Data Sheet

ADPL21504

Micropower Step-Up DC/DC Converter in a ThinSOT Package

FEATURES

- Low Quiescent Current:
  - 20µA in Active Mode
  - <2µA in Shutdown Mode
- Operates with a V_{IN} as Low as 1.2V
- Low V_{CESAT} Switch: 270mV at 300mA
- Uses Small Surface Mount Components
- High Output Voltage: Up to 30V
- Low Profile (1mm) ThinSOT™ Package

APPLICATIONS

- Portable Electronics
- Battery Backup
- Digital Cameras
- Organic Light Emitting Diode (OLED) Power
- Medical Diagnostic Equipment

GENERAL DESCRIPTION

The **ADPL21504** is a micropower step-up DC/DC converter in a 5-lead, low-profile (1mm) ThinSOT package. The ADPL21504 is designed for higher power systems with a 350mA current limit and an input voltage range of 1.2V to 15V. The ADPL21504 features a quiescent current of only 20µA at no load, which further reduces to 2µA (max) in shutdown. A current-limited, fixed off-time control scheme conserves operating current, resulting in high efficiency over a broad range of load currents. The 32V switch enables the generation of high-voltage outputs up to 30V in a simple boost topology, eliminating the need for costly transformers. The ADPL21504's low off-time of 400ns permits the use of tiny, low-profile inductors and capacitors, minimizing footprint and cost in space-conscious portable applications.

TYPICAL APPLICATION

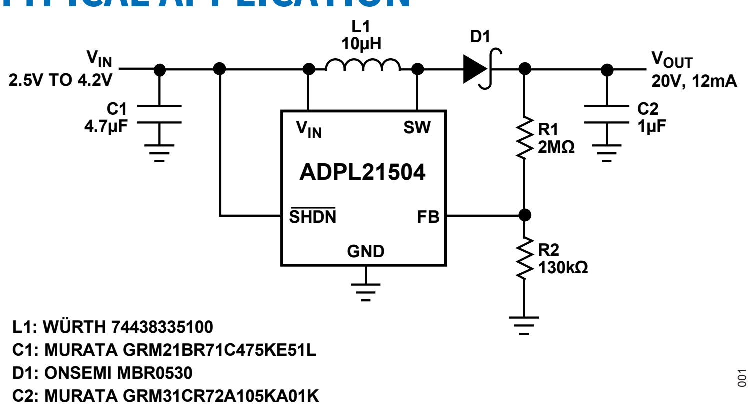

Figure 1. 1-Cell Li-Ion to 20V Converter for LCD Bias

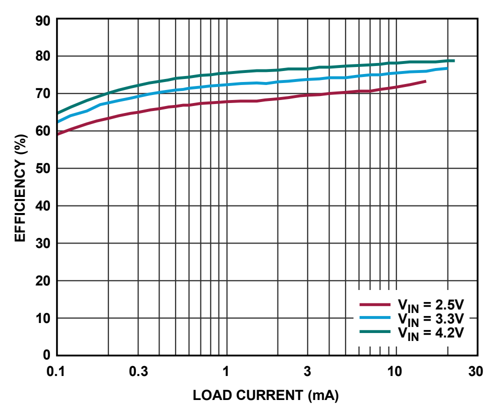

Figure 2. Efficiency vs. Load Current

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REVISION HISTORY

05/2025 - Rev. 0, Initial Release.

SPECIFICATIONS

Table 1. Electrical Characteristics

(Specifications are at T_A = 25°C. V_{IN} = 1.2V, $V_{\overline{SHDN}}$ = 1.2V unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	COMMENTS	MIN	TYP	MAX	UNITS
Minimum Input Voltage	V_{INMIN}					1.2	V
Quiescent Current	I_Q	Not Switching			20	35	µA
		$V_{\overline{SHDN}}$ = 0V				2	µA
FB Comparator Trip Point	V_{FB_TRIP}		-40°C ≤ T_J ≤ 85°C	1.205	1.23	1.255	V
FB Comparator Hysteresis	V_{FB_HYS}				8		mV
Output Voltage Line Regulation		1.2V < V_{IN} < 12V			0.06	0.12	%/V
FB Pin Bias Current[1]	I_{FB_BIAS}	V_{FB} = 1.23V	-40°C ≤ T_J ≤ 85°C		50	100	nA
Switch Off Time	t_{OFF}	V_{FB} > 1V			400		ns
		V_{FB} < 0.6V			1.5		µs
Switch V_{CESAT}	V_{SW_CESAT}	I_{SW} = 300mA			270	375	mV
Switch Current Limit	I_{LIM}			300	350	400	mA
$\overline{SHDN}$ Pin Current	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = 1.2V			2	4	µA
		$V_{\overline{SHDN}}$ = 5V			8	15	µA
$\overline{SHDN}$ Input Voltage High	$V_{\overline{SHDN}\_HIGH}$			0.9			V
$\overline{SHDN}$ Input Voltage Low	$V_{\overline{SHDN}\_LOW}$					0.25	V
Switch Leakage Current	I_{SW_LKG}	Switch Off, V_{SW} = 5V			0.02	6	µA

1 Bias current flows into the FB pin.

ABSOLUTE MAXIMUM RATINGS

Table 2. Absolute Maximum Ratings

PARAMETER	RATING
V_{IN}, $\overline{SHDN}$ Voltage	15V
SW Voltage	32V
FB Voltage	V_{IN}
Current into the FB Pin	1mA
Junction Temperature	125°C
Operating Temperature Range[2]	−40°C to 85°C
Storage Temperature Range	−65°C to 150°C
Lead Temperature (Soldering, 10 sec)	300°C

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

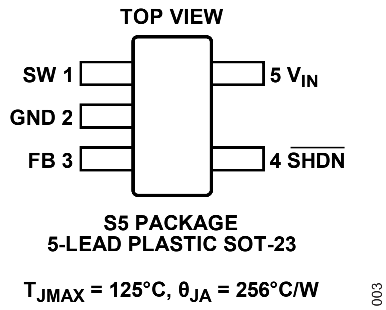


Figure 3. Pin Configuration

Pin Descriptions

Table 3. Pin Descriptions

PIN	NAME	DESCRIPTION
Pin 1	SW	Switch Pin. This is the collector of the internal NPN power switch. Minimize the metal trace area connected to this pin to minimize Electromagnetic interference (EMI).
Pin 2	GND	Ground. Tie this pin directly to the local ground plane.
Pin 3	FB	Feedback Pin. Set the output voltage by selecting values for R1 and R2 (see *Figure 4* for more details): $$R1 = R2 \times \left(\frac{V_{OUT}}{1.23} - 1\right)$$
Pin 4	$\overline{SHDN}$	Shutdown Pin. Tie this pin to 0.9V or higher to enable the device. Tie below 0.25V to turn off the device.
Pin 5	V_{IN}	Input Supply Pin. Bypass this pin with a capacitor that is as close to the device as possible.

BLOCK DIAGRAM

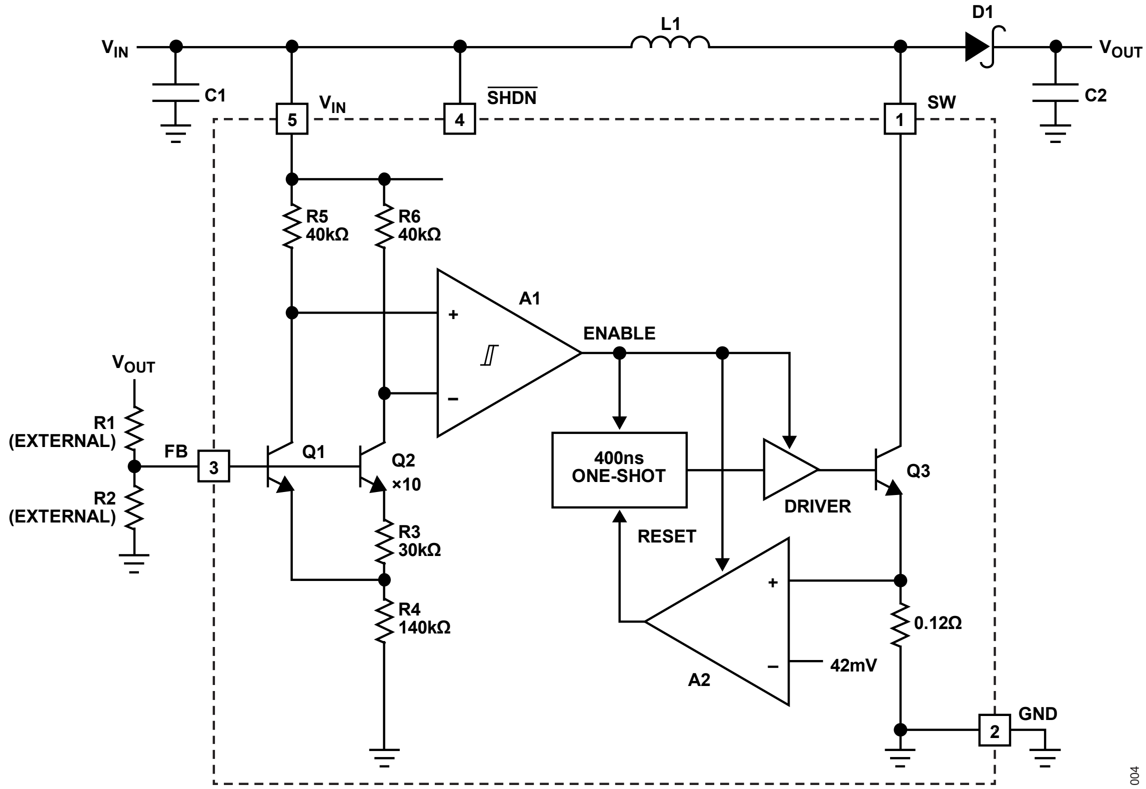


Figure 4. ADPL21504 Block Diagram

TYPICAL PERFORMANCE CHARACTERISTICS

(T_A = 25°C, V_{IN} = 1.2V, $V_{\overline{SHDN}}$ = 1.2V, unless otherwise noted.)

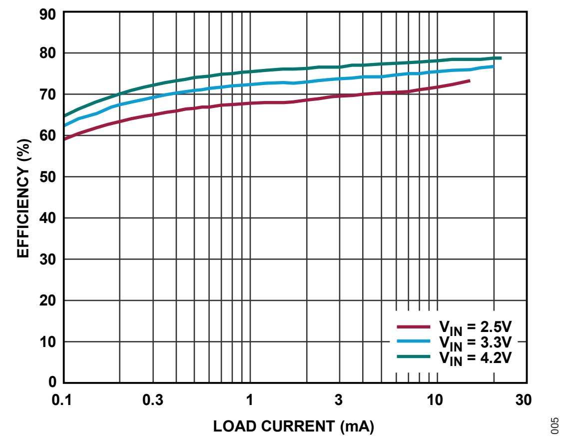


Figure 5. Efficiency vs. Output Current (See Figure 1, Typical Application Circuit)

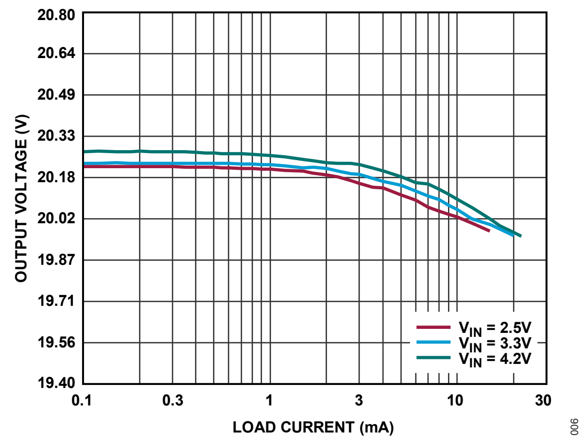


Figure 6. Output Voltage vs. Output Current (See Figure 1, Typical Application Circuit)

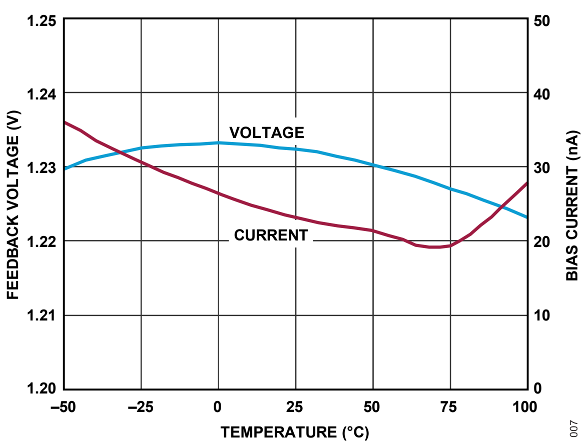


Figure 7. Feedback Pin Voltage and Bias Current

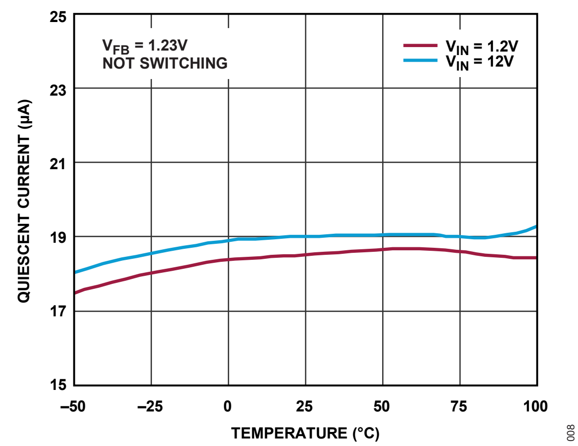


Figure 8. Quiescent Current

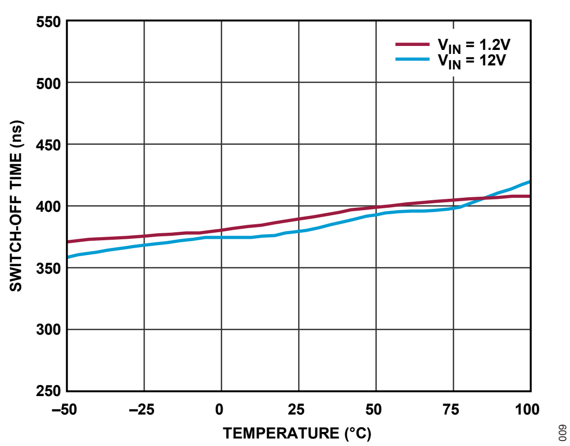


Figure 9. Switch-off Time

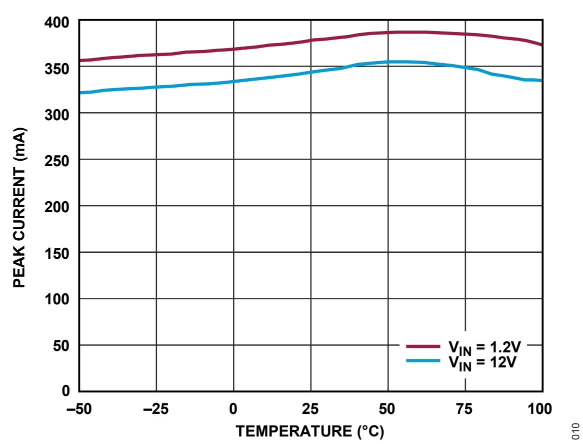


Figure 10. Switch Current Limit

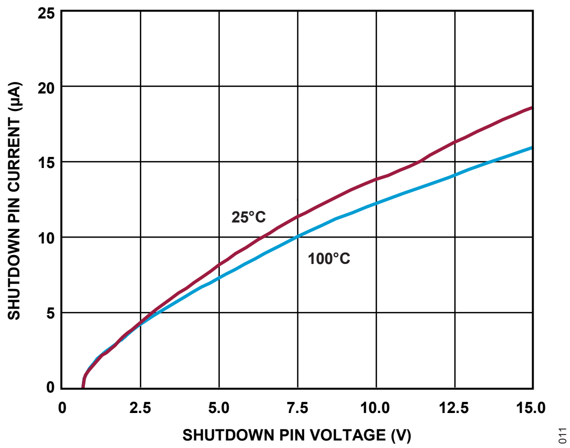


Figure 11. Shutdown Pin Current

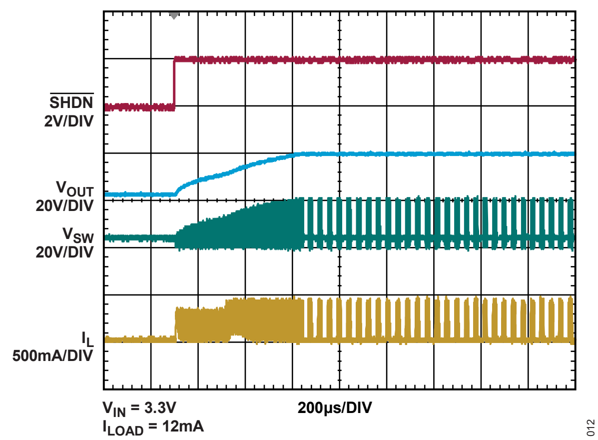


Figure 12. Start-up Waveform (See Figure 1, Typical Application Circuit)

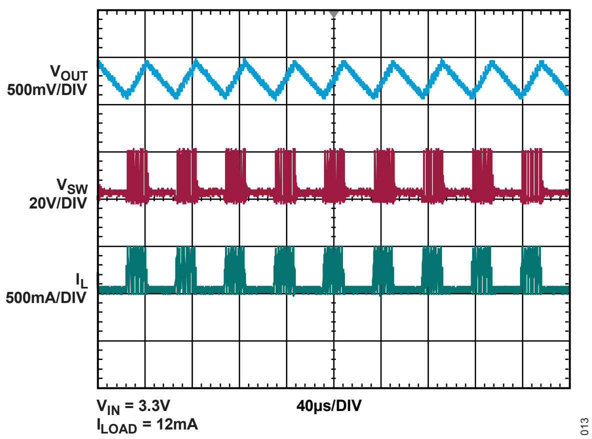


Figure 13. Steady-state Waveforms at Full Load (See Figure 1, Typical Application Circuit)

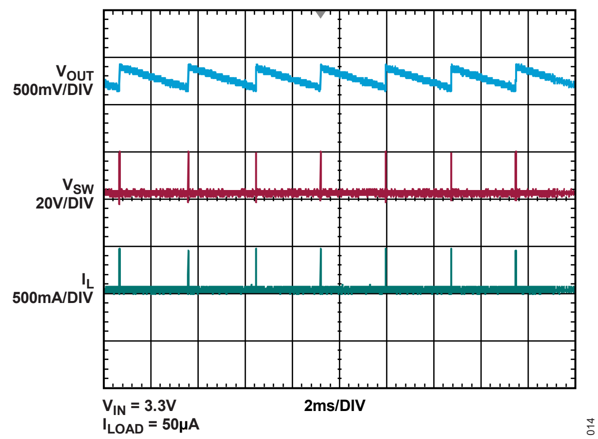


Figure 14. Steady-state Waveform at Light Load (See Figure 1, Typical Application Circuit)

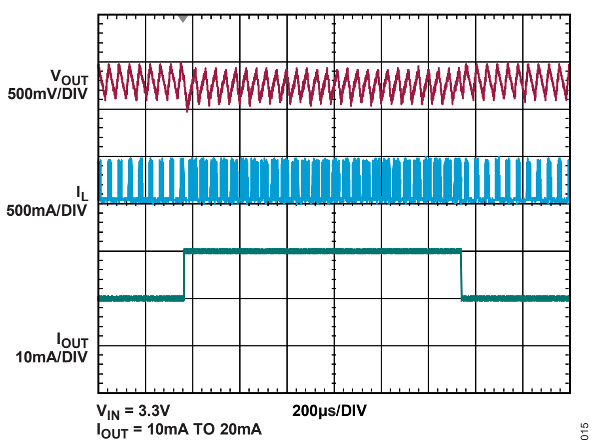


Figure 15. Transient Response 10mA to 20mA (See Figure 1, Typical Application Circuit)

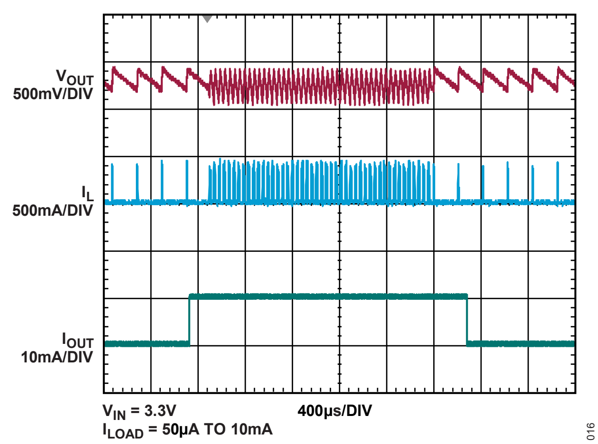


Figure 16. Transient Response Light Load to 10mA (See Figure 1, Typical Application Circuit)

THEORY OF OPERATION

The ADPL21504 uses a constant off-time control scheme to provide high efficiencies over a wide range of output currents. *Figure 4* (Block Diagram) provides the best understanding of the operation. Q1 and Q2, along with R3 and R4, form a bandgap reference used to regulate the output voltage. When the voltage at the FB pin is slightly above 1.23V, comparator A1 disables most of the internal circuitry. The Output current is then provided by capacitor C2, which slowly discharges until the voltage at the FB pin drops below the lower hysteresis point of A1 (typical hysteresis at the FB pin is 8mV).

A1 then enables the internal circuitry, turns on power switch Q3, and the current in inductor L1 begins ramping up. Once the switch current reaches 350mA, comparator A2 resets the one shot, which turns off Q3 for 400ns. L1 then delivers current to the output through diode D1 as the inductor current ramps down. Q3 turns on again, and the inductor current ramps back up to 350mA, then A2 resets the one shot, again allowing L1 to deliver current to the output. This switching action continues until the output voltage is charged up (until the FB pin reaches 1.23V), and then A1 turns off the internal circuitry, and the cycle repeats. The ADPL21504 contains additional circuitry to provide protection during start-up and under short-circuit conditions. When the FB pin voltage is less than approximately 600mV, the switch off-time is increased to 1.5µs, and the current limit is reduced to around 250mA (70% of its normal value). This reduces the average inductor current and helps minimize the power dissipation in the ADPL21504 power switch and in the external inductor and diode.

APPLICATIONS INFORMATION

Choosing an Inductor

Several recommended inductors that work well with the ADPL21504 are listed in *Table 4*. However, many other manufacturers and devices can be used. Consult each manufacturer for more detailed information and their entire selection of related parts. Many different sizes and shapes are available. Use the equations and recommendations in the following sections to find the correct inductance value for your design.

Table 4. Recommended Inductors

PART	VALUE (µH)	MAX DCR (Ω)	MANUFACTURER
LQH32CN4R7M23 LQH32CH100K33 LQH32CH220K23	4.7 10 22	0.26 0.39 0.92	Murata
74438335047 74438335100 74438335220	4.7 10 22	0.162 0.513 1.040	Würth Elektronik
LPS3015-472 LPS3015-103 LPS3015-223	4.7 10 22	0.20 0.44 0.83	Coilcraft

Inductor Selection—Boost Regulator

Equation 1 calculates the appropriate inductor value to be used for a boost regulator using the ADPL21504 (or at least provides a good starting point). This value provides a good tradeoff in inductor size and system performance. Pick a standard inductor close to this value. A larger value can be used to increase the available output current slightly, but limit it to around twice the value calculated as shown in Equation 1, as too large of inductance will increase the output voltage ripple without providing much additional output current. A smaller value can be used (especially for systems with output voltages greater than 12V) to give a smaller physical size. Inductance can be calculated as:

$$L = \left(\frac{V_{OUT} - V_{INMIN} + V_D}{I_{LIM}}\right) \times t_{OFF} \qquad (1)$$

where V_D = 0.4V (Schottky diode voltage), I_{LIM} = 350mA, and t_{OFF} = 400ns; for designs with varying V_{IN}, such as battery-powered applications, use the minimum V_{IN} value in Equation 1. For most systems with output voltages below 7V, a 4.7µH inductor is the best choice, even though Equation 1 can specify a smaller value. This is due to the inductor current overshoot that occurs when very small inductor values are used (see *Current Limit Overshoot* section for more details).

For higher output voltages, Equation 1 will give large inductance values. For a 2V to 20V converter (typical LCD Bias application), a 21µH inductor is called for with the Equation 1, but a 10µH inductor could be used without excessive reduction in maximum output current.

Inductor Selection—SEPIC Regulator

Equation 2 calculates the approximate inductor value to be used for a SEPIC regulator using the ADPL21504. Regarding the boost inductor selection, either a larger or smaller value can be used.

$$L = 2 \times \left(\frac{V_{OUT}+V_D}{I_{LIM}}\right) \times t_{OFF} \qquad (2)$$

Current Limit Overshoot

For the constant off-time control scheme of the ADPL21504, the power switch is turned off only after the 350mA current limit is reached. There is a 100ns delay between the time when the current limit is reached and when the switch actually turns off. During this delay, the inductor current exceeds the current limit by a small amount. The peak inductor current can be calculated by:

$$I_{PEAK} = I_{LIM} + \left(\frac{V_{INMAX} - V_{SW\_CESAT}}{L}\right) \times 100\text{ns} \qquad (3)$$

Where V_{SAT} = 0.27V (switch saturation voltage). The current overshoot will be most evident for systems with high input voltages and for systems where smaller inductor values are used. This overshoot can be beneficial as it helps increase the amount of available output current for smaller inductor values. This will be the peak current seen by the inductor (and the diode) during normal operation. For designs using small inductance values (especially at input voltages greater than 5V), the current limit over-shoot can be quite high. Although the internal current is limited to 350mA, the power switch of the ADPL21504 can handle larger currents without problems, but the overall efficiency will suffer. Best results will be obtained when I_{PEAK} is maintained below 700mA for the ADPL21504.

Capacitor Selection

Low ESR (Equivalent Series Resistance) capacitors should be used at the output to minimize the output ripple voltage. Multilayer ceramic capacitors are the best choice, as they have a very low ESR and are available in very small packages. Their small size makes them a good companion to the ADPL21504's Small outline transistor (SOT)-23 package. Solid tantalum capacitors (like the AVX TPS series, Vishay Sprague 593D series) or OS-CON capacitors can be used, but they will occupy more board area than a ceramic and will have a higher ESR. Always use a capacitor with a sufficient voltage rating.

Ceramic capacitors are also a good choice for the input decoupling capacitor, and they should be placed as close as possible to the ADPL21504. A 4.7µF input capacitor is sufficient for most applications.

Diode Selection

For most ADPL21504 applications, the MBR0520 surface mount Schottky diode (0.5A, 20V) is an ideal choice. Schottky diodes, with their low forward voltage drop and fast switching speed, are the best match for the ADPL21504. For higher output voltage applications, the 30V MBR0530 can be used. Many different manufacturers make equivalent parts, but make sure that the component is rated to handle at least 0.35A.

Lowering Output Voltage Ripple

Using low ESR capacitors will help minimize the output ripple voltage, but proper selection of the inductor and the output capacitor also plays a big role. The ADPL21504 provides energy to the load in bursts by ramping up the inductor current and then delivering that current to the load. If an inductor value is too large or too small of a capacitor value is used, the output ripple voltage will increase because the capacitor will be slightly overcharged each burst cycle. To reduce the output ripple, increase the output capacitor value or add a 4.7pF feed-forward capacitor in the feedback network of the ADPL21504 (see the circuits in the *Typical Applications* section for more details). This small, inexpensive 4.7pF capacitor will greatly reduce the output voltage ripple.

TYPICAL APPLICATIONS

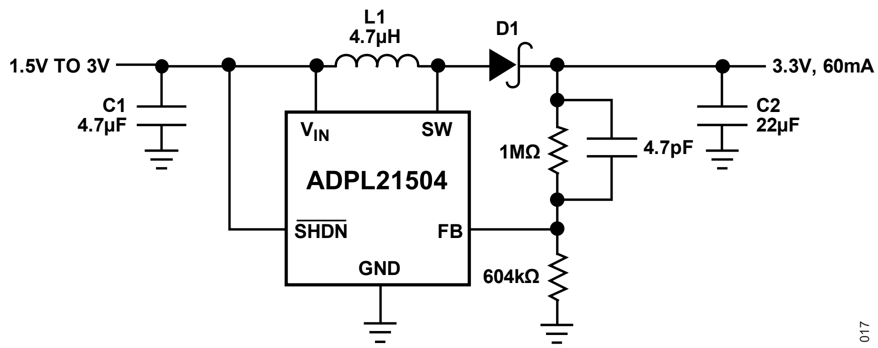


Figure 17. 2-Cell Alkaline to 3.3V Boost Converter

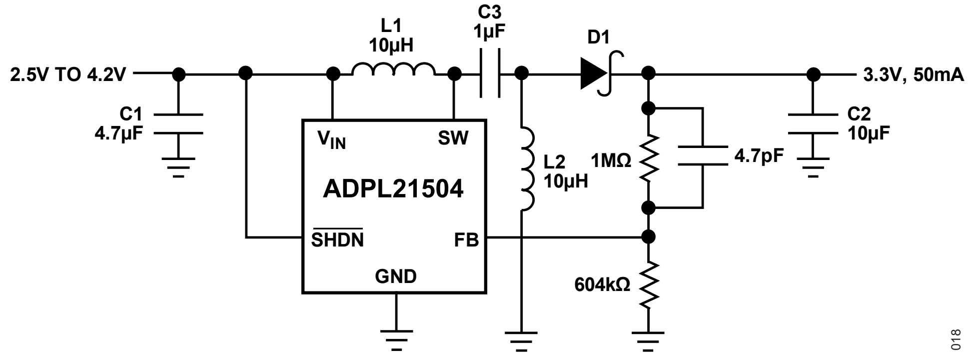


Figure 18. 1-Cell Li-Ion to 3.3V SEPIC Converter

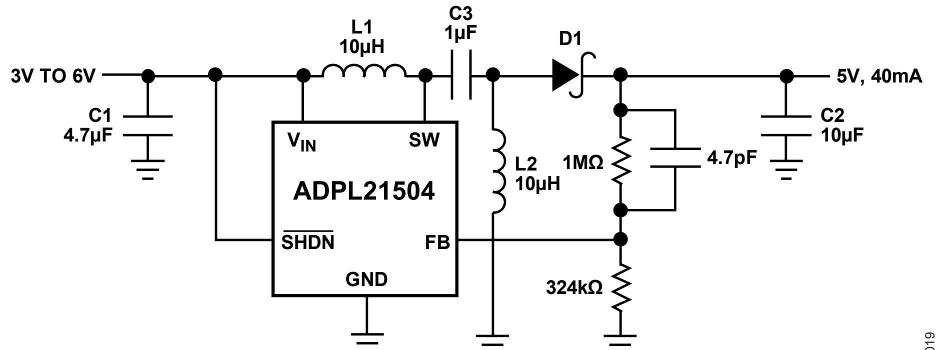


Figure 19. 4-Cell Alkaline to 5V SEPIC Converter

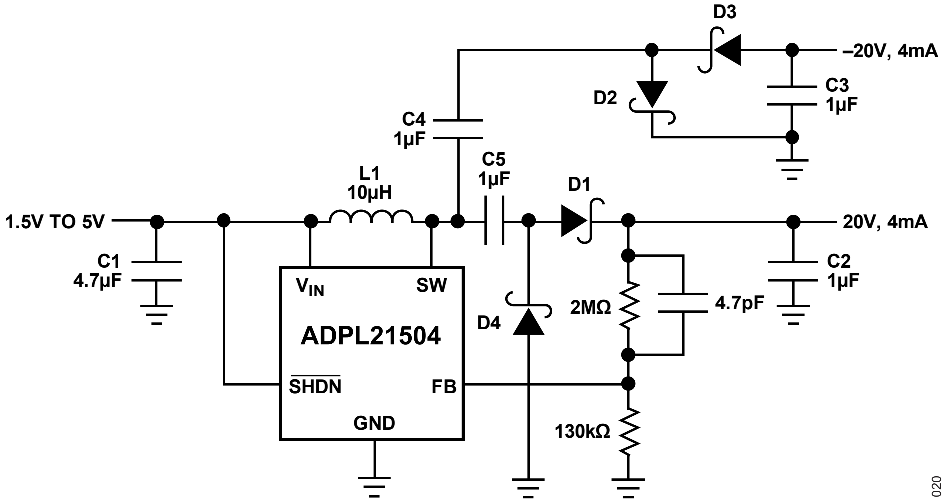
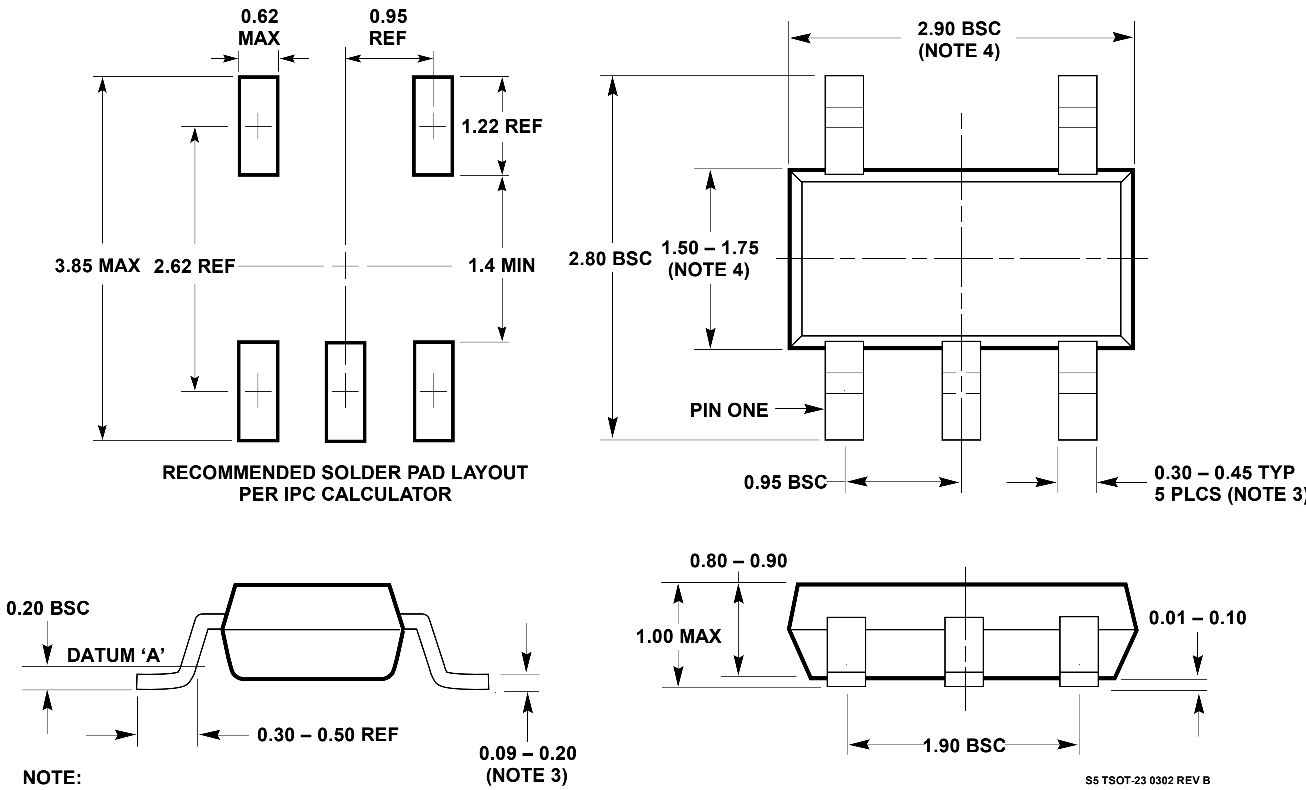


Figure 20. ±20V Dual Output Converter with Output Disconnect

PACKAGE DESCRIPTION



NOTE:
1. DIMENSIONS ARE IN MILLIMETERS
2. DRAWING NOT TO SCALE
3. DIMENSIONS ARE INCLUSIVE OF PLATING
4. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH AND METAL BURR
5. MOLD FLASH SHALL NOT EXCEED 0.254 mm
6. JEDEC PACKAGE REFERENCE IS MO-193

ORDERING GUIDE

Table 5. Ordering Guide

TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
ADPL21504IS5#TRPBF	ADHXJ	S5 PACKAGE 5-LEAD PLASTIC SOT-23	−40°C to 85°C

*The temperature grade is identified by a label on the shipping container.

Tape and reel specifications.

Table 6. Evaluation Boards

PART NUMBER	DESCRIPTION
EVAL-ADPL21504-AZ	Evaluates: ADPL21504 in a 20V Output Voltage Application.