

## Up to 1A step down switching regulator

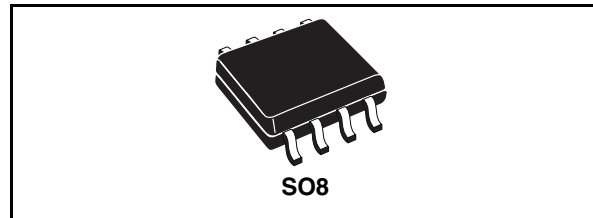
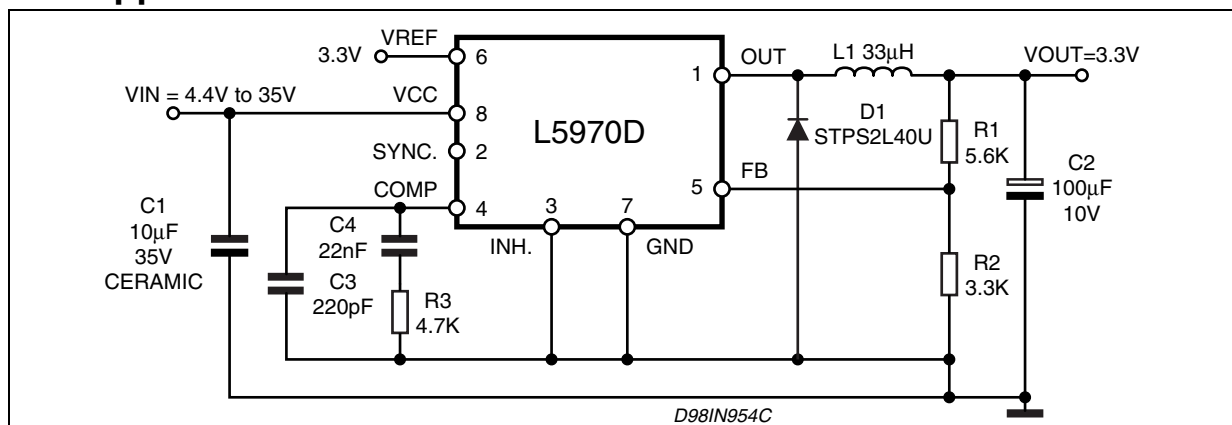
### General features

- Up to 1A output current
- Operating input voltage from 4.4V to 36V
- 3.3V / ( $\pm 2\%$ ) reference voltage
- Output voltage adjustable from 1.2V to 35V
- Low dropout operation: 100% duty cycle
- 250KHz 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

- Consumer: STB, DVD, TV, VCR, car radio, LCD monitors
- Networking: XDSL, modems, DC-DC modules
- Computer: printers, audio/graphic cards, optical storage, hard disk drive
- Industrial: changers, car battery, DC-DC converters

### Test application circuit



### Description

The L5970D is a step down monolithic power switching regulator capable to deliver up to 1A at output voltages from 1.2V to 35V.

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

An internal oscillator fixes the switching frequency at 250KHz.

Having a minimum input voltage of 4.4V only, it is particularly suitable for 5V bus, available in all computer related applications.

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

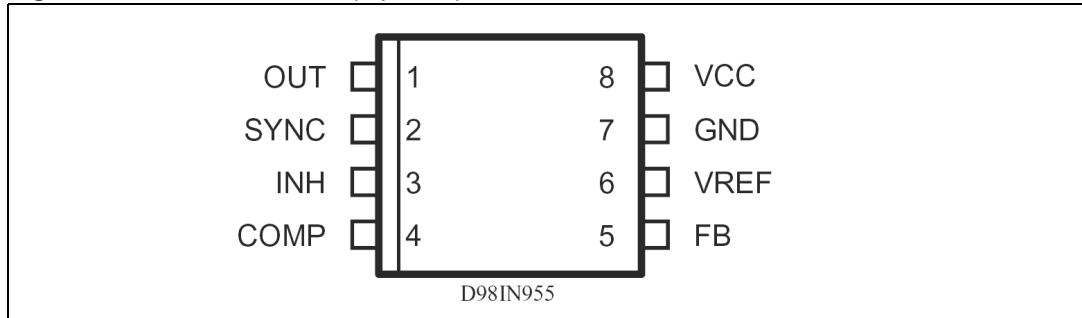
# Contents

<b>1</b>	<b>Pin settings</b> .....	<b>3</b>
	1.1 Pin connection .....	3
	1.2 Pin description .....	3
<b>2</b>	<b>Electrical data</b> .....	<b>4</b>
	2.1 Maximum ratings .....	4
	2.2 Thermal data .....	4
<b>3</b>	<b>Electrical characteristics</b> .....	<b>5</b>
<b>4</b>	<b>Typical characteristics</b> .....	<b>7</b>
<b>5</b>	<b>Application circuit</b> .....	<b>9</b>
<b>6</b>	<b>Application ideas</b> .....	<b>11</b>
<b>7</b>	<b>Package mechanical data</b> .....	<b>12</b>
<b>8</b>	<b>Order code</b> .....	<b>14</b>
<b>9</b>	<b>Revision history</b> .....	<b>15</b>

# 1 Pin settings

## 1.1 Pin connection

Figure 1. Pin connection (top view)



## 1.2 Pin description

Table 1. Pin description

N°	Type	Description
1	OUT	Regulator output.
2	SYNC	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 1.23V. An external resistive divider is required for higher output voltages.
6	VREF	3.3V $V_{REF}$ 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
$V_1$	Output DC voltage Output peak voltage at $t = 0.1\mu\text{s}$	-1 to 40 -5 to 40	V V
$I_1$	Maximum output current	int. limit.	
$V_4, V_5$	Analog pins	4	V
$V_3$	INH	-0.3V to $V_{CC}$	
$V_2$	SYNC	-0.3 to 4	V
$P_{TOT}$	Power dissipation at $T_A \leq 60^\circ\text{C}$	0.75	W
$T_J$	Operating junction temperature range	-40 to 150	$^\circ\text{C}$
$T_{STG}$	Storage temperature range	-55 to 150	$^\circ\text{C}$

### 2.2 Thermal data

**Table 3. Thermal data**

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

1. Package mounted on board

### 3 Electrical characteristics

**Table 4. Electrical characteristics** (  $T_J = 25^\circ\text{C}$ ,  $V_{CC} = 12\text{V}$ , unless otherwise specified)

Symbol	Parameter	Test condition	Min	Typ	Max	Unit	
$V_{CC}$	Operating input voltage range	$V_o = 1.235\text{V}$ ; $I_o = 2\text{A}$	(1)	4.4		36	V
$R_{DS(on)}$	Mosfet on Resistance		(1)		0.250	0.5	$\Omega$
$I_l$	Maximum limiting current	$V_{CC} = 4.4\text{V}$ to $36\text{V}$		1.5	1.87	2.25	A
$f_s$	Switching frequency		(1)	212	250	280	KHz
				225	250	275	KHz
	Duty cycle			0		100	%
<b>Dynamic characteristics</b> (see test circuit ).							
$V_5$	Voltage feedback	$4.4\text{V} < V_{CC} < 36\text{V}$ , $20\text{mA} < I_o < 2\text{A}$		1.220	1.235	1.25	V
			(1)	1.198	1.235	1.272	V
$h$	Efficiency	$V_o = 5\text{V}$ , $V_{CC} = 12\text{V}$			90		%
<b>DC characteristics</b>							
$I_{qop}$	Total operating quiescent current		(1)		3	5	mA
$I_q$	Quiescent current	Duty cycle = 0; $V_{FB} = 1.5\text{V}$				2.5	mA
$I_{qst-by}$	Total stand-by quiescent current	$V_{inh} > 2.2\text{V}$	(1)		50	100	$\mu\text{A}$
		$V_{CC} = 36\text{V}$ ; $V_{inh} > 2.2\text{V}$	(1)		80	150	$\mu\text{A}$
<b>Inhibit</b>							
	INH threshold voltage	Device ON				0.8	V
		Device OFF		2.2			V
<b>Error amplifier</b>							
$V_{OH}$	High level output voltage	$V_{FB} = 1\text{V}$		3.5			V
$V_{OL}$	Low level output voltage	$V_{FB} = 1.5\text{V}$				0.4	V
$I_o$ source	Source output current	$V_{COMP} = 1.9\text{V}$ ; $V_{FB} = 1\text{V}$		200	300		$\mu\text{A}$
$I_o$ sink	Sink output current	$V_{COMP} = 1.9\text{V}$ ; $V_{FB} = 1.5\text{V}$		1	1.5		mA

**Table 4. Electrical characteristics** (  $T_J = 25^\circ\text{C}$ ,  $V_{CC} = 12\text{V}$ , unless otherwise specified)

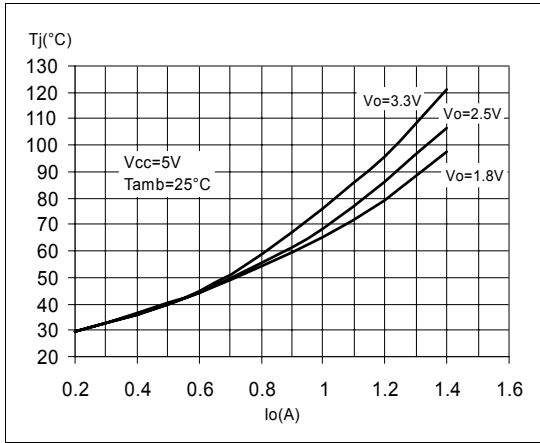
Symbol	Parameter	Test condition	Min	Typ	Max	Unit	
$I_b$	Source bias current			2.5	4	$\mu\text{A}$	
	DC open loop gain	$R_L = \infty$	50	65		dB	
gm	Transconductance	$I_{\text{comp}} = -0.1\text{mA}$ to $0.1\text{mA}$ $V_{\text{COMP}} = 1.9\text{V}$		2.3		mS	
<b>Sync function</b>							
	High input voltage	$V_{CC} = 4.4\text{V}$ to $36\text{V}$	2.5		$V_{\text{REF}}$	V	
	Low input voltage	$V_{CC} = 4.4\text{V}$ to $36\text{V}$			0.74	V	
	Slave sink current	$V_{\text{sync}} = 0.74\text{V}$ <sup>(2)</sup> $V_{\text{sync}} = 2.33\text{V}$	0.11 0.21		0.25 0.45	mA mA	
	Master output amplitude	$I_{\text{source}} = 3\text{mA}$	2.75	3		V	
	Output pulse width	no load, $V_{\text{sync}} = 1.65\text{V}$	0.20	0.35		$\mu\text{s}$	
<b>Reference section</b>							
	Reference voltage		3.234	3.3	3.366	V	
		$I_{\text{REF}} = 0$ to $5\text{mA}$ $V_{CC} = 4.4\text{V}$ to $36\text{V}$	(1)	3.2	3.3	3.399	V
	Line regulation	$I_{\text{REF}} = 0\text{mA}$ $V_{CC} = 4.4\text{V}$ to $36\text{V}$		5	10	mV	
	Load regulation	$I_{\text{REF}} = 0$ to $5\text{mA}$		8	15	mV	
	Short circuit current		10	18	30	mA	

1. Specification Referred to  $T_J$  from  $-40$  to  $125^\circ\text{C}$ . Specification over the  $-40$  to  $+125$   $T_J$  Temperature range are assured by design, characterization and statistical correlation.

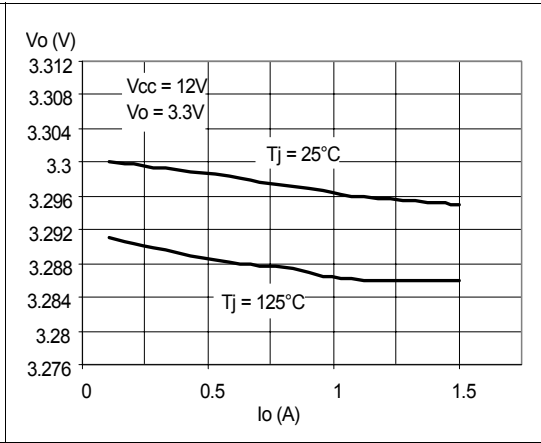
2. Guaranteed by design.

# 4 Typical characteristics

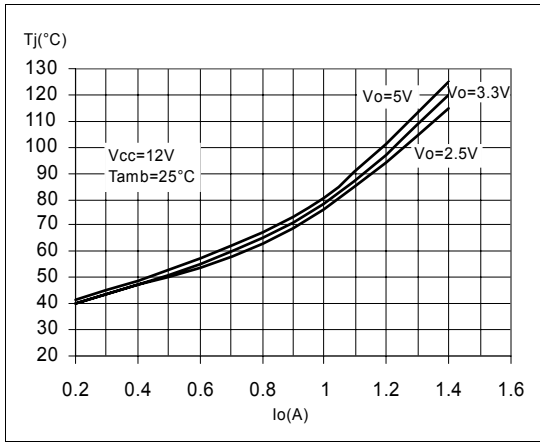
**Figure 2. Junction temperature vs. output current**



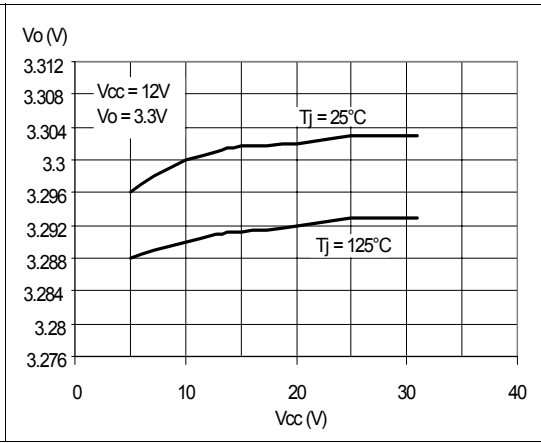
**Figure 3. Load regulator**



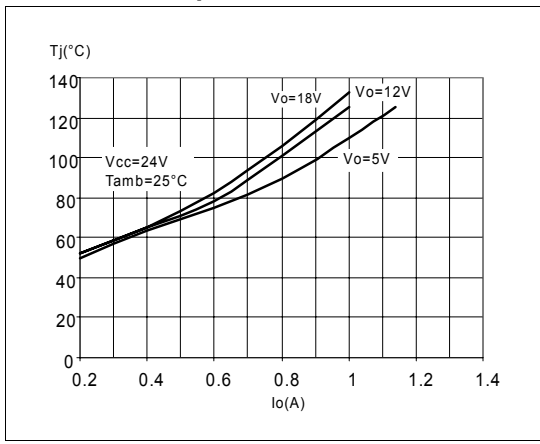
**Figure 4. Junction temperature vs. output current**



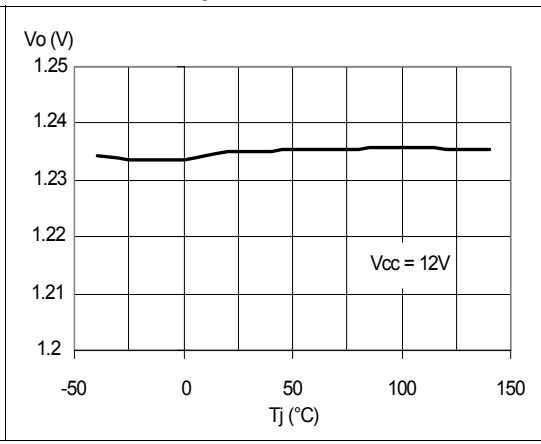
**Figure 5. Line regulator**



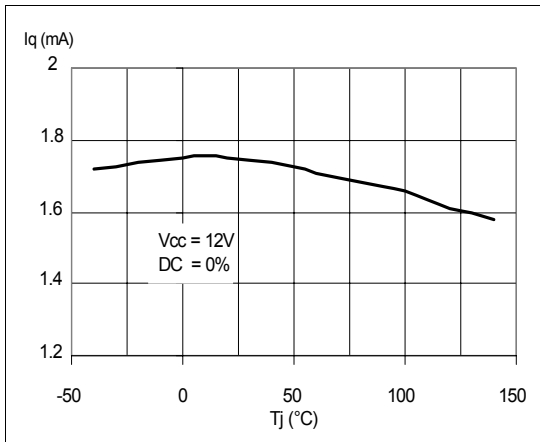
**Figure 6. Junction temperature vs. output current**



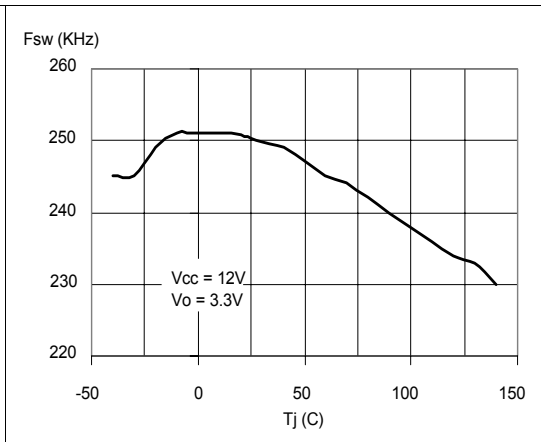
**Figure 7. Output voltage vs. junction temperature**



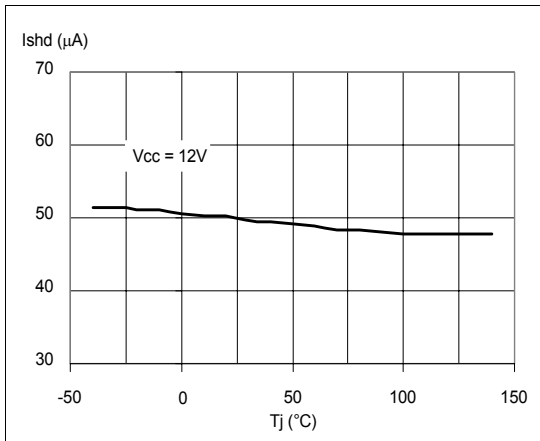
**Figure 8. Quiescent current vs. junction temperature**



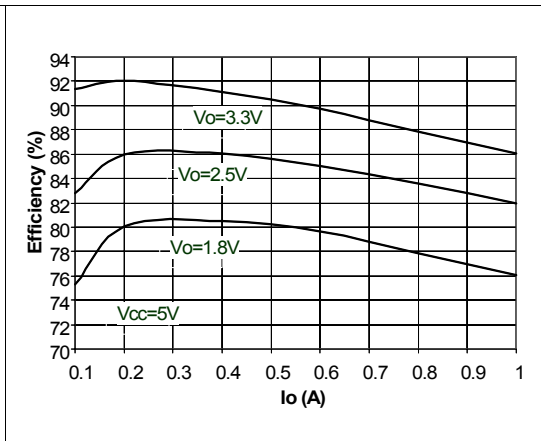
**Figure 9. Switching frequency vs. junction temperature**



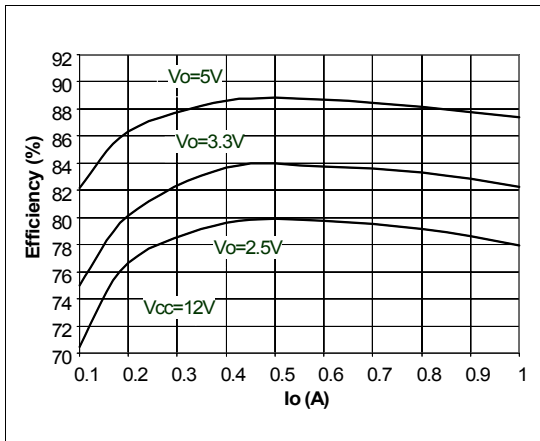
**Figure 10. Shutdown current vs. junction temperature**



**Figure 11. Efficiency vs. output current**



**Figure 12. Efficiency vs. output current**



## 5 Application circuit

Figure 13. Demo board application circuit

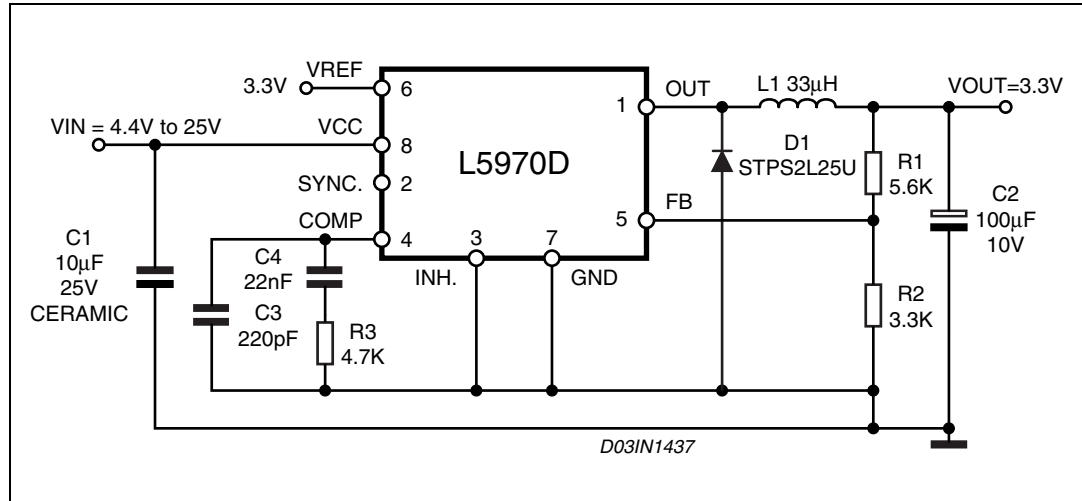


Table 5. Component list

Reference	Part number	Description	Manufacturer
C1	C3225X5R1E106M	10µF, 25V	TDK
C2	POSCAP 10TPB100M	100µF, 10V	Sanyo
C3	C1206C221J5GAC	220pF, 5%, 50V	KEMET
C4	C1206C223K5RAC	22nF, 10%, 50V	KEMET
R1		5.6K, 1%, 0.1W 0603	Neohm
R2		3.3K, 1%, 0.1W 0603	Neohm
R3		4.7K, 1%, 0.1W 0603	Neohm
D1	STPS2L25U	2A, 25V	STMicroelectronics
L1	DO3316P-333	33µH, 2A	COILCRAFT

Figure 14. PCB layout (component side)

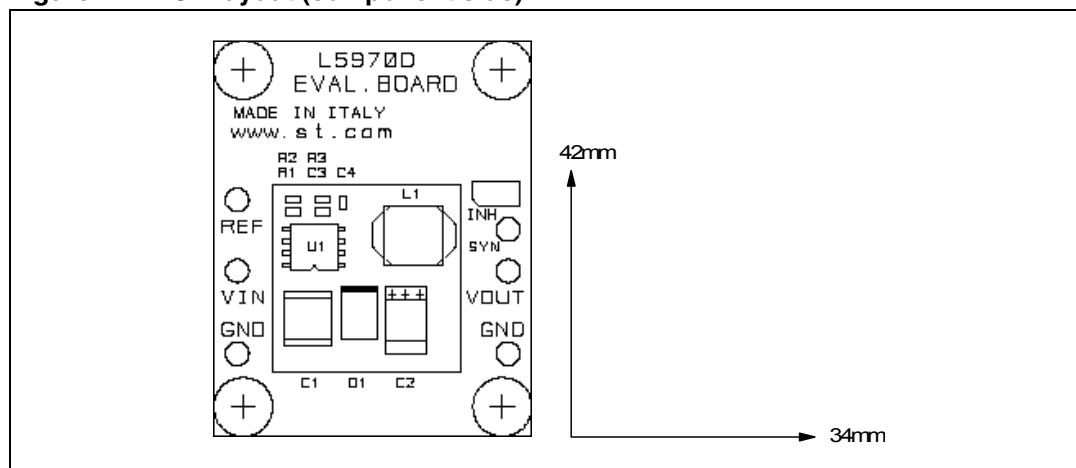


Figure 15. PCB layout (bottom side)

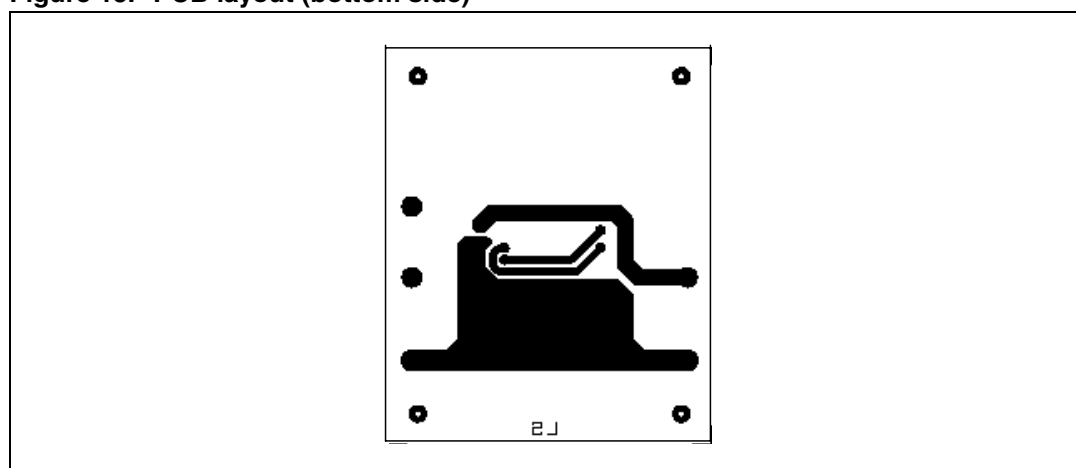
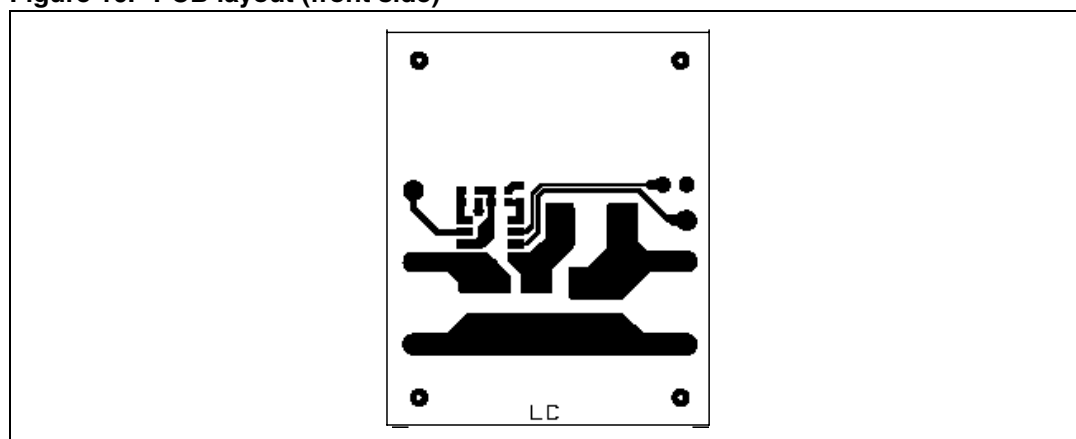


Figure 16. PCB layout (front side)



## 6 Application ideas

Figure 17. Dual output voltage with auxiliary winding

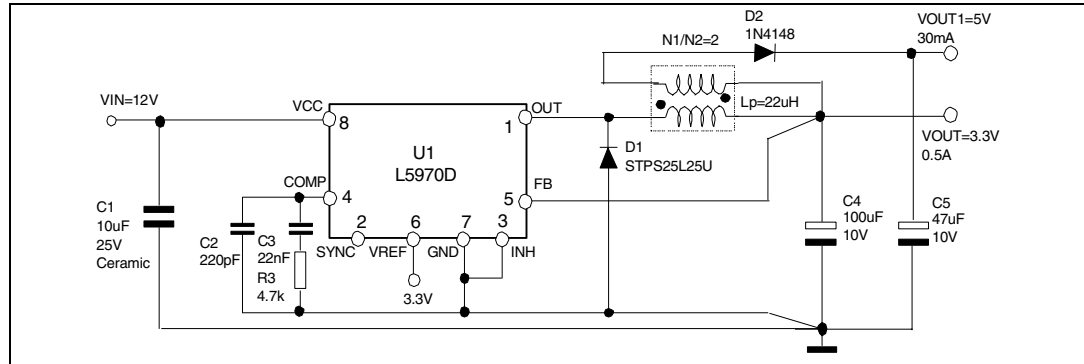


Figure 18. Buck-boost regulator

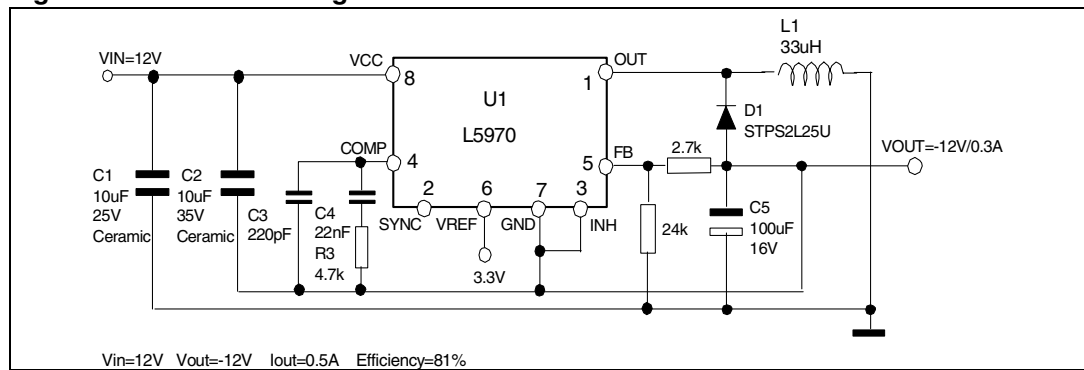


Figure 19. Positive Buck-Boost regulator

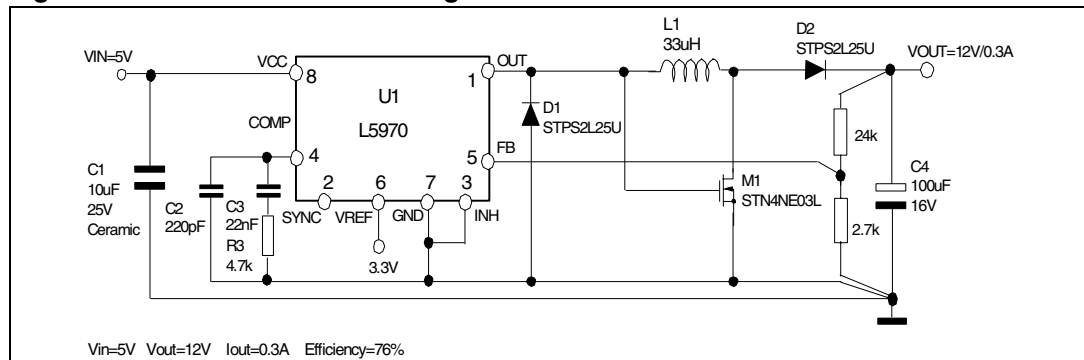
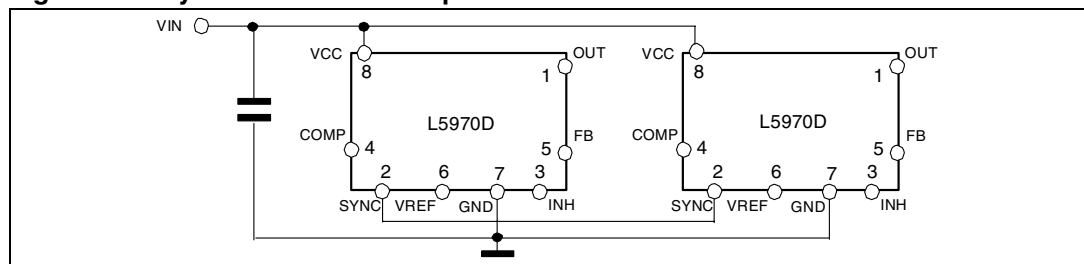


Figure 20. Synchronization example



## 7 Package mechanical data

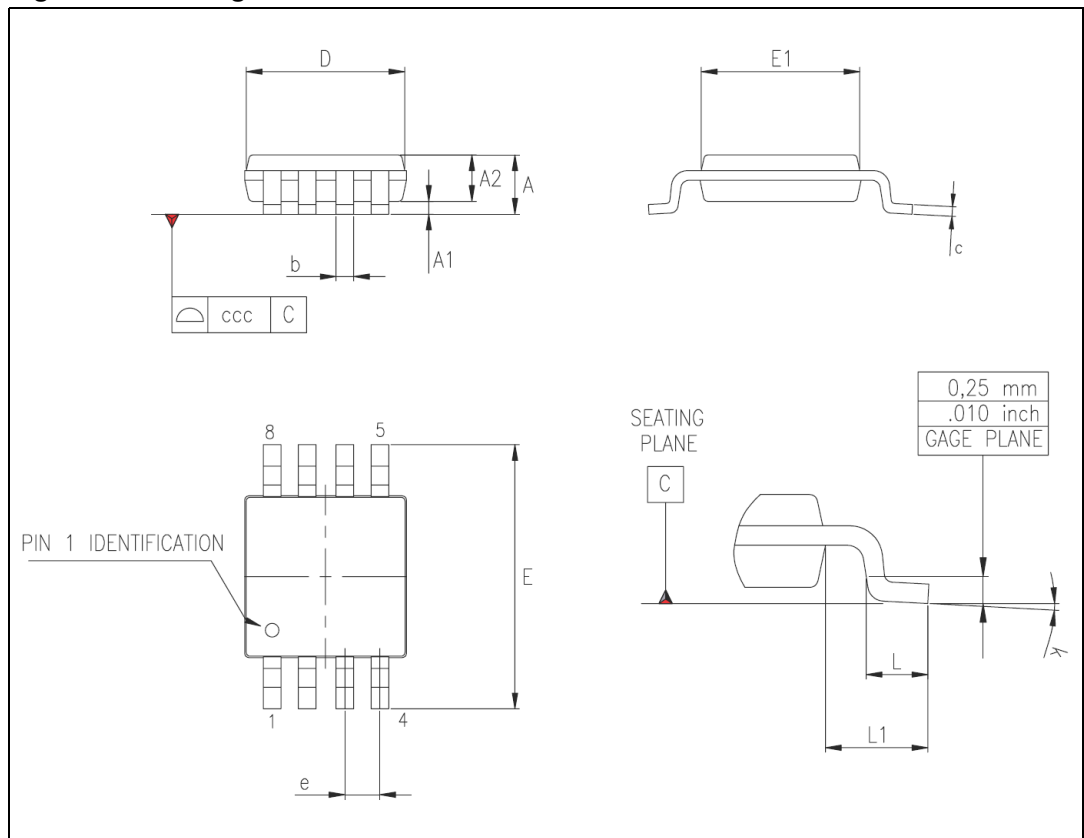
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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 6. MSOP8 Mechanical data

Dim.	mm.			inch		
	Min	Typ	Max	Min	Typ	Max
A			1.10			0.043
A1	0.050		0.150	0.002		0.006
A2	0.750	0.850	0.950	0.03	0.033	0.037
b	0.250		0.400	0.010		0.016
c	0.130		0.230	0.005		0.009
D (1)	2.900	3.000	3.100	0.114	0.118	0.122
E	4.650	4.900	5.150	0.183	0.193	0.20
E1 (1)	2.900	3.000	3.100	0.114	0.118	0.122
e		0.650			0.026	
L	0.400	0.550	0.700	0.016	0.022	0.028
L1		0.950			0.037	
k	0° (min.) 6° (max.)					
aaa			0.100			0.004

1. D and F does not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm (.006inch) per side.

Figure 21. Package dimensions



## 8 Order code

**Table 7. Order code**

<b>Part number</b>	<b>Package</b>	<b>Packaging</b>
L5970D	SO8	Tube
L5970D013TR	SO8	Tape and reel

## 9 Revision history

**Table 8. Revision history**

Date	Revision	Changes
26-Jan-2007	14	Updated <a href="#">Table 5 on page 9</a>

**Please Read Carefully:**

Information in this document is provided solely in connection with ST products. STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, modifications or improvements, to this document, and the products and services described herein at any time, without notice.

All ST products are sold pursuant to ST's terms and conditions of sale.

Purchasers are solely responsible for the choice, selection and use of the ST products and services described herein, and ST assumes no liability whatsoever relating to the choice, selection or use of the ST products and services described herein.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted under this document. If any part of this document refers to any third party products or services it shall not be deemed a license grant by ST for the use of such third party products or services, or any intellectual property contained therein or considered as a warranty covering the use in any manner whatsoever of such third party products or services or any intellectual property contained therein.

**UNLESS OTHERWISE SET FORTH IN ST'S TERMS AND CONDITIONS OF SALE ST DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY WITH RESPECT TO THE USE AND/OR SALE OF ST PRODUCTS INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION), OR INFRINGEMENT OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT.**

**UNLESS EXPRESSLY APPROVED IN WRITING BY AN AUTHORIZED ST REPRESENTATIVE, ST PRODUCTS ARE NOT RECOMMENDED, AUTHORIZED OR WARRANTED FOR USE IN MILITARY, AIR CRAFT, SPACE, LIFE SAVING, OR LIFE SUSTAINING APPLICATIONS, NOR IN PRODUCTS OR SYSTEMS WHERE FAILURE OR MALFUNCTION MAY RESULT IN PERSONAL INJURY, DEATH, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE. ST PRODUCTS WHICH ARE NOT SPECIFIED AS "AUTOMOTIVE GRADE" MAY ONLY BE USED IN AUTOMOTIVE APPLICATIONS AT USER'S OWN RISK.**

Resale of ST products with provisions different from the statements and/or technical features set forth in this document shall immediately void any warranty granted by ST for the ST product or service described herein and shall not create or extend in any manner whatsoever, any liability of ST.

ST and the ST logo are trademarks or registered trademarks of ST in various countries.

Information in this document supersedes and replaces all information previously supplied.

The ST logo is a registered trademark of STMicroelectronics. All other names are the property of their respective owners.

© 2007 STMicroelectronics - All rights reserved

STMicroelectronics group of companies

Australia - Belgium - Brazil - Canada - China - Czech Republic - Finland - France - Germany - Hong Kong - India - Israel - Italy - Japan - Malaysia - Malta - Morocco - Singapore - Spain - Sweden - Switzerland - United Kingdom - United States of America

[www.st.com](http://www.st.com)