

# Design of Automatic Pipette Controller

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**Abstract**— The auto pipetting system plays an important role in different fields and it is one of the most important fields in medical and chemical industries, for transferring or measuring out small quantities of liquid, especially in a laboratory. Auto pipetting are highly useful in delivering the exact quantity of the substance at given periods of time as required. This research discusses a design method to create a cost effective working prototype of pipette for variable and very precise or low delivery rates for the supervision of small volumes. The design is a microcontroller based system. The contribution of this work is in the design of the system and in choosing the appropriate components. Such system can be implemented by using various hardware tools like Microcontroller, stepper motor as well as software utilities i.e. Integrated Development Environment (IDE) according to the design requirements.

**Key words:** auto pipetting, microcontroller, stepper motor, IDE

## I. INTRODUCTION

“Pipettes are specially calibrated droppers that are used to distribute a precise amount of liquid”. There are several types of pipettes, which include manual, auto, reusable and disposable pipettes.

The simplest pipettes are manually functioned, while the most complex are electric and controlled by advanced computers.

With the manually controlled pipette there was many drawbacks occurred like:

- 1) Accuracy
- 2) Speed of system in transferring liquids
- 3) Small volumes range like micro liter and milliliter are difficult to handle

If it does not fulfill the accurate proportion requirement either it gets rejected or if it's taken into further process it may create undefined behavior. So to overcome these above issues there is a need to make system which do the above accurately in automation fashion and hence the idea of automatic pipetting arises.

An automated pipetting system is generally a device which performs programmed transferring of chemicals between the containers. Automatic pipetting can be used for various applications such as medical and pharmaceutical industries where accurate measurements are crucial. The pipetting mechanism is controlled using stepper motor which provides a very precise flow rate. Controlling of the stepper motor used for actuating the pipette is done using microcontrollers. The current generated by the microcontroller is not enough to drive the stepper motor, therefore we need a motor driver circuit to drive the necessary current for driven the stepper motor.

## II. WHY DO WE NEED IT

- Since the manually operated pipettes were resulting in errors which may change the behavior of the substance and this may threaten patient's safety, therefore, there was a need for developing automated system.
- The main obstacle for the existing automated system is the power supply
- Since the system may operate in rural places , where power supply is not direct, the prerequisites of the design are:
- System should be portable. This implies that is has to be very small in size and should run with a battery.
- System should be able to run for long hours (three to five days) without restart to ensure a data could be stored for long time to be examined correctly.
- To achieve these battery optimization through hardware or through firmware is the biggest challenge of the design process.

## III. PROPOSED SOLUTION SYSTEM

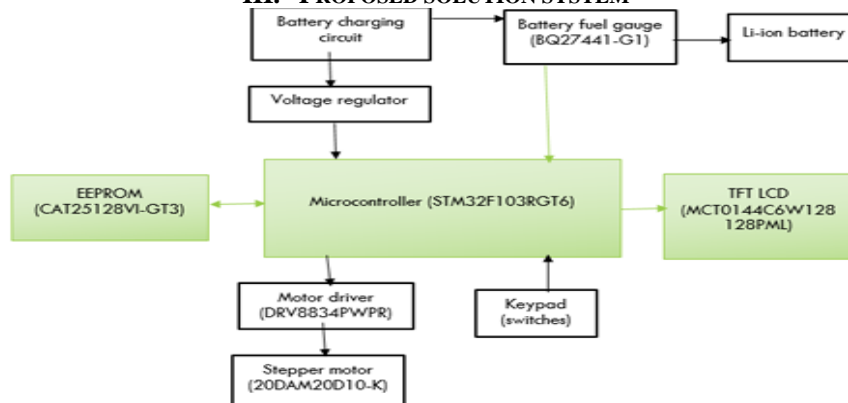


Fig. 1: system block diagram

Automated pipetting system consists of pipette attached to stepper motor which is driven by a motor driver and this driver is controlled by a mean of microcontroller

TFT LCD and Push buttons are used for user interface. Once an input is given through the TFT LCD and the push buttons (switches), it is processed by the controller and the instruction is then fed to the stepper motor via motor driver. The motor runs and the pipette attached with the motor rotate. Thus, the pipette will start pumping the substance.

The speed of the motor can be varied by varying the number of steps and delay time.

For programming aspect, components must be programmed in optimized way to meet the requirements and ensure high efficiency.

To make the device portable, batteries will be used as a source of power. Then, all components will be put together in a proper physical model that can be effortlessly held by hand.

The proposed model is a user-friendly system, wherein login information is required to access the interface. External EEPROM is attached to store the data which has to be available during reboots such as timing, the configuration, and the passwords.”

The speed of the motor can be varied by varying the number of steps and delay time. Motor is driven accurate amount of reading controlled by MCU as per the keypad/LCD given commands.”

In the LCD we have icon named favorites click on it, then pipetting click on it u will get two options using the keypads either up or down, up for pumping the substance and down for dispensing it. The device is made of four essential units. These are:

#### A. Controlling unit:

This is the microcontroller part which is used to controller the speed and direction of the stepper motor. STM32F103RGT6 is chosen for this design, since the system design is based on battery therefore a low power microcontroller is used in the design. This microcontroller is based on ARM Cortex-M3 CPU and it provides a maximum frequency of 72 MHZ and up to 1 byte flash memory.

#### B. Display unit:

TFT LCD which is a graphical LCD is used in this design. This is together with the keypads are used as an interface between the microcontroller. Graphical GUI is built to make navigation in the application so easily. TFT LCD used here is MCT0144C6WPML. This is an SPI based 1.44” LCD with 128x128 resolution. ST microelectronics provide a well-built library called STEWIN library. External EEPROM will be used to save permanent data like configuration details, system passwords, huge GUI details...etc. CAT25128 EEPROM is used in this work and this EEPROM is and SPI based communication peripheral and it is 128 KB.

#### C. Power unit:

Since is the system is portable a battery power is chosen. Li-ion battery which is rechargeable is used here. Battery fuel gauge is used with in the battery so that it can protect the battery from over charging, discharging process, showing the battery percentage...etc. This will be charging using USB. Power from the battery will be used for microcontroller via voltage regulator which is used for protection of the microcontroller. The battery fuel gauge used is BQ27441-G1 from Texas instruments and it is an I2C based peripheral.

#### D. Motor unit:

Bipolar stepper motor is used here and it is driven by the microcontroller. Since the current from the microcontroller is not enough to drive the stepper motor, motor driver is used to drive the necessary current for driving the stepper motor .the stepper motor in this work is 20DAM20d10-k which is hybrid stepper motor with step accuracy of +/- 1.5 % . The motor driver used to drive the stepper motor is DRV8833 from Texas instruments and IC for this driver is A3909.

#### E. Software design:

The STM32 platform provides a number of ways to program its microcontroller, such as atollic truestudio, IAR embedded workbench, eclipse based IDE...etc. But in this work IAR embedded work bench is used which is licensed.

#### System setup:

The hardware components of the proposed system is connected to the microcontroller as shown in the figure below:

The system setup consists of the following parts:

- 1) stm32f103 microcontroller
- 2) EEPROM
- 3) Motor driver
- 4) Keypad(switches)
- 5) TFT LCD
- 6) Stepper Motor
- 7) Battery fuel gauge
- 8) Li-ion Battery

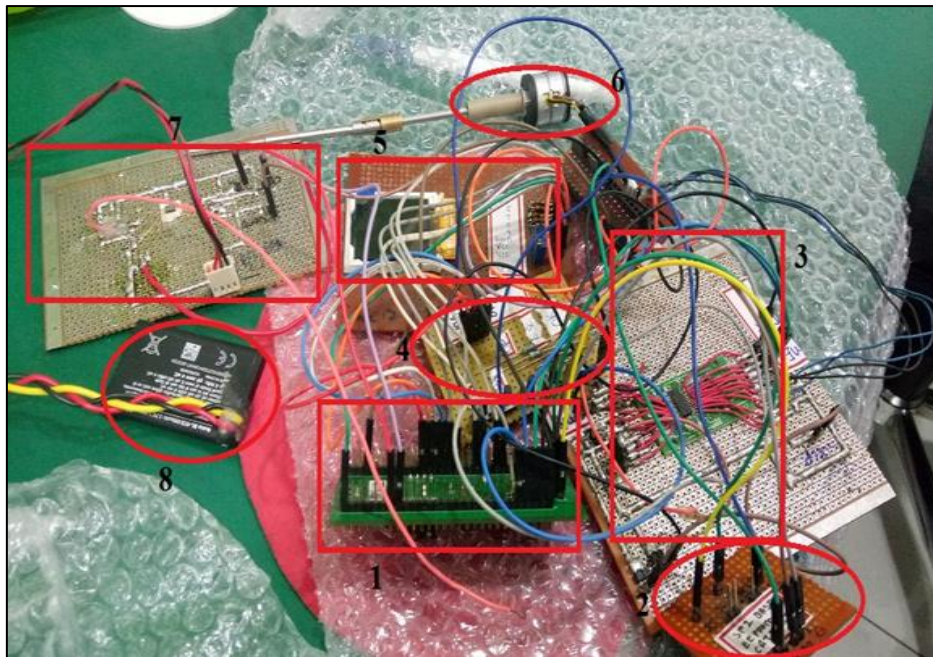


Fig. 2: system setup

#### IV. INTERFACING STM32F103 TO KEYPAD

Five user buttons are required in these application .These keys are up key, down key, OK key, Esc key and trigger key, and these buttons are connected to:

PB3→UP-----→ through external line 0  
 PB4→DOWN-----→ through external line 1  
 PB5→OK-----→ through external line 2  
 PB6→ESC-----→ through external line 3  
 PB3→triggering-----→ through external line 4

Using these keypads we can control our device graphically.

#### V. INTERFACING STM32F103 TO EEPROM

This is configured using spi2 of the stm32f103 is used. The parameters for this communication the configuration are

- speed 4mbits/s
  - Mode 00
  - MSB first 8 bit
  - -Master mode Full duplex
- SPI2 GPIO Configuration

PB13 -----> SPI2\_SCK  
 PB14 -----> SPI2\_MISO -in  
 PB15 -----> SPI2\_MOSI  
 PB12 -----> SPI2\_CS -out

Information such as system configuration, passwords, patient details are stored in this external EEPROM.

#### VI. INTERFACING STM32F103 LCD

Configure spi1 for LCD communication

SPI functionality

- Master mode Full duplex
- 8bit data MSB first
- Mode 00

Pin connections for SPI1 are

CS-->PA4  
 SCK-->PA5  
 MISO-->PA6  
 MOSI-->PA7  
 LCD reset-->PA0  
 LCD Register select-->PA2, tim2-ch3

Using GUI library for ST microcontrollers called stemwin library (graphical library from ST microelectronics) GUI is made to access LCD graphically. Some GUI is made, there are more than five GUI icons developed i.e. up icon, down icon, ESC icon, labelling icon, battery icon, ok icon, pipetting icon, favorite's icon.

Using the switches (keypads) we can navigate within the GUIs created. For example if we want to pump the liquid from the container press on pipetting icon and then you can specify the amount of the substance needed to be pumped.

All this can be visible graphically in the TFT LCD (see figure 3 and figure 4 below).



Fig. 3: GUI icons

After getting this display, by clicking on pipetting, this display (fig.4) will be observed.

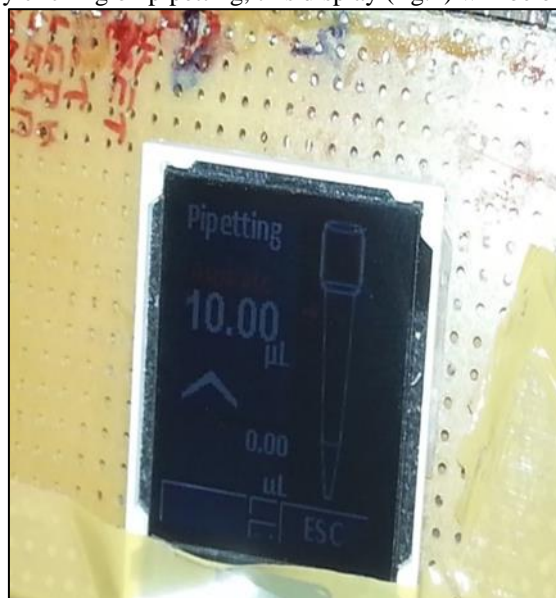


Fig. 4: GUI icon for pipetting

## VII. INTERFACING STM32F103 TO STEPPER MOTOR

This is SPI based communication. The stepper motor via its driver will be connected to SPI2 of the microcontroller. The Step angle is 1.8 degrees which indicates that it has rpm of 200 steps ( $360/200=1.8$ degree).

PA8 → M1 pin as output

PC9 → M0 pin as output

PC8 → STEPPER MOTOR STEP PIN

PC7 → STEPPER MOTOR Enable and Disable PIN

PC6 → stepper motor direction pin

PC5 → stepper motor sleep pin

A 200 step per rotation motor would have 50 pole pairs on the rotor and need 50 electrical cycles per mechanical rotation.

### VIII. INTERFACING STM32F103 BATTERY FUEL GAUGE

BQ27741 is an I2C based peripheral; this will be connected to the I2C1 of the STM32F103 microcontroller.

The Pin connection between the microcontroller and the battery fuel gauge will be as following:

PB10-----→ SCL

PB11-----→ SDA

### IX. CONCLUSION

This Auto-pipette system designed using the above procedure will give the required accuracy keeping in mind components placement in the PCB should be handled carefully. Some modifications and improvements could be added to improve the performance and quality of the deliverables to go with. Gathering all these setups and with the optimized coding technique a system which can operate for long hours without recharging is designed successfully. The designed system can be upgraded to more sophisticated device especially in medical applications by adding some biomedical sensors which can sense the body parameters and continuously update this to the microcontroller. Hence, later the medical personnel can access this data regarding the patient health records.

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