1. Proximity Sensor

Proximity sensors or switches, are pilot devices that detect the presence of an object (usually called the target) *without physical contact.*

These solid-state electronic devices are completely encapsulated to protect against excessive vibration, liquids, chemicals, and corrosive agents found in the industrial environment.

Proximity sensors are used when:

• The object being detected is too small, lightweight, or soft to operate a mechanical switch.

• Rapid response and high switching rates are required, as in counting or ejection control applications.

• An object has to be sensed through nonmetallic barriers such as glass, plastic, and paper cartons.

• Hostile environments demand improved sealing properties, preventing proper operation of mechanical switches.

• Long life and reliable service are required.

• A fast electronic control system requires a bounce free input signal.

Proximity sensors operate on different principles, depending on the type of matter being detected.

There are two types of proximity sensors:

1. Inductive proximity sensors
2. Capacitive proximity sensors

Inductive proximity sensors are used to detect both ferrous metals (containing iron) and nonferrous metals (such as copper, aluminum, and brass).

Inductive proximity sensors operate under the electrical principle of inductance, where a fluctuating current induces an electromotive force (emf) in a target object.

The block diagram for an inductive proximity sensor is shown in Figure 6-18 and its operation can be summarized
as follows:

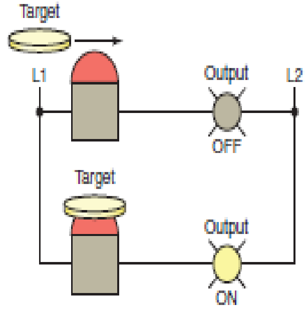
• The oscillator circuit generates a high-frequency electromagnetic field that radiates from the end of the sensor.

• When a metal object enters the field, eddy currents are induced in the surface of the object.

• The eddy currents on the object absorb some of the radiated energy from the sensor, resulting in a loss of energy and change of strength of the oscillator.

• The sensor's detection circuit monitors the oscillator's strength and triggers a solid-state output at a specific level.

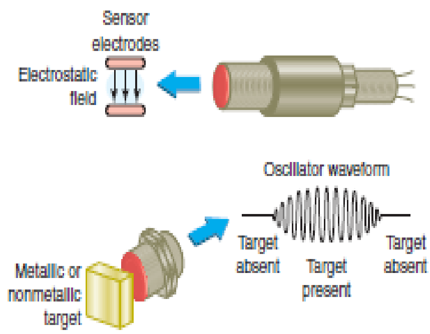
• Once the metal object leaves the sensing area, the oscillator returns to its initial value.



Capacitive proximity sensors

- *Capacitive proximity sensors* are similar to inductive proximity sensors. The main differences between the two types are that capacitive proximity sensors produce an electrostatic field instead of an electromagnetic field and are actuated by both conductive and nonconductive materials.
- Figure illustrates the operation of a capacitive sensor. A capacitive sensor contains a high-frequency oscillator along with a sensing surface formed by two metal electrodes.

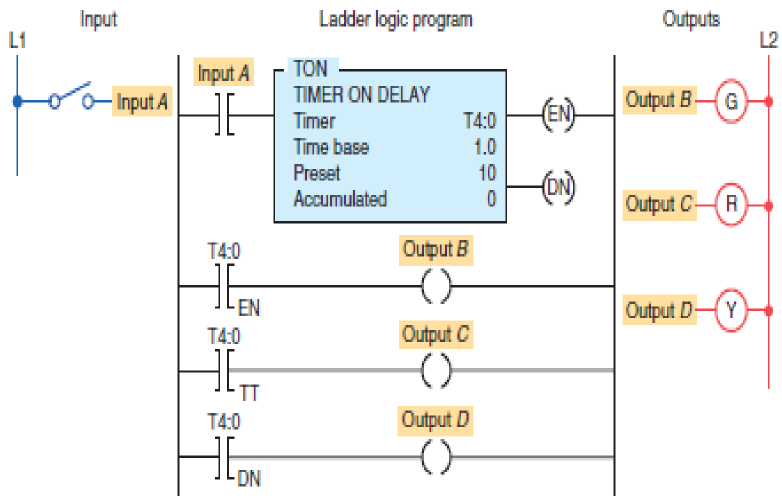
- When the target nears the sensing surface, it enters the electrostatic field of the electrodes and changes the capacitance of the oscillator. As a result, the oscillator circuit begins oscillating and changes the output state of the sensor when it reaches certain amplitude.
- As the target moves away from the sensor, the oscillator's amplitude decreases, switching the sensor back to its original state.
- Capacitive proximity sensors will sense metal objects as well as nonmetallic materials such as paper, glass, liquids, and cloth.
- They typically have a short sensing range of about 1 inch, regardless of the type of material being sensed. The larger the dielectric constant of a target, the easier it is for the capacitive sensor to detect



2. 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.
There are three different PLC timer types:
on-delay timer (TON),
off-delay timer (TOF),
retentive timer on (RTO).
The most common is the on-delay timer, which is the basic function

On-Delay Timer

An *on-delay timer* is used when you want to program a time delay before an instruction
becomes true.
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 energized.
• If the switch is opened before the timer is timed out, the accumulated time is automatically reset to 0.
• This timer configuration is termed *non-retentive* because any loss of continuity to the timer causes the timer instruction to reset.
• This timing operation is that of an on-delay timer because output D is switched on 10 s after the switch has been actuated from the off to the on position



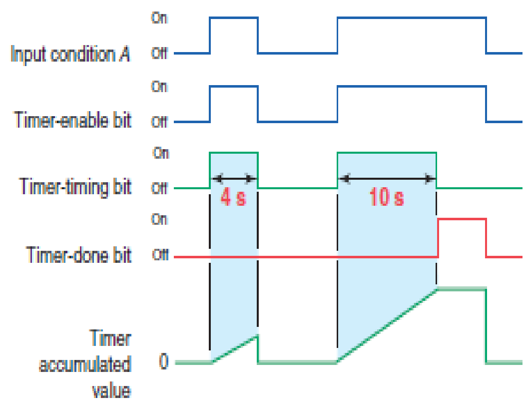


Figure shows the timing diagram for the on-delay timer's control bits. The sequence of operation is as follows:

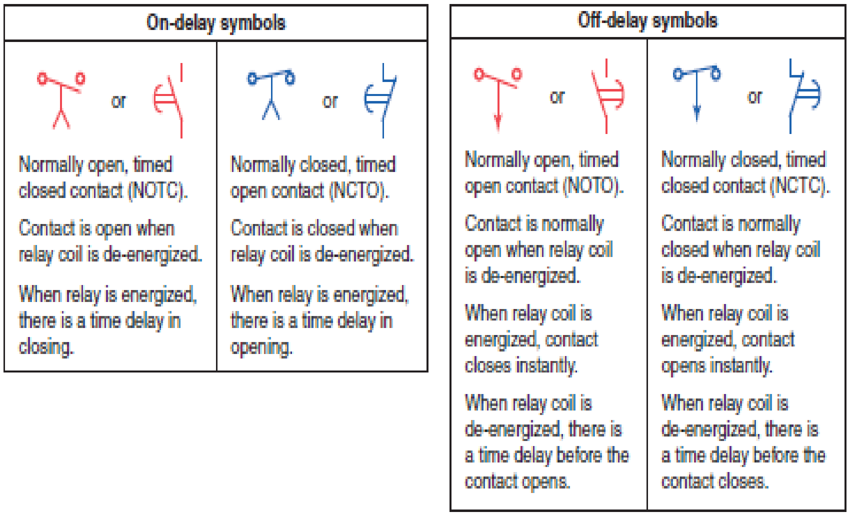
- The first true period of the timer rung shows the timer timing to 4 s and then going false.
- The timer resets, and both the timer-timing bit and the enable bit go false. The accumulated value also resets to 0.
- For the second true period input *A* remains true in excess of 10 s.
- When the accumulated 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.

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.

Retentive Timer

A *retentive timer* accumulates time whenever the device receives power, and it maintains the current time should 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.



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

8. Figure-1 shows an on-delay timer circuit that uses a normally open, timed closed (NOTC) 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 the timing period starts. TD1 contacts are delayed from closing so L1 remains off.
- After the 10 s time-delay period has elapsed, TD1contacts close and L1 is switched on.
- When S1 is opened, TD coil is de-energized and TD1 contacts open instantly to switch L1 off.

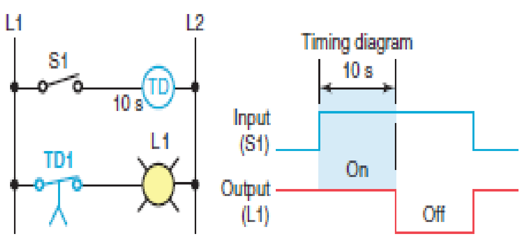


Fig-2

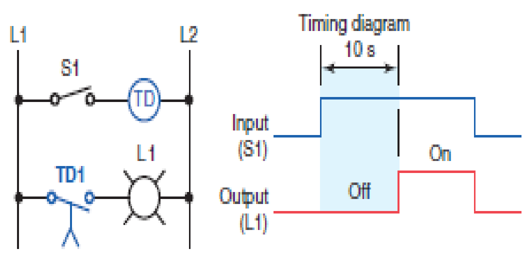


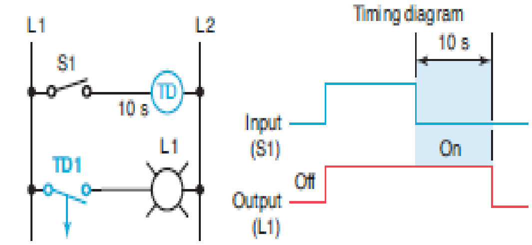
Fig-1

Fig-2 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.

Figure -3 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.



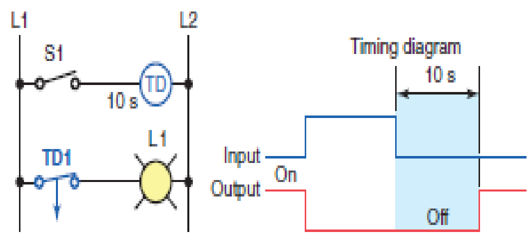
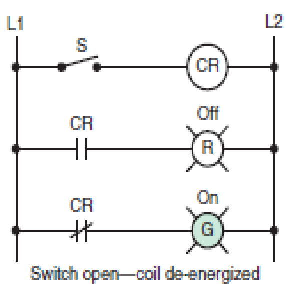


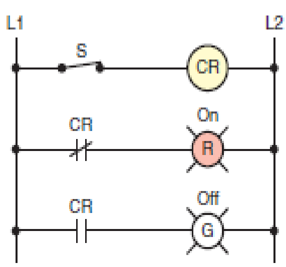
Fig-3 Fig-4

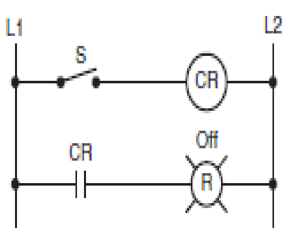
Figure 4 shows an off-delay timer circuit that uses a normally closed, timed closed (NCTC) contact. The operation of the circuit can be summarized as follows:

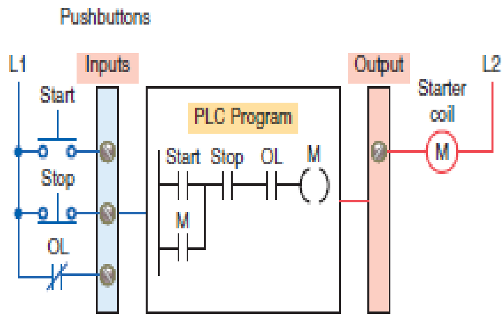
• With S1 initially open, TD coil is de-energized so TD1 contacts are closed and light L1 will be on.
• When S1 is closed, TD coil is energized and TD1 contacts open instantly to switch light L1 off.
• When S1 is opened, TD coil is de-energized and the timing period starts. TD1 contacts are delayed from closing so L1 remains off.
• After the 10 s time-delay period has elapsed, TD1 contacts close to switch the light on.

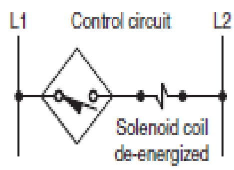
4.a



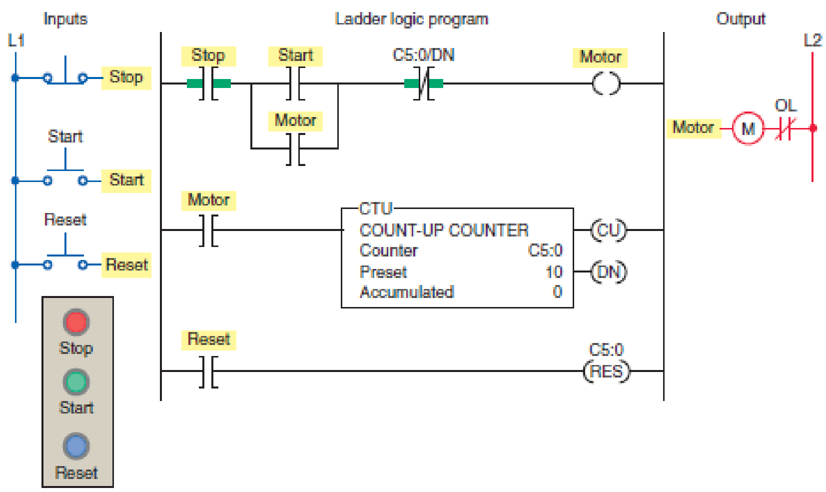




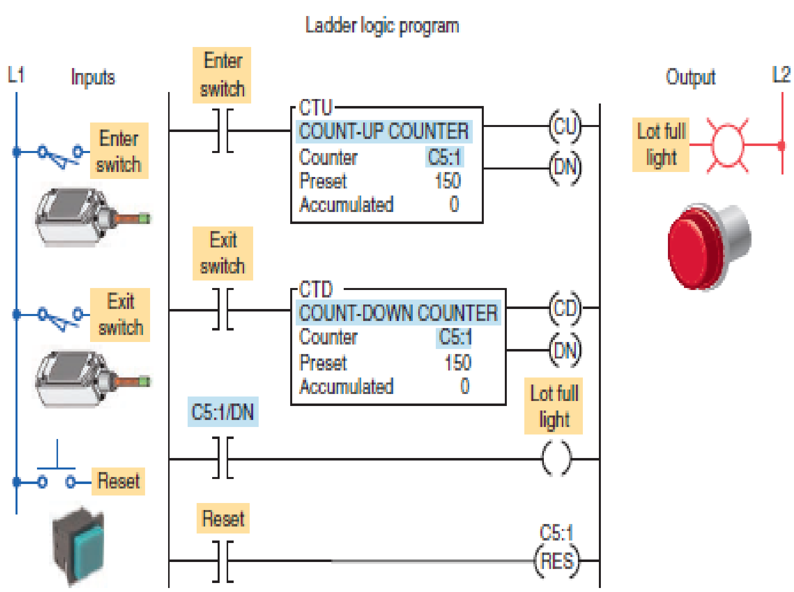




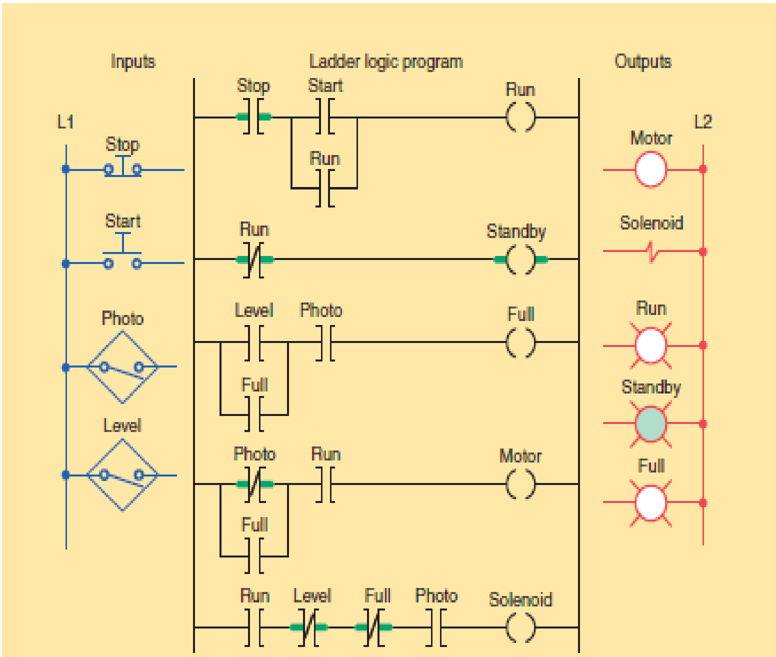
6 explanation



7 explanation



3.



Inputs
Ladder logic program
Outputs
L1
Stop
Start
Photo
Level
Stop
Start
Run
Run
Run
Standby
Level
Photo
Full
Full
Photo
Run
Motor
Full
Run
Level
Full
Photo
Solenoid
L2
Motor
Solenoid
Run
Standby
Full