Extending Battery Life With the TPS61040 Low-Power, DC-DC Boost Converter

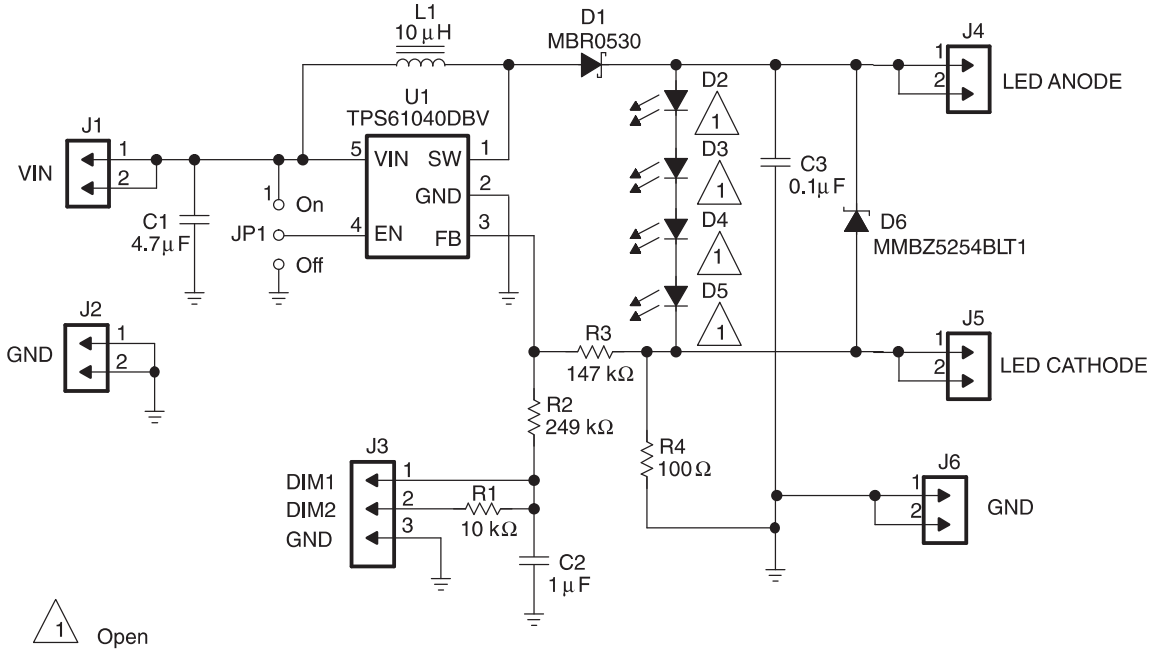
PMP Portable Power

ABSTRACT

This document describes application examples and reference designs for the TPS61040 boost converter. The following application example describes how to implement the TPS61040 low-power, dc-dc boost converter to drive white light LEDs. Also provided are design equations for calculating the proper resistor values for a white LED driver that includes provisions for dimming the LED brightness. The reference design shows an implementation of the TPS61040 to help extend battery life.

1 Features

- 1.8 V to 6 V Input Voltage Range
- Adjustable Output Voltage Range up to 28 V
- 400 mA (TPS61040) and 250 mA (TPS61041) Internal Switch Current
- Up to 1 MHz Switching Frequency
- 28 µA Typical No Load Quiescent Current
- 1 µA Typical Shutdown Current
- Internal Softstart
- Available in a Tiny 5-Pin SOT23 Package



The preceding application drives four LEDs and includes the capability to dim the light output. The following equations calculate the correct resistor values for the circuit.

$$R_4 = \frac{V_{CS}}{I_{out\_max}}$$

$$R_2 = R_{bias} \times \frac{\left(V_{adj\_max} - V_{fb}\right) \times V_{CS} + V_{fb} \times \left(V_{adj\_min} - V_{adj\_max}\right)}{\left(V_{fb} - V_b\right) \times V_{CS}}$$

$$R_3 = \frac{\left(V_{fb} - V_{CS}\right) \times R_{bias} \times R_2}{\left(R_2 \times V_b - R_2 \times V_{fb} + R_{bias} \times V_{adj\_min} - R_{bias} \times V_{fb}\right)} \quad (1)$$

Where:

V_{CS} is the desired maximum voltage across the current sense resistor.
I_{out_max} is the maximum LED current.
R_{bias} is the chosen value for the additional bias resistor.
V_{adj_min} is the minimum voltage used to adjust the LED current.
V_{adj_max} is the maximum voltage used to adjust the LED current.
V_{fb} is the reference voltage of the TPS61040 (1.233 V).
V_b is the bias voltage

2 TPS61040 Reference Design

The following reference design uses the TPS61040 boost converter to provide 20 mA of bias current to a four-element white LED from a single-cell Li-Ion battery (3 V to 4.2 V).

2.1 TPS61040 Bill of Materials

Qty	Reference Designator	Description	Size	MFR	Part Number
1	C2	Capacitor, ceramic, 1.0 µF, 6.3 V, X5R, 15%	603	Murata	GRM188R60J105KA01
1	C3	Capacitor, ceramic, 0.1µF, 16 V, X7R, 10%	603	Murata	GRM188R71C104KA01
1	D1	Diode, Schottky, 350 mA, 40V	SOD-123	OnSemi	MBR0530T1
	D2–D5	Unpopulated (open)			
1	D6	Diode, Zener, 27 V, 94 mA, 225 mW, 5%	SOT23	Motorola	MMBZ5254BLT1
5	J1, J2, J4–J6	Header, 2 pin, 100 -mil spacing, (36-pin strip)	0.100 × 2"	Sullins	PTC36SAAN
1	J3	Header, 3 pin, 100-mil spacing, (36-pin strip)	0.100 × 3"	Sullins	PTC36SAAN
1	JP1	Header, 3 pin, 100-mil spacing, (36-pin strip)	0.100 × 3"	Sullins	PTC36SAAN
1	L1	Inductor, SMT, 10 mH, 0.76 A, 0.23 mΩ	0.150 × 0.162	Sumida	CR32-100
1	R1	Resistor, chip, 10.0 kΩ, 1/16 W, 1%	603	Std	Std
1	R2	Resistor, chip, 249 kΩ, 1/16 W, 1%	603	Std	Std
1	R3	Resistor, chip, 147 kΩ, 1/16 W, 1%	603	Std	Std
1	R4	Resistor, chip, 100 Ω, 1/16 W, 1%	603	Std	Std
1	U1	IC, High-efficiency boost converter	SOT23-5 (DBV)	TI	TPS61040DBV
1	–	PCB, 1.6 In × 1.1 In × 0.062 In		Any	SLVP210
1	–	Shunt, 100 mil, black	0.100	3M	929950-00

The first table that follows shows calculated resistor value to help extend the battery life. The battery life is calculated using a 1000-mA/hr Li-Ion battery. The second table shows how the new resistor values extend battery life.

V_{CS} (V)	0.5	0.5	0.5	0.25	0.25	0.25
Vbias (V)	3.3	5	12.7	3.3	5	12.7
Rbias (kΩ)	499	499	499	499	499	499
R2 (kΩ)	1466	8.4	264	3430	1882	618
R3 (kΩ)	222	122	40	260	143	47
R4 (Ω)	25	25	25	12.5	12.5	12.5

V_{CS} (V)	2	0.5	0.5	0.25	0.25
Vbias (V)	N/A	5	Vout(1)	5	Vout(2)
Iout (mA	20	20	20	20	20
Vout (V)	14.77	13.17	13.17	12.92	12.92
Iin (mA	95.8	84.9	85	83.1	83.4
Effiec (%)	85.6	86.2	86.2	86.3	86.1
Battery Life at 100% duty (hours)	10.4	11.8	11.8	15.4	15.4

(1) Vout is approximately 13.17 V
(2) Vout is approximately 12.92 V

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265