

Fundamentals of Solid-State Lighting

LEDs, OLEDs, and Their
Applications in
Illumination and Displays



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The transistor, inductor, capacitor, and integrated circuit (IC) are connected in several different configurations known as SMPS topologies. Depending on the use of constant on-time and constant frequency control, various modulation schemes have been formulated. They are all based on the modulation of current flowing in the inductor. The controlling parameter in the SMPS circuits is the ratio of time for which the transistor is on to the total time (on time + off time) called the *duty cycle*.

LEDs have a variety of forward voltages according to the color of light emitted. The forward voltage also depends on temperature and binning. Taking variations possible from all these factors into consideration, a value of the forward voltage of LED can be indubitably decided such that this value will never be exceeded during operation. Once this value is resolute, the following three cases arise: (i) The supply voltage is always greater than LED forward voltage. Here, it is necessary to lower the supply voltage to the required value, and a buck converter serves the intent. (ii) The supply voltage is always less than the LED forward voltage. Here, the supply voltage must be increased to the desired value, and a boost converter is required. (iii) The supply voltage is sometimes less and occasionally greater than the LED forward voltage. Here, a buck-boost converter is used, serving both the functions of (i) and (ii).

Suppose we have a white LED with a forward voltage of 3.2 V at 350 mA. This forward voltage decreases with temperature and therefore this value (3.2 V) represents a maximum. Also, suppose four alkaline cells are used to operate the LED. These cells have a total voltage of $4 \times 1.5 = 6.0$ V when new and $4 \times 0.9 = 3.6$ V when old. Their total forward voltage lies in the range 3.6–6.0 V. Since this voltage is always higher than the LED forward voltage, the converter to be used will have to decrease the supply voltage to the required amount. It is called a *buck converter*.

Consider the case of two cells of total voltage 2×1.5 V = 3.0 V (maximum) and 2×0.9 V = 1.8 V (minimum) values, used to drive the 3.2 V forward voltage drop LED. The supply voltage is always below the LED forward voltage and therefore a converter to increase the supply voltage, called the *boost converter*, is used.

Suppose three cells are used for driving the LED of forward voltage 3.2 V. The total voltage available = $3 \times 1.5 = 4.5$ V (maximum) and $3 \times 0.9 = 2.7$ V (minimum). Obviously, the available supply voltage is now and again higher than the LED forward voltage and from time to time lower than it. Therefore the converter will have to perform both the functions of decreasing and increasing the voltage, that is, both bucking and boosting. Hence, it is called a *buck-boost converter*. The necessity of a buck-boost converter is felt because a fresh battery has a higher voltage but an old battery has lower voltage than the rated value due to loss of a part of the voltage by discharging.

21.6 Buck Converter

The buck converter is a step-down DC-to-DC converter (Figure 21.3). It takes the input voltage V_{INPUT} and decreases it to a lower voltage V_{OUTPUT} .