

AS1321 130mA Step-Up DC-DC Converter

General Description

The AS1321 is a high-efficiency step-up DC-DC converter designed to generate a fixed output voltage of +5.0V.

The AS1321 achieves an efficiency of up to 96%. The minimum input voltage is +1.5V, the output voltage is fixed at +5.0V, and output current is up to 130mA (@ 2V VBATT).

In order to save power the AS1321 features a shutdown mode, where it draws less than 1µA. In shutdown mode the battery is connected directly to the output enabling the supply of real-time-clocks.

The AS1321 provides a power-on reset output that goes high-impedance when the output reaches 90% of its regulation point.

The SHDNN trip threshold of the AS1321 can be used as an input voltage detector that disables the device when the battery voltage falls to a predetermined level.

An internal synchronous rectifier is included, which is parallel with the external Schottky diode.

The AS1321 is available in a 6-pin SOT23 package.

2 Key Features

Fixed Output Voltage: +5.0V

Output Current: Up to 130mA (@ 2V VBATT)

Internal Synchronous Rectifier

Shutdown Mode Supply Current: Less Than 1µA

Efficiency: Up to 96%

Minimum Input Voltage: +1.5V

Accurate Shutdown Low-Battery Cutoff Threshold

Battery Input Connected to Pin OUT in Shutdown Mode for Backup Power

6-pin SOT23 Package

3 Applications

The AS1321 is ideal for low-power applications where ultra-small size is critical as in medical diagnostic equipment, hand-held instruments, pagers, digital cameras, remote wireless transmitters, cordless phones, and PC cards.

The device is also perfect as a local +5.0V supply or as a battery backup.

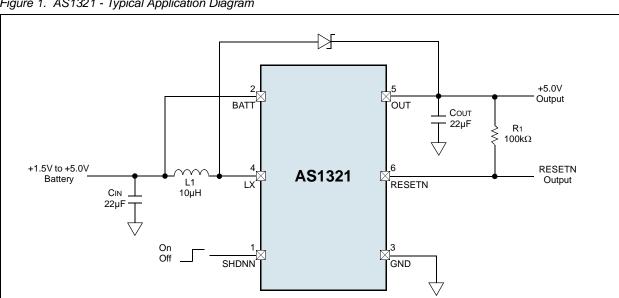


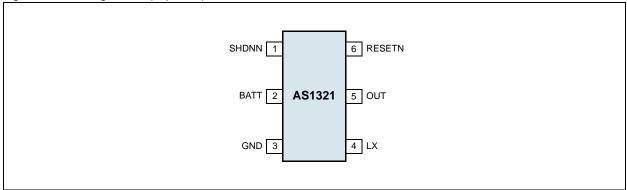
Figure 1. AS1321 - Typical Application Diagram



4 Pinout

Pin Assignments

Figure 2. Pin Assignments (Top View)



Pin Descriptions

Table 1. Pin Descriptions

Name	Pin Number	Description	
		Active-Low Logic Shutdown Input	
SHDNN	1	0 = The AS1321 is off and the current into BATT is \leq 1 μ A (typ).	
		1 = The AS1321 is on.	
BATT	2	Battery Voltage Input	
GND	3	Ground	
LX	4	External Inductor Connection	
OUT	5	Output Voltage	
RESETN	6	Active-Low reset output	



5 Absolute Maximum Ratings

Stresses beyond those listed in Table 2 may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in Section 6 Electrical Characteristics on page 4 is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Table 2. Absolute Maximum Ratings

Parameter	Min	Max	Units	Comments
All Pins to GND	-0.3	7	V	
LX Current		1	Α	
Latch-Up	-100	100	mA	JEDEC 78
Package Power Dissipation (TAMB = +70°C)		500	mW	(ΘJA = 9.1mW/°C above +70°C)
Operating Temperature Range	-40	+85	°C	
Electrostatic Discharge	-500	+500	V	HBM MIL-Std. 883E 3015.7 methods
Humidity (Non-Condensing)	5	85	%	
Storage Temperature Range	-55	125	°C	
Junction Temperature		150	۰C	
Package Body Temperature		260	°C	The reflow peak soldering temperature (body temperature) specified is in compliance with IPC/JEDEC J-STD-020D "Moisture/ Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices".



6 Electrical Characteristics

TAMB = -40 to $+85^{\circ}$ C, VBATT = +2V, VOUT = +5.0, VSHDNN = +1.5V (unless otherwise specified). Typ values @ $TAMB = +25^{\circ}$ C. Table 3. Electrical Characteristics

Parameter	Symbol	Conditions	Min	Тур	Max	Unit	
Battery Input Range	VBATT		1.5		5.0	V	
1	Vsu	RLOAD = 100Ω , TAMB = $+25^{\circ}$ C		1.22	1.5	V	
Startup Battery Input Voltage ¹		RLOAD = 100Ω , TAMB = -40 to $+85$ °C		1.24		V	
2	Vout	TAMB = +25°C	4.950	5.000	5.050	— V	
Output Voltage ²		TAMB = $-40 \text{ to } +85^{\circ}\text{C}$	4.875		5.125		
N-Channel	RNCH	ILX = 100mA, TAMB = +25°C		0.3	1.2	Ω - Ω - mA	
On-Resistance		$ILX = 100mA$, $TAMB = -40 \text{ to } +85^{\circ}C$			1.5		
P-Channel On-Resistance	D	ILX = 100mA, TAMB = +25°C		0.4	1.3		
P-Channel On-Resistance	RPCH	$ILX = 100mA$, $TAMB = -40 \text{ to } +85^{\circ}C$			1.6		
	larase	TAMB = +25°C	550	700	850		
I-Channel Switch Current Limit 1	IMAX	TAMB = $-40 \text{ to } +85^{\circ}\text{C}$	450		950		
Switch Maximum	4	$TAMB = +25^{\circ}C$	5	7	9	μs	
On-Time	ton	TAMB = $-40 \text{ to } +85^{\circ}\text{C}$	4		10		
Synchronous Rectifier		TAMB = +25°C	8	30	60		
Zero-Crossing Current		TAMB = $-40 \text{ to } +85^{\circ}\text{C}$	0		65	mA	
Quiescent Current into OUT ³		VOUT = +5.5V, TAMB = +25°C		35	55		
		Vout = +5.5V, TAMB = -40 to +85°C			60	μA	
		VSHDNN = 0V, TAMB = +25°C		0.01	1		
Shutdown Current into OUT		VSHDNN = 0V, TAMB = -40 to +85°C			2	μA	
3		Vout = +5.5V, TAMB = +25°C		0.01	1	μА	
Quiescent Current into BATT ³		Vout = +5.5V, TAMB = -40 to +85°C			2		
0 0		VSHDNN = 0V, TAMB = +25°C		0.01	1	μА	
Shutdown Current into BATT		VSHDNN = 0V, TAMB = -40 to +85°C			2		
SHDNN Logic Low ¹		VBATT = +1.5 to +5.0V			0.3	V	
		Rising Edge, TAMB = +25°C	1.185	1.228	1.271	.,	
SHDNN Threshold		Rising Edge, TAMB = -40 to +85°C	1.170		1.286	V	
SHDNN Threshold Hysteresis		-		0.02		V	
		Falling Edge, TAMB = +25°C	4.288	4.500	4.712		
RESETN Threshold		Falling Edge, TAMB = -40 to +85°C	4.242		4.758	V	
DEGET N.V.		IRESETN = 1mA, VOUT = +2.5V, TAMB = +25°C			0.15	.,	
RESETN Voltage Low		IRESETN = 1mA, VOUT = +2.5V, TAMB = -40 to +85°C			0.2	V	
DECETAL L		VRESETN = +5.5V, TAMB = +25°C		0.1	100	100 nA	
RESETN Leakage Current		VRESETN = +5.5V, TAMB = +85°C		1			
		TAMB = +25°C		0.1	1000	_	
LX Leakage Current		TAMB = +85°C		10		nA	
Maximum Load Current	ILOAD	VBATT = +2V		130		mA	
Efficiency	η	VBATT = +3V, ILOAD = 100mA		91		%	
Lindiditoy	'	V D/(11 = 10 V, 120AD = 100HIA				/0	

- 1. Guaranteed by design.
- 2. Voltage which triggers next loading cycle. Ripple and rms value depend on external components.
- 3. The Quiescent current is measured while the DC-DC Converter is not switching.



7 Typical Operating Characteristics

VBATT = 2.0V, VOUT = 5.0V, TAMB = +25°C (unless otherwise specified).

Figure 3. Efficiency vs. Load Current

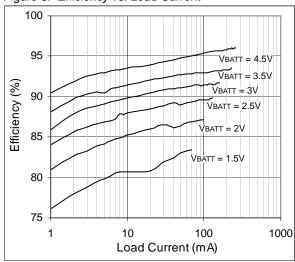


Figure 5. Vout vs. VBATT; On, 39Ω

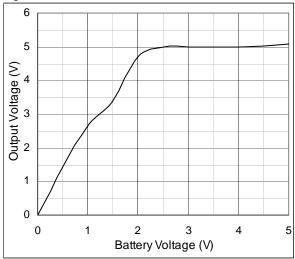


Figure 7. Vout vs. VBATT; Shutdown, 130mA Load

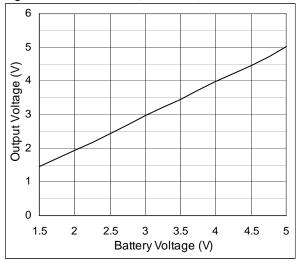


Figure 4. Efficiency vs. Input Voltage

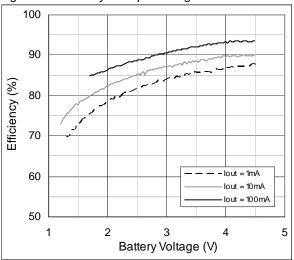


Figure 6. Vout vs. VBATT; On, 470Ω

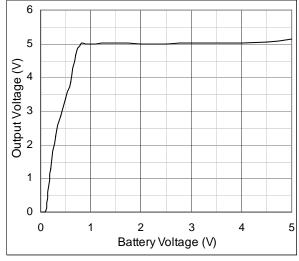
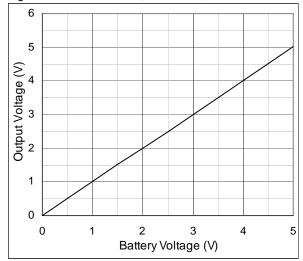


Figure 8. Vout vs. VBATT; Shutdown, no Load



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Figure 9. Maximum Output Current vs. VBATT

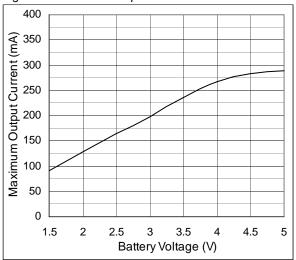


Figure 10. Startup Voltage vs. Load Resistance

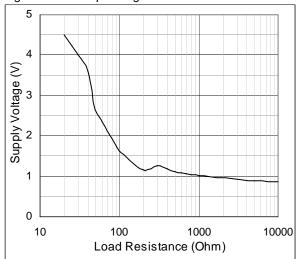


Figure 11. Input Current vs. Input Voltage

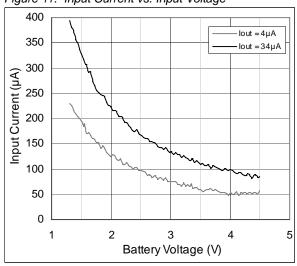


Figure 12. Waveforms; $RLOAD = 100\Omega$, VBATT = 3V

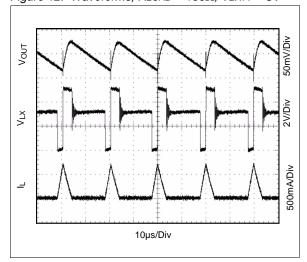


Figure 13. Line Transient

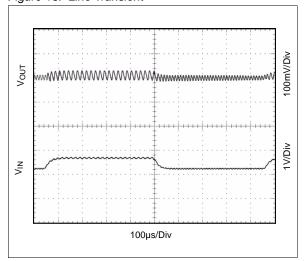


Figure 14. Load Transient

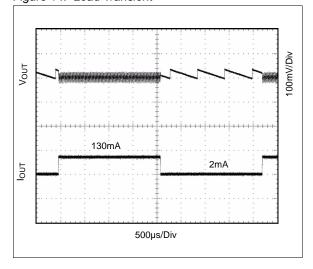




Figure 15. On / Off Response; $RLOAD = 100\Omega$

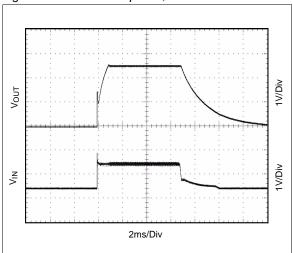
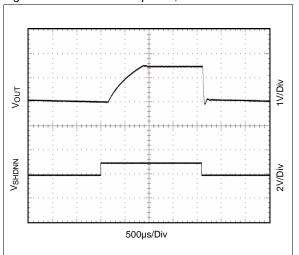


Figure 16. Shutdown Response; $RLOAD = 100\Omega$

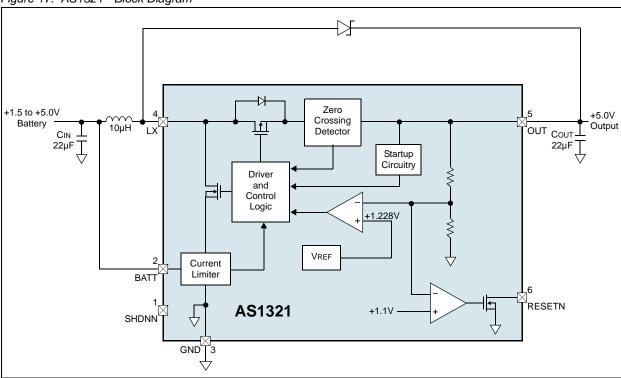




8 Detailed Description

The AS1321 is a high-efficiency, compact step-up converter with 35µA quiescent supply current which ensures the highest efficiency over a wide load range. With a minimum of +1.5V input voltage, the device is well suited for applications with one- or two-cells, such as lithium ion (Li+), nickel-metal-hydride (NiMH), or alkaline.

Figure 17. AS1321 - Block Diagram



The input battery is connected to the device through an inductor and an internal P-FET when pin SHDNN is low. In this state, the step-up converter is off and the voltage drop across the P-FET body diode is eliminated, and the input battery can be used as a battery-backup or real-time-clock supply.

The built-in synchronous rectifier significantly improves efficiency.

Control Circuitry

The AS1321 integrated current-limited key circuitry provides low quiescent current and extremely-high efficiency over a wide Vout range without the need for an oscillator. Inductor current is limited by the 7µs switch maximum on-time or by the 0.7A N-channel current limit. At each cycle, the inductor current must ramp down to zero after the on-time before the next cycle may start. When the error comparator senses that the output has fallen below the regulation threshold, another cycle begins.

Shutdown

When pin SHDNN is low the AS1321 is switched off and no current is drawn from battery; when pin SHDNN is high the device is switched on. If SHDNN is driven from a logic-level output, the logic high-level (on) should be referenced to Vout to avoid intermittently switching the device on.

Note: If pin SHDNN is not used, it should be connected directly to pin OUT.

In shutdown the battery input is connected to the output through the inductor and the internal synchronous rectifier P-FET. This allows the input battery to provide backup power for devices such as an idle microcontroller, memory, or real-time-clock, without the usual diode forward drop. In this way a separate backup battery is not needed.

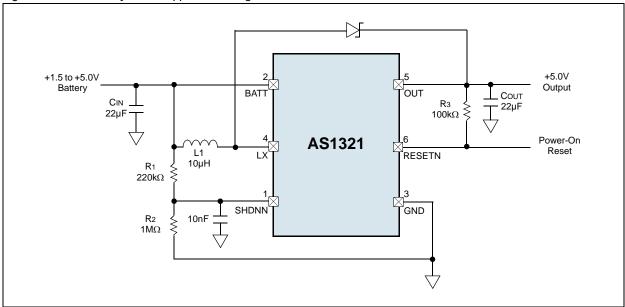
In cases where there is residual voltage during shutdown, some small amount of energy will be transferred from pin OUT to pin BATT immediately after shutdown, resulting in a momentary spike of the voltage at pin BATT. The ratio of CIN and COUT partly determine the size and duration of this spike, as does the current-sink ability of the input device.



Low-Battery Cutoff

The AS1321 SHDNN trip threshold (1.228V) can be used as an input voltage detector that disables the device when the battery input voltage falls to a pre-set level. An external resistor-divider network can be used to set the battery-detection voltage (see Figure 18).

Figure 18. Low-Battery Cutoff Application Diagram



For the resistor-divider network shown in Figure 18, calculate the value for R₁ by:

$$R_1 = R_2 \times ((VOFF/VSHDNN) - 1)$$
 (EQ 1)

Where:

VOFF is the battery voltage at which the AS1321 shuts down.

VSHDNN = 1.228V

The value of R₂ should be between $100k\Omega$ and $1M\Omega$ to minimize battery drain.

Note: Input ripple can cause false shutdowns, therefore to minimize the effect of ripple, a low-value capacitor from SHDNN to GND should be used to filter out input noise. The value of the capacitor should be such that the R/C time constant is > 2ms.

Power-On Reset

The AS1321 provides a power-on reset output (RESETN) that goes high-impedance when the output reaches 90% of its regulation point. RESETN goes low when the output is below 90% of the regulation point. A $100k\Omega$ to $1M\Omega$ pullup resistor between pin RESETN and pin OUT can provide a microprocessor logic control signal.

Note: Connect pin RESETN to GND when the power-on reset feature is not used.



9 Application Information

Inductor Selection

The control circuitry of the AS1321 permits a wide range of inductor values to be selected – from 4.7 to $47\mu H$; $10\mu H$ is ideal for most applications.

The intended application should dictate the value of L. The trade-off between required PCB surface area and desired output ripple are the determining factors: smaller values for L require less PCB space, larger values of L reduce output ripple. If the value of L is large enough to prevent IMAX from being reached before ton expires, the AS1321 output power will be reduced.

For maximum output current calculate the value for L as:

$$(VBATT(MAX) (1\mu S))/0.7A < L < (VBATT(MIN)(7\mu S))/0.7A$$
 (EQ 2)

$$IOUT(MAX) = (0.7A/2)(VBATT(MIN) - (0.7A/2)(RNCH + RIND))/VOUT$$
 (EQ 3)

Where:

RIND is the inductor series resistance.

RNCH is the RDS(ON) of the N-channel MOSFET (0.3 Ω typ).

Note: Coils should be able to handle 500mARMs and have a ISAT \geq 1A and should have a RIND \leq 100m Ω .

Capacitor Selection

Cout Selection

Choose a Cout value to achieve the desired output ripple percentage. A 22µF ceramic capacitor is a good initial value. The value for Cout can be determined by:

COUT >
$$(L + 2.5\mu H) \times VBATT(MAX)^2 / (r\% \times 4)$$
 (EQ 4)

Where:

r is the desired output ripple in %.

CIN Selection

CIN reduces the peak current drawn from the battery and can be the same value as Cout. A larger value for CIN can be used to further reduce ripple and improve AS1321 efficiency.

External Diode

An external Schottky diode must be connected, in parallel with the on-chip synchronous rectifier, from LX to OUT. Use diodes such as MBR0520L, EP05Q03L, or the generic 1N5817. The diode should be rated for 500mA, since it carries current during startup and after the synchronous rectifier turns off. The Schottky diode must be connected as close to the IC as possible. Ordinary rectifier diodes must not be used, since the slow recovery rate will compromise efficiency.

PC Board Layout and Grounding

Well-designed printed circuit-board layout is important for minimizing ground bounce and noise.

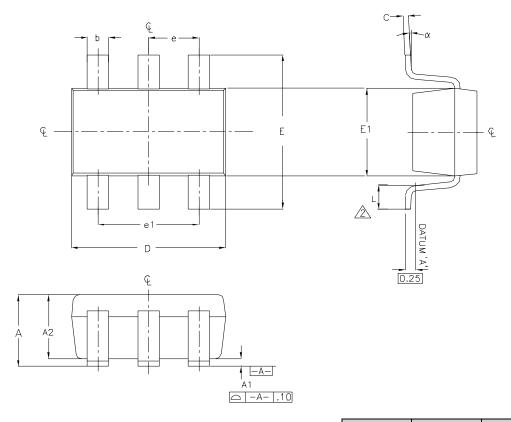
- Place pin GND lead and the ground leads of CIN and COUT as close to the device as possible.
- Keep the lead to pin LX as short as possible.
- To maximize output power and efficiency and minimize output ripple voltage, use a ground plane and solder the GND pin directly to the ground plane.



10 Package Drawings and Markings

The AS1321 is available in a 6-pin SOT23 package.

Figure 19. 6-pin SOT23 Package



Notes:

- 1. All dimensions are in millimeters.
- 2. Foot length is measured at the intercept point between datum A and lead surface.
- 3. Package outline exclusive of mold flash and metal burr.
- 4. Pin 1 is the lower left pin when reading the top mark from left to right.
- 5. Pin 1 identifier dot is 0.3mm. min and is located above pin 1.
- 6. Meets JEDEC MO178.

Symbol	Min	Max		
Α	0.90	1.45		
A1	0.00	0.15		
A2	0.90	1.30		
b	0.35	0.50		
С	0.08	0.20		
D	2.80	3.00		
E	2.60	3.00		
E1	1.50	1.75		
L	0.35	0.55		
е	0.95 REF			
α	00	10°		



11 Ordering Information

The AS1321 is available as the standard products shown in Table 4.

Table 4. Ordering Information

Ordering Code	Marking	Description	Delivery Form	Package	
AS1321-T	ASKX	130mA Step-Up DC-DC Converter	Tape and Reel	6-pin SOT23	

Note: All products are RoHS compliant and Pb-free.

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