



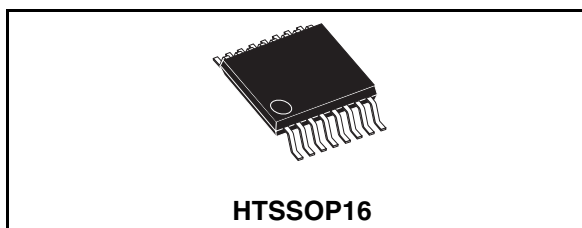
## L5988

### 4A step-down switching regulator with synchronous rectification

Preliminary Data

#### Features

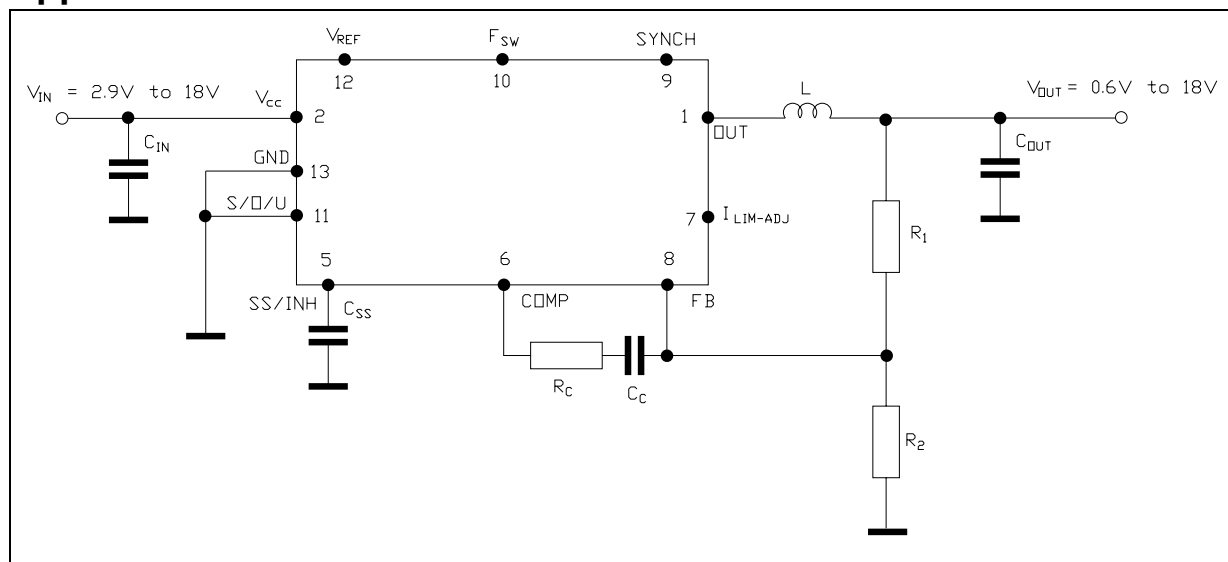
- 4A DC output current
- 2.9V to 18V input voltage
- Output voltage adjustable from 0.6V
- 400KHz switching frequency, programmable up to 1MHz
- Soft-start and inhibit
- $1.8V \pm 2\%$  reference voltage
- Low dropout operation: 100% duty cycle
- Voltage feed-forward
- Zero load current operation
- Sink current capability
- Over current, over voltage and thermal protection
- HTSSOP16 package



#### Applications

- Consumer:
  - STB, DVD, DVD recorder, TV, VCR, Car audio, LCD monitors
- Networking:
  - XDSL, Modems, DC-DC modules
- Computer:
  - Optical storage, Hard disk drive, Printers, Audio/Graphic cards
- Industrial:
  - Chargers, car battery, DC-DC converters

#### Application circuit



#### Order codes

| Part Number | Package  | Packaging     |
|-------------|----------|---------------|
| L5988D      | HTSSOP16 | Tube          |
| L5988DTR    | HTSSOP16 | Tape and reel |

August 2006

Rev 3

1/10

This is preliminary information on a new product now in development or undergoing evaluation. Details are subject to change without notice. [www.st.com](http://www.st.com)

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# 1 Technical characteristics

The L5988D is a synchronous step down monolithic power switching regulator capable of delivering up to 4A. The input voltage can range from 2.9V to 18V.

Thanks to the very short minimum ON time, the device is able to manage extremely low duty cycles, allowing very low output voltages. Requiring a minimum set of external components, the device includes an internal 400 KHz switching frequency oscillator that can be externally adjusted up to 1MHz. The regulator can provide 100% duty-cycle. A multifunction pin allows to enable-disable the sink mode current capability after soft-start, to enable-disable the latch mode for the OVP and to set the UVLO threshold for the 3.3V BUS and 12V BUS. The current limit can be externally adjusted to fit the application requirements. The current is sensed during both the on-time and the off-time and so the protection is effective with both very low or very high duty-cycle and/or with high switching frequency. The HTSSOP16 package with exposed pad allows reducing the  $R_{thJA}$  to 40°C/W

## 2 Pin connections and functions

Figure 1. Pin connection ( Top view)

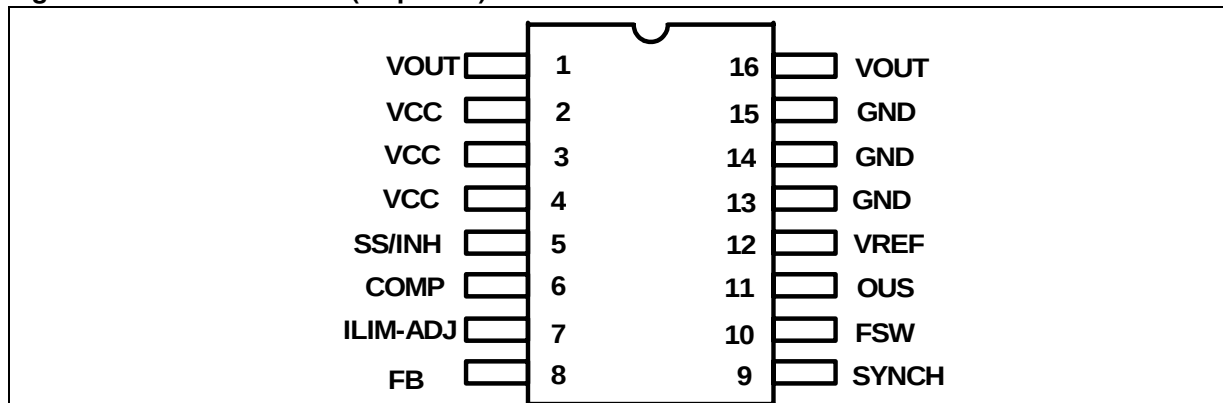


Table 1. Pin functions

| N° Pin   | Name             | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2,3,4    | V <sub>CC</sub>  | Unregulated DC input voltage.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 1,16     | V <sub>OUT</sub> | Regulator output.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 13,14,15 | GND              | Ground.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 9        | SYNCH            | It is a Master-Slave pin. Two or more devices can be synchronized by simply connecting the SYNCH pins together. The device operating with the highest FSW will be the Master. The Slave devices will operate with 180° phase shift from the Master.                                                                                                                                                                                                                                                           |
| 10       | FSW              | Connecting an external resistor from this pin to GND, the external frequency can be increased up to 1 MHz. Connecting an external resistor from this pin to VREF (1.8V), the switching frequency can be decreased down to 200 KHz. If the pin is left open, the default switching frequency is 400 KHz. The pin voltage is 1.2V. In OVP the pin is pulled up to 3.3V (only in latched mode).                                                                                                                  |
| 8        | FB               | This pin is connected to the error amplifier inverting input. Connect it to the output resistor divider (if used) or directly to Vout. This pin is also used to sense the output voltage in order to manage the over voltage condition.                                                                                                                                                                                                                                                                       |
| 6        | COMP             | This pin is connected to the error amplifier output and is used to compensate the voltage control feedback loop.                                                                                                                                                                                                                                                                                                                                                                                              |
| 5        | SS/INH           | The soft-start time is programmed connecting an external capacitor from this pin and GND. The internal current generator forces a current of 22 µA through the capacitor. When the voltage at this pin is lower than 0.65V the device is disabled.                                                                                                                                                                                                                                                            |
| 12       | V <sub>REF</sub> | Internally regulated voltage of 1.8V. It is used to provide a voltage reference for the multifunction pin. Filter this pin to ground with at least 1µF ceramic cap.                                                                                                                                                                                                                                                                                                                                           |
| 7        | ILIM-ADJ         | Connecting a resistor between this pin and GND it is possible to increase the over current protection threshold. Connecting a resistor between this pin and V <sub>REF</sub> it is possible to decrease the over current protection threshold.                                                                                                                                                                                                                                                                |
| 11       | S/O/U            | Multifunction pin. Depending on the voltage level at the input, with this pin it is possible: <ul style="list-style-type: none"> <li>– to enable-disable the sink mode current capability after soft-start;</li> <li>– to enable-disable the latch mode for the OVP;</li> <li>– to set the UVLO threshold for the 3.3V BUS and 12V BUS. (2.4V and 8V respectively);</li> </ul> The device continuously checks the analog value present at this pin and sets the function according with the measured voltage. |

### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol                                        | Parameter                                       | Value      | Unit               |
|-----------------------------------------------|-------------------------------------------------|------------|--------------------|
| $V_{CC}$                                      | Input voltage                                   | 20         | V                  |
| $V_{OUT}$                                     | Output DC voltage                               | -0.3 to 20 | V                  |
| S/O/U, SS/INH, FB, COMP, SYNCH, Fsw, ILIM-ADJ | Analog pins                                     | -0.3 to 4  | V                  |
| $P_{TOT}$                                     | Power dissipation at $T_A = 60^{\circ}\text{C}$ |            | W                  |
| $T_J$                                         | Junction temperature range                      | -40 to 150 | $^{\circ}\text{C}$ |
| $T_{storage}$                                 | Storage temperature range                       | -55 to 150 | $^{\circ}\text{C}$ |

### 4 Electrical characteristics

$V_{CC} = 12\text{V}$ ,  $T_J = 25^{\circ}\text{C}$ , unless otherwise specified

**Table 3. Electrical characteristics**

| Symbol          | Parameter                        | Test condition                      | Min | Typ | Max | Unit          |
|-----------------|----------------------------------|-------------------------------------|-----|-----|-----|---------------|
| $V_{CC}$        | Operating input voltage range    | $V_O = 0.6\text{V}$                 | 2.9 |     | 18  | V             |
| $R_{dson\_hs}$  | On resistance high-side MOSFET   |                                     |     | 75  |     | m $\Omega$    |
| $R_{dson\_ls}$  | On resistance low-side MOSFET    |                                     |     | 60  |     | m $\Omega$    |
| $I_l$ peak      | Current limit                    | $I_{LIM-ADJ} = \text{float}$        |     | 4   |     | A             |
|                 |                                  | $R = 270\text{K}\Omega$ to GND      |     | 5   |     | A             |
|                 |                                  | $R = 47\text{K}\Omega$ to $V_{REF}$ |     | 1.3 |     | A             |
| $I_l$ valley    | Current limit                    | $I_{LIM-ADJ} = \text{float}$        |     | 4.6 |     | A             |
|                 |                                  | $R = 270\text{K}\Omega$ to GND      |     | 5.6 |     | A             |
|                 |                                  | $R = 47\text{K}\Omega$ to $V_{REF}$ |     | 1.8 |     | A             |
| $I_{qst-by}$    | Total shutdown quiescent current | SS to GND                           |     | 35  |     | $\mu\text{A}$ |
| <b>Power-ON</b> |                                  |                                     |     |     |     |               |
| 3.3V BUS        | Turn-On $V_{CC}$ threshold       |                                     |     | 2.8 |     | V             |
|                 | Turn-Off $V_{CC}$ threshold      |                                     |     | 2.6 |     | V             |
| 12V BUS         | Turn-On $V_{CC}$ threshold       |                                     |     | 8   |     | V             |
|                 | Turn-Off $V_{CC}$ threshold      |                                     |     | 7   |     | V             |

**Table 3. Electrical characteristics**

| Symbol                        | Parameter                                               | Test condition                                              | Min | Typ   | Max | Unit |
|-------------------------------|---------------------------------------------------------|-------------------------------------------------------------|-----|-------|-----|------|
| <b>Soft start and inhibit</b> |                                                         |                                                             |     |       |     |      |
| I <sub>SS</sub>               | Soft start current                                      | SS = 2V                                                     |     | 18    |     | μA   |
|                               | Inhibit current                                         | SS = 0V                                                     |     | 5     |     | μA   |
|                               | Device ON level                                         |                                                             | 0.8 |       |     | V    |
|                               | Device OFF level                                        |                                                             |     |       | 0.3 | V    |
| <b>Oscillator</b>             |                                                         |                                                             |     |       |     |      |
| f <sub>S</sub>                | Switching frequency                                     | F <sub>SW</sub> = open                                      |     | 400   |     | KHz  |
|                               | Duty cycle <sup>(1)</sup>                               |                                                             | 0   |       | 100 | %    |
| <b>Voltage feedback</b>       |                                                         |                                                             |     |       |     |      |
| V <sub>FB</sub>               | Output voltage                                          | 2.9V < V <sub>CC</sub> < 18V                                |     | 0.6   |     | V    |
| <b>Error amplifier</b>        |                                                         |                                                             |     |       |     |      |
| V <sub>COMP</sub>             | Output voltage                                          | V <sub>SS</sub> = 3V                                        | 0   |       | 3   | V    |
| I <sub>FB</sub>               | Bias current                                            | V <sub>FB</sub> = 0V to 2.5V                                |     | 0.290 |     | μA   |
| I <sub>O</sub> source         | Source output pin                                       |                                                             |     | 25    |     | mA   |
| I <sub>O</sub> sink           | Sink output pin                                         |                                                             |     | 40    |     | mA   |
| V <sub>CM</sub>               | Common mode voltage                                     |                                                             | 0   |       | 2.3 | V    |
| V <sub>OFFSET</sub>           | Error amplifier offset                                  | V <sub>ref</sub> = 0.6V                                     | -5  |       | +5  | mV   |
| G <sub>V</sub>                | Open loop voltage gain                                  |                                                             |     | 100   |     | dB   |
| <b>Reference section</b>      |                                                         |                                                             |     |       |     |      |
| V <sub>REF</sub>              | Reference voltage                                       | I <sub>ref</sub> = 0 to 5mA<br>V <sub>CC</sub> = 2.9 to 18V |     | 1.8   |     | V    |
|                               | Line regulation                                         | I <sub>ref</sub> = 0 mA<br>V <sub>CC</sub> = 2.9 to 18V     |     | 6     |     | mV   |
|                               | Load regulation                                         | I <sub>ref</sub> = 0 to 5mA                                 |     | 7.5   |     | mV   |
|                               | Short circuit current                                   |                                                             |     | 12    |     | mA   |
| <b>Protections</b>            |                                                         |                                                             |     |       |     |      |
|                               | Over voltage trip<br>(V <sub>FB</sub> / 0.6V int. ref.) | V <sub>FB</sub> Rising                                      |     | 20    |     | %    |

1. Guaranteed by design

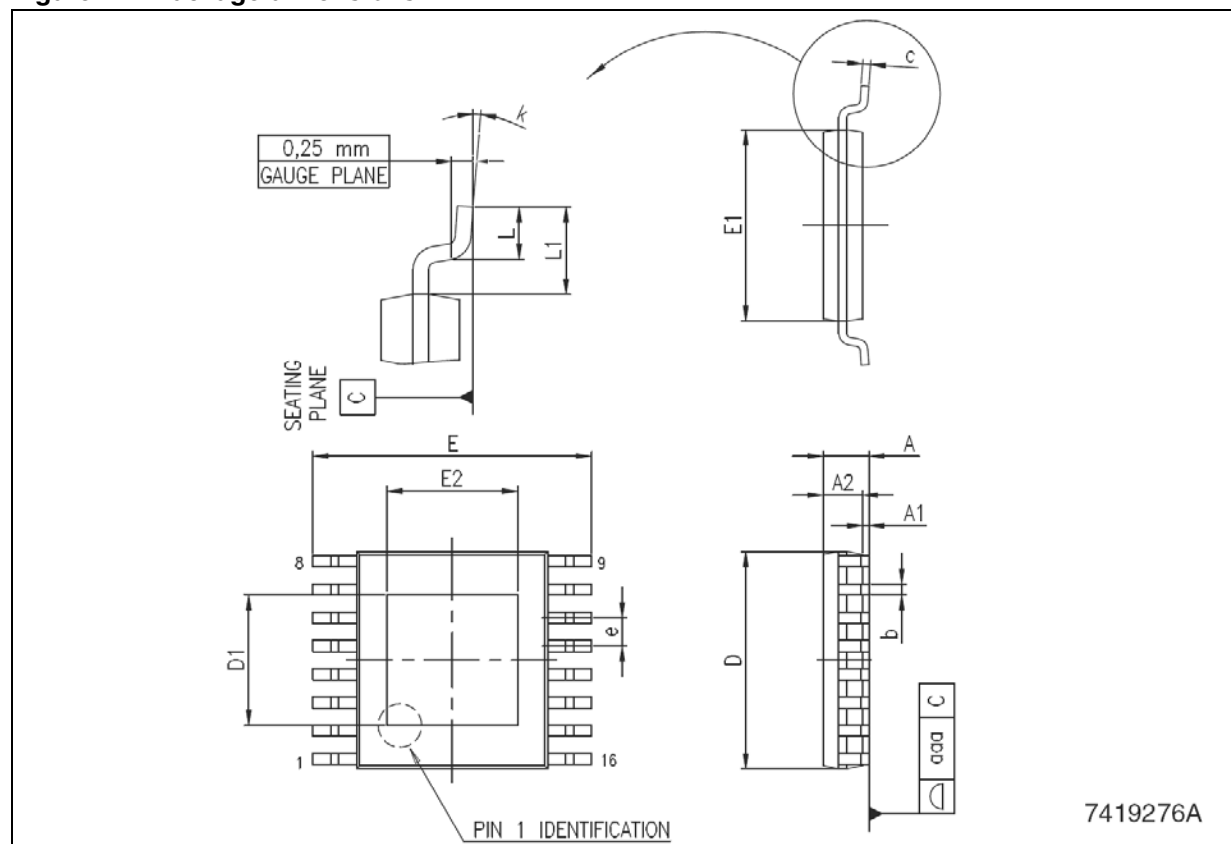
## 5 Package mechanical data

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 4. TSSOP16 exposed pad mechanical data

| Dim. | mm.  |      |      | Inch  |        |        |
|------|------|------|------|-------|--------|--------|
|      | Min  | Typ  | Max  | Min   | Typ    | Max    |
| A    |      |      | 1.2  |       |        | 0.047  |
| A1   |      |      | 0.15 |       | 0.004  | 0.006  |
| A2   | 0.8  | 1    | 1.05 | 0.031 | 0.039  | 0.041  |
| b    | 0.19 |      | 0.30 | 0.007 |        | 0.012  |
| c    | 0.09 |      | 0.20 | 0.004 |        | 0.0089 |
| D    | 4.9  | 5    | 5.1  | 0.193 | 0.197  | 0.201  |
| D1   | 1.7  |      |      | 0.067 |        |        |
| E    | 6.2  | 6.4  | 6.6  | 0.244 | 0.252  | 0.260  |
| E1   | 4.3  | 4.4  | 4.5  | 0.169 | 0.173  | 0.177  |
| E2   | 1.5  |      |      | 0.059 |        |        |
| e    |      | 0.65 |      |       | 0.0256 |        |
| K    | 0°   |      | 8°   | 0°    |        | 8°     |
| L    | 0.45 | 0.60 | 0.75 | 0.018 | 0.024  | 0.030  |

Figure 2. Package dimensions



## 6 Revision history

**Table 5. Revision history**

| Date        | Revision | Changes                                         |
|-------------|----------|-------------------------------------------------|
| 25-Nov-2005 | 1        | Initial release                                 |
| 10-Jan-2006 | 2        | Various updates on <a href="#">Table 1</a>      |
| 08-Aug-2006 | 3        | Added Electrical data <a href="#">Table 3</a> . |

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