4-Switch Buck-Boost Controller with Pass-Thru Capability Eliminates Switching Noise

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Introduction

A common dc-to-dc converter problem is generating a regulated voltage when the input voltage can be above, below, or equal to the output—that is, the converter must perform both step-up and step-down functions. This scenario is typical when powering vehicle electronics from a nominal 12 V battery, which can vary from engine cold crank (down to 3 V) and load dump (up to 100 V), or a reverse battery voltage from operator error. There are several dc-to-dc converter topologies that can perform both step-up and step-down operations, from SEPIC to 4-switch topologies, but none of these solutions pass the input voltage directly to the output without actively switching—until now, that is.

The LT8210 is a synchronous buck-boost controller that can operate in Pass-Thru™ mode, which eliminates EMI and switching losses, and maximizes efficiency (up to 99.9%). Pass-Thru operation passes the input directly to the output when the input voltage is within a user programmable window. The LT8210 operates over an input voltage range of 2.8 V to 100 V, allowing it to regulate from the minimum input voltage during cold crank to the peak amplitude of an unsuppressed load dump. The LT8210 can operate as a conventional buck-boost controller with pin-selectable continuous conduction mode (CCM), pulse skipping, or Burst Mode® operation, or in a new Pass-Thru mode in which the output voltage is regulated to a programmed window. When the input voltage resides in this window it is passed directly to the output without actively switching the FETs, resulting in ultralow I_Q operation and the elimination of switching noise.

Pass-Thru Operating Mode

Figure 1 shows a simplified schematic of an LT8210 configured for Pass-Thru operation with the output regulated to be between 8 V and 16 V. The top and bottom voltages of the Pass-Thru window are set by the FB2 and FB1 resistor dividers, respectively.

Figure 2 shows the input/output transfer characteristic of this circuit. When the input voltage is above the Pass-Thru window, the LT8210 steps it down to a regulated 16 V output. If the input voltage drops below the window, the LT8210 boosts to maintain the output at 8 V. When the input voltage is within the Pass-Thru window, the top switches, A and D, turn on continuously, allowing the output to track the input and the part to enter a low power state with typical quiescent currents on the V_{IN} and V_{INP} pins of 4 µA and 18 µA, respectively. In this non-switching state, there are neither EMI nor switching losses, making efficiencies greater than 99.9% achievable.

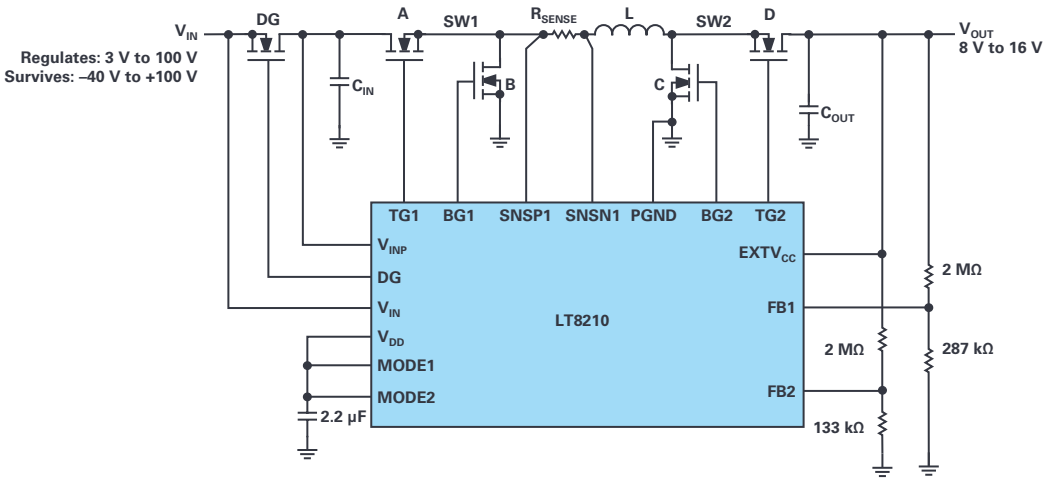

Figure 1. LT8210 8 V to 16 V Pass-Thru regulator circuit.

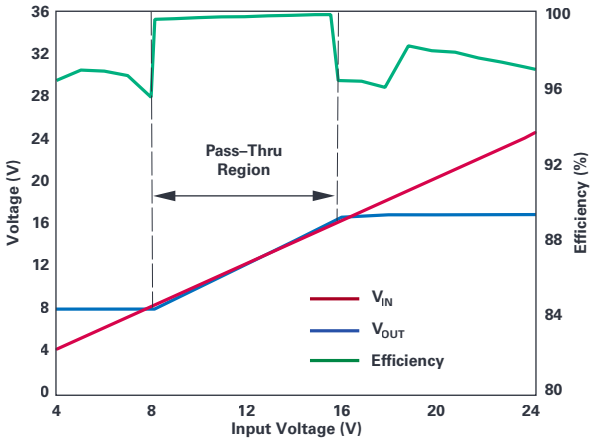

Figure 2. Pass-Thru operation enables 99.9% efficiency in the Pass-Thru input voltage window.

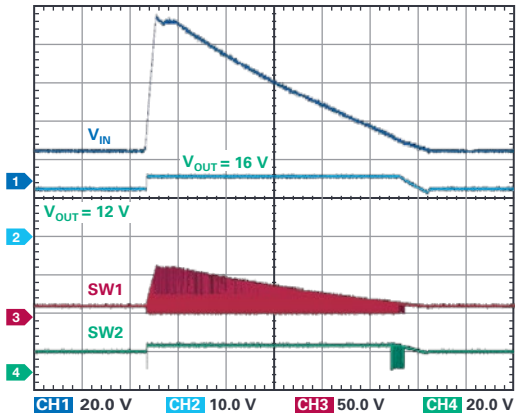

Figure 3. The LT8210 in Pass-Thru mode quickly responds to an 80 V unsuppressed load dump pulse, limiting the output to the programmed 16 V maximum.

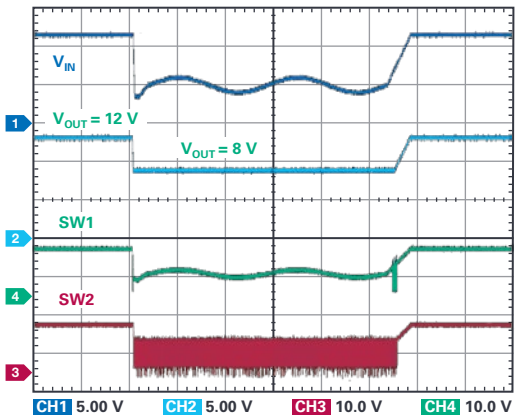

Figure 4. The LT8210 in Pass-Thru mode responds to a cold crank pulse (<4 V) by boosting to the programmed 8 V minimum output voltage.

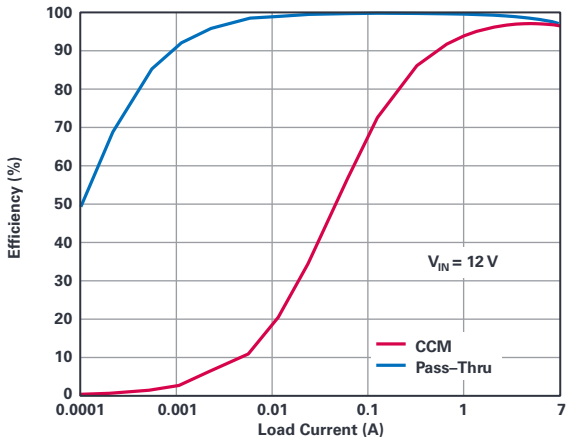

Figure 5. In the Pass-Thru region, efficiency reaches nearly 100%, compared to continuous conduction mode efficiency.

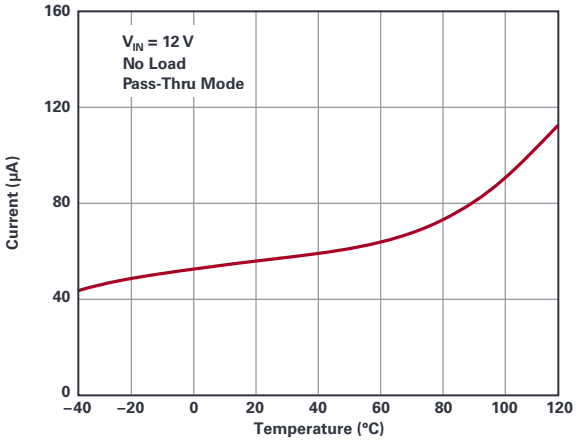

Figure 6. The LT8210 features ultralow quiescent current in the Pass-Thru region.

Conclusion

Automotive batteries and similar wide voltage range power sources are a complex problem for dc-to-dc converter designers, requiring protection features and buck and boost conversion at high efficiency. The LT8210 synchronous buck-boost controller eliminates complexity by combining protection features with a wide input range buck-boost converter and a unique Pass-Thru option. It operates over a 2.8 V to 100 V operating range with built-in reverse voltage protection. Its Pass-Thru mode eliminates switching losses and noise while achieving ultralow quiescent current. In Pass-Thru mode, the output voltage is not regulated in the conventional sense, but is instead bounded by a programmable voltage window.

About the Authors

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Bruce Haug received his B.S.E.E. from San Jose State University in 1980. He joined Linear Technology (now a part of ADI) as a product marketing engineer in April 2006. Bruce's past experience includes stints at Cherokee International, Digital Power, and Ford Aerospace. He is an avid sports participant. He can be reached at *bruce.haug@analog.com*.

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