

AN-2171 Designing Constant-On-Time Buck Regulators for Low Drop-Out Voltage

ABSTRACT

This application note presents a simple scheme to improve the drop-out voltage in constant-on-time buck regulators.

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1 Description

Constant-On-Time (COT) regulators provide a simple, cost-effective way of implementing a step down buck regulator with nearly fixed frequency. Constant-On-Time regulators do not require loop compensation and provide excellent transient performance with minimum design effort and part count.

In a COT buck regulator, the high side switch is controlled by a 'T_{ON}' timer. Once the timer expires, the high side switch turns off and does not turn back on again until the voltage at the feedback node falls below the reference voltage. To avoid spurious turn-on caused by switching noise and to allow the bootstrap capacitor to charge, there is a minimum built-in 'OFF' time (T_{OFF (min)} = 347ns max) in LM5006. This minimum T_{OFF} restricts the maximum duty cycle of the converter for a given switching frequency. This effect is more pronounced at higher switching frequencies as shown in Figure 2 for the circuit of Figure 1. The output voltage (V_{OUT}) drops below 10V for input voltage (V_{IN}) smaller than about 14.0V.

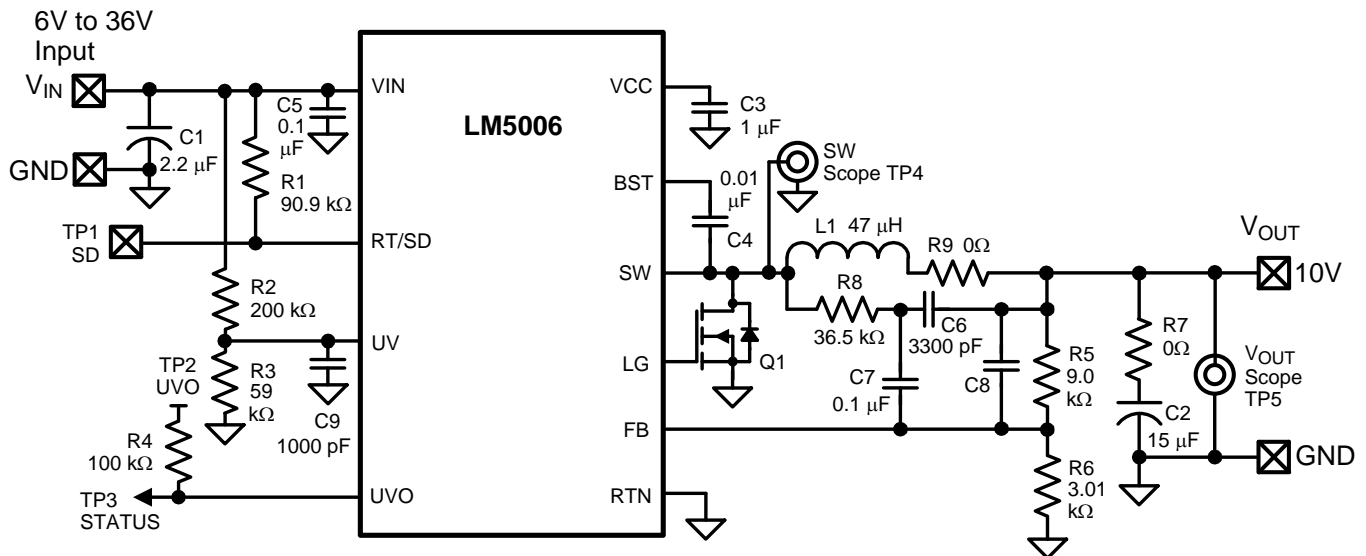


Figure 1. LM5006 Buck Application Circuit, R1 = 90.9kΩ, fsw = 920kHz

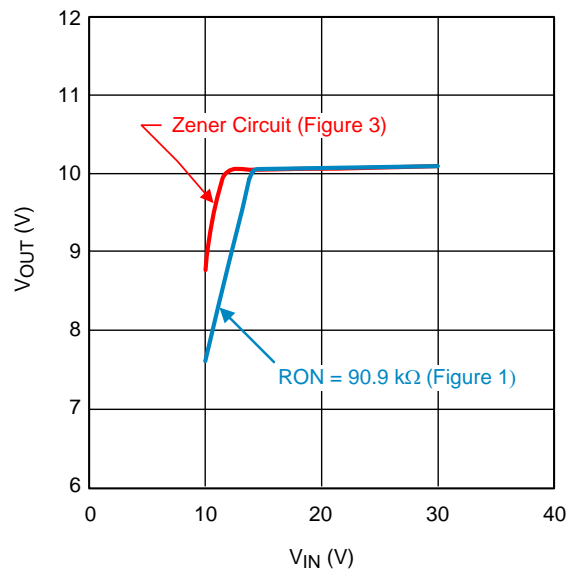


Figure 2. LM5006, V_{IN} vs V_{OUT} (Low V_{IN} Range Extended for Zener Circuit)

In some applications it may be desirable to minimize the dropout voltage in low input voltage condition. One way to minimize the drop out voltage is to reduce the switching frequency. But low frequency operation at high and nominal V_{IN} does not allow the designer to choose smaller filter components. It is, therefore, desirable to keep higher switching frequency for high and nominal V_{IN} range and reduce it only at low V_{IN} to reduce the drop-out voltage. This can be done by modifying adding external components to R_T pin as shown in Figure 3. The parts shown in blue are added to create non-linear R_T resistor. The zener and series resistors are selected so that the NFET turns on at a V_{IN} slightly above 14V where the converter of Figure 1 dropped out of regulation. For $V_{IN} > 14V$, the external NFET is 'on' and the effective R_T is 90k Ω , the same as in Figure 1. For $V_{IN} < 14V$, the external NFET is 'off' and the effective R_T is 360k Ω . For this higher R_T , the ' T_{ON} ' of the converter increases resulting in higher duty cycles. As shown in Figure 2 (red curve), the input voltage range of converter is extended down to $V_{IN}=12V$ for a well regulated output. A low leakage FET (such as BSP123) should be selected to emulate an ideal switch effect. The designer should select the zener and resistor dividers so that the maximum ratings of the components are not exceeded. As always, the design should be verified over the input voltage range.

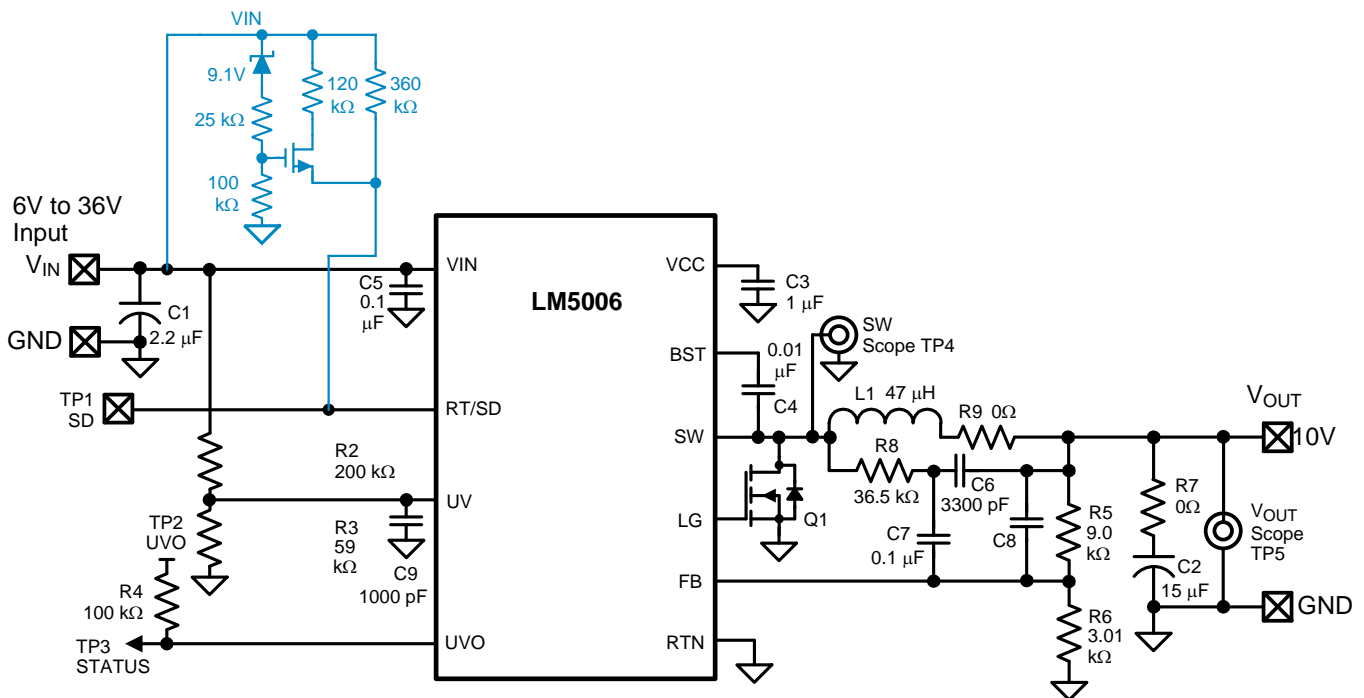


Figure 3. Application Schematic of Figure 1 Modified to Replace R1 With a Non-Linear Zener Circuit

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