Technical Article

Quantifying the Value of Wide VIN

TEXAS INSTRUMENTS

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When designing a power supply, one of the challenges designers often face is dealing with voltage transients. It is important to protect circuitry from voltage spikes greater than the rated input voltage (V_{IN}) of the integrated circuit (IC). When dealing with voltage transients, designers have a choice between using a DC/DC converter on the front end of the system with a wide-enough input voltage range to cover any transients, or a lower V_{IN} DC/DC converter with additional clamping circuitry to provide transient protection.

At first glance, it may appear that choosing the first solution, a DC/DC converter with a wide V_{IN} input rating of 36V or 60V, is more expensive because the 1ku price is higher than a converter with a lower voltage input rating. However, the extra voltage-clamp circuitry needed for the transient protection of a lower V_{IN} converter can add 10 to 12 external components that will increase the bill-of-materials (BOM) count and cost, as well as solution size. In this post, I will compare the solution size and cost of the SIMPLE SWITCHER® LM43603 36 V_{IN}, 3A buck converter against a comparable 17 V_{IN}, 3A converter solution with additional clamping circuitry used to absorb the surge voltage.

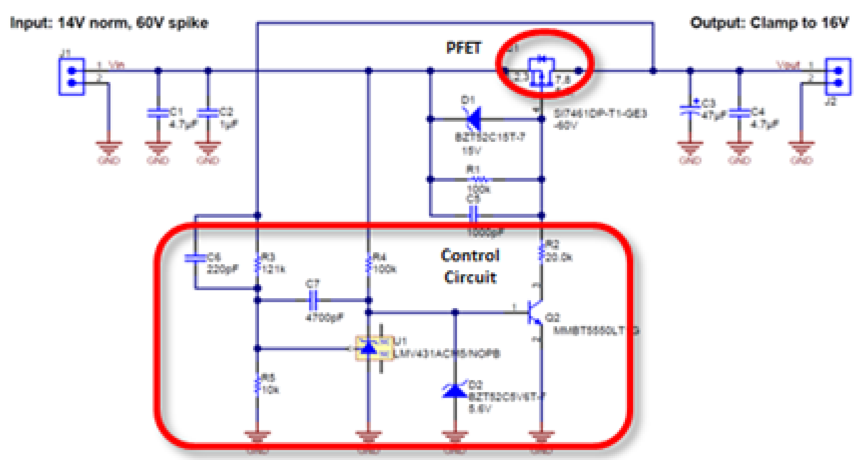

Figure 1. Discrete Solution Used to Clamp the Input Voltage

The schematic in Figure 1 is an example of a discrete solution used to clamp the input voltage when the IC's voltage rating is lower than the maximum input spike. This solution uses the LMV431 shunt regulator and a NPN transistor as a control circuit. The P-channel field-effect transistor (PFET) carries the pass-through current and has an increased voltage drop as the V_{IN} surges and thus takes the increased power loss and protects the DC/DC converter. More detail on this technique can be found in the application note "Over Voltage Protection Circuit for Automotive Load Dump."

As seen in Figure 1, this input clamping control circuitry and PFET adds 13 extra external components to the solution. As Figure 2 shows, based on 1ku quantities published online, these 13 external components would add \$1.19 to the total cost. The solution cost of a 17 $V_{IN,}$ 3A converter may be around \$1.62, using 1ku-quantity pricing of \$0.96 and including the cost of external components like the inductor, capacitors and resistors. This brings the total solution cost of using a 17 V_{IN} buck converter plus clamping circuitry to approximately \$1.62 + \$1.19 = \$2.81. Additionally, the control circuitry and PFET add approximately 210 mm^2 to the solution size of the lower V_{IN} solution. A 17 $V_{IN,}$ 3A converter may be around 100 mm^2, which makes the total solution size 100 mm^2+250 mm^2 = 350 mm^2.

	Unit Price*	Quantity	Cost
Resistor	$0.016	5	$0.08
Capacitor	$0.016	3	$0.05
Zener Diode	$0.075	2	$0.15
LMV431	$0.270	1	$0.27
NPN	$0.050	1	$0.05
PFET	$.590	1	$.59
Total		13	$1.19

Figure 2. Control Circuit Cost Breakdown

Another option is to use a DC/DC converter with a wider input-voltage range to cover the maximum V_{IN} spike like the SIMPLE SWITCHER® LM43603 36 V_{IN}, 3A synchronous buck converter. Using a wide-V_{IN} device like the LM43603 enables designers to eliminate the additional clamping circuitry which saves time, cost and board space. The total solution cost of the LM43603 is approximately $2.51 using the published 1ku quantity price of $1.85 and including the cost of external components like the inductor, resistors and capacitors. This means that using the wider V_{IN} LM43063 saves $0.30 or approximately 12%: $2.51 vs. $2.81. The benefits increase when you look at solution size. The total solution size of the LM43603 is approximately 250 mm^2 which is about 24% or 60 mm^2 smaller than the previous solution.

Another benefit to a wide V_{IN} solution like the LM43603 is increased reliability. As I talked about in more detail in an earlier post, adding additional external components introduces additional risk into the system. The most reliable solution is the simplest solution with the fewest number of external components, because it reduces the risk of one component malfunctioning. Increasing reliability is very important particularly in the harsh conditions of some automotive and industrial applications. Plus, designing the additional clamping control circuitry adds significant work to the design cycle. Using the control circuitry and PFET means that you must select 12 more external components and run additional testing and simulations to ensure that it works. Why put in that effort when you can get a regulator with a wider V_{IN} range with lower system costs and higher reliability?

Of course, pricing and solution size can vary widely based on volumes and contracts between vendors and suppliers, as well as design layouts. The size and cost percentage saved with a wide V_{IN} solution will likewise vary. However, I hope this analysis shows that despite the higher upfront 1ku price, a wide V_{IN} solution like the LM43603 can provide savings in solution cost, board space and design time when dealing with input-voltage transients.

Get more information on TI's wide V_{IN} DC/DC power solutions.