Design & Development of a Microcontroller Based Model of an Automated Bottle Filling System for Student Demonstration in Lab

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Abstract: The aim is to design, develop and implement a time controlled automated bottle filling system. The system is made highly versatile and has been developed around an eight bit microcontroller platform. The automatic liquid filling machine is developed to be lower in price as compare to the other filling machines in the market. The machine is also easy to operate and user friendly, where simple steps are needed to operate the machine. The machine controller is also portable and can be attached with conveyor system or can be left standalone.

Keywords: Microcontroller, Bottle filling system, Solenoid valves, Liquid level measurement

Introduction

The field of automation had a notable impact in a wide range of industries beyond manufacturing. One of the important applications of automation is in the soft drink and other beverage industries, where a particular liquid has to be filled continuously. Our Project aim is to be making a filling machine having different volume of bottle. The filling operation is controlled using microcontroller. The microcontroller is cost effective, space efficient and reduces complexity. By programming we control the entire system.

Problem Formulation

In order to implement the automated bottle filling system, a versatile control panel has been designed and developed. The previous discussion of this study involves the need for the study and review of literature involving similar control systems. After going through previous research papers a tentative design is prepared. The basic block diagram and working of the entire setup both are explained in the subsections below along with the detailed list of components and their specifications. After designing the block diagram and deciding the features of the control system, hardware required for implementing the setup was studied. The components, circuits and other miscellaneous hardware was enlisted, bought and fabricated. For testing, the control panel was interfaced with the solenoids through relays and then was tested. These relays were switched in a sequence for different time periods. The ON-time period for individual relays can be set by using an array of tactile switches interfaced with the microcontroller. The status of the relays was displayed on LED indicators and ON-time period was displayed on a alphanumeric LCD screen. Also the multiplexed liquid level measurement technique was tested for different liquid levels in all the tanks available. The liquid level in all the three tanks was measured by deploying an ultrasonic sensor in each tank individually. The output we got was on a multicolor LED array.

Implemented Work

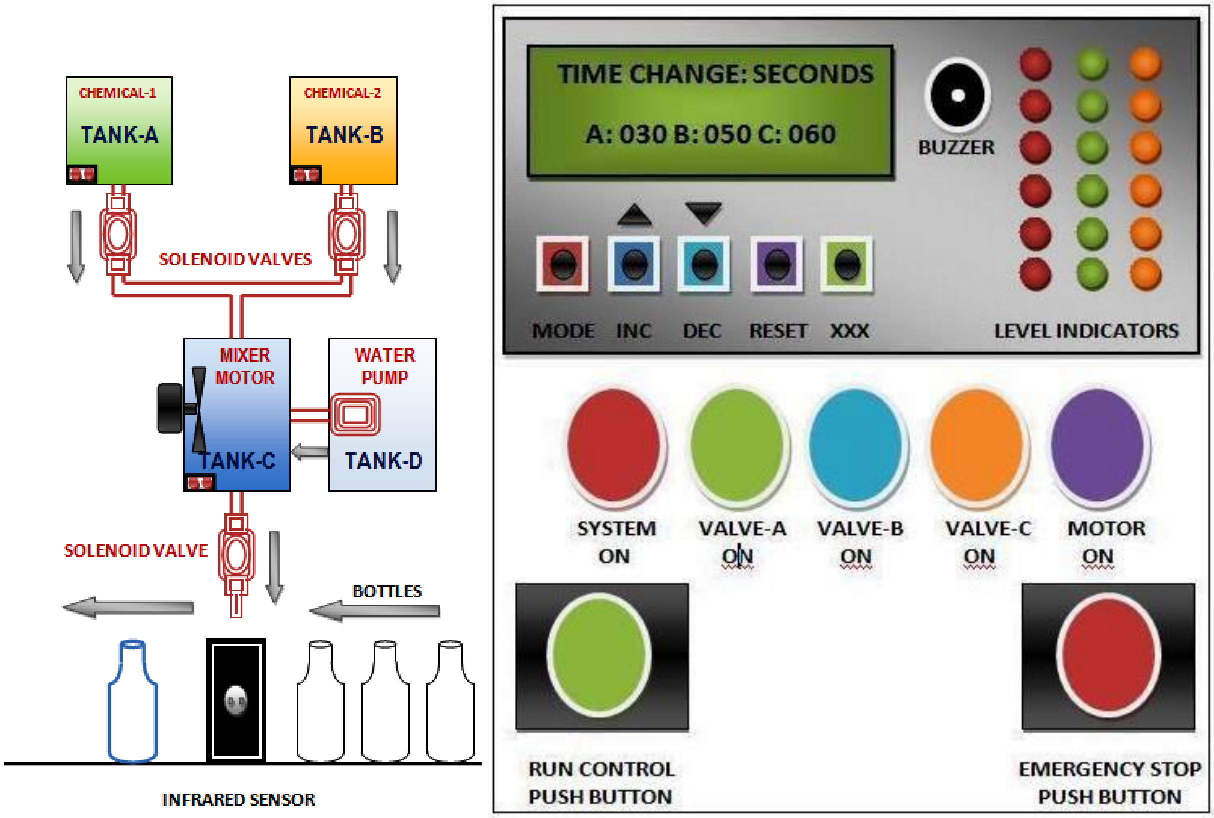

Figure-1: Implemented Model and Design of its Control Panel

The above shown figures provides an outlook of how the overall system looks like and what will be the flow of process during its operation. Also the control panel design is shown that will be available to the user for the overall control of the system. The above figures can be considered as the block diagram and the function of individual block and component is described below.

Relays: Relays are the components which allow a low-power circuit to switch a relatively high current on and off, or to control signals that must be electrically isolated from the controlling circuit itself. To make a relay operate, we have to pass a suitable pull-in and holding current (DC) through its energizing coils. Generally relay coils are designed to operate from a particular supply voltage often 12V or 5V, in the case of many of the small relays used for electronics work.

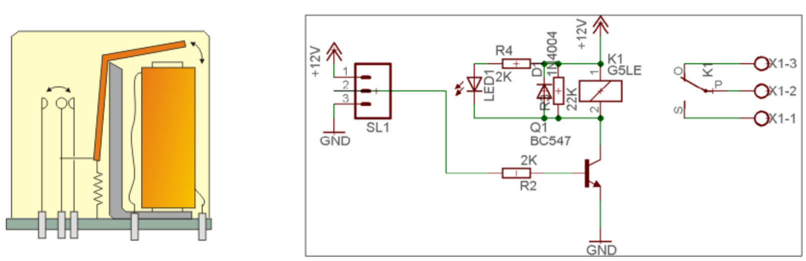

Figure-2: Relay Structure & Interfacing Circuit

Solenoid Valves: A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. A 2-way valve, for example, has 2 ports; if the valve is open, then the two ports are connected and fluid may flow between the ports; if the valve is closed, then ports are isolated. If the valve is open when the solenoid is not energized, then the valve is termed normally open (N.O.). Similarly, if the valve is closed when the solenoid is not energized, then the valve is termed normally closed.

Regulated DC Power Supply: Here a 5V regulated DC power supply is used. The circuit uses a cheap integrated three-terminal positive regulator LM7805, and provides high-quality voltage stability and quite enough current upto 1A to enable the microcontroller and peripheral electronics to operate normally.

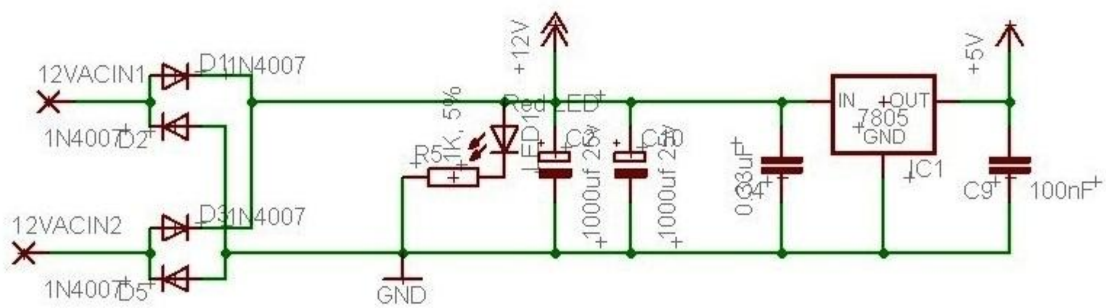

Figure-3 Regulated DC Power Supply Circuit

LCD & Keypad: A 16x2 line LCD is interfaced to the microcontroller in 8-bit mode. It can display 16 alphanumeric characters (each of 5x7 dot) in each of the two lines. It has three control pins, eight data pins, contrast control pin and LCD backlight control pins. For driving LCD with the microcontroller, in the firmware, the first step is to initialize the LCD using Command Register and then data to be displayed in the form of ASCII code is given to the LCD by using Data Register. Here a set of four keys were interfaced to the microcontroller to select the specific mode and increment or decrement the timer values. The keys are basically tactile switches connected to I/O port pins and microcontroller recognizes the key press when a logic low is detected at a particular pin. As these are mechanical switches so when a switch is actuated, the contacts often bounces for some time before settling down to a stable state. It happens when a key is pressed as well as when a key is released. So, to debounce the switch through software a debounce time of 20milliseconds is generally provided into the logic to ensure a real key press.

Methodology Adopted

The methodology adopted to control the system is by using an embedded system to control the overall process. The microcontroller based system possesses low cost, low power, light weight, portable and highly configurable as compared to the PLC based systems. The system is made user friendly. The algorithms were designed and firmwares were tested for individual modules interfaced to the microcontroller. The microcontroller used here is a high performance 8-bit widely used 8051 core microcontroller i.e. AT89S52. The microcontroller has some distinct features like four input/output ports with a total 32 pins, the port pins are multiplexed and are multifunctional. It has two 16-bit timers/counters, one serial port and six interrupt source. It is having 128bytes of RAM and 4Kbytes of inbuilt ROM and upto 60Kbytes expandable. It operates on 5volt DC supply.

Algorithm

The step-by-step approach to configure individual timer values using an array of tactile switches is shown below. There are a total of four tactile switches available on board to control the timers operation in this system. These four keys play the purpose of (i) Entering into Value Change Mode (ii) Increment Value (iii) Decrement Value (iv) Exiting from Value Change Mode.

1. First of all Clear Register R1 i.e. R1=0
2. Then Initialize External Interrupt INT0
3. When 1st Key Press detected as an interrupt, the program counter branch to its ISR.
4. In the ISR, wait for another 3-second and check whether the key is still pressed or not. This is done to avoid false triggering.
5. If the key is still pressed then program counter will enter into an infinite loop where user can Increment or Decrement the available timer values before Exiting.
6. To select a particular Timer for changing its values and to exit this infinite loop a dedicated key is provided that increments the R1 value for each press. This R1 value is compared to a preset reference value to select a particular Timer or to Exit the loop. For eg.: for R1=0 user can change only Timer-1 values and for R1=4 user can Exit the loop.
7. The system scans a continuous loop for increment key, then decrement key, then Exit key.

Experimental Results

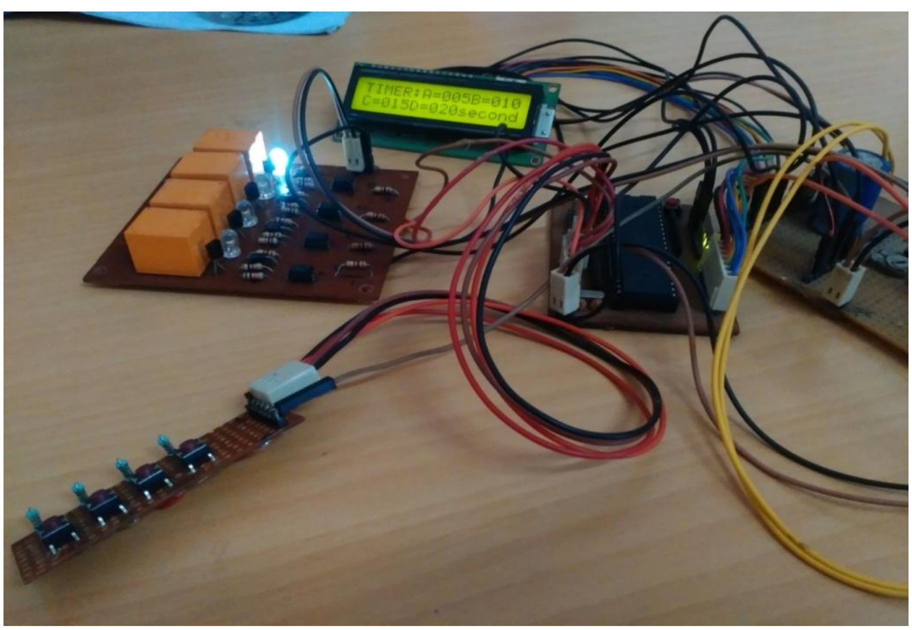

Figure-4: Experimental Set-up of Microcontroller Based Control Panel

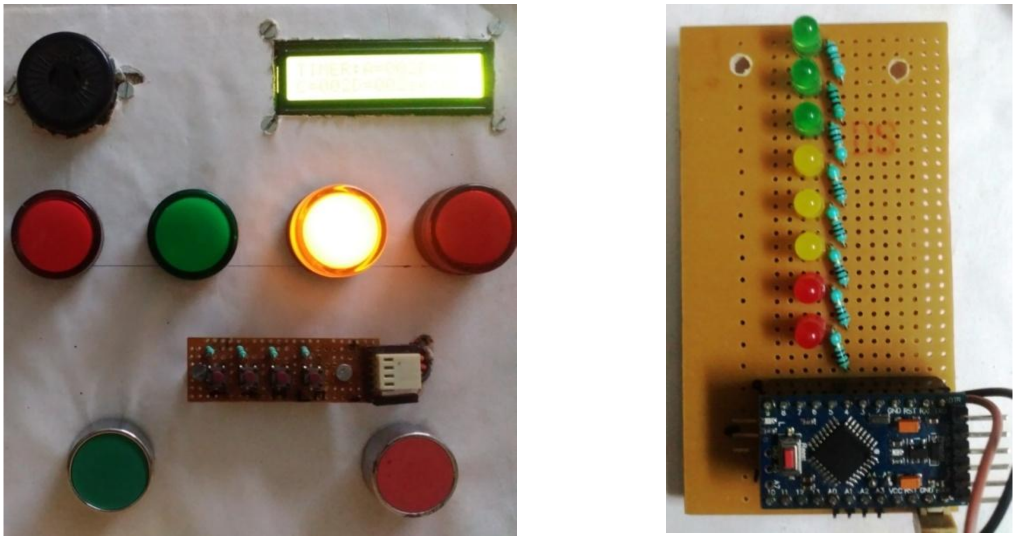

Figure-5: Outlook of Developed Control Panel and Liquid Level Indicator

Conclusion & Future Scope

The system can perform the task of autonomous quality control system used in industrial production and it is most suitable for student demonstration in laboratory for education purpose as definite process is set by programming. The developed system is found to be the cheap and best method to enhance knowledge of students and make them aware of what all factors need to be considered while designing a project based on automation. Further optimizations are possible in this system by the integration of more sophisticated techniques to make it more flexible and versatile with reduced cost.

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