

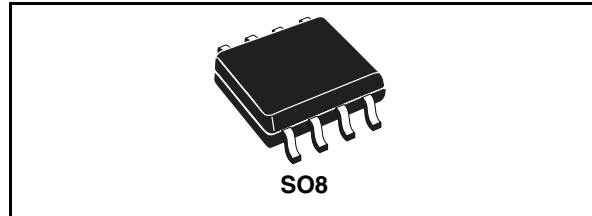
## Up to 1A step down switching regulator

### 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



### 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.

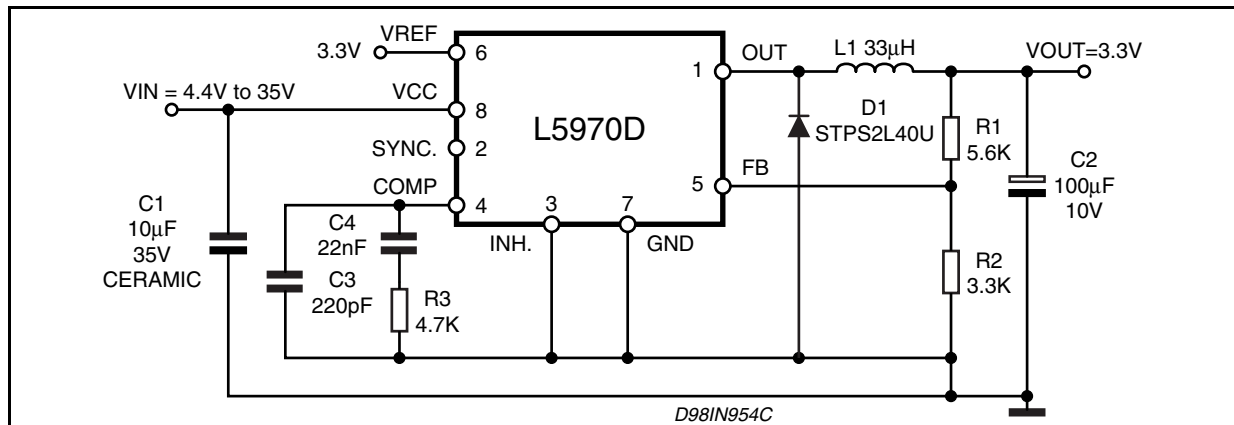
The device uses an internal P-Channel D-MOS transistor (with a typical  $R_{ds(on)}$  of 250m $\Omega$ ) as switching element to minimize the size of the external components.

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.

**Figure 1. Test application circuit**



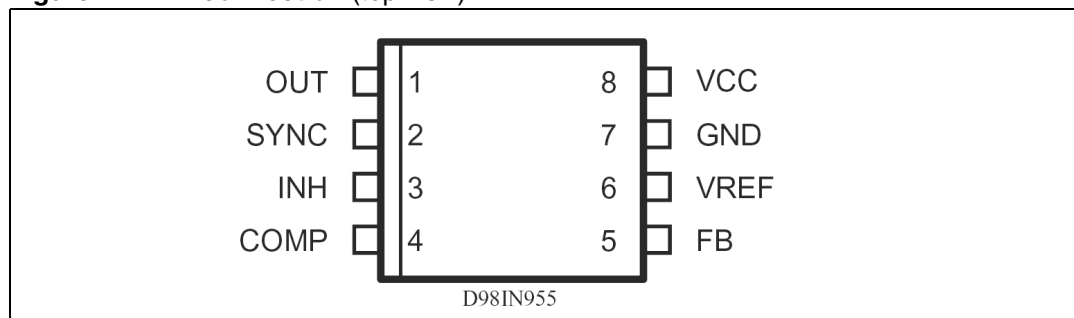
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# 1 Pin settings

## 1.1 Pin connection

Figure 2. 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		$\mu\text{A}$

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

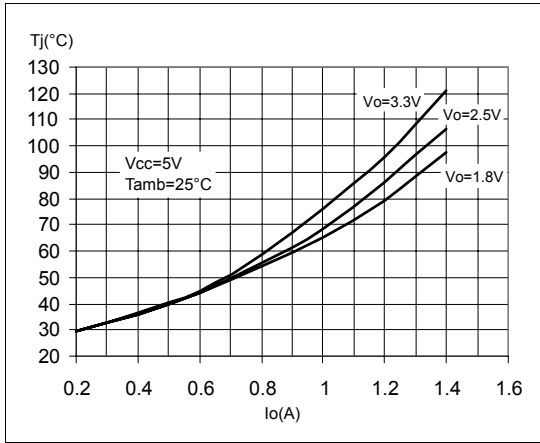
Symbol	Parameter	Test condition	Min	Typ	Max	Unit	
$I_{o\text{ sink}}$	Sink output current	$V_{\text{COMP}} = 1.9\text{V};$ $V_{\text{FB}} = 1.5\text{V}$	1	1.5		mA	
$I_b$	Source bias current			2.5	4	$\mu\text{A}$	
	DC open loop gain	$R_L = \infty$	50	65		dB	
$g_m$	Transconductance	$I_{\text{comp}} = -0.1\text{mA}$ 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.

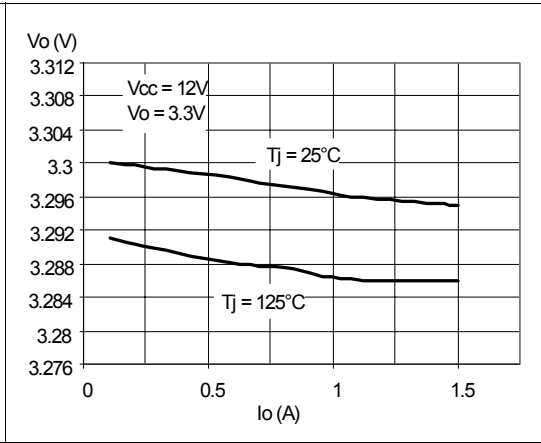
2. Guaranteed by design.

# 4 Typical characteristics

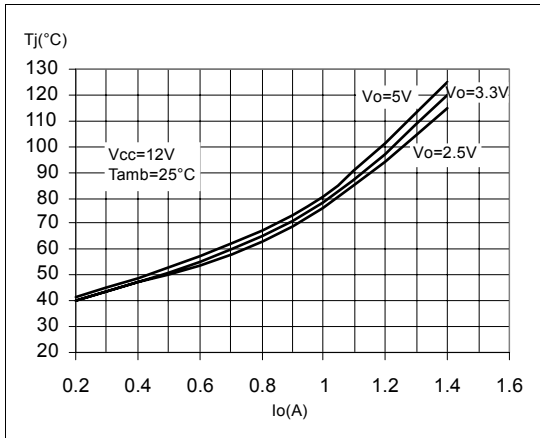
**Figure 3. Junction temperature vs output current**



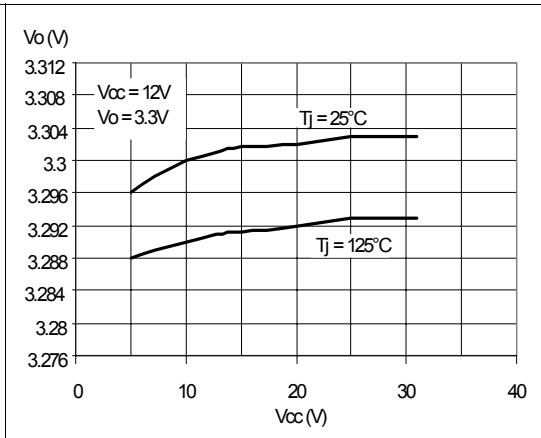
**Figure 4. Load regulator**



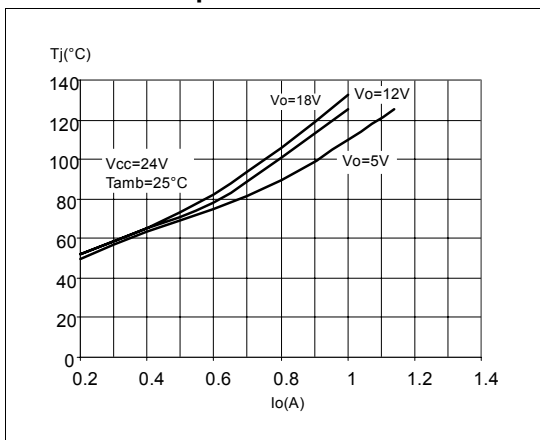
**Figure 5. Junction temperature vs output current**



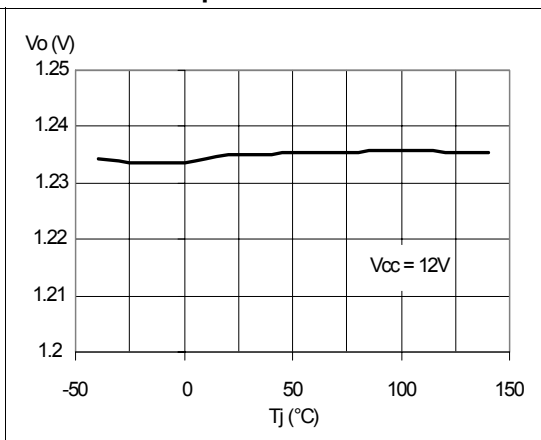
**Figure 6. Line regulator**



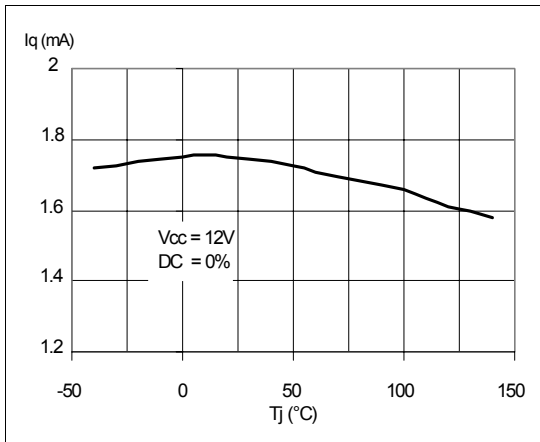
**Figure 7. Junction temperature vs output current**



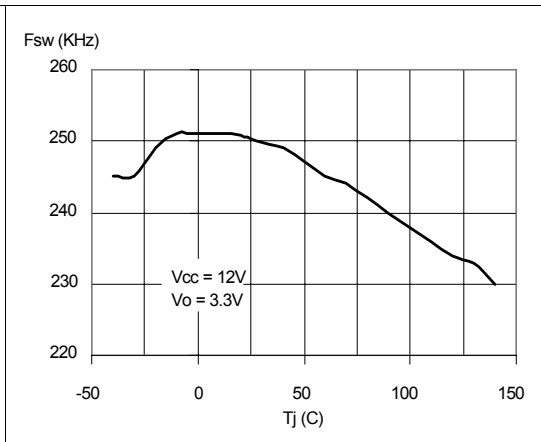
**Figure 8. Output voltage vs junction temperature**



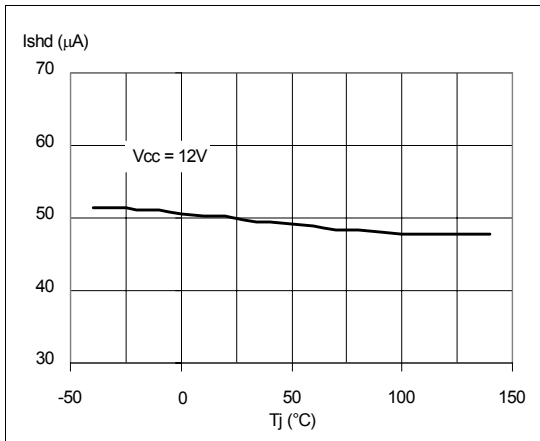
**Figure 9. Quiescent current vs junction temperature**



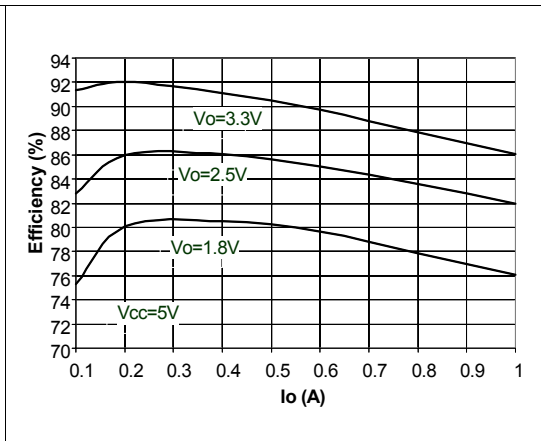
**Figure 10. Switching frequency vs junction temperature**



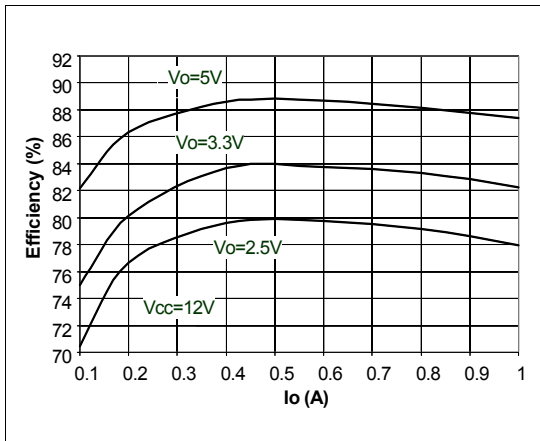
**Figure 11. Shutdown current vs junction temperature**



**Figure 12. Efficiency vs output current**



**Figure 13. Efficiency vs output current**





## 5 Application circuit

Figure 14. Demo board application circuit

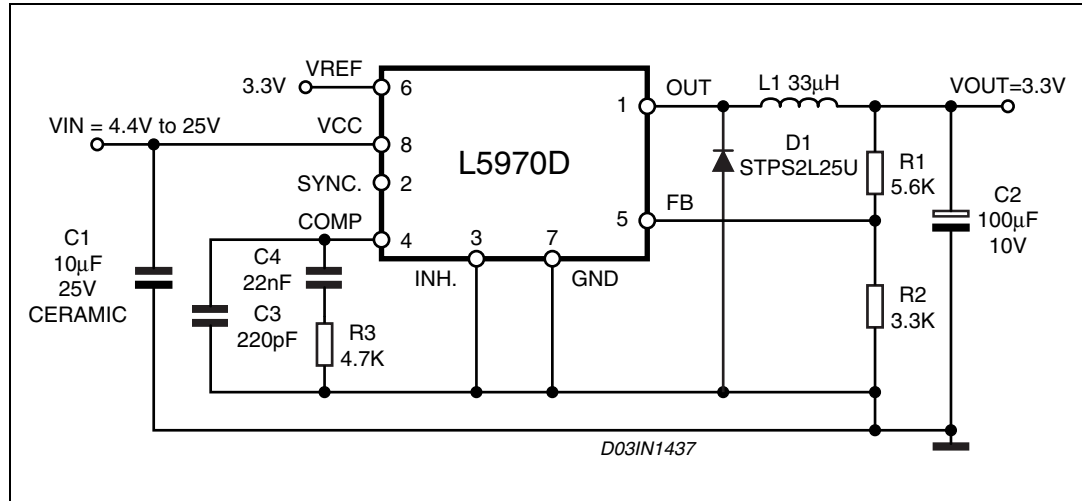


Table 5. Component list

Reference	Part number	Description	Manufacturer
C1	GRM32DR61E106KA12L	10µF, 25V	MURATA
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 15. PCB layout (component side)

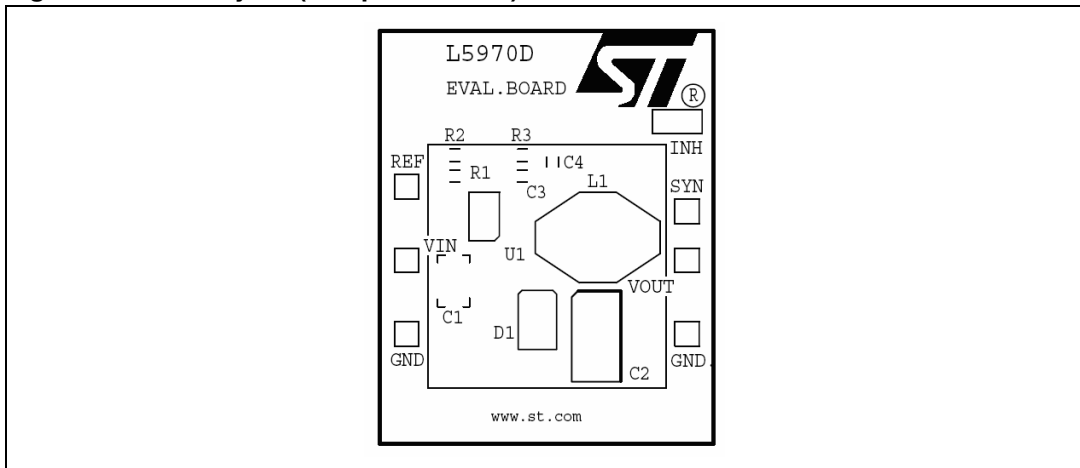


Figure 16. PCB layout (bottom side)

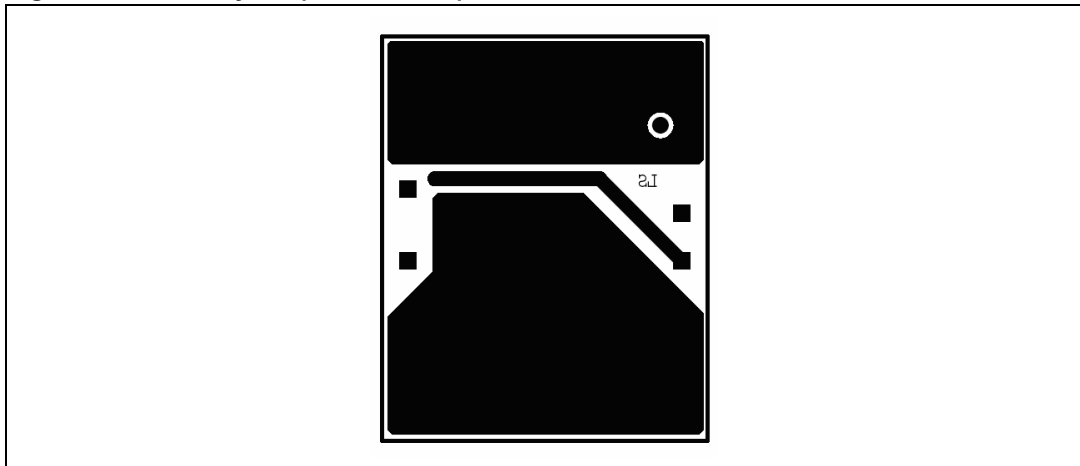
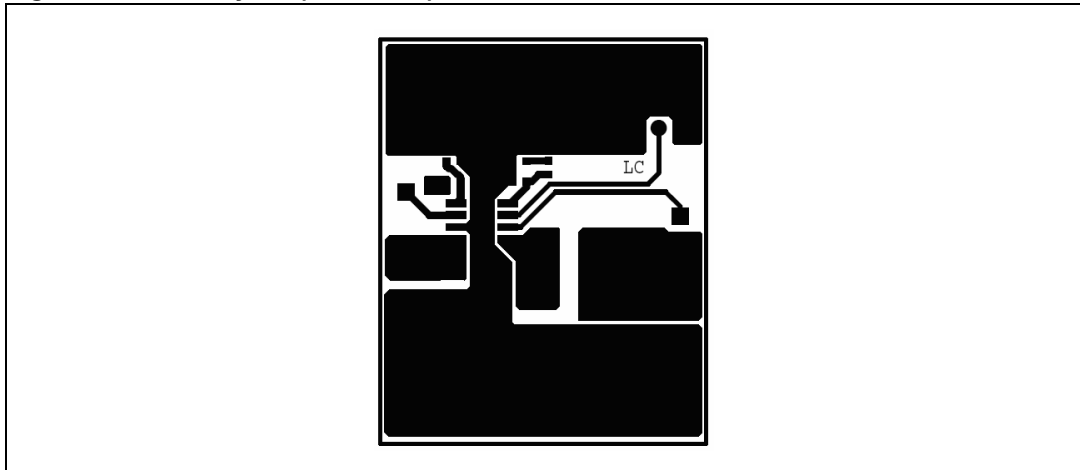


Figure 17. PCB layout (front side)



## 6 Application ideas

Figure 18. Dual output voltage with auxiliary winding

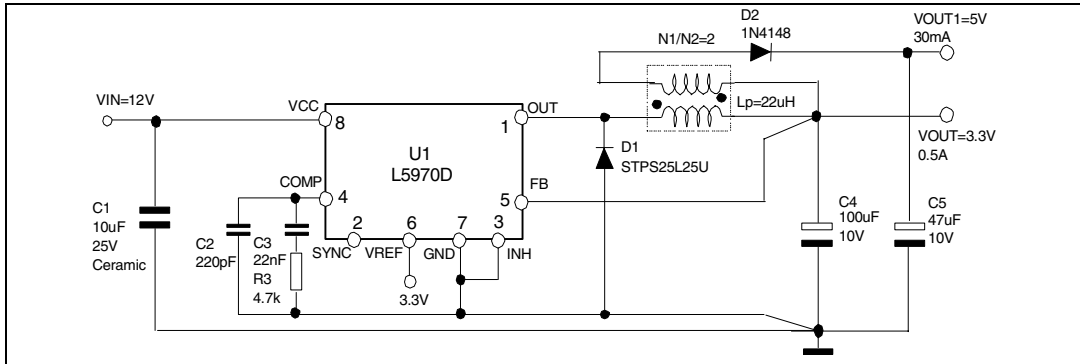


Figure 19. Buck-boost regulator

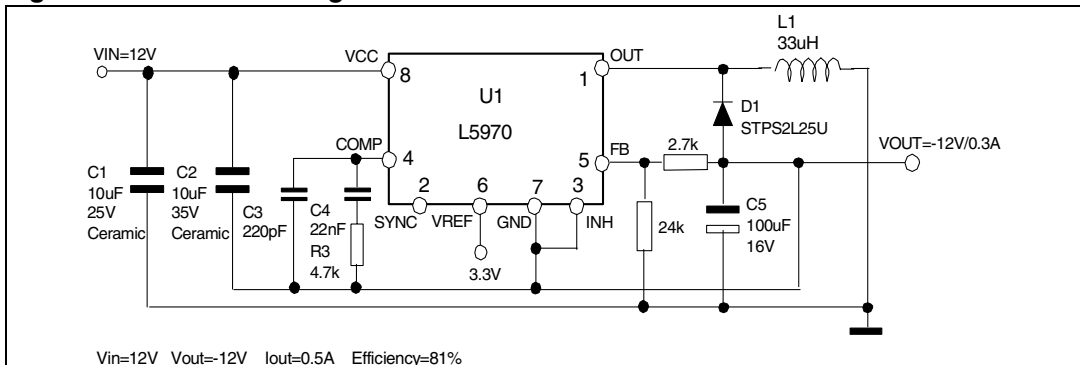


Figure 20. Positive Buck-Boost regulator

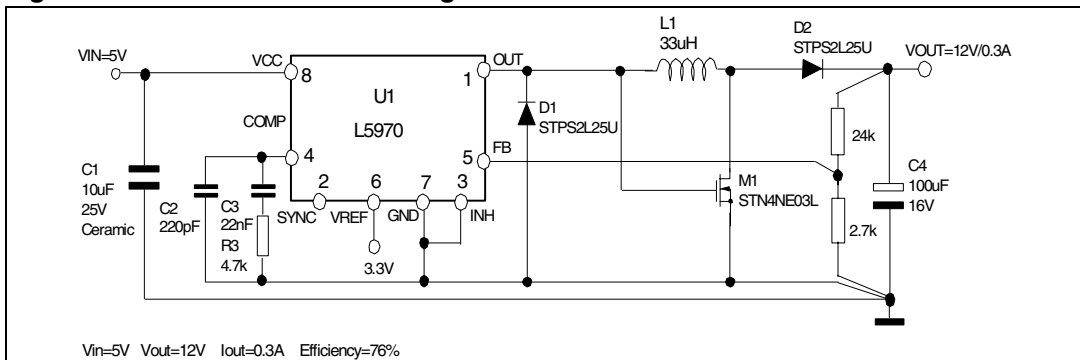
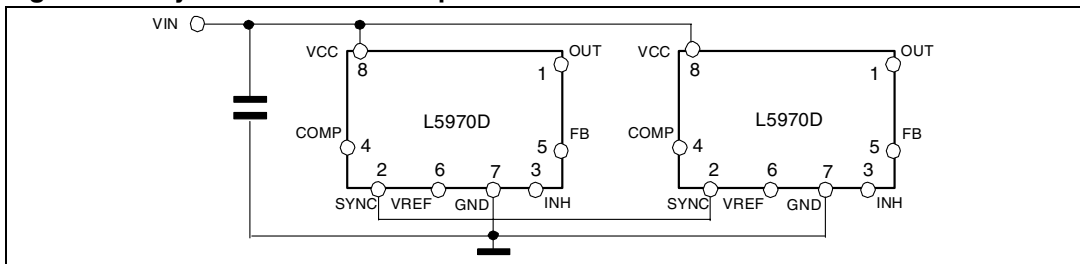


Figure 21. Synchronization example



## 7 Package mechanical data

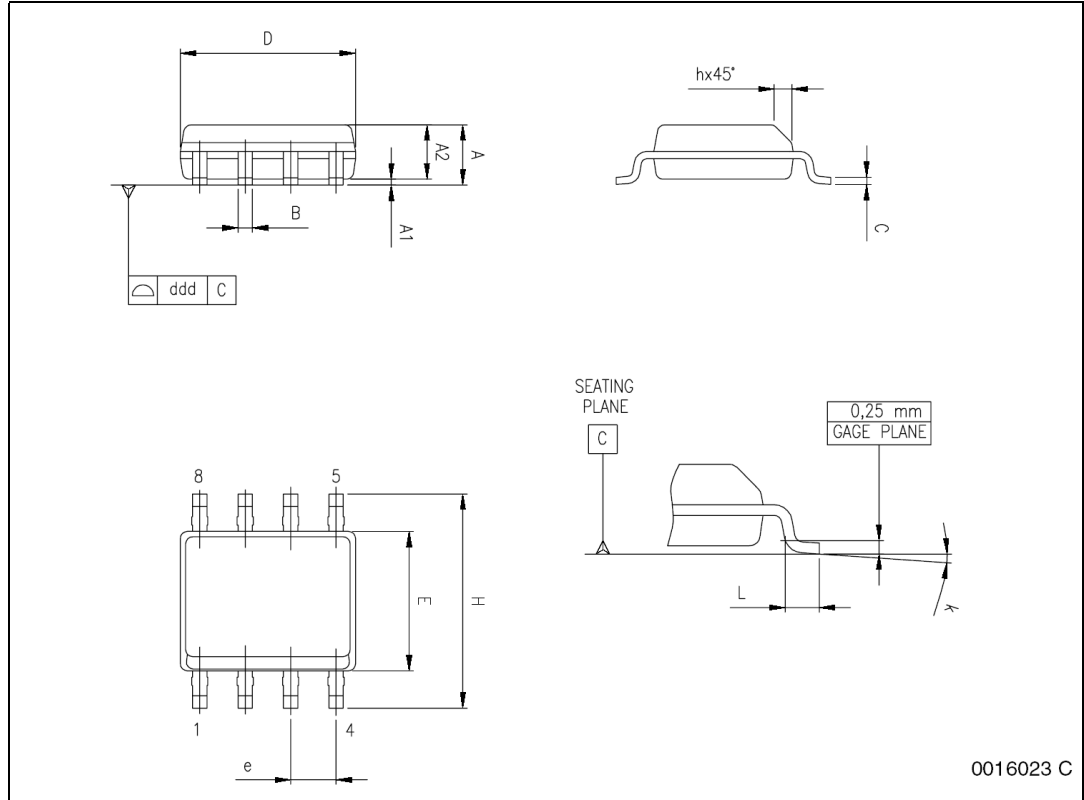
In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second level interconnect . The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings 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. 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 (1)	4.80		5.00	0.189		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.)					
ddd			0.10			0.004

1. Dimensions D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15mm (.006inch) in total (both side).

Figure 22. Package dimensions



0016023 C

## 8 Order codes

**Table 7. Order codes**

Part number	Package	Packaging
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>
16-Mar-2007	15	Mechanical data typo
16-Oct-2007	16	Updated <a href="#">Section 5: Application circuit on page 9</a>