Arduino-Based Lubrication System Controller

🚀 Introduction

This project implements a smart lubrication system that adjusts pump speed based on engine RPM using an Arduino. It uses a 3-cell LiPo battery for power, a BTS7960 motor driver for pump control, an LM2596 buck converter for voltage regulation, and a 3D-printed settling chamber with one inlet and three outlets for lubricant distribution.

🧰 Components Used

Component	Specification / Function
Battery	3-cell LiPo (11.1V nominal, 12.6V fully charged)
LM2596	Buck converter used to step down voltage to power Arduino
BTS7960	43A H-bridge motor driver for controlling the DC lubrication pump
Lubrication Pump	Receives PWM-controlled voltage to vary lubricant flow
Settling Chamber	3D-printed; one input and three output ports (2 × 1mm, 1 × 1.4mm)
Arduino Uno/Nano	Microcontroller for logic and motor control
Voltage Divider	Two resistors (R1 = 19.8kΩ, R2 = 5.4kΩ) to scale down LiPo voltage for Arduino input
Creality Printer	Used to fabricate the custom 3D-printed settling chamber

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🪛 Wiring Diagram and Connections

🔌 Power Supply:

- **LiPo 3S Battery** powers:
    - The **lubrication pump** directly
    - The **Arduino** via the **LM2596 buck converter**

⚡ Voltage Divider (for Battery Voltage Monitoring):

- **R1 (19.8kΩ)**: Connect one end to LiPo **positive terminal**
- **R2 (5.4kΩ)**: Connect one end to **GND**
- The junction of R1 and R2 connects to **A0** on Arduino

🧠 Arduino to BTS7960 Motor Driver:

BTS7960 Pin	Arduino Pin
RPWM	D5
LPWM	D6
REN	D7
LEN	D8

🧩 Other Connections:

- A3 pin set to **INPUT** with **internal pull-down** to avoid floating

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🧪 3D Printed Settling Chamber

- Printed with **Creality 3D Printer**
- Dimensions: **1-inch diameter**, **2-inch height**
- **Inlet** placed at **mid-height** of the chamber
- **Three outlets** at the bottom:
  - Two outlets of **1mm diameter**
  - One outlet of **1.4mm diameter**
  - All outlets spaced **30° apart on the same plane**
- Entire structure 3D printed as a **single, integrated unit** for leak-free operation

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💻 Arduino Code Breakdown

📜 **Pin Definitions:**

const int RPWM = 5;

const int LPWM = 6;

const int REN = 7;

const int LEN = 8;

const int supplyPin = A0;

⚙️ **Voltage Divider Ratio:**

const float voltageDividerRatio = (19.8 + 5.4) / 5.4;

This calculates the scaling factor for mapping voltage read at A0 to actual LiPo voltage.

🧮 **Flow Rate Formula:**

float term1 = 0.2 * (rpm * rpm);

float term2 = 0.6 * rpm;

float constant = 3.5224;

flowRate = term1 + term2 + constant;

⚡ **Desired Voltage Based on Flow Rate:**

V = 0.0054 * flowRate^2 + 0.4961 * flowRate + 1.8575;

🧠 **PWM Duty Cycle and Application:**

int rawValue = analogRead(supplyPin);

float voltageOut = (rawValue / 1023.0) * 5.15;

float supplyVoltage = voltageOut * voltageDividerRatio;

int dutyCycle = (desiredVoltage / max(supplyVoltage, 1.0)) * 255;

dutyCycle = constrain(dutyCycle, 0, 255);

```
    analogWrite(RPWM, dutyCycle);
    analogWrite(LPWM, 0);
```

🖨️ **Debug Serial Output:**

Logs real-time system status every 10 seconds:

- Raw ADC values
- Battery voltage
- RPM and flow rate
- Calculated voltage and PWM duty

📊 **System Workflow Summary**

1. Read battery voltage via A0 (using voltage divider)
2. Accept RPM input (manual for now)
3. Compute flow rate using a quadratic model
4. Derive voltage required to achieve that flow rate
5. Translate voltage to PWM duty cycle
6. Send signal to BTS7960 to control the pump speed
7. Pump circulates lubricant into the settling chamber and outlets

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📌 **Future Enhancements**

- Integrate RPM sensor for dynamic input
- OLED/LCD screen to monitor system status
- Add low-voltage cutoff for battery protection
- Build waterproof housing for harsh environments

👤 Author & Credits

This system was engineered using:

- 3S LiPo Battery
- LM2596 Voltage Regulator
- BTS7960 Motor Driver
- Arduino (Uno/Nano)
- Custom 3D-Printed Settling Chamber

Printed using **Creality 3D Printer** and tested in a lubrication setup with dynamic output ports.

End of Documentation.