Application Note

TPS92201 Advantage in Building Automation Video Doorbell, Security Cam System

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ABSTRACT

With the progress of building automation, more and more end equipments use IR LEDs for infrared sensing, especially for video doorbell and security cam. But the current IR LED driver design has many criticisms. This application report showcases how to use TPS92201 in such application with the advantages of better accuracy of reference voltage, smaller size, and the ripple for output voltage.

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Trademarks

1 Introduction

1.1 Why Building Automation Need IR LED in Video Doorbell, Security Cam System

In Infrared LED illumination sub-system cameras with day and night vision, the system features a cut filter control, LED dimming, ambient light measuring, and ballasting for the current of each IR LED string. Ballasting is an alternative for driving multi-string LED arrays with a single string LED driver while maintaining uniform illumination under low-light conditions.

PARAMETER	SPECIFICATIONS
Power supply voltage	2.5 approximately 5.5V
IR LED current	Max 1.5A
IR LED minimum	15mA
IR LED current matching	<5%
IR LED wavelength	800 approximately 980nm
Operation temperature	-40 °C to 85 °C

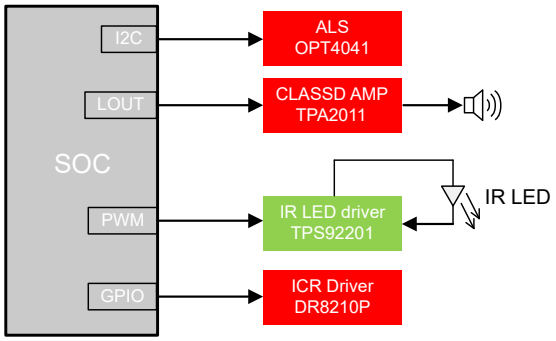

Figure 1-1. Simply Block Diagram in IR LED system

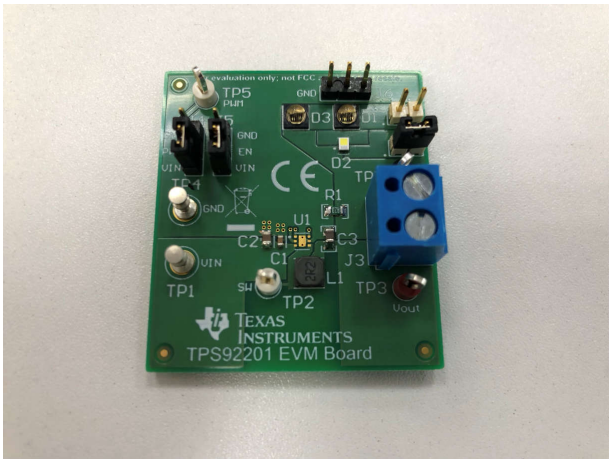

Figure 1-2. TPS92201 EVM Board

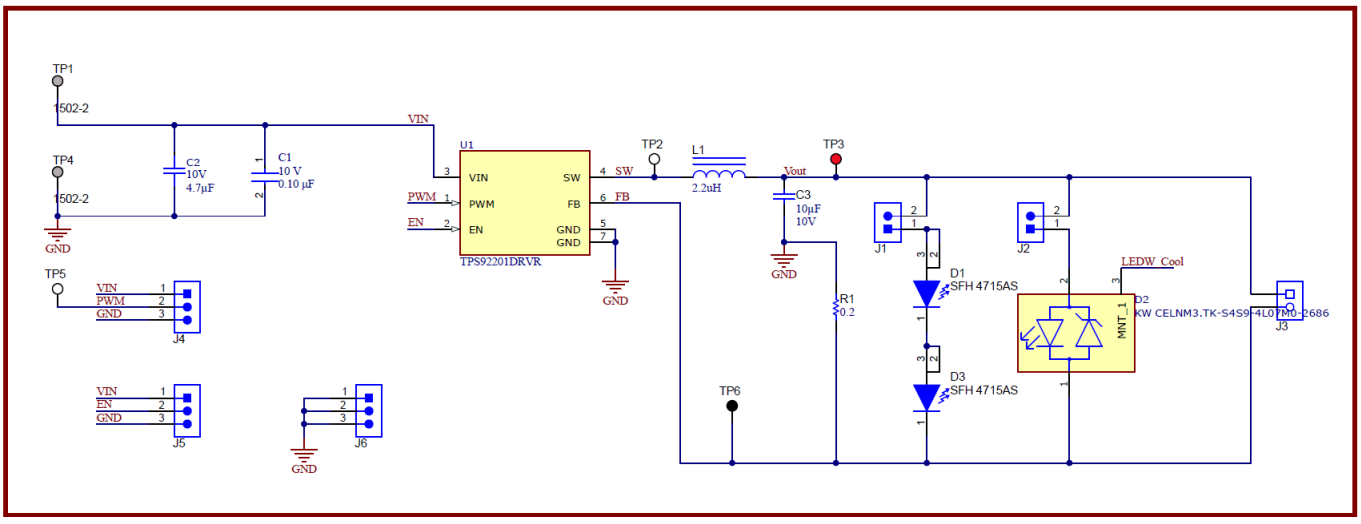

Figure 1-3. TPS92201 EVM Schematic

2 Basic Dimming Knowledge – PWM and Analog Dimming

2.1 Analog Dimming

Analog dimming is the adjustment of the average continuous LED current. This method of dimming typically has the lowest dimming ratio among standard dimming techniques. The dimming ratio can vary from 10 to 1 to up to 250 to one. The performance of the dimming ratio varies based off of the control topology of the LED driver, as well as how you implement analog dimming. For dimming ratios in the thousands to one range, typically you need to use a pulse width modulation dimming method or a combination of analog and pulse width modulation.

Some customers prefer to stay in the linear dimming range, primarily because of the simplicity of having a linear relationship between the output current and light, and linear dimming can also be more efficient.

Analog dimming is typically the simplest dimming method to implement. To implement the dimming, simply adjust the analog voltage on the current adjust pin on an LED driver, which is used as a reference to adjust the output LED current. Depending upon the specific LED driver, you can adjust the analog voltage through the pin or using a resistor divider or even using a signal from a microcontroller that is converted PWM signal through a filter into analog voltage.

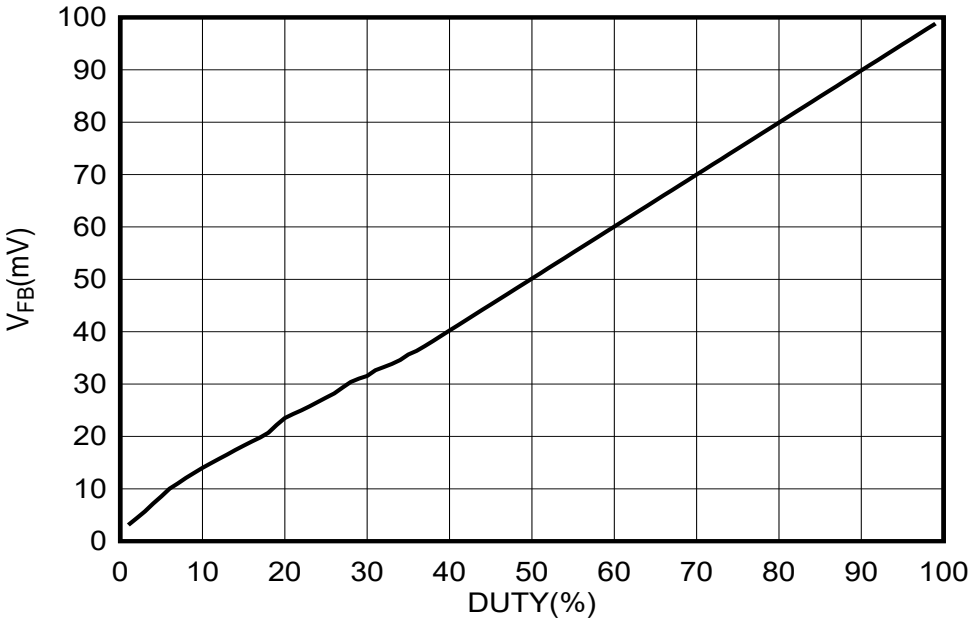

Figure 2-1. DIM Duty Cycle vs FB Voltage in Analog Dimming

2.2 PWM Dimming

PWM dimming modulates the regulated current through the LED at a much lower frequency than the switching frequency of the converter. However, the dimming frequency must be faster than the human eye can detect, 200 hertz or above, so there is no visible flickering in the LED light output.

The average LED current is proportional to the duty cycle of the PWM dimming command. Well-implemented PWM dimming generally results in a wider linear dimming range than analog dimming. With PWM dimming, the LED current is either zero or at the nominal LED current level, which minimizes color shift that can occur during analog dimming. However, PWM dimming can add complexity to the design compared to analog dimming.

There are three types of PWM dimming:

- Main FET dimming
- Series FET dimming
- Shunt FET dimming

Using main FET PWM dimming, dimming is achieved through the enabling and disabling the main switching MOSFET in the power converter. This dimming method is compatible with all converter typologies.

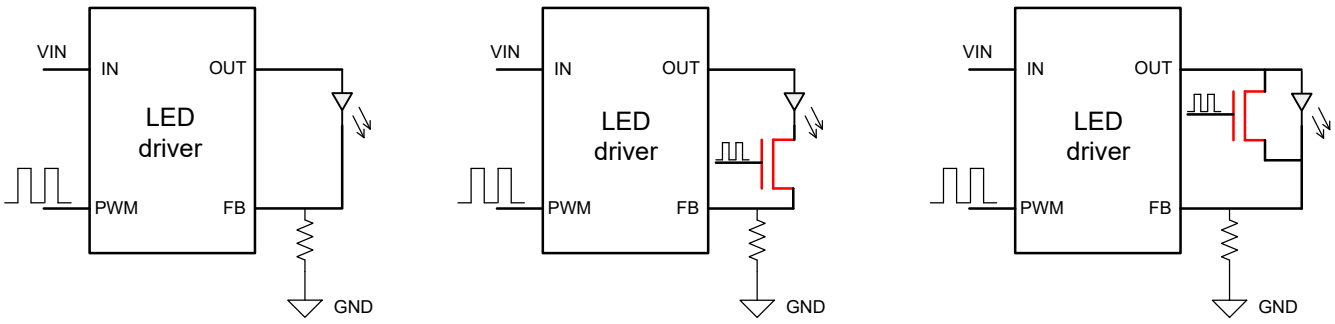

Figure 2-2. Three Types of PWM Dimming

3 Video Doorbell, Security Cam Industry Common Design for IR LED

3.1 External PWM Low Pass Filter

Figure 3-1 is the common design in Cam and doorbell that is usually seen in the industry. Customers usually use a PWM dimming IC and connect an external resistor and capacitor as a low pass filter and adjust the current. Adjusting the current makes the design as analog dimming.

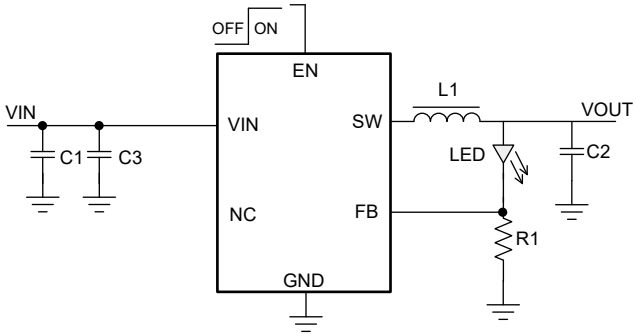

Figure 3-1. Current Comment Design

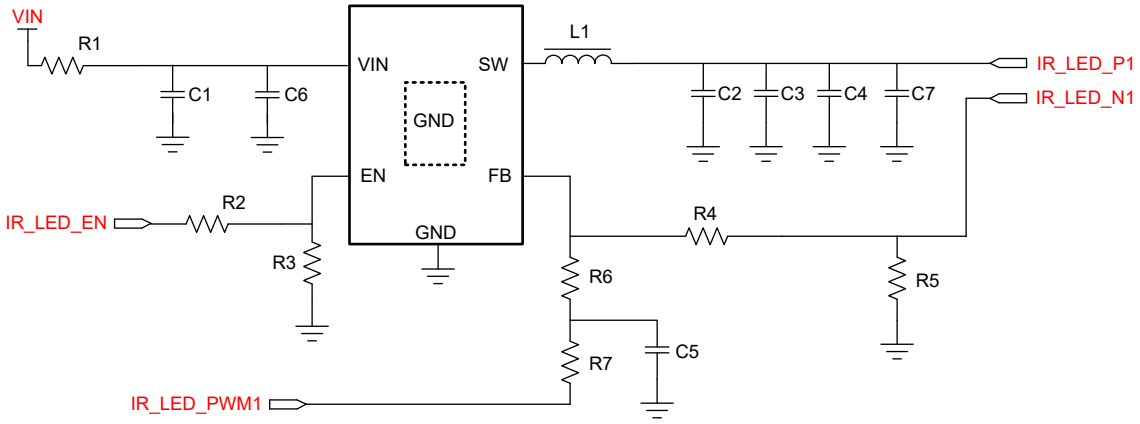

Figure 3-2. Design Schematic

3.2 Industry Application Advantage and Disadvantage

The advantage to this design is that the design can easily achieve the LED Current adjustment from SOC PWM signal with low pass filter. There is no need to change the current through BOM changing. This process is a smart way to use SOC to control the current. Also, this process can make a PWM dimming design to becoming an analog dimming design. The design does not have a flicker issue when video surveillance system captures the video since the design changes to analog dimming.

The disadvantage to this design is not a formal way to design a IR LED driver. The design is not wrong, but there are better options. The design needs to add extra resistor and capacitor to make the low pass filter. Also, the linearity is not easy to make a combination. Also, accuracy is not enough. Please see TI TPS92201 to address the previous issue.

4 TPS92201 Design in Video Doorbell, Security Cam

TPS92201 integrate analog dimming function converts digital PWM signal from SOC into FB pin as a voltage level. The TPS92201 is a high-efficiency, Adaptive off-time with peak current control scheme is adapted in the TPS92201. To get the smallest output ripple, the device operates at typically 1.5-MHz pulse width modulation (PWM) mode in full current range, At light load, the device automatically enters pulse frequency modulation (PFM) to maintain high efficiency over the entire load current range.

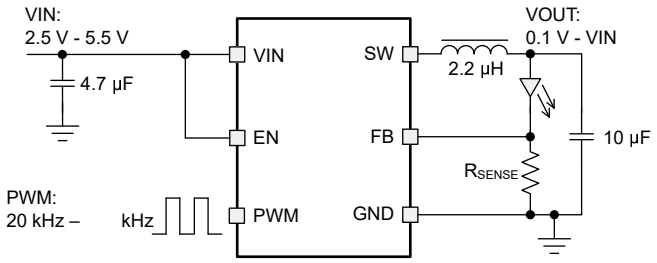

Figure 4-1. TPS92201 Simplified Schematic

Compare with industry common design.

- Do not need extra resistor and capacitor. Can save the cost.
- Do not need to use resistor as a combination for current adjustment. Just Use the Simple PWM signal.
- Smaller ripple due to Adaptive off-time with peak current control scheme is adapted in the TPS92201
- The feedback reference produces a precise ±5% voltage reference over whole temperature range when the PWM duty cycle is 100%, which is typically 100mV. In analog dimming mode, the feedback voltage is proportional to the duty cycle of PWM input as shown in Figure 4-1.

The following images are bench test results including efficiency and FB linearity and accuracy compared with TPS92201 and current design.

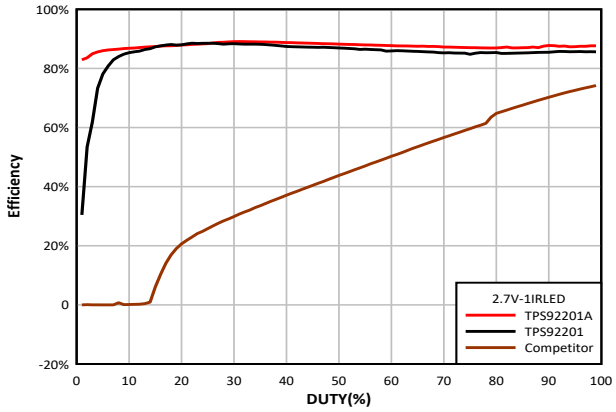

Figure 4-2. Efficiency_1IR_2.7V

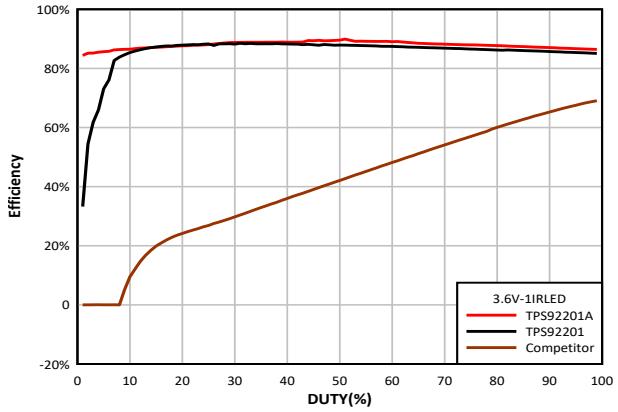

Figure 4-3. Efficiency_1IR_3.6V

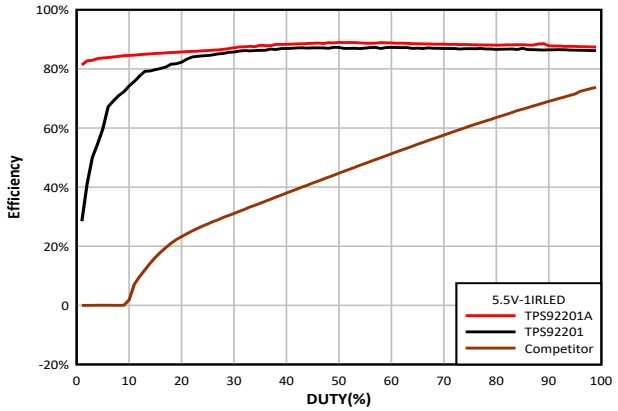

Figure 4-4. Efficiency_1IR_5.5V

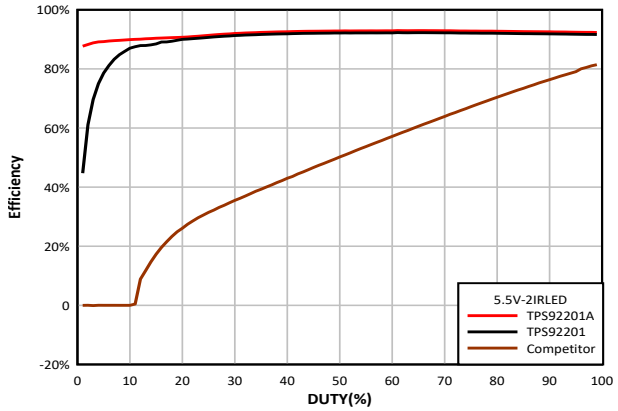

Figure 4-5. Efficiency_2IR_5.5V

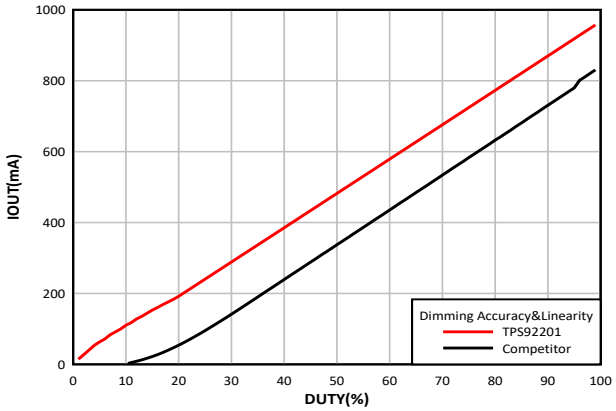

Figure 4-6. Dimming Accuracy and Linearity

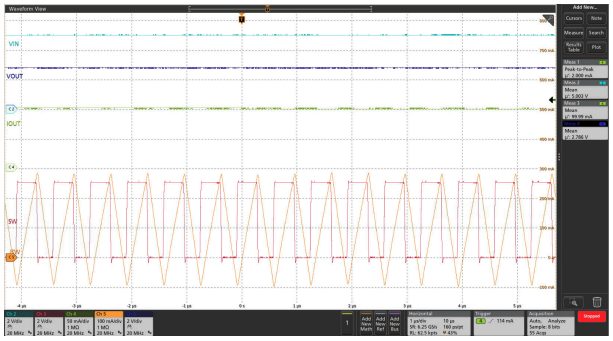

Figure 4-7. Output Current Ripple of TPS92201 at Light Load

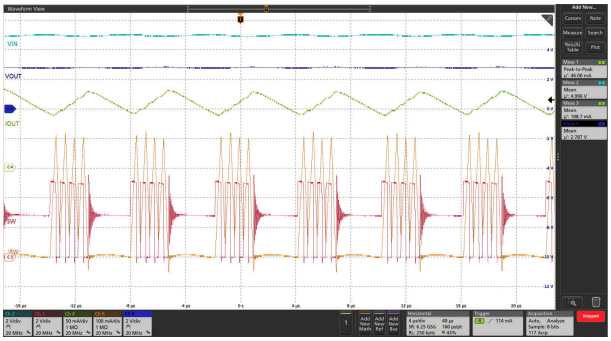

Figure 4-8. Output Current Ripple of TPS92201A at Light Load

5 Summary

IR LED design is very important depend on current range, accuracy requirement especially in low current and how much the current ripple can be accepted.

Some product spec are usually 350 mA as 100% current. Old design issue happened at current below 25 mA around 7% duty. Old design can go into Power saving mode. In the meantime, voltage ripple can go up to 100 m V which is unacceptable. Most customers can have 50 mv ripple which is acceptable for their system. Usually, use 70 to approximately 80% as an average max dimming current.

IR LED design also needs high dimming resolution. Some product spec dimming resolution is around 1% as a stage, customer mention normally in this industry 2% accuracy is hard to achieve. So TPS92201 can make analog dimming as 1% accuracy.

6 References

- Texas Instruments, *TPS92201, 1.5-A High Efficiency Synchronous Buck LED Driver*, data sheet.

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