

**Features**

- Simple low parts count
- 1A output current
- Single pin on/off and brightness control Using DC voltage or PWM
- Soft-start Function
- High efficiency (up to 97%)
- Wide input voltage range : 6V to 36V
- Output shutdown
- Up to 1MHz switching frequency
- Inherent open-circuit LED protection
- Typical 5% output current accuracy
- Package : SOT23-5L,ESOP-8L

**Applications**

- Low voltage halogen replacement LEDs
- Automotive lighting
- Low voltage industrial lighting
- LED back-up lighting

**General Description**

The LSP3312 is a continuous mode inductive step-down converter, designed for driving single or multiple series connected LEDs efficiently from a voltage source higher than the LED voltage. The device operates from an input supply between 6V and 36V and provides an externally adjustable output current of up to 1A. Depending upon supply voltage and external components, this can provide up to 30 watts of output power.

The LSP3312 includes the output switch and a high-side output current sensing circuit, which uses an external resistor to set the nominal average output current.

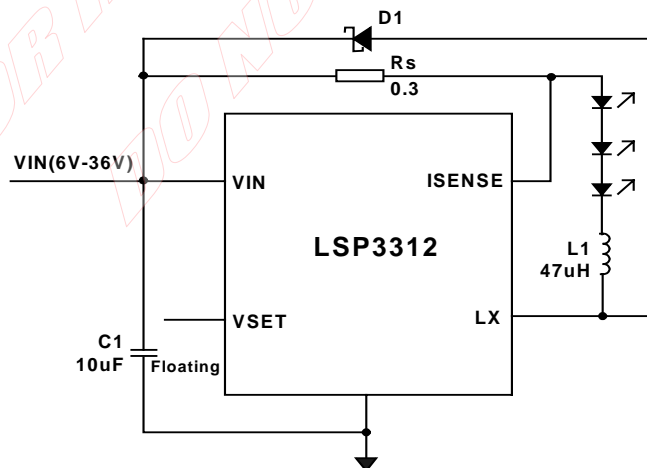
Output current can be adjusted below the set values, by applying an external control signal to the VSET pin.

The VSET pin will accept either a DC voltage or a PWM waveform.

The soft-start time can be increased using an external capacitor from the VSET pin to ground.

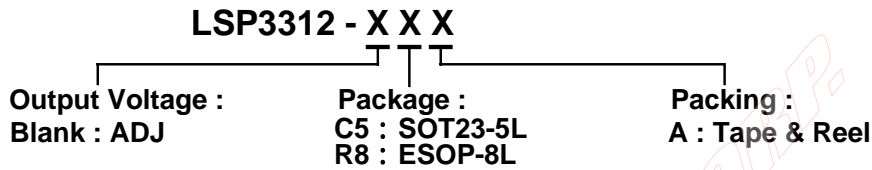
Applying a voltage of 0.2V or lower to the VSET pin turns the output off and switches the device into a low current standby state.

**Typical Application Circuit**



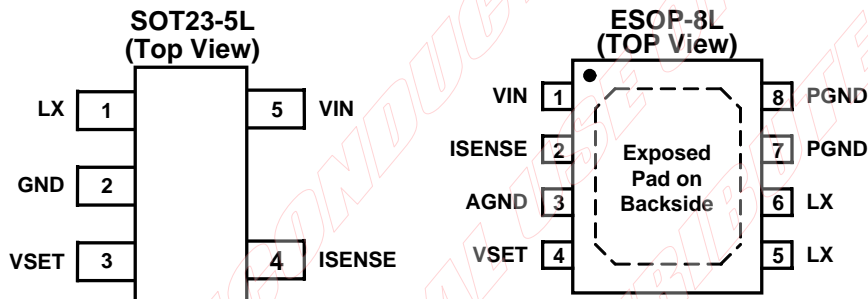
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**Ordering Information**



Device	Package Code	Package	Tape & Reel	
			Quantity	Part Number Suffix
LSP3312-C5A	C5	SOT23-5L	3000	A
LSP3312-R8A	R8	ESOP-8L	2500	A

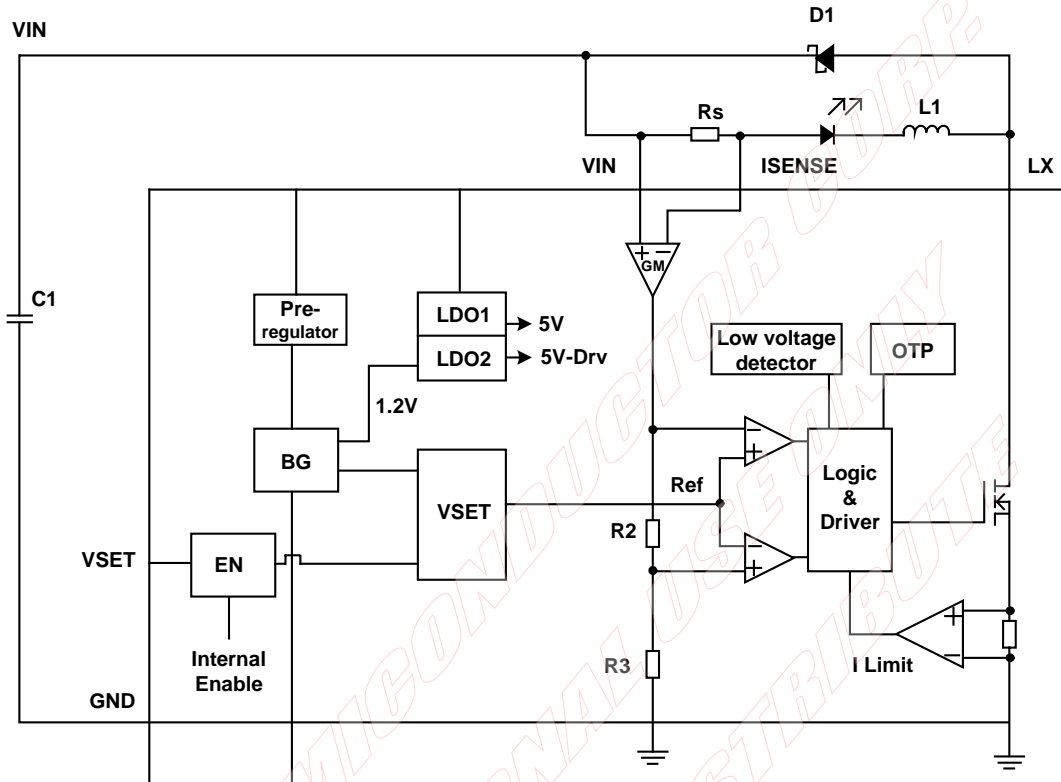
**Pin Assignments**



**Pin Descriptions**

Pin Number		Name	Description
SOT23-5L	ESOP-8L		
1	5,6	LX	Drain of NDMOS switch
2		GND	Ground
	3	AGND	Analog Ground
	7,8	PGND	Power Ground
3	4	VSET	Multi-function On/Off and brightness control pin: Leave floating for normal operation. Drive to voltage below 0.1V to turn off output current Drive with DC voltage ( $0.4V < VSET < 2.4V$ ) to adjust output current from 16% to 100% of IOUT nom Drive with PWM signal from open-collector or open-drain transistor, to adjust output current. Adjustment range 1% to 100% of IOUT nom for $f < 500Hz$ Connect a capacitor from this pin to ground to increase soft-start time. (Default soft-start time = 0.1ms. Additional soft-start time is approx.1.5ms/nF)
4	2	ISENSE	Connect resistor RS from this pin to VIN to define nominal average output current $I_{OUTnom} = 0.1/Rs$ (Note: $RSMIN = 0.1_{\Omega}$ with VSET pin open-circuit)
5	1	VIN	Input voltage (6V to 36V). Decouple to ground with 4.7μF or higher X7R ceramic capacitor close to device.
	Exposed Pad	Exposed Pad	This pin has to connect to ground.

**Block Diagram**



**Absolute Maximum Ratings**

Parameter	Value	Unit
Input Voltage Range	-0.3 to 40	V
LX,ISENSE Pin voltage	-0.3 to 40	V
V <sub>SET</sub> Pin voltage	-0.3 to 6	V
Power Dissipation	Internally limited by maximum junction temperature of 150°C	mW
Thermal Resistance (Junction to Case), $\theta_{jC}$	SOT23-5L	130 °C/W
	ESOP-8L	10 °C/W
Thermal Resistance (Junction to Environment) , $\theta_{jA}$	SOT23-5L	250 °C/W
	ESOP-8L	50 °C/W
Storage Temperature Range	-65 to +150	°C
Maximum Junction Temperature	150	°C

**Recommended Operating Conditions**

Parameter	Min	Max	Unit
Input Supply Voltage	6	36	V
Operating Junction Temperature	-20	+125	°C

**Electrical Characteristics**

( $V_{IN} = 16V$ ,  $T_A = 25^\circ C$  unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Output Current	ILED	Rs=0.3Ω		333		mA
		Rs=0.1Ω				
Shutdown Current	ISD	VSET pin grounded		20	40	μA
Quiescent Current without switching	IQ	VSET pin floating, $V_{IN}$		0.6		mA
Mean current sense threshold Voltage	Vsense	Measured on Isense pin with respect to $V_{IN}$	95	100	105	mV
Sense threshold hysteresis	Vsense_hys			13		%
Isense pin input current	Isense	$V_{sense} = V_{in} - 0.1$		8		μA
Vset range on VSET pin	Ven	For DC dimming	0.3		2.5	V
DC voltage on VSET pin to enable	Venon	Ven rising		0.25		V
DC voltage on VSET pin to disable	Venoff	Ven falling		0.2		V
LX switch on resistance	RLX	@ILX=100mA		0.3		Ω
LX switch leakage current	ILX(leak)				5	μA
Soft start time	Tss	$V_{IN}=16V$ , $C_{en} = 1nF$		1.5		ms
Operating frequency	FLX	$V_{IN}=16V$ , $V_o=9.6V$ (3 LEDs), $L=47\mu H$ , $\Delta I=0.25A$ (ILED=1A)		233		KHz
Recommended minimum switch ON time	Ton_rec	For 4% accuracy		500		ns
Recommended maximum switch frequency	FLXmax				1.0	MHZ
Max duty circle				98		%
Recommended duty cycle range	DLX		25		75	%
Internal comparator propagation delay	T <sub>PD</sub> *			45		ns
Over temperature protection	T <sub>OTP</sub>			150		°C
Temp protection hysteresis	T <sub>OTP_hys</sub>			40		°C

\*parameters are not tested at production, but guaranteed by design.

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## **Application Description**

### **Setting nominal average output current with external resistor $R_s$**

The nominal average output current in the LED(s) is determined by the value of the external current sense resistor ( $R_s$ ) connected between VIN and ISENSE and is given by:

$$I_{OUTnom} = \frac{0.1}{R_s}$$

The table below gives values of nominal average output current for several preferred values of current setting resistor ( $R_s$ ) in the typical application circuit shown on page1.

<b><math>R_s</math> ( )</b>	<b>Nominal average output current (mA)</b>
0.1	1000
0.13	760
0.15	667
0.3	333

The above values assume that the VSET pin is floating and at a nominal voltage of VREF (1.25V). Note that  $R_s=0.1$  is the minimum allowed value of sense resistor under these conditions to maintain switch current below the specified maximum value. It is possible to use different values of  $R_s$  if the VSET pin is driven from an external voltage.

### **Capacitor selection**

A low ESR capacitor should be used for input decoupling, as the ESR of this capacitor appears in series with the supply source impedance and lowers overall efficiency. This capacitor has to supply the relatively high peak current to the coil and smooth the current ripple on the input supply. A minimum value of 4.7uF is acceptable if the input source is close to the device, but higher values will improve performance at lower input voltages, especially when the source impedance is high. The input capacitor should be placed as close as possible to the IC.

For maximum stability over temperature and voltage, capacitors with X7R, X5R, or better dielectric are recommended. Capacitors with Y5V dielectric are not suitable for decoupling in this application and should NOT be used.

### **Inductor selection**

Recommended inductor values for the LSP3312 are in the range 33uH to 100uH. Higher values of inductance are recommended at higher supply voltages in order to minimize errors due to switching delays, which result in increased ripple and lower efficiency. Higher values of inductance also result in a smaller change in output current over the supply voltage range. The inductor should be mounted as close to the device as possible with low resistance connections to the LX and VIN pins. The chosen coil should have a saturation current higher than the peak output current and a continuous current rating above the required mean output current.

The inductor value should be chosen to maintain operating duty cycle and switch 'on'/'off' times within the specified limits over the supply voltage and load current range. The following equations can be used as a guide.

LX Switch 'On' time

$$T_{ON} = \frac{L\Delta I}{V_{IN} - V_{LED} - I_{LED}(R_S + R_L + R_{LX})}$$

LX Switch 'Off' time

$$T_{OFF} = \frac{L\Delta I}{V_{LED} + V_D + I_{LED}(R_S + R_L)}$$

Where: L is the coil inductance;  $R_L$  is the coil resistance;  $R_S$  is the current sense resistance  $I_{LED}$  is the required LED current ;  $\Delta I$  is the coil peak-peak ripple current (Internally set to  $0.25 \times I_{LED}$  );  $V_{IN}$  is the supply voltage;  $V_{LED}$  is the total LED forward voltage;  $R_{LX}$  is the switch resistance (0.3 nominal);  $V_D$  is the diode forward voltage at the required load current.

#### Diode selection

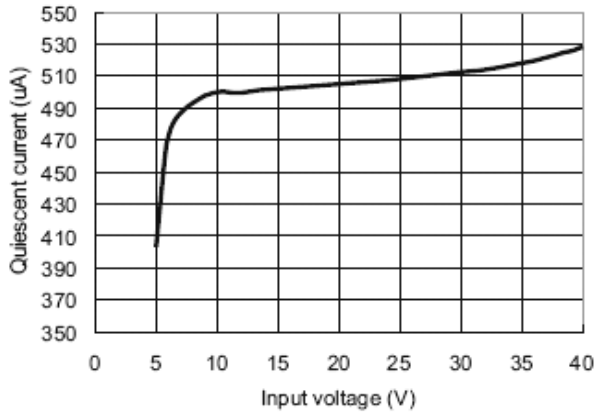
For maximum efficiency and performance, the rectifier (D1) should be a fast low capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature. They also provide better efficiency than silicon diodes, due to a combination of lower forward voltage and reduced recovery time.

It is important to select parts with a peak current rating above the peak coil current and a continuous current rating higher than the maximum output load current. It is very important to consider the reverse leakage of the diode when operating above 85°C. Excess leakage will increase the power dissipation in the device and if close to the load may create a thermal runaway condition.

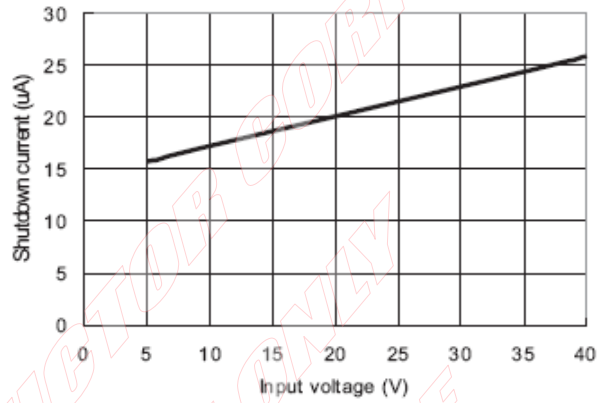
The higher forward voltage and overshoot due to reverse recovery time in silicon diodes will increase the peak voltage on the LX output. If a silicon diode is used, care should be taken to ensure that the total voltage appearing on the LX pin including supply ripple, does not exceed the specified maximum value.

**Typical Performance Characteristics**

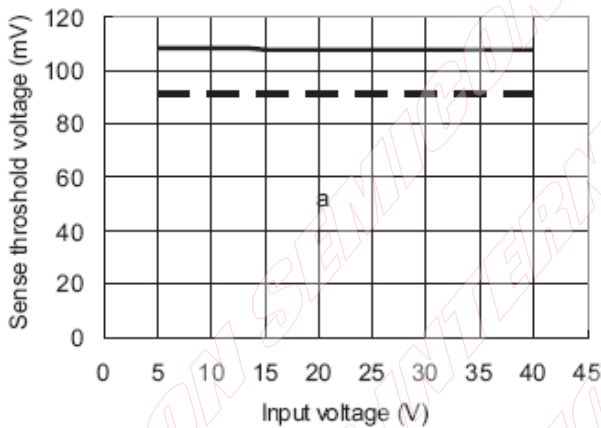
**1. Quiescent Current vs Input Voltage**



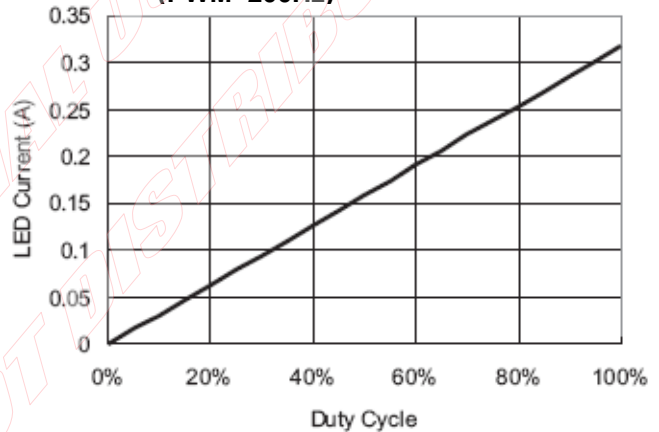
**2. Shutdown Current vs Input Voltage**



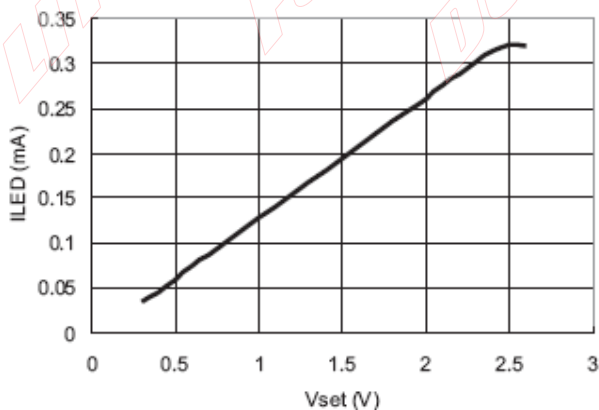
**3. Feedback Voltage vs Vin**



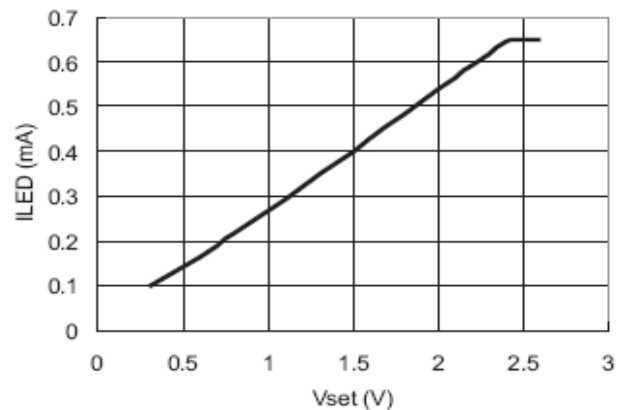
**4. Duty Cycle vs LED Current (PWM=200Hz)**



**5. I<sub>LED</sub> vs V<sub>SET</sub>  
(V<sub>IN</sub>=16V, 3 LEDs, 47uH, R<sub>s</sub>=0.3 )**

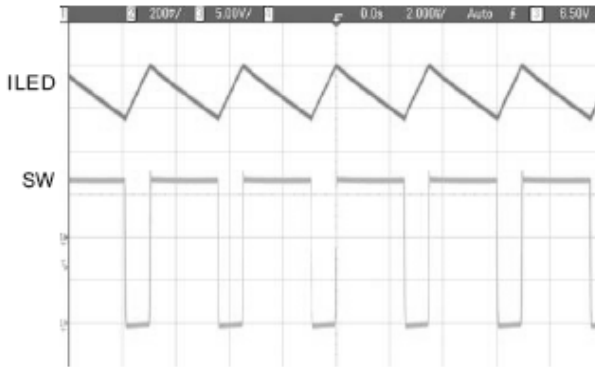


**6. I<sub>LED</sub> vs V<sub>SET</sub>  
(V<sub>IN</sub>=16V, 3 LEDs, 100uH, R<sub>s</sub>=0.15 )**

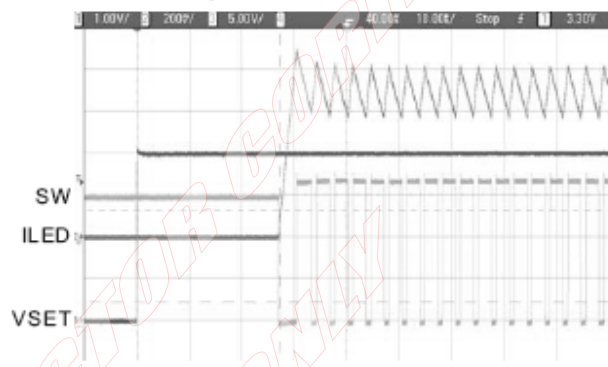


**Typical Performance Characteristics (Continued)**

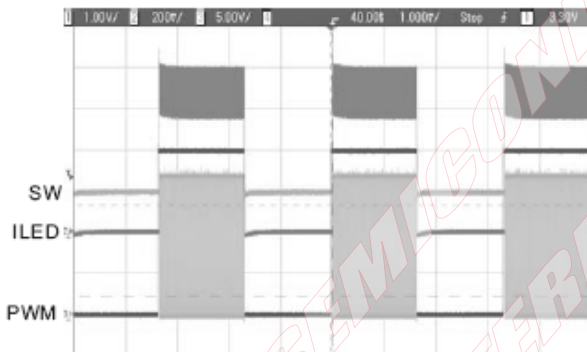
**7. Steady State Waveforms**



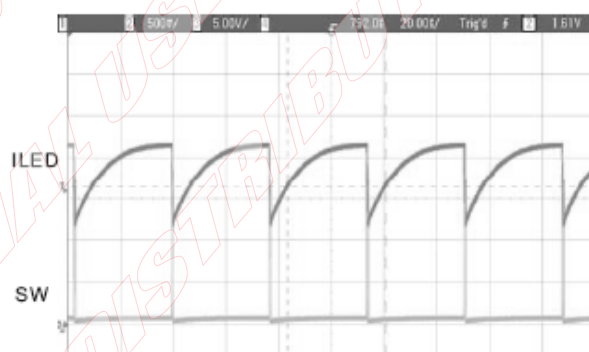
**8. Start up Waveforms**



**9. Dimming Waveforms (PWM=50%)**

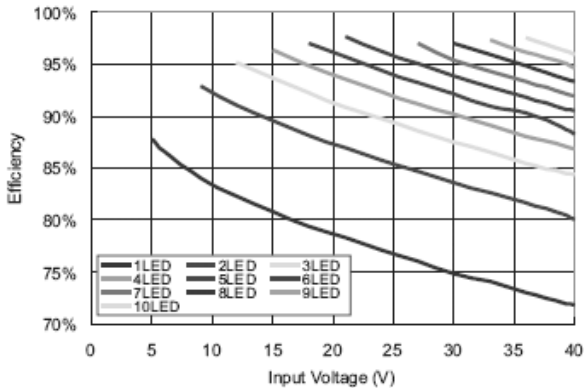


**10. Pulse skip mode**

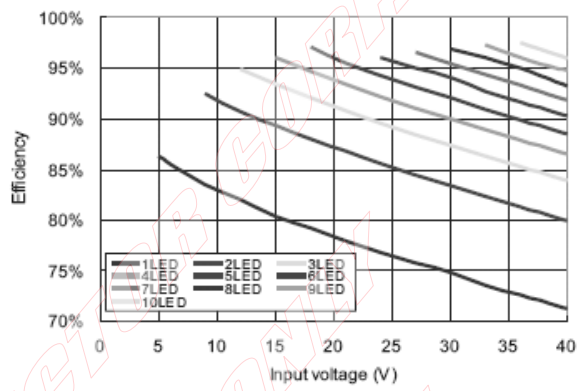


**Typical Performance Characteristics (Continued)**

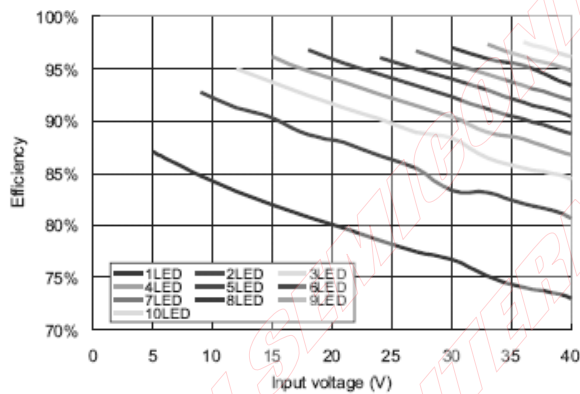
**11. Efficiency vs Input Voltage**  
(Rs=0.3 ,L=100uH)



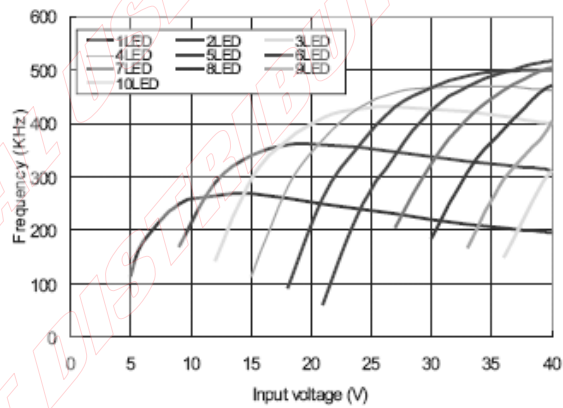
**12. Efficiency vs Input Voltage**  
(Rs=0.15 ,L=47uH)



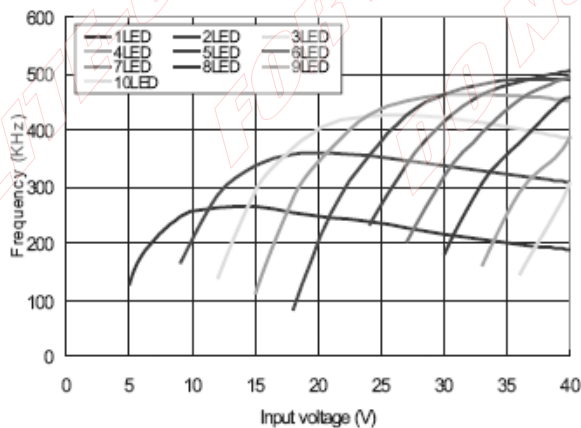
**13. Efficiency vs Input Voltage**  
(Rs=0.1 ,L=33uH)



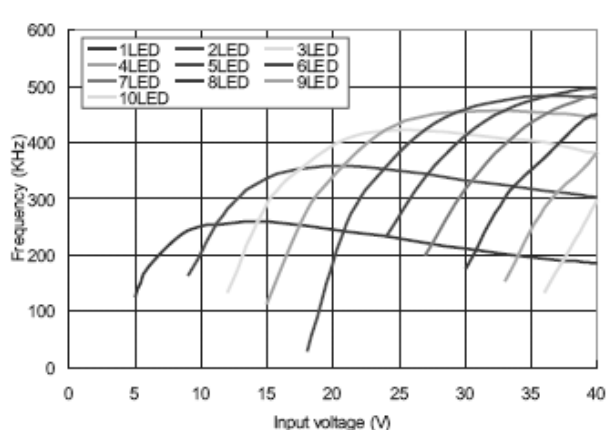
**14. Operating Frequency vs Input Voltage**  
(Rs=0.3 ,L=100uH)



**15. Operating Frequency vs Input Voltage**  
(Rs=0.15 ,L=47uH)

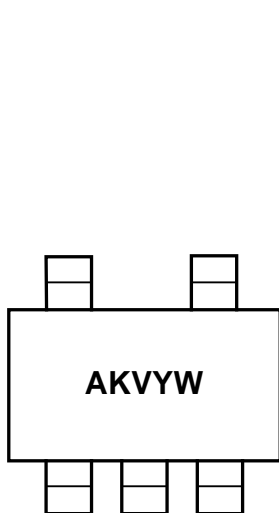


**16. Operating Frequency vs Input Voltage**  
(Rs=0.1 ,L=33uH)



**Marking Information**

**SOT23-5L**



**AK V YW**

**Date Code**

Y : Year(9=2009,0=2010,1=2011,2=2012...)

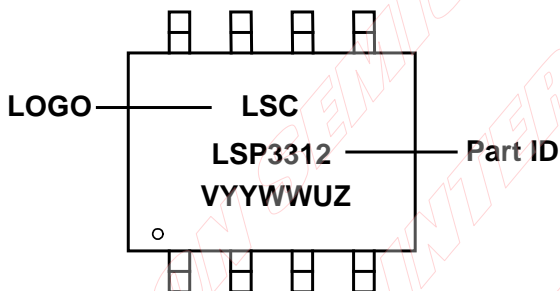
W : Week

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Code#	1	2	3	4	5	6	7	8	9	A	B	C	D
Week	14	15	16	17	18	19	20	21	22	23	24	25	26
Code#	E	F	G	H	J	K	L	M	N	P	Q	R	S
Week	27	28	29	30	31	32	33	34	35	36	37	38	39
Code#	T	U	V	W	X	Y	Z	a	b	c	d	e	f
Week	40	41	42	43	44	45	46	47	48	49	50	51	52/53
Code#	g	h	i	m	n	p	q	s	t	u	v	w	x

**Output Voltage**  
Blank=ADJ

**Product Code**  
AK : LSP3312

**ESOP-8L**



**V YYWW UZ**

Internal Code

**Date code**

YY : Year(09=2009,10=2010,11=2011,12=2012...)

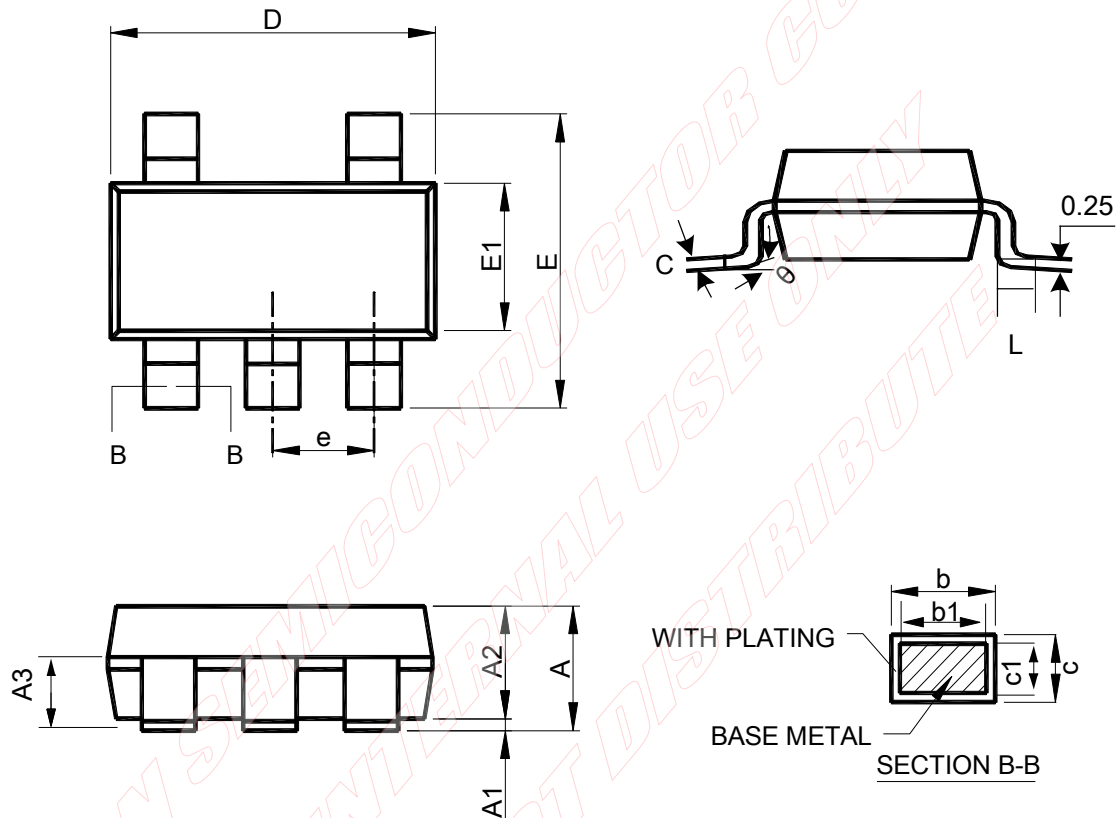
WW : Week(01~53)

**Output Voltage**

Blank=ADJ

**Package Information** (All Dimensions in min)

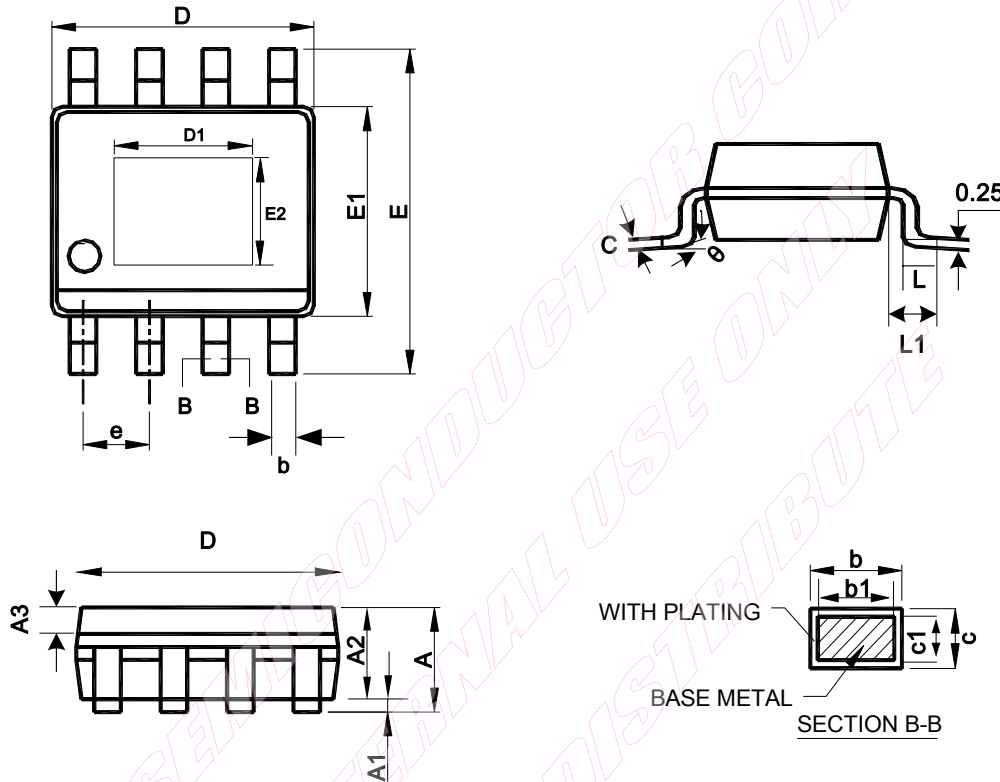
SOT23-5L



Symbol	Dimensions In Millimeters		
	Min	Typ	Max
A	-	-	1.35
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.55	0.65	0.75
b	0.34	-	0.43
b1	0.33	0.35	0.38
c	0.15	-	0.21
c1	0.14	0.15	0.16
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	0.60	1.80
e	0.95BSC		
L	0.30	-	0.60
	0	-	8°

**Package Information** (All Dimensions in min) (Continued)

**ESOP-8L**



Symbol	Dimensions In Millimeters		
	Min	Nom	Max
A	-	-	1.75
A1	0.05	-	0.15
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	-	0.48
b1	0.38	0.41	0.43
c	0.21	-	0.26
c1	0.19	0.20	0.21
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27BSC		
L	0.50	-	0.80
L1	1.05BSC		
	0	-	8°
D1	2.13REF		2.90REF
E2	2.13REF		2.00REF

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