➢Chapter 7
Programming Timers

❑Mechanical Timing Relay

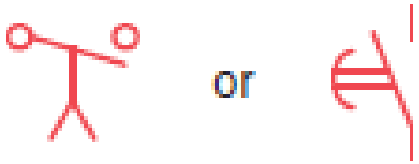
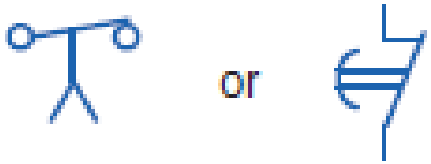
➢Mechanical timing relays are used to delay the opening or closing of contacts for circuit control

➢The operation of a mechanical timing relay is similar to that of a control relay, except that certain of its contacts are designed to operate at a preset time interval, after the coil is energized or de-energized

➢ Mechanical timing relays provide time delay through two arrangements.

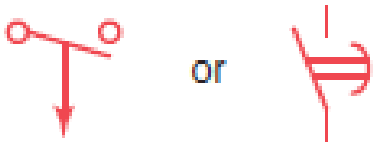
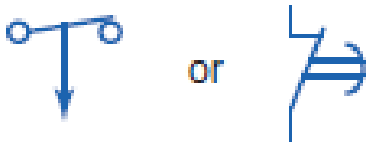
❑Mechanical Timing Relays

➢The first arrangement, *on delay, provides* time delay when the relay coil is *energized*

On-delay symbols	
	
Normally open, timed closed contact (NOTC). Contact is open when relay coil is de-energized. When relay is energized, there is a time delay in closing.	Normally closed, timed open contact (NCTO). Contact is closed when relay coil is de-energized. When relay is energized, there is a time delay in opening.

❑Mechanical Timing Relays

➢The second arrangement, *off delay, provides time delay when* the relay coil is *de-energized*

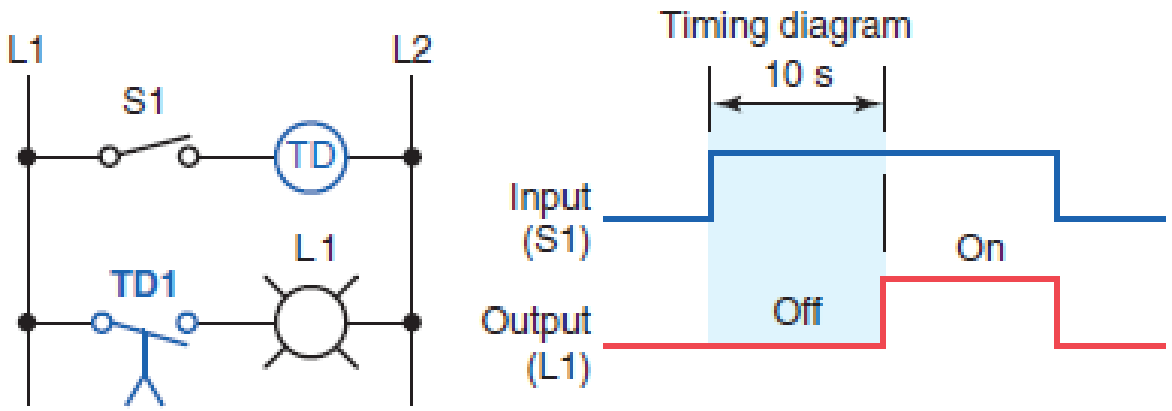
Off-delay symbols	
	
Normally open, timed open contact (NOTO).	Normally closed, timed closed contact (NCTC).
Contact is normally open when relay coil is de-energized.	Contact is normally closed when relay coil is de-energized.
When relay coil is energized, contact closes instantly.	When relay coil is energized, contact opens instantly.
When relay coil is de-energized, there is a time delay before the contact opens.	When relay coil is de-energized, there is a time delay before the contact closes.

❑Mechanical Timing Relays

➢The on-delay timer is sometimes referred to as DOE, which stands for delay on energize.

➢The time delay of the contacts begins once the timer is switched on; hence the term *on-delay timing.*

➢*Figure shows an on-delay timer circuit* that uses a normally open, timed closed (NOTC) contact.



❑Mechanical Timing Relays

➢The operation of the circuit can be summarized as follows:

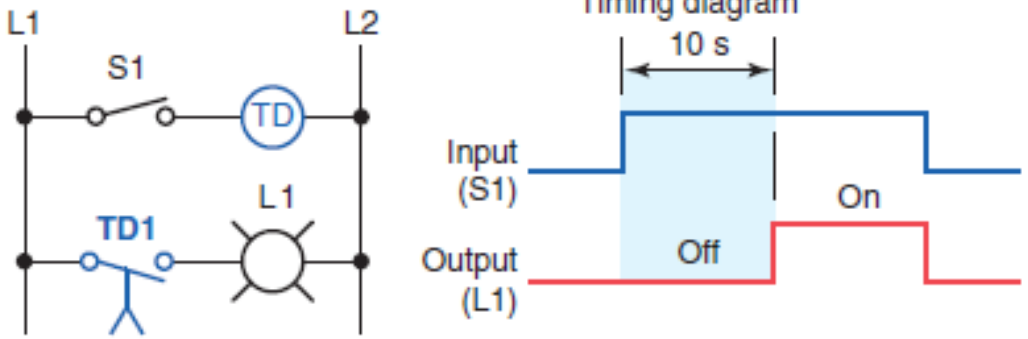
• With S1 initially open, TD coil is de-energized so TD1 contacts are open and light L1 will be off.

• When S1 is closed TD coil is energized and the timing period starts.

• TD1 contacts are delayed from closing so L1 remains off.

• After the 10 s time-delay period has elapsed, TD1 contacts close and L1 is switched on.

• When S1 is opened, TD coil is de-energized and TD1 contacts open instantly to switch L1 off.



❑Mechanical Timing Relays

➢Figure shows an on-delay timer circuit that uses a normally closed, timed open (NCTO) contact.

➢The operation of the circuit can be summarized as follows:

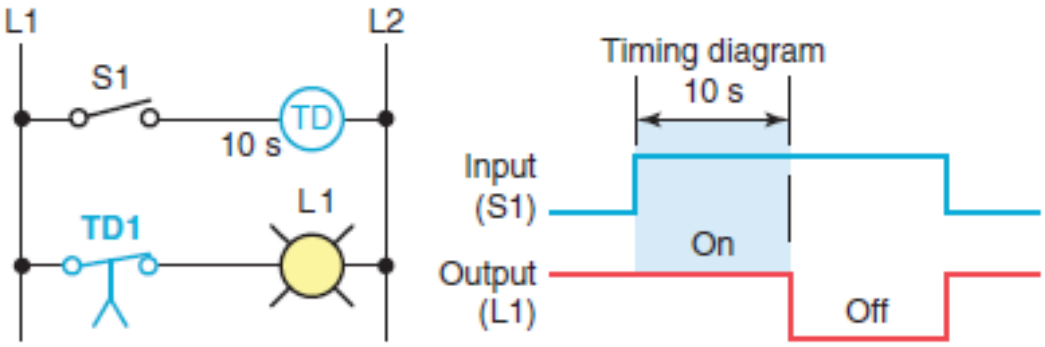
• With S1 initially open, TD coil is de-energized so TD1 contacts are closed and light L1 will be on.

• When S1 is closed, TD coil is energized and the timing period starts.

• TD1 contacts are delayed from opening so L1 remains on.

• After the 10 s time-delay period has elapsed, TD1 contacts open and L1 is switched off.

• When S1 is opened, TD coil is de-energized and TD1 contacts close instantly to switch L1 on



❑Mechanical Timing Relays

➢Figure shows an off-delay timer circuit that uses a normally open, timed open (NOTO) contact.

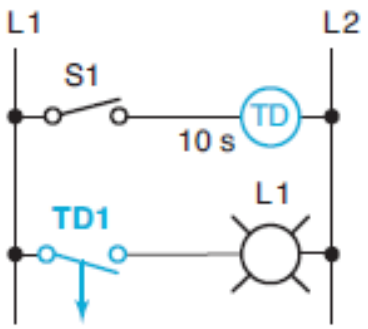
➢The operation of the circuit can be summarized as follows:

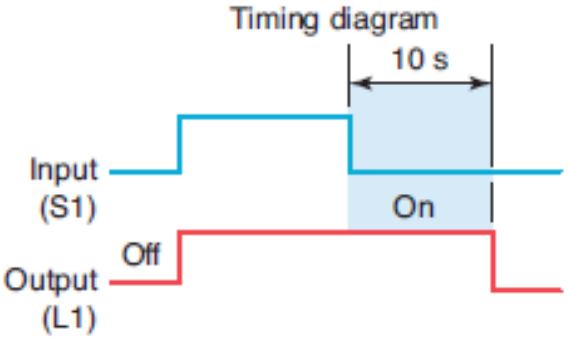
• With S1 initially open, TD coil is de-energized so TD1 contacts are open and light L1 will be off.

• When S1 is closed, TD coil is energized and TD1 contacts close instantly to switch light L1 on.

• When S1 is opened, TD coil is de-energized and the timing period starts.

• After the 10 s time-delay period has elapsed, TD1contacts open to switch the light off.





❑Mechanical Timing Relays

➢Figure shows an off-delay timer circuit that uses a normally closed, timed closed (NCTC) contact.

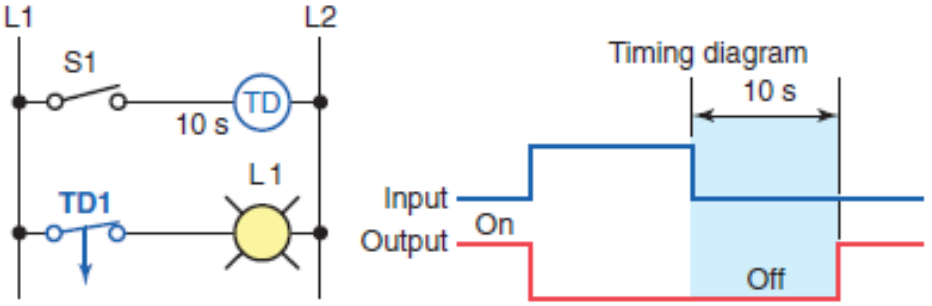
➢The operation of the circuit can be summarized as follows:

• With S1 initially open, TD coil is de-energized so TD1 contacts are closed and light L1 will be on.

• When S1 is closed, TD coil is energized and TD1 contacts open instantly to switch light L1 off.

• When S1 is opened, TD coil is de-energized and the timing period starts. TD1 contacts are delayed from closing so L1 remains off.

• After the 10 s time-delay period has elapsed, TD1 contacts close to switch the light on.



❑Timer Instructions

➢PLC timers are instructions that provide the same functions as on-delay and off-delay mechanical and electronic timing relays.

➢PLC timers offer several advantages over their mechanical and electronic counterparts.

➢These include the fact that:

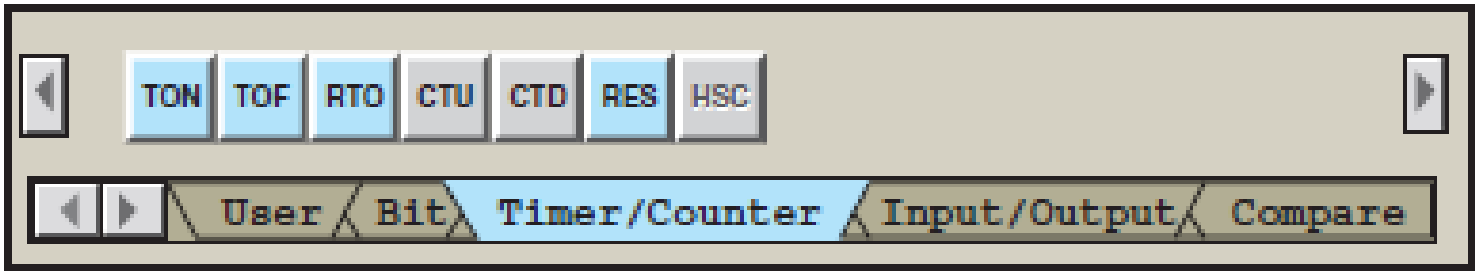
• Time settings can be easily changed.

• The number of them used in a circuit can be increased or decreased through the use of programming changes rather than wiring changes.

• Timer accuracy and repeatability are extremely high because its time delays are generated in the PLC processor.

❑Timer Instructions

- In general, there are three different PLC timer types:
- The *on-delay timer (TON), off-delay timer (TOF), and retentive timer on (RTO).*
- *The most common is the on-delay timer,* which is the basic function.
- There are also many other timing configurations, all of which can be derived from one or more of the basic time-delay functions.
- Figure shows the timer selection toolbar for the Allen-Bradley SLC 500 PLC and its associated RSLogix software.



❑Timer Instructions

➢These timer commands can be summarized as follows:

TON (Timer On Delay) —Counts time-based intervals when the instruction is true.

TOF (Timer Off Delay) —Counts time-based intervals when the instruction is false.

RTO (Retentive Timer On) —Counts time-based intervals when the instruction is true and retains the accumulated value when the instruction goes false or when power cycle occurs.

RES (Reset) —Resets a retentive timer's accumulated value to zero.

❑Timer Instructions

➢Several quantities are associated with the timer instruction:

• The *preset time represents the time duration for* the timing circuit. For example, if a time delay of 10 s is required, the timer will have a preset of 10 s.

• The *accumulated time represents the amount of* time that has elapsed from the moment the timing coil became energized.

• Every timer has a *time base. Once the timing rung* has continuity, the timer counts in time-based intervals and times until the preset value and accumulated value are equal or, depending on the type of ontroller, up to the maximum time interval of the timer.

➢The intervals that the timers time out at are generally referred to as the time bases of the timer.

❑Timer Instructions

➢Timers can be programmed with several different time bases: 1 s, 0.1 s, and 0.01 s are typical time bases.

➢If a programmer entered 0.1 for the time base and 50 for the number of delay increments, the timer would have a 5 s delay (50 x 0.1 s = 5 s).

➢The smaller the time base selected, the better the accuracy of the timer.

❑Timer Instructions

➢Figure shows a coil formatted timer instruction.

➢Its operation can be summarized as follows:

• The timer is assigned an address and is identified as a timer.

• Also included as part of the timer instruction is the time base of the timer, the timer's preset value or time-delay period, and the accumulated value or current time-delay period for the timer.

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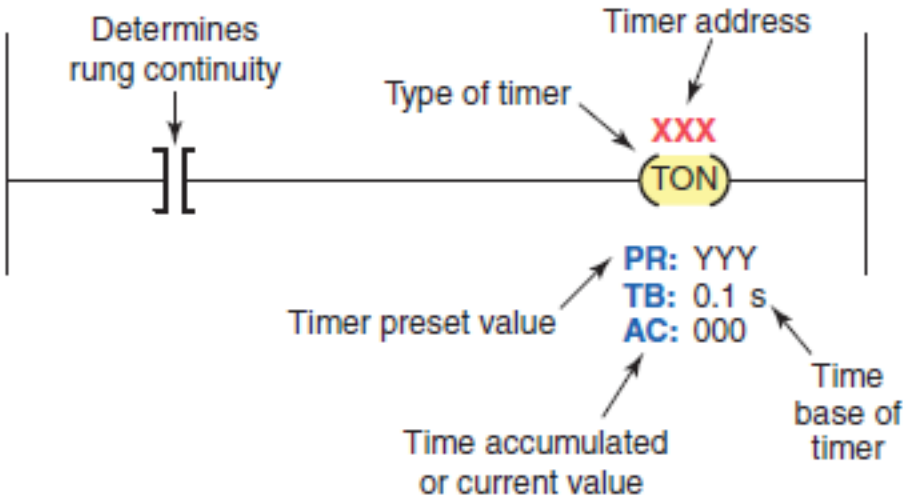
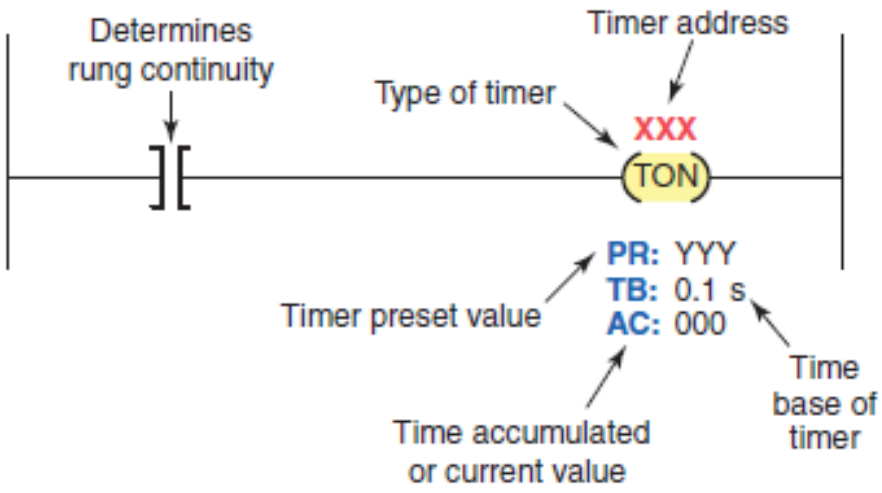


❑Timer Instructions

- When the timer rung has logic continuity, the timer begins counting time-based intervals and times until the accumulated value equals the preset value.
- When the accumulated time equals the preset time, the output is energized and the timed output contact associated with the output is closed.
- The timed contact can be used as many times as you wish throughout the program as an NO or NC contact.



❑On-Delay Timer Instruction

➢ Figure illustrates the principle of operation of an on-delay timer.

➢Its operation can be summarized as follows:

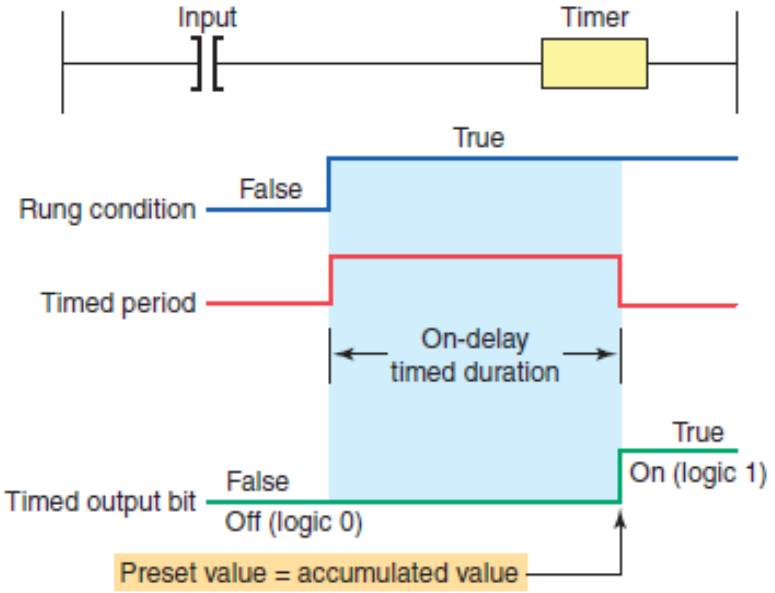
• The on-delay timer operates such that when the rung containing the timer is true, the timer time-out period commences.

• At the end of the timer time-out period, an output is made true.

• The timed output becomes true sometime after the timer rung becomes true; hence, the timer is said
To have an on-delay.

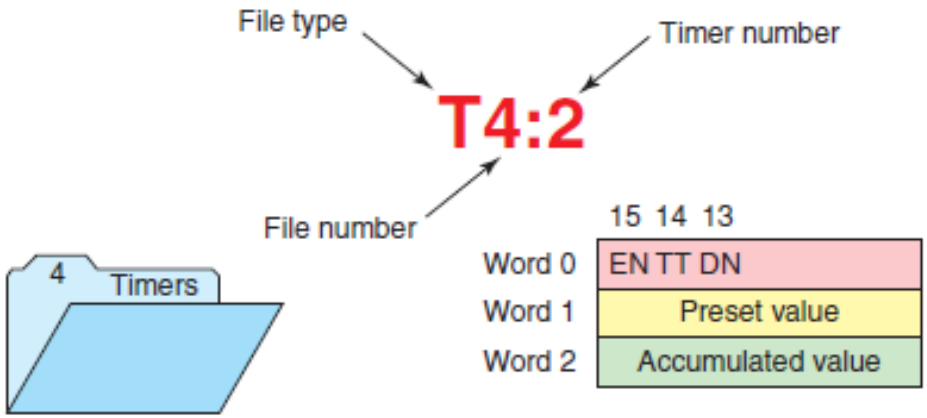
• The length of the time delay can be adjusted by changing the preset value.

• In addition, some PLCs allow the option of changing the time base, or resolution, of the timer. As the time base you select becomes smaller, the Accuracy of the timer increases.



❑On-Delay Timer Instruction

- ➢The Allen-Bradley SLC 500 timer file is file 4 (Figure).
- ➢Each timer is composed of three 16-bit words, collectively called a timer element.
- ➢There can be up to 256 timer elements.
- ➢ Addresses for timer file 4, timer element number 2 (T4:2), are listed below.
- ➢T4 timer file
- ➢: 2 timer element number 2 (0–255 timer elements) per file)



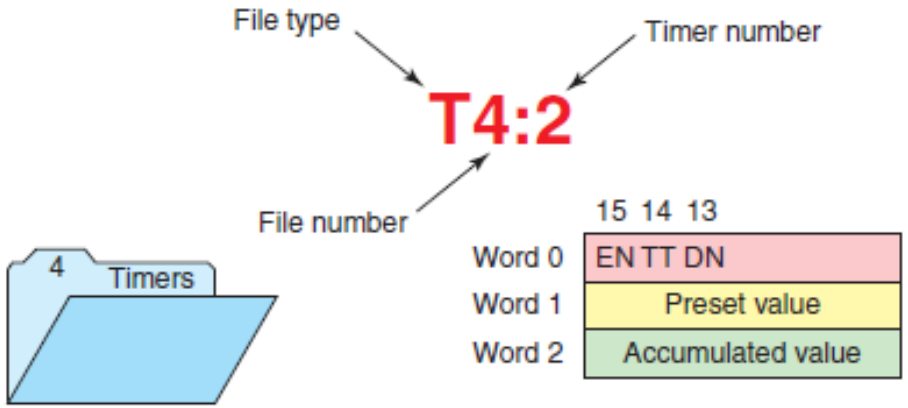
❑On-Delay Timer Instruction

➢The *control word uses the following three control bits:*

➢**Enable (EN) bit —**The enable bit is true (has a status of 1) whenever the timer instruction is true. When the timer instruction is false, the enable bit is false (has a status of 0).

➢**Timer-timing (TT) bit —**The timer-timing bit is true whenever the accumulated value of the timer is changing, which means the timer is timing. When the timer is not timing , the accumulated value is not changing, so the timer-timing bit is false.

➢**Done (DN) bit —**The done bit changes state whenever the accumulated value reaches the preset value.



➢On-Delay Timer Instruction

➢The *preset value (PRE) word is the set point of the timer,* that is, the value up to which the timer will time.

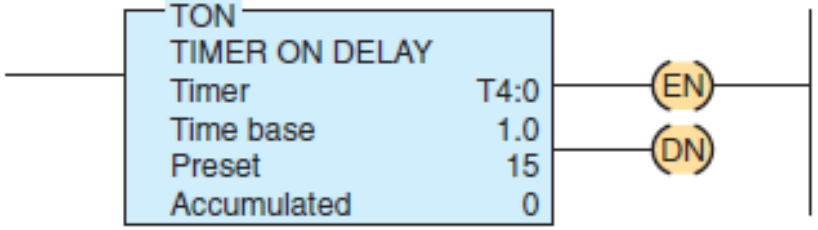
➢ The preset word has a range of 0 through 32,767 and is stored in binary form.

➢The preset will not store a negative number.

➢The *accumulated value (ACC) word is the value that increments* as the timer is timing.

➢The accumulated value will stop incrementing when its value reaches the preset value.

➢The timer instruction also requires that you enter a *time base, which is either 1.0 s or 0.01 s.*



➢On-Delay Timer Instruction

➢The on-delay timer (TON) is the most commonly used timer.

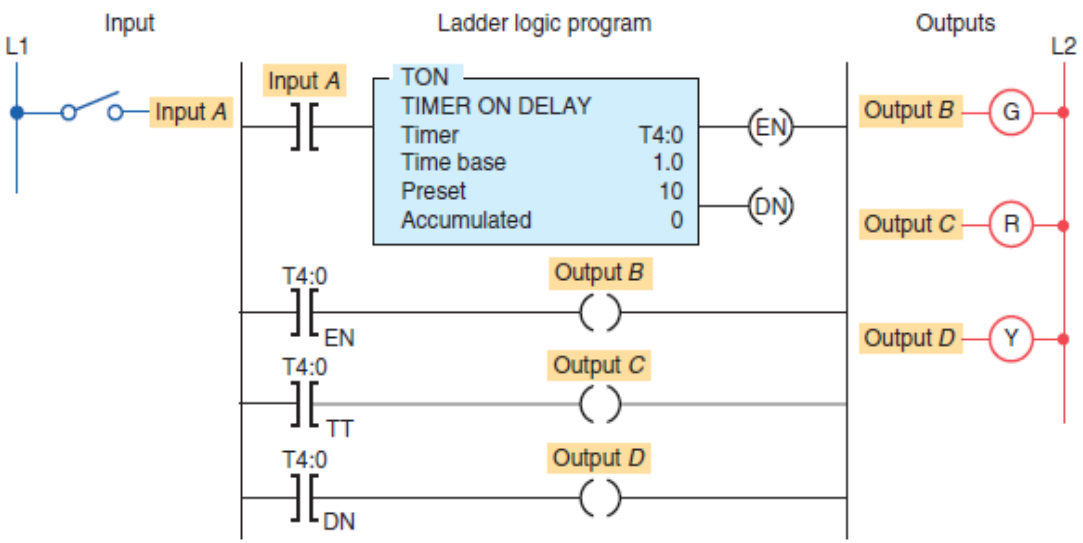
➢Figure shows a PLC program that uses an on delay timer.

➢The operation of the program can be summarized as follows:

• The timer is activated by input switch A.

• The preset time for this timer is 10 s, at which time output D will be energized.

• When input switch is A is closed, the timer becomes true and the timer begins counting and counts until the accumulated time equals the preset value; the output D is then energize



➢On-Delay Timer Instruction

• Figure shows the timing diagram for the on delay timer's control bits. The sequence of operation is as follows:

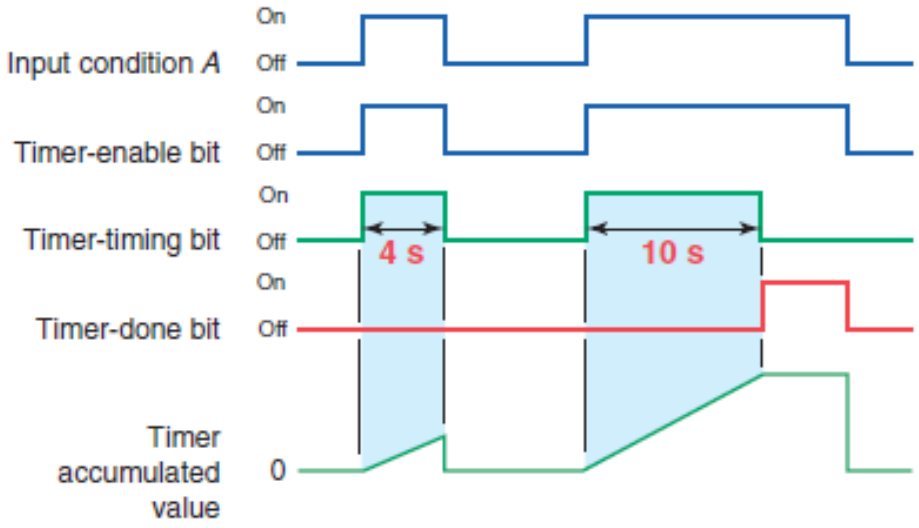
• The first true period of the timer rung shows the timer timing to 4 s and then going false.

• The timer resets, and both the timer-timing bit and the enable bit go false.

• The accumulated value also resets to 0.

• For the second true period input *A remains true in* excess of 10 s.

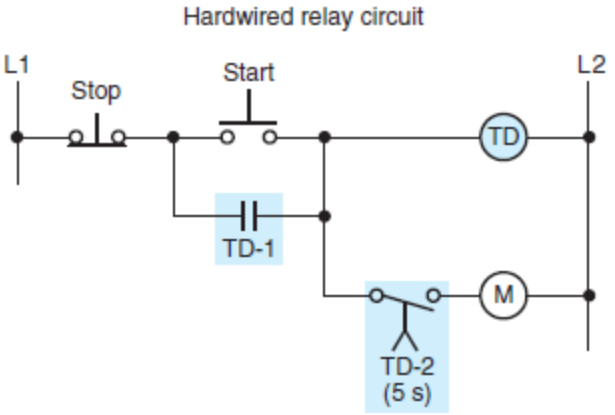
• When the accumulated value reaches 10 s, the done bit (DN) goes from false to true and the timer Timing bit (TT) goes from true to false.

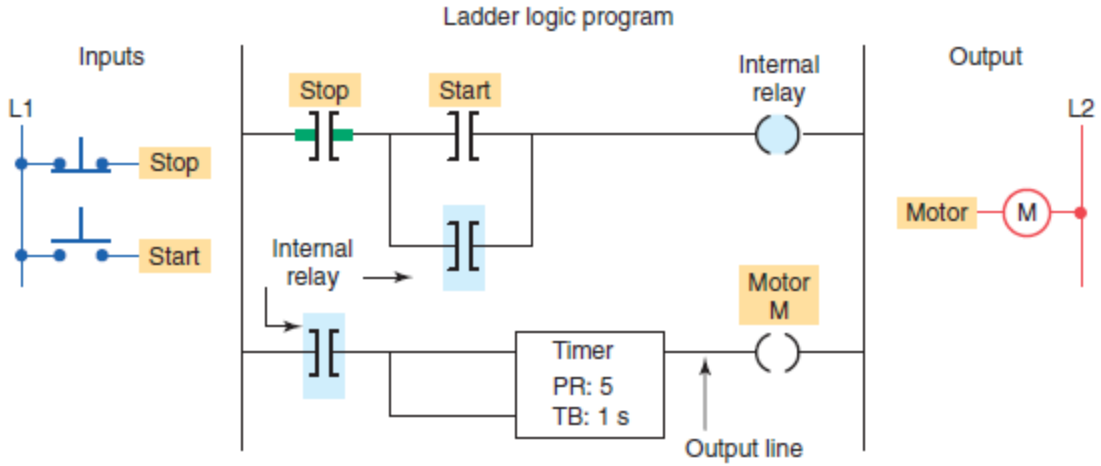


• When input *A goes false, the timer instruction goes* false and also resets, at which time the control bits are all reset and the accumulated value resets to 0.

➢On-Delay Timer Instruction

• According to the hardwired relay circuit diagram, coil M is to be energized 5 s after the start pushbutton is pressed.



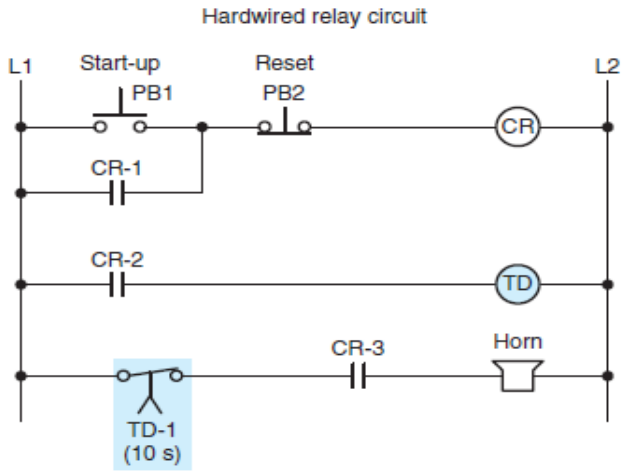


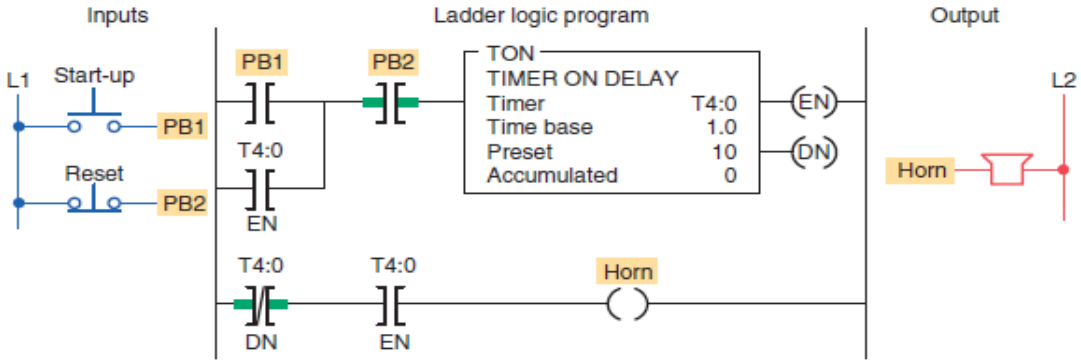
➢On-Delay Timer Instruction

• This circuit is used as a warning signal when moving equipment, such as a conveyor motor, is about to be started.

• The operation of the circuit according to the hardwired relay circuit diagram, coil CR is energized when the s is momentarily actuated.

• As a result, contact CR-1 closes to seal in CR coil, contact CR-2 closes to energize timer coil TD, and contact CR-3 closes to sound the horn.



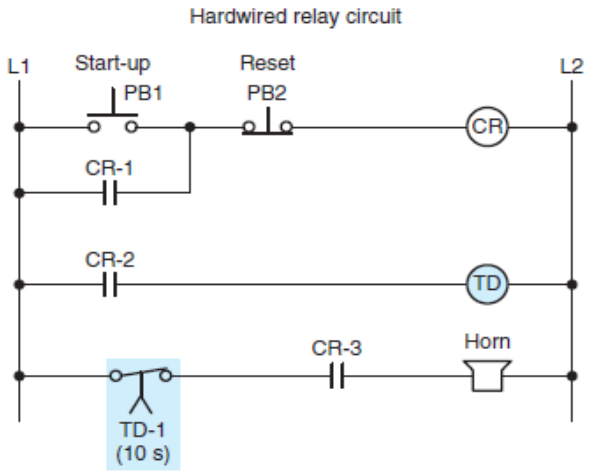


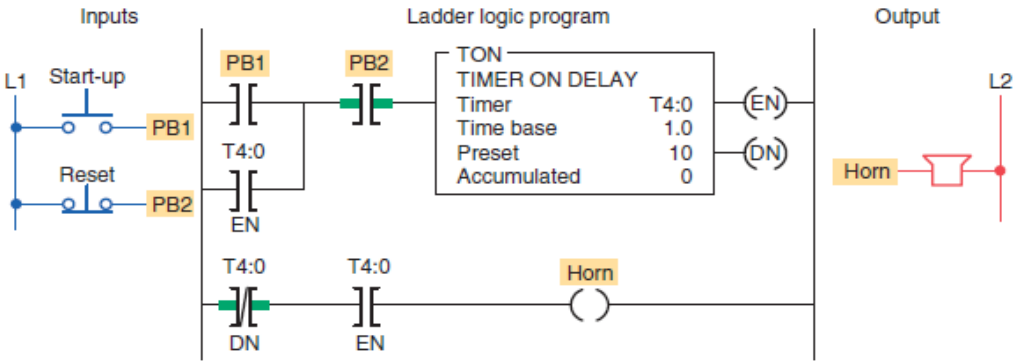
➢On-Delay Timer Instruction

• After a 10-s time-delay period, timer contact TD-1 opens to automatically switch the horn off.

• The ladder logic program shows how an equivalent circuit could be programmed using a PLC.

• The logic on the last rung is the same as the timer Timing bit and as such can be used with timers that do not have a timer-timing output





➢On-Delay Timer Instruction

➢According to the relay ladder schematic , lube-oil pump motor starter coil M1 is energized when the start pushbutton PB2 is momentarily actuated.

- As a result, M1-1 control contact closes to seal in M1, and the lube-oil pump motor starts.
- When the lube-oil pump builds up sufficient oil pressure, the lube-oil pressure switch PS1 closes.
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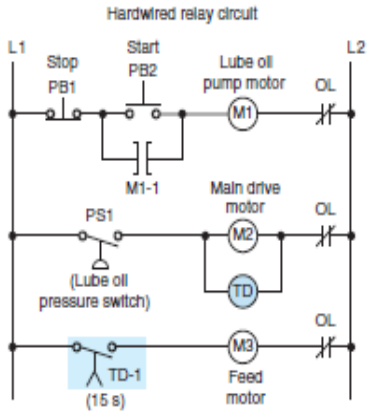
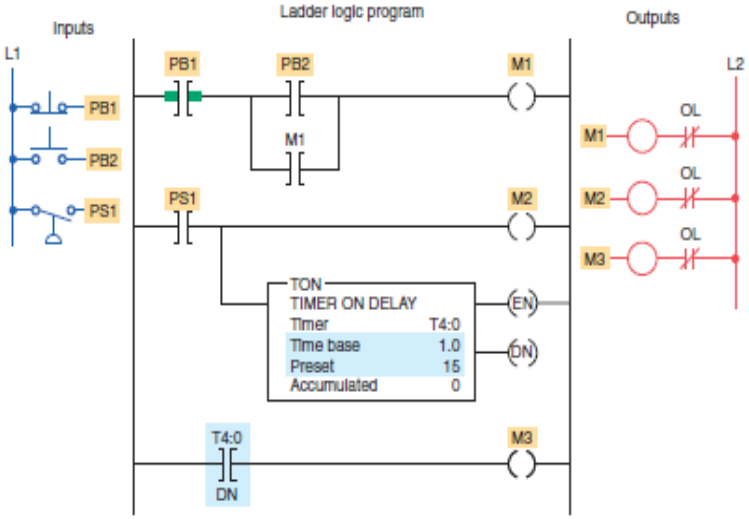
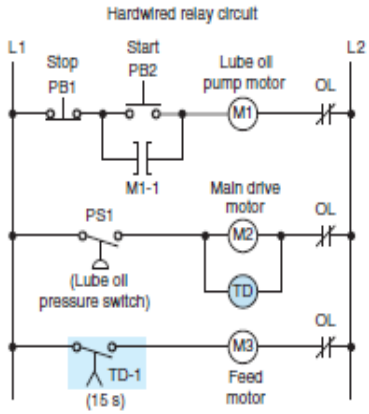
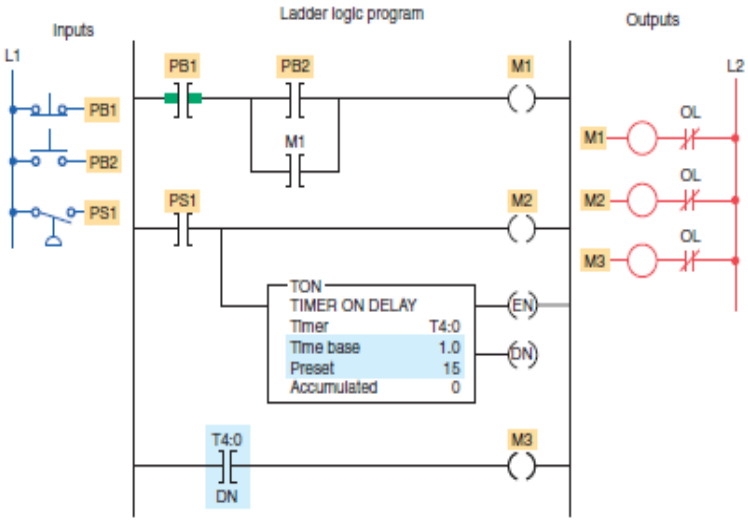




➢On-Delay Timer Instruction

- This in turn energizes coil M2 to start the main drive motor and energizes coil TD to begin the time delay period.
- After the preset time-delay period of 15 s, TD-1 contact closes to energize coil M3 and start the feed motor.
- The ladder logic program shows how an equivalent circuit could be programmed using a PLC..



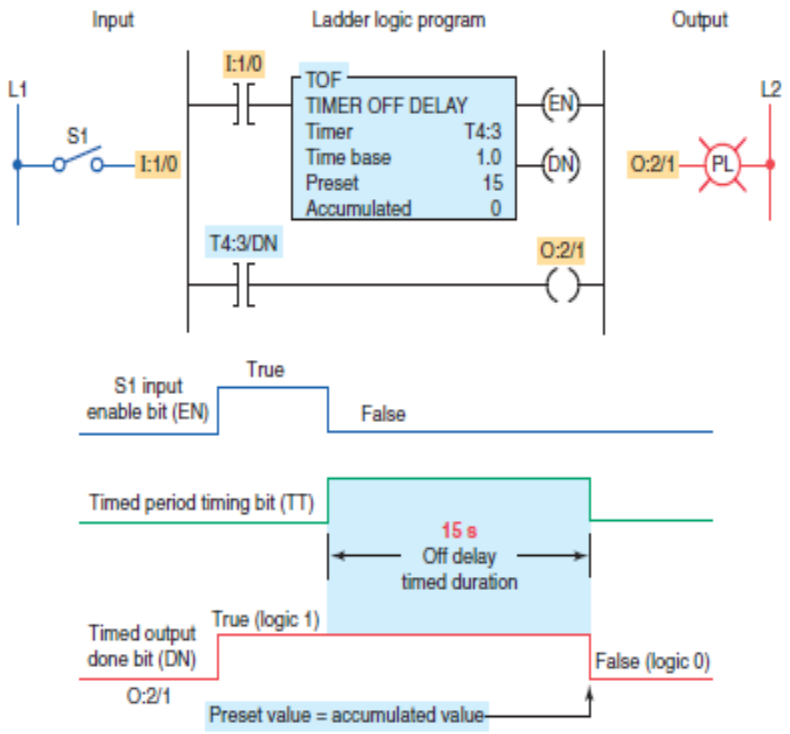


Off-Delay Timer Instruction

➢The *off-delay timer (TOF) operation will keep the output* energized for a time period after the rung containing the timer has gone false.

➢ Figure illustrates the programming of an off-delay timer that uses the SLC 500 TOF timer instruction.

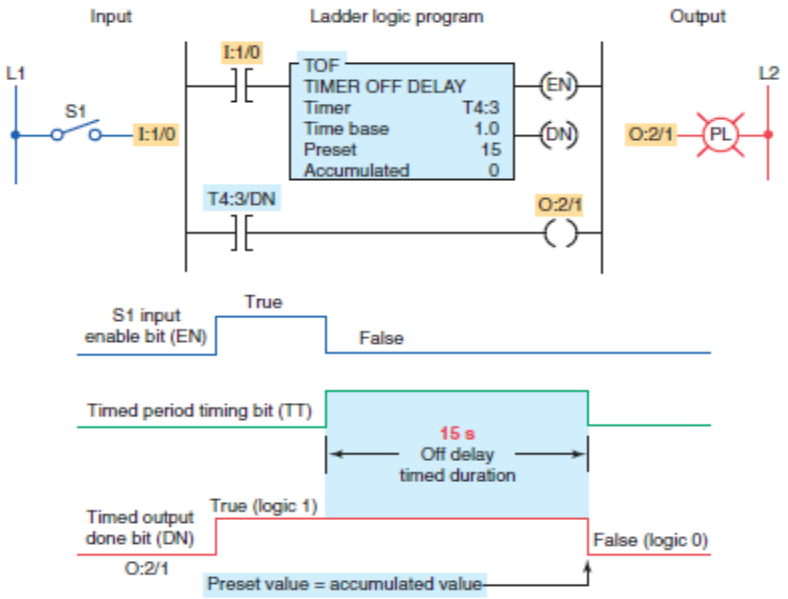
➢If logic continuity is *lost, the* timer begins counting time-based intervals until the accumulated time equals the programmed preset value.



Off-Delay Timer Instruction

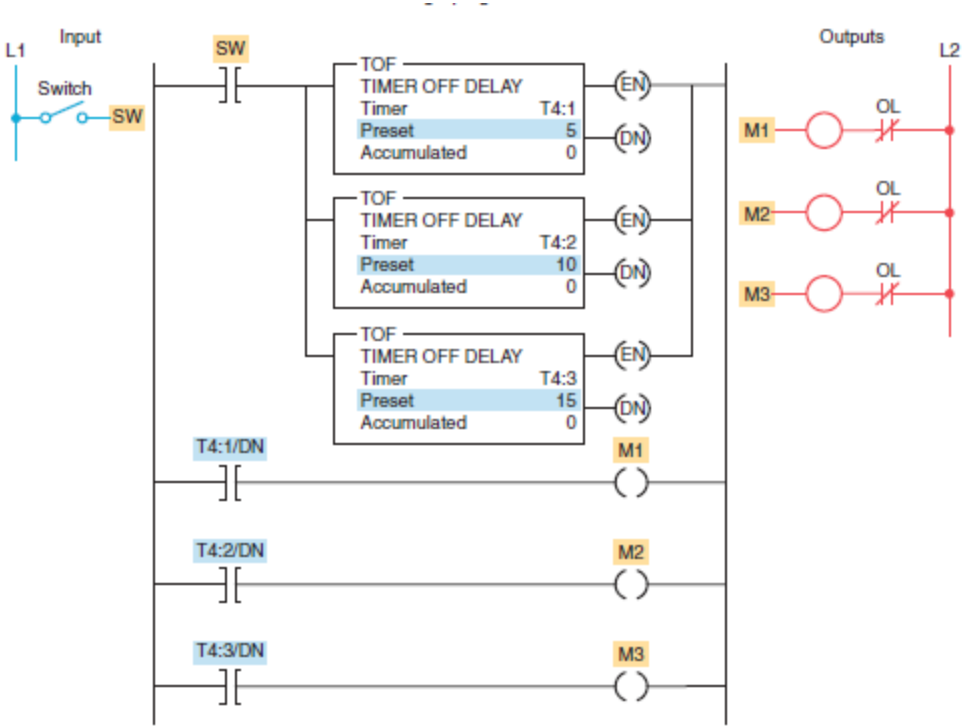
The operation of the circuit can be summarized as follows:

- When the switch connected to input I:1/0 is first closed, timed output O:2/1 is set to 1 immediately and the lamp is switched on.
- If this switch is now opened, logic continuity is lost and the timer begins counting.
- After 15 s, when the accumulated time equals the preset time, the output is reset to 0 and the lamp switches off.
- If logic continuity is gained before the timer is timed out, the accumulated time is reset to 0.



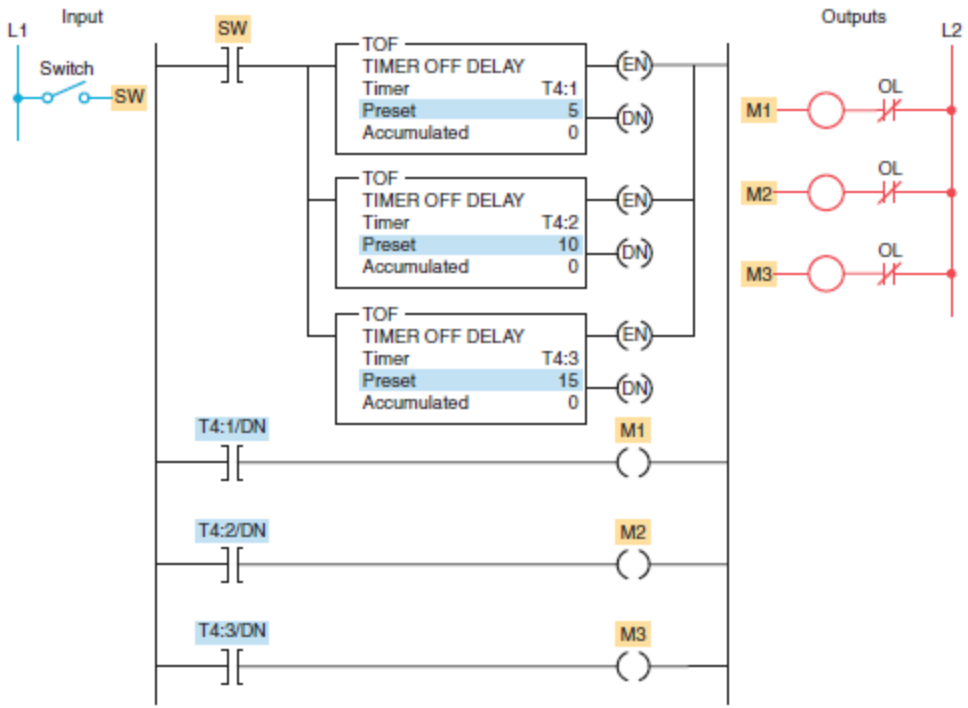
Off-Delay Timer Instruction

- Fig illustrates the use of an off-delay timer instruction used to switch motors *off sequentially at* 5 second intervals.
- The operation of the program can be summarized as follows:
- Timer preset values for T4:1, T4:2, and T4:3 are set for 5 s, 10s, and 15 s, respectively.
- Closing the input switch SW immediately sets the done bit of each of the three off-delay timers to 1, immediately turning on motors M1, M2, and M3.
- If SW is then opened, logic continuity to all three timers is lost and each timer begins counting.



Off-Delay Timer Instruction

- Timer T4:1 times out after 5 s resetting its done bit to zero to de-energize motor M1.
- Timer T4:2 times out 5 s later resetting its done bit to zero to de-energize motor M2.
- Timer T4:3 times out 5 s later resetting its done bit to zero to de-energize motor M3.



Off-Delay Timer Instruction

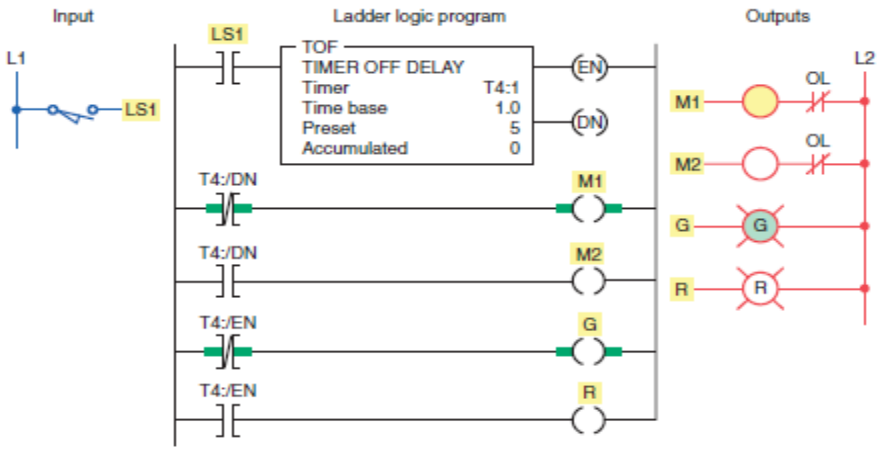
➢Figure shows how a hardwired off-delay timer relay circuit with both instantaneous and timed contacts.

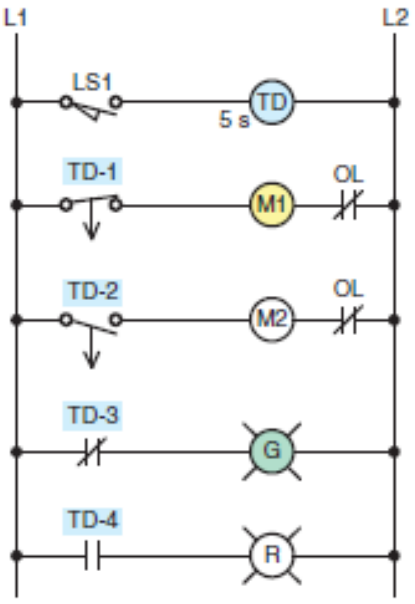
➢The operation of the circuit can be summarized as follows:

• When power is first applied (limit switch LS open), motor starter coil M1 is energized and the green pilot light is on.

• At the same time, motor starter coil M2 is de-energized, and the red pilot light is off.

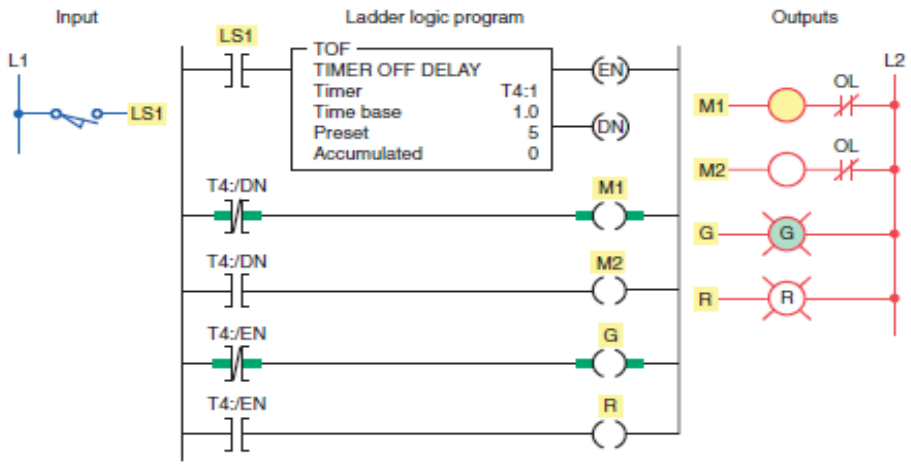
• When limit switch LS closes, off-delay timer coil TD energizes.

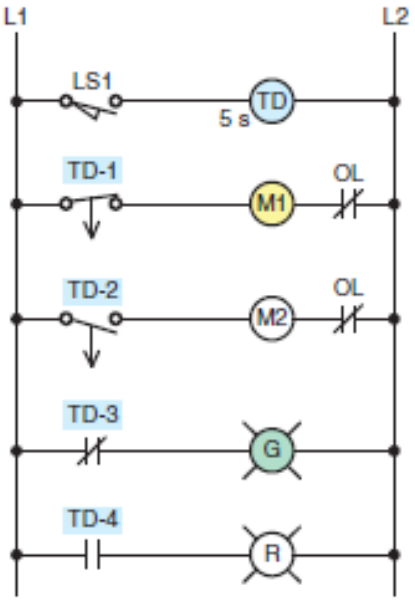




Off-Delay Timer Instruction

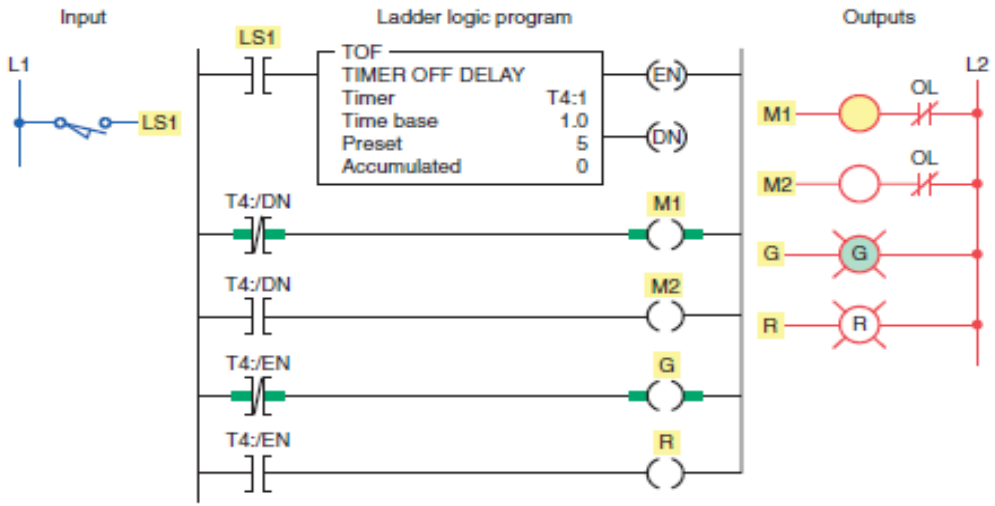
- As a result, timed contact TD-1 opens to de-energize motor starter coil M1, timed contact TD-2 closes to energize motor starter coil M2, instantaneous contact TD-3 opens to switch the green light off, and instantaneous contact TD-4 closes to switch the red light on.
- The circuit remains in this state as long as limit switch LS1 is closed.
- When limit switch LS1 is opened, the off-delay timer coil TD de-energizes and the time-delay period is started.

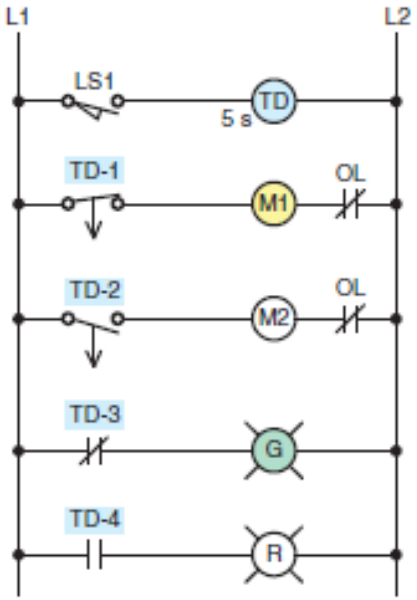




Off-Delay Timer Instruction

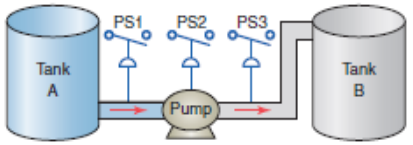
- Instantaneous contact TD-3 closes to switch The green light on, and instantaneous contact TD-4 opens to switch the red light off.
- After a 5-s time-delay period, timed contact TD-1 closes to energize motor starter M1, and timed contact TD-2 opens to de-energize motor starter M2.



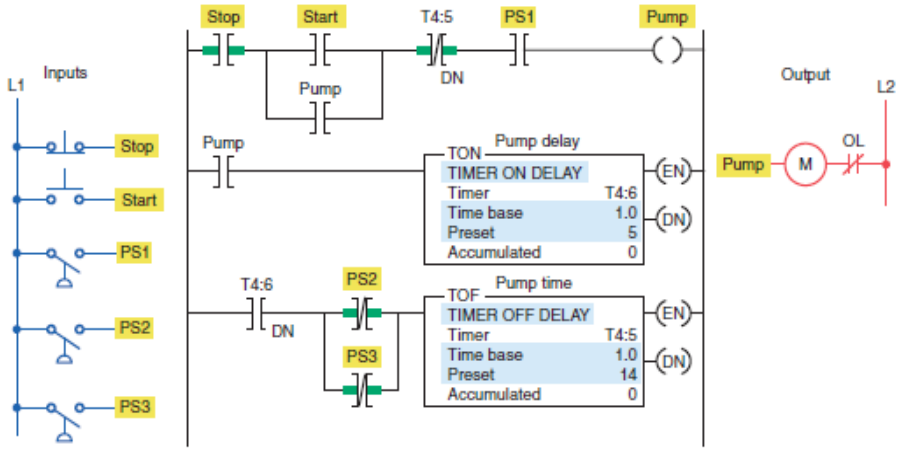


Off-Delay Timer Instruction

- Figure shows a program that uses both the on-delay and the off-delay timer instruction.
- The process involves pumping fluid from tank A to tank B.
- The operation of the process can be summarized as follows:
- Before starting, PS1 must be closed.
- When the start button is pushed , the pump starts.
- The button can then be released and the pump continues to operate.
- When the stop button is pushed, the pump stops.
- PS2 and PS3 must be closed 5 s after the pump starts. If either PS2 or PS3 opens, the pump will shut off and will not be able to start again for another 14 s.



Ladder logic program

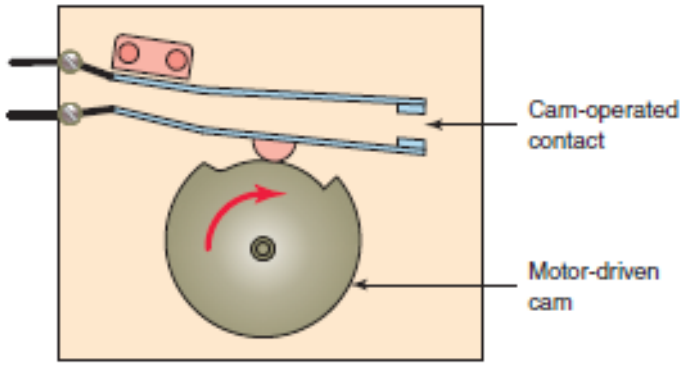


Retentive Timer

- A *retentive timer accumulates time whenever the device* receives power, and it maintains the current time when power be removed from the device.
- When the timer accumulates time equal to its preset value, the contacts of the device change state.
- Loss of power to the timer after reaching its preset value does not affect the state of the contacts.
- The retentive timer must be intentionally reset with a separate signal for the accumulated time to be reset and for the contacts of the device to return to its non-energized state.

Retentive Timer

- A Figure illustrates the action of a motor-driven, electromechanical retentive timer used in some appliances.
- The shaft-mounted cam is driven by a motor. Once power is applied, the motor starts turning the shaft and cam.
- The positioning of the lobes of the cam and the gear reduction of the motor determine the time it takes for the motor to turn the cam far enough to activate the contacts.
- If power is removed from the motor, the shaft stops but *does not reset.*

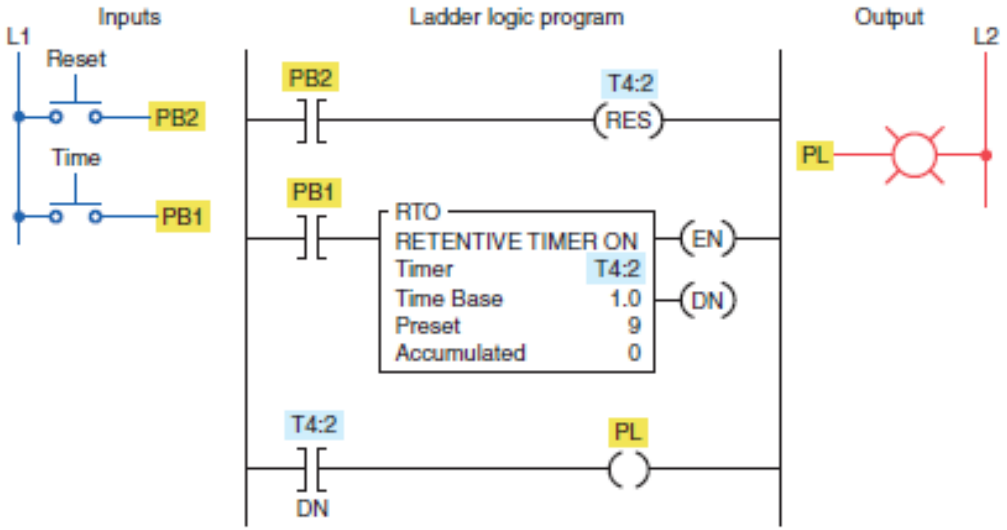


Retentive Timer

- PLC retentive timer is used when you want to retain accumulated time values through power loss or the change in the rung state from true to false.
- The PLC-programmed retentive on-delay timer (RTO) is programmed in a manner similar to the non-retentive on-delay timer (TON), with one major exception—a retentive timer reset (RES) instruction.
- Unlike the TON, the RTO will hold its accumulated value when the timer rung goes false and will continue timing where it left off when the timer rung goes true again.
- This timer must be accompanied by a timer reset instruction to reset the accumulated value of the timer to 0.

Retentive Timer

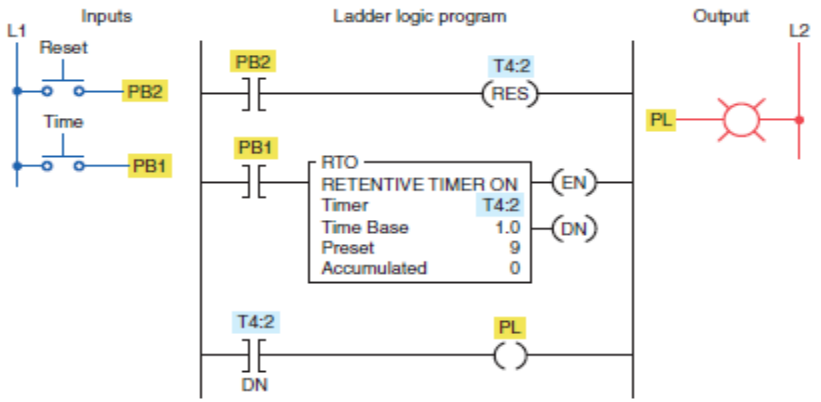
- The RES instruction has the same address as the timer it is to reset.
- Whenever the RES instruction is true, both the timer accumulated value and the timer done bit (DN) are reset to 0.
- Figure shows a PLC program for a retentive on-delay timer.



Retentive Timer

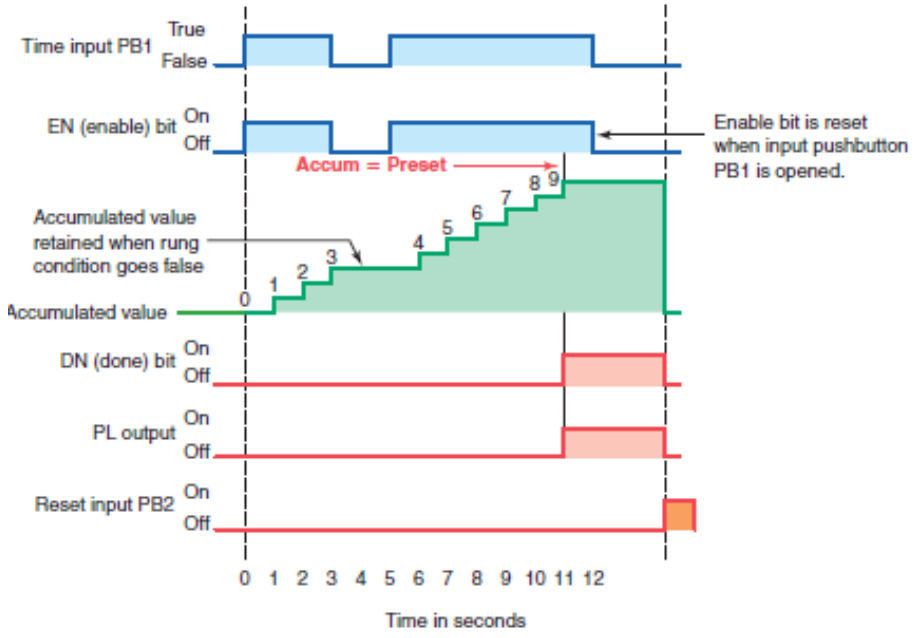
➢The operation of the program can be summarized as follows:

- The timer will start to time when time pushbutton PB1 is closed.
- If the pushbutton is closed for 3 seconds and then opened for 3 seconds, the timer accumulated value will remain at 3 seconds.
- When the time pushbutton is closed again, the timer picks up the time at 3 seconds and continues timing.
- When the accumulated value (9) equals the preset value (9), the timer done bit T4:2/DN is set to 1 and the pilot light output PL is switched on.
- Whenever the momentary reset pushbutton is closed the timer accumulated value is reset to 0.



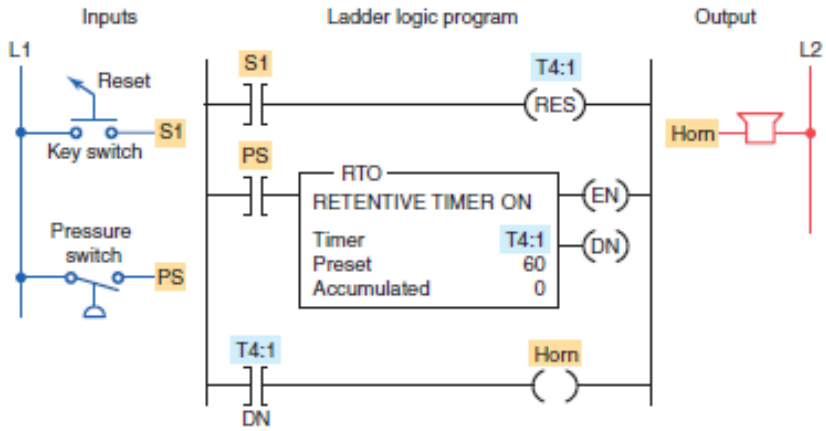
Retentive Timer

- Figure shows a timing chart for the retentive on-delay timer program.
- The timing operation can be summarized as follows:
- When the timing rung is true (PB1 closed) the timer will commence timing.
- If the timing rung goes false the timer will stop timing but will recommence timing for the stored accumulated value each time the rung goes true.
- When the reset PB2 is closed, the T4:2/DN bit is reset to 0 and turns the pilot light output off.
- The accumulated value is also reset and held at zero until the reset pushbutton is opened.



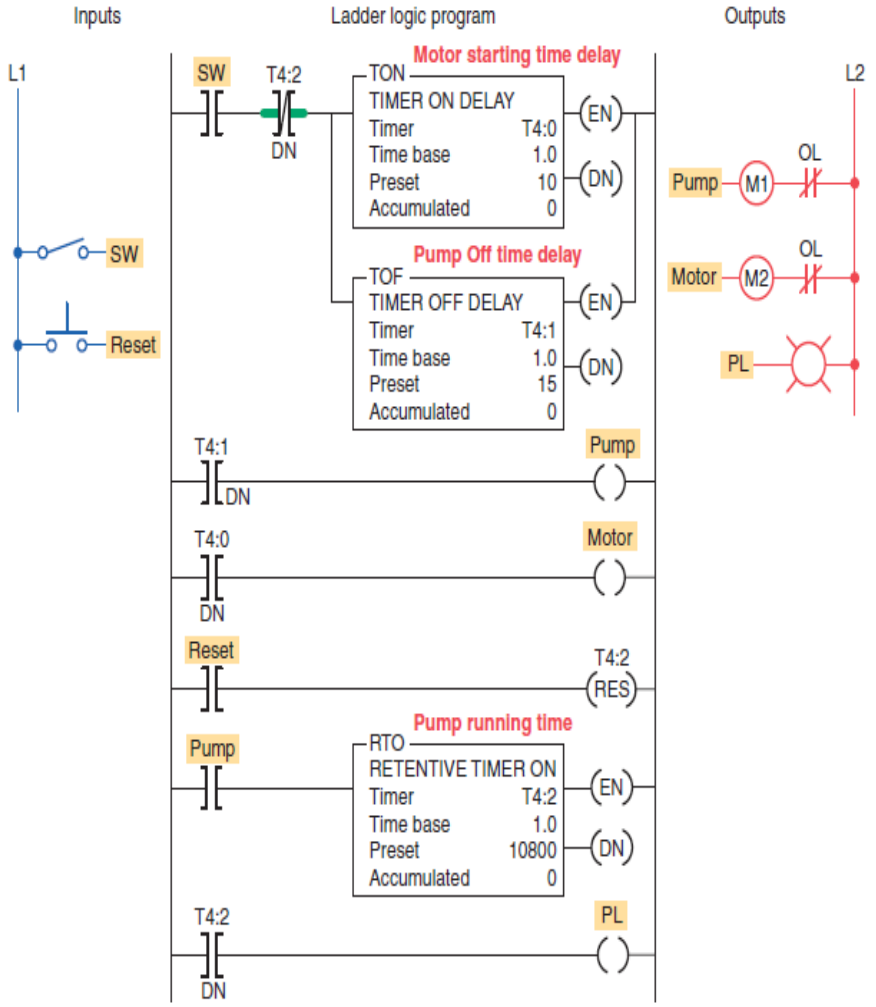
Retentive Timer

- The program drawn in Figure illustrates a practical application for an RTO.
- The purpose of the RTO timer is to detect whenever a piping system has sustained *cumulative overpressure condition for 60 s.*
- *At that* point, a horn is sounded automatically to call attention to the malfunction.
- When they are alerted, maintenance personnel can silence the alarm by switching the key switch S1 to the reset (contact closed) position.
- After the problem has been corrected , the alarm system can be reactivated by switching the key switch to open Contact position.



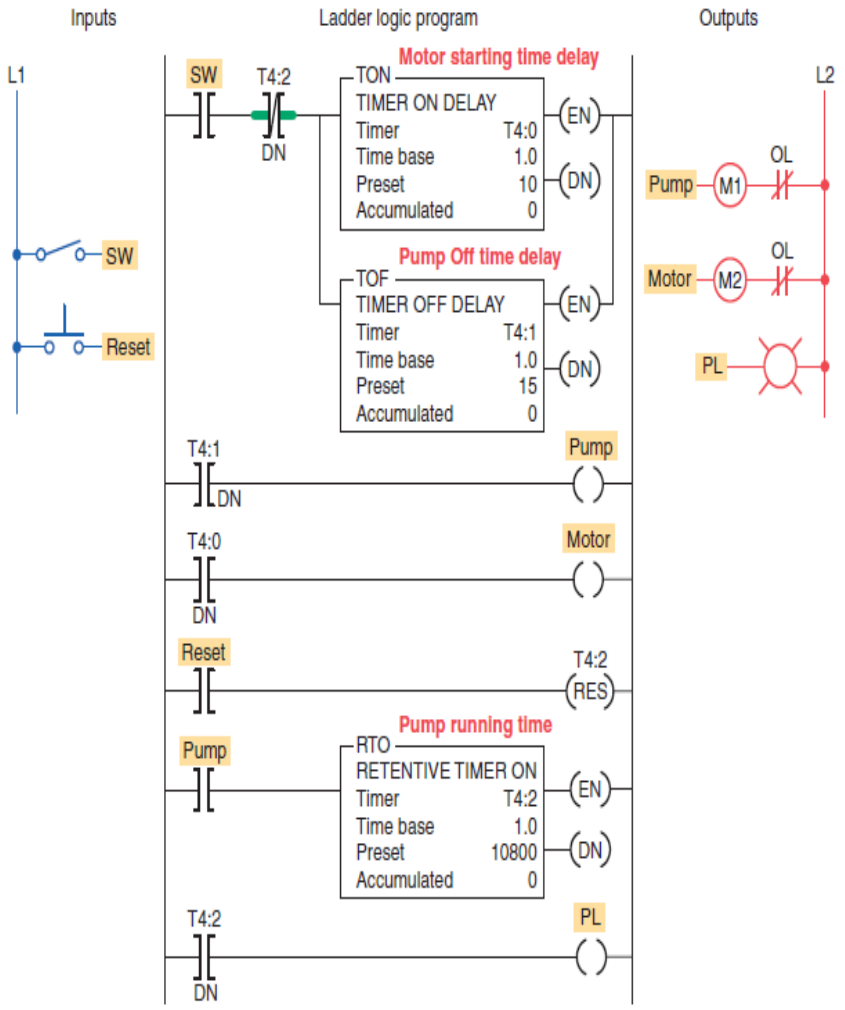
Retentive Timer

- Figure shows a practical application that uses the on-delay, off-delay, and retentive on-delay instructions in the same program
- In this industrial application, there is a machine with a large steel shaft supported by bearings.
- This shaft is coupled to a large electric motor.
- The bearings need lubrication, whic is supplied by an oil pump driven by a small electric motor.



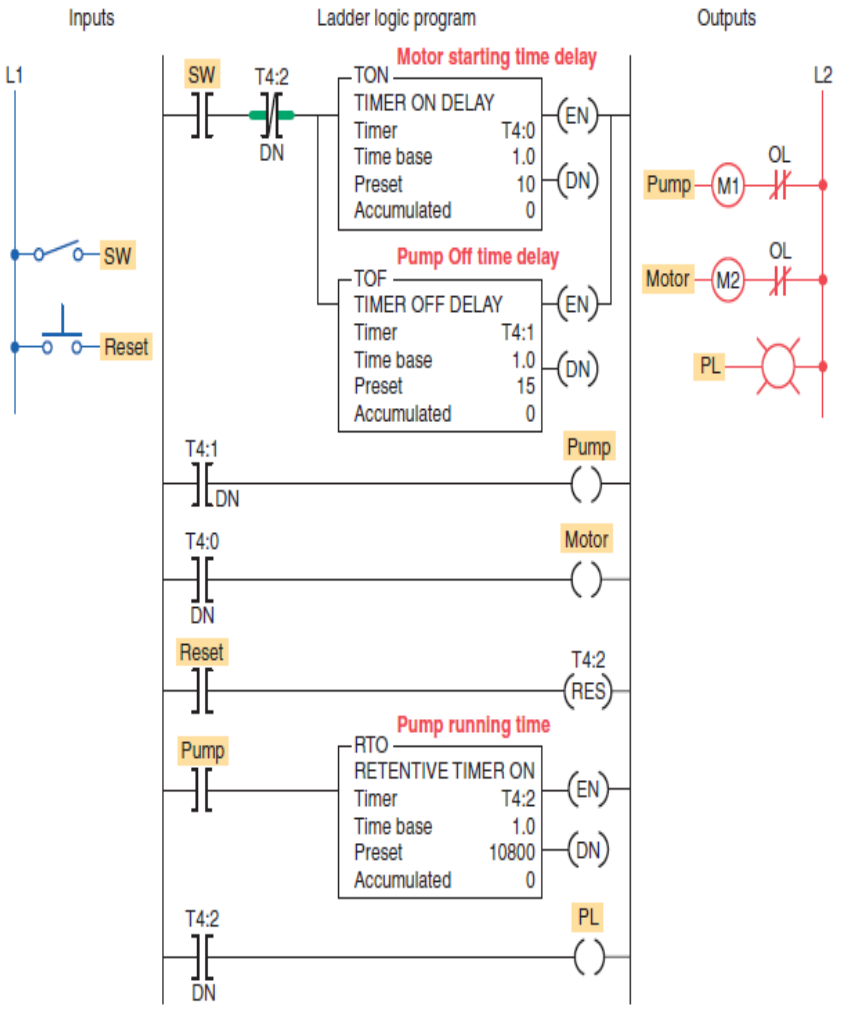
Retentive Timer

- To start the machine, the operator turns SW on.
- Before the *motor shaft starts to turn, the bearings* are supplied with oil by the *pump for 10 seconds.*
- The bearings also receive oil when the machine is running.
- When the operator turns SW off to stop the machine, the oil pump continues to supply oil for 15 seconds.



Retentive Timer

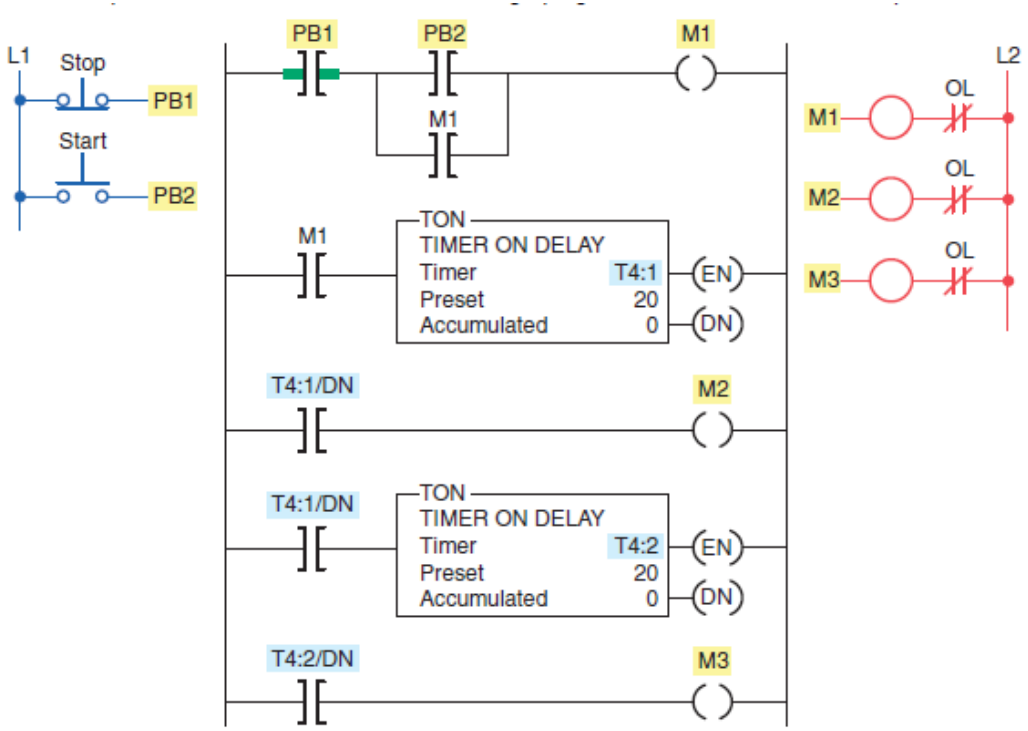
- A retentive timer is used to track the total running time of the pump. When the total run 3 hours, the motor is shut down and a pilot light is turned on to indicate that the filter and oil need to be changed.
- A reset button is provided to reset the process after the filter and oil have been changed.

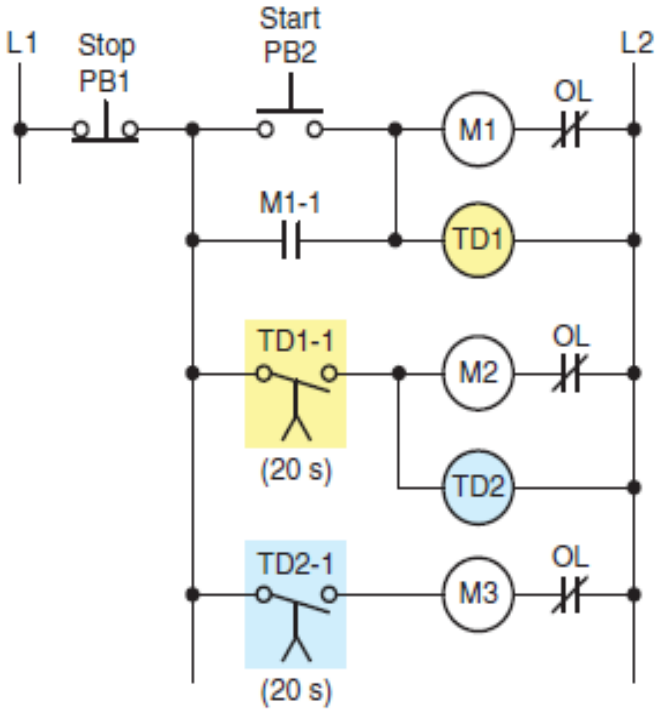


➢Cascading Timers

✓Figure shows how three motors can be started automatically in sequence with a 20 s time delay between each using two hardwired on-delay timers.

✓The operation of the circuit can be summarized as follows:





Cascading Timers

- Motor starter coil M1 is energized when the momentary start pushbutton PB2 is actuated.
- As a result, motor 1 starts, contact M1-1 closes to seal in M1, and timer coil TD1 is energized to begin the first time-delay period.
- After the preset time period of 20 s, TD1-1 Contact closes to energize motor starter coil M2.
- As a result, motor 2 starts and timer coil TD2 is energized to begin the second time-delay period.
- After the preset time period of 20 s, TD2-1 contact closes to energize motor starter coil M3, and so motor 3 starts.