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Configurable IC Enables Flexible And Efficient LED Lamp Driver

by Serhiy Prykhodko, Dialog Semiconductor, Lviv, Ukraine

LEDs have high efficiency and brightness, which makes them the performance leaders in many lighting applications. However, the LED driver can also play a key role in the performance of these applications. Among the many LED driver ICs available to designers, a new, high-voltage version of Dialog Semiconductor's GreenPAK configurable, mixed-signal matrix IC, the SLG47105, offers particular advantages when configured as a LED driver.

This chip, which is also known as the HV PAK, enables a very compact driver design that is simultaneously very flexible and highly efficient. Meanwhile, any function implemented within this LED driver can be improved or modified due to the IC's flexibility.

This article describes the configuration of the HV PAK as an LED driver with brightness and color temperature control. In this case, the SLG47105^[1] is configured as the LED driver with four buttons to control LED brightness and color temperature. These features are useful for LED table lamps (see Fig. 1) or other lighting fixtures. In support of this article, there are design files which can be found in the Reference section.^[2-4]



Fig. 1. An example LED table lamp.

Construction And Control

The design has four inputs for the LED driver control, as shown on Fig. 2:

- Pin#3—increase lamp brightness
- Pin#17—decrease lamp brightness
- Pin#14—shift color temperature to the warm range
- Pin#2—shift color temperature to the cold range.

The general block diagram for the SLG47105 can be found in Fig. 3.

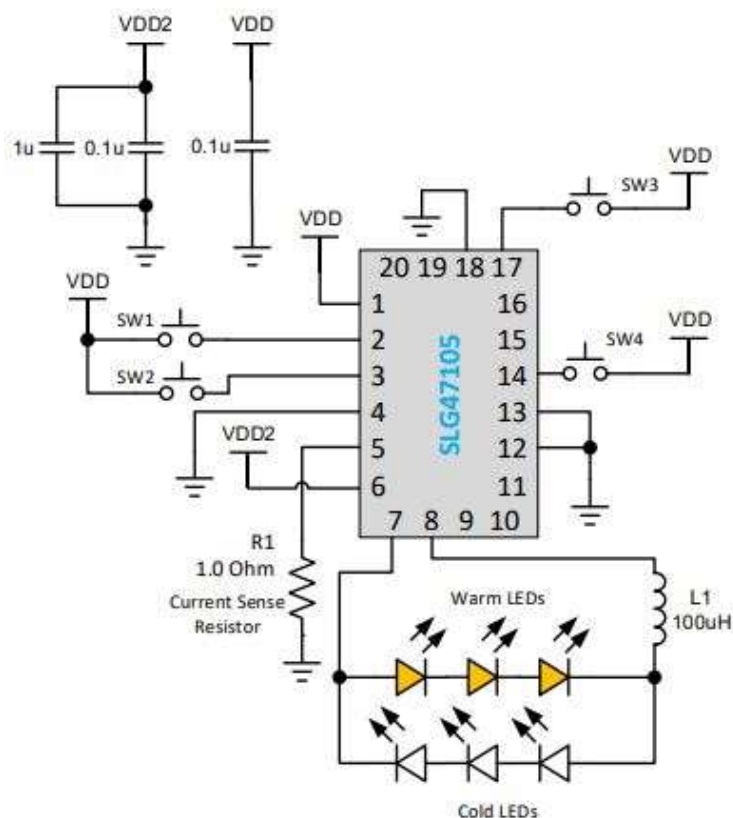


Fig. 2. The proposed application circuit for an HV PAK configured as an LED driver with color brightness and color temperature controls.

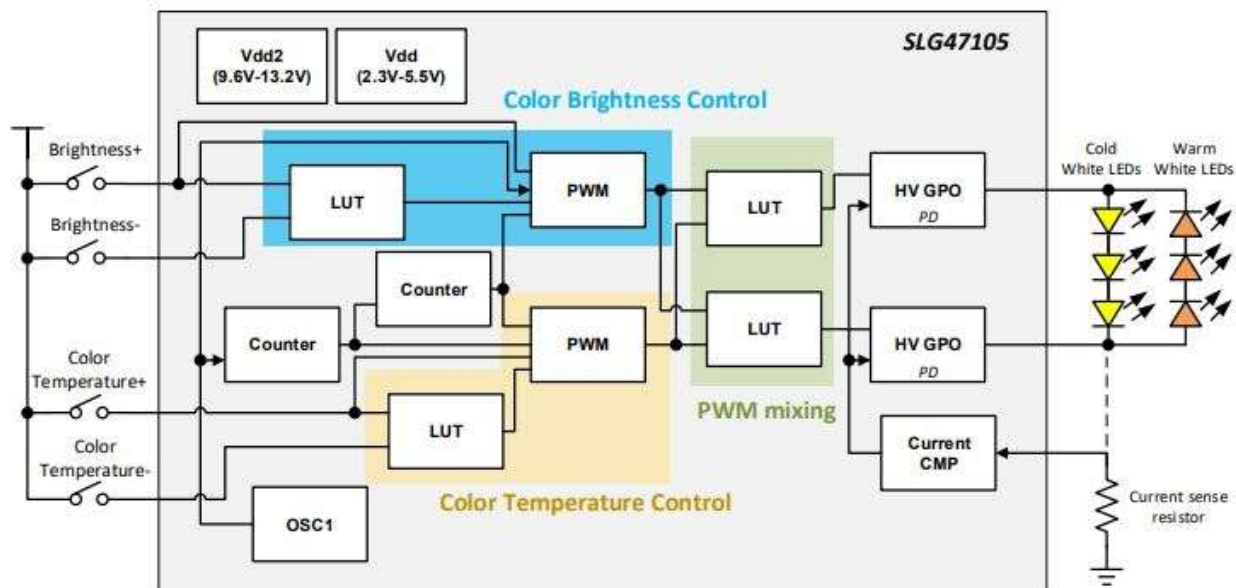


Fig. 3. The internal block diagram of the SLG47105 configured for the proposed LED driver circuit.

As shown in both Figs. 2 and 3, the driver controls current to two LED strings—one using white LEDs that emit a cold white color temperature, and another using white LEDs that emit a warm white color temperature. The table below specifies the range of wavelengths produced by an example LED series at the specified drive current. The resulting light temperature will be selected in this range.

Table. Peak wavelengths of emitted light for the two LED types.

Name	Current (mA)	Voltage (V)	Power (W)	Emitted color	Peak wavelength (nm)
GNL-5630UWC-Y50	150	3.2	0.5	Warm white	2800K-3200K
GNL-5630UWC-C50				Cold white	5500K-7000K

In this design example, the LEDs were used without a PCB. Because of the resulting thermal limitations, the LED current was limited to 100 mA. In Fig. 3, Current CMP is a comparator that senses the LED current and disables HV OUTs when LED current is higher than 100 mA.

The reference voltage required for the current comparator is

$$V_{ref_CCMP} = I_{LED_MAX} * GAIN_{CCMP} * R_{SENSE} = 100 \text{ mA} * 8 * 1 \Omega = 800 \text{ mV}$$

The power supply voltage for three LEDs connected in series should be higher than 9.6 V (3.2 V x 3). Since the maximum voltage is 13.2 V for the SLG47105, this LED voltage requirement is well within the IC's range. Figs. 4 and 5 show LEDs connected to an evaluation board implementation of the LED driver design with warm and cold LEDs each alternately turned fully on. Buttons SW1 and SW4 allow setting the color temperature anywhere in between the extremes.



Fig. 4. The HV PAK eval board configured with the proposed LED driver design, operated with buttons set for warm LEDs on and cold LEDs off. The warm LEDs produce a yellowish light.



Fig. 5. The same LED driver circuit operated with buttons set for cold LEDs on and warm LEDs off. The cold LEDs produce a whiter light.

Configuring The Chip

Design Operation

In the LED driver circuit, there are two PWM blocks, as shown in Fig. 6.

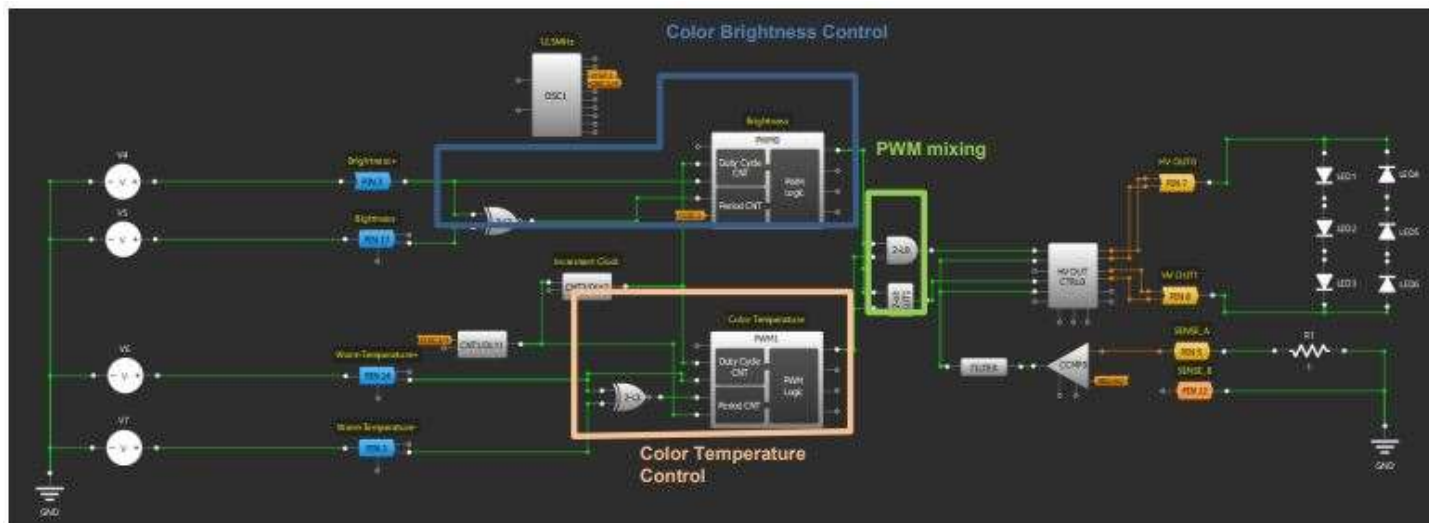


Fig. 6. A design view of the HV PAK's internal circuit blocks as seen in the configuration tool.

The PWM0 block (shown inside the dark blue box) generates a 49-kHz frequency and controls the LEDs' overall brightness (for cold and warm LED strings together) using the PWM duty cycle. The duty cycle can be changed by PIN3 (increase) and PIN17 (decrease) in a range from 0% to 100%. The high level on PIN3 or PIN17 disables the PWM0 KEEP signal through NXOR 2-L2, and CNT2 starts to clock the duty cycle. The KEEP signal is active when PIN3 and PIN17 are low or high together.

The PWM1 block (shown inside the tan box) generates a PWM signal with 120-Hz frequency to control the LEDs' color temperature. When PWM1 OUT is high, then only warm LEDs are turned on, and when OUT is low—only cold LEDs are turned on (Fig. 7). The PWM1 duty cycle can be changed by PIN14 (increase) and PIN2 (decrease). The buttons for PWM1 work similarly to PWM0 control buttons.

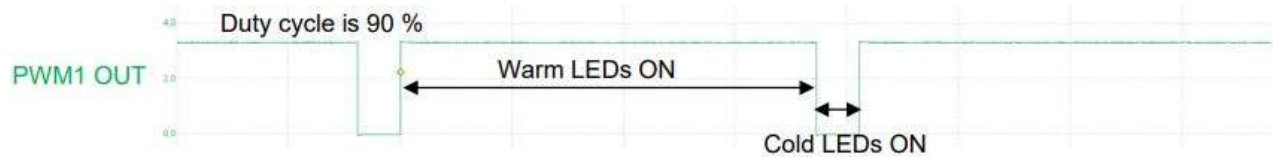


Fig. 7. The PWM1 OUT signal.

The PWM1 signal is modulated by the PWM0 signal, as shown on Fig. 8. As a result, the general brightness depends on the PWM0 duty cycle and the color temperature depends on the PWM1 duty cycle.

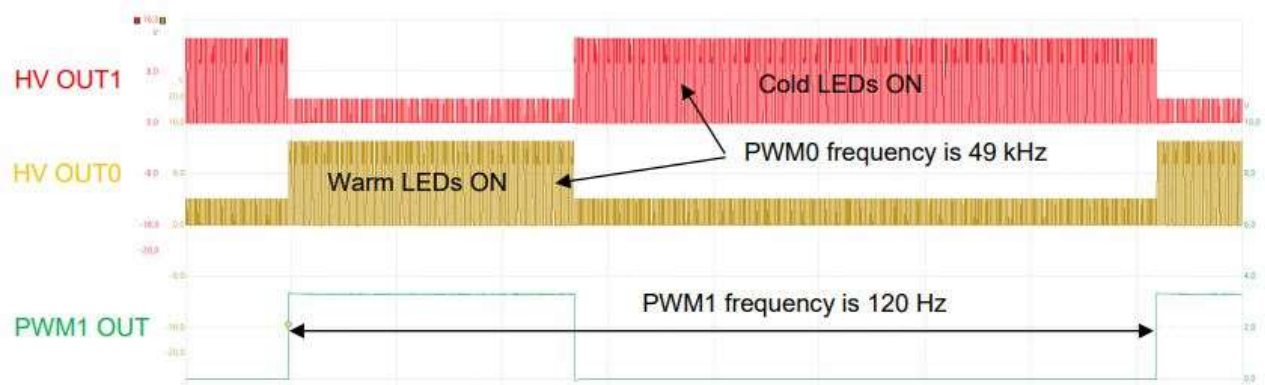


Fig. 8. The modulated PWM1 signal.

Current Limitation

As noted previously, the CCMP turns off HV OUTs when current is higher than 100 mA. Fig. 9 depicts how the PWM0 waveform, which controls brightness, responds to the LED current exceeding the current-limiting threshold.



Fig 9. Current limitation. When LED current exceeds the 100-mA threshold, the PWM0 output, which controls brightness, goes low.

Driver Output Behavior

The following example waveforms depict driver behavior in the cases where only the warm LED string is active (Fig. 10), only the cold LED string is active (Fig. 11) and the “neutral” light case (Fig. 12) where both strings shine at the same time.

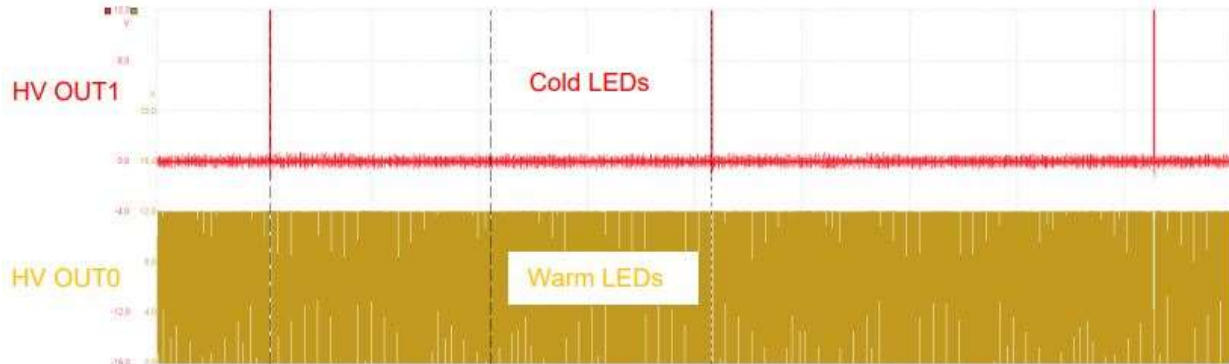


Fig. 10. Warm LEDs on max brightness. Current goes from HV OUT0 to HV OUT1 through the warm LED string only. So the cold LEDs are not active.



Fig. 11. Cold LEDs on max brightness. Current goes from HV OUT1 to HV OUT0 through the cold LED string only.

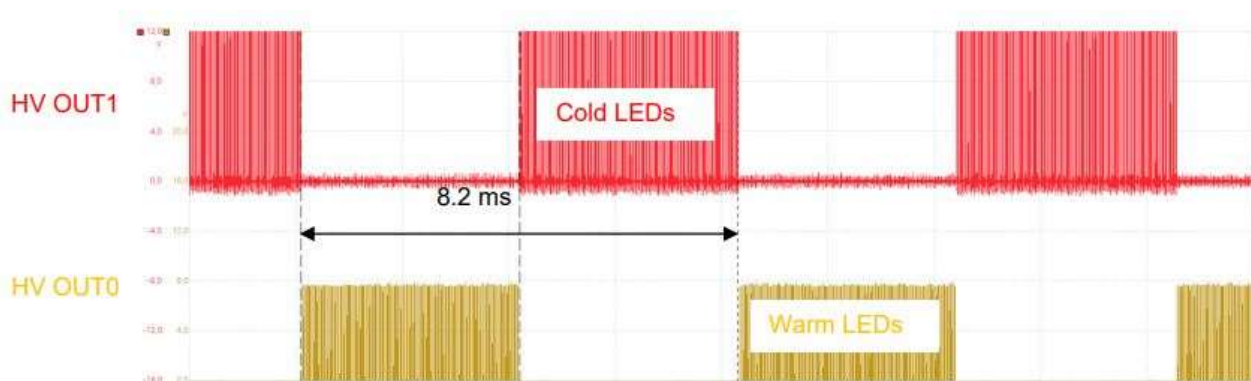


Fig. 12. Cold LEDs 50% and warm LEDs 50% brightness. Current throughout changes direction. So, 50% of the time the warm LEDs shine and 50% of the time the cold LEDs shine. The frequency is so high that the eye can't see these changes and perceives the light as having a neutral color temperature.

Conclusion

This article has described how to configure the HV PAK for advanced LED control. The driver has a flexible configurable control logic, PWM frequency, and current limit. The HV PAK can control loads with current up to 2 A per output, so it is possible to create powerful solutions using a single small GreenPAK IC, all with a minimum of external components.

References

For related documents and software, please visit the Dialog Semiconductor [website](#) where you can download the free GreenPAK Designer software^[2] to open the .gp files^[3] and view the proposed circuit design. Use the GreenPAK development tools^[4] to freeze the design into your own customized IC in a matter of minutes. Dialog Semiconductor provides a complete library of application notes^[5] featuring design examples as well as explanations of features and blocks within the Dialog IC.

1. [SLG47105 datasheet](#)
2. [GreenPAK Designer Software](#), Software Download and User Guide
3. [AN-CM-301, LED Lamp Driver.gp](#), GreenPAK Design File
4. [GreenPAK Development Tools](#), GreenPAK Development Tools Webpage
5. [GreenPAK Application Notes](#), GreenPAK Application Notes Webpage

About The Author



Serhiy Prykhodko is a team lead for Product Development Engineering at Dialog Semiconductor. Serhiy joined Dialog Semiconductor (Silego Technology before the acquisition by Dialog Semiconductor) in December, 2013. Prior to Dialog, he worked on Smart Home projects. Serhiy received a master's degree of Applied Physics and Electronics from Ivan Franko National University, Lviv, Ukraine.

For further reading on designing power circuits with Dialog's GreenPAK devices, see the How2Power [Design Guide](#), and do a keyword search on "GreenPAK". For further reading on LED driver design, locate the Power Supply Function category and select "Lamp ballasts and LED drivers." Or locate the Popular Topics category and select "LED Lighting".