be opened.

The respective floor door is opened parallel to the cage door. It is opened when the cage door is open and the corresponding lift limit switch supplies a 1-Signal, i.e. when it is closed.
Complete the four networks for controlling the doors K2, K3, K4 and K5.



3.4 Determining the Up/Down Direction of the Lift

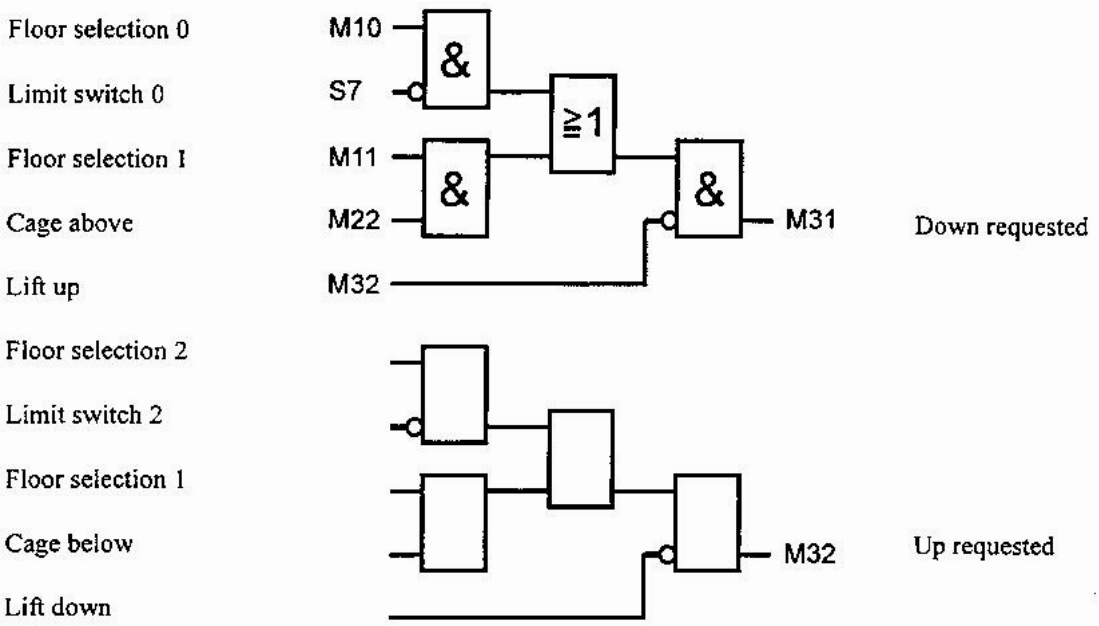
The up/down direction of the cage is dependent on the current position of the lift and the requested destinations. The lift destinations are stored in the markers M 10, Ml 1 and Ml 2 described in Chapter 5.2. For the position it suffices to know whether the cage was last on the ground floor or on the second floor. For this two RS flip-flops can be used. The first one is set when the ground floor is reached and reset when the 1st floor is reached. The second one is set when the second floor is reached and is also reset when the 1st floor is reached. The markers M21 and M22 are to be used for the 2 RS flip-flops.
M21: Cage was previously on the ground floor
M22: Cage was previously up on the 2nd floor



Now the lift up/down direction can be determined. The cage goes down if someone wants **to** reach the ground floor, but has not yet reached it or when the cage was on the second floor and the destination selected was the 1 st floor. When travelling down, lift up operation must still be inhibited so that the cage does not continuously change directions. This results in a control whereby the previous direction, even with a stopover, still has the first priority; prior instructions are treated with preference.
The lift up direction becomes active when someone requests the 2nd floor as destination, but has not yet arrived there or when the lift was down on the ground floor and the 1st floor was selected as the destination. Likewise, when travelling up the lift down operation must be inhibited.
We now set two new markers:
M31: request lift direction down
M32: request lift direction up

Exercise 10

Study the logic diagram for the lift down operation and develop from that the condition for lift up operation.

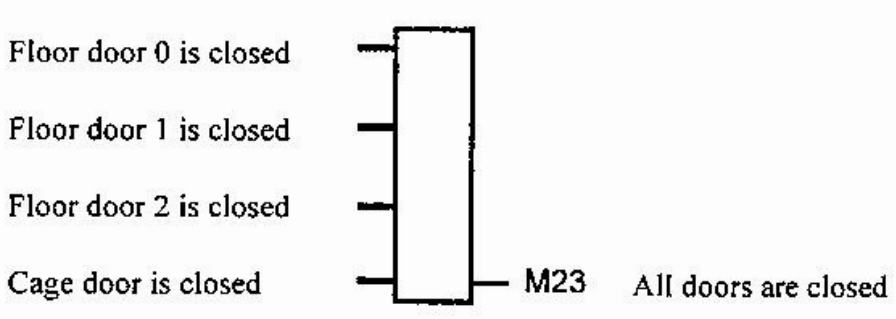


3.5 Control of the Motor Contactors

Once the lift direction up/down has been defined in the last chapter, the motor contactors KO and Kl can be controlled.
The cage is moved down, when lift-down has been requested (M31), no open-door request is present (M20) and all of the doors are closed.
The same correspondingly applies for lift-up in that the up direction must be requested (M32), no open-door request is present (M20) and all doors are closed.
A new marker serves to indicate that all of the doors are closed.
M23: All doors are closed

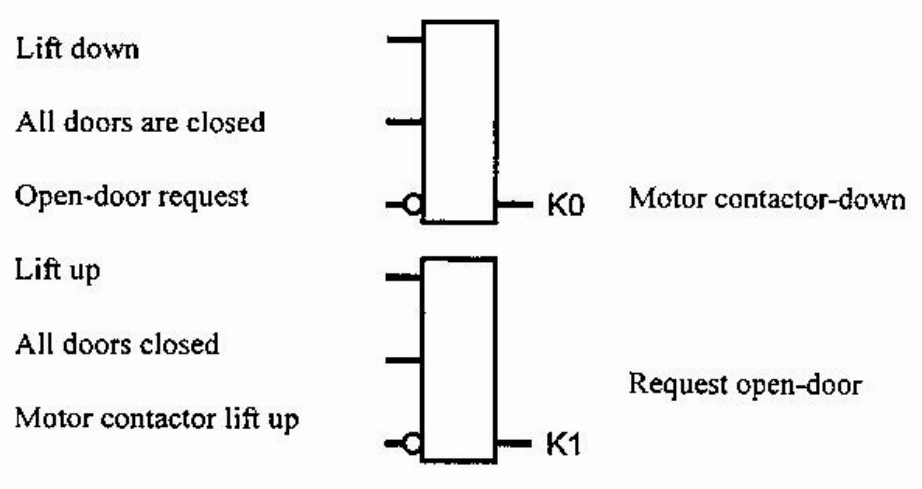
Exercise 11

Develop the network (logic diagram) for marker M23.



Exercise 12

Now develop the networks for the two motor contactors KO and K1.

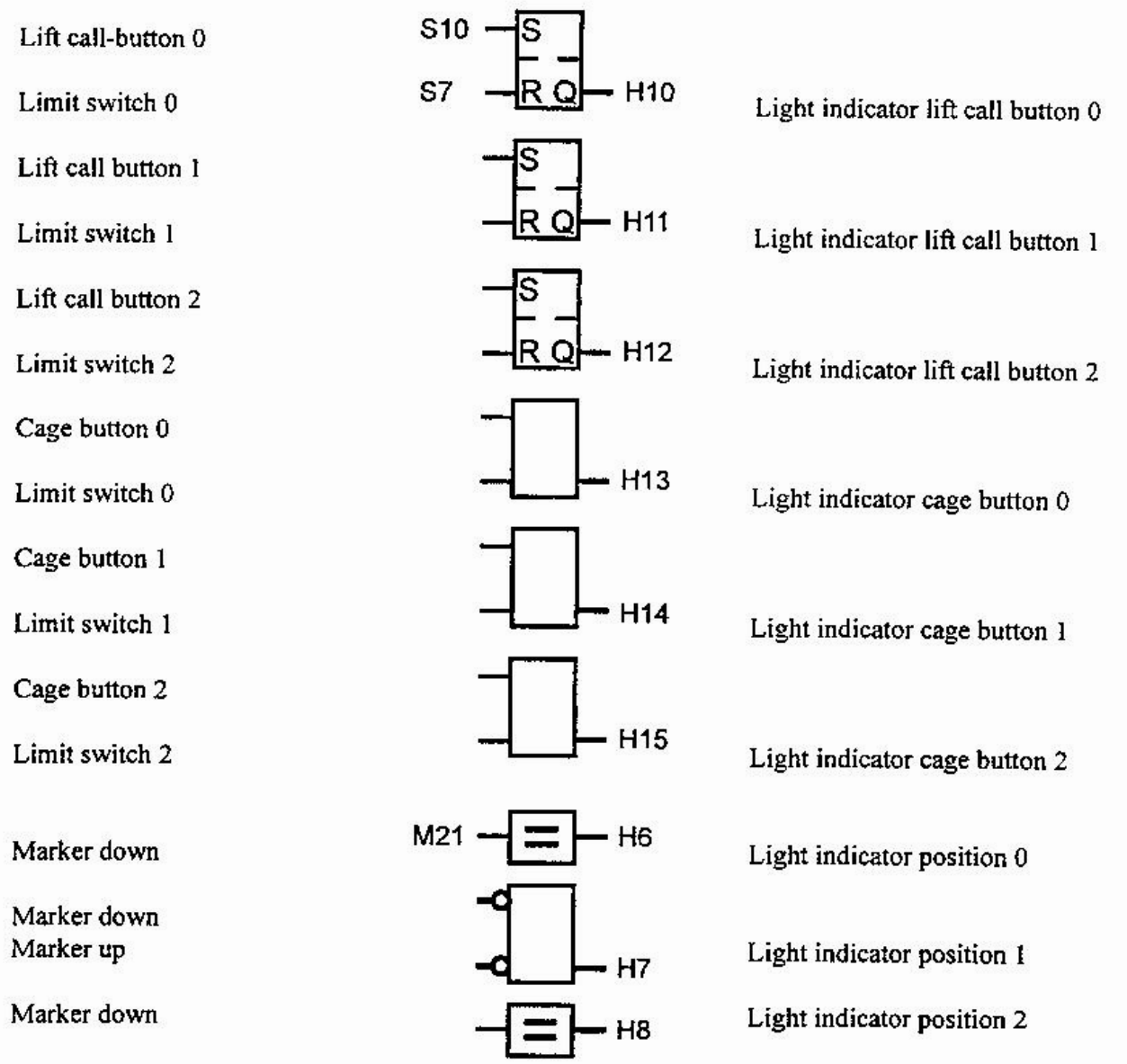


3.6 Signalling

If an operating element is activated for floor selection, the appropriate signal indicators are switched on until the destination floor is reached. The pushbuttons are lit up. For every one of these six light indicators we must have a flip-flop function available. Since we no longer need the statuses of the light indicators otherwise, markers are not used and only PLC outputs are used directly instead.
The floor last reached should be indicated by the light indicators H6 to H8 inside the cage.
These light indicators also appear once again next to the door on the ground floor. They are internally wired in parallel configuration.

Exercise 13

Complete the six networks for the signal indicators H10 up to HI 5.
Then develop the three networks for the light indicators H6 up to H8. For this only use marker M21 (cage below) and M22 (cage above) from chapter 5.4 and an additional AND-Gate.



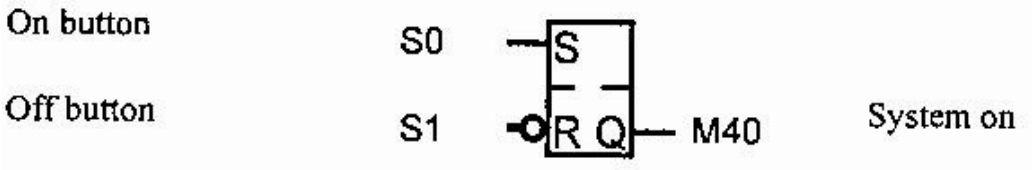
3.7 Starting Behaviour

Now all of the control elements have been developed to the extent that the PLC can be programmed or the control circuit can be set up and wired.
Set up a list for the markers being used.
If the programming device used can also be programmed in the logic diagram representation, you can enter the designed networks directly. For this use the assignment list of the inputs and outputs from Exercise 6.
If your programming device only understands a statement list, all of the networks must be converted first. The individual commands can be taken from the PLC manual. In the appendix you will find some examples of statement lists.

The lift simulation now responds like the one demonstrated in the DEMO operating mode.
However, it cannot yet be switched off and on again.

Switching box

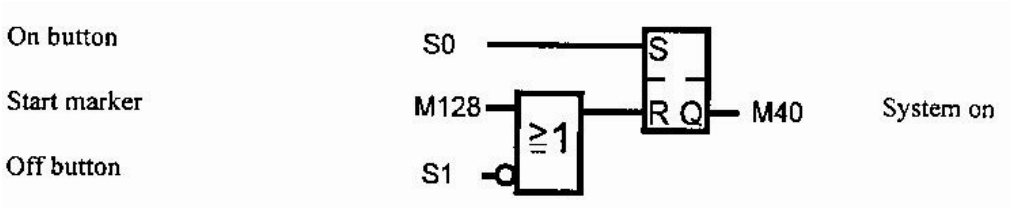
The switching box has a red off-button designed as an NC contact and a green on-button designed as an NO contact. This switching box can be used to switch on the complete system and to switch it off at any given time. Naturally, in reality such off-buttons are externally wired, so that the system can still be reliably switched off in case of a PLC failure.
For switching the system on and off, an additional RS flipflop is installed so that the system is set using the on-button and reset using the off-button. The reset operation must be programmed in the statement list subsequent to the setting operation, so that the switch off of the system has priority. A break in a cable within the current circuit of the off-button thus leads to the system being reliably switched off. The switch-off of the system is thus fail-safe.
M40: System on



In order for the complete system to be switched off, all of the contactors and indicator lights must be interlocked or disabled via the M40 marker. For example, in order to be able to switch the motor contactors KO and Kl on or off via M40, we only need to equip the AND- element from Exercise 12 with an additional input, which is then connected to M40. With this configuration, the motor contactors can be switched off at any time via the off-button S1.
Consider all of the locations where the M40 marker must be integrated within the network and make the corresponding alterations to the control program.

Starting behavior

When the lift facility is put into operation for the first time, it should be put into the off-state. Programmable logic controls possess start markers. When the PLC is restarted, then the start marker supplies a 1-signal. At the end of the first PLC-program cycle, reset the start marker.
The start marker can be used directly in the first program cycle to reset the starter marker M40 at the beginning of the control program. The reset input of the RS flipflop is operated via an OR-gate using the off-switch and the start marker M128.
M128: Start marker



After restarting the control the lift facility is always in the off state and must first be switched
using the on-pushbutton S0.

3.8 Additional Variations

The lift facility can also be controlled so that the cage travels to a particular floor immediately after switch on and waits there with the cage door open.
Think about how this can be realised with the aid of the M128 start marker of the PLC and the floor selection markers from Exercise 7.