Circuit Idea
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Stacked Transistor in a High-Side Buck to Increase Input Voltage Range, Applicable to LinkSwitch-TN2 Automotive Applications

Summary of the Idea
This Circuit Idea presents an implementation of stacking an external transistor, such as a MOSFET, in series with a high side switch of a buck regulator. The stacked MOSFET could expand the operational input voltage range of the PI LinkSwitch-TN2 integrated buck controller beyond the typical operating input range for the device.

Description
Buck regulators are popular in many applications that do not need galvanic isolation because of their simplicity, low number of components, higher efficiency, lower heat dissipation and overall reliability. Recently they have become of special interest in the automotive industry. However, for automotive applications, the buck regulator may need to operate with input voltages greater than 800 V dc.

Most of the existing buck regulators in the market use buck controller ICs with an integrated switch in the IC. The maximum dc input voltage of such regulators is defined by the integrated switch technology, which is mostly designed for 500-600 V dc. For example, the LinkSwitch-TN2 input voltage range for the smaller sized integrated switch (e.g.; LNK3206GQ) is approximately 60-550 V dc.

The high-voltage dc input solution presented here enables automotive applications with high input voltage requirements up to 1000 V dc to use such lower voltage range buck regulators with modifications to comply with their emergency high voltage bus network. This high voltage buck regulator solution potentially replaces a high loss linear regulator that otherwise would be used by some customers.

The schematic of FIG. 1 shows a circuit diagram of the LinkSwitch-TN2 for automotive applications (LNK-TN2™) from Power Integrations (PI), with the added stacked MOSFET circuitry.

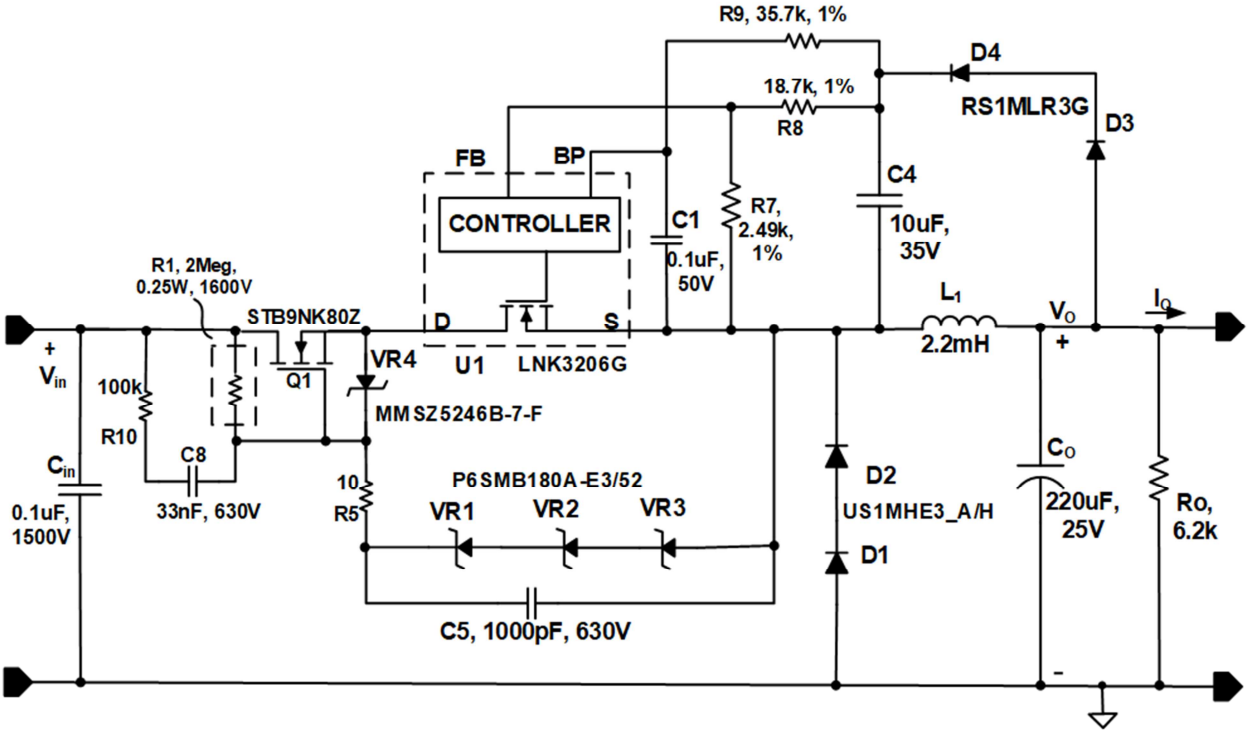

Figure 1: LinkSwitch-TN2 high-side buck regulator with a stacked MOSFET. Maximum input voltage extended from 550 to 950 V dc.

Description of Figure 1

The LinkSwitch-TN2 controller has an integrated internal MOSFET across D and S terminals. An additional stacked MOSFET is externally coupled in series with the integrated MOSFET of the LinkSwitch-TN2 controller. The buck regulator's input voltage range with the stacked MOSFET is extended from the original input range of LNK3206GQ, which is 60-550 V dc.

The LinkSwitch-TN2 does not require an optocoupler in the high-side buck regulator. This modified configuration presents a reliable solution for operation of LinkSwitch-TN2 with a lower voltage integrated switch option in a buck regulator from a dc bus that may be higher than the rated voltage of the integrated switch.

The general concept of stacking transistors is that a single low-voltage gating signal from the controller triggers the integrated MOSFET in the IC device, and a voltage division across the parasitic and the externally inserted capacitances in the circuit is used to turn on the single or multiple external series transistors (e.g. stacked MOSFETs). The voltage across the IC device could then be clamped below the maximum rated voltage.

In Figure 1, the high-side buck configuration uses LinkSwitch-TN2, LNK3206G, with an additional stacked MOSFET circuit. The network of transient voltage suppressors, VR1, VR2, and VR3 connected between the gate of the transistor Q1 and the source of the LNK-TN2 IC device U1 clamps the voltage across U1 to below the rating of U1. The voltage stress would then be shared between U1 and Q1.

C5 is an optional capacitance that may turn ON Q1 if the capacitance of the transient voltage suppressors, VR1, VR2 and VR3 is insufficient.

Reducing the startup overshoot on the transistor Q1 could be achieved by adding R-C circuitry. The optional components R10 and C8 across resistor R1, shown as a 2 megohm resistor in FIG. 1, can reduce the startup overshoot on Q1.

Description of Table 1

Table 1 gives results predicted by PI Expert for the circuit in Figure 1 that meets the requirements of a particular application. Higher operational voltages; e.g., 1100 V dc, are possible with adjustments to components such as the value of inductor L1.

Topology: Buck Converter	
Input Voltage Range	60 V dc – 950 V dc
Output Voltage	18 V dc
Output Power	2.7W (150 mA); (4 W/1 µs to charge gate capacitor)
Environmental Condition:	
Ambient Temperature	-40 to +125° C

Table 1: The modified ratings of the high-side buck regulator in Figure 1.

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