



## A5970D

Up to 1 A step down switching regulator  
for automotive applications

### Features

- Qualified following the AEC-Q100 requirements (temperature grade 3), see PPAP for more details.
- Up to 1 A DC output current
- Operating input voltage from 4 V to 36 V
- Output voltage adjustable from 1.235 V to 35 V
- Low dropout operation: 100 % duty cycle
- 250 kHz Internally fixed frequency
- Voltage feedforward
- Zero load current operation
- Internal current limiting
- Inhibit for zero current consumption
- Synchronization
- Protection against feedback disconnection
- Thermal shutdown

### Applications

- Dedicated to automotive applications



### Description

The A5970D is a step down monolithic power switching regulator capable to deliver up to 1 A at output voltages from 1.2 V to 35 V.

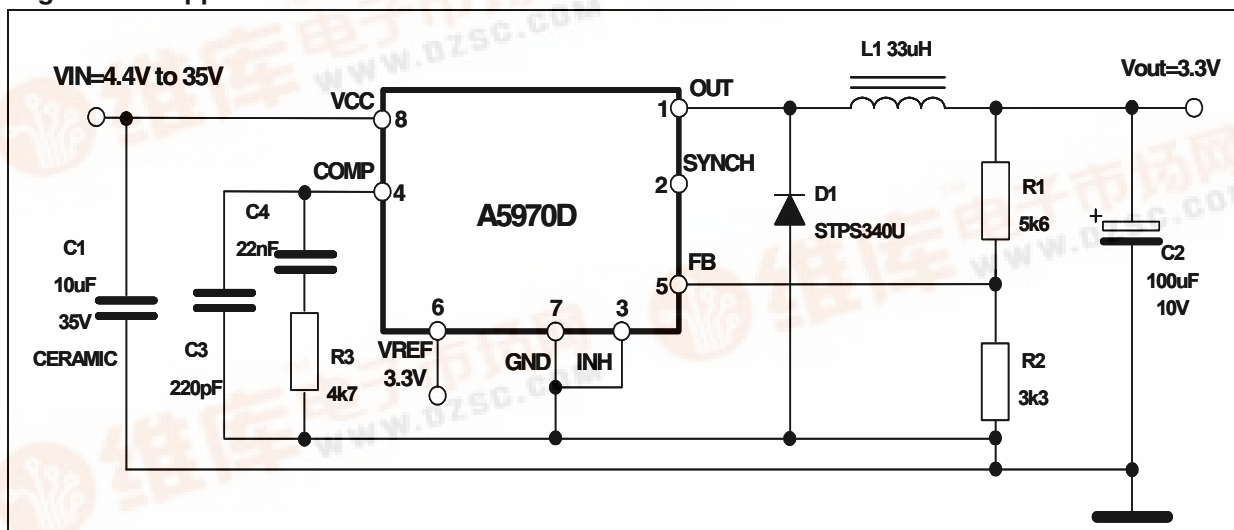
The device uses an internal P-channel D-MOS transistor (with a typical  $R_{DS(on)}$  of 250 m $\Omega$ ) as switching element to minimize the size of the external components.

An internal oscillator fixes the switching frequency at 250 kHz.

Having a minimum input voltage of 4 V only, it is particularly suitable for 5 V bus.

Pulse by pulse current limit with the internal frequency modulation offers an effective constant current short circuit protection.

Figure 1. Application schematic



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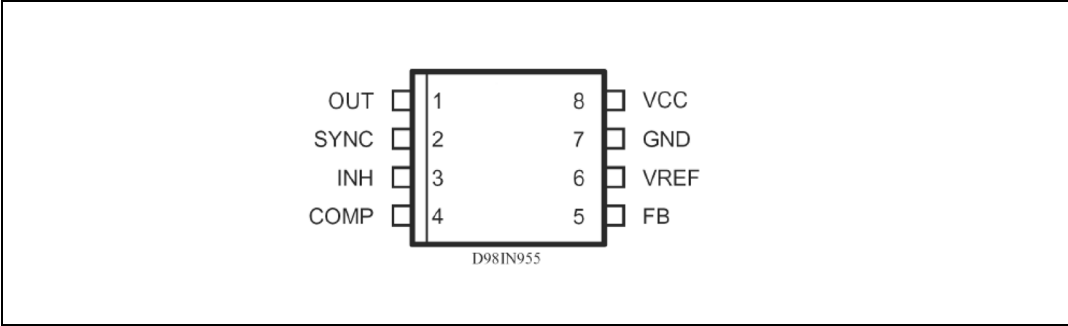
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# 1 Pin settings

## 1.1 Pin connection

**Figure 1. Pin connection (top view)**



## 1.2 Pin description

**Table 1. Pin description**

N	Pin	Description
1	OUT	Regulator output.
2	SYNCH	Master/slave synchronization.
3	INH	A logical signal (active high) disables the device. If INH not used the pin must be grounded. When it is open an internal pull-up disable the device.
4	COMP	E/A output for frequency compensation.
5	FB	Feedback input. Connecting directly to this pin results in an output voltage of 1.23 V. An external resistive divider is required for higher output voltages.
6	VREF	3.3 V VREF. No cap is requested for stability.
7	GND	Ground.
8	VCC	Unregulated DC input voltage.

## 2 Electrical data

### 2.1 Maximum ratings

**Table 2. Absolute maximum ratings**

Symbol	Parameter	Value	Unit
$V_8$	Input voltage	40	V
$V_1$	OUT pin DC voltage	-1 to 40	V
	OUT pin peak voltage at $\Delta t = 0.1 \mu s$	-5 to 40	V
$I_1$	Maximum output current	int. limit.	
$V_4, V_5$	Analog pins	4	V
$V_3$	INH	-0.3 to $V_{CC}$	V
$V_2$	SYNCH	-0.3 to 4	V
$P_{TOT}$	Power dissipation at $T_A \leq 70^\circ C$	0.75	W
$T_j$	Operating junction temperature range	-40 to 150	$^\circ C$
$T_{STG}$	Storage temperature range	-55 to 150	$^\circ C$

### 2.2 Thermal data

**Table 3. Thermal data**

Symbol	Parameter	SO8	Unit
$R_{thJA}$	Maximum thermal resistance junction-ambient	120 <sup>(1)</sup>	$^\circ C/W$

1. Package mounted on board

### 3 Electrical characteristics

**Table 4. Electrical characteristics**

( $T_J = -40$  to  $125\text{ }^{\circ}\text{C}$ ,  $V_{CC} = 12\text{ V}$ , unless otherwise specified)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit
V <sub>CC</sub>	Operating input voltage range	V <sub>0</sub> = 1.235 V; I <sub>0</sub> = 1 A	4		36	V
R <sub>DS(on)</sub>	MOSFET on resistance			0.250	0.5	Ω
I <sub>L</sub>	Maximum limiting current <sup>(1)</sup>	V <sub>CC</sub> = 5 V	1.35	1.87	2.25	A
		V <sub>CC</sub> = 5 V, T <sub>J</sub> = 25 °C	1.5	1.87	2.25	
f <sub>SW</sub>	Switching frequency		212	250	280	kHz
	Duty cycle		0		100	%
Dynamic characteristics (see test circuit).						
V <sub>5</sub>	Voltage feedback	4.4 V < V <sub>CC</sub> < 36 V, 20 mA < I <sub>0</sub> < 2 A	1.198	1.235	1.272	V
η	Efficiency	V <sub>0</sub> = 5 V, V <sub>CC</sub> = 12 V		90		%
DC characteristics						
I <sub>qop</sub>	Total operating quiescent current			3	5	mA
I <sub>q</sub>	Quiescent current	Duty cycle=0; V <sub>FB</sub> =1.5 V			2.5	mA
I <sub>qst-by</sub>	Total stand-by quiescent current	V <sub>inh</sub> > 2.2 V		50	100	μA
		V <sub>CC</sub> = 36 V; V <sub>inh</sub> > 2.2 V		80	150	μA
Inhibit						
	INH threshold voltage	Device ON			0.8	V
		Device OFF	2.2			V
Error amplifier						
V <sub>OH</sub>	High level output voltage	V <sub>FB</sub> = 1 V	3.5			V
V <sub>OL</sub>	Low level output voltage	V <sub>FB</sub> = 1.5 V			0.4	V
I <sub>o source</sub>	Source output current	V <sub>COMP</sub> = 1.9 V; V <sub>FB</sub> = 1 V	190	300		μA
I <sub>o sink</sub>	Sink output current	V <sub>COMP</sub> = 1.9 V; V <sub>FB</sub> =1.5 V	1	1.5		mA
I <sub>b</sub>	Source bias current			2.5	4	μA
	DC open loop gain	R <sub>L</sub> =∞	50	65		dB

**Table 4. Electrical characteristics (continued)**(T<sub>J</sub> = -40 to 125 °C, V<sub>CC</sub> = 12 V, unless otherwise specified)

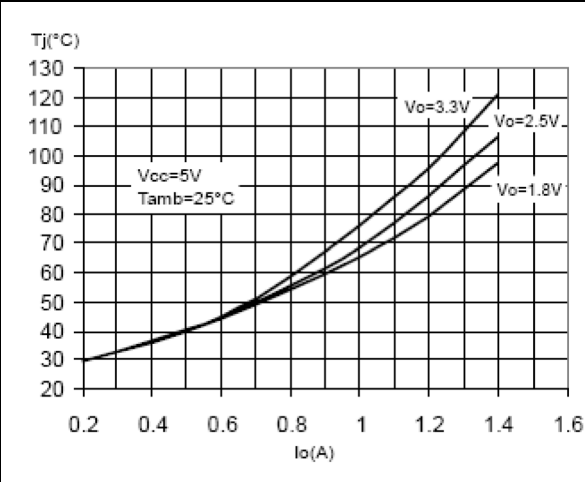
Symbol	Parameter	Test condition	Min	Typ	Max	Unit
gm	Transconductance	I <sub>COMP</sub> = -0.1 mA to 0.1 mA; V <sub>COMP</sub> = 1.9 V		2.3		mS
<b>Synch function</b>						
	High input voltage	V <sub>CC</sub> = 4.4 to 36 V;	2.5		V <sub>REF</sub>	V
	Low input voltage	V <sub>CC</sub> = 4.4 to 36 V;			0.74	V
	Slave synch current	V <sub>synch</sub> = 0.74 V <sup>(2)</sup> V <sub>synch</sub> = 2.33 V	0.11 0.21		0.25 0.45	mA
	Master output amplitude	I <sub>source</sub> = 3 mA	2.75	3		V
	Output pulse width	no load, V <sub>synch</sub> = 1.65 V	0.20	0.35		μs
<b>Reference section</b>						
	Reference voltage	I <sub>REF</sub> = 0 to 5 mA V <sub>CC</sub> = 4.4 V to 36 V	3.2	3.3	3.399	V
	Line regulation	I <sub>REF</sub> = 0 mA V <sub>CC</sub> = 4.4 V to 36 V		5	10	mV
	Load regulation	I <sub>REF</sub> = 0 mA		8	15	mV
	Short circuit current		5	18	35	mA

1. With T<sub>J</sub> = 85 °C, I<sub>lim\_min</sub> = 1.5 A, assured by design, characterization and statistical correlation.

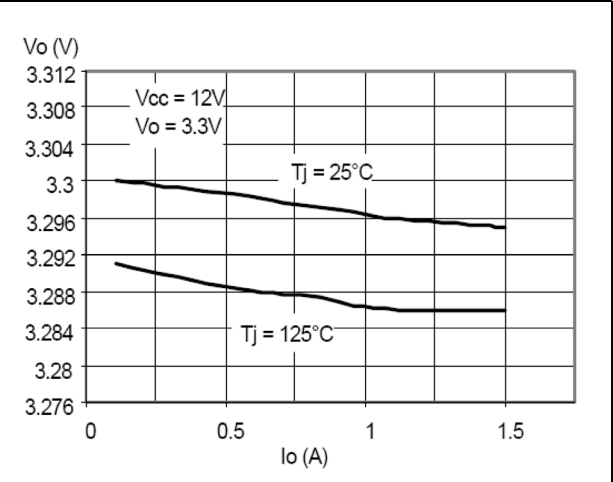
2. Guaranteed by design

## 4 Typical characteristics

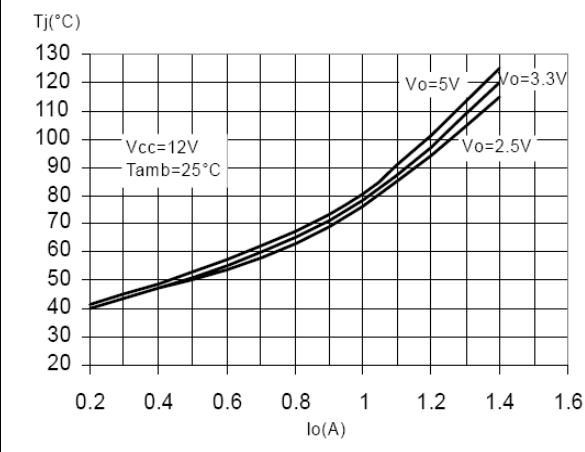
**Figure 2. Junction temperature vs output current**



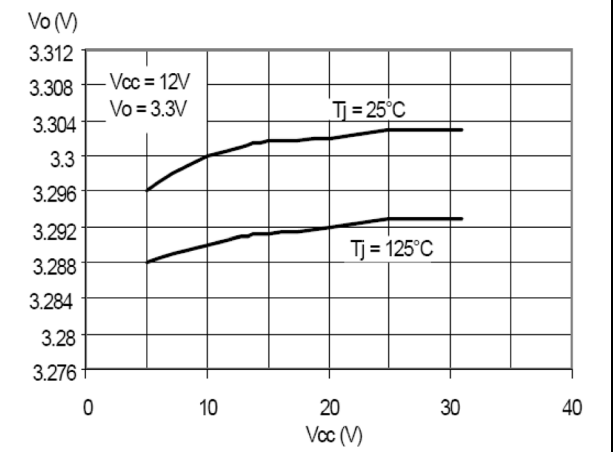
**Figure 3. Load regulation**



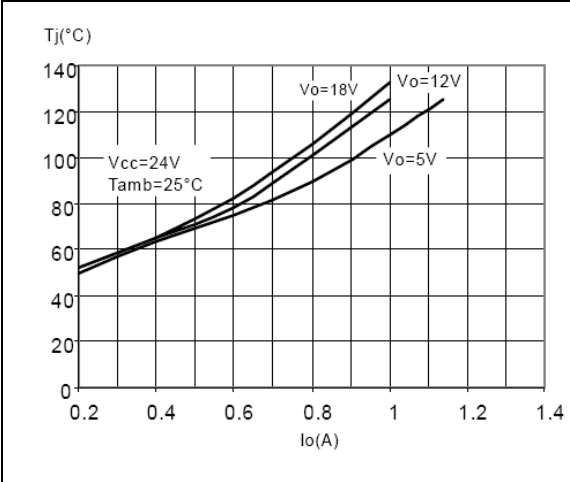
**Figure 4. Junction temperature vs output voltage**



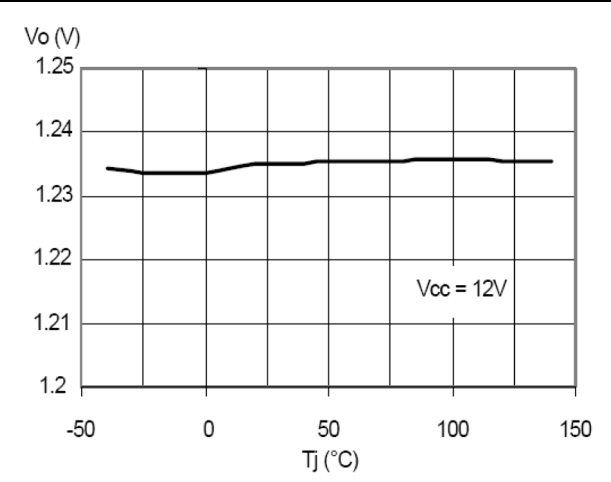
**Figure 5. Line regulation**



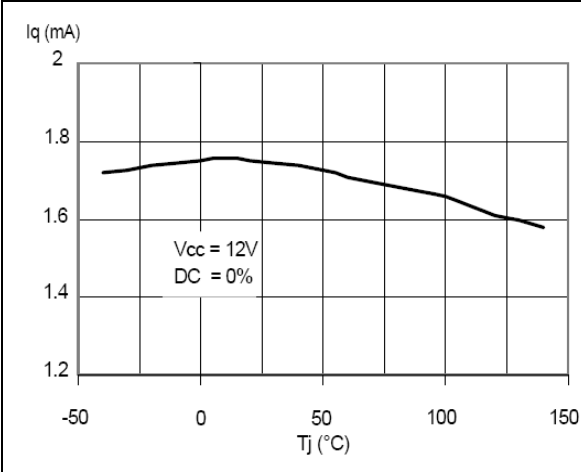
**Figure 6. Junction temperature vs output current**



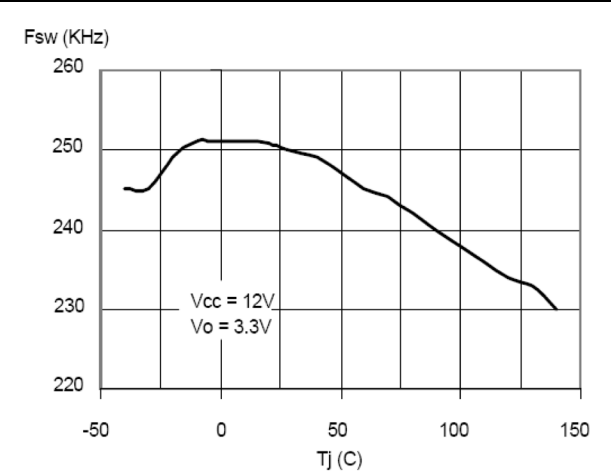
**Figure 7. Output voltage vs junction temperature**



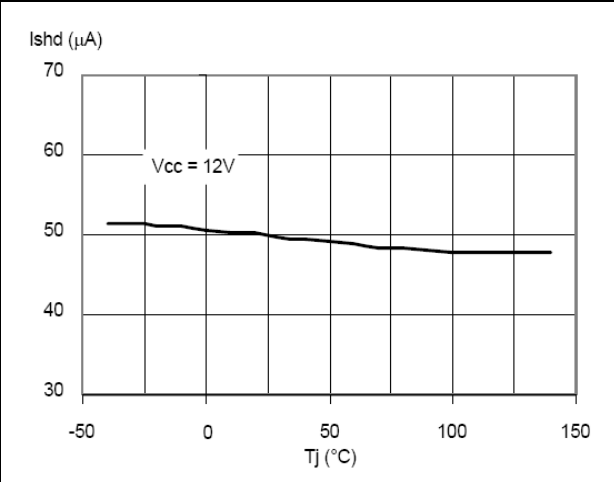
**Figure 8. Quiescent current vs junction temperature**



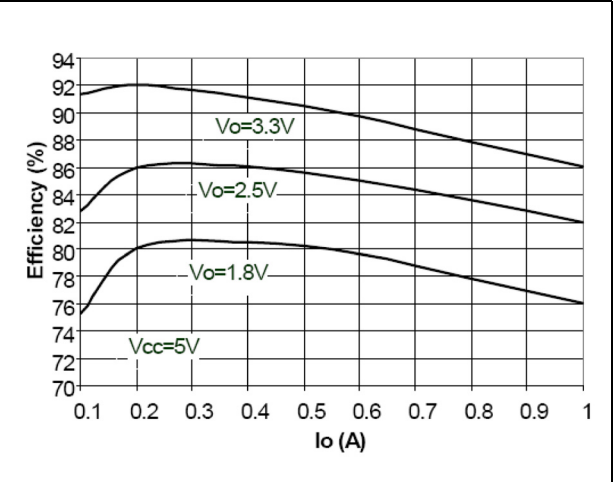
**Figure 9. Switching frequency vs junction temperature**



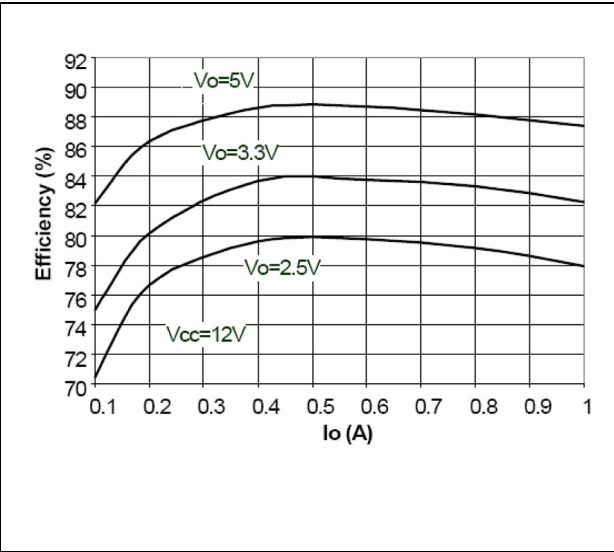
**Figure 10. Shutdown current vs junction temperature**



**Figure 11. Efficiency vs output current**



**Figure 12. Efficiency vs output current**

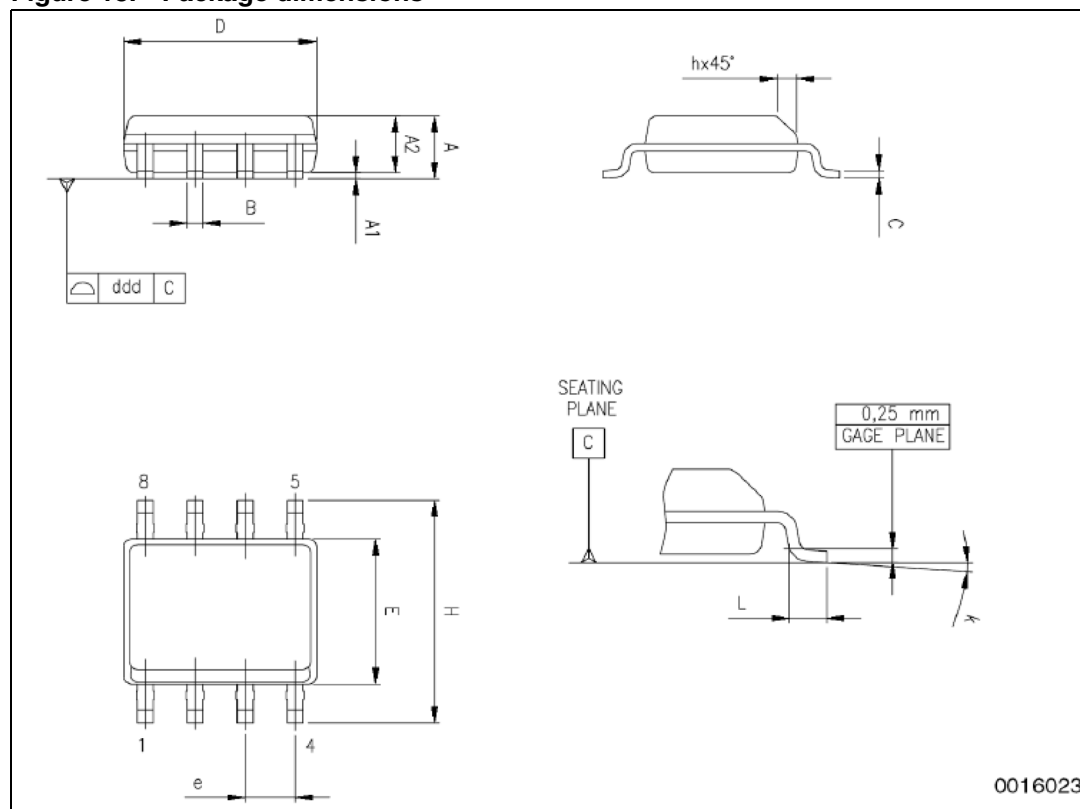


## 5 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com)

**Table 5. SO-8 mechanical data**

Dim	mm			inch		
	Min	Typ	Max	Min	Typ	Max
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.004		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D <sup>(1)</sup>	4.80		5.00	0.1890		0.197
E	3.80		4.00	0.15		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	0° (min), 8° (max)					
ccc			0.10			0.0039

**Figure 13. Package dimensions**

## 6 Revision history

**Table 6. Document revision history**

Date	Revision	Changes
06-Aug-2007	1	Initial release.
24-Oct-2007	2	Updated: <a href="#">Table 4 on page 5</a>
2-May-2008	3	Updated: Cover page, <a href="#">Table 4 on page 5</a>
27-Aug-2008	4	Updated: Coverpage and <a href="#">Table 4 on page 5</a>

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