LUMISSIL MICROSYSTEMS

IS31FL3761
Lumissil's latest full featured matrix LED driver

LED lighting has become a popular method for displaying device operational status. It is relatively simple to individually drive several LEDs. However, as the number of LEDs increases, the number of I/O hardware pins required to individually operate these LEDs grows to an unmanageable level. Driving large numbers of LEDs requires the use of a scanning matrix architecture.

In a matrix format, LEDs are arranged in rows and columns and driven using multiplex scanning. The multiplex sequence requires a complex scan timing which is the most efficient method for driving a large number of LEDs (over 50) from a single IC package.

Each LED in the matrix can be addressed by specifying its location in terms of row (CSx) and column (SWy) position. For example, in Figure 1, the top-left LED is addressed in software as (SW1,CS33). This method of addressing also indicates the flow of electrical current. To turn ON this LED, current must flow from SW1, through the LED, and down the CS33 current sink. The other LEDs remain off because their respective row and column switches are not enabled, preventing current flow.

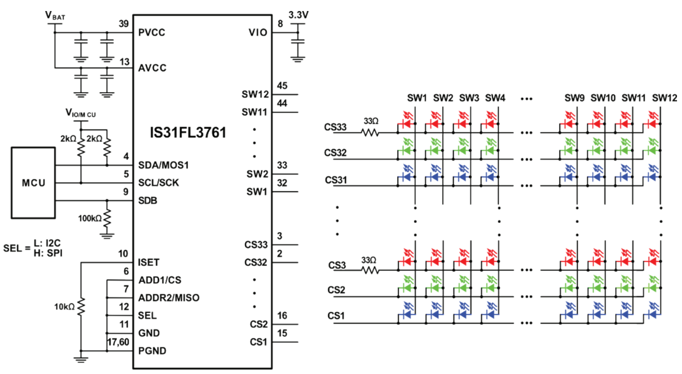

Figure 1 IS31FL3761 Application Circuit

BRIGHTNESS CONTROL VIA PULSE WIDTH MODULATION (PWM)

LEDs are current-driven devices, meaning their light output depends on the current flowing through them. Adjusting the current to control LED brightness (analog dimming) is not common because it requires a highly precise current source or sink. It is more common to implement digital dimming using Pulse Width Modulation (PWM). With PWM, each CSx LED is turned on to the full LED current for a specific duration within a given SWy PERIOD. The ratio of the LED ON time to its period is known as the LED duty cycle. For example, in Figure 2, the red LED has a 75% (75ms/100ms) duty cycle, the green LED has a 50% duty cycle, and the blue LED has a 25% duty cycle. Using PWM diming on RGB LEDs will result in the blending of different light intensities of Red, Green, and Blue to create unique colors.

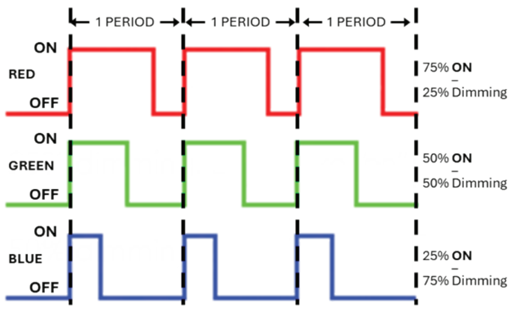

Figure 2 RGB PWM Color Mixing

PERSISTENCE OF VISION

By combining a scanning matrix with PWM, it's possible to individually control the brightness of each LED within the matrix array. The process involves several steps: first, a column (SWy) is enabled to power all current sink rows (CSx). Then, individual PWM timing is activated for each CSx current sink. After one period duration, the process repeats by enabling the next SWy and applying new PWM values to the CSx current sinks. This sequence continues until the last SW12 is enabled, after which the sequence restarts with SW1, see Figure 3.

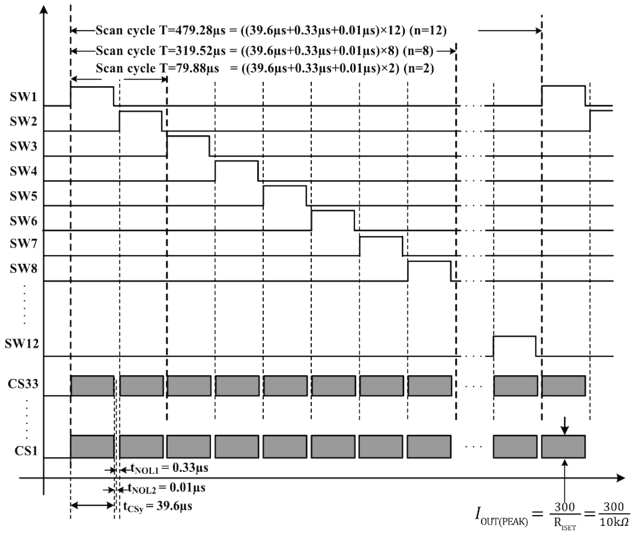

Figure 3 Scan Cycle Timing for IS31FL3761

This scanning sequence is repeated rapidly enough that the human eye perceives all columns (SWy) as being enabled simultaneously. This technique leverages a phenomenon known as "persistence of vision," where an LED that is briefly turned ON and then turned OFF but is still perceived as being ON. This effect allows matrix LED drivers to create the illusion that all LEDs in the matrix are ON at the same time, despite only one column being active at any given moment.

The persistence of vision effect is beneficial for matrix scanning, making it appear that all LEDs in the array are ON. However, since LEDs are current-driven devices, this effect naturally results in dimmer light output. This can be quantified as a lower average LED current, ILED(AVG). Despite the LED driver being set to a specific maximum current, the average LED brightness will be lower than expected due to the matrix scanning and the persistence of vision effect.

For example in Figure 3, when n = 12, the average LED current LED ILED(AVG) can be calculated by:

$$I_{OUT(PEAK)} = \frac{300}{R_{ISET}} = \frac{300}{10k\Omega} = 30\text{mA; this is the max } CS_x \text{ current}$$

$$I_{LED(AVG)} = I_{OUT(PEAK)} \times \text{Duty; where,}$$

$$Duty = \frac{t_{CSx}}{(t_{CSx}+t_{NOL1}+t_{NOL2})} \times \frac{1}{n} = \frac{39.6\mu s}{(39.6\mu s+0.33\mu s+0.01\mu s)} \times \frac{1}{12} = \frac{1}{12.1}$$

In the equations above, RISET is the resistor value used for setting the max LED driver current. For calculating Duty when n=12, the values are as follows: tCSx, the period that CSx is ON, is 39.6µs; is, tNOL1, the non-overlap time used for de-ghost (discharge of parasitic array capacitance), is 0.33µs; and tNOL2, the CSx delay time, is 0.01µs.

The calculations show that when n=12, the average LED current (brightness) will be 1/12.1. When n=8 it will be 1/8.07, and when n=2 it will be 1/2.02. Simplified, the average LED current is IOUT(PEAK)/n. Therefore, the fewer SWy (n), the brighter the LEDs will be for the same RISET current setting.

IS31FL3761

Lumissil's latest matrix driver, the IS31FL3761 is a high-performance LED matrix driver that integrates 33 constant current sinks (CSx) with a selectable number of switching MOSFETs (SWy), n (n = 1~12). As discussed previously, matrix LEDs operate with a matrix scan timing, and the scan cycle duration depends on the number of SWy switches (n) that need to be cycled. The ability to select the scan size allows designers to use a single matrix driver for different LED array sizes, reducing software development and inventory costs by enabling the reuse of the same matrix driver in various designs.

The IS31FL3761 matrix driver can be configured for either I2C (1MHz) or SPI (12MHz) interfaces for programming or reading the device registers. For instance, the IS31FL3761 can detect and store LED open or short conditions in Open/Short Registers, which the MCU can read via the I2C or SPI compatible interface.

For accurate blending of RGB LEDs, the IS31FL3761 supports both analog and PWM dimming methods. In analog dimming, the current for each LED can be individually adjusted, or all LEDs in the array can be globally adjusted with 256 current levels. The driver also features 8 or 12-bit configurable PWM generators for smooth digital dimming. As previously discussed, turning the LEDs ON/OFF with a varying duty cycle provides the capability for dimming and blending RGB LED colors.

To mitigate any electromagnetic interference (EMI) and audible noise generated by these PWM generators, the IS31FL3761 incorporates spread spectrum and group phase shifting techniques reducing EMI, audible noise, and power supply ripple.

Operating from 2.7V to 5.5V, the IS31FL3761 features very low shutdown and operational current. It functions over a temperature range of -40°C to +125°C and is available in a QFN-60 package. An automotive-grade version (IS32FL3761) with PPAP in accordance with AEC-Q100 is also available.

Lumissil continues to grow its LED driver portfolio. Visit our website www.lumissil.com to explore our latest product offerings. Contact us for samples, evaluation boards and sample code.