EMBEDDED SYSTEMS-I (MCT-238L)

Semester Project Report
AMBULATOR

Submitted by:

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INTRODUCTION:

This is the report of a semester project in which a mechanism is designed and made so it can pump or press the medical or portable device named AMBU bag according to a person’s requirement. The AMBU bag is pressed by a mechanism which is controlled by a stepper motor using a C language code. As the amount of oxygen required by a child’s lungs and an adult’s lungs is different so how much the AMBU bag is pressed depend on many factors such as:

- Tidal Volume
- Respiratory rate
- Inspiration/Expiration (IE) ratio

The main aspects of the device and the working of project is explained below:

AMBU BAG:

A bag valve mask (BVM), often known as an AMBU bag, is a portable device that provides positive pressure ventilation to any patient who is not breathing enough or effectively enough. The term "AMBU" is an abbreviation for "Artificial Manual breathing unit," and it was initially applied to this kind of device when it was created by Testa Laboratory. The business changed its name to AMBU in the 1980s, and since then, the phrase "AMBU bag" has been frequently used to describe this kind of gadget.

PURPOSE OF AMBU BAG:

Resuscitation in emergency situations, including cardiac arrest, is one of the main uses of an AMBU bag. It can also be used to give patients who are unable to breathe on their own, either momentarily or for an extended period of time, respiratory support. AMBU bags may also be used to preserve airway patency, for instance, in cases of acute allergic responses or asthma attacks.

WORKING PRINCIPLE:

In order to provide the patient breaths through the mask or mouthpiece, the user must manually squeeze the bag. The user can regulate both the air flow and the amount of pressure by using the valve. Patients of all ages, from infants to adults, can use AMBU bags.

ADVANTAGES OF AMBU BAG:

The main advantages of AMBU bag are as follows:

- Portable and easy to use.
- Suitable for use in a variety of settings, including hospitals, ambulances, and emergency care units.
- Useful tool to have on hand in case of an emergency, as it can provide life-saving support to a patient until more advanced medical care is available.
- Can be used for patients with various respiratory conditions.
- Provides quick and effective ventilation[1].

Figure 1 AMBU Bag

HARDWARE COMPONENTS:

TIVA C MICROCONTROLLER:

Texas Instruments develops a microcontroller called the TM4C123GH6PM popularly known as TIVA C series that is based on the ARM Cortex-M4 CPU. It is a capable 32-bit microcontroller that excels in a variety of applications, including industrial control, medical equipment, and consumer electronics. It also includes a range of peripherals such as timers, analog-to-digital converters (ADCs), and communication interfaces such as UART, SPI, and I2C[2].

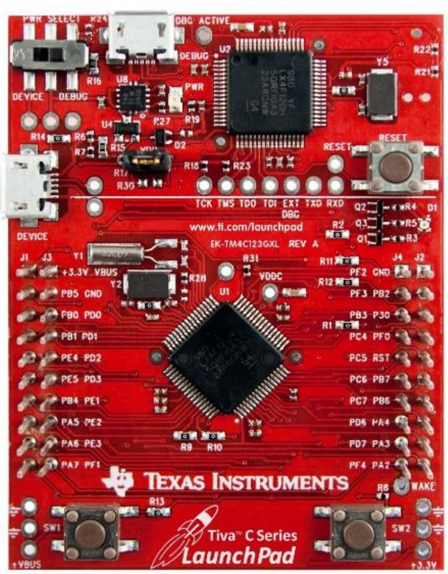

Figure 2 Tiva C MicroController

STEPPER MOTOR (NEMA 23):

A stepper motor with a 2.3 x 2.3-inch (57 x 57 mm) faceplate is called a NEMA 23 stepper motor. NEMA 23 high torque stepper motors offer excellent affordability without compromising on quality. The motor has 1.8° step angle with 200 step rotation. These motors are designed to deliver the most torque while reducing audible noise and vibration[3].

Figure 3 NEMA 23 Stepper Motor

MOTOR DRIVER (TB6600):

TB6600 Stepper Motor Driver is an easy-to-use professional stepper motor driver, that could control a two-phase stepping motor. It is compatible with many microcontrollers that can output a 5V digital pulse signal. TB6600 stepper motor driver has a wide range of power input, 9~42V DC power supply. It can output 4A peak current, which is enough for most stepper motors[4].

Figure 4 Stepper Motor Driver

LCD MODULE (1602A):

LCD 1602 Alphanumeric Display Module also known as LCD 162a Blue Backlight provides a 16-character 2-line LCD with I2C interface for easy control by a microcontroller. It is a fast way to have your project show status messages. It displays white characters on blue background. These displays are straightforward to use and great way to provide a user interface on many projects[5].

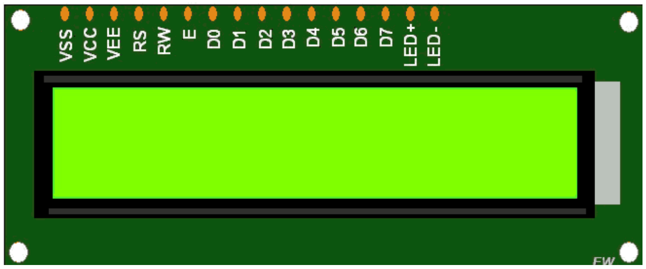

Figure 5 LCD (1602)

BUCK CONVERTER:

A DC-to-DC buck converter is a type of power converter that converts a high voltage, low current input voltage into a lower voltage, higher current output voltage. It is a type of switched-mode power supply (SMPS) that uses a transistor switch to rapidly turn on and off the input voltage to produce the desired output voltage[6].

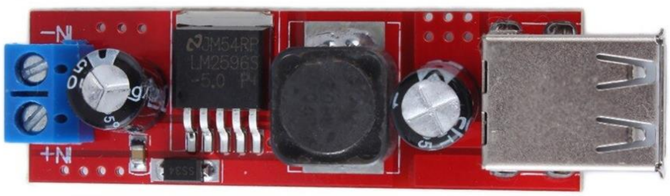

Figure 6 Buck Convertor

PUSH BUTTONS:

A push button switch is a mechanical device used to control an electrical circuit in which the operator manually presses a button to actuate an internal switching mechanism. They come in a variety of shapes, sizes, and configurations, depending on the design requirements. They are also referred to as pushbutton switches, push switches, or simply push buttons.

Figure 7 Push Buttons

PIN CONFIGURATION:

The pin-out of each component for connection in circuit is given below with proper labelling:

1. **Tiva C Microcontroller:**

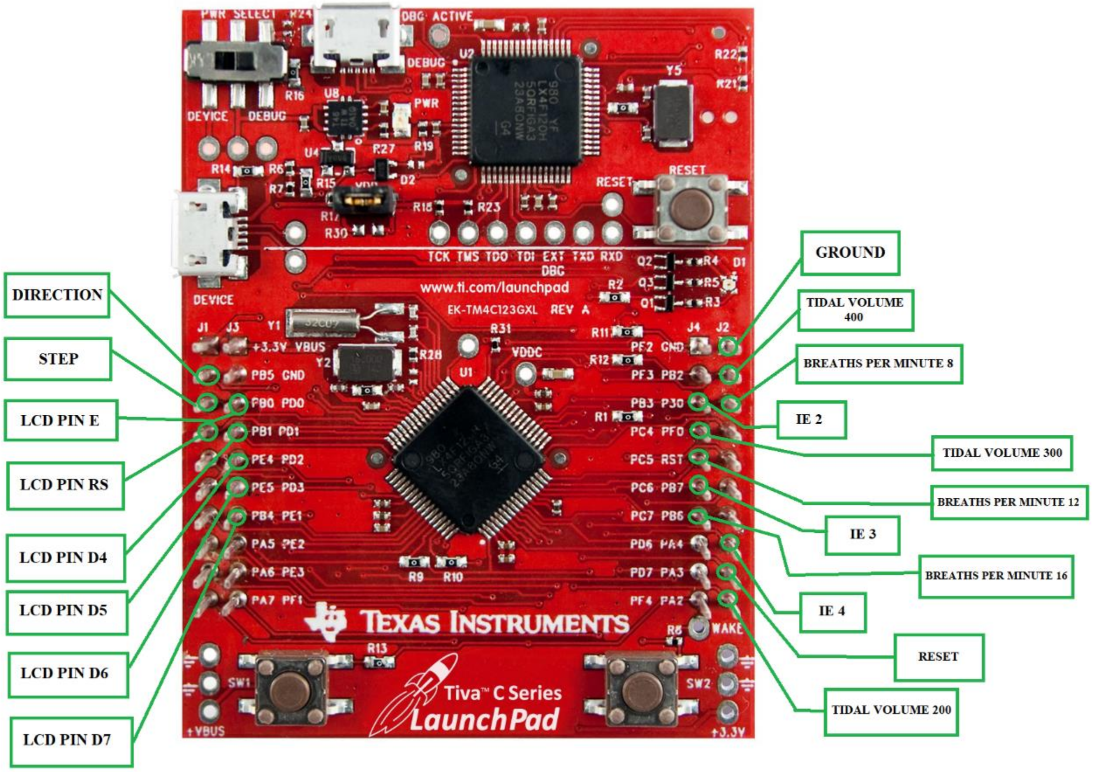

Figure 8 Pinouts of Tiva C Controller

2. **LCD 1602:**

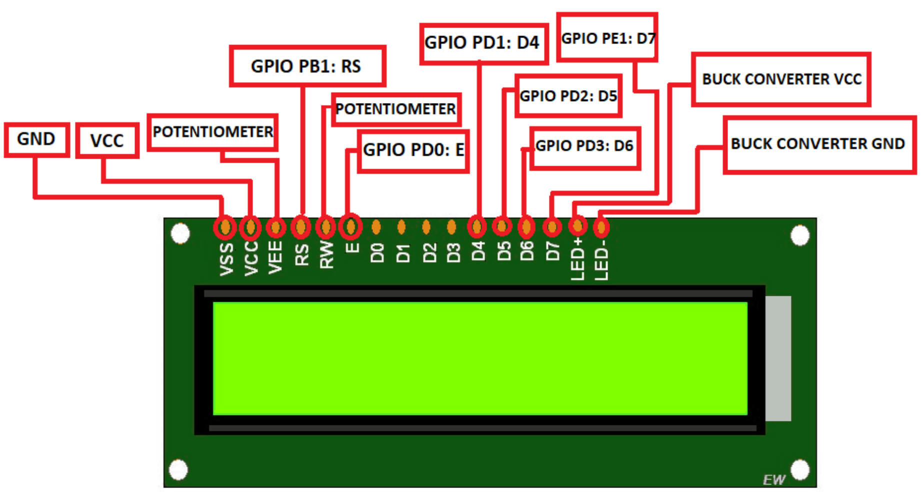

Figure 9 Pinouts of LCD Display

3. Motor Driver TB6600:

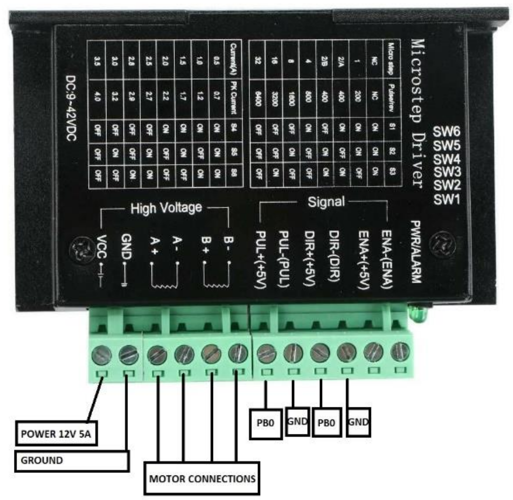

Figure 10 Pinouts for TB6600

CIRCUIT DIAGRAM:

The complete circuit diagram is drawn using online tools and implemented on PCB as:

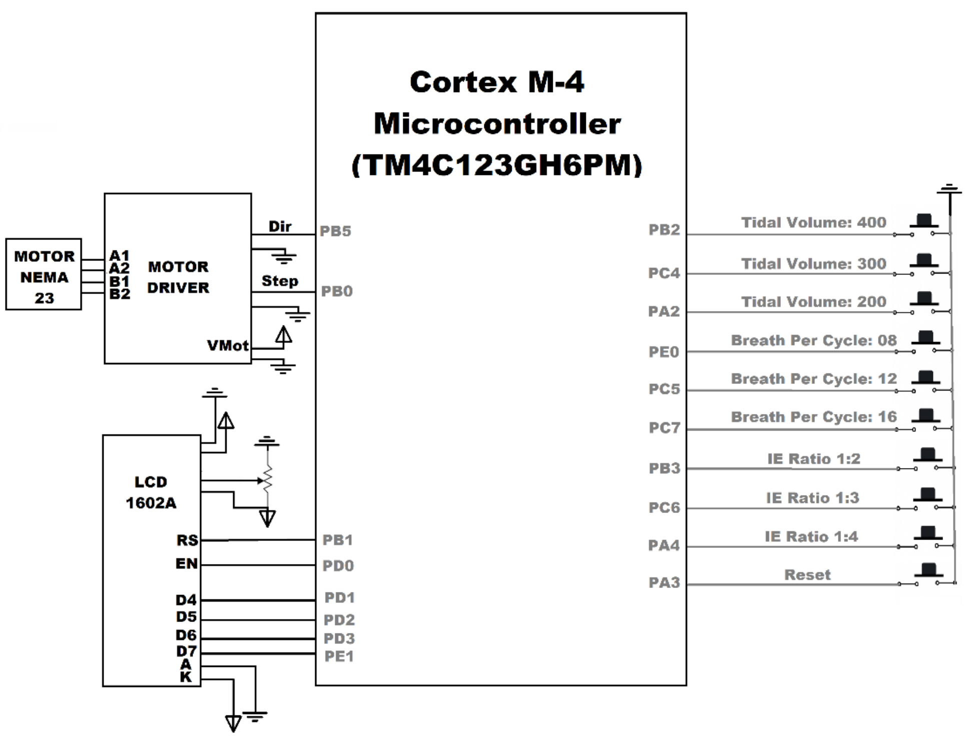

Figure 11 Complete Circuit Diagram

CALCULATIONS:

The code in Python language is written for calculating the 27 configurations of pressing AMBU bag using Tidal Volume, Respiratory Rate and Inhale/Exhale Ratio.

```
"""
Motor Revolutions required for Different Tidal Volume
TD = 200 >> 3.2 Revolutions
TD = 300 >> 4.8 Revolutions
TD = 400 >> 6.4 Revolutions
"""
motor_revolutions = 3.2

"""
Inhale Exhale Ratios
1. 1:2
2. 1:3
3. 1:4
"""
inhale_exhale_ratio = (1, 2)

"""
Breaths per minute
1. 8
2. 12
3. 16
"""
breaths_per_minute = 16
"""
Steps per revolution set on the Motor driver
"""
steps_per_revolution = 6400
# Total motor steps required by by the mechanism for one breathing cycle
total_steps = motor_revolutions*steps_per_revolution

# Total Time required by by the mechanism for one breathing cycle
total_time = 60/breaths_per_minute
# Total Delay per step of inhale and exhale parts combined (in Microseconds)
total_delay = total_time/total_steps

sum_of_parts = sum(inhale_exhale_ratio)
# Delay for inhale part in Code (in Microseconds)
inhale_delay = (total_delay/sum_of_parts)*inhale_exhale_ratio[0]
# Delay for exhale part in Code (in Microseconds)
exhale_delay = (total_delay/sum_of_parts)*inhale_exhale_ratio[1]
# print(inhale_delay*1000000, exhale_delay*1000000)
```

Figure 12 Python code for Calculations

Using above code, Step Delay values for Inhale and Exhale in microseconds for all 27 configurations are:

Step Delay For 27 Conditions in Microseconds			
TD 400 (6.4)	"1:2"	"1:3"	"1:4"
8 BPM	31, 61	23,69	18,73
12 BPM	20,41	15,46	12,49
16 BPM	15,31	11,34	9,37
TD 300 (4.8)	"1:2"	"1:3"	"1:4"
8 BPM	41,81	31,92	24,98
12 BPM	27,54	20,61	16,65
16 BPM	20,41	15,46	12,49
TD 200 (3.2)	"1:2"	"1:3"	"1:4"
8 BPM	61,122	46,137	37,146
12 BPM	41,81	31,92	24,98
16 BPM	31,61	23,69	18,73

Figure 13 Delay Per Step for Inhale, Exhale

FINAL HARDWARE:

The complete picture of desired hardware along with mechanism is:

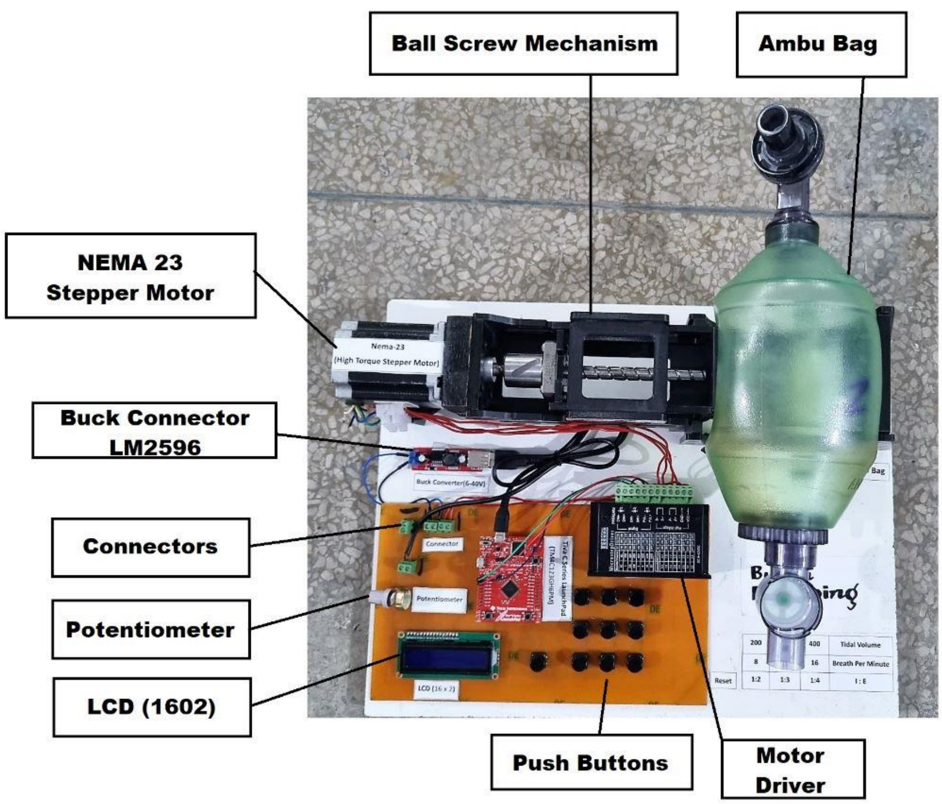

Figure 14 Final Hardware

BILL OF MATERIALS (BOM):

There are many items or quantities used in this project. Their Bill of Materials is given in separate file and its link is given below as:

https://docs.google.com/spreadsheets/d/1OHB8ZYBf-6u7WghKPaWU1Xnc8Y-RyrmRIWo1nMxeakE/edit?usp=sharing

REFERENCES:

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5. *LCD 16X2 1602 Alphanumeric Display Module Blue Backlight 16-Character 2-Line*. 2023 [cited 2023 21-05-2023]; Available from: https://www.majju.pk/product/lcd-16x2-1602-blue-backlight-16-character-2-line/.
6. *Buck Converter*. 2023 [cited 2023 22-05-2023]; Available from: https://analog.com/en/products/power-management/buck-converters.html.
7. This mechanism design was inspired from a 3D designer named **FRAX3D** and was modified to calculate all configurations.