

$1/T_d$ is the number of cycles that the current waveform repeats per second. The current switches either to I_{OH} or zero repeatedly, the luminance intensity emitted from LEDs would switch also. If the dimming frequency is not fast enough, flickering problem may exist, this flickering problem can be alleviated by increasing the dimming frequency.[13]

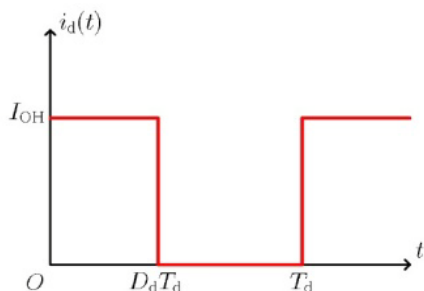


Figure 13: ideal LED forward current timing waveform under PWM driving method

8. PWM LED Driving Circuit

Buck converter is one of PWM dimming methods, high efficiency LED driver based on Buck converter, which could operate under a wide AC input voltage range (85 V - 265 V) and drive a series of high power LEDs, Buck converter shown in figure(14).

During the time interval of state 1, the metal oxide semiconductor field effect transistor (MOS-FET) S is turned on, current flows through MOS switch S, input inductor L, storage capacitor C, the load LED strings and sampling resistor R_s . The power supply stores energy in the inductor L, the storage capacitor C and the free-wheeling diode.

D is off at the moment. During the time interval of state 2, the MOS switch S turns off. The LED strings power is provided by the storage capacitor C, and the energy stored in inductor L flows through the free-wheeling diode D simultaneously. Then the circuit proceeds back to stage 1 when the MOS switch S turns on again.

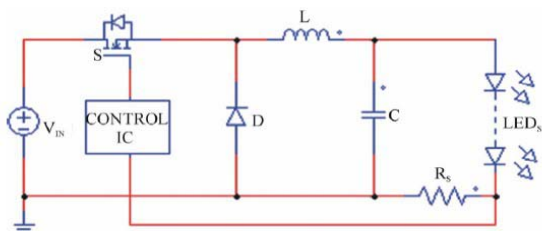


Figure 14: Circuit diagram of Buck converter

To avoid colour variation and get accurate current control over full range, PWM dimming regulators in which the pulse current is kept constant, the power dissipation on the power switch S is described in following Equation (5):

$$P_{S(on)} = I_O^2 \times R_{S(on)} \times D$$

Equation (5)

$R_{S(on)}$ is conduction resistor of MOS switch, I_O is the LED strings current and D is the duty cycle of the power switch. In fact, there is still some power dissipation in the MOS switch when it operates in high frequency. Especially when

LED constant current driving circuit is working in frequency more than 100 kHz, this power dissipation is quite substantial. Equation(6)

$$P_{S(high-freq)} = Q_{gs} \times V_{GS} \times f_s + \frac{1}{2} \times V_{IN} \times I_O \times (t_r + t_d) \times f_s$$

Equation(6)

Q_{gs} MOS gate-source charge and V_{GS} is the MOSFET gate drive voltage V_{IN} is the input voltage, t_r , t_d are the needed time of MOS turn-on and turn-off respectively, f_s is the switching frequency. From the Equation (6), that the power dissipation is proportional to the switching frequency. Combining Equation (6) together with Equation (5).[14]

$$P_S = P_{S(on)} + P_{S(high-freq)} = I_O^2 \times R_{S(on)} \times D + Q_{gs} \times V_{GS} \times f_s + \frac{1}{2} \times V_{IN} \times I_O \times (t_r + t_d) \times f_s$$

Equation (7)

9. Conclusion

In this article, PWM technique in LED systems is being introduced, Matlab is being used for PWM signal generation.

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