Chapter Five

Internal Relays

This chapter continues from the previous chapters on programming and introduces internal relays.

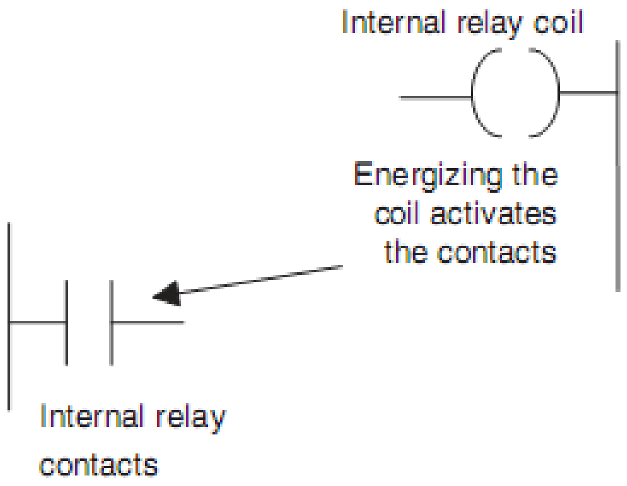
Internal Relays

A variety of other terms are often used to describe this element, such as **auxiliary relay**, **marker**, **flag**, **coil**, and **bit storage**. This is one of the elements included among the special built-in functions with PLCs and are very widely used in programming.

- Internal relays **do not exist as real-world switching devices** but are merely bits in the storage memory that behave in the same way as relays being able to be switched on or off and to switch other devices on or off.
- They can be treated in the same way as an external relay output that can be activated by an input device.

On one rung of the program:
External inputs activate the internal relay output.

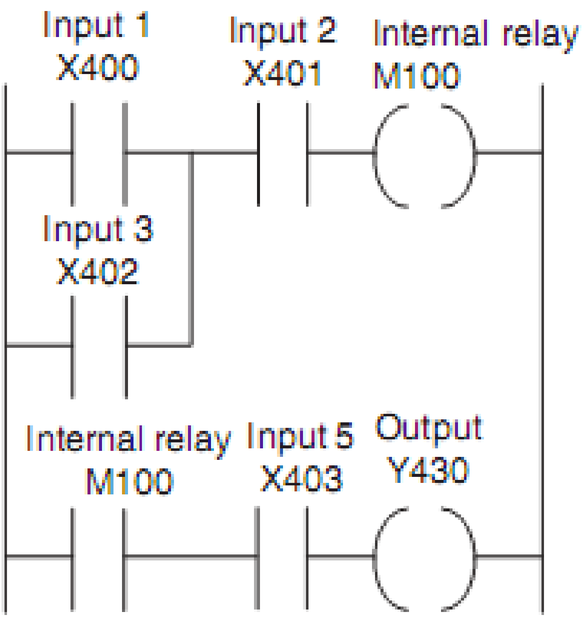
On a later rung of the program:
As a consequence internal relay contacts are activated and so control some output.



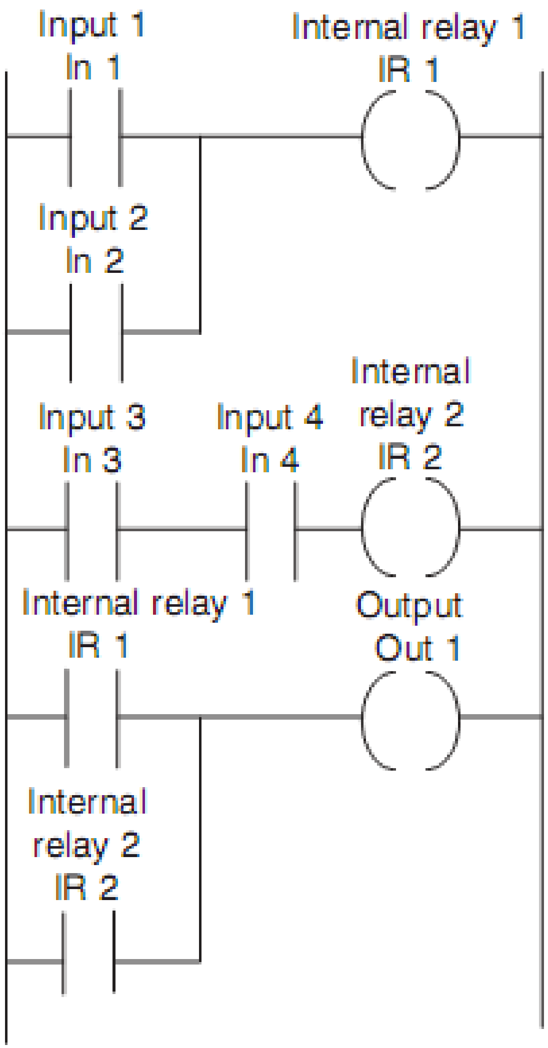
To distinguish internal relay outputs from external relay outputs, they are given different types of addresses. Different manufacturers tend to use different terms for internal relays. For example, **Mitsubishi** uses the term auxiliary relay or marker and the notation M100, M101, and so on. **Siemens** uses the term flag and the notation F0.0, F0.1, and so on. **Telemecanique** uses the term bit and the notation B0, B1, and so on. **Toshiba** uses the term internal relay and the notation R000, R001.

As an illustration of the use that can be made of internal relays, consider the following situation. A system is to be activated when **two different sets of input conditions are realized**.

The first input conditions then are used to give an output to an internal relay. This relay has associated contacts that then become part of the input conditions with the second input.
The figure shows how this would appear in **Mitsubishi** notation.

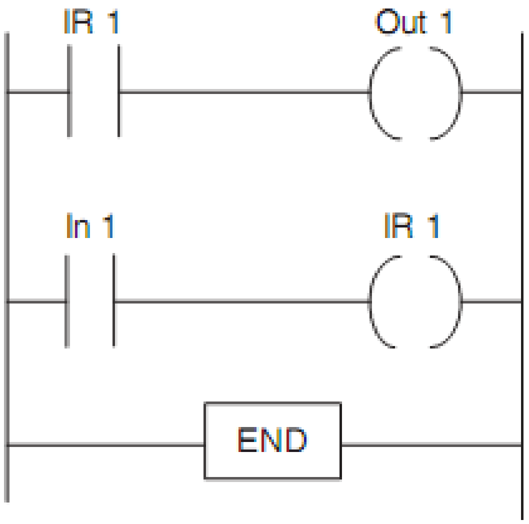


Another example of a ladder program involving internal relays.



Note that:

A ladder program is read from left to right and from top to bottom. Thus if an output device, such as an internal relay, is set in one scan cycle and the output has to be fed back to earlier in the program, it will require a second scan of the program before it can be activated. The figure illustrates this concept.



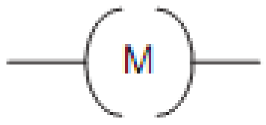
IR 1 not energized as a result of input to In 1 in the first scan until the second scan of the program.

Battery-Backed Internal Relays

If the power supply is cut off from a PLC while it is being used, all the output relays and internal relays will be turned off. Thus when the power is restored, all the contacts associated with those relays will be set differently from when the power was on. Therefore, if the PLC was in the middle of some sequence of control actions, it would resume at a different point in the sequence.

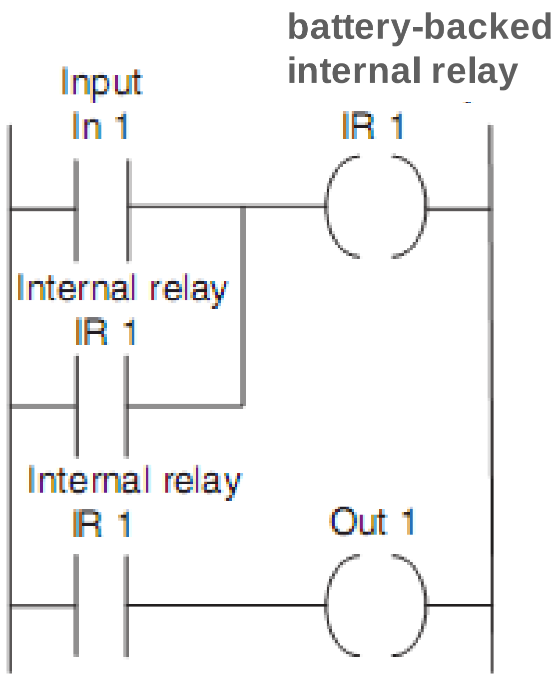
To overcome this problem, some internal relays have **battery backup** so that they can be used in circuits to ensure a safe shutdown of a plant in the event of a power failure and so enable it to restart in an appropriate manner. **Such battery-backed relays retain their state of activation, even when the power supply is off**. The relay is said to have been made **retentive.**

The term **retentive memory coil** is frequently used for such elements. The figure shows the **IEC 1131-3** standard symbol for such elements.



With **Mitsubishi** PLCs, battery-backed internal relay circuits use **M300 to M377** as addresses for such relays.

Example: IR 1 is a battery-backed internal relay. When input In 1 contacts close, output IR 1 is energized. This closes the IR 1 contacts, latching so that IR 1 remains on even if input In 1 opens. The result is an output from Out 1. If there is a power failure, IR 1 still remains energized and so the IR 1 contacts remain closed and there will be an output from Out 1 when the power comes back.



One-Shot Operation

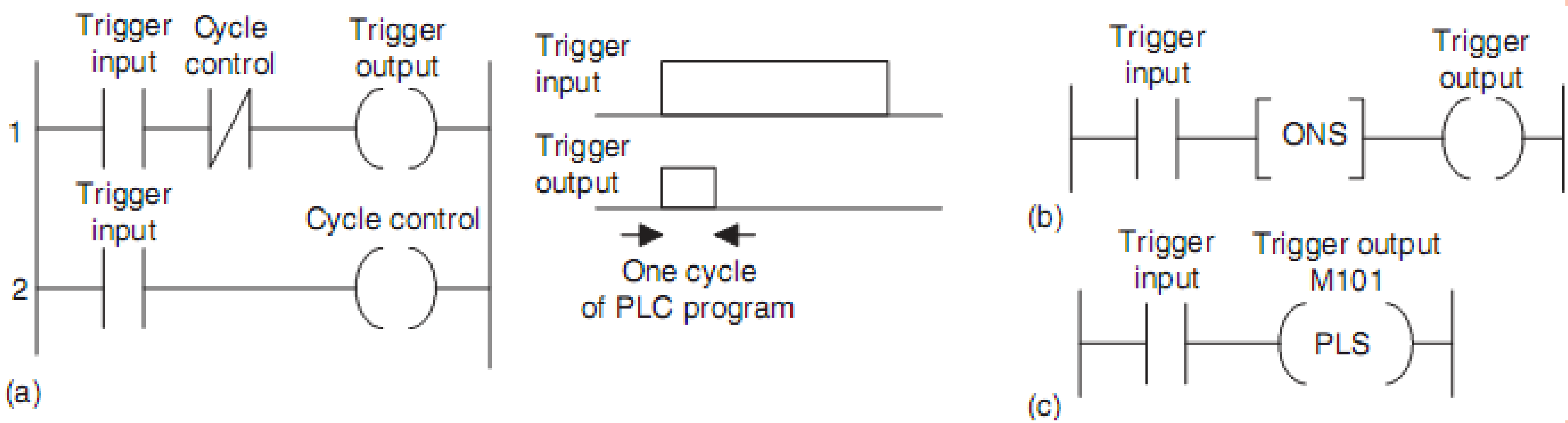
One of the functions provided by some PLC manufacturers is **the ability to program an internal relay so that its contacts are activated for just one cycle**, that is, one scan through the ladder program. Hence when operated, the internal relay provides a **fixed duration pulse** at its contacts. This function is often termed **one-shot**.

The **IEC 1131-3** gives standards for the symbols for **positive transition-sensing** and **negative transition-sensing** coils (see the figure).

(a) Positive transition-sensing coil, and (b) negative transition-sensing coil.

With the **positive transition-sensing** coil, if the power flow to it changes from **off to on**, the output is set on for one scan cycle. With the **negative transition-sensing** coil, if the power to it changes from **on to off**, the output is set on for one scan cycle.

Figures **(b)** and **(c)** show the **built-in facilities** with **Allen-Bradley** and **Mitsubishi** PLCs.



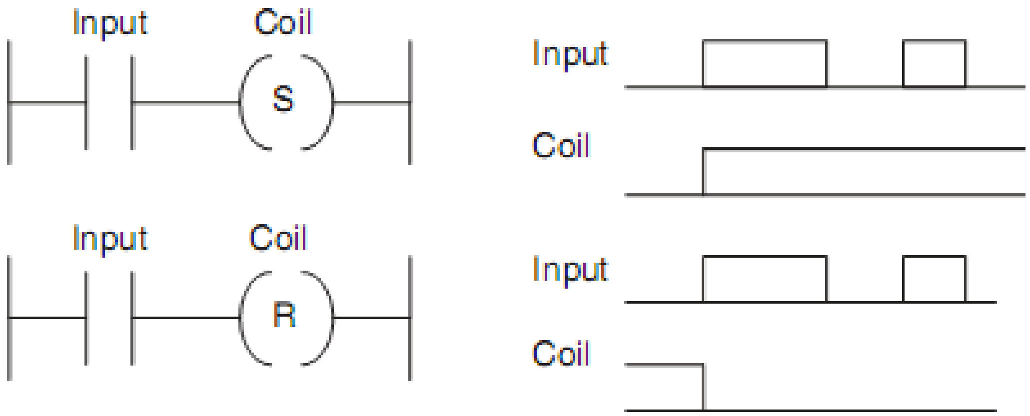
One-shot (a) program, (b) facility in an Allen-Bradley PLC, and (c) facility in a Mitsubishi PLC.

Such a function can also easily be developed with just two rungs of a **ladder program**. For figure **(a)**, when the trigger input occurs, it gives a trigger output in rung 1. In rung 2 it gives a cycle control output on an internal relay. Because rung 2 occurs after rung 1, the effect of the cycle control is not felt until the next cycle of the PLC program, when it opens the cycle control contacts in rung 1 and stops the trigger output. The trigger output then remains off, despite there being a trigger input. The trigger output can only occur again when the trigger input is switched off and then switched on again.

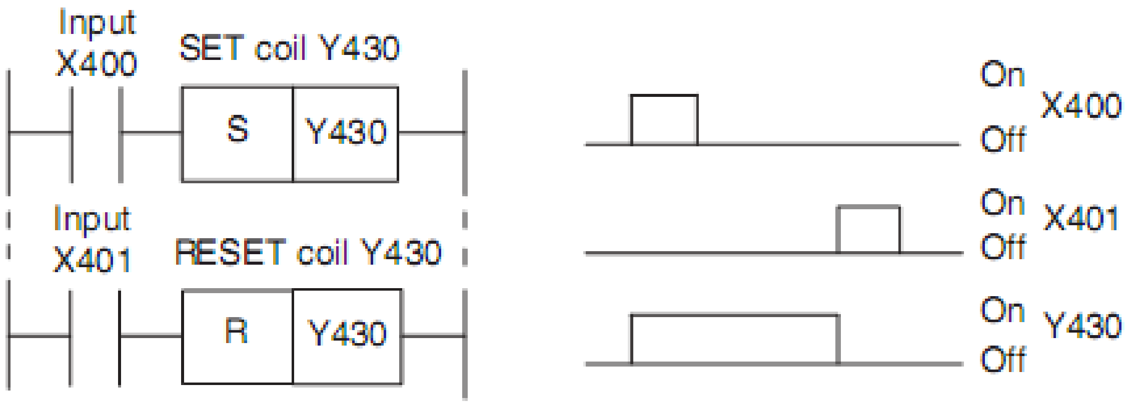
Set and Reset

Another function that is often available is the ability to set and reset an internal relay. **The set instruction causes the relay to self-hold, that is, latch. It then remains in that condition until the reset instruction is received**.

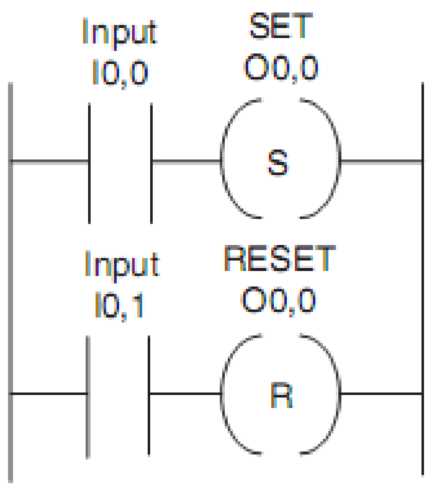
The figure shows the **IEC 1131-3** standards for such coils.



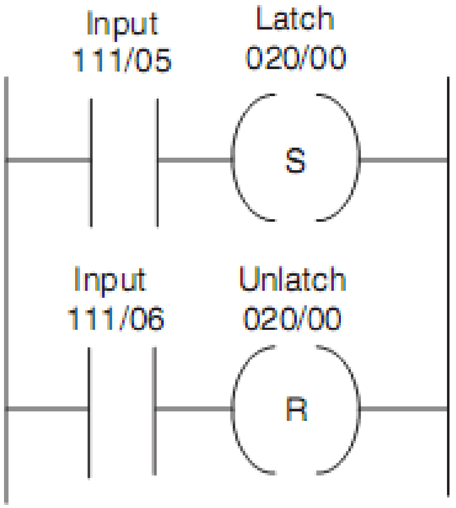
The next figures show the ladder diagram for **Mitsubishi.**



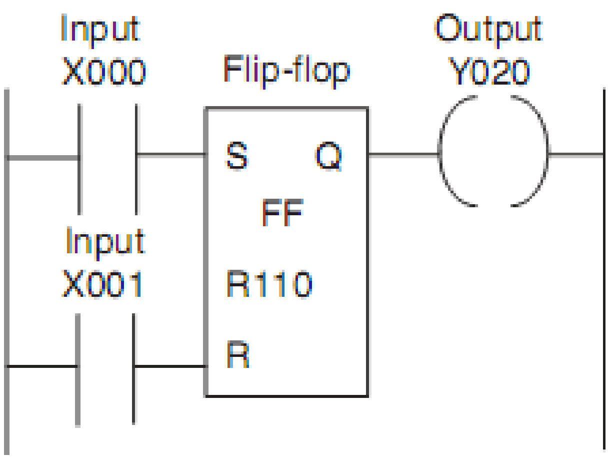
For **Telemecanique**, and **Allen-Bradley**, and **Toshiba** PLCs



SET and RESET (Telemecanique PLC).



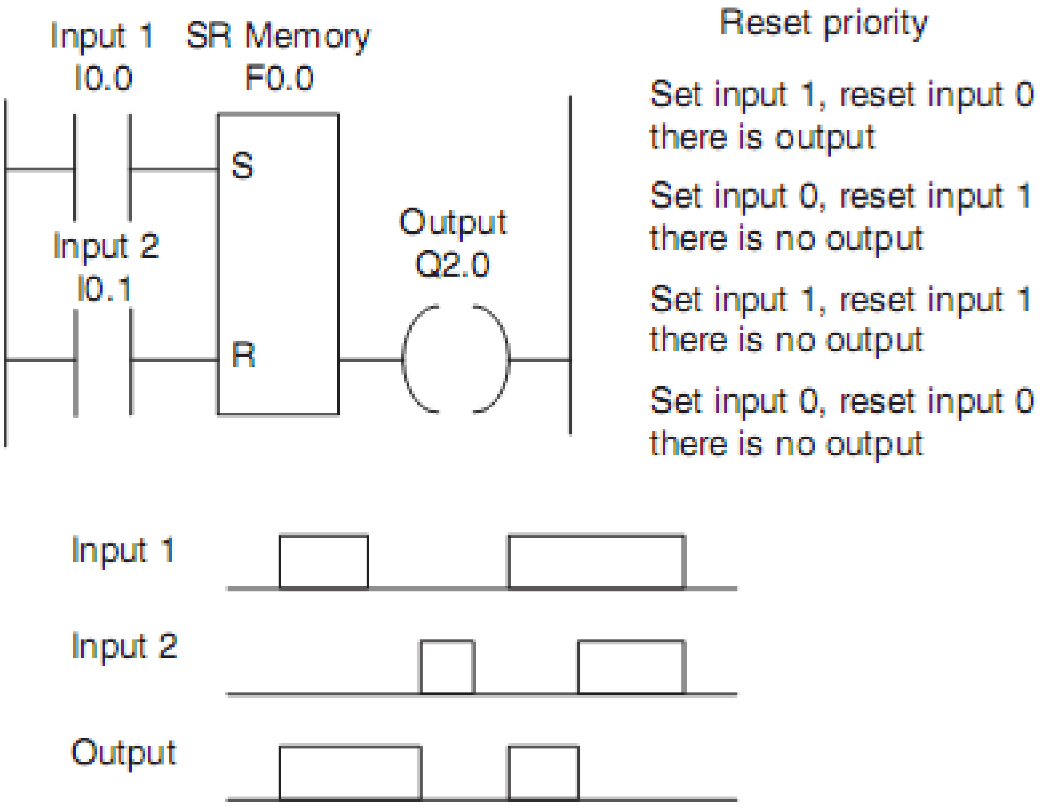
Latch and unlatch (Allen-Bradley PLC).



Flip-flop (Toshiba PLC).

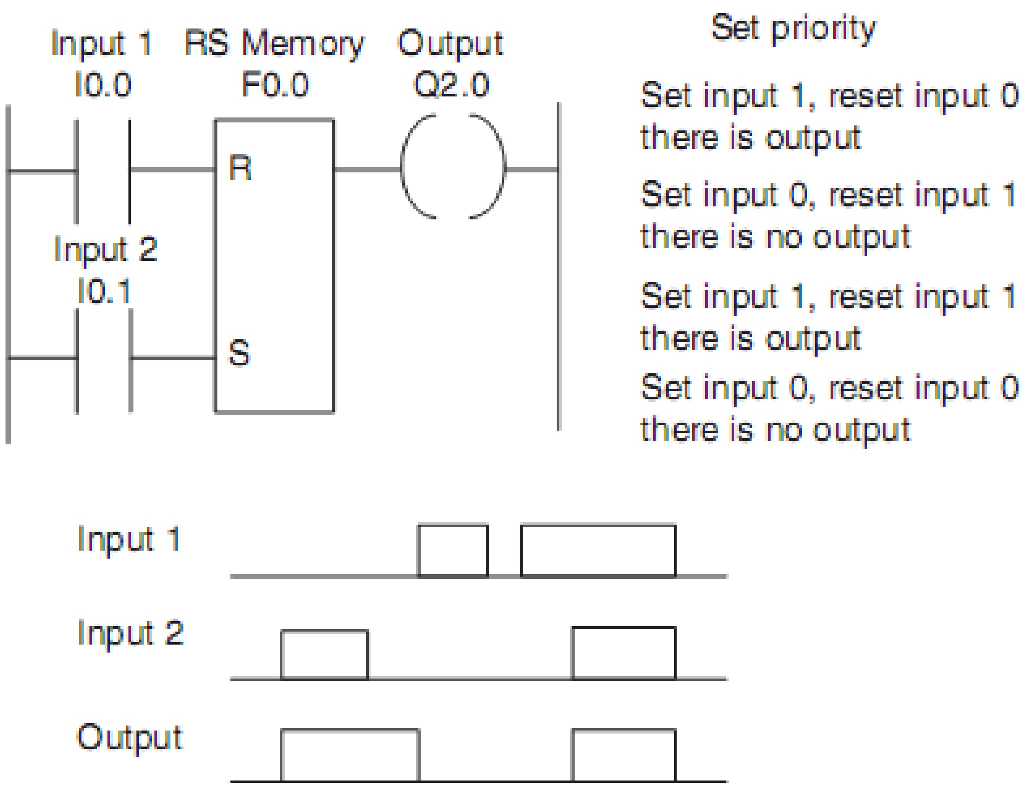
With a **Siemens** PLC the SET and RESET coil symbols are often combined in a single box symbol.

The box is termed an **SR** or **reset priority** memory function in that reset has priority.



SET and RESET, with reset priority (Siemens PLC).

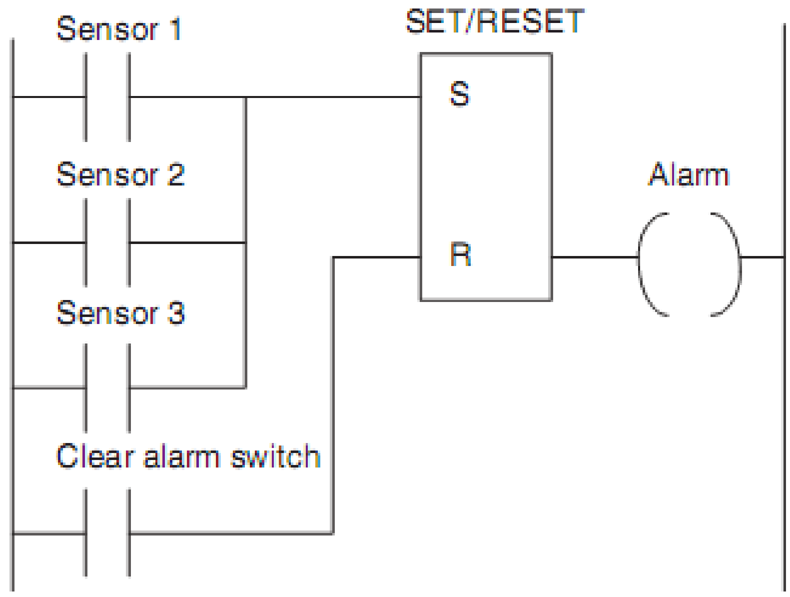
With **set priority** (**RS** memory box), the arrangement is as shown in figure



SET and RESET, with set priority (Siemens PLC).

Program Example

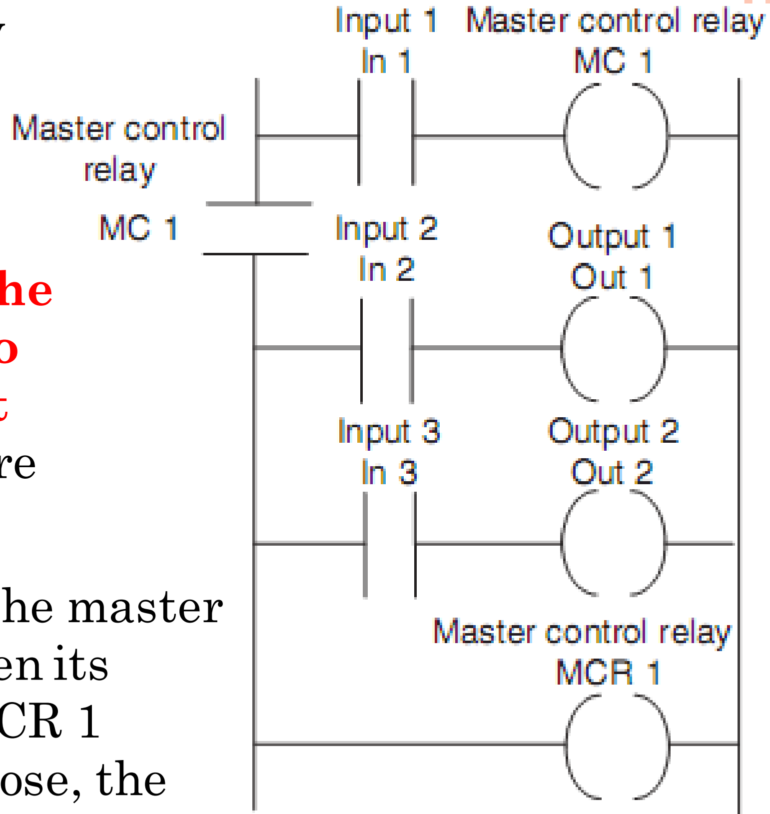
An example of the basic elements of a simple program for use with a **fire alarm system** is shown in the figure. Fire sensors provide inputs to a SET/RESET function block so that if one of the sensors is activated, the alarm is set and remains set until it is cleared by being reset.



Master Control Relay

When large numbers of outputs have to be controlled, it is **sometimes necessary for whole sections of ladder diagrams to be turned on or off when certain criteria are realized**. This could be achieved by including the contacts of the same internal relay in each of the rungs so that its operation affects all of them. An alternative is to use a master control relay.

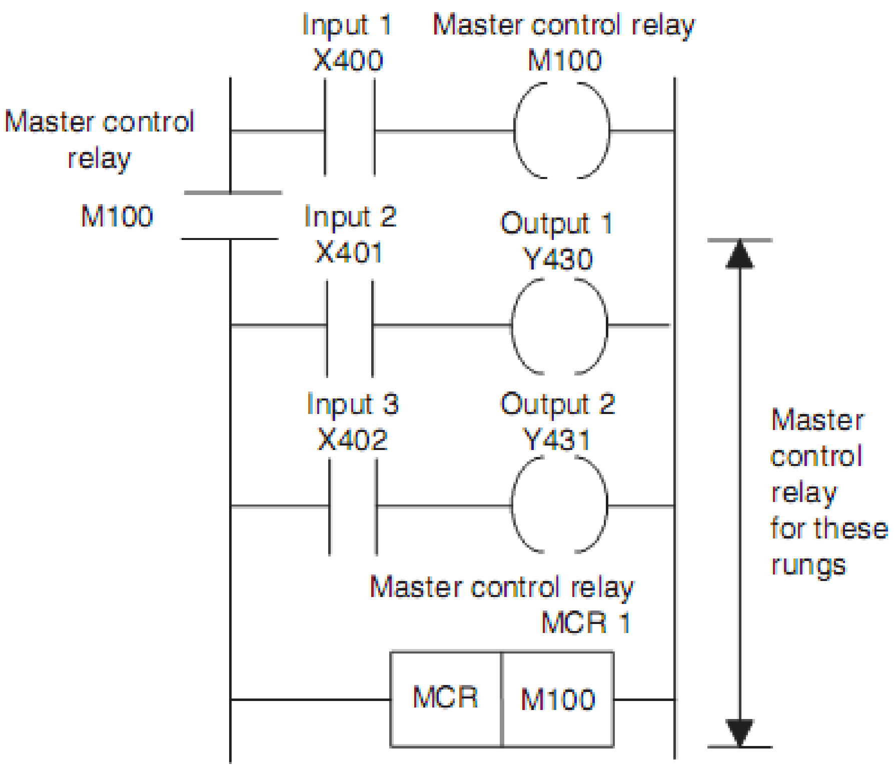
The figure illustrates the use of such a relay to control a section of a ladder program.



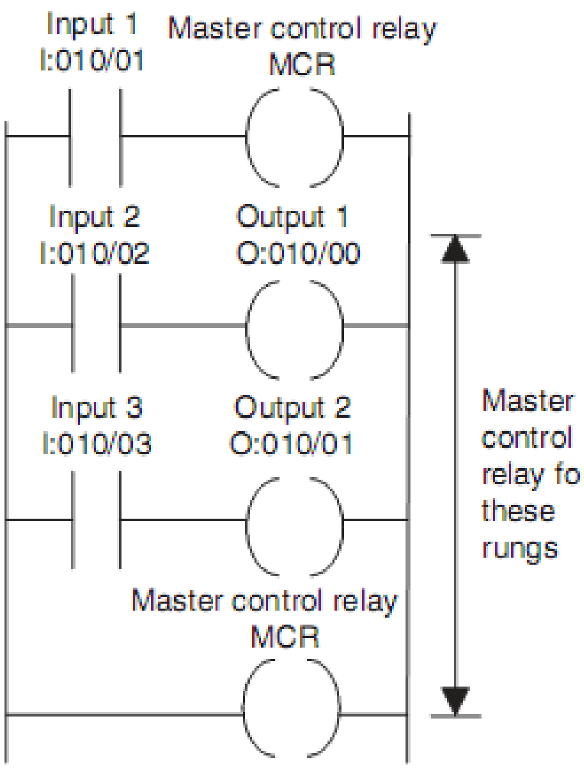
With no input to input In 1, the output internal relay MC 1 is not energized, and so its contacts are open. This means **that all the rungs between where it is designated to operate and the rung on which its reset MCR or another master control relay** are switched off.

So, in the example shown, if the In 1 is off, the master relay MC 1 is off and so all the rungs between its contacts MC1 and the rung with its reset MCR 1 (rungs 2 and 3). When input In 1 contacts close, the master relay MC 1 is energized and so the rungs 2 and 3.

The ladder diagram of the previous example with **Mitsubishi** and **Allen-Bradley** addresses is shown in the figure. In Allen-Bradley to end the control of one master control relay (MCR), a second master control relay (MCR) is used with no contacts or logic preceding it.



MCR with Mitsubishi PLC.

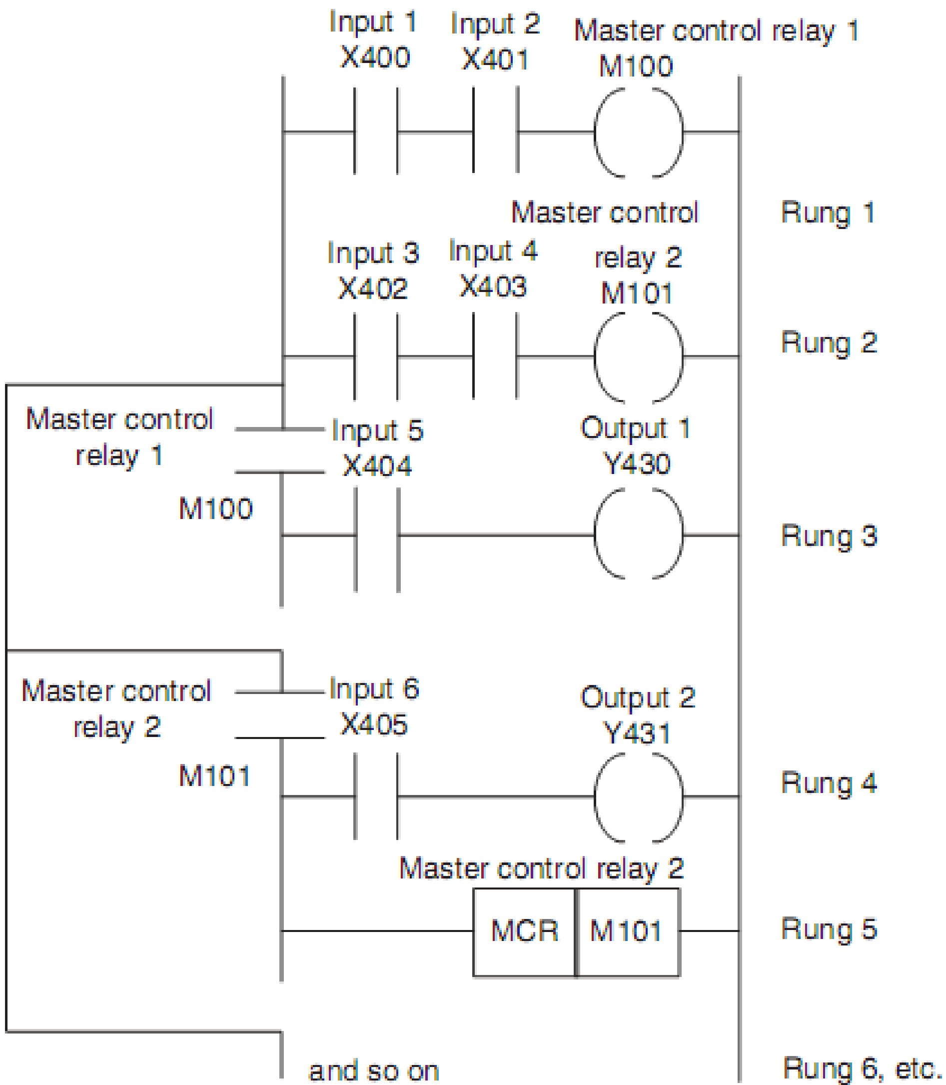


An MCR with Allen-Bradley PLC.

A program might use **a number of MCRs**, enabling various sections of a ladder program to be switched in or out.

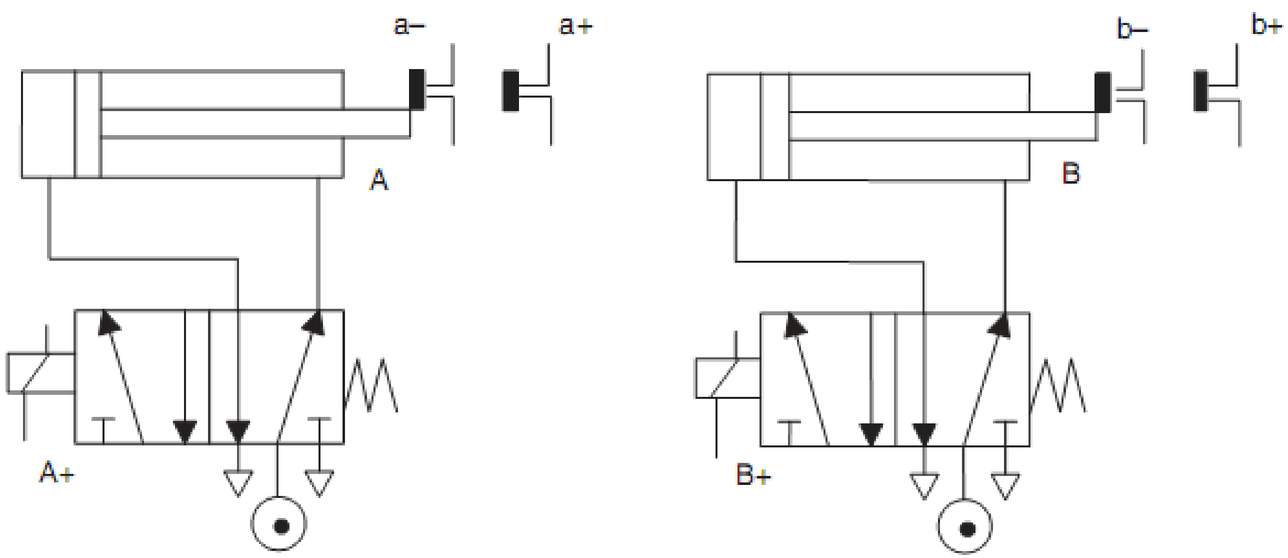
The figure shows a ladder program in **Mitsubishi** format involving two MCRs. With M100 switched on but M101 off, the sequence is: rungs 1, 2, 3, 6, and so on. The end of the M100 controlled section is indicated by the occurrence of the other MCR, M101.

With M101 switched on but M100 off, the sequence is: rungs 1, 2, 4, 5, 6, and so on. The end of this section is indicated by the presence of the reset. **This reset has to be used since the rung is not followed immediately by another MCR**.



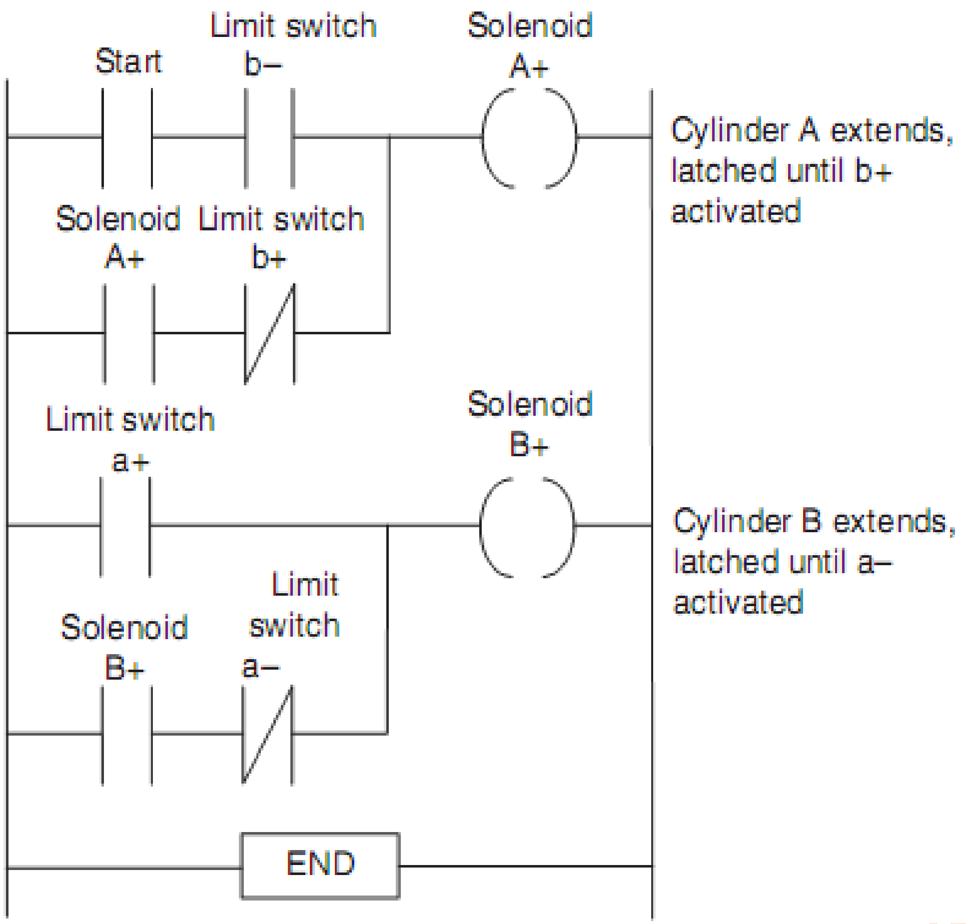
Examples of Programs

Consider a pneumatic system with single-solenoid controlled valves and involving two cylinders A and B with limit switches a–, a+, b–, b+ detecting the limits of the piston rod movements as shown in the figure.



The next figure shows the ladder diagram that can be used if the required sequence is A+,B+, A–, B–. The sequence must not start unless the two cylinders are in the retracted positions.

The solenoid A+ is energized when the start switch and limit switch b– are closed. This provides latching to keep A+ energized as long as the normally closed contacts for limit switch b+ are not activated. When limit switch a+ is activated, solenoid B+ is energized. This provides latching that keeps B+ energized as long as the normally closed contacts for limit switch a– are not activated. When cylinder B extends, the limit switch b+ opens its normally closed contacts and unlatches the solenoid A+. Solenoid A thus retracts. When it has retracted and opened the normally closed contacts a–, solenoid B+ becomes unlatched and cylinder B retracts.



Home work:

Try to repeat the previous example if the required sequence are:

1- A+,B+, B–, A–

2- A+, A–,B+, B–