9 Timers

In many control tasks there is a need to control time. For example, a motor or a pump might need to be controlled to operate for a particular interval of time, or perhaps be switched on after some time interval. PLCs thus have timers as built-in devices. Timers count fractions of seconds or seconds using the internal CPU clock. This chapter shows how such timers can be programmed to carry out control tasks.

9.1 Types of timers

PLC manufacturers differ on how timers should be programmed and hence how they can be considered. A common approach is to consider timers to behave like relays with coils which when energised result in the closure or opening of contacts after some preset time. The timer is thus treated as an output for a rung with control being exercised over pairs of contacts elsewhere (Figure 9.1(a)). This is the predominant approach used in this book. Some treat a timer as a delay block which when inserted in a rung delays signals in that rung reaching the output (Figure 9.1(b)).

There are a number of different forms of timers that can be found with PLCs. With small PLCs there is likely to be just one form, the *on-delay timers*. These are timers which come on after a particular time delay (Figure 9.2(a)). *Off-delay timers* are on for a fixed period of time before turning off (Figure 9.2(b)). Another type of timer that occurs is the *pulse timer*. This timer switches on or off for a fixed period of time (Figure 9.2(c)). Figure 9.3 shows the IEC 1131-3 standard symbols for timers. TON is used to denote on-delay, TOF off-delay. TP pulse timers. On-delay is also represented by T–0 and off-delay by 0–T.

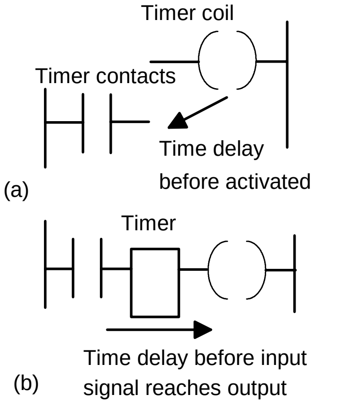


Figure 9.1 *Treatment of timers*

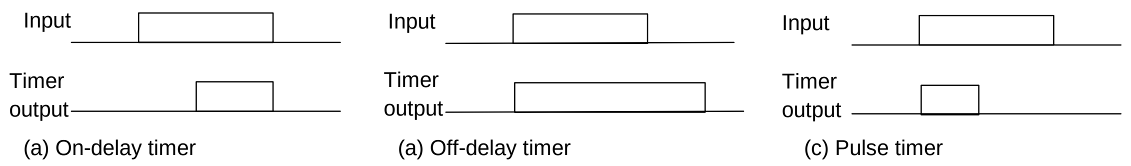


Figure 9.2 *Timers: (a) on-delay, (b) off-delay, (c) pulse*

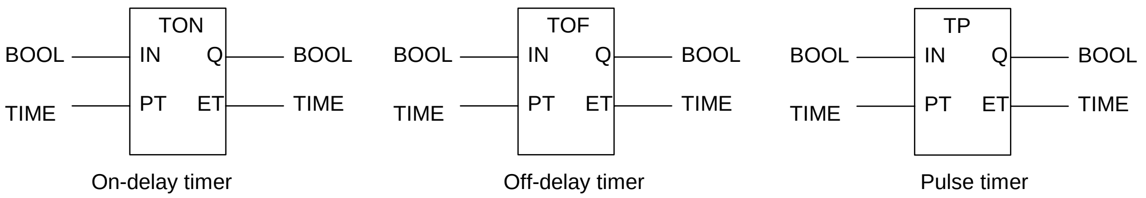


Figure 9.3 *IEC 1131-1 standards. BOOL indicates a Boolean input/output, i.e. on/off. IN is the input. Q is the output. ET is the elapsed time output. PT is the input used to specify the time.*

The time duration for which a timer has been set is termed the preset and is set in multiples of the time base used. Some time bases are typically 10 ms, 100 ms, 1 s, 10 s and 100 s. Thus a preset value of 5 with a time base of 100 ms is a time of 500 ms. For convenience, where timers are involved in this text, a time base of 1 s has been used.

9.2 Programming timers

All PLCs generally have delay-on timers, small PLCs possibly having only this type of timer. Figure 9.4(a) shows a ladder rung diagram involving a delay-on timer. Figure 9.4(a) is typical of Mitsubishi. The timer is like a relay with a coil which is energised when the input In 1 occurs (rung 1). It then closes, after some preset time delay, its contacts on rung 2. Thus the output occurs some preset time after the input In 1 occurs. Figure 9.4(b) shows the timer to be a delay item in a rung, rather than as a relay, the example being for Siemens. When the signal at the timer's start input changes from 0 to 1, the timer starts and runs for the programmed duration, giving its output then to the output coil. The time value (TV) output can be used to ascertain the amount of time remaining at any instant. A signal input of 1 at the reset input resets the timer whether it is running or not. Techniques for the entry of preset time values vary. Often it requires the entry of a constant K command followed by the time interval in multiples of the time base used. Figure 9.4(c), (d) and (e) shows ladder diagrams Telemecanique, Toshiba and Allen-Bradley.

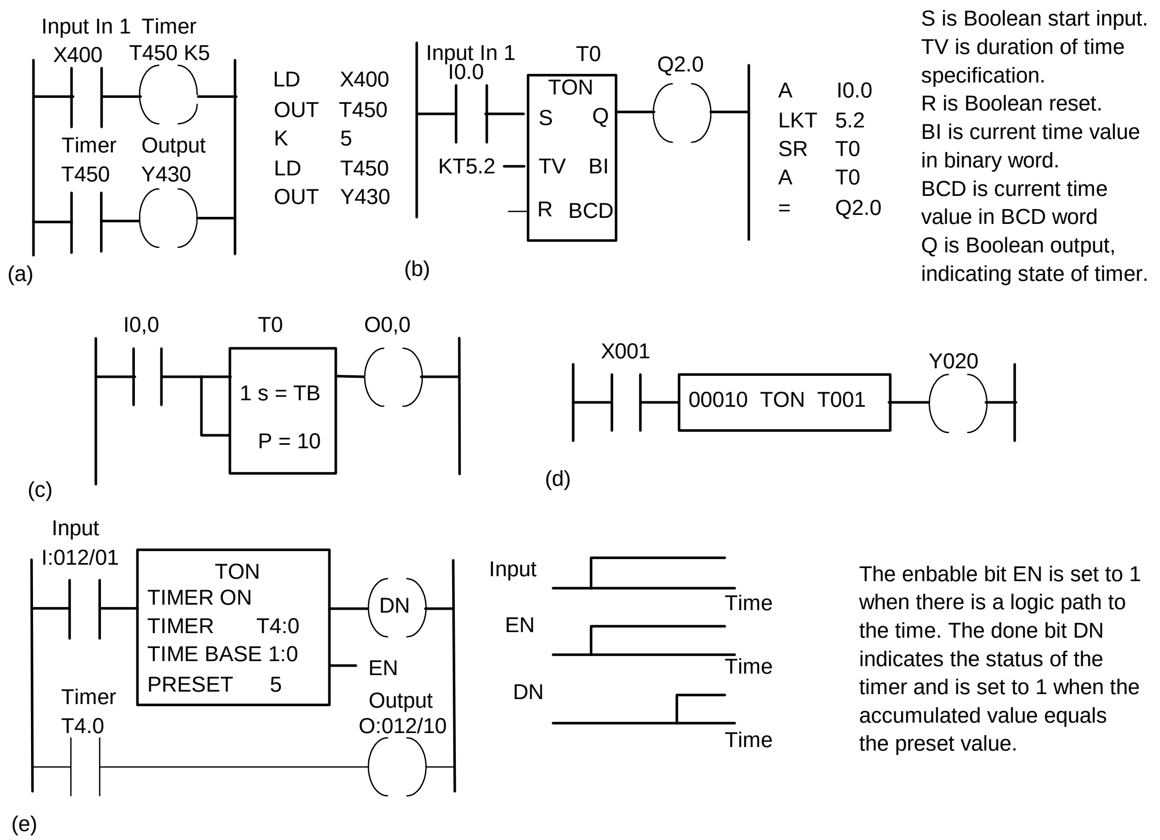


Figure 9.4 *Timers: (a) Mitsubishi, (b) Siemens, (c) Telemecanique, (d) Toshiba, (e) Allen-Bradley*

9.2.1 Sequencing

As an illustration of the use of a timer, consider the ladder diagram shown in Figure 9.5(a). When the input In 1 is on, the output Out 1 is switched on. The contacts associated with this output then start the timer. The contacts of the timer will close after the preset time delay, in this case 5.5 s. When this happens, output Out 2 is switched on. Thus, following the input In 1, Out 1 is switched on and followed 5.5 s later by Out 2. This illustrates how timed sequence of outputs can be achieved. Figure 9.5(b) shows the same operation where the format used by the PLC manufacturer is for the timer to institute a signal delay.

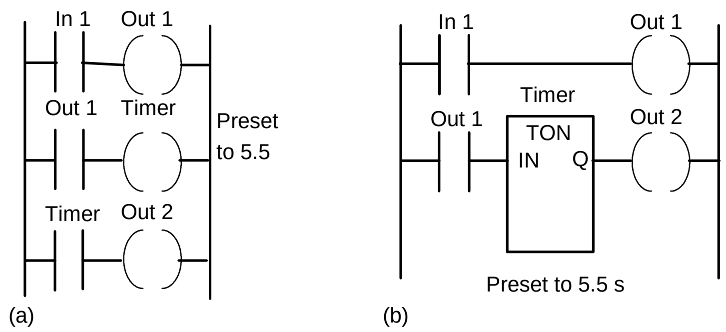


Figure 9.5 *Sequenced outputs*

Figure 9.6 shows two versions of how timers can be used to start three outputs, e.g. three motors, in sequence following a single start button being pressed. In (a) the timers are programmed as coils, whereas in (b) they are programmed as delays. When the start push button is pressed there is an output from internal relay IR1. This latches the start input. It also starts both the timers, T1 and T2, and motor 1. When the preset time for timer 1 has elapsed then its contacts close and motor 2 starts. When the preset time for timer 2 has elapsed then its contacts close and motor 3 starts. The three motors are all stopped by pressing the stop push button. Since this is seen as a complete program, the end instruction has been used.

9.2.2 Cascaded timers

Timers can be linked together, the term *cascaded* is used, to give longer delay times than are possible with just one timer. Figure 9.7(a) shows the ladder diagram for such an arrangement. Thus we might have timer 1 with a delay time of 999 s. This timer is started when there is an input to In 1. When the 999 s time is up, the contacts for timer 1 close. This then starts timer 2. This has a delay of 100 s. When this time is up, the timer 2 contacts close and there is an output from Out 1. Thus the output occurs 1099 s after the input to In 1. Figure 9.7(b) shows the Mitsubishi version of this ladder diagram and the program instructions for that ladder.

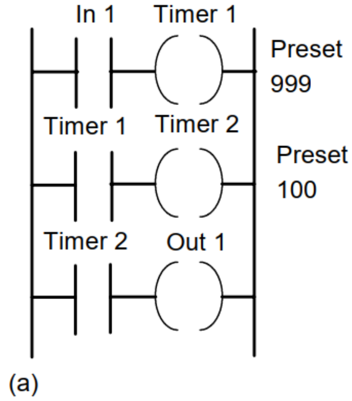


Figure 9.7 *Cascaded timers*

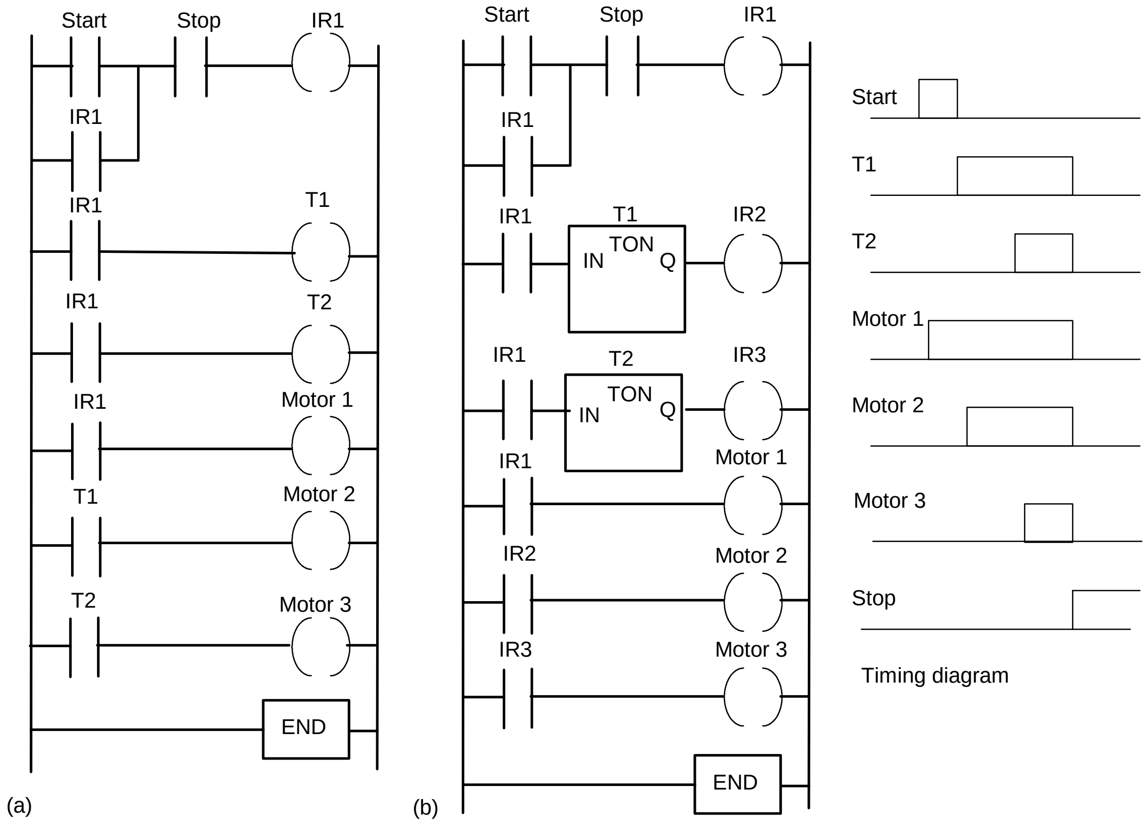


Figure 9.6 *Motor sequence*

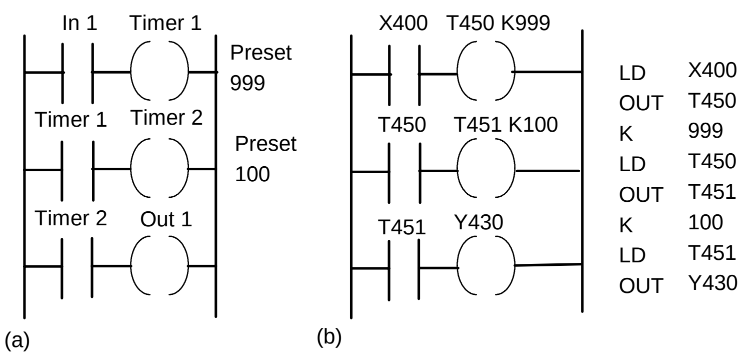


Figure 9.7 *Cascaded timers*

9.2.3 On-off cycle timer

Figure 9.8 shows how on-delay timers can be used to produce an *on-off cycle timer*. The timer is designed to switch on an output for 5 s, then off for 5 s, then on for 5 s, then off for 5 s, and so on. When there is an input to In 1 and its contacts close, timer 1 starts. Timer 1 is set for a delay of 5 s. After 5 s, it switches on timer 2 and the output Out 1. Timer 2 has a delay of 5 s. After 5 s, the contacts for timer 2, which are normally closed,

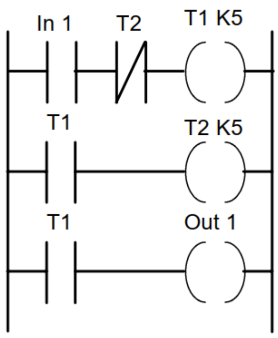


Figure 9.8 *On-off cycle timer*

open. This results in timer 1, in the first rung, being switched off. This then causes its contacts in the second rung to open and switch off timer 2. This results in the timer 2 contacts resuming their normally closed state and so the input to In 1 causes the cycle to start all over again.

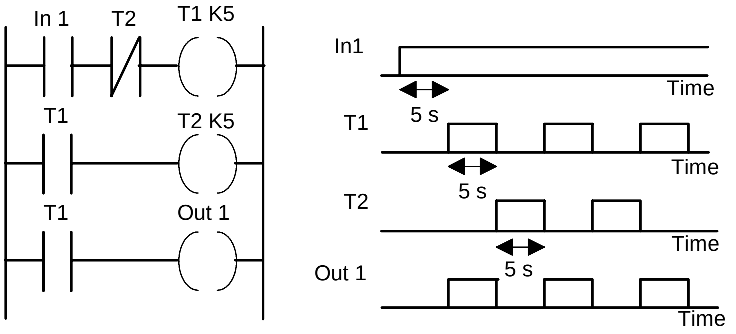


Figure 9.8 *On - off cycle timer*

Figure 9.9 shows how the above ladder program would appear in the format used with a timer considered as a delay, rather than as a coil. This might, for example, be with Siemens or Toshiba. When input In 1 closes, the timer T1 starts. After its preset time, there is an output to Out 1 and timer T2 starts. After its preset time there is an output to the internal relay IR1. This opens its contacts and stops the output from Out 1. This then switches off timer T2. The entire cycle can then repeat itself.

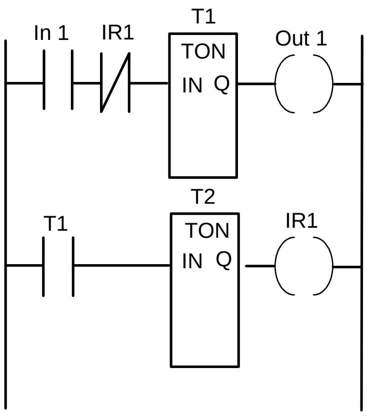


Figure 9.9 *On–off cycle timer*

9.3 Off-delay timers

Figure 9.10 shows how a on-delay timer can be used to produce an *off-delay timer*. With such an arrangement, when there is a momentary input to In 1, both the output Out 1 and the timer are switched on. Because the input is latched by the Out 1 contacts, the output remains on. After the preset timer time delay, the timer contacts, which are normally closed, open and switch off the output. Thus the output starts as on and remains on until the time delay has elapsed.

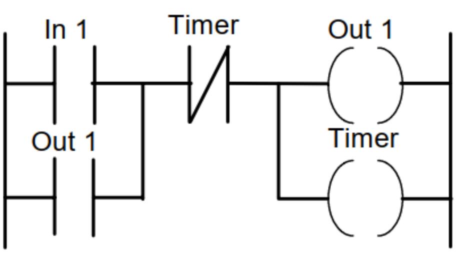


Figure 9.10 *Off-delay timer*

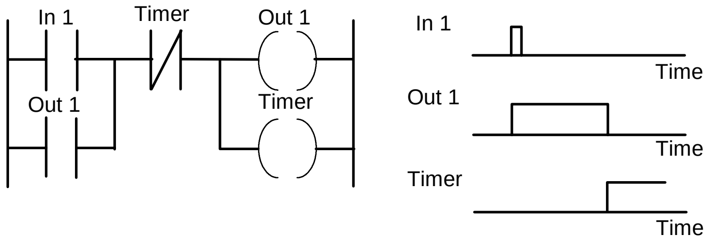
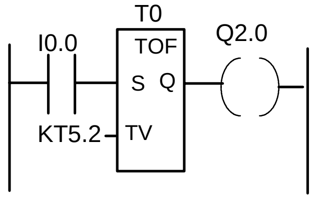


Figure 9.10 *Off-delay timer*

Some PLCs have, as well as on-delay timers, built-in off-delay timers and thus there is no need to use an on-delay timer to produce an off-delay timer. Figure 9.11 illustrates this for a Siemens PLC, giving the ladder diagram and the instruction list. Note that with this manufacturer, the timer is considered to be a delay item in a rung, rather than as a relay. In the rectangle symbol used for the timer, the 0 precedes the T and indicates that it is an on-delay timer.




```
A    I0.0
LKT  5.2
SF   T0
A    T0
=    Q2.0
```

Figure 9.11 *Off-delay timer*

As an illustration of the use of an off-delay timer, consider the Allen-Bradley program shown in Figure 9.12. TOF is used to indicate that it is an off-delay, rather than on-delay (TON) timer. The time base is set to 1:0 which is 1 s. The preset is 10 so the timer is preset to 10 s.

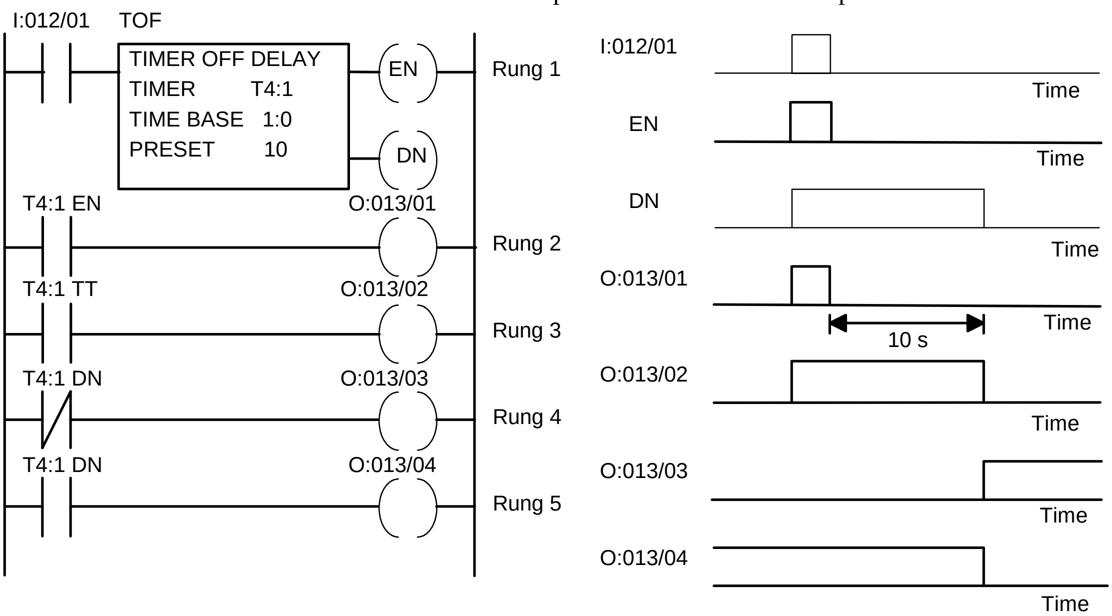


Figure 9.12 *Application of an off-delay timer*

In the first rung, the output of the timer is taken from the EN (for enable) contacts. This means that there is no time delay between an input to I:012/01 and the EN output. As a result the EN contacts in rung 2 close immediately there is an I:012/01 input. Thus there is an output from O:013/01 immediately the input I:012/01 occurs. The TT (for timer timing) contacts in rung 3 are energised just while the timer is running. Because the timer is an off-delay timer, the timer is turned on for 10 s before turning off. Thus the TT contacts will close when the set time of 10 s is running. Hence output O:012/02 is switched on for this time of 10 s. The DN (for done) contacts which are normally closed, open after the 10 s and so output O:013/03 comes on after 10 s. The DN contacts which are normally open, close after 10 s and so output O:013/04 goes off after 10 s.

9.4 Pulse timers

Pulse timers are used to produce a fixed duration output from some initiating input. Figure 9.13(a) shows a ladder diagram for a system that will give an output from Out 1 for a predetermined fixed length of time when there is an input to In 1, the timer being one involving a coil. There are two outputs for the input In 1. When there is an input to In 1, there is an output from Out 1 and the timer starts. When the predetermined time has elapsed, the timer contacts open. This switches off the output. Thus the output remains on for just the time specified by the timer.

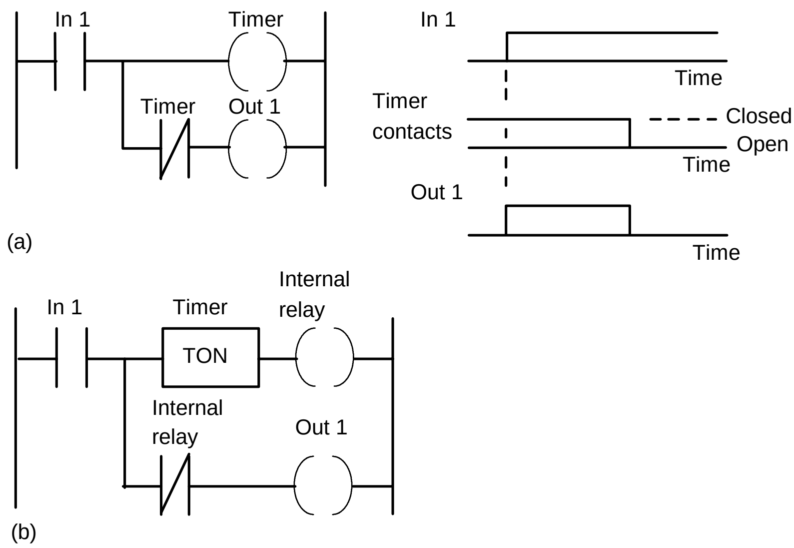


Figure 9.13 *Pulse-on timer*

Figure 9.13(b) shows an equivalent ladder diagram to Figure 9.13(a) but employing a timer which produces a delay in the time taken for a signal to reach the output.

In Figure 9.13, the pulse timer has an output switched on by an input for a predetermined time, then switching off. Figure 9.14 shows another pulse timer that switches an output on for a predetermined time after the input ceases. This uses a timer and two internal relays. When there is an input to In 1, the internal relay IR 1 is energised. The timer does not start at this point because the normally closed In 1 contacts are open. The closing of the IR 1 contacts means that the internal relay IR 2 is energised. There is, however, no output from Out 1 at this stage because, for the bottom rung, we have In 1 contacts open. When the input to In 1 ceases, both the internal relays remain energised and the timer is started. After the set time, the timer contacts, which are normally closed, open and switch off IR 2. This in turn switches off IR 1. It also, in the bottom rung, switches off the output Out 1. Thus the output is off for the duration of the input, then being switched on for a predetermined length of time.

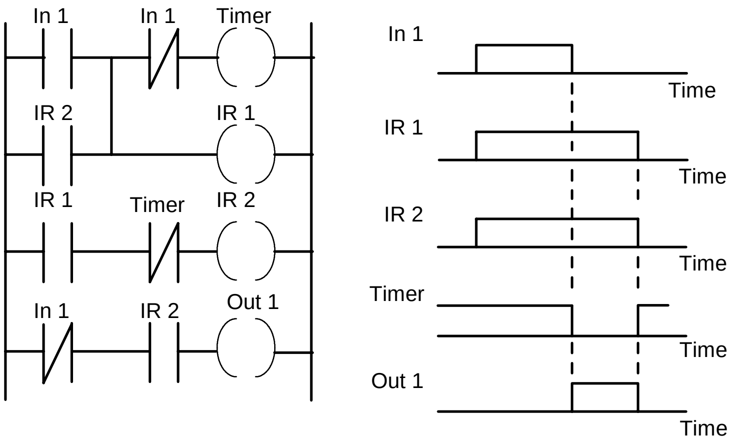


Figure 9.14 *Pulse timer on, when output ceases*

9.5 Programming examples

Consider a program (Figure 9.15) that could be used to flash a light on and off as long as there is some output occurring. Thus we might have both timer 0 and timer 1 set to 1 s. When the output occurs, then timer 0 starts and switches on after 1 s. This closes the timer 0 contacts and starts timer 1. This switches on after 1 s and, in doing so, switches off timer 0. In so doing, it switches off itself. The lamp is only on when timer 0 is on and so we have a program to flash the lamp on and off as long as there is an output.

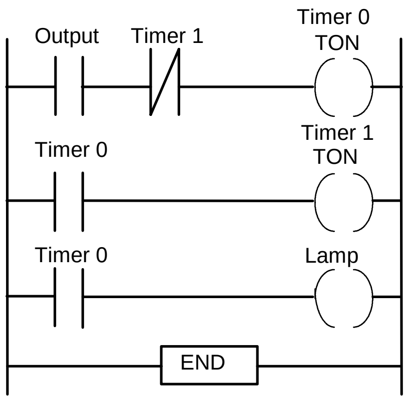


Figure 9.15 *Flashing light*