➢Chapter 8
Programming Counters

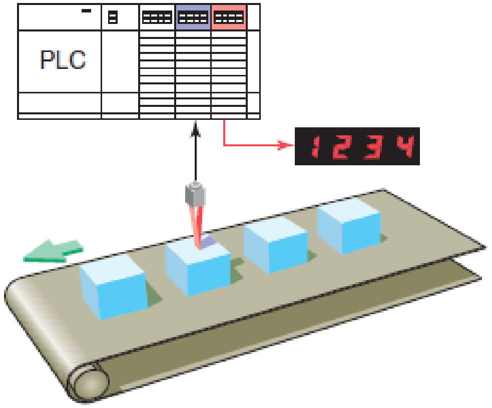
❑Counter Instructions

➢Programmed counters can serve the same function as mechanical Counters.

➢ Although the majority of counters used in industry are up-counters, numerous applications require the implementation of down-counters or of combination up/down-counters.

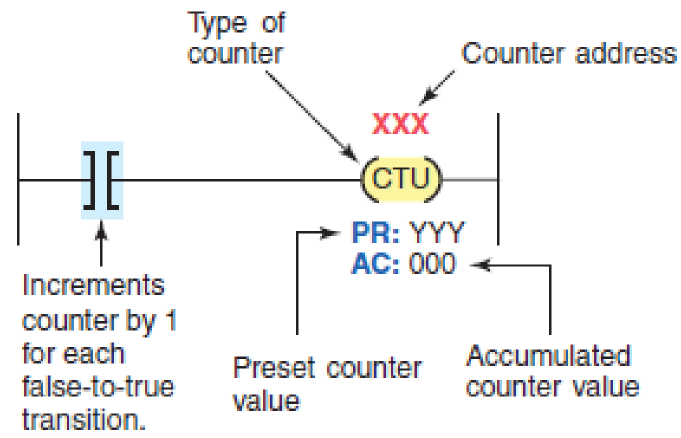
➢All PLC manufacturers offer some form of counter instruction as part of their instruction set.

➢One common counter application is keeping track of the number of items moving past a given point as illustrated in Figure .



❑Counter Instructions

- ➢Counters are similar to timers except that they do not operate on an internal clock but are dependent on external or program sources for counting.
- ➢The two methods used to represent a counter within a PLC's ladder logic program are the coil format and the block format.
- ➢Figure shows a typical coil-formatted up-counter instruction.
- ➢The up-counter increments its accumulated value by 1 each time the counter rung makes a false-to-true transition.
- ➢When the accumulated count equals the preset count the counter output is energized or set to 1.



❑Counter Instructions

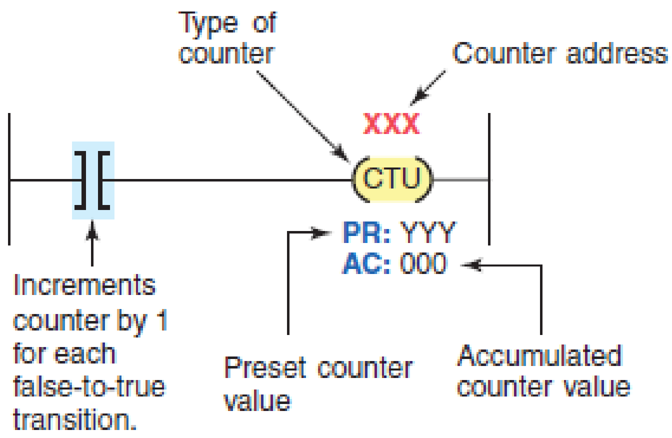
➢ Fig Shown as part of the instruction are the:

✓Counter type

✓Counter address

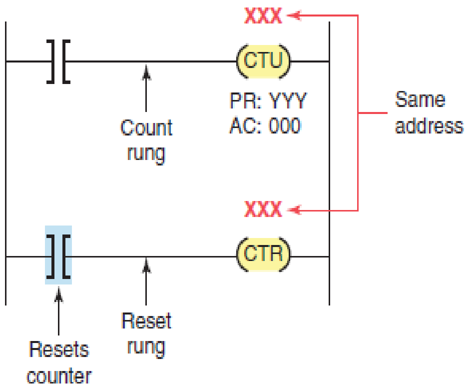
✓Counter preset value

✓Accumulated count



❑Counter Instructions

- The counter reset instruction must be used in conjunction with the counter instruction.
- Up-counters are always reset to zero.
- Down-counters may be reset to zero or to some preset value.
- Some manufacturers include the reset function as a part of the general counter instruction, whereas others dedicate a separate instruction for resetting the counter.
- Figure shows a coil-formatted counter instruction with a separate instruction for resetting the counter.
- When programmed, the counter Reset coil (CTR) is given the same reference address as the counter (CTU) it is to reset.
- In this example the reset instruction is activated whenever the CTR rung condition is true.



❑Counter Instructions

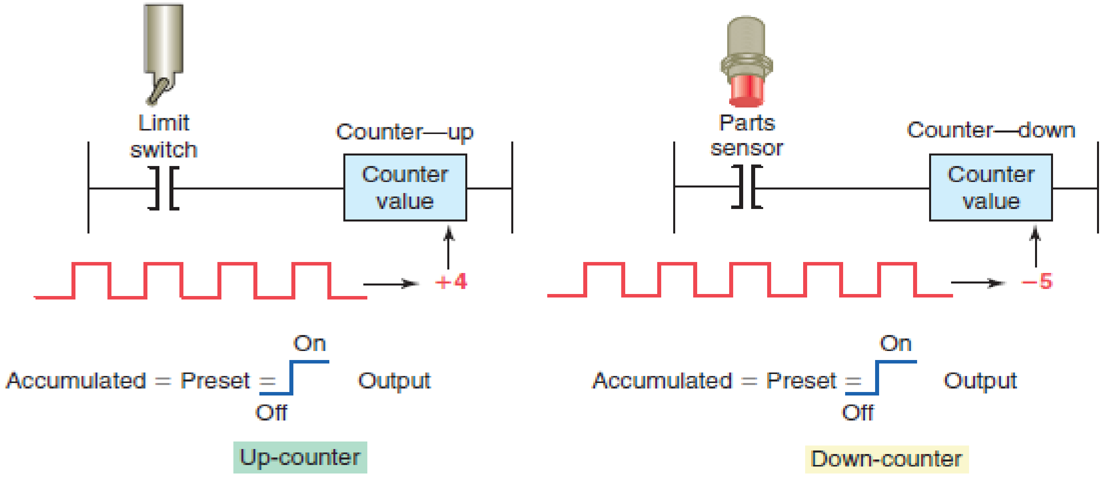
- The counter has two input conditions associated with it, namely, the count and reset.
- All PLC counters operate, or count, on the leading edge of the input signal.
- The counter will either increment or decrement whenever the count input transfers from an off state to an on state.
- Some manufacturers require the reset rung or line to be true to reset the counter, whereas others require it to be false to reset the counter
- PLC counters are normally retentive; that is, whatever count was contained in the counter at the time of a processor shutdown will be restored to the counter on power-up.

❑Counter Instructions

- PLC counters can be designed to count up to a preset value or to count down to a preset value.
- The *up-counter* is incremented by 1 each time the rung containing the counter is energized.
- The *down-counter decrements by 1* each time the rung containing the counter is energized.
- These rung transitions can result from events occurring in the program, such as parts traveling past a sensor or actuating a limit switch.
- The preset value of a programmable controller counter can be set by the operator or can be loaded into a memory location as a result of a program decision.

❑Counter Instructions

- Figure illustrates the counting sequence of an up counter and a down-counter.
- The value indicated by the counter is termed the *accumulated value.*
- *The counter will* increment or decrement, depending on the type of counter, until the accumulated value of the counter is equal to or greater than the preset value, at which time an output will be produced.
- A counter reset is always provided to cause the counter accumulated value to be reset to a predetermined value.



❑Up-Counter

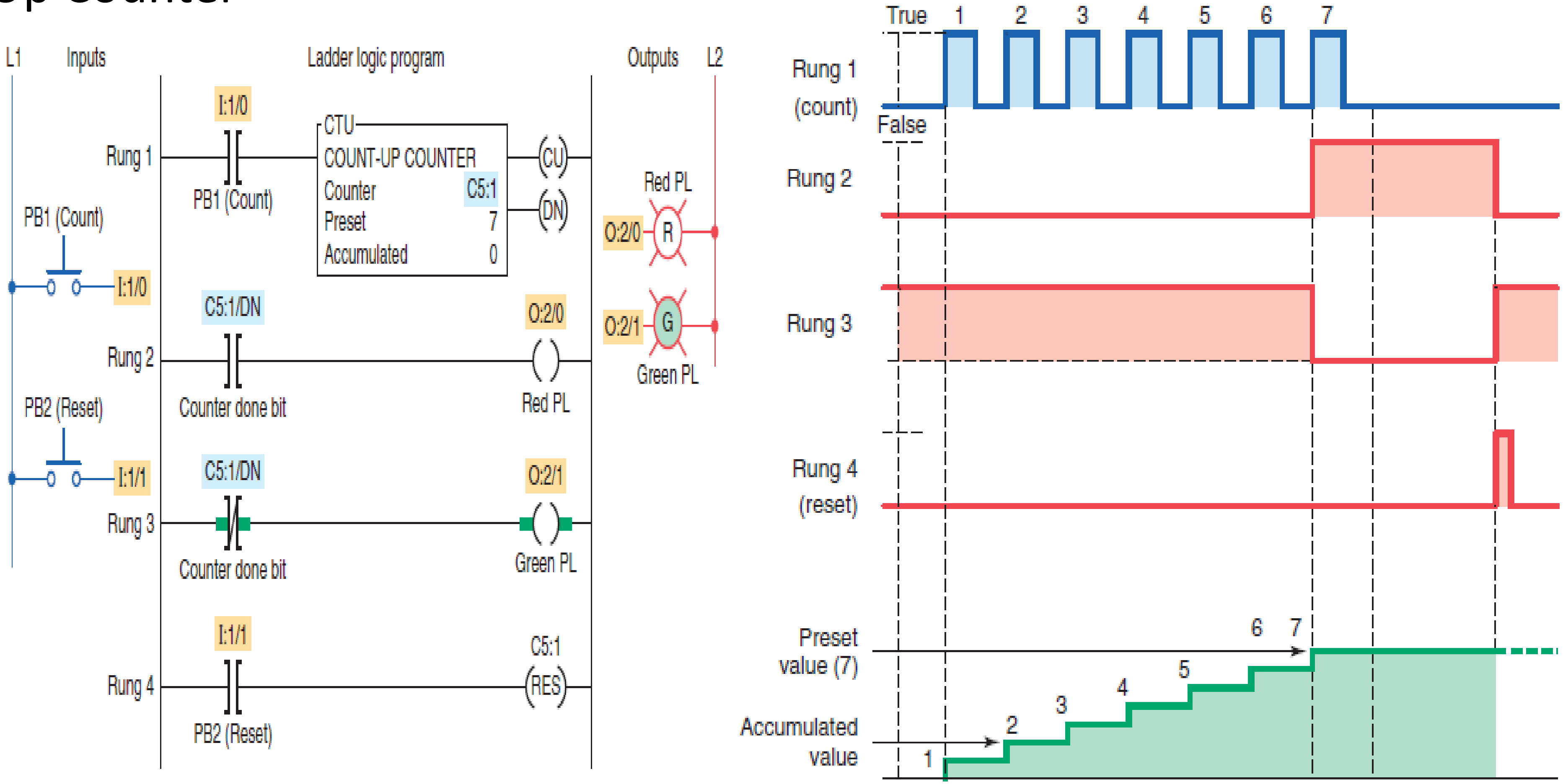
➢ The up-counter is an output instruction whose function is to increment its accumulated value on false-to-true transitions of its instruction.

➢It thus can be used to count false to true transitions of an input instruction and then trigger an event after a required number of counts or transitions.

➢The up-counter output instruction will increment by 1 each time the counted event occurs

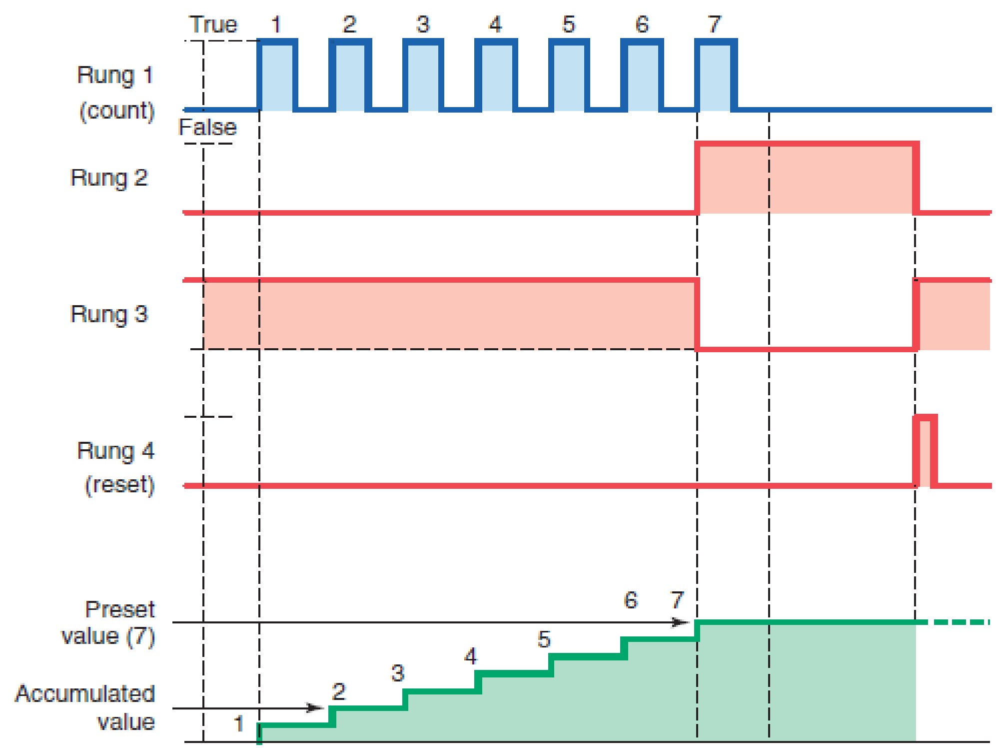
❑Up-Counter

➢ Figure shows the program and timing diagram for an SLC 500 Count-Up Counter



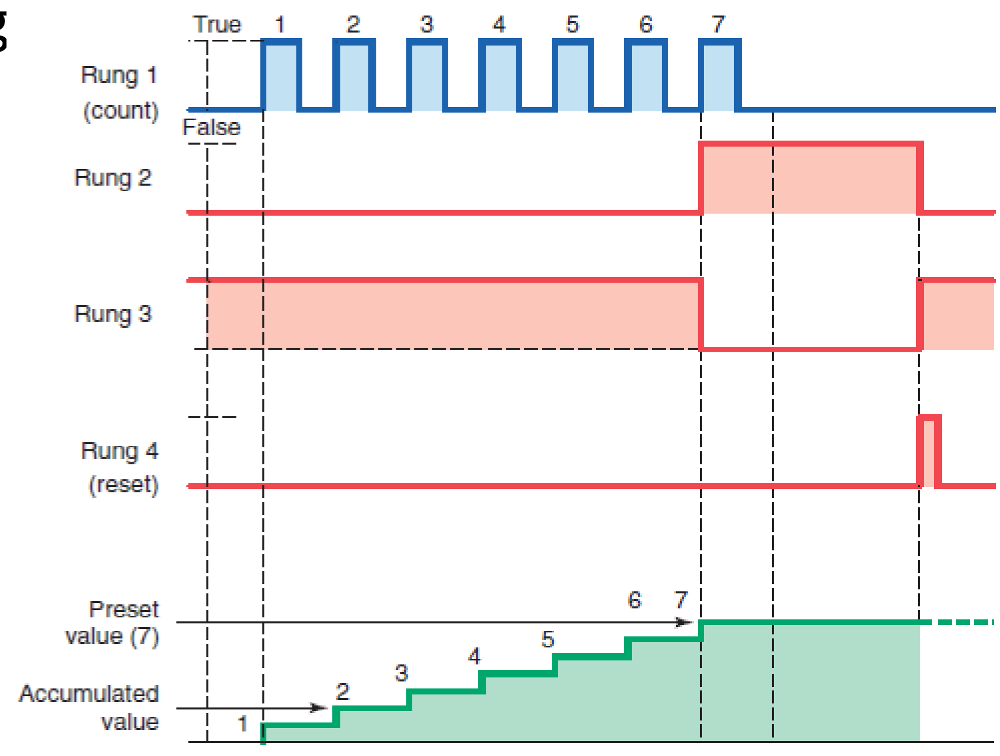
❑Up-Counter

- Operating pushbutton PB1 provides the off-to-on transition pulses that are counted by the counter.
- The preset value of the counter is set for 7.
- Each false-to-true transition of rung 1 increases the counter's accumulated value by 1.
- After 7 pulses, or counts, when the preset counter value equals the accumulated counter value, output DN is energized.
- As a result, rung 2 becomes true and energizes output O:2/0 to switch the red pilot light on.



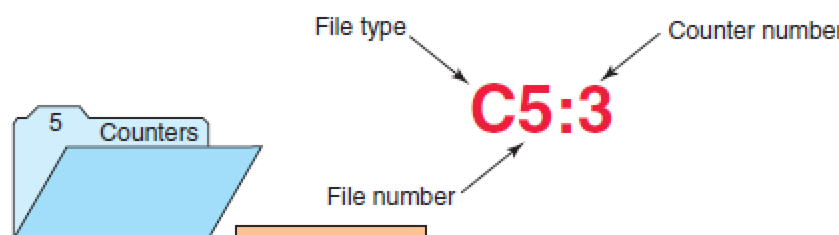
❑Up-Counter

- At the same time, rung 3 becomes false and deenergizes output O:2/1 to switch the green pilot light off.
- The counter is reset by closing pushbutton PB2, which makes rung 4 true and resets the accumulated count to zero.
- Counting can resume when rung 4 goes false again.



❑Up-Counter

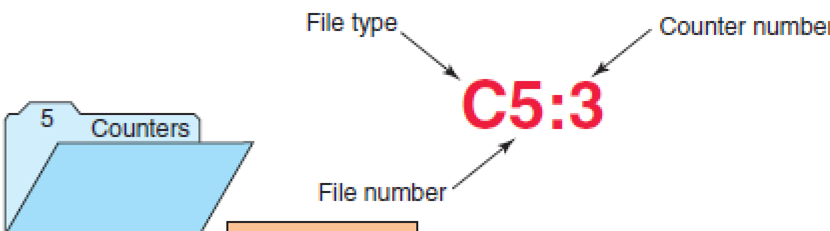
- The Allen-Bradley SLC 500 counter file is file 5 (Figure).
- Each counter is composed of three 16-bit words, collectively called a counter element.
- These three data words are the control word, preset word, and accumulated word.
- Each of the three data words shares the same base address, which is the address of the counter itself.
- There can be up to 256 counter elements.
- Addresses for Counter file 5 counter element 3 (C5:3), are listed below.



Counter address																	
C5:3	Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
C5:3.0	Word 0	CU	CD	DN	OV	UN	UA	Internal use (not addressable)									
C5:3.1	Word 1	Preset value															
C5:3.2	Word 2	Accumulated value															

❑Up-Counter

- ✓ C5= counter file 5
- ✓:3 counter element 3 (0–255 counter elements per file)
- ✓C5:3/DN is the address for the done bit of the counter.
- ✓C5:3/CU is the address for the count-up enable bit of the counter.
- ✓C5:3/CD is the address for the count-down enable bit of the counter.
- ✓C5:3/OV is the address for the overflow bit of the counter.
- ✓C5:3/UN is the address for the underflow bit of the counter.
- ✓C5:3/UA is the address for the update accumulator bit of the counter.



Counter address																	
C5:3	Bit	15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
C5:3.0	Word 0	CU	CD	DN	OV	UN	UA	Internal use (not addressable)									
C5:3.1	Word 1	Preset value															
C5:3.2	Word 2	Accumulated value															

❑Up-Counter

✓ Figure shows the counter table for the Allen-Bradley SLC 500 controller. The *control word uses status* control bits consisting of the following:

✓**Count-Up (CU) Enable Bit —**The count-up enable bit is used with the count-up counter and is true whenever the count-up counter instruction is true.

✓If the count-up counter instruction is false, the CU bit is false.

✓**Count-Down (CD) Enable Bit —**The count-down enable bit is used with the count-down counter and is true whenever the count-down counter instruction is true.

✓ If the count-down counter instruction is false, the CD bit is false.

Counter Table

	/CU	/CD	/DN	/OV	/UN	/UA	.PRE	.ACC
C5:0	0	0	0	0	0	0	0	0
C5:1	0	0	0	0	0	0	0	0
C5:2	0	0	0	0	0	0	0	0
C5:3	0	0	0	0	0	0	50	0
C5:4	0	0	0	0	0	0	0	0
C5:5	0	0	0	0	0	0	0	0

Address C5:3 Table: C5: Counter

❑Up-Counter

✓**Done (DN) Bit —**The done bit is true whenever the accumulated value is equal to or greater than the preset value of the counter, for either the count-up or the count-down counter.

✓**Overflow (OV) Bit —**The overflow bit is true whenever the counter counts past its maximum value, which is 32,767.

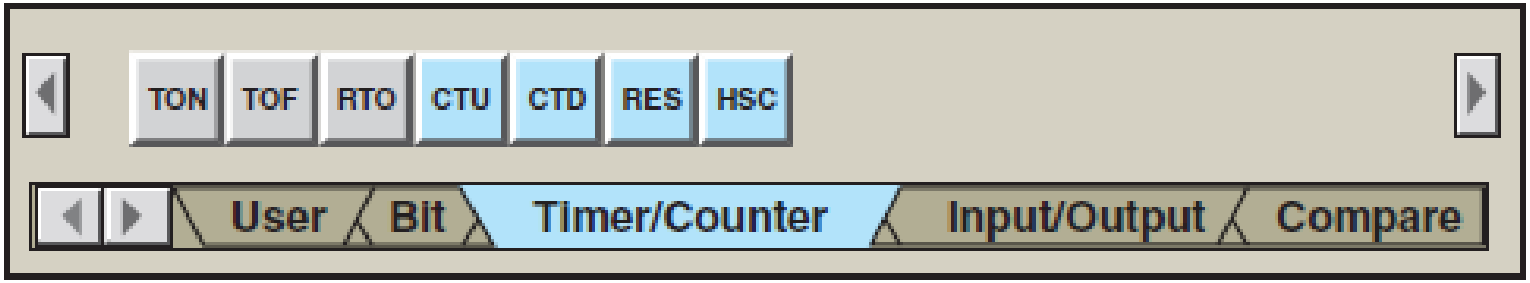
✓**Underflow (UN) Bit —**The underflow bit will go true when the counter counts below -32,768.

✓**Update Accumulator (UA) Bit —**The update accumulator bit is used only in conjunction with an external HSC (high-speed counter).

❑Up-Counter

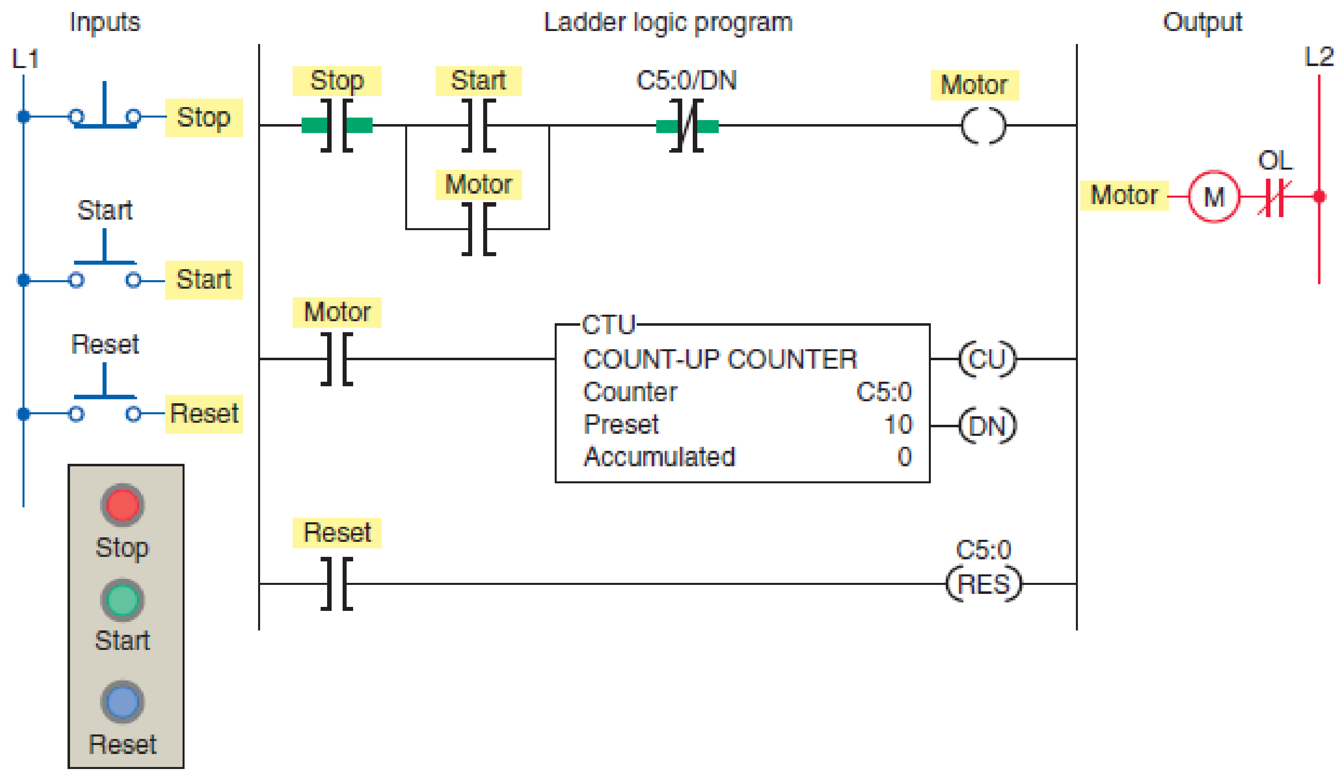
Figure 8-12 shows the timer/counter menu tab from the RSLogix toolbar

CTU (Count-Up) —Increments the accumulated value at each false-to-true transition and retains the accumulated value when an off/on power cycleoccurs.
CTD (Count-Down) —Decrements the accumulated value at each false-to-true transition and retains the accumulated value when an on/off power cycle occurs.
HSC (High-Speed Counter) —Counts high-speed pulses from a high-speed input.



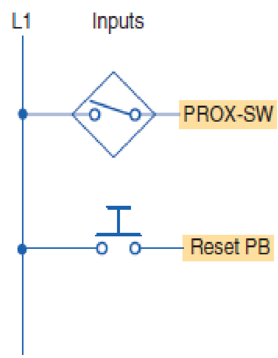
❑Up-Counter

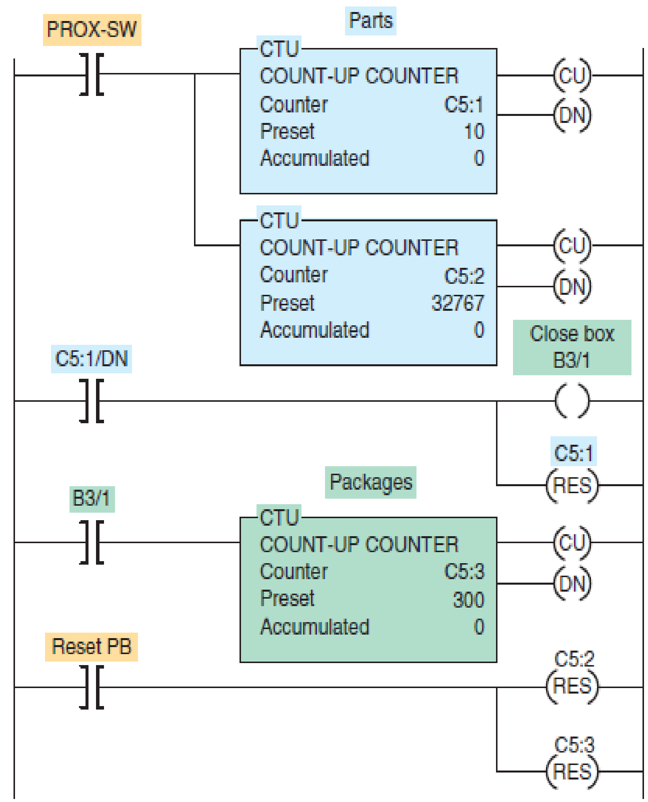
Figure shows a PLC counter program used to stop a motor from running after 10 operations.



❑Up-Counter

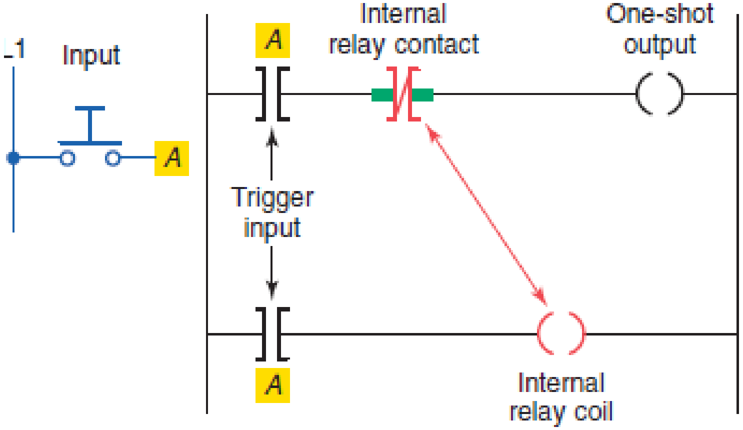
- Counter C5:2 counts the total number of cans coming off an assembly line for final packaging.
- Each package must contain 10 parts.
- When 10 cans are detected, counter C5:1 sets bit B3/1 to initiate the box closing sequence.
- Counter C5:3 counts the total number of packages filled in a day. (The maximum number of packages per day is 300.)
- A pushbutton is used to restart the total part and package count from zero daily.

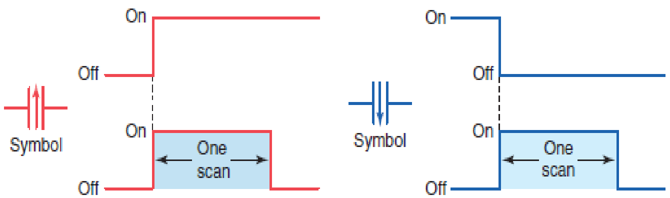




❑One-Shot Instruction

- Figure shows the program for a *one-shot, or transitional, contact circuit that is often used to automatically* clear or reset a counter.
- The program is designed to generate an output pulse that, when triggered, goes on for the duration of one program scan and then goes off.
- The one-shot can be triggered from a momentary signal or from a signal that comes on and stays on for some time.
- Whichever signal is used, the one-shot is triggered by the leading-edge (off-to-on) transition of the input signal.
- It stays on for one scan and goes off.
- It stays off until the trigger goes off, and then comes on again.
- The one-shot is perfect for resetting both counters and timers since it stays on for one scan only.





(a) Off-to-on transitional contact
(b) On-to-off-transitional contact

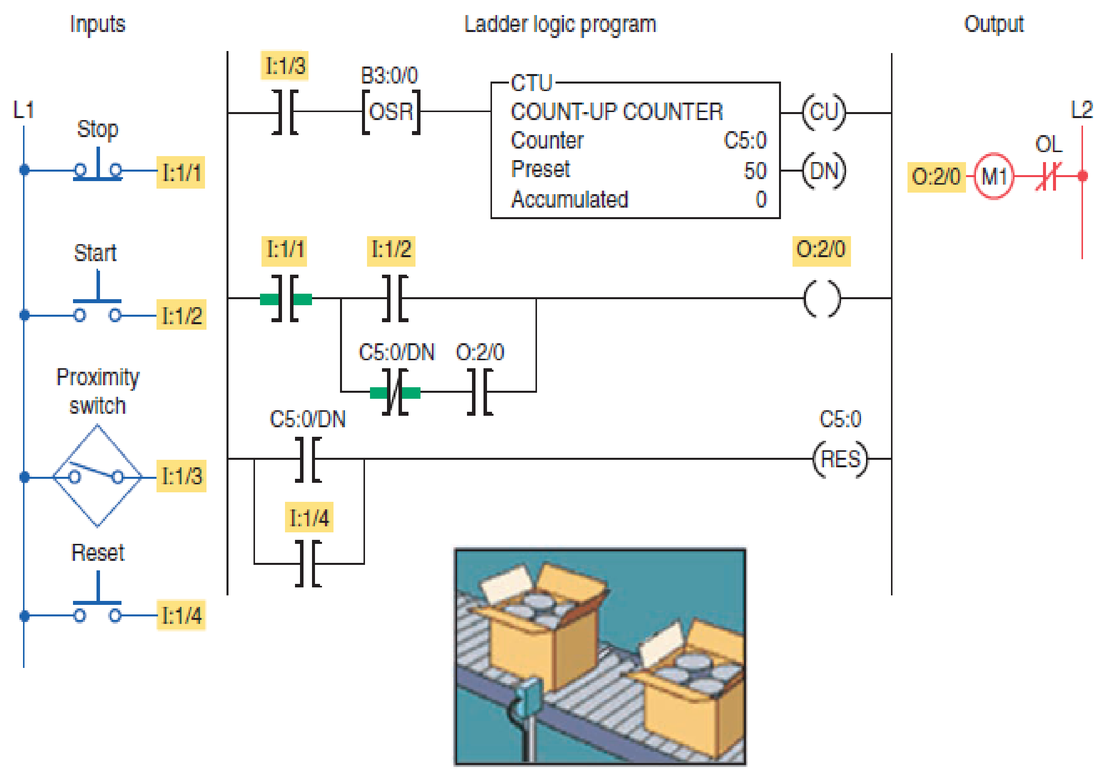
❑One-Shot Instruction

• The conveyor motor PLC program of Figure illustrates the application of an up-counter along with a programmed one-shot (OSR) transitional contact instruction.

• The counter counts the number of cases coming off the conveyor.

• When the total number of cases reaches 50, the conveyor motor stops automatically.

• The trucks being loaded will take a total of only 50 cases of this particular product; however, the count can be changed for different product lines.



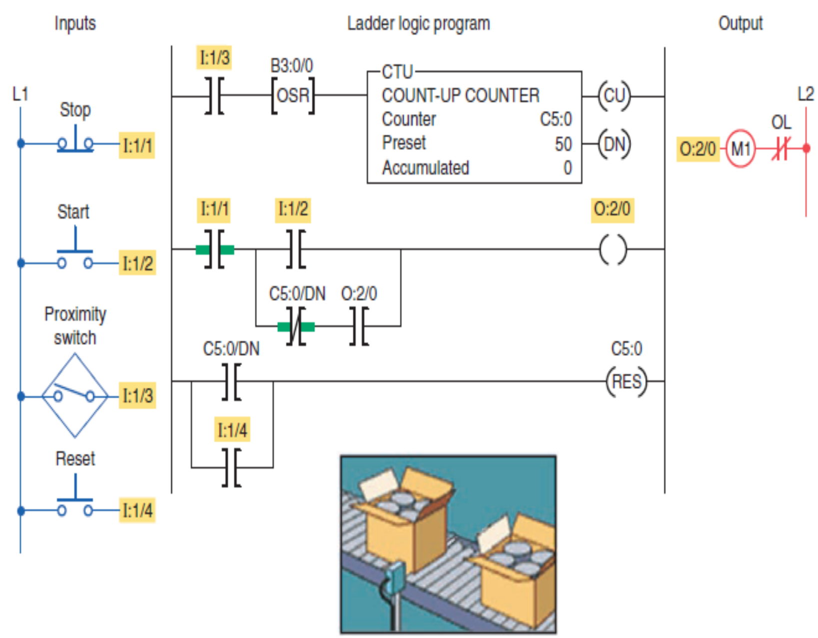
❑One-Shot Instruction

• The momentary start button is pressed to start the conveyor motor M1.

• The passage of cases is sensed by the proximity switch.

• Cases move past the proximity switch and increment the counter’s accumulated value with each false-to-true transition of the switch.

• After a count of 50, the done bit of the counter changes state to stop the conveyor motor automatically and reset the counter’s accumulated value to zero.



• The conveyor motor can be stopped and started manually at any time without loss of the accumulated count.

• The accumulated count of the counter can be reset manually at any time by means of the count reset button

❑One-Shot Instruction

• Figure illustrates the operation of an OSR rung which can be summarized as follows:

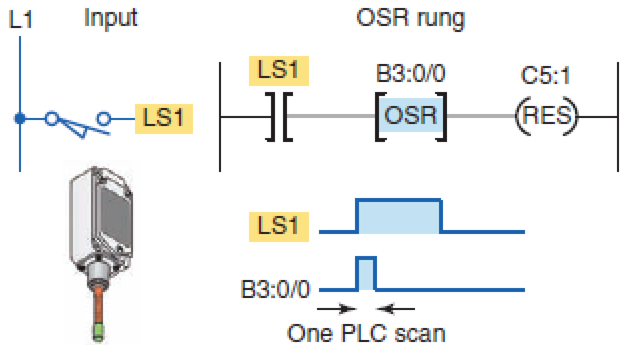
• The OSR, one-shot rising instruction is used to make the counter reset instruction (RES) true for one scan when limit switch input LS1 goes from false to true.

• The OSR is assigned a Boolean bit (B3:0/0) that is not used anywhere else in the program.

• The OSR instruction must immediately precede the output instruction.

• When the limit switch closes the LS1 and OSR, input instructions go from false to true.

• The OSR instruction conditions the rung so that the counter C5:1 reset output instruction goes true for one program scan.

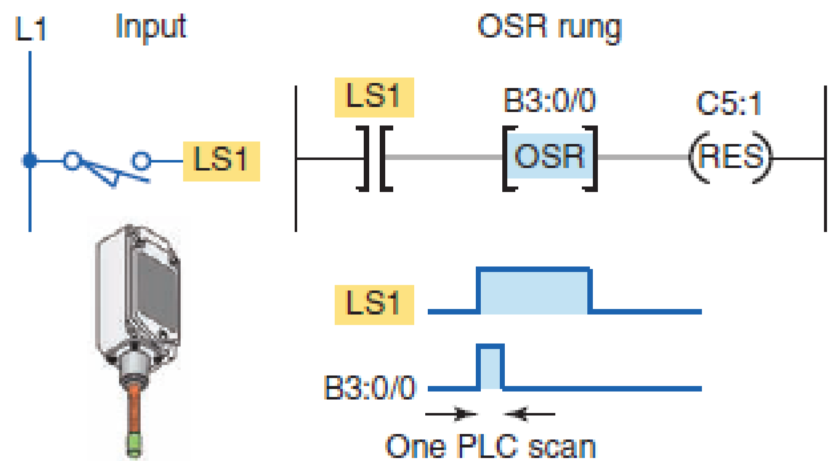


❑One-Shot Instruction

• The output reset instruction goes false and remains false for successive scans until the input makes another false-to-true transition.

• The OSR bit is set to 1 as long as the limit switch remains closed.

• The OSR bit is reset to 0 when the limit switch is opened.

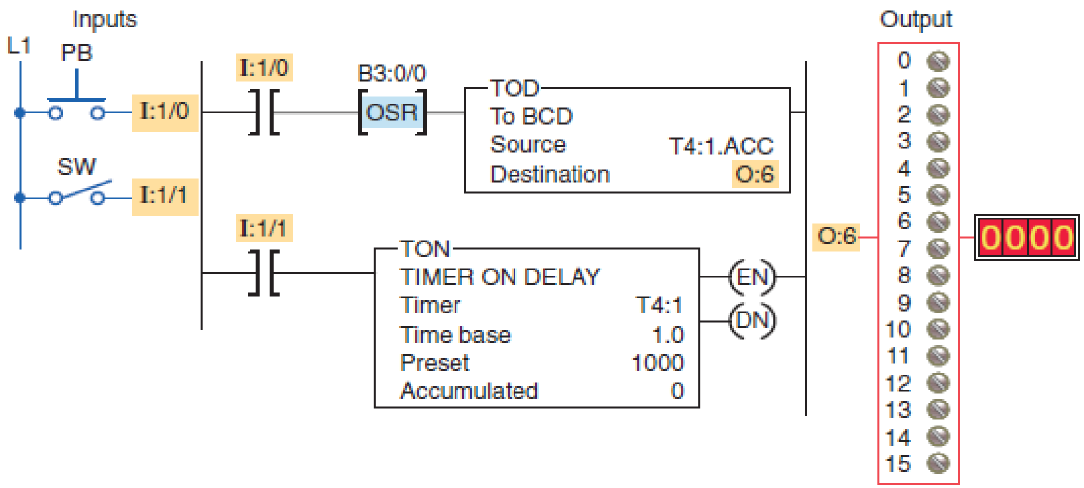


❑One-Shot Instruction

• Applications for the OSR instruction include freezing rapidly displayed LED values.

• Figure shows a one-shot instruction used to send data to an output LED display.

• The one-shot allows the rapidly changing accumulated time from the timer to be frozen to ensure a readable, stable display.



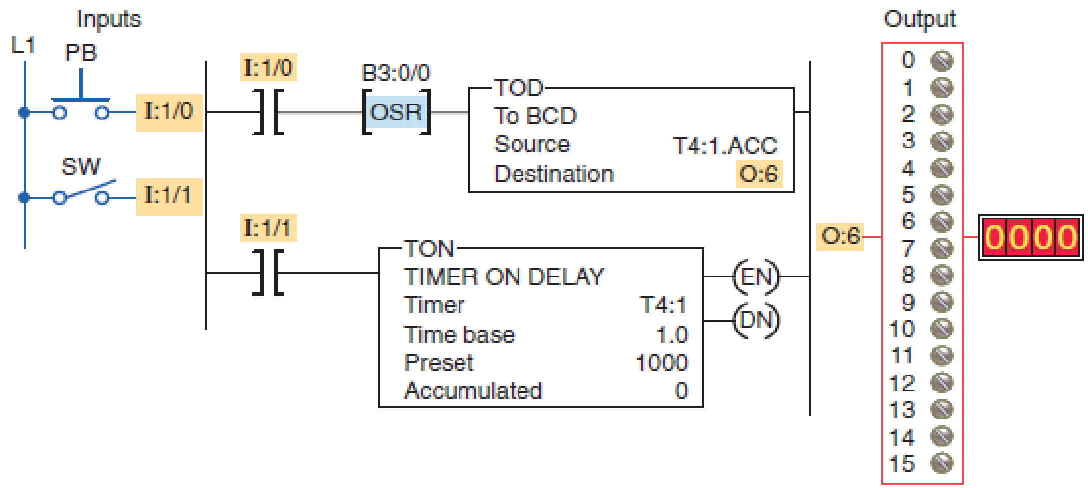
❑One-Shot Instruction

➢The operation of the program is summarized as follows:

• The accumulated value of timer T4:1 is converted to Binary Coded Decimal (BCD) and moved to output word O:6 where an LED display is connected.

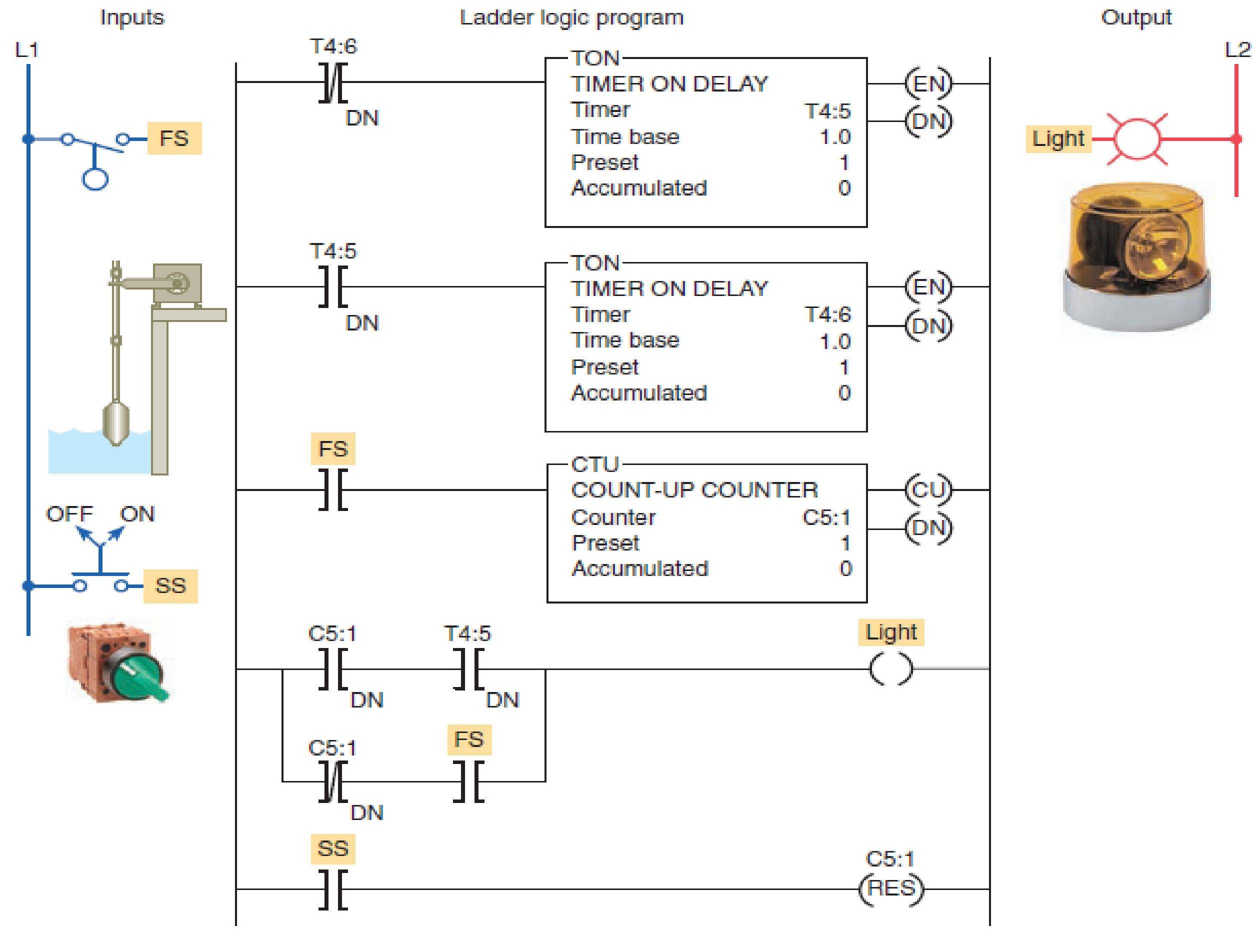
• When the timer is running, SW (I:1/1) closed, the accumulated value changes rapidly.

• Closing the momentary pushbutton PB (I:1/0) will freeze and display the value at that point in time.



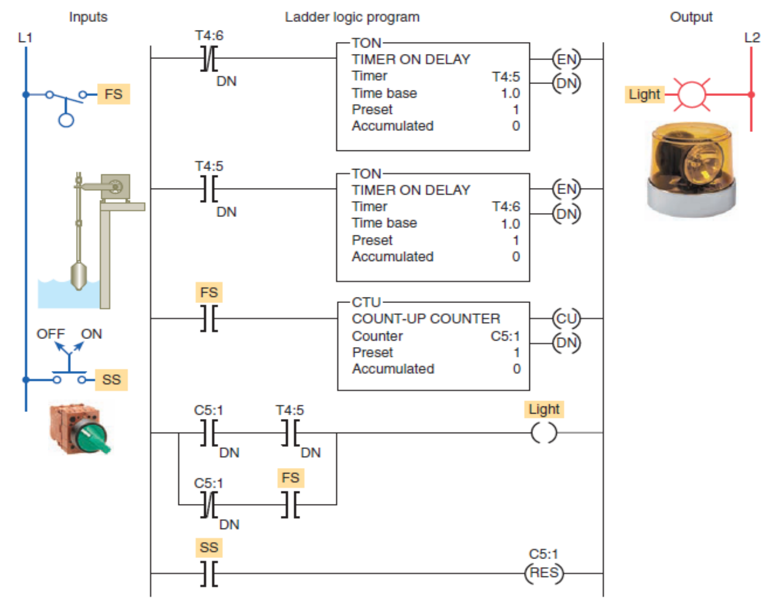
❑One-Shot Instruction

➢The alarm monitor PLC program of Figure illustrates the application of an up-counter used in conjunction with the programmed timed oscillator circuit.



❑One-Shot Instruction

The operation of the program can be Summarized as follows:



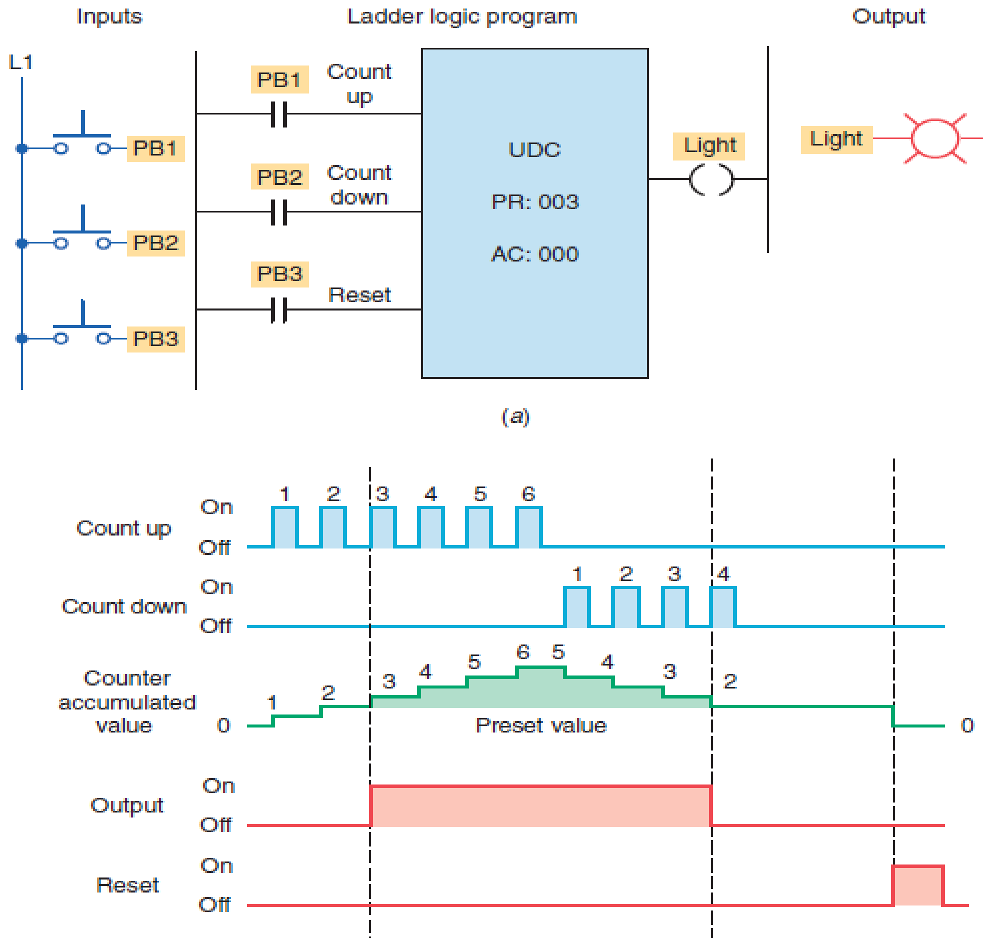
- The alarm is triggered by the closing of float switch FS.
- The light will flash whenever the alarm Condition is triggered and has not been acknowledged, even if the alarm condition clears in the meantime.
- The alarm is acknowledged by closing selector switch SS.
- The light will operate in the steady on mode when the alarm trigger condition still exists but has been acknowledged

❑Down counter

- ➢ The down-counter instruction will count down or decrement by 1 each time the counted event occurs.
- ➢Each time the down-count event occurs, the accumulated value is decremented.
- ➢Normally the down-counter is used in conjunction with the up-counter to form an up/down-counter.

❑Down counter

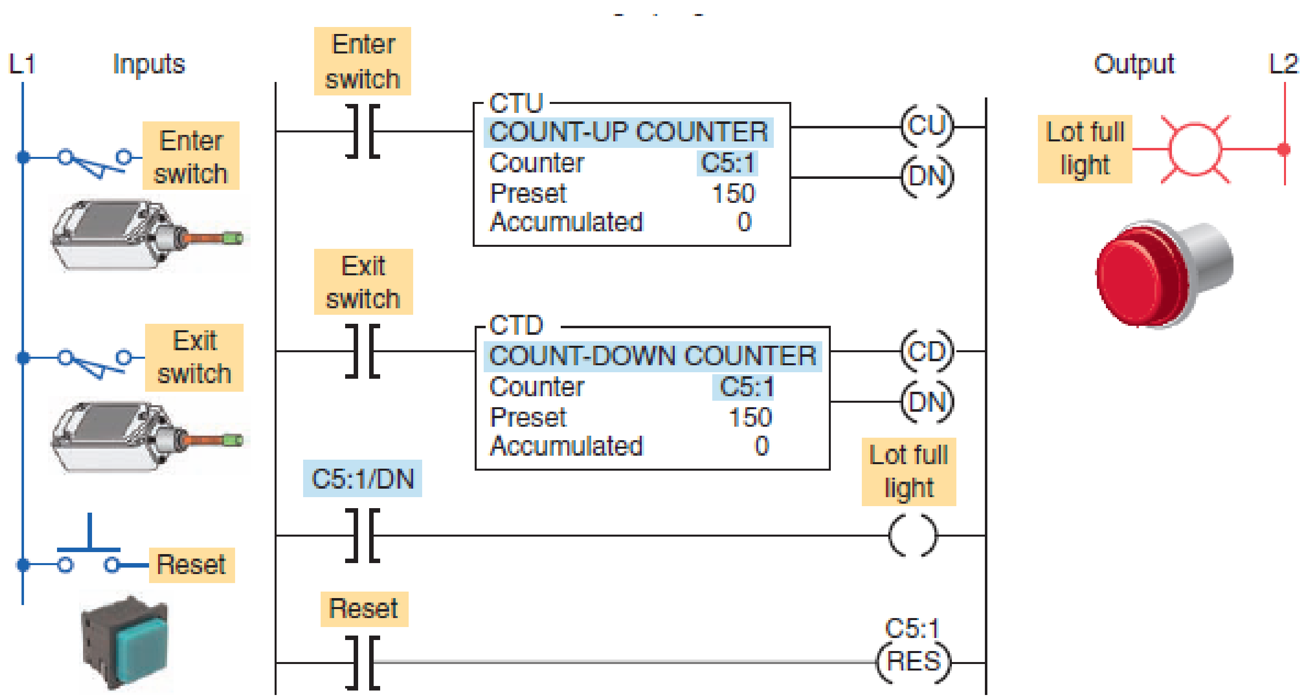
➢Figure shows the program and timing diagram for a generic, block-formatted up/down-counter.



❑Down counter

➢ One application for an up/down-counter is to keep count of the cars that enter and leave a parking garage.

➢Figure shows a typical PLC program that could be used to implement this



❑Down counter

➢ Figure shows an example of the count-down counter instruction used as part of the Allen-Bradley SLC 500 controller instruction set.

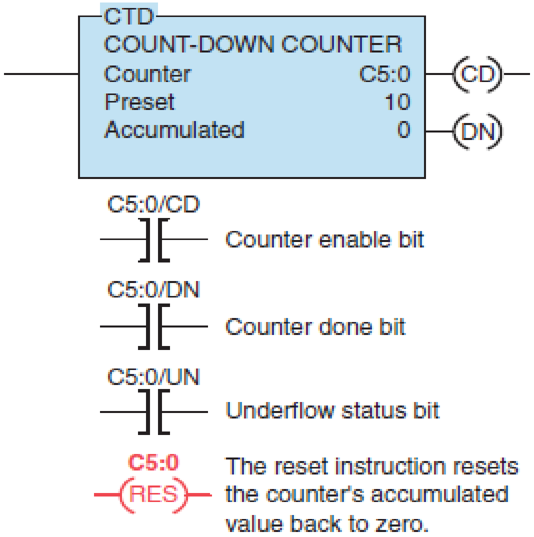
➢The information to be entered into the instruction is the same as for the count-up counter instruction.

➢The CTD instruction decrements its accumulated value by 1 every time it is transitioned.

➢It sets its done bit when the accumulated value is equal to or greater than the preset value.

➢The CTD instruction requires the RES instruction to reset its accumulated value and status bits.

➢Because it resets its accumulated value to 0, the CTD instruction then counts negative when it transitions

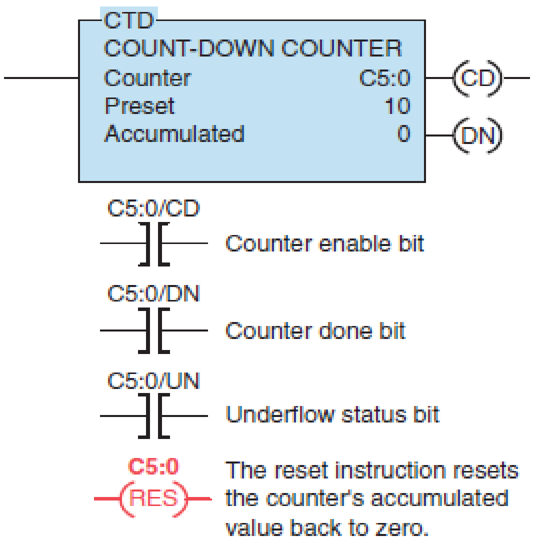


❑Down counter

➢ If the CTD instruction were used by itself with a positive preset value, its done bit would be reset when the accumulated value reached 0.

➢Then, counting in a negative direction, the accumulated value would never reach its preset value and set the done bit.

➢However, the preset can be entered with a negative value; then the done bit is cleared when the accumulated value becomes less than the preset value.



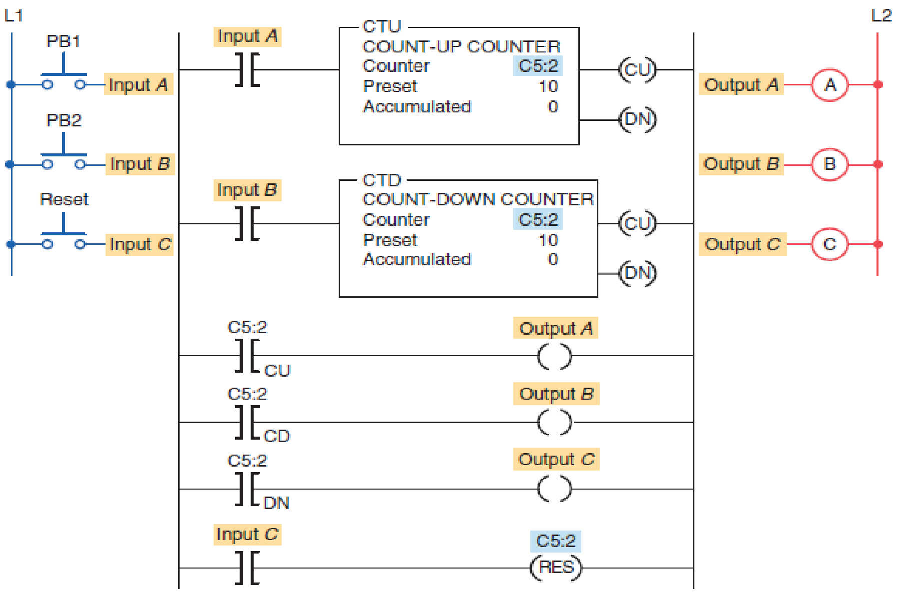
❑Down counter

➢ Figure shows an up/down-counter program that will increase the counter's accumulated value when pushbutton PB1 is pressed and will decrease the counter's accumulated value when pushbutton PB2 is pressed.

➢Note that the same address is given to the *up-counter instruction,* the down-counter instruction, and the reset instruction.

➢All three instructions will be looking at the *same address in the counter file.*

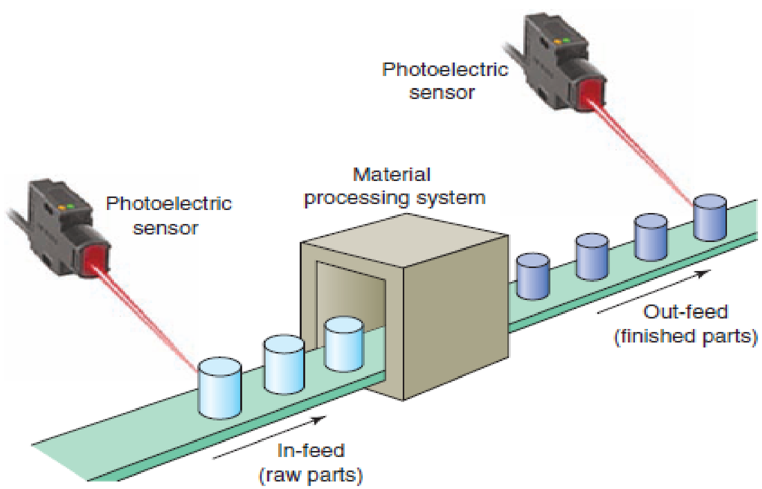
➢*When input A goes from false* to true, one count is added to the accumulated value.

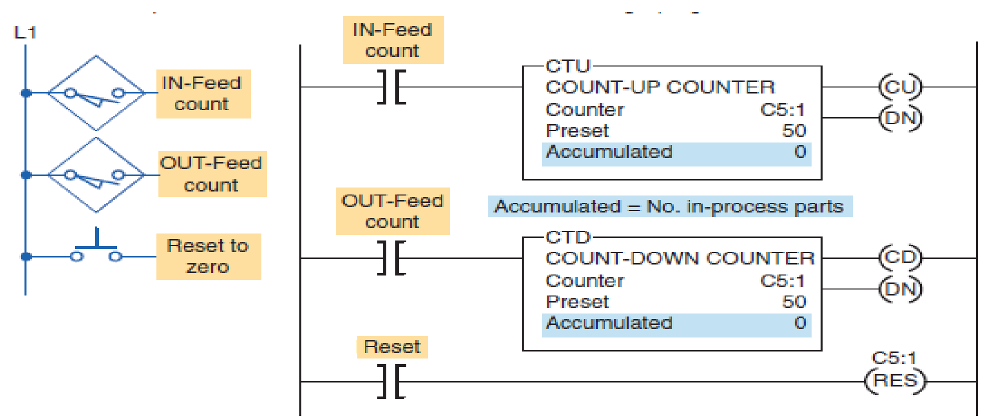


➢When input *B goes from false to true, one count is subtracted* from the accumulated value.

❑Down counter

- Figure illustrates the operation of the up/down counter program used to provide continuous monitoring of items in process.
- An in-feed photoelectric sensor counts raw parts going into the system, and an out-feed photoelectric sensor counts finished parts leaving the machine.
- The number of parts between the in-feed and out-feed is indicated by the accumulated count of the counter. Counts applied to the up-input are added, and counts applied to the down-input are subtracted





(b)

❑Cascading Counters

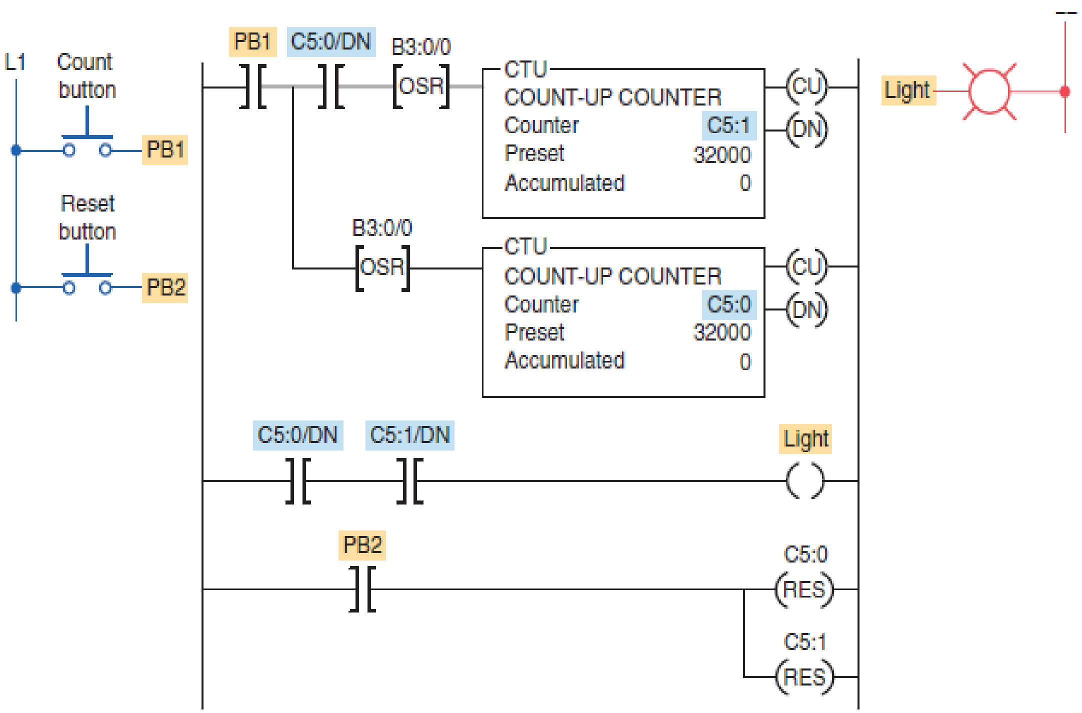
➢ The program of Figure 8-26 illustrates the application of the technique.

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

• The output of the first counter is programmed into the input of the second counter.

• The status bits of both counters are programmed in series to produce an output.

• These two counters allow twice as many counts to be measured.

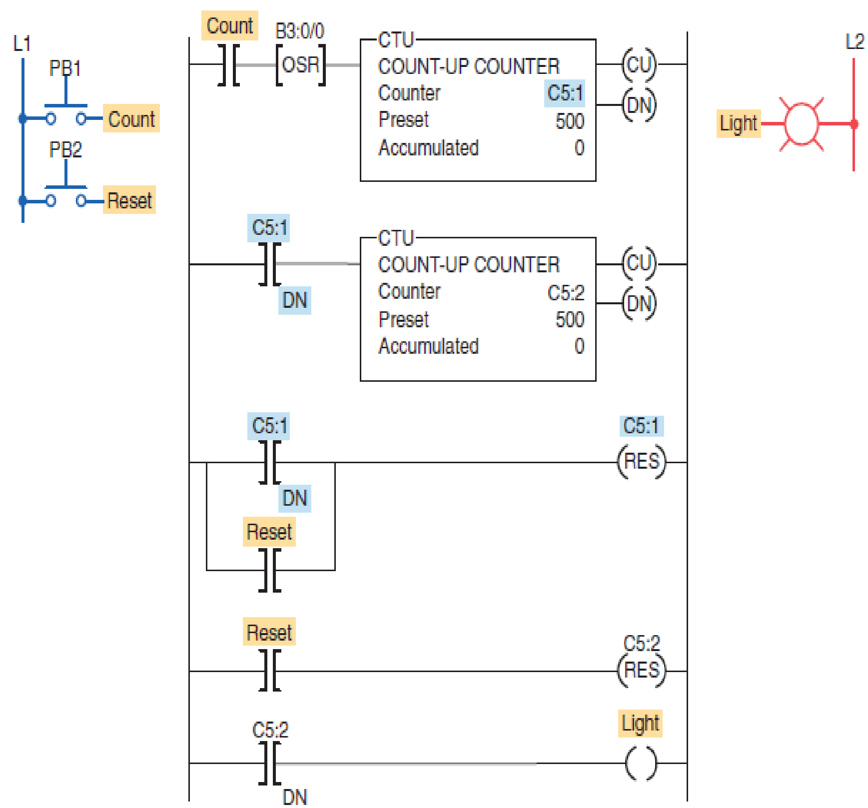


❑Cascading Counters

➢ Figure shows how the two counters would be programmed for this purpose

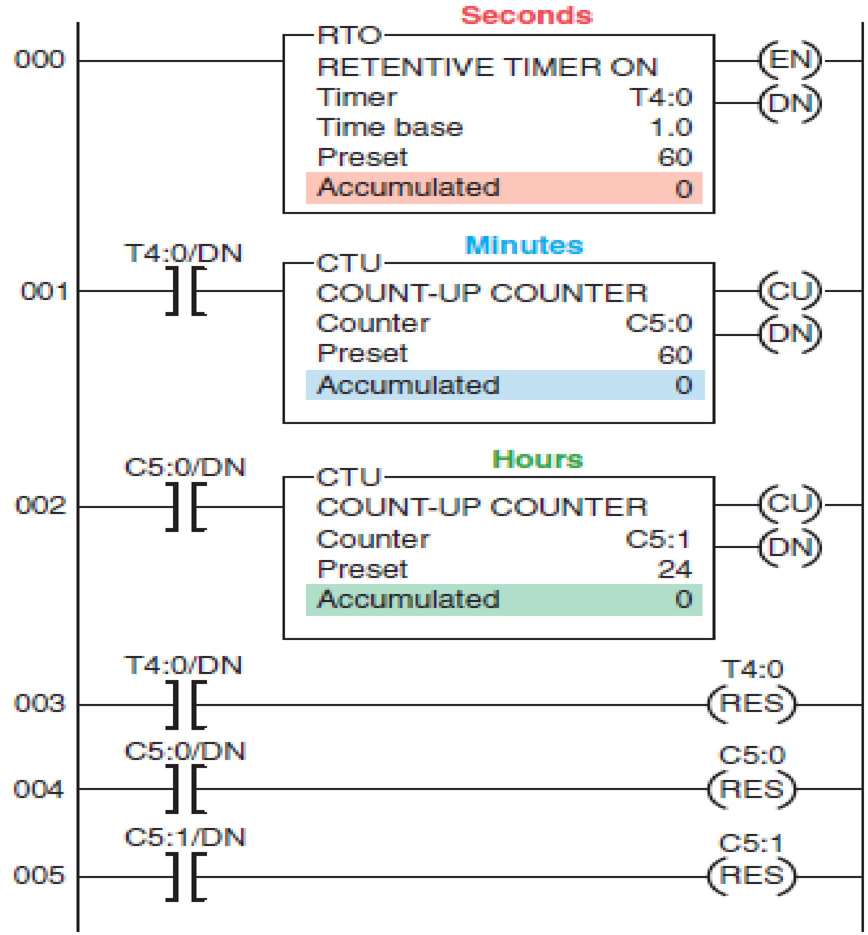
➢Counter C5:1 has a preset value of 500 and counter C5:2 has a preset value of 500.

- Whenever counter C5:1 reaches 500, its done bit resets counter C5:1 and increments counter C5:2 by 1.
- When the done bit of counter C5:1 has turned on and off 500 times, the output light becomes energized. Therefore, the output light turns on after 500 3 500, or 250,000, transitions of the count input.



❑Cascading Counters

➢ Figure illustrates a timer-counter program that produces a time-of-day clock measuring time in hours and minutes.



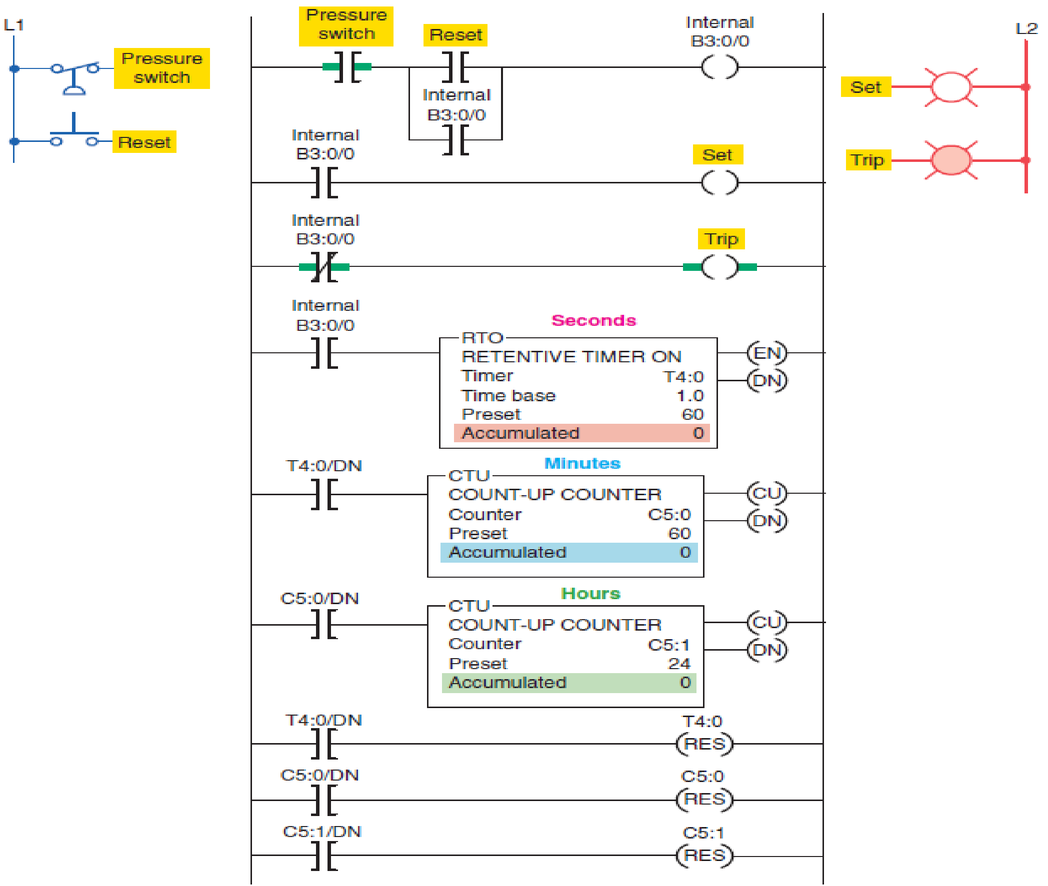
❑Cascading Counters

✓ The 24-hour clock can be used to record the time of an event.

✓Figure illustrates the principle of this technique.

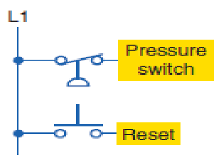
✓In this application the time of the opening of appressure switch is to be recorded

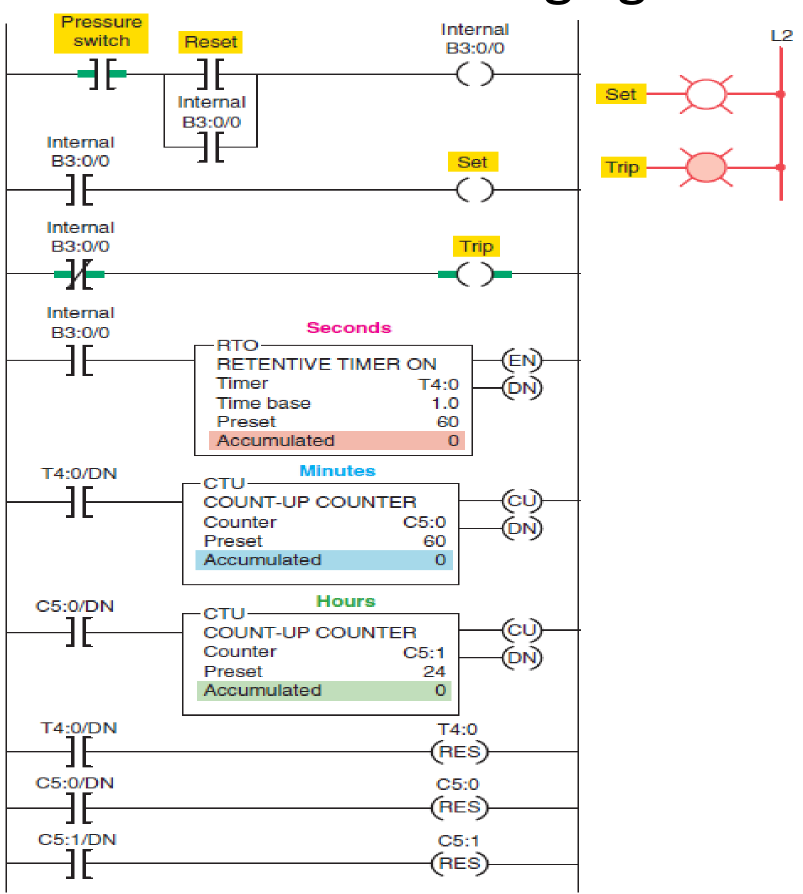
The operation of the program can be summarized as follows:



❑Cascading Counters

- The circuit is set into operation by pressing the reset button and setting the clock for the time of day.
- This starts the 24-hour clock and switches the set indicating light on.
- Should the pressure switch open at any time, The clock will automatically stop and the trip indicating light will switch on.
- The clock can then be read to determine the time of the pressure switch.





➢ Incremental Encoder-Counter Applications

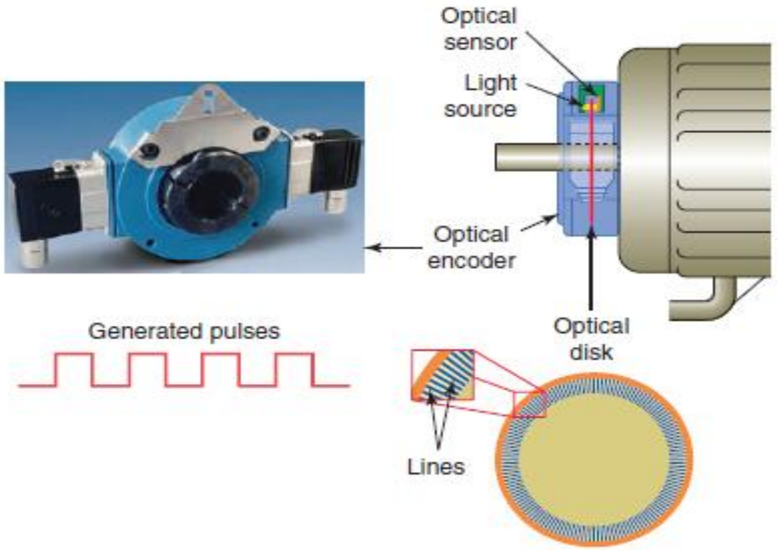
• The incremental optical encoder shown in Figure creates a series of square waves as its shaft is rotated.

• The encoder disk interrupts the light as the encoder shaft is rotated to produce the square wave output waveform.

➢ encoder can be made to correspond to the mechanical movement required.

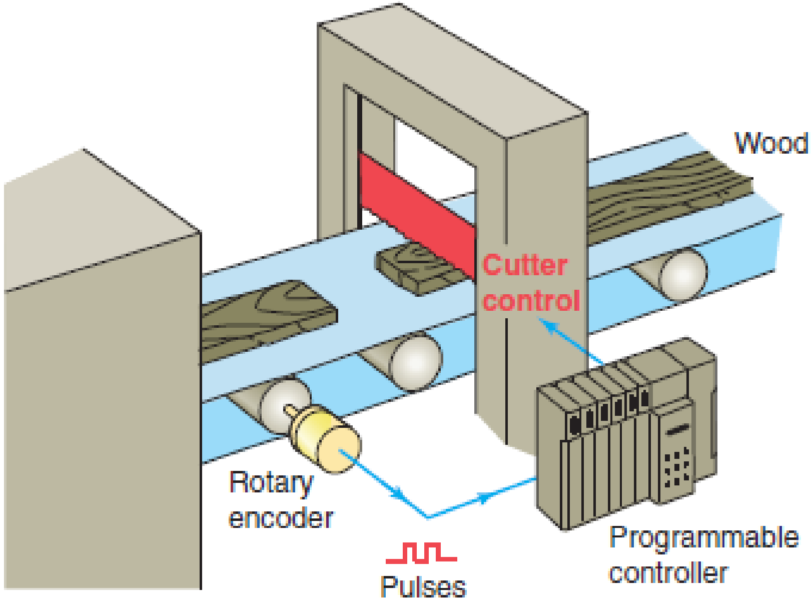
➢ For example, to divide a shaft revolution into 100 parts, an encoder could be selected to supply 100 square wave-cycles per revolution.

➢ By using a counter to count those cycles , we could tell how far the shaft had rotated



➢Incremental Encoder-Counter Applications

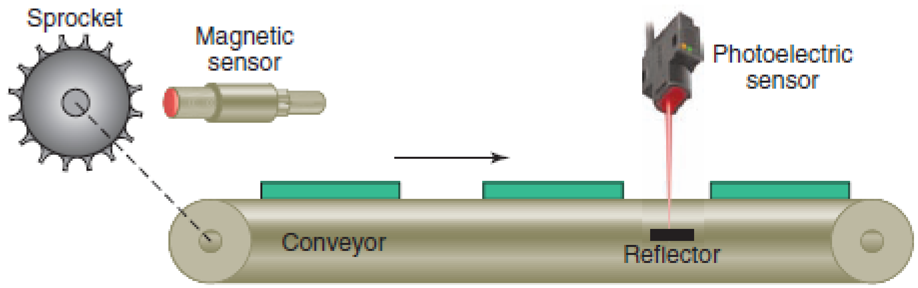
- Figure illustrates an example of cutting objects to a specified length.
- The object is advanced for a specified distance and measured by encoder pulses to determine the correct length for cutting.



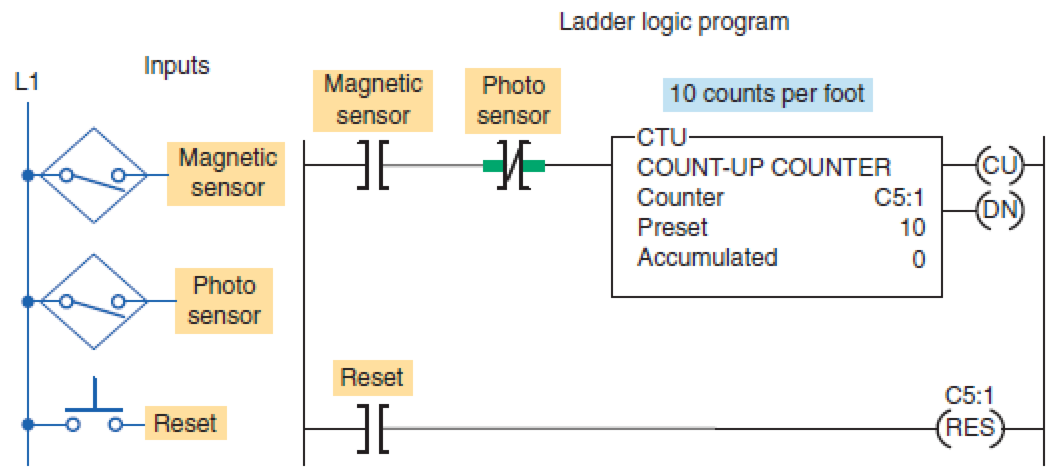
➢Incremental Encoder-Counter Applications

• Figure shows a counter program used for length measurement.

• This system accumulates the total length of random pieces of bar stock moved on a conveyor.

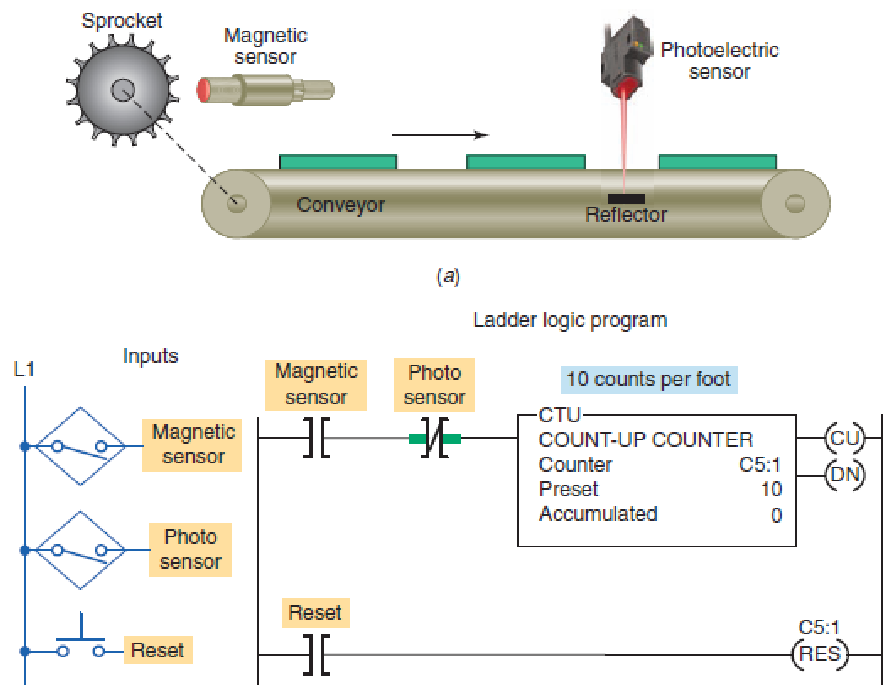


(a)



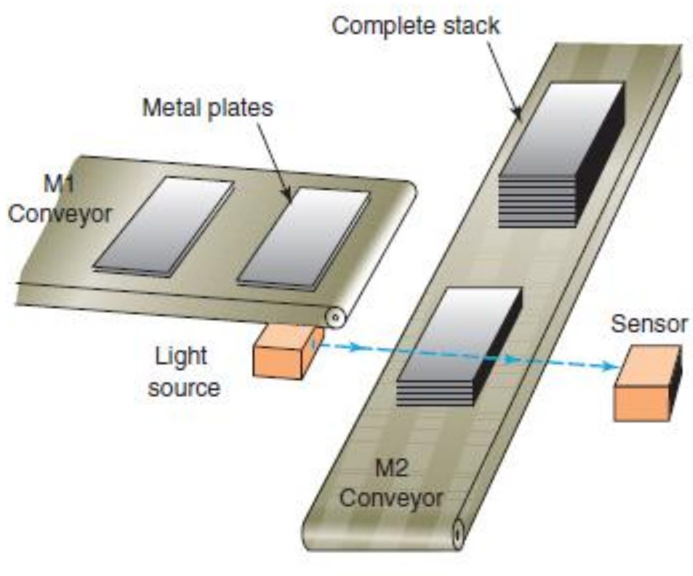
➢ Incremental Encoder-Counter Applications

- The operation of the program can be summarized as follows:
- Count input pulses are generated by the magnetic sensor, which detects passing teeth on a conveyor drive sprocket.
- If 10 teeth per foot of conveyor motion pass the sensor, the accumulated count of the counter would indicate feet in tenths.
- The photoelectric sensor monitors a reference point on the conveyor.
- When activated, it prevents the unit from counting, thus permitting the counter to accumulate counts only when bar stock is moving.
- The counter is reset by closing the reset button.

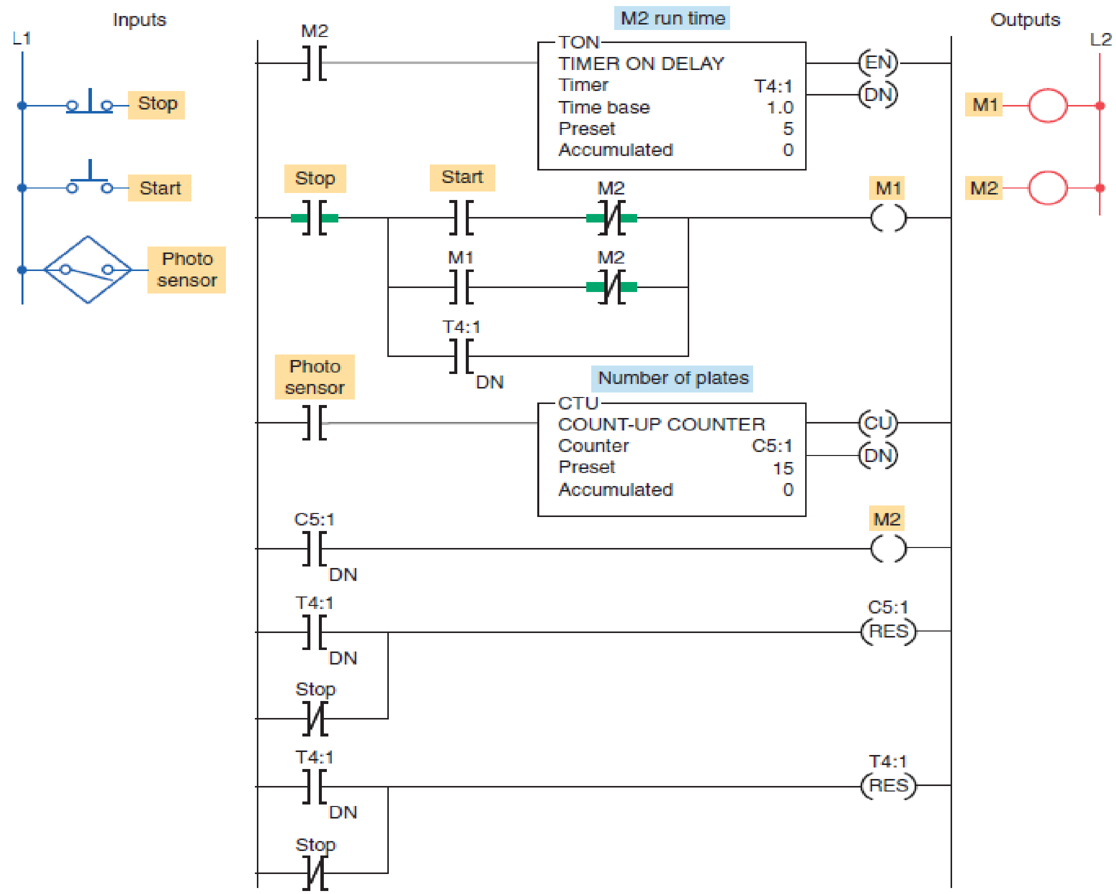


❑Combining Counter and Timer Functions

- Many PLC applications use both the counter function and the timer function.
- Figure illustrates an automatic stacking program that requires both a timer and counter.



(a)



❑Combining Counter and Timer Functions

- When the start button is pressed, conveyor M1 begins running.
- After 15 plates have been stacked, conveyor M1 stops and conveyor M2 begins running.
- After conveyor M2 has been operated for 5 s, it stops and the sequence is repeated automatically.
- The done bit of the timer resets the timer and the counter and provides a momentary pulse to Automatically restart conveyor M1.