PID/PI-Based LED Illuminance Control Using BH1750 Feedback

Microprocessor Lab Project (Concept Description)

December 22, 2025

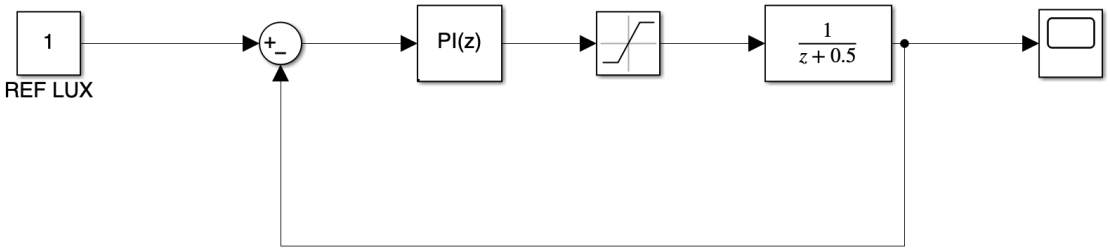
1 Project Idea

The goal of this project is to automatically regulate the brightness of an LED by adjusting the PWM duty cycle based on real-time illuminance feedback measured by a BH1750 digital light sensor. The desired illuminance level (reference) is compared with the measured illuminance, producing a control error. A discrete-time PI controller processes this error and updates the PWM duty cycle such that the measured illuminance tracks the reference value.

This is a classical closed-loop feedback control system. Proportional action provides fast reaction to deviations, while integral action eliminates steady-state error and helps compensate disturbances such as changes in ambient light.

2 Control Structure

- Reference input L_{ref} (lux),
- Feedback signal L_{meas} (lux) from the BH1750 sensor,
- Discrete PI controller (implemented in the microcontroller),
- Saturation/nonlinearity block to model PWM duty cycle limits,
- Plant model representing the LED + optics + sensor dynamics.



3 Hardware Implementation Concept

The LED is driven using PWM from a microcontroller timer channel. A MOSFET is used as a low-side switch to control current through the LED. The BH1750 sensor (connected via I^2C, not shown in the power schematic) measures the resulting illuminance in lux and provides the feedback signal to the controller.

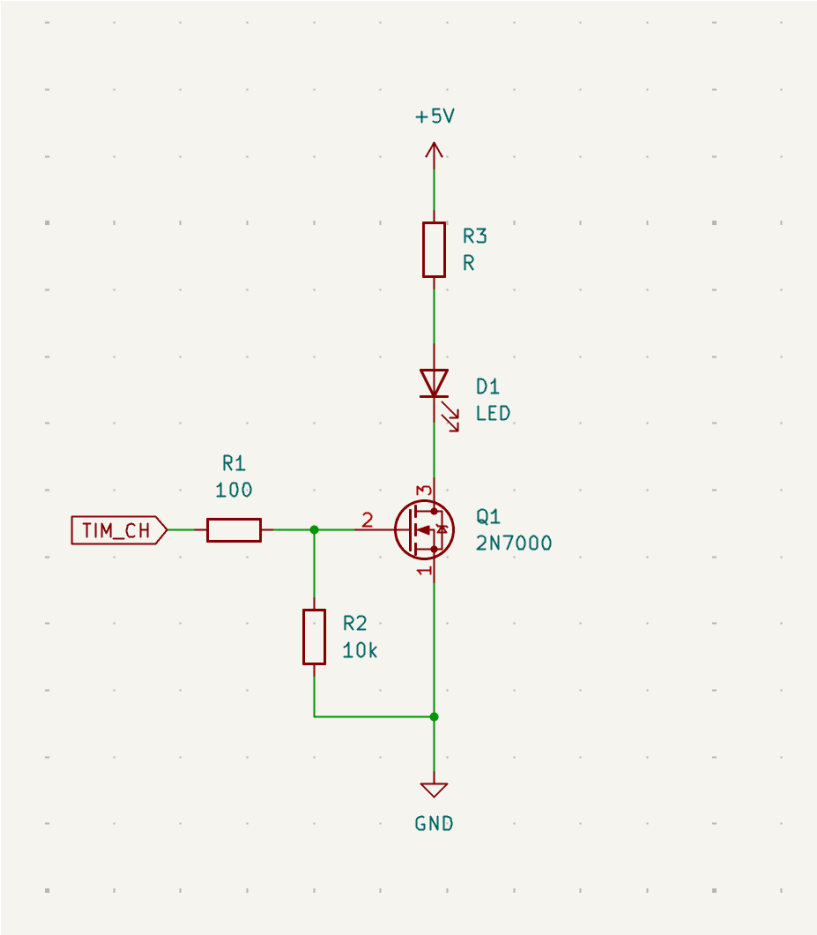


Figure 1: Conceptual LED driver: PWM timer channel drives an N-channel MOSFET (2N7000) as a low-side switch. R1 is a gate resistor, R2 is a pull-down to ensure the MOSFET remains off during reset, and R3 limits LED current.

4 Ideas to Be Added and Extended Experiments

Several extensions can be considered to further demonstrate the robustness and practical behavior of the proposed control system.

- **Disturbance :** An additional LED or external light source can be introduced as a controlled disturbance. The PI controller should compensate for variations in ambient illuminance and restore the measured lux value to the desired reference level.
- **Measurement filtering CMSIS-DSP:** Digital filtering of the illuminance measurements can be introduced using a simple FIR low-pass filter (e.g., implemented with the CMSIS-DSP library). This filtering step can reduce measurement noise and prevent unnecessary fluctuations of the PWM duty cycle, improving overall control smoothness.