

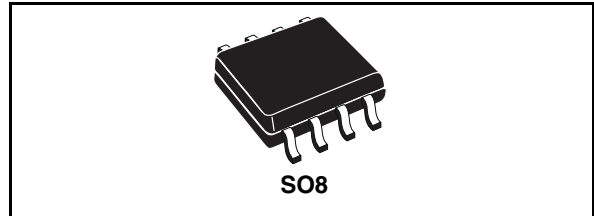
## Up to 1A step down switching regulator

### 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.

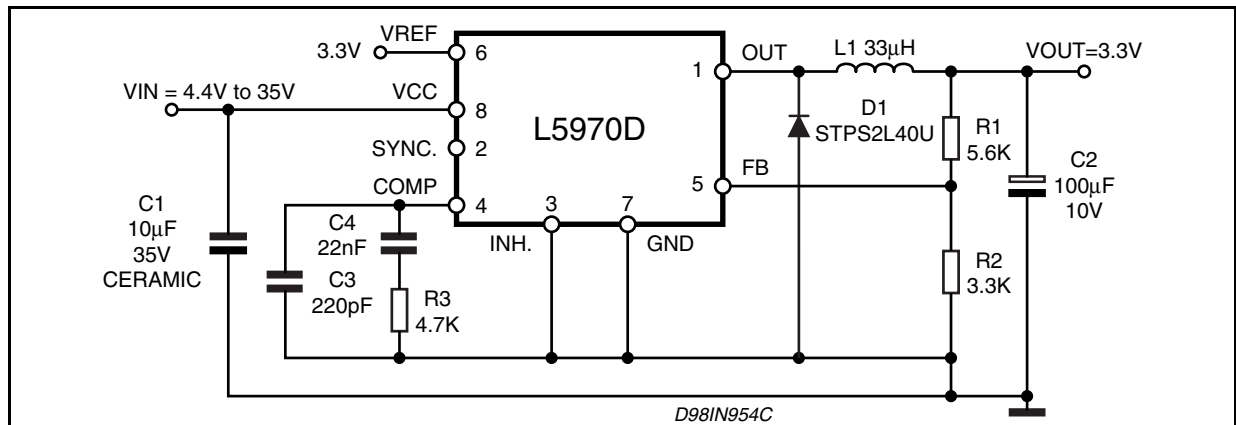
The device uses an internal P-Channel D-MOS transistor (with a typical  $R_{ds(on)}$  of 250m $\Omega$ ) as switching element to minimize the size of the external components.

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**



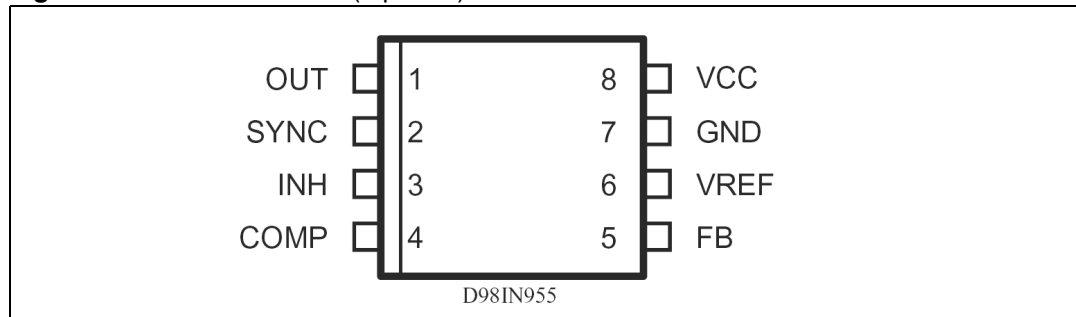
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# 1 Pin settings

## 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<br>Output peak voltage at $t = 0.1\mu\text{s}$ | -1 to 40<br>-5 to 40 | V<br>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 <sub>CC</sub>                              | Operating input voltage range     | V <sub>O</sub> = 1.235V; I <sub>O</sub> = 2A                | (1) | 4.4   |       | 36    | V    |
| R <sub>DS(on)</sub>                          | Mosfet on Resistance              |                                                             | (1) |       | 0.250 | 0.5   | Ω    |
| I <sub>I</sub>                               | Maximum limiting current          | V <sub>CC</sub> = 4.4V to 36V                               |     | 1.5   | 1.87  | 2.25  | A    |
| f <sub>s</sub>                               | Switching frequency               |                                                             | (1) | 212   | 250   | 280   | KHz  |
|                                              |                                   |                                                             |     | 225   | 250   | 275   | KHz  |
|                                              | Duty cycle                        |                                                             |     | 0     |       | 100   | %    |
| Dynamic characteristics (see test circuit ). |                                   |                                                             |     |       |       |       |      |
| V <sub>5</sub>                               | Voltage feedback                  | 4.4V < V <sub>CC</sub> < 36V,<br>20mA < I <sub>O</sub> < 2A |     | 1.220 | 1.235 | 1.25  | V    |
|                                              |                                   |                                                             | (1) | 1.198 | 1.235 | 1.272 | V    |
| h                                            | Efficiency                        | V <sub>O</sub> = 5V, V <sub>CC</sub> = 12V                  |     |       | 90    |       | %    |
| DC characteristics                           |                                   |                                                             |     |       |       |       |      |
| I <sub>qop</sub>                             | Total operating quiescent current |                                                             | (1) |       | 3     | 5     | mA   |
| I <sub>q</sub>                               | Quiescent current                 | Duty cycle = 0;<br>V <sub>FB</sub> = 1.5V                   |     |       |       | 2.5   | mA   |
| I <sub>qst-by</sub>                          | Total stand-by quiescent current  | V <sub>inh</sub> > 2.2V                                     | (1) |       | 50    | 100   | μA   |
|                                              |                                   | V <sub>CC</sub> = 36V;<br>V <sub>inh</sub> > 2.2V           | (1) |       | 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> = 1V                                        |     | 3.5   |       |       | V    |
| V <sub>OL</sub>                              | Low level output voltage          | V <sub>FB</sub> = 1.5V                                      |     |       |       | 0.4   | V    |
| I <sub>o source</sub>                        | Source output current             | V <sub>COMP</sub> = 1.9V;<br>V <sub>FB</sub> = 1V           |     | 200   | 300   |       | μA   |

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

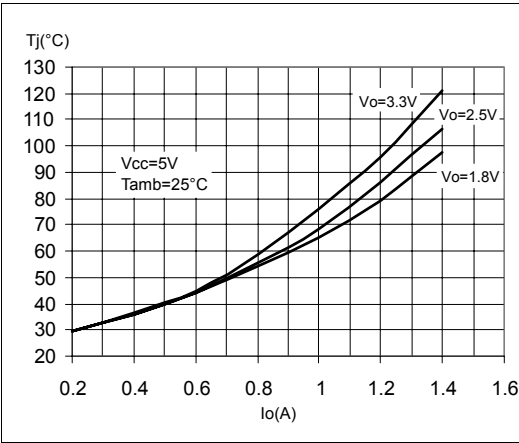
| Symbol                   | Parameter               | Test condition                                                                            | Min          | Typ  | Max              | Unit          |
|--------------------------|-------------------------|-------------------------------------------------------------------------------------------|--------------|------|------------------|---------------|
| $I_{o\text{ sink}}$      | Sink output current     | $V_{\text{COMP}} = 1.9\text{V};$<br>$V_{\text{FB}} = 1.5\text{V}$                         | 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            |
| gm                       | Transconductance        | $I_{\text{comp}} = -0.1\text{mA}$ to<br>$0.1\text{mA}$<br>$V_{\text{COMP}} = 1.9\text{V}$ |              | 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><br>$V_{\text{sync}} = 2.33\text{V}$       | 0.11<br>0.21 |      | 0.25<br>0.45     | mA<br>mA      |
|                          | Master output amplitude | $I_{\text{source}} = 3\text{mA}$                                                          | 2.75         | 3    |                  | V             |
|                          | Output pulse width      | no load,<br>$V_{\text{sync}} = 1.65\text{V}$                                              | 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 $5\text{mA}$<br>$V_{CC} = 4.4\text{V}$ to $36\text{V}$            | (1) 3.2      | 3.3  | 3.399            | V             |
|                          | Line regulation         | $I_{\text{REF}} = 0\text{mA}$<br>$V_{CC} = 4.4\text{V}$ 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.

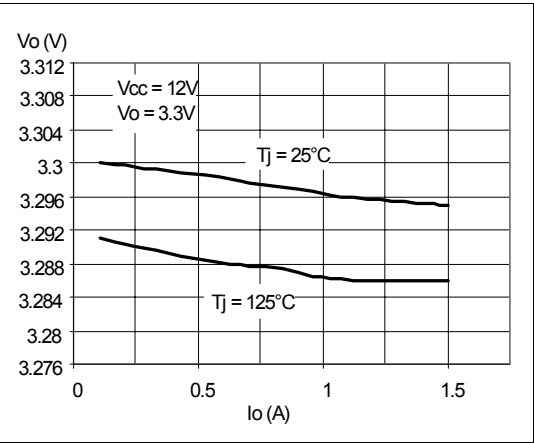
2. Guaranteed by design.

# 4 Typical characteristics

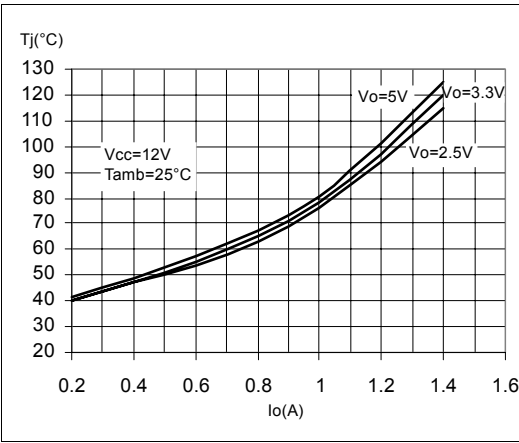
**Figure 3. Junction temperature vs output current**



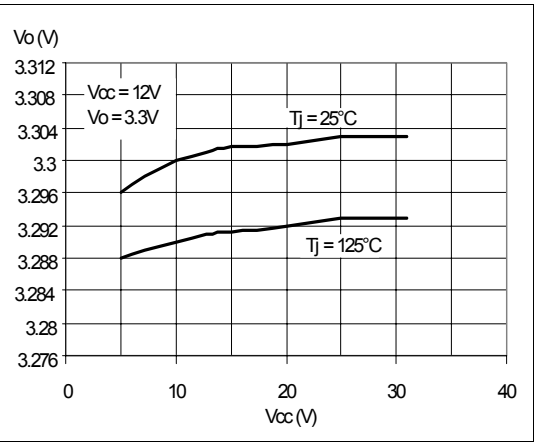
**Figure 4. Load regulator**



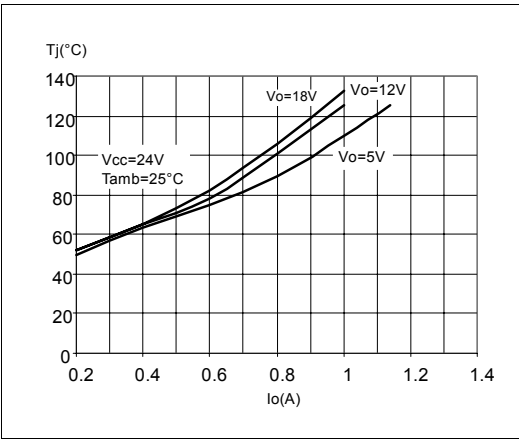
**Figure 5. Junction temperature vs output current**



**Figure 6. Line regulator**



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



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

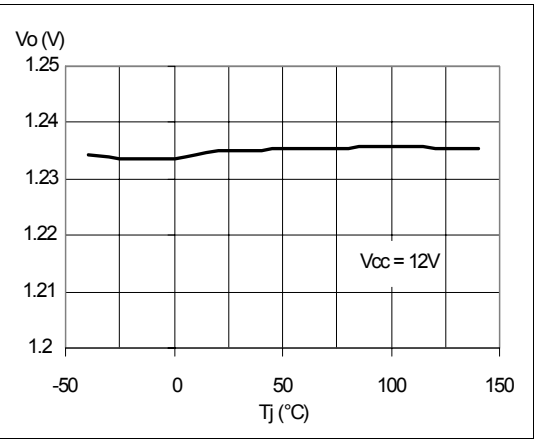


Figure 9. Quiescent current vs junction temperature

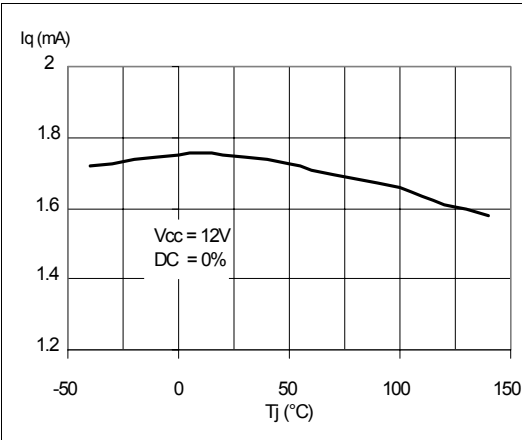


Figure 10. Switching frequency vs junction temperature

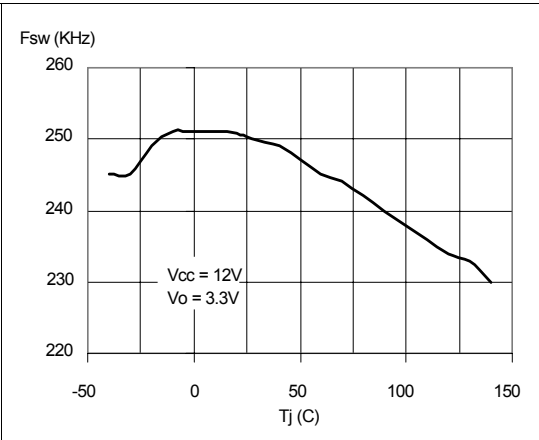


Figure 11. Shutdown current vs junction temperature

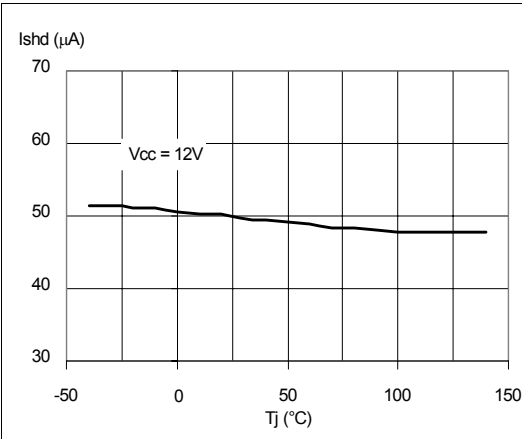


Figure 12. Efficiency vs output current

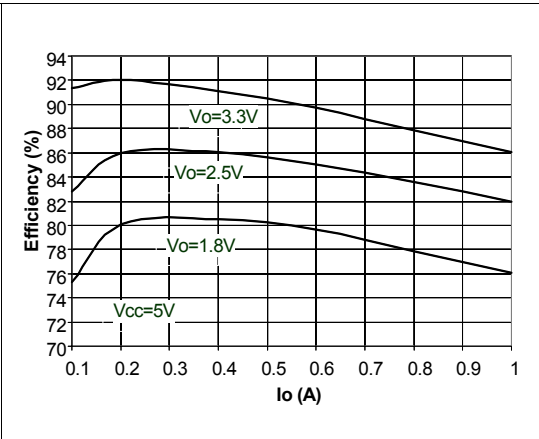
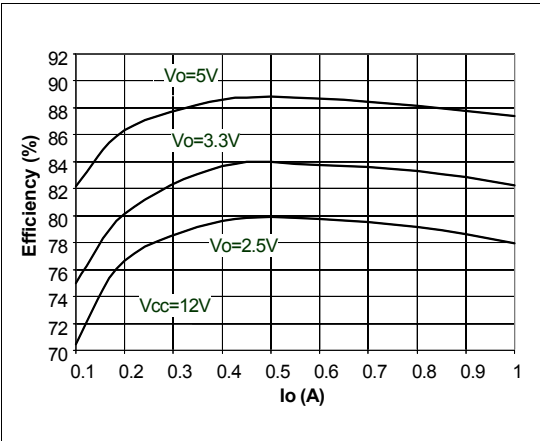


Figure 13. Efficiency vs output current



# 5 Application circuit

Figure 14. Demo board application circuit

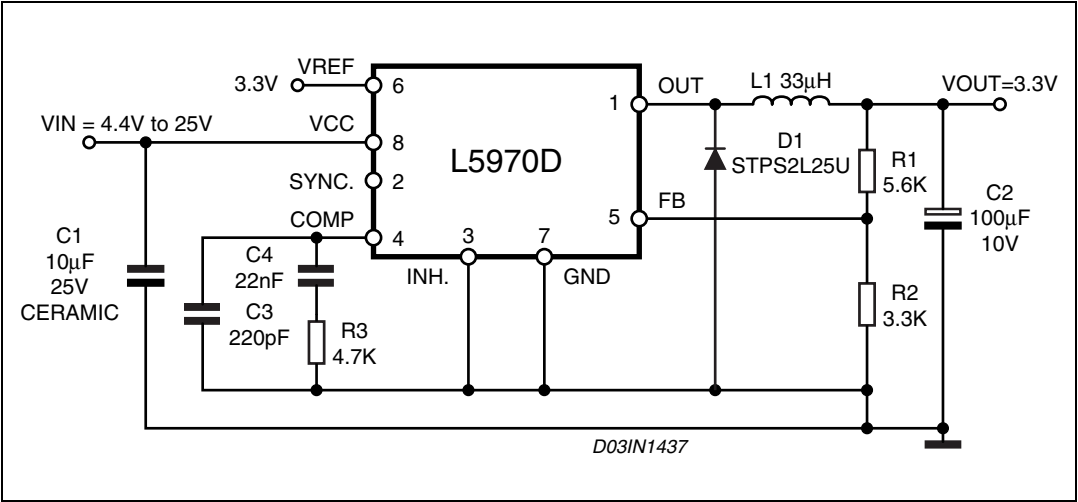


Table 5. Component list

| 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)

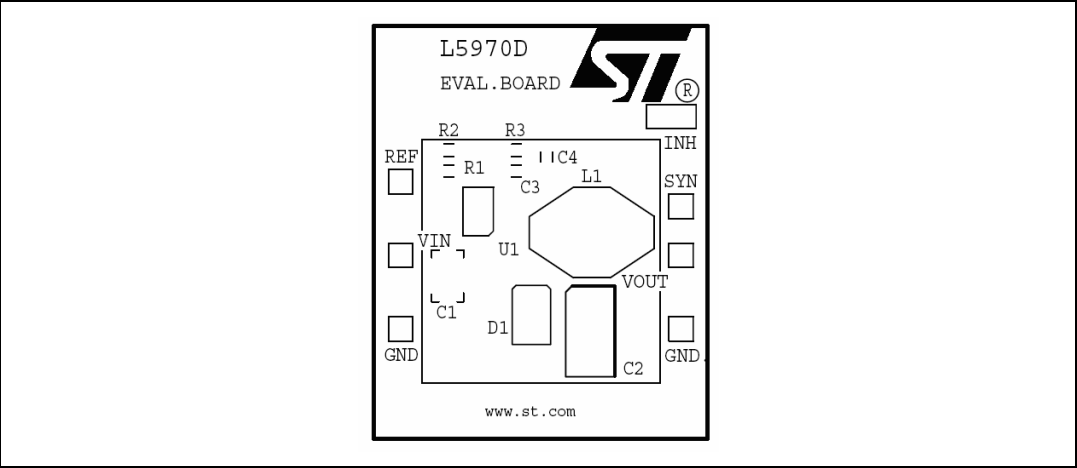


Figure 16. PCB layout (bottom side)

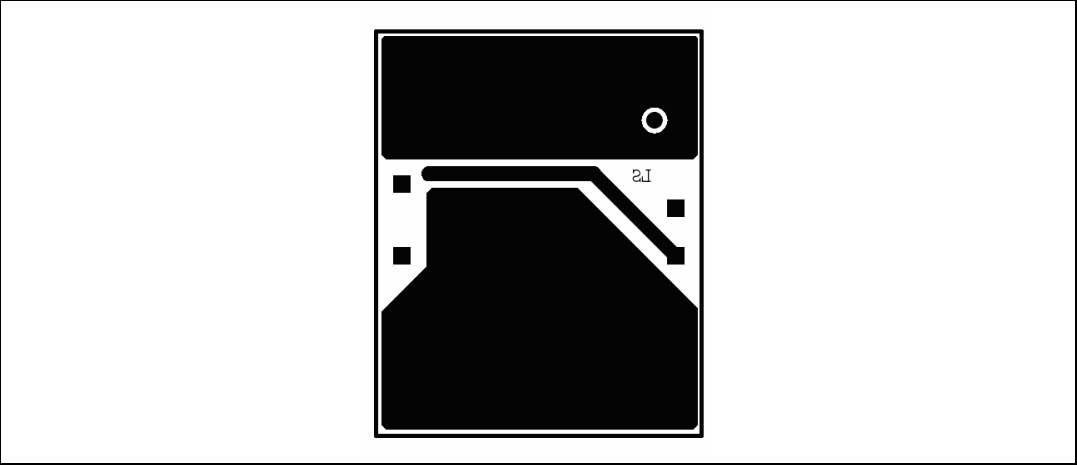
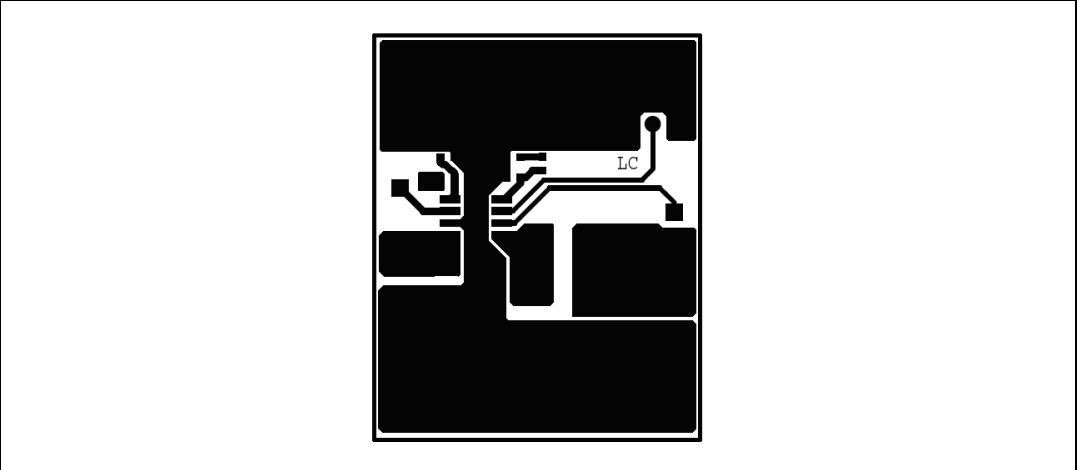


Figure 17. PCB layout (front side)



## 6 Application ideas

Figure 18. Dual output voltage with auxiliary winding

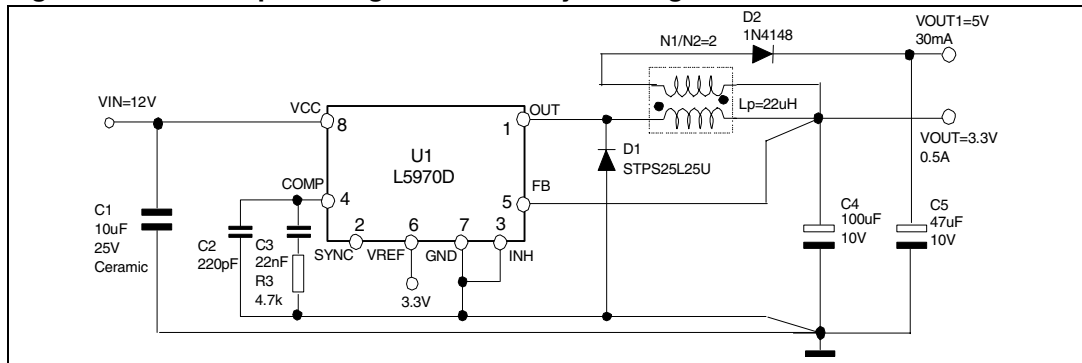


Figure 19. Buck-boost regulator

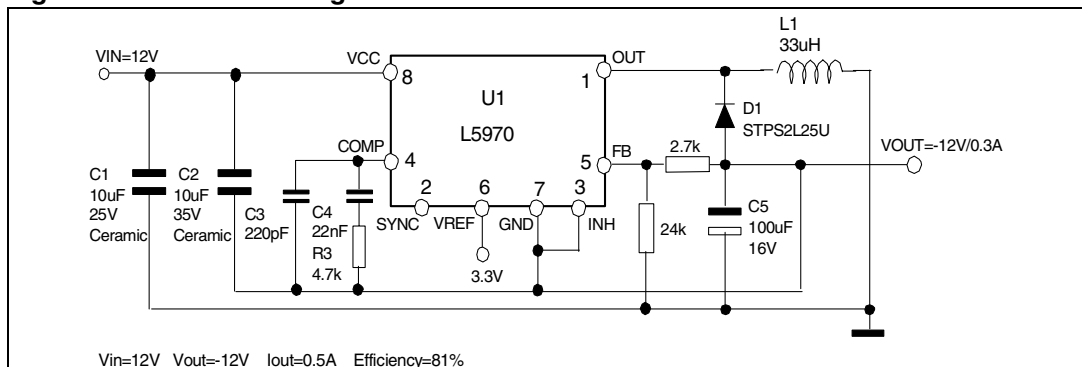


Figure 20. Positive Buck-Boost regulator

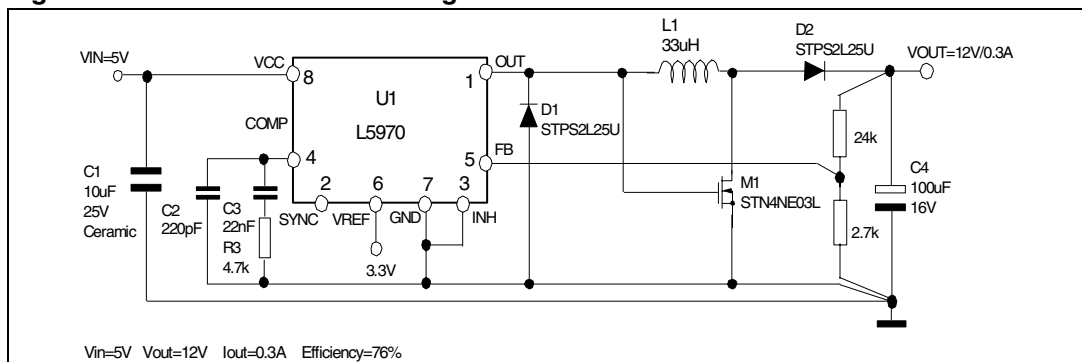
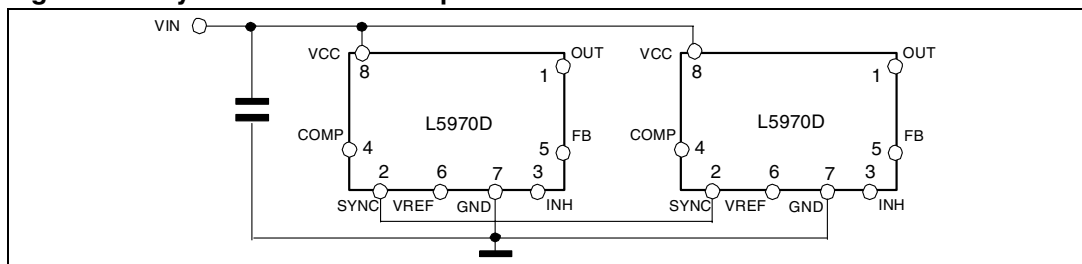


Figure 21. Synchronization example



## 7      **Package mechanical data**

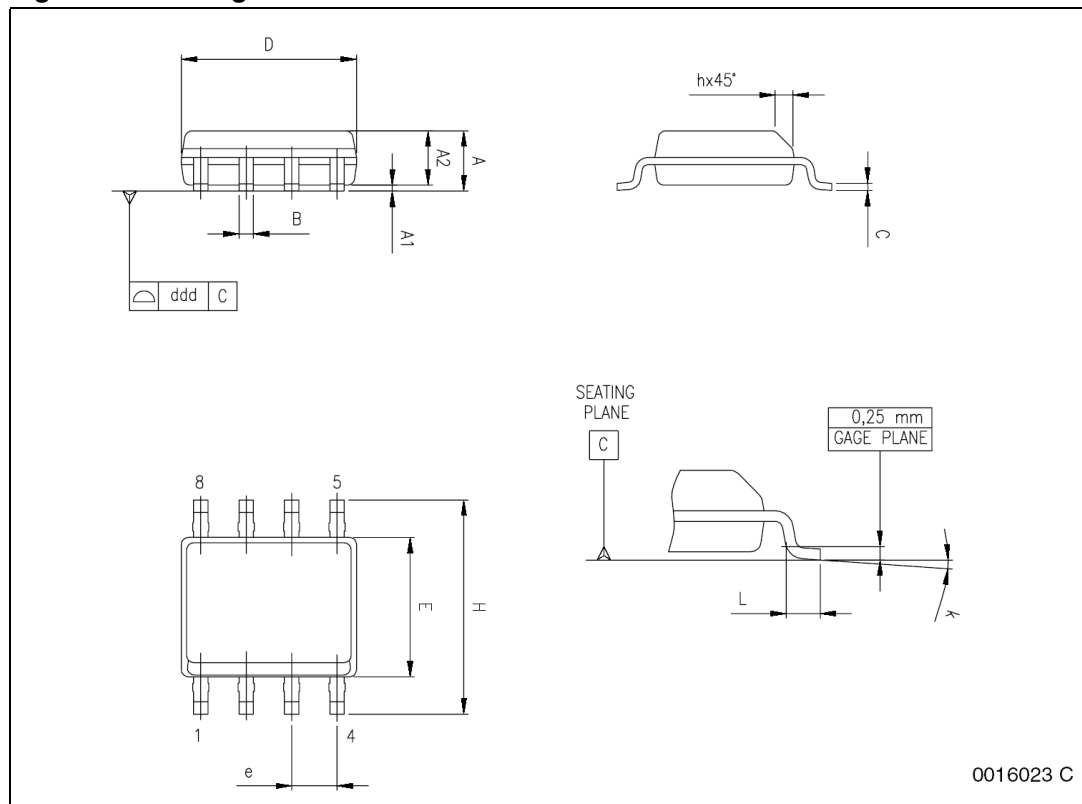
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Table 6. SO-8 mechanical data

| 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 <sup>(1)</sup> | 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



## 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> |

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