ams

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 AS1345 – 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

For order related information, please refer to "Ordering Information" on page 24.

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.

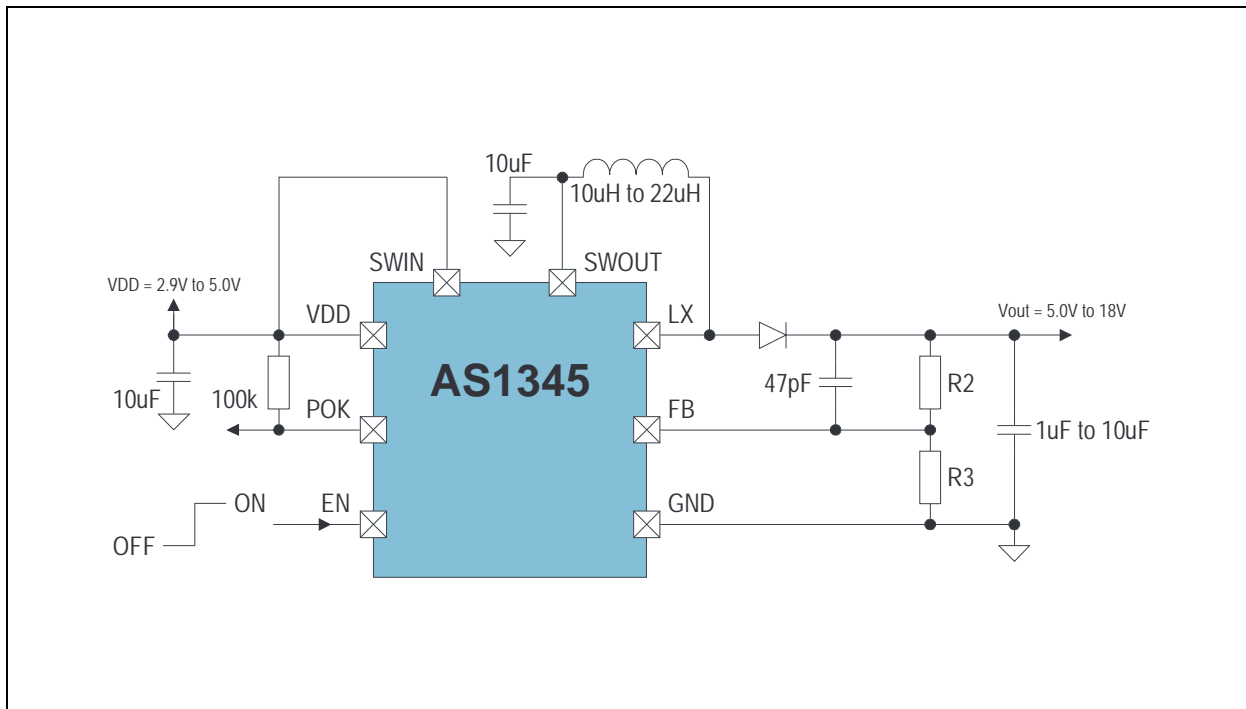**Figure AS1345 – 2:**
Key Benefits and Features

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

![ams logo]

Benefits	Features
Supports a variety of end applications	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 and 3D shutter glasses.

Figure AS1345 – 3:
Typical Application Diagram

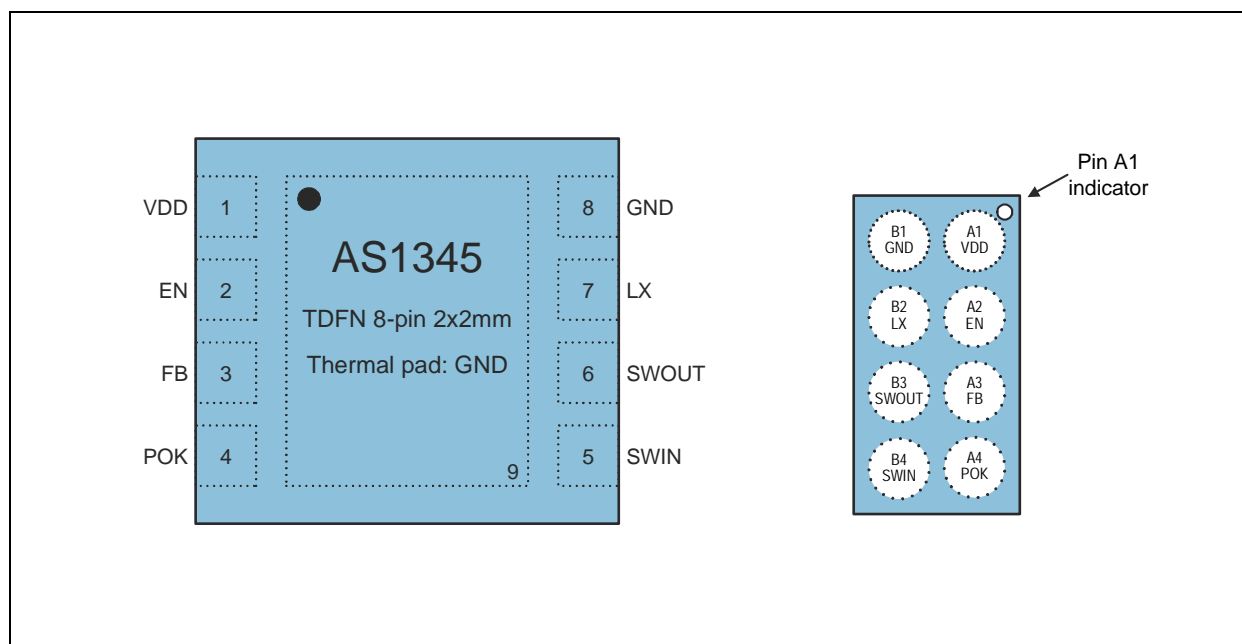## Pin Assignments

Figure AS1345 – 4:
Pin Assignments (Top View)

Figure AS1345 – 5:
Pin Descriptions

Pin Number		Pin Name	Description
TDFN	WLP		
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).
8	B1	GND	Ground
7	B2	LX	**Inductor.** The drain of the internal N-channel MOSFET. Connect to power inductor and to anode of a schottky diode.
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}.

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.
5	B4	SWIN	**Shutdown Disconnect Switch In**. Input pin of the internal P-channel MOSFET.
1	A1	VDD	**Supply Voltage**. Connect to a 2.9V to 5.0V input supply. Bypass this pin with a 10µF capacitor.
9	-	NC	**Exposed Pad**. This pad is not connected internally. This pin also functions as a heat sink. Solder it to a large pad or to the circuit-board ground plane to maximize power dissipation.

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" on page 6 is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Figure AS1345 – 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	Norm: JEDEC 78
SWIN to SWOUT Current Limit			1	A	
Electrostatic Discharge					
Electrostatic Discharge HBM		±2		kV	Norm: MIL 883 E method 3015
Temperature Ranges and Storage Conditions					
Junction temperature			+110	ºC	
Storage temperature range		-55	+125	ºC	for WL-CSP
		-55	+150	ºC	for TDFN
Package thermal data	WL-CSP		60	ºC/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	ºC	Norm IPC/JEDEC J-STD-020
	TDFN				Norm IPC/JEDEC J-STD-020
Humidity non-condensing		5	85	%	
Moisture sensitive level		3			Represents a maximum floor life time of 168h for TDFN
		1			Represents a maximum floor life time of unlimited for WL-CSP

Note: 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".

Electrical Characteristics

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

$V_{DD} = V_{SHDNN} = V_{SWIN} = 3.7V$, $V_{OUT} = 15V$, $C_{IN} = C_{OUT} = 10\mu F$, typical values @ $T_{AMB} = +25°C$ (unless otherwise specified). All limits are guaranteed.

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
				15		
				17		
V_{FB}	Feedback voltage	For adjustable V_{OUT} only		1.25		V
	Feedback input current			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		%
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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
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

![ams logo]

Typical Operating Characteristics V_{OUT} = 15V

Figure AS1345 – 7:
Efficiency vs. I_{OUT}; V_{IN} = 2.7V, I_{LIMIT} = 100mA
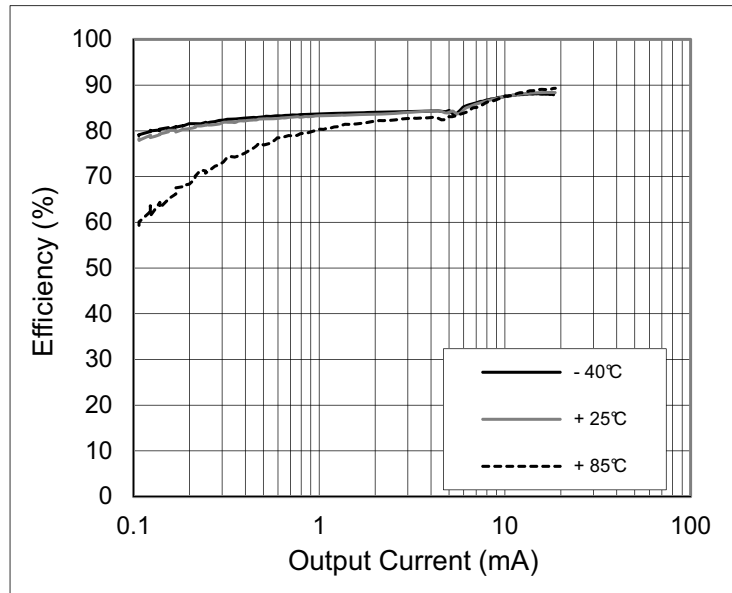
Figure AS1345 – 8:
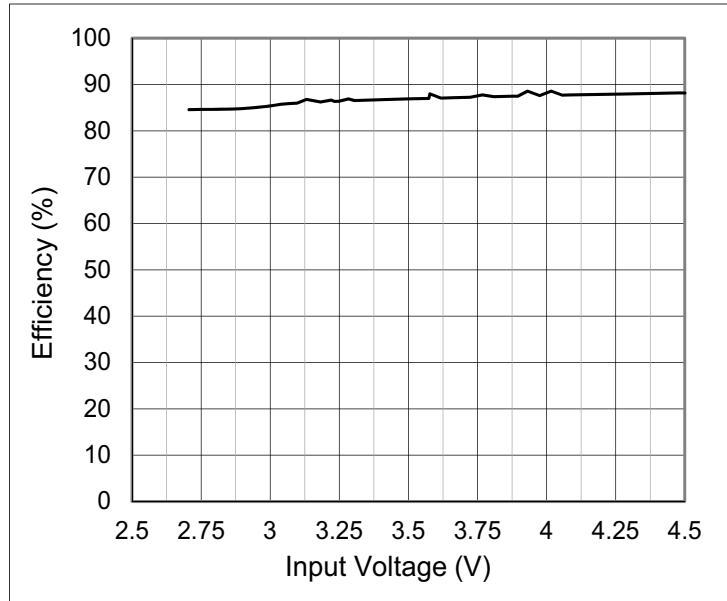**Efficiency vs. I_{OUT}; V_{IN} = 2.7V, I_{LIMIT} = 500mA**
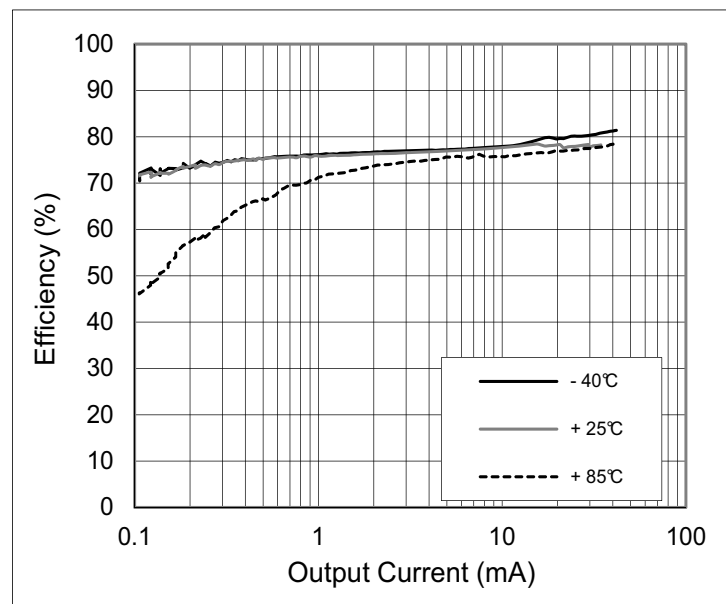
Figure AS1345 – 9:
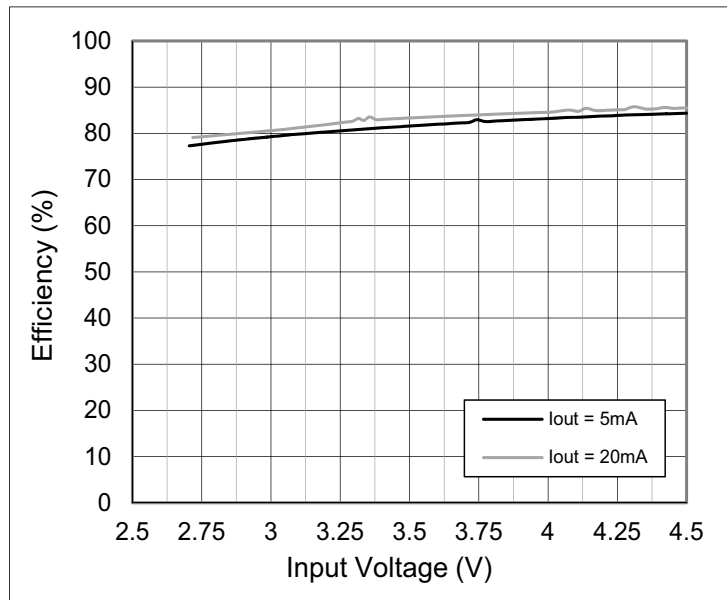**Efficiency vs. I**OUT**; V**IN **= 4.5V, I**LIMIT **= 100mA**
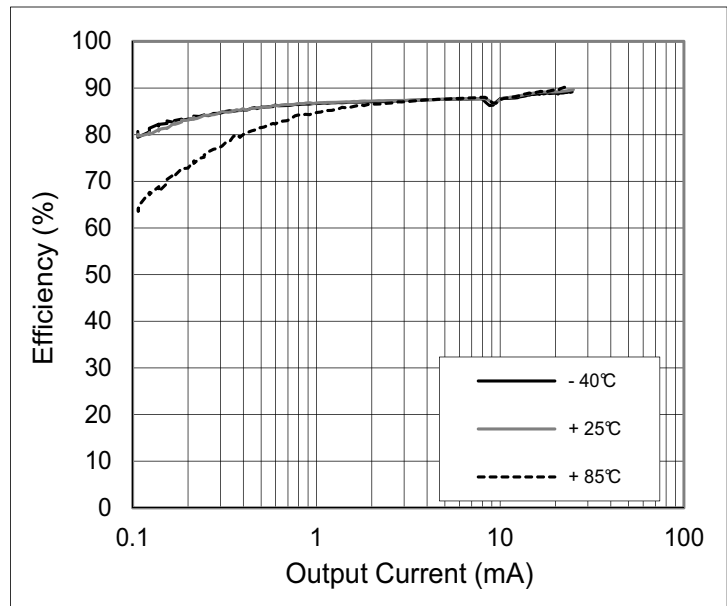
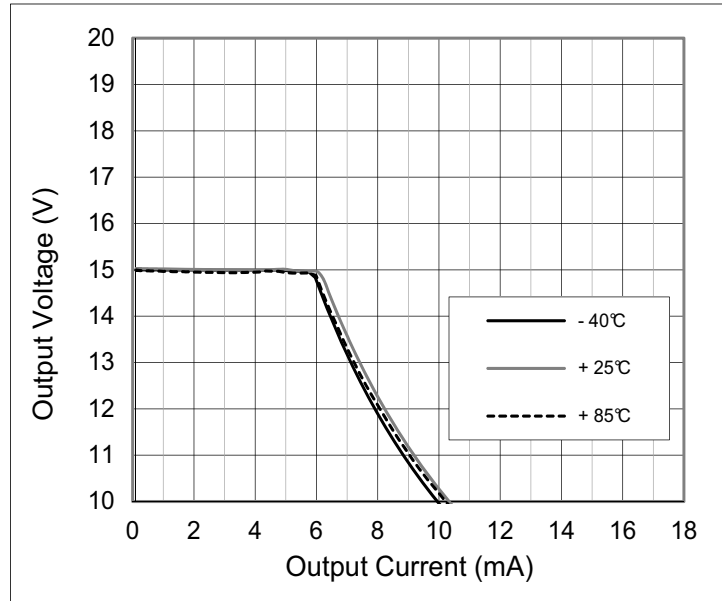**Figure AS1345 – 10:**
Efficiency vs. IOUT**; V**IN **= 4.5V, I**LIMIT **= 500mA**
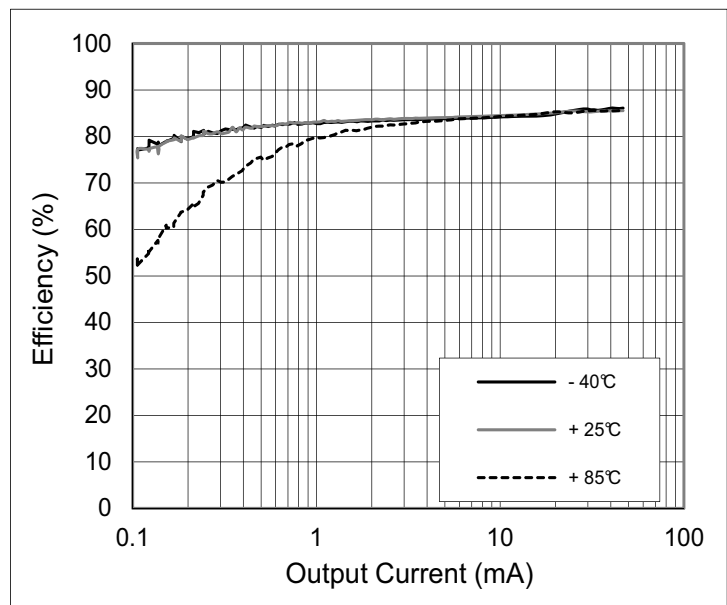
Figure AS1345 – 11:
Efficiency vs. V_{IN}; I_{LOAD} = 5mA, I_{LIMIT} = 100mA

Figure AS1345 – 12:
Efficiency vs. V_{IN}; I_{LOAD} = 5mA/20mA, I_{LIMIT} = 500mA

![ams logo]

Figure AS1345 – 13:
V_{OUT} **vs.** I_{OUT}; V_{IN} = 2.7V, I_{LIMIT} = 100mA

Figure AS1345 – 14:
V_{OUT} **vs.** I_{OUT}; V_{IN} = 4.5V, I_{LIMIT} = 100mA
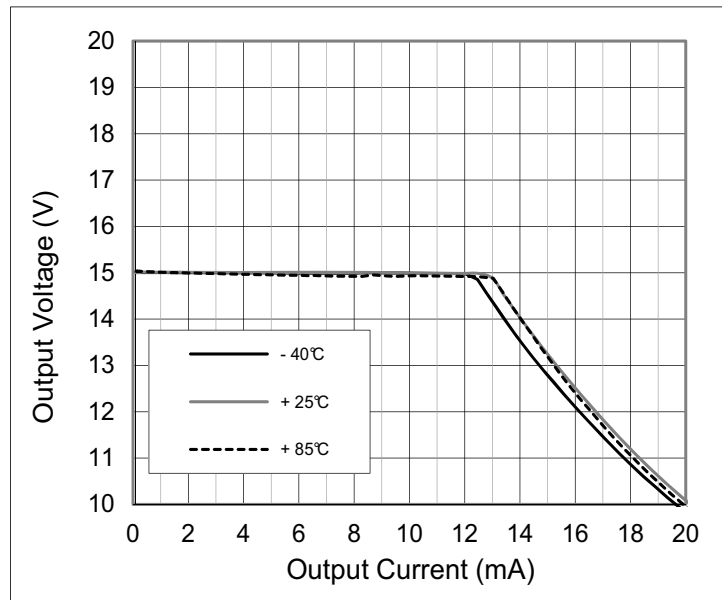
Figure AS1345 – 15:
V_{OUT} **vs.** I_{OUT}; V_{IN} = 4.5V, I_{LIMIT} = 500mA
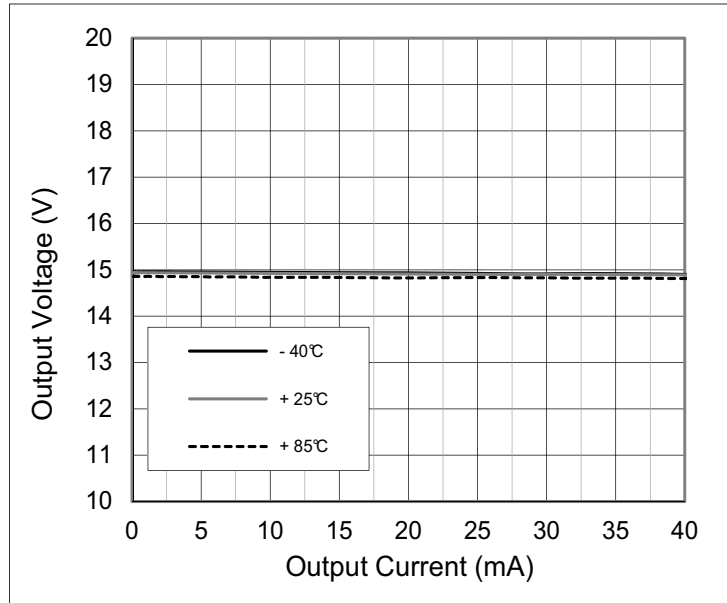
Detailed Description

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 AS1345 – 16:
Block Diagram
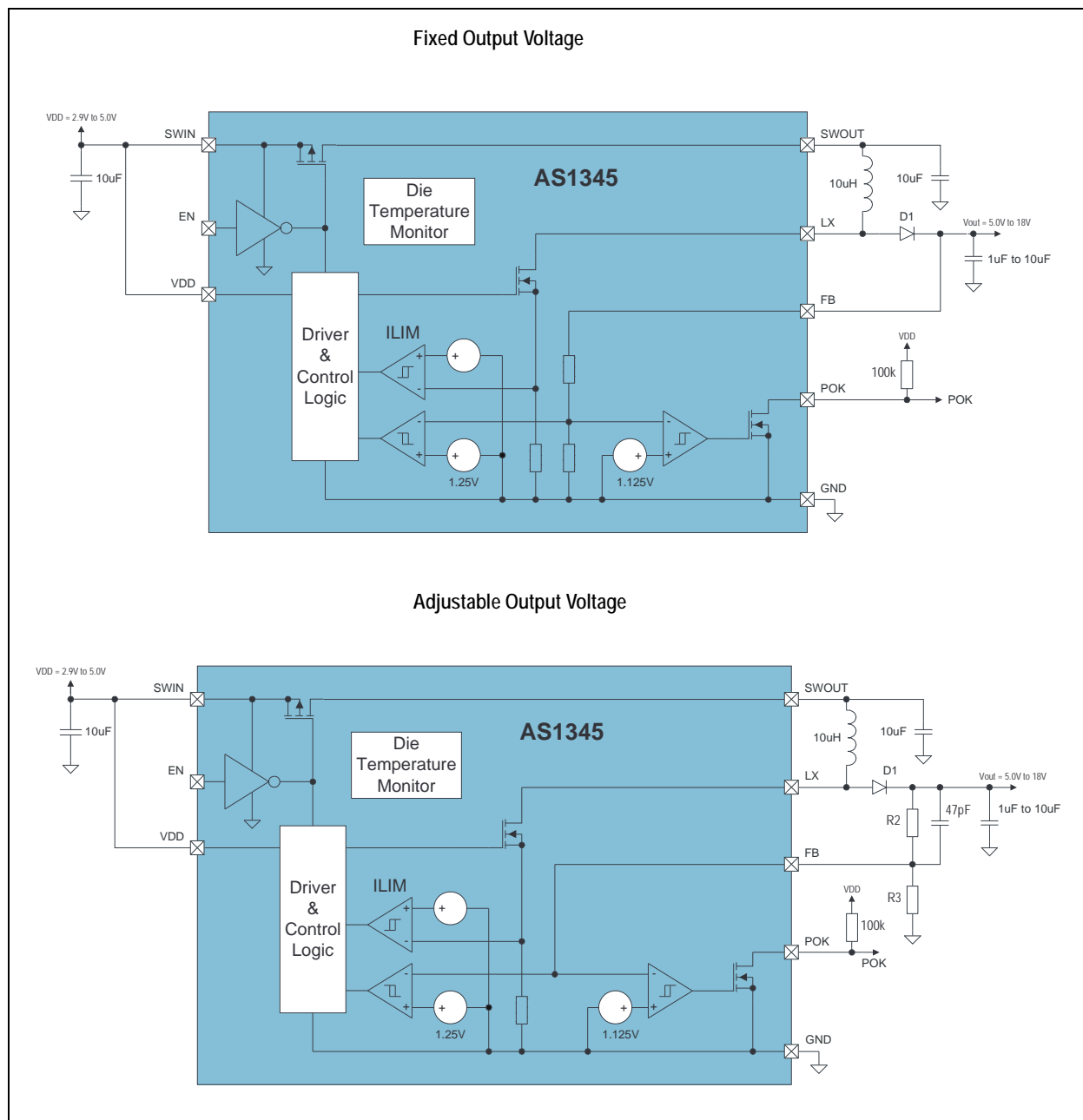
Modes of Operation

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 3). 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 17 and Figure 18). Select R1 from 10kΩ to 600kΩ and calculate R2 with the following equation:

(EQ 1)

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

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 19 and Figure 20).

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.
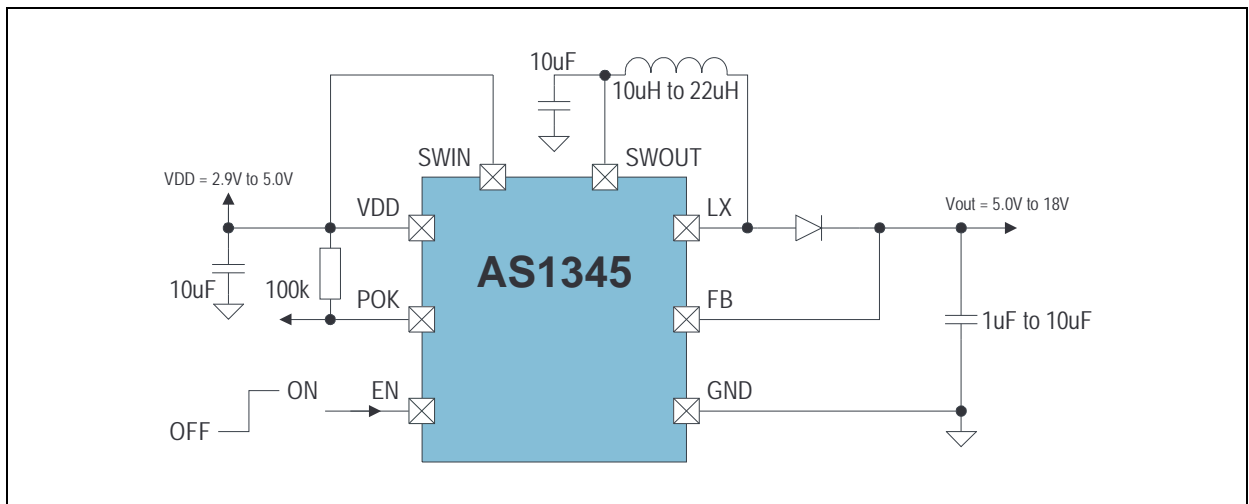
Figure AS1345 – 17:
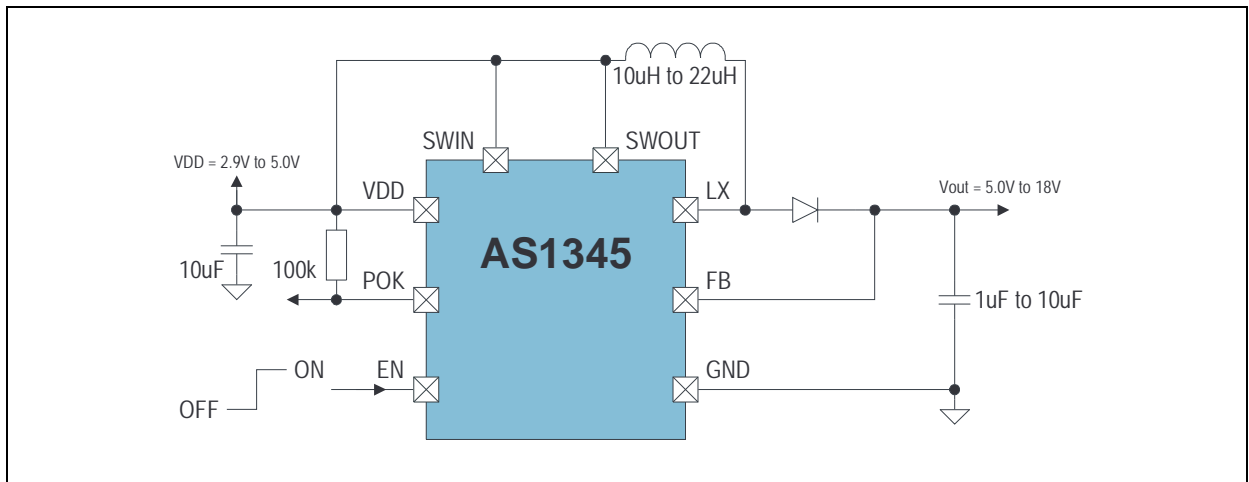**AS1345 with Adjustable Output Voltage, with Output Disconnect**
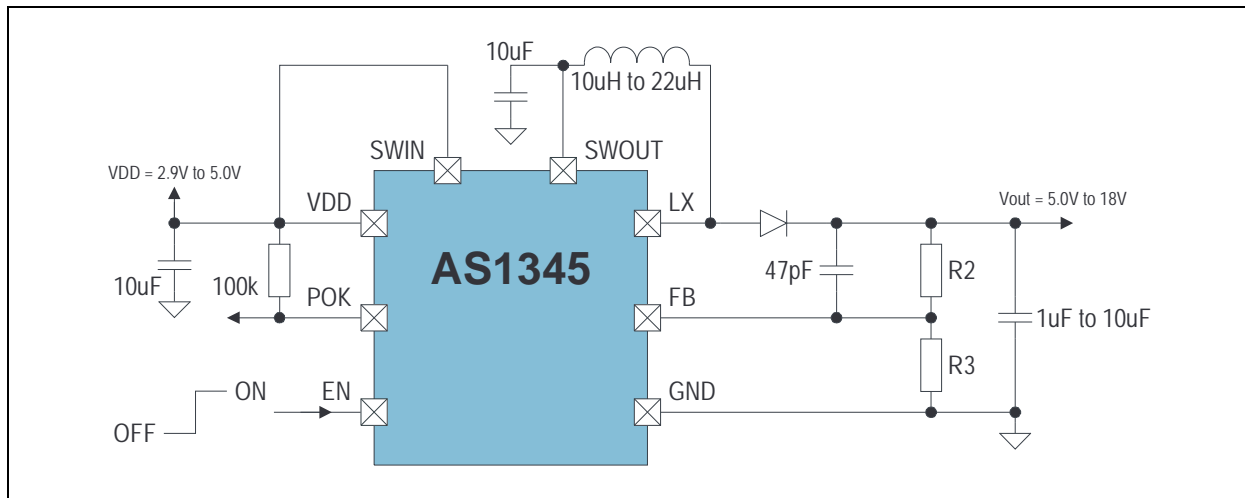
Figure AS1345 – 18:
AS1345 with Adjustable Output Voltage, without Output Disconnect
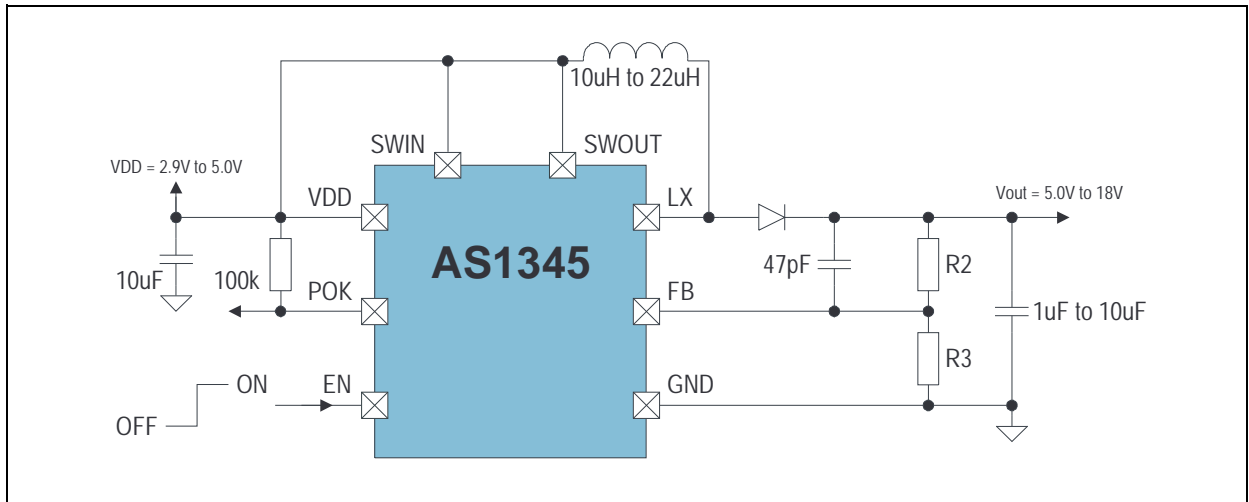
Figure AS1345 – 19:
AS1345 with Fixed Output Voltage, with Output Disconnect

Figure AS1345 – 20:
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. It is recommended to solder the Exposed Pad to the GND plane.

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.

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 V_{IN} capacitor should be 10μF. The V_{OUT} 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 V_{OUT}. See table below for a list of capacitors for input and output capacitor selection.

Figure AS1345 – 22:
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 I_{OUT} is very low most of the time, and V_{OUT} is high, select a diode with a low reverse current for best efficiency. For lower V_{OUT} and higher I_{OUT}, select a diode with a lower $V_{FORWARD}$ and $R_{FORWARD}$.

Figure AS1345 – 23:
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 24 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 AS1345 – 24:
AS1345 - Inductor Current Paths
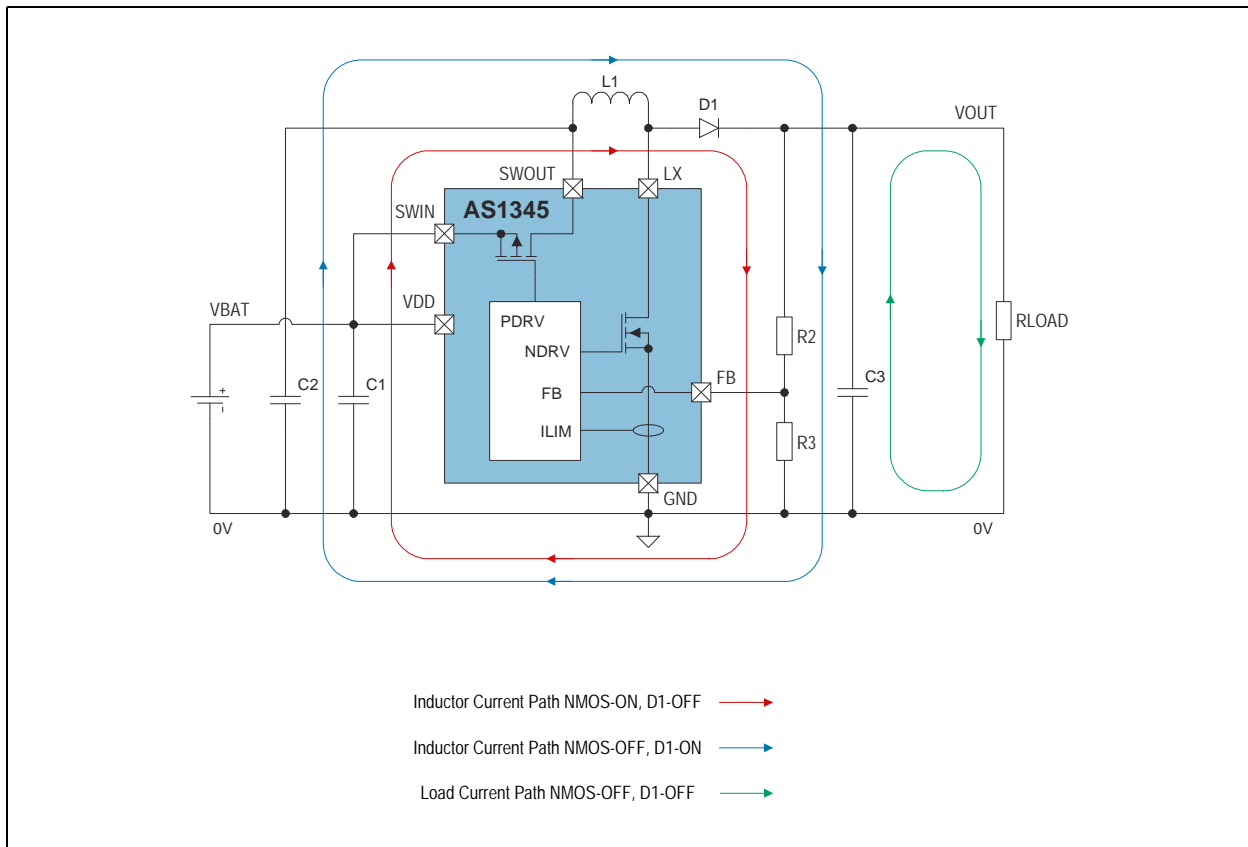
Package Drawings and Markings

The product is available in a 8-pin (2x2) TDFN and 8-bump (1.570mm x 0.895mm) WL-CSP package.
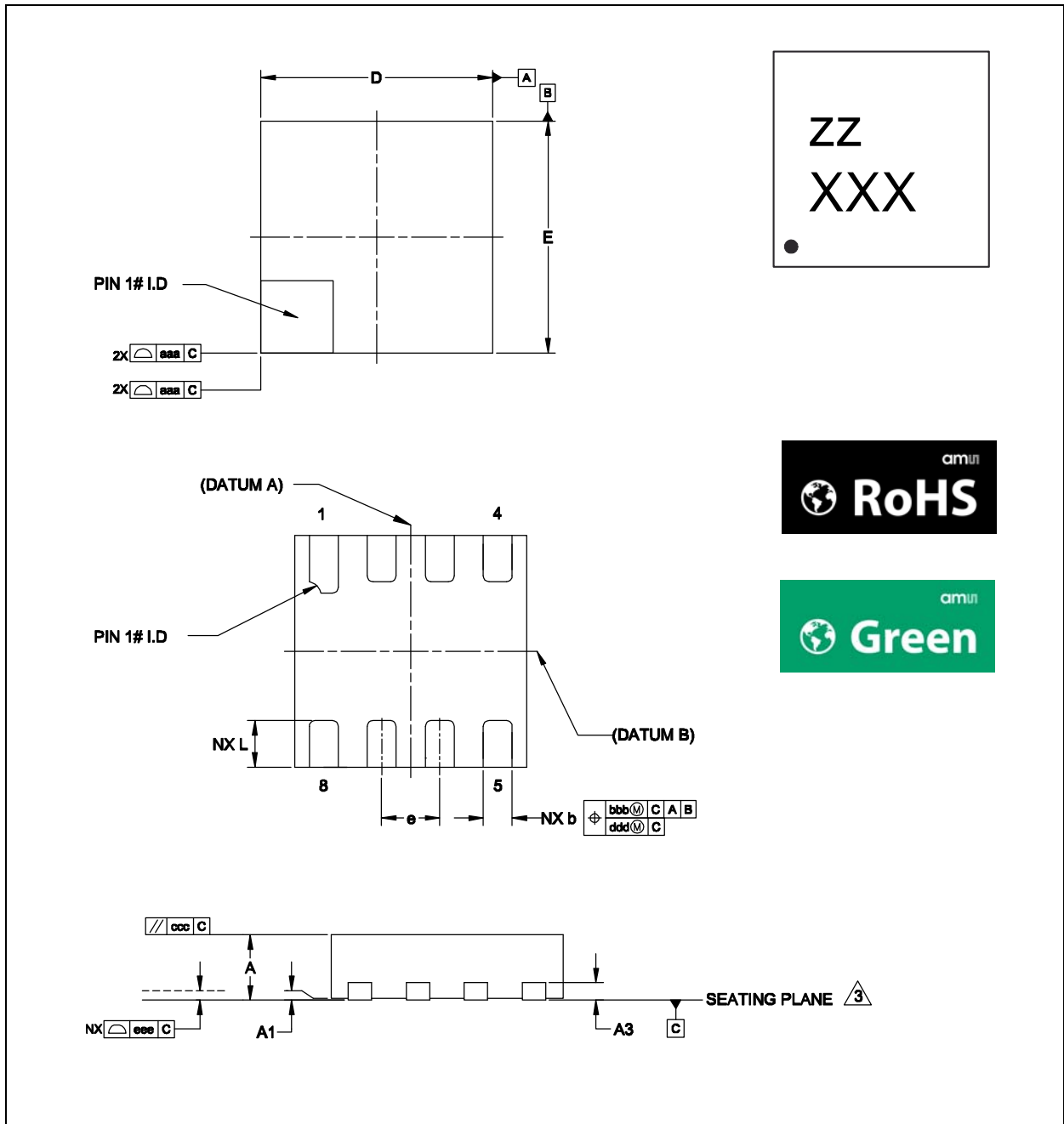
Figure AS1345 – 25:
8-bump WL-CSP with 0.4mm Pitch

top through view

bottom view (ball side)

die-size after cutting: 1615x940μm ±20μm
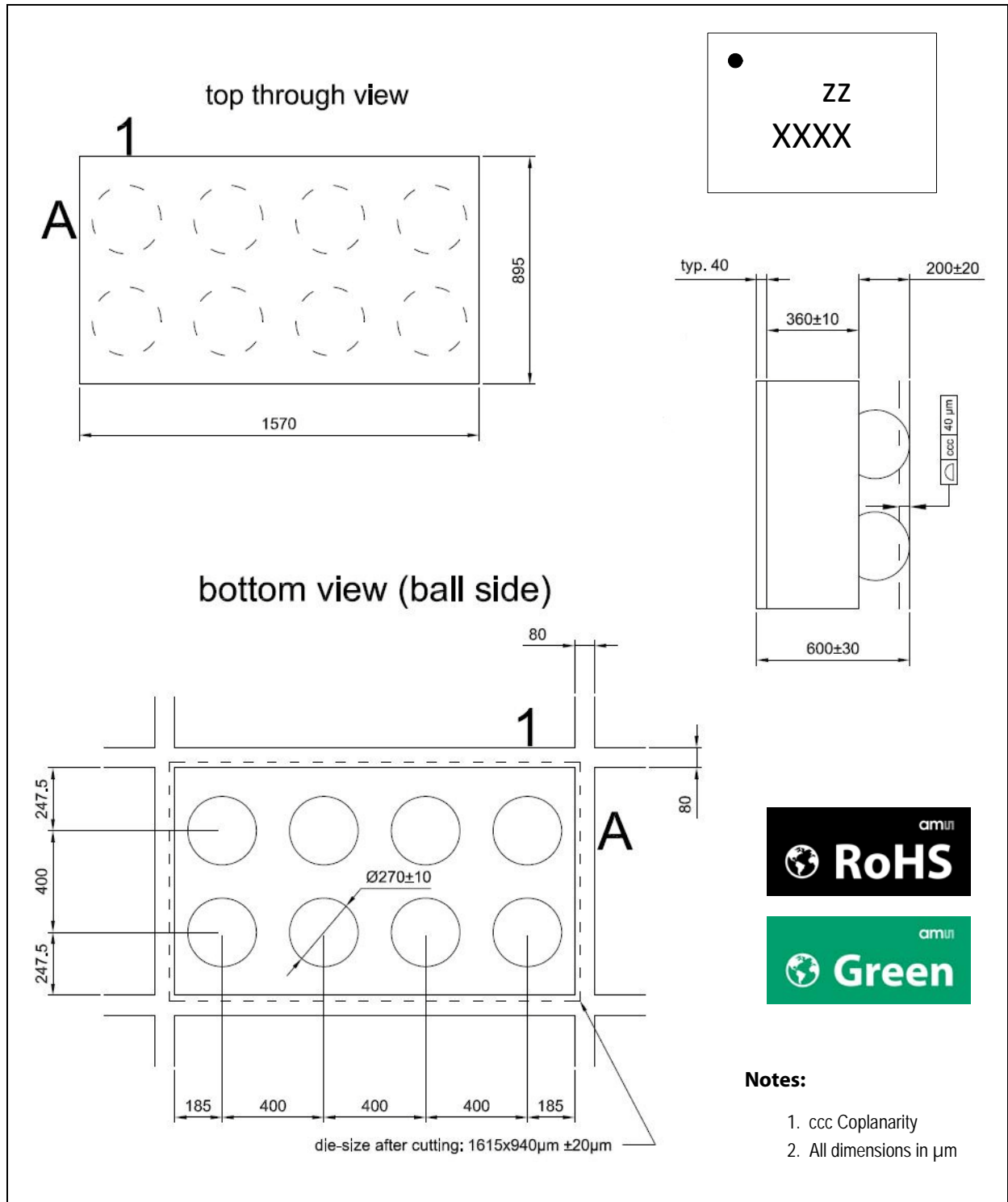
Notes:

1. ccc Coplanarity
2. All dimensions in μm

Encoded Date Code	Marking Code
XXXX	zz

Encoded Date Code	Marking Code
XXX	ZZ

Notes:

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

Figure AS1345 – 27:
Package Dimensions

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		

Ordering 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 AS1345 – 28:
Ordering Information

Ordering Code	Marking	I_{LIMIT}	Output	Description	Delivery Form	Package
AS1345A-BWLT-AD	BK	100mA	adjustable	18V, High Efficiency DCDC Step-up Converter	Tape and Reel	8-bumps (1.570x0.895mm) WL-CSP
AS1345A-BWLT-12	BS		12V			
AS1345A-BWLT-15	CA		15V			
AS1345A-BWLT-17	CI		17V			
AS1345A-BTDT-AD	BI	100mA	adjustable			8-pin (2x2mm) TDFN
AS1345B-BTDT-AD	BJ	200mA	adjustable			
AS1345C-BTDT-AD	CD	350mA	adjustable			
AS1345D-BTDT-AD	CL	500mA	adjustable			
AS1345D-BWLT-15	BG	500mA	15V			8-bumps (1.570x0.895mm) WL-CSP
AS1345D-BWLT-17	BH	500mA	17V			

Notes:

1. All products are RoHS compliant and ams green.
2. Buy our products or get free samples online at www.ams.com/ICdirect
3. Technical Support is available at www.ams.com/Technical-Support
4. For further information and requests, e-mail us at sales@ams.com
   (or) find your local distributor at www.ams.com/distributor

RoHS Compliant and ams Green Statement

The term RoHS complaint means that ams products fully comply with current RoHS directive. Our semiconductor products do not contain any chemicals for all 6 substance categories, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, RoHS compliant products are suitable for use in specified lead-free processes. ams Green means RoHS compliant and no Sb/Br). ams defines Green that additionally to RoHS compliance our products are free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material).

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