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AS1322

Data Sheet

Low Voltage, Micropower, DC-DC Step-Up Converters

1 General Description

The AS1322A and the AS1322B are synchronous, fixed frequency, very high-efficiency DC-DC boost converters capable of supplying 3.3V at 150mA from a single AA-supply. Compact size and minimum external parts requirements make these devices perfect for modern portable devices.

High-speed switching frequency (1.2MHz) and internally compensated PWM current mode design provide highly-reliable DC-DC conversion, especially when driving white LEDs.

The converters are available as the standard products listed in Table 1.

Table 1. Standard Products

Model	Light Load Switching
AS1322A	Automatic Powersave Operation
AS1322B	Continuous Switching

The devices contain two internal MOSFET switches: one NMOS switch and one PMOS synchronous rectifier.

Anti-ringing control circuitry reduces EMI by damping the inductor in discontinuous mode, and the devices exhibit extremely low quiescent current (< 1µA) in shutdown.

In shutdown mode the battery is connected to the output and VOUT is held at approximately VIN - 0.6V.

The AS1322 is available in a 6-pin TSOT-23 package.

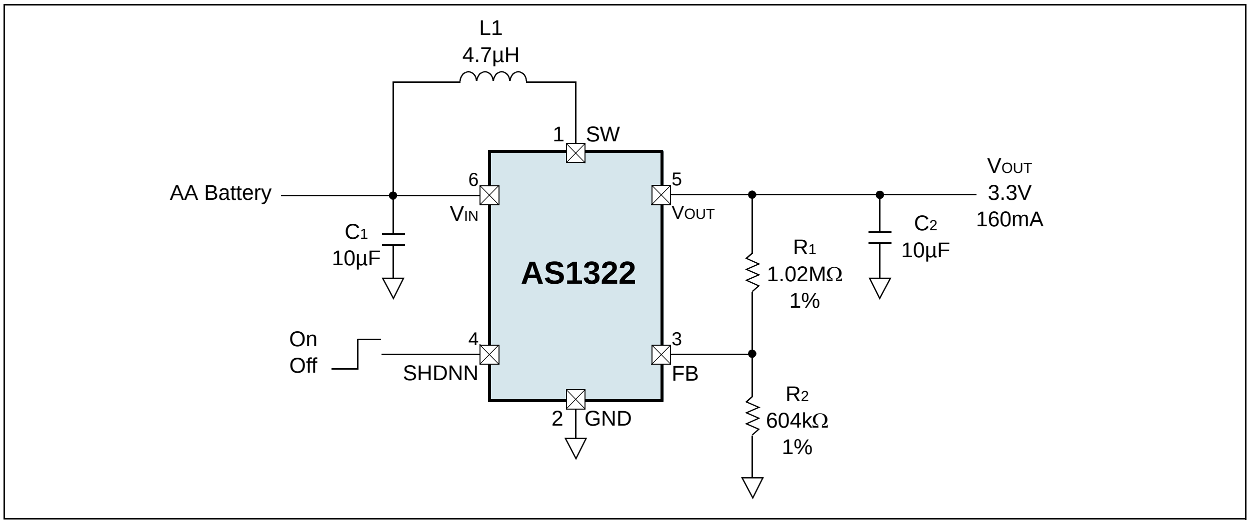
2 Key Features

- 95% Efficiency
- Single-Cell Operation
- Delivers 160mA @ 3.3V (from Single AA Cell)
- Delivers 220mA @ 5.0V (from Two AA Cells)
- Delivers 570mA @ 3.3V (from Two AA Cells)
- Low Start-Up Voltage: 0.85V
- High-Speed Fixed-Frequency: 1.2MHz
- Internal PMOS Synchronous Rectifier
- Automatic Powersave Operation (AS1322A)
- Continuous Switching at Light Loads (AS1322B)
- Anti-Ringing Control Minimizes EMI
- Logic Controlled Shutdown (< 1µA)
- Output Range: 2.5 to 5.0V
- 6-pin TSOT-23 Package

3 Applications

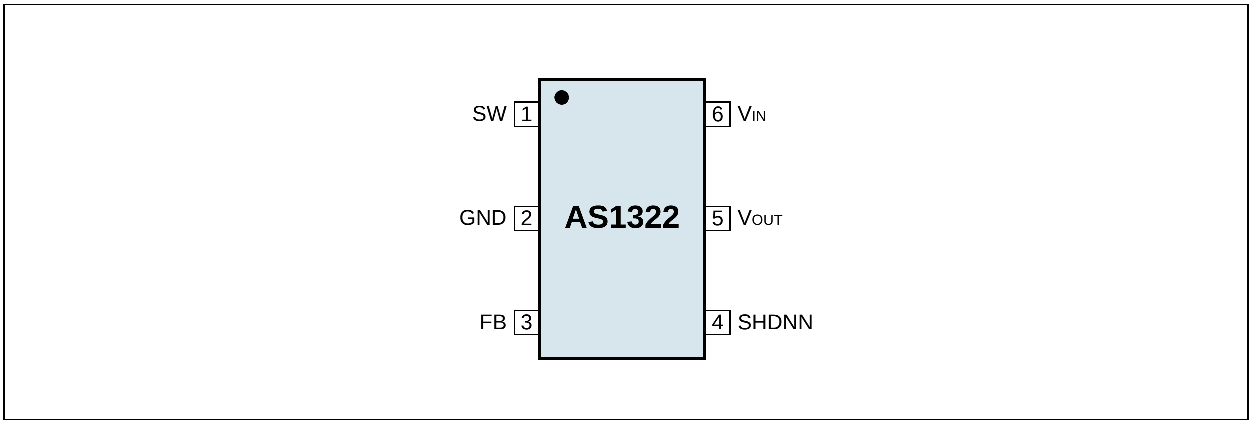
The AS1322 is ideal for low-power applications where ultra-small size is critical as in medical diagnostic equipment, hand-held instruments, pagers, digital cameras, remote wireless transmitters, MP3 players, LCD bias supplies, cordless phones, GPS receivers, and PC cards.

Figure 1. Typical Application Diagram – Single Cell to 3.3V Synchronous Boost Converter



4 Pin Assignments

Figure 2. Pin Assignments (Top View)



Pin Descriptions

Table 2. Pin Descriptions

Pin Name	Pin Number	Description
SW	1	**Switch Pin**. Connect an inductor between this pin and V_{IN}. Keep the PCB trace lengths as short and wide as is practical to reduce EMI and voltage overshoot. If the inductor current falls to zero, or pin SHDNN is low, an internal 100Ω anti-ringing switch is connected from this pin to V_{IN} to minimize EMI. **Note:** An optional Schottky diode can be connected between this pin and V_{OUT}.
GND	2	**Signal and Power Ground**. Provide a short, direct PCB path between this pin and the negative side of the output capacitor(s).
FB	3	**Feedback Pin**. Feedback input to the g_m error amplifier. Connect a resistor divider tap to this pin. The output voltage can be adjusted from 2.5 to 5V by: $V_{OUT} = 1.23V[1 + (R_1/R_2)]$
SHDNN	4	**Shutdown Pin**. Logic controlled shutdown input. 1 = Normal operation, 1.2MHz typical operating frequency. 0 = Shutdown; quiescent current <1µA. If SHDNN is undefined, pin SW may ring. **Note:** In a typical application, SHDNN should be connected to V_{IN} through a 1MΩ pull-up resistor.
V_{OUT}	5	**Output Voltage Sense Input and Drain of the Internal PMOS Synchronous Rectifier**. Bias is derived from V_{OUT} when V_{OUT} exceeds V_{IN}. PCB trace length from V_{OUT} to the output filter capacitor(s) should be as short and wide as is practical. V_{OUT} is held at approximately V_{IN} - 0.6V during shutdown.
V_{IN}	6	**Input Voltage**. The AS1322 gets its start-up bias from V_{IN} unless V_{OUT} exceeds V_{IN}, in which case the bias is derived from V_{OUT}. Thus, once started, operation is completely independent from V_{IN}. Operation is only limited by the output power level and the internal series resistance of the supply.

5 Absolute Maximum Ratings

Stresses beyond those listed in Table 3 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 3. Absolute Maximum Ratings

Parameter	Min	Max	Units	Notes
V_{IN} to GND	-0.3	7	V	
SHDNN, SW to GND	-0.3	7	V	
FB to GND	-0.3	5	V	
V_{OUT}	-0.3	7	V	
Operating Temperature Range	-40	+85	ºC	
Storage Temperature Range	-65	+125	ºC	
Package Body Temperature		+260	ºC	The reflow peak soldering temperature (body temperature) specified is in accordance with *IPC/JEDEC J-STD-020C “Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices”.* The lead finish for Pb-free leaded packages is matte tin (100% Sn).

6 Electrical Characteristics

T_{AMB} = -40 to +85ºC, V_{IN} = +1.2V, V_{OUT} = +3.3, V_{SHDNN} = +1.2V (unless otherwise specified). Typ values @ T_{AMB} = +25ºC.

Table 4. Electrical Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
	Minimum Start-Up Voltage	I_{LOAD} = 1mA		0.85	1	V
	Minimum Operating Voltage	SHDNN = V_{IN} [1]		0.65	0.85	V
	Output Voltage Adjust Range	T_{AMB} = 25ºC	2.5		5	V
V_{FB}	Feedback Voltage	T_{AMB} = T_{MIN} to T_{MAX}	1.192	1.23	1.268	V
I_{FB}	Feedback Input Current	V_{FB} = 1.25V [2]		1		nA
I_{QPWS}	Quiescent Current (Powersave Operation)	V_{FB} = 1.4V [3], AS1322A only		30	50	µA
I_{QSHDNN}	Quiescent Current (Shutdown)	V_{SHDNN} = 0V		0.01	1	µA
I_Q	Quiescent Current (Active)	V_{FB} = 1.4V [3] , AS1322B only		150	300	µA
$I_{NMOSSWL}$	NMOS Switch Leakage	V_{SW} = 5V		0.1	5	µA
$I_{PMOSSWL}$	PMOS Switch Leakage	V_{SW} = 0V		0.1	5	µA
R_{ONNMOS}	NMOS Switch On Resistance	V_{OUT} = 3.3V		0.35	0.8	Ω
		V_{OUT} = 5V		0.20	0.7	
R_{ONPMOS}	PMOS Switch On Resistance	V_{OUT} = 3.3V		0.45	0.8	Ω
		V_{OUT} = 5V		0.30	0.7	
I_{NMOS}	NMOS Current Limit	V_{IN} = 2.5V		850		mA
I_{PS}	Powersave Operation Current Threshold	AS1322A only [2]		3		mA
	Max Duty Cycle	V_{FB} = 1V, T_{AMB} = T_{MIN} to T_{MAX}	80	87		%
f_{SW}	Switching Frequency	T_{AMB} = 25ºC	0.95	1.2	1.5	MHz
		T_{AMB} = T_{MIN} to T_{MAX}	0.85	1.2	1.5	
V_{SHDNNH}	SHDNN Input High		1			V
V_{SHDNNL}	SHDNN Input Low				0.35	V
I_{SHDNN}	SHDNN Input Current	V_{SHDNN} = 5.0V		0.01	1	µA

1. Minimum V_{IN} operation after start-up is only limited by the battery's ability to provide the necessary power as it enters a deeply discharged state.
2. Specification is guaranteed by design and not 100% production tested.
3. I_{QPWS} is measured at V_{OUT}. Multiply this value by V_{OUT}/V_{IN} to get the equivalent input (battery) current.

7 Typical Operating Characteristics

Figure 3. Powersave mode threshold vs. VIN, VOUT = 3.0V

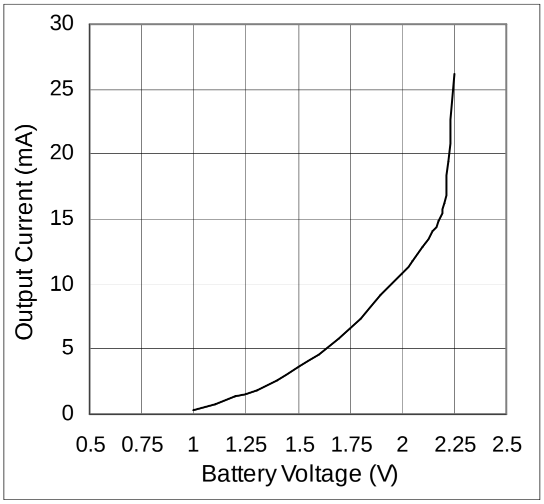


Figure 4. Efficiency vs. Output Current, VOUT = 3.3V

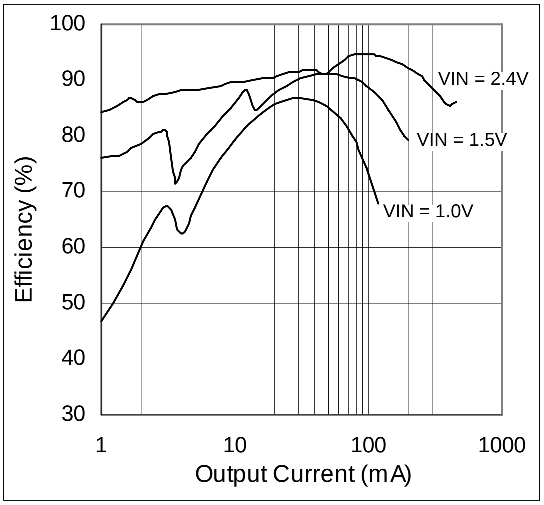


Figure 5. Output Voltage vs. Temperature; VOUT = 3.3V, IOUT = 10mA

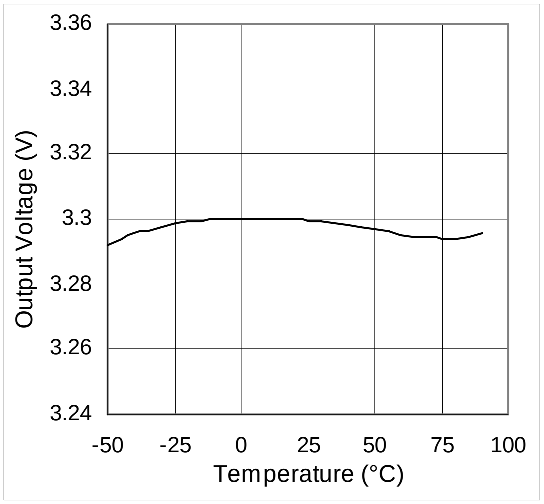


Figure 6. Output Voltage vs. Battery Voltage; VOUT = 3.3V, IOUT = 10mA

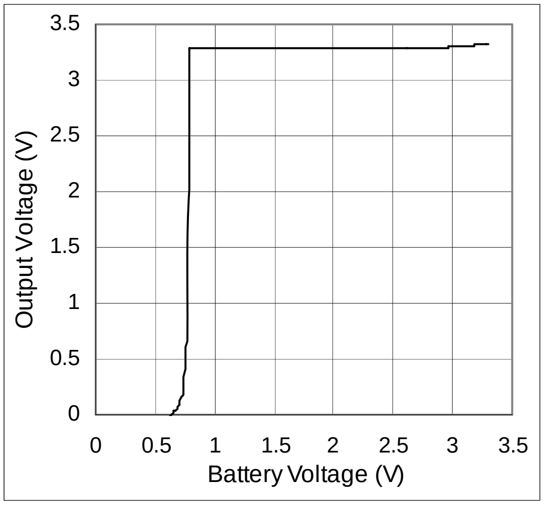


Figure 7. Startup Voltage vs. Output Current;

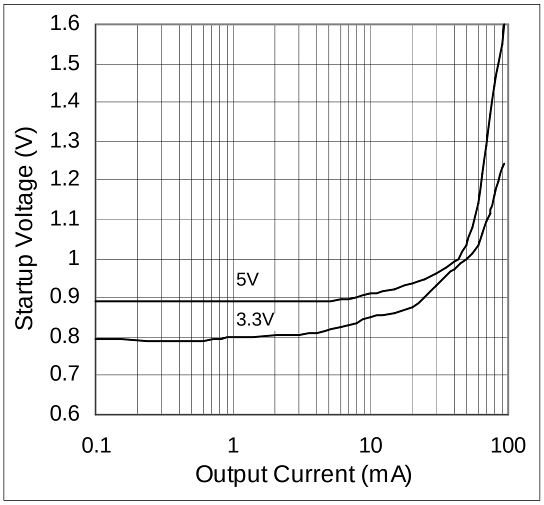


Figure 8. Output Current vs. Battery Voltage; VOUT = 3.3V, 3% Tolerance

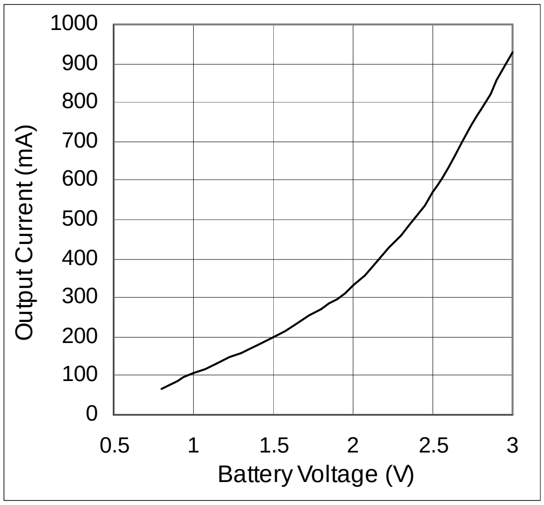


Figure 9. Output Current vs. Battery Voltage; V_{OUT} = 5.0V, 3% Tolerance

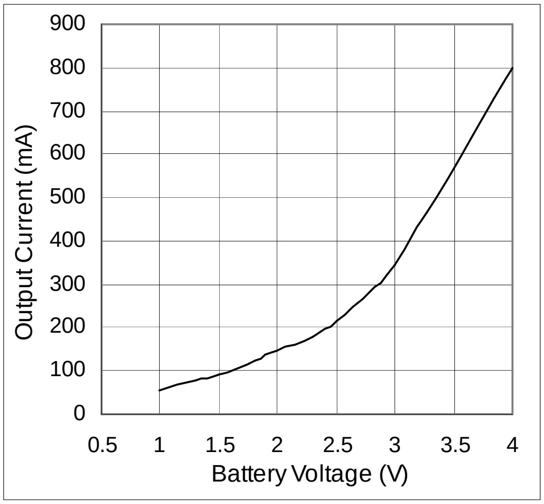


Figure 10. No Load Battery Current vs. V_{BATT} V_{OUT} = 3.3V, T_{AMB} = 25ºC

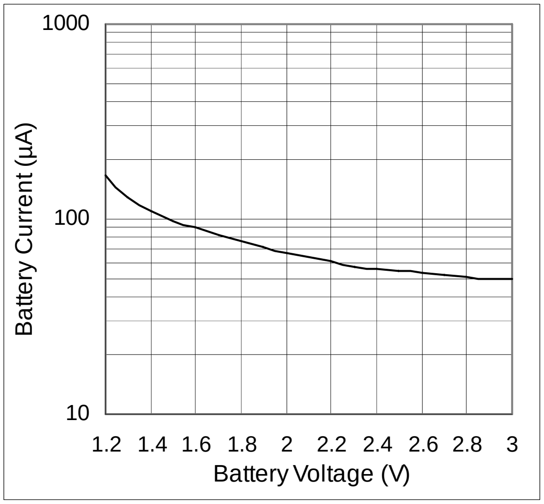


Figure 11. SW Pin Antiringing Operation V_{IN} = 1.3V, V_{OUT} = 3.3V, L = 10µH, C = 10µF, I_{OUT} = 5mA

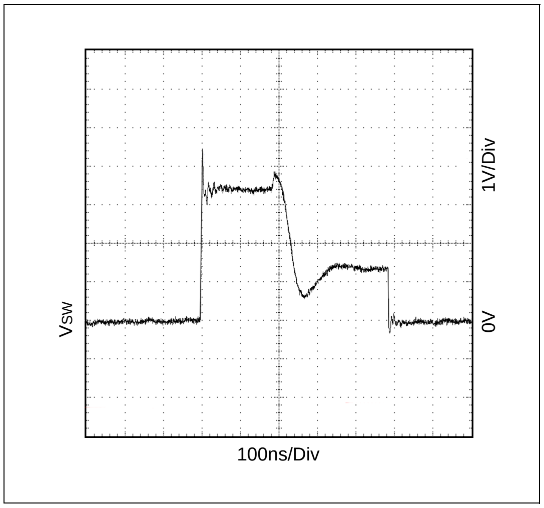


Figure 12. SW Pin Fixed Frequency Continuous Current V_{IN} = 1.3V, V_{OUT} = 3.3V, L = 10µH, C = 10µF, I_{OUT} = 100mA

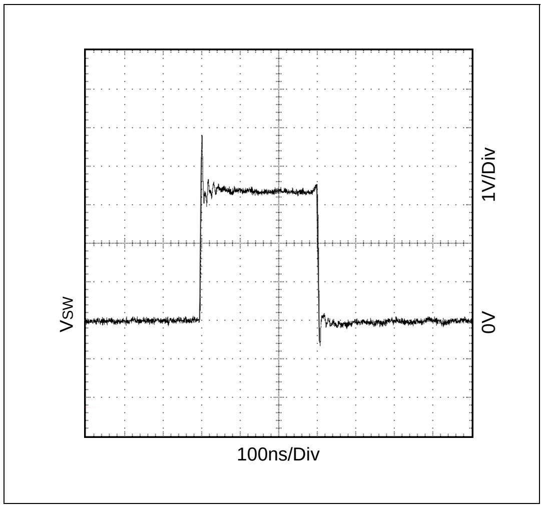


Figure 13. V_{OUT} Transient Response. V_{IN} = 1.3V, V_{OUT} = 3.3V, L = 10µH, C = 10µF

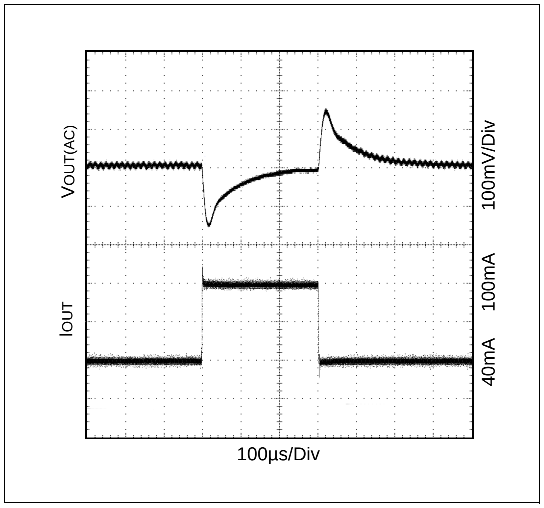
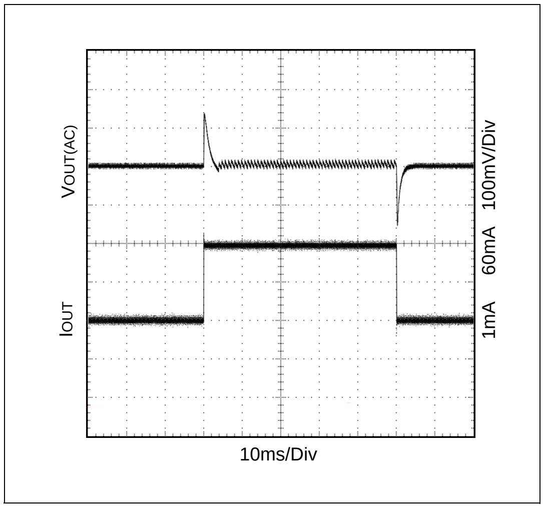


Figure 14. Fixed Frequency vs. Powersave Operation V_{IN} = 1.3V, V_{OUT} = 3.3V, L = 10µH, C = 10µF



Parts used for measurments: 10µH (MOS6020-103ML) Inductor, 10µF (GRM31CR70J106KA01L) C_{IN} and C_{OUT}

8 Detailed Description

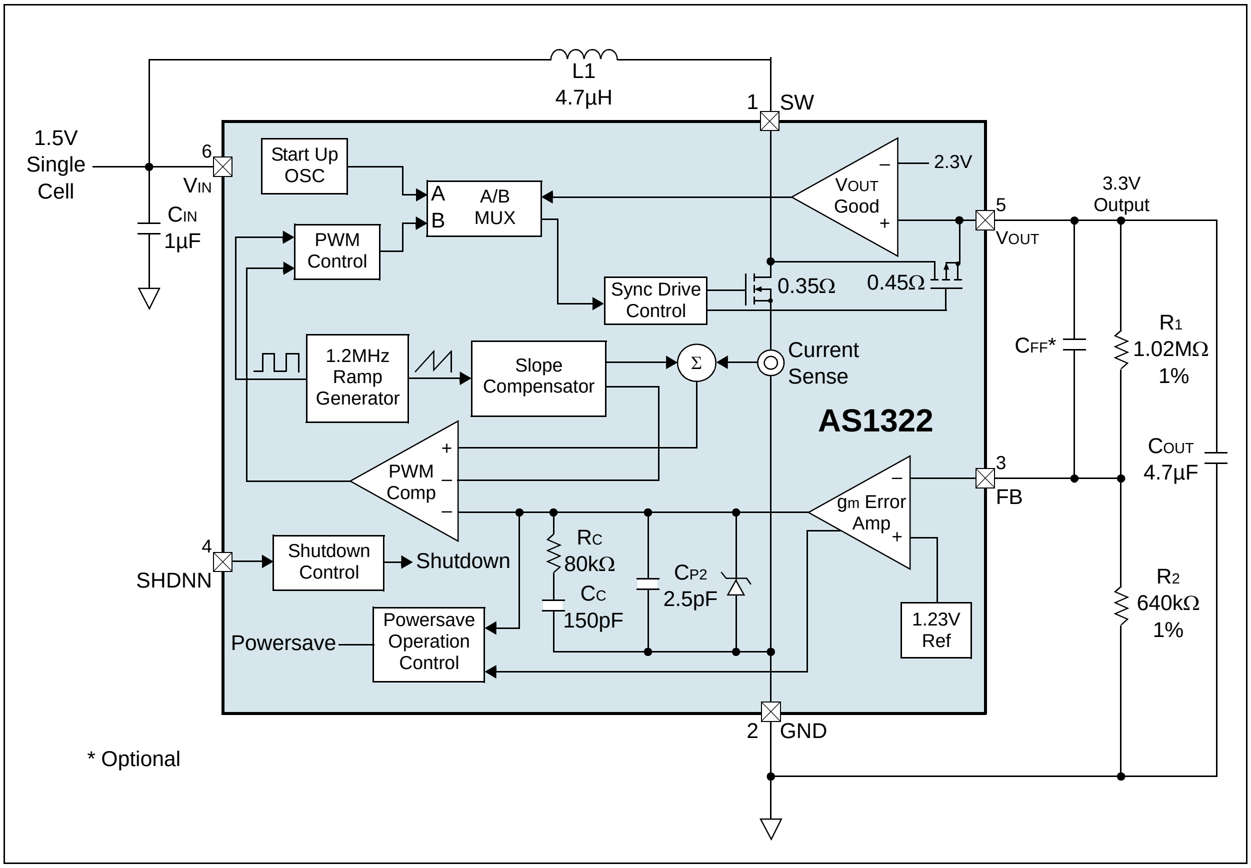
The AS1322/AS1322B can operate from a single-cell input voltage (V_{IN}) below 1V, and feature fixed frequency (1.2MHz) and current mode PWM control for exceptional line- and load-regulation. With low $R_{DS(ON)}$ and gate charge internal NMOS and PMOS switches, the devices maintain high-efficiency from light to heavy loads.

Modern portable devices frequently spend extended time in low-power or standby modes, switching to high power-drain only when certain functions are enabled. The AS1322A and the AS1322B are ideal for portable devices since they maintain high-power conversion efficiency over a wide output power range, thus increasing battery life in these types of devices.

In addition to high-efficiency at moderate and heavy loads, the AS1322A includes an automatic powersave mode that improves efficiency of the power converter at light loads. The powersave mode is initiated if the output load current falls below a factory programmed threshold (see Figure 3 on page 5).

Note: The AS1322B does not support powersave mode and provides continuous operation at light loads, eliminating low-frequency V_{OUT} ripple at the expense of light load efficiency.

Figure 15. Block Diagram



Low-Voltage Start-Up

The AS1322 requires V_{IN} of only 0.85V (typ) or higher to start up. The low-voltage start-up circuitry controls the internal NMOS switch up to a maximum peak inductor current of 850mA (typ), with 1.5ms (approx.) off-time during start-up, allowing the devices to start up into an output load.

With a V_{OUT} > 2.3V, the start-up circuitry is disabled and normal fixed-frequency PWM operation is initiated. In this mode, the AS1322 operates independent of V_{IN}, allowing extended operating time as the battery can drop to several tenths of a volt without affecting output regulation. The limiting factor for the application is the ability of the battery to supply sufficient energy to the output.

Low-Noise Fixed-Frequency Operation

Oscillator

The AS1322 switching frequency is internally fixed at 1.2MHz allowing the use of very small external components.

Error Amplifier

The integrated error amplifier is an internally compensated trans-conductance (g_m) type (current output). The internal 1.23V reference voltage is compared to the voltage at pin FB to generate an error signal at the output of the error amplifier. A voltage divider from V_{OUT} to GND programs the output voltage from 2.5 to 5V via pin FB as:

$$V_{OUT} = 1.23V(1 + (R_1/R_2)) \qquad \text{(EQ 1)}$$

Current Sensing

A signal representing the internal NMOS-switch current is summed with the slope compensator. The summed signal is compared to the error amplifier output to provide a peak current control command for the PWM. Peak switch current is limited to approximately 850mA independent of V_{IN} or V_{OUT}.

Zero Current Comparator

The zero current comparator monitors the inductor current to the output and shuts off the PMOS synchronous rectifier once this current drops to 20mA (approx.). This prevents the inductor current from reversing polarity and results in improved converter efficiency at light loads.

Anti-Ringing Control

Anti-ringing control circuitry prevents high-frequency ringing on pin SW as the inductor current approaches zero. This is accomplished by damping the resonant circuit formed by the inductor and the capacitance on pin SW (C_{SW}).

Powersave Operation (AS1322A)

In light load conditions, the integrated powersave feature removes power from all circuitry not required to monitor V_{OUT}. When V_{OUT} has dropped approximately 1% from nominal, the AS1322A powers up and begins normal PWM operation.

C_{OUT} (see Figure 15 on page 7) recharges, causing the AS1322A to re-enter powersave mode as long as the output load remains below the powersave threshold. The frequency of this intermittent PWM is proportional to load current; i.e., as the load current drops further below the powersave threshold, the AS1322A turns on less frequently. When the load current increases above the powersave threshold, the AS1322A will resume continuous, seamless PWM operation.

Notes:

1. An optional capacitor (C_{FF}) between pins V_{OUT} and FB in some applications can reduce $V_{OUTp\text{-}p}$ ripple and input quiescent current during powersave mode. Typical values for C_{FF} range from 15 to 220pF.
2. In powersave mode the AS1322A draws only 30µA from the output capacitor(s), greatly improving converter efficiency.

Shutdown

When pin SHDNN is low the AS1322 is switched off and <1µA 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 V_{OUT} to avoid intermittently switching the device on.

Note: If pin SHDNN is not used, it should be connected directly to pin OUT. V_{OUT} is held at approximately V_{IN} - 0.6V during shutdown.

In shutdown the battery input is connected to the output through the inductor and the internal synchronous rectifier P-FET. Due to the body diode of the internal synchronous rectifier PFET, V_{OUT} is held at approximately V_{IN} - 0.6V during shutdown. 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.

9 Application Information

The AS1322 is perfectly suited for LED matrix displays, bar-graph displays, instrument-panel meters, dot matrix displays, set-top boxes, white goods, professional audio equipment, medical equipment, industrial controllers to name a few applications.

Along with Figure 1 on page 1, Figures 16-19 depict a few of the many applications for which the AS1322 converters are perfectly suited.

Figure 16. Single AA Cell to 3.3V Synchronous Boost Converter with Load Disconnect in Shutdown

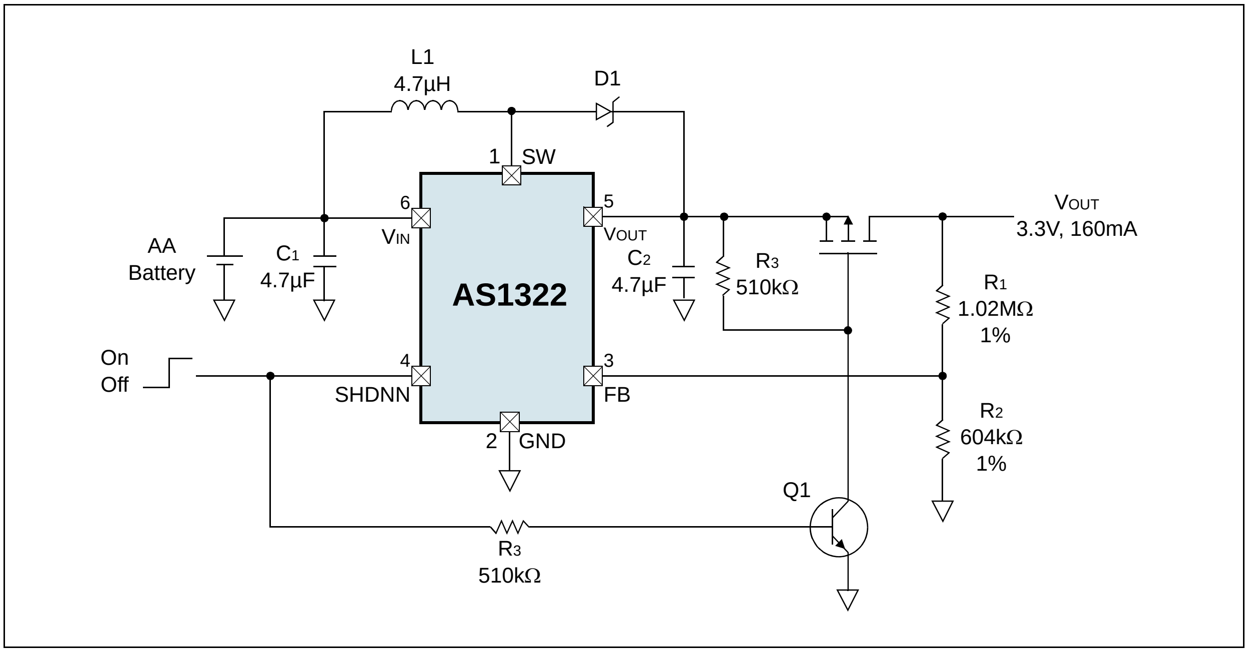


Figure 17. Single Lithium Cell to 5V, 250mA

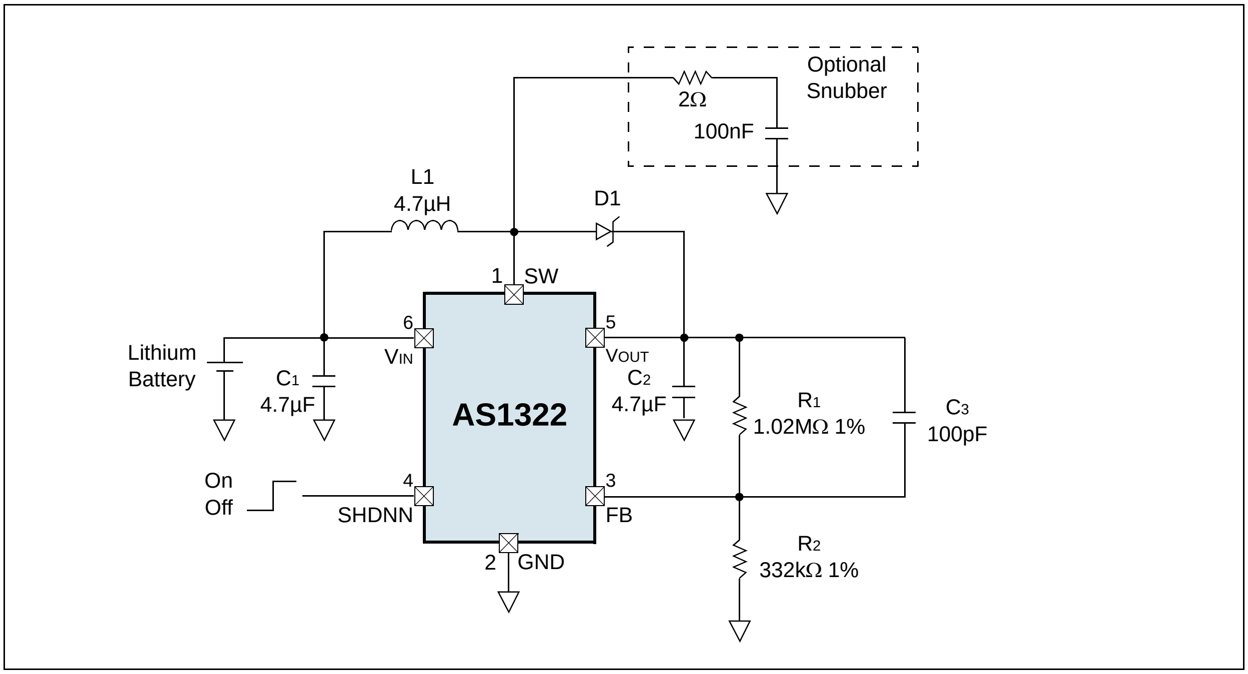


Figure 18. Single AA Cell to ±3V Synchronous Boost Converter

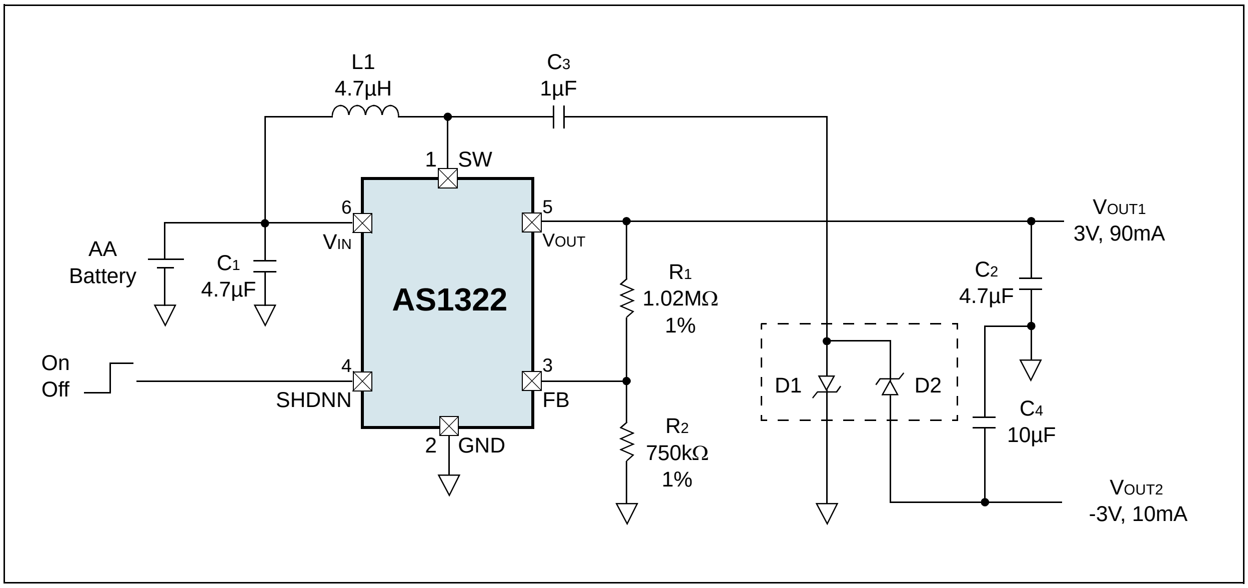
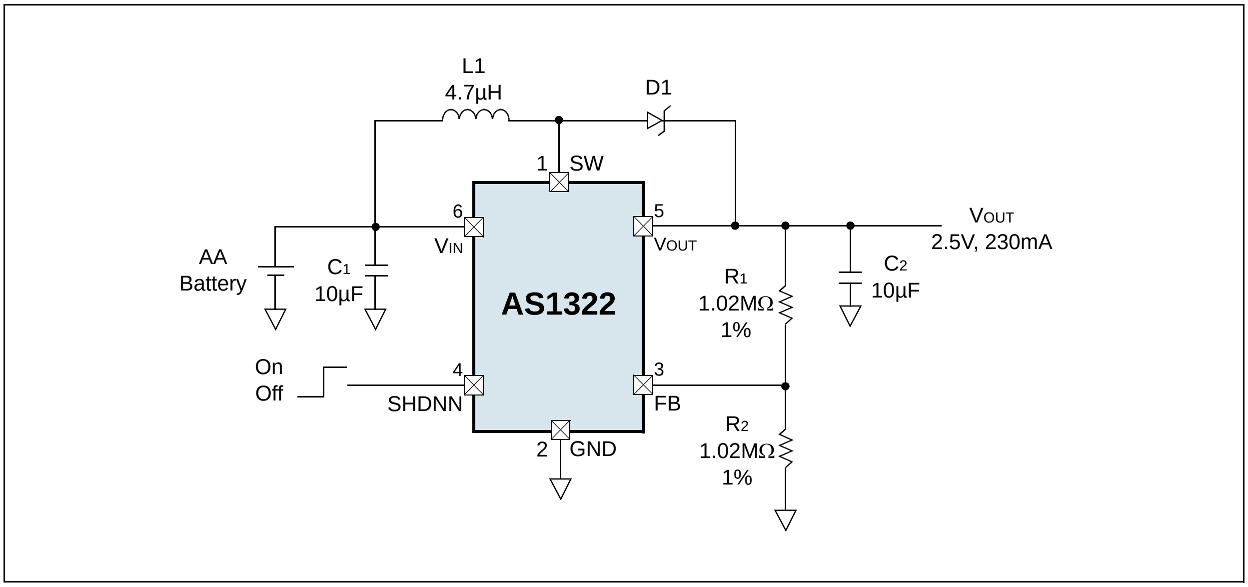


Figure 19. Single AA Cell to 2.5V Synchronous Boost Converter



External Component Selection

Inductor Selection

The fast switching frequency (1.2MHz) of the AS1322 allows for the use of small surface mount or chip inductor for the external inductor (see Figure 15 on page 7).

The required minimum values for the external inductor are:

- 3.3µH for applications ≤ 3.6V
- 4.7µH for applications > 3.6V

Larger inductor values allow greater output current capability by reducing the inductor ripple current. Increasing the inductance above 10µH will increase size while providing negligible improvement in output current capability.

The approximate output current capability of the AS1322 versus inductor value is given in:

$$I_{OUT(MAX)} = \eta \cdot \left(I_P - \frac{V_{IN} \cdot D}{f \cdot L \cdot 2}\right) \cdot (1 - D) \qquad \text{(EQ 2)}$$

Where:

η is the estimated efficiency;
I_P is the peak current limit value (0.6A);
V_{IN} is the input voltage;
D is the steady-state duty ratio = (V_{OUT} - V_{IN})/V_{OUT};
f is the switching frequency (1.2MHz typ);
L is the inductor value.

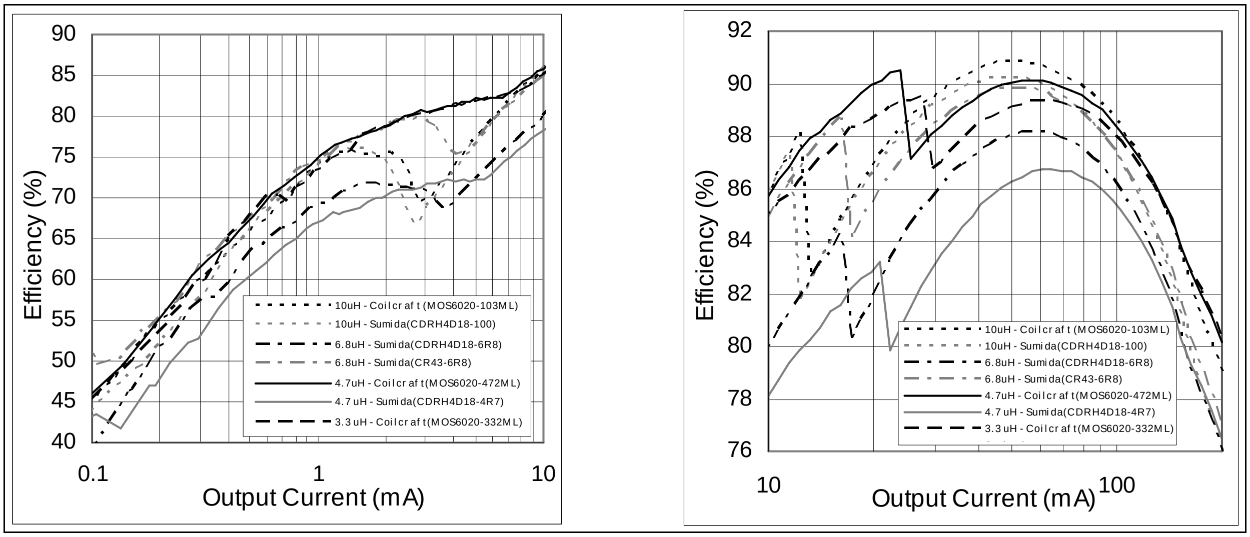
The inductor current ripple is typically set for 20 to 40% of the maximum inductor current (I_P). High-frequency ferrite core inductor materials reduce frequency dependent power losses compared to less expensive powdered iron types, which result in improved converter efficiency.

The inductor should have low ESR to reduce the I^2R power losses, and must be able to handle the peak inductor current without saturating. Molded chokes and some chip inductors normally do not have enough core to support the peak inductor currents of the AS1322 (850mA typ). To minimize radiated noise, use a toroid, pot core, or shielded bobbin inductor.

Table 5. Recommended Inductors

Part Number	L	DCR	Current Rating	Dimensions (L/W/T)	Manufacturer
MOS6020-103ML	10µH	93mΩ	1A	6.8x6.0x2.4mm	Coilcraft www.coilcraft.com
MOS6020-472ML	4.7µH	50mΩ	1.5A	6.8x6.0x2.4mm	
MOS6020-332ML	3.3µH	46mΩ	1.8A	6.8x6.0x2.4mm	
CDRH4D18-100	10µH	200mΩ	0.61A	6.9x5.0x2.0mm	Sumida www.sumida.com
CDRH4D18-6R8	6.8µH	200mΩ	0.76A	6.9x5.0x2.0mm	
CR43-6R8	6.8µH	131.2mΩ	0.95A	4.8x4.3x3.5mm	
CDRH4D18-4R7	4.7µH	162mΩ	0.84A	6.9x5.0x2.0mm	

Figure 20. Efficiency Comparison of Different Inductors, V_{IN} = 1.5V, V_{OUT} = 3.3V



Output Capacitor Selection

Low ESR capacitors should be used to minimize V_{OUT} ripple. Multi-layer ceramic capacitors are recommended since they have extremely low ESR and are available in small footprints. A 2.2 to 10µF output capacitor is sufficient for most applications. Larger values up to 22µF may be used to obtain extremely low output voltage ripple and improve transient response.

An additional phase lead capacitor may be required with output capacitors larger than 10µF to maintain acceptable phase margin. X5R and X7R dielectric materials are recommended due to their ability to maintain capacitance over wide voltage and temperature ranges.

Table 6. Recommended Output Capacitor

Part Number	C	TC Code	Rated Voltage	Dimensions (L/W/T)	Manufacturer
JMK212BJ226MG-T	22µF ±20%	X5R	6.3V	2x1.3x1.3mm	Taiyo Yuden www.t-yuden.com

Input Capacitor Selection

Low ESR input capacitors reduce input switching noise and reduce the peak current drawn from the battery. Ceramic capacitors are recommended for input decoupling and should be located as close to the device as is practical. A 4.7µF input capacitor is sufficient for most applications. Larger values may be used without limitations.

Table 7. Recommended Input Capacitor

Part Number	C	TC Code	Rated Voltage	Dimensions (L/W/T)	Manufacturer
GRM31CR70J106KA01L	10µF ±10%	X7R	6.3V	3.2x1.6x1.6mm	Murata www.murata.com

Diode Selection

A Schottky diode should be used to carry the output current for the time it takes the PMOS synchronous rectifier to switch on. For V_{OUT} < 4.5V a Schottky diode is optional, although using one will increase device efficiency by 2 to 3%.

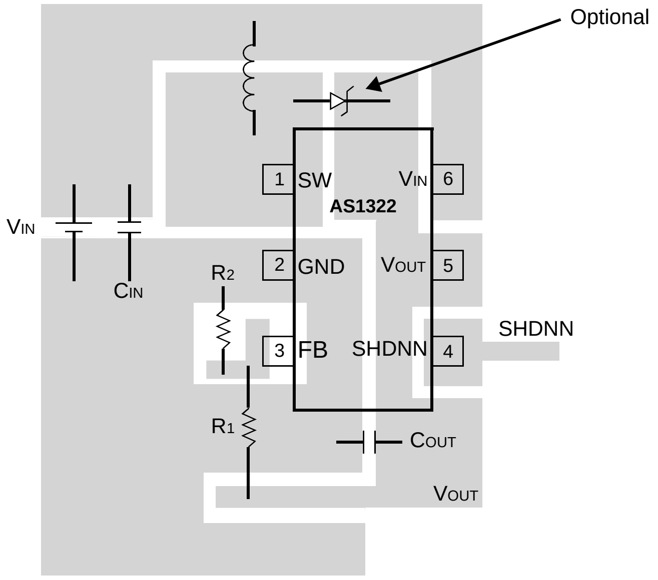
Note: Do not use ordinary rectifier diodes, since the slow recovery times will compromise efficiency.

PCB Layout Guidelines

The high-speed operation of the AS1322 requires proper layout for optimum performance. Figure 21 shows the recommended component layout.

- A large ground pin copper area will help to lower the device temperature.
- A multi-layer board with a separate ground plane is recommended.
- Traces carrying large currents should be direct.
- Trace area at pin FB should be as small as is practical.
- The lead-length to the battery should be as short as is practical.

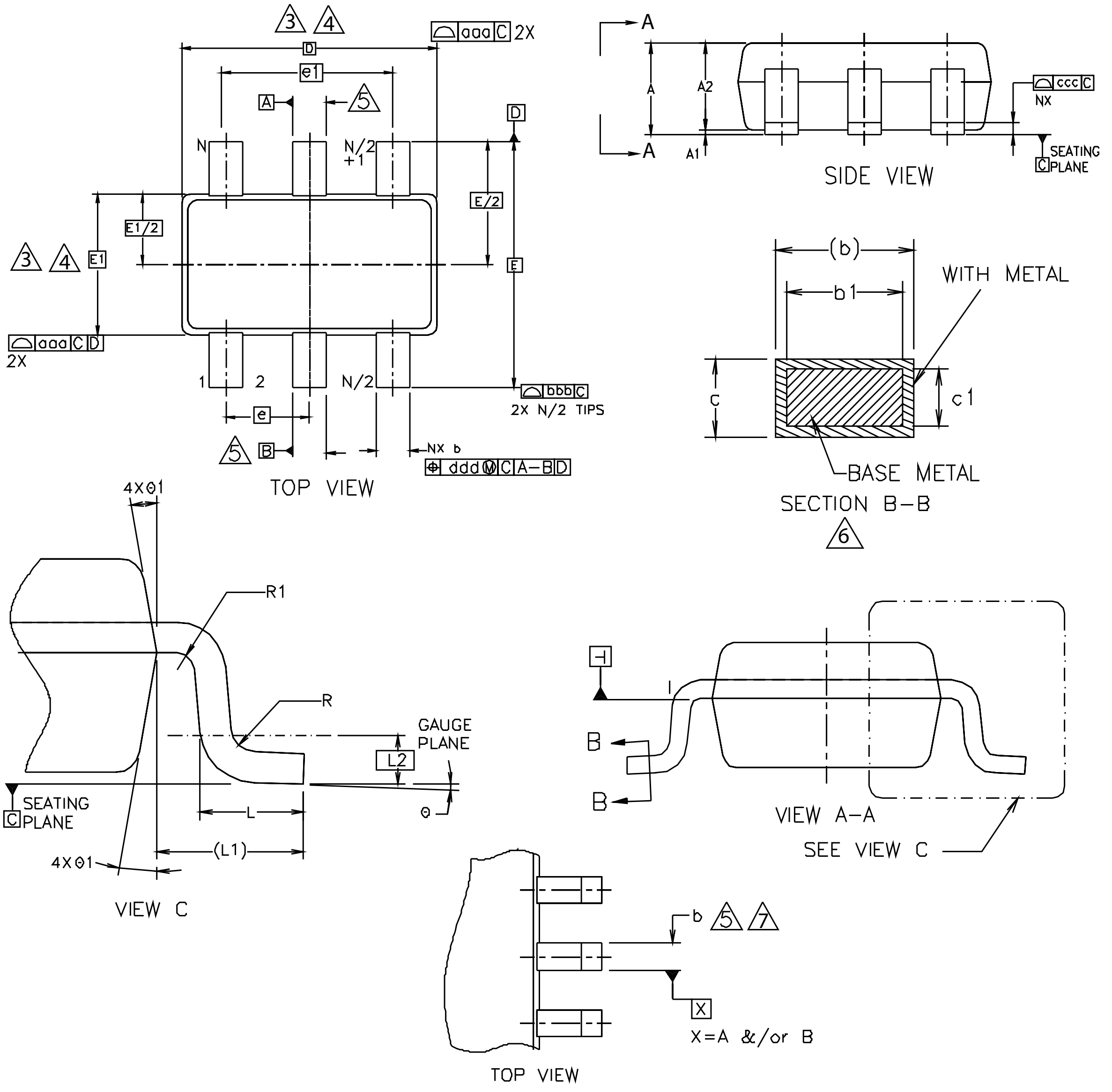
Figure 21. Recommended Single-Layer Component Placement



10 Package Drawings and Markings

The device is available in a 6-pin TSOT-23 package.

Figure 22. 6-pin TSOT-23 Package



Notes:

1. Dimensioning and tolerancing conform to *ASME Y14.5M - 1994.*
2. Dimensions are in millimeters.
3. Dimension D does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, and gate burrs shall not exceed 0.15mm per end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.15mm per side. Dimensions D and E1 are determined at datum H.
4. The package top can be smaller than the package bottom. Dimensions D and E1 are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs, and interlead flash, but include any mistmatches between the top of the package body and the bottom. D and E1 are determined at datum H.
5. Datums A and B are to be determined at datum H.

6. These dimensions apply to the flat section of the lead between 0.08 and 0.15mm from the lead tip.
7. Dimension b does not include dambar protrusion. Allowable dambar protrusion shall be 0.08mm total in excess of the b dimension at the maximum material condition. The dambar cannot be located on the lower radius of the foot. Minimum space between the protrusion and an adjacent lead shall not be less than 0.77mm.

Symbol	Min	Typ	Max	Notes
A			1.00	
A1	0.01	0.05	0.10	
A2	0.84	0.87	0.90	
b	0.30		0.45	6,7
b1	0.31	0.35	0.39	6,7
c	0.12	0.15	0.20	6
c1	0.08	0.13	0.16	6
D	2.90BSC			3,4
E	2.80BSC			3,4
E1	1.60BSC			3,4
e	0.95BSC			
e1	1.90BSC			
L	0.30	0.40	0.50	
L1	0.60REF			
L2	0.25BSC			
N		6		
R	0.10			
R1	0.10		0.25	
θ	0º	4º	8º	
θ1	4º	10º	12º	
Tolerances of Form and Position				
aaa		0.15		1,2
bbb		0.25		1,2
ccc		0.10		1,2
ddd		0.20		1,2

11 Ordering Information

The device is available as the standard products listed in Table 8.

Table 8. Ordering Information

Model	Marking	Descriptiom	Delivery Form	Package
AS1322A-BTTT	ASKQ	Low Voltage, Micropower, DC-DC Step-Up Converter with Automatic Powersave Operation	Tape and Reel	6-pin TSOT-23
AS1322B-BTTT	ASKZ	Low Voltage, Micropower, DC-DC Step-Up Converter with Continuous Switching	Tape and Reel	6-pin TSOT-23

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