Application Report

SLVA136 - JUNE 2003

Single Cell TPS61041 LED Driver

Michael Day

Low Power DC/DC Applications

ABSTRACT

This application report shows how to operate the TPS61041 in a constant current LED drive configuration from input voltages less than 1.8 V. Although most applications using this device connect the VIN pin to the boost inductor, L1, as shown in Figure 1, this is not required. Separating the power stage from the control IC, allows the use of input voltages that are both above or below the operating range of these devices. The ability to operate from input voltages less than 1.8 V allows these devices to operate from single cell alkaline, Ni-Cd, and Ni-Mh sources. This provides low cost solutions for applications such as backlight or indoor/outdoor lighting applications that require high efficiency to extend battery life.

Description

The TPS61041 is an integrated boost converter that can be configured as a constant current LED driver. Although this device has been designed to operate from input voltages between 1.8 V and 6 V, implementing the circuits shown in this application report allow the use of lower input voltages. This application report covers several possible application scenarios for powering this device from a single cell input.

Few solutions exist for generating a constant current LED drive circuit from a single cell input. Figure 1 shows one possible solution. A TPS60300 converts the single cell input into an intermediate 3.3-V bus. The 3.3-V bus is then fed into the TPS61041. Although this solution works, it is less than optimal. Overall system efficiency suffers due to the *double* power conversion created by this architecture. Overall efficiency is the product of the single cell input-to-3.3 V conversion efficiency times the 3.3 V-to-LED driver conversion efficiency. The individual efficiencies for each converter are approximately 85%; therefore, the total efficiency is 0.85×0.85, or 72%.

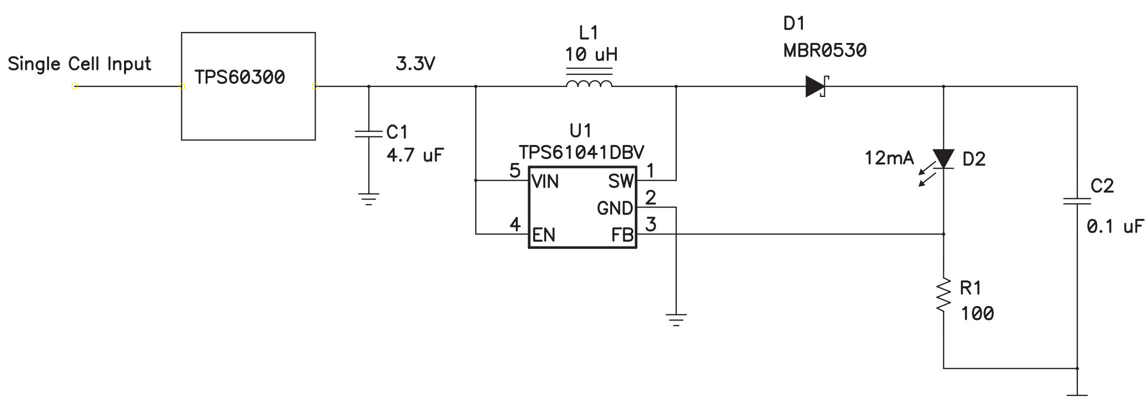

Figure 1. Single Cell Operation With Intermediate Voltage Conversion

The circuit in Figure 2 is a significant improvement over the circuit in Figure 1. With this topology the TPS60300 only generates a 3.3-V bias voltage for the TPS61041. Note the difference between this topology and the topology shown in Figure 1. While the 3.3-V bus is still tied directly to the VIN and EN pins on the TPS61041, the power stage of the boost converter is tied directly to the battery. The advantage of this topology is two fold. The TPS61041 power stage is driven directly from the battery, so there is no costly hit on efficiency by requiring a *double conversion*. Power for the control circuitry is negligible; therefore the overall conversion efficiency is 85%. The second advantage is that the TPS61041 draws less than 0.5 mA from the TPS60300. This allows the full current capability of the TPS60300 to be used for other system components such as logic devices or a low power processor.

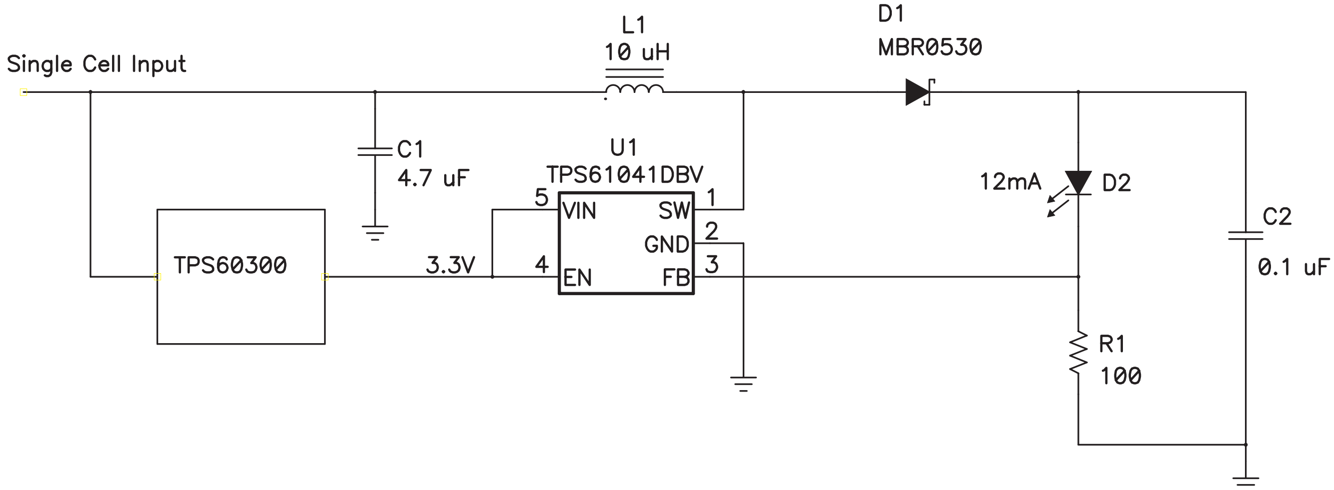

Figure 2. Single Cell Operation With Auxiliary Bias Voltage

When no other system voltages are available, both the power stage and bias voltage must be derived from the battery. Figure 3 shows how this can be accomplished with a push-button startup. When the push-button switch, S1, is pressed, current flows through the inductor, L2, and switch to ground while being current limited by the resistor. When the switch is released, the energy stored in the inductor is transferred through D4 into C3. The voltage on C3 increases above the under voltage lockout of the IC, 1.5 V, as L2 discharges. At this point, the supply is enabled and starts switching. As the output voltage increases during softstart, it is fed back around to the VIN and EN inputs through D3. The current required at these pins is less than 0.5 mA. Once started, the supply can operate until the battery is depleted to 0.9 V or less. If desired, this circuit can be modified to allow the user to disable the supply. The Zener diode, D5, is required to protect the IC from excessively high startup voltages that occur when a fresh battery is at the upper end of its operating voltage range.

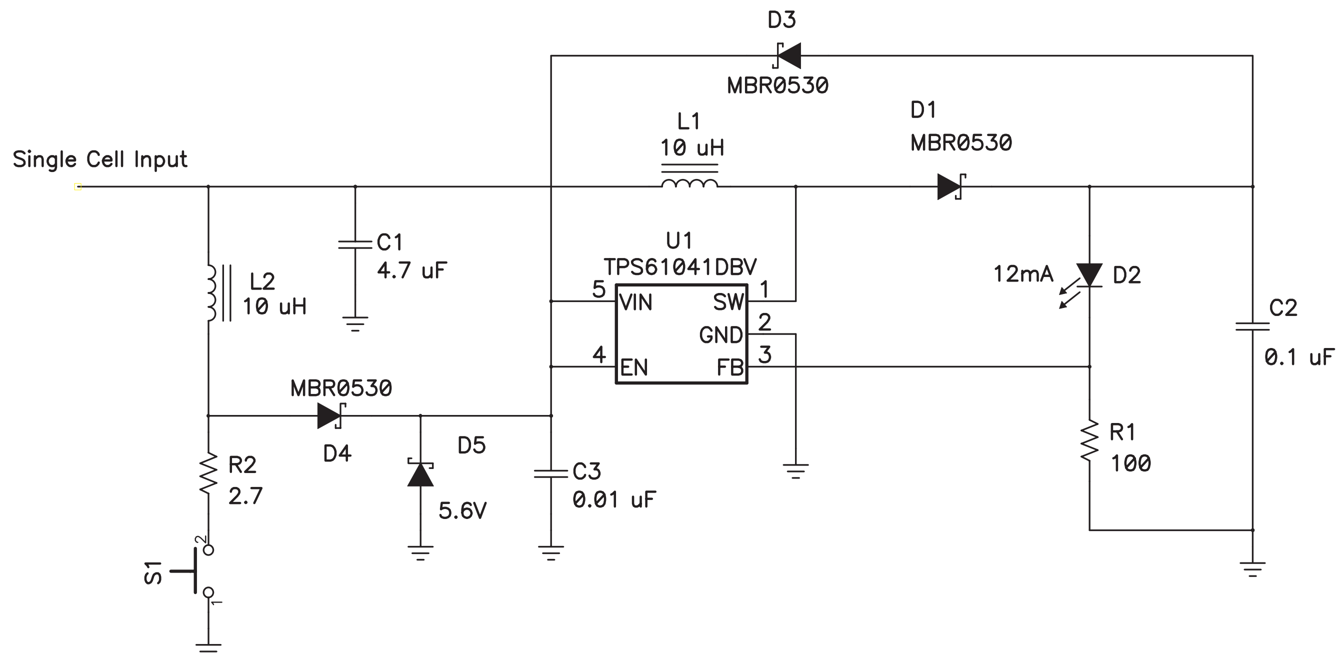

Figure 3. Single Cell Operation With Push-Button Startup

To summarize, the TPS61040, TPS61041, and TPS61042 can be configured to operate from input voltages less than 1.8 V. This provides a high efficiency, inexpensive power solution from single cell battery inputs. Although the example circuits are shown in a constant current LED drive configuration, this method can also be used when these devices are configured as a standard boost topology.

Table 1. Other Boost Converters Available From Texas Instruments

DEVICE	TYPE	IOUT mA	SWITCH LIMIT mA (max)	Vin V	Vout V	SWITCHING FREQUENCY kHz (max)	SHUTDOWN	LDO (mA)	LOW BATTERY	PG	POWER SEQUENCING	UVLO	CURRENT LIMIT	THERMAL LIMIT
TPS61000	Boost	100/250	1100	0.8–3.3	1.5–3.3	840	x		x			x	x	
TPS61010	Boost	100/250	1130	0.8–3.3	1.5–3.3	840	x		x			x	x	
TPS61030	Boost	1000	4500	1.8–5.5	1.8–5.5	700	x		x			x	x	x
TPS61040	Boost	20 at 18 V	400	1.8–6.0	Vin – 28	1000	x					x	x	
TPS61041	Boost	20 at 18 V	250	1.8–6.0	Vin – 28	1000	x					x	x	
TPS61042	Boost	6 white LEDs	500	1.8–6.0	28	1000	x					x		x
TPS61045	Boost	LCD drive	450	1.8–6.0	30	1000	x				x	x		x
TPS61100	Boost + LDO	200	1500	0.8–3.3	1.5–5.5	800	x	120	x	x			x	x
TPS61120	Boost + LDO	500	1600	1.8–5.5	2.5–5.5	600	x	200	x	x			x	x

Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265