Circuit Idea

20141001

Input Line Regulation Circuitry for High-Side Switching Buck Converter

Summary of the Idea

An efficient simple circuit with low component count may be added to the feedback circuitry of a high-side switching buck converter to dramatically improve the input line regulation.

The proposed solution addresses the line regulation issues that otherwise may be encountered in many high-side switching buck converter applications.

The input line compensation is easy to address for buck converters with low-side switching because the power switch, controller and feedback signal are all referenced to the system ground. However, for high-side switching buck converters the compensation must be implemented in a special manner. Ordinary direct compensation is not possible because the SOURCE pin of the buck switch switches between the input voltage and the system ground. An input-voltage-dependent discharge circuit is implemented to compensate the feedback signal derived from the resistor that senses current in the freewheeling diode.

In one example of a buck LED driver with high-side switch (for example in the PI products LinkSwitch™-PL and LYTSwitch™-0) the line regulation could be improved from 18% down to 2%. This would limit the stress in LED diodes during brown-out conditions.

Description

In applications where the output of the power converter is not accessible by the consumer during normal operation, non-isolated converters may be utilized with lower component count and lower weight and size. For example, non-isolated buck converters are commonly used in driver applications for various lamps, such as CFLs, halogen lamps, or LED bulbs.

In the low-side switching buck converter (switch in the return line) the switch and controller are both referenced to the return which results in a simple structure of the gate driver and an easier control design. On the other hand, the typical high-side switching buck converter (switch in the high line) may provide a better load and line regulation and is desirable in some applications. The high-side configuration can utilize either N or P channel MOSFET switches depending on the controller's design. The N-channel MOSFET needs a floating gate-drive signal. The floating gate-drive is usually part of the PWM (pulse width modulation) controller IC. Figure 1 is an example high-side switching buck converter where switcher S1 is shown as a simple four-terminal module that may integrate the buck switch plus the controller in an IC (for example PI LinkSwitch-PL; LYTSwitch-0).

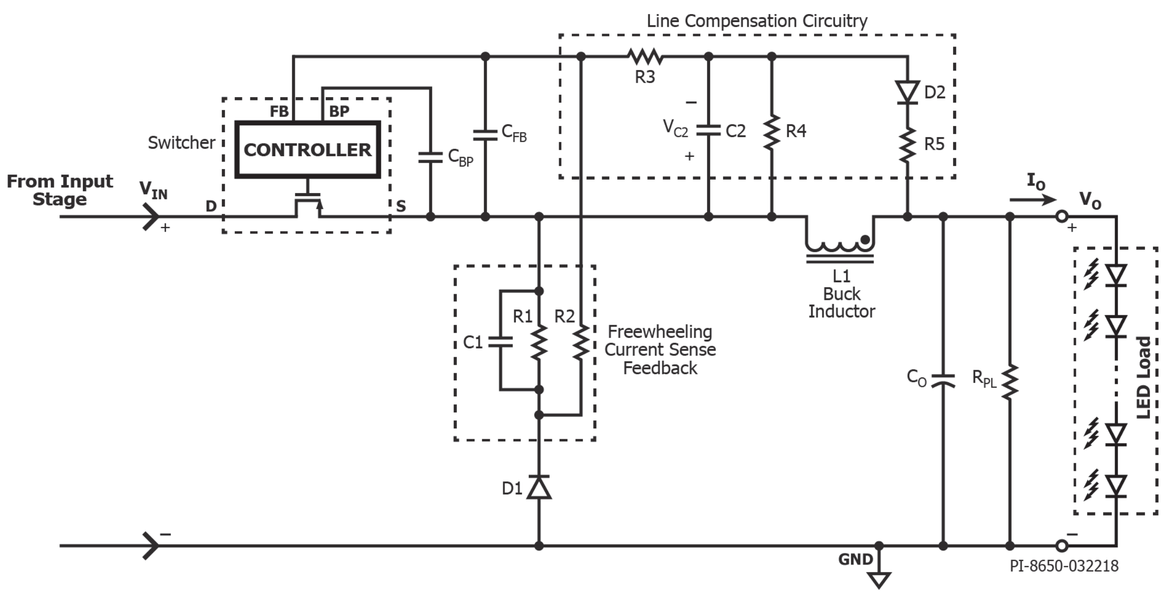

Figure1. Example of the Input Line Regulation Circuitry Implemented in a Buck Converter with High-Side Switching.

Supply voltage for the controller may be provided through an internal tap terminal (not shown) on the high-voltage side of the buck switch and applied to the BYPASS pin across an external bypass capacitor C_{BP}.

To regulate the output to an LED load, the load current should be sensed and monitored as a feedback signal to the controller. A conventional way to measure the output current is to include a sense resistor at the output of the power converter that conducts the load current. However, the voltage drop across the sense resistor may be large and referenced to a voltage level different from that of the controller. As such, the feedback signal would often need additional circuitry such as an optocoupler or a bias winding to level shift the voltage across the sense resistor to interface with the controller.

In the example figures, the sense resistor R1 for feedback generation and output current regulation is located in the path of the freewheeling diode D1 (circulating path of the inductor/load current) which has a common reference level with the controller. The optional capacitor C1 in parallel with R1 acts as a filter to improve the performance. The sensed feedback signal is coupled through resistor R2 to the FEEDBACK pin of the controller across the feedback capacitor C_{FB}. Since the average voltage on the FEEDBACK pin has a weak dependence on the duty ratio of the switch (increasing at lower duty ratios for the same current in D1), the regulated output current I_O decreases when the input voltage increases. The line compensation circuitry tends to reduce the dependence of the feedback voltage on the duty ratio, improving the line regulation of the output current I_O.

Figure 1 and Figure 2 show variants of the circuit for input line compensation in buck converters with high-side switching. Feedback capacitor C_{FB} charges from the current in R2 to a positive value with respect to the SOURCE pin of the switcher. When the switch is on, capacitor C2 charges through D2 and R5 to a negative voltage that is more negative for higher input line. The network formed by R3, C2, R4, D2, and R5 functions as a negative feedforward to compensate for excess feedback voltage on C_{FB} at higher input line. The negative voltage on capacitor C2 removes charge from feedback capacitor C_{FB} through a relatively high value resistor R3. Resistor R4 with R5 establishes the average voltage on C2. A third variant with lower efficiency (not shown) may charge C2 by diverting the charging current in R5 to ground instead of to the output.

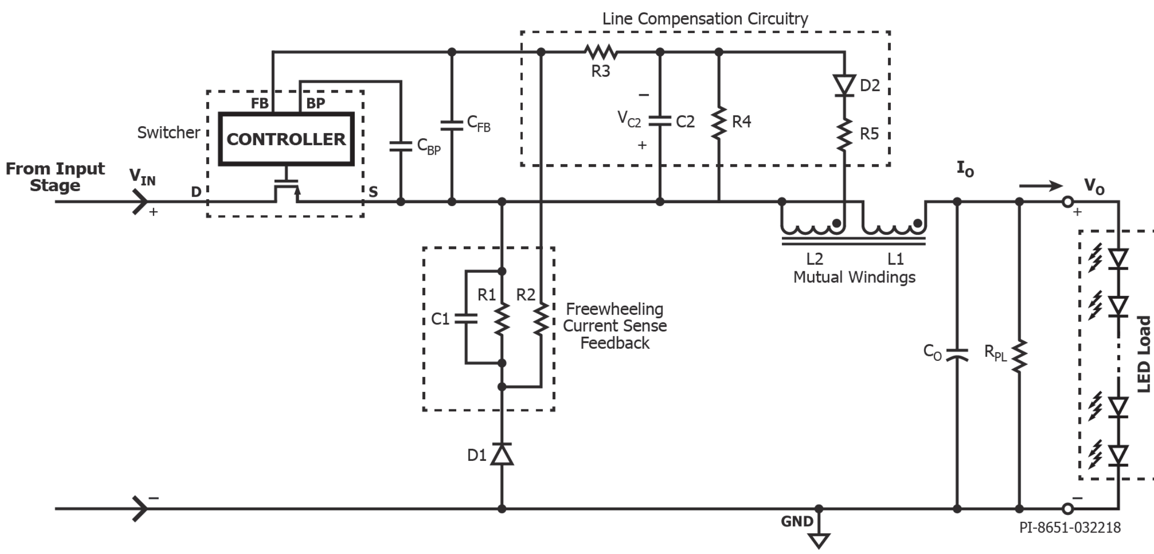

Figure 2. The Input Line Regulation Circuitry Implemented Through a Winding on the Inductor.