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A Way of Implementing a Complex Electrical Switching Pattern in the Industrial Processing Unit with Plc

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ABSTRACT-*An industrial automation system often needs a flexible automation unit so that an operator can design its operation in any order by assigning any parameter to meet any system requirement. This machine controlling flexibility in the industrial processing unit can be successfully obtained by a programmable logic controller (PLC) based Electrical switching technique. A complex pattern of electrical switching can be easily developed by the convenient utilization of PLCs binary operation feature. In this paper, we have developed a ladder logic diagram (LLD) to build an accommodating and complex electrical switching pattern for the industrial processing unit.It provides output according to the system layout. So, the operator can easily plan a machine control system pattern and develop an LLD to run his own computer-based automation factory or any automation based industrial processing unit.*

KEYWORDS- *Complex electrical switching technique, Electrical Switching technique, Electrical switching with PLC, LLD for complex electrical switching, PLC solution in complex electrical* switching

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I. INTRODUCTION

The invention of the method of the invention was the greatest invention of the nineteenth century.[13]The sagacious observing abilities, prudent problem-solving skills, insightful ideas of developing tools and pieces of machineryand the ingenious proficiencies of improvisation of engineers and technologists have led human civilization to devise the method of the invention in the modern era. Hence, plenty of machines and modern automatic systems are being continuously introduced in the factories and industries. PLC based electrical control systems are one of those modern automation techniques that control machines and processes of an industry. Before the origination of this sophisticated PLC concepts, industries were highly dependent on manually operated power and control relays, electro-mechanical counters and pneumatic plunger timers.[11] It was very difficult to maintain an electrical enclosure that was full of wires, controlling utilities and other components. Automation industry has been revolutionized by the PLC-based control technologies. [11] There are also a lot of other applications of modern PLC, like- traffic control[9], light controls in advertisements[3], home automation safety control[1], coal handling and burner control in power plant, ore processing[8] and many more. In this paper, we are going to introduce another use of PLC. It is a complex electrical switching pattern to control industrial processing unit. We are going to take the advantage of a feature of PLC to develop any arrangement of switching pattern into operation so that number of pieces of machinery in a factory can be turned on or off in any time in any kind of pattern according to industrial system requirements.

II. PLC BASEDELECTRICAL SWITCHING

An electrical switch is a stand-alone unit which uses the motion of actuating mechanism either to interfere or to make a bridge to the flow of electricity between two contacts or circuit arrangements.[7]It is a binary device that leads a circuit to be ON (closed) or OFF (open) state.[7]It can be controlled manually or automatically. The outcome of the automatically controlled switch is set by the operator by integrating sensors, logic and electrical circuits. PLC based Electrical switching is one of the forms of self-executing controlled switching techniques where a predetermined sequence of state shifting of switch contacts can be obtained based on effects of inputs and on the functional application program installed in the battery-backed or non-volatile memory of PLC unit.[12] PLC based switches are being used in industrial automation because of its flexibility in operation. With the help of PLC, output or the machines of an industry can be analyzed, monitored and operated with full of variety. Before implementing PLC based electrical switching system, we have to consider the number of switches needed in an industry, system requirements of the industry to design a switching pattern and length of each phase operation and whole cycle for synchronization of switching control operation with the actual working unit.[9]

III. ADVANTAGES OF PLC APPLICATIONIN ELECTRICAL SWITCHING

There are several advantages of using PLC in the industrial electrical switching system. Such as-

1. Marinating and troubleshooting are much easier than relay system in industrial switching.[11]
2. The cable arrangement is less complex and the whole system can be accommodated within limited space.[11]
3. There are provisions for expansion of inputs and outputs.[11]
4. It is much precise and reliable control system than analog switching technology as it eradicates flaws of manually operated mode of switching.[2]
5. PLC is robust computer device. It has immunity to electrical noise, resistance to vibration and has protection from dust, moisture, mechanical shock and unfavorable temperature.[1]
6. It can be programmed sequentially or in any complicated pattern according to the requirements of the system design. So, it is very convenient for the operator to run a number of machines of an industry at any time or any period of time in any pattern in a process. It is a very flexible control system.
7. It can be reprogrammed and can be implemented in another control system without facing any difficulties. Replacement of PLC base control system is much easier than a conventional relay -based electrical switching technology.
8. It takes less time to find an error and to solve it without holding up a control panel for a long time.[11]
9. It is an energy efficient system as a considerable amount of relay circuits, timers and counters are being replaced by a simple microprocessor-based digital control system.
10. It can capture data of a control unit and those data can be stored for future analysis for quality control, maximizing the capacity of the equipment and process optimization.[12]

IV. SYSTEM LAYOUT

Complex electrical switching pattern is a method of switching a large number of pieces of machinery of a factory at any time in any pattern according to the industrial automation system requirements. In this system, the operators can choose a way to make machines behave in a particular pattern by implementing logic in switching control operation technique. PLC based complex switching system which replaces power and control relays, timers and counters, controls switching operation of a number of machines of an industry by turning those ON or OFF. The ON and OFF operations are as similar as the binary operation. The PLC actually process the binary operations according to the logical program that an operator places in it and it provides output in a form that a human wants from it. To implement a complex pattern, we only need a PLC unit and switching unit of the machines. PLC itself has two units- Hardware and software unit. Hardware unit follows the command of software units.

The flexibility of manipulating decimal to binary mathematical conversion[2] in PLC unit ensure the provisions of developing a complex switching pattern. Such as- with a decimal input 1, we can control one of eight switches of an industrial switching control arrangement and with decimal 2, another switch can be controlled and the previous one can be turned off. Similarly, input decimal 4 can assist us to control third of eight switches of a switching control arrangement. A decimal input number 3 can help us to run first 2 switches of those eight switches as $(3)_{10} = (00000011)_2$. So, we have to develop an LLD according to the way we want the industrial switching operations to run.

In this paper, we are developing an LLD for an industrial switching system. It has total eight outputs or eight machine switching control units. We are going to run those machine one after another. The following table provides us a visual understanding of switching pattern we want to implement in our system:

TABLE 1: Mathematical conversions and system outputs of a PLC unit

	Actual mathematical operation inside PLC unit		Visible Output from PLC (Actual switching operation)							
Number of actions	Decimal number	Equivalent Binary number	Q0.7	Q0.6	Q0.5	Q0.4	Q0.3	Q0.2	Q0.1	Q0.0
1	0	00000000	○	○	○	○	○	○	○	○
2	1	00000001		○	○	○	○	○	○	●
3	2	00000010	○	○	○	○	○	○	●	○
4	4	00000100	○	○	○	○	○	●	○	○
5	8	00001000	○	○	○	○	●	○	○	○
6	16	00010000	○	○	○	●	○	○	○	○
7	32	00100000	○	○	●	○	○	○	○	○
8	64	01000000	○	●	○	○	○	○	○	○
9	128	10000000	●	○	○	○	○	○	○	○

In this table, Q0.0, Q0.1, Q0.2, Q0.3, Q0.4, Q0.5, Q0.6, and Q0.7 are eight outputs and we are going to develop such a system which will activate the switches according to the plan. The system plan is showed in the table mentioned in “Visual Output from PLC”. So, before we develop an LLD, we have to consider this switching pattern plan, duration of action (ON/OFF) of each switch and total cycle length of the whole operation.

V. SYSTEM DESIGN

According to the system plan, we only have to use 0, 1, 2, 4, 8, 16, 32, 64 and 128 decimal numbers in the input of LLD program to turn on Q0.7 to Q0.0 one after another. In this design, when one output is ON, all the others remain OFF.

The LLD of complex electrical switching pattern consists of counters, move and first-in-first-out instruction, memory units, special memory bits, like- SM0.5, SM0.0 and positive transition commands. According to the instruction manual, SM0.0 is always ON, SM0.5 is 0.5s ON/0.5s OFF, and SM0.1 is only at first scan.[3] The assigned variable memory units are VW200, VW202, VW204, VW206, VW208, VW210, VW212, VW214, and VW216. Counter units to run operation in and after a particular time unit, MOV_W operation is to send decimal IN data to output variable unit. Here, in VW500 memory unit is placed for converting the decimal data and for writing the result to PLC output points Q0.7 to Q0.0.[3]

In network 1, we run counter C0. SM0.5 is 0.5s ON and SM0.0 is always ON are applied in counter CU and CD. The counter will run up to 5ms and then it will reset itself. The output of counter C0 is CTUD.

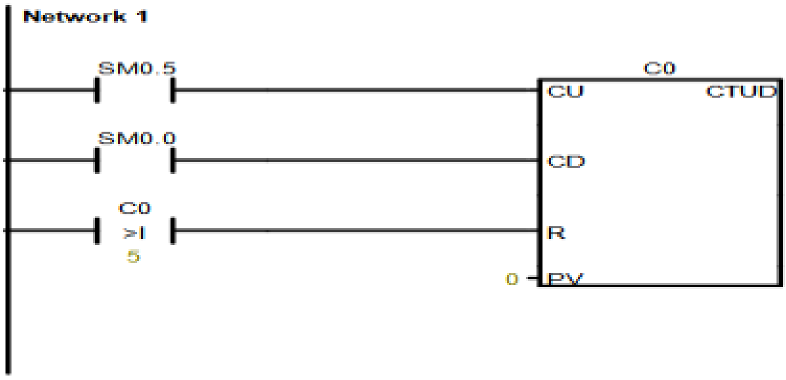
In network 2, SM0.1 or the first scan or M0.0 and positive transition condition is applied for setting value in variable memory units. Here, max table length (VW200)= 15 and entry count (VW202)=7. By MOV_W operation, VW204=1, VW206=2, VW208=4, VW210=8, VW212=16, VW214=32 and VW216=64.

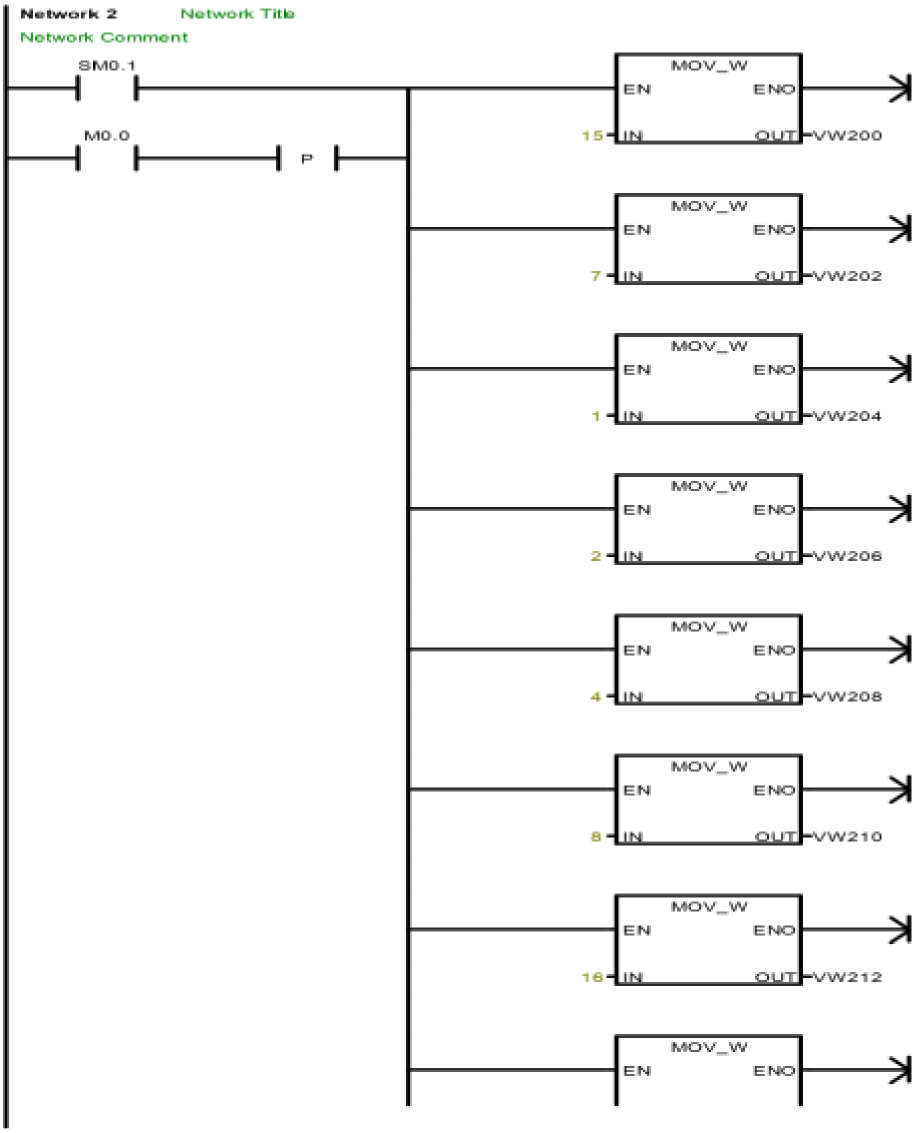
In network 3, when variable byte VB203 is greater than 0, C0 is running and is equal 1, turning hardware input switch I0.0 ON and with a positive transition, the FIFO command removes the data of the table from VW200 to VW400 and increment out the count VB500.

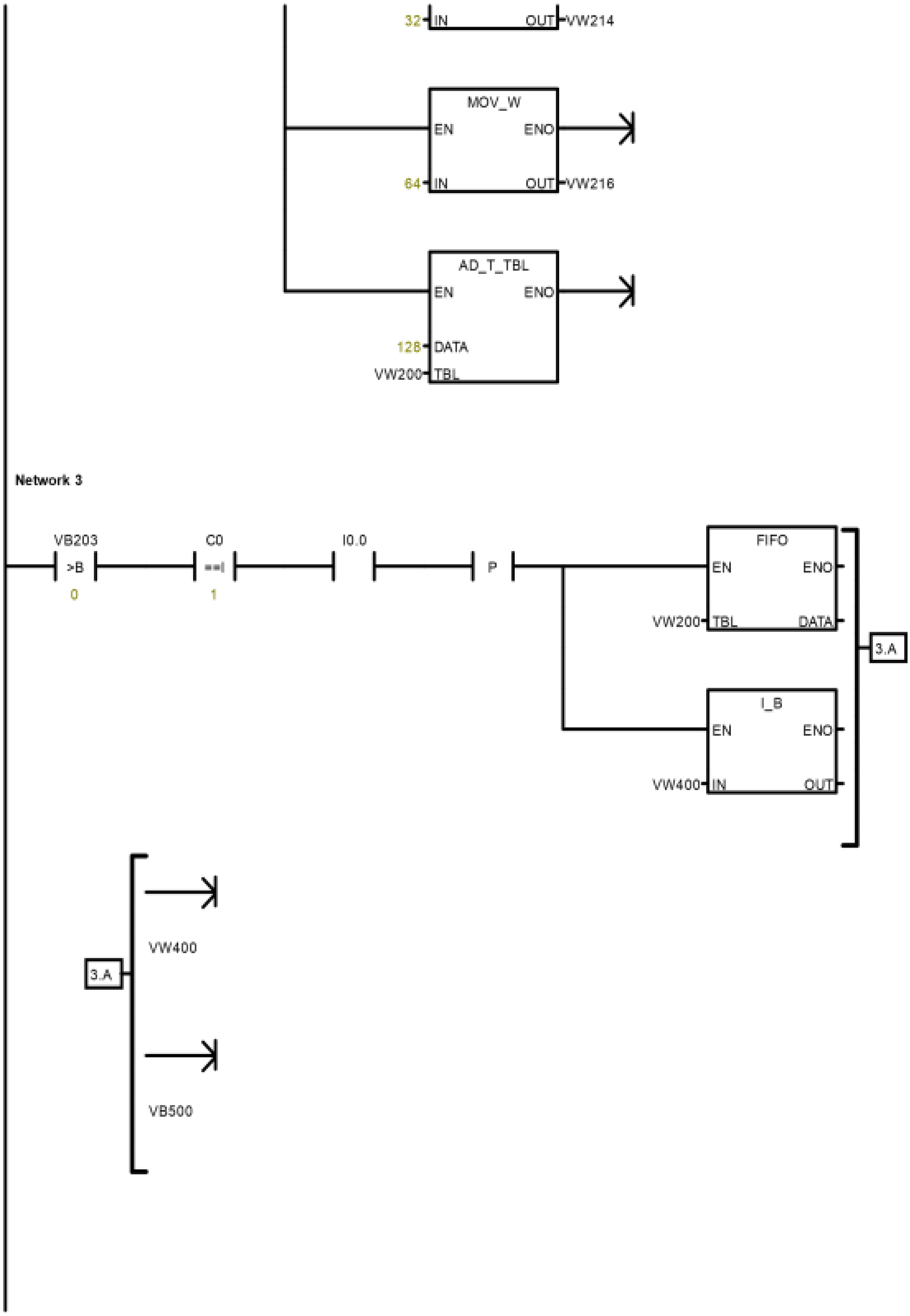
In network 4, MOV_B operation is to convert the integer in VB500 to binary data and send it QB0 after writing the result of PLC output points Q0.7 to Q0.0.

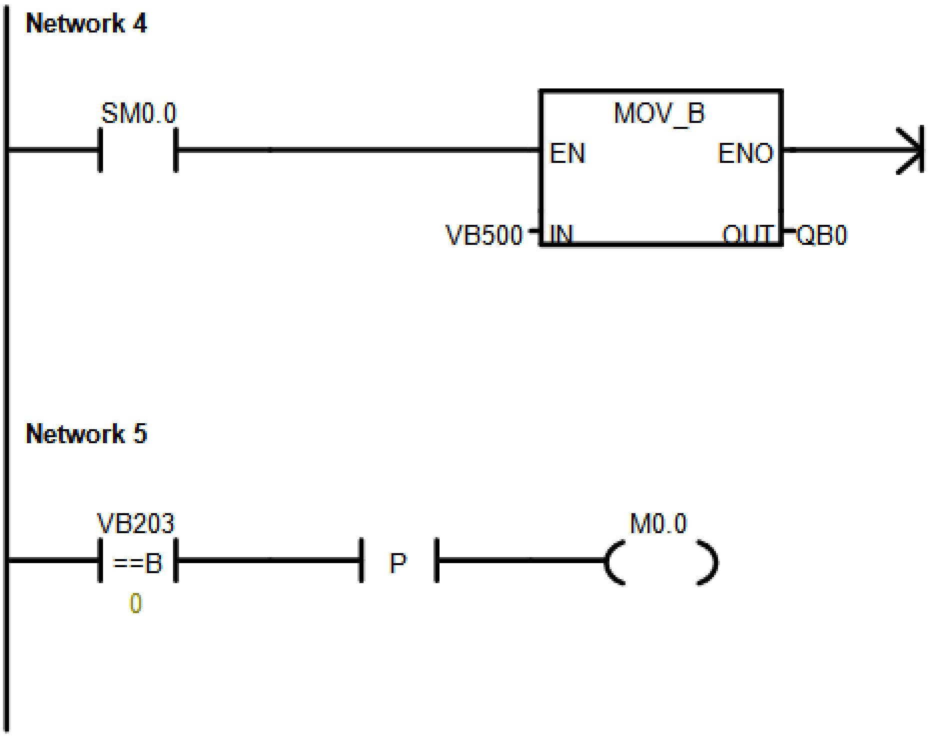
In network 5, when the out count of VB203 is equal to 0 with a positive transition, set M0.0 to recreate the table of network 2. Thus, a table will continue to recreate and the output Q0.7 to Q0.0 will turn on one after another like the way mentioned in TABLE 1.

The LLD diagram of a pre-planned sample of complex electrical switching pattern in the industrial processing unit is illustrated below:


Network 1
SM0.5
SM0.0
C0
>I
5
C0
CU
CTUD
CD
R
0
PV


Network 2
Network Title
Network Comment
SM0.1
M0.0
P
MOV_W
EN
ENO
15
IN
OUT
VW200
7
VW202
1
VW204
2
VW206
4
VW208
8
VW210
16
VW212


32
IN
OUT
VW214
MOV_W
EN
ENO
64
IN
OUT
VW216
AD_T_TBL
EN
ENO
128
DATA
VW200
TBL
Network 3
VB203
>B
0
C0
==I
1
I0.0
P
FIFO
EN
ENO
VW200
TBL
DATA
3.A
I_B
EN
ENO
VW400
IN
OUT
3.A
VW400
VB500



VI. SYSTEM TEST RESULT

We have developed the LLD according to the plan stated in TABLE 1. Now, it should be put to test whether it actually works or not. To run the program, we have S-7 200 simulator program installed on the computer. It is a platform in which any LLD program ofV4.0 STEP 7 MicroWIN SP9 can be tested easily.[9] It has a virtual environment for that purpose. So, we can do laboratory test and can check our result before applying it in actual industrial purpose. The program has multiple CPUs and virtual input switching units. We can check program output from KOP screen and from virtual output units. The virtual output can be obtained from a green light signal indicator of virtual SIEMENS PLC (CPU 224) output unit.In the CPU224, the 8 signal indicators are placed side by side on the top of virtual PLC unit.[9]When a green light is turned on in any of the signal indicators, we can understand that a particular switch has been activated.

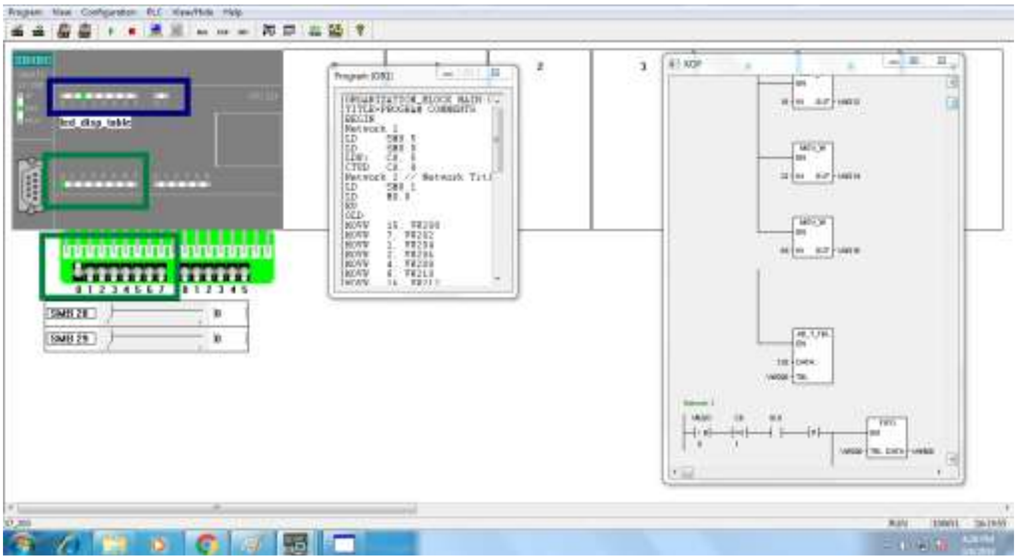


Figure 1: Siemens SIMATICS-7 200 Simulator test result while switching '0' button ON

When the pre-designed complex pattern of electric switching program is loaded, we can obtain KOP output here. KOP showed us the program that is running in the system. As we assigned condition in network 3 that I0.0 should be ON to run the table, we have to turn on first push button (0) in the virtual unit. So, when the push button has been turned ON, we can see the program is running and in Figure 1, we can identify that the green signal indicator reaches on 3rd(2) signal indicator which means Q0.5 is ON or internally 00000100 conversions is running. When the system is running and green light signal indicator reaches to 6th (5) position, we turned OFF the push button (0). It has been shown in Figure 2. So, the signal indicator is not changing its position and remains there as I0.0 is OFF now. In our test, we have checked that all the output Q0.7 to Q0.0 are working according to the TABLE 1 system requirements. Hence, the LLD program and the system are working successfully.

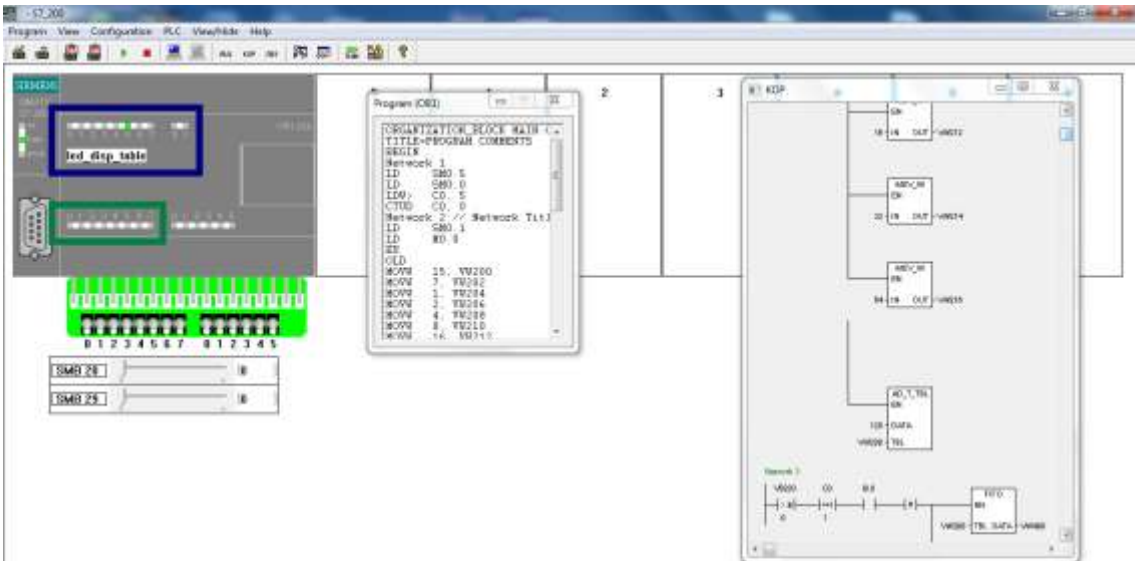


Figure 2: Siemens SIMATICS-7 200 Simulator test result while switching ‘0’ button OFF

VII. DISCUSSION

In this paper, an LLD for a tabular formatted complex pattern of electrical switching for industrial automation has been developed and tested successfully. This system will provide a flexibility in choosing machines in operation without physically changing the machines or machine control switches settings. An operator will be able to run any machines any time in any pattern in an industry. This will eliminate extra-hassle and extra hold up operation time if in case an operator wants to change the control settings of some machines to run a factory automation unit in a different way. In future, we want to implement this system in industrial automation unit and want to gain some data to analyze whether this LLD has any impact on the productivity of a factory.

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