ILD8150 in tunable white and multichannel LED applications

About this document

Scope and purpose

Tunable white and multichannel LED lighting are increasingly popular applications and they are becoming more standardized. They enable adjustment of the comparative color temperature (CCT) in the range of 2700 to 6500 K. Color temperature positively affects human activity during the day. In the morning, a cold color temperature is desirable, as this keeps us awake and alert. In the evening, a warm color temperature will help us relax and rest. Some systems are designed to make adjustments automatically according to the time of day. Besides being used in hospitals, schools and offices, tunable white lighting is also widely used in retail outlets, where proper color temperature can make products look more attractive and increase sales. Multiple light sources must be aligned to have the same comparative color temperature with high accuracy to prevent visible color difference.

Furthermore, multichannel LED lighting is also popular in horticultural LED lighting. A combination of four colors – deep blue, hyper-red, far-red and white – are used to achieve more effective energy use. Multichannel RGB lighting is also quite popular in architectural lighting and entertainment applications.

This document describes a multichannel application as a system and includes tips on how to properly design it.

Intended audience

This document is intended for engineers and students designing highly efficient LED drivers with adjustable light temperature or adjustable light color.

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1 System description

A typical tunable white LED driver block diagram is shown in Figure 1. Usually, such systems consist of two or more identical channels of a buck or linear stage connected to the AC-DC source with constant output voltage. Every channel supplies the dedicated LED string with a certain color temperature or color. The ratio between currents in the channels gives the desired result. A control circuit provides analog or pulse-width modulated (PWM) signals to the buck/linear stages. It is usually supplied from the same AC-DC PFC stage through an auxiliary winding supply or from a DC-DC converter deriving the voltage from the main channel.

![Tunable white block diagram](image)

**Figure 1** Tunable white block diagram

The tunable white/dimming circuit engine can be wired or wireless. It can be programmed to change the dimming level according to the lighting sensor information, and the light color can be synchronized to the real-time clock to produce more natural light. The system can also be integrated into IoT infrastructure with many sensors, to turn lights on and off and control brightness level and color.

The engine supply and other important subjects are described in section 2. Tunable white and multichannel lighting may appear quite simple, but there are many details that can affect system performance.
2 Schematics and performance

Board features:
- Input voltage range: 16 to 70 V DC
- Input auxiliary voltage range: 5 to 15 V DC
- Output LED voltage: 10 to 56 V DC
- Output LED current: 600 to 1050 mA
- Dimming range: 0.5 to 100 percent
- Channels ratio: 0 to 100 percent
- Output auxiliary voltage: 3.3 V DC
- Output auxiliary current: Less than 60 mA
- Standby current consumption of the two channels: Less than 280 µA
- Board dimensions: 120 mm (L) × 27 mm (B) × 20 mm (H)

The tunable white solution based on ILD8150E, shown in Figure 2, consists of two identical channels and one auxiliary 3.3 V supply. To achieve higher light quality it employs output electrolytic capacitors of 47 µF to smooth output current. An electrolytic capacitor of 1000 µF/16 V and an LDO, IFX1117ME V33, are used to provide a smooth supply of 3.3 V and up to 60 mA for the dimming control circuit (e.g. a microcontroller). Two channels operate at frequencies of up to 500 kHz, which minimizes the bus fluctuation effect on current accuracy described earlier. Jumpers X9 and X29 change output current in the range 250 to 1500 mA. The board also includes connector X41, which provides 3.3 V, dimming inputs of the channels, and one common shutdown pin, which puts the buck converters into standby mode.

<table>
<thead>
<tr>
<th>Jumper X9(X29)A</th>
<th>Jumper X9(29)B</th>
<th>Jumper X9(29)C</th>
<th>Output current (mA)</th>
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<td>–</td>
<td>V</td>
<td>–</td>
<td>600 (+/-3 percent)</td>
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<tr>
<td>V</td>
<td>–</td>
<td>–</td>
<td>700 (+/-3 percent)</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>V</td>
<td>1050 (+/-3 percent)</td>
</tr>
</tbody>
</table>
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Schematics and performance

**Figure 3** shows the modular system with a primary stage based on XDPL8219, a feedback board and the tunable white board. XDPL8219 is a digital high-performance secondary-side regulated flyback controller with a high power factor and constant voltage output. By using plug and play Infineon’s REF-XDPL8219-U40W (40 W high power factor flyback converter) can simply be combined with the secondary side. This enables a very efficient solution for a tunable white LED driver.

The modular method enables changing the configuration quite easily, so the secondary-stage buck could be exchanged to a linear stage. REF_TW_BCR601_55V_0.5A is such a reference solution, with the linear LED drivers BCR601 and BCR602. This combination with a secondary-side linear regulator enables an efficient as well as cost effective solution for a tunable white LED driver with highest light quality.

**Figure 4** and **Figure 5** show the board schematics and the layout, respectively.
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Schematics and performance

Figure 5  ILD8150E tunable white PCB top and bottom

Attention: Making LED connections across different channels will damage the board!

System efficiency at 230 V AC/50 Hz over the dimming range at equal input power up to 30 W with different LED numbers is shown in Figure 6. Jumpers X9 and X29 are used for maximum LED current setting to achieve equal input power.

Figure 6  System efficiency over dimming at 50/50 percent channels split with different numbers of LEDs at equal output power. 17 X9 LEDs, X29 jumpers at positions 3 to 4, 13 X9 LEDs, and X29 jumpers at positions 1 to 2 and 3 to 4, 10 X9 LEDs, and X29 jumpers at positions 5 to 6.
Power efficiency, THD and power factor are shown in Figures 7 to 9.

**Figure 7**  System efficiency over dimming for different input voltages. Maximum output power 43 W.

**Figure 8**  THD over dimming for different input voltages. Maximum output power 43 W.
Figure 9  Power factor over dimming for different input voltages. Maximum output power 43 W.

Because the board has one common SD pin, the dimming engine provides an SD signal, which puts it into standby mode. The IC consumption in standby mode is about 100 μA, so two channels consume about 16 mW.

The bill of materials (BOM) is listed in Table 2, below.
# Table 2  
## Bill of materials

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<tr>
<th>#</th>
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<td>2</td>
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</tr>
</tbody>
</table>
Design hints

3 Design hints

Pulse width modulation (PWM) dimming of two or more channels can create interference, because the PWM frequencies and phases are not exactly the same. If these interferences are in the range of a few Hz to a few hundred Hz, they may cause visible flicker and stroboscopic effects. Figure 10 is an example of two channels operating in PWM dimming mode at 3.4 kHz. The pink channel is a light sensor signal; the blue is the sum of the currents of the two LED channels. An interference frequency of 43 Hz is clearly visible in both signals.

On the evaluation board, 47 µF electrolytic capacitors are used at the LED output of each channel to filter the PWM dimming frequency of 3.4 kHz.

A better solution could be to synchronize the PWM frequencies in multichannel applications to avoid flicker. If multiple light sources with tunable white are used, this is quite difficult, so in this case, purely analog dimming is preferable.

Figure 10  Interference effect at hybrid dimming mode when two channels are not synchronized

Bus voltage fluctuation during burst mode can affect light quality by causing flicker at low dimming levels in PWM modes. This happens when the switching period and dimming pulse width are similar. In Figure 11, you can see two oscillograms; green is the bus voltage, pink is the output current. On the left, the switching period is similar to a dimming pulse of 1 percent, and as a result, the LED buck converter cannot regulate LED current in one cycle, which results in flicker at the burst mode frequency. On the right, the switching period is ten times shorter than the minimum dimming pulse; therefore, the LED current is much more precise, and the flicker level is negligible.

If you consider PWM dimming using its calculated minimum frequency switching, select a much higher switching period than the minimum dimming pulse. This will help to avoid or minimize the flicker level at minimum dimming in burst mode.
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Figure 11  Hybrid dimming mode at bus voltage fluctuation. On the left – low switching frequency, right – high switching frequency.

Comparative color temperature accuracy is important. Mismatching minimum currents may lead to different light colors, different from dimming accuracy. If the second-stage channels are supplied from the same bus voltage, having the same LED number and operating temperature, the mismatch will be minimized. Color temperature accuracy, in this case, is related to dimming accuracy as an error between a linear dimming curve and a straight line, as shown in Figure 12.

Figure 12  Comparative color temperature accuracy over dimming for tunable white application

It is much easier to achieve high color accuracy when bus voltage and LED voltages are similar, considering only IC accuracy and component tolerances.
References for related documents and tunable white/dimming engines

(https://www.infineon.com/dgdl/Infineon-ApplicationNote_reference_design_REF_ILD8150_DC_1.5A_LightingICs_LED_driver-ApplicationNotes-v01_00-EN.pdf?fileId=5546d462689a790c0168c39bfa86810)

[2] Infineon: “Application Note AN_1907_PL39_1907_083934 (Revision 1.0)”, 2019-08-05
(https://www.infineon.com/dgdl/Infineon-Reference_design_REF_ILD8150_DC_1.5A_high_frequency_operation-ApplicationNotes-v01_00-EN.pdf?fileId=5546d4626d66c2b1016d73f768f820ae)
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Revision history

## Revision history

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<th>Document version</th>
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<th>Description of changes</th>
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<td>29-01-2021</td>
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First release
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