USB-Powered LED Dimmer Board

Overview

This board is a compact USB-powered LED dimmer that uses a 555 timer (NE555P) in astable mode to generate a pulse-width modulated (PWM) signal. The PWM signal controls the brightness of an LED strip via an NMOS transistor. Designed for educational and prototyping purposes, it demonstrates power protection, ESD safety, and efficient PWM control in a double-sided PCB.

Key Features

- Power Source: 5 V from USB-B connector
- Output Device: NMOS transistor driver for LED strip
- Control: Adjustable PWM frequency and duty cycle (up to ~1.2 kHz)

- **Protection**:
  - Polyfuse (F1): Protects against overcurrent and accidental short circuits
  - USBLC6-2SC6: ESD protection for USB data lines (D+ / D–)

- **PWM Generation:**
  - NE555P in astable mode
  - Adjustable resistor network (R1, R2) sets frequency and duty cycle
  - Diode (D1) enables asymmetric charge/discharge for smoother control

- **Switching Stage:**
  - N-channel MOSFET (Q1) used for high-current LED strip control
  - LED indicator (D2) demonstrates output operation

Operation

- The 555 timer outputs a PWM waveform whose duty cycle determines LED brightness.
- Higher duty cycle → higher average voltage → brighter LED.
- The PWM frequency (~1.2 kHz) is above the human flicker perception limit, ensuring steady illumination.
- The NMOS transistor acts as a low-side switch, handling the load current while isolating the 555 timer from power-hungry LEDs.

PCB Design Highlights

- Compact 2-layer KiCad layout with clear separation between control and power paths.
- Wide copper traces for output current flow to LED load.
- Ground plane to minimize noise and improve thermal performance.
- USB input stage placed near the board edge for easy connectivity and ESD isolation.

Applications

- LED strip dimming and testing
- Learning 555 PWM control and MOSFET driving
- USB-powered electronic demonstrations