DEVELOPMENT OF A HANDS FREE URINAL FLUSHING SYSTEM

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Abstract

In this paper an automatic urinal flushing system that ensures hands free flushing and conservation of water is proposed. Use is made of a delta DVP-I4SS2 programmable logic controller (PLC), limit switch and a solenoid valve to achieve the hardware design. A limit switch is actuated the moment a user steps on a standing pad placed at the front of the urinal thereby turning on the PLC input. The PLC uses this information to give an output command to actuate a solenoid valve to flush the urinal. Ladder control program was developed for the hardware control using WPLSoft software. Programming and testing of control program with the proposed system suggested that the system can be easily implemented at public places, banks, schools, restaurants and bus stop terminals at an estimated cost of US $ 202.

Key Words: *Flush, PLC, Limit switch, solenoid valve, WPLSoft, DVP-14SS2*

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1. INTRODUCTION

Maintaining a good hygiene and pleasant sight in every washroom is a key priority in every public and commercial establishment. However, there are more times when users of the washroom fail to flush after visiting the washroom resulting in bad odor and unpleasant sights. In other instances users leave the tap opened or not properly closed after using the washroom simply because they feel uncomfortable to touch the unhygienic parts of the urinal [1]. Such actions result in unpleasant environments and waste of water. Moreover, using the same operating knob/handle by all washroom attendants to flush the urinal can cause health problems as communicable diseases can be transferred. Traditionally, urinals were provided with mechanical actuators to flush after using the urinal. Unfortunately, since urinals are usually installed in public places, place of work and places often used by the general public, users pay no obligation to the cleanliness of the premises. Such a mechanical system cannot be guaranteed and soon breaks down and without maintenance; users continue to use it in that condition resulting in strong smell of either spilt or dried urine [2]. The diagram as shown in figure 1 is the result of negligence, non-flushing and lack of maintenance of a typical urinal system. A system such as this is not what society would like to have and hence the need to resolve such a pressing issue.

Fig -1: Traditional Urinal System

Recent developments have taken the urinal flushing system a step further by designing automatic flushing system that flushes at regular time intervals irrespective of actual use or not. This approach eliminates direct contact with the urinal and eliminates the problems presented by the former. However it suffers the setback of water wastage [2]. This problem was addressed by the works of [2]-[5]. In this research, a PLC based automatic urinal system is proposed. The design also incorporates a manual bypass incase of power failure or system's malfunction.

2. MATERIALS AND METHODS

The hardware design proposes a hands-free urinal flushing system using PLC, limit switch and solenoid valve. The layout diagram is given in Figure 2 whiles the block diagram is given in Figure 3.

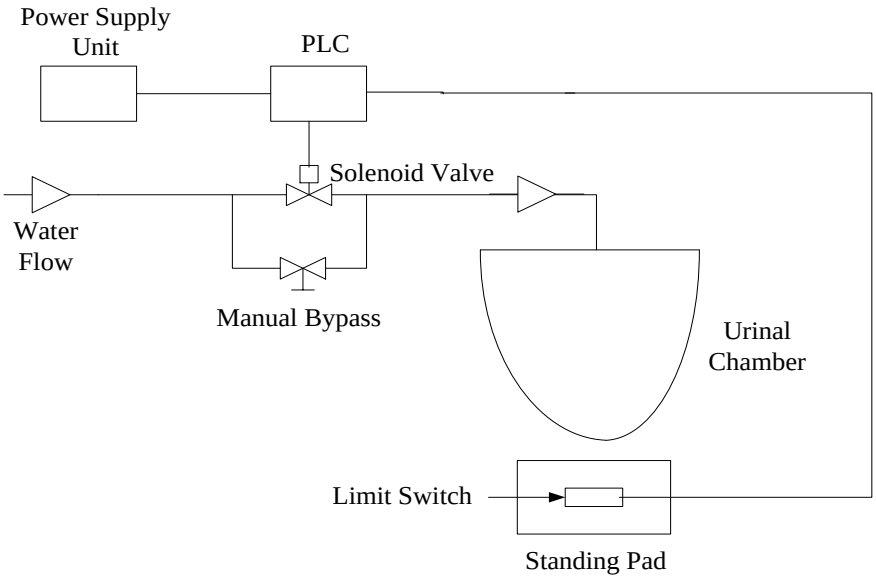

Fig -2: Layout Diagram of Proposed Automatic Urinal Flusher

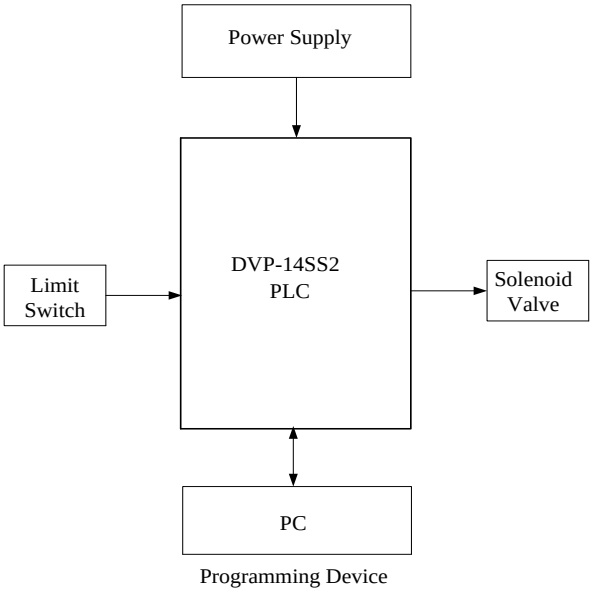

Fig -3: Block Diagram of Proposed Urinal Flusher

2.1 Plc

Delta DVP14SS211R PLC is used in this design to achieve the desired control using a written ladder diagram program. We created the program using WPLSoft programming software. Figure 4 shows the pin layout diagram of the PLC and Table 1 shows the specifications of DVP14SS2 PLC. We selected this type of PLC because it is relatively cheap, small in size, flexible and easy to use.

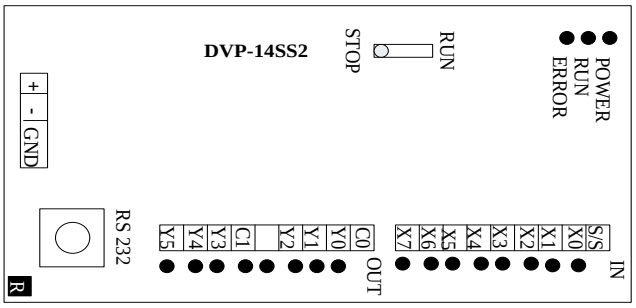

Fig -4: Pin Layout Diagram of DVP-14SS2 PLC

Table -1: Specifications of Delta DVP14SS211R

Description	Specification
Model	DVP14SS2R
Number of I/O	14 (discrete, I=8, O= 6)
Input signal	24 VDC
Output type	Relay and Transistor
Power supply	24 VDC

2.2 Power Supply Unit (PSU)

The main power supply line to the controller is 24 VDC. This power supply line is distributed to the central processing unit (CPU), the input module through the input devices and the output module thought the output devices. The 24 VDC supply is a converted power from a 230 VAC source as shown in figure 5.

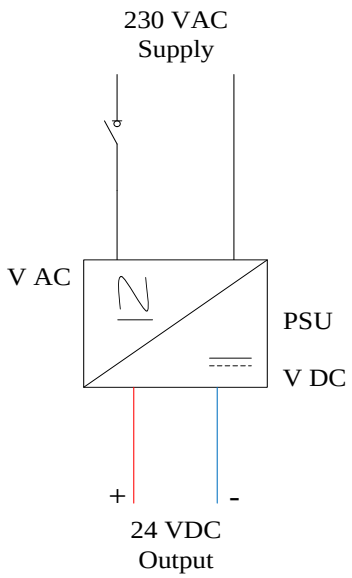

Fig -5: Power Supply Unit

2.3 Solenoid Valve

We selected a 24 VDC, ½' BSPP, 2-way normally closed plastic solenoid valve for automatically opening and closing the pipe line to control the flushing of the urinal. The chosen valve is less expensive and the body is made of plastic so the issue of corrosion is eliminated. Figure 6 shows the diagram of the proposed solenoid valve [6].

Fig -6: Diagram of a Solenoid Valve

2.4 Limit Switch

We used a limit switch in this design to detect a urinal attendant when he/she steps on the standing pad to urinate. Omron, D4A-0E00, 6A, 24VDC, XLNT, limit switch [7] was selected for this purpose.

2.5 Programming Device

This is a personal computer or handheld device with appropriate installed programming software that is used to create, edit, monitor, download or upload a control program into or from the PLC. Dell latitude E5430, core i5 laptop with windows 8.1 operating system is used as a programming device in this paper. We downloaded and installed WPLSoft software on the windows operating system for the PLC programming. We also interfaced the PLC with the laptop using an RS-232 communication cable.

2.6 Schematic Circuit Diagram of Proposed Design

The entire circuit diagram of the proposed automatic urinal system is as given in figure 7.

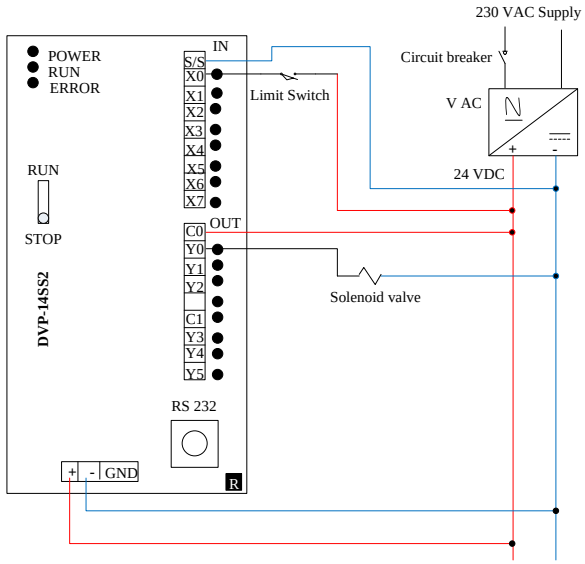

Fig -7: Control Circuit Diagram of Proposed Design

3. RESULTS AND DISCUSSIONS

A ladder logic control program was developed to control the automatic flushing of the urinal system using WPLSoft software. The ladder logic control program was developed based on the following control scenarios [8]:

1. If a user stands in front of the urinal for more than 4 s, the flushing control device will flush the urinal for 4 s (the first flushing). When the user leaves the urinal, flush for another 5 s then stop automatically (the second flushing). This is illustrated by the timing diagram of figure 8.

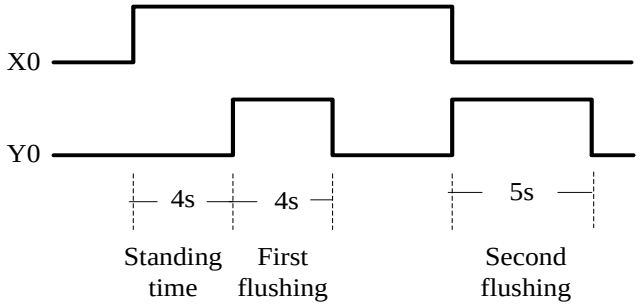

Fig -8: Timing Diagram of First Scenario

2. Stopping the first flushing and starting the second flushing if the first user leaves the urinal during the first flushing process. This is shown by figure 9.

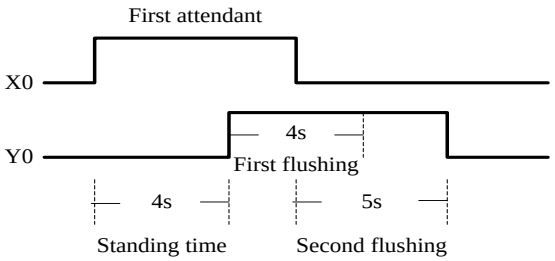

Fig -9: Timing Diagram of Second Scenario

3. If the second user comes before the finishing of the 5 s flushing, the flusher will finish the 5 s flushing process and skip the first 4 s flushing process. When the second user leaves the urinal, the flusher will perform another 5 s flushing as shown in figure 10.

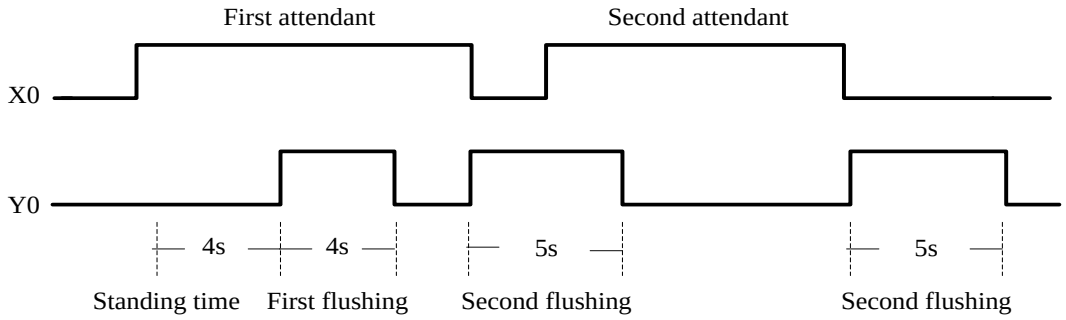

Fig -10: Timing Diagram of Third Scenario

Figure 11 gives the ladder logic control program of the complete system. The control program was successfully compiled and downloaded to the PLC memory via the RS-232 communication cable. The program device list is as shown in table 2.

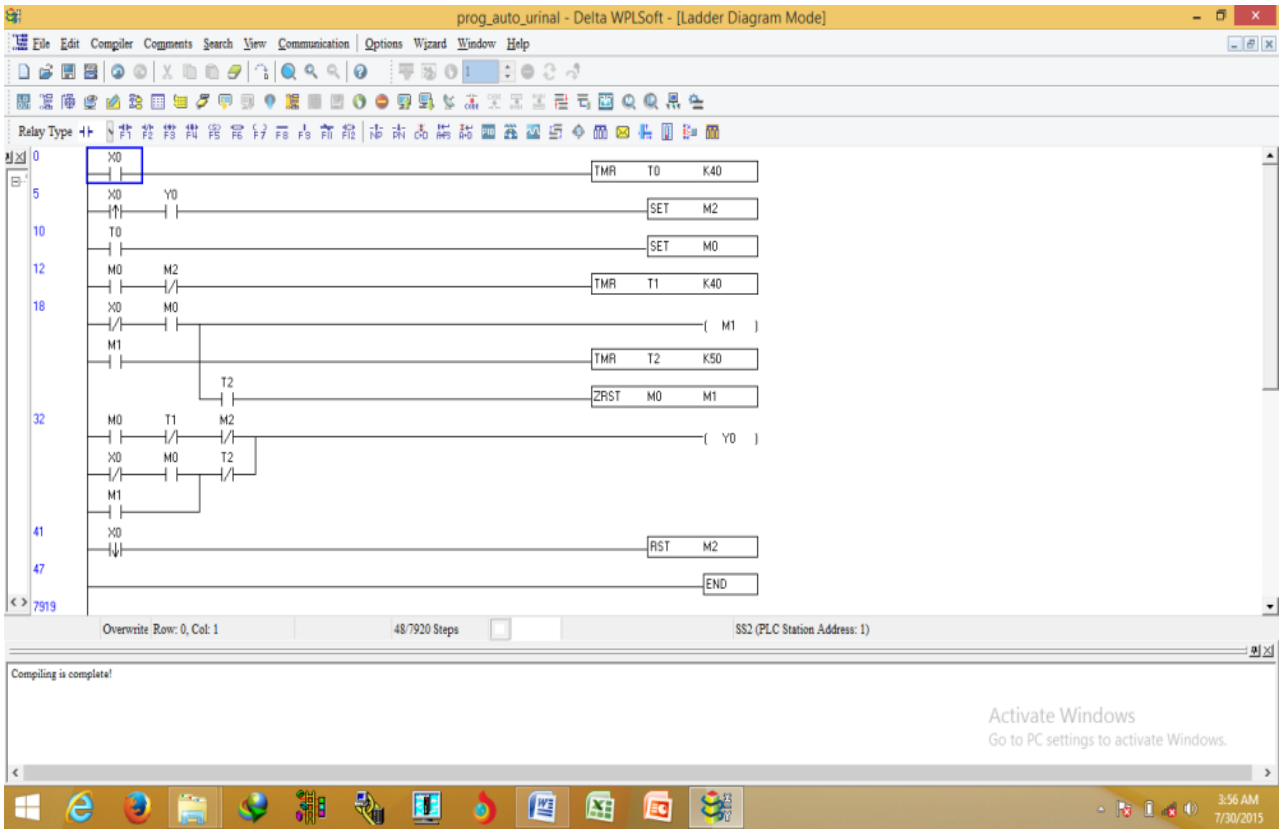

Fig -11: Ladder Logic Control Program of Proposed Urinal System

Table -2: Device List of Control Program

Device	Function
X0	Limit switch
M0-M2	Internal relay
T0	4 s timer. Time base: 100 ms
T1	4 s timer. Time base: 100 ms
T2	5 s timer. Time base: 100 ms
Y0	Solenoid valve for flushing

As a way of testing the control program, we connected a toggle switch in place of a limit switch and a pilot lamp in place of a solenoid valve. Figure 12 gives a screen shot of the ladder logic program when the toggle switch was OFF whiles figure 13 shows the ON condition. Figure 14 and 15 give the corresponding hardware displays. We observed that, manually operating the toggle switch according to the control scenarios causes the pilot lamp to behave accordingly.

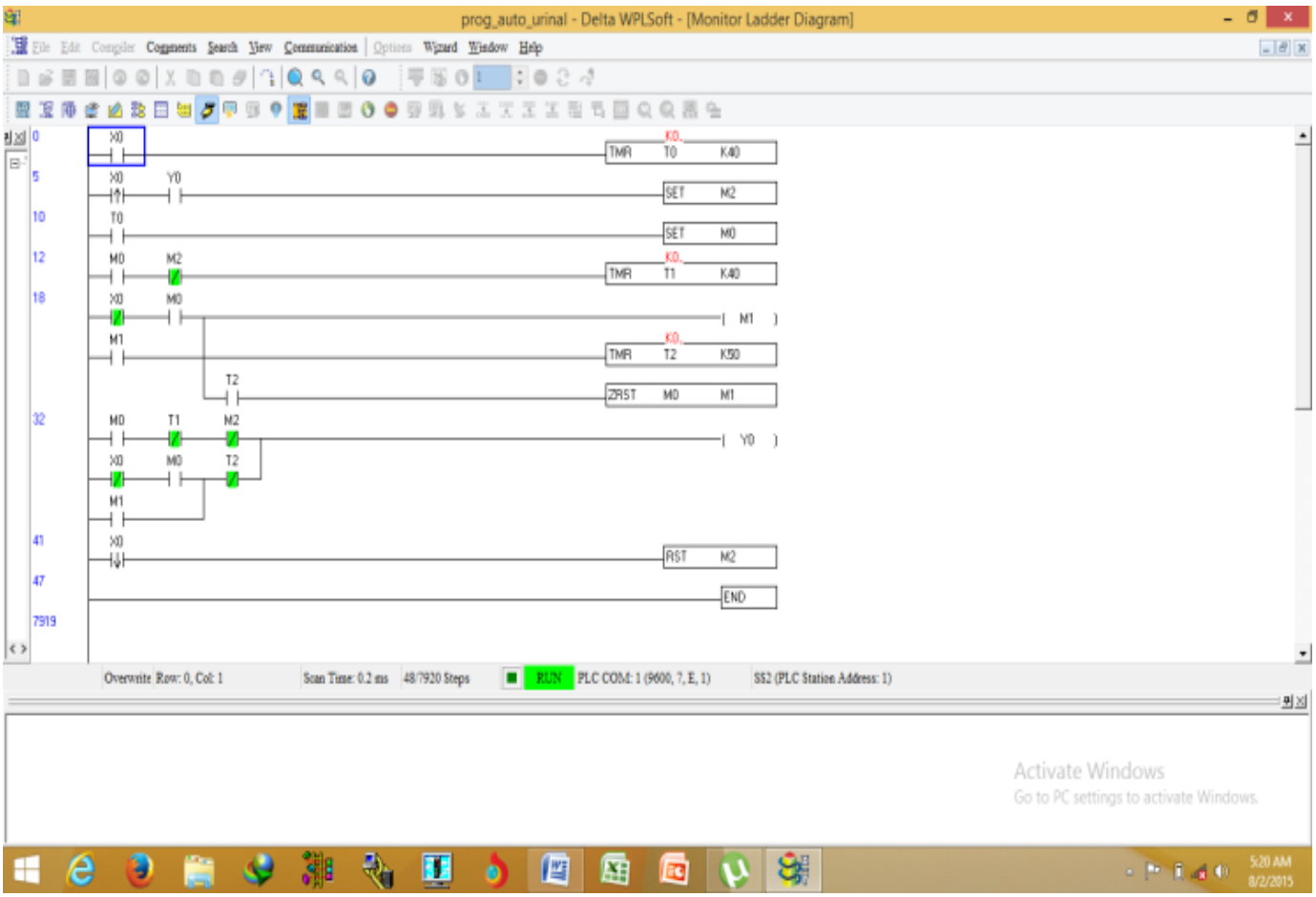

Fig -12: Program when Toggle Switch was OFF

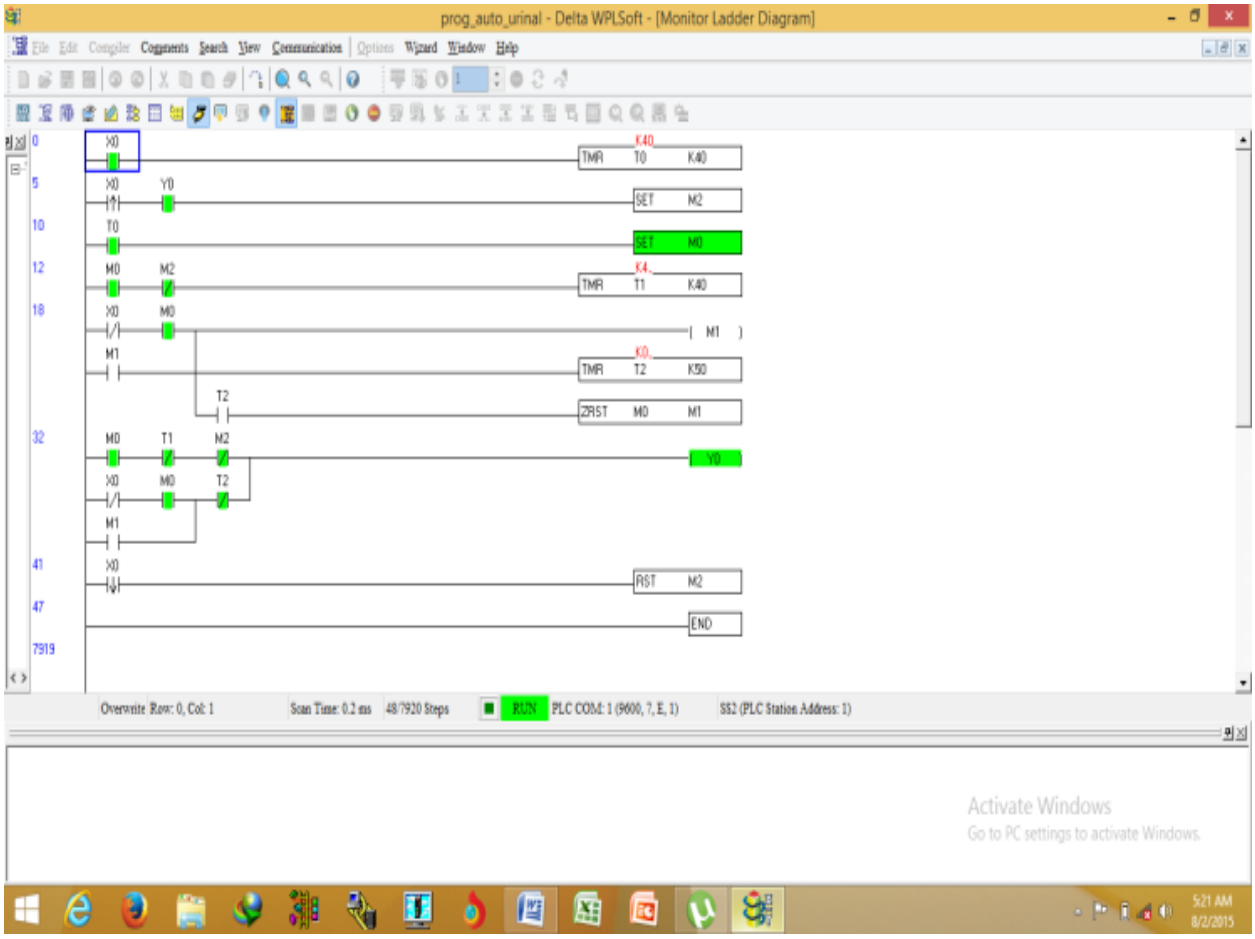

Fig -13: Program When Toggle Switch Was Turned ON

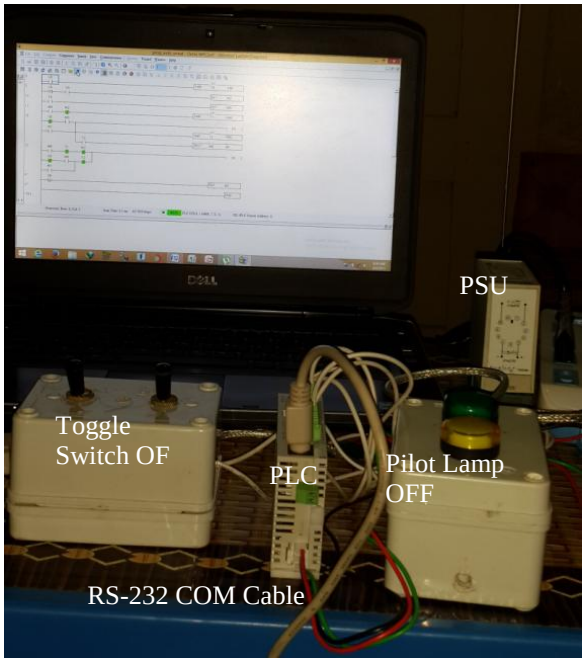

Fig -14: Corresponding Hardware Display when Toggle Switch was OFF

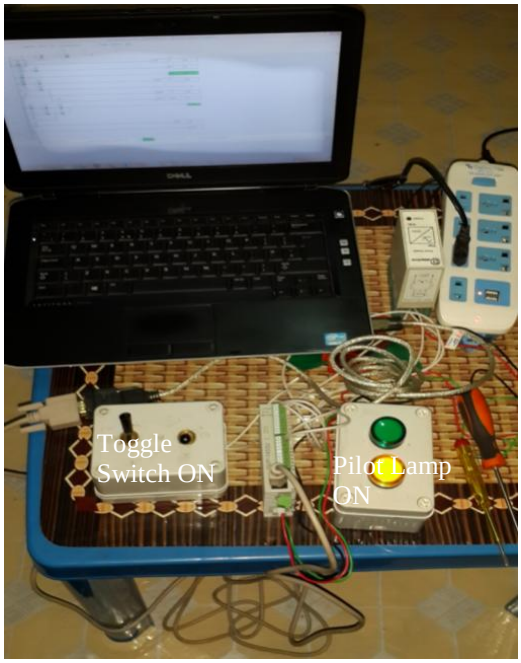

Fig -15: Corresponding Hardware Display when Toggle Switch was Turned ON after 4 s

3.1 Cost Analysis

Our cost analysis showed that the entire project implementation cost US $ 202.Table 3 gives the detailed cost analysis of the design.

Table -3: Cost Analysis

Item	Description	Quantity	Unit	Rate	Cost US $
PLC	Delta DVP14SS211R PLC	1	Pieces	100	100
PSU	Delta DVPPS01/DVPPS02 power supply unit	1	Pieces	50	50
Programming Cable	Delta DVPACAB2A30 programming cable	1	Pieces	25	25
Solenoid Valve	24 VDC, ½' BSPP, 2-way normally closed plastic solenoid valve	1	Pieces	9	9
Limit Switch	Omron, D4A-0E00, 6A, 24VDC, XLNT, limit switch	1	Pieces	18	18
TOTAL					**202**

4. CONCLUSIONS

A hands-free urinal flushing system has been successfully developed using PLC, limit switch and a solenoid valve. A ladder control program was developed, compiled and downloaded to the PLC to control the automatic urinal flusher. The control program was successfully tested with the hardware design using a toggle switch and a pilot lamp which represented the limit switch and solenoid valve respectfully. Public places, banks, schools, restaurants and bus stop terminals can give a consideration to this design as a means of conserving water and keeping the urinals in a good hygienic condition. The overall project cost was approximated to US $ 202.

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