HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY

PROJECT:

DESIGN AN ALGORITHM TO ADJUST FUEL INJECTION ANGLE AND INJECTION TIME BASED ON MOTORCYCLE ENGINE SPEED

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Class: CC18OTO

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SOCIALIST REPUBLIC OF VIETNAM
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THESIS MISSION

1. **Student's name:** Lại Công Minh **- Student ID:** 1652369
2. **Major:** Automotive Engineering **- Class:** CC18OTO
3. **Thesis title:** Design an algorithm to adjust fuel injection angle and injection time based on motorcycle engine speed.
4. **Content:**
   - ❖ Introduction
     - General information about Electronic fuel injection system in motorcycle engine.
     - Pictorial diagram showing the aim of the project to fuel injection control signal.
     - Design the principal diagram.
   - ❖ Algorithm design:
     - Design the timing diagram.
     - Design the algorithm flowchart
     - Select the components for the product.
     - Arduino programming
       - Timer control
       - Analog to Digital Converter Control.
   - ❖ Result:
     - Simulate the working process of the system using Proteus software.
5. **Product:**

✓ Presentation report.	✓ Poster.
✓ Microcontroller program.	✓ Proteus simulation.

6. **Assigned day:** April, 2021.
7. **Finished day:** June, 2021.

The content and requirements of the thesis is already approved by the Head of Department of Automotive Engineering.

HCMC, day....... month…… year 2021

Head of Department

HCMC, day....... month…… year 2021

Instructor

I. Introduction: 4
1.1Type of design 4
1.2 Objectives: 4
1.3Wiring diagram: 5
1.4 Working principles of the system: 6
II. Algorithm Design: 7
2.1 Timing diagram 7
2.2 Algorithms: 8
III. Simulation: 10
3.1 Choosing Component and microcontroller: 10
3.1.1 Crankshaft Position Sensor. 10
3.1.2 Microcontroller ..... Error! Bookmark not defined.
3.2 Proteus Simulation: 13
IV. Conclusion: 16
V. Reference 16

I. INTRODUCTION:

1.1 Type of design: Design algorithm.

1.2 Objectives: Fuel injectors in motorcycle engine.

Theoretical basis:

The electronic fuel injection system on a 1-cylinder motorcycle uses the crankshaft position sensor signal to send a signal to the ECU. From that signal to adjust the fuel injection angle and ignition timing to let the engine operate with optimal performance and fuel economy while reducing environmental pollution the most.

The figure 1.1 illustrates the goal of the fuel injector control signal and the figure 1.2 illustration of fuel injection signal with desired timing and fuel quantity.

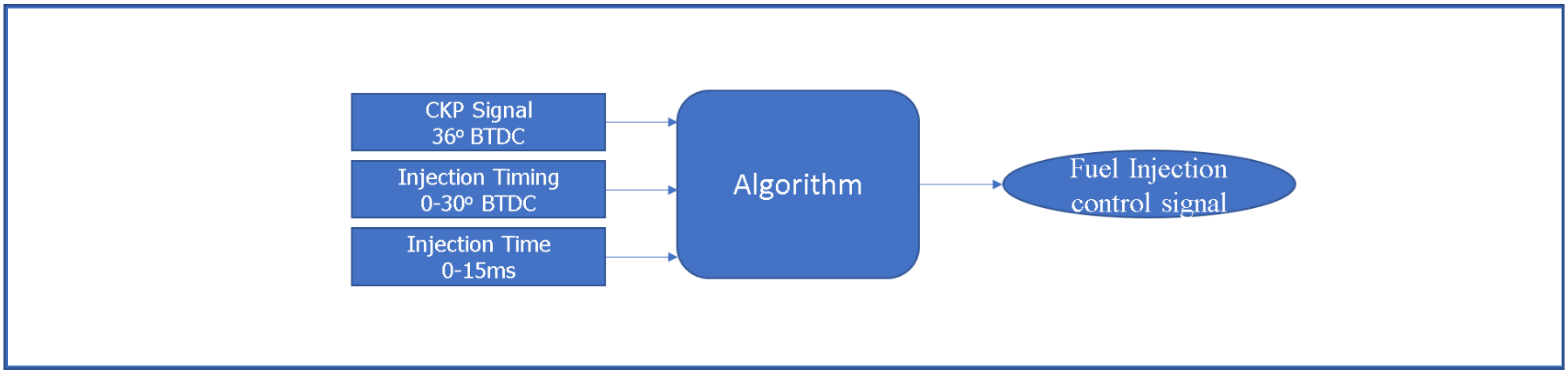

Figure 1.1: Pictorial diagram showing the aim of the project

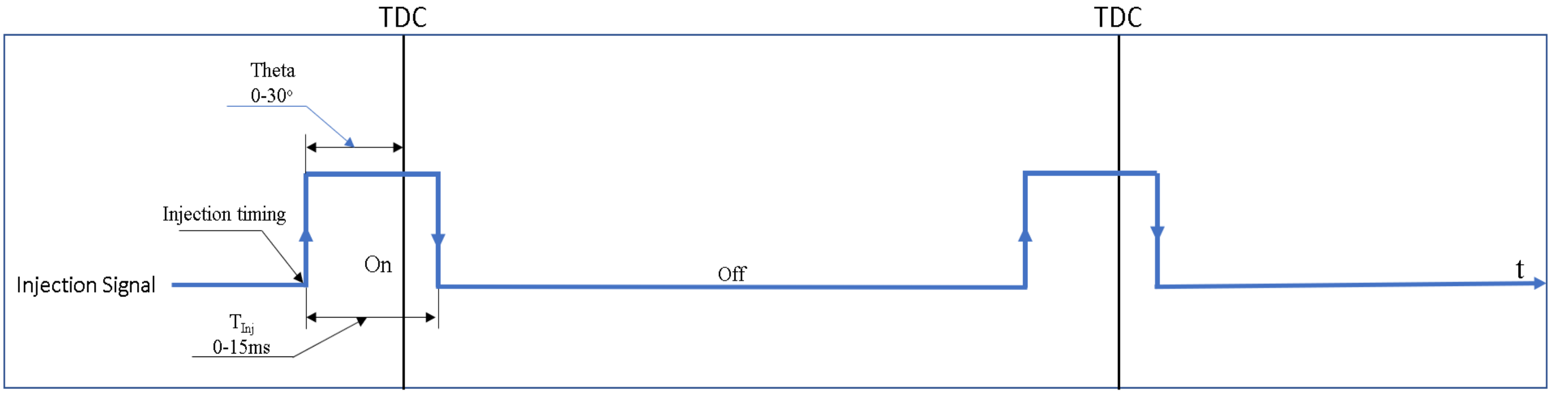

Figure 1.2 Fuel Injection Control Signal

1.3 Wiring diagram

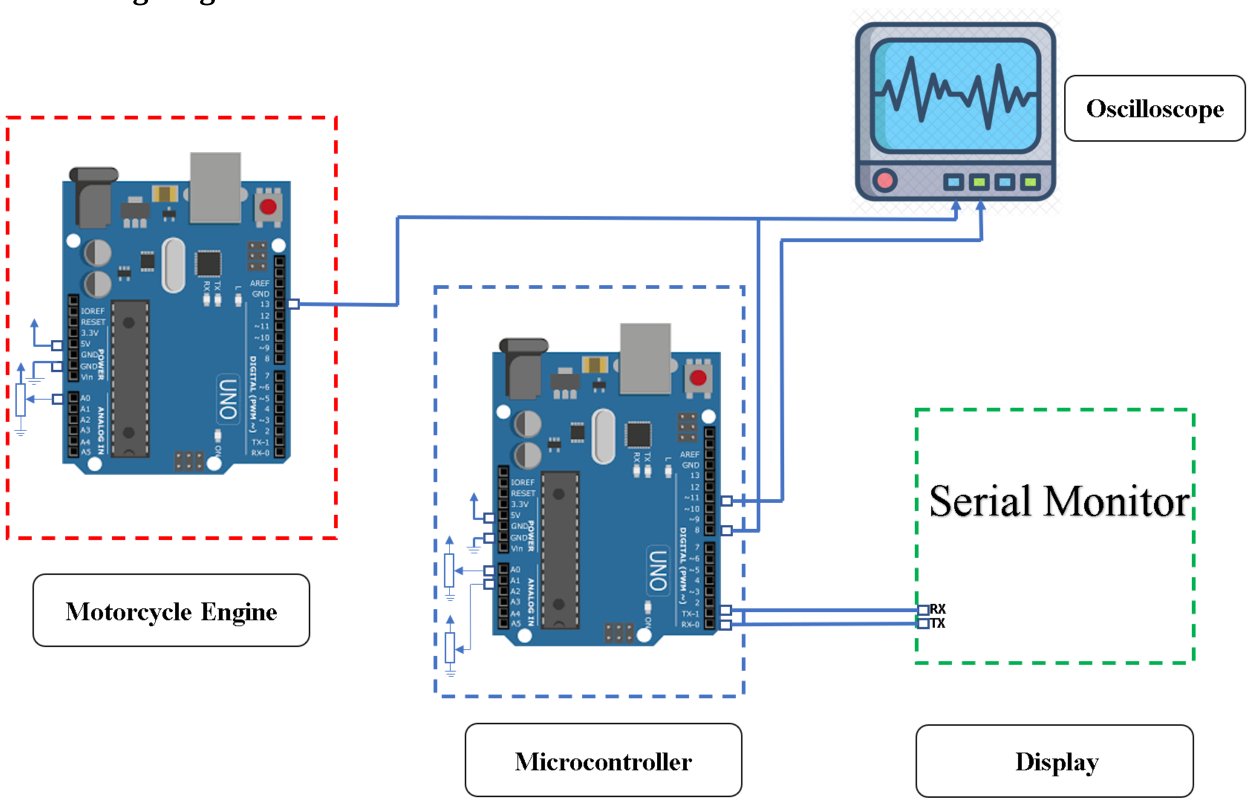

Figure 1.3: wiring diagram

This system includes 3 main part:

- Communication part: Using Arduino Uno R3 to simulate the motor engine to output the corresponding motor signal
- Controlling part: Using another Arduino uno R3
    - Function: receive signal pulse from board 1 and calculate the rotation period of the motor.
    - Determine the timing of fuel injection
    - Adjust the desired amount of fuel injection quantity.
- Display the parameters on the monitor screen and oscilloscope.

1.4 Working principles of the system:

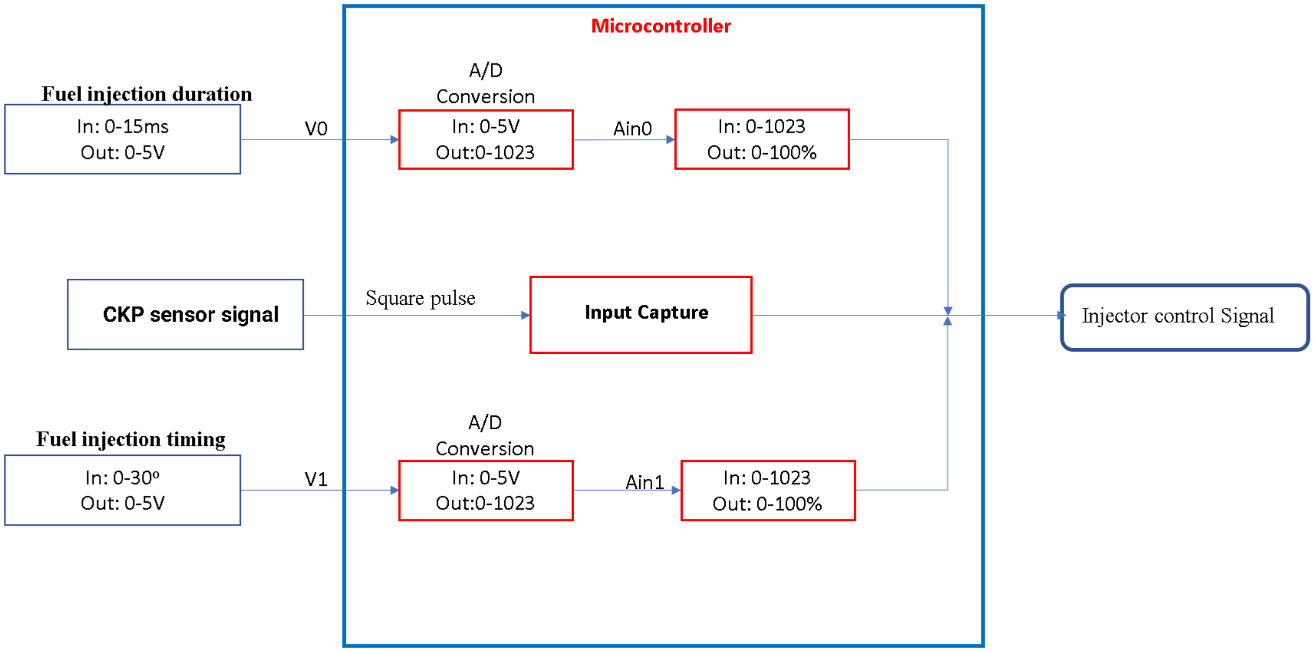

Figure 1.4: Principal diagram

- **Input Signal.**
  - One analog input signal – voltage value from the potentiometer which reflects the desired engine speed value from 0-100%. (120-12000 RPM).
  - One analog input signal - voltage value from potentiometer to adjust fuel injection timing
  - One analog input signal - voltage value from potentiometer to adjust fuel injection time

- **Output Signal.**
  - Digital output signal – PWM control injector signal.

- **Input and Output relationship.**
  - The relationship between 2 analog input values and digital output value (PWM value) is the analog-to-digital converter (ADC).
  - Depending on the input voltage, microcontroller can adjust fuel injection control signal
  - Pulse width at output pin will be dependent on voltage value from the potentiometer at the input A0 of Engine and microcontroller

II. ALGORITHM DESIGN

2.1 Timing Diagram.

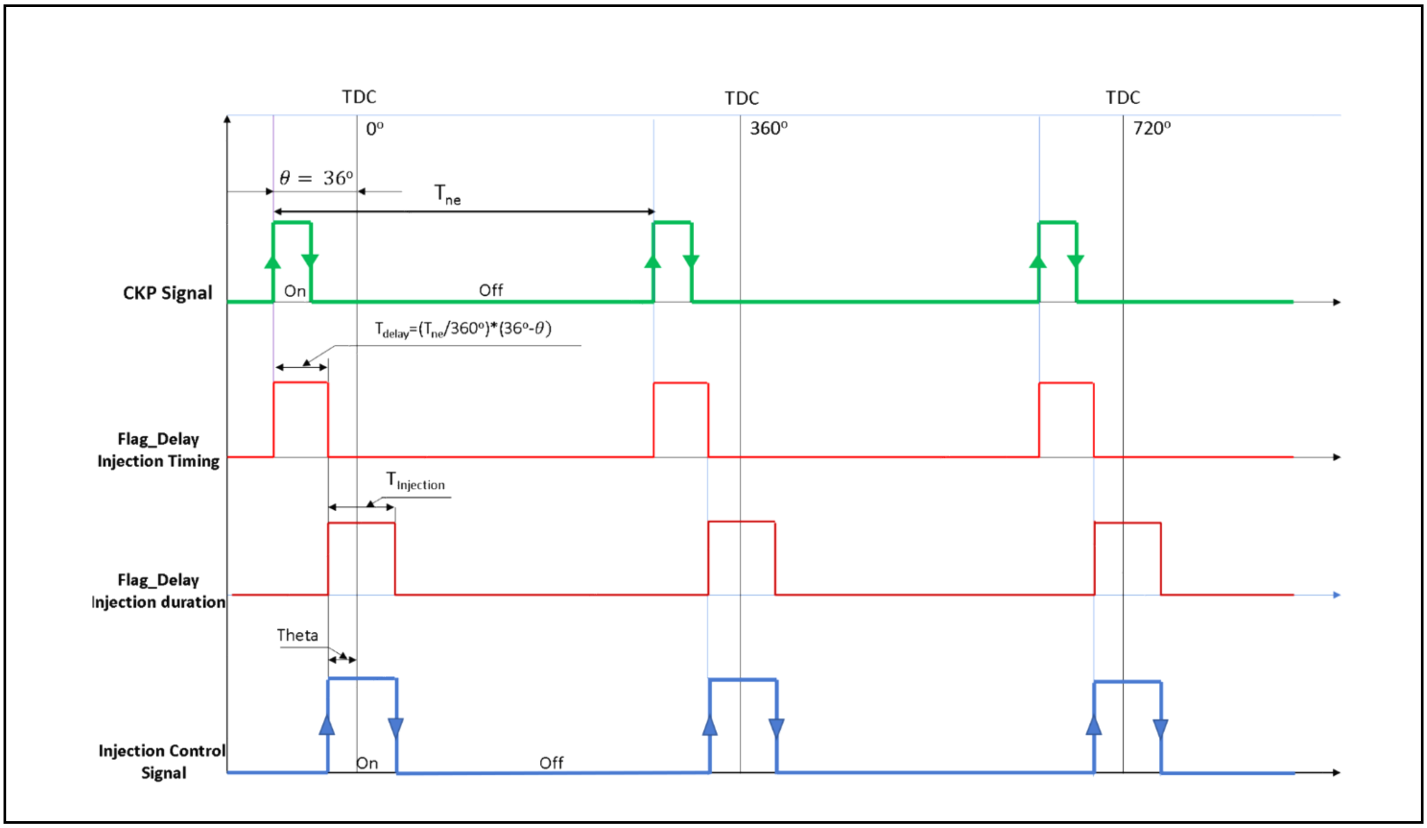

Figure 2.1: Timing diagram of the program

- CKP signal of the engine in the subject to determine 36° before Top Dead Center at the rising edge of the CKP signal pulse.
- Flag_Delay: T_{delay} to create the time delay to the desired fuel injection timing (Theta from0-30° BTDC).
- Injection timing is the time when the rising edge of the fuel injection signal pulse appears.
- The injection time is the distance between the rising edge and the falling edge of the fuel injection signal pulse. ($T_{Injection}$ from 0-15ms)

2.2 Algorithms.

2.2.1 Start the program.

- Selection of input and output pins (Injection pins, potentiometer to change fuel injection timing).
- Initialize variables T_ne, chuki, value, T_delay, tg_phun, THETA, stt_new to store values of system such as period, time delay, injection time, theta angle, new state appears.
- Turn off interrupts.
- Reset timer 1
- Set timer1: 1024 divider, Input Capture mode to set clock speed.
- Reset timer 2.
- Set timer2: 32 splitter, CTC mode, compare interrupt at 0.01ms
- Enable interrupt.
- Define function for signal input and output pins.

2.2.2 Measuring engine speed.

- The capture input mode will measure the pulse width of the speed pulse rising edge, the value is stored in the ICR register.
- When have the value of the ICR register, multiply with the setting resolution to get the cycle

2.2.3 Calculating the values.

- Theta angle: read the analog input value, convert the measurement range from 0-1023 to 0-30 degrees using the map's function.
- Period: ICR*[timer resolution 1].
- Injection time: Converting cycle measurement and fuel injection time, with limited fuel injection time.
- T_delay: (chuki / 360) * (36 - THETA).
- Value: convert T_delay value to a range of values equivalent to the number of timer 2 interrupts according to 0.01ms.

2.2.4 Fuel injection pulse generation.

- When the pulse rises, the end of T_delay means that the value of N decreases to 0.
- When the pulse is down, the end of the spray time means that N is set by the injection time variable. When n decreases to 0, the signal will be low.

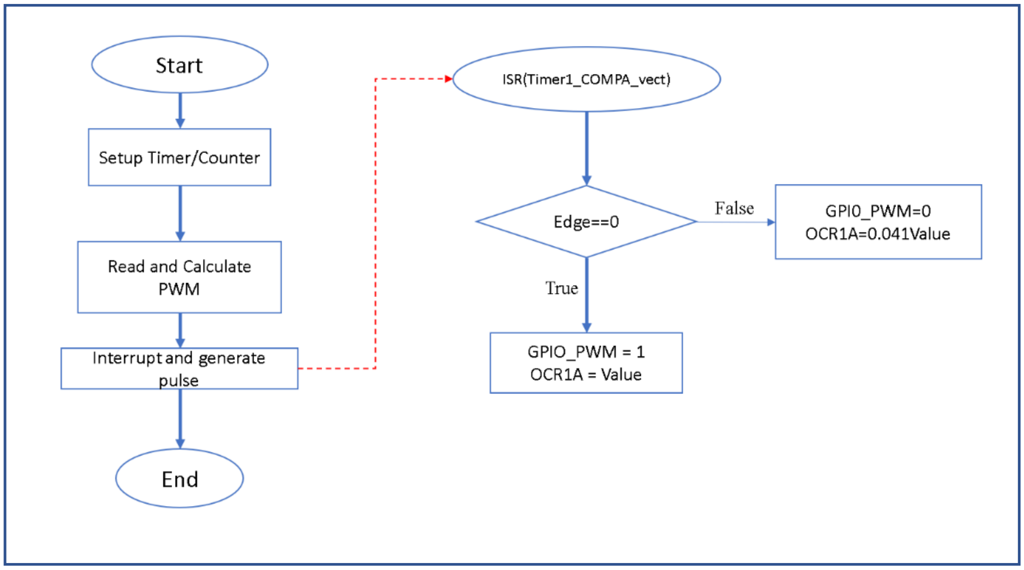

Figure 2.1 Algorithm for speed signal generator program

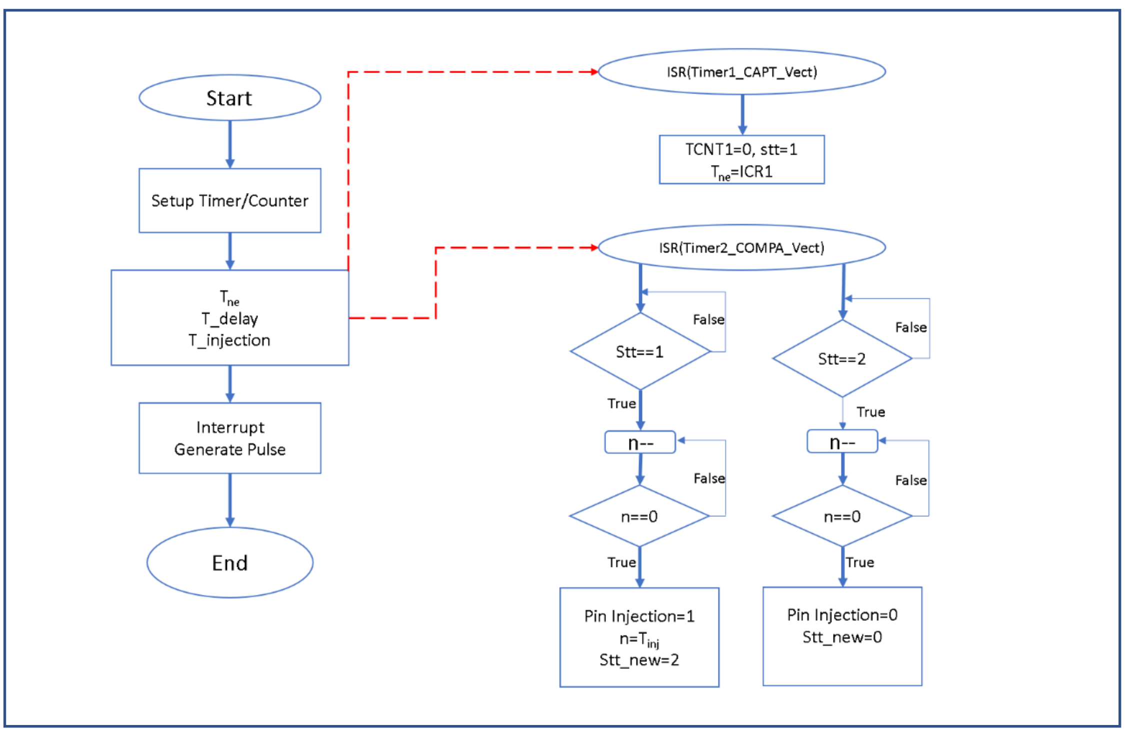

Figure 2.3. Algorithm for fuel injector control program

III. SIMULATION

3.1 Choosing Component and microcontroller:

3.1.1 Crankshaft position sensor. (CKP Sensor)

The crankshaft position sensor is responsible for measuring the crankshaft speed signal, the crankshaft position is sent to the ECU and the ECU uses that signal to calculate the basic ignition advance angle, basic fuel injection time. for engine.

There are 3 types of CKP sensor: Crankshaft position sensor magnetic sensor type, Hall type crankshaft position sensor and Optical type crankshaft position sensor.

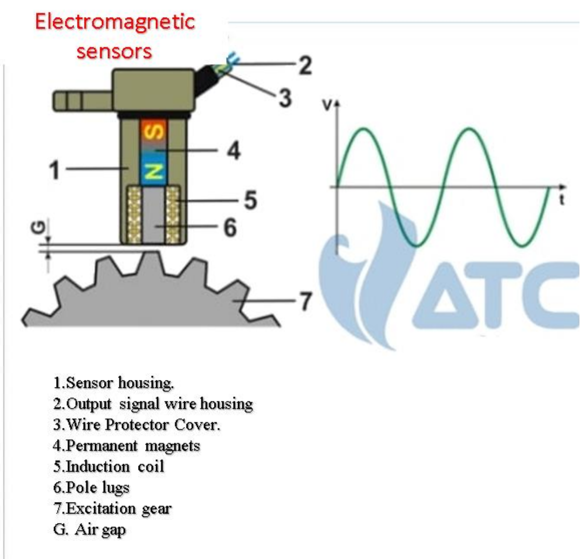

Figure3.1 Crankshaft position sensor magnetic sensor type.

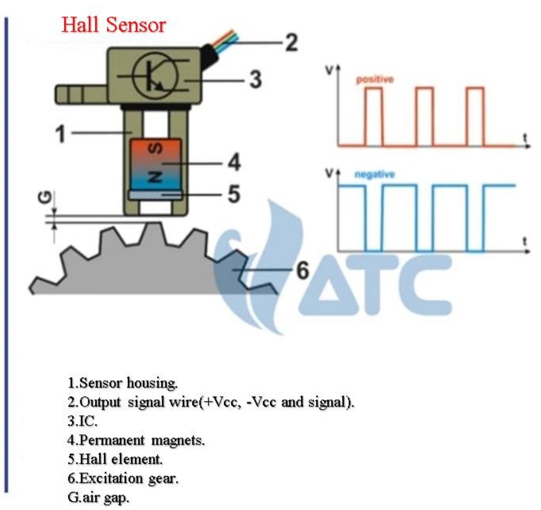

Figure3.2: Hall type crankshaft position sensor.

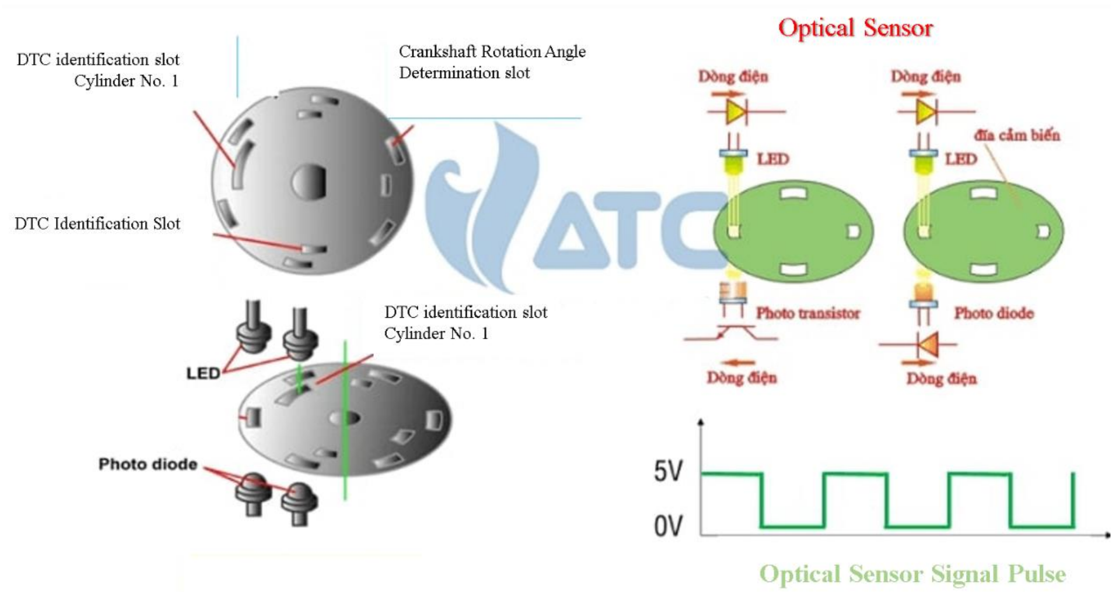

Figure3.3: Optical type crankshaft position sensor.

3.1.2 Microcontroller.

Arduino Uno R3:

Using Arduino Uno R3 to calculate desired engine speed control output PWM signal to another board Arduino Uno R3 to control fuel injection timing and ignition advance angle.

Microcontroller	ATmega328 with 8bit
Power	5V DC (USB only)
Working frequency	16 MHz
Digital pins	14 (6 pins for PWM)
Consumption current	30mA
input voltage	7-12V DC
Limit input voltage	6-20V DC

Analog pins	6
Maximum current per I/O pin	30mA

Table 3.1 Arduino's parameter.

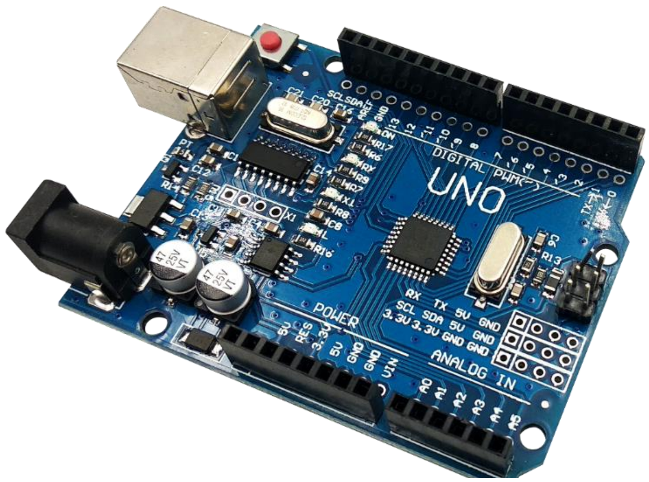

Figure 3.5: Arduino UNO R3

Advantages of Arduino:

- Simple structure, easy to use, low cost.
- Familiar C/C++ programming language.
- Working in a multi-OS environment, can be run on Windows, MacOS or Linux.
- Design programs can be loaded from a computer via a convenient USB cable.
- Having a diverse and rich library due to owning many users. This helps significantly shorten the project completion time.

Display

Serial Monitor:

- It is a separate pop-up window that acts as a separate terminal that communicates by receiving and sending Serial Data.
- Serial communication on pins TX/RX uses TTL logic levels (5V or 3.3V depending on the board)

3.2 Proteus Simulation.

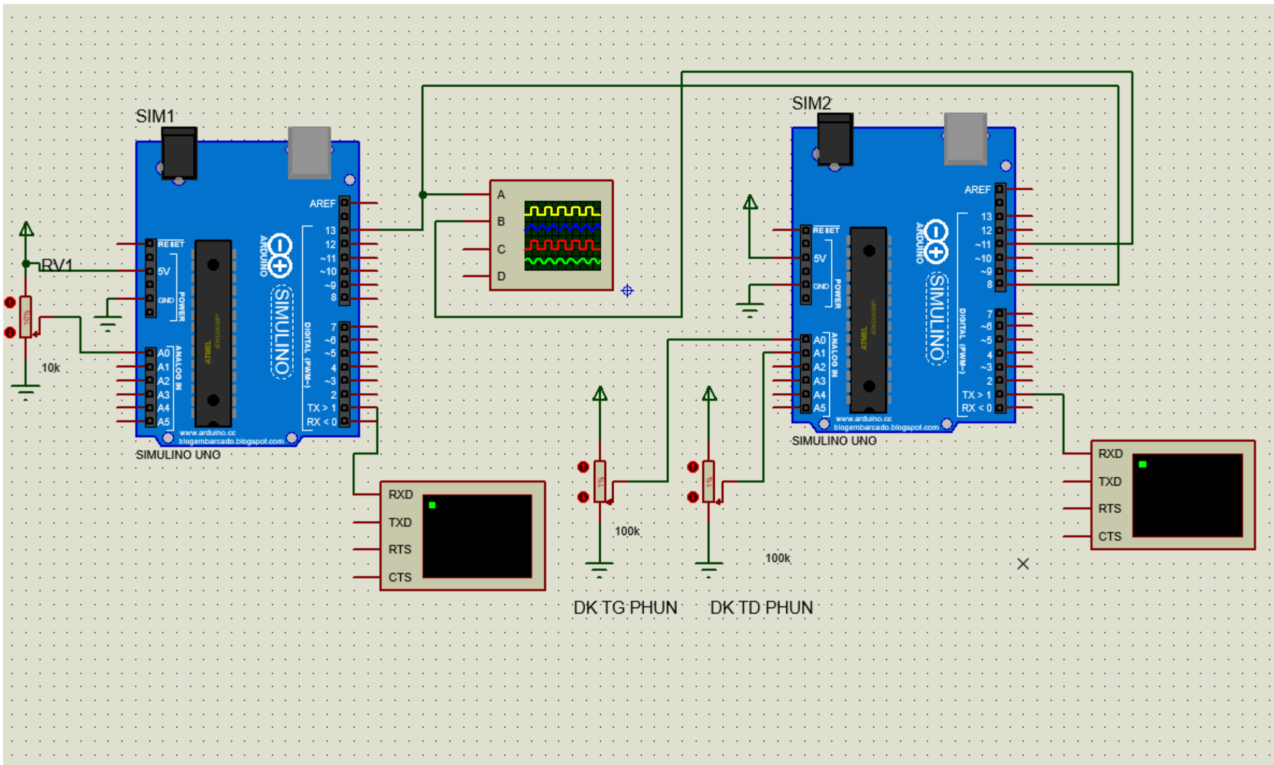

Figure 3.6: Electrical diagram in Proteus

- Using the Proteus Software to simulate the electrical diagram.
- Potentiometer is supplied by a 5V source. The output voltage of the potentiometer will connect to pin A0 on Arduino to adjust the speed of the motor from 120 rpm to 12000 rpm
- Transmit pulse signal to microcontroller to determine Top Dead Center calculation of desired fuel injection timing and injection time based on engine speed
- Using digital oscilloscope and virtual terminal to display the result.

3.2.1 Adjust the speed and keep the fuel Injection timing and Injection time

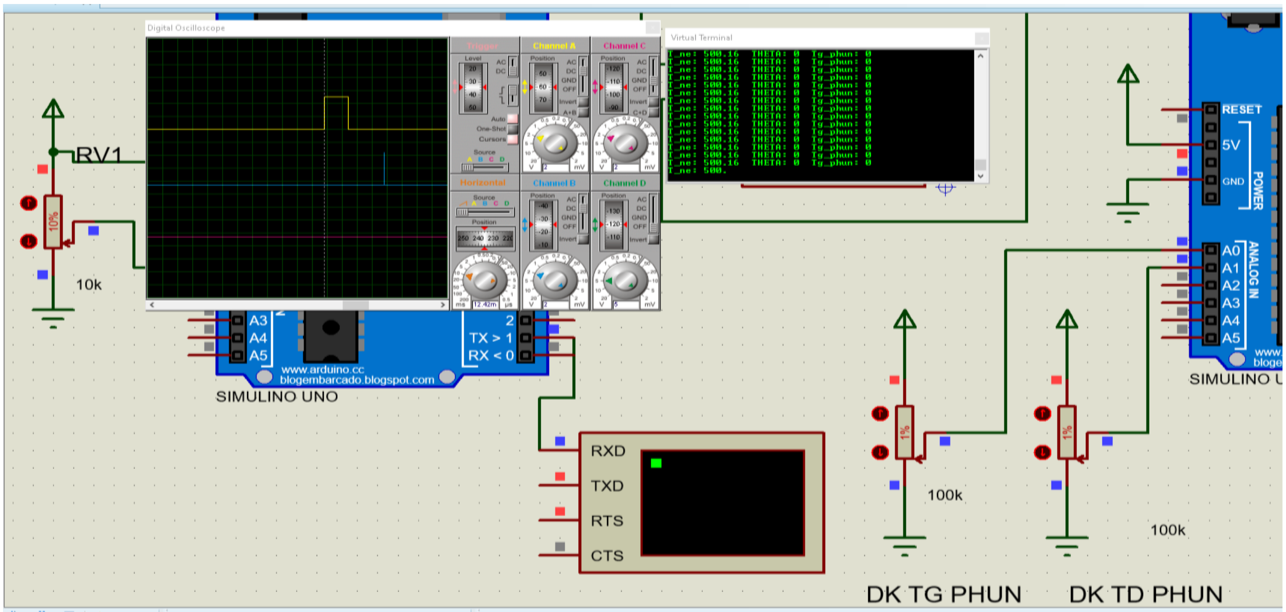

Figure 3.7: Speed at 120RPM, Injection timing at BTDC, Injection time is 0 ms

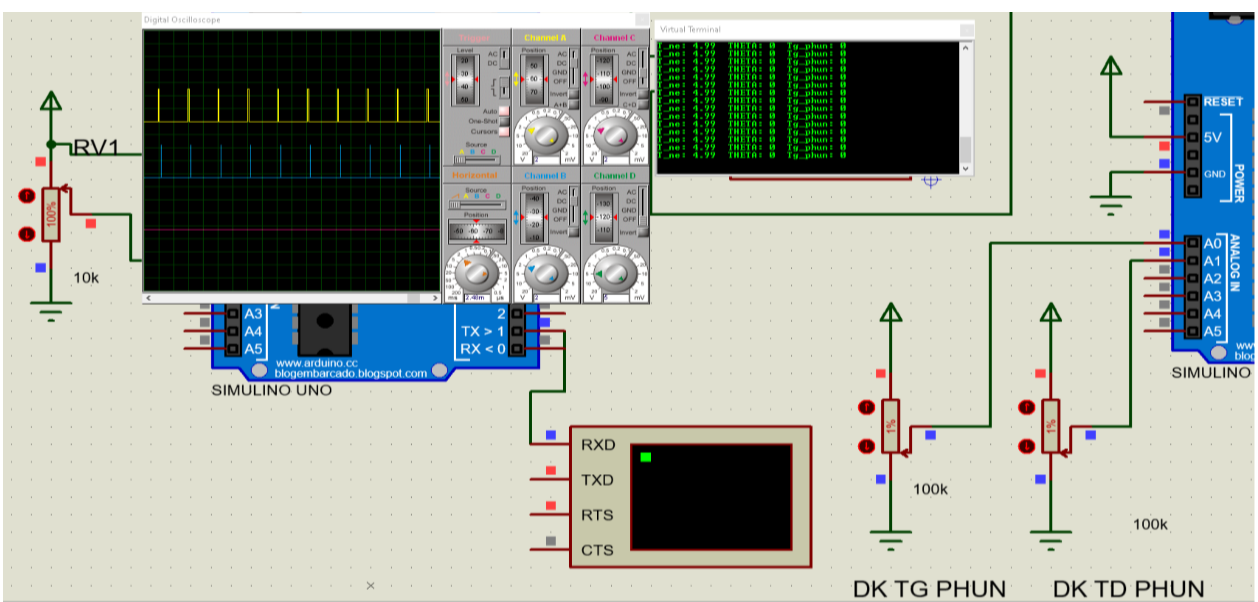

Figure 3.8: Speed at 12000RPM, Injection timing at BTDC, Injection time is 0 ms

3.2.2 Keep the same speed and adjust the fuel injection timing from 0-30º BTDC

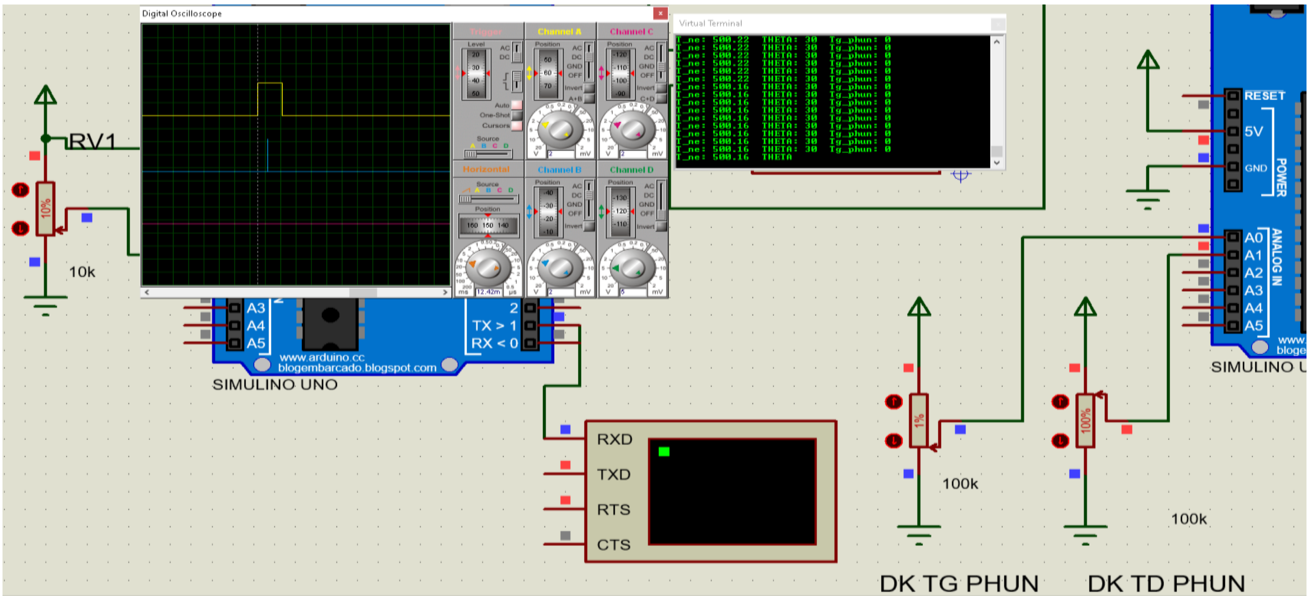

Figure 3.9: Speed at 120RPM, Injection timing at 30º BTDC, Injection time is 0 ms

3.2.3 Keep the same speed and the fuel injection timing adjust injection time.

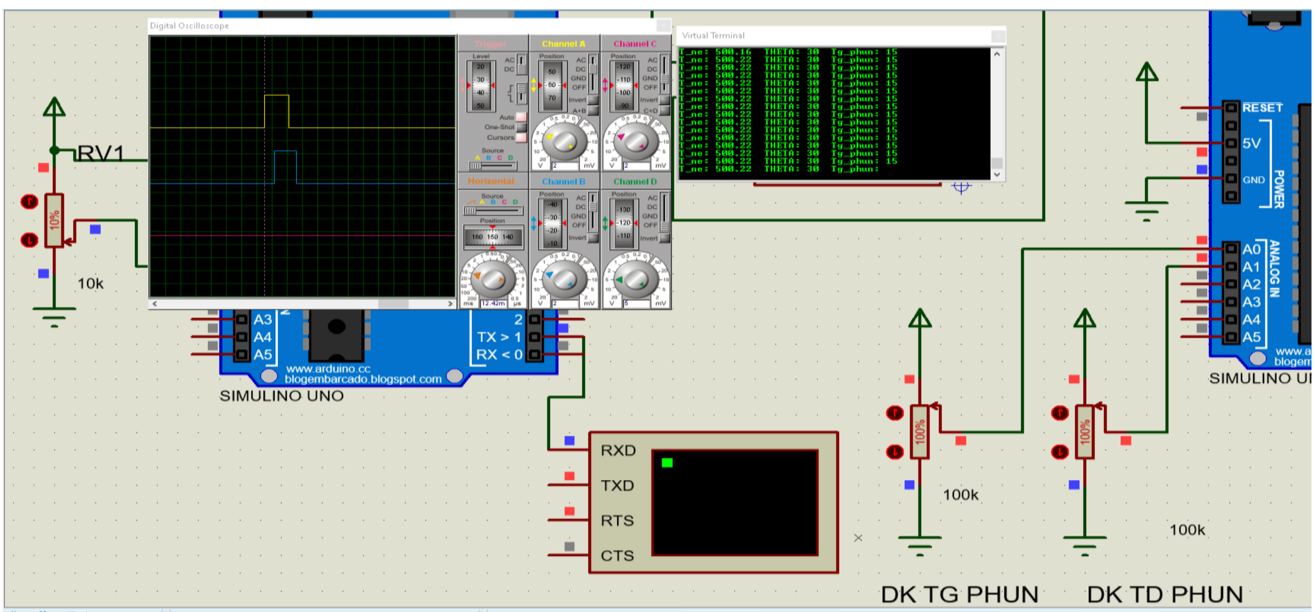

Figure 3.10: Speed at 120RPM, Injection timing at 30º BTDC, Injection time is 15 ms

IV. Conclusion:

After working on the project, design an algorithm to adjust the fuel injection angle and injection time based on the engine speed by using a microcontroller. The system has satisfied the following conditions:

- Using potentiometer adjust desired motor speed.
- Determine the desired fuel injection timing from 0 to 30^o BTDC based on the CKP signal.
- Fuel injection time is in accordance with the engine's rotation period

However, the system also has weakness:

- Lagging in displaying the value in proteus.

V. REFERENCE.

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