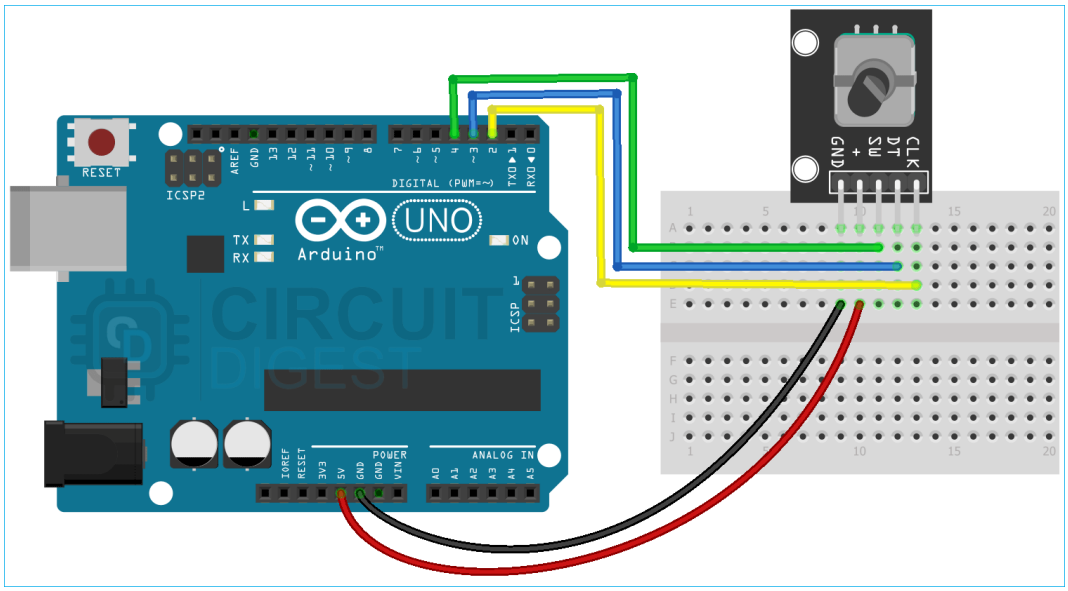
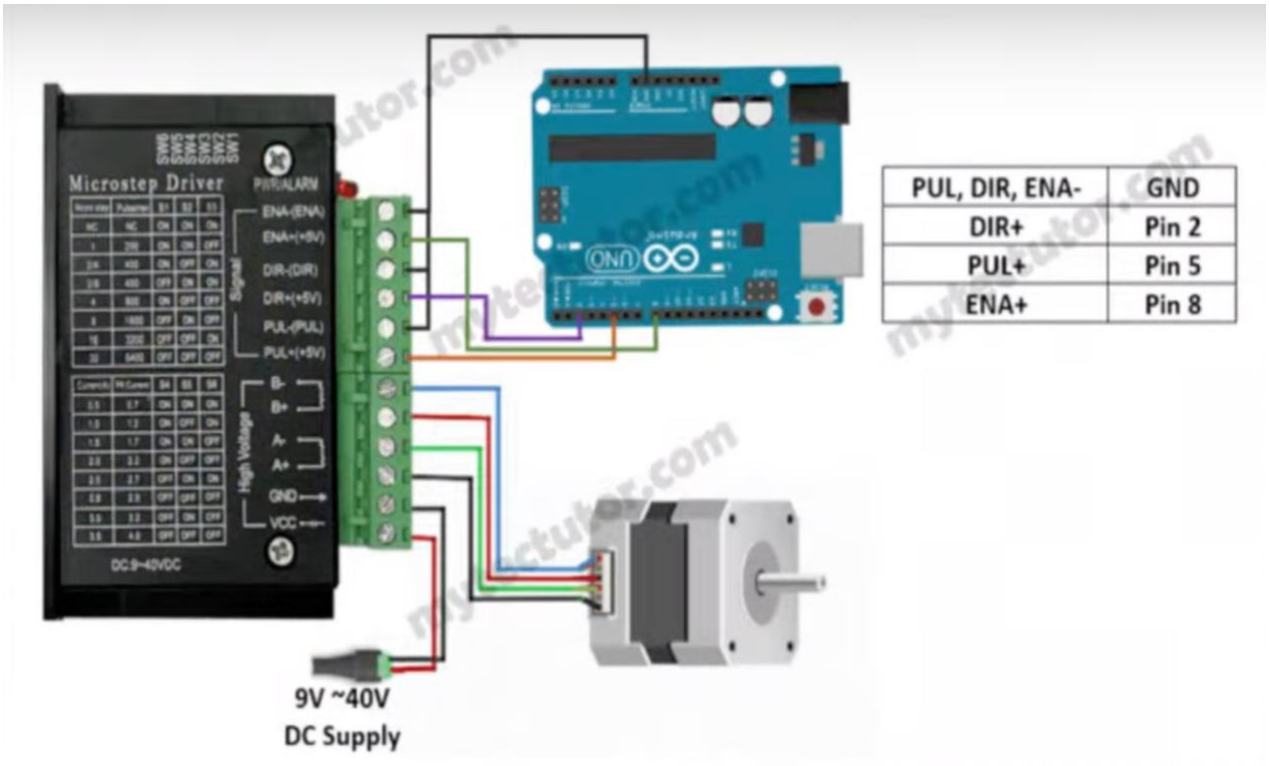
Practical No./Project ID:	9
Project Title:	Stepper Motor Control with Arduino Nano V3.0 (with 0.91" OLED display)
Description (In Brief):	Controlling the speed and the direction of a stepper motor with Arduino Nano. Arduino Nano will perform the generation of the control signal for the stepper. Use KY-040 (or similar) Rotary Encoder to change the motor parameters. Those parameters should be displayed on the built-in display.
Group No.:	1
Date of Completion:	1st February 2024
Required Resources:	***a) Development Board / Single-Board Computer:*** *Arduino Nano V3.0* ***b) Equipment (i.e. Power Supply Unit, etc.):*** *12V Power Supply with AC-DC Converter* *Stepper Motor Driver (TB6600)* ***c) Accessories (i.e. Cables, Memory Card, Video Converters, USB-Hubs, etc.):*** *Stepper Motor* *KY-040 Rotary Encoder* ***d) Software / Libraries:*** *Software: Arduino IDE* *Libraries: Arduino.h, U8g2lib.h, SPI.h, Wire.h* ***e) Other (i.e. Jumper Wires, etc.):*** *Jumper Wires* *Micro USB Cable* *A Circuit Board (Bread Board)*
Data Sheets:	**For Rotary Encoder**: https://www.rcscomponents.kiev.ua/datasheets/ky-040-datasheet.pdf

Schematic Diagram(s):



The Configurations used for the KY-040 Rotary Encoder and a Microcontroller (The connection for CLK was ignored in the real scenario)



The Configurations used for the TB6600 Motor Driver along with the stepper motor

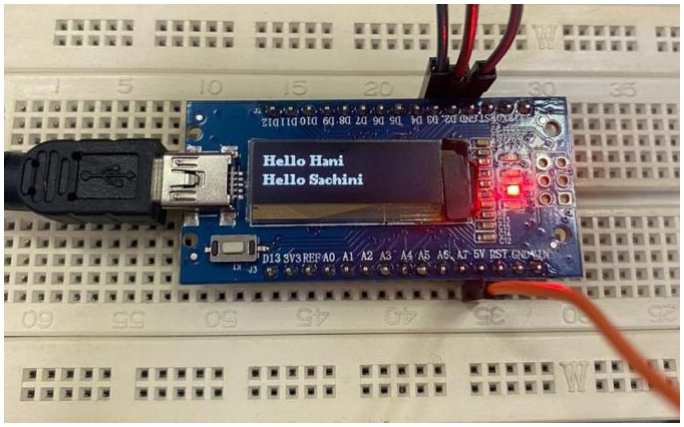
Procedures followed:

1. **Testing out the features of Built-In display of Arduino Nano**

    - First the functionality of the built-in display Arduino board was demonstrated using the Arduino forum discussions (https://forum.arduino.cc/t/displaying-random-number-on-nano-builtin-oled/1170519)

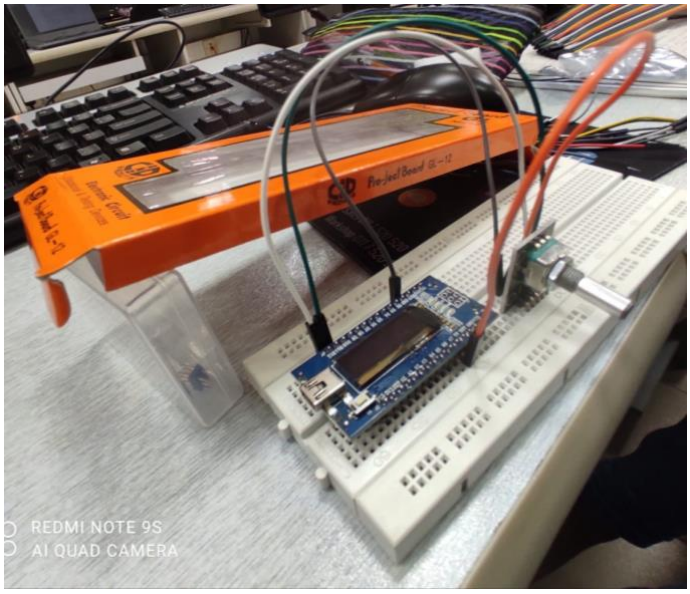
    - The following libraries were found essential when displaying the required text in the display.
        - Arduino.h – To access GPIO and analog ports in the microcontroller.
        - U8g2lib.h – The graphics library for monochrome OLEDs and LCDd
        - SPI.h - Facilitate short-distance communication between a microcontroller and an IC. (SPI = Serial Peripheral Interface)
        - Wire.h – Used to communicate with devices over the I2C and SPI busses.

    - Issues Encountered: Due to a loose connection between the Micro-USB and the computer the OLED display output was found slower than the Serial Communication in the IDE.



Testing the display capability of the Arduino Nano OLED Display

2. **Demonstrating the Functionality of the Rotary Encoder**



Rotary Encoder and Arduino Nano Connections

- First the rotary encoder and the Arduino Nano board was fixed to a bread board and connections were made using wires.

- The pinouts of the rotary encoder had following connections with the microcontroller board.
    - 5V from encoder → 5V of Arduino Nano
    - GND from encoder → GND from Arduino
    - Output Pin A → D10 of Arduino
    - Output Pin B → D11 of Arduino

- The rotation angle along with its direction was identified by rotating the screw of the rotary encoder.

  Working Principle of a Rotary Encoder
    - A rotary encoder consists of a disc with evenly spaced slots and an optical sensor that detects these slots as the disc rotates.
    - As the disc rotates, it alternately blocks and unblocks the light between the optical sensor and the disc. This blocking and unblocking are detected as changes in the channel A and channel B signals.
    - If two waves generated by A and B are 90 degrees out-of-phase, the rotation direction is clockwise.
    - If two waves generated by A and B are 90 degrees in-phase, the rotation direction is anti-clockwise.

- Finally, the position and angle were printed out in the Serial Monitor of the Arduino IDE.

The final output of the reading received by the rotary encoder.

3. Demonstrating the Functionality of Stepper Motor and Its Driver

- First the 12V Power Supply with AC-DC Converter was powered up and configured to output recommended voltage and current with the lecturer's support.

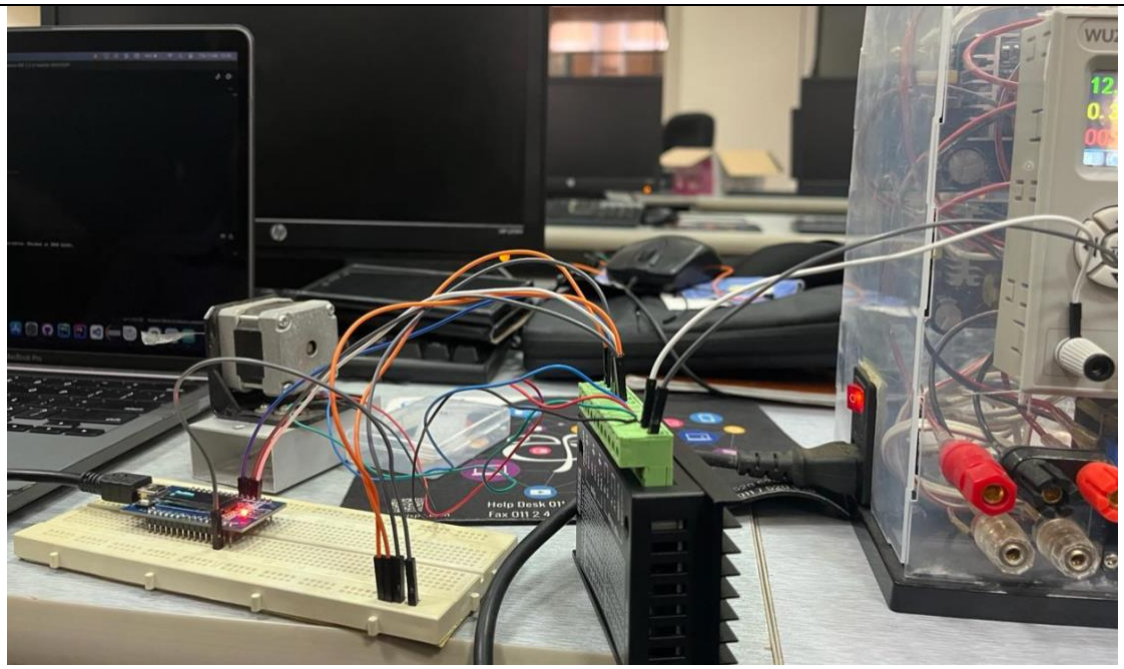
The AC-DC Converter and Voltage Regulator after being configured.

- The wires of the stepper motor were then fixed to the stepper motor driver in the following order.
    - Blue wire of Stepper motor → B- screw of motor driver
    - Red wire of Stepper motor → B+ screw of motor driver
    - Green wire of Stepper motor → A- screw of motor driver
    - Black wire of Stepper motor → A+ screw of motor driver

- The control pins of the stepper motor driver have following functionalities.
    - EN – Enable/ Disable the driver to driver the stepper motor.
    - DIR – Controls the direction of the rotation.
    - PUL – Associated with speed of rotation of the motor. The number of pulses received for this pin, determine the speed of rotation.

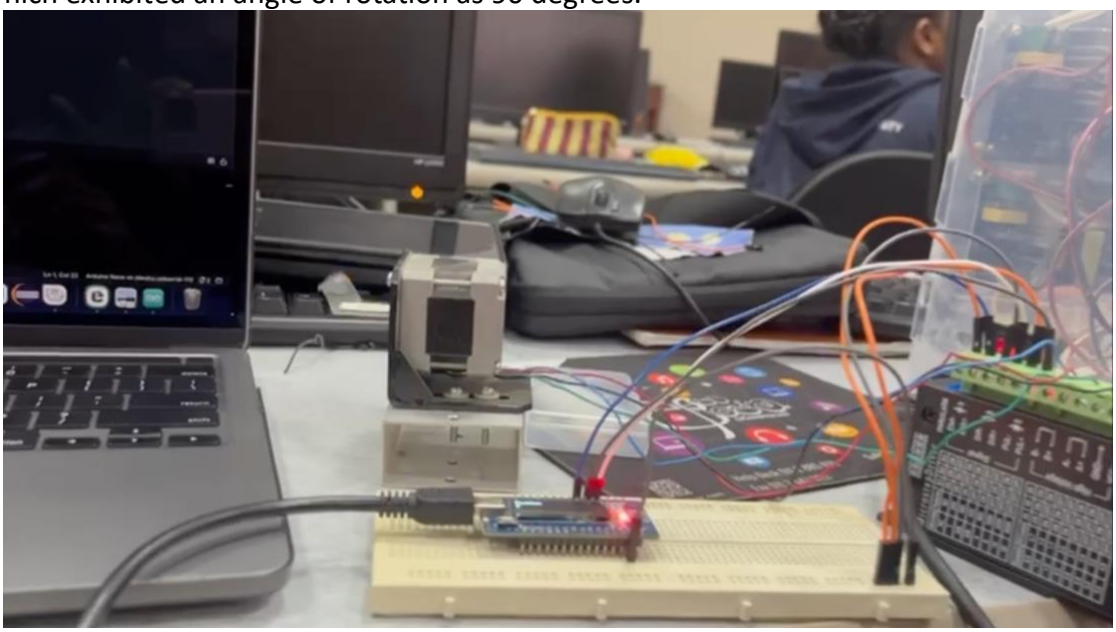
- Then the ENA+, DIR+ and PUL+ of the stepper motor driver were connected to the microcontroller board for following pins. Connecting "+" pins for controlling the power supply is also known as Common Anode Configuration.
    - ENA+ → Pin D4 of Microcontroller
    - DIR+ → Pin D2 of Microcontroller
    - PUL+ → Pin D3 of Microcontroller

- Also, all the ENA-, DIR- and PUL- were grounded using the microcontroller ground pin.



The finalized connections with power supply, motor driver, motor and microcontroller.

- The motor was then rotated by 800 steps both clockwise and anti-clockwise direction which exhibited an angle of rotation as 90 degrees.



The final workings of the motor after the demonstration process.

Discussion / Recommendations:

1. Introduction

   The purpose of the experiment was to control the speed and direction of a stepper motor using an Arduino microcontroller. Also, it was expected to use a rotary encoder to control the motor parameters, and display the parameters in the built-in OLED display.

2. Results

   All the required functionalities of the components were demonstrated successfully.

- The functionality of a rotary encoder was identified.
- The build-in OLED display of the Arduino Nano was configured and tested.
- The stepper motor was configured successfully alongside its motor driver.

The integrating all 3 components together could not be performed due to the time restrictions.

3. Comparisons with Theoretical Expectations

    - For the determination of position of rotary encoder, the readings of the two input pins A, B should be compared whereas in theory it's given that there will be an in-phase and out-of-phase operation.

4. Key Findings

    - The working principles of all individual components (Built-In OLED display, rotary encoder and stepper motor and its driver) were identified and understood.
    - The use of libraries and possible delays of communications were also noted during the practical.

5. Sources of Error

    - The OLED display's function was often interrupted due to a loose connection between micro-USB to USB of computer. The power was not received as planned and the display was delayed than expected rather than the Serial monitor of the Arduino IDE.

Conclusion(s):

In conclusion, the practical session successfully identified the functionality of a rotary encoder, configured and tested the built-in OLED display of the Arduino Nano, and successfully configured the stepper motor alongside its motor driver. While the integration of these components to control the speed and direction of the stepper motor with the Arduino Nano could not be performed, the individual components were tested and verified to be functional. This lays a solid foundation for future integration and development of the project.

Complete Project Files and Demonstrations:

https://github.com/SA-Tester/StepperMotor--RotaryEncoder--ArduinoNano

Additional References:

1. For Rotary Encoder: https://howtomechatronics.com/tutorials/arduino/rotary-encoder-works-use-arduino/
2. For Stepper Motor: https://www.youtube.com/watch?v=idVcItHfGS4

Signature of the Group Leader:	**Date:**
	**13th February 2024**

Group Members:

Enrollment Number	Name
UWU/CST/20/002	R.M.K.M. Rathnayake
UWU/CST/20/004	A.M.S.I. Attanayake
UWU/CST/20/043	D.G.S. Pathulpana
UWU/CST/20/062	W.D. Eranga Chamini
UWU/CST/20/076	H.M.S.T. Ranathunga
UWU/CST/20/082	P.W.T.D. Weerasingha
UWU/CST/20/095	W.A.N.M. Weragama
UWU/CST/20/097	R.P.B. Nishadhi