

Keyboard Backlighting Using the 96 LED Matrix Driver LED171596A

Randy Dahl, Eric Sato

ABSTRACT

Today, advanced keyboards use LED matrix drivers to control the light behind each individual key. This control allows for an even distribution of light across the keyboard and lighting customization for different applications. A single LED171596A matrix driver is capable of controlling up to 96 LEDs across 24 channels, which can provide enough backlighting for a keyboard (without a number pad). Other specifications include a dimming resolution of 17 bits, a ghosting cancellation setting, a peak current of 60 mA per channel, and an average current of 15 mA per channel. Additional LED matrix drivers can also be added to create RGB lighting effects on the keyboard. This application note discusses how the LED171596A device can be used to drive keyboard backlights.

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1 Keyboard Backlight Implementation

In this application, the LED171596A is connected to a keyboard. A human interface device (HID) controller is also attached to the LED driver, which allows the user to change the LED lighting effects. For keyboards that have more than 96 keys, additional matrix drivers can be cascaded together. In the demo, different patterns are shown to display the numerous possibilities for controlling each LED individually. All of the LEDs are monochromatic in this example.

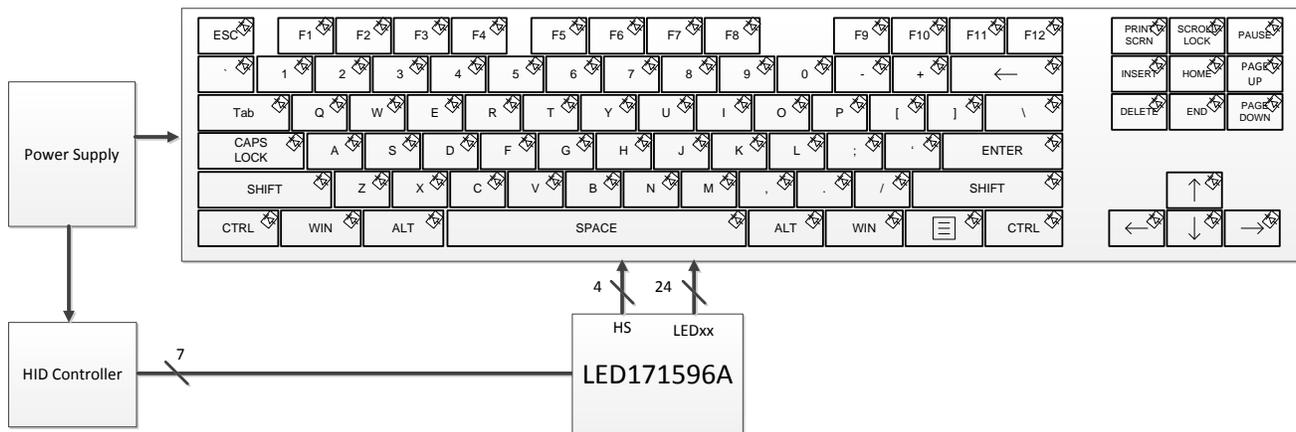


Figure 1. LED171596A LED Matrix Driver With Monochromatic Keyboard

The LED171596A also has the capability to use RGB lighting. This application is useful because RGB gaming keyboards and laptops are growing in popularity in recent years. The configuration shown in [Figure 2](#) requires at least three LED drivers for the RGB setup to work. However, the LED171596A still benefits from its compact design.

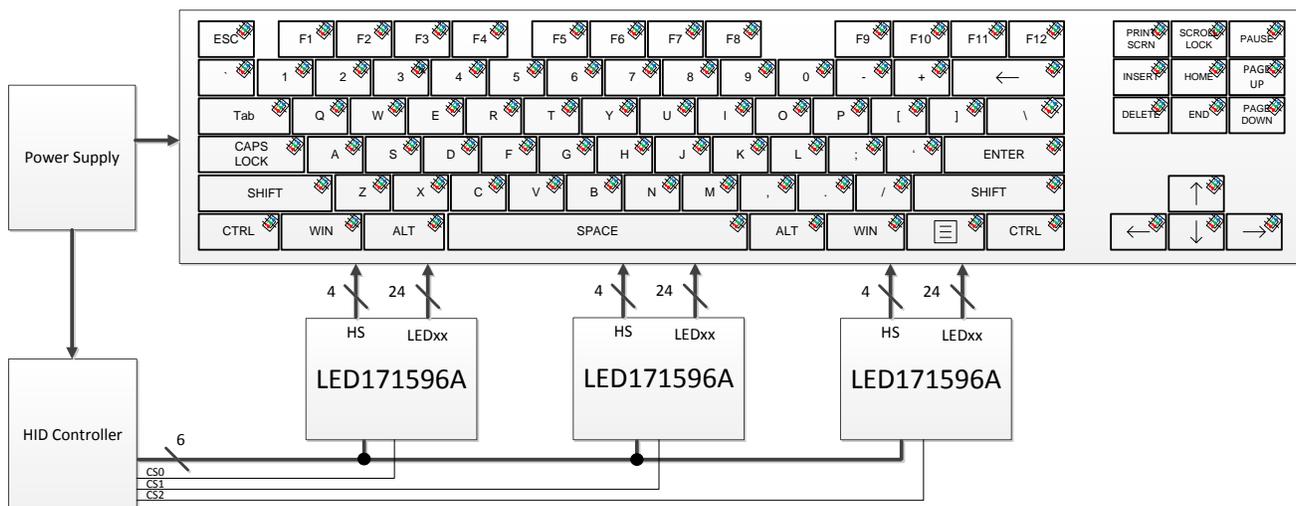


Figure 2. LED171596A LED Matrix Driver With RGB Keyboard

2 Design Overview

The LED171596A comes with 24 programmable current sinks and 4 high-side PMOS switches. The maximum peak current for each LED is 60 mA, but the average current is only 15 mA as each LED only gets a quarter of the time to stay on before the cycle repeats. The brightness of each LED can be modified with the I²C or the SPI interface.

The LED171596A has many advantages. Even though the matrix driver provides independent dimming control for 96 LEDs, it requires only 28 pins (24 for the programmable current sinks and 4 for the high-side PMOS switches) to access all 96 LEDs. There is also less need to cascade it with additional matrix drivers due to the large number of LEDs that the driver can control. However, cascading does become necessary when RGB effects are added, or more than 96 LEDs need to be turned on. Additionally, the LED171596A has special features such as ghosting cancellation and sloping to improve the backlighting quality. See the [LED171596A data sheet](#) for more information.

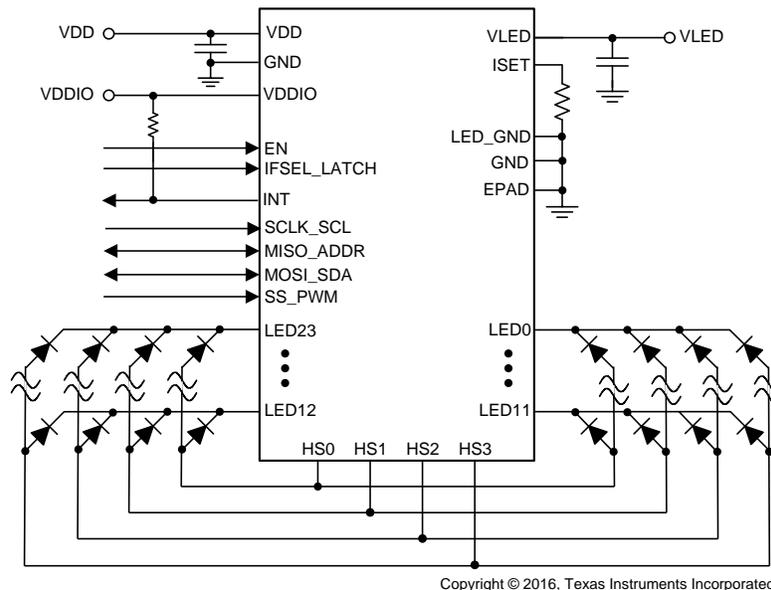


Figure 3. LED171596A Schematic

As the schematic in [Figure 3](#) shows:

VDD connects to 3.3 V to power the analog and digital circuitry.

VDDIO connects to a power supply to provide the voltage for the logic pins.

EN enables the device.

INT is the interrupt pin, which can indicate fault condition detection or sloper completion.

IFSEL_LATCH configures the protocol. The LED171596A supports two protocols: I²C and SPI. I²C uses three pins for simpler light patterns, while SPI uses four pins for more complex light patterns. The keyboard demo uses the SPI protocol.

SCLK_SCL, MISO_ADDR, and MOSI_SDA are the controls for I²C and SPI.

SS_PWM is used to control the SPI slave select. In addition, it is used as the global PWM input, which enables the master PWM brightness control.

LED0 to LED23 are the constant-current outputs. Each one controls 4 LEDs.

HS0, HS1, HS2, and HS3 are the high-side PMOS switches. Only a single switch can be on at a time.

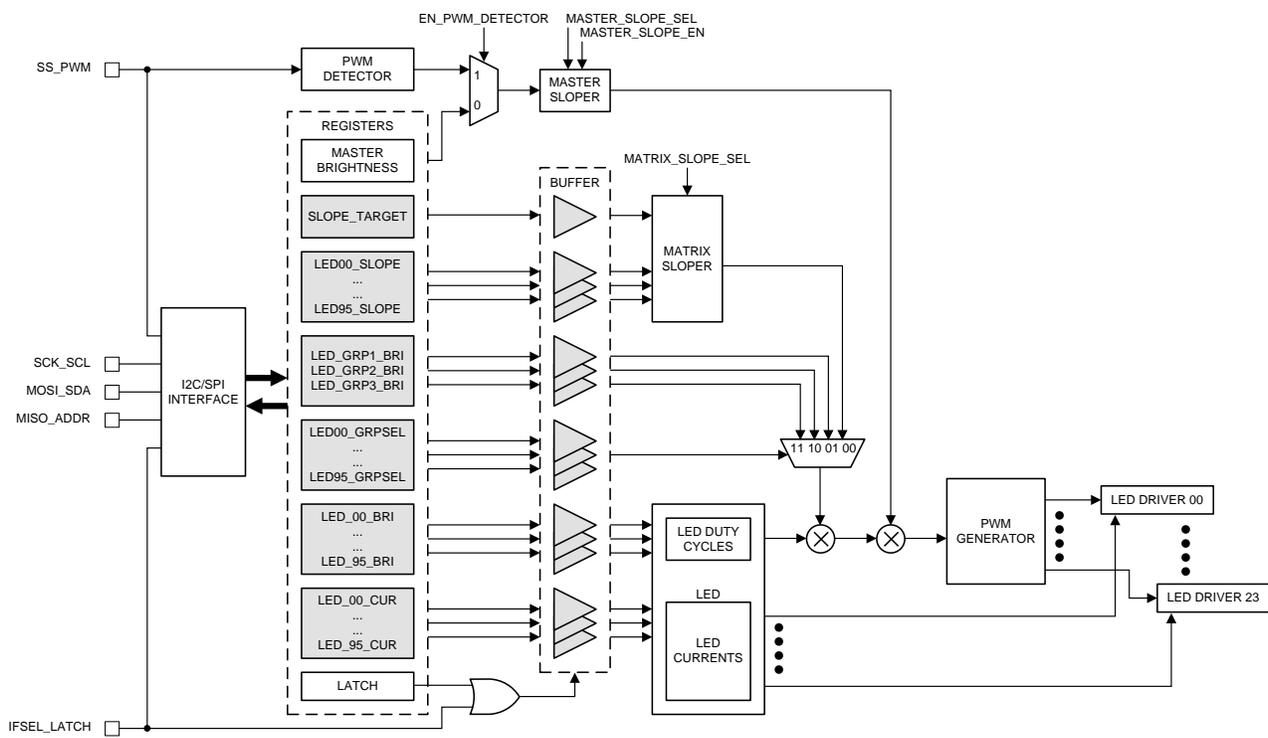
ISET sets the maximum current for each current sink.

VLED connects to a power supply to provide the voltage for the high-side switches.

3 Brightness Control

There are two independent methods to control the brightness of the LEDs. The first method involves changing the maximum current through each LED string. The second method uses pulse width modulation (PWM). Both are used in tandem to dim and brighten the LEDs. In the keyboard demo, the individual LED currents are calibrated so that each key is given the proper amount of light from the LEDs. For example, the Windows key requires less light than the period key because there is more of an opening on the key for the light to illuminate it. Calibrating each LED current provides uniform keyboard lighting after applying the master brightness PWM to dim or brighten the entire keyboard.

The brightness controls use 17 bits for each LED brightness adjustment. PWM uses 9 of these bits, whereas the current control uses 8 of these bits. This allows for smoother brightness transitions and more uniform LED displays. The LED171596A provides 96 current and 96 PWM brightness registers to control the LEDs. The individual current can be controlled with registers LED00_CUR (0x100) through LED95_CUR (0x15F). The individual PWM can be controlled with registers LED00_BRI (0x160) through LED95_BRI (0x1BF). Additionally, there is a master PWM that can affect the brightness of all of the LEDs. It can be controlled with register MASTER_BRI (0x1C0).



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Figure 4. Brightness Path

4 Summary

The LED171596A is designed to enhance keyboard backlighting. The compact design, the independent current and PWM controls per LED, and the additional features are substantial improvements over past LED matrix drivers. Moreover, this device has the versatility to use either monochromatic or RGB lighting, which can provide users with more options to customize their keyboard lighting effects.

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