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AS1345

18V, High Efficiency, DC/DC Step-Up Converter

General Description

The AS1345 high efficiency DC/DC step-up converter contains an internal N-channel and an internal P-channel output isolation switch.

The device operates from a 2.9V to 5.0V supply and can boost voltages up to 18V.

A hysteretic control scheme is used to provide the highest operating efficiency over a wide range of input and output load conditions. The internal MOSFET switches reduce the external component count and a high switching frequency allows the use of tiny surface mount components.

The AS1345 employ a factory set current limit to reduce ripple and external component size in low output current applications. With a 500mA current limit the AS1345 is capable of providing 20mA @ 18V output.

Figure 1:
Available Products

Devices	Peak Coil Current	Output
AS1345A	100mA	Adjustable or fixed
AS1345B	200mA	Adjustable or fixed
AS1345C	350mA	Adjustable or fixed
AS1345D	500mA	Adjustable or fixed

Built-in safety features protect the internal switches and output components from fault conditions. Additional power-saving attributes include a very low quiescent current and a true shutdown mode.

Ordering Information and Content Guide appear at end of datasheet.

Key Benefits & Features

The benefits and features of AS1345, 18V, High Efficiency, DC/DC Step-Up Converter are listed below:

Figure 2:
Added Value of Using AS1345

Benefits	Features
• Supports Lithium primary and re-chargeable batteries	• Input Voltage Range: 2.9V to 5.0V
• Supports a variety of end applications	• Adjustable Output Voltage Range: 5.0V to 18V • Output Current up to 40mA
• Allows optimization of circuit depending on output power demands	• Inductor Peak Currents: 100, 200, 350 and 500 mA
• Battery life improved	• 90% Efficiency
• Battery supply isolated during shutdown	• True Shutdown
• Fault tolerant	• Short Circuit and Thermal Protection
• Small chipscale package	• Packages: • 8-pin (2x2mm) TDFN • 8-bumps (1.570mm x 0.895mm) WL-CSP with 0.4mm pitch

Applications

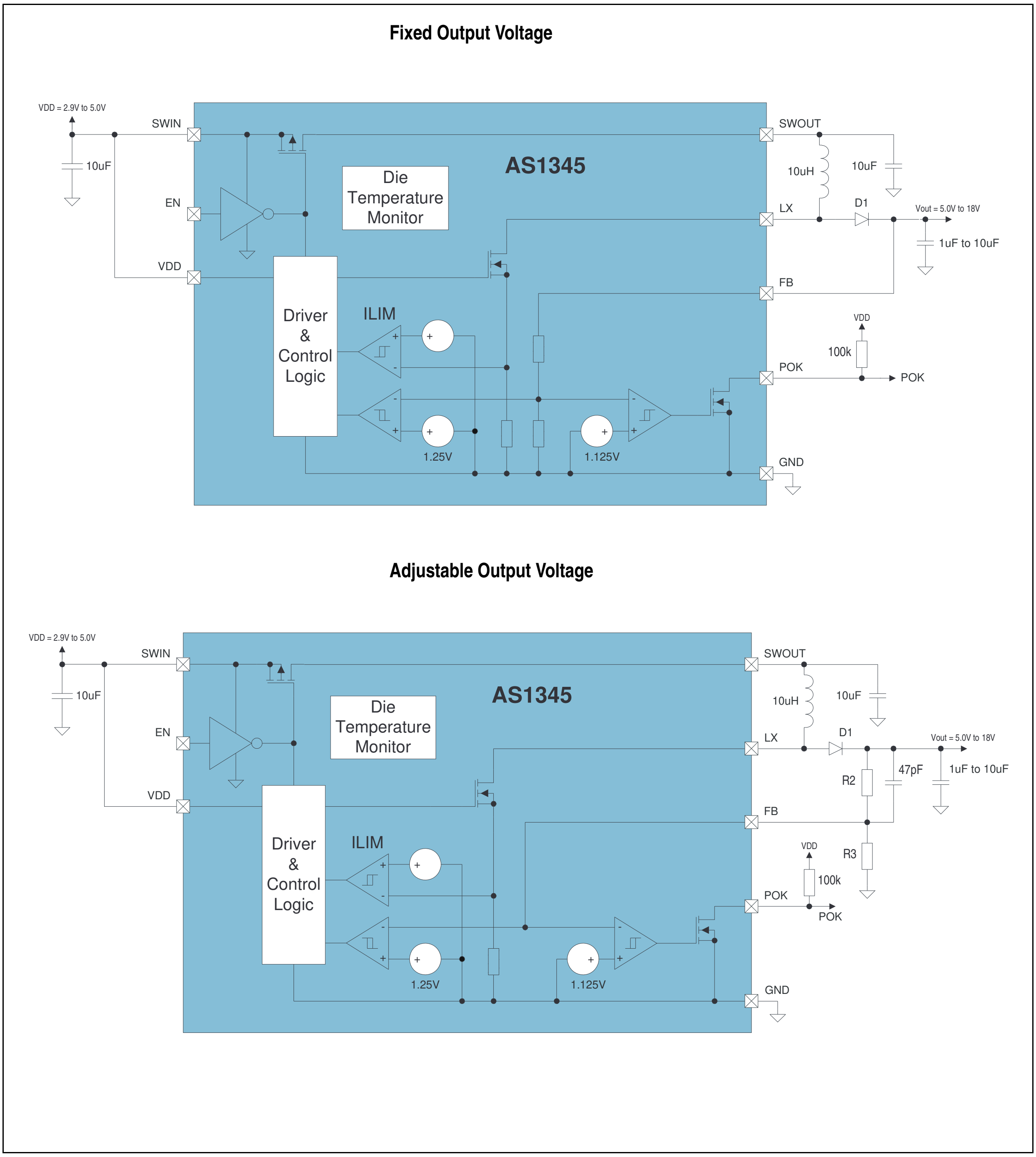
The AS1345 is ideal for:

- Small and low current demand LCD panels as well as for polymer LEDs (OLED)
- Cell phones, PDAs
- Readers
- Mobile terminals
- 3D shutter glasses

Block Diagram

The functional blocks of this device are shown below:

Figure 3:
AS1345 Block Diagram



Pin Assignment

Figure 4:
Pin Diagram (Top View)

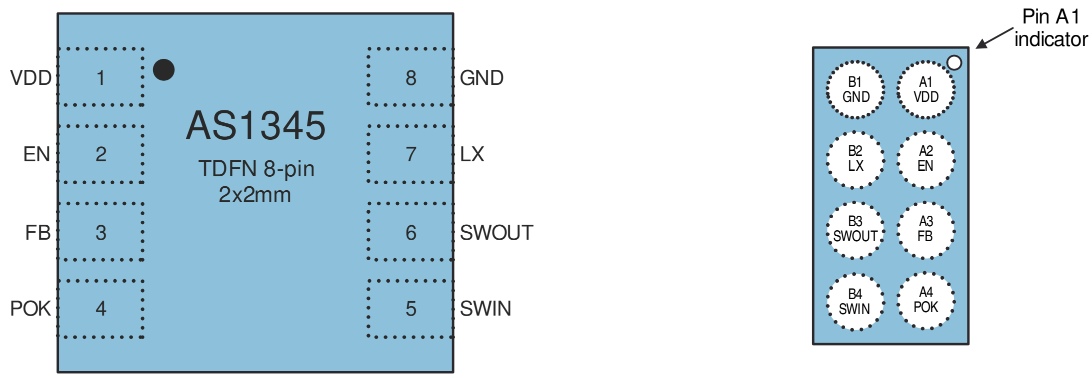


Figure 5:
Pin Description

Pin Number		Pin Name	Description
TDFN	WLP		
1	A1	VDD	**Supply Voltage**. Connect to a 2.9V to 5.0V input supply. Bypass this pin with a 10µF capacitor.
2	A2	EN	**Enable Pin**. Logic controlled shutdown input, 1.8V CMOS compatible; 1 = Normal operation 0 = Shutdown On request a 100kΩ pull-down resistor can be enabled (factory set).
3	A3	FB	**Feedback Pin**. Feedback input to the gm error amplifier. For an adjustable output voltage connect a resistor divider to this pin. The output can be adjusted from 5.0V to 18V by: $V_{OUT} = V_{REF} \times (1 + R2/R3)$ If the fixed output voltage version is used, connect this pin to V_{OUT}.
4	A4	POK	**POK**. Open Drain Output. POK remains low while V_{OUT} is less than 90% of nominal V_{OUT}. Connect a 100kΩ pull-up resistor from this pin to V_{DD}.
5	B4	SWIN	**Shutdown Disconnect Switch In**. Input pin of the internal P-channel MOSFET.

Pin Number		Pin Name	Description
TDFN	WLP		
6	B3	SWOUT	**Shutdown Disconnect Switch Out**. Output pin of the internal P-channel MOSFET. Connect to power inductor and decouple to GND with a 10µF low ESR ceramic capacitor. When the input disconnect feature is not desired, SWOUT should be connected to SWIN and VDD.
7	B2	LX	**Inductor.** The drain of the internal N-channel MOSFET. Connect to power inductor and to anode of a schottky diode.
8	B1	GND	Ground

Absolute Maximum Ratings

Stresses beyond those listed in the table below 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 Electrical Characteristics is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure 6:
Absolute Maximum Ratings

Parameter		Min	Max	Unit	Comments
Electrical Parameters					
VDD, SWIN, SWOUT to GND		-0.3	7	V	
LX, FB to GND		-0.3	20	V	
Input Current (latch-up immunity)		-100	100	mA	JEDEC 78
SWIN to SWOUT Current Limit			1	A	
Electrostatic Discharge					
Electrostatic Discharge HBM		±2		kV	MIL 883 E method 3015
Temperature Ranges and Storage Conditions					
Junction temperature			110	°C	
Storage temperature range	WL-CSP	-55	125	°C	
	TDFN	-55	150	°C	
Package thermal data	WL-CSP		60	°C/W	Junction-to-ambient thermal resistance is very dependent on application and board-layout. In situations where high maximum power dissipation exists, special attention must be paid to thermal dissipation during board design.
	TDFN		97		
Package body temperature	WL-CSP		260	°C	IPC/JEDEC J-STD-020
	TDFN(2)				IPC/JEDEC J-STD-020
Relative humidity non-condensing		5	85	%	
Moisture sensitivity level	WL-CSP	1			Represents an unlimited floor life time
	TDFN	1			Represents an unlimited floor life time

Note(s):

1. The reflow peak soldering temperature (body temperature) specified is in accordance with IPC/JEDEC J-STD-020"Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Mount Devices".
2. The lead finish for Pb-free leaded packages is "Matte Tin" (100% Sn).

Electrical Characteristics

All limits are guaranteed. The parameters with Min and Max values are guaranteed by production tests or SQC (Statistical Quality Control) methods.

Figure 7:
V_{DD} = V_{SHDNN} = V_{SWIN} = 3.7V, V_{OUT} = 15V, CIN = COUT = 10µF, Typical Values @ T_{AMB} = 25°C (unless otherwise specified)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
T_{AMB}	Operating temperature range		-40		85	°C
T_J	Operating junction temperature range		-40		110	°C
			Input			
V_{DD}	Supply voltage range	SWIN connected to VDD	2.9		5.0	V
	Minimum startup voltage	VDD = SWIN		2.7		V
V_{UVLO}	V_{DD} undervoltage lockout	V_{DD} decreasing (50mV Hysteresis)		2.7		V
			Regulation			
V_{OUT}	Adjustable output voltage range	External FB divider	5		18	V
	Feedback voltage tolerance	Tolerance of FB resistors not included	-3		3	%
	Fixed output voltage	Internal FB divider		12		V
	Fixed output voltage	Internal FB divider		15		V
	Fixed output voltage	Internal FB divider		17		V
V_{FB}	Feedback voltage	For adjustable V_{OUT} only		1.25		V
	Feedback input current	For adjustable V_{OUT} only		10	1000	nA
	Line regulation	VDD = 3.5V to 3.7V		200		mV
	Load regulation	V_{OUT} = 15V, I_{LOAD} = 0mA to 5mA		50		mV
η	Efficiency	L = 22µH, V_{DD} = V_{SWIN} = 3.7V, V_{OUT} = 15V, I_{LOAD} = 10mA		90		%

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Operating Current						
I_{SHDN}	Shutdown current @ VDD	V_{SHDNN} = 0V			1	µA
	Shutdown current @ SWIN				1	
I_Q	Quiescent current	No switching, V_{FB} = 1.5V		25		µA
I_{DDLOAD}	Load current	V_{OUT} = 15V, I_{LOAD} = 5mA		25		mA
I_{LIMIT}	Coil peak current limit	AS1345A		100		mA
		AS1345B		200		mA
		AS1345C		350		mA
		AS1345D		500		mA
Switches						
R_{NMOS}	NMOS resistance			0.3		Ω
R_{PMOS}	PMOS resistance			0.15		Ω
POK Output						
	POK output voltage 'low'	POK sinking 1mA		0.01	0.2	V
	POK output voltage 'high'	POK leakage 1µA	VDD		VDD - 0.1	V
	POK output high leakage current	POK = 3.7V			1	µA
	POK threshold	Rising edge, referenced to $V_{OUT(NOM)}$		90		%
Shutdown						
V_{SHDNH}	SHDN input 'high'	2.9V < V_{DD} < 5.0V, no load	1.26			V
V_{SHDNL}	SHDN input 'low'				0.55	V
I_{SHDN}	SHDN input current		-1		1	µA
Soft Start						
I_{PRE}	Pre-charge current			100		mA
Thermal Shutdown						
	Thermal shutdown			150		°C
	Thermal shutdown hysteresis			10		°C

Typical Operating Characteristics

VOUT = 15V

Figure 8:
Efficiency vs. I_{OUT}; V_{IN} = 2.7V, I_{LIMIT} = 100mA

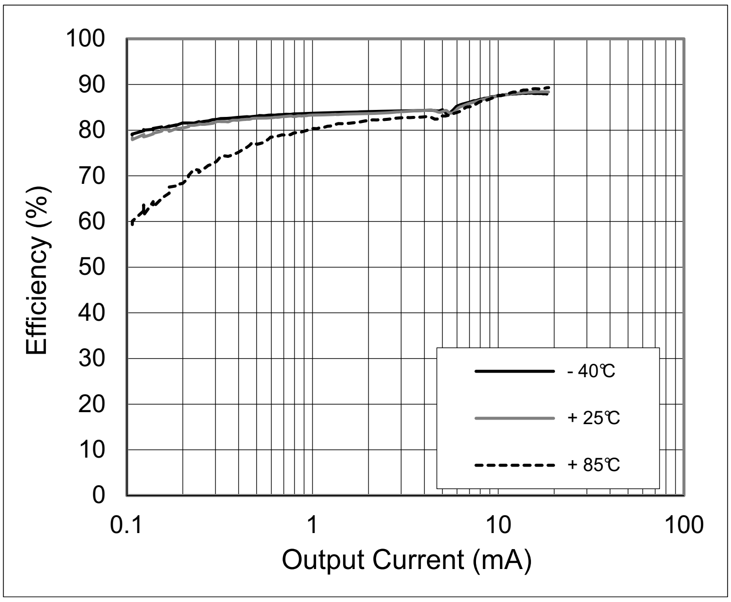


Figure 9:
Efficiency vs. I_{OUT}; V_{IN} = 2.7V, I_{LIMIT} = 500mA

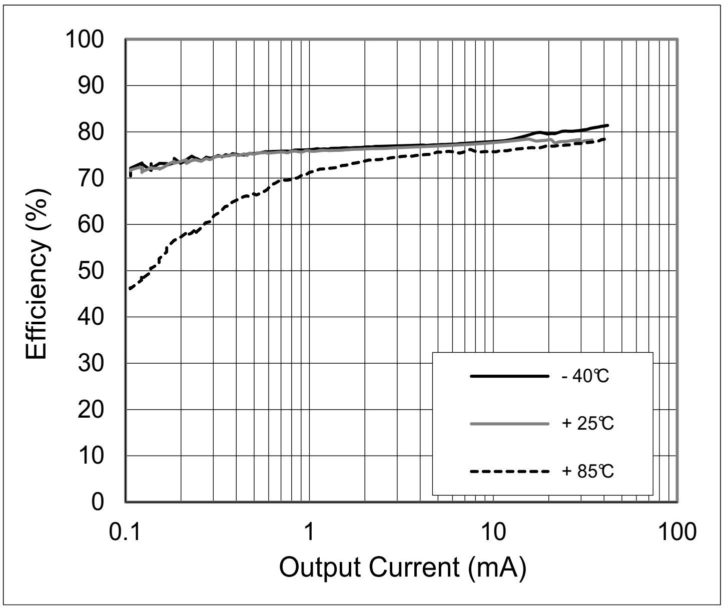


Figure 10:
Efficiency vs. I_{OUT}; V_{IN} = 4.5V, I_{LIMIT} = 100mA

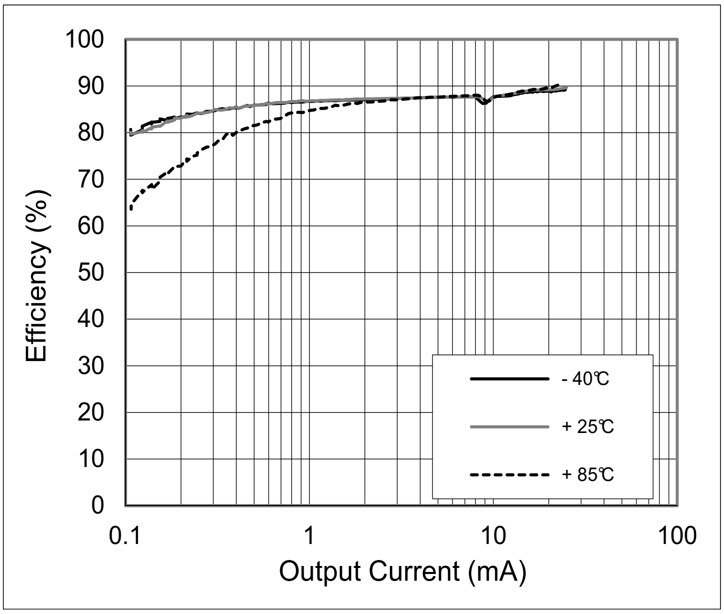


Figure 11:
Efficiency vs. I_{OUT}; V_{IN} = 4.5V, I_{LIMIT} = 500mA

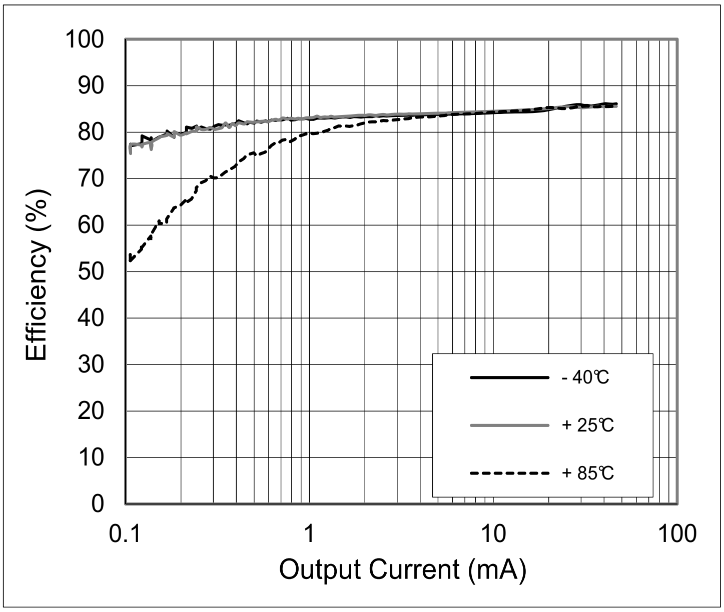


Figure 12:
Efficiency vs. V_{IN}; I_{LOAD} = 5mA, I_{LIMIT} = 100mA

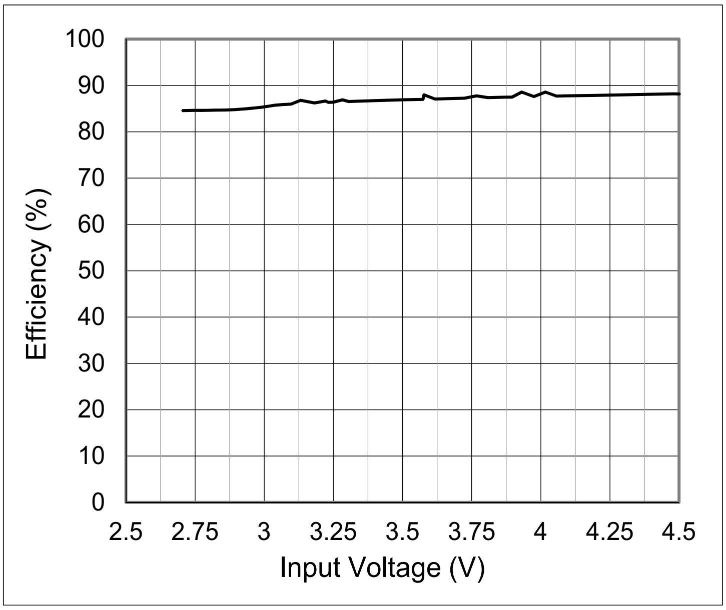


Figure 13:
Efficiency vs. V_{IN}; I_{LOAD} = 5mA/20mA, I_{LIMIT} = 500mA

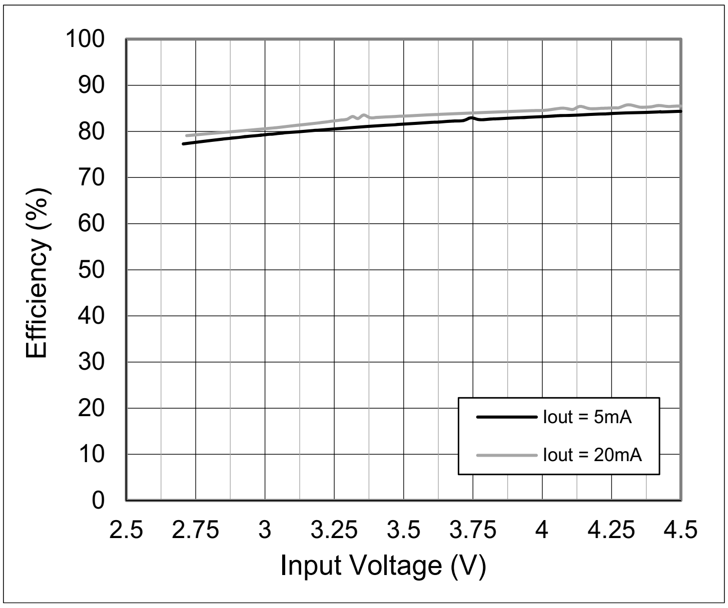


Figure 14:
V_{OUT} vs. I_{OUT}; V_{IN} = 2.7V, I_{LIMIT} = 100mA

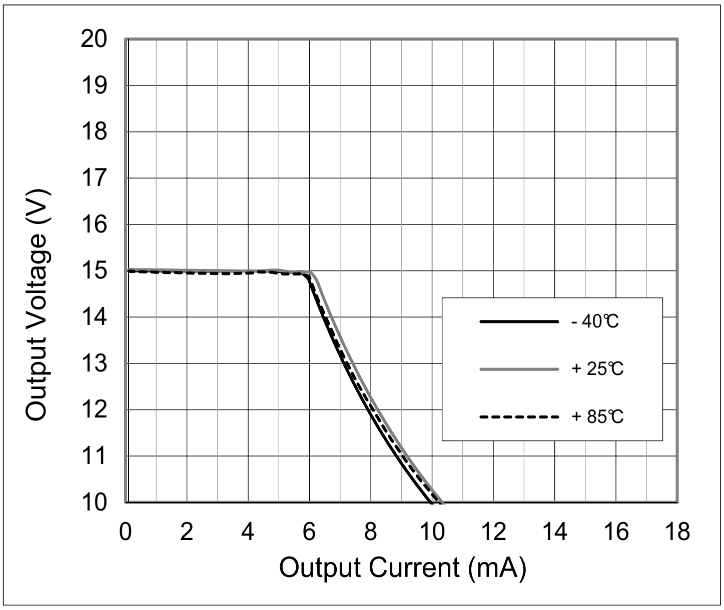


Figure 15:
V_{OUT} vs. I_{OUT}; V_{IN} = 4.5V, I_{LIMIT} = 100mA

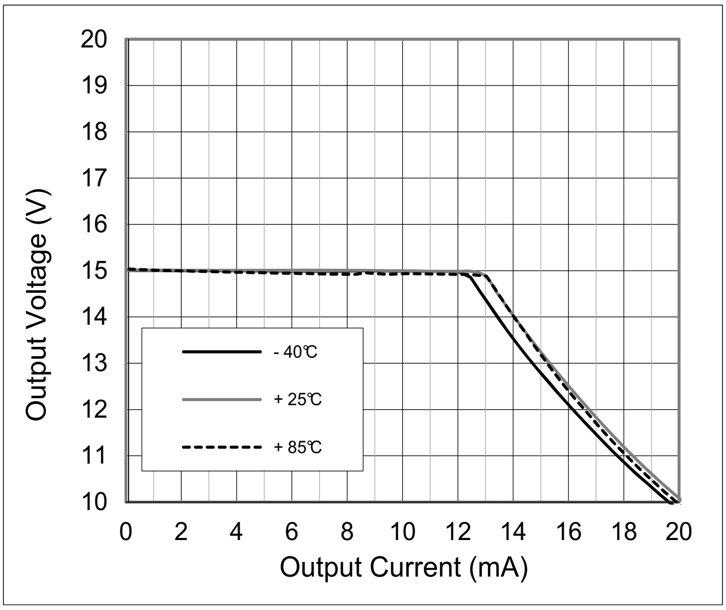
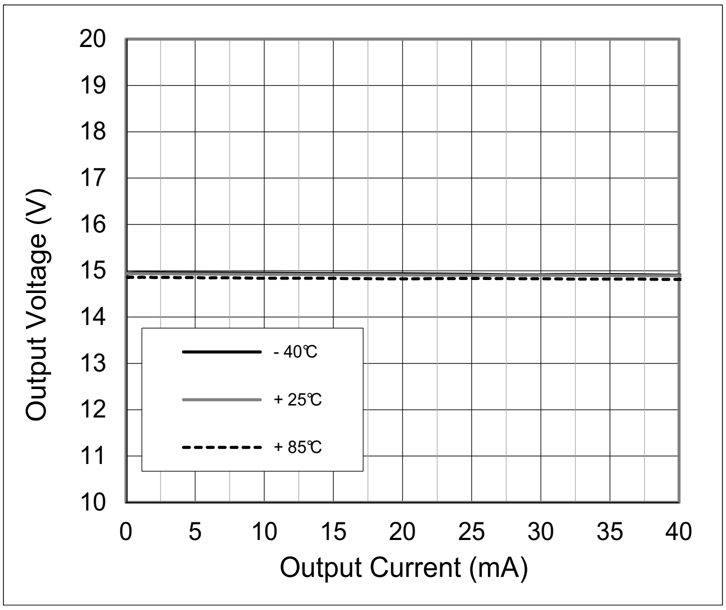


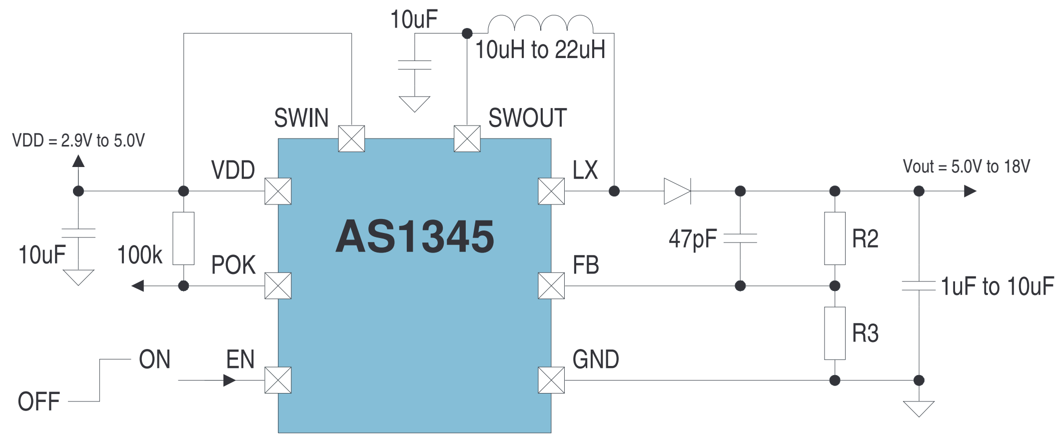
Figure 16:
V_{OUT} vs. I_{OUT}; V_{IN} = 4.5V, I_{LIMIT} = 500mA



Detailed Description

The AS1345 is a compact step-up DC/DC converters that operates from a 2.9V to 5.0V supply. Consuming only 25µA of Quiescent current. These devices include an internal MOSFET switch with a low on-resistance. A true shutdown feature disconnects the battery from the load and reduces the supply current to 0.05µA (typ). These DC/DC converters are available with either a fixed output or are adjustable up to 18V. Four current-limit options are available: 100mA, 200mA, 350mA and 500mA.

Figure 17:
Typical Application Diagram



Modes of Operation

The AS1345 features an advanced current-limited control scheme operating in hysteretic mode. An internal P-channel MOSFET switch connects VDD to SWIN to provide power to the inductor when the converter is operating. When the converter is shut down, this switch disconnects the input supply from the inductor (see Figure 17). To boost the output voltage an N-channel MOSFET switch turns on and allows current to ramp up in the inductor. Once this current reaches the current limit, the switch turns off and the inductor current flows through D1 to supply the output. The switching frequency varies depending on the load and input voltage and can be up to 10kHz.

Shutdown

Drive EN low to enter shutdown mode. During shutdown the supply current drops to 0.05µA (typ), the output is dis-connected from the input, and LX enters a high impedance state. The capacitance and load at the output set the rate at which V_{OUT} decays. EN can be pulled as high as 6V regardless of the input and output voltages.

With a typical step-up converter circuit, the output remains connected to the input through the inductor and output rectifier, holding the output voltage to one diode drop below V_{DD} when the converter is shutdown and allowing the output to draw power from the input.

The AS1345 features a True-Shutdown mode, disconnecting the output from the input with an internal P-channel MOSFET switch when shut down. This eliminates power draw from the input during shutdown mode.

Start-up and Inrush Limiting

If the ENABLE pin is high, the AS1345 uses a multi-stage start-up sequence. With increasing supply voltage, first the power-on circuitry becomes active and some internal blocks are initiated. If the supply exceeds the under-voltage-lockout threshold (2.7V typ), the pre-charge-phase is initiated. The capacitor at the SWOUT pin is charged to V_{IN}, and the capacitor at V_{OUT} is charged to V_{IN}-VSD. During this phase the current is limited to 100mA typical. After the completion of the pre-charge-phase, the AS1345 enters into switching mode. Here the specified current-limit I_{PEAK} is used. The circuit operates at maximum frequency until the desired V_{OUT} is reached. Then AS1345 switches to normal hysteretic operation mode.

If the load current is too high (>50mA) during the start-up-phase, the attainment of normal operation mode might be delayed or not done at all.

Adjustable Output Voltage

The output voltage of the AS1345 is adjustable from 5.0V to 18V by using a resistor voltage-divider (see Figure 18 and Figure 19). Select R1 from 10kΩ to 600kΩ and calculate R2 with the following equation:

$V_{OUT} = V_{REF} (1 + R_2/R_3)$ **(EQ1)**

Where: $V_{REF} = 1.25V$

V_{OUT} can range from 5.0V to 18V

For best accuracy, ensure that the bias current through the feedback resistors is at least 2µA.

The AS1345 can also be used with a fixed output voltage. When using one of these parts, connect FB directly to the output (see Figure 20 and Figure 21).

For improved regulation speed and lower ripple C3 should be applied. For best ripple performance always the adjustable variant of the AS1345 together with C3 should be used. Other measures to reduce the ripple could be to select a low peak current I_{PEAK} and increase C4 and to decrease the value of L.

Figure 18:
AS1345 with Adjustable Output Voltage, with Output Disconnect

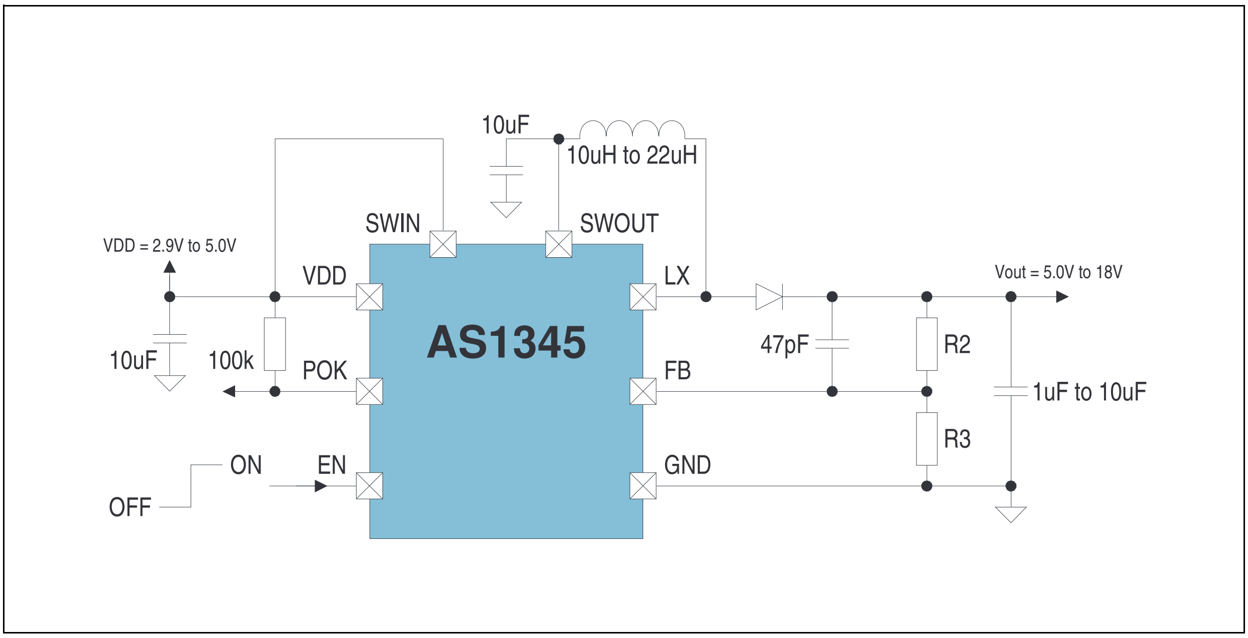


Figure 19:
AS1345 with Adjustable Output Voltage, without Output Disconnect

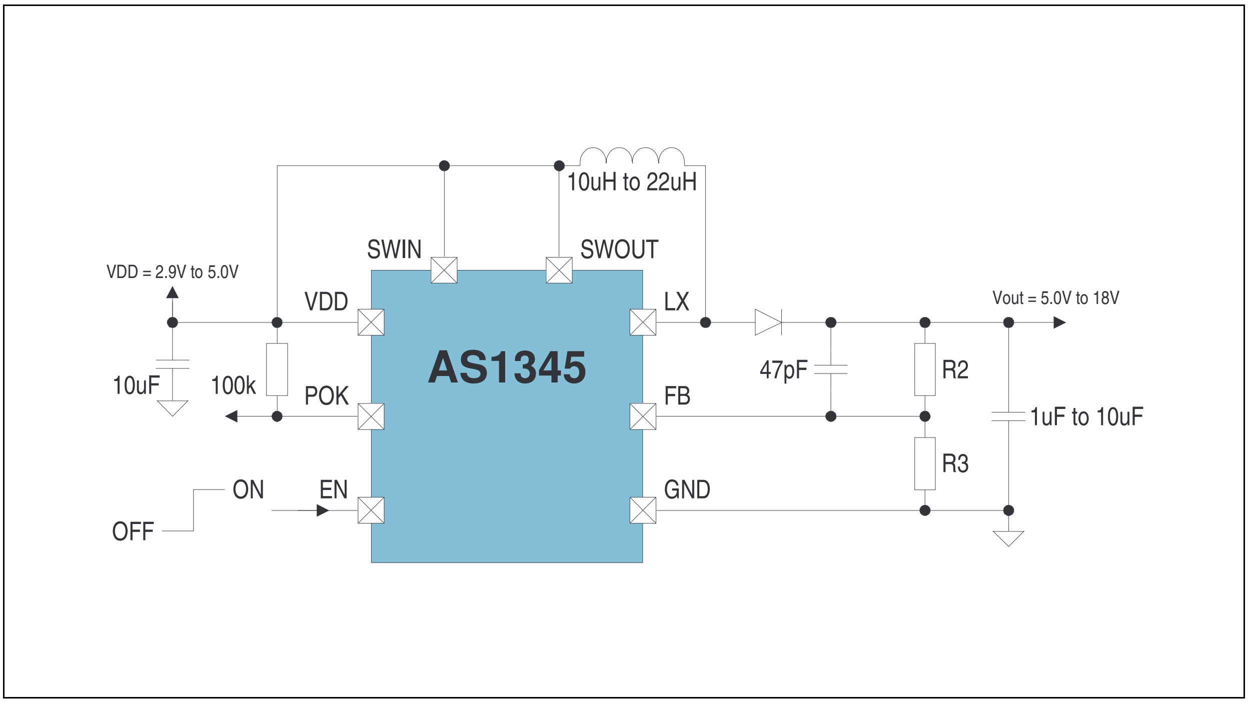


Figure 20:
AS1345 with Fixed Output Voltage, with Output Disconnect

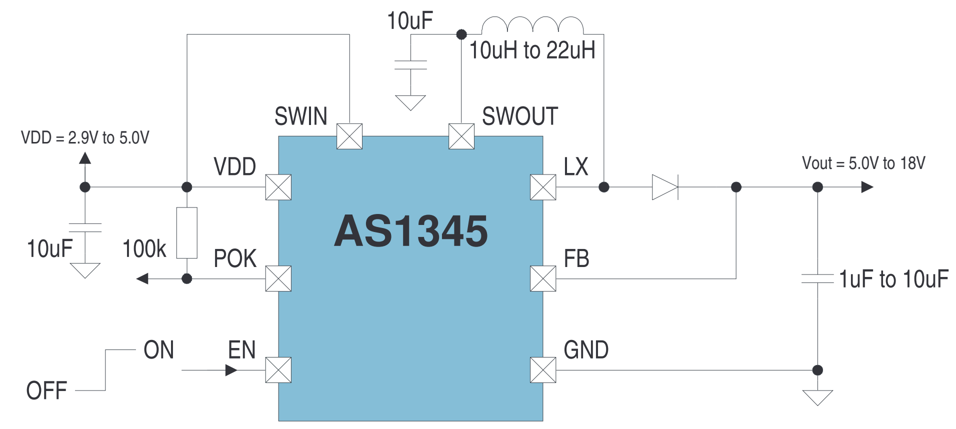
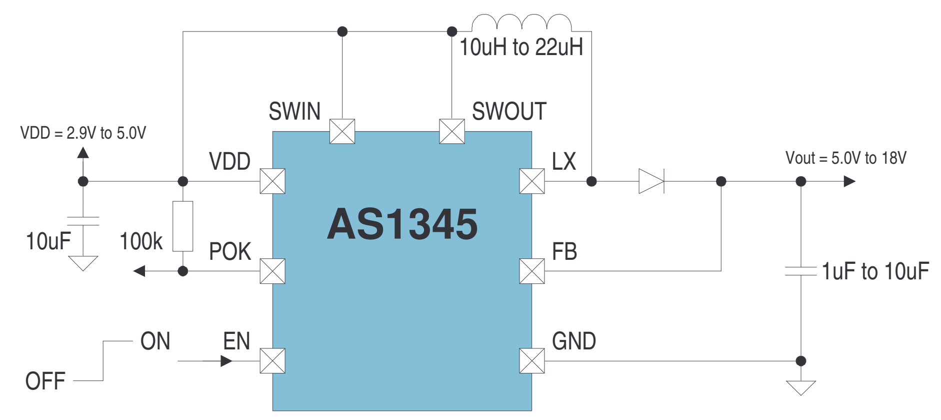


Figure 21:
AS1345 with Fixed Output Voltage, without Output Disconnect



Power OK Operation

If desired the POK functionality can be used. In this case a resistor R1 (~100k) has to be applied between the POK pin and VIN, because the POK output is an open drain type. If the POK functionality is not used the pin should be unconnected.

During shut-down the POK pin is high impedance to save current. Therefore it shows VIN if connected to VIN with a resistor or is floating otherwise. During start-up the POK goes to LOW. During normal operation it is usually HIGH but it goes to LOW if for some reason VOUT drops below 90% of the nominal output voltage.

Thermal Shutdown

To prevent the AS1345 from short-term misuse and overload conditions the chip includes a thermal overload protection. To block the normal operation mode all switches will be turned off. The device is in thermal shutdown when the junction temperature exceeds 150°C typ. To resume the normal operation the temperature has to drop below 140°C typ. A good thermal path should be provided to dissipate the heat generated within the package, especially at higher output power. To dissipate as much heat as possible from the package into a copper plane with as much area as possible, it's recommended to use multiple vias in the printed circuit board.

Continuing operation in thermal overload conditions may damage the device, and therefore, is considered a bad practice.

Inductor Selection

For best efficiency, choose an inductor with high frequency core material, such as ferrite, to reduce core losses. The inductor should have low DCR (DC resistance) to reduce the I^2R losses, and must be able to handle the peak inductor current without saturating. A 10µH to 22µH inductor with greater than 500mA current rating and less than 500mΩ DCR is recommended. When smaller peak currents are selected, the inductor current specification can be reduced accordingly.

Figure 22:
Recommended Inductors

Part Number	Value	Current	Resistance	Size (ins)	Supplier
ELJLA100KF	10µH	600mA	0.71Ω	1210	Panasonic www.panasonic.com
ELJLA220KF	22µH	420mA	1.9Ω	1210	
ELJPA100KF2	10µH	400mA	0.35Ω	1210	
ELJPA220KF2	22µH	290mA	0.66Ω	1210	
ELJPA100KF	10µH	240mA	0.5Ω	1210	
ELJPA150KF	15µH	220mA	0.74Ω	1210	
ELJPA220KF	22µH	185mA	1.15Ω	1210	
ELJPC100MF3	10µH	140mA	0.58Ω	1008	
ELJPC220MF3	22µH	100mA	1.22Ω	1008	
LQH32PN100MNO	10µH	750mA	0.38Ω	1210	Murata Manufacturing Company www.murata.com
LQH32PN150MNO	15µH	600mA	0.57Ω	1210	
LQH32PN220MNO	22µH	500mA	0.81Ω	1210	
LQH3NPN100NGO	10µH	500mA	0.38Ω	1212	
LQH3NPN150NGO	15µH	370mA	0.91Ω	1212	
LQH3NPN220NGO	22µH	340mA	1.1Ω	1212	
LQH2MCN100M52	10µH	200mA	2.27Ω	0806	
LQH2MCN150M52	15µH	150mA	3.5Ω	0806	
LQH2MCN220M52	22µH	130mA	5.5Ω	0806	

Capacitor Selection

The convertor requires three capacitors. Ceramic X5R or X7R types will minimize ESL and ESR while maintaining capacitance at rated voltage over temperature. The VIN capacitor should be 10µF. The VOUT capacitor should be between 1µF and 10µF. A larger output capacitor should be used if lower peak to peak output voltage ripple is desired. A larger output capacitor will also improve load regulation on VOUT. See table below for a list of capacitors for input and output capacitor selection.

Figure 23:
Recommended Capacitors

Part Number	Value	Voltage	TC Code	Size (ins)	Supplier
GRM31CR71E106KA12L	10µF	25V	X7	1206	Murata Manufacturing Company www.murata.com
GRM31CR71C106KAC7L	10µF	16V	X7	1206	
GRM31CR71A106KA01L	10µF	10V	X7	1206	
GRM21BR70J106KE76L	10µF	6.3V	X7	0805	
GRM31CR71E475KA88L	4.7µF	25V	X7	1206	
GRM21BR71C475KA73L	4.7µF	16V	X7	0805	
GRM188R71E105KA12D	1µF	25V	X7	0603	
GRM188R71C105KA12D	1µF	16V	X7	0603	

Schottky Diode Selection

The selection of the external diode depends on the application. If IOUT is very low most of the time, and VOUT is high, select a diode with a low reverse current for best efficiency. For lower VOUT and higher IOUT, select a diode with a lower $V_{FORWARD}$ and $R_{FORWARD}$.

Figure 24:
Recommended Diodes

Part Number	Reverse Voltage	Average Rectified Current	Forward Voltage	Reverse Leakage Current	Package	Supplier
MBR0540	40V	500mA	460mV @ 500mA	1µA @ 20V	SOD123	Fairchild Semiconductor www.fairchildsemi.com
B140HW	40V	1000mA	460mV @ 500mA	0.35µA @ 20V	SOD123	Diodes Inc www.diodes.com
PMEG2010AEB	20V	1A	200mV @ 500mA	320µA @ 20V	SOD523	NXP Semiconductors www.nxp.com
CRS04	40V	1A	450mV @ 500mA	40µA @ 20V	3-2A1A (Toshiba)	Toshiba www.toshiba-components.com
CRS06	20V	1A	325mV @ 500mA	250µA @ 20V	3-2A1A (Toshiba)	

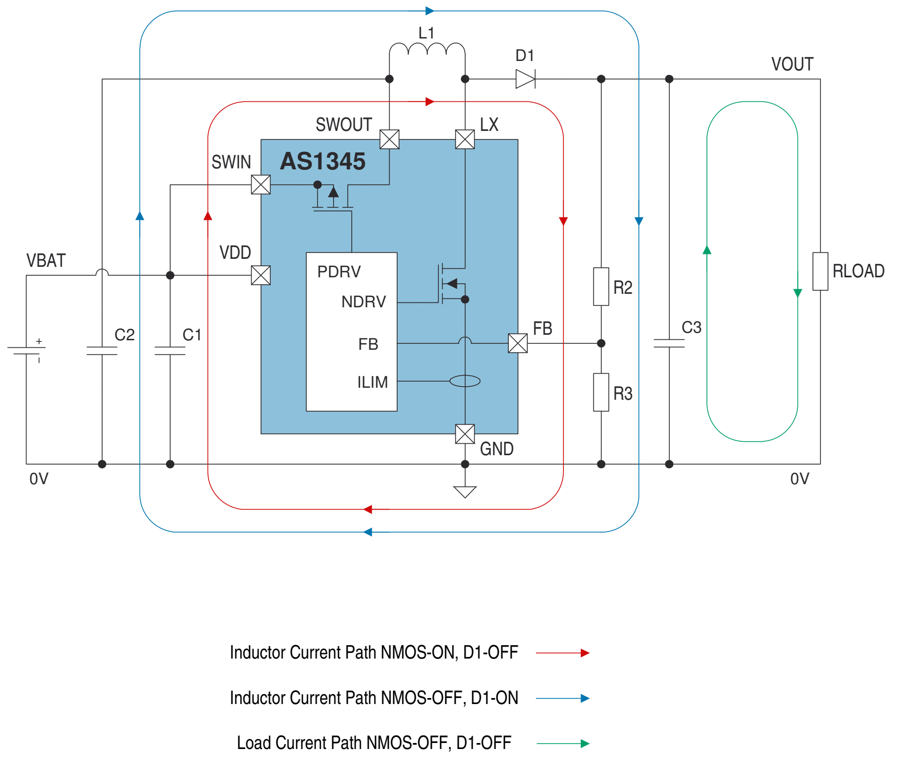
PCB Layout

Carefully printed circuit layout is important for minimizing ground bounce and noise. Keep the GND pin and ground pads for the input and output capacitors as close together as possible. Keep the connection to LX as short as possible. Locate the feedback resistors as close as possible to the FB pin and keep the feedback traces routed away from noisy areas such as LX.

EMI and overall performance quality are affected by the PCB layout. The high speed operation of the AS1345 demands careful attention to board layout. Stated performance will be difficult to achieve with careless layout. Figure 25 identifies the high current paths during an operation cycle involving the switching of the N-channel and P-channel internal switches. The current paths between SWIN, VIN, C1, C2, C4, L1, D1 and GND should be short and wide for lowest intrinsic resistive loss and lowest stray inductance.

A large ground pin copper area will help to lower the chip temperature. A multilayer board with a separate ground plane is ideal, but not absolutely necessary.

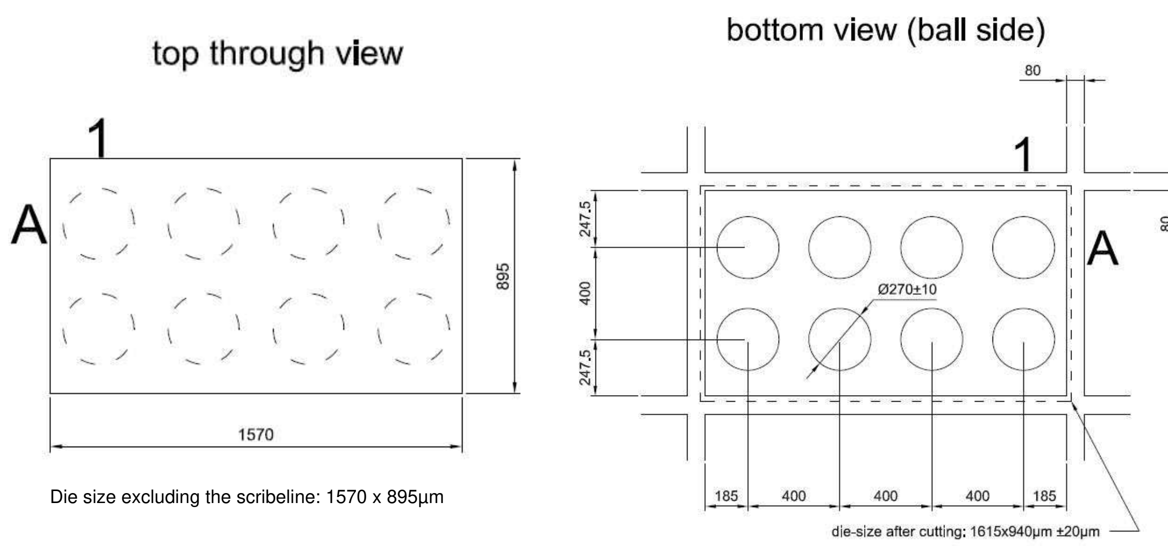
Figure 25:
AS1345 - Inductor Current Paths

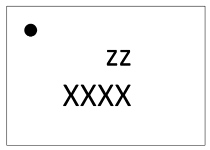


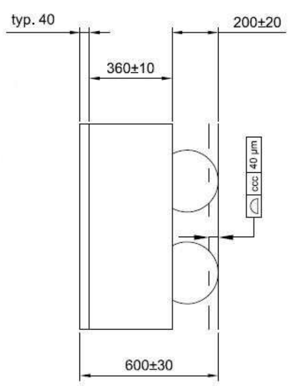
Package Drawings & Markings

The product is available in a 8-pin (2x2) TDFN and 8-bump (1.570mm x 0.895mm) WL-CSP package.

Figure 26:
8-bump WL-CSP with 0.4mm Pitch







Dimensions	Min [µm]	Nom [µm]	Max [µm]
Package x-dimension	1595	1615	1635
Package y-dimension	920	940	960
Package height	570	600	630
Bump height	180	200	220
Bump Diameter	260	270	280

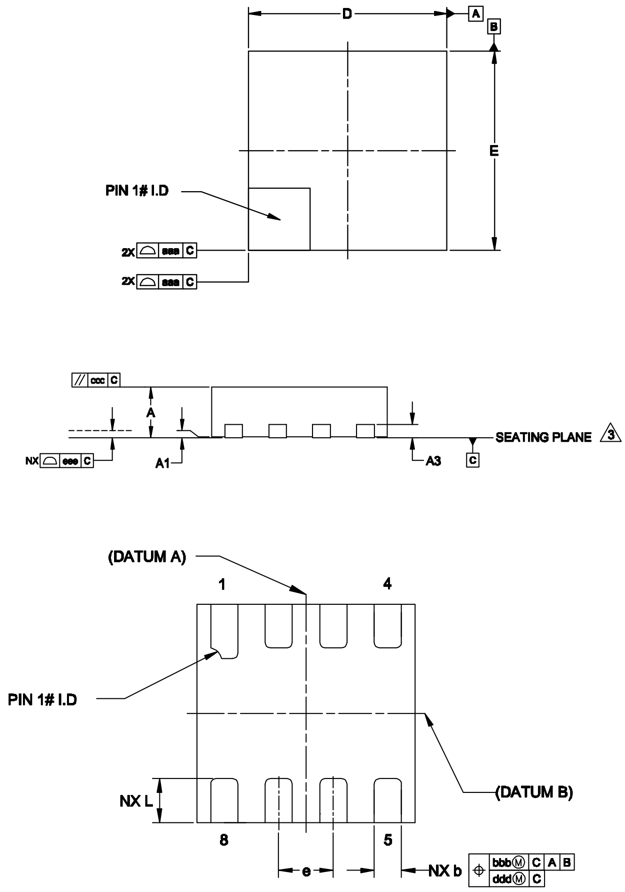
Note(s):

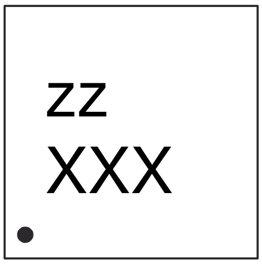
1. ccc Coplanarity.
2. All dimensions in µm.

Figure 27:
Package Marking

Tracecode	Marking Code
XXXX	zz

Figure 28:
8-pin (2x2) TDFN Package





Symbol	Min	Nom	Max
A	0.51	0.55	0.60
A1	0.00	0.02	0.05
A3	-	-	0.22
L	0.45	0.55	0.65
b	0.15	0.20	0.25
D		2.00 BSC	
E		2.00 BSC	
e		0.50 BSC	
aaa	-	0.15	-
bbb	-	0.10	-
ccc	-	0.10	-
ddd	-	0.05	-
eee	-	0.08	-
N		8	

RoHS Green

Note(s):

1. Dimensions & tolerancing conform to *ASME Y14.5M-1994*.
2. All dimensions are in millimeters. Angles are in degrees.
3. Coplanarity applies to the terminal.
4. Radius on terminal is optional.
5. N is the total number of terminals.

Figure 29:
Package Marking

Trace Code	Marking Code
XXX	zz

Ordering & Contact Information

The device is available as the standard products listed in the table below.

On request, all devices can be factory set to enable a 100kΩ pull-down resistor for the EN pin.

Figure 30:
Ordering Information

Ordering Code	Package	Marking	I_{LIMIT}	Output	Delivery Form	Delivery Quantity
AS1345A-BWLT-AD	8-balls WL-CSP	BK	100mA	Adj.	Tape & Reel	1000 pcs/reel
AS1345A-BWLT-12	8-balls WL-CSP	BS	100mA	1.2V	Tape & Reel	1000 pcs/reel
AS1345A-BWLT-15	8-balls WL-CSP	CA	100mA	1.5V	Tape & Reel	1000 pcs/reel
AS1345A-BWLT-17	8-balls WL-CSP	CI	100mA	1.7V	Tape & Reel	1000 pcs/reel
AS1345B-BWLT-AD	8-balls WL-CSP	CB	200mA	Adj.	Tape & Reel	1000 pcs/reel
AS1345D-BWLT-AD	8-balls WL-CSP	BN	500mA	Adj.	Tape & Reel	1000 pcs/reel
AS1345D-BWLT-15	8-balls WL-CSP	BG	500mA	1.5V	Tape & Reel	1000 pcs/reel
AS1345D-BWLT-17	8-balls WL-CSP	BH	500mA	1.7V	Tape & Reel	1000 pcs/reel
AS1345A-BTDT-AD	8-pin TDFN	BI	100mA	Adj.	Tape & Reel	1000 pcs/reel
AS1345B-BTDT-AD	8-pin TDFN	BJ	200mA	Adj.	Tape & Reel	1000 pcs/reel
AS1345C-BTDT-AD	8-pin TDFN	CD	350mA	Adj.	Tape & Reel	1000 pcs/reel
AS1345D-BTDT-AD	8-pin TDFN	CL	500mA	Adj.	Tape & Reel	1000 pcs/reel

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