Simulations of PLC Programs for Flashlight, Car Parking System and Conveyor Applications

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ABSTRACT
In this paper, the three programmable logic controller (PLC) programs are described for shift register instruction, up and down counters instructions and timer instructions. The programs are written by logicpro software. The logicpro software is adopted by Allen Bradley manufacturer. The three programs are used for applications of flash light, car parking and conveyor applications.

Keywords *- PLC, Logicpro, Shift Register, Timers, Counters.*

I. INTRODUCTION
A programmable logic controller (PLC) is a specialized computer used for the control and operation of manufacturing and machinery[2]. This uses a programmable memory to store instructions and execute functions including on/off control, timing, counting, sequencing, shifting, arithmetic and data handling[3]. PLC are used in almost every aspect of industry to expand and enhance production. Where older automated systems would use hundreds or thousands of electromechanical relays, a single PLC can be programmed as an efficient replacement. Sophisticated motion control, process control, distributive control systems, and complex networking have now been added to the PLC's function [1].

II. DESCRIPTION
A programmable logic controller (PLC) is a special form of microprocessor-based controller. The term logic is used because programming is primarily concerned with implementing logic and switching operations. Input devices, e.g, sensors such as switches, and output devices in the system being controlled, e.g. motors, valves, etc., are connected to the PLC. The operator then enters a sequence of instructions, i.e. a program, into the memory of the PLC. The controller then monitors the inputs and outputs according to this program [4]. The programmable logic controller consists of computer hardware, which is programmed to simulate the operation of the individual logic and sequence elements that might be contained in a bank of relays, timers, counters and other hard-wired components.

As PLCs have developed and expanded, programming languages have developed with them. Programming language allow the user to enter a control program into a PLC [5]. The International Electrotechnical Commission (IEC 1131-3) standard defines three graphical languages and two text-based languages for use in PLC programming. The graphical languages use symbols to program control instructions, while the text-based languages use character strings to program instructions.

- Graphical languages
  - ladder diagrams (LD)
  - function block diagram (FBD)
  - Sequential function charts (SFC)
- Text-based languages
  - instruction list (IL)
  - structured text (ST)

Ladder diagram is the most widely used programming language in industrial automation today. Its ease of use, traceability, and visual representation of physical components make it the favored programming method of many engineers. Ladder diagram is a graphical programming language, initially programmed with simple contacts that simulate the opening and closing of relays. Ladder logic programming has been expanded to include functions such as counters, timers, shift registers and math operations[4]. The method of writing programs became adopted by most PLC manufacturers, however each tended to have developed their own versions. Some of PLC Programming Software are as follow:

- Allen-Bradley –Rockwell Software RSLogix500
- Modicon - Modsoft
- Omron – Syswin
- GE-Fanuc Series 6 – LogicMaster6
- Square D- PowerLogic
- Texas Instruments – Simatic
- Telemecanique – Modicon TSX Micro

- Matsushita-FPWIN

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Shift register instructions are PLC output instructions that are used to load data into a bit array, one bit at a time. The data is shifted through the bit array, and then unloaded from the bit array one bit at a time. The PLC on the Allen Bradley's trainer includes the following shift register instructions: the bit shift left (BSL) instruction and the bit shift right (BSR) instruction. To enter a BSL or BSR instruction, the following parameters must be programmed:

- File: address of the bit array through which the bits are shifted. The array must start at the first bit position of a 16-bit element (element 1,2,3 etc.) in a binary (B) data file.
- Control: 3-word register (R-data file) that stores the status bits of the BSL or BSR instruction and the length of the bit array as shown in Table 1.

Table 1. R data file Structure

Word	B_{15}	B_{14}	B_{13}	B_{12}	B_{11}	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	B_3	B_2	B_1	B_0
0	EN			DN		ER	UL									
1	Length (size) of the bit array															
2	Reserved															

- Bit Address: location of the source bit that is inserted into the array. With a BSL instruction, this bit is inserted into the first (lowest) bit position of the array. With a BSR instruction, this bit is inserted into the last (highest) bit position of the array.
- Length: total number of bits to be shifted within the bit array.

In many control tasks**,** there is a need to control time. PLCs thus have **timers** as built-in devices. Timer counts fractions of seconds or seconds using the internal CPU clock. There are a number of different forms of timers that can be found with PLCs: on-delay, off-delay, and retentive timers.

- On-delay timers (TON) come on after a particular time delay. Thus as the input goes from 0 to 1, the elapsed time starts to increase, and when it reaches the time specified by the input PT, the output goes to 1.
- An off-delay timer (TOF) is on for a fixed period of time before turning off. The timer starts when the input signal changes from 1 to 0.
- Another type of timer is the retentive timer. Its lets the timer starts and stops without resetting the accumulated value.

The Allen-Bradley timer symbol shows the type of timer concerned, the timer address, and the time base that indicates the increments by which the timer moves to the preset value, such as 0.001 s, 0.01 s, 0.1 s or 1 s. The preset value (PRE) is the number of time increments that the timer must accumulate to reach the required time delay, and the accumulator (ACC) indicates the number of increments that the timer has accumulated while the timer is active and is reset to zero when the timer is reset (useful if a program needs to record how long a particular operation took). The Allen-Bradley timers have three Boolean bits for ladder logic control: a timer enable bit (EN), which goes on when the timer accumulator is incrementing, a timer done bit (DN), which goes on after the set time delay, and a timer timing bit (TT) that is on when the accumulator is incrementing and remains on until the accumulator reaches the present value. The TOF timer functions the opposite of TON timer.

Counters are provided as built-in elements in PLC and allow the number of occurences of input signals to be counted. A counter is set to some present number and when this number of input pulses has been received, it will operate it contacts. Thus normally open contacts would be closed, normally close contacts opened. There are two types of counters; up-counter and down-counter. Up-counters count from zero up to the present value. When the counter reaches the preset value, its contacts change states. Down counters count down from the present value to zero. When the counter reaches the zero value, its contacts change states [7].

III. IMPLEMENTATION STEPS

- The three ladder logic programs are made for flashlight, car-parking system and 4-bit shift register conveyor application.
- The programs are simulated and debugged.
- The programs are saved on the logicPro software.
- The programs are documented.

IV. DESIGN PROGRAMS & SIMULATION RESULTS

For the proposed research, 4-bit shift register is considered. Input I:1/0 is used to input the first internal relay in the register. Input I:1/1is used to shift the states of internal relays along by one. Input I:1/2 is used to

reset the shift register, i.e; all the values at zero. Each of the internal relay in the register, i.e. B3:0/0, B3:0/1, B3:0/2 and B3:0/3, is connected to an output O:2/0, O:2/1, O;2/2 and O:2/3. At first, a momentary input to I:1/2 is set to 0 and so the states of the four internal relays B3:0/0, B3:0/1, B3:0/2 and B3:0/3 are 0,0,0 and 0. When I:1/0 is momentarily closed there is a 1 input to the first internal relay. Thus the states of the internal relays B3:0/0, B3:0/1, B3:0/2 and B3:0/3 are now 1,0,0,0. An I:1/0 contact close and end up with an output from O:2/0. Then a momentarily input to I:1/1, the 1 is shift from the first relay to the second. The states of the internal relays are now 0,1,0,0.

Allen-Bradley's LogicPro software is used for the proposed work. The 4-bit Shift Register PLC Ladder Program is shown in Figure 1 and its simulation is shown in Figure 2.

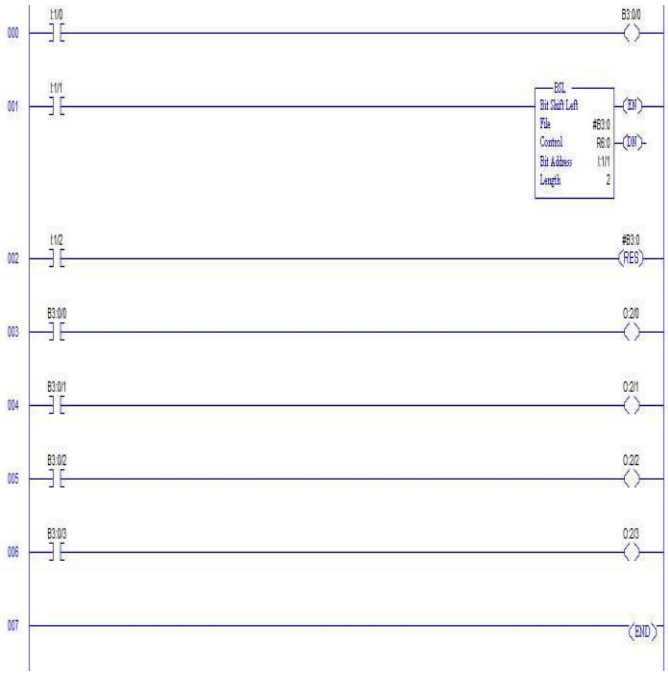

Figure 1. 4-bit Shift Register PLC Ladder Program

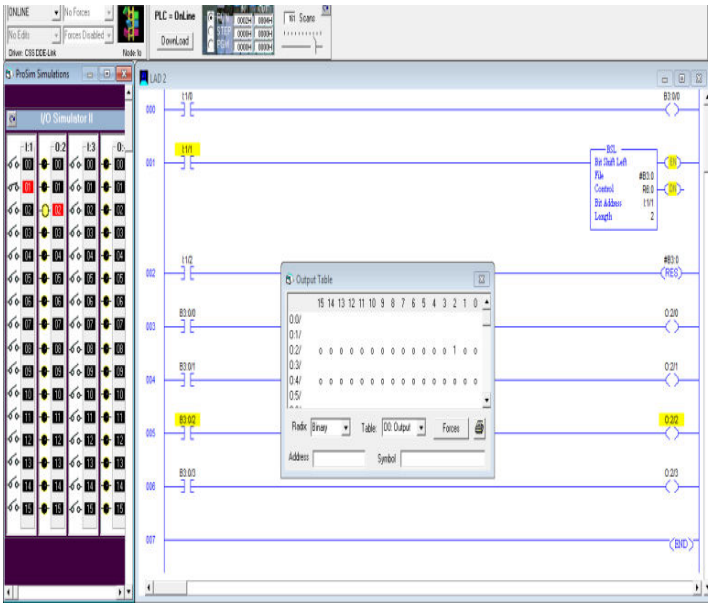

Figure 2. 4-bit Shift Register Simulations

In this paper, both up and down counters are used for counting up and downing the number of cars in the car parking. The tasks of counting cars as they leave or enter in a multi storage parking lot. An output is to be triggered if the number of cars entering is some number greater than the number leaving. i.e, the number in the parking lot has reached a 'saturation' value. The output might be to illuminate a 'No empty space' signs. The ladder program for this application is shown in Figure 3 and its simulation is shown in Figure 4.

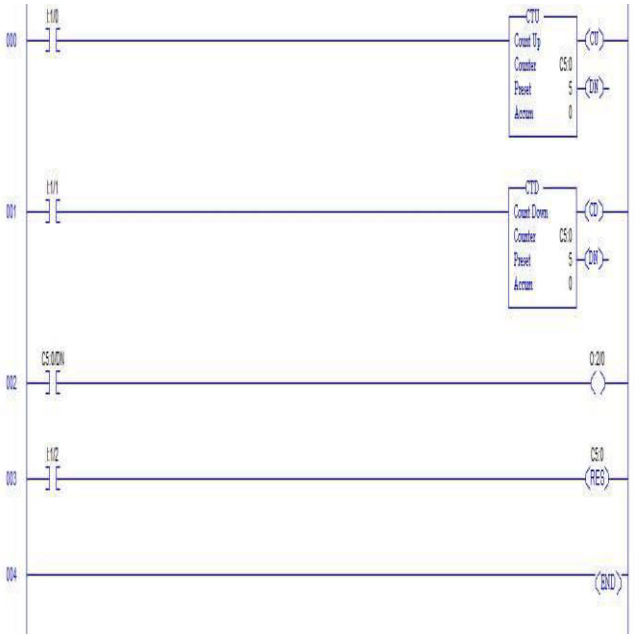

Figure 3. Up/Down Counter Program

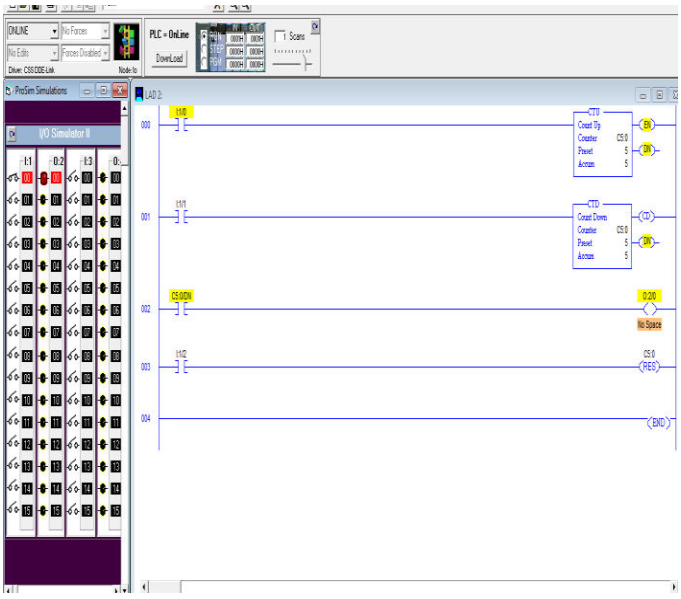

Figure 4. Simulation with Up/Down Counting Application

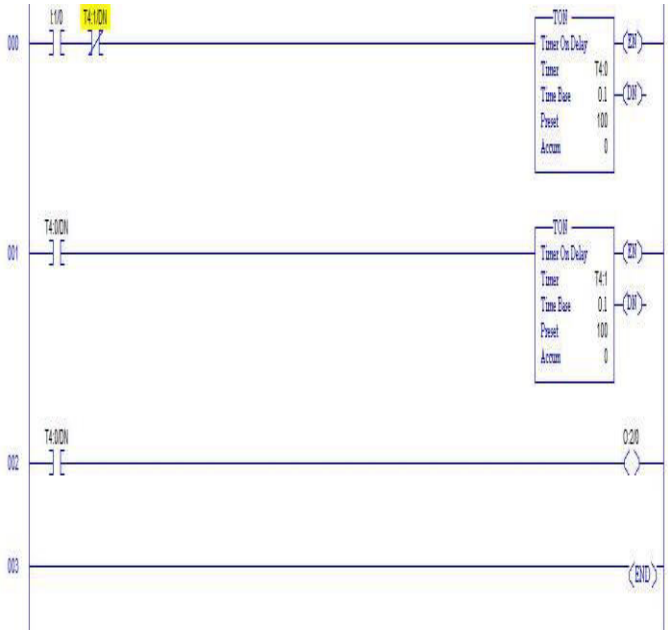

Figure 5. Flashing Light Program

As a third ladder program in this paper, 2 timers (T4:0 and T4:1) are used to flash a light on and off as long as there is some output occuring. When the output occurs, then timer T4:0 start and switches on after 10 sec (Preset value 100). This closes the timer T4:0 contact and starts time T4:1. This switches on after 10 sec, and in doing so, switches off timer T4:0. In so doing, it switches off itself. The lamp is only on when T4:0 is on and so a flash light is on and off as long as there is an output. The flashlight program is shown in Figure 5 and its simulation is shown in Figure 6.

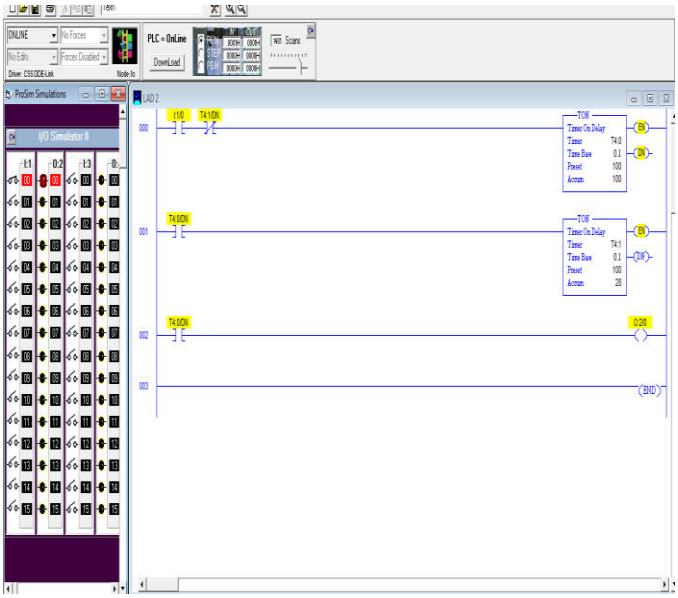

Figure 6. Simulation with Flashing light Application

V. CONCLUSION

In many applications, it is necessary store the status of an event that has previously happened. A group of registers can be used to from a train of bits(cars) to store the previous on/off status. Each new change in status gets stored in the first bit and the remaining bits get shifted down the train. Shift register instructions are useful in conveyor applications and product evaluation (pass/fail) control. The programs in this paper can be used for applications of flashlight, car parking system and conveyor belt.

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