

# Software Design and Development of Beverage Vending Machine System Using ARM Architecture with LPC2148

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## ABSTRACT

Beverage vending machine systems are becoming popular in the Indian market. These systems are today available in Indian MNCs and some top rated restaurants and hotels. In most systems the operation are carried manually by the operator in which the billing and change making is carried out by the owner who running the shop or restaurant. In India tea and coffee habits were cultured by the colonial rule of the British and the Portuguese, even today the colonial rule had been over but the habits of tea and coffee beverage consumptions becomes as the routine daily life. Hence there is a need to understand beverage vending machine systems to serve the Indian Market. In this paper, a critical analysis of requirement has been carried out and the system design had been arrived at. The system requirement demand an ARM based controller for better system performance. To meet the system performance criteria and richest of peripherals an LPC2148 with low cost had been selected. The system is more efficient to analyse the change making and the identification had been carried out using the motors, LCDs, water heater, solenoid valve, money box, change making and dispensing unit. The system is tested and validated for the specified test cases. The milk motor run for 10 rotations to drive 200 milligrams of milk powder to the container to make to tea or coffee beverage. In this system a stepper motor had been used can be replaced by using dc motors to avoid power losses. In future an ATM or credit card based payment system can be incorporated to these systems.

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## 1. INTRODUCTION

A beverage vending machine is a system which dispenses beverages such as tea, coffee, milk and black tea. In India most of such systems are available in multi-national companies, and restaurants. These machines don't have the money collection or the changing making unit within the system. In such cases, the billing is done by the business owner or by the concerned person associated with it. In this paper, an attempt has been made to introduce the cash dispensing and change making unit using an advanced processor like ARM.

## 2. REQUIREMENTS ANALYSIS

Economic growth, development of cities changed lifestyle and eating & drinking habits leading to a huge market for vending machines. Some of the requirements of beverage vending machine systems are as follows. The beverage vending machine has to serve the beverages requirement for the families and the

society when they need it. The business opportunities for such system are in huge demands in places like schools, colleges, universities, cinema halls, public gardens and various other public places. The systems need to be self-operable and should be user friendly and customer supported, so that the user/customers can avail full benefit of such systems. This system provides an appropriate and attractive system display unit to attract the customer for the beverages need. It supports a selection of buttons to select coffee, milk, tea, and black tea with an attractive well-designed panel. When the customer interacts with the system, the customer makes a choice of their beverages. The customer also inserts the required money, so a money acceptor unit is attached to the vending machine. A change making unit will make the necessary change making when required by the customer. The system designer has to carefully select the advanced quality buttons and display units considering all the safety nomenclatures. With this the exterior functional requirement should satisfy the customer need and satisfactions. These systems need to be uploaded with the necessary resources such as tea, coffee, milk sugar whenever required.

### 2.1. Technical Specification

Need a robust processor such as ARM with a rich set of peripherals that are low cost. ARM7TDMI is a better controller available with LPC2148 controller with its rich set of peripherals. A set of motors are required for loading different material for the beverage making. Stepper motor leads to the reliability and low cost source of motors. Stepper motor consists of a permanent magnet rotating shaft called the rotor and the electromagnets which are surrounded to the shaft are called the stator. The electromagnets are energized by an external control circuit, such as ARM controller. To make the motor shaft turn, first, one electromagnet is given power. In this design, a high torque stepper motor which drives more power is used.

Extreme variations in temperature (too cold, too hot) can spoil the drinks and damage the motors. Hence, a temperature controller is required to monitor the temperature of the system components and the motors. The solenoid valves are mainly used in tea / coffee vending machines systems. These liquid dispensing valves are reliable and dependable low pressure valves designed to dispense water or similar liquid from tank. It has a built-in flow controller for precise control. It is designed & developed to meet harsh tropical demands. The solenoid valve mainly finds application in coffee vending machines. It has two coils for double control and has a controlled forward flow as well as a reverse leakage control. Solenoid Valve is used to control the flow of hot water for the preparation of coffee, tea, milk and black tea. A solenoid valve is an electromechanical valve for use with liquid. The valve is controlled by an electric current through a solenoid; in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Water heating Coil converts electrical energy into heat energy. Beverage vending machine systems uses water heating coil to get hot water which is required for the preparation of hot beverages.

A vending machine consists of a money box comprising of currency detector and currency dispenser. It accepts payment and dispenses the change to the customer. The process involves examining the currency that has been inserted, and by using various tests, determine if the currency is counterfeit. In operation, if the item is accepted, it is retained by the machine and placed in a storage device. If the item is rejected, the machine returns the item. Later based on customer's selection of beverage, the operation is preceded. For the system a weatherproof LCD screen that is installed at the front face of the machine as a user interface is used. The screen provides an interactive user interface for user to select a desired product whether tea, black tea, coffee, or cold coffee.

The LCD screen alternately will display preloaded advertisement images one at a time when there is no interface with the user. The video will be cleared when a user wishes to buy something from the machine by simply pressing the right switch. For every electronic device there is a need for power supply to conduct its operation. It is equipped with a battery that able to stores energy which sufficient enough for the machine to and an electric supply backup.

A vending machine reads currency based on the physical characteristics of individual pieces of currency such as the diameter, thickness and ridges of the edge. A Vending Machine scans paper money by automated denomination recognition. The primary method vending machines use to recognize the denomination of paper money is through a magnetic scan, paper currency is printed with magnetic ink, similar to the ink on the MICR line of a check, that makes it easily identifiable to machines with magnetic scanners whether it is a original currency or not. In addition, each denomination is marked with different fluorescent properties. Many vending machines and other machines that read paper currency use an ultraviolet light to scan the bill and give the appropriate credit i.e. what amount of currency is being fed.

The currency dispensing mechanism as an electric eye that counts the each bill as it exits the dispenser, in money stack in which there will be separate slots for different amount, so that it will be help full while dispensing money, currency paper note dispenser unit will be having a roller and a hopper by using this

note is pulled out of the stack upon receiving signal from host processor, similarly different sized coins are placed in different slots it dispense the exact amount upon receiving the signal from the host processor.

Safety features are needed for the protection of this machine which will be operated smoothly. Some of the safety features:

- Insulation System: To keep all cables and devices well insulated as to maintain its longevity and effectiveness.  
To prevent the devices from short-circuit.
- Relay: to protect from any excessive current
- Circuit Breakers: To protect an electrical circuit from damage caused by overload or short circuit.

### 3. DESIGN AND DEVELOPMENT

When the cash is inserted into the currency acceptor, the magnetic scan scans the cash to detect whether it is an original or fake currency. Then the ultra violet scans the cash to know the value of the cash. Once the value of the cash is known it returns the remaining amount if the cash inserted is more than that of the value of the respective beverages. Coins are detected based on the diameter and the thickness. The block diagram of the beverage vending machine system is shown in Figure 1.

#### 3.1. Sequence of Operation to Make Beverage

- Initially the LCD display will be displaying some advertisements like” WELCOME TO BEVERAGE VENDING MACHINE SYSTEM”.
- It gets cleared when the user press the switch to get the beverage. Below the LCD display there will be switches for tea, sugarless tea, coffee, cold coffee. This is shown in figure 2.
- After pressing the right key it will display the cost for respective beverages. It is shown below  
TEA→10/-  
BLACK TEA→10/-  
COFFEE→10/-
- The system asks to enter the amount. Then the amount is inserted into the coin acceptor/detector. Then it detects the amount entered is valid or not. Also it scans paper money by automated denomination recognition. If it’s not a valid amount then it is returned back.
- Once it detects the valid amount, corresponding motor will run and does appropriate mixing to get the required beverages.

#### 3.2. Mixing Ratio to Make the Beverage

- To prepare coffee, 200 milligrams of milk powder, 100 milligrams of coffee powder, hot water is required.
- To prepare tea, 200 milligrams of milk powder, 120 milligrams of tea powder, hot water is required.
- To prepare black tea, 160 milligrams of tea powder and hot water is required. Here milk powder is not required.

#### 3.3. Time Rrequired to Deliver the Beverage

- In case of coffee, the motor will drop 20 milligrams of powder into a container for every rotation. Hence the milk motor will rotate for 10 times to drop 200mg of milk powder. Coffee motor will rotate for 5 times to drop 100mg of coffee powder. Then hot water supply is given to the container and mixed, then supplied to the cup.
- In case of tea, the milk motor will rotate for 10 times to drop 200mg of milk powder. Tea motor will rotate for 6 times to drop 120mg of tea powder.
- In case of black tea, tea motor will rotate for 8 times to drop 160mg of tea powder. And mixed with the hot water. Here milk is not required.
- The time required is calculated based on the rotation of the motor.

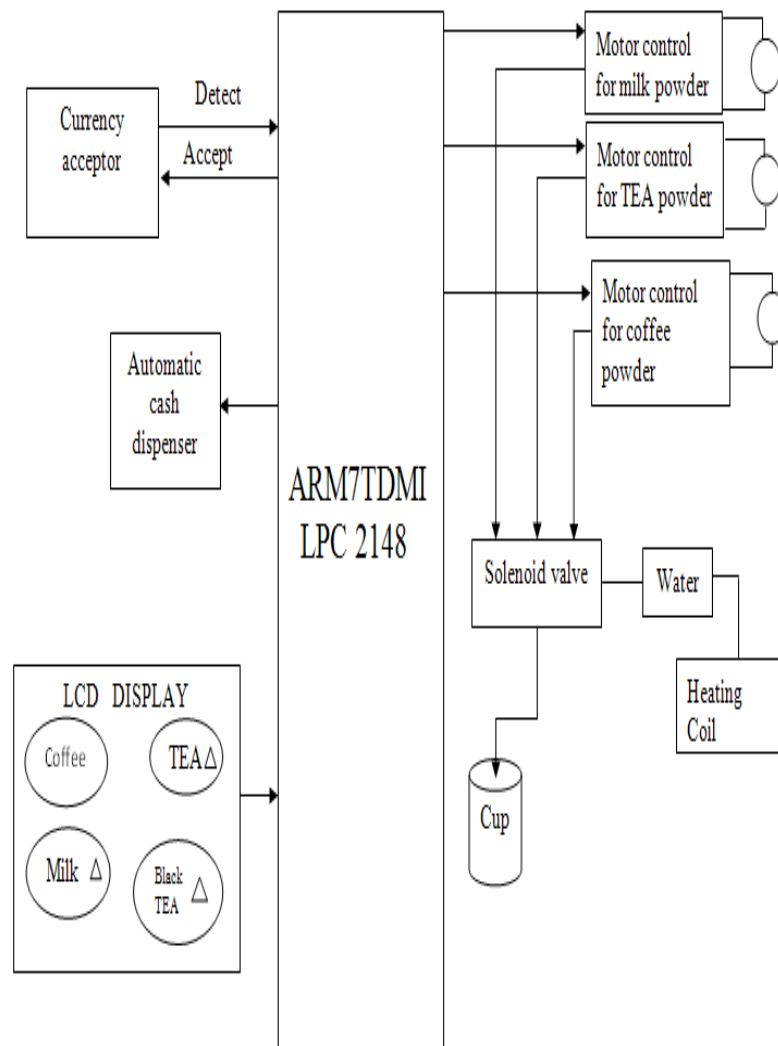


Figure 1. Block Diagram of the Beverage Vending Machine System

As shown in Figure 3 the system is primarily driven by current GPS locations of fishing vessel hence on the input side GPS receiver module is interfaced. The data from GPS receiver is received in standard NMEA format in the form of packet digital data. An input keypad module is used to facilitate the entering of passcode for authentication of operator. The output peripherals will consist of a display unit to display various message notifications to operator in runtime conditions. The EEPROM memory is used to support storage of GPS data along with time stamps in case of distress signalling emulating black box support. The actuators for fuel injection cut-off during boundary crossover conditions and a buzzer for warning beeps while nearing international maritime boundary is also provided. The GSM modem is also interfaced for supporting delivery of distress message to base station or coast guard. The processing logic for the system is split up across two computing platforms of similar specifications. The reasons for using two platforms include the lack of adequate amount of GPIO pins for interfacing certain peripherals and the need for multiple UART protocol compatible transmitter and receiver pins.

### 3.4. Implementation

Beverage vending machine system implementation using ARM processor is carried out. It includes software programming and hardware components like motors, LCDs, heater, temperature sensors, cash dispenser module, change maker, rollers and belts. Implementation on ARM based processor along with its peripherals is done by developing the C code. Different circuits used for this implementation had been modeled and analysed. Most of the operational models are dynamic, discrete-change and stochastic, which

invariably need a computing facility to see the result within a given time. The system had been simulated using the Kiel tool and the LPC2148 ARM board as shown in Figure 3.

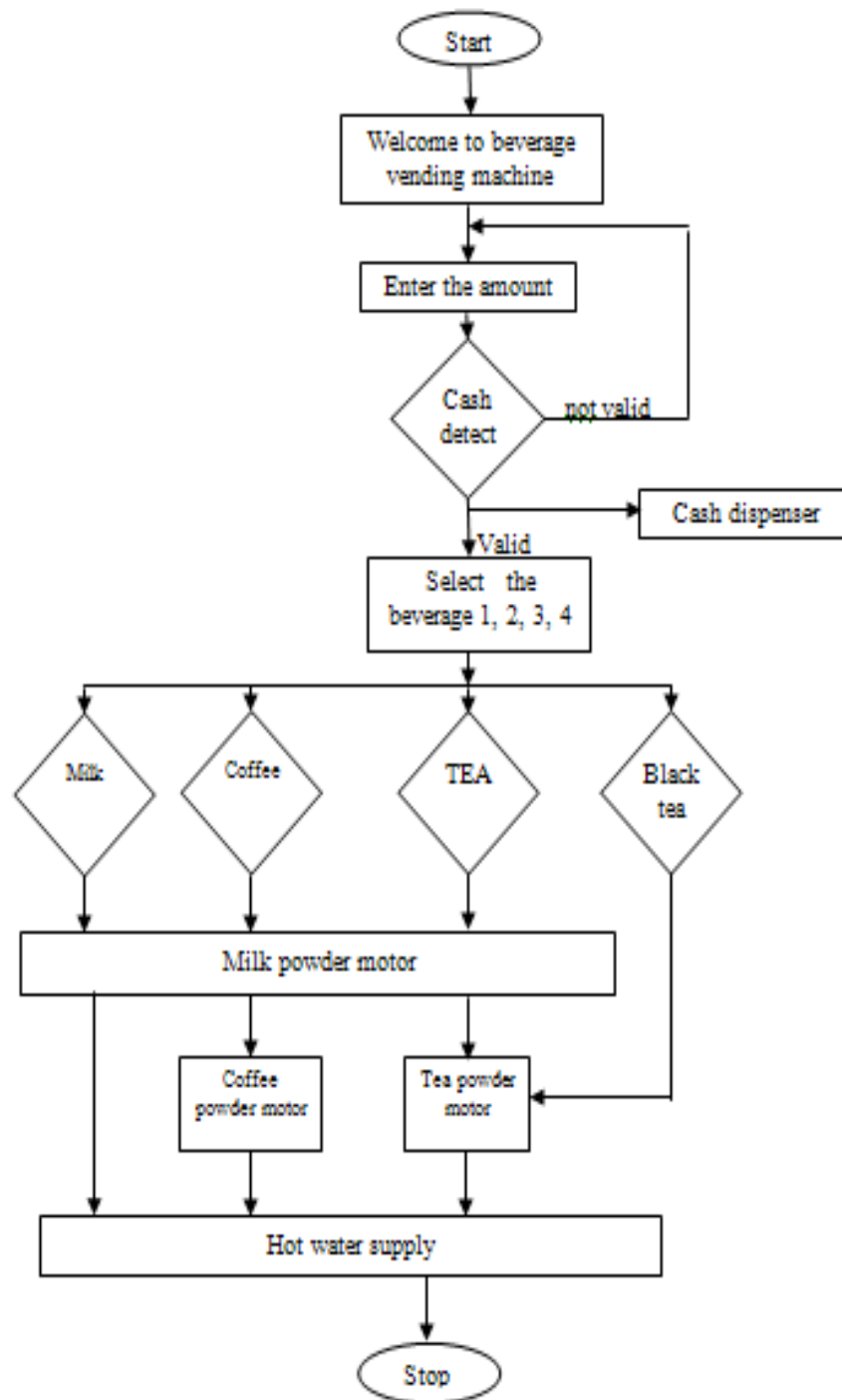


Figure 2. Flowchart for the Developed Beverage Vending Machine Systems

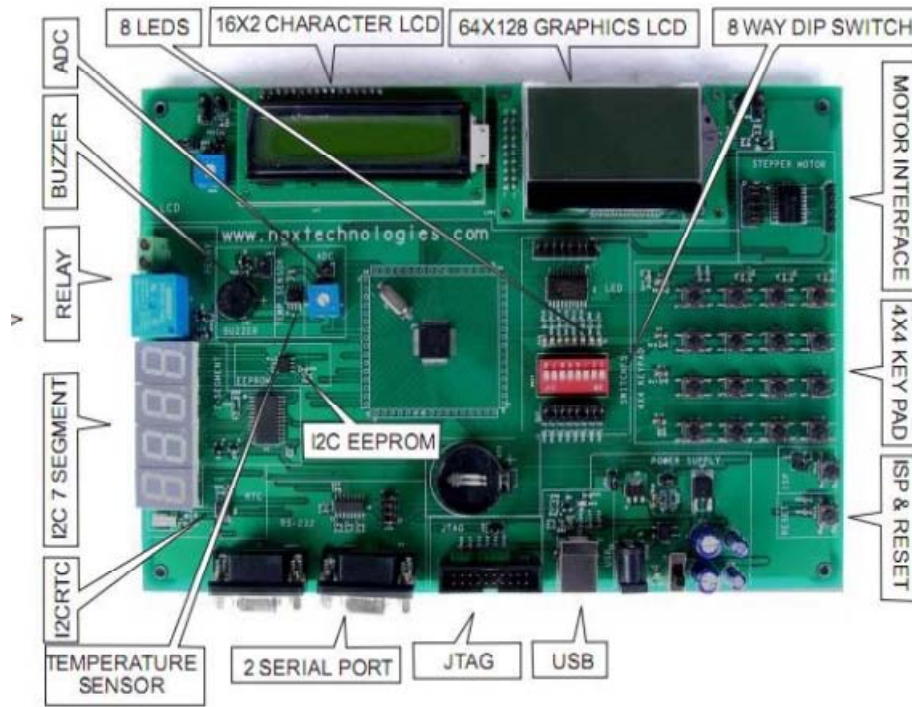


Figure 3. ARM based LPC2148 Board

#### 4. RESULTS

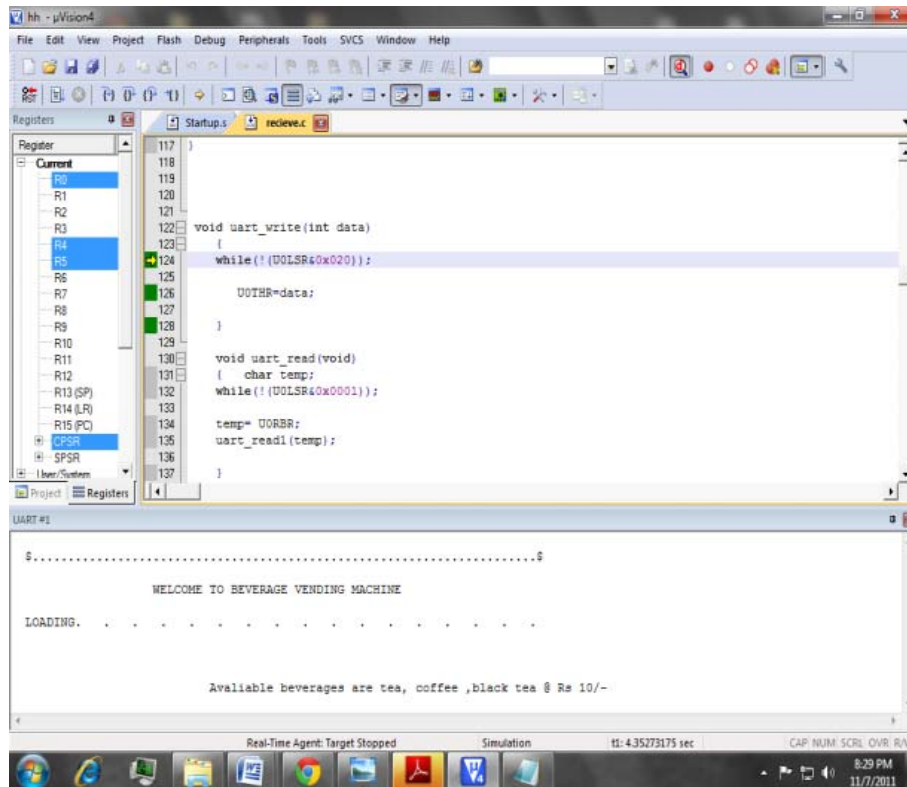


Figure 4. Displaying Welcome message and Beverage Costs

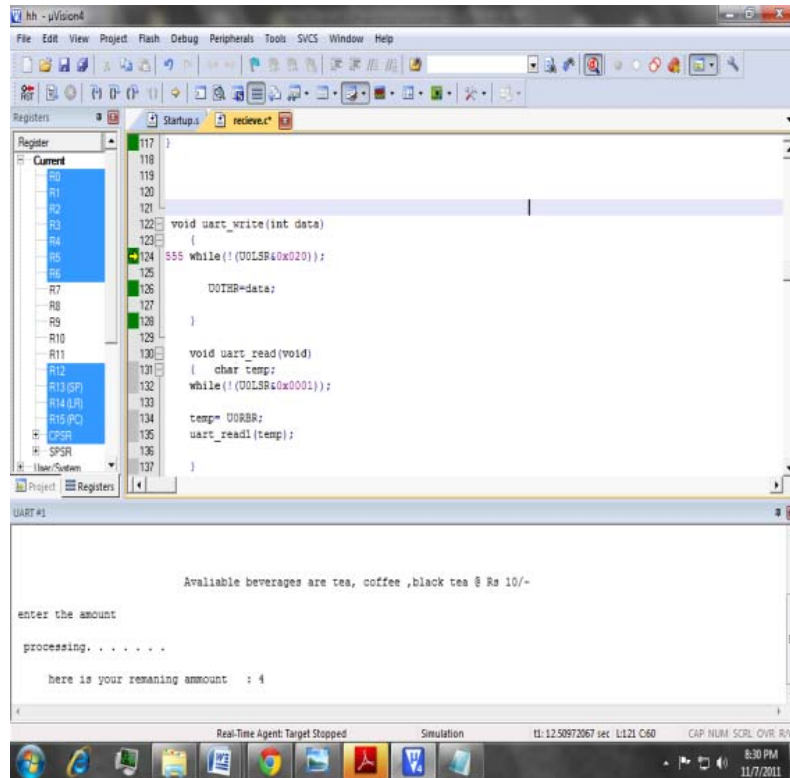


Figure 5. Entering the Amount

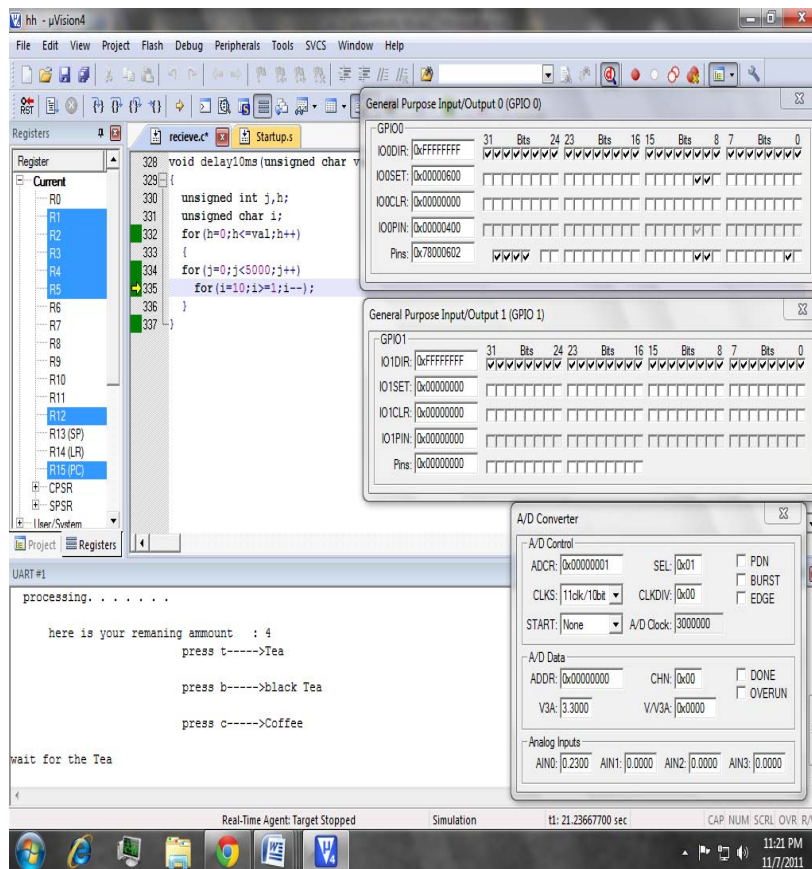


Figure 6. Indicates Button 't' is Pressed and Milk Motor Running

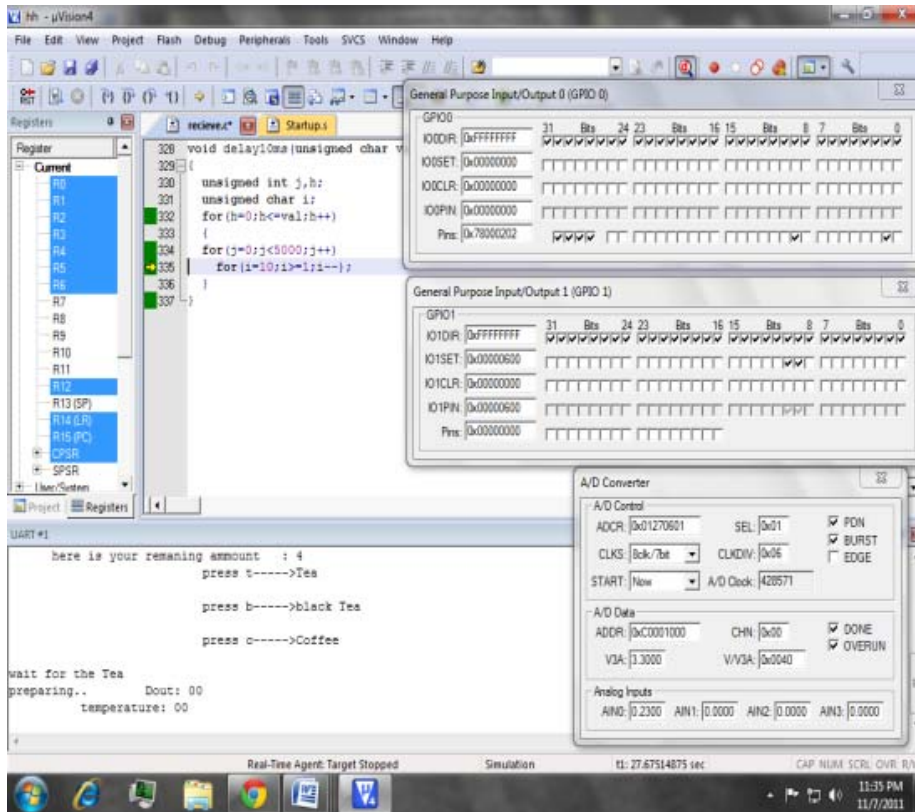


Figure 7. Indicates Tea Motor Running and the Initial Temperature

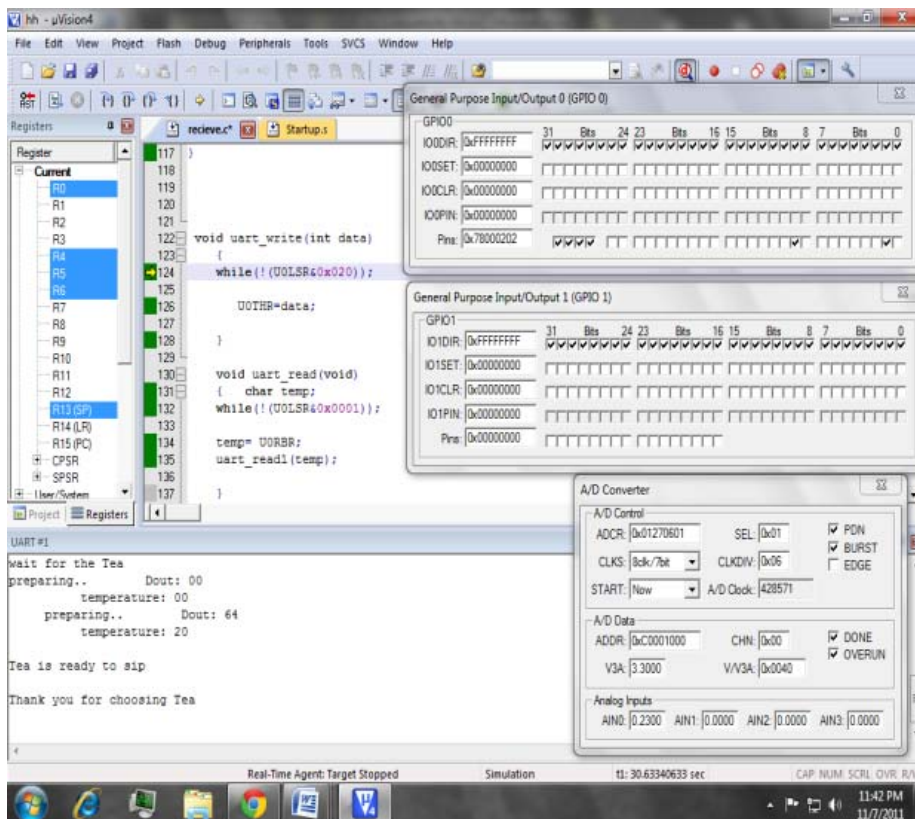


Figure 8. Indicates Final Temperature of the system



Interfacing is done by UART and it displays the message in UART window when the program is executed. Initially it displays the welcome message followed by the beverages that are available with its prices. These messages will be displayed on LCD display and below that there will be buttons to select the beverage of the customer's choice. This is shown in Figure 4.

After displaying the messages, it then asks for entering the amount. Then if the customer enters the amount, processing is done and remaining amount is given back to the customer. This is shown in Figure 5. It indicates the button 't' is pressed for tea. As soon as this button is pressed, the signal is given to the motors. Initially the milk motor runs for 10 rotations to drive 200 milligrams of milk powder to the container. The milk motor which runs is shown in the GPIO port0. This is shown in Figure 6.

It shows after the milk motor has run for 10 rotations, the tea motor starts rotating and runs until 6 rotations as it requires driving 160 milligrams of tea powder into the container in which milk powder is already present. The tea motor which runs is shown in the GPIO port1. This is shown in Figure 7. Figure 8 shows the final temperature during the beverage mixing is done with hot water. Then it shows that the beverage is ready.

## 5. CONCLUSION

In this design a stepper motor which has low efficiency i.e. the motor draws substantial power regardless of load. Instead if a use dc motor it has high efficiency, it can approach 90% at little loads. Also dc motor had much reduced stepper motor. Instead of accepting the coins and cash, if an attempt can be made to improve it to accept ATM credit cards it would be a better option to customers as it jus requires a card swipe. Also there will be some problems occurred when the customers enter high currency notes, in this case sometimes it would be difficult to return back the remaining amount to the customers. Also instead of using switches or buttons in the design the system can improve by adding a touch screen. Since buttons can get jammed. Once it gets jammed it is very tough for the customers to select the beverages of their choices. Cash box security is a main problem, so by using some cameras or server tracking we can put some safety measures on the beverage vending machine.

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